MATERIALS

TESTING MANUAL

SAMPLING AND TESTING PROCEDURES

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(2 Pages)

MATERIALS TESTING MANUAL

INTRODUCTION

The Materials Testing Manual has been prepared for the purpose of standardizing sampling and testing procedures in the various laboratories which test materials for conformance to Arizona Department of Transportation specifications. The procedures found in this manual fall into one of four categories.

1. Those procedures which follow an established standard. The American Association of State Highway and Transportation Officials (AASHTO) is the primary contributor. Some procedures are conducted in accordance with the American Society for Testing and Materials (ASTM). Commonly used procedures in this category are listed in the Table of Contents, but these listings are not intended to include all procedures referenced in the Arizona Department of Transportation specifications.

2. Those procedures which generally follow an established standard, but which have been modified in some degree. They have been designated as modifications in a subheading beneath the title.

3. Those procedures that are modifications of testing procedures used by other state transportation departments.

4. Those procedures which have been originated by the Arizona Department of Transportation and which may not be fully described in national publications. These have been subtitled "An Arizona Method".

Each procedure in category 1 listed above is assigned an alphanumeric designation either by AASHTO or ASTM. AASHTO publishes the "*Standard Specifications for Transportation Materials and Methods of Sampling and Testing*" and the "*AASHTO Provisional Standards*" annually. Unless otherwise specified, the effective date of AASHTO standards is the first day of the month following publication and distribution of the published standards. Additional information regarding AASHTO standards can be obtained on the AASHTO website (www.transportation.org). The "*Annual Book of ASTM Standards*" is published in separate volumes throughout the year. Additional information regarding ASTM standards can be obtained on the ASTM website (www.astm.org).

Each procedure in category 2, 3, or 4 listed above is given a number prefixed by "ARIZ". Revised test designations will have a letter suffix, for example, the first revision of test method

ARIZ 201 would be ARIZ 201a, the second revision will be 201b, etc. Each procedure, or revision to it, is also identified by a date on which it becomes effective. References made to procedures in the manual which either do not include a letter suffix or have a suffix which has been superseded shall be understood to refer to the latest revision of the respective numbered procedure. The Table of Contents lists all Arizona sampling and testing procedures included in the manual, with their respective necessary letter suffixes.

The manual is divided into 10 different series, and an Appendix section, concerned with sampling and testing procedures for specific materials, design methods, or certification procedures.

It is the intent of Construction & Materials Group to describe the procedures in such detail that a competent operator who is unfamiliar with the method can obtain accurate results when the procedure is followed in detail. We will welcome any suggestions for improvement in these procedures that will assist in accomplishing this objective.

All revisions to the Materials Testing Manual shall officially originate from Construction & Materials Group, Quality Assurance Section, under the direction of the ADOT Standards Committee.

Revisions will be issued following approval by the ADOT Standards Committee. Revisions issued will be effective for projects with a bid opening date on or after the effective date of the revisions.

The Construction & Materials Group will welcome any suggestions for the improvement of the Materials Testing Manual, as it is hoped and intended that manual users will participate its formulation and revision.

July 15, 2005
(11 pages)

GLOSSARY OF TERMS

Abrasion - The wearing away of the surface of a solid by friction.

Abscissa - The distance measured in the "x" or horizontal direction on a graph.

Absorption - Process of a soil or aggregate holding a fluid mechanically, by capillary action. This applies both to water and asphalt.

Adhesion - (1) Shearing resistance between soil and another material under zero externally applied temperature.

(2) Molecular attraction exerted between the surfaces of bodies in contact.

Admixtures for Portland Cement Concrete - Materials other than water, aggregate, Portland cement, and fiber reinforcement that is used as an ingredient of Portland cement concrete to modify its freshly mixed, setting, or hardened properties and that is added to the batch before or during its mixing.

Aggregate - Any hard, inert mineral material used for mixing in graduated fragments. It includes sand, gravel, crushed stone, and blast-furnace slag.

(1) Coarse aggregate for Portland cement concrete - that retained on a No. 8 (2.36 mm) sieve.

(2) Fine aggregate for Portland cement concrete - that passing a 3/8" (9.5 mm) sieve and almost entirely passing a No. 4 (4.75 mm) sieve, and predominantly retained on a No. 200 (75μm) sieve.

Air-Entraining Agent - An admixture used in Portland cement concrete to increase the amount of entrained air in the mixture. Air is entrained in minute bubbles in the concrete or mortar during mixing.

Aliquot - A part of the whole that divides evenly into the whole, as 3 mL is an aliquot portion, 1/8 of 24 mL.

Anhydrous - A material which has an affinity for water due to the fact that the water in its crystalline structure has been removed.

Asphalt - A dark brown to black cementitious material, solid or semi-solid in consistency, in which the predominating constituents are bitumens which occur in nature as such or are obtained as residual in refining petroleum.

Asphalt Cement - Asphalt that is refined to meet specifications for paving, industrial, and special purposes.

Asphalt Emulsion Slurry Seal - A mixture of slow-setting emulsified asphalt, fine aggregate and mineral filler, with water added to produce a slurry consistency.

Asphalt Joint Fillers - Asphaltic products used for filling cracks and joints in pavement and other structures.

Asphaltic Concrete - A thoroughly controlled hot mixture of asphalt cement and well-graded aggregate, thoroughly compacted into a uniform dense mass.

Auger - A drill for test holes in unconsolidated material modeled after the conventional screw auger.

Bitumen - Hydrocarbon material of natural and/or pyrogenous origin, frequently accompanied by their non-metallic derivatives, which may be gaseous, liquid, semi solid or solid, and is completely soluble in carbon disulfide.

Bleeding - (1) Upward migration of bituminous material resulting in a film of asphalt on the surface.

(2) Escape of water from freshly placed concrete commonly observed as an accumulation on a horizontal surface.

Boulder - A rock fragment, usually rounded by weathering or abrasion, which will be retained on a 3 inch (75 mm) sieve.

Capillarity - The rise or movement of a liquid in the interstices of a soil due to capillary forces.

Chemical Change - Any change resulting in formation of a new substance.

Clay (Clay Soil) - Fine-grained soil or the fine-grained portion of a soil that can be made to exhibit plasticity within a range of water contents and that exhibits considerable strength when air-dry.

Coal Tar - Tar produced by destructive distillation of bituminous coal.

Cohesion - (1) The property of a soil that makes its particles stick together (clay is a cohesive soil).

(2) The property of a bituminous material that holds the mass together.

Colloidal - Pertaining to soil particles that are so small (less than 0.001 mm) that the surface activity has an appreciable influence on the properties of the aggregate.

Compaction - The densification of a soil by means of mechanical manipulation.

Compressibility - Property of a soil pertaining to its susceptibility to decrease in volume when subjected to load.

Consistency - (1) The relative ease with which a soil can be deformed.

(2) Relative mobility of freshly mixed concrete commonly defined as slump.

Corrugations - Regular transverse undulations on the surface of sheet metal, consisting of alternate valleys and crests.

Curing of Concrete - A period provided to prevent formation of surface cracks due to rapid loss of water while concrete is plastic, and to assure attainment of maximum strength.

Curing Compound (Liquid) - A liquid, membrance-forming material used in curing Portland cement concrete, which prevents moisture loss during the early hardening period. Papers and other impermeable sheet materials can be used for the same purpose.

Cutback (Liquid) Asphalt - Asphalt cement which has been liquified by blending with petroleum distillates. Upon exposure to atmospheric conditions the diluents evaporate, leaving the asphalt cement to perform its function.

(1) Rapid Curing (RC) - Composed of asphalt cement and a naphtha or gasoline-type diluent of high volatility.

(2) Medium Curing (MC) - Composed of asphalt cement and a kerosene-type medium volatility.

(3) Slow Curing (SC) - Composed of asphalt cement and oils of low volatility.

Deflocculant - An agent that prevents fine soil particles in suspension from coalescing to form flocs; for example the working solution employed in the Sand Equivalent test.

Density (Unit Weight) - Weight of a material per unit volume.

Disintegration - Deterioration or separation into smaller fragments from any cause.

Distillation - Process of driving off gas or vapor from liquids or solids, with heat, in a retort or still, and condensing products therefrom.

Ductility - Capability of being drawn out or hammered thin. A common test for bituminous materials, which determines, indirectly, the adhesive quality, and temperature susceptibility.

Elasticity - That property of a body which causes it to recover its original shape and size when it is deformed and the deforming forces are removed.

Emulsified Asphalt - A heterogeneous system containing two normally immiscible phases (asphalt cement and water) with a small amount of emulsifying agent. It exists in a liquid state at normal temperatures. Emulsified asphalts may be anionic, with electro-negatively charged asphalt globules; or cationic, with electropositively charged asphalt globules, depending upon the emulsifying agent.

Erosion - The loosening and transporting of rock debris and soil by moving agents operating on the earth's surface. The four main agents are: wind, waves and currents in bodies of water, glaciers, and running water.

Expansion Joint - Joint permitting pavement to expand in length.

Fabricating Plant - A plant where steel members are riveted or welded together to form steel beams, trusses, metal pipe, etc.

Fineness Modulus - An index of the fineness or coarseness of an aggregate; the summation of the cumulative percentages of the material retained on the specified series of sieves divided by 100. It is **not** an indication of grading. Sieve sizes used are No. 100 (150 μm), No. 50 (300 μm), No. 30 (600 μm), No. 16 (1.18 mm), No. 8 (2.36 mm), No. 4 (4.75 mm), 3/8 inch (9.5 mm), 3/4 inch (19.0 mm), 1-1/2 inch (37.5 mm), and larger, increasing in the ratio of 2 to 1.

Floc - Loose, open-structured mass formed in a suspension by aggregation of minute particles.

Flocculation - Process of forming flocs.

Free Water (Ground Water) - Water that is free to move through a soil mass under the influence of gravity.

Friable - Easily broken or crumbled.

Frost Action - Freezing and thawing of moisture in materials and the resultant effects on these materials and on structures of which they are a part or with which they are in contact.

Gradation - Proportion of material of each grain-size present in a given aggregate sample.

Granular - Material that does not contain more than 35 percent of soil particles which will pass a No. 200 (75 μm) sieve.

Gravel - Rounded or semi-rounded particles of rock that will pass a 3 inch (75 mm) sieve and be retained on a No. 10 (2.00 mm) sieve.

Heave - Upward movement of soil caused by expansion or displacement resulting from phenomena such as moisture absorption, removal of overburden, driving of piles, frost action, etc.

Honeycomb - A surface or interior defect in a concrete mass characterized by lack of mortar between the coarse aggregate particles.

High-Early Strength Cement - A finer ground cement with a different chemical composition that reaches a high strength in a shorter period of time than regular cement.

Hydrated Lime - A dry powder obtained by treating quicklime with water enough to satisfy its chemical affinity for water under the conditions of its hydration. It is predominantly calcium hydroxide.

Hydraulic Cement - A cement that sets and hardens by chemical interaction with water and that is capable of doing so under water.

Hydrophilic - Literally, water-loving. The property that defines a material as having an affinity (attractive force) for water.

Hydrophobic - Literally, water-averting. The property that defines a material as lacking an affinity (attractive force) for water.

Hygroscopic Water - Water retained in an air-dried soil. It is held by each soil grain in a very thin film and has both physical and chemical affinity for the grain. This moisture is in equilibrium with the air humidity.

Joint (Pavement) - A narrow space separating two slabs or sections of pavement.

Leaching - The removal of soluble salts or other soluble particles by percolating water.

Liquid Limit - (1) The moisture content which is the boundary between the liquid and plastic states for the minus No. 40 (425 μm) fraction of a soil.

(2) That moisture content at which a soil fraction will close a standard groove for a length of about 1/2 inch (13 mm) when subjected to 25 blows in a liquid limit device.

Macadam - An asphalt pavement construction using a coarse, open-graded aggregate that is usually produced by crushing and screening stone, slag or gravel.

Maximum Size of Soil and Aggregate - The smallest sieve opening through which the entire amount of material will pass.

Note: Another definition, which applies only to aggregates used in Superpave mixes (Section 417, "Asphaltic Concrete (End Product) SHRP Volumetric Mix", of the ADOT Specifications) is: Maximum Aggregate Size - One size larger than the nominal maximum aggregate size.

Mesh - The square opening of a sieve.

Modulus of Rupture - A measure of the flexural strength of concrete when it is broken by bending. The higher the values the greater the strength.

Moisture Content - (1) The proportion of moisture in soil or aggregate material, expressed as a percent of the dry weight.

(2) Optimum Moisture Content - The percentage of moisture at which the greatest density of a particular soil can be obtained through compaction by a specified method.

(3) The proportion of moisture in bituminous mixtures, expressed as a percent of the wet weight.

Nominal Maximum Size of Soil and Aggregate - The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.

Note: Another definition, which applies only to aggregates used in Superpave mixes (Section 417, "Asphaltic Concrete (End Product) SHRP Volumetric Mix", of the ADOT Specifications) is: Nominal Maximum Aggregate Size - One size larger than the first sieve that retains more than 10 percent aggregate.

Ordinate - The distance measured in the "y" or vertical direction on a graph.

Overlay - One or more courses of asphalt construction on an existing pavement, generally including a leveling course, followed by a uniform course or courses to provide needed thickness.

Penetration - The consistency of a bituminous material expressed as the distance that a standard needle vertically penetrates a sample of the material under known conditions of loading, time and temperature.

Permeability - That property of a material which permits a liquid to flow through its pores or interstices.

pH - An index of acidity or alkalinity, in terms of the logarithm of the reciprocal of the hydrogen ion concentration. A pH of seven, the value for pure distilled water, is regarded as neutral; pH values of less than seven indicate acidity; and, pH values of greater than seven indicate alkalinity.

Plasticity - The property of a soil which allows it to be deformed beyond the point of elastic recovery without cracking or appreciable volume change.

Plasticity Index (PI) - Numerical difference between the liquid limit and the plastic limit.

Plastic Limit - (1) The water content corresponding to an arbitrary limit between the plastic and semisolid states of consistency of a soil.

(2) Water content at which a soil will just begin to crumble when rolled into a thread about 1/8 inch (3 mm) in diameter.

Porosity - The ratio, in percent, of the volume of void space (pores) of a material to the total volume of its mass.

Portland Cement - A hydraulic cement made by pulverizing portland-cement clinker (a clinker, partially fused by pyroprocessing, consisting predominantly of crystalline hydraulic calcium silicates), and usually containing calcium sulfate.

Prime Coat - The first application of a bituminous material to an existing absorbent surface.

Pumping - The ejection of foundation soil wet or dry, through joints or cracks, or along edges of rigid slabs, due to vertical movements under traffic.

Quicklime - A calcined material, the major part of which is calcium oxide or calcium oxide in association with a lesser amount of magnesium oxide, capable of slaking with water.

Raveling - Progressive disintegration of a pavement surface by dislodgment of aggregate particles.

Relative Density - (1) Soils - The ratio of *(1)* the difference between the void ratio of a cohesionless soil in the loosest state and any given void ratio, to *(2)* the difference between the void ratios in the loosest and in the densest states. This definition is expressed as an equation below:

$$Dr = \frac{Emax - En}{Emax - Emin}$$

Where: Dr = Relative density of cohesionlesss soils
$Emax$ = Void ratio of soil in the loosest state
$Emin$ = Void ratio of soil in the densest state
En = Any given void ratio

(2) Asphaltic Concrete – Often used for specimens prepared by means of the Superpave gyratory compactor; the ratio, expressed as a percentage, of the bulk specific gravity (at any number of gyrations) to the theoretical maximum specific gravity.

Riprap - Broken rock used for the protection of embankments, cut slopes, etc., against agents of erosion, primarily water.

Road Mix - A mixture of aggregate and asphalt prepared in place.

Rock - Natural solid mineral matter occurring in large masses or fragments.

Rutting - Formation of longitudinal depressions by the lateral displacement of soils or surfaces under traffic.

Sand - Particles of rock that will pass the No. 4 (4.75 mm) sieve and be retained on the No. 200 (75 μm) sieve.

Saturated Surface-Dry - Term used to describe the condition of an aggregate in which the pores of all the particles are completely filled with water, but their surfaces are free from moisture.

Screed - To strike off excess material to bring the top surface to proper contour and elevation.

Screen - An apparatus, in which the apertures are circular, for separating sizes of material.

Seal Coat - A thin asphaltic surface treatment used to improve the texture of and to waterproof an asphalt pavement surface.

Settlement - The reduction in elevation of short sections of pavement or structures, due to compressibility of underlying soils.

Shear Strength - The maximum resistance of a soil to shearing stresses.

Shear Stress - An action or stress, resulting from applied forces, which tends to cause two contiguous parts of a body to slide relatively to each other in a direction parallel to their plane of contact.

Sieve - An apparatus, in which the apertures are square, for separating sizes of material.

Silt - Material passing the No. 200 (75 μm) sieve that is nonplastic or very slightly plastic and that exhibits little or no strength when air-dried.

Slump - The measure of the consistency of concrete determined by placing the concrete in a standard slump cone, removing the cone, and allowing the concrete to settle under its own weight.

Soil - Sediments or other consolidated accumulations of solid particles produced by the chemical and physical disintegration of rocks, and which may or may not contain organic matter.

Soil Profile - Vertical section of a soil, showing the nature and sequence of the various layers, as developed by deposition or weathering or both.

Soundness - Resistance to both physical and chemical deterioration.

Spalling - Peeling away of a surface, particularly Portland cement concrete.

Specific Gravity (Absolute) - The ratio of the weight in air of a given volume of material at a stated temperature, to the weight in air of the volume of water which the material displaces.

Specific Gravity (Apparent) - Ratio of the weight in air of a given volume of impermeable material (that is, the solid matter including the impermeable pores) to the weight of an equal volume of water at a stated temperature.

Specific Gravity (Bulk) - Ratio of the weight of a given volume of permeable material (including permeable and impermeable voids) to the weight of an equal volume of water at a stated temperature.

Spelter - The zinc coating used for rustproofing iron or steel by galvanizing.

Stability - Property of a material which enables it to retain its other essential characteristics throughout the range of conditions expected in service.

Stone - Crushed or naturally angular particles of rock that will pass a 3 inch (75 mm) sieve and be retained on a No. 10 (2.00 mm) sieve.

Stripping - Separation of bituminous films from aggregate particles due to presence of moisture.

Swell - Increase in volume due to the absorption of water into the intergranular pore space.

Tack Coat - A very thin spraying of bituminous material on an existing surface to increase the adhesion, or bond, between a new course of construction and the old surface.

Titration - The volumetric addition of a solution, of known concentration, to another solution to determine an end point reaction.

Top Soil - Usually the upper 6 inches (150 mm) of native soil and that portion used in dressing and landscaping earth slopes.

Viscosity - The property of a fluid to resist internal flow.

Void - Space in a mass not occupied by solid mineral matter; it may be occupied by air, or other fluids.

Warping - Deviation of pavement surface from original shape caused by temperature and moisture differentials within the slab.

Yield - Ratio of the volume of a Portland cement concrete mixture produced to that which theoretically should be produced.

NOTE: Additional information on Terminology and Definitions of Terms can be found in various other sources, including the following:

AASHTO M 146: "Terms Relating to Subgrade, Soil-Aggregate, and Fill Materials".

AASHTO R 10: "Definition of Terms for Specifications and Procedures".

ASTM C 125: "Standard Terminology Relating to Concrete and Concrete Aggregates".

ASTM C 219: "Standard Terminology Relating to Hydraulic Cement".

ASTM D 8: "Standard Terminology Relating to Materials for Roads and Pavements".

ASTM D 653: "Standard Terminology Relating to Soil, Rock, and Contained Fluids".

ASTM E 456: "Standard Terminology Relating to Quality and Statistics".

SERIES 100
SAMPLING

SAMPLING BITUMINOUS MATERIALS

(An Arizona Method)

1. SCOPE

1.1 This procedure covers best practices for sampling of Bituminous materials (paving grade asphalt, crumb rubber asphalt and emulsions) in the field.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 For the purpose of this test method Bituminous materials other than Emulsions will be referred to as “Asphalt Binder”, and Emulsified Bituminous material i.e. (RS-1, SS-1, CSS-1, etc…) will be referred to as “Emulsions”.

2. SIZE OF SAMPLES

2.1 A minimum of 1 gal. of Asphalt Binder.

2.2 A minimum of two ½ gal. containers per sample of Emulsions.

3. CONTAINERS

3.1 Containers for Asphalt Binder, shall be double friction top cans.

3.2 Containers for Emulsion samples shall be wide mouth containers made of plastic.

4. PROTECTION AND PRESERVATION OF SAMPLES

4.1 Containers shall be new and free of any moisture, contaminants, or residue from any manufacturing process. The top and container shall fit together tightly.

4.2 The container shall be tightly sealed immediately after obtaining the sample.

4.3 The filled sample container shall not be cleaned using a solvent. If cleaning is necessary use a clean dry cloth.

4.4 Samples of Emulsion shall be protected from freezing.

4.5 Transferring samples from one container to another shall be avoided if possible.

4.6 Sample containers shall be identified using sample tags that are securely fastened to the side of the container so they will not be lost in transit, and shall be clearly marked for identification with a suitable permanent marker on the side of the container itself.

5. PROCEDURE

5.1 Samples of Asphalt Binder shall be taken from the last possible point before the bituminous material is introduced into the hot plant. This is usually from a spigot or faucet on the circulation line.

5.2 Bituminous materials applied to pavement surfaces, i.e. Tack Coat, Fog Coat shall be sampled from the distributor truck at the project.

5.3 Clearly identify the side (not the lid) of a new clean container of appropriate size with the sample number, date, project number, type of material, and any other pertinent information.

5.4 To ensure the sample is representative, draw off and discard a minimum of 1 gal. of Bituminous material prior to obtaining the sample from the sampling valve.

5.5 From the sampling valve draw off the minimum amount of Bituminous material required for the type of material being sampled. Care should be taken to avoid spilling any material on the outside of the container or over filling the container. The container should be filled to no closer than one inch from the top.

5.6 Immediately after obtaining the sample, the clearly identified container shall be tightly and positively sealed.

SAMPLING ASPHALTIC CONCRETE MIXTURES

(An Arizona Method)

1. SCOPE

1.1 This procedure describes the methods which are to be used when sampling asphaltic concrete mixtures in order to best assure representative samples of the materials being placed.

1.2 Sampling asphaltic concrete mixtures by this procedure may involve hazardous material, operations, or equipment. This procedure does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 For the purpose of this method, asphaltic concrete mixtures are referred to as either Asphaltic Concrete (AC) or Asphaltic Concrete Friction Course (ACFC), regardless of the asphalt binder type.

2. APPARATUS

2.1 Sampling Plate - A 4 foot x 1 foot x 1/16 inch steel plate, which has been prepared with a 1/8 inch hole at each corner of one end and a sufficient length of wire tied through each hole to form a loop approximately 4 feet in length. The sampling plate may be used when sampling AC mixtures.

2.2 Cookie-Cutter Template - As an alternate to obtaining the sample from the sampling plate, a rectangular metal template ("cookie cutter") and metal plate of sufficient size may be used to sample the AC mixture. The metal template and plate shall be of sufficient size so that the desired amount of material is obtained by a single use of the template and plate at any one location. The metal plate shall be prepared with a wire(s) of sufficient length attached to each corner on one side of the metal plate (the short side when the plate is not square) so the metal plate may be located by raising the wire(s) after the laydown machine has passed.

2.3 Miscellaneous Brushes - May be helpful when obtaining the entire amount of AC mixture from a cookie-cutter template.

2.4 Flat Square Point Shovel - A flat square point shovel shall be used when sampling AC mixtures. A flat square point shovel may also facilitate sampling ACFC mixtures and when sampling by other procedures as described below.

2.5 5-Gallon Bucket, or other suitable container - Shall be used when sampling AC mixtures and ACFC mixtures.

3. SIZE OF SAMPLES

3.1 For AC mixtures designed with Marshall design procedures, minimum 75 pounds.

3.2 For AC mixtures designed with Gyratory design procedures, minimum 130 pounds.

3.3 For ACFC mixtures, minimum 50 pounds.

4. SAMPLING AC MIXTURES

4.1 The sampling plate shall be placed on the roadway just ahead of the laydown machine. Except for wider mats when a sample is being taken from the middle of the mat, the sampling plate is placed so that the end with the wire is approximately one foot in from the right or left edge of the mat being laid. The sampling should be alternated between the right and left edges when practical. The wire attached to the end of the plate shall be held to the ground to allow the laydown machine to pass over the plate and wire.

4.2 After the laydown machine has passed, locate the plate by raising the wire.

4.3 The sample shall be taken from the plate using a flat square point shovel. The sample shall consist of the full depth of material for one shovel width from the center portion of the plate over its entire length. Material covering the entire plate shall not be taken. A single pass of the shovel shall be made, moving along the surface of the plate until the shovel is full. Carefully deposit the AC mixture into a 5-gallon bucket, or other suitable container. Material which has sloughed into the resultant trench shall not be obtained. At the next undisturbed area of material on the plate, repeat shoveling and placing the material into the container. If necessary, additional material may be obtained by using an

additional plate(s) in the immediate vicinity and combining all material. The use of an additional plate(s) cannot be used in lieu of splitting.

Note: When sampling with the "cookie cutter", the metal plate shall be placed on the roadway at the location where the sample is to be taken, just ahead of the laydown machine. If the metal template is not square, it shall be placed on the roadway so that the longest side is in a transverse direction across the roadway. The wire(s) shall be held to the ground to allow the laydown machine to pass over the plate and wire(s). After the laydown machine has passed, locate the plate by raising the wire(s). The template is pressed through the AC mixture until it rests squarely upon the plate. The entire amount of AC mixture is removed from the interior of the template and carefully placed into a 5-gallon bucket, or other suitable container. Obtaining multiple samples cannot be used in lieu of splitting.

5. SAMPLING ACFC MIXTURES

5.1 When sampling ACFC mixtures, an adequate amount of material shall be taken from the truck at the mixing plant and placed into a 5-gallon bucket, or other suitable container. The sample shall be taken from at least 3 random locations, approximately 12" below the surface, within five minutes from the time the loading of the truck is completed.

5.2 Material that is to be tested immediately after it has been sampled shall be protected to avoid heat loss while it is being transported to the laboratory.

6. SAMPLING FINISHED AC PAVEMENT

6.1 Samples of AC from finished pavement shall be taken through the complete thickness of the pavement or lift, in such a manner which causes minimum disturbance to the sample.

6.2 If a coring apparatus is used, the coring bit shall be subjected to enough vertical pressure to penetrate the pavement without causing damage to equipment or disturbance of the sample. The minimum core diameter shall be 4 inches.

6.3 If coring equipment is not available, the sample may be taken with the use of a saw, pick, jackhammer, or other suitable means if a suitable specimen can be obtained for the intended testing.

6.4 All samples shall be handled carefully so that they maintain their original form. The samples shall be transported on a relatively flat surface, and adequately protected to preserve their shape and to prevent damage.

6.5 The use of ice may be found helpful in obtaining and/or preserving the condition of the specimen.

6.6 Samples shall be delivered to the laboratory for testing as expeditiously as reasonably possible. Samples shall be transported carefully in a covered container out of extreme environmental conditions.

7. SAMPLING MISCELLANEOUS PLACEMENT OF AC MIXTURES

7.1 When required, samples of AC mixtures placed in miscellaneous areas shall be obtained from locations and by means to provide appropriate representation of the AC mixture being placed. Miscellaneous areas are locations where representative samples would be difficult to obtain in-place due to geometry, paving area size, limited access, or other factors. These areas could include paving slopes, median islands, utility trenches, tapers, radius paving and any other area designated by the Engineer.

8. SAMPLE IDENTIFICATION

8.1 Each sample shall be identified by an accompanying sample ticket. Sample tickets shall be filled out as required to provide necessary information. The remarks area of the sample ticket shall be used as necessary to provide additional information, including the phone number of an individual who can be contacted regarding the sample.

8.2 The source of the sample shall be the "original source" of the material, as indicated on the sample ticket.

8.3 An example of a completed sample ticket used by ADOT for construction projects is shown in Figure 1. Commonly used codes for filling out the sample ticket are shown on the back side of the sample ticket (see Figure 2).

8.4 The sample ticket consists of three copies. The center copy is kept by the person submitting the sample, the original copy is included inside the sample container, and the third copy is attached to the sample container. When filling out sample tickets, make certain information is clear and easily read on all three copies.

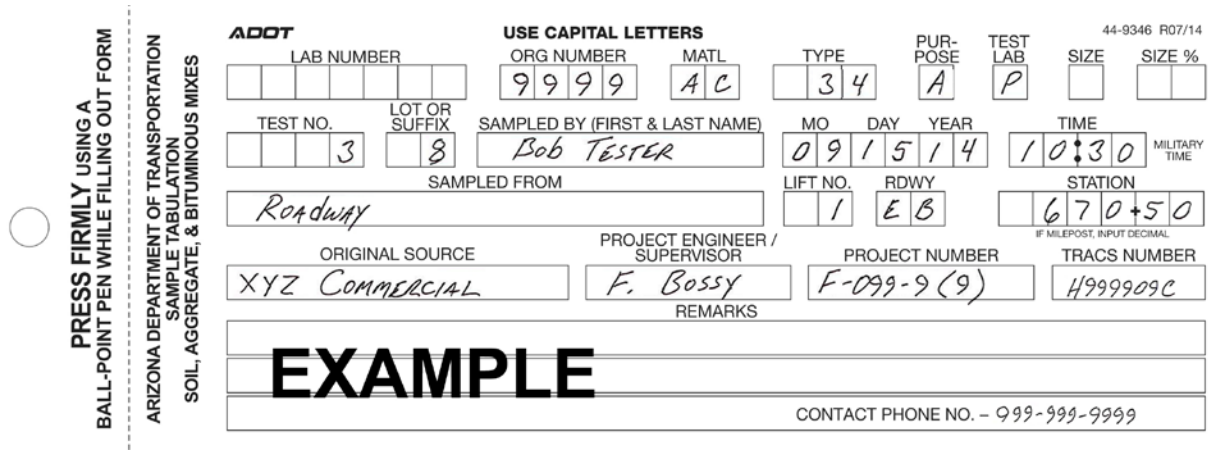


FIGURE 1

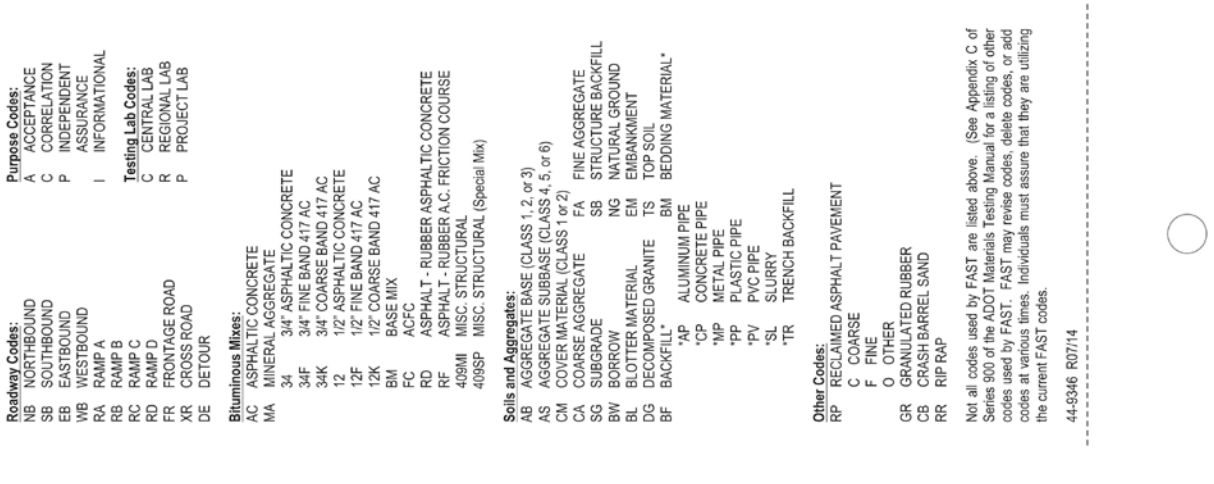


FIGURE 2

SAMPLING SOILS AND AGGREGATES

(An Arizona Method)

1. SCOPE

1.1 This method describes the methods which are to be used when sampling soils and aggregates.

1.2 Sampling is equally as important as the testing, and the individual doing the sampling shall use every precaution to obtain samples that will be representative of the materials being sampled.

1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 Table 1 shall be used to determine minimum sample weights based on the size of aggregate. The amount of material required may be greater depending on the tests that are to be performed on the material.

Table 1
Minimum Sample Sizes

Nominal Maximum Aggregate Size *	Sample Mass	
	lbs	kg
Fine Aggregate		
#8	22	10
#4	22	10
Coarse Aggregate		
3/8”	22	10
1/2”	35	15
3/4”	55	25
1”	110	50
1-1/2”	165	75
2”	220	100
2-1/2”	275	125
3”	330	150

* The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.

2. SAMPLING FROM STOCKPILES

2.1 In sampling materials from stockpiles it is difficult to ensure unbiased samples, due to the segregation which often occurs when the material is stockpiled with coarser particles rolling to the outside base of the pile. If power equipment is available then it would be advantageous to enlist the use of that equipment to develop a separate, small sampling pile composed of materials drawn from various levels and locations in the main stockpile. Once a small sampling pile has been established then a sample shall be taken from that pile by taking several increments and combining.

2.2 The stockpile may also be sampled by placing a wood or metal shield upslope from the point of sampling to prevent loose aggregate from sliding down into the sampling area. Remove approximately 3 to 6 inches of material from the sampling area. Utilizing a square point shovel, take a sample near the top, at the middle and near the bottom of the stockpile. The sample taken at each location shall be one shovelful of material. Repeat this operation at the sampling locations as shown in Figure 1, and combine all samples taken from the stockpile.

3. SAMPLING FROM BINS

3.1 A sample shall be taken by passing a sampling device through the entire cross-section of the flow of material as it is being discharged (see Figures 2 and 3). Sufficient material shall be allowed to pass at the beginning of discharge to ensure uniformity of material before the sample is taken. Repeat sampling procedure as necessary until the desired amount of material from each bin is obtained. Material from each bin shall be properly identified.

4. SAMPLING FROM A CONVEYOR BELT

4.1 Sampling from a conveyor belt may be performed either while the conveyor belt is running (by using a sampling device which diverts or intercepts the flow of material) or by taking a sample while the conveyor belt is stopped. The stopped belt method is also used when approving a sampling device used for sampling while the belt is running.

4.1.1 If the sample is obtained while the conveyor belt is running, samples of the aggregate shall be taken utilizing a sampling device to divert or intercept the entire flow of material in such a manner that all portions of the flow are diverted or intercepted for an equal amount of time.

4.1.2 Samples may be obtained by stopping the conveyor belt and sampling the full width of the belt utilizing a template which is shaped to the same contour of the belt. All material which is within the template area shall be removed, utilizing a brush to obtain all the fine aggregate material.

5. SAMPLING FROM A WINDROW

5.1 Figure 4 illustrates the method used to sample a windrow. At each point in the windrow where a sample is to be taken, remove sufficient material from the top of the windrow so that a representative sample can be obtained from the center of the freshly exposed top of the windrow using a square point shovel. The sample taken at each sampling location shall be one shovelful of material. Repeat the sampling as necessary, at the required number of locations in the windrow, to obtain the desired amount of material. The samples taken shall be combined.

6. SAMPLING FROM THE ROADWAY

6.1 In the case of sampling material in-place from the roadway, at least 3 samples shall be taken with a shovel at equally distributed locations across the width of the roadway. It may be necessary to use a hammer and chisel or similar tools to cut the hole in the compacted roadway. Care shall be taken to obtain all material from the hole which is dug. The samples taken shall be combined.

7. REDUCING FIELD SAMPLES TO TESTING SIZE

7.1 The reduction of samples to obtain the amount required for particular tests shall be performed in accordance with AASHTO R 76.

8. SAMPLE IDENTIFICATION

8.1 Each sample shall be identified by an accompanying sample ticket. Sample tickets shall be filled out as required to provide necessary information. The remarks area of the sample ticket shall be used as necessary to provide additional information, including the phone number of an individual who can be contacted regarding the sample.

8.2 The source of the sample shall be the “original source” of the material, as indicated on the sample ticket.

8.3 An example of a completed sample ticket used by ADOT for construction projects is shown in Figure 5. Commonly used codes for filling out the sample ticket are shown on the back side of the sample ticket (see Figure 6).

8.4 The sample ticket consists of three copies. The center copy in kept by the person submitting the sample, the original copy is included inside the sample container, and the third copy is attached to the sample container. When filling out sample tickets, make certain information is clear and easily read on all three copies.

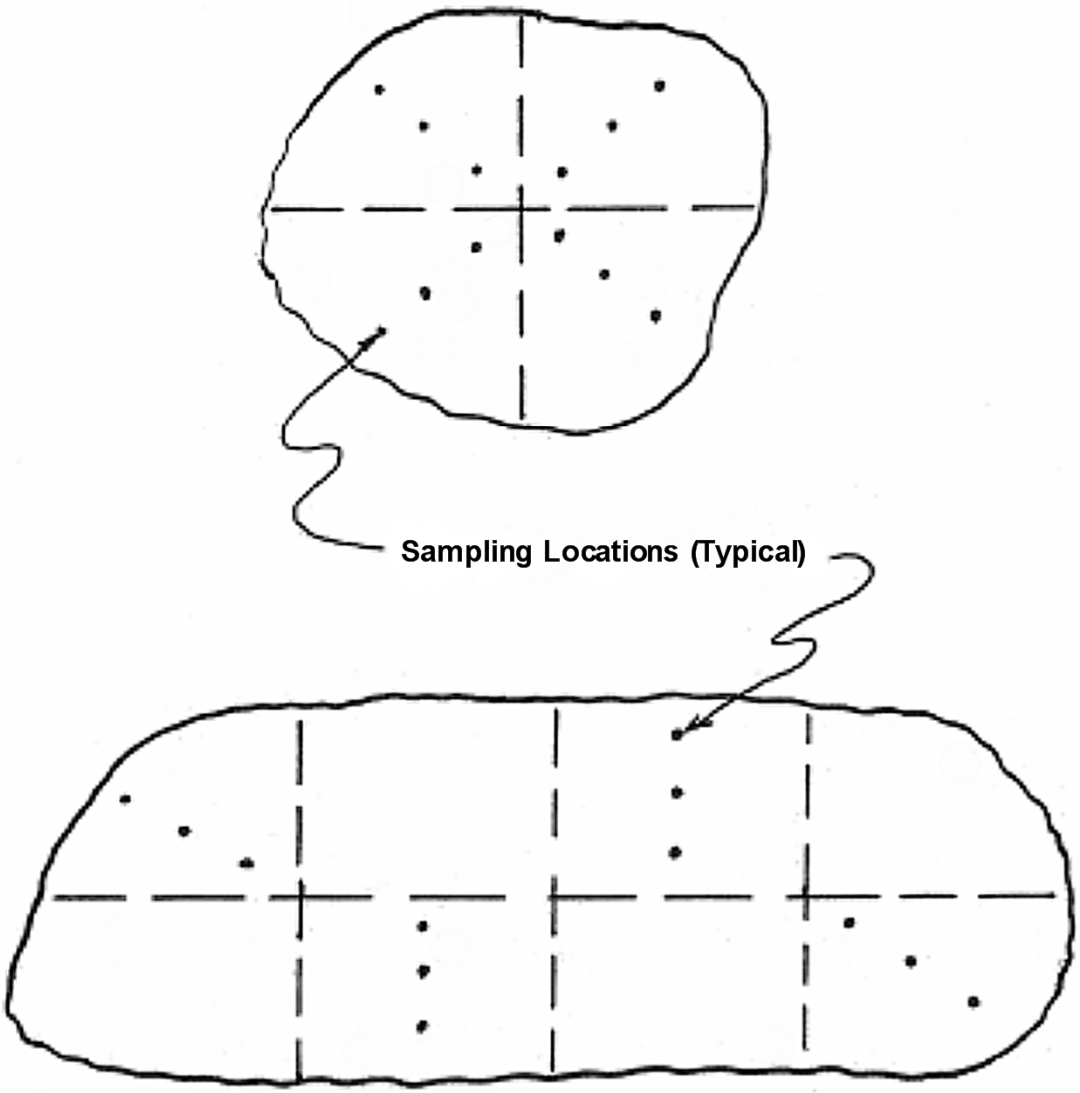
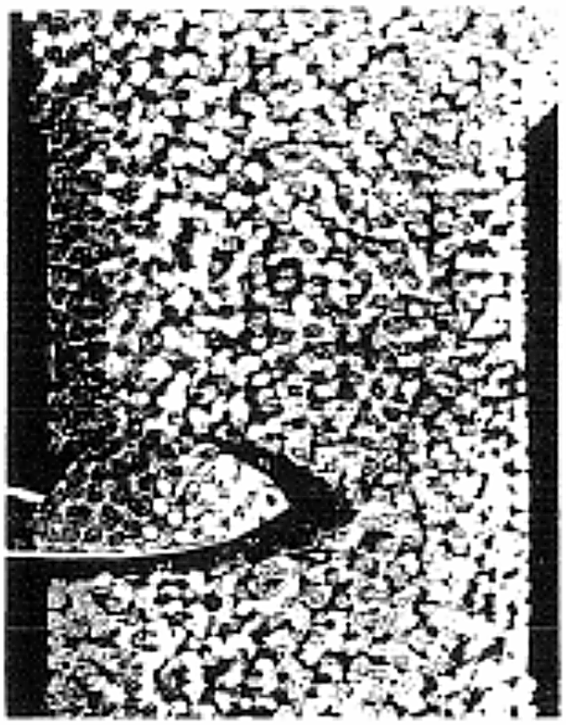


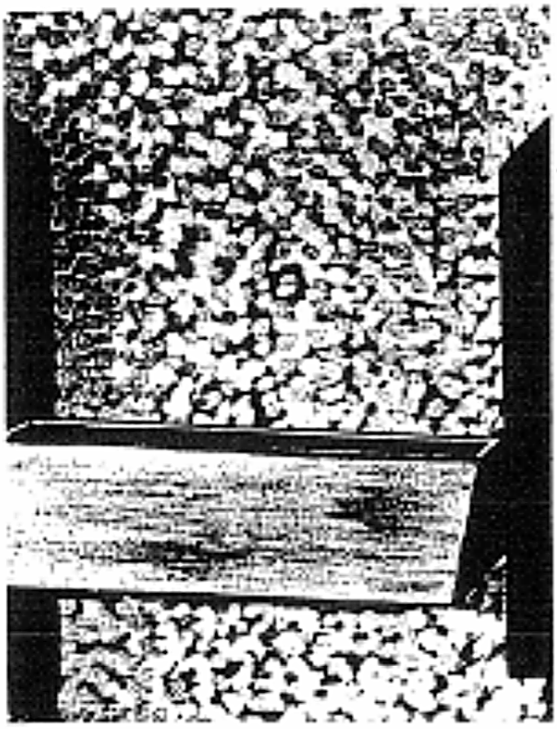
Illustration of Sampling Locations for Different Stockpile Types

FIGURE 1



WRONG

When aggregate is passed over a screen, the fines tend to drop through immediately and accumulate on one side of the hopper. A sample taken with a shovel or other small container will not be representative.

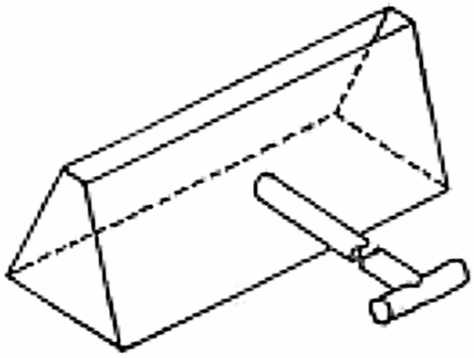


RIGHT

A sample taken by inserting the sampling device through the full flow of material will yield a representative sample. The restricted opening prevents the sampling device from filling all at once.

Illustration of Bin Sampling

FIGURE 2



Typical Bin Sampler

FIGURE 3

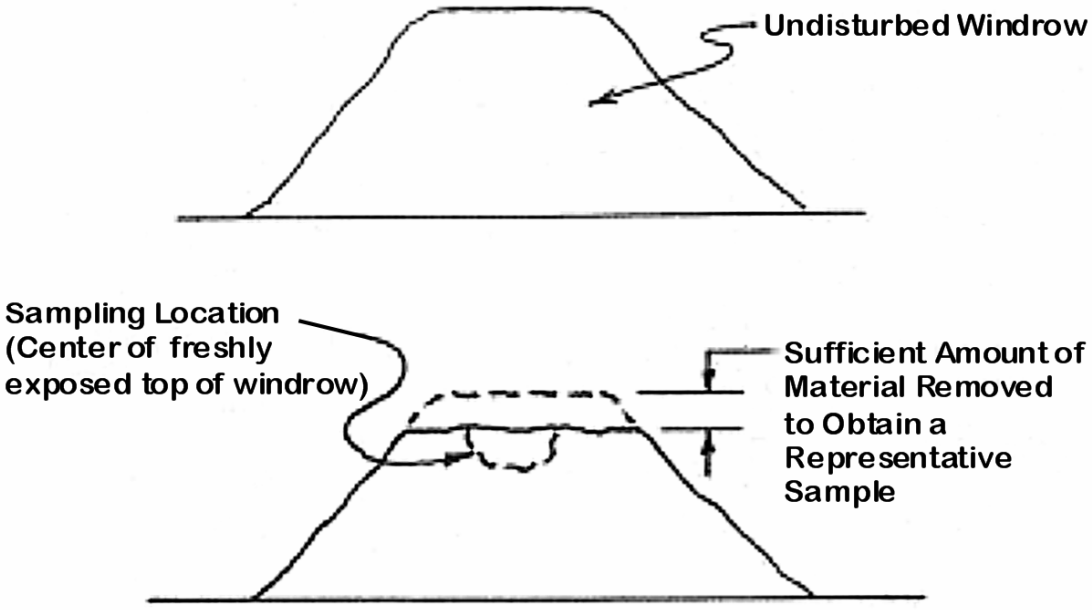
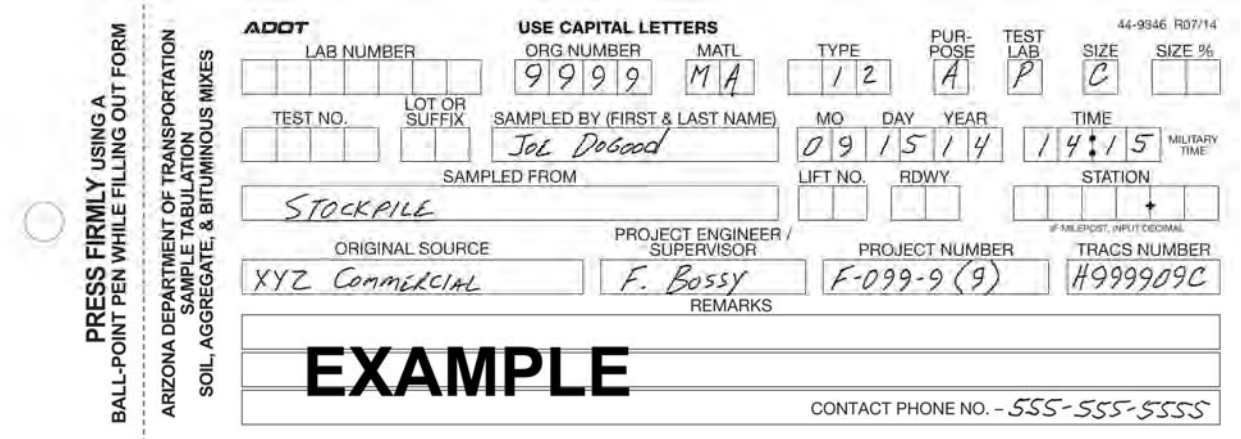


Illustration of Sampling From a Windrow

FIGURE 4



PRESS FIRMLY USING A BALL-POINT PEN WHILE FILLING OUT FORM

ARIZONA DEPARTMENT OF TRANSPORTATION
SAMPLE TABULATION
SOIL, AGGREGATE, & BITUMINOUS MIXES

ADOT — USE CAPITAL LETTERS — 44-9346 R07/14

LAB NUMBER	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
	9999	MA	12	A	P	C	

TEST NO.	LOT OR SUFFIX	SAMPLED BY (FIRST & LAST NAME)	MO	DAY	YEAR	TIME
		Joe DoGood	09	15	14	14:15 (MILITARY TIME)

SAMPLED FROM	LIFT NO.	RDWY	STATION
STOCKPILE			+ (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
XYZ Commercial	F. Bossy	F-099-9(9)	H999909C

REMARKS

EXAMPLE

CONTACT PHONE NO. – 555-555-5555

FIGURE 5

Roadway Codes:
NB NORTHBOUND
SB SOUTHBOUND
EB EASTBOUND
WB WESTBOUND
RA RAMP A
RB RAMP B
RC RAMP C
RD RAMP D
FR FRONTAGE ROAD
XR CROSS ROAD
DE DETOUR

Purpose Codes:
A ACCEPTANCE
C CORRELATION
P INDEPENDENT ASSURANCE
I INFORMATIONAL

Testing Lab Codes:
C CENTRAL LAB
R REGIONAL LAB
P PROJECT LAB

Bituminous Mixes:
AC ASPHALTIC CONCRETE
MA MINERAL AGGREGATE
34 3/4" ASPHALTIC CONCRETE
34F 3/4" FINE BAND 417 AC
34K 3/4" COARSE BAND 417 AC
12 1/2" ASPHALTIC CONCRETE
12F 1/2" FINE BAND 417 AC
12K 1/2" COARSE BAND 417 AC
BM BASE MIX
FC ACFC
RD ASPHALT - RUBBER ASPHALTIC CONCRETE
RF ASPHALT - RUBBER A.C. FRICTION COURSE
409MI MISC. STRUCTURAL
409SP MISC. STRUCTURAL (Special Mix)

Soils and Aggregates:
AB AGGREGATE BASE (CLASS 1, 2, or 3)
AS AGGREGATE SUBBASE (CLASS 4, 5, or 6)
CM COVER MATERIAL (CLASS 1 or 2)
CA COARSE AGGREGATE
FA FINE AGGREGATE
SG SUBGRADE
SB STRUCTURE BACKFILL
BW BORROW
NG NATURAL GROUND
BL BLOTTER MATERIAL
EM EMBANKMENT
DG DECOMPOSED GRANITE
TS TOP SOIL
BF BACKFILL*
BM BEDDING MATERIAL*
*AP ALUMINUM PIPE
*CP CONCRETE PIPE
*MP METAL PIPE
*PP PLASTIC PIPE
*PV PVC PIPE
*SL SLURRY
*TR TRENCH BACKFILL

Other Codes:
RP RECLAIMED ASPHALT PAVEMENT
C COARSE
F FINE
O OTHER
GR GRANULATED RUBBER
CB CRASH BARREL SAND
RR RIP RAP

Not all codes used by FAST are listed above. (See Appendix C of Series 900 of the ADOT Materials Testing Manual for a listing of other codes used by FAST. FAST may revise codes, delete codes, or add codes at various times. Individuals must assure that they are utilizing the current FAST codes.

44-9346 R07/14

FIGURE 6

SAMPLING HYDRATED LIME & LIME PRODUCTS

Scope

1. These methods are intended to outline procedures for sampling of hydrated lime and lime products in powdered form. In instances where a specific case is not covered, ASTM Designation C-50 shall be referred to.

Sampling

2. (a) Sampling from Bulk Shipment at Point of Discharge to Storage. — As the material is being dropped from the truck or car into the silo entrance at ground level, take samples with a scoop or small shovel along the side of the discharge pipe. Take enough increments of material to completely fill a one-gallon can or an equivalent container which will hold at least 5 pounds.

(b) In sampling material that is placed in silos by air pressure through a system of pipes, open the bleed-valve, which is at ground level, and divert the flow of material into a one-gallon can or other suitable container. After the can has been filled, or a 5-pound sample has been discharged, close the bleed-valve.

(c) In all Other Cases Not Covered. — If the above methods are not applicable, material shall be taken from the most convenient location, provided the sample obtained will be representative of the total quantity. Increments shall be taken with a scoop or small shovel, and from at least 3 random locations within the bulk.

Quantity Required

3. All samples shall be collected in quantity enough to fill a ½-gallon, air-tight metal container. This is equivalent to aproximately 5 pounds. For quicklime, the containers shall be made of glass.

Identification

4. (a) Each sample container shall have legibly marked thereon the name of the product, the name of the manufacturer, place of manufacture, and the brand name, if any.

(b) The sample card shall have the following information:

(1) Name of person sampling

(2) Name and designation of project

(3) Quantity represented

(4) Date sampled

(5) Manufacturer's name, address

SAMPLING METALLIC MATERIALS

Scope

1. These methods are intended for use in sampling the respective metallic materials named.

Sampling Bronze Bearing Plates

2. Samples shall be not less than 6 inches in length and 1½ inch in diameter, cast as an integral part of the plate. At least one sample shall be taken, at the point of manufacture, for each melt.

Sampling Castings

3. (a) Cast Iron Castings. – Two samples, not less than 1.20 inch in diameter and 21 inches in length, shall be cast from each melt. These samples are ordinarily obtained at the time of manufacture. All castings as received shall be sounded by means of a hammer to detect possible flaws.

(b) Steel Castings. – Two samples not less than 1¼ inch in diameter and 10 inches in length shall be obtained from each melt at the time of manufacture. All castings as received shall be sounded with a hammer to detect possible flaws.

Sampling Fence Stays (Metal)

4. One random sample shall be cut that is representative of 10 bundles.

Sampling Galvanized Sheet Metal

5. One sample at least 6 inches x 6 inches shall be cut in such a manner as not to disturb or damage the coating. The area in which it is taken shall not be damaged.

Sampling Metal Pipe Products

6. (a) Bituminous Coated Corrugated Metal Pipe

(1) Field Inspection. – Whenever the pipe is shipped from a source outside the Phoenix area, one sample at least 6 inches x 6 inches shall be taken and submitted for testing.

(2) Central Laboratory Inspection. – One sample shall be obtained from each supplier each time a dipping tank is replenished, but no less than one sample per year shall be taken.

(3) Samples shall be taken in an area where the coating has not been disturbed, and in such a manner as not to disturb the coating.

(b) Other Corrugated Metal Pipe

(1) Field Inspection. – Field inspection shall be made before the pipe is installed. This shall consist of the examination of the pipe to determine that the workmanship and fabrication are in accordance with specifications and that the pipe and galvanized coating have not been damaged.

(2) Central Laboratory Inspection. – The central laboratory shall obtain and test one sample of each size pipe at least once a year. The samples shall be sent by each supplier. Sample size shall be at least 6 inches x 6 inches.

(c) Cast Iron Pipe

(1) One piece approximately 16 inches long shall be taken from each size pipe. It shall be taken at least 6 inches from the end of a section.

Sampling Metal Posts

7. Both steel guide posts and fence posts shall be represented by one post selected at random from each project.

Sampling Reinforcing Steel

8. (a) Specifications of the State Highway Department call for one sample at least 4 feet long, selected at random from each shipment.

Sampling Steel Strands, Wire, Anchorages

9. (a) Steel strand is composed of seven wires having a center wire enclosed tightly by 6 helically-wrapped outer wires, forming a single strand for pre-tensioning in prestressed concrete. Samples shall be cut directly from the reel. Discard the first 4 feet, and obtain one sample at least 4 feet long.

(b) Steel wire is uncoated stress-relieved wire used for post-tensioning of prestressed concrete. The manner of obtaining samples shall be identical to 11(a).

(c) Anchorages are wedge-type devices used to anchor post-tensioning wire assemblies. Samples shall be selected at random from a shipment.

Sampling Structural Steel

10. All required sampling of structural steel is performed by the Bridge Division.

Sampling Wire

11. (a) Barbed Wire. — Samples of barbed wire shall be taken directly from the spool. The first 3 feet of wire from the spool shall be discarded and one sample at least 3 feet long shall be obtained. The spool of wire shall be selected at random.

(b) Wire Mesh. — Wire mesh samples shall be selected at random. Each sample shall have dimensions of at least 2 feet x 2 feet.

SAMPLING MISCELLANEOUS MATERIALS

Scope

1. These methods are intended as procedures for sampling those items not found in the preceding sections of sampling.

Sampling Brick

2. For the purpose of tests, full size brick shall be selected. Specimens shall be representative of the whole lot of brick from they are selected and shall include specimens representative of the complete range of colors and sizes of the brick in the shipment. If the brick shows variation in hardness or appearance, each type shall be selected in proportion to the quantity of each type in the lot.

Sampling Clay Pipe

3. One full-sized specimen or joint shall be selected at random from every 100 pipes, or fraction thereof, of each size.

Sampling Fence Stays (Wood)

4. These shall be inspected in the field and 1 copy of a written report stating that they comply with specifications shall be submitted to the Materials Division.

Sampling Glass Beads for Paints

5. When glass beads are furnished in cans or other types of individual containers, one container shall be selected at random, and a 5-pound sample shall be selected by the quartering or riffling methods used for sampling aggregate (ARIZ 105).

Sampling Paints and Solvents

6. (a) Aluminum pigment and vehicle for aluminum paint are shipped unmixed and, therefore, shall be sampled separately.

(b) A single package out of each batch shall be taken at random as a representative of the whole. In case the material is packaged in large containers, such as barrels or tanks, a number of small samples of not more than one quart shall be taken from the top, bottom, and intermediate points by means of a sampling tube. These small samples shall then be mixed to form a composite sample of not less than one quart. This sample shall be transferred to a clean glass or tin container and securely sealed.

Sampling Liquid Membrane Curing Compound

7. The compound to be sampled shall be shaken or stirred thoroughly in the container prior to sampling until both pigment and vehicle are blended to the extent that a representative sample can be obtained. The sample shall be placed in a ½-gallon container and sealed airtight.

Sampling Paper

8. A representative sample approximately 1 foot by 2 feet shall be cut from the roll or sheet. This sampling shall apply to Asbestos, White Top, Insulating, and Roofing Paper.

Sampling Treated Wood Pilings & Timbers

9. These materials will usually be inspected and sampled at the treating plant, in which case no sampling is required. If this is not the case, a piece 18 inches to 24 inches long shall be cut from one end of a piling or timber. If no laboratory reports have been received, it is advisable to determine from the Materials Division if sampling is necessary.

Sampling Wood Fence Posts

10. This includes guide, guard, and line fence posts. These shall be inspected in the field and reports sent to the Materials Division. Samples representative of any doubtful posts shall be submitted to the central laboratory for testing.

Sampling Reflector Buttons

11. One sample of 10 reflector buttons shall be selected at random from each lot.

Sampling Water for Concrete

12. (a) No sample of water is necessary if the water is potable and comes from a proven source; however, a memo to this effect must be submitted to the Materials Division.

(b) If possible, the sample shall be taken from a faucet connected to the pipeline used for the specified project, and water shall be pumped. Allow water to run at a high enough rate to discharge any sediment or other impurities from the pipe. Place a clean, 1-gallon jar beneath the running water and fill the jar completely.

Sampling Liquid Admixtures for Concrete

13. (a) Liquid material shall be submitted in a ½-pint clean glass container. They shall be agitated thoroughly immediately prior to taking the sample. The liquid shall be drawn from one barrel selected at random out of the lot. The sample should be drawn from a depth sufficient enough to get proportionate quantities of components.

(b) The trade name of the agent must be noted on the sample card.

Sampling Creosote, Creosote-Coal Tar, and Creosote-Fuel Oil Solutions

14. (a) Because some of the creosote may crystallize below a temperature of 120° F, the creosote shall be heated to a temperature above 120° F before sampling. Because of separation of the lighter-weight water, the creosote must be thoroughly agitated, and three samples must be taken at different levels and combined to form a composite.

(b) At least ½ gallon of material shall be taken and sealed in an airtight container.

Sampling Preformed Expansion Joint Filler

15. Each sample shall be at least 6 inches by 18 inches, and enough samples shall be taken to represent each thickness in the lot. Samples shall be packed for transportation in such a manner that there will be no danger of distortion or breakage. No tests shall be made on samples deformed or broken in handling.

Sampling Concrete Pipe, Reinforced and Plain

16. The project for which the pipe is to be used shall be notified of the dates when the pipe has been approved, or the pipe may be stenciled "Inspected – AHD". If neither of these has been accomplished, this division shall be notified immediately, and the pipe in question shall not be used until so approved.

SERIES 200
SOILS AND AGGREGATES

ARIZ 201e
November 2, 2018
(19 Pages)

SIEVING OF COARSE AND FINE GRADED SOILS AND AGGREGATES

(An Arizona Method)

1. SCOPE

1.1 This procedure describes the method for sieving and determining the sieve analysis of fine and coarse graded soils and aggregates, including the determination of minus No. 200 material by elutriation.

1.2 The procedure for sample preparation, sieving, and calculating the sieve analysis which is given in Sections 3 through 10 applies in general for all sieving operations. Section 11 gives a brief outline of the procedure for performing the sieve analysis when the sample is dried to constant weight prior to sieving. Section 12 gives an outline and description of the procedure for performing the sieve analysis when the sample is not dried to constant weight prior to sieving. Additional methods are given in Arizona Test Method 248, "Alternate Procedures for Sieving of Coarse and Fine Graded Soils and Aggregates".

1.3 A washed gradation, utilizing an appropriate alternate procedure as described in either Alternate #1, 3, 4, or 5 of ARIZ 248, is to be used for all soil and aggregate materials with specification requirements for gradation. The washing requirement may be waived if the Engineer determines that it is unnecessary. However, in cases of dispute, the referee method shall be a washed gradation. Composited samples of mineral aggregate for bituminous mix designs shall be tested in accordance with either Alternate #3, 4, or 5 of ARIZ 248. If desired, the washed gradation of samples from individual stockpiles or bins may be determined and used in calculating the composite gradation.

1.4 This test method may involve hazardous materials, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Sieves of sizes as required for screening, conforming to the requirements of ASTM E11.

2.3 Any mechanical shaker may be used which produces the required thoroughness of sieving, as specified in Subsection 4.5.

2.4 Balances or scales - Conforming to the requirements of AASHTO M 231, except when determining weights of 5000 grams or less, the readability and sensitivity shall be at least one gram; and when determining weights of greater than 5000 grams, the readability and sensitivity shall be at least 20 grams.

2.5 Sample splitters - Shall conform to the requirements of, and be used in accordance with the procedures given in, AASHTO R 76.

2.6 Heating/Drying Device - An oven or suitable heating device which is capable of drying samples without aggregate breakage or loss of material due to splattering. A microwave oven may be used to dry materials, provided proper attention is given to the use of apparatus and the intensity of heat generated.

2.7 Brass wire brush for cleaning fine sieves coarser than No. 100, and a soft bristle brush for sieves No. 100 and No. 200.

2.8 A suitable mechanical washing device with No. 200 mesh wire (Similar to Figure 1) for performing washing of fine soils and aggregates as described in Section 6, equipped with a metal tube(s) connected to a water and an air outlet; or a vessel of sufficient capacity and a nest of No. 16 and No. 200 sieves for use with the hand washing method. When utilizing mechanical washing equipment, the provision for air may be eliminated if the water pressure provides adequate agitation to wash sample as specified in Section 6.

2.9 Miscellaneous pans, scoops, spatulas, brushes, pulverizing equipment, etc. for preparing, washing, and drying samples.

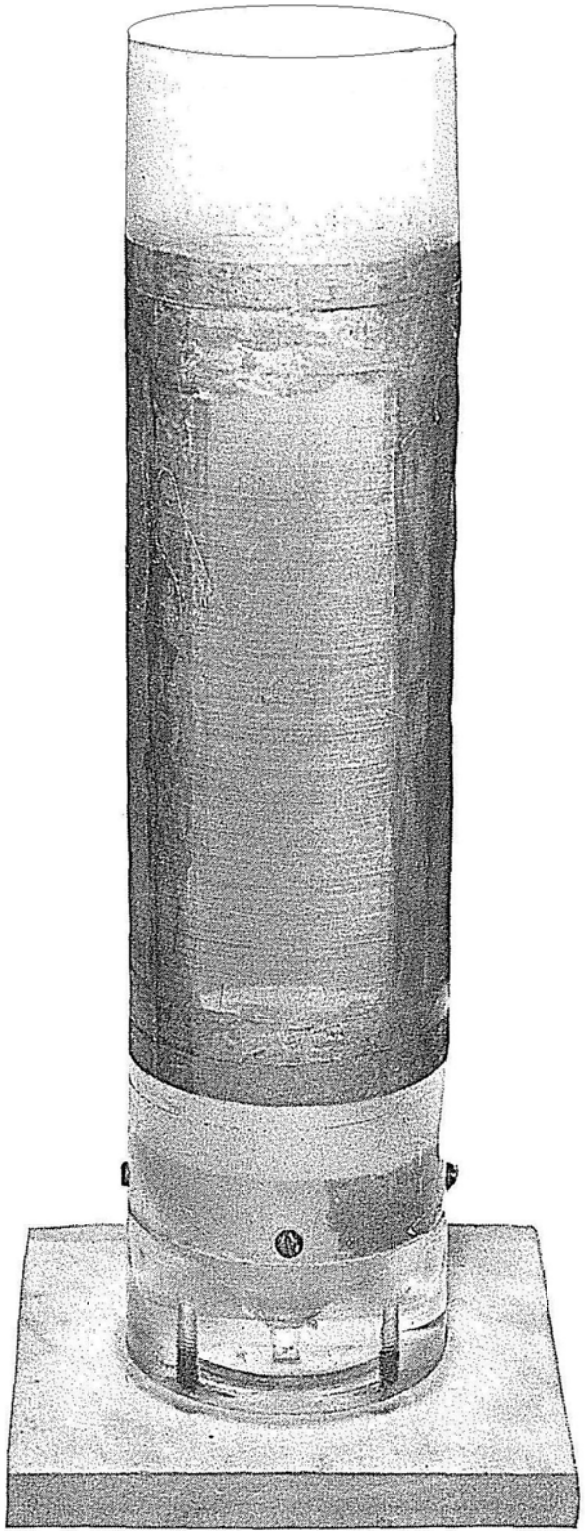


FIGURE 1

3. SAMPLE PREPARATION

3.1 A representative sample of the amount indicated in Subsection 3.2 below shall be obtained. Dry the sample sufficiently to permit separation of particles on the No. 4 and larger sieves, and to develop a free-flowing condition in the portion passing the No. 4 sieve. The use of sunlight, ovens, fans, or warm air are the most common drying methods. Turn the sample frequently to prevent formation of hard clay lumps. If the sample contains hard clods or coated coarse aggregate particles, break up the clods by means which will not reduce the size of any rock. (The use of a rubber covered mallet or the raking of the material over an old screen have been found to be satisfactory methods.) When subsequent testing is to be performed on the material, it shall be assured that any temperature restrictions, as given in the appropriate test method(s), are not exceeded. A number of soil and aggregate tests, such as plasticity index, proctor maximum density, and sand equivalent, require that samples not be heated in excess of 140 °F.

3.2 If necessary, samples shall be reduced in size in accordance with the splitting or quartering methods in AASHTO R 76 to obtain the appropriate sample size as shown below.

Nominal Maximum Size of Particle *	Minimum Weight of Sample, grams (lbs.)
3/8”	1000 (2.2)
1/2”	2000 (4.4)
3/4”	5000 (11)
1”	10000 (22)
1-1/2”	15000 (33)
2”	20000 (44)
2-1/2”	25000 (55)
3”	30000 (66)
3” Slot	35000 (77)

*The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.

3.3 If desired, the sample may be dried to constant weight. The sample may be considered to be at constant weight when, after an initial drying period of at least one hour, further drying causes or would cause less than 0.1% additional loss in weight within a five minute drying period. If desired, the material may be dried to constant weight utilizing a microwave oven in accordance with Subsection 2.6.

3.4 Allow the sample to cool, if necessary, and record the weight of the material.

4. COARSE SIEVING

4.1 Normally the coarse sieving of material is performed utilizing the No. 4 sieve as the smallest sieve.

4.2 When material being screened contains a large amount of passing No. 4 material, such that there may be overloading in the bottom pan during shaking operations, the sample shall be initially sieved over a No. 4 sieve to separate excess amounts of this material. This passing No. 4 material is saved and combined with the remaining portion of passing No. 4 material from subsequent coarse sieving. When material contains large rocks that are not to be sieved in the nest of coarse sieves during the actual shaking operation, the sample shall be pre-sieved to separate these particles. Unless all material will pass the largest sieve in the nested sieves, the material shall be pre-sieved over a sieve of the next larger size than that of the largest sieve size being utilized in the nested sieves. Large rocks separated in this manner are individually tested for passing the appropriate sieve, determining and recording the weight of any rock retained on these sieves.

4.3 Empty the sample into the nest of sieves that is to be used for screening material. If pre-sieving has not been performed, remove any particles which may be retained on the top sieve and test these for passing the appropriate sieve, determining and recording the weight of any rock retained on these sieves.

4.4 The material shall be subjected to sieving by hand or in a mechanical sieve shaker. The sieving action shall cause the particles to bounce and turn so as to present different orientations to the sieving surface. No particles shall be hand manipulated for passing any of the nested sieves. The sieving shall be of sufficient time to assure that the criteria for “thoroughness of sieving” described in Subsection 4.5 below is achieved.

4.5 The criteria for "thoroughness of sieving" is that after completion of sieving, not more than 0.5 percent by weight of the total sample passes any sieve during one minute of continuous hand sieving in an 8 inch or 12 inch sieve as appropriate. If the thoroughness of sieving is being determined for sieves larger than 12 inches, the material retained on the respective sieve, or portions of that material shall be placed in a 12 inch sieve of the same sieve size opening, so as to not overload the sieve. Hold the individual sieve, provided with a snug fitting pan and cover,

in a slightly inclined position in one hand. Strike the side of the sieve sharply and with an upward motion against the heel of the other hand at the rate of about 150 times per minute, turn the sieve about one-sixth of a revolution at intervals of about 25 strokes. A frequent check should be performed to assure that the thoroughness of sieving specified is being maintained in sieving operations.

4.6 Overloading of sieves shall be avoided. The quantity of material on a given sieve at the completion of sieving shall not exceed the amount shown in the table below. As the weight retained on each individual sieve size is determined, it should be compared with the corresponding overloading criteria prior to combining the weighed material. If overloading occurs, proper corrective action to regulate the amount of material on a sieve shall be taken. This may be accomplished by splitting the material which is retained on the overloaded sieve, resieving each portion, and combining weights.

Sieve Size	Maximum Weight Allowed (grams/ sq. in.)	Maximum Weight Allowed (grams)	
		12” Dia. Sieve	14-3/4” x 22-3/4” Sieve
3”	*	*	*
2-1/2”	*	*	*
2”	*	*	*
1-1/2”	25	2827	8389
1”	18	2036	6040
3/4”	14	1583	4698
1/2”	10	1131	3356
3/8”	8	905	2685
1/4”	6	679	2013
No. 4	5	565	1678

*Normally particles of material retained on these sieves are tested individually, so no maximum weight allowed is specified.

4.7 Starting with the largest of the nested sieves, the material retained on each sieve and in the bottom pan is weighed and recorded.

4.8 Do not discard any of the sieved material until the sum of the individual weights is compared to the weight of sample prior to sieving. If the difference between the two weights is less than or equal to 1.0% of the weight of sample prior to sieving, an adjustment in weight shall be made on the sieve which has the largest

weight retained, except no adjustments shall be made on the minus No. 4 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

5. SAMPLE FOR ELUTRIATION AND FINE SIEVING

5.1 A representative minimum 500 gram sample of the passing No. 4 material from the coarse sieving shall be obtained by the use of a splitter in accordance with AASHTO R 76. The selection of an exact predetermined weight shall not be attempted. The sample size may be reduced if the minimum of 500 grams is not obtained from coarse sieving, or if there is insufficient material for performing other desired tests utilizing the pass No. 4 material. When utilizing the mechanical washing device, the requirement for a minimum 500 gram sample may be reduced to a minimum of 200 grams for materials that tend to clog the No. 200 sieve (for example, fine soils such as blow sand, silty soils, or clay).

5.2 The weight of the sample for elutriation and fine sieving is recorded to the nearest gram as “Dry Wt. Pass No. 4 Split”.

5.3 Subject the sample to elutriation by either mechanical washing (Section 6) or hand washing (Section 7).

6. MECHANICAL WASHING

6.1 This method is generally utilized for passing No. 4 material, although it may also be used with the alternate procedure described in Section 2 of Arizona Test Method 248 for testing materials containing small amounts of Plus No. 4 material (100% passing 3/8"). Generally, a maximum of 600 grams may be tested utilizing the mechanical washing device.

6.2 Fill the washing device with water to the bottom of the windows. Transfer the sample to the washing device, and wash all material clinging to the sample container into the washing device. Utilizing the water tube, and air tube if necessary, agitate the sample vigorously enough so that it causes the material to go into suspension, but not enough to cause splattering to reach the top of the cylinder. Continue this washing action, taking care that there is no loss of sample by splattering or overflowing. (If the No. 200 sieve tends to plug excessively, this may be overcome to some extent by tapping the washing device with the palm of the hand or by washing down the inside of the sieve with a low stream of water.) Washing shall continue until the wash water becomes clear.

6.3 Turn off the water and compressed air and remove the metal tube(s), rinsing clinging material back into the sample. Wash the sample into a container of sufficient capacity to hold the water and sample; allow the particles to settle and decant the excess water.

6.4 Dry the sample to constant weight at a temperature that will not cause the material to be lost due to splattering.

6.5 Allow the sample to cool, reweigh and record to the nearest gram as the fine sieve "Total Dry Weight".

6.6 Subtract the "Total Dry Weight" from the "Dry Wt. of Pass No. 4 Split", and record as the "Elutriation".

7. HAND WASHING (REFEREE METHOD)

7.1 Place the sample in a pan of sufficient size and capacity to allow washing without spillage. Cover with adequate water to thoroughly wash aggregate. Agitate the contents of the pan vigorously in order to completely separate all particles finer than the No. 200 sieve from the coarser particles, and to bring the finer material into suspension so that it will be removed by decantation of the water.

7.2 Decant the wash water through a nest of No. 16 and No. 200 sieves.

7.3 Repeat the washing and decanting cycle until the water becomes clear.

7.4 Thoroughly wash all material remaining on the No. 16 and the No. 200 sieves and return to the sample.

7.5 After the particles have settled in the pan, carefully decant any excess water, assuring that no particles are lost.

7.6 Dry the sample to constant weight at a temperature that will not cause material to be lost due to splattering.

7.7 Allow the sample to cool, reweigh and record to the nearest gram as the fine sieve "Total Dry Weight".

7.8 Subtract the "Total Dry Weight" from the "Dry Wt. of Pass No. 4 Split", and record as the "Elutriation".

8. SIEVING OF FINE AGGREGATE

8.1 Place the washed and dried fine aggregate sample into the top of the nested sieves, close the nest of sieves with lid.

8.2 The material shall be subjected to sieving by hand or in a mechanical sieve shaker. The sieving action shall cause the particles to bounce and turn so as to present different orientations to the sieving surface. No particles shall be hand manipulated for passing any of the nested sieves. The sieving shall be of sufficient time to assure that the criteria for "thoroughness of sieving" described in Subsection 4.5 is achieved.

8.3 Overloading of sieves shall be avoided. The quantity of material on a given sieve at the completion of sieving shall not exceed 4 grams per square inch of sieving area (201 grams for an 8 inch diameter sieve and 452 grams for a 12 inch sieve). As the weight retained on each individual sieve size is determined, it should be compared with the corresponding overloading criteria prior to combining the weighed material. If overloading occurs, proper corrective action to regulate the amount of material on a sieve shall be taken. This may be accomplished by splitting the material which is retained on the overloaded sieve, resieving each portion, and combining weights.

8.4 Starting with the largest of the nested sieves, the material retained on the individual sieves and in the bottom pan shall be weighed and recorded.

8.5 Do not discard any of the sieved material until the sum of the individual weights is compared to the weight of sample prior to sieving. If the difference between the two weights is less than or equal to 1.0% of the weight of sample prior to sieving, an adjustment in weight shall be made on the sieve which has the largest weight retained, except no adjustments shall be made on the minus No. 200 material. If the difference is greater than 1.0% the sample shall be recombined, resieved, and carefully reweighed.

9. PRECAUTIONS

9.1 Check sieves at least daily for broken or distorted wire, and replace any sieves found to be damaged or excessively worn.

9.2 Sieves not conforming to AASHTO M 92 must be replaced.

9.3 Do not repair wire cloth.

9.4 Clean sieves carefully after each shaking, using the proper instrument to reduce chances of damaging the mesh.

9.5 All mechanical equipment shall be inspected frequently and maintained by greasing, cleaning, and repair of worn out parts.

10. CALCULATIONS

10.1 The calculations for determining the sieve analysis are as follows. Examples of these calculations are given in Figures 2 and 3.

10.2 The calculations to determine the % passing values for the coarse sieve anaylsis are performed as described below:

10.2.1 For the largest sieve which has no material retained, record the percent passing as 100. Determine a factor for calculating the coarse sieve analysis by the following. Record the coarse sieve factor to at least six decimal places.

$$\text{Coarse Sieve Factor} = \frac{100}{\text{Coarse Sieve Total}}$$

10.2.2 The percent passing for each sieve in the coarse sieve analysis is determined by multiplying the weight retained on that sieve times the coarse sieve factor, and subtracting the result from the unrounded % passing for the next larger sieve, as shown below. Values for "weight retained times the coarse sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to at least six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest whole percent.

$$\begin{matrix}\text{Percent}\\ \text{Passing}\\ \text{Desired}\\ \text{Sieve}\end{matrix} = \begin{pmatrix}\text{Unrounded}\\ \text{\% Pass for}\\ \text{next larger}\\ \text{sieve}\end{pmatrix} - \begin{pmatrix}\text{Weight}\\ \text{Retained on}\\ \text{Desired Sieve}\end{pmatrix} \text{ x } \begin{pmatrix}\text{Coarse}\\ \text{Sieve}\\ \text{Factor}\end{pmatrix}$$

10.2.3 As a check on the coarse sieve analysis, multiply the weight of minus No. 4 material times the coarse sieve factor, as shown below. The result of this calculation, rounded to the nearest whole percent, should be the same as the value for percent passing the No. 4 sieve determined in the paragraph above.

$$\begin{pmatrix}\text{Check for Percent}\\ \text{Passing No. 4}\end{pmatrix} = \begin{pmatrix}\text{Wt. of Pass}\\ \text{No. 4 sieve}\end{pmatrix} \text{ x } \begin{pmatrix}\text{Coarse}\\ \text{Sieve}\\ \text{Factor}\end{pmatrix}$$

10.3 The calculations to determine the % passing values for the fine sieve analysis are performed as described below:

10.3.1 Determine a factor for the fine sieve analysis by dividing the percent passing the No. 4 sieve (which has been recorded to the nearest whole percent) by the "Dry Weight of Pass #4 Split", as shown below. Record the fine sieve factor to at least six decimal places. If all the pass No. 4 material from coarse sieving was subjected to elutriation and fine sieving, a fine sieve factor is not determined. Rather, the coarse sieve factor is utilized and the calculation of the percent passing each sieve is continuous through the entire sieve analysis.

$$\text{Fine Sieve Factor} = \frac{\text{Rounded Percent Pass No. 4}}{\text{Dry Wt. of Pass No. 4 Split}}$$

10.3.2 The percent passing for each sieve in the fine sieve analysis is determined by multiplying the weight retained on that sieve times the fine sieve factor, and subtracting the result from the unrounded % passing the next larger sieve, with the exception of the percent passing the No. 4 which has previously been recorded to the nearest whole percent. The equation for determining the percent passing each sieve is shown below. Values for "weight retained times the fine sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to at least six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest whole percent, except the percent passing the No. 200 sieve is recorded to the nearest 0.1 percent.

$$\begin{pmatrix}\text{Percent}\\ \text{Passing}\\ \text{Desired}\\ \text{Sieve}\end{pmatrix} = \begin{pmatrix}\text{Unrounded}\\ \text{\% Pass for}\\ \text{next Larger}\\ \text{sieve}\end{pmatrix} - \begin{pmatrix}\text{Weight}\\ \text{Retained on}\\ \text{Desired Sieve}\end{pmatrix} \text{ x } \begin{pmatrix}\text{Fine}\\ \text{Sieve}\\ \text{Factor}\end{pmatrix}$$

10.3.3 As a check on the fine sieve analysis, the weight of material passing the No. 200 from sieving is added to the elutriation weight, and this total is multiplied times the fine sieve factor, as shown below. The result of this calculation, rounded to the nearest 0.1 percent, should be the same as the value for the percent passing the No. 200 determined in the paragraph above.

$$\begin{pmatrix}\text{Check for Percent}\\ \text{Passing No. 200}\end{pmatrix} = \left(\begin{pmatrix}\text{Weight of}\\ \text{Passing No. 200}\end{pmatrix} + \begin{pmatrix}\text{Elutriation}\\ \text{Weight}\end{pmatrix}\right) \text{x} \begin{pmatrix}\text{Fine Sieve}\\ \text{Factor}\end{pmatrix}$$

10.4 If desired, obtain the percent retained on each sieve by subtracting the rounded % passing value for that sieve from the rounded % passing value for the next larger sieve, as shown below.

$$\begin{pmatrix}\text{\% Retained}\\ \text{for Desired}\\ \text{Sieve}\end{pmatrix} = \begin{pmatrix}\text{Rounded \%}\\ \text{Pass Next}\\ \text{Larger Sieve}\end{pmatrix} - \begin{pmatrix}\text{Rounded \%}\\ \text{Pass the}\\ \text{Desired Sieve}\end{pmatrix}$$

10.5 Other methods may be used that differ from that specified in Subsections 10.2 and 10.3 above to determine % passing each sieve, so long as the method utilized has been proven to give equivalent results. However, any procedure which includes recording percent retained values prior to completing the calculation of all percent passing values is not allowed.

11. PROCEDURE WHEN SAMPLE IS DRIED TO CONSTANT WEIGHT PRIOR TO SIEVING

11.1 The following is a brief outline of the procedure to be used when the sample is dried to constant weight prior to sieving. An example of this procedure is shown in Figure 2.

11.2 Prepare sample, dry to constant weight, allow to cool, and record as “Coarse Sieve Total”, (3087 in the example).

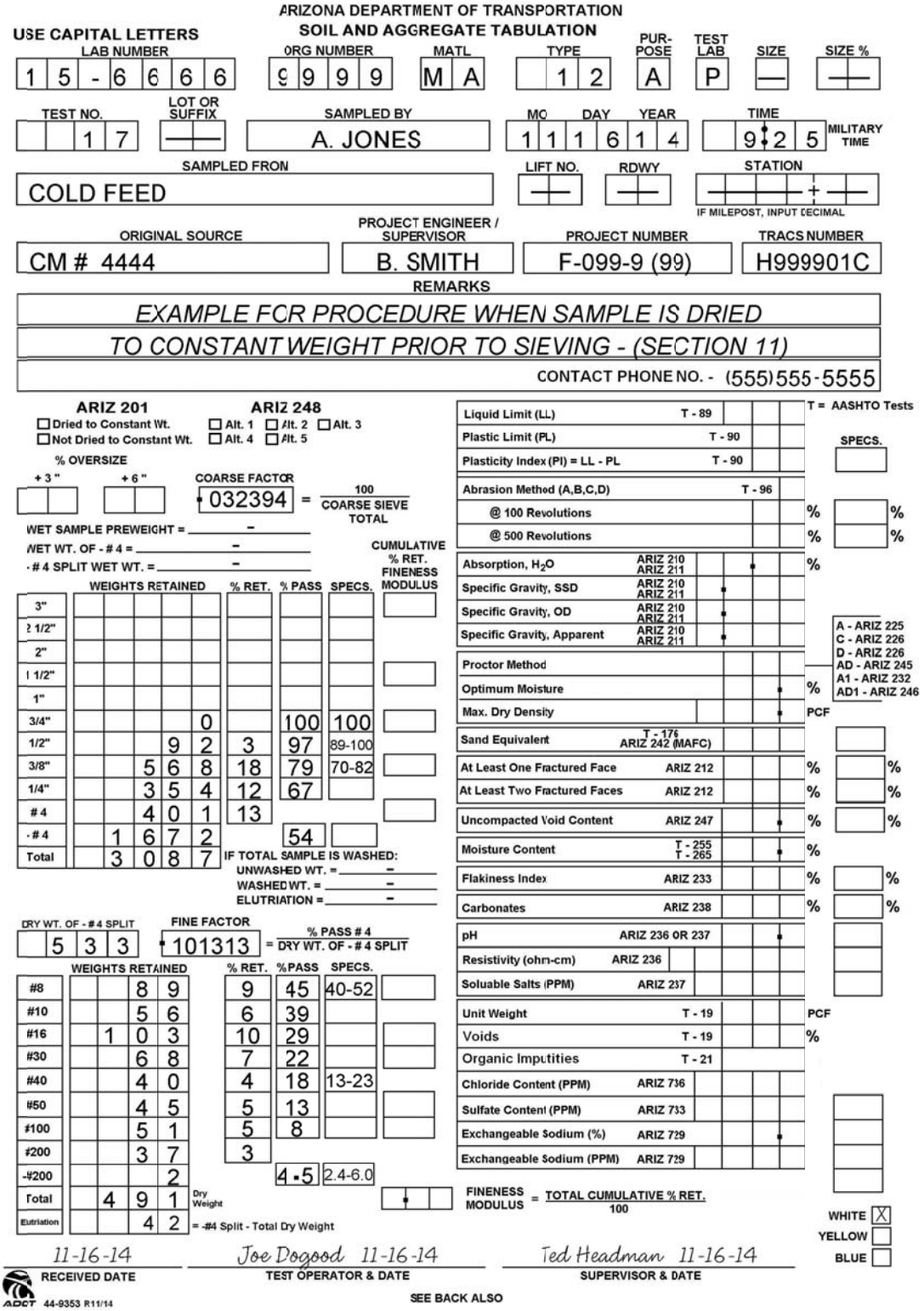
11.3 Perform coarse sieving.

11.4 Record the weight of the material in the appropriate “Weights Retained” box for each sieve and the pan.

11.5 Sum the individual weights retained for each sieve, compare to the weight of sample prior to sieving (Coarse Sieve Total), and adjust or resieve as necessary.

11.6 Split the pass No. 4 material to at least 500 grams and record as "Dry Wt. of Pass No. 4 Split", (533).

11.7 Perform elutriation on the dry - #4 split, dry back to constant weight, allow to cool, and record as the "Total Dry Weight", (491).



ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

USE CAPITAL LETTERS

LAB NUMBER: 15-6666 | ORG NUMBER: 9999 | MATL: MA | TYPE: 12 | PURPOSE: A | TEST LAB: P | SIZE: — | SIZE %: —

TEST NO.: 17 | LOT OR SUFFIX: — | SAMPLED BY: A. JONES | MO DAY YEAR: 11 16 14 | TIME: 925 MILITARY TIME

SAMPLED FROM: COLD FEED | LIFT NO.: — | RDWY: — | STATION: — + — (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE: CM # 4444 | PROJECT ENGINEER / SUPERVISOR: B. SMITH | PROJECT NUMBER: F-099-9 (99) | TRACS NUMBER: H999901C

REMARKS

EXAMPLE FOR PROCEDURE WHEN SAMPLE IS DRIED
TO CONSTANT WEIGHT PRIOR TO SIEVING - (SECTION 11)

CONTACT PHONE NO. - (555)555-5555

ARIZ 201
☐ Dried to Constant Wt.
☐ Not Dried to Constant Wt.

ARIZ 248
☐ Alt. 1 ☐ Alt. 2 ☐ Alt. 3
☐ Alt. 4 ☐ Alt. 5

% OVERSIZE: +3" ___ +6" ___

COARSE FACTOR: 032394 = 100 / COARSE SIEVE TOTAL

WET SAMPLE PREWEIGHT = ___
WET WT. OF - #4 = ___
- #4 SPLIT WET WT. = ___

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3"					
2 1/2"					
2"					
1 1/2"					
1"					
3/4"	0		100	100	
1/2"	92	3	97	89-100	
3/8"	568	18	79	70-82	
1/4"	354	12	67		
#4	401	13			
- #4	1672		54		
Total	3087				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = ___
WASHED WT. = ___
ELUTRIATION = ___

DRY WT. OF - #4 SPLIT: 533 | FINE FACTOR: 101313 = % PASS #4 / DRY WT. OF - #4 SPLIT

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8	89	9	45	40-52	
#10	56	6	39		
#16	103	10	29		
#30	68	7	22		
#40	40	4	18	13-23	
#50	45	5	13		
#100	51	5	8		
#200	37	3			
-#200	2		4.5	2.4-6.0	
Total	491	Dry Weight			
Elutriation	42	= -#4 Split - Total Dry Weight			

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

		SPECS.
Liquid Limit (LL)	T - 89	
Plastic Limit (PL)	T - 90	
Plasticity Index (PI) = LL - PL	T - 90	
Abrasion Method (A,B,C,D)	T - 96	
@ 100 Revolutions	%	%
@ 500 Revolutions	%	%
Absorption, H_2O	ARIZ 210 ARIZ 211	%
Specific Gravity, SSD	ARIZ 210 ARIZ 211	
Specific Gravity, OD	ARIZ 210 ARIZ 211	
Specific Gravity, Apparent	ARIZ 210 ARIZ 211	
Proctor Method		
Optimum Moisture	%	
Max. Dry Density	PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)	
At Least One Fractured Face	ARIZ 212	%
At Least Two Fractured Faces	ARIZ 212	%
Uncompacted Void Content	ARIZ 247	%
Moisture Content	T - 255 T - 265	%
Flakiness Index	ARIZ 233	%
Carbonates	ARIZ 238	%
pH	ARIZ 236 OR 237	
Resistivity (ohm-cm)	ARIZ 236	
Soluable Salts (PPM)	ARIZ 237	
Unit Weight	T - 19	PCF
Voids	T - 19	%
Organic Impurities	T - 21	
Chloride Content (PPM)	ARIZ 736	
Sulfate Content (PPM)	ARIZ 733	
Exchangeable Sodium (%)	ARIZ 729	
Exchangeable Sodium (PPM)	ARIZ 729	

A - ARIZ 225
C - ARIZ 226
D - ARIZ 226
AD - ARIZ 245
A1 - ARIZ 232
AD1 - ARIZ 246

WHITE [X]
YELLOW [ ]
BLUE [ ]

11-16-14 RECEIVED DATE | Joe Dogood 11-16-14 TEST OPERATOR & DATE | Ted Headman 11-16-14 SUPERVISOR & DATE

ADOT 44-9353 R11/14

SEE BACK ALSO

FIGURE 2

11.8 Determine and record "Elutriation" by subtracting the "Total Dry Weight" from the "Dry Wt. of Pass No. 4 Split", (533 - 491 = 42).

11.9 Perform fine sieving on the material left from elutriation using the No. 8 sieve down to the No. 200.

11.10 Record the weight of material in the appropriate “Weights Retained” box for each sieve.

11.11 Sum the individual weights retained for each sieve, compare to the weight of sample prior to sieving (fine sieve Total Dry Weight), and adjust or resieve as needed.

11.12 Determine the sieve analysis of the material as described in Section 10.

12. PROCEDURE WHEN SAMPLE IS NOT DRIED TO CONSTANT WEIGHT PRIOR TO SIEVING

12.1 The following is an outline and description of the procedure to be used when the sample is not dried to constant weight prior to sieving. An example of this procedure is shown in Figure 3.

12.2 Prepare sample, dry to free flowing condition, and record this weight as “Wet Sample Preweight”, (13010 in the example).

12.3 Perform coarse sieving.

12.4 Record the weight of the material in the appropriate "Weights Retained" box for each sieve, except record the weight of pass No. 4 material as the "Wet Wt. of - #4", (7365).

12.5 Sum the individual weights retained for each sieve, compare to weight of sample prior to sieving (Wet Sample Preweight), and adjust or resieve as needed.

12.6 The wet weight of pass No. 4 material is corrected for moisture using either a split of, or the entire amount of, the pass No. 4 material.

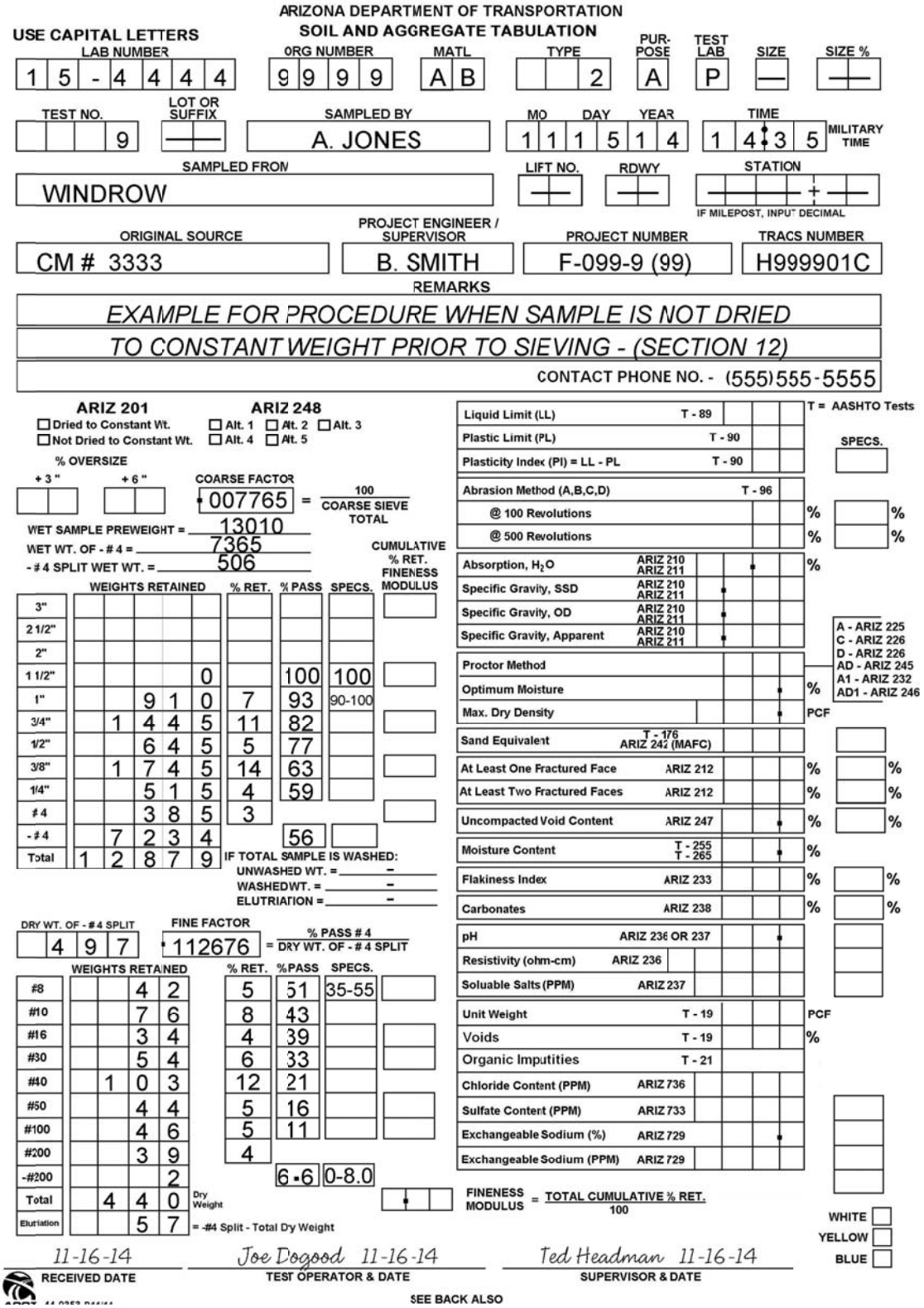

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION
USE CAPITAL LETTERS
LAB NUMBER 15-4444
ORG NUMBER 9999
MATL AB
TYPE 2
PURPOSE A
TEST LAB P
SIZE
SIZE %
TEST NO. 9
LOT OR SUFFIX
SAMPLED BY A. JONES
MO DAY YEAR 11 15 14
TIME 1435 MILITARY TIME
SAMPLED FROM WINDROW
LIFT NO.
RDWY
STATION
IF MILEPOST, INPUT DECIMAL
ORIGINAL SOURCE CM # 3333
PROJECT ENGINEER / SUPERVISOR B. SMITH
PROJECT NUMBER F-099-9 (99)
TRACS NUMBER H999901C
REMARKS
EXAMPLE FOR PROCEDURE WHEN SAMPLE IS NOT DRIED
TO CONSTANT WEIGHT PRIOR TO SIEVING - (SECTION 12)
CONTACT PHONE NO. - (555)555-5555
ARIZ 201
Dried to Constant Wt.
Not Dried to Constant Wt.
ARIZ 248
Alt. 1 Alt. 2 Alt. 3
Alt. 4 Alt. 5
% OVERSIZE
+ 3 "
+ 6 "
COARSE FACTOR 007765 = 100 / COARSE SIEVE TOTAL
WET SAMPLE PREWEIGHT = 13010
WET WT. OF - # 4 = 7365
- # 4 SPLIT WET WT. = 506
CUMULATIVE % RET. FINENESS MODULUS
WEIGHTS RETAINED
3" 2 1/2" 2" 1 1/2" 0 100 100
1" 910 7 93 90-100
3/4" 1445 11 82
1/2" 645 5 77
3/8" 1745 14 63
1/4" 515 4 59
4 385 3
- # 4 2345 56
Total 12879
IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. =
WASHED WT. =
ELUTRIATION =
DRY WT. OF - # 4 SPLIT 497
FINE FACTOR 112676 = % PASS # 4 / DRY WT. OF - # 4 SPLIT
WEIGHTS RETAINED
#8 42 5 51 35-55
#10 76 8 43
#16 34 4 39
#30 54 6 33
#40 1034 12 21
#50 44 5 16
#100 46 5 11
#200 39 4
-#200 2 6.6 0-8.0
Total 4440
Elutriation 57
Dry Weight
= -#4 Split - Total Dry Weight
FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100
T = AASHTO Tests
SPECS.
Liquid Limit (LL) T - 89
Plastic Limit (PL) T - 90
Plasticity Index (PI) = LL - PL T - 90
Abrasion Method (A,B,C,D) T - 96
@ 100 Revolutions %
@ 500 Revolutions %
Absorption, H2O ARIZ 210 ARIZ 211 %
Specific Gravity, SSD ARIZ 210 ARIZ 211
Specific Gravity, OD ARIZ 210 ARIZ 211
Specific Gravity, Apparent ARIZ 210 ARIZ 211
A - ARIZ 225
C - ARIZ 226
D - ARIZ 226
AD - ARIZ 245
A1 - ARIZ 232
AD1 - ARIZ 246
Proctor Method
Optimum Moisture %
Max. Dry Density PCF
Sand Equivalent T - 176 ARIZ 242 (MAFC)
At Least One Fractured Face ARIZ 212 %
At Least Two Fractured Faces ARIZ 212 %
Uncompacted Void Content ARIZ 247 %
Moisture Content T - 255 T - 265 %
Flakiness Index ARIZ 233 %
Carbonates ARIZ 238 %
pH ARIZ 236 OR 237
Resistivity (ohm-cm) ARIZ 236
Soluable Salts (PPM) ARIZ 237
Unit Weight T - 19 PCF
Voids T - 19 %
Organic Imputities T - 21
Chloride Content (PPM) ARIZ 736
Sulfate Content (PPM) ARIZ 733
Exchangeable Sodium (%) ARIZ 729
Exchangeable Sodium (PPM) ARIZ 729
WHITE
YELLOW
BLUE
11-16-14
RECEIVED DATE
Joe Dogood 11-16-14
TEST OPERATOR & DATE
Ted Headman 11-16-14
SUPERVISOR & DATE
SEE BACK ALSO

FIGURE 3

12.7 If a split of the pass No. 4 material is to be used to correct the weight of pass No. 4 material for moisture, immediately split the passing No. 4 material to at least 500 grams and record as the "- #4 Split Wet Wt.", (506). Dry the sample to constant weight, allow to cool, and record the weight as "Dry Wt. of Pass #4 Split", (497). If an elutriation and fine sieve analysis is to be performed, this split is used for that testing. Determine and record the "weight of pass No. 4 material" (7234) by the following:

$$\begin{pmatrix}\text{Weight of}\\ \text{Pass No. 4}\\ \text{Material}\end{pmatrix} = \begin{pmatrix}\text{Wet Wt.}\\ \text{of Pass}\\ \text{No. 4}\end{pmatrix} \text{ x } \left(\frac{\begin{matrix}\text{Dry Wt. of Pass}\\ \text{No. 4 Split}\end{matrix}}{\begin{matrix}\text{Pass No. 4 Split}\\ \text{Wet Wt.}\end{matrix}}\right)$$

12.8 If the entire amount of the pass No. 4 material is to be used to correct the weight of pass No. 4 material for moisture, the material is dried to constant weight and allowed to cool. The dry weight is recorded as the "weight of pass No. 4 material". If an elutriation and fine sieve analysis is to be performed on this material, the dry weight is also recorded as the "Dry Wt. of Pass No. 4 Split".

12.9 Determine and record the sample “Coarse Sieve Total”, (12879), by the following:

$$\begin{pmatrix}\text{Coarse}\\ \text{Sieve}\\ \text{Total}\end{pmatrix} = \begin{pmatrix}\text{Wet Sample}\\ \text{Preweight}\end{pmatrix} - \begin{pmatrix}\text{Wet Wt.}\\ \text{of Pass}\\ \text{No. 4}\end{pmatrix} - \begin{pmatrix}\text{Weight of}\\ \text{Pass No. 4}\\ \text{Material}\end{pmatrix}$$

12.10 If required, perform elutriation on the dry - #4 split, dry back to constant weight, allow to cool, and record as the "Total Dry Weight", (440).

12.11 Determine and record “Elutriation” by subtracting the “Total Dry Weight” from the “Dry Wt. of Pass No. 4 Split”, (497 - 440 = 57).

12.12 Perform fine sieving on the material left from elutriation using the No. 8 sieve down to the No. 200.

12.13 Record the weight of material in the appropriate “Weights Retained” box for each sieve.

12.14 Sum the individual weights retained for each sieve, compare to the weight of sample prior to sieving (fine sieve Total Dry Weight), and adjust or resieve as needed.

12.15 Determine the sieve analysis of the material as described in Section 10.

13. REPORT

13.1 The sieve analysis shall be reported either as shown in the example given in Figure 2 for a sample which has been dried to constant weight prior to sieving, or as shown in the example given in Figure 3 for a sample which has not been dried to constant weight prior to sieving.

13.2 A blank Soils and Aggregate Tabulation laboratory card is provided in Figure 4.

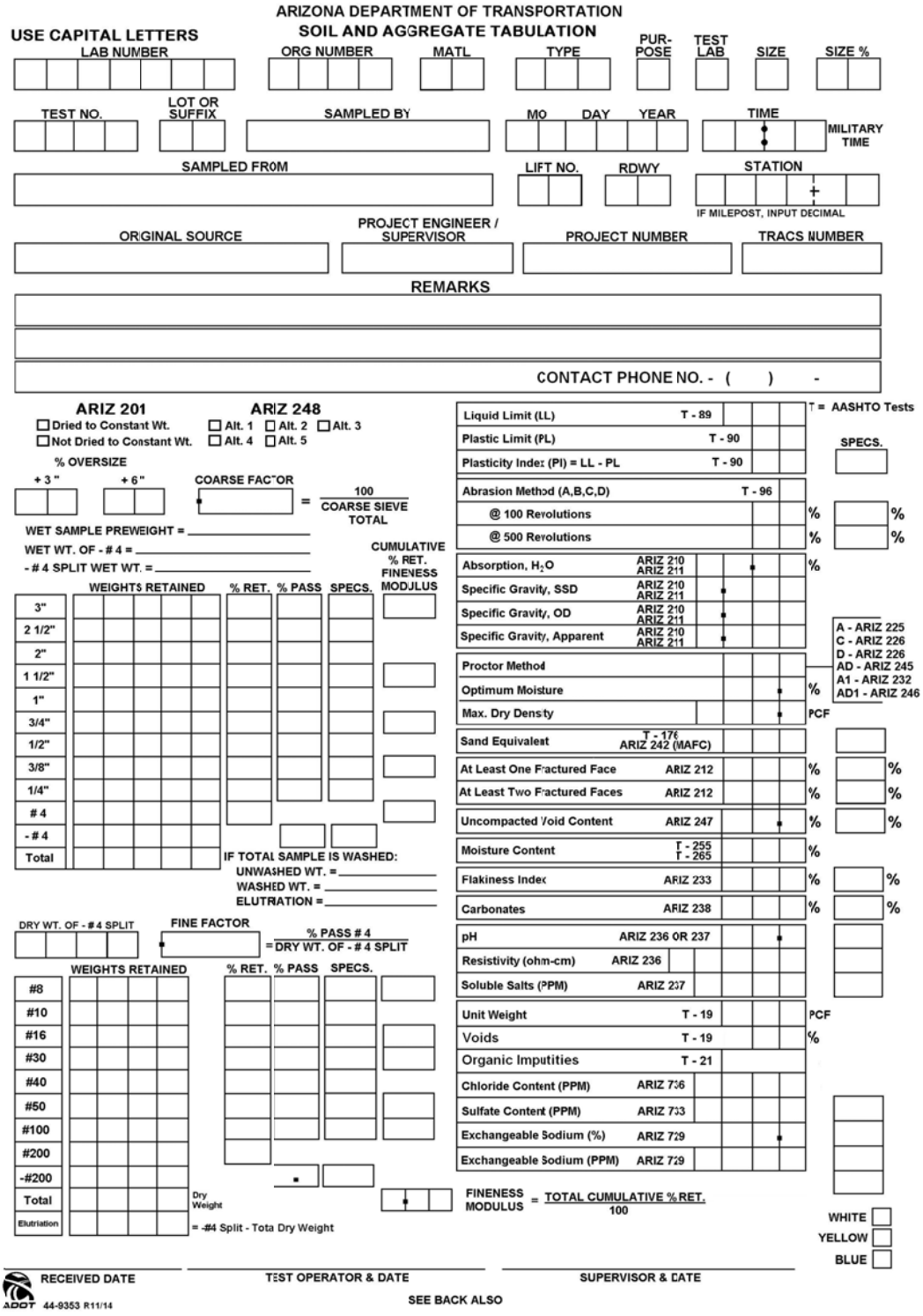

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION
USE CAPITAL LETTERS
LAB NUMBER
ORG NUMBER
MATL
TYPE
PUR-POSE
TEST LAB
SIZE
SIZE %
TEST NO.
LOT OR SUFFIX
SAMPLED BY
MO DAY YEAR
TIME
MILITARY TIME
SAMPLED FROM
LIFT NO.
RDWY
STATION
IF MILEPOST, INPUT DECIMAL
ORIGINAL SOURCE
PROJECT ENGINEER / SUPERVISOR
PROJECT NUMBER
TRACS NUMBER
REMARKS
CONTACT PHONE NO. - ( ) -
ARIZ 201
ARIZ 248
Dried to Constant Wt.
Not Dried to Constant Wt.
Alt. 1 Alt. 2 Alt. 3
Alt. 4 Alt. 5
% OVERSIZE
+ 3 "
+ 6 "
COARSE FACTOR
100 / COARSE SIEVE TOTAL
WET SAMPLE PREWEIGHT =
WET WT. OF - # 4 =
- # 4 SPLIT WET WT. =
CUMULATIVE % RET. FINENESS MODULUS
WEIGHTS RETAINED
% RET.
% PASS
SPECS.
3"
2 1/2"
2"
1 1/2"
1"
3/4"
1/2"
3/8"
1/4"
4
- # 4
Total
IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. =
WASHED WT. =
ELUTRIATION =
DRY WT. OF - # 4 SPLIT
FINE FACTOR
% PASS # 4 / DRY WT. OF - # 4 SPLIT
#8
#10
#16
#30
#40
#50
#100
#200
-#200
Total
Elutriation
Dry Weight
= -#4 Split - Tota Dry Weight
FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100
T = AASHTO Tests
Liquid Limit (LL) T - 89
Plastic Limit (PL) T - 90
Plasticity Index (PI) = LL - PL T - 90
Abrasion Method (A,B,C,D) T - 96
@ 100 Revolutions
@ 500 Revolutions
Absorption, H2O ARIZ 210 ARIZ 211
Specific Gravity, SSD ARIZ 210 ARIZ 211
Specific Gravity, OD ARIZ 210 ARIZ 211
Specific Gravity, Apparent ARIZ 210 ARIZ 211
Proctor Method
Optimum Moisture
Max. Dry Density
PCF
Sand Equivalent T - 176 ARIZ 242 (MAFC)
At Least One Fractured Face ARIZ 212
At Least Two Fractured Faces ARIZ 212
Uncompacted Void Content ARIZ 247
Moisture Content T - 255 T - 265
Flakiness Index ARIZ 233
Carbonates ARIZ 238
pH ARIZ 236 OR 237
Resistivity (ohm-cm) ARIZ 236
Soluble Salts (PPM) ARIZ 237
Unit Weight T - 19
Voids T - 19
Organic Imputities T - 21
Chloride Content (PPM) ARIZ 736
Sulfate Content (PPM) ARIZ 733
Exchangeable Sodium (%) ARIZ 729
Exchangeable Sodium (PPM) ARIZ 729
SPECS.
A - ARIZ 225
C - ARIZ 226
D - ARIZ 226
AD - ARIZ 245
A1 - ARIZ 232
AD1 - ARIZ 246
WHITE
YELLOW
BLUE
RECEIVED DATE
TEST OPERATOR & DATE
SUPERVISOR & DATE
ADOT 44-9353 R11/14
SEE BACK ALSO

FIGURE 4

COMPOSITE GRADING

(An Arizona Method)

Scope

1. This is a method of combining two or more samples of different gradations to produce a final product of a composited gradation.

Procedure

2. (a) For each sample; multiply the percent retained on each sieve by the "Decimal % of Composite" for the sample and record the results to the nearest 0.1%, except that the amount passing the No. 200 sieve shall be to the nearest 0.01%. Adjust the fractions of material for each aggregate sample as necessary to correspond to the total percent of composite for that sample, except that the percent passing the No. 200 sieve shall not be adjusted.

(b) Add the resultant percentages retained on each sieve for all samples and record as the composite % retained. Round the % retained for each sieve to the nearest 1%, except the amount passing the No. 200 sieve shall be rounded and recorded to the nearest 0.1%.

NOTE: Adjustments to the % retained and the % retained rounded may be necessary so that the total equals 100%, except that the % passing the No. 200 sieve shall not be adjusted.

(c) To obtain the composite percent passing each sieve, start with the Pass No. 200 fraction (rounded to the nearest whole percent), in the example 3%; and add the percent retained on the No. 200 sieve (3%), and record the sum as the % passing the No. 100 sieve (6%). Add the % retained on the No. 100 to this total and record as the % passing the No. 50 sieve (6 + 8 = 14). Repeat this procedure for all sieves, the final value should be 100%.

(d) If it is preferred, the % passing each sieve may be determined by beginning with the largest sieve which has material retained, in the example 13% was retained on the 1/2" sieve; subtract the % retained from 100 and record as % passing (100 - 13 = 87); subtract the % retained on the next smaller sieve and record as % passing (87 - 11 retained on the 3/8" = 76); continue this procedure for all sieves, the final value should be the percent passing the No. 200 sieve, rounded to the whole percent.

NOTE: Figure 1 shows an example of a sieve analysis as reported from ARIZ 201, for four individual samples. Figure 2 shows an example of the calculations described in paragraphs (a), (b), (c), and (d), and a completed composite grading of the four individual samples.

(e) If a calculated composite is desired using the percent passing each sieve, it may be obtained by multiplying the % pass each sieve by the "decimal % of composite" for each sample, and accumulate for the resultant composite percent pass each sieve in similar manner as in the method described above for composite % retained. After the composite % passing each sieve is calculated the composite % retained is determined by the following:

$$\left[\begin{array}{c}\text{\% Retained on} \\ \text{Individual} \\ \text{Sieve}\end{array}\right] = \left[\begin{array}{c}\text{\% Passing} \\ \text{next larger} \\ \text{sieve size}\end{array}\right] - \left[\begin{array}{c}\text{\% Passing} \\ \text{desired} \\ \text{sieve size}\end{array}\right]$$

NOTE: Figure 3 shows an example of the calculations described in paragraph (e), and a completed composite grading of the four individual samples.

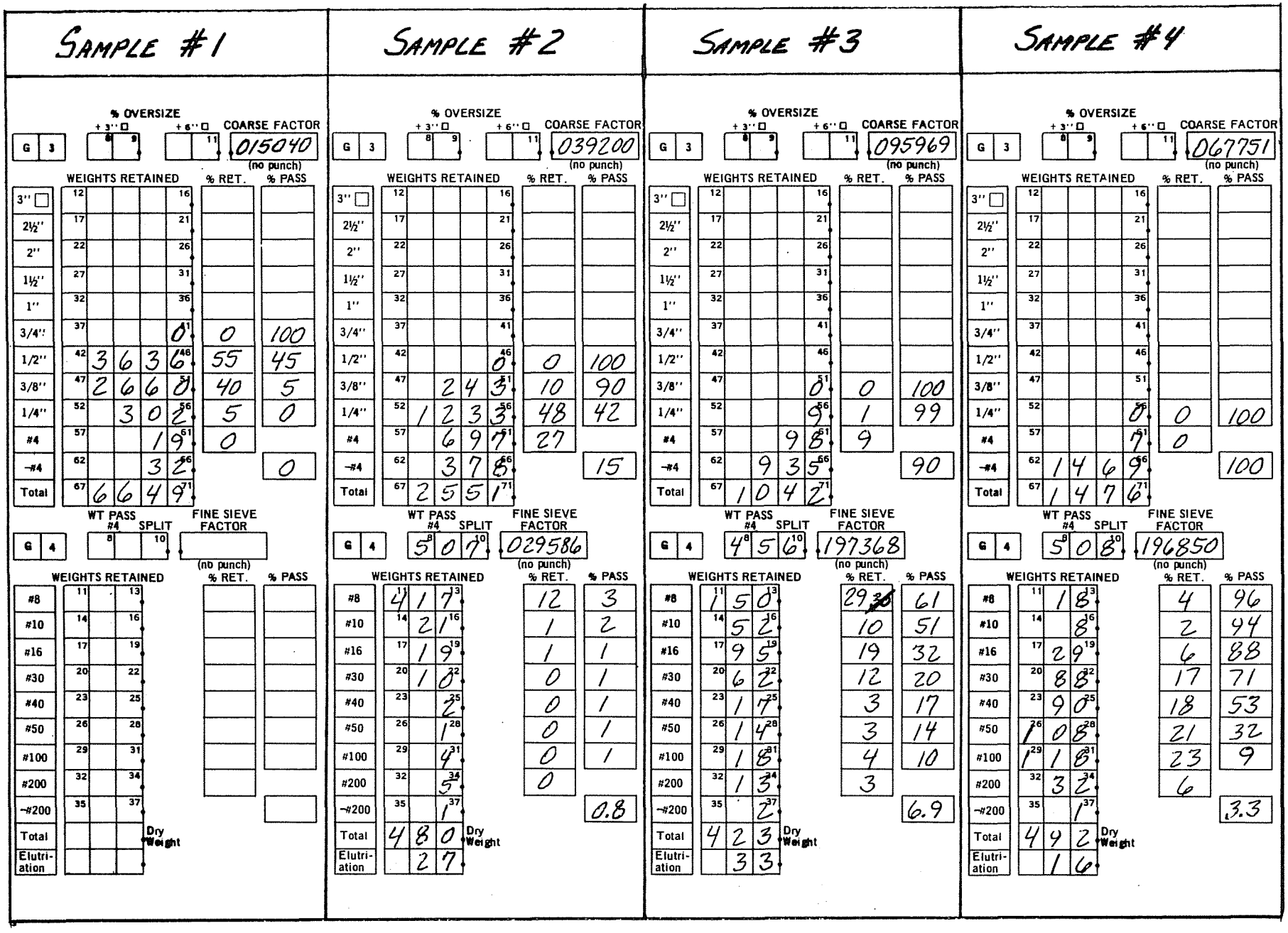

SAMPLE #1
% OVERSIZE
+3" □
+6" □
COARSE FACTOR
G 3
015040
(no punch)
WEIGHTS RETAINED
% RET.
% PASS
3" □
2½"
2"
1½"
1"
3/4"
1/2"
3/8"
1/4"
#4
-#4
Total
0
100
55
45
40
5
5
0
0
WT PASS #4 SPLIT
FINE SIEVE FACTOR
G 4
(no punch)
#8
#10
#16
#30
#40
#50
#100
#200
-#200
Total
Elutri-ation
Dry Weight
SAMPLE #2
039200
0
100
10
90
48
42
27
15
0.8
SAMPLE #3
095969
0
100
1
99
9
90
6.9
SAMPLE #4
067751
0
100
100
4
96
2
94
6
88
17
71
18
53
21
32
23
9
6
3.3

FIGURE 1

SIEVE SIZE	SAMPLE #1 % OF COMPOSITE = 23 % Ret.	% Comp.	% Ret.	SAMPLE #2 % OF COMPOSITE = 20 % Ret.	% Comp.	% Ret.	SAMPLE #3 % OF COMPOSITE = 27 % Ret.	% Comp.	% Ret.	SAMPLE #4 % OF COMPOSITE = 30 % Ret.	% Comp.	% Ret.	COMPOSITE % Ret. % Ret.	Rounded	% Pass
3/4	0	x.23													100
1/2	55	x.23	12.6	0									12.6	13	87
3/8	40	x.23	9.2	10	x.20	2.0	0						11.2	11	76
1/4	5	x.23	1.2	48	x.20	9.6	1	x.27	0.3				11.1	11	65
#4	0	x.23		27	x.20	5.4	9	x.27	2.4	0			7.8	8	57
#8	0	x.23		12	x.20	2.4	29	x.27	7.9 ~~7.8~~	4	x.30	1.2	11.5	11	46
#10	0	x.23		1	x.20	0.2	10	x.27	2.7	2	x.30	0.6	3.5	4	42
#16	0	x.23		1	x.20	0.2	19	x.27	5.1	6	x.30	1.8	7.1	7	35
#30	0	x.23		0	x.20		12	x.27	3.2	17	x.30	5.1	8.3	8	27
#40	0	x.23		0	x.20		3	x.27	0.8	18	x.30	5.4	6.2	6	21
#50	0	x.23		0	x.20		3	x.27	0.8	21	x.30	6.3	7.1	7	14
#100	0	x.23		0	x.20		4	x.27	1.1	23	x.30	6.8 ~~6.8~~	7.9	8	6
#200	0	x.23		0	x.20		3	x.27	0.8	6	x.30	1.8	2.6	3	3.0
Pass #200	0	x.23		0.8	x.20	0.16	6.9	x.27	1.86	3.3	x.30	0.99	3.01	3.0	
TOTAL	100		23.0	99.8		19.96	99.9		26.96	100.3		29.99	99.91		

FIGURE 2

SIEVE SIZE	SAMPLE #1 % OF COMPOSITE = 23			SAMPLE #2 % OF COMPOSITE = 20			SAMPLE #4 % OF COMPOSITE = 27			SAMPLE #4 % OF COMPOSITE = 30			COMPOSITE		
	% Pass	% Comp.	% Pass	% Pass	% Comp.	% Pass	% Pass	% Comp.	% Pass	% Pass	% Comp.	% Pass	% Pass	% Ret.	% Pass Rounded
3/4	100	x.23	23.0	100	x.20	20.0	100	x.27	27.0	100	x.30	30.0	100.0	100	100
1/2	45	x.23	10.4	100	x.20	20.0	100	x.27	27.0	100	x.30	30.0	87.4	13	87
3/8	5	x.23	1.2	90	x.20	18.0	100	x.27	27.0	100	x.30	30.0	76.2	11	76
1/4	0	x.23	0	42	x.20	8.4	99	x.27	26.7	100	x.30	30.0	65.1	11	65
#4				15	x.20	3.0	90	x.27	24.3	100	x.30	30.0	57.3	8	57
#8				3	x.20	0.6	61	x.27	16.5	96	x.30	28.8	45.9	11	46
#10				2	x.20	0.4	51	x.27	13.8	94	x.30	28.2	42.4	4	42
#16				1	x.20	0.2	32	x.27	8.6	88	x.30	26.4	35.2	7	35
#30				1	x.20	0.2	20	x.27	5.4	71	x.30	21.3	26.9	8	27
#40				1	x.20	0.2	17	x.27	4.6	53	x.30	15.9	20.7	6	21
#50				1	x.20	0.2	14	x.27	3.8	32	x.30	9.6	13.6	7	14
#100				1	x.20	0.2	10	x.27	2.7	9	x.30	2.7	5.6	8	6
#200				0.8	x.20	0.16	6.9	x.27	1.86	3.3	x.30	0.99	3.01	3	3.0

FIGURE 3

SPECIFIC GRAVITY AND ABSORPTION OF COARSE AGGREGATE

(A Modification of AASHTO Designation T 85)

1. SCOPE

1.1 This test method covers the determination of specific gravity and absorption of coarse aggregate. The specific gravity may be expressed as bulk oven dry (OD) specific gravity, bulk saturated surface dry (SSD) specific gravity, or apparent specific gravity. The bulk (SSD) specific gravity and absorption are based on aggregate after 15 to 19 hours soaking in water. This method is not intended to be used with lightweight aggregate.

1.2 The specific gravity and absorption of coarse aggregate is normally determined on Plus No. 4 Material. When corresponding fine aggregate specific gravity and absorption are determined on Minus No. 8 Material, in accordance with Arizona Test Method 211, the coarse aggregate specific gravity and absorption shall be performed on Plus No. 8 Material. "Coarse aggregate" as herein referenced will be for either Plus No. 4 or Plus No. 8 Material. Coarse aggregate specific gravity and absorption for mineral aggregates used in asphaltic concrete, other than asphaltic concrete friction course, shall be determined on Plus No. 4 Material.

1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.5 Reference may be made to AASHTO T 85 for additional information, including: terminology, significance and use, precision and bias, development of equations, and interrelationships between specific gravities and absorption as defined in AASHTO T 85 and T 84.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least one gram. The balance shall be equipped with a suitable apparatus for suspending the sample container in water from the center of the weighing platform or pan of the balance.

2.3 Sample Container - A wire basket, of adequate size for the material being tested, and so constructed to prevent trapping of air when submerged. For test samples of Plus No. 4 Material, the wire mesh shall be No. 6 or finer. For test samples of Plus No. 8 Material, the wire mesh shall be No. 10 or finer. The wire for suspending the container from the balance shall be of the smallest practical size to minimize any possible effects of a variable immersed length.

2.4 Water Tank - A watertight tank into which the sample and container are placed for complete immersion while suspended below the balance, equipped with an overflow for maintaining a constant water level.

2.5 Sieves - Conforming to ASTM E11, and consisting of the necessary sieve sizes as described in Subsection 3.2 through 3.3.

3. SAMPLING

3.1 Sample the aggregate in accordance with Arizona Test Method 105.

3.2 The sample shall be sieved over the appropriate No. 4 or No. 8 sieve and the specific gravity and absorption determined as given in Subsections 5.3 and 5.5; or, testing may be performed on separate coarse size fractions, as described in Subsection 3.4 and the average values for specific gravity and absorption determined as given in Subsections 5.4 and 5.6. When testing is performed on separate size fractions of the coarse aggregate, a sieve analysis of the material shall be performed in accordance with Arizona Test Method 201. If the specific gravity and absorption of the fine aggregate is to be determined, save the appropriate Pass No. 4 or Pass No. 8 Material for testing in accordance with Arizona Test Method 211, otherwise it can be discarded.

3.3 If testing is not to be performed using separate size fractions, a representative test sample of the Plus No. 4 or Plus No. 8 Material with a minimum mass as shown below shall be obtained.

Nominal Maximum Sieve Size, inches	Minimum Mass of Test Sample, kilograms (pounds)
6	125 (276)
5	75 (165)
4-1/2	50 (110)
4	40 (88)
3-1/2	25 (55)
3	18 (40)
2-1/2	12 (26)
2	8 (18)
1-1/2	5 (11)
1	4 (8.8)
3/4	3 (6.6)
1/2 or less	2 (4.4)

3.4 It may be desirable to test the material in separate size fractions. An example is given below which illustrates the procedure to be followed. [If the sample contains more than 15 percent retained on the 1-1/2" sieve, test the Plus 1-1/2" Material in one or more size fractions separately from the smaller size fraction(s).] When an aggregate is tested in separate size fractions, the minimum mass of test sample for each fraction shall be the difference between the masses specified above for the largest and smallest sieve sizes of the fraction. The smallest size fraction tested shall meet the minimum mass requirements listed above, corresponding to the largest sieve size (passing) of the fraction. Size fractions of more than one sieve shall be proportionate with the sieve analysis for the sizes included.

Example: (A sample with the following sieve analysis is tested in the selected separate size fractions shown below.)

Sieve Size	% Retained	% Pass
2”	0	100
1-1/2”	16	84
1”	10	74
3/4”	8	66
1/2”	6	60
3/8”	4	56
1/4”	10	46
# 4	5	41

Size fraction of Pass 2” to Retained 1-1/2”: 8000 g - 5000 g = 3000 g

Size fraction of Pass 1-1/2” to Retained 3/4": 5000 g - 3000 g = 2000 g

For each sieve in this size fraction, the proportionate amount is determined:

Pass 1-1/2” to Retained 1”: [10 / (10 + 8)] x 2000 g = 1111 g
Pass 1” to Retained 3/4": [8 / (10 + 8)] x 2000 g = 889 g

Size fraction of Pass 3/4" to Retained No. 4: 3000 g

For each sieve in this size fraction, the proportionate amount is determined:

Pass 3/4" to Retained 1/2": [6 / (6 + 4 + 10 + 5)] x 3000 g = 720 g
Pass 1/2" to Retained 3/8”: [4 / (6 + 4 + 10 + 5)] x 3000 g = 480 g
Pass 3/8” to Retained 1/4": [10 / (6 + 4 + 10 + 5)] x 3000g = 1200g
Pass 1/4" to Retained No. 4: [5 / (6 + 4 + 10 + 5)] x 3000 g = 600 g

4. PROCEDURE

4.1 Thoroughly wash the test sample to remove dust or other coatings from the surface.

4.2 Dry the test sample in a suitable pan or vessel to constant mass (see Subsection 4.4 below) at a temperature of 230 ± 9 °F. Constant mass shall be determined as follows: Dry the sample for at least 1 hour at 230 ± 9 °F. Record the weight of the sample to at least the nearest 1.0 gram. Continue drying and weighing until the weight does not change more than 1.0 gram at drying intervals of a minimum of 30 minutes.

4.3 Cool in air at room temperature for 1 to 3 hours for test samples of 1-1/2" nominal maximum size, or longer for larger sizes until the aggregate has cooled to a temperature that is comfortable to handle (approximately 122 °F).

4.4 Subsequently immerse the aggregate in water at room temperature for a period of 15 to 19 hours.

Note 1: Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial

drying to constant mass may be eliminated and, if the surfaces of the particles in the sample have been kept continuously wet until testing, the 15 to 19 hour soaking may also be eliminated.

Note 2: Values for absorption and bulk (SSD) specific gravity may be significantly higher for aggregate not oven dried before soaking than for the same aggregate which has been dried and soaked as specified in Subsections 4.2 through 4.4. This is especially true of particles larger than 3 inches since the water may not be able to penetrate the pores to the center of the particle in the prescribed soaking period.

4.5 Remove the test sample from the water and roll it in a large absorbent cloth or towel until all visible films of water are removed from the surface of the aggregate, wiping the larger particles individually as necessary. Take care to avoid loss of water from aggregate pores during surface-drying by completing the operation as quickly as possible. Immediately determine the mass of the test sample in the saturated surface-dry condition. Record this and all subsequent masses to at least the nearest gram.

4.6 After determining the saturated-surface-dry mass place the test sample in the sample container and determine its mass in water at 73 $\pm$ 3 °F. Take care to remove all entrapped air before determining the mass by shaking the container while immersed. The container shall be immersed to a depth sufficient to cover it and the test sample during mass determination.

4.7 Dry the test sample to constant mass at a temperature of 230 $\pm$ 9 °F. Constant mass shall be determined as described in Subsection 4.2. Cool in air at room temperature for 1 to 3 hours, or until the aggregate has cooled to a temperature that is comfortable to handle (approximately 122 °F) and determine the mass. Record the mass of the sample to at least the nearest gram.

5. CALCULATIONS

5.1 Calculate the bulk (OD) specific gravity as shown below:

$$\text{Bulk (OD) Specific Gravity} = \frac{A}{(B - C)}$$

Where: A = Mass of oven-dry test sample in air, grams.
B = Mass of saturated-surface-dry test sample in air, grams.
C = Mass of saturated test sample in water, grams.

5.2 Calculate the bulk (SSD) specific gravity as shown below:

$$\text{Bulk (SSD) Specific Gravity} = \frac{B}{(B - C)}$$

5.3 Calculate the apparent specific gravity as shown below:

$$\text{Apparent Specific Gravity} = \frac{A}{(A - C)}$$

5.4 When the sample is tested in separate size fractions, the average value for bulk (OD) specific gravity, bulk (SSD) specific gravity, or apparent specific gravity can be computed as the average of the respective specific gravities for the individual size fractions, weighted in proportion to the mass percentage of the size fractions in the original sample.

$$G = \frac{1}{\frac{P1}{100(G1)} + \frac{P2}{100(G2)} + \ldots + \frac{Pn}{100(Gn)}}$$

Where: G = Average specific gravity. All forms of expression of specific gravity can be averaged in this manner.
P1, P2, ... Pn = Mass percentage for each size fraction in original sample (total equals 100).
G1, G2, ... Gn = Respective specific gravity values for each size fraction for the type of specific gravity being averaged.

5.5 Calculate the percent absorption as shown below:

$$\text{Percent Absorption} = \frac{(B - A)}{A} \times 100$$

5.6 When the sample is tested in separate size fractions, the average value for percent absorption can be computed as the average of the individual percent absorption values for the respective size fractions, weighted in proportion to the mass percentage of the size fractions in the original sample.

$$A = \left[\frac{(P1)(A1)}{100}\right] + \left[\frac{(P2)(A2)}{100}\right] + \ldots + \left[\frac{(Pn)(An)}{100}\right]$$

Where: A = Average percent absorption.
P1, P2, ... Pn = Mass percentages for each size fraction in original sample (total equals 100).
A1, A2, ... An = Individual percent absorption values for the respective size fractions.

6. REPORT

6.1 Report specific gravity results to the nearest 0.001, and indicate the type of specific gravity, whether bulk (OD), bulk (SSD), or apparent.

6.2 Report the absorption result to the nearest 0.01%.

6.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in Subsection 4.4, it shall be noted in the report.

6.4 The size of the material tested shall be noted, i.e., Plus No. 4 or Plus No. 8.

7. PROCEDURE FOR DETERMINING COMBINED SPECIFIC GRAVITIES AND ABSORPTION FOR DIFFERENT SOURCES OF MATERIAL

7.1 Two methods are given below for determining the combined specific gravities and absorption for different sources of material, as described in Subsections 7.1.1 and 7.1.2.

7.1.1 The specific gravity and absorption may be determined for coarse aggregates from different sources which have been composited in the desired proportions and thoroughly blended.

7.1.2 The specific gravity and absorption of the coarse aggregate from each individual source may be determined and the combined specific gravity and absorption calculated as described in Subsections 7.1.3 through 7.1.7 below. (Refer to the example given in Subsection 7.1.7 for an illustration of the procedure and calculations.) The same size of material, either Plus No. 4 or Plus No. 8, shall be used to determine the individual specific gravities and absorption for each of the different sources.

7.1.3 For each individual material in the composite, its contribution to the total percent of coarse aggregate in the composite is determined and recorded to the nearest 0.01% as "IP":

$$IP = \frac{\left[\begin{array}{c}\text{Percent of Individual}\\ \text{Material in Composite}\end{array}\right] \times \left[\begin{array}{c}\text{Percent of Coarse Aggregate}\\ \text{in Individual Material}\end{array}\right]}{100}$$

Where: IP = Contribution by each individual material to the total percent of coarse aggregate in the composite.

7.1.4 For each individual source, the percent of coarse aggregate in the composite is determined by summing the values for "IP" for that source, and recording the total as "P".

7.1.5 The combined specific gravity is calculated by the following:

$$G = \frac{P1 + P2 + \ldots + Pn}{\frac{P1}{G1} + \frac{P2}{G2} + \ldots + \frac{Pn}{Gn}}$$

Where: P1, P2, ... Pn = For each individual source, the percent of coarse aggregate in the composite, "P".
G1, G2, .. Gn = The coarse specific gravity for each individual source.

7.1.6 The combined absorption is calculated by the following:

$$\text{Combined Absorption} = \frac{\left[\begin{array}{c}\text{Combined Bulk}\\ \text{(SSD) Specific}\\ \text{Gravity}\end{array}\right] - \left[\begin{array}{c}\text{Combined}\\ \text{Bulk (OD) Specific}\\ \text{Gravity}\end{array}\right]}{\left[\begin{array}{c}\text{Combined Bulk (OD)}\\ \text{Specific Gravity}\end{array}\right]}$$

7.1.7 The following is an example of the procedure and calculations described in Subsections 7.1.2 through 7.1.6 above. The example given is for a composite consisting of 26% coarse aggregate, 12% intermediate, and 47% fines from the primary source; with 15% blend from a secondary source. The coarse aggregate has 98% Plus No. 4, the intermediate has 94% Plus No. 4, the fines have 9% Plus No. 4, and the blend has 24% Plus No. 4.

Specific gravity and absorption for each of the different sources:

Primary Source (Coarse, Intermediate, Fine):

Bulk (OD) Specific Gravity = 2.549
Bulk (SSD) Specific Gravity = 2.586
Apparent Specific Gravity = 2.651
Absorption = 1.45%

Secondary Source (Blend):

Bulk (OD) Specific Gravity = 2.665
Bulk (SSD) Specific Gravity = 2.724
Apparent Specific Gravity = 2.781
Absorption = 2.21%

Determination of "IP" for individual materials, and "P" for individual sources, for the Primary Source (Coarse, Intermediate, Fine) and the Secondary Source (Blend):

Primary Source:

$$\text{"IP" Coarse} = \frac{(26)\,x\,(98)}{100} = 25.48\%$$

$$\text{"IP" Intermediate} = \frac{(12)\,x\,(94)}{100} = 11.28\%$$

$$\text{"IP" Fine} = \frac{(47)\,x\,(9)}{100} = \ 4.23\%$$

"P" for Primary Source = 40.99%

Secondary Source:

$$\text{"IP" Blend} = \frac{(15)\,x\,(24)}{100} = \ 3.60\%$$

"P" for Secondary Source = 3.60%

[P (Primary)] + [P (Secondary)] = 44.59%

$$\left[\begin{array}{l}\text{Combined}\\ \text{Bulk (OD)}\\ \text{Specific}\\ \text{Gravity}\end{array}\right] = \frac{44.59}{\frac{40.99}{2.549} + \frac{3.60}{2.665}} = 2.558$$

$$\left[\begin{array}{l}\text{Combined}\\ \text{Bulk (SSD)}\\ \text{Specific}\\ \text{Gravity}\end{array}\right] = \frac{44.59}{\frac{40.99}{2.586} + \frac{3.60}{2.724}} = 2.597$$

$$\left[\begin{array}{l}\text{Combined}\\ \text{Apparent}\\ \text{Specific}\\ \text{Gravity}\end{array}\right] = \frac{44.59}{\frac{40.99}{2.651} + \frac{3.60}{2.781}} = 2.661$$

$$\left[\begin{array}{l}\text{Combined}\\ \text{Absorption}\end{array}\right] = \frac{2.597 - 2.558}{2.558}\,x\,100 = 1.52\%$$

FIGURE 1

EXAMPLE OF CALCULATIONS FOR COARSE SPECIFIC GRAVITY

Bulk Sp. Gr. (O.D. basis) = $\frac{A}{B - C}$ $\quad\frac{(\ 4197\ )}{(\ 4291\ ) - (\ 2610\ )}$ = ***2.497***

Where: **A =** mass of oven-dry sample in air, g. **4197**
B = mass of saturated-surface-dry sample in air, g. **4291**
C = mass of saturated sample in water, g. **2610**

Bulk Sp. Gr. (SSD basis) = $\frac{B}{B - C}$ $\quad\frac{(\ 4291\ )}{(\ 4291\ ) - (\ 2610\ )}$ = ***2.553***

Apparent Sp. Gr. = $\frac{A}{A - C}$ $\quad\frac{(\ 4197\ )}{(\ 4197\ ) - (\ 2610\ )}$ = ***2.645***

Absorption, percent = $\frac{B - A}{A} \times 100$ $\quad\frac{(\ 4291\ ) - (\ 4197\ )}{(\ 4197\ )} \times 100$ = ***2.24*** %

SPECIFIC GRAVITY AND ABSORPTION OF FINE AGGREGATE

(A Modification of AASHTO Designation T 84)

1. SCOPE

1.1 This method covers the determination of specific gravity and absorption of fine aggregate. The specific gravity may be expressed as bulk oven dry (OD) specific gravity, bulk saturated surface dry (SSD) specific gravity, or apparent specific gravity.

1.2 The specific gravity and absorption of fine aggregate is normally determined on Minus No. 4 Material. When the fine aggregate sample (Minus No. 4) contains a substantial amount of Minus No. 4 to Plus No. 8 Material, such as in mineral aggregate for asphaltic concrete friction course, the fine aggregate specific gravity and absorption shall be performed on Minus No. 8 Material. The fine aggregate specific gravity and absorption for mineral aggregates used in asphaltic concrete, other than asphaltic concrete friction course, shall be determined on Minus No. 4 Material. "Fine aggregate" as herein referenced will be either Minus No. 4 or Minus No. 8 Material. Corresponding coarse aggregate specific gravity and absorption testing, utilizing the appropriate Plus No. 4 or Plus No. 8 Material, shall be performed in accordance with Arizona Test Method 210.

1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.5 When the specific gravity and absorption of the fine aggregate and the coarse aggregate are known, the combined aggregate specific gravity and absorption is determined, if necessary, utilizing Arizona Test Method 251.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

2.3 Pycnometer - A 500 mL volumetric flask into which the fine aggregate test sample can be readily introduced and in which the volume content can be reproduced within 0.2 mL. Figure 1 is an illustration of the type of flask that must be utilized. The volume of the flask filled to the mark shall be at least 50 percent greater than the space required to accommodate the test sample. If this requirement is not met for a particular aggregate, the normal sample size of 500 $\pm$ 10 grams may be reduced only enough to satisfy the requirement.

2.4 Mold - A metal mold in the form of a frustum of a cone with dimensions as follows: 40 $\pm$ 3 mm inside diameter at the top, 90 $\pm$ 3 mm inside diameter at the bottom, and 75 $\pm$ 3 mm in height, with the metal having a minimum thickness of 0.8 mm (See Figure 2).

2.5 Tamper - A metal tamper having a mass of 340 $\pm$ 15 grams, and having a flat circular tamping face 25 $\pm$ 3 mm in diameter (See Figure 2).

2.6 Oven - Capable of maintaining a temperature of 230 $\pm$ 9 °F.

3. SAMPLING

3.1 Sample the aggregate in accordance with Arizona Test Method 105.

4. PREPARATION OF TEST SAMPLE

4.1 Obtain a representative approximate 1200 gram test sample of the fine aggregate.

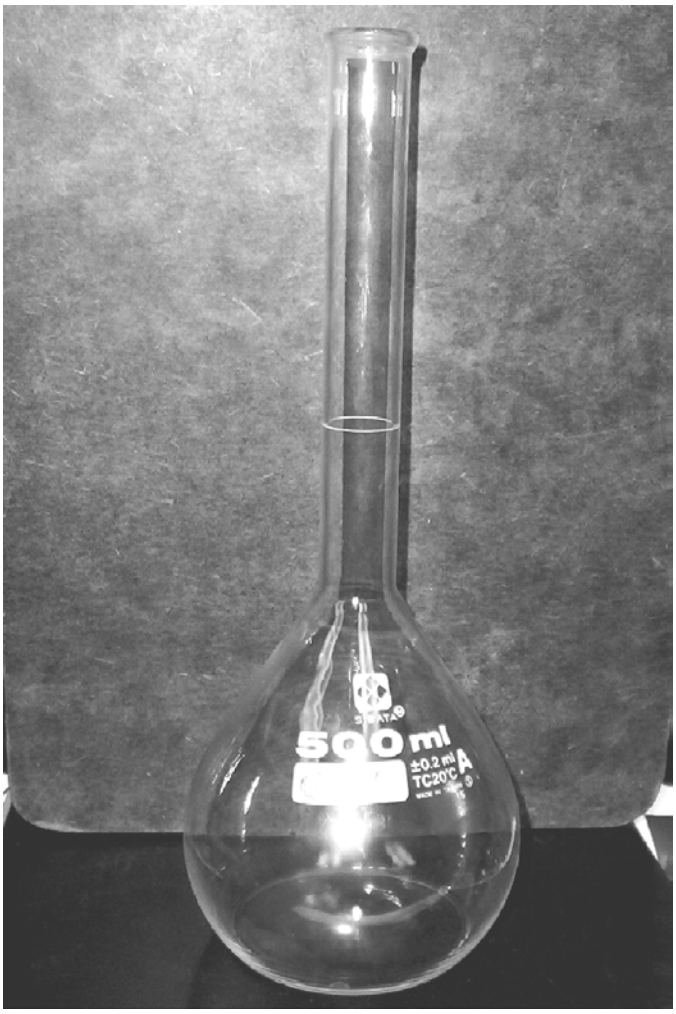


FIGURE 1

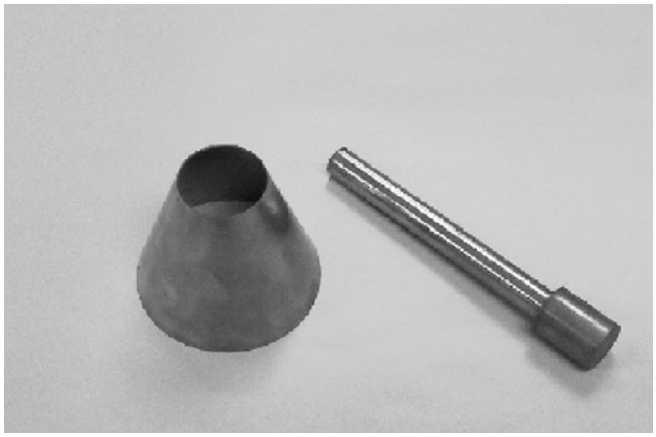


FIGURE 2

4.2 Dry the test sample in a suitable pan or vessel to constant mass (see Subsection 4.3 below) at a temperature of 230 ± 9 °F. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at 230 ± 9 °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.) Allow the sample to cool to comfortable handling temperature, cover with sufficient water to completely immerse it throughout the soaking period, and permit to stand for 15 to 19 hours.

4.3 Where the absorption and specific gravity values are to be used in proportioning concrete mixtures in which the aggregates will be in their naturally moist condition, the requirement for initial drying to constant mass may be eliminated and, if the surfaces of the particles in the sample have been kept continuously wet until testing, the 15 to 19 hour soaking may also be eliminated.

Note: Values for absorption and bulk (SSD) specific gravity may be significantly higher for aggregate not oven dried before soaking than for the same aggregate which has been dried and soaked as specified in Subsection 4.2.

4.4 Decant excess water with care to avoid loss of fines, spread the sample on a flat nonabsorbent surface exposed to a gently moving current of ambient or warm air, and stir frequently to secure homogeneous drying. Continue stirring and drying until the sample approaches a free-flowing condition. As the material begins to dry sufficiently, it may be necessary to work it with the hands in a rubbing motion to break up any conglomerations, lumps, or balls of material that develop.

4.5 Follow the procedure (cone test for surface moisture) given in Subsection 4.6 below to determine whether or not surface moisture is present on the fine aggregate particles. It is intended that the first trial will be made with some surface water in the sample. Continue drying with constant stirring, working the material with a hand-rubbing motion as necessary, and test at frequent intervals until the test indicates that the sample has reached a surface-dry condition. If the first trial of the surface moisture test indicates that moisture is not present on the surface, it has been dried past the saturated surface-dry condition. In this case, thoroughly mix a few milliliters of water with the fine aggregate and permit the specimen to stand in a covered container for 30 minutes. Then resume the process of drying and testing at frequent intervals for the onset of the surface-dry condition.

4.6 With one hand, hold the mold firmly on a smooth nonabsorbent surface with the large diameter down. The mold must be held firmly in place throughout the process of filling the mold, tamping, and removal of excess material from around the base of the mold. With the other hand, place a portion of the partially dried fine aggregate loosely in the mold, filling it until overflowing occurs, and heaping additional material above the top of the mold. Lightly tamp the fine aggregate into the mold with 25 light drops of the tamper. Each drop should start about 0.2 inch above the top surface of the fine aggregate. Permit the tamper to fall freely on each drop. Adjust the starting height to the new surface elevation after each drop and distribute the drops over the surface. Remove loose material from around the base of the mold, and lift the mold vertically. If surface moisture is still present, the fine aggregate will retain the molded shape. When the fine aggregate slumps slightly, it indicates that it has reached a surface-dry condition. Some angular fine aggregate or material with a high proportion of fines may not slump in the cone test upon reaching a surface-dry condition. This may be the case if fines become airborne upon dropping a handful of the sand from the cone test 4 to 6 inches onto a surface. For these materials, the saturated surface-dry condition should be considered as the point that one side of the fine aggregate slumps slightly upon removing the mold.

5. PROCEDURE

5.1 Only a pycnometer calibrated in accordance with the requirements of Appendix A3 of the Materials Testing Manual shall be used to perform this test. The mass of the pycnometer filled to its calibration capacity with water at 73 ± 3 °F is determined and recorded to the nearest 0.1 gram. Prior to determining the mass of the pycnometer filled with water to the calibration mark, the inside of the neck of the pycnometer just above calibration level shall be dried with a rolled up paper towel.

5.2 Obtain a representative 500 ± 10 gram sample of the saturated surface-dry fine aggregate prepared as described in Section 4. Immediately determine and record the weight of the sample to the nearest 0.1 gram.

5.3 Partially fill the calibrated pycnometer with water. Introduce the sample into the pycnometer and fill with additional water to approximately 90 percent of total capacity so that the water level after the elimination of all air bubbles is above the bottom of the neck but below the calibration line. Roll and agitate the pycnometer to eliminate all air bubbles.

Note: Adding a few drops of 99% grade isopropyl alcohol (ASTM D 770), after removal of air bubbles and just prior to bringing

the water level to its calibrated capacity, has been found useful in dispersing foam on the water surface.

5.4 Rinse the inside of neck of pycnometer with water and add sufficient water to bring the water level in the pycnometer to its calibrated capacity. Adjust its temperature to 73 ± 3 °F, if necessary by immersion in circulating water. With a rolled up paper towel, dry the inside neck of pycnometer just above the calibration level. Determine and record the mass of the pycnometer, sample, and water to the nearest 0.1 gram.

5.5. Remove the fine aggregate from the pycnometer and dry to constant mass at a temperature of 230 ± 9 °F. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at 230 ± 9 °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.) Cool in air at room temperature for 1.0 ± 0.5 hours. Determine and record the mass to the nearest 0.1 gram.

Note: In lieu of drying and weighing the sample which has been removed from the pycnometer, a second portion of the saturated surface dry sample may be used to determine the oven dry weight. This sample must be obtained at the same time and shall weigh within ± 0.2 grams of the sample which is introduced into the pycnometer.

6. CALCULATIONS

6.1 Calculate the bulk (OD) specific gravity as shown below:

$$\text{Bulk (OD) Specific Gravity} = \frac{A}{(B + S - C)}$$

Where: A = mass of oven-dry test sample in air.
B = mass of pycnometer filled with water to calibration mark.
S = mass of saturated surface-dry test sample.
C = mass of pycnometer with test sample and water to calibration mark.

6.2 Calculate the bulk (SSD) specific gravity as shown below:

$$\text{Bulk (SSD) Specific Gravity} = \frac{S}{(B + S - C)}$$

6.3 Calculate the apparent specific gravity as shown below:

$$\text{Apparent Specific Gravity} = \frac{A}{(B + A - C)}$$

6.4 Calculate the percent absorption as shown below:

$$\text{Percent Absorption} = \frac{(S - A)}{A} \times 100$$

7. REPORT

7.1 Report specific gravity results to the nearest 0.001, and indicate the type of specific gravity, whether bulk (OD), bulk (SSD), or apparent.

7.2 Report the absorption result to the nearest 0.01%.

7.3 If the specific gravity and absorption values were determined without first drying the aggregate, as permitted in Subsection 4.3, it shall be noted in the report. The source of the sample and the procedures used to prevent drying prior to testing shall also be reported.

7.4 The size of the material tested shall be noted, i.e., Minus No. 4 or Minus No. 8.

8. PROCEDURE FOR DETERMINING COMBINED SPECIFIC GRAVITIES AND ABSORPTION FOR DIFFERENT SOURCES OF MATERIAL

8.1 Two methods are given below for determining the combined specific gravities and absorption for different sources of material, as described in Subsections 8.2 and 8.3.

8.2 The specific gravity and absorption may be determined for fine aggregates from different sources which have been composited in the desired proportions and thoroughly blended.

8.3 The specific gravity and absorption of the fine aggregate from each individual source may be determined and the combined specific gravity and absorption calculated as described in Subsections 8.3.1 through 8.3.4 below. (Refer to the example given in Subsection 8.4 for an illustration of the procedure and calculations) The same size of material, either Minus No. 4 or pass Minus No. 8, shall be used to determine the individual specific gravities and absorption for each of the different sources.

8.3.1 For each individual material in the composite, its contribution to the total percent of fine aggregate in the composite is determined and recorded to the nearest 0.01% as "IP":

$$IP = \frac{\left(\begin{array}{c}\text{Percent of Individual}\\ \text{Material in Composite}\end{array}\right) x \left(\begin{array}{c}\text{Percent of Fine Aggregate in}\\ \text{Individual Material}\end{array}\right)}{100}$$

Where: IP = Contribution by each individual material to the total percent of fine aggregate in the composite.

8.3.2 For each individual source, the percent of fine aggregate in the composite is determined by summing the values for "IP" for that source, and recording the total as "P".

8.3.3 The combined specific gravity is calculated by the following:

$$G = \frac{P1 + P2 + \ldots + Pn}{\frac{P1}{G1} + \frac{P2}{G2} + \ldots + \frac{Pn}{Gn}}$$

Where: P1, P2, ... Pn = For each individual source, the percent of fine aggregate in the composite, "P".

G1, G2, ... Gn = The fine specific gravity for each individual source.

8.3.4 The combined absorption is calculated by the following:

$$\text{Combined Absorption} = \frac{\left(\begin{array}{c}\text{Combined Bulk (SSD)}\\ \text{Specific Gravity}\end{array}\right) - \left(\begin{array}{c}\text{Combined Bulk (OD)}\\ \text{Specific Gravity}\end{array}\right)}{\left(\begin{array}{c}\text{Combined Bulk (OD)}\\ \text{Specific Gravity}\end{array}\right)}$$

8.4 The following is an example of the procedure and calculations described in Subsections 8.3.1 through 8.3.4 above. The example given is for a composite consisting of 26% coarse aggregate, 12% intermediate aggregate, and 47% fine aggregate from the primary source; with 15% aggregate from a secondary source. The coarse aggregate has 2% pass the No. 4 sieve, the intermediate aggregate has 6% pass the No. 4 sieve, the fine aggregate has 91% pass the No. 4 sieve, and the aggregate from the secondary source has 76% pass the No. 4 sieve.

Fine aggregate specific gravity and absorption for each of the different sources:

Primary Source (Coarse, Intermediate, Fine):

Bulk (OD) Specific Gravity = 2.576
Bulk (SSD) Specific Gravity = 2.611
Apparent Specific Gravity = 2.669
Absorption = 1.36%

Secondary Source:

Bulk (OD) Specific Gravity = 2.641
Bulk (SSD) Specific Gravity = 2.686
Apparent Specific Gravity = 2.764
Absorption = 1.70%

Determination of "IP" for individual materials, and "P" for individual sources:

Primary Source (Coarse, Intermediate, Fine):

$$\text{"IP" Coarse} = \frac{(26)\,x\,(2)}{100} = 0.52\%$$

$$\text{"IP" Intermediate} = \frac{(12)\,x\,(6)}{100} = 0.72\%$$

$$\text{"IP" Fine} = \frac{(47)\,x\,(91)}{100} = 42.77\%$$

"P" for the Primary Source = IP (Coarse) + IP (Intermediate) + IP (Fine)

= (0.52%) + (0.72%) + (42.77%) = 44.01%

Secondary Source:

$$\text{"IP" (Secondary Source)} = \frac{(15)\,x\,(76)}{100} = 11.40\%$$

"P" for Secondary Source = IP (Secondary Source) = 11.40%

Total fine aggregate in the composite = P(Primary Source) + P(Secondary Source)

$$= (44.01\%) + (11.40\%) = 55.41\%$$

$$\text{Combined Bulk (OD) Specific Gravity} = \frac{55.41}{\frac{44.01}{2.576} + \frac{11.40}{2.641}} = 2.589$$

$$\text{Combined Bulk (SSD) Specific Gravity} = \frac{55.41}{\frac{44.01}{2.611} + \frac{11.40}{2.686}} = 2.626$$

$$\text{Combined Apparent Specific Gravity} = \frac{55.41}{\frac{44.01}{2.669} + \frac{11.40}{2.764}} = 2.688$$

$$\text{Combined Absorption} = \frac{2.626 - 2.589}{2.589} \times 100 = 1.43\%$$

EXAMPLE OF CALCULATIONS FOR FINE SPECIFIC GRAVITY

Bulk Sp. Gr. (O.D. basis) = $\frac{A}{B + S - C}$ = $\frac{(\ 499.9\ )}{(\ 683.7\ ) + (\ 503.3\ ) - (\ 990.1\ )}$ = ***2.539*** / *2.538852*

Where:
- **A =** mass of oven-dry sample in air, g. **499.9**
- **B =** mass of pycnometer filled with water, g. **683.7**
- **C =** mass of pycnometer with sample and water to calibration mark, g. **990.1**
- **S =** mass of saturated-surface-dry sample, g. **503.3**

Bulk Sp. Gr. (SSD basis) = $\frac{S}{B + S - C}$ = $\frac{(\ 503.3\ )}{(\ 683.7\ ) + (\ 503.3\ ) - (\ 990.1\ )}$ = ***2.556*** / *2.556120*

Apparent Sp. ($\frac{A}{B + A - C}$ = $\frac{(\ 499.9\ )}{(\ 683.7\ ) + (\ 499.9\ ) - (\ 990.1\ )}$ = ***2.583*** / *2.583463*

Absorption, percent = $\frac{S - A}{A} \times 100$ = $\frac{(\ 503.3\ ) - (\ 499.9\ )}{(\ 499.9\ )}$ x 100 = ***0.68*** % / *0.680136*

FIGURE 3

PERCENTAGE OF FRACTURED COARSE AGGREGATE PARTICLES

(An Arizona Method)

1. SCOPE

1.1 This test method describes the procedure for determining the percentage of fractured particles in coarse aggregate. This test procedure is performed on plus No. 8 and larger material, unless otherwise specified.

1.2 When this test procedure is referenced for the determination of "crushed faces", such as in specifications or other test procedures, it shall be understood to be the determination of "fractured coarse aggregate particles".

1.3 A fractured face is defined as an angular, broken surface of an aggregate particle created by crushing, by other artificial means, or by nature. A face is only considered fractured if it has sharp and well defined edges and the projected area of the fractured face is at least 25 percent of the maximum projected area of the aggregate particle visible considering the particle's outline at all possible orientations of the aggregate particle.

1.4 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.5 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 1 gram.

2.3 A magnifying glass, preferably mounted on a stand and with a built-in light.

2.4 Sieves conforming to ASTM E11, of sizes necessary for the material being tested.

2.5 Miscellaneous pans, containers, spatulas, etc.

3. SAMPLE PREPARATION

3.1 A representative sample of the aggregate shall be obtained. The coarse aggregate test sample shall be proportionate for the gradation of the material being tested. The size of the test sample shall be such that it contains a minimum of 500 particles. It is not expected that an actual count of the number of particles be made to assure compliance with this requirement. It is required, however, that a reasonably accurate estimate be made to determine that the test sample contains at least 500 particles. Fractured face determination must be made on all particles in the test sample.

4. PROCEDURE

4.1 Weigh the test sample, and record the weight to the nearest gram as "Wa". To facilitate the inspection of the particles, the test sample may be washed and dried to constant weight prior to determining the test sample weight.

4.2 Spread the test sample onto a flat surface, and observe the aggregate particles under the magnifying glass with adequate light.

4.3 If not otherwise specified, separate aggregate particles having at least one fractured face from those that are unfractured. If specifications require that a percentage of the aggregate particles having at least two fractured faces be determined, separate aggregate particles having at least two fractured faces from those that have less than two fractured faces. A spatula or other blade-like tool may be helpful in separating particles.

4.4 Weigh the portion of fractured particles, and record the weight to the nearest gram. If aggregate particles with at least one fractured face have been

determined, record the weight as "Wf". If aggregate particles with at least two fractured faces have been determined, record the weight as "W2".

5. CALCULATIONS

5.1 If aggregate particles with at least one fractured face have been determined, calculate the percentage of fractured particles, "FF", and record to the nearest percent as shown below:

$$FF = \frac{W_f}{W_a} x\,100$$

Where: FF = Percentage of fractured particles with at least one fractured face.
W_f = Weight of fractured particles with at least one fractured face.
W_a = Weight of test sample.

5.2 If aggregate particles with at least two fractured faces have been determined, calculate the percentage of fractured particles, "FF2", and record to the nearest percent as shown below:

$$FF_2 = \frac{W_2}{W_a} x\,100$$

Where: FF_2 = Percentage of fractured particles with at least two fractured faces.
W_2 = Weight of fractured particles with at least two fractured faces.
W_a = Weight of test sample.

DETERMINATION OF CEMENTITIOUS MATERIAL CONTENT FOR CEMENTITIOUSLY TREATED MIXTURES

1. SCOPE

1.1 This procedure is used to determine the cementitious material content of a cement treated mixture.

1.2 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 4 inch proctor mold having a capacity of approximately 1/30 cubic foot, with an internal diameter of 4.000 plus 0.024 or minus 0.016 inches and a height of 4.584 plus 0.005 or minus 0.008 inches. The mold shall have a nominal wall thickness of 1/4 inch. It shall be equipped with an extension collar approximately 2-3/8 inches high.

2.3 A hand or mechanical rammer weighing 5.50 $\pm$ 0.02 pounds, having a flat face, and equipped with a suitable arrangement to control the height of drop to a free fall of 12 $\pm$ 0.06 (1/16) inches above the elevation of the soil. The rammer face shall be circular with a diameter of 2.000 plus 0.010 or minus 0.015 inches.

2.4 Hardened-steel straightedge, at least 10 inches in length. It shall have one beveled edge, and at least one longitudinal surface (used for final trimming) shall be plane within 0.01 inch per 10 inches (0.1 percent) of length with the portion used for trimming the soil.

2.5 A circular sample follower with a diameter slightly less than the inner diameter of the proctor mold to aid in the removal of the mold collar.

2.6 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least 0.1 g.

2.7 Oven capable of maintaining a temperature of 230 ± 9 °F

2.8 Sieves of sizes as required for screening conforming to the requirements of ASTM E11.

2.9 Miscellaneous mixing tools and pans.

2.10 Equipment as required for ARIZ 241, "Compressive Strength of Molded Cement Treated Base or Soil-Cement Specimens".

2.11 Non-absorptive glass or plexiglass plates larger than the diameter of the 4 inch proctor mold.

3. SAMPLE

3.1 Approximately 75 kg of material will be required. The amount required for the sieve analysis will be as determined in ARIZ 201, approximately 20000 g will be required for the optimum moisture determination, and approximately 40000 g will be required to develop the five separate 7500 g test samples.

3.2 If the sample is damp when received, it shall be dried until it becomes friable under a trowel. Drying may be accomplished by air drying or by the use of a drying apparatus such that the temperature of the sample does not exceed 140 °F. Prepare the sample for testing by separating the Plus No. 4 Material and breaking up the remaining soil aggregations to pass the No. 4 sieve in such a manner to avoid reducing the natural size of individual particles.

3.3 Select and prepare five separate test samples of approximately 7500 g and one 20000 g sample for optimum moisture content determination, corresponding to the sieve analysis of the total sample, in accordance with the following procedure.

Determine the gradation of the sample in accordance with ARIZ 201. For samples containing Plus 3/4 Inch Material, the material retained on the 1/2 inch, 3/8 inch, 1/4 inch, and No. 4 sieves shall be stored separately. Aggregate retained on the 3/4 inch sieve shall not be used, but its percentage shall be distributed proportionately among the aforementioned sieves.

NOTE: No change is made in the Percent Pass No.4 Material. See Subsection 3.3 of ARIZ 221 for further information regarding the proportional redistribution of the Plus 3/4 Inch Material.

3.4 Determine the optimum moisture content of the 20000 g sample in accordance with ARIZ 221 with the anticipated required cement content included in the material during the performance of the procedure.

3.5 The moisture content to be added to each of the five 7500 g test samples prior to compaction is the optimum moisture content obtained in Subsection 3.4.

3.6 Add the first of the cement contents to be used, to the first sample, and mix together thoroughly.

4. COMPACTION

4.1 Form a specimen by compacting the prepared mixture in the four inch mold (with the extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

4.2 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the wet density, "WD", of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb)}}$$

Where:
WD = Wet density of compacted soil, lb./cu. ft.
M1 = Weight of compacted specimen and mold, grams
M2 = Weight of the mold, grams

VM = Volume of the mold, cu. ft., determined in accordance with ARIZ 225, Appendix A

4.3 Compact the other two specimens from the first sample, at the same cementitious material contents, in the same manner as Subsection 4.1.

4.4 Extrude all three specimens from their respective molds, place on glass or plexiglass plates, and store for curing in a moist condition.

4.5 Determine the moisture content of the specimens from the left over material from the first sample in accordance with AASHTO T 265, "Laboratory Determination of Moisture Content of Soils". Calculate percent moisture and record to the nearest 0.1 percent by the following:

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

Where: WW = Weight of wet soil, grams
DW = Weight of dry soil, grams

4.6 Calculate the dry density and record to the nearest 0.1 lb./cu. ft. by the following:

$$DD = \frac{WD}{\% \text{ Moisture} \times 100} \times 100$$

Where: DD = Dry density of compacted soil, lb./cu. ft.
WD = Wet density of compacted soil, lb./cu. ft.

4.7 Repeat the procedures in Subsections 4.1 to 4.6 to the additional samples with increased cementitious material contents of 2% increments, until a complete bracketing of the specification requirements is met.

5. PROCEDURE

5.1 All specimens must be cured in a moist condition for six days and then immersed for a period of 24 hours in saturated lime water at 65 to 80 °F for 24 hours.

5.2 Specimens shall then be prepared and tested for compressive strength in accordance with ARIZ 241.

6. REPORT

6.1 Report the cylinder number, dry density, cementitious material content, moisture content, and 7-day compressive strength of all specimens tested, and the average 7-day compressive strength for the specimens tested at each of the cementitious material contents.

6.2 Following is an example of testing information obtained and how the information would be compared to the Special Provisions of a project for the purpose of determining the appropriate cementitious material content:

Assume the test information as shown in the following table was obtained:

RESULTS OF CEMENTITIOUSLY TREATED SPECIMENS PREPARED AT OPTIMUM MOISTURE CONTENT

Cylinder Number	Density (lbs./cu. ft.)	Cementitious Material Content	Moisture Content	7-Day Strength (PSI)	Average 7-Day Strength (PSI)
1	117	2	9.4	131	
2	117	2	9.5	135	133
3	118	4	9.5	235	
4	118	4	9.6	247	241
5	119	6	9.3	412	
6	119	6	9.5	394	403
7	120	8	9.5	613	
8	120	8	9.4	605	609

If the Special Provisions required that Cement Treated Base shall have a compressive strength between 300 and 500 pounds per square inch at seven days, this test information would indicate that in order to meet this requirement, six percent cementitious material by total weight should be used.

MOISTURE-DENSITY RELATIONS OF CEMENTITIOUSLY TREATED MIXTURES

1. SCOPE

1.1 This method covers procedures for determining the relationship between moisture content and the density of cement treated mixtures when compacted at varying hydration curing times dependent on and consistent with construction operation procedures.

1.2 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 4 inch proctor mold having a capacity of approximately 1/30 cubic foot, with an internal diameter of 4.000 plus 0.024 or minus 0.016 inches and a height of 4.584 plus 0.005 or minus 0.008 inches. The mold shall have a nominal wall thickness of 1/4 inch. It shall be equipped with an extension collar approximately 2-3/8 inches high.

2.3 A hand or mechanical rammer weighing 5.50 $\pm$ 0.02 pounds, having a flat face, and equipped with a suitable arrangement to control the height of drop to a free fall of 12 $\pm$ 0.06 (1/16) inches above the elevation of the soil. The rammer face shall be circular with a diameter of 2.000 plus 0.010 or minus 0.015 inches.

2.4 Hardened-steel straightedge, at least 10 inches in length. It shall have one beveled edge, and at least one longitudinal surface (used for final trimming) shall be plane within 0.01 inch per 10 inches (0.1 percent) of length with the portion used for trimming the soil.

2.5 A circular sample follower with a diameter slightly less than the inner diameter of the proctor mold to aid in the removal of the mold collar.

2.6 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least 0.1 g.

2.7 Oven capable of maintaining a temperature of 230 ± 9 °F.

2.8 Sieves of sizes as required for screening conforming to the requirements of ASTM E11.

2.9 Miscellaneous mixing tools and pans.

3. SAMPLE PREPARATION

3.1 If the sample is damp when received, it shall be dried until it becomes friable under a trowel. Drying may be accomplished by air drying or by the use of a drying apparatus such that the temperature of the sample does not exceed 140 °F. Prepare the sample for testing by separating the Plus No. 4 Material and breaking up the remaining soil aggregations to pass the No. 4 sieve in such a manner as to avoid reducing the natural size of individual particles.

3.2 Select and prepare five separate 2500 g test samples, corresponding to the sieve analysis of the total sample, in accordance with the following procedure.

3.3 Determine the gradation of the sample in accordance with ARIZ 201. For samples containing Plus 3/4 Inch Material, the material retained on the 1/2 inch, 3/8 inch, 1/4 inch, and No. 4 sieves shall be stored separately. Aggregate retained on the 3/4 inch sieve shall not be used, but its percentage shall be distributed proportionately among the aforementioned sieves.

3.4 Determine a Percent Retained Factor for calculating the Adjusted Percent Retained by the following:

$$\% \text{ Retained Factor} = \frac{\text{Total Retained on 3/4” Sieve}}{\text{Cumulative \% Retained on 1/2”, 3/8”, 1/4”, and No. 4 Sieves}}$$

Record the Percent Retained Factor to at least four decimal places.

3.5 Calculate the Adjusted Percent Retained for the 1/2 inch, 3/8 inch, 1/4 inch and No. 4 sieves by the following:

Adjusted Percent Retained = (% Retained x % Retained Factor) + % Retained

Record the adjusted percent retained for each sieve to the nearest hundredth.

3.6 The sum of the new Adjusted Percent Retained values should total 100% when rounded.

3.7 Multiply each of the newly Adjusted Percent Retained values by 2500, then divide by 100, to obtain the quantity of material for each sieve size that should be combined to create each sample.

NOTE: Due to rounding in the procedure, the sample may not equal exactly 2500 g.

3.8 An example of a coarse sieve analysis which requires adjusting to prepare test samples of 2500 g is shown in Table 1.

TABLE 1

Sieve Size	% Retained	Rounded Adjusted % Retained	Weight in g (2500 g sample)	Accumulative Total
2”	0			
2-1/2”	0			
1”	8			
3/4”	4			
1/2”	4	7.20	180	180
3/8”	1	1.80	45	225
1/4"	5	9.00	225	450
#4	5	9.00	225	675
Pass #4	73	73.00	1825	2500
Total	100	100	2500	

4. COMPACTION

4.1 Add to the prepared samples the required amount of cementitious material as determined in ARIZ 220, “Cement Content Required for Cement Treated Mixtures.” If this has not yet been determined, an estimate shall be made and

this amount added. Mix thoroughly to a uniform color. Add sufficient water to dampen the mixture to approximately four to six percentage points below the estimated optimum moisture content, and mix thoroughly. Cover and allow to cure for 5 minutes to aid dispersion of the moisture.

4.2 Form a specimen by compacting the prepared mixture in the four inch mold (with the extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

4.3 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted specimen even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the wet density, “WD”, of the compacted specimen by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb)}}$$

Where:
- WD = Wet density of compacted specimen, lb./cu. ft.
- M1 = Weight of compacted specimen and mold, grams
- M2 = Weight of the mold, grams
- VM = Volume of the mold, cu. ft., determined in accordance with ARIZ 225, Appendix A

4.4 Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Weigh immediately, and dry to a constant weight in an oven at $230 \pm 9\ ^{\circ}F$ to determine the moisture content in accordance with AASHTO T 265. Record the weight of wet soil to the nearest 0.1 gram as "WW", and record the weight of oven dry soil to the nearest 0.1 gram as "DW". Calculate percent moisture and record to the nearest 0.1 percent by the following:

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

Where: WW = Weight of wet soil, grams
DW = Weight of dry soil, grams

4.5 Calculate the dry density and record to the nearest 0.1 lb./cu. ft. by the following:

$$DD = \frac{WD}{\% \text{ Moisture} \times 100} \times 100$$

Where: DD = Dry density of compacted soil, lb./cu. ft.
WD = Wet density of compacted soil, lb./cu. ft.

Repeat the procedure in Subsections 4.1 through 4.5 for the sample, increasing the moisture content for each specimen by approximately two percentage points, as necessary to establish a moisture-density curve which rises to a peak and then falls away.

4.6 Maximum density and optimum moisture content shall be determined as described in Subsections 7.1 through 7.4 of ARIZ 225.

Repeat the procedures in Subsections 4.1 through 4.6 on samples allowed to cure prior to compaction for the following curing time periods: 5 minutes, 30 minutes, and 60 minutes. (It will not be necessary to make a four-hour determination for all mixtures. This need should be established on an individual basis.) These separate determinations shall be used for developing a family of curves for use for compaction control with each curve designated according to its respective curing time. If it is determined that the delay in compaction time (i.e., the curing time between incorporation of the cement and compaction) will not vary throughout the project construction schedule, then the number of delayed compaction curves can be limited to only those applicable without running the complete family.

ROCK CORRECTION PROCEDURE FOR MAXIMUM DENSITY DETERMINATION OF CEMENT TREATED MIXTURES

(An Arizona Method)

Scope

1. This method is to be used to determine the maximum density of the total sample of cement treated mixture for which the percentage of material retained on the No. 4 sieve has been determined as well as the maximum dry density of the passing No. 4 fraction and the bulk specific gravity of the plus No. 4 fraction. This test procedure is basically the same as ARIZ 227, Rock Correction Procedure for Maximum Density Determination, except for the addition of the concept of delay compaction time.

Procedure

2. The test is made in the following manner:

(a) Determine the maximum dry density of the material passing the No. 4 sieve by means of ARIZ 221, consistent with the desired curing time.

(b) Determine the percentage of rock (larger than the No. 4 sieve) in the total sample.

(c) Determine the bulk specific gravity of the rock in accordance with AASHTO T 85, on an oven-dried basis.

NOTE: *Once determined for a source, the specific gravity may usually be used for all rock corrections on material from that source. Any slight change in specific gravity should not change the maximum density to a large extent. (A change of ± 0.02 could result in a change of ± 0.6 lb. per cubic foot.) Similarly, the maximum dry density of the passing No. 4 material having been determined by Method A for a source may usually be used for that source providing the screen analysis of the passing No. 4 material and the Plasticity Index remain reasonably uniform.*

(d) Determine the maximum dry density of the total sample by use of the formula (e) or by use of the nomograph (f).

(e) Determination of density by use of formula:

$$D = \frac{(100 - R)\, d + (0.9\, RS \times 62.4)}{100}$$

$$= \frac{(100 - R)\, d + 56.2\, RS}{100}$$

Where:

D = Dry density of total sample containing R percent rock, lbs/cu. ft. (Varies according to curing time required.)

R = Percent of rock retained on No. 4 sieve.

d = Dry density of material passing No. 4 sieve, lbs./cu. ft.

S = Specific Gravity of rock.

Example:

R = 29% rock

d = 110.0 lbs. per cu. ft. (2 hour curing time.)

S = 2.50

$$D = \frac{(100 - 29)\ 110.0 + (56.2 \times 29 \times 2.50)}{100}$$

$$D = \frac{(71 \times 110.0) + 4074}{100}$$

$$D = \frac{7810 + 4074}{100} = 118.8 \text{ lbs. per cu. ft.}$$

D = 118.8 lbs. per cubic foot = Maximum density of total sample containing 29% rock retained on No. 4 sieve, with 2 hours allowed for sample to cure.

(f) Determination of density by use of nomograph: Use the nomograph shown in Fig. 1 following the instructions given. Data from the example above has been used to show methods for nomograph solutions.

Limitation of Method

3. The rock correction procedure is not accurate when the rock content (retained on No. 4 sieve) is in excess of 50% (or 60% in the case of uniformly graded rock which consists of 100% passing the 1 inch sieve), or when the material contains rock which will not pass a 3-inch sieve. If any of these conditions are present, the test should not be completed; however, the report should state that the test cannot be made due to excess rock, or large rock, and the sieve analysis reported to verify this. This limitation shall apply except for the case stated in Section 4.

Volcanic Cinders or Light Porous Material

4. The rock correction procedure is not accurate when the rock in the material consists of volcanic cinders or light weight porous material on which the specific gravity determination cannot be accurately made; for these materials, Methods C or D (ARIZ 226) shall be used.

Use of Results

5. The maximum density obtained by this method shall be used in comparison with the determination of the field density to determine the percentage of compaction.

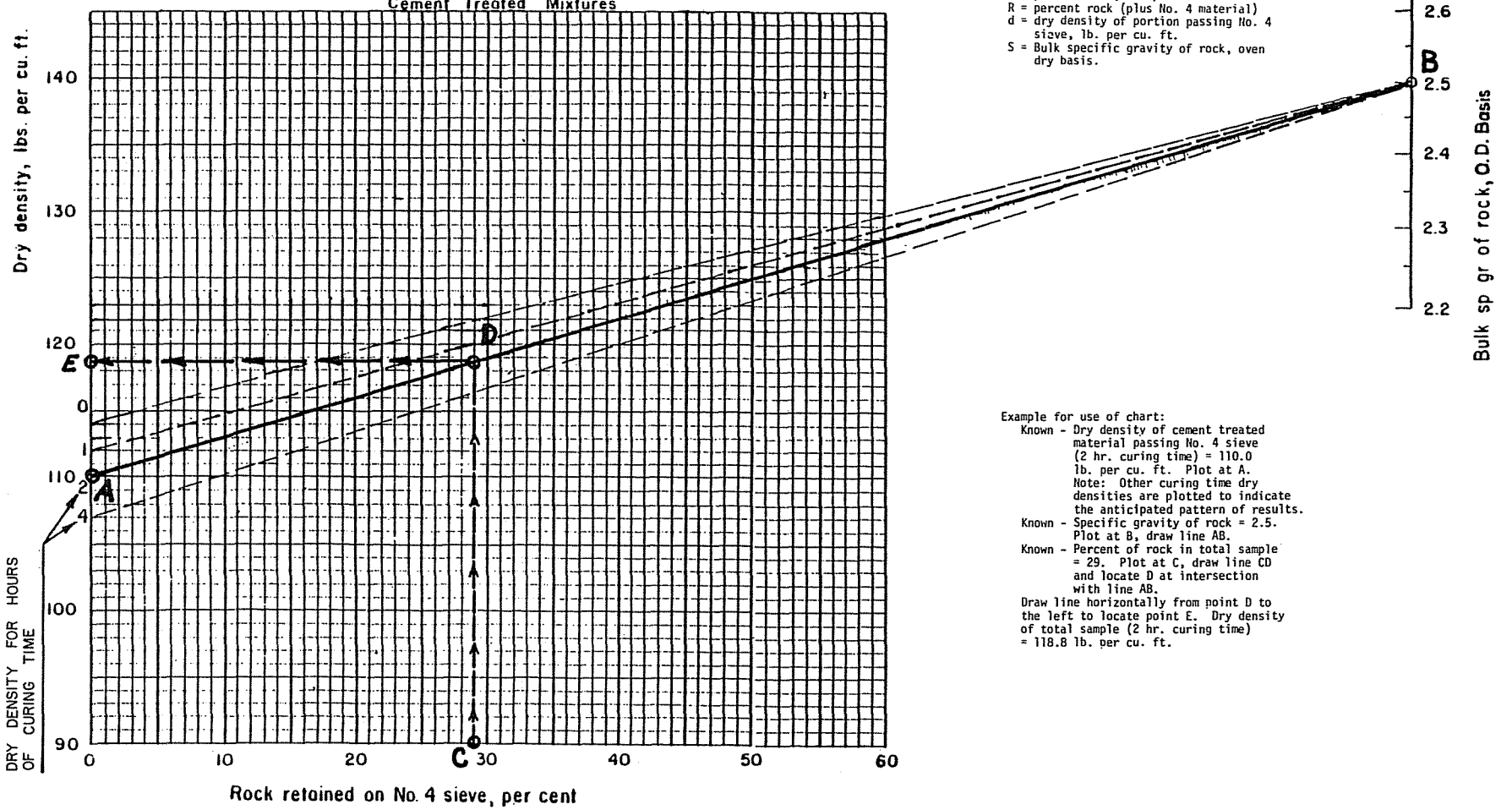
ARIZONA DEPARTMENT OF TRANSPORTATION

MATERIALS SECTION

Rock Correction Procedure for Maximum Density Determination of Cement Treated Mixtures

$$D = \frac{(100-R)d + (56.2\,RS)}{100}$$

Where:
D = dry density of sample containing "R" percent rock, lb. per cu. ft.
R = percent rock (plus No. 4 material)
d = dry density of portion passing No. 4 sieve, lb. per cu. ft.
S = Bulk specific gravity of rock, oven dry basis.



Example for use of chart:
Known - Dry density of cement treated material passing No. 4 sieve (2 hr. curing time) = 110.0 lb. per cu. ft. Plot at A.
Note: Other curing time dry densities are plotted to indicate the anticipated pattern of results.
Known - Specific gravity of rock = 2.5. Plot at B, draw line AB.
Known - Percent of rock in total sample = 29. Plot at C, draw line CD and locate D at intersection with line AB.
Draw line horizontally from point D to the left to locate point E. Dry density of total sample (2 hr. curing time) = 118.8 lb. per cu. ft.

Figure 1.

FIELD DENSITY OF CEMENT TREATED MIXTURES BY SAND CONE METHOD OR BY RUBBER BALLOON METHOD

Scope

1. These methods are used to determine the in-place density of cement treated mixtures by determining the weight and moisture content of material removed from a test hole and subsequent measure of the test hole volume by either the Rubber Balloon Method (ARIZ 231) or the Sand Cone Method (ARIZ 230). Tests ARIZ 230 or 231 should be followed except for the differences outlined under **Procedures** below.

Procedures

1. Determine the time elapsed between the incorporation of cement and water to the mixture and the completion of compaction. This information is needed to refer to the proper Rock Correction Delayed **Curing** line (ARIZ 222).

2. If the rock content is greater than 50% (or 60% in the case of materials which are to consist of 100% passing the 1-inch sieve) report the sieve analysis with a note stating that the density is not determinable due to excess rock.

3. If any rock is retained on the 3-inch sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating that the density is not determinable due to the presence of rock retained on the 3-inch sieve.

MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE OF SOILS BY PROCTOR METHOD A

(A Modification of AASHTO Designation T 99)

1. SCOPE

1.1 This test method describes the procedure for determining the maximum dry density and optimum moisture content for a soil by the Proctor Method A. Some materials may be more appropriately tested by Arizona Test Method 245, "Maximum Dry Density and Optimum Moisture of Soils by Proctor Alternate Method D ".

1.2 Method A may be used for all maximum dry density and optimum moisture content determinations except for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is greater than 4.0%.

1.3 Method A may be used except when greater than 50% (60% for Aggregate Base) of the material is retained on the No. 4 sieve.

1.4 An example is provided in Figure 2 for the calculations and determinations referenced herein.

1.5 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.6 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 4 inch proctor mold having a capacity of approximately 1/30 cubic foot, with an internal diameter of 4.000 plus 0.024 or minus 0.016 inches and a height of 4.584 plus 0.005 or minus 0.008 inches. The mold shall have a nominal wall thickness of 1/4 inch. It shall be equipped with an extension collar approximately 2-3/8 inches high. A baseplate as shown in Figure 1 shall be provided.

2.3 A hand or mechanical rammer weighing 5.50 $\pm$ 0.02 pounds, having a flat face, and equipped with a suitable arrangement to control the height of drop to a free fall of 12 $\pm$ 0.06 (1/16) inches above the elevation of the soil. The rammer face shall be circular with a diameter of 2.000 plus 0.010 or minus 0.015 inches. If a mechanical apparatus is used, it must be monitored through the ADOT proficiency sample program and maintain a rating of 3 or better based on the results of testing ADOT and AMRL proficiency samples.

2.4 Hardened-steel straightedge, at least 10 inches in length. It shall have one beveled edge, and at least one longitudinal surface (used for final trimming) shall be plane within 0.01 inch per 10 inches (0.1 percent) of length with the portion used for trimming the soil.

2.5 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least one gram.

2.6 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least 0.1 gram.

2.7 Oven capable of maintaining a temperature of 230 $\pm$ 9 °F.

2.8 No. 4 and 3 inch sieves conforming to the requirements of ASTM E11.

2.9 Miscellaneous mixing tools and pans.

2.10 Sample Extruder (optional) consisting of a jack, lever, frame, or other device for extruding the compacted sample from the mold.

3. CALIBRATION OF MOLD

3.1 Molds shall be calibrated in accordance with APPENDIX A of this procedure.

4. SAMPLE

4.1 Enough soil material shall be provided from the field to make five compacted specimens. A minimum sample size of 20,000 grams (approximately 45 lbs.) is normally required.

4.2 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air or by use of a slow fan or other drying apparatus such that the temperature of the sample does not exceed 140 °F.

4.3 Thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

4.4 Weigh out an approximate 20,000 gram sample of representative soil. Record the weight of the sample, and sieve the material over a No. 4 sieve. If the percentage of coarse aggregate or rock retained on the No. 4 sieve is not already known from gradation testing, save any material retained on the No. 4 sieve and weigh. Calculate the percent of coarse aggregate or rock particles retained on the No. 4 sieve according to the following equation:

$$PR4 = \frac{WR4}{WT} \times 100$$

Where:
- PR4 = Percentage of coarse aggregate or rock particles retained on the No. 4 sieve
- WR4 = Weight of coarse aggregate or rock particles retained on the No. 4 sieve
- WT = Total weight of material sieved

4.5 If "PR4" is greater than 50% (60% for Aggregate Base), Alternate Method D, Arizona Test Method 245, shall be used to determine the maximum dry density. If "PR4" is less than or equal to 50% (60% for Aggregate Base), blend material passing the No. 4 sieve thoroughly and proceed to Section 5 of this test method. If a specific gravity and absorption determination, in accordance with AASHTO T 85, is to be made for the plus No. 4 material, save an adequate amount of this material, otherwise, discard it.

5. PROCEDURE

5.1 From the thoroughly blended passing No. 4 material from Subsection 4.5, split out 5 representative approximate 2500 gram samples.

5.2 Select one sample and thoroughly mix with sufficient water to dampen it to approximately three percentage points below optimum moisture content.

Note: If desired, an additional three samples may be mixed at this time with approximate moisture contents of 1% below optimum, 1% over optimum, and 3% over optimum. The moisture in each of these samples shall be retained by covering with a damp cloth or being sealed in air tight containers until they are compacted. One of the five samples should be retained for future use since it is necessary to have at least two points defined on each side of the moisture-density curve.

5.3 Heavy clay soils or materials which tend to break down, or those in which it is difficult to incorporate water, shall require approximately 12 hours for uniform moisture absorption to be achieved. This shall be accomplished by preparing separate samples for each increment of water to be added, and then placing and sealing these samples in air tight containers for the 12-hour period.

5.4 Form a specimen by compacting the prepared soil in the four inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

Note: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

5.5 When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and baseplate.

5.6 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, "WD", of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}}$$

Where:
- WD = Wet density of compacted soil, lb./cu. ft.
- M1 = Weight of compacted specimen and mold, grams
- M2 = Weight of the mold, grams
- VM = Volume of the mold, cu. ft. (See Section 3 of this procedure.)

5.7 The estimated dry density, "ED", of the compacted soil may be calculated and recorded to the nearest 0.1 lb./cu. ft. as follows:

$$ED = \frac{WD}{(\text{Approx. \% of water added}) + 100} \times 100$$

Where:
- ED = Estimated dry density of compacted soil, lb./cu. ft.
- WD = Wet density of compacted soil, lb./cu. ft.

Note: These estimated densities are approximate only and will be corrected when final moisture results are obtained.

5.8 The estimated dry density is useful in deciding how much water to add in later trial batches, if the procedure described in the note following Subsection 5.2, for initially preparing three additional samples with varying moisture contents is not utilized. By carefully observing the estimated dry density of the compacted samples, the operator should be able to vary the moisture content as the test proceeds so that when the final moisture-density results are plotted, a curve will result that rises to a peak and then falls away.

5.9 Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Weigh immediately, and dry to a constant weight in an oven at 230 ± 9 °F to determine the moisture content in accordance with AASHTO T 265. Record the weight of wet soil to the nearest 0.1 gram as "WW", and record the weight of oven dry soil to the nearest 0.1 gram as "DW".

5.10 For granular, free-draining materials, the moisture content shall be determined using the entire compacted proctor specimen. Determine the weight of wet soil, "WW", by subtracting the weight of the mold, "M2", from the weight of compacted specimen and mold, "M1". Record the weight of wet soil, "WW", and the weight of oven dry soil, "DW", to at least the nearest gram. All clinging material shall be removed from the inside of the mold and included with the specimen. To facilitate drying, the specimen may be broken up and spread out in a large pan, being careful to not lose any soil particles.

5.11 Select another of the samples which was split in Subsection 5.1, and if not already done, thoroughly mix with water in sufficient amount to increase the moisture content by approximately two percentage points.

5.12 Repeat the procedure in Subsections 5.3 through 5.10 for the sample at each moisture content, as necessary to establish a moisture-density curve which rises to a peak and then falls away.

6. CALCULATIONS

6.1 Calculate percent moisture and record to the nearest 0.1 percent by the following:

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

Where: WW = weight of wet soil, grams
DW = weight of oven dry soil, grams

6.2 Calculate dry density and record to the nearest 0.1 lb./cu. ft. by the following:

$$DD = \frac{WD}{\%\ Moisture + 100} \times 100$$

Where: DD = Dry density of compacted soil, lb./cu. ft.
WD = Wet density of compacted soil, lb./cu. ft.

7. MOISTURE-DENSITY RELATIONSHIP

7.1 The percent moisture and corresponding dry density for each of the compacted soil specimens shall be plotted on the graph provided on the proctor density test form shown in Figure 3. For a good plot, the majority of the graph is utilized. Normally, three increments on the horizontal axis shall equal one percent of moisture, and three increments on the vertical axis shall equal one lb./cu. ft. of dry density. If another number of increments other than three is utilized, the number of increments for one percent moisture and one lb./cu. ft. dry density shall always be the same.

7.2 On each side of the maximum density curve, at least two points should be utilized to form two straight lines. The intersection point of these two lines defines the peak point of the density-moisture content relationship, or the maximum density and optimum moisture content for the soil. In general it will be found that higher unit mass soils assume steeper slopes with high maximum dry densities at low optimum moisture contents, while the lower unit mass soils assume flatter, more gently sloped lines with high optimum moisture contents and low maximum dry densities. Figure 4 gives examples of moisture-density plots which show the different slopes associated with different maximum dry density ranges.

7.3 Optimum moisture content - The percent moisture content corresponding to the peak (intersection point of the two lines) of the moisture-density curve shall be termed the "optimum moisture content", and shall be reported as "OM" to the nearest 0.1 percent.

7.4 Maximum dry density - The dry density at optimum moisture content corresponding to the peak (intersection point of the two lines) of the moisture-density curve shall be termed the "maximum dry density", and shall be reported as "MD" to the nearest 0.1 lb./cu. ft.

Note: The optimum moisture and maximum dry density determinations above are for the material passing the No. 4 sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

8. REPORT

8.1 Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required. A blank laboratory test form is provided in Figure 3.

APPENDIX A

CALIBRATION OF PROCTOR MOLDS

1. CALIBRATION

1.1 Molds shall be calibrated at least once a year, or sooner if there is reason to question the accuracy of the calibration.

1.2 Lightly coat the bottom of the mold with a waterproofing grease. (Dow Corning High Vacuum Grease, or similar, has proven satisfactory for this application.) For split molds, waterproofing grease is also necessary on the edges of the split mold halves which join together.

1.3 Fit mold into baseplate and secure snugly into place.

1.4 Wipe excess grease from the mold and the baseplate.

1.5 Record weight of baseplate, empty mold, and glass plate to at least the nearest 0.1 gram.

Note: An example which illustrates the recording of calibration data and calculations is shown in Figure 5. Figure 6 is a blank calibration form.

1.6 With the mold and baseplate assembly on a flat and level surface fill the mold with distilled water at room temperature 77 ± 9 °F.

1.7 Determine and record the temperature of the water to the nearest one degree Fahrenheit.

1.8 With a small rod, remove any air bubbles that may be clinging to the sides or bottom of the mold. Add additional water to completely fill the mold, using a glass plate in such a way to ensure accurate filling of the mold, eliminating air bubbles and excess water. Check bottom of mold to assure there is no leakage.

1.9 Dry the base plate, glass and outside of mold with a dry, absorbent cloth. Care must be taken to not lose water from inside of mold during drying. Record weight of baseplate, mold filled with water, and glass plate to at least the nearest 0.1 gram.

APPENDIX A - (Continued)

1.10 Determine the weight of water to fill mold by subtracting the weight of baseplate, empty mold, and glass plate from the weight of the baseplate, mold filled with water, and glass plate.

1.11 For the temperature of the water, determine its corresponding unit weight from the table below.

Temperature	**Unit Weight of Water**
Temp °F	**lbs/cu. Ft.**
68	62.315
69	62.308
70	62.301
71	62.293
72	62.285
73	62.277
74	62.269
75	62.261
76	62.252
77	62.243
78	62.234
79	62.225
80	62.216
81	62.206
82	62.196
83	62.186
84	62.176
85	62.166
86	62.155

1.12 Calculate the volume of the mold, in cu. ft., as shown on the calibration form in Figures 5 and 6, and record to the nearest four decimal places.

1.13 Thoroughly clean grease from the mold and base plate. On the mold, record the identification of the mold, the date of calibration, and the volume of the mold.

1.14 Documentation of the calibration data shall be kept on file.

2. REQUIRED DOCUMENTATION

2.1 Record of weights, temperatures, and calculations required in the calibration procedure.

2.2 Identification of mold.

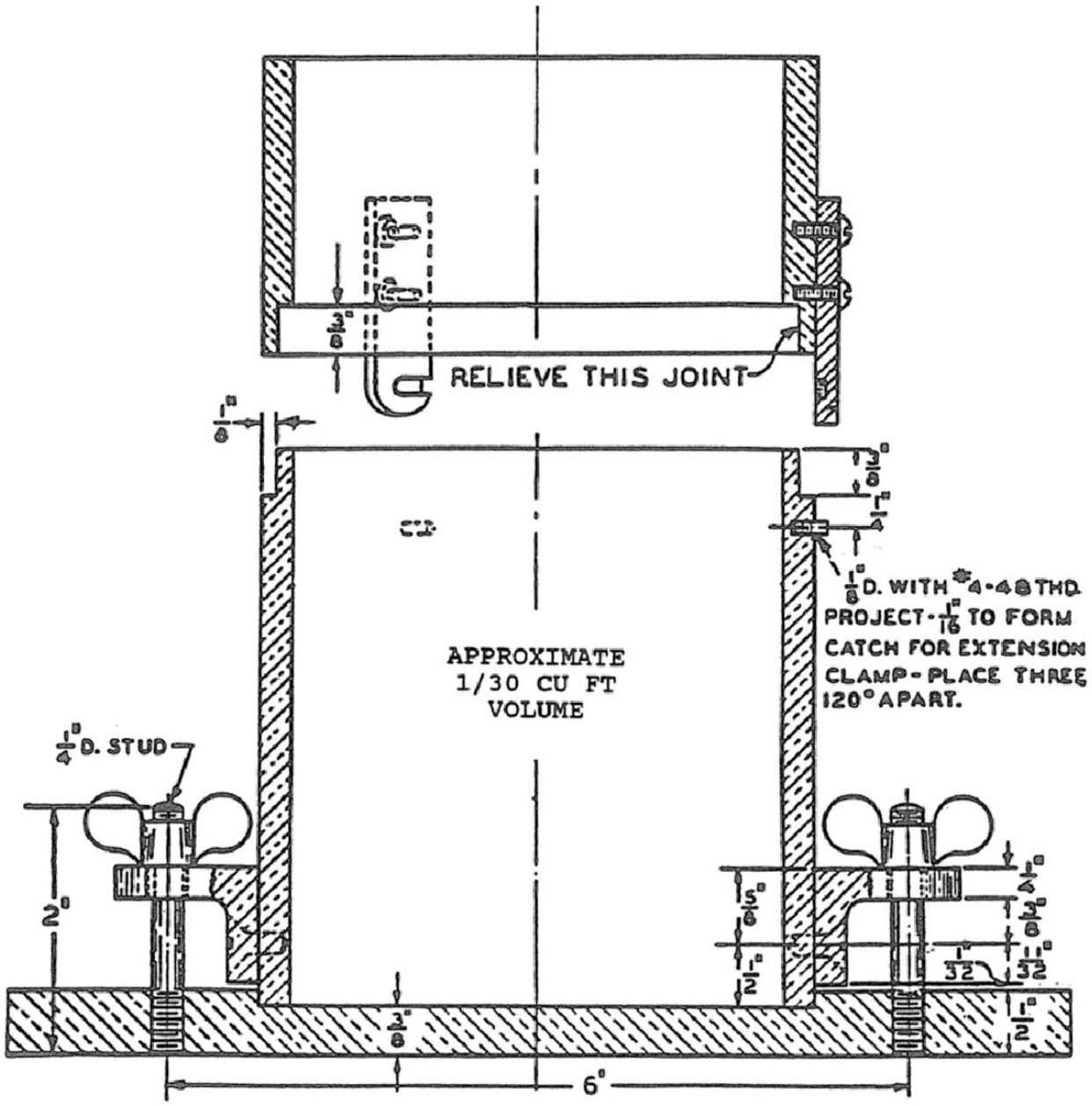
2.3 Date of calibration.

2.4 Volume of the mold.

2.5 Operator performing calibration.

2.6 Supervisor check of calibration data.

2.7 Date of calibration expiration.



CYLINDRICAL MOLD, COLLAR,
AND BASEPLATE
(4 INCH MOLD)

FIGURE 1

Arizona Department of Transportation
METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY
(Arizona Test Method 225 or 245)

TRACS No: H999901C Lab No : Rec'd Date: 08/15/2015
Source and Type of Material :
Proctor Method Used : **Method A** ✓ or **Alternate Method D**
Test Operator and Date : Supervisor and Date:

Weight of Mold = **M2** = 1970 grams | Volume of Mold = **VM** = 0.0336 cu. ft. | **a** = VM x 453.6 = 15.2410

b	M1	c	WD	ED	Moisture Determination WW	DW	d	e	DD
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample M1 - M2	Wet Density lb/ cu ft c / a	Est. Dry Density WD x 100 / b + 100	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water WW - DW	Percent Moisture d x 100 / DW	Dry Density lb/cu ft WD x 100 / e + 100
11	3884	1914	125.6	113.2	354.6	318.9	35.7	11.2	112.9
13	3955	1985	130.2	115.2	320.1	283.8	36.3	12.8	115.4
15	3995	2025	132.9	115.6	410.6	356.7	53.9	15.1	115.5
17	3986	2016	132.3	113.1	344.6	293.8	50.8	17.3	112.8

METHOD A
WT = 21556 WR4 = 4462
PR4 = WR4 / WT x 100 = 21 %

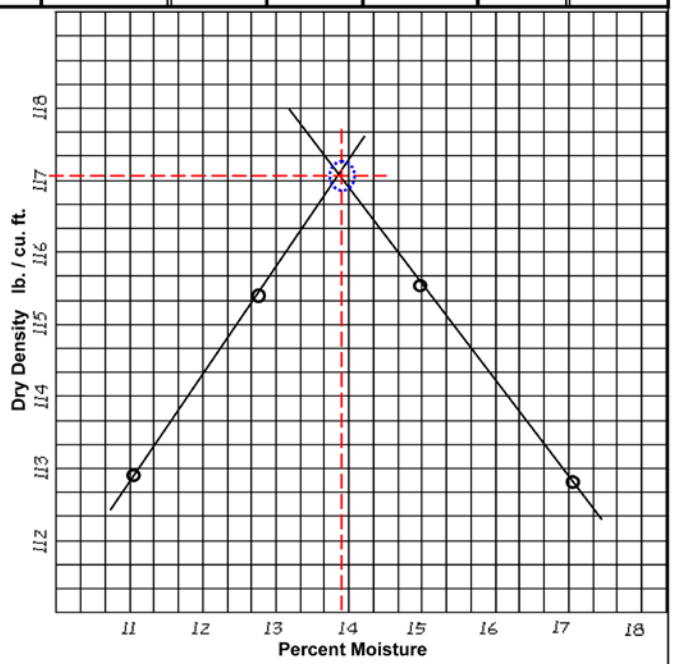
ALTERNATE METHOD D
WT = WR 3/4 =
PR 3/4 = WR 3/4 / WT x 100 = %

Coarse Aggregate Bulk Oven Dry Specific Gravity : 2.476

Coarse Aggregate Absorption : 1.83 %

OPTIMUM MOISTURE CONTENT = OM = 13.9 %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = 117.1



Remarks :

44-1002 Rev 11/15

FIGURE 2

Arizona Department of Transportation
METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY
(Arizona Test Method 225 or 245)

Project No: _____ Lab No : _____ Rec'd Date: _____
Source and Type of Material : _____
Proctor Method Used : **Method A** _____ or **Alternate Method D** _____
Test Operator and Date : _____ Supervisor and Date: _____

Weight of Mold = **M2** = _____ grams | Volume of Mold = **VM** = _____ cu. ft. | a = VM x 453.6 = _____

b	M1	c	WD	ED	Moisture Determination				DD
					WW	DW	d	e	
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample **M1 - M2**	Wet Density lb/ cu ft **c / a**	Est. Dry Density **WD x 100 / b + 100**	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water **WW - DW**	Percent Moisture **d x 100 / DW**	Dry Density lb/cu ft **WD x 100 / e + 100**

METHOD A
WT = _____ WR4 = _____
PR4 = WR4 / WT x 100 = _____ %

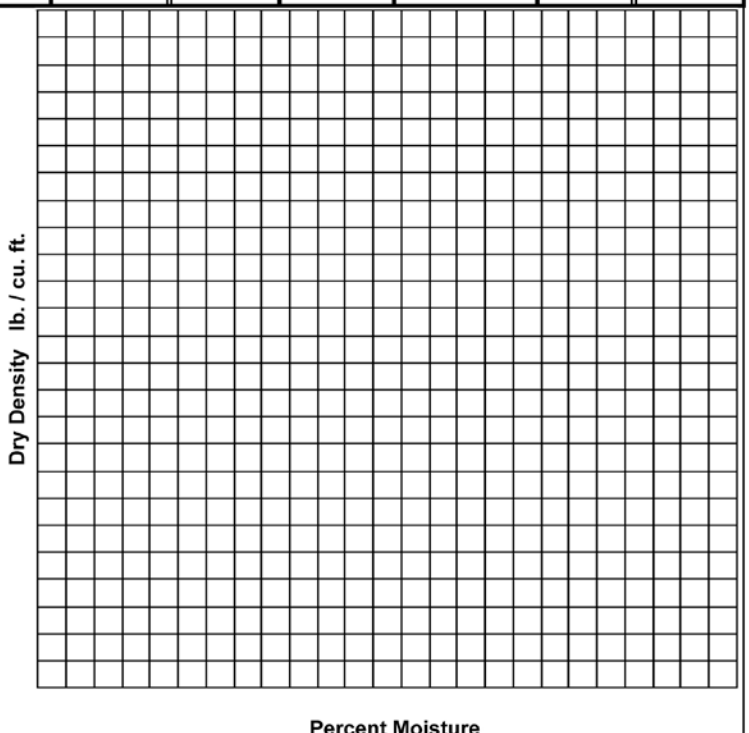
ALTERNATE METHOD D
WT = _____ WR 3/4 = _____
PR 3/4 = WR 3/4 / WT x 100 = _____ %

Coarse Aggregate Bulk Oven Dry Specific Gravity : _____

Coarse Aggregate Absorption : _____ %

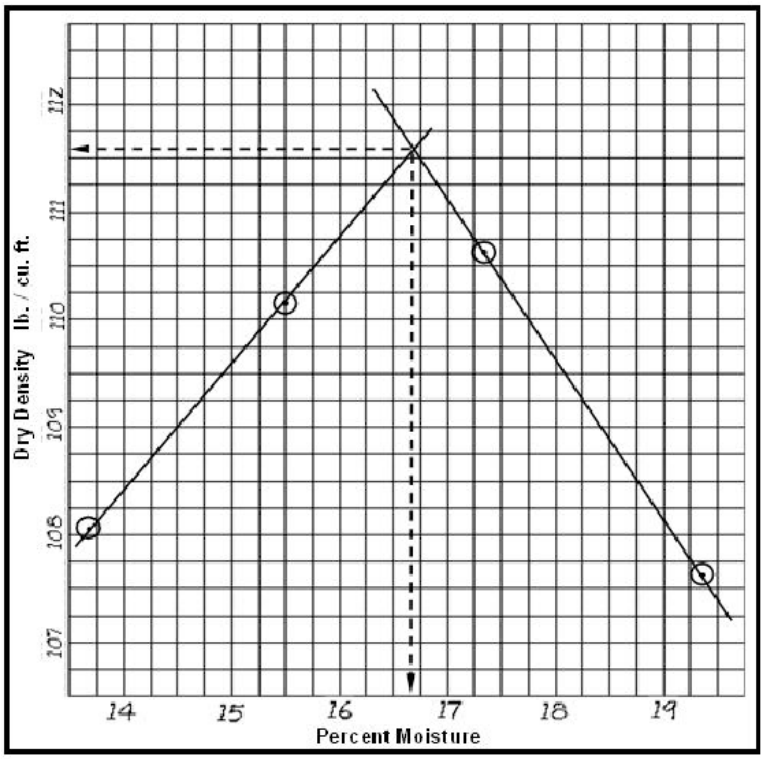
OPTIMUM MOISTURE CONTENT = OM = _____ %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = _____



Remarks : _____

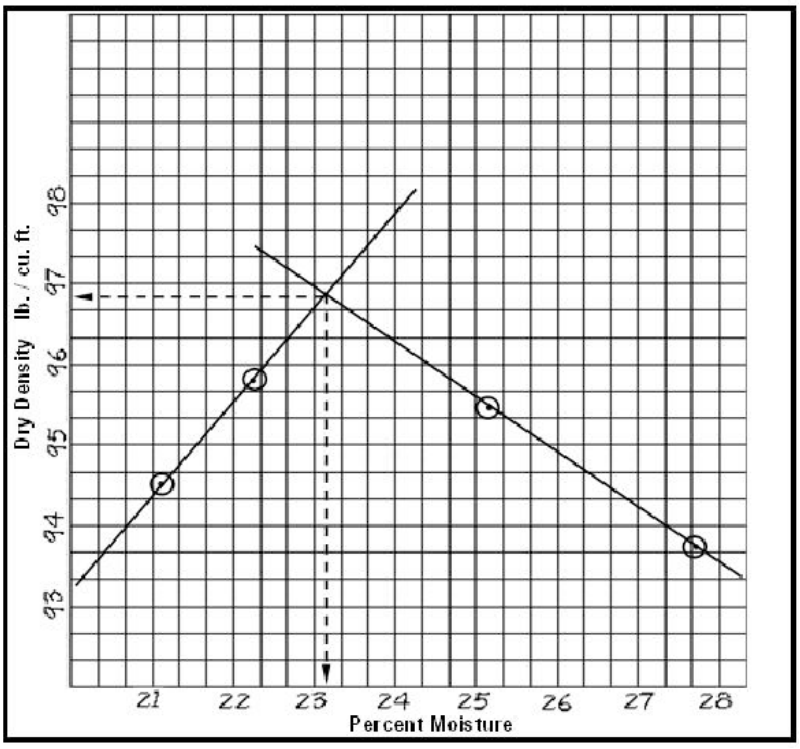
FIGURE 3



CLAYEY SAND

% Moisture	Dry Density
13.7	108.1
15.5	110.2
17.3	110.6
19.4	107.6

Maximum Density = 111.6 lb/cu ft
Optimum Moisture = 16.7%



FINE CLAY

% Moisture	Dry Density
21.2	94.5
22.3	95.8
25.2	95.1
27.8	93.1

Maximum Density = 96.7 lb/cu ft
Optimum Moisture = 23.1%

FIGURE 4

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

✓ Four Inch Mold _____ Six Inch Mold Mold I. D. #: 4A

Calibration Date: 08/15/15 Calibration Expiration Date: 08/15/16

Temperature of water used for Calibration: 73 ° F

Unit Weight of Water: 62.277 lb. /cu. ft.

Test Operator: Joe Tester Supervisor and Date: Joe Supervisor 08/17/15

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)
4458.7	5407.9	949.2

$$V = \left[\text{Volume of Mold (cu. ft.)}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\text{Unit Weight of Water (lb. / cu. ft.}\right] \text{ X } [453.6 \text{ (grams / lb.)}]}$$

$$V = \frac{(\ 949.2\ )}{(\ 62.277\ ) \text{ X } (\ 453.6\ )} = \frac{0.0336}{0.033601371} \text{ cu. ft.}$$

REMARKS: _____

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 5

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

_____ Four Inch Mold _____ Six Inch Mold Mold I. D. #: _____

Calibration Date: _____ Calibration Expiration Date: _____

Temperature of water used for Calibration: _____ ° F

Unit Weight of Water: _____ lb. /cu. ft.

Test Operator: _____ Supervisor and Date: _____

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)

$$V = \left[\text{Volume of Mold (cu. ft.)}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\text{Unit Weight of Water (lb. / cu. ft.}\right] \text{ X } \left[453.6 \text{ (grams / lb.)}\right]}$$

$$V = \frac{(\qquad\qquad)}{(\qquad\qquad) \text{ X } (\qquad\qquad)} = _____ \text{ cu. ft.}$$

REMARKS: _____

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 6

MAXIMUM DENSITY AND OPTIMUM MOISTURE OF SOILS METHODS C & D

(A Modification of AASHO T 99, Methods C & D)

Scope

1. **Method C** shall be used only on volcanic cinders and light porous material containing less than 50% of material retained on the No. 4 sieve.

Method D shall be used only on volcanic cinders and light porous materials containing more than 50% and less than 60% of material retained on the No. 4 sieve. If the material contains more than 60% retained on the No. 4 sieve, report the sieve analysis with a note stating the density is not determinable due to excess material retained on the No. 4 sieve.

Apparatus

2. The apparatus shall consist of the following:

(a) 4.0-in. proctor mold (for Method C) having a capacity of 1/30 (.0333) cu. ft. with internal diameter of 4.0 ±.005 in. and a height of 4.584 ±.005 in.

(b) 6.0-in. proctor mold (for Method D) having a capacity of 1/13.33 (0.075) cu. ft., with internal diameter of 6.0 ±0.005 in. and a height of 4.584 ±0.005 in. (See Fig. 1.)

(c) A hand rammer or mechanical compactor of 2-in. diameter, having a flat circular face and weighing 5.5 lb.

(d) Steel straightedge 12" or longer, having one beveled edge.

(e) Balance, capacity 20 kg. sensitive to 1 g.

(f) Drying oven, operating range 110° ±5° C.

(g) Miscellaneous mixing tools and pans.

Sample

3. Enough material should be on hand to make five compacted samples.

Approximately 13,000 g. for Method C.

Approximately 25,000 g. for Method D.

(These weights may have to be adjusted depending on the type of material.)

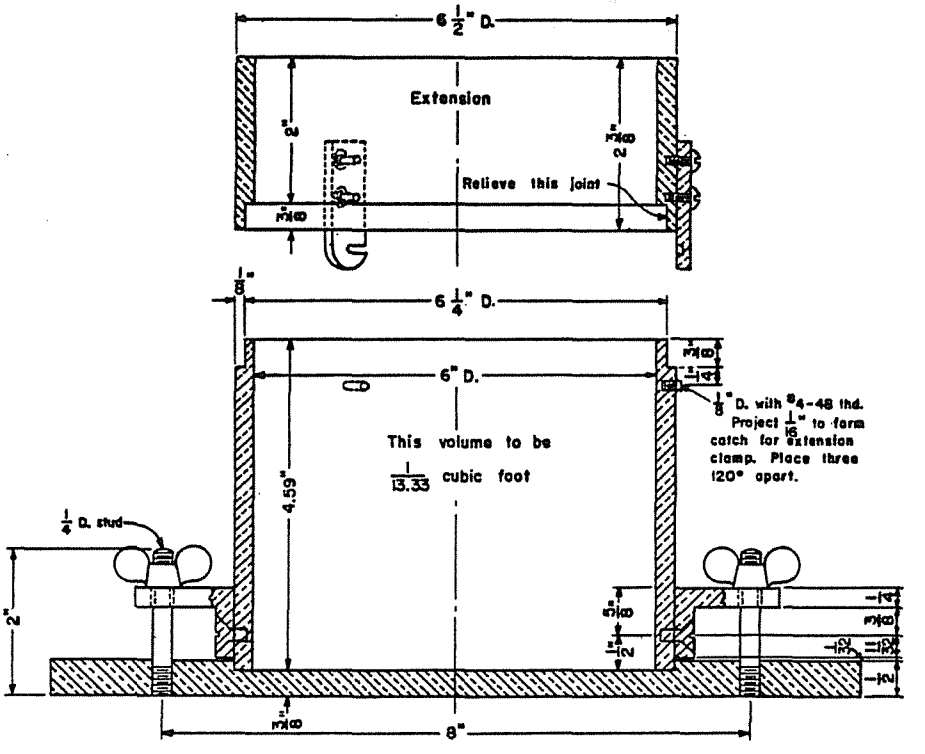


FIGURE 1
Cylindrical Mold, 6.0-in., for Soil Tests

(a) A sieve analysis, (ARIZ 201 and 203) must be run to determine the proportion of rock.

Samples which contain approximately 100% passing the ¾" sieve shall be prepared in accordance with the folowing procedure:

A uniform sample of approximately 15,000 g. so as to obtain not less than five compaction samples or test charges, shall be used. The sample shall be separated by means of a mechanical sample splitter into equal portions of approximately the desired weight. With some practice the charges can be obtained by using **only** the splitter. The operator shall not add to or take away from any portion by scooping with the hand or other means, as this may cause segregation.

(b) Samples containing rock retained on the ¾" sieve shall be processed in the following manner:

The material retained on the ½", ⅜", ¼", and No. 4 sieves shall be stored in separate containers during the sieve analysis procedure. Rock retained on the ¾" sieve shall not be used, but its percentage shall be distributed proportionately among the sieves mentioned above. Table I shows a coarse sieve analysis which required adjusting, shows the adjusted percentages, and also shows the material to build up a 2200 g. charge. Essentially the same procedure shall be followed to build a 5000 g. charge in the case of Method D. These weights may require adjustment if the charge is too large.

(c) The adjusted % retained values are found by dividing each of the percentages retained on the ½", ⅜", ¼" and No. 4 (from Table I), by the total percentage of material coarser than No. 4, x 10, and adding these quotients to the respective sieves below the ¾", i.e., $7 \div 36 = 1.9 = 2$; $8 \div 36 = 2.2 = 2$; and $12 \div 36 = 3.3 = 3$. The final correction should total 100%.

(d) Use the "adjusted % Ret." values to build up the compaction charges of 2200 g. each, i.e.,

$$\frac{2200 \times 9}{100} = 198 \text{ g. of } ½"$$

rock needed (Table I). The accumulative total is for weighing the charge as follows:

1. Weigh out the first size (½") into the balance scoop (198 g. in Table I), then set the weights at 374 g. (198 + 176) and add the ⅜" rock until the instrument balances. Next set the weights at 638 g., (374 + 264) and add the ¼" rock until the instrument again comes to balance. Continue in this manner until the charge weighing 2200 g. is built up. Weigh out 5 such charges and save them in separate pans.

Mixing

4. The amount of water that will be required for a sample is variable and requires some experience on the part of operator, but the following general rule may be of help. Add 4% water to the sample and mix thoroughly; when mixing is complete, pick up a handful of dirt and squeeze it, then open the hand, let the dirt fall, and immediately blow the breath upon the open hand. If the hand feels cool, but not cold, another 2% water shall be added, thoroughly mixed, and the squeeze and blow test repeated. Continue to add 2% portions of water, and check, until the feeling of coolness changes to cold. At this point, gather the material into a compact pile and cover it with a slightly damp cloth to inhibit drying. Record the total percentage of water added.

Compaction

5. Compact the material as follows:

(a) Place approximately ⅓ of the mixed material in the mold, moving the scoop around the top of the mold to insure even distribution of the material. Tamp the material lightly with the end of the hand rammer,

TABLE 1

Sieve No.	% Ret.	Adjusted % Ret.	Wt. in Grams (2200 gram sample)	Accumulative Total
2"	0			
1½"	2			
1"	3			
¾"	4	0		
½"	7	9 (7+2)	198	198
⅜"	6	8 (6+2)	176	374
¼"	9	12 (9+3)	264	638
#4	6	8 (6+2)	176	814
Pass #4	63	63	1386	2200
TOTAL	100	100	2200	

NOTE: *No change is made in the percentage of pass No. 4 material; this is always used at the same percentage in which it occurred in the original sample.*

or with the knuckles if the mechanical rammer is used.

(b) Compact this first layer with the rammer falling through a distance of 12 inches, moving the rammer to a different place each time so the whole surface is covered.

Method "C" requires 25 blows per layer.

Method "D" requires 56 blows per layer.

(c) Add another ⅓ portion of the dampened material and compact it as before.

(d) Add and compact the third and final layer. This last layer, when compacted, should extend up into the extension collar a short distance.

(e) Place the mold in the mixing pan and remove the collar so as to not crack or crumble the compacted specimen, then strike off the top of the specimen even with the top of the mold, using the steel straightedge. If any holes are left as rocks are scraped out, these holes shall be filled with fine material and smoothed off.

Calculations

6. The samples are weighed and calculations are as follows:

(a) Remove the base, wipe away any dirt from the mold and weigh the sample and mold to the nearest gram. Record the weight on the work card.

(b) Subtract the weight of the mold to obtain the wet weight of the sample in grams.

(c) Calculate the wet Density (D_w) in pounds per cu. ft. as follows:

Method C

D_w = wet wt. x 0.06614
= 1607 g. x 0.06614 = 106.3 lb./cu. ft.

$$\text{Where } 0.06614 = \frac{1}{\text{Vol. of 4" mold x 453.6 g./lb.}}$$

Method D

D_w = wet wt. x 0.02939
= 3617 g. x 0.02939 = 106.3 lb./cu. ft.

$$\text{Where } 0.02939 = \frac{1}{\text{Vol. of 6" mold x 453.6 g./lb.}}$$

(d) The approximate dry density of the sample (D_a) may be calculated as follows:

$$D_a = \frac{D_w}{100 + \%\text{ water added}} \times 100$$

Example:

Wet Density, D_w = 106.3 lb./cu. ft.
% Water added = 14

$$D_a = \frac{106.3}{114} \times 100 = 93.2 \text{ lb./cu. ft.}$$

NOTE: *These densities are approximate only and will be corrected when final moisture results are obtained.*

The approximate dry density is useful in deciding how much water to add in later trial batches. For instance, if the 14% water in the example, shown on the previous page, gave a density of 93.2 lb. per cu. ft., and a later increase to 16% gave the same density of 93.2 lb. per cu. ft., then the next trial to be run should be dropped to 12% water. (This was tried and resulted in a compaction of 92.1 lb. per cu. ft., giving a curve which rose from 12% to 14% and fell away at 16%.) One or two additional samples with either 10% or 18% water added should be compacted, to aid in establishing the curve. By carefully observing the approximate dry density of the compacted samples, the operator should be able to vary the moisture content as the test proceeds so that when the final results are plotted a curve will result that rises to a peak and then recedes.

Moisture Determination

7. The percentage of moisture in the compacted samples is determined as follows:

(a) Break the compacted sample into small pieces, being careful to **lose none.** Dry the sample in an oven at 110° ±5° C to constant weight, and record the weight.

NOTE: *The "Speedy" Method is not applicable for moisture determinations.*

(b) Calculate the moisture content as follows:

$$\%\text{ Moisture} = \frac{W_w - W_d}{W_d} \times 100$$

Where:

W_w = weight of wet soil, g.
W_d = weight of dry soil, g.

Example:

$$\%\text{ Moisture} = \frac{322 \text{ g.} - 286 \text{ g.}}{286 \text{ g.} - 22 \text{ g.}} \times 100$$

$$= \frac{36 \text{ g.}}{264 \text{ g.}} \times 100 = 13.6\%$$

(c) The dry density in lb. per cu. ft. for each sample is calculated as follows:

$$D = \frac{D_w}{100 + \%\ \text{moisture}} \times 100$$

Where:

D = dry density of soil, lb./cu. ft.
D_w = wet density of soil, lb./cu. ft.

Example:

$$D = \frac{106.3\ \text{lb./cu. ft.}}{113.6} \times 100 = 93.6\ \text{lb./cu. ft.}$$

Maximum Density and Optimum Moisture

8. The optimum moisture is determined as follows:

(a) The results of all samples are plotted on graph paper, using the percentage of moisture as the horizontal axis and the dry weight per cubic foot as the vertical axis.

(b) Draw a curve through the resulting points. The peak of the curve represents the "Maximum Density", in pounds per cubic foot, and the percentage of water at the peak represents the "Optimum Moisture Content" necessary to produce maximum density when compacted under these conditions.

Figure 2 gives a typical example of the calculations involved.

METHOD "C & D" PROCTOR

EXAMPLE OF CALCULATIONS FOR ARIZ-226

a	b	c	d	e	f	g	h	i
Approx. % Water Added	Wet Weight of Mold & Soil(gm	Weight of Mold (gm.)	Wet weight of Soil (gm.)	Factor	Wet Density lb./cu. ft.	Approx. Dry Density lb./cu.ft.	Actual % Water Added	Actual Dry Density lb./cu.ft.
			(b-c) = d		(dxe) = f	$\frac{f}{100+a} \times 100 = g$	(From Moisture Chart Below)	$\frac{f}{100+h} \times 100 = i$
10	3335	1820	1515	0.06614	100.2	91.1	10.3	90.8
12	3380	1820	1560	0.06614	103.2	92.1	11.9	92.2
14	3427	1820	1607	0.06614	106.3	93.2	13.6	93.6
16	3455	1820	1635	0.06614	108.1	93.2	16.2	93.0
18	3453	1820	1633	0.06614	108.0	91.5	18.1	91.4
			(Factor for Method "D" = 0.02939)					

MOISTURE CHART

a	j	k	l	h
Approx. % Water Added	Wet Weight (gm.)	Dry Weight (gm.)	Weight Water (j-k)=l	% Water Added $\frac{l}{k} \times 100 = h$
10	300	272	28	10.3
12	300	268	32	11.9
14	300	264	36	13.6
16	300	258	42	16.2
18	300	254	46	18.1

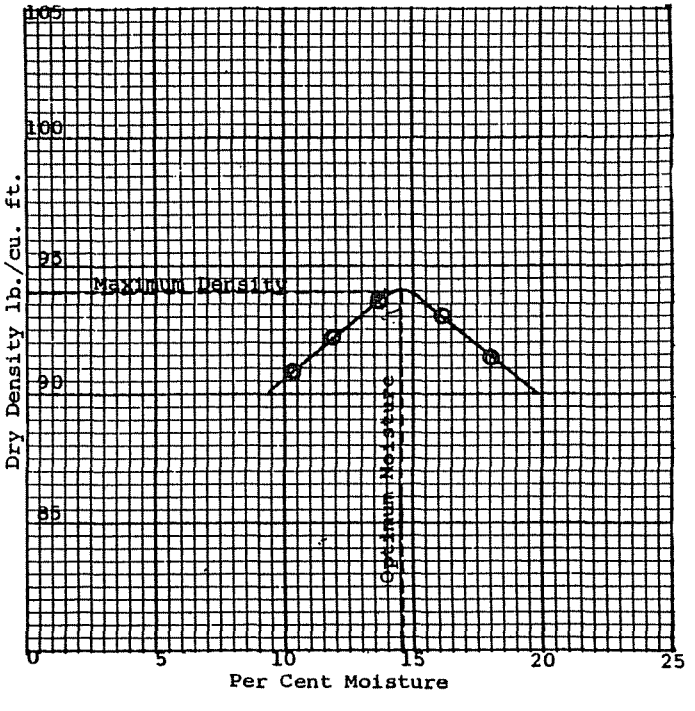


Fig. 2.

ARIZ 227e
November 2, 2018
(5 Pages)

ROCK CORRECTION PROCEDURE FOR MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE CONTENT DETERMINATION

(A Modification of AASHTO Designation T 99 - ANNEX)

1. SCOPE

1.1 This procedure is used to determine the corrected maximum dry density and optimum moisture content for a sample of material when coarse aggregate or rock particles are retained on the No. 4 sieve (for Method A proctor) or 3/4 inch sieve (for Alternate Method D proctor).

1.2 The rock correction procedure shall not be used when the material consists of volcanic cinders or light weight porous material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is greater than 4.0%.

1.3 The rock correction procedure shall not be used when the percent rock retained on the No. 4 for Method A is less than 10% or greater than 50% (greater than 60% in the case of an aggregate base material); or when the percent rock retained on the 3/4 inch sieve for Alternate Method D is less than 10% or greater than 40%.

2. NECESSARY INFORMATION

2.1 Refer to, or determine the maximum dry density and optimum moisture content of the material by Method A (Arizona Test Method 225 or 232); or Alternate Method D (Arizona Test Method 245 or 246).

2.2 For Method A, the percentage of rock particles in the sample which are coarser than the No. 4 sieve is recorded as "PR4". For Alternate Method D, the percentage of rock particles in the sample which are coarser than the 3/4 inch sieve is recorded as "PR3/4".

2.3 If not known, determine the bulk oven-dry specific gravity of the coarse aggregate in accordance with AASHTO T 85.

Note: Once determined for a source, the specific gravity may usually be used for all rock corrections on material from that source. Any slight change in specific gravity should not change the maximum dry density to a large extent. (A change of ± 0.02 could result in a change of ± 0.6 lb. per cubic foot.) Similarly, the maximum dry density of the passing No. 4 or passing 3/4 inch material, having been determined by Method A or Alternate Method D for a source, may usually be used for that source providing the sieve analysis of the passing No. 4 or passing 3/4 inch material and the Plasticity Index remain reasonably uniform.

3. ROCK CORRECTED MAXIMUM DRY DENSITY

3.1 The corrected maximum dry density of the total sample for the amount of rock (plus No. 4 for Method A proctor or plus 3/4 inch for Alternate Method D proctor) shall be determined by the following equation:

$$CMD = \frac{\left[(100 - PR) \times (MD)\right] + \left[(56.2) \times (PR) \times (SG)\right]}{100}$$

Where:

CMD = Corrected maximum dry density of the total sample containing "PR" percent coarse rock particles, lbs./cu. ft.

PR = "PR4", percent rock retained on the No. 4 sieve for Method A; or "PR3/4" percent rock retained on the 3/4 inch sieve for Alternate Method D.

MD = Maximum dry density (Method A for plus No. 4; or Alternate Method D for plus 3/4 inch), lbs./cu. ft.

SG = Bulk O.D. Specific Gravity of the coarse aggregate.

Example (For Method A):

PR = PR4 = 29% rock retained on the No. 4 sieve.
MD = 114.0 lbs./cu. ft.
SG = 2.499

$$CMD = \frac{\left[(100-29)\,x\,(114.0)\right] + \left[(56.2)\,x\,(29)\,x\,(2.499)\right]}{100}$$

$$CMD = \frac{\left[(71)\,x\,(114.0)\right] + \left[4072.9\right]}{100} = \frac{\left[8094.0\right] + \left[4072.9\right]}{100}$$

CMD = 121.7 lbs./cu. ft. [Corrected maximum dry density of the total sample containing 29% rock retained on the No. 4 sieve.]

Example (For Alternate Method D):

PR = PR3/4 = 32% rock retained on the 3/4 inch sieve.
MD = 112.6 lbs./cu. ft.
SG = 2.526

$$CMD = \frac{\left[(100-32)\,x\,(112.6)\right] + \left[(56.2)\,x\,(32)\,x\,(2.526)\right]}{100}$$

$$CMD = \frac{\left[(68)\,x\,(112.6)\right] + \left[4542.8\right]}{100} = \frac{\left[7656.8\right] + \left[4542.8\right]}{100}$$

CMD = 122.0 lbs./cu. ft. [Corrected maximum dry density of the total sample containing 32% rock retained on the 3/4 inch sieve.]

4. ROCK CORRECTED OPTIMUM MOISTURE CONTENT

4.1 The rock corrected optimum moisture content of the total sample shall be determined by the following equation:

$$COM = \frac{\left[(OM)\,x\,(100-PR)\right] + (PR)}{100}$$

Where: COM = Corrected optimum moisture content for the total sample.

OM = optimum moisture content for Pass No. 4 (Method A) or pass 3/4 inch material (Alternate Method D).

PR = "PR4", % rock retained on the No. 4 sieve for Method A; or "PR3/4", % rock retained on the 3/4 inch sieve for Alternate Method D.

Example (For Method A):

OM = 14.3%
PR = PR4 = 29% rock retained on the No. 4 sieve.

$$COM = \frac{\left[(14.3)\,x\,(100-29)\right]+(29)}{100}$$

$$COM = \frac{\left[(14.3)\,x\,(71)\right]+(29)}{100} = \frac{(1015.3)+(29)}{100}$$

COM = 10.4% [Corrected optimum moisture content of the total sample containing 29% rock retained on the No. 4 sieve.]

Example (For Alternate Method D):

OM = 15.2%
PR = PR3/4 = 32% rock retained on the 3/4 inch sieve.

$$COM = \frac{\left[(15.2)\,x\,(100-32)\right]+(32)}{100}$$

$$COM = \frac{\left[(15.2)\,x\,(68)\right]+(32)}{100} = \frac{(1033.6)+(32)}{100}$$

COM = 10.7% [Corrected optimum moisture content of the total sample containing 32% rock retained on the 3/4 inch sieve.]

5. USE OF RESULTS

5.1 The corrected maximum dry density obtained by this method is used, in comparison with the field density of the material, to determine the percentage of compaction.

5.2 The corrected optimum moisture content is used to determine the amount of moisture which should be added to the material to achieve maximum dry density.

6. REPORT

6.1 Report the corrected maximum dry density to the nearest 0.1 lb./cu. ft.

6.2 Report the corrected optimum moisture content to the nearest 0.1 percent.

CALIBRATION OF STANDARD SAND AND SAND CONE

(A Modification of AASHTO Designation T 191)

Scope

1. This method of test is to determine a weight per cubic foot of sand to be used in soil density determinations, and the volume of the sand to fill the funnel on the sand cone.

Apparatus

2. The apparatus shall be as follows:

(a) Sand Cone Assembly. - A 1-gal. jar and a detachable appliance consisting of a cylindrical valve with an orifice 1/2-in. in diameter and having a small funnel connecting to a standard G mason jar top on one end and a large funnel on the other end. The valve shall have stops to prevent rotating the valve past the completely open or closed positions. See Fig. 1.

(b) Sand to be standardized, clean, dry, free flowing and uncemented (obtained from warehouse).

(c) 1/13.33 (0.075) cu. ft. mold. (Volume of mold shall be recalibrated occasionally.)

(d) Straightedge

(e) Balance, 20 kg. capacity, accurate to 1.0 g., or 35 lb. capacity, accurate to 0.01 lb.

Procedure

3. The test shall be as follows:

(a) Fill the jar with the sand to be used and attach the funnel.

(b) Weigh the empty 0.075 cu. ft. mold.

(c) Set the mold in a flat square pan large enough to catch any excess sand.

(d) Invert the apparatus and set the funnel directly over the mold.

(e) Open the valve and let the sand flow freely into the mold being careful not to jar the apparatus, until the sand ceases to move in the jar.

(f) Close the valve sharply and carefully remove the apparatus from the mold.

(g) Using the straightedge, strike off the sand, being careful not to jar the mold. Work the straightedge in the least number of strokes possible until sand is level with the mold. Tap the edge of the mold and weigh and record.

(h) Repeat steps (a) through (g) twice more.

(i) The jar shall now be refilled with the sand, the funnel attached, and the apparatus weighed and recorded.

(j) Place the base plate in the bottom of a level, smooth pan.

(k) Invert the apparatus and place on the base plate in the same manner as the apparatus would be placed over a field density hole.

(l) Open the valve all the way and allow the sand to flow freely, being careful not to jar the apparatus, until the sand ceases to move.

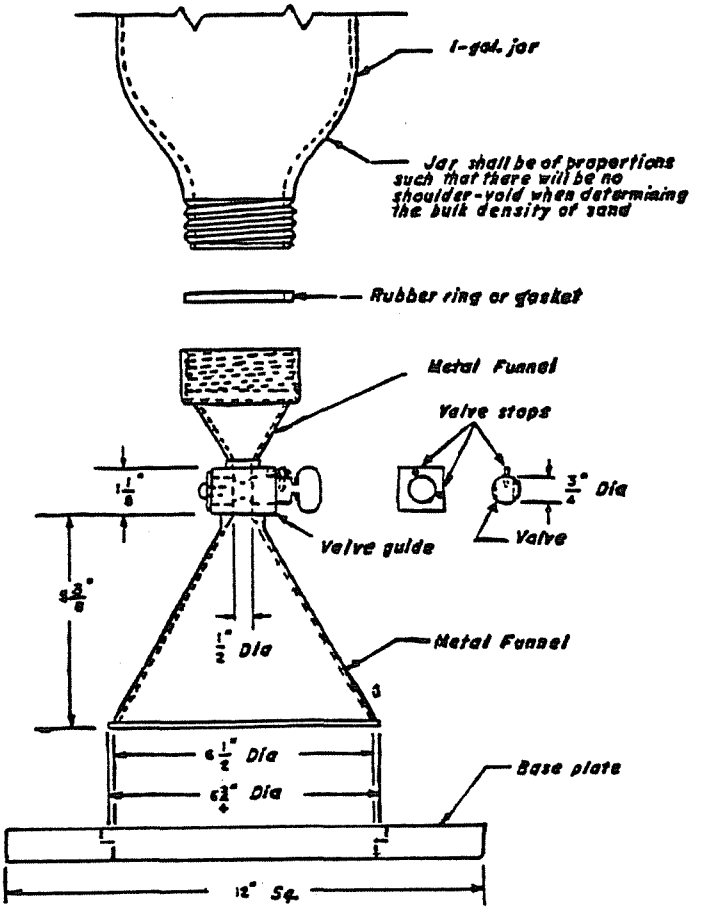


FIGURE 1
Density Apparatus

(m) Close the valve and carefully remove the apparatus from the base plate; weigh the jar and record the weight.

(n) Repeat steps (i) through (m) twice more.

Calculations

4. The calculations are as follows:

(a) Density, D_S, of standard sand, lb./cu. ft.:

	Initial Weight	Final Weight	Difference
Trial #1	5068 g.	1786 g.	3282 g.
Trial #2	5060 g.	1784 g.	3276 g.
Trial #3	5075 g.	1796 g.	3279 g.
		Total	9837 g.

$$\text{Average} = \frac{9837 \text{ g.}}{3} = 3279 \text{ g.}$$

The average of three readings shall be used for computing density (D_S) of standard sand:

$$D_S = \frac{\text{Avg. of 3 wts. (g.)}}{(453.6 \text{ g/lb.}) \text{ (vol. of mold)}}$$

Example:

$$D_S = \frac{3279}{(453.6)\ (0.075)} = 96.4 \text{ lb./cu. ft.}$$

(b) Volume of Funnel & Base Plate:

	Initial Weight	Final Weight	Difference
Trial #1	5068 g.	3288 g.	1780 g.
Trial #2	5072 g.	3289 g.	1783 g.
Trial #3	5065 g.	3289 g.	1776 g.
		Total	5339 g.

$$\text{Average} = \frac{5339 \text{ g.}}{3} = 1780 \text{ g.}$$

The average of three readings shall be used for computing the volume of the funnel and base plate.

$$\text{Vol., cu. ft.} = \frac{\text{Avg. of 3 wts. (g.)}}{(453.6)\ (D_S)}$$

Example:

$$\text{Vol., cu. ft.} = \frac{1780}{(453.6)\ (96.4)} = .0407 \text{ cu. ft.}$$

FIELD DENSITY BY THE SAND CONE METHOD

(A Modification of AASHTO Designation T 191)

SCOPE

1. (a) This method is used to determine the density of compacted soils or aggregates by determining the weight and moisture content material removed from a test hole and measuring the volume of the test hole.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. Apparatus for this test procedure shall consist of the following:

(a) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 lbs or at least the nearest gram.

(a) Miscellaneous digging tools.

(b) Sand cone apparatus consisting of base plate, cone and sand jar.

(c) Standard sand. (Sand shall be kept dry and free flowing).

(d) Containers with air tight covers (cylinder molds are satisfactory).

(e) Oven, hot plate, stove or Speedy Moisture Tester.

NOTE: Calibration of the sand and sand cone apparatus shall be done in accordance with AZ 229.

PREPARATION OF TEST SITE

3. The surface of the area where the test is to be conducted shall be prepared as follows:

(a) Clean away all loose soil and rock from an area of about 3 feet square at the spot where the test is to be made. In areas compacted by 'Sheep's foot' rollers, it is necessary to get below the depth of the 'foot' imprints.

(b) The top of the material at the chosen location shall be prepared to a plane and level surface for an area slightly larger than the size of the base plate. The base plate shall then be placed on this level surface.

PROCEDURE

4. (a) A hole shall be dug approximately the diameter of the hole in the base plate and to the desired depth. (Usually 6 inches to 8 inches). While digging, especially using a hammer and chisel, care must be taken to avoid prying as this may deform the hole, disturb the surrounding material and give a false reading. All of the material removed from the hole shall be carefully recovered and put into a suitable container and covered with a lid or damp cloth, also making sure to get the hole as clean as possible. This operation shall be done as quickly as possible to avoid any excessive drying of the sample.

Suggested test hole volumes and corresponding moisture sample weights are given in Table 1. There will be occasions where the values listed in Table 1 will be difficult to arrive at or follow, such as in the case where we are limited to a shallow depth of compacted material. This table is offered as a guide and should be followed in most cases, however, deviations from theses values are allowable when conditions warrant. The 'Speedy' Moisture Method (AASHTO T-217) may be used to determine the moisture content. The 'Speedy' Method will give the percent moisture on the passing the No. 4 material. If the sample contains material retained on the No. 4 sieve the 'Speedy' results must be adjusted in accordance with the following formula to obtain the percent moisture of the total sample.

$$W = \frac{w(100 - R) + R}{100}$$

Where:

W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 sieve)

An example of this formula is shown under Calculations in this procedure.

Table 1

Maximum Particle Size Retained	Minimum Test Hole Volume cu ft	Minimum Moisture Content Sample grams
No. 4 sieve	0.060	100
½ in.	0.060	250
1 in.	0.075	500
2 in.	0.100	1000
2-1/2 in.	0.135	1500

(b) Weigh the filled sand cone apparatus and place over the base plate with the cone down. A match mark on the cone of the apparatus and the base plate is required to ensure that the apparatus is placed on the base plate the same way every time.

(c) Make sure there is no construction equipment operating in the immediate vicinity as any vibrations will cause a false volume determination.

(d) Open the valve all the way and let the sand flow freely, being careful not to jar the apparatus while the sand is flowing. When the sand ceases to move in the bottle, close the valve and remove the apparatus.

(e) Weigh the sand cone apparatus with the remaining sand to determine the volume of the hole.

REFERENCE TO METHOD 'A' PROCTOR

5. If referencing to Method 'A' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the No. 4 sieve.

(f) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(g) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +\#4 material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 50% (or 60% in the case of Aggregate Base) report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 50% (or 60% in the case of Aggregate Base) is retained on the No. 4 sieve, proceed with the following calculations.

CALCULATIONS

6. (a) Weight of sand, in lbs., to fill hole and funnel (W_s):

$$W_s = \frac{W_o - W_f}{453.6 \text{ g/lb}}$$

Where:

W_o = original wt. of sand and apparatus, g.
W_f = final wt. of sand and apparatus, g.

Example:

$$W_s = \frac{(8560 \text{ g}) - (4314 \text{ g})}{453.6 \text{ g/lb}}$$

$$= \frac{4246 \text{ g}}{453.6 \text{ g/lb}}$$

$$= 9.36 \text{ lbs}$$

(b) Volume, in cubic feet, of hole (V):

$$V = \frac{W_s}{D_s} - V_c$$

Where:
W_s = wt. of sand to fill hole and funnel, lb.
D_s = density of sand, lb/cu. ft.
V_c = volume of cone and base plate

Example:

$$V = \frac{(9.36 \text{ lbs})}{(96.4 \text{ lb/cu ft})} - (.0407 \text{ cu ft})$$

$$= .0564 \text{ cu ft}$$

(c) Percent moisture of pass No. 4 material may be determined by utilizing the Speedy Test Method, (AASHTO T 217), or by oven-dry Method, (AASHTO T 265).

$$w = \frac{W_w - W_d}{W_d} \times 100$$

Where:

W_w = weight of wet soil, g.
W_d = weight of dry soil, g.
w = % moisture in pass No. 4 material

Example:

$$W = \frac{(322\text{ g}) - (289\text{ g})}{(289\text{ g})} \times 100 = \frac{33\text{ g}}{289\text{ g}}$$

$$= 11.4\ \%$$

(d) Moisture content of the total sample expressed in percentage shall be calculated as follows:

$$W = \frac{w(100 - R) + R}{100}$$

Where:
W = % moisture in total sample
w = % moisture in Pass No. 4 material
R = % rock (Plus No. 4 material)

Example:

w = 11.4 %
R = 29 %

$$W = \frac{11.4\ (100 - 29) + 29}{100} = \frac{838.4}{100} = 8.4\ \%$$

The formula assumes that the rock has a moisture content of 1% and is sufficiently accurate to use in most cases. If the moisture content of the rock is appreciably above 2% as on absorbent materials, the central laboratory should be contacted for instructions.

(e) Wet density, D_w in lb/cu. ft. of material:

$$D_w = \frac{W_t}{V}$$

Where:

W_t = weight of total sample, lb.

Example:

$$D_w = \frac{7.41 \text{ lbs}}{.0564 \text{ cu ft}} = 131.4 \text{ lb/ cu ft}$$

(f) Field dry density, D_d in lb/ cu. ft, of material:

$$D_d = \frac{D_w}{100 + W} \times 100$$

Example:

$$D_d = \frac{131.4 \text{ lb/ cu ft}}{100 + 8.4} \times 100 = 121.2 \text{ lb/ cu ft}$$

(g) $$\% \text{ compaction} = \frac{D_d \times 100}{\text{Maximum Density (Corrected)}}$$

Example:

Maximum Dry Density (pass No. 4 material) = 114.0 lb/ cu ft

Percent rock = 29 %

Corrected Maximum Dry Density = 122.0 lb/ cu ft

Note: Compaction shall be reported to the nearest whole percent

$$\% \text{ compaction} = \frac{121.2 \text{ lb/ cu ft} \times 100}{122.0 \text{ lb/ cu ft}}$$

$$= 99 \%$$

REFERENCE TO ALTERNATE METHOD 'D' PROCTOR

7. If referencing to Alternate Method 'D' Proctor continue as follows:

(a) Weigh the material removed from the test hole.

(b) Screen over a 3" and No. 3/4 sieve.

(c) With a small brush clean as many fines from the rock as possible.

(d) If any rock is retained on the 3" sieve, verify this with a sieve analysis and call this the end point. This sieve analysis shall be reported with a note stating the density is not determinable due to the rock retained on a 3" sieve.

(e) Weigh and record the weight of the material retained on the 3/4" sieve.

(f) Screen the material that passes the 3/4" sieve over the No. 4 sieve. Weigh the material that is retained on the No. 4 sieve and add this weight to the weight of the material retained on the 3/4" sieve.

(g) Immediately weigh a moisture sample from the passing No. 4 material to be run either by 'Speedy' or Hot Plate Method.

(h) Determine the percent of rock by the following equation.

$$\% \text{ Rock} = \frac{\text{wt. of +3/4" material}}{\text{total wt. of material removed from hole}} \times 100$$

(h) If the rock content is greater than 40% report the sieve analysis with a note stating that the density is not determinable due to excess rock.

Note: When conditions prevent density determination in areas due to the presence of excessive rock or rock retained on the 3" sieve, an attempt shall be made to compact these areas comparable to those surrounding locations where the required compaction was found through testing to be satisfactory.

(i) If less than 40% is retained on the 3/4" sieve, proceed with the following calculations.

CALCULATIONS

8. (a) The calculations are the same as those for referencing to a Method 'A' Proctor. Section 6.

ARIZ 232b
November 14, 2008
(10 Pages)

MOISTURE - DENSITY RELATIONSHIP USING TYPICAL MOISTURE - DENSITY CURVES (ONE POINT PROCTOR) METHOD A

(An Arizona Method)

SCOPE

1. (a) This method of test is for the determination of the optimum moisture content and maximum dry density of a soil or soil-aggregate mixture utilizing one moisture-density determination on the portion of the sample passing the No. 4 sieve. Some materials may be more appropriately tested by Arizona Test Method 246, "Moisture-Density Relationship using Typical Moisture-Density Curves (One Point Proctor) Alternate Method D".

(b) The one-point proctor is used with the typical moisture-density curves, shown on the back of the One Point Proctor Density Test Card (Figures 1 and 2); or by utilizing a family of moisture-density curves developed for the immediate local conditions.

(c) This method is not to be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the absorption of the coarse aggregate is greater than 4.0%.

(d) This method may be used to determine if an existing proctor maximum density determination is valid for the soil being tested. If the existing proctor maximum density determination is not valid, a full proctor according to Arizona 225 should normally be run to determine the maximum density required for that soil type.

(e) An example is provided in Section 7, and Figures 3 and 4, for the calculations and determinations referenced herein.

(f) This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

APPARATUS

2. The apparatus shall consist of the following:

(a) The general apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 225.

(b) In place of the oven listed in the general apparatus, a hot plate or stove capable of maintaining a temperature of approximately 230° F. may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

(c) Instead of the scale or balance capable of measuring the weight to be determined to at least one gram, a scale capable of measuring the weight to at least 0.01 pound may be utilized.

CALIBRATION OF MOLD

3. Molds shall be calibrated in accordance with APPENDIX A of ARIZ 225.

SAMPLE

4. A representative sample of passing No. 4 material weighing approximately 2500 grams shall be obtained for each one-point proctor.

PROCEDURE

5. (a) The approximate 2500 gram sample of passing No. 4 material shall be thoroughly mixed with sufficient water to bring the sample to slightly less than its optimum moisture content.

(b) Form a specimen by compacting the prepared soil in the four inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

NOTE: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

(c) When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and base plate.

(d) Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, "WD", of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb)}^*}$$

Where:
- WD = Wet density of compacted soil, lb./cu. ft.
- Ml = Weight of compacted specimen and mold, grams or lbs.
- M2 = Weight of the mold, grams or lbs.
- VM = Volume of the mold, cu. ft. (See Section 3 of this procedure).

* If the weights of the compacted specimen and mold, Ml, and the empty mold, M2, are measured in pounds, eliminate 453.6 (grams/lb.) from the denominator of the above equation.

(e) Remove the material from the mold and slice vertically through the center. Take a representative minimum 300 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as "WW". Dry the sample to constant weight at approximately 230° F. and record weight of dry soil to the nearest 0.1 gram as "DW". The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample. For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217), may be used. For the Speedy Moisture Tester, a representative

sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus.

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

MAXIMUM DENSITY DETERMINATION

6. (a) The point representing the wet density and moisture content (dry basis) is then plotted on the Typical Moisture-Density Curves (Figure 2) and the maximum wet density and optimum moisture content determined. When this plotted point falls between two moisture-density curves, a minor interpolation is necessary. The maximum dry density in lb/cu. ft. and the corresponding percent optimum moisture is then read directly or interpolated from the chart. The family of typical moisture-density curves provided should be periodically verified for the local conditions. If it is ascertained that the family of curves provided by Figure 2 is of questionable reliability for given local conditions, then an independent family of curves should be established and used.

(b) The plotted point for wet density and moisture content should be on the dry side of the curve at or near optimum, as it is difficult to interpolate between curves for friable soils when on the wet side of the peak.

(c) If the plotted point representing the wet density and moisture content of the compacted material is on the right of the peak, the test should be repeated using a lower moisture content. An exception to this rule must be made for those soils having high clay contents and relatively flat curves. These soils cannot readily be dried to optimum in the field due to the creation of a cloddy condition which will cause voids in the proctor. Proctors for these materials should be made as near to optimum as possible.

EXAMPLE

7. An illustration of determining the maximum dry density and optimum moisture content is described below, and shown in Figures 3 and 4:

For:

Wet Density	= 120.0 lb./cu. ft.
Moisture Content	= 20.0%

By plotting this point on the Typical Moisture-Density Curves and interpolating, it shows a point which is approximately 60 percent of the distance from Curve Q to Curve R. From the chart, the dry density for Curve Q is 102.4 @ 20.3% moisture and Curve R is 99.9 @ 21.5% moisture.

By interpolation:

Density: 102.4 - 99.9 = 2.5
.60 X 2.5 = 1 .5 lb./cu. ft. difference

Moisture: 21 .5 - 20.3 = 1 .2
.60 X 1.2 = 0.7% difference

Therefore:

Maximum dry density = 102.4 - 1.5
= 100.9 lb./cu. ft.

Optimum Moisture = 20.3 + 0.7 = 21.0%

* As an alternate to performing the interpolation procedure, Table 1 below can be used to determine the maximum dry density and optimum moisture content when the plotted point falls between two moisture-density curves.

NOTE: The optimum moisture and maximum dry density determinations above are for the material passing the No. 4 sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

REPORT

8. Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required.

A	**141.8**	**6.6**	**F**	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**
10%	141.5	6.7	**10%**	129.0	9.8	**10%**	116.8	13.6	**10%**	104.5	19.3	**10%**	91.9	26.0
20%	141.3	6.7	**20%**	128.8	9.9	**20%**	116.5	13.7	**20%**	104.2	19.4	**20%**	91.7	26.1
30%	141.0	6.8	**30%**	128.5	9.9	**30%**	116.3	13.8	**30%**	104.0	19.5	**30%**	91.4	26.3
40%	140.7	6.8	**40%**	128.2	10.0	**40%**	116.0	13.9	**40%**	103.8	19.6	**40%**	91.2	26.4
50%	140.5	6.9	**50%**	128.0	10.1	**50%**	115.8	14.1	**50%**	103.6	19.8	**50%**	91.0	26.6
60%	140.2	7.0	**60%**	127.7	10.2	**60%**	115.6	14.2	**60%**	103.3	19.9	**60%**	90.8	26.8
70%	139.9	7.0	**70%**	127.4	10.3	**70%**	115.3	14.3	**70%**	103.1	20.0	**70%**	90.6	26.9
80%	139.6	7.1	**80%**	127.1	10.3	**80%**	115.1	14.4	**80%**	102.9	20.1	**80%**	90.3	27.1
90%	139.4	7.1	**90%**	126.9	10.4	**90%**	114.8	14.5	**90%**	102.6	20.2	**90%**	90.1	27.2
B	**139.1**	**7.2**	**G**	**126.6**	**10.5**	**L**	**114.6**	**14.6**	**Q**	**102.4**	**20.3**	**V**	**89.9**	**27.4**
10%	138.8	7.3	**10%**	126.4	10.6	**10%**	114.3	14.7	**10%**	102.2	20.4	**10%**	89.7	27.6
20%	138.5	7.3	**20%**	126.1	10.6	**20%**	114.1	14.8	**20%**	101.9	20.5	**20%**	89.4	27.8
30%	138.3	7.4	**30%**	125.9	10.7	**30%**	113.8	15.0	**30%**	101.7	20.7	**30%**	89.2	28.0
40%	138.0	7.5	**40%**	125.6	10.8	**40%**	113.6	15.1	**40%**	101.4	20.8	**40%**	88.9	28.2
50%	137.7	7.6	**50%**	125.4	10.9	**50%**	113.3	15.2	**50%**	101.2	20.9	**50%**	88.7	28.5
60%	137.4	7.6	**60%**	125.2	10.9	**60%**	113.0	15.3	**60%**	100.9	21.0	**60%**	88.5	28.7
70%	137.1	7.7	**70%**	124.9	11.0	**70%**	112.8	15.4	**70%**	100.7	21.1	**70%**	88.2	28.9
80%	136.9	7.8	**80%**	124.7	11.1	**80%**	112.5	15.6	**80%**	100.4	21.3	**80%**	88.0	29.1
90%	136.6	7.8	**90%**	124.4	11.1	**90%**	112.3	15.7	**90%**	100.2	21.4	**90%**	87.7	29.3
C	**136.3**	**7.9**	**H**	**124.2**	**11.2**	**M**	**112.0**	**15.8**	**R**	**99.9**	**21.5**	**W**	**87.5**	**29.5**
10%	136.1	8.0	**10%**	124.0	11.3	**10%**	111.8	15.9	**10%**	99.7	21.6	**10%**	87.3	29.6
20%	135.9	8.0	**20%**	123.7	11.3	**20%**	111.5	16.0	**20%**	99.4	21.7	**20%**	87.0	29.7
30%	135.6	8.1	**30%**	123.5	11.4	**30%**	111.3	16.1	**30%**	99.2	21.9	**30%**	86.8	29.8
40%	135.4	8.1	**40%**	123.2	11.5	**40%**	111.0	16.2	**40%**	98.9	22.0	**40%**	86.5	29.9
50%	135.2	8.2	**50%**	123.0	11.6	**50%**	110.8	16.4	**50%**	98.7	22.1	**50%**	86.3	30.0
60%	135.0	8.3	**60%**	122.7	11.6	**60%**	110.6	16.5	**60%**	98.4	22.2	**60%**	86.0	30.1
70%	134.8	8.3	**70%**	122.5	11.7	**70%**	110.3	16.6	**70%**	98.2	22.3	**70%**	85.8	30.2
80%	134.5	8.4	**80%**	122.2	11.8	**80%**	110.1	16.7	**80%**	97.9	22.5	**80%**	85.5	30.3
90%	134.3	8.4	**90%**	122.0	11.8	**90%**	109.8	16.8	**90%**	97.7	22.6	**90%**	85.3	30.4
D	**134.1**	**8.5**	**I**	**121.7**	**11.9**	**N**	**109.6**	**16.9**	**S**	**97.4**	**22.7**	**X**	**85.0**	**30.5**
10%	133.9	8.6	**10%**	121.5	12.0	**10%**	109.4	17.0	**10%**	97.1	22.9	**10%**	84.8	30.6
20%	133.7	8.6	**20%**	121.2	12.1	**20%**	109.1	17.1	**20%**	96.8	23.0	**20%**	84.6	30.7
30%	133.5	8.7	**30%**	121.0	12.1	**30%**	108.9	17.3	**30%**	96.6	23.2	**30%**	84.4	30.8
40%	133.3	8.7	**40%**	120.7	12.2	**40%**	108.6	17.4	**40%**	96.3	23.4	**40%**	84.2	30.9
50%	133.1	8.8	**50%**	120.5	12.3	**50%**	108.4	17.5	**50%**	96.0	23.6	**50%**	84.0	31.0
60%	132.8	8.8	**60%**	120.3	12.4	**60%**	108.1	17.6	**60%**	95.7	23.7	**60%**	83.8	31.1
70%	132.6	8.9	**70%**	120.0	12.5	**70%**	107.9	17.7	**70%**	95.4	23.9	**70%**	83.6	31.2
80%	132.4	8.9	**80%**	119.8	12.5	**80%**	107.6	17.9	**80%**	95.2	24.1	**80%**	83.4	31.3
90%	132.2	9.0	**90%**	119.5	12.6	**90%**	107.4	18.0	**90%**	94.9	24.2	**90%**	83.2	31.4
E	**132.0**	**9.0**	**J**	**119.3**	**12.7**	**O**	**107.1**	**18.1**	**T**	**94.6**	**24.4**	**Y**	**83.0**	**31.5**
10%	131.7	9.1	**10%**	119.1	12.8	**10%**	106.9	18.2	**10%**	94.4	24.5	**10%**	82.8	31.6
20%	131.5	9.1	**20%**	118.8	12.9	**20%**	106.6	18.3	**20%**	94.1	24.7	**20%**	82.6	31.7
30%	131.2	9.2	**30%**	118.6	12.9	**30%**	106.4	18.4	**30%**	93.9	24.8	**30%**	82.4	31.8
40%	130.9	9.3	**40%**	118.4	13.0	**40%**	106.1	18.5	**40%**	93.6	25.0	**40%**	82.2	31.9
50%	130.7	9.4	**50%**	118.2	13.1	**50%**	105.9	18.7	**50%**	93.4	25.1	**50%**	82.1	32.0
60%	130.4	9.4	**60%**	117.9	13.2	**60%**	105.7	18.8	**60%**	93.1	25.2	**60%**	81.9	32.1
70%	130.1	9.5	**70%**	117.7	13.3	**70%**	105.4	18.9	**70%**	92.9	25.4	**70%**	81.7	32.2
80%	129.8	9.6	**80%**	117.5	13.3	**80%**	105.2	19.0	**80%**	92.6	25.5	**80%**	81.5	32.3
90%	129.6	9.6	**90%**	117.2	13.4	**90%**	104.9	19.1	**90%**	92.4	25.7	**90%**	81.3	32.4
F	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**	**Z**	**81.1**	**32.5**

TABLE 1

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = _____ Cu. ft.
Weight of Mold = M2 = _____ grams _____ pounds
Weight of Sample and Mold = M1 = _____ grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = _____ \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = _____ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

$$\text{Total \% Moisture} = TW = \frac{W(100 - PR4) + PR4}{100} = _____ \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = _____ lb./cu. ft.
Percent Optimum Moisture = OM = _____ %

REMARKS: _____

FIGURE 1

Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

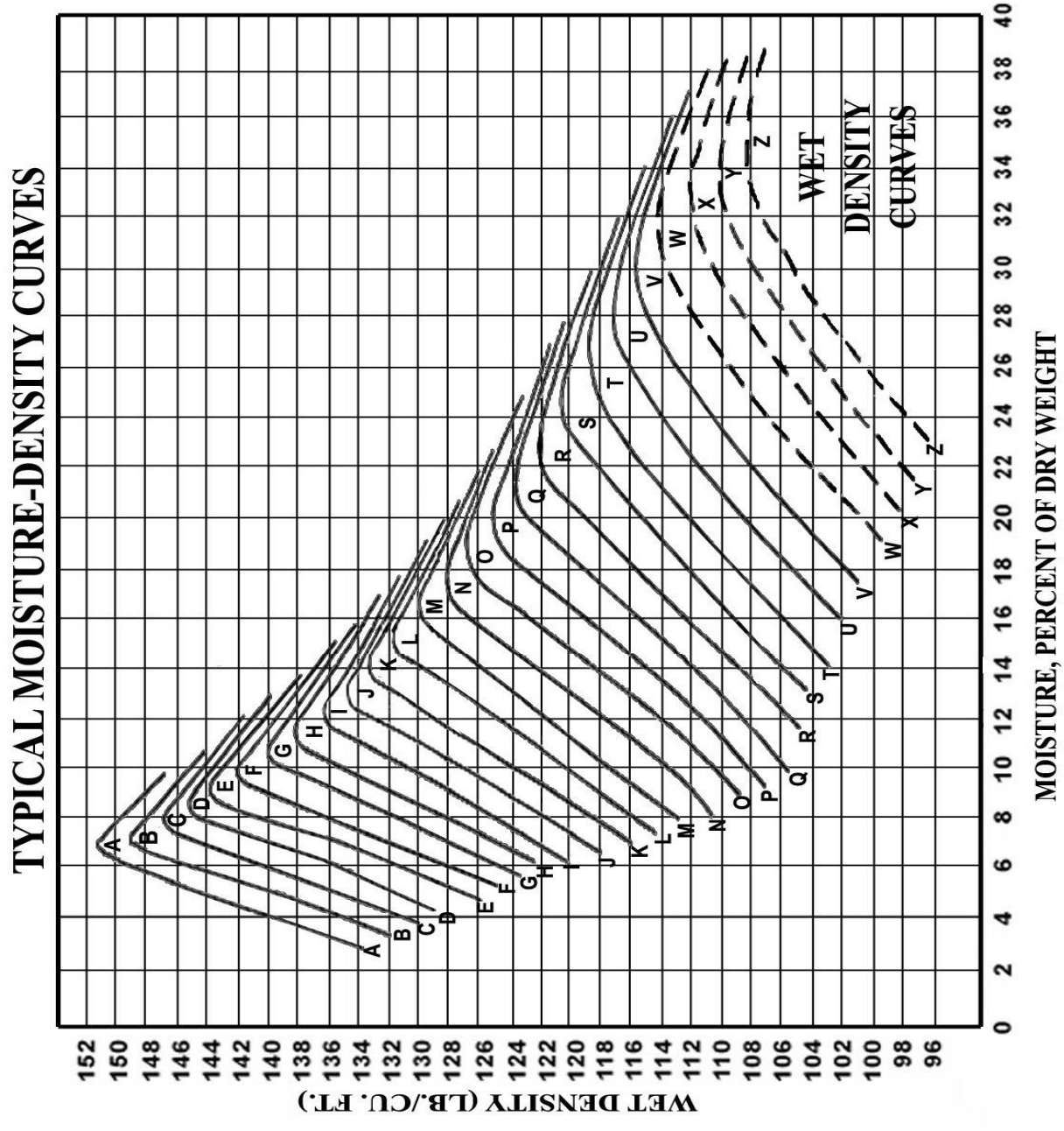


FIGURE 2

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ Tracs No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A **X** Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = **0.0335** Cu. ft.
Weight of Mold = M2 = _____ grams **10.23** pounds
Weight of Sample and Mold = M1 = _____ grams **14.25** pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \textbf{120.0} \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = **340.4** grams
Dry Weight of Moisture Sample = DW = **283.7** grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = \textbf{20.0} \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

% Moisture in Pass No. 4 material from Speedie = W = _____ %

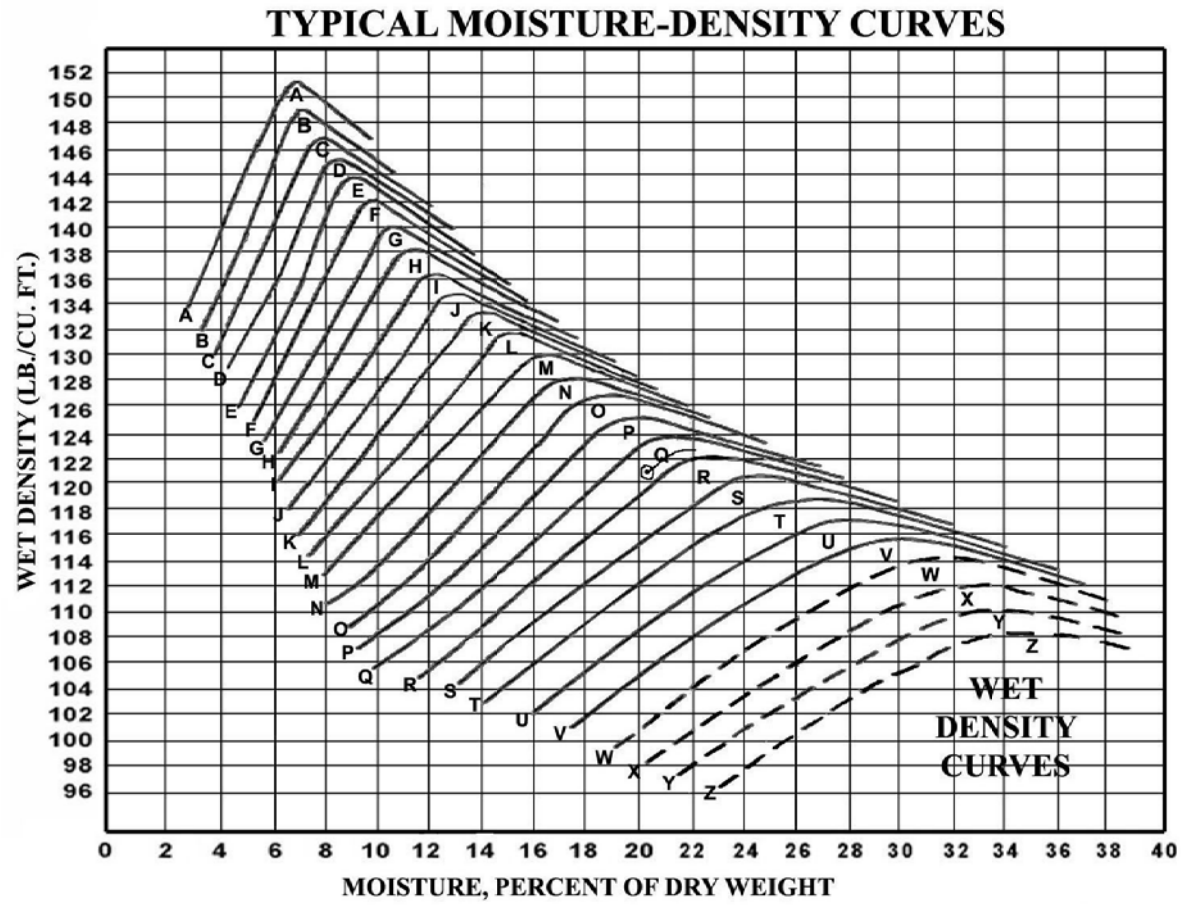
$$\text{Total \% Moisture} = TW = \frac{W(l00 — PR4) + PR4}{100} = _____ \%$$

From Typical Moisture-Density Curves:

Maximum Dry Density = MD = **100.9** lb./cu. ft.
Percent Optimum Moisture = OM = **21.0** %

REMARKS: _____

FIGURE 3



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

FIGURE 4

Approx. 60% Below Curve Q

Interpolated Max. Dry Density: 102.4 (Curve Q)
- 99.9 (Curve R)
2.5 X 0.60 = 1.5 lb./cu. ft.

102.4 - 1.5 = 100.9 lb. / cu. ft.

Interpolated % Optimum Moisture: 21.5 (Curve R)
- 20.3 (Curve Q)
1.2 X 0.60 = 0.7%

20.3 + 0.7 = 21.0%

FLAKINESS INDEX OF COARSE AGGREGATE

(An Arizona Method)

1. SCOPE

1.1 This test method describes the procedure for determining the "Flakiness Index" (flatness) of coarse plus No. 8 aggregate. The Flakiness Index is the percentage of particles having a least dimension smaller than 60 percent of the mean size of each of one or more of the coarse sieve fractions. The lower the index for any sample of aggregate, the more nearly the aggregate particles approximate a cubical shape.

1.2 Once the Flakiness Index is known, the average least dimension of the aggregate can be determined if required, for example as in Arizona Test Method 819, “Design of Exposed Aggregate Seal Coats”. The procedure for determining the average least dimension of the aggregate is described in Section 6 of this test method.

1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 For each size of material to be tested, a 16 gauge steel plate (1/16 inch nominal thickness) with a slotted opening approximately 4 inches in length and having a width conforming to the applicable requirements given below. If desired, the same plate may contain all or some of the required slots, rather than a separate plate for each.

Size of Material Passing	Size of Material Retained	Slot Width (inches)	Slot Width Tolerance (inches)
1-1/2"	1"	0.738	± 0.023
1"	3/4"	0.520	± 0.016
3/4"	1/2"	0.372	± 0.012
1/2"	3/8"	0.260	± 0.008
3/8"	1/4"	0.187	± 0.006
1/4"	No. 4	0.131	± 0.004
No. 4	No. 8	0.084	± 0.003

2.3 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least one gram.

2.4 Sieves conforming to the requirements of ASTM E11, of sizes 1-1/2", 1", 3/4", 1/2", 3/8", 1/4", No. 4, and No. 8, as necessary for the material being tested.

3. SAMPLE PREPARATION

3.1 A representative sample of the aggregate for the specified use shall be obtained. The size of sample shall be at least the size required by Arizona Test Method 201, and larger if necessary to provide adequate material for the applicable required individual size fractions indicated below. See Subsection 3.3 below for determination of the individual size fractions to be tested.

Size of Material Passing	Size of Material Retained	Minimum Test Sample (grams)
1-1/2"	1"	3000
1"	3/4"	1500
3/4"	1/2"	1000
1/2"	3/8"	500
3/8"	1/4"	200
1/4"	No. 4	100
No. 4	No. 8	50

3.2 The sample shall be subjected to sieve analysis in accordance with Arizona Test Method 201. If both the coarse and fine sieve analysis of the material are performed, material passing the No. 4 sieve shall be separated into No. 8 and

passing No. 8 fractions by sieving over a No. 8 sieve. Reference can also be made to Section 3 of Arizona Test Method 248 for utilizing a No. 8 sieve in the coarse sieving, and a fine sieve analysis not being required. The coarse aggregate size fractions of No. 8 and larger shall be placed in individual containers. The material passing the No. 8 sieve may be discarded.

3.3 From each size fraction that has a percent retained value from sieve analysis which is equal to or greater than 10%, obtain a representative test sample of the weight specified in Subsection 3.1 above.

4. FLAKINESS INDEX TEST PROCEDURE

4.1 Weigh each test sample to the nearest gram and record as the "Weight of Test Sample", for the respective size fraction.

4.2 The particles from the test sample for each size fraction shall be individually tested for their ability to pass through the appropriate slot, as specified in Subsection 2.2. Weigh the material which passes the appropriate slot, and record to the nearest gram as the "Weight Passing Slot", for the respective size fraction.

5. CALCULATIONS FOR FLAKINESS INDEX DETERMINATION

5.1 Figure 1 is an example of the calculations. Figure 2 is a blank Flakiness Index form which contains the required calculations.

5.2 Calculate the "Percent Passing Slot", for each respective size fraction, and record to the nearest percent.

5.3 Calculate the "Flakiness Index", and report the result to the nearest percent.

6. DETERMINATION OF AVERAGE LEAST DIMENSION OF AGGREGATE

6.1 When it is required (such as in Arizona Test Method 819), the average least dimension of the aggregate may be determined by using Figures 3 and 4. (These figures include an example which illustrates the procedure described in the paragraphs below.)

6.2 The median size of the aggregate is determined as shown in the example in Figure 3. Plot the % passing from sieve analysis for the two sieve sizes sufficient to locate the 50% line intercept. Draw a line between the two points. From the 50% passing point on the right side of the chart, proceed horizontally to the left until the line drawn between the two points is intercepted. Draw a line vertically from this point to intercept the "Median Size" scale at the bottom of the chart. Read the resultant median size to the nearest 0.01 inch.

6.3 The average least dimension of the aggregate is determined as shown in the example in Figure 4. Find the point for "Median Size" on the left side of the chart. Proceed horizontally to the right until the corresponding line for Flakiness Index is intercepted. Draw a line vertically from this point to intercept the "AVERAGE LEAST DIMENSION" at the bottom of the chart. Read and record the average least dimension of the aggregate to the nearest 0.01 inch.

FLAKINESS INDEX CALCULATIONS

(ARIZONA TEST METHOD 233)

Project No.: F-099-9 (9) / H099901C Lab No.: 15-524 Material: Cover Material

Sieve Size	1-1/2"	1"	3/4"	1/2"	3/8"	1/4"	#4	# 8
% Pass from Sieve Analysis				100	78	27	13	2
% Ret. From Sieve Analusis **(F)**				0	22	51	14	11
Weight of Test Sample				-	611	263	139	78
Weight Passing Slot				-	104	71	28	19
* Percent Passing Slot **(P)**				-	17	27	20	24
NOTE: Only the size fractions which have 10 or more percent retained are tested for passing the apporpriate slot, and uses to determine the flakiness Index by the equation below.	*Percent Passing Slot (P) = $\frac{\text{Weight Passing Slot}}{\text{Weight of Test Sample}}$ x 100							

FLAKINESS INDEX = $\frac{[\mathbf{F}\ 1\text{-}1/2" \times \mathbf{P}\ 1\text{-}1/2"] + \ldots + \ldots + [\mathbf{F}\ \text{No. 8} \times \mathbf{P}\ \text{No. 8}]}{[\mathbf{F}\ 1\text{-}1/2" + \ldots + \ldots + [\mathbf{F}\ \text{No. 8}]}$

FLAKINESS INDEX = $\frac{(\ 22 \times 17\ ) + (\ 51 \times 27\ ) + (\ 14 \times 20\ ) + (\ 11 \times 24\ )}{(\ 22\ ) + (\ 51\ ) + (\ 14\ ) + (\ 11\ )}$ = ***23*** %

REMARKS:

Test Operator and Date: **Joe Tester 11/20/96** Supervisor and Date: **Peter Headman 11/20/96**

FIGURE 1

FLAKINESS INDEX CALCULATIONS

(ARIZONA TEST METHOD 233)

Project No.: _____ Lab No.: _____ Material: _____

Sieve Size	1-1/2"	1"	3/4"	1/2"	3/8"	1/4"	#4	# 8
% Pass from Sieve Analysis								
% Ret. From Sieve Analusis **(F)**								
Weight of Test Sample								
Weight Passing Slot								
* Percent Passing Slot **(P)**								
NOTE: Only the size fractions which have 10 or more percent retained are tested for passing the apporpriate slot, and uses to determine the flakiness Index by the equation below.	*Percent Passing Slot (P) = $\frac{\text{Weight Passing Slot}}{\text{Weight of Test Sample}} \times 100$							

$$\text{FLAKINESS INDEX} = \frac{[\mathbf{F}\ 1\text{-}1/2" \times \mathbf{P}\ 1\text{-}1/2"] + \ldots + \ldots + [\mathbf{F}\ \text{No. 8} \times \mathbf{P}\ \text{No. 8}]}{[\mathbf{F}\ 1\text{-}1/2" + \ldots + \ldots + [\mathbf{F}\ \text{No. 8}]}$$

$$\text{FLAKINESS INDEX} = \frac{\text{x} \quad) + (\quad \text{x} \quad) + (\quad \text{x} \quad) + (\quad \text{x} \quad)}{(\quad + \quad + \quad + \quad)} = _____\ \%$$

REMARKS:

Test Operator and Date: _____ Supervisor and Date: _____

FIGURE 2

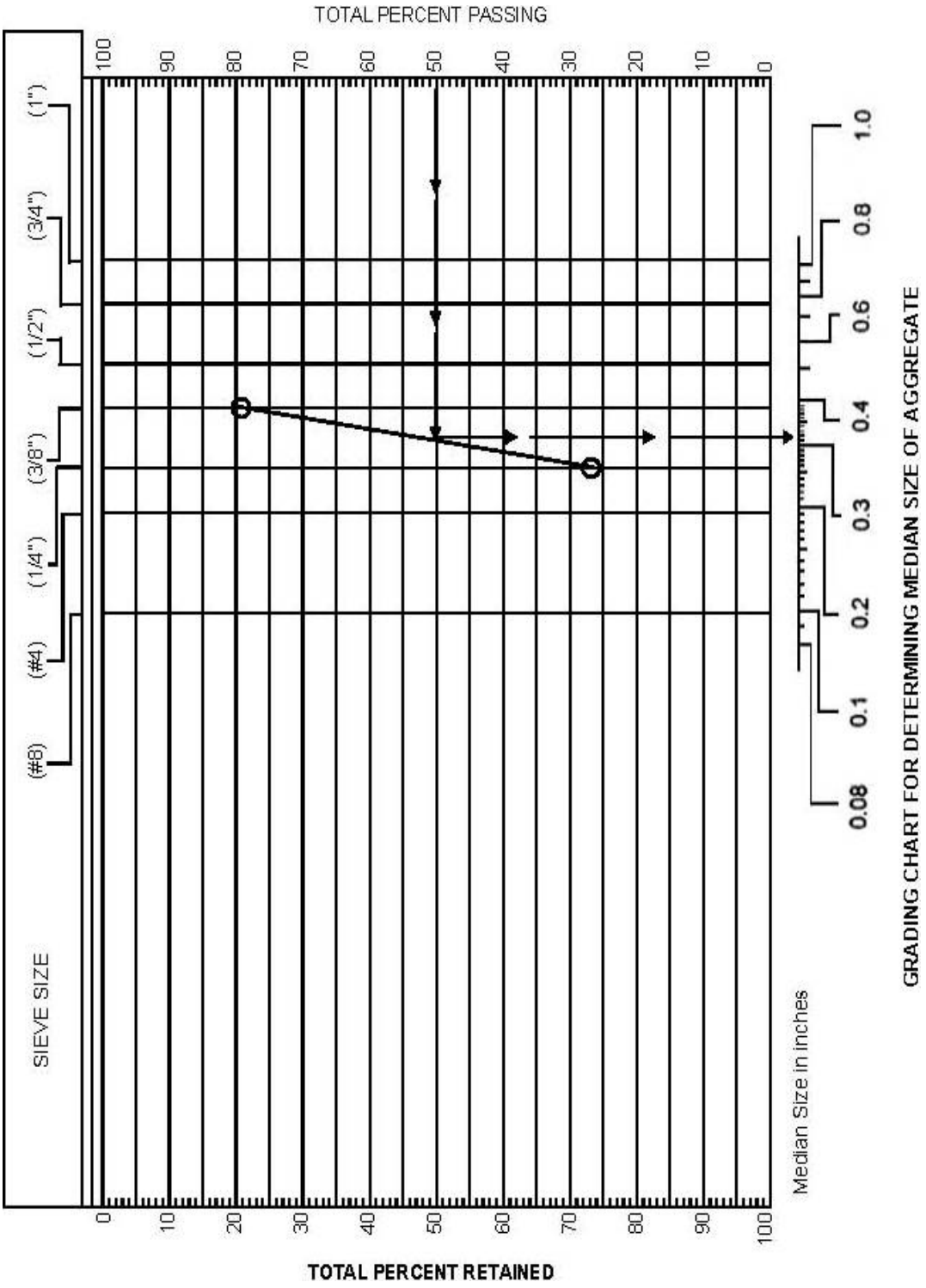

TOTAL PERCENT PASSING
100
90
80
70
60
50
40
30
20
10
0
SIEVE SIZE
(1")
(3/4")
(1/2")
(3/8")
(1/4")
(#4)
(#8)
0
10
20
30
40
50
60
70
80
90
100
TOTAL PERCENT RETAINED
Median Size in inches
1.0
0.8
0.6
0.4
0.3
0.2
0.1
0.08
GRADING CHART FOR DETERMINING MEDIAN SIZE OF AGGREGATE

FIGURE 3

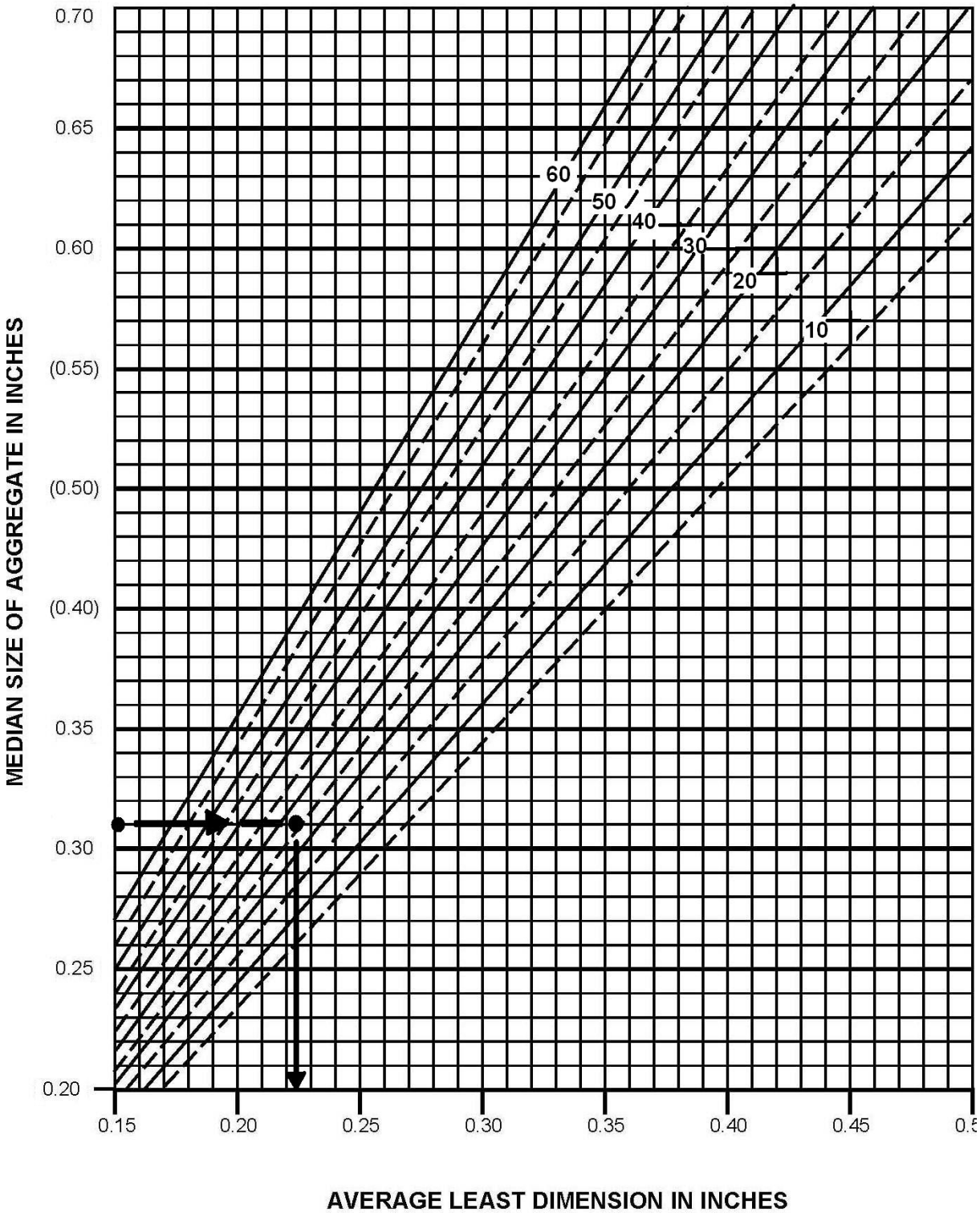

0.70
0.65
0.60
(0.55)
(0.50)
(0.40)
0.35
0.30
0.25
0.20
MEDIAN SIZE OF AGGREGATE IN INCHES
60
50
40
30
20
10
0.15
0.20
0.25
0.30
0.35
0.40
0.45
AVERAGE LEAST DIMENSION IN INCHES

FIGURE 4

ARIZ 235
November 1, 1992
(13 Pages)

FIELD DENSITY AND MOISTURE CONTENT OF SOIL AND SOIL-AGGREGATE MIXTURES BY THE NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This method is used to determine the in-place density and moisture content of compacted soil and soil-aggregate mixtures to a depth of 12 inches with a nuclear gauge. This test method is especially suited for soils of a specified gradation such as aggregate base course, or fine soils of a consistent nature. Rock correction of the Proctor maximum density requires excavation of the soils at the test site to determine rock content, which increases the time required for the test and decreases test efficiency. This method is acceptable for normal soil and aggregate density testing, including pumping and heaving soils, but should not be used for open-graded aggregate.

(b) An example is provided in Figure 1 for the calculations and determinations referenced herein.

SAFETY

2. (a) This test method involves hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(b) Safety procedures for operation, transport and storage of nuclear gauges shall be in accordance with the manufacturer's recommendations and the applicable regulations of the Arizona Radiation Regulatory Agency (ARRA).

APPARATUS

3. The apparatus shall consist of the following:

(a) Moisture/Density Nuclear gauge capable of determining densities by the direct transmission method. Calibration of the gauge shall be performed in accordance with AASHTO T238, Subsection 3.1., on an annual basis. Adjustment of the calibration curve for field soil conditions shall be done as needed in accordance with AASHTO T238, Subsection 3.3.

(b) Reference standard block or test stand to obtain standard counts for moisture and density which are used to check the gauge stability.

(c) Nuclear gauge transport case and labels which comply with A.R.R.A. Regulations.

(d) Charging cord, if applicable.

(e) Scraper plate and drill rod guide.

(f) Drill rod.

(g) Hammer for driving the drill rod to make the hole for the direct transmission probe.

(h) A #10 sieve or a supply of dry, fine-sieved sand to be used as a sand blanket for surface irregularities at the test site and a fine brush for sand removal.

(i) A #4 and 3/4 inch sieve for use in removing plus #4 or plus 3/4 inch material for rock correction, depending upon the proctor method.

(j) A 3 inch sieve for determining the presence of oversize rock material.

(k) Safety goggles for eye protection, steel-toed footwear, and the radiation exposure badge.

(l) Information packet for the nuclear gauge which shall contain the following items:

1) Moisture/Density Calibration Tables (if required), and a standard count log book.

2) Manufacturer's Gauge Operation Manual for the nuclear gauge.

3) Applicable documentation necessary to meet requirements of ARRA for gauge safety.

4) Blank test forms for use on the applicable nuclear gauge (See Figure 2).

(m) Calculator for necessary computations.

(n) Miscellaneous equipment including watch, pencils, writing paper, ruler, eraser, clip board, and hand cart as required.

GAUGE STABILITY CHECK

4. A density standard count and moisture standard count shall be taken at the beginning of each day of testing at the project where the field density testing is to be performed. The gauge stability check shall be performed as follows:

(a) Place the reference standard block on any asphalt, concrete, compacted aggregate or similar surface which is dry and level. The reference standard block should be at least 24 inches away from any vertical projection, at least 15 feet away from any large object, or vehicle, and at least 50 feet away from another nuclear gauge.

(b) Seat the nuclear gauge on the reference block in accordance with the gauge operation manual. It is very important that the gauge is seated properly on the standard reference block.

(c) Remove the lock on the source handle and make sure the source handle is in the safe or stored position (the top notch on the index rod).

(d) Turn the gauge on (in standby power condition) and allow it to warm-up, if neccessary, for the recommended time as given in the gauge operation manual, normally 15 minutes.

(e) After the warm-up period, take a standard moisture count and a standard density count.

(f) Record the moisture and density standard counts in the proper columns of the standard count log book along with the appropriate additional information, such as date, time, temperature, and location.

(g) Return the gauge to the standby power condition. The gauge should be left in the standby mode for subsequent testing.

(h) Determine if the standard counts are within the limits for normal operation in accordance with the gauge operation manual. This is usually done by comparing the standard counts to the average of the four previous standard counts or utilizing an internal statistical test which is available on some gauges. Additional standard counts may be necessary if initially the gauge does not appear to be operating properly. If the gauge does not meet the normal operating parameters as specified by the Standard Count procedure in the gauge operation manual, the gauge should not be used for testing. It should be sent in for servicing to determine the problem.

NOTE: Some gauges will store standard counts for later use in calculations performed by the gauge itself. The most recent standard counts will usually be stored automatically over preexisting standard counts.

(i) On a weekly basis, compare the average of the four most recent standard counts with the average of four standard counts immediately after gauge calibration or at least three months previous, whichever is shorter. If the accumulative shift in standard count exceeds 2% for moisture or 3% for density, the nuclear gauge should be recalibrated.

SITE PREPARATION

5. (a) Select a location for the field density test at random where the gauge will be at least 24 inches from any vertical projection such as a trench wall, retaining wall or pipe, at least 15 feet away from any vehicle, and at least 50 feet away from another nuclear gauge. If within 24 inches of a vertical projection, refer to section 8, Trench Correction.

(b) Remove all loose, disturbed, and excess material as necessary to reach the top of the compacted lift to be tested. Prepare a horizontal area sufficient in size to accommodate the gauge using the scraper plate supplied with the gauge. Plane the area to a smooth condition removing loose stones to obtain maximum contact between the gauge and the soil or aggregate being tested. Make sure the gauge sits solidly on the test site without rocking.

(c) Use native fines which pass a #10 sieve, or fine dry sand to fill voids only, and level the excess with the scraper plate. The total area of voids filled with fines or sand should be minimized as much as possible.

OBTAINING NUCLEAR MOISTURE AND DENSITY COUNTS

6. (a) Nuclear Density Counts and Moisture Counts shall be obtained by inserting the probe into the soil at the test site. (Refer to the gauge operation manual.) Prior to density count determination, select the mode of testing as follows based on the lift thickness of the soil or aggregate being tested:

LIFT THICKNESS "T" INCHES	TRANSMISSION MODE
$T < 2$	Backscatter
$2 \leq T < 4$	Direct - 2 inch
$4 \leq T < 6$	Direct - 4 inch
$6 \leq T < 8$	Direct - 6 inch
$8 \leq T \leq 12$	Direct - 8 inch
$12 < T$	See 6(b) Below

(b) Tests which require the density for a lift greater than 12 inches in thickness require an initial surface test to determine the density of the upper portion of the lift. Then the soil must be excavated downward to allow another test or tests to determine the density of the lower portion of the lift.

(c) To prepare the gauge for direct transmission testing, place the scraper plate drill rod guide on the test site so that the access hole for the probe will be at the desired location.

(d) Securely hold the scraper plate in place while driving the drill rod into the material. The hole should be at least 2 inches deeper than the depth to be tested. Safety goggles and steel-toed footwear should be worn while driving the drill rod. Note the depth marks on the drill rod. It would be desirable to turn the drill rod slightly after every other blow to allow easier removal.

(e) Remove the drill rod by pulling straight up in order to avoid disturbing the access hole.

(f) Remove the scraper plate and clear away all loose surface material. Using fine material as stated previously, fill any voids caused by driving the drill rod.

(g) Carefully place the gauge over the access hole and extend the probe into the hole to the desired direct transmission mode depth according to the lift thickness as outlined previously. Do not force the probe into the hole. If the probe will not extend into the hole, pull the probe back up. Lift up the gauge and check for a probe imprint. This will help determine if a slight change in the

position of the gauge is necessary to allow the probe to enter the hole. Once the probe is in the hole, gently push it down. Some minor shifting of the gauge may be required to extend the probe in gravelly soils. However, if an obstruction is encountered, it may be necessary to use the drill rod again to open up the hole.

(h) Once the probe is fully extended to the direct transmission depth, pull the gauge firmly, toward the scaler or readout end of the gauge, so that the probe is in firm contact with the soil or aggregate on the scaler side of the hole.

(i) Take density and moisture counts for a minimum one minute time period by pressing the proper button on the gauge. Both counts normally will occur simultaneously during the count period (Refer to the gauge operation manual).

(j) After the count period, press the proper button to obtain the moisture count. Record the moisture count on the data sheet, as "MC". Also, in a similar manner, obtain the density count. Record the density count on the data sheet, as "DC". It is also possible to get a wet density and moisture content readout in lbs./cu.ft. at this time for gauges capable of storing the standard counts and calculating these values (Refer to the gauge operation manual). If so, obtain these values and record on the test data sheet as "WD" and "M" respectively. The gauge may also be capable of calculating the moisture content in %, "M%", and the dry density in lbs./cu.ft., "DD". If so, these values may be recorded on the test data sheet. However, the gauge internal calculations may require some additional corrections as required by the test location or soil type. Refer to Sections 8 and 9 for further information on the trench and moisture corrections.

(k) In those instances when the soil or soil-aggregate mixture being tested in-place is not homogeneous and/or contains substantial variations in the rock content, it may be necessary to rotate the gauge 90 degrees at each test site and obtain an additional moisture and wet density reading at that position. If the new moisture and wet density readings differ by 5% or less from the original readings, the two readings may be averaged for use in later calculations. If they differ from the original readings by more than 5%, the gauge should be moved to a new test site.

PROCTOR DENSITY ROCK CORRECTION

7. (a) For determining the percent compaction based on the maximum proctor densities determined by Method A (Arizona Test Method 225 or 232) or Alternate Method D (Arizona Test Method 245 or 246), a rock correction may be

required for the amount of plus No. 4 (Method A) or plus 3/4 inch (Alternate Method D) rock or coarse aggregate in the material tested by the nuclear gauge.

(b) If it appears that 10% of the material will be retained on the No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D), excavate the area occupied by the base of the gauge at the testing location to the depth of the test, which is normally the lift thickness. If an average rock correction is to be utilized, refer to 7(f).

(c) Obtain a minimum 3000 gram (7 pound) sample of excavated material and weigh to the nearest gram. Record the weight of this sample as "A". Sieve this material first over a 3 inch sieve to determine the presence of any oversize rock material. If any oversize rock is encountered, proceed to 7(d). If not, sieve the material over a No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D), and record the weight of retained material as "B". Proceed to 7(e).

(d) If any rock is retained on the 3 inch sieve, this shall be reported with a note stating that the density is not determinable due to rock being retained on the 3 inch sieve. Additional attempts should be made to locate an area where the test can be accomplished.

(e) Calculate the percent of coarse particles, "PR" according to the following equation:

$$PR = \frac{B}{A} \times 100$$

Where: PR = Percent of coarse aggregate or rock particles retained on either the No. 4 sieve for Method A or the 3/4 inch for Alternate Method D.

B = Weight of coarse aggregate or rock particles retained on the No. 4 sieve (Method A) or 3/4 inch sieve (Alternate Method D).

A = Weight total of sample which is sieved.

(f) If the material has from 10 to 50 percent (10 to 60 percent in the case of an Aggregate Base) retained on the No. 4 sieve (Method A) or 10 to 50 percent retained on the 3/4 inch sieve (Alternate Method D), the maximum proctor density will require a rock correction. Record the data at the appropriate locations on the data sheet.

(g) If the percent retained on the No. 4 sieve or 3/4 inch exceeds the maximum values listed above (50 or 60 percent), report the percent rock with a note stating that the density is not determinable due to excess rock. Additional attempts should be made to locate an area where a test can be accomplished. Also, if the proctor is a Method A proctor, an Alternate Method D proctor may be considered for this material.

Note: When conditions prevent the determination of density at a specific location, due to the presence of excesssive rock or rock retained on the 3 inch sieve, the compactive effort in those areas should be the same as that performed in surrounding locations where the required density was found through testing to be satisfactory.

(h) If, from the results of a minimum of five samples, it is indicated that no rock is retained on the 3 inch sieve and the percent rock retained on the No. 4 or 3/4 inch sieve is within a 12% range (plus or minus 6% from the average), then an average percent of rock based on the five samples may be utilized. However, if a failing density test results from utilization of this average percent of rock, then the test site must be excavated and the actual percent of rock must be determined in accordance with 7(c) and 7(d) above. If there is a visible change in the material including the percent of rock, then a new proctor is required and a new average percent of rock must be determined.

TRENCH CORRECTION

8. (a) Moisture and dry density test results may be affected when a gauge is operated within 24 inches of a vertical projection such as a trench wall, pipe or retaining wall which contains moisture. The density counts, determined in the direct transmission mode, should not be affected, but moisture counts will possibly be affected. Without a trench correction, the moisture content determined could be higher than the actual moisture content which would cause the dry density determined to be too low. If the density test passes without a trench correction, then a trench correction would not be necessary.

(b) When a trench correction is necessary, refer to the gauge operation manual for the proper procedure in making a trench correction. Usually it is necessary that a moisture count be taken on the standard block in the trench at the same position and orientation that the moisture count for the density test is taken.

(c) Based on the original standard moisture count and the moisture count taken on the standard block in the trench, a trench correction may be made internally in most gauges by a calculation process or by an external manual moisture count shift. Refer to gauge operation manual for the proper input of the trench correction. Be sure to delete this correction after each test since each test location would have a different correction.

MOISTURE CORRECTION

9. (a) Moisture and dry density test results may be affected by hydrogen in the soil unrelated to actual moisture. Only the moisture reading is affected. The wet density reading is not affected.

(b) The moisture correction is obtained by determining the difference between the average oven dry moisture contents and the average nuclear gauge moisture contents for five or more samples obtained per paragraph 7(c). The oven-dry moisture content in percent, "TW", will be determined for each representative sample according to AASHTO T265. The sample shall include all plus No. 4 or 3/4 inch material, since the nuclear gauge measures total moisture. If the moisture is determined by the Speedy Moisture Tester and the sample contains material retained on the No. 4 sieve, the "Speedy" results must be adjusted in accordance with the following formula to obtain the percent moisture of the total sample.

$$TW = \frac{[W(100 - PR)] + PR}{100}$$

Where: TW = % moisture content in total sample
W = % moisture in Pass No. 4 material
PR = % rock retained on the No. 4 sieve

(c) A moisture correction is needed if the difference calculated indicates that the gauge moisture results are more than 1% higher or lower than the oven dry or Speedy results. Moisture corrections of 1% or less may be disregarded.

(d) Most gauges have the capability for correction of the moisture content in % by an internal calculation or an external moisture count shift. Simply apply the moisture correction up or down as applicable in the gauge according to the procedures in the gauge operation manual. Future density calculations within the gauge will apply this moisture count shift until it is deleted by the operator.

MOISTURE-DENSITY CALCULATIONS

10. Calculations shall be performed as follows:

(a) Record the standard counts for moisture and density on the data sheet in the spaces for "MS" and "DS" respectively.

(b) Most current gauges have the internal capability to calculate the moisture content in lbs./cu.ft. and %, the wet density in lbs./cu.ft., and the dry density in lbs./cu.ft. If so, record "M", "M%", "WD" and "DD" at the appropriate locations on the test data form. Also, list any corrections which have been input into the gauge and apply to these calculations. If it is necessary to use count ratios and calibration tables to determine the moisture content, wet density, and dry density, this should be done in accordance with the procedures in the gauge operation manual. Any data calculated in this manner should also be recorded on the test data sheet at the proper location.

(c) Determine from the correction data obtained in Section 7 whether a rock correction is necessary. If so, determine the rock corrected maximum density using the maximum proctor dry density and percent rock according to the Rock Correction Method, ARIZ 227.

(d) The percent of compaction, based on the maximum dry density (corrected, if necessary) is determined and reported to the nearest whole percent.

$$\% \text{ compaction} = \frac{DD \times 100}{MD \text{ or } CMD}$$

Where: MD = Maximum Proctor Dry Density (if no rock correction)
CMD = Corrected Maximum Density (if rock correction is necessary).

NOTE: If a rock correction is not necessary, many current nuclear gauges have the capability to perform all of the other density and moisture calculations internally, with results shown in the display or output to an external printer or computer. Refer to the gauge operation manual to take advantage of all possible gauge options.

REPORT

11. Record the pertinent moisture and density data on the test form along with the test number, location and other information required. An example is given in Figure 1. A blank test form is provided in Figure 2.

ARIZONA DEPARTMENT OF TRANSPORTATION
FIELD DENSITY/MOISTURE OF SOILS BY THE NUCLEAR METHOD
ARIZONA TEST METHOD 235

TRACS Number H 9999 01C
Project Code 8888
Date JAN. 13, 1993
Tested By JOE DOGOOD
Material Type EMBANKMENT
Test Number 22
Proctor Number EM #1
Material Source INPLACE
Test Location S.R. #51, STA. 97+00, 60' LT. E

Project Number F-099-9(11)
Contractor BUILD M. GOOD, INC.
Badge Number 19
Gauge Type 5001
Gauge Number 1146
Proctor Type METHOD A
Lift 7

STANDARD COUNTS
Density Standard (DS) 3239.4
Moisture Standard (MS) 415.1

FIELD COUNTS
Density Count (DC) 1645.8
Wet Density (WD) 126.7 PCF
Dry Density (DD) 124.0 PCF
Moisture Count (MC) 93.3
Moisture Content (M) 2.7 PCF
Moisture Content (M%) 2.2 %

ROCK CORRECTION [IF NECESSARY] (ARIZ 227)
Wet Wt. of Material (A) 24.72 lb.
Wet Wt. Retained (B) 6.07 lb.
Percent Rock (PR)
PR = (B/A) x 100 = 25 %

TRENCH CORRECTION [IF NECESSARY]
Trench Moist. Stand. (TMS) _____
Trench Moist. Count (TMC) _____
Trench Correction (TC)
TC = TMC - TMS = _____

MOISTURE CORRECTION [IF NECESSARY]
Moisture Correction _____ %
Input into gauge [YES/NO] _____

PROCTOR DATA (ARIZ 225 or 245)
Max. Dry Density (MD) 121.0 PCF
Coarse Agg. Sp. Gr. (SG) 2.609
Optimum Moisture 11.5 %
Proctor % Rock Retained 43 %
Corrected Maximum Dry Density (CMD) [For Rock Correction]:

$$CMD = \frac{[(100 - PR) \times (MD)] + [(56.2) \times (PR) \times (SG)]}{100} = 127.4 \text{ PCF}$$

ONE POINT PROCTOR DATA (ARIZ 232 or 246)
Wt. of Mold and Soil (M1) _____ lb
Mold Volume (VM) _____ CF
Moisture Content _____ %
Max. Dry Density (MD) _____ PCF
Wt. of Mold (M2) _____ lb
Wet Density (M1-M2)/VM _____ PCF
Density Curve I.D. _____
Corr. Max. Dry Dens. (CMD) _____ PCF

COMPACTION COMPLIANCE CALCULATION
Required Compaction 95 %
Pass ✓ Fail _____
Percent Compaction =
(DD x 100)/MD or CMD = 97.3 %

Remarks: _____

Lab Supervisor TED HEADMAN Date 1-13-93

44-1001 10/92

FIGURE 1

ARIZONA DEPARTMENT OF TRANSPORTATION
FIELD DENSITY/MOISTURE OF SOILS BY THE NUCLEAR METHOD
ARIZONA TEST METHOD 235

TRACS Number _____ Project Number _____
Project Code _____ Contractor _____
Date _____ Badge Number _____
Tested By _____ Gauge Type _____
Material Type _____ Gauge Number _____
Test Number _____ Proctor Type _____
Proctor Number _____ Lift _____
Material Source _____
Test Location _____

STANDARD COUNTS

Density Standard (DS) _____ Moisture Standard (MS) _____

FIELD COUNTS

Density Count (DC) _____ Moisture Count (MC) _____
Wet Density (WD) _____PCF Moisture Content (M) _____PCF
Dry Density (DD) _____PCF Moisture Content (M%) _____%

ROCK CORRECTION [IF NECESSARY] (ARIZ 227)

Wet Wt. of Material (A) _____ Percent Rock (PR)
Wet Wt. Retained (B) _____ PR = (B/A) x 100 = _____%

TRENCH CORRECTION [IF NECESSARY]

Trench Moist. Stand. (TMS) _____ Trench Correction (TC)
Trench Moist. Count (TMC) _____ TC = TMC - TMS = _____

MOISTURE CORRECTION [IF NECESSARY]

Moisture Correction _____% Input into gauge [YES/NO] _____

PROCTOR DATA (ARIZ 225 or 245)

Max. Dry Density (MD) _____PCF Optimum Moisture _____%
Coarse Agg. Sp. Gr. (SG) _____ Proctor % Rock Retained _____%
Corrected Maximum Dry Density (CMD) [For Rock Correction]:

$$CMD = \frac{[(100 - PR) \times (MD)] + [(56.2) \times (PR) \times (SG)]}{100} = _____ PCF$$

ONE POINT PROCTOR DATA (ARIZ 232 or 246)

Wt. of Mold and Soil (M1) _____lb Wt. of Mold (M2) _____lb
Mold Volume (VM) _____CF Wet Density (M1-M2)/VM _____PCF
Moisture Content _____% Density Curve I.D. _____
Max. Dry Density (MD) _____PCF Corr. Max. Dry Dens. (CMD) _____PCF

COMPACTION COMPLIANCE CALCULATION

Required Compaction _____% Percent Compaction =
Pass _____ Fail _____ (DD x 100)/MD or CMD = _____%

Remarks: _____

Lab Supervisor _____ Date _____

44-1001 10/92

FIGURE 2

DETERMINING pH AND MINIMUM RESISTIVITY OF SOILS AND AGGREGATES

(An Arizona Method)

1. SCOPE

1.1 This test method outlines the procedure for determining the pH and minimum resistivity of soil and aggregate materials.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Drying Apparatus - Any suitable device capable of drying samples at a temperature not exceeding 140 °F.

2.3 100 mL glass beaker or other suitable non-metallic container.

2.4 200 mL minimum capacity cylinder graduated in 1 mL increments.

2.5 Distilled Water.

2.6 pH Meter and combination probe, both having a relative accuracy of $\pm$ 0.05 pH units, minimum. The pH meter must be capable of registering a minimum pH range of 4.0 - 10.0, and be equipped with temperature compensation controls.

2.7 Standard Buffer Solutions of pH values 4.0, 7.0, and 10.0. The expiration date of the solution shall be noted on the container. Solution shall not be used past the expiration date.

2.8 Soil Box - Designed for use with the resistance meter. An example of an acceptable soil box is shown in Figure 1. Soil boxes which are commercially available may be used provided they meet the requirements specified herein. Soil boxes may vary in size. A unique soil box factor is determined for each soil box.

2.9 Resistance Meter - Instrument to determine resistance (ohms), readable to at least the nearest 10 ohms.

Note: The accuracy of the meter shall be established at these measurement levels: 50, 100, 200, 500, 900, 1500 ohms. The resistance standard(s) will have a tolerance of ± 1%. Any deviation greater than 5% from the known resistance shall require either calibration to within specified limits or the development of a calibration curve. Calibration results shall be recorded, dated, signed, and maintained on file for review.

2.10 No. 8 sieve conforming to ASTM E11.

2.11 A Balance or Scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.12 Thermometer - A thermometer accurate to 1 °F.

2.13 Miscellaneous mixing tools and pans.

3. SAMPLE PREPARATION

3.1 The soil sample as received from the field shall be dried thoroughly in air or the drying apparatus at a temperature not exceeding 140 °F.

3.2 A representative test sample of approximately 2000 grams shall then be obtained by splitting or quartering.

3.3 Screen the test sample through a No. 8 sieve.

3.4 From the screened Pass No. 8 Material, split out approximately 1500 grams for the resistivity test and obtain approximately 50 grams for the pH test. Record the weight of the pH material to the nearest 0.1 gram.

3.5 Combine the pH sample with an equal weight of distilled water in the 100 mL beaker. Stir until well mixed into a slurry and then stir at regular intervals of 8 to 10 minutes for an hour.

3.6 The temperature of the standard buffer solutions must be within 2 °F of the pH sample. Also, temperatures of the standard buffer solutions and the pH sample must be within the manufacturer's recommended temperature compensation range of the pH meter.

3.7 Place the resistivity sample in a mixing bowl. Add approximately 200 mL of distilled water to moisten the sample and mix thoroughly.

4. TEST PROCEDURE FOR pH

4.1 Per the manufacturer's instructions, standardize the pH meter using two of the standard buffer solutions: 7.0 and either 4.0 or 10.0, whichever is nearest to the estimated pH of the sample.

4.2 For each standard buffer solution, measure its temperature and adjust the temperature controller of the pH meter before testing for the standard solution pH value. This may not be needed on meters with automatic temperature compensation; follow manufacturer's instructions.

4.3 Stir the slurry mixture in the 100 mL beaker. Measure the temperature of the slurry and adjust the temperature controller of the pH meter before testing for the pH value of the slurry. This may not be needed on meters with automatic temperature compensation; follow manufacturer's instructions.

4.4 Carefully insert the pH probe in the slurry mixture. Do not place the electrode(s) into the soil; place them only into the slurry mixture. Determine the pH reading when the meter reading stabilizes.

4.5 If the pH reading is unstable when the electrode is immersed in the slurry, leave the electrode immersed until the pH reading has stabilized. In some cases, the waiting period for stabilization of the pH reading may take up to 5 minutes.

4.6 Record the pH value of the slurry mixture, to the nearest tenth.

5. TEST PROCEDURE FOR MINIMUM RESISTIVITY

5.1 Place moistened soil in a soil box with a known soil box factor, compact lightly with fingers and level off the top with a straightedge. Connect the resistance meter to the side terminals of the box. Determine resistance as per the manufacturer's instructions and record the resistance to the nearest 10 ohms.

5.2 Empty the soil back into the mixing bowl and add 50 mL of distilled water at room temperature and mix until all the water is dispersed uniformly through the soil.

5.3 Clean the soil box by rinsing with distilled water after each test application.

5.4 Fill the soil box by lightly hand compacting the wet soil, making sure that the soil completely fills the box. Level off the top of the hand compacted sample with a straightedge. Connect the resistance meter to the box. Read and record the resistance.

5.5 Repeat the above procedure, adding distilled water in increments of 50 mL. Ensure that each addition of water is dispersed evenly through the sample. The resistance readings should decrease, with the increase in moisture content, for several readings before an increase is noted. The lowest resistance reading before an increase is used for calculating the minimum resistivity of the soil.

6. CALCULATIONS FOR MINIMUM RESISTIVITY

6.1 Determine the length and width of the electrodes to the nearest 1 mm.

6.2 The soil box factor (SBF) expressed to the nearest 0.01 centimeter, is determined by the following equation:

$$SBF = \frac{A}{D} \times 0.10$$

Where: A = Area of one electrode, mm^2
D = Distance between electrodes, mm

Example: (For electrodes having a length of 152 mm and a width of 45 mm, and at a distance between electrodes of 102 mm.)

$A = 152\ mm \times 45\ mm = 6840\ mm^2$
$D = 102\ mm$

$$SBF = \frac{6840}{102} \times 0.10 = 6.71\,cm$$

Note: The soil box factor will depend on the soil box dimensions.

6.3 The minimum resistivity is determined by the following equation:

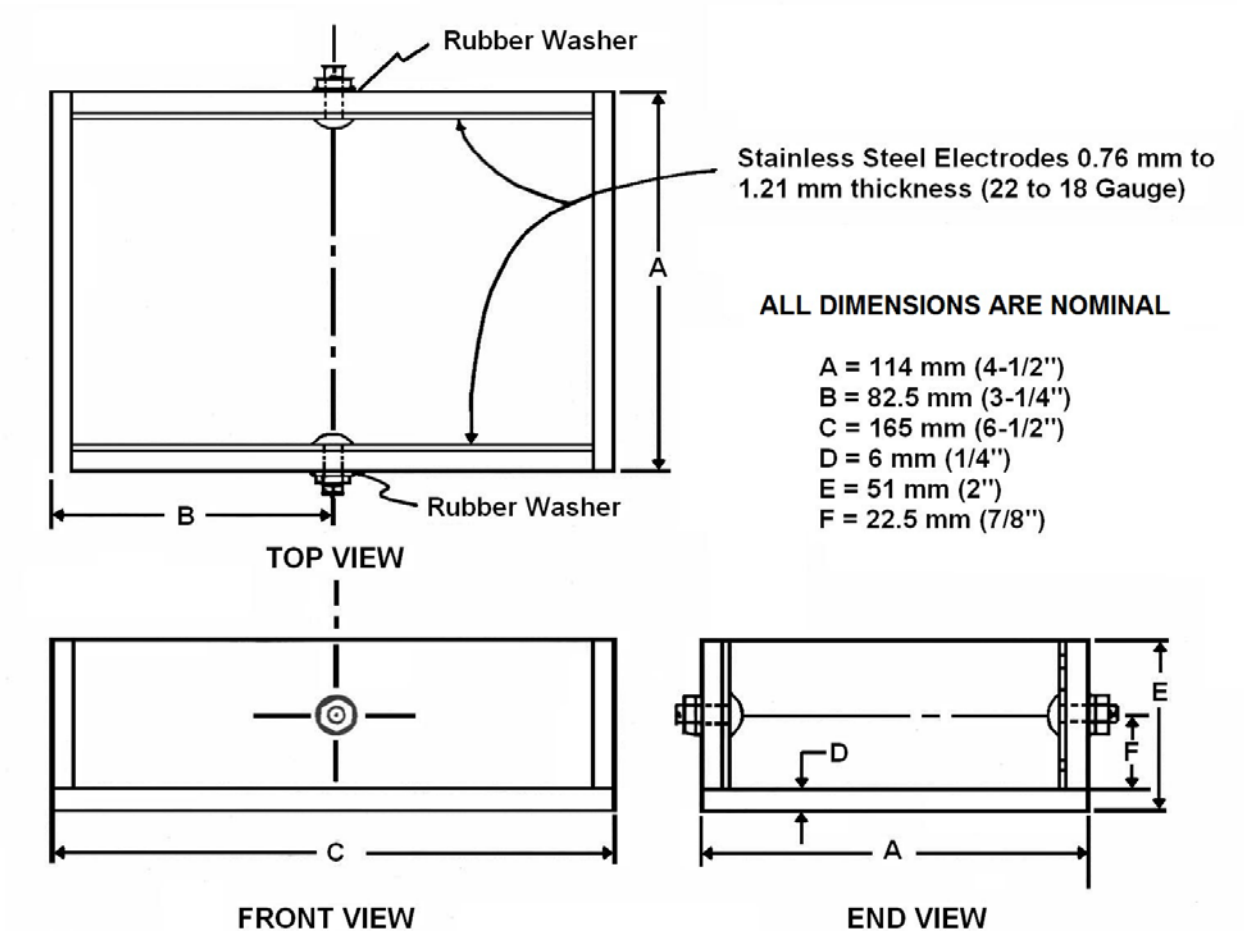
$$\begin{bmatrix}\text{Minimum Resistivity} \\ \text{(ohm - cm)}\end{bmatrix} = \begin{bmatrix}\text{Resistance} \\ \text{(ohms)}\end{bmatrix} \times \begin{bmatrix}\text{SBF} \\ \text{(cm)}\end{bmatrix}$$

Example: (For a resistance reading of 480 ohms and a soil box factor of 6.71 cm.)

Minimum Resistivity = (480 ohms) x (6.71 cm)
= 3220.8 ohm-cm
= 3221 ohm-cm

6.4 The minimum resistivity value is reported to the nearest whole number.

EXAMPLE OF AN ACCEPTABLE SOIL BOX



Box Material [6 mm (1/4”) Plastic]

Bottom - 1 piece: 165 mm x 114 mm x 6mm (6-1/2” x 4-1/2” x 1/4”)
Ends - 2 pieces: 114 mm x 45 mm x 6 mm (4-1/2” x 1-3/4” x 1/4”)
Sides - 2 pieces: 152 mm x 45 mm x 6 mm (6” x 1-3/4” x 1/4”)

Electrodes [0.76 mm to 1.21 mm thickness (22 to 18 Gauge) Stainless Steel]

2 pieces: 152 mm x 45 mm (6” x 1-3/4”)

Hardware - 2 each No. 8-32 x ¾” (or longer), or metric equivalent, Stainless Steel or Brass Machine Screw with Washer and Nut

Gasket - Rubber Washer

FIGURE 1

DETERMINING pH AND SOLUBLE SALTS OF SOILS

(An Arizona Method)

1. SCOPE

1.1 This test method describes the procedure for determining the pH and soluble salts content of soils.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Drying Apparatus - Any suitable device capable of drying samples at a temperature not exceeding 140 °F.

2.3 100 mL glass beaker or other suitable non-metallic container

2.4 250 mL glass beaker or other suitable non-metallic container

2.5 200 mL minimum capacity cylinder graduated in 1 mL increments

2.6 Richards or Buchner funnel

2.7 Vacuum Source

2.8 Conductance Meter

2.9 Conductivity Cell (Cell constant = 1.0/centimeter preferred)

2.10 Distilled Water

2.11 pH Meter and Combination Probe, both having a relative accuracy of ± 0.05 pH units, minimum. The pH meter must be capable of registering a minimum pH range of 4.0 - 10.0, and be equipped with temperature compensation controls.

2.12 Standard Buffer Solutions of pH values 4.0, 7.0, and 10.0. The expiration date of the solution shall be noted on the container. Solution shall not be used past the expiration date.

2.13 No. 8 sieve conforming to ASTM E11.

2.14 A Balance or Scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.15 Thermometer - A thermometer accurate to 0.5 °C (1 °F)

2.16 Miscellaneous mixing tools and pans

3. SAMPLE PREPARATION

3.1 The soil sample as received from the field shall be dried thoroughly in air or the drying apparatus at a temperature not exceeding 140 °F.

3.2 A representative test sample of approximately 500 grams shall then be obtained by splitting or quartering.

3.3 Screen the test sample through a No. 8 sieve.

3.4 From the screened Minus No. 8 Material, split out approximately 250 grams for the soluble salts test and approximately 50 grams for the pH test. Record the weight of the pH material to the nearest 0.1 gram.

3.5 Combine the pH sample with an equal weight of distilled water in the 100 mL beaker. Stir until well mixed into a slurry and then stir at regular intervals of 8 to 10 minutes for an hour.

3.6 The temperature of the standard buffer solutions must be within 2 °F of the pH sample. Also, temperatures of the standard buffer solutions and the pH sample must be within the manufacturer's recommended temperature compensation range of the pH meter.

3.7 Prepare a saturated soil paste from the soluble salts test sample by placing the soil in the 250 mL beaker. Begin adding distilled water and stirring with a spatula. From time to time tap the container on a work bench to consolidate the soil-water mixture. At saturation, the soil paste glistens as it reflects light, flows slightly when the container is tipped, and slides freely and cleanly off the spatula except for soils containing much clay. Allow the sample to stand overnight and then recheck the preceding criteria for saturation. Free water should not collect on the soil surface nor should the paste stiffen markedly or lose its glistening appearance on standing. If this occurs, remix with more water.

4. TEST PROCEDURE FOR pH

4.1 Per the manufacturer's instructions, standardize the pH meter using two of the standard buffer solutions: 7.0 and either 4.0 or 10.0, whichever is nearest to the estimated pH of the sample.

4.2 For each standard buffer solution, measure its temperature and adjust the temperature controller of the pH meter before testing for the standard solution pH value. This may not be needed on meters with automatic temperature compensation; follow manufacturer's instructions.

4.3 Stir the slurry mixture in the 100 mL beaker. Measure the temperature of the slurry and adjust the temperature controller of the pH meter before testing for the pH value of the slurry. This may not be needed on meters with automatic temperature compensation; follow manufacturer's instructions.

4.4 Carefully insert the pH probe in the slurry mixture. Do not place the electrode(s) into the soil; place them only into the slurry mixture. Determine the pH reading when the meter reading stabilizes.

4.5 If the pH reading is unstable when the electrode is immersed in the soil slurry, leave the electrode immersed until the pH reading has stabilized. In some cases, the waiting period for stabilization of the pH reading may take up to 5 minutes.

4.6 Record the pH value of the soil mixture, to the nearest tenth.

5. TEST PROCEDURE FOR SOLUBLE SALTS

5.1 Transfer the saturated soil paste to a filter funnel with a filter paper in place and apply vacuum until air begins to pass through the filter. Collect the extract in a bottle or test tube. Determine the temperature of the extract. Insert the conductivity cell into the extract, and determine electrical conductance. If the conductance falls above the highest range on the conductance meter, dilute the extract to one-tenth its original concentration of salts by diluting one part extract with 9 parts of distilled water. (The conductance reading obtained on the diluted extract must then be multiplied by ten since the conductance of the diluted extract is one-tenth the conductance of the original extract.)

6. CALCULATIONS FOR SOLUBLE SALTS

6.1 If conductance reading was taken in units other than microsiemens, convert it to conductance in microsiemens. For example, if reading was taken in millisiemens, multiply the reading by 1000 to convert to conductance in microsiemens.

6.2 Convert conductance to electrical conductivity, expressed as microsiemens per centimeter, by multiplying by the cell constant.

6.3 Correct the conductivity at the test temperature to conductivity at 25°C (77 °F), by the following formula:

$$EC_{25} = (EC) \times (f_t)$$

Where: EC_{25} = Electrical conductivity (microsiemens/cm), corrected for 25 °C.
EC = Electrical conductivity (microsiemens/cm), at test temperature.
f_t = Factor obtained from Figure 1.

6.4 Calculate the soluble salts content in parts per million (ppm) by the following formula:

$$\text{Soluble Salts (ppm)} = (EC_{25}) \times (0.64)$$

6.5 Report the soluble salts to the nearest 10 ppm.

°C	°F	f_t	°C	°F	f_t	°C	°F	f_t
3.0	37.4	1.709	22.0	71.6	1.064	29.0	84.2	0.925
4.0	39.2	1.660	22.2	72.0	1.060	29.2	84.6	0.921
5.0	41.0	1.613	22.4	72.3	1.055	29.4	84.9	0.918
6.0	42.8	1.569	22.6	72.7	1.051	29.6	85.3	0.914
7.0	44.6	1.528	22.8	73.0	1.047	29.8	85.6	0.911
8.0	46.4	1.488	23.0	73.4	1.043	30.0	86.0	0.907
9.0	48.2	1.448	23.2	73.8	1.038	30.2	86.4	0.904
10.0	50.0	1.411	23.4	74.1	1.034	30.4	86.7	0.901
11.0	51.8	1.375	23.6	74.5	1.029	30.6	87.1	0.897
12.0	53.6	1.341	23.8	74.8	1.025	30.8	87.4	0.894
13.0	55.4	1.309	24.0	75.2	1.020	31.0	87.8	0.890
14.0	57.2	1.277	24.2	75.6	1.016	31.2	88.2	0.887
15.0	59.0	1.247	24.4	75.9	1.012	31.4	88.5	0.884
16.0	60.8	1.218	24.6	76.3	1.008	31.6	88.9	0.880
17.0	62.6	1.189	24.8	76.6	1.004	31.8	89.2	0.877
18.0	64.4	1.163	25.0	77.0	1.000	32.0	89.6	0.873
18.2	64.8	1.157	25.2	77.4	0.996	32.2	90.0	0.870
18.4	65.1	**1.152**	25.4	77.7	0.992	32.4	90.3	0.867
18.6	65.5	1.147	25.6	78.1	0.988	32.6	90.7	0.864
18.8	65.8	1.142	25.8	78.5	0.983	32.8	91.0	0.861
19.0	66.2	1.136	26.0	78.8	0.979	33.0	91.4	0.858
19.2	66.6	1.131	26.2	79.2	0.975	34.0	93.2	0.843
19.4	66.9	1.127	26.4	79.5	0.971	35.0	95.0	0.829
19.6	67.3	1.122	26.6	79.9	0.967	36.0	96.8	0.815
19.8	67.6	1.117	26.8	80.2	0.964	37.0	98.6	0.801
20.0	68.0	1.112	27.0	80.6	0.960	38.0	100.2	0.788
20.2	68.4	1.107	27.2	81.0	0.956	39.0	102.2	0.775
20.4	68.7	1.102	27.4	81.3	0.953	40.0	104.0	0.763
20.6	69.1	1.097	27.6	81.7	0.950	41.0	105.8	0.750
20.8	69.4	1.092	27.8	82.0	0.947	42.0	107.6	0.739
21.0	69.8	1.087	28.0	82.4	0.943	43.0	109.4	0.727
21.2	70.2	1.082	28.2	82.8	0.940	44.0	111.2	0.716
21.4	70.5	1.078	28.4	83.1	0.936	45.0	113.0	0.705
21.6	70.9	1.073	28.6	83.5	0.932	46.0	114.8	0.694
21.8	71.2	1.068	28.8	83.8	0.929	47.0	116.6	0.683

FIGURE 1

ARIZ 238a
September 5, 1996
(3 Pages)

PERCENT CARBONATES IN AGGREGATE

(An Arizona Method)

SCOPE

1. (a) This test method describes the procedure for determining the percentage of carbonates in aggregate. A combination of hydrogen peroxide and nitric acid is used to react with the carbonates.

(b) This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS AND MATERIALS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus and materials for this test procedure shall consist of the following:

(a) Drying apparatus - Any suitable device capable of drying samples at a temperature of 110 ± 5 °C (230 ± 9 °F).

(b) 1000 mL heavy duty beaker.

(c) Hydrogen Peroxide (3% solution) - H_2O_2.

(d) Nitric Acid (concentrated) - HNO_3.

(e) Distilled water.

(f) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

(g) Neutral Litmus Paper.

(h) Glass or Plastic Stirring Rod.

SAMPLE PREPARATION

3. Prepare the sample according to the following:

(a) For material samples from stockpile(s), obtain a representative 300 ± 10 gram sample of plus 4.75 mm (No. 4) material. Wash the sample over a 4.75 mm (No. 4) sieve and discard minus 4.75 mm (No. 4) material.

(b) For uncrushed material samples, obtain a representative sample and crush to appropriate grading. Obtain a representative 300 ± 10 gram sample of plus 4.75 mm (No. 4) material. Wash the sample over a 4.75 mm (No. 4) sieve and discard minus 4.75 mm (No. 4) material.

(c) The prepared sample shall be oven dried to constant weight at 110 ± 5 °C (230 ± 9 °F).

TEST PROCEDURE

4. (a) Allow sample to cool and place in a tared 1000 mL beaker. Weigh and record the weight of aggregate as the "weight of original sample" or "A" to the nearest 0.1 gram.

(b) Under a fume hood, add approximately 300 mL of H_2O_2 (3% solution) and stir. When the bubbling subsides, begin adding small amounts (approximately 10 mL) of concentrated HNO_3 to the beaker. Bubbling will be vigorous as the carbonates are being dissolved. Stir occasionally.

(c) When the bubbling has ceased and addition of HNO_3 causes no more bubbles, begin to wash by decantation, using distilled water. Care shall be taken not to lose any of the coarse aggregate. Wash by decantation at least 4 times. At this point, neutral litmus paper in the water should show only slight pink.

(d) Decant the water and oven dry to constant weight at 110 ± 5 °C (230 ± 9 °F).

(e) Let cool, weigh, and record the weight of aggregate as the "weight of non-reactive aggregate" or "B" to the nearest 0.1 gram.

CALCULATIONS

5. (a) Calculate the percent of carbonates as follows:

$$\text{Percent of Carbonates} = \frac{A - B}{A} \times 100$$

Where: A = weight of original sample
B = weight of non-reactive aggregate

(b) Report the percent of carbonates to the nearest 1%.

ARIZ 240a
September 5, 1996
(2 Pages)

SIEVE ANALYSIS AND SEPARATION OF SALVAGED AC PAVEMENT PARTICLES FOR RECYCLED ASPHALTIC CONCRETE

(An Arizona Method)

SCOPE

1. (a) This procedure provides a method for separation and sieve analysis of salvaged asphaltic concrete pavement particles which are obtained by crushing, milling, or other processes which renders particles which are to be used in the design and/or construction of recycled asphaltic concrete pavement.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of necessary splitting equipment, sieves for the coarse screening of the materials, shaker, balance, and other miscellaneous items as specified in Arizona Test Method 201.

PROCEDURE

3. A representative sample of salvaged pavement particles is subjected to coarse sieving in accordance with Arizona Test Method 201, except the following:

(a) If separated material is to be used in the design of a recycled mix, the entire nest of coarse [4.75 mm (No. 4) and larger] sieves shall be used. The material is subjected to shaking for 5 minutes $\pm$ 15 seconds.

b) If separation of material on a particular sieve size is desired, for example, the 9.5 mm (3/8 inch) sieve, enough larger size sieves shall be used to prevent overloading of the desired sieve size. The material is subjected to shaking for 5 minutes $\pm$ 15 seconds, and the material retained on each sieve is combined.

NOTE: The use of a specified time of shaking provides for a control on the "breaking down" of the particles of salvaged material into smaller size fractions. A sieving to completion is not attempted in this procedure.

SIEVE ANALYSIS

4. The sieve analysis on the separation of particles is performed as specified in Arizona Test Method 201.

COMPRESSIVE STRENGTH OF MOLDED CEMENT TREATED BASE OR SOIL-CEMENT SPECIMENS

(An Arizona Method)

1. SCOPE

1.1 This test method is used to determine the unconfined compressive strength of cement treated base or soil-cement specimens.

1.2 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 4 inch split ring proctor molds having a capacity of approximately 1/30 cubic foot, with an internal diameter of 4.000 plus 0.024 or minus 0.016 inches and a height of 4.584 plus 0.005 or minus 0.008 inches shall be used. The molds shall have a nominal wall thickness of 1/4 inch. They shall be equipped with an extension collar approximately 2-3/8 inches high.

2.3 A hand or mechanical rammer weighing 5.50 ± 0.02 pounds, having a flat face, and equipped with a suitable arrangement to control the height of drop to a free fall of 12 ± 0.06 (1/16) inches above the elevation of the soil. The rammer face shall be circular with a diameter of 2.000 plus 0.010 or minus 0.015 inches.

2.4 Hardened-steel straightedge, at least 10 inches in length. It shall have one beveled edge, and at least one longitudinal surface (used for final trimming) shall be plane within 0.01 inch per 10 inches (0.1 percent) of length with the portion used for trimming the soil.

2.5 A circular sample follower with a diameter slightly less than the inner diameter of the proctor mold to aid in the removal of the mold collar.

2.6 Sieves of sizes as required for screening conforming to the requirements of ASTM E11.

2.7 Screw type or hydraulically operated compression testing machine capable of meeting the requirements of Subsection 6.3 below.

2.8 Miscellaneous mixing tools and pans.

3. SAMPLE PREPARATION

3.1 A representative sample of approximately 10 kg shall be obtained in a random manner from the completed mixture prior to final compaction, and immediately placed in an air-tight container. Not more than 90 minutes shall lapse between the time of mixing and the final mold fabrication.

3.2 Sieve the material over a 3/4 inch sieve and discard any Plus 3/4 Inch Material.

4. FABRICATION

4.1 The required number of specimens shall be promptly fabricated, following the procedure below.

4.2 Form a specimen by compacting the prepared soil in the four inch mold (with the extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. The top of the first and second layers shall be scratched to aid in bonding to subsequent layer. Compact each layer with 25 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

NOTE: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 100 lbs, supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

4.3 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the specimen in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted specimen even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Level the specimen again with the straightedge, spraying with a fine mist of water as necessary to maintain specimen surface in a moist condition.

4.4 If it is necessary to transport the specimens, transport the specimens in the molds with the baseplate and collar attached, in a secure, moist environment as described in Subsection 5.2.

4.5 Following arrival at the location where curing will occur, remove specimens from molds within one hour, taking proper care in removing the specimens so that the shape of the molded specimens is maintained. To assure that specimens are in a moist condition they may be sprayed with a fine mist of water upon demolding, and promptly placed in the curing environment.

5. CURING

5.1 The specimens to be tested for acceptance shall be cured in a fog room at 100% humidity between 65°F and 80°F for six days. The specimens shall be protected from direct contact with free water to prevent saturation and/or leaching of cementitious material from the specimen.

5.2 If the specimens are cured where a “fog” room is not available, the curing is to be accomplished by surrounding the specimens with pre-saturated perlite or asbestos free vermiculite in a sealed container. Pre-saturation is determined as the maximum amount of water which can be absorbed without the presence of free standing water. This sealed container shall be promptly placed in a 65°F and 80°F environment. Store the specimens on a rigid, non-absorbent surface.

5.3 After six days the specimens to be tested for acceptance shall be immersed in saturated lime water at 65 to 80 °F for 24 hours.

NOTE: Informational specimens utilized for 1-day compressive strength testing are not immersed in saturated lime water.

6. COMPRESSIVE STRENGTH

6.1 Carefully remove the specimens from the water and towel dry. Due to the fragility of the specimens they must be handled carefully to assure that they are not damaged. Determine the diameter of each test specimen to the nearest 0.01 inch by averaging two diameter determinations measured at right angles to each other at mid-height of the specimen. The specimens shall be capped in accordance with ASTM C617/AASHTO T 231, and broken as soon as practical while specimens are in their moist condition after capping.

6.2 Place each specimen on the bearing block of the compression machine and center it under the loading head.

6.3 Continuously apply a uniform load to the specimen at the rate of 0.05 ± 0.01 inches per minute for the screw type testing machines, or 20 to 50 psi/sec for the hydraulically operated machines until failure is noted. Record the load at failure and convert to psi using the diameter determined in Subsection 6.1 above. No further correction shall be applied to the results. The average of three results shall constitute one test value for purposes of compressive strength specification compliance.

7. REPORT

7.1 Record the load failure point and compressive strength in psi for each specimen, and the average compressive strength for the three specimens.

SAND EQUIVALENT TEST FOR MINERAL AGGREGATE FOR ASPHALTIC CONCRETE FRICTION COURSE

(A Modification of AASHTO T 176)

This test procedure is the same as specified in AASHTO T 176, except:

1. The following is added: "This procedure is used for determining the sand equivalent value for mineral aggregate to be used in ACFC. The mineral aggregate gradation requirements for ACFC yield a large percentage of material which passes the 4.75 mm (No. 4) sieve and is retained on the 2.36 mm (No. 8) sieve. Due to the amount of material retained on the 2.36 mm (No. 8), the sand equivalent test, when performed as outlined in AASHTO T 176, utilizing minus 4.75 mm (No. 4) material does not lend itself to testing the mineral aggregate required for ACFC."

2. The following is added: "This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use."

3. The following is added: "See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy."

4. The following is added: "Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

5. The following is added: "Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual."

6. In Section 4, "Sample Preparation", all references to "4.75 mm (No. 4) sieve" shall be replaced by "2.36 mm (No. 8) sieve."

ARTIFICIAL GRADING OF MINERAL AGGREGATE

(An Arizona Method)

Scope

1. This method may be utilized to adjust composites of mineral aggregate by artificially grading the material to meet desired target values for specified screens.

Preparation of Pass No. 4 Sieve Size Samples

2. After samples of each stockpile or bin have been separated into individual sizes of Plus No. 4 and larger, and Pass No. 4 material by coarse sieving as described in ARIZ 201 the Pass No. 4 material is processed by the following procedures. Figure 1 gives an illustration of the steps necessary which may prove helpful in understanding the procedure.

(a) For each stockpile or bin of mineral aggregate the Pass No. 4 material is separated into No. 8 and Pass No. 8 fractions and weights recorded for each.

(b) The Pass No. 8 fractions for each stockpile or bin are proportionately combined and thoroughly blended together.

NOTE: It is important that the material be completely and accurately sieved into the three separate size fractions.

(c) The combined Pass No. 8 material is screened over a series of sieves which includes a No. 8, No. 40, No. 200 sieve, and other intermediate sizes as necessary to prevent overloading individual sieves.

(d) Material which passes the No. 8 sieve and is retained on the No. 40 sieve and any intermediate sieves is combined and saved.

(e) Material which passes the No. 40 sieve and is retained on the No. 200 sieve and any intermediate sieves is combined and saved.

(f) The material passing the No. 200 sieve is also saved.

(g) An approximate 500 gram sample is obtained from the fraction of material which is Pass No. 8 to Retained No. 40, and another approximate 500 gram sample is obtained from the fraction of material which is Pass No. 40 to Retained No. 200.

(h) Each of the samples are subjected to elutriation and fine screening as specified in ARIZ 201, Section 6 or 7, and 8. The sieve analysis of each is determined in accordance with Section 11 of ARIZ 201, except the % passing each sieve is determined and recorded to the nearest 0.01%.

(i) From the elutriation and fine screening of the Pass No. 8 to Retained No. 40 fraction, the % passing the No. 40 sieve and larger than the No. 200 sieve is determined (% Pass No. 200 subtracted from % Pass No. 40), and recorded as "a". The % passing the No. 200 sieve is recorded as "b".

Example:

Sieve size	% Passing
# 8	100
# 40	0.34
# 200	0.25

"a" = (0.34 - 0.25) = 0.09%
"b" = 0.25%

(j) From the elutriation and fine screening of the Pass No. 40 to Retained No. 200 fraction, the % passing No. 200 sieve is recorded as "c".

Example:

Sieve Size	% Passing
# 40	100
# 200	1.32

"c" = 1.32%

NOTE: The size fractions used above for artificial grading and throughout this method are based on meeting desired values for % passing the No. 8, No. 40 and No. 200 sieves. If other or additional sieves are used in artificial grading or adjusting the composite, the procedures of this test method will apply, with appropriate modifications.

Procedure for Adjusting Composite for Pass No. 8 Material

3. The composite of mineral aggregate for Pass No. 8 material is then adjusted to meet desired values. The Pass No. 8 to Retained No. 40 fraction from screening has material clinging to it which will contribute to Pass No. 40 to Retained No. 200 and Pass No. 200 material in the adjusted composite, and the Pass No. 40 to Retained No. 200 fraction from screening has material clinging to it which will contribute to the Pass No. 200 material in the adjusted composite. The procedure below uses results from the elutriation and the fine screening of material from each fraction of material to account for the total contribution to each desired size. Figure 2 provides an illustration which may be useful in understanding the

method. The calculations outlined below are utilized to determine the % of each size fraction from screening that is necessary to be used to obtain desired values. An example is provided with the method for each calculation. The illustration in paragraph (h) is a tabulation of the results for the example provided and should be referred to as the procedure is followed to understand the contributions to each desired value from the individual fractions of material.

(a) The amount of Pass No. 8 to Retained No. 40 material for the desired gradation is determined, (% Pass No. 40 subtracted from % Pass No. 8) and recorded as "d". The amount of Pass No. 40 to Retained No. 200 material for the desired gradation is determined, (% Pass No. 200 subtracted from % Pass No. 40), and recorded as "e". The amount of Pass No. 200 for the desired gradation is recorded as "f".

Example:

Sieve Size	Composite Gradation % Pass Values	Desired Gradation % Pass Values
# 8	45	48
# 40	21	18
# 200	6.5	5.7

"d" = (48 - 18) = 30 %
"e" = (18 - 5.7) = 12.3%
"f" = 5.7%

(b) The percent of the Pass No. 8 to Retained No. 40 fraction of material necessary to be utilized to obtain the desired adjusted % Pass No. 8 is determined and recorded as "g".

$$\text{"g"} = (d) \times \left[1 + \frac{a + b}{100} \right]$$

Example:

$$\text{"g"} = (30) \times \left[1 + \frac{0.09 + 0.25}{100} \right] = 30.10\%$$

(c) The proportional amounts of Pass No. 40 to Retained No. 200, and Pass No. 200 material which are in the Pass No. 8 to Retained No. 40 fraction, and which need to be accounted for in the adjusted composite are determined and recorded as "h" and "i" respectively:

$$\text{"h"} = (g - d) \times \left[\frac{a}{a + b} \right]$$

$$\text{"i"} = (g - d) \times \left[\frac{b}{a + b} \right]$$

Example:

$$\text{"h"} = (30.10 - 30) \times \left[\frac{0.09}{0.09 + 0.25}\right] = 0.03\%$$

$$\text{"i"} = (30.10 - 30) \times \left[\frac{0.25}{0.09 + 0.25}\right] = 0.07\%$$

(d) The amount of Pass No. 40 to Retained No. 200 material from the Pass No. 40 to Retained No. 200 fraction that is required to give the desired value for Pass No. 40 to Retained No. 200 in the adjusted composite is determined and recorded as "j":

$$\text{"j"} = (e - h)$$

Example:

$$\text{"j"} = (12.3 - 0.03) = 12.27\%$$

NOTE: The sum of the contributions to the Pass No. 8 to Retained No. 40, "h" + "j", will equal the total amount desired in the adjusted composite, "e".

(e) The percent of the Pass No. 40 to Retained No. 200 fraction of material, necessary to be utilized to obtain the desired value for Pass No. 40 to Retained No. 200 is determined and recorded as "k":

$$\text{"k"} = (j) \times \left[1 + \frac{c}{100}\right]$$

Example:

$$\text{"k"} = (12.27) \times \left[1 + \frac{1.32}{100}\right] = 12.43\%$$

(f) The amount of Pass No. 200 material which is in the Pass No. 40 to Retained No. 200 fraction, and which needs to be accounted for in the adjusted composite is determined and recorded as "l":

$$\text{"l"} = (k - j)$$

Example:

$$\text{"l"} = (12.43 - 12.27) = 0.16\%$$

(g) The percent of Pass No. 200 material necessary to be utilized to obtain the desired % Pass No. 200 is determined and recorded as "m":

"m" = (f - i - l)

Example:

"m" = (5.7 - 0.07 - 0.16) = 5.47%

NOTE: The sum of the contributions to the % Pass No. 200 material, "i" + "l" + "m", will equal the total amount desired in the adjusted composite, "f".

(h) The following illustration shows the contributions to the adjusted composite from each of the size fractions:

	Pass #8 to Ret. #40 Fraction	Pass #40 to Ret. #200 Fraction	Pass #200 Fraction	Desired Values
% Pass #8 to Ret. #40	30 (d)			30 (d)
% Pass #40 to Ret. #200	0.03(h)	12.27(j)		12.3 (e)
% Pass #200	0.07(i)	0.16(l)	5.47(m)	5.7 (f)
% of each size fraction to be used to obtain desired values	30.10(g)	12.43(k)	5.47(m)	

(i) The percentages of each size fraction which are to be used in the adjusted composite to meet desired values are recorded:

Example:

Pass No. 8 to Retained No. 40 = 30.10%
Pass No. 40 to Retained No. 200 = 12.43%
Pass No. 200 = 5.47%

Procedure for Adjusting Composite for Plus No. 8 Material

4. The composite is adjusted for the Plus No. 8 material to obtain desired % pass values for each size.

(a) The % retained for each sieve size for the desired adjusted composite is divided by the corresponding % retained value for each sieve size in the stockpile or bin composite. This value is multiplied by the individual fractions of that size for each stockpile or bin. This will give an adjusted amount of each size fraction in the stockpile or bin composite which will be the gradation of the desired composite. An example of this for a composite for an asphaltic concrete mix design is shown in Figure 3.

Checking Adjusted Composite

5. A sample of appropriate size as specified in ARIZ 201, for the maximum aggregate size, is prepared for the adjusted composite using material from the individual size fractions for Plus No. 8 material, the Pass No. 8 to Retained No. 40 fraction, the Pass No. 40 to Retained No. 200 fraction, and the Pass No. 200 fraction. This sample is subjected to ARIZ 201 and the resultant gradation compared to the desired gradation.

Preparing Samples Using Material from Artificial Grading

6. The samples necessary are prepared and weighed up for testing utilizing the adjusted composite.

(a) For the Plus No. 8 material, the individual size fractions from the adjusted composite for each stockpile or bin are utilized to prepare samples.

(b) For Pass No. 8 material the amount of each fraction for Pass No. 8 to Retained No. 40, Pass No. 40 to Retained No. 200, and Pass No. 200 from the adjusted composite is utilized to prepare samples.

(c) A weigh up sheet which is used for asphaltic concrete mix designs, which illustrates the use of the adjusted composite fractions is shown in Figure 4.

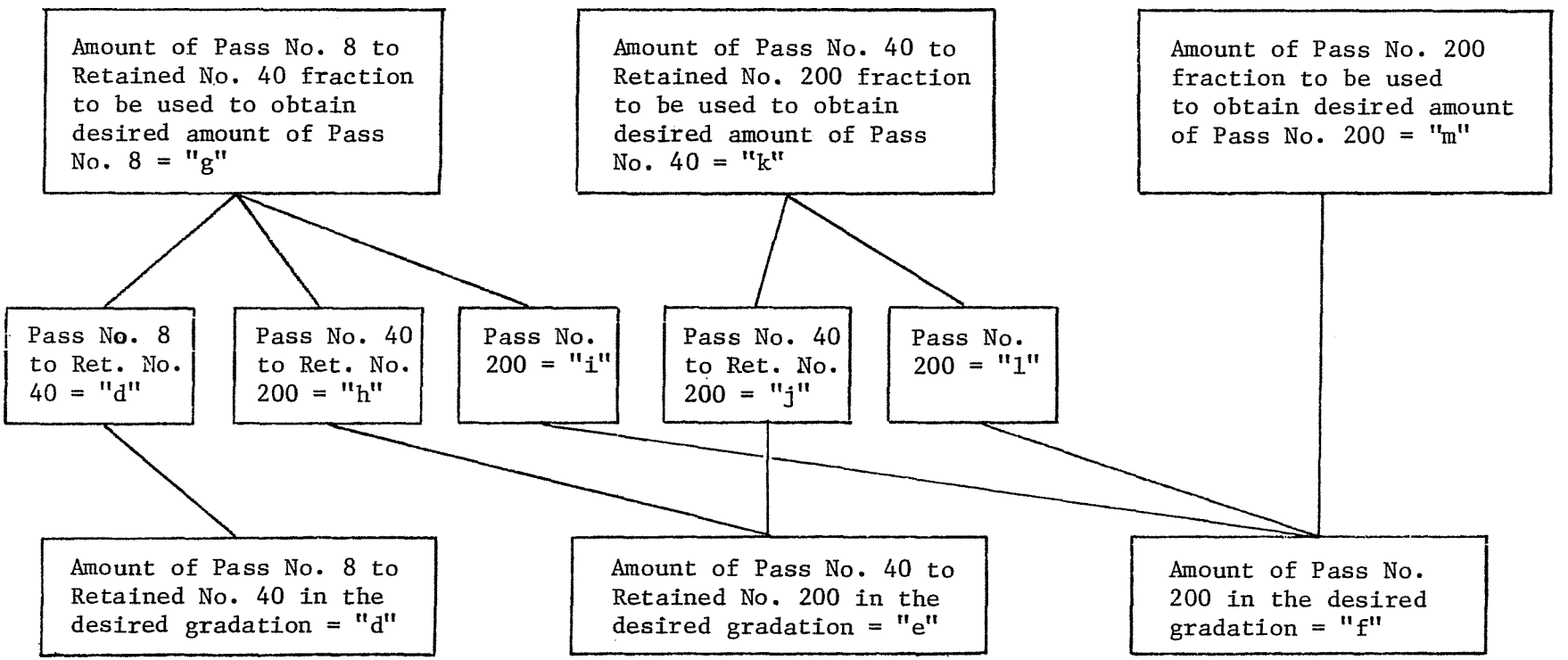

Amount of Pass No. 8 to Retained No. 40 fraction to be used to obtain desired amount of Pass No. 8 = "g"
Amount of Pass No. 40 to Retained No. 200 fraction to be used to obtain desired amount of Pass No. 40 = "k"
Amount of Pass No. 200 fraction to be used to obtain desired amount of Pass No. 200 = "m"
Pass No. 8 to Ret. No. 40 = "d"
Pass No. 40 to Ret. No. 200 = "h"
Pass No. 200 = "i"
Pass No. 40 to Ret. No. 200 = "j"
Pass No. 200 = "l"
Amount of Pass No. 8 to Retained No. 40 in the desired gradation = "d"
Amount of Pass No. 40 to Retained No. 200 in the desired gradation = "e"
Amount of Pass No. 200 in the desired gradation = "f"

FIGURE 1

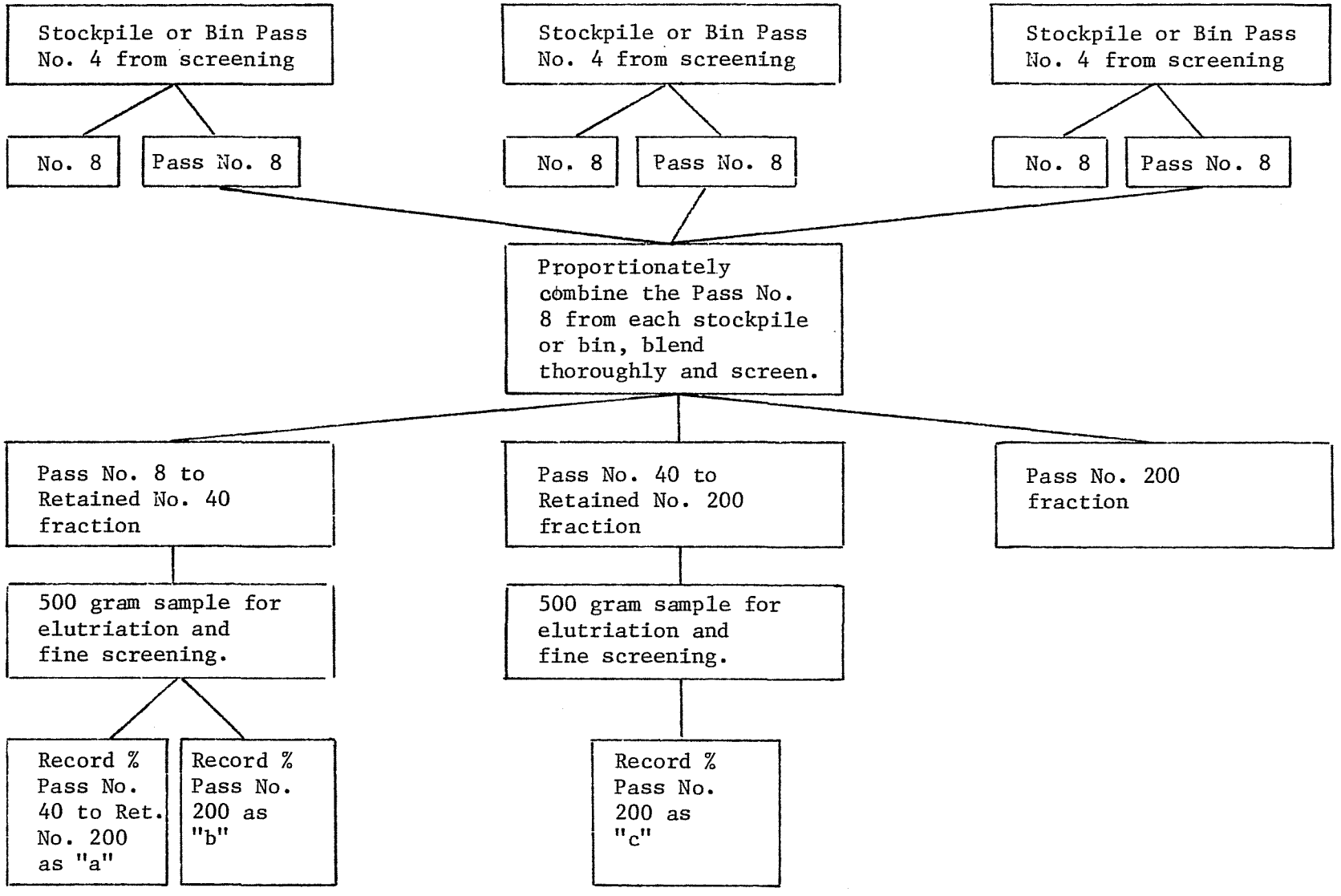

Stockpile or Bin Pass No. 4 from screening
Stockpile or Bin Pass No. 4 from screening
Stockpile or Bin Pass No. 4 from screening
No. 8
Pass No. 8
No. 8
Pass No. 8
No. 8
Pass No. 8
Proportionately combine the Pass No. 8 from each stockpile or bin, blend thoroughly and screen.
Pass No. 8 to Retained No. 40 fraction
Pass No. 40 to Retained No. 200 fraction
Pass No. 200 fraction
500 gram sample for elutriation and fine screening.
500 gram sample for elutriation and fine screening.
Record % Pass No. 40 to Ret. No. 200 as "a"
Record % Pass No. 200 as "b"
Record % Pass No. 200 as "c"

FIGURE 2

COMPOSITE ADJUSTED TO DESIRED COMPOSITE OF PLUS NO. 8 MATERIAL

DATE _____ PROJECT NO. _____ LAB. NO. _____ DESIGN _____

Sieve Size	Aggregate "% of composite" C 30%	I 25%	F 45%			% Ret.	% Ret. Rounded	% Pass	DESIRED ADJUSTED ~~Design Specs.~~ COMPOSITE
1"							0	100	100
3/4"	2.6 ~~3.1~~	0.4 ~~0.5~~				3 ~~3.6~~	4	96	97
1/2"	11.4 ~~11.6~~	3.6 ~~3.6~~				15 ~~15.2~~	15	81	82
3/8"	8.5 ~~7.5~~	2.5 ~~2.2~~				11 ~~9.7~~	10	71	71
1/4"	1.7 ~~2.4~~	2.2 ~~3.1~~	0.1 ~~0.2~~			4 ~~5.7~~	6	65	67
#4	2.5 ~~2.2~~	1.6 ~~1.4~~	1.9 ~~1.7~~			6 ~~5.3~~	5	60	61
#8	2.6 ~~3.0~~	5.4 ~~6.3~~	5.0 ~~5.9~~			13 ~~15.2~~	15	45	48
#10	0	0.3	1.6			1.9	2	43	
#16	0	0.9	4.8			5.7	6	37	
#30	0	1.4	6.8			8.2	8	29	
#40	0	1.7	6.3			8.0	8	21	18
#50	0	0.9	6.2			7.1	7	14	
#100	0	0.8	4.4			5.2	5	9	
#200	0	0.4	2.3			2.7	3	6.5	5.7
Pass #200	0.16	1.53	4.79			6.48	6.5		

MIX DESIGN CRITERIA REQUIREMENTS:

IMC RET.~
MIN. WET STRENGTH~
VOIDS ~
V.M.A. ~
MIN. STABILITY~
FLOW ~

COMPOSITE OF PASS NO. 8 FROM GRADATION OF EACH STOCKPILE OR BIN:

LAB #	-#8
COARSE	0.2
INTER	7.9
FINE	37.2

TOTAL = 45.3

Sieve Size	Adjusted "% of composite" for use of mineral admixture						Calc. % Pass	% Ret.	% Pass	Design Specs.
1"	=	=	=	=	=	=				
3/4"										
1/2"										
3/8"										
1/4"										
#4										
#8										
#10										
#16										
#30										
#40										
#50										
#100										
#200										

Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted "% of composite" = Adjusted % Mineral Admix. =

REMARKS

$3/4: \frac{3}{3.6} = 0.8333$

$1/2: \frac{15}{15.2} = 0.9868$

$3/8: \frac{11}{9.7} = 1.1340$

$1/4: \frac{4}{5.7} = 0.7018$

$\#4: \frac{6}{5.3} = 1.1321$

$\#8: \frac{13}{15.2} = 0.8553$

FIGURE 3

44-9361 10/83

ASPHALTIC CONCRETE MIX DESIGN WEIGH UP CARD

MATERIAL | LAB NO. | DATE

PROJECT NO. | PROJECT NAME

CONTRACTOR | MIX DESIGN REQUEST

LAB NO.	SIZE	ACCUM % RET.	1 RICE	3 STABS	3 IMC	1 COARSE SP. GR.	1 COARSE SAND EQUIV.	1 CRUSH FACES	COARSE C.K.E.	LIME-STONE	FLAKI-NESS INDEX	1 ABRASION "B"	BLEND SP. GR.	1 FINE SAND EQUIV.	1 FINE SP. GR.	1 - #8 MAKE-UP MAT'L	SIZE	LAB NO
COARSE	3/4	2.6	78	86	88	267	26	15				—						
	1/2	14.0	420	462	476	1436	138	81				1900						
	3/8	22.5	675	742	765	2308	221	130				3832						
	1/4	24.2	726	799	823	2482	238	140				—						
	#4	26.7	801	881	908	2738	263	154				—						
INTER	3/4	27.1	813	894	921	2779	267	156				—						
	1/2	30.7	921	1013	1044	3149	302	177				4432						
	3/8	33.2	996	1096	1129	3405	327	192				5000						
	1/4	35.4	1062	1168	1204	3631	348	204										
	#4	37.0	1110	1221	1258	3795	364	213										
FINE	1/4	37.1	1113	1224	1261	3805	365	214										
	#4	39.0	1170	1287	1326	4000	384	225										
COARSE	#8	41.6	1248	1373	1414			240						26	51	—	#8	COARSE
INTER	#8	47.0	1410	1551	1598			271						79	157	—	#8	INTER
FINE	#8	52.0	1560	1716	1768			300						128	256	—	#8	FINE
PASS 8-RET 40		82.10	2463	2709	2791									424	848	376	PASS 8-RET 40	
PASS 40-RET 200		94.53	2836	3119	3214									546	1092	532	PASS 40-RET 200	
PASS 200		100	3000	3300	3400									600	1200	600	PASS 200	

REMARKS:

FIGURE 4

MAXIMUM DRY DENSITY AND OPTIMUM MOISTURE OF SOILS BY PROCTOR ALTERNATE METHOD D

(A Modification of AASHTO Designation T 99)

1. SCOPE

1.1 This test method describes the procedure for determining the maximum dry density and optimum moisture content for a soil by the Proctor Alternate Method D.

1.2 Alternate Method D may be used for all maximum dry density and optimum moisture content determinations except for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the moisture absorption for the coarse aggregate is greater than 4.0%.

1.3 Alternate Method D may be used except when greater than 40% of the material is retained on the 3/4 inch sieve.

1.4 An example is provided in Figure 2 for the calculations and determinations referenced herein.

1.5 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whomever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 6 inch proctor mold having a capacity of approximately 1/13.33 cubic foot, with an internal diameter of 6.000 plus 0.039 or minus 0.026 inches and a height of

4.584 plus 0.005 or minus 0.008 inches. The mold shall have a nominal wall thickness of 1/4 inch. It shall be equipped with an extension collar approximately 2-3/8 inches high. A baseplate as shown in Figure 1 shall be provided.

2.3 A hand or mechanical rammer weighing 5.50 $\pm$ 0.02 pounds, having a flat face, and equipped with a suitable arrangement to control the height of drop to a free fall of 12 $\pm$ 0.06 (1/16) inches above the elevation of the soil. The hand rammer face shall be circular with a diameter of 2.000 plus 0.010 or minus 0.015 inches. The mechanical rammer face shall have the shape of a piece of pie, with a radius of approximately 3 inches, and having an area of 3.134 $\pm$ 0.039 square inches. If a mechanical apparatus is used, it must be monitored through the ADOT proficiency sample program and maintain a rating of 3 or better based on the results of testing ADOT and AMRL proficiency samples.

2.4 Hardened-steel straightedge, at least 10 inches in length. It shall have one beveled edge, and at least one longitudinal surface (used for final trimming) shall be plane within 0.01 inch per 10 inches (0.1 percent) of length with the portion used for trimming the soil.

2.5 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least one gram.

2.6 Scale or balance capable of measuring the maximum weight to be determined, accurate to at least 0.1 gram.

2.7 Oven capable of maintaining a temperature of 230 $\pm$ 9 °F.

2.8 3/4 inch and 3 inch sieves conforming to the requirements of ASTM E11.

2.9 Miscellaneous mixing tools and pans.

2.10 Sample Extruder (optional) consisting of a jack, lever, frame, or other device for extruding the compacted sample from the mold.

3. CALIBRATION OF MOLD

3.1 Molds shall be calibrated in accordance with APPENDIX A of Arizona Test Method 225.

4. SAMPLE

4.1 Enough soil material shall be provided from the field to make five compacted specimens. A minimum sample size of 45,000 grams (approximately 100 lbs.) is normally required.

4.2 If the soil sample is damp when received from the field, dry it until it becomes friable under a trowel. Drying may be in air or by use of a slow fan or other drying apparatus such that the temperature of the sample does not exceed 140 °F.

4.3 Thoroughly break up the aggregations in such a manner as to avoid reducing the natural size of individual particles.

4.4 Weigh out an approximate 45,000 gram sample of representative soil. Record the weight of the sample, and sieve the material over a 3/4 inch sieve. If the percentage of coarse aggregate or rock retained on the 3/4 inch sieve is not already known from gradation testing, save any material retained on the 3/4 inch sieve and weigh. Calculate the percent of coarse aggregate or rock particles retained on the 3/4 inch sieve according to the following equation:

$$PR3/4 = \frac{WR3/4}{WT} \times 100$$

Where: PR3/4 = Percentage of coarse aggregate or rock particles retained on the 3/4 inch sieve

WR3/4 = Weight of coarse aggregate or rock particles retained on the 3/4 inch sieve

WT = Total weight of material sieved

4.5 If "PR3/4" is greater than 40%, then too much rock is present to allow for a reasonable maximum dry density determination If "PR3/4" is less than or equal to 40%, blend material passing the 3/4 inch sieve thoroughly and proceed to Section 5 of this test method. If a specific gravity and absorption determination, in accordance with AASHTO T 85, is to be made for the plus 3/4 inch material, save an adequate amount of this material, otherwise, discard it.

5. PROCEDURE

5.1 From the thoroughly blended passing 3/4 inch material from Subsection 4.5, split out 5 representative approximate 5000 gram samples.

5.2 Select one sample and thoroughly mix with sufficient water to dampen it to approximately three percentage points below optimum moisture content.

Note: If desired, an additional three samples may be mixed at this time with approximate moisture contents of 1% below optimum, 1% over optimum, and 3% over optimum. The moisture in each of these samples shall be retained by covering with a damp cloth or being sealed in air tight containers until they are compacted. One of the five samples should be retained for future use since it is necessary to have at least two points defined on each side of the moisture-density curve.

5.3 Heavy clay soils or materials which tend to break down, or those in which it is difficult to incorporate water, shall require approximately 12 hours for uniform moisture absorption to be achieved. This shall be accomplished by preparing separate samples for each increment of water to be added, and then placing and sealing these samples in air tight containers for the 12-hour period.

5.4 Form a specimen by compacting the prepared soil in the six inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 56 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid and stable foundation.

Note: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: A block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

5.5 When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom

of the mold with waterproofing grease. All excess grease shall be wiped from the mold and baseplate.

5.6 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, "WD", of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}}$$

Where: WD = Wet density of compacted soil, lb./cu. ft.
M1 = Weight of compacted specimen and mold, grams
M2 = Weight of the mold, grams
VM = Volume of the mold, cu. ft. (See Section 3 of this procedure.)

5.7 The estimated dry density, "ED", of the compacted soil may be calculated and recorded to the nearest 0.1 lb./cu. ft. as follows:

$$ED = \frac{WD}{\text{(Approx. \% of water added)} + 100} \times 100$$

Where: ED = Estimated dry density of compacted soil, lb./cu. ft.
WD = Wet density of compacted soil, lb./cu. ft.

Note: These estimated densities are approximate only and will be corrected when final moisture results are obtained.

5.8 The estimated dry density is useful in deciding how much water to add in later trial batches, if the procedure described in the note following Subsection 5.2, for initially preparing three additional samples with varying moisture contents is not utilized. By carefully observing the estimated dry density of the compacted

samples, the operator should be able to vary the moisture content as the test proceeds so that when the final moisture-density results are plotted, a curve will result that rises to a peak and then falls away.

5.9 Remove the material from the mold and slice vertically through the center. Take a representative minimum 600 gram sample from the full length and width of one of the cut faces. Weigh immediately, and dry to a constant weight in an oven at 230 ± 9 °F to determine the moisture content in accordance with AASHTO T 265. Record the weight of wet soil to the nearest 0.1 gram as "WW", and record the weight of oven dry soil to the nearest 0.1 gram as "DW".

5.10 For granular, free-draining materials, the moisture content shall be determined using the entire compacted proctor specimen. Determine the weight of wet soil, "WW", by subtracting the weight of the mold, "M2", from the weight of compacted specimen and mold, "M1". Record the weight of wet soil, "WW", and the weight of oven dry soil, "DW", to at least the nearest gram. All clinging material shall be removed from the inside of the mold and included with the specimen. To facilitate drying, the specimen may be broken up and spread out in a large pan, being careful to not lose any soil particles.

5.11 Select another of the samples which was split in Subsection 5.1, and if not already done, thoroughly mix with water in sufficient amount to increase the moisture content by approximately two percentage points.

5.12 Repeat the procedure in Subsections 5.3 through 5.10 for the sample at each moisture content, as necessary to establish a moisture-density curve which rises to a peak and then falls away.

6. CALCULATIONS

6.1 Calculate percent moisture and record to the nearest 0.1 percent by the following:

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100$$

Where: WW = weight of wet soil, grams
DW = weight of oven dry soil, grams

6.2 Calculate dry density and record to the nearest 0.1 lb./cu. ft. by the following:

$$DD = \frac{WD}{\% \text{ Moisture} + 100} \times 100$$

Where: DD = Dry density of compacted soil, lb./cu. ft.
WD = Wet density of compacted soil, lb./cu. ft.

7. MOISTURE-DENSITY RELATIONSHIP

7.1 The percent moisture and corresponding dry density for each of the compacted soil specimens shall be plotted on the graph provided on the proctor density test form shown in Figure 3. For a good plot, the majority of the graph is utilized. Normally, three increments on the horizontal axis shall equal one percent of moisture, and three increments on the vertical axis shall equal one lb./cu. ft. of dry density. If another number of increments other than three is utilized, the number of increments for one percent moisture and one lb./cu. ft. dry density shall always be the same.

7.2 On each side of the maximum density curve, at least two points should be utilized to form two straight lines. The intersection point of these two lines defines the peak point of the density-moisture content relationship, or the maximum density and optimum moisture content for the soil. In general it will be found that higher unit mass soils assume steeper slopes with high maximum dry densities at low optimum moisture contents, while the lower unit mass soils assume flatter, more gently sloped lines with high optimum moisture contents and low maximum dry densities. Figure 4 gives examples of moisture-density

plots which show the different slopes associated with different maximum dry density ranges.

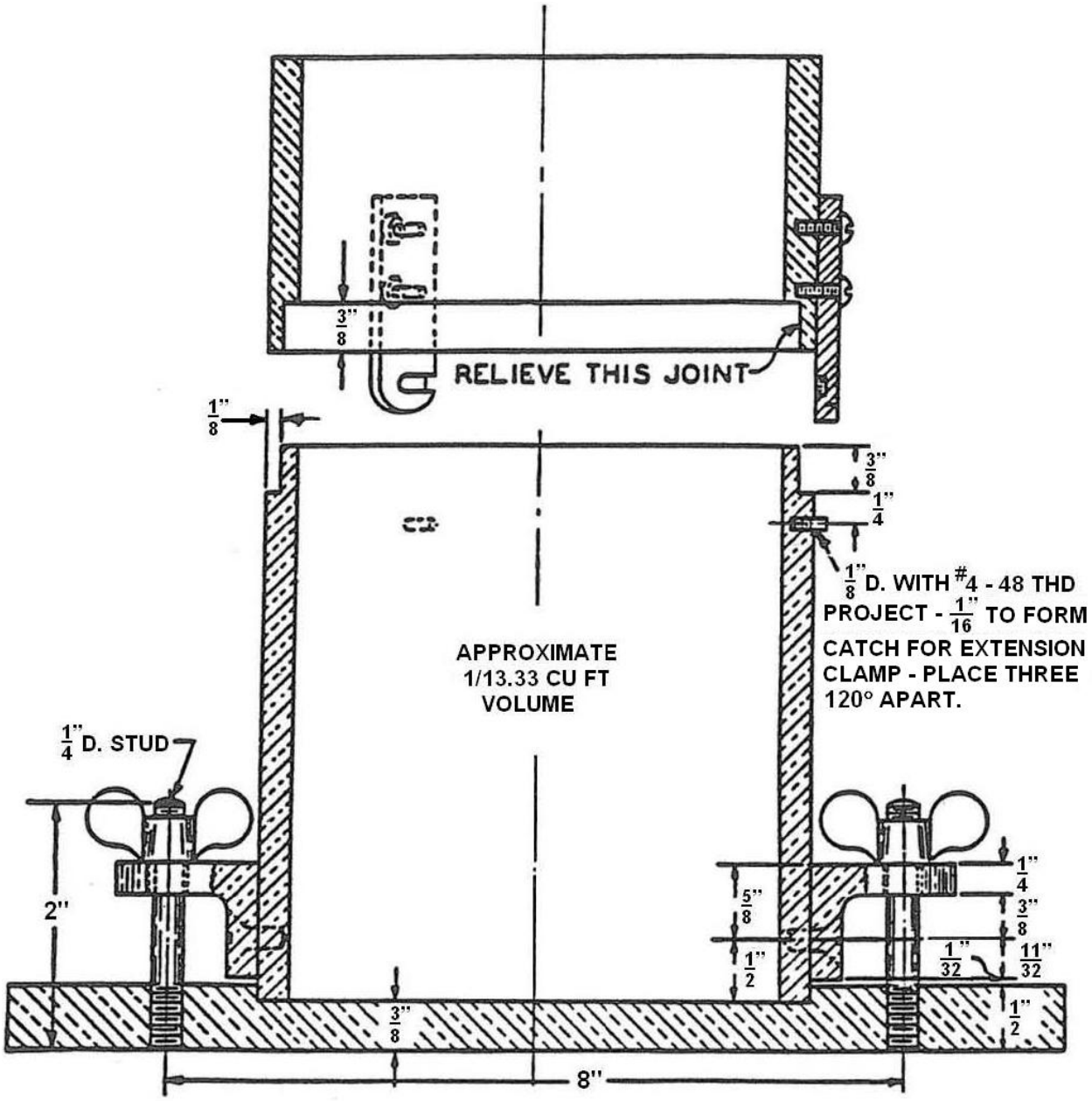
7.3 Optimum moisture content - The percent moisture content corresponding to the peak (intersection point of the two lines) of the moisture-density curve shall be termed the "optimum moisture content", and shall be reported as "OM" to the nearest 0.1 percent.

7.4 Maximum dry density - The dry density at optimum moisture content corresponding to the peak (intersection point of the two lines) of the moisture-density curve shall be termed the "maximum dry density", and shall be reported as "MD" to the nearest 0.1 lb./cu. ft.

Note: The optimum moisture and maximum dry density determinations above are for the material passing the 3/4 inch sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with ARIZ 227, for the percent rock which the field sample contains.

8. REPORT

8.1 Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required. A blank laboratory test form is provided in Figure 3.



CYLINDERICAL MOLD, COLLAR,
AND BASEPLATE
(6 INCH MOLD)

FIGURE 1

Arizona Department of Transportation
METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY
(Arizona Test Method 225 or 245)

Project No: _____ Lab No : _____ Rec'd Date: _____
Source and Type of Material : _____
Proctor Method Used : **Method A** _____ or **Alternate Method D** ✓
Test Operator and Date : _____ Supervisor and Date: _____

Weight of Mold = **M2** = **2840** grams | Volume of Mold = **VM** = **0.0744** = cu ft | **a** = VM x 453.6 = **33.7478**

b	M1	c	WD	ED	Moisture Determination WW	DW	d	e	DD
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample M1 - M2	Wet Density lb/ cu ft c/a	Est. Dry Density WD x 100 / b + 100	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water WW - DW	Percent Moisture d x 100 / DW	Dry Density lb/cu ft WD x 100 / e + 100
7	7180	4340	128.6	120.2	655.5	613.8	41.7	6.8	120.4
9	7376	4536	134.4	123.3	685.3	628.7	56.6	9.0	123.3
11	7474	4634	137.3	123.7	658.4	592.1	66.3	11.2	123.5
13	7457	4617	136.8	121.1	645.9	572.1	73.8	12.9	121.2

METHOD A
WT = _____ WR4 = _____
PR4 = WR4 / WT x 100 = _____

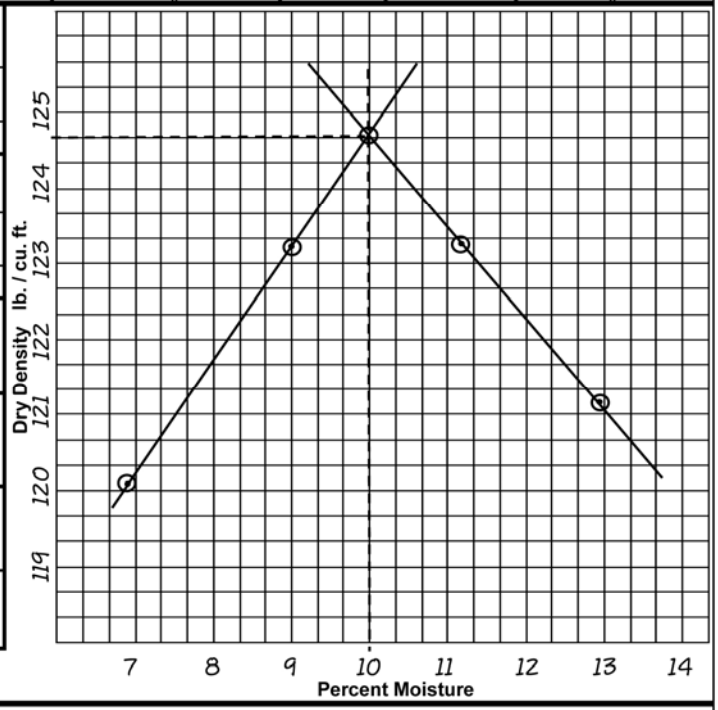
ALTERNATE METHOD D
WT = 48780 WR 3/4 = 17951
PR 3/4 = WR 3/4 / WT x 100 = 37 %

Coarse Aggregate Bulk Oven Dry Specific Gravity : 2.631

Coarse Aggregate Absorption : 2.28 %

OPTIMUM MOISTURE CONTENT = OM = 10.0 %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = 124.6



Remarks : _____

FIGURE 2

Arizona Department of Transportation
METHOD A or **ALTERNATE METHOD D** PROCTOR DENSITY
(Arizona Test Method 225 or 245)

Project No: _____ Lab No : _____ Rec'd Date: _____

Source and Type of Material : _____

Proctor Method Used : **Method A** _____ or **Alternate Method D** _____

Test Operator and Date : _____ Supervisor and Date: _____

Weight of Mold = **M2** = _____ grams | Volume of Mold = **VM** = _____ = cu ft | a = VM x 453.6 = _____

b	M1	c	WD	ED	Moisture Determination				DD
					WW	DW	d	e	
Approx % of water Added	Wt. of Sample and Mold	Wet Wt. of Sample M1 - M2	Wet Density lb/ cu ft c / a	Est. Dry Density WD x 100 / b + 100	Wet Wt. of Moisture Sample	Dry Wt. of Moisture Sample	Wt. of Water WW - DW	Percent Moisture d x 100 / DW	Dry Density lb/cu ft WD x 100 / e + 100

METHOD A

WT = _____ WR4 = _____

PR4 = WR4 / WT x 100 = _____

ALTERNATE METHOD D

WT = _____ WR 3/4 = _____

PR 3/4 = WR 3/4 / WT x 100 = _____ %

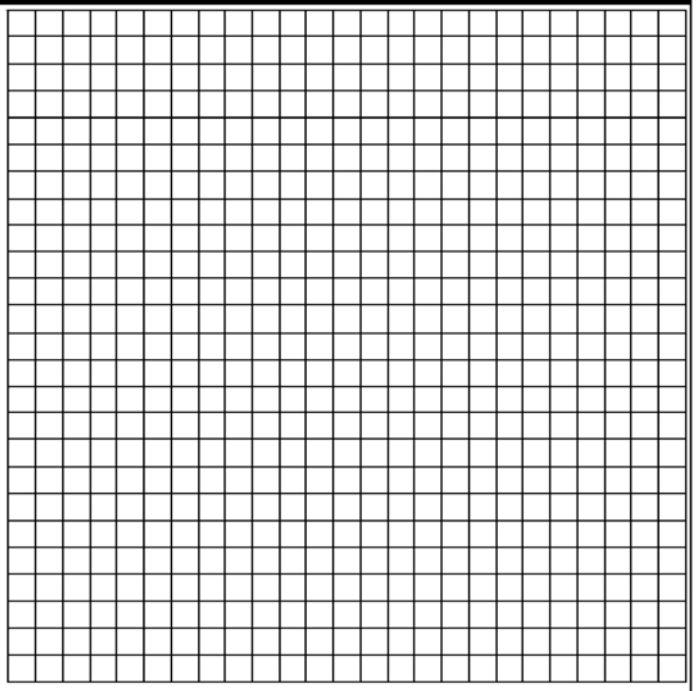
Coarse Aggregate Bulk Oven Dry Specific Gravity : _____

Coarse Aggregate Absorption : _____ %

OPTIMUM MOISTURE CONTENT = OM = _____ %

MAXIMUM DRY DENSITY (lb. / cu. ft.) = MD = _____

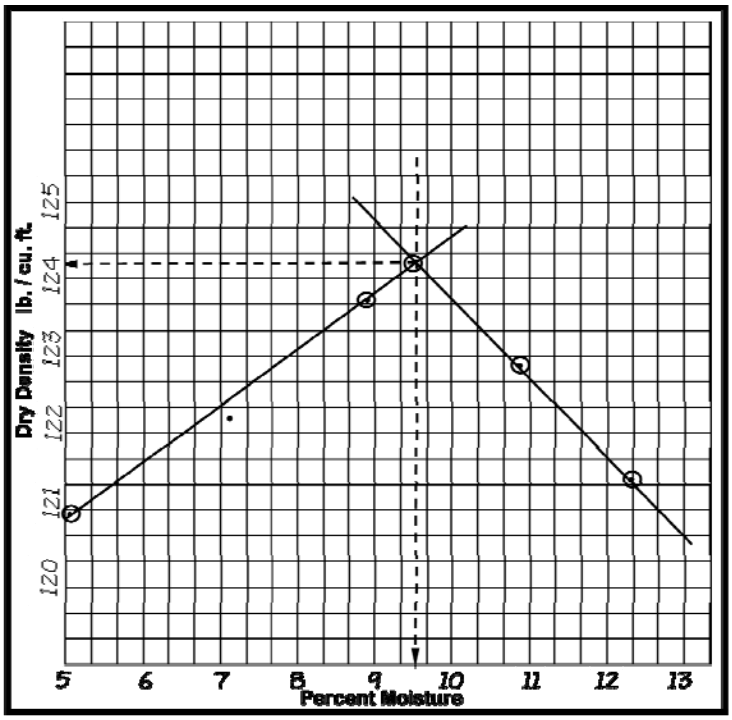
Dry Density lb. / cu. ft.



Percent Moisture

Remarks : _____

FIGURE 3



AGGREGATE BASE COURSE

% Moisture	Dry Density
5.1	120.8
7.1	122.1
8.9	123.7
10.8	122.7
12.3	121.3

Moisture Density = 124.1 lb/cu ft
Optimum Moisture = 9.4 %

SILTY SAND AND GRAVEL

% Moisture	Dry Density
7.2	127.0
8.1	129.6
9.4	127.9
10.1	126.6

Moisture Density = 130.0 lb/cu ft
Optimum Moisture = 8.3 %

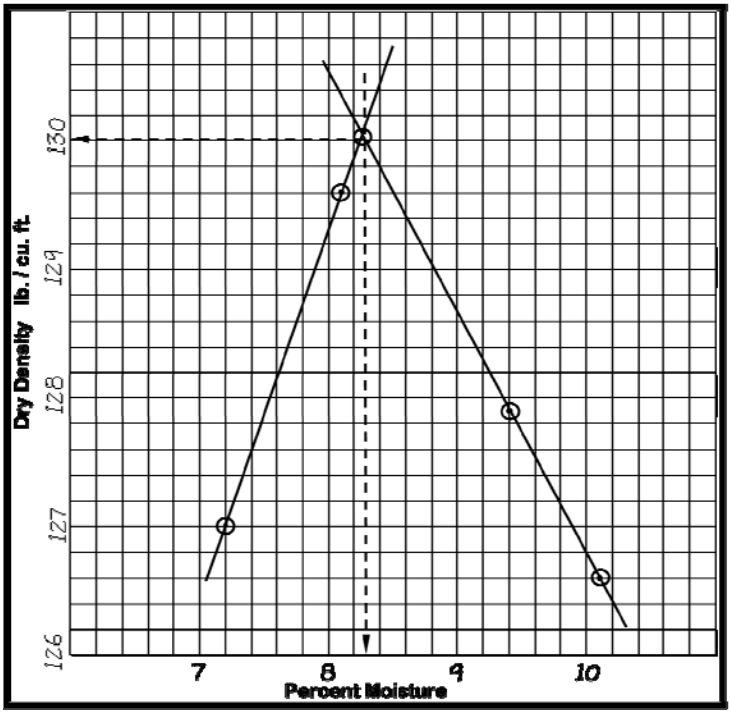


FIGURE 4

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

____ Four Inch Mold ✓ Six Inch Mold Mold I. D. #: 6A

Calibration Date: 09/15/15 Calibration Expiration Date: 09/15/16

Temperature of water used for Calibration: 75 ° F

Unit Weight of Water: 62.261 lb. /cu. ft.

Test Operator: Joe Tester Supervisor and Date: Joe Supervisor 09/17/15

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)
6185.8	8287.0	2101.2

$$V = \left[\begin{matrix}\text{Volume of}\\ \text{Mold}\\ \text{(cu. ft.)}\end{matrix}\right] = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\begin{matrix}\text{Unit Weight}\\ \text{of Water}\\ \text{(lb. / cu. ft.}\end{matrix}\right] \text{X } [453.6 \text{ (grams / lb.)}]}$$

$$V = \frac{(\ 2101.2\ )}{(\ 62.261\ ) \text{X} (\ 453.6\ )} = \frac{0.0744}{0.074400911} \text{ cu. ft.}$$

28241.5896

REMARKS: _____

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 5

ADOT Intermodal Transportation

ARIZONA DEPARTMENT OF TRANSPORTATION

CALIBRATION OF PROCTOR MOLD
ARIZ 225 Appendix A

_____ Four Inch Mold _____ Six Inch Mold Mold I. D. #: _____

Calibration Date: _____ Calibration Expiration Date: _____

Temperature of water used for Calibration: _____ ° F

Unit Weight of Water: _____ lb. /cu. ft.

Test Operator: _____ Supervisor and Date: _____

Weight of Baseplate, Empty Mold, and Glass Plate (grams)	Weight of Baseplate, Mold Filled with Water, and Glass Plate (grams)	Weight of Water to Fill Mold (grams)

$$V = \frac{\text{Weight of Water to Fill Mold (grams)}}{\left[\begin{array}{c}\text{Unit Weight} \\ \text{of Water} \\ \text{(lb. / cu. ft.}\end{array}\right] \text{X } [453.6 \text{ (grams / lb.)}]}$$

$$V = \frac{(\qquad\qquad)}{(\qquad\qquad) \text{ X } (\qquad\qquad)} = _____ \text{ cu. ft.}$$

REMARKS: _____

Unit Weight of Water Table

Temp °F	lbs/cu. Ft.	Temp °F	lbs/cu. Ft.
68	62.315	77	62.243
69	62.308	78	62.234
70	62.301	79	62.225
71	62.293	80	62.216
72	62.285	81	62.206
73	62.277	82	62.196
74	62.269	83	62.186
75	62.261	84	62.176
76	62.252	85	62.166
		86	62.155

FIGURE 6

MOISTURE - DENSITY RELATIONSHIP USING TYPICAL MOISTURE - DENSITY CURVES (ONE POINT PROCTOR) ALTERNATE METHOD D

(An Arizona Method)

1. SCOPE

1.1 This method of test is for the determination of the optimum moisture content and maximum dry density of a soil or soil-aggregate mixture utilizing one moisture-density determination on the portion of the sample passing the 3/4 inch sieve.

1.2 The one-point proctor is used with the typical moisture-density curves, shown on the back of the One Point Proctor Density Test Card (Figures 1 and 2); or by utilizing a family of moisture-density curves developed for the immediate local conditions.

1.3 This method is not to be used for volcanic cinders or light porous material on which the specific gravity cannot be determined with consistency or when the absorption of the coarse aggregate is greater than 4.0%.

1.4 This method may be used to determine if an existing proctor maximum density determination is valid for the soil being tested. If the existing proctor maximum density determination is not valid, a full proctor according to Arizona Test Method 245 should normally be run to determine the maximum density required for that soil type.

1.5 An example is provided in Section 7, and Figures 3 and 4, for the calculations and determinations referenced herein.

1.6 This test method may involve hazardous materials, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of who ever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 The apparatus shall consist of the following:

2.1.1 The apparatus utilized for this test method shall conform to the apparatus requirements of Arizona Test Method 245.

2.1.1.1 Instead of the 230 ± 9 °F oven, a hot plate or stove capable of maintaining a temperature of approximately 230 °F may be used. A Speedy Moisture Tester with a conversion table or calibration curve may also be used for moisture determinations made in the field. Finally, a microwave oven may be used in accordance with Arizona Test Method 719.

2.1.1.2 Instead of the scale or balance capable of measuring the weight to be determined to at least one gram, a scale capable of measuring the weight to at least 0.01 pound may be utilized.

3. CALIBRATION OF MOLD

3.1 Molds shall be calibrated in accordance with APPENDIX A of Arizona Test Method 225.

4. SAMPLE

4.1 A representative sample of passing 3/4 inch material weighing approximately 5000 grams shall be obtained for each one-point proctor.

5. PROCEDURE

5.1 If the Speedy Moisture Tester is <u>not</u> to be used in making the moisture content determination, proceed to Subsection 5.4.

5.2 For testing performed in the field, the Speedy Moisture Tester (AASHTO T 217) may be used to make the moisture content determination. The approximate 5000 gram sample of pass 3/4 inch material is sieved over a No. 4 sieve. Calculate the percent of coarse aggregate or rock particles retained on the No. 4 sieve by the following:

$$PR4 = \frac{WR4}{WT} \times 100$$

Where: PR4 = Percentage of coarse aggregate or rock particles retained on the No. 4 sieve.
WR4 = Weight of coarse aggregate or rock particles retained on the No. 4 sieve.
WT = Total Weight of material sieved.

5.3 Recombine and thoroughly blend the plus No. 4 material with the passing No. 4 material.

5.4 The approximate 5000 gram sample of passing 3/4 inch material shall be thoroughly mixed with sufficient water to bring the sample to slightly less than its optimum moisture content.

5.5 Form a specimen by compacting the prepared soil in the six inch mold (with extension collar attached) in three equal layers to give a total compacted depth of about 5 inches. Compact each layer with 56 uniformly distributed blows from the rammer, dropping free from a height of 12 inches. While each layer is being compacted, the remainder of material shall be in a pan covered by a damp cloth. During compaction, the mold shall rest firmly on a dense, uniform, rigid, and stable foundation.

Note: Each of the following has been found to be a satisfactory base on which to rest the mold during compaction of the soil: a block of concrete, weighing not less than 200 lbs., supported by a stable foundation; a sound concrete floor; and for field application, such surfaces as found in concrete box culverts, bridges, and pavements.

5.6 When compacting granular, free-draining materials, at moisture contents which are at or above optimum, the mold shall be prepared by first sealing the bottom of the mold with waterproofing grease. All excess grease shall be wiped from the mold and base plate.

5.7 Following compaction, carefully remove the extension collar. It may be necessary to use a follower to retain the soil in the mold while removing the collar to prevent damage or disturbance of the soil below the top of the mold. Carefully trim the compacted soil even with the top of the mold by means of the straightedge. If any voids are created during trimming, these shall be filled with fine material and smoothed off. Determine the weight of compacted specimen and mold. Determine the wet density, “WD”, of the compacted soil by the following:

$$WD = \frac{M1 - M2}{VM \times 453.6\ (grams/lb.)\ *}$$

Where: WD = Wet density of compacted soil, lb./cu. ft.
M1 = Weight of compacted specimen and mold, grams or lbs.
M2 = Weight of the mold, grams or lbs.
VM = Volume of the mold, cu. ft. (See Section 3 of this procedure).

* If the weights of the compacted specimen and mold, M1, and the empty mold, M2, are measured in pounds, eliminate "453.6 (grams/lb.)" from the denominator of the above equation.

5.8 The moisture content of the sample is determined either by drying (See Subsection 5.9); or, when testing is performed in the field, the Speedy Moisture Tester may be used (See Subsection 5.10).

5.9 When the percent moisture is determined by drying, remove the material from the mold and slice vertically through the center. Take a representative minimum 600 gram sample from the full length and width of one of the cut faces. Record the weight of wet soil to the nearest 0.1 gram as "WW". Dry the sample to constant weight at approximately 230 °F and record weight of dry soil to the nearest 0.1 gram as "DW". The percent moisture shall be recorded to the nearest 0.1 percent. The equation below is used when the percent moisture is determined by drying the sample.

$$\%\,Moisture = \frac{WW - DW}{DW} \times 100$$

Where: WW = Wet weight of moisture sample.
DW = Dry weight of moisture sample.

5.10 For testing in the field, the percent moisture may be determined using the Speedy Moisture Tester. Remove the material from the mold and slice vertically through the center. Obtain a minimum of 600 grams of material from the full length and width of one of the cut faces. This material is screened over a No. 4 sieve as rapidly as possible to avoid drying of the sample. A representative sample of the pass No. 4 material shall be utilized and tested in accordance with the instructional manual for that apparatus. The percent moisture of the pass No. 4 material determined

by the Speedy Moisture Tester is recorded to the nearest 0.1 percent as "W". The moisture content of the pass 3/4 inch material is determined and recorded as "TW" to the nearest 0.1 percent by the following:

$$TW = \frac{[W\ (100 - PR4)] + PR4}{100}$$

Where: TW = % moisture in pass 3/4 material.
W = % moisture in pass No. 4 material (determined by Speedy).
PR4 = % rock retained on the No. 4 sieve (determined in Subsection 5.2).

6. MAXIMUM DENSITY DETERMINATION

6.1 The point representing the wet density and moisture content (dry basis) is then plotted on the Typical Moisture-Density Curves (Figure 2) and the maximum wet density and optimum moisture content determined. When this plotted point falls between two moisture-density curves, a minor interpolation is necessary. The maximum dry density in lb/cu. ft. and the corresponding percent optimum moisture is then read directly or interpolated from the chart. The family of typical moisture-density curves provided should be periodically verified for the local conditions. If it is ascertained that the family of curves provided by Figure 2 is of questionable reliability for given local conditions, then an independent family of curves should be established and used.

6.2 The plotted point for wet density and moisture content should be on the dry side of the curve at or near optimum, as it is difficult to interpolate between curves for friable soils when on the wet side of the peak.

6.3 If the plotted point representing the wet density and moisture content of the compacted material is on the right of the peak, the test should be repeated using a lower moisture content. An exception to this rule must be made for those soils having high clay contents and relatively flat curves. These soils cannot readily be dried to optimum in the field due to the creation of a cloddy condition which will cause voids in the proctor. Proctors for these materials should be made as near to optimum as possible.

7. EXAMPLE

7.1 An illustration of determining the maximum dry density and optimum moisture content is described below, and shown in Figures 3 and 4:

For:

Wet Density = 122.5 lb./cu. ft.
Moisture Content = 18.7%

By plotting this point on the Typical Moisture-Density Curves and interpolating to the peak, it shows a point which is approximately 20 percent of the distance from Curve P to Curve Q. From the chart, the dry density for Curve P is 104.7 lb./cu. ft. @ 19.2% moisture and the dry density for Curve Q is 102.4 lb./cu. ft. @ 20.3% moisture.

By interpolation:

Density: 104.7 - 102.4 = 2.3
0.20 X 2.3 = 0.5 lb./cu. ft. difference

Moisture: 20.3- 19.2 = 1.1
0.20 X 1.1 = 0.2% difference

Therefore:

Maximum dry density = 104.7 - 0.5
= 104.2 lb./cu. ft.

Optimum Moisture = 19.2 + 0.2 = 19.4%

7.1.1 As an alternate to performing the interpolation procedure above, TABLE 1 can be used to determine the maximum dry density and optimum moisture content when the plotted point falls between two moisture-density curves.

Note: The optimum moisture and maximum dry density determinations above are for the material passing the 3/4 inch sieve. When testing field samples for comparison to proctor optimum moisture and maximum dry density, a correction to the proctor optimum moisture and maximum dry density must be made, in accordance with Arizona Test Method 227, for the percent rock which the field sample contains.

8. REPORT

8.1 Record the moisture and density data on the laboratory test form along with the laboratory number, material source and type, and other information required.

TYPICAL MOISTURE-DENSITY TABLE

Curve Letter	Lb. Cu. Ft.	% Moist.	Curve Letter	Lb. Cu. Ft.	% Moist.	Curve Letter	Lb. Cu. Ft.	% Moist.	Curve Letter	Lb. Cu. Ft.	% Moist.	Curve Letter	Lb. Cu. Ft.	% Moist.
A	**141.8**	**6.6**	**F**	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**
10%	141.5	6.7	**10%**	129.0	9.8	**10%**	116.8	13.6	**10%**	104.5	19.3	**10%**	91.9	26.0
20%	141.3	6.7	**20%**	128.8	9.9	**20%**	116.5	13.7	**20%**	104.2	19.4	**20%**	91.7	26.1
30%	141.0	6.8	**30%**	128.5	9.9	**30%**	116.3	13.8	**30%**	104.0	19.5	**30%**	91.4	26.3
40%	140.7	6.8	**40%**	128.2	10.0	**40%**	116.0	13.9	**40%**	103.8	19.6	**40%**	91.2	26.4
50%	140.5	6.9	**50%**	128.0	10.1	**50%**	115.8	14.1	**50%**	103.6	19.8	**50%**	91.0	26.6
60%	140.2	7.0	**60%**	127.7	10.2	**60%**	115.6	14.2	**60%**	103.3	19.9	**60%**	90.8	26.8
70%	139.9	7.0	**70%**	127.4	10.3	**70%**	115.3	14.3	**70%**	103.1	20.0	**70%**	90.6	26.9
80%	139.6	7.1	**80%**	127.1	10.3	**80%**	115.1	14.4	**80%**	102.9	20.1	**80%**	90.3	27.1
90%	139.4	7.1	**90%**	126.9	10.4	**90%**	114.8	14.5	**90%**	102.6	20.2	**90%**	90.1	27.2
B	**139.1**	**7.2**	**G**	**126.6**	**10.5**	**L**	**114.6**	**14.6**	**Q**	**102.4**	**20.3**	**V**	**89.9**	**27.4**
10%	138.8	7.3	**10%**	126.4	10.6	**10%**	114.3	14.7	**10%**	102.2	20.4	**10%**	89.7	27.6
20%	138.5	7.3	**20%**	126.1	10.6	**20%**	114.1	14.8	**20%**	101.9	20.5	**20%**	89.4	27.8
30%	138.3	7.4	**30%**	125.9	10.7	**30%**	113.8	15.0	**30%**	101.7	20.7	**30%**	89.2	28.0
40%	138.0	7.5	**40%**	125.6	10.8	**40%**	113.6	15.1	**40%**	101.4	20.8	**40%**	88.9	28.2
50%	137.7	7.6	**50%**	125.4	10.9	**50%**	113.3	15.2	**50%**	101.2	20.9	**50%**	88.7	28.5
60%	137.4	7.6	**60%**	125.2	10.9	**60%**	113.0	15.3	**60%**	100.9	21.0	**60%**	88.5	28.7
70%	137.1	7.7	**70%**	124.9	11.0	**70%**	112.8	15.4	**70%**	100.7	21.1	**70%**	88.2	28.9
80%	136.9	7.8	**80%**	124.7	11.1	**80%**	112.5	15.6	**80%**	100.4	21.3	**80%**	88.0	29.1
90%	136.6	7.8	**90%**	124.4	11.1	**90%**	112.3	15.7	**90%**	100.2	21.4	**90%**	87.7	29.3
C	**136.3**	**7.9**	**H**	**124.2**	**11.2**	**M**	**112.0**	**15.8**	**R**	**99.9**	**21.5**	**W**	**87.5**	**29.5**
10%	136.1	8.0	**10%**	124.0	11.3	**10%**	111.8	15.9	**10%**	99.7	21.6	**10%**	87.3	29.6
20%	135.9	8.0	**20%**	123.7	11.3	**20%**	111.5	16.0	**20%**	99.4	21.7	**20%**	87.0	29.7
30%	135.6	8.1	**30%**	123.5	11.4	**30%**	111.3	16.1	**30%**	99.2	21.9	**30%**	86.8	29.8
40%	135.4	8.1	**40%**	123.2	11.5	**40%**	111.0	16.2	**40%**	98.9	22.0	**40%**	86.5	29.9
50%	135.2	8.2	**50%**	123.0	11.6	**50%**	110.8	16.4	**50%**	98.7	22.1	**50%**	86.3	30.0
60%	135.0	8.3	**60%**	122.7	11.6	**60%**	110.6	16.5	**60%**	98.4	22.2	**60%**	86.0	30.1
70%	134.8	8.3	**70%**	122.5	11.7	**70%**	110.3	16.6	**70%**	98.2	22.3	**70%**	85.8	30.2
80%	134.5	8.4	**80%**	122.2	11.8	**80%**	110.1	16.7	**80%**	97.9	22.5	**80%**	85.5	30.3
90%	134.3	8.4	**90%**	122.0	11.8	**90%**	109.8	16.8	**90%**	97.7	22.6	**90%**	85.3	30.4
D	**134.1**	**8.5**	**I**	**121.7**	**11.9**	**N**	**109.6**	**16.9**	**S**	**97.4**	**22.7**	**X**	**85.0**	**30.5**
10%	133.9	8.6	**10%**	121.5	12.0	**10%**	109.4	17.0	**10%**	97.1	22.9	**10%**	84.8	30.6
20%	133.7	8.6	**20%**	121.2	12.1	**20%**	109.1	17.1	**20%**	96.8	23.0	**20%**	84.6	30.7
30%	133.5	8.7	**30%**	121.0	12.1	**30%**	108.9	17.3	**30%**	96.6	23.2	**30%**	84.4	30.8
40%	133.3	8.7	**40%**	120.7	12.2	**40%**	108.6	17.4	**40%**	96.3	23.4	**40%**	84.2	30.9
50%	133.1	8.8	**50%**	120.5	12.3	**50%**	108.4	17.5	**50%**	96.0	23.6	**50%**	84.0	31.0
60%	132.8	8.8	**60%**	120.3	12.4	**60%**	108.1	17.6	**60%**	95.7	23.7	**60%**	83.8	31.1
70%	132.6	8.9	**70%**	120.0	12.5	**70%**	107.9	17.7	**70%**	95.4	23.9	**70%**	83.6	31.2
80%	132.4	8.9	**80%**	119.8	12.5	**80%**	107.6	17.9	**80%**	95.2	24.1	**80%**	83.4	31.3
90%	132.2	9.0	**90%**	119.5	12.6	**90%**	107.4	18.0	**90%**	94.9	24.2	**90%**	83.2	31.4
E	**132.0**	**9.0**	**J**	**119.3**	**12.7**	**O**	**107.1**	**18.1**	**T**	**94.6**	**24.4**	**Y**	**83.0**	**31.5**
10%	131.7	9.1	**10%**	119.1	12.8	**10%**	106.9	18.2	**10%**	94.4	24.5	**10%**	82.8	31.6
20%	131.5	9.1	**20%**	118.8	12.9	**20%**	106.6	18.3	**20%**	94.1	24.7	**20%**	82.6	31.7
30%	131.2	9.2	**30%**	118.6	12.9	**30%**	106.4	18.4	**30%**	93.9	24.8	**30%**	82.4	31.8
40%	130.9	9.3	**40%**	118.4	13.0	**40%**	106.1	18.5	**40%**	93.6	25.0	**40%**	82.2	31.9
50%	130.7	9.4	**50%**	118.2	13.1	**50%**	105.9	18.7	**50%**	93.4	25.1	**50%**	82.1	32.0
60%	130.4	9.4	**60%**	117.9	13.2	**60%**	105.7	18.8	**60%**	93.1	25.2	**60%**	81.9	32.1
70%	130.1	9.5	**70%**	117.7	13.3	**70%**	105.4	18.9	**70%**	92.9	25.4	**70%**	81.7	32.2
80%	129.8	9.6	**80%**	117.5	13.3	**80%**	105.2	19.0	**80%**	92.6	25.5	**80%**	81.5	32.3
90%	129.6	9.6	**90%**	117.2	13.4	**90%**	104.9	19.1	**90%**	92.4	25.7	**90%**	81.3	32.4
F	**129.3**	**9.7**	**K**	**117.0**	**13.5**	**P**	**104.7**	**19.2**	**U**	**92.1**	**25.8**	**Z**	**81.1**	**32.5**

TABLE 1

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ TRACS No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D _____
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = _____ cu. ft.
Weight of Mold = M2 = _____ grams _____ pounds
Weight of Sample and Mold = M1 = _____ grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = _____ \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = _____ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = _____ WR4 = _____ PR4 = $\frac{WR4}{WT} \times 100$ = _____ %

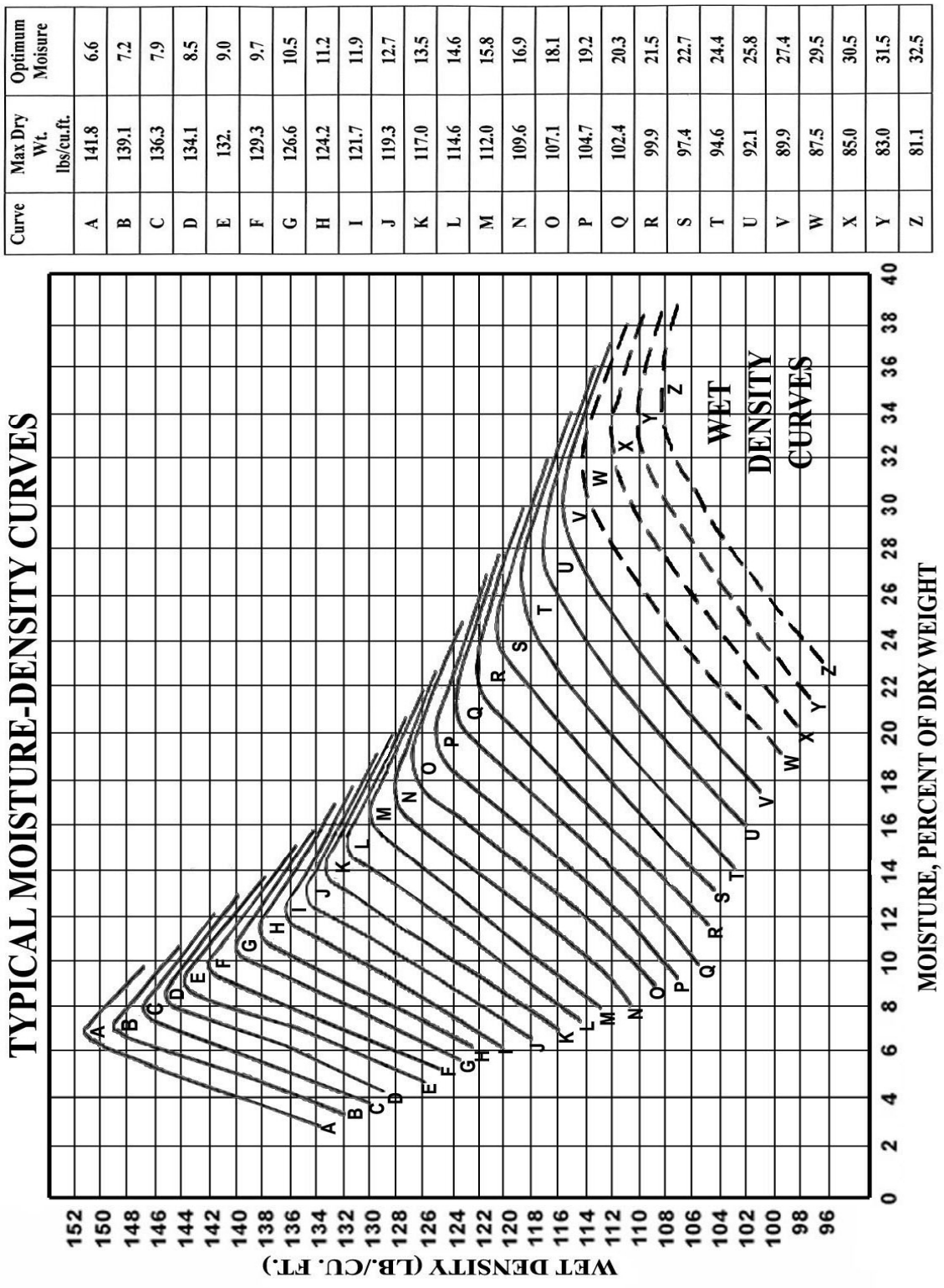
% Moisture in Pass No. 4 material from Speedie = W = _____ %

$$\text{Total \% Moisture} = TW = \frac{[W(100 - PR4)] + PR4}{100} = _____ \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = _____ lb./cu. ft.
Percent Optimum Moisture = OM = _____ %

REMARKS: _____

FIGURE 1



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

FIGURE 2

ONE POINT PROCTOR DENSITY

Lab. No: _____ Org No.: _____ Date: _____
Project No. _____ TRACS No. _____
Original Source: _____ Type of Material: _____
Coarse Agg. % Absorp.: _____ Coarse Agg. Bulk O.D. Sp. Gr.: _____
Proctor Method Used: Method A _____ Alternate Method D **X**
Test Operator: _____ Date: _____
Supervisor: _____ Date: _____

Wet Density Determination

Volume of Mold = VM = **0.0758** cu. ft.
Weight of Mold = M2 = **6608** grams _____ pounds
Weight of Sample and Mold = M1 = **10820** grams _____ pounds

$$\text{Wet Density} = WD = \frac{M1 - M2}{VM \times 453.6 \text{ (grams/lb.)}^*} = \textbf{122.5} \text{ lb./cu.ft.}$$

*If M1 and M2 are in pounds, eliminate "453.6 (grams/lb.)" from denominator in above equation.

Percent Moisture Determination

For either Method A or Alternate Method D, when sample is oven dried:

Wet Weight of Moisture Sample = WW = _____ grams
Dry Weight of Moisture Sample = DW = _____ grams

$$\% \text{ Moisture} = \frac{WW - DW}{DW} \times 100 = _____ \%$$

For Method A, when Speedie Moisture Tester is used:

% Moisture = _____ %

For Alternate Method D, when Speedie Moisture Tester is used:

WT = **5736** WR4 = **1274** PR4 = $\frac{WR4}{WT} \times 100$ = **22** %

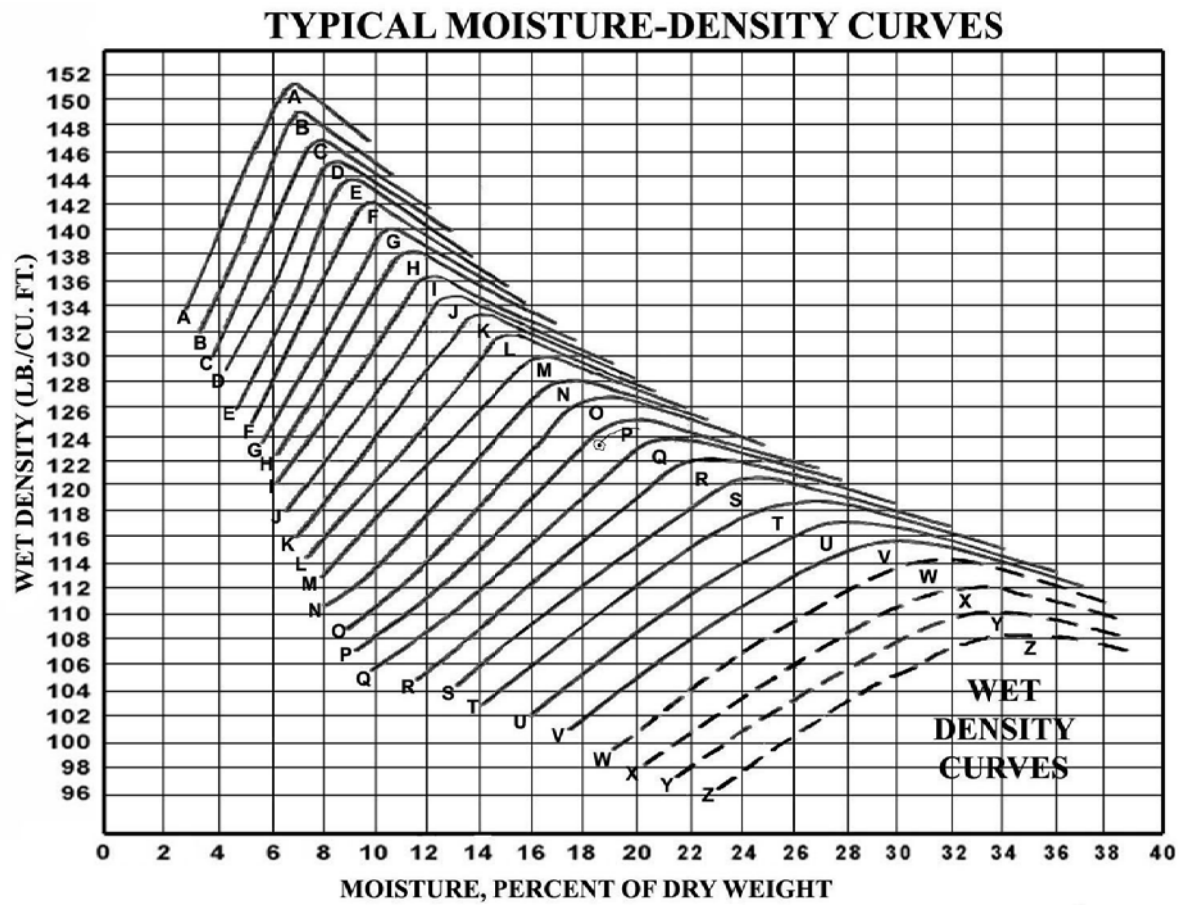
% Moisture in Pass No. 4 material from Speedie = W = **23.7** %

$$\text{Total \% Moisture} = TW = \frac{[W(100 - PR4)] + PR4}{100} = \textbf{18.7} \%$$

From Typical Moisture-Density Curves:
Maximum Dry Density = MD = **104.2** lb./cu. ft.
Percent Optimum Moisture = OM = **19.4** %

REMARKS: _____

FIGURE 3



Curve	Max Dry Wt. lbs/cu.ft.	Optimum Moisure
A	141.8	6.6
B	139.1	7.2
C	136.3	7.9
D	134.1	8.5
E	132.	9.0
F	129.3	9.7
G	126.6	10.5
H	124.2	11.2
I	121.7	11.9
J	119.3	12.7
K	117.0	13.5
L	114.6	14.6
M	112.0	15.8
N	109.6	16.9
O	107.1	18.1
P	104.7	19.2
Q	102.4	20.3
R	99.9	21.5
S	97.4	22.7
T	94.6	24.4
U	92.1	25.8
V	89.9	27.4
W	87.5	29.5
X	85.0	30.5
Y	83.0	31.5
Z	81.1	32.5

Approx. 20% Below Curve P

Interpolated Max. Dry Density: 104.7 (Curve P)
- 102.4 (Curve Q)
2.3 X 0.20 = 0.5 lb./cu. ft.

104.7 - 0.5 = 104.2 lb. / cu. ft.

Interpolated % Optimum Moisture: 20.3 (Curve Q)
- 19.2 (Curve P)
1.1 X 0.20 = 0.2%

19.2 + 0.2 = 19.4%

FIGURE 4

PARTICLE SHAPE AND TEXTURE OF FINE AGGREGATE USING UNCOMPACTED VOID CONTENT

(A Modification of AASHTO T 304)

1. SCOPE

1.1 This method covers the determination of the "Uncompacted Void Content" of a fine aggregate for use as a measure of its angularity and texture.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 This procedure provides a numerical result in terms of percent void content, determined under standardized conditions, which correlates with the particle shape and texture properties of a fine aggregate. An increase in void content indicates greater angularity and rougher texture. Lower void content results are associated with more rounded smooth particles.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 A funnel having a volume of at least 200 cm^3, or being equipped with a supplemental container to provide the required volume. (See Figure 1)

2.3 Funnel Stand - A support capable of holding the funnel firmly in position with its axis vertically in line with the axis of the measure, and the funnel opening 4.5 ± 0.1 inches above the top of the cylinder. A suitable arrangement is shown in Figure 1.

2.4 Measure - A cylinder of approximately 100 cm^3 capacity. (See Figure 2)

2.5 A flat metal or plastic pan of sufficient size for containing the funnel stand, and preventing loss of material that overflows the measure during filling and strike off. The pan shall not be warped so as to prevent rocking of the apparatus during testing.

2.6 A straight metal spatula at least 1" greater than the diameter of the measure and at least 1/2" wide. The end shall be cut at a right angle to the edges. The straight edge of the spatula is used to strike off the fine aggregate. (See Figure 3)

2.7 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.8 Sieves of sizes No. 8, No. 16, No. 30, No. 50 and No. 100, conforming to the requirements of ASTM E11.

3. CALIBRATION OF MEASURE

3.1 Determine and record the weight of the dry, empty measure and a flat, glass plate slightly larger than it's diameter. Fill the measure with water at a temperature of 77 $\pm$ 1 °F. Place the glass plate on the measure, being sure that no air bubbles remain. It may be necessary to lightly coat the top edge of the measure with grease prior to determining the weight of the empty measure and glass plate. Dry the outer surfaces of the measure and determine and record the combined weight of measure, glass plate, and water.

3.2 Determine and record the volume of the measure to the nearest 0.01 cm^3 by the following calculation:

$$V = \frac{w}{0.997}$$

Where: V = volume of cylinder in cm^3
w = net weight of water in grams
0.997 g/cm^3 = the density of water at 77 ± 1 °F

4. SAMPLE PREPARATION

4.1 Obtain a sample of Minus No. 8 Material of sufficient size (but not less than 500 grams) to yield the quantities required in Subsection 4.3 below. The sample used for this test may either be virgin aggregate, or aggregate obtained from the extraction of a bituminous mixture.

4.2 Utilizing either a No. 100 or a No. 200 sieve, wash the sample in accordance with either Section 6 or 7 of Arizona Test Method 201. Dry the material to constant weight and sieve into size fractions as indicated in Subsection 4.3 below. Maintain the material in a dry condition in separate containers for each of the sizes specified. The sieving is to be accomplished in accordance with Arizona Test Method 201.

Note: Processing additional material may be required.

4.3 Weigh out and combine the following quantities of dry fine aggregate from each of the sizes below:

PASS	RETAINED	WEIGHT IN GRAMS	ACCUM. WEIGHT
# 8	# 16	44 ± 0.2	44 ± 0.2
# 16	# 30	57 ± 0.2	101 ± 0.4
# 30	# 50	72 ± 0.2	173 ± 0.6
# 50	# 100	17 ± 0.2	190 ± 0.8

5. PROCEDURE

5.1 If the fine aggregate has become moist, dry to constant weight and cool to room temperature.

5.2 Record the weight of the empty measure to the nearest 0.1 gram, place the funnel and measure in the funnel stand, and place the assembly in the pan described in Subsection 2.5.

5.3 Mix the test sample until it appears homogeneous. Using a finger to block the opening, pour the test sample into the funnel. Lightly level the top of the material using the end of the spatula. Remove the finger and allow the sample to fall freely into the measure.

5.4 After the funnel empties, remove excess fine aggregate from the measure by a single pass of the spatula with the edge of the blade vertical and in light contact with the top of the measure. Until this operation is complete, exercise care to avoid vibration or disturbance that could cause compaction of the fine aggregate in the measure. After strike-off, tap the measure lightly to compact the sample to make it easier to transfer the measure to the balance without spilling any of the sample. Brush adhering material from the outside of the measure and determine and record the weight of the measure and contents to the nearest 0.1 gram. (See Figure 3)

Note: The intent of this process is to allow the sample to flow freely into the measure without any vibrations or disturbance of the cylinder until the operation is complete. The cylinder may be held during strikeoff as long as there is no vibration or disturbance from the strike off process.

5.5 Collect all of the fine aggregate from the pan and measure, and repeat the procedure again.

5.6 For each determination, record the net weight of the fine aggregate in the measure. If the two net weights differ by 0.5 gram or less, average the two weights and record to the nearest 0.1 gram as the "average net weight of fine aggregate in measure", (W). If the two weights differ by more than 0.5 gram, the procedure shall be repeated until any two results are achieved which differ by 0.5 gram or less. The average of these two results is recorded to the nearest 0.1 gram as the "average net weight of fine aggregate in measure", (W).

6. CALCULATION

6.1 Determine and record the "Uncompacted Void Content" (U), to the nearest 0.1% by the following calculation:

$$U = \frac{V - (W/G)}{V} \times 100$$

Where: U = Uncompacted Void Content, percent.

V = volume of measure in cm^3.

W = average net weight of fine aggregate in measure.

G = bulk oven dry specific gravity of fine aggregate, measured in accordance with Arizona Test Method 211, "Specific Gravity and Absorption of Fine Aggregate".

6.2 For most aggregate sources the fine aggregate specific gravity does not vary much from sample to sample. It is intended that the value used in the above calculation be from a routine specific gravity test which is representative of the fine aggregate. A difference in specific gravity of 0.05 will change the calculated "Uncompacted Void Content" about one percent.

7. REPORT

7.1 The "Uncompacted Void Content" (U), to the nearest 0.1%.

7.2 The bulk oven dry specific gravity of the fine aggregate (G), to the nearest 0.001.

FUNNEL, FUNNEL STAND, AND MEASURE

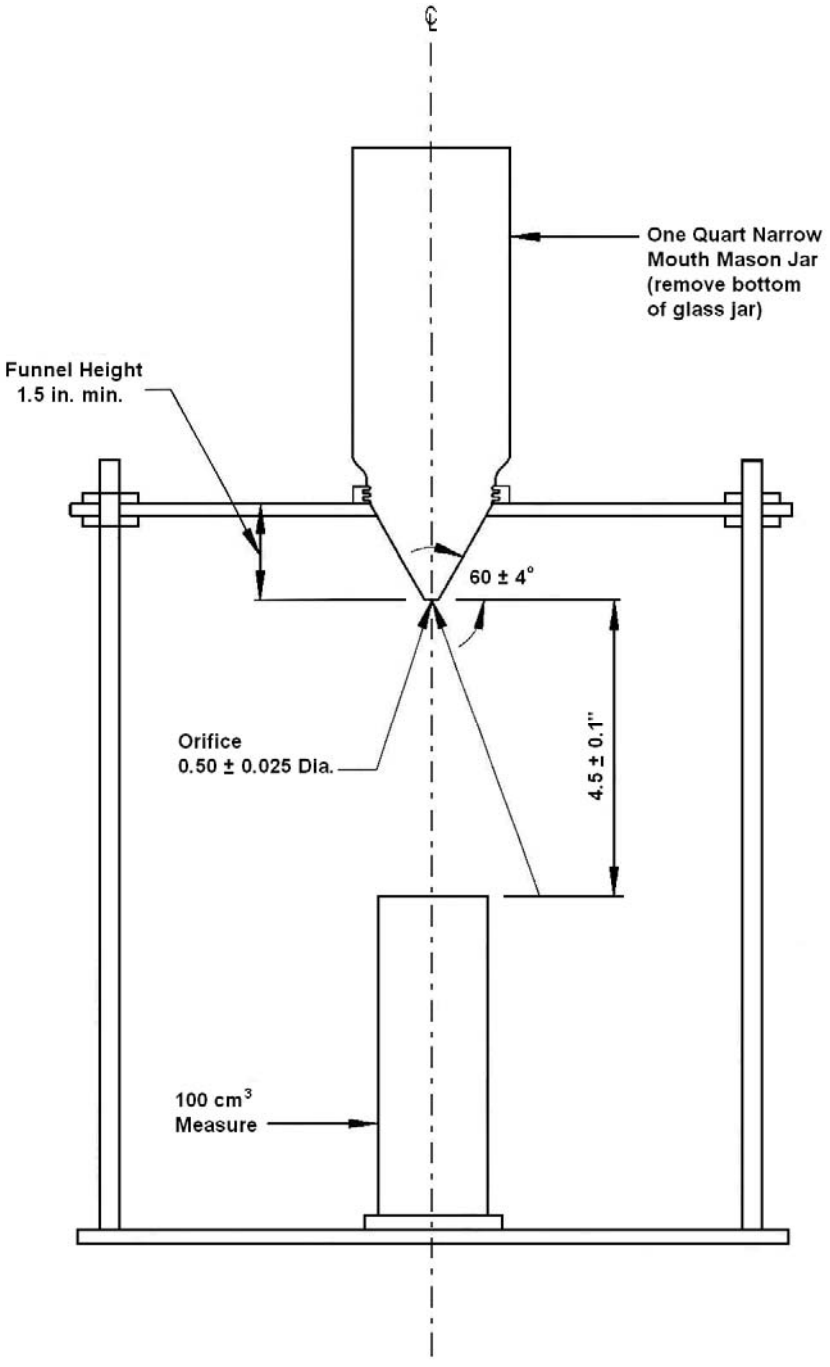


FIGURE 1

MEASURE

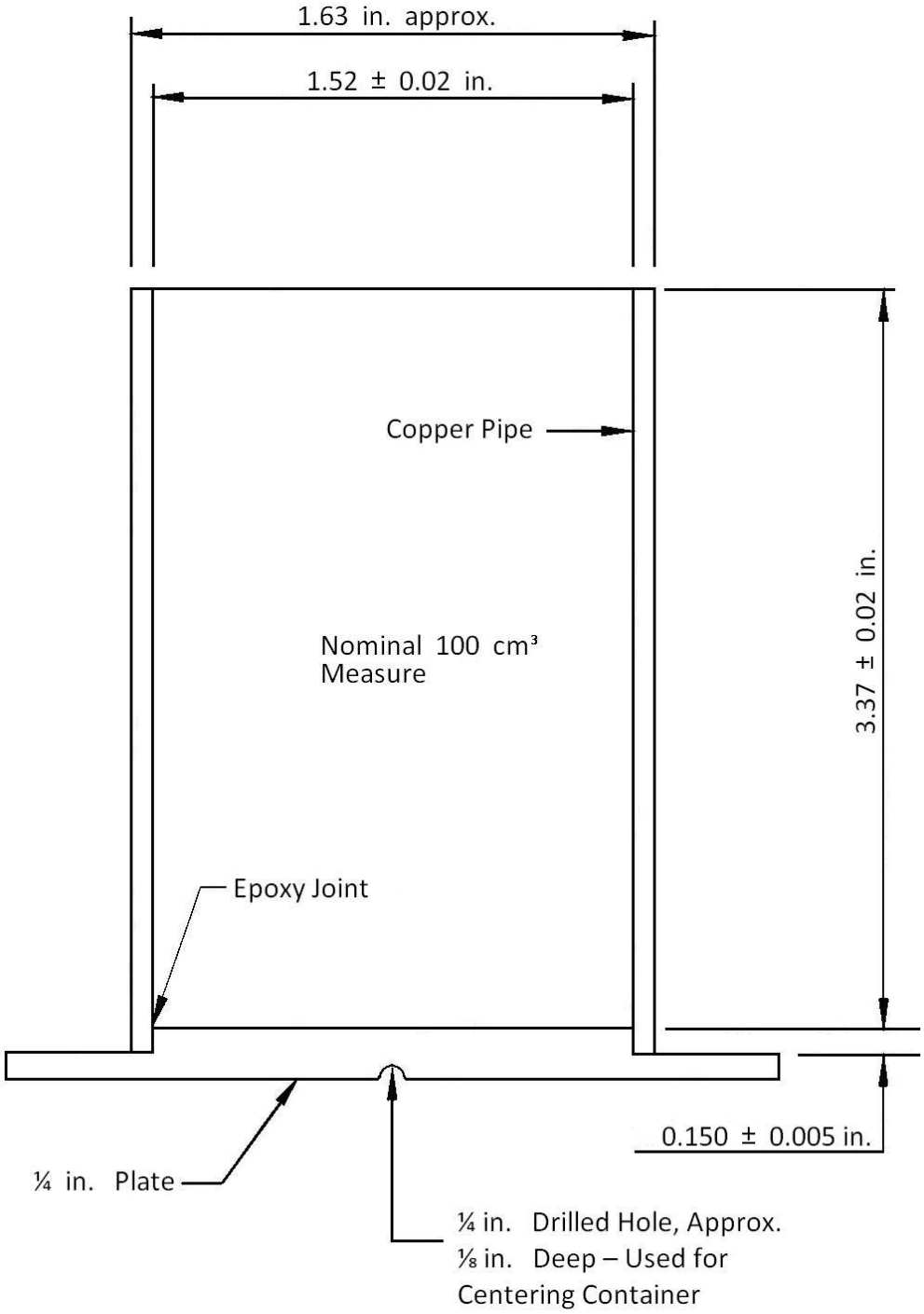
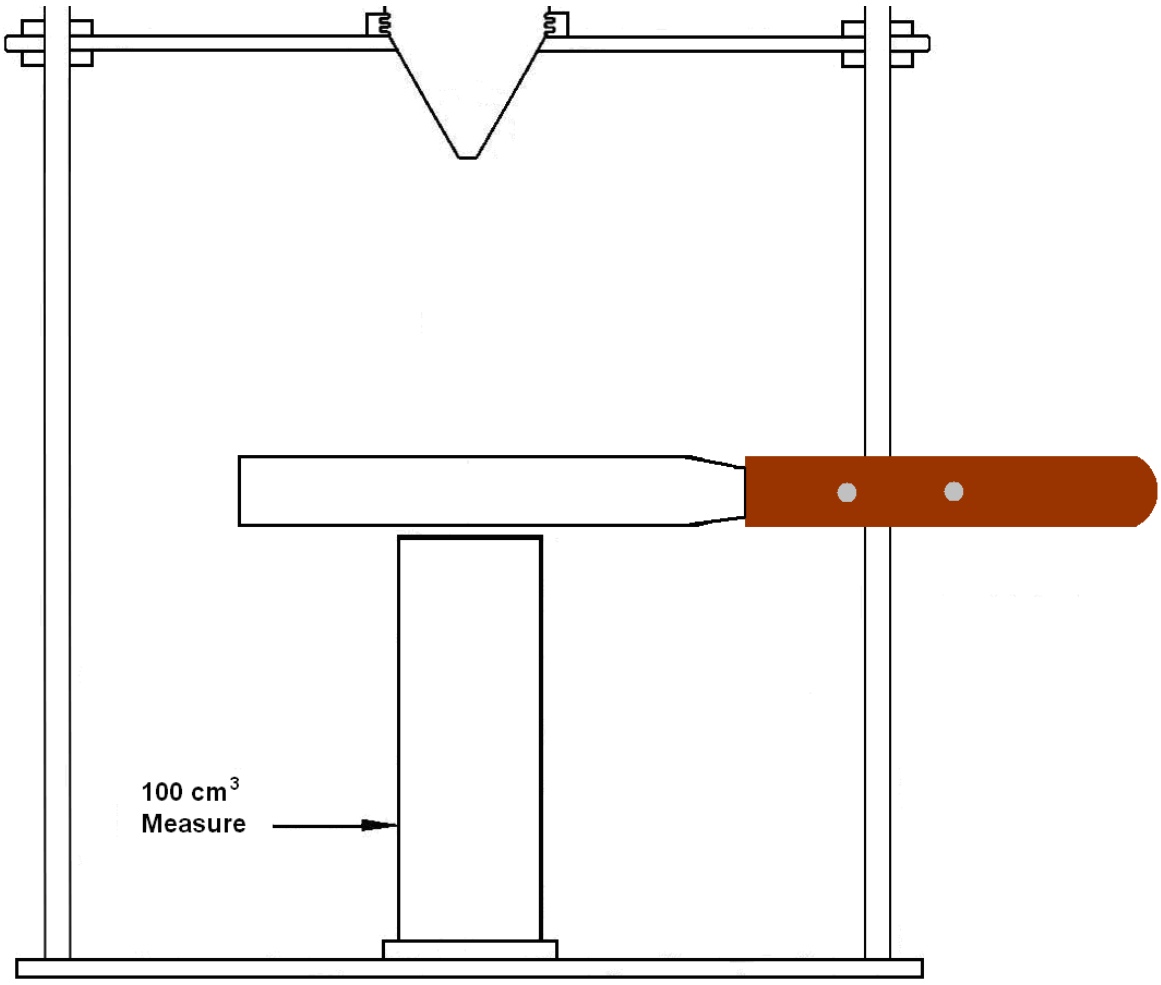


FIGURE 2



Straight Metal Spatula

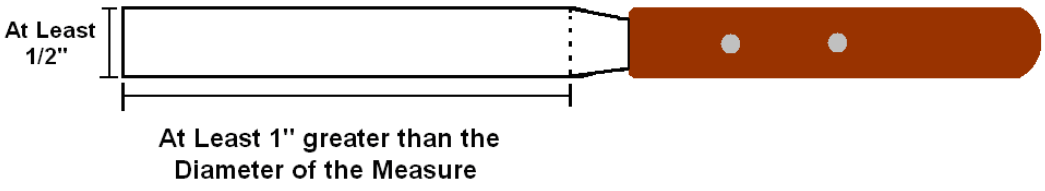


FIGURE 3

ARIZ 248
September 1, 1993
(14 Pages)

ALTERNATE PROCEDURES FOR SIEVING OF COARSE AND FINE GRADED SOILS AND AGGREGATES

(An Arizona Method)

SCOPE

1. (a) This test method contains five alternate procedures for sieving and determining the sieve analysis of fine and coarse graded soils and aggregates.

(b) This test method must be used in conjunction with Arizona Test Method 201. In general, the method for sample preparation, sieving, and calculation of the sieve analysis as described in Arizona Test Method 201 will be followed, with the changes and additional information being outlined and described herein for each alternate procedure shown below.

1) Alternate #1 (Section 2) - Fine screening of aggregate which contains a small amount of Plus No. 4 (100% pass 3/8") material, e.g., fine aggregate for concrete.

2) Alternate #2 (Section 3) - Utilizing a No. 8 screen in the coarse sieving, and a fine sieve analysis not being required.

3) Alternate #3 (Section 4) - Subjecting the entire sample to washing, and a minus No. 4 split for fine screening is not required.

4) Alternate #4 (Section 5) - Subjecting the entire sample to washing, and a minus No. 4 split for fine screening is required.

5) Alternate #5 (Section 6) - Washing of coarse aggregate (Plus No. 4) to remove clinging particles and adjusting the fine sieve analysis.

ALTERNATE #1

2. Fine screening of aggregate which contains a small amount of Plus No. 4 (100% pass 3/8") material, e.g., fine aggregate for concrete. An example of this procedure is shown in Figure 1.

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER	PROJ CODE	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
93-2222	7777	8888	FA	+	A	P	-	+

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
18	+	A. JONES	12	08	93	1135 AM ☒ / PM ☐

SAMPLED FROM: STOCKPILE
LIFT NO.: + | RDWY: + | STATION: — | PLUS: + (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
PIT # 5555	B. SMITH	F-099-9 (99)	H999901C

REMARKS:
EXAMPLE FOR FINE SCREENING WHEN FINE AGGREGATE CONTAINS A SMALL AMOUNT OF PLUS No. 4 MATERIAL - (ALTERNATE #1)

ARIZ 201

% OVERSIZE: +3" ☐ | +6" ☐
COARSE FACTOR: 177936

WET SAMPLE PREWEIGHT = —
WET WT. OF -#4 = —
-#4 SPLIT WET WT. = —

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐					
2 1/2"					
2"					
1 1/2"					
1"					
3/4"					
1/2"					
3/8"	0		100	100	
1/4"	8	1	99		
#4	15	3			
-#4	—				
Total	—		96	95-100	

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = 562
WASHED WT. = 547
ELUTRIATION = 15

DRY WT. OF -#4 SPLIT: + | FINE FACTOR: —

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.
#8	13	2	94	
#10	42	8	86	
#16	91	16	70	45-80
#30	67	12	58	
#40	123	22	36	
#50	41	7	29	0-30
#100	121	22	7	0-10
#200	24	4		
-#200	2	✓	3.0	0-4
Total	547 Dry Weight			
Elutriation	15			

T = AASHTO Tests

		SPECS.
Liquid Limit (LL)	T - 89	
Plastic Limit (PL)	T - 90	
Plasticity Index (PI) = LL - PL	T - 90	
Abrasion Method (A,B,C,D)	T - 96	
@ 100 Revolutions	%	%
@ 500 Revolutions	%	%
Absorption, H_2O	T - 85 ARIZ 211	%
Specific Gravity, SSD	T - 85 ARIZ 211	
Specific Gravity, OD	T - 85 ARIZ 211	
Proctor Method		A - ARIZ 225; C - ARIZ 226; D - ARIZ 226; AD - ARIZ 245; AI - ARIZ 232; ADI - ARIZ 246
Optimum Moisture	%	
Max. Dry Density	PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)	
Fractured Faces Weight (Wf)		
Total Sample Weight (Wa)		
Fractured Faces (FF) = Wf/Wa x 100	ARIZ 212	%
Wet Weight (W)	g	
Dry Weight (D)	g	
Moisture Content = (W-D)/D x 100	T - 255 T - 265	%
Flakiness Index	ARIZ 233	%
Carbonates	ARIZ 238	%
pH	ARIZ 236 OR 237	
Resistivity (ohm-cm)	ARIZ 236	
Soluble Salts (PPM)	ARIZ 237	

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

WHITE ☒
YELLOW ☐
BLUE ☐

12-08-93 — RECEIVED DATE
Joe Dogood 12-08-93 — TEST OPERATOR & DATE
Ted Headman 12-08-93 — SUPERVISOR & DATE

44-0333 R9/93

FIGURE 1

(a) A representative minimum 500 gram sample is obtained and dried to constant weight. Allow the sample to cool, and record the weight to the nearest gram as the "Unwashed Wt", (562 in the example).

(b) Subject the sample to either mechanical or hand washing.

(c) Dry the sample to constant weight and allow to cool. Record weight to the nearest gram as "Washed Wt" and also as the fine sieve "Total Dry Weight", (547).

(d) Determine and record "Elutriation" by subtracting the "Washed Wt" from the "Unwashed Wt", (562 - 547 = 15).

(e) Additional sieves (Plus No. 4) as required are added to the nest of sieves used in the fine screening.

(f) The sample is subjected to screening and the weight retained on each sieve and in the pan is recorded.

(g) The sum of the individual weights retained for each sieve is compared to the weight of sample prior to sieving (Washed Wt. or fine sieve Total Dry Weight). Adjust or resieve as necessary.

(h) Determine the sieve analysis of the material. The factor for calculating the sieve analysis is determined by dividing 100 by the "Unwashed Wt", (100/562 = 0.177936). The calculation of the percent passing each sieve is continuous through the entire sieve analysis.

ALTERNATE #2

3. Utilizing a No. 8 screen in the coarse sieving, and a fine sieve analysis not being required. An example is given in Figure 2.

(a) A representative sample is obtained and the weight recorded as the "Coarse Sieve Total", (14683 in the example).

(b) Subject the sample to coarse sieving using the No. 8 as the smallest sieve. If desired, the material may be screened using a No. 4 as the smallest sieve, and the pass No. 4 material further separated into No. 8 and pass No. 8 fractions.

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER	PROJ CODE	ORG NUMBER	MATL TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
93-3333	7777	8888	CA 57	A	P	-	+

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO DAY YEAR	TIME
6	+	A. JONES	12 02 93	2:40 ☐ AM ☒ PM

SAMPLED FROM: STOCKPILE
LIFT NO.: + | RDWY: + | STATION: — | PLUS: + (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
PIT # 5555	B. SMITH	F-099-9(99)	H999901C

REMARKS: EXAMPLE FOR USING A No. 8 SIEVE IN THE COARSE SIEVING AND NO FINE SIEVE ANALYSIS REQUIRED - (ALTERNATE #2).

ARIZ 201

% OVERSIZE: +3" ☐ +6" ☐ COARSE FACTOR: 006811

WET SAMPLE PREWEIGHT = _____
WET WT. OF -#4 = _____
-#4 SPLIT WET WT. = _____

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐					
2 1/2"					
2"					
1 1/2"	0		100	100	
1"	505	3	97	95-100	
3/4"	2850	20	77		
1/2"	4410	30	47	25-60	
3/8"	2350	16	31		
1/4"	1915	13	18		
#4	1325	9			
-#4	—		9	0-10	
Total	14683				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = _____
WASHED WT. = _____
ELUTRIATION = _____

DRY WT. OF -#4 SPLIT: + | FINE FACTOR: —

-#8

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8	1255	9	—		
#10	73	—	0	0-5	✓
#16					
#30					
#40					
#50					
#100					
#200					
-#200					
Total				0-1.0	
Beaker					

Dry Weight: _____

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

			SPECS.
Liquid Limit (LL)	T - 89		
Plastic Limit (PL)	T - 90		
Plasticity Index (PI) = LL - PL	T - 90		
Abrasion Method (A,B,C,D)	T - 96		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%
Absorption, H_2O	T - 85 ARIZ 211	%	
Specific Gravity, SSD	T - 85 ARIZ 211		
Specific Gravity, OD	T - 85 ARIZ 211		
Proctor Method			A - ARIZ 225 C - ARIZ 226 D - ARIZ 226 AD - ARIZ 245 AI - ARIZ 232 ADI - ARIZ 246
Optimum Moisture		%	
Max. Dry Density		PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)		
Fractured Faces Weight (Wf)			
Total Sample Weight (Wa)			
Fractured Faces (FF) = Wf/Wa x 100	ARIZ 212	%	%
Wet Weight (W)		g	
Dry Weight (D)		g	
Moisture Content = (W-D)/D x 100	T - 255 T - 265	%	
Flakiness Index	ARIZ 233	%	%
Carbonates	ARIZ 238	%	%
pH	ARIZ 236 OR 237		
Resistivity (ohm-cm)	ARIZ 236		
Soluble Salts (PPM)	ARIZ 237		

WHITE ☒
YELLOW ☐
BLUE ☐

12-02-93 RECEIVED DATE
Joe DoGood 12-03-93 TEST OPERATOR & DATE
Ted Headman 12-03-93 SUPERVISOR & DATE

44-9363 R9/93

FIGURE 2

(c) The weight of material retained on each of the sieves No. 8 and larger, and the weight of pass No. 8 material is recorded on the laboratory sieve analysis card, modifying the card for the pass No. 8 material as shown in the example.

(d) The sum of the individual weights retained for each sieve is compared to the weight of the sample prior to sieving (Coarse Sieve Total). Adjust or resieve as needed.

(e) Determine the sieve analysis of the material. The coarse sieve factor is determined by dividing 100 by the "Coarse Sieve Total", (100/14683 = 0.006811). The calculation of the percent passing each sieve is continuous through the entire sieve analysis.

ALTERNATE #3

4. Subjecting the entire sample to washing, and a minus No. 4 split for fine screening is <u>not</u> required. An example of this procedure is given in Figure 3.

(a) A representative sample is be obtained, dried to constant weight, allowed to cool, and the weight recorded as the "Coarse Sieve Total" and also as the "Unwashed Weight", (1137 in the example).

(b) Subject the sample to hand washing.

(c) Dry the sample to constant weight and allow to cool. The weight of the sample is recorded as the "Washed Wt", (1118).

(d) Determine "Elutriation" by subtracting the "Washed Wt" from the "Unwashed Wt", (1137 - 1118 = 19).

(e) Subject the sample to coarse screening and record the weight retained on each sieve and in the pan, except the weight of pass No. 4 material is not recorded in the coarse sieve area, but rather as the fine sieve "Total Dry Weight", (468).

(f) Determine and record the weight of pass No. 4 for coarse sieve analysis by adding the "elutriation" and the fine sieve "Total Dry Weight", (468 + 19 = 487).

(g) The sum of the individual weights retained for each sieve is compared to the weight of sample prior to sieving (Washed Wt.). Adjust or resieve as necessary.

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER	PROJ CODE	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
93-5555	7777	8888	AA	FC	A	P	-	+

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
3	+	A. JONES	10	07	93	12:10 ☐ AM ☒ PM

SAMPLED FROM	LIFT NO.	RDWY	STATION	PLUS
COLD FEED	+	+		IF MILEPOST, INPUT DECIMAL

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
PIT # 4444	B. SMITH	F-099-9(99)	H999901C

REMARKS: EXAMPLE WHEN ENTIRE SAMPLE IS WASHED AND A MINUS No. 4 SPLIT FOR FINE SIEVING IS NOT REQUIRED - (ALTERNATE # 3).

ARIZ 201

% OVERSIZE: +3" ☐ +6" ☐ COARSE FACTOR 087951

WET SAMPLE PREWEIGHT = —
WET WT. OF -#4 = —
-#4 SPLIT WET WT. = —

468 + 19 = 487

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐					
2 1/2"					
2"					
1 1/2"					
1"					
3/4"					
1/2"					
3/8"	0		100	100	
1/4"	269	24	76		
#4	381	33			
-#4	487	43	33-45		
Total	1137				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = 1137
WASHED WT. = 1118
ELUTRIATION = 19

DRY WT. OF -#4 SPLIT: + ☐ FINE FACTOR —

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8	342	30	13	6-18	
#10	23	2	11		
#16	34	3	8		
#30	11	1	7		
#40	22	2	5		
#50	12	1	4		
#100	10	1	3		
#200	13	1			
-#200	1	✓	1.8	0-3.8	
Total	468				
Elutriation	19				

Dry Weight

T = AASHTO Tests

		SPECS.
Liquid Limit (LL)	T - 89	
Plastic Limit (PL)	T - 90	
Plasticity Index (PI) = LL - PL	T - 90	
Abrasion Method (A,B,C,D)	T - 96	
@ 100 Revolutions	%	%
@ 500 Revolutions	%	%
Absorption, H_2O	T - 85 ARIZ 211	%
Specific Gravity, SSD	T - 85 ARIZ 211	
Specific Gravity, OD	T - 85 ARIZ 211	
Proctor Method		
Optimum Moisture	%	
Max. Dry Density	PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)	
Fractured Faces Weight (Wf)		
Total Sample Weight (Wa)		
Fractured Faces (FF) = $\frac{Wf}{Wa}$ x 100	ARIZ 212	% %
Wet Weight (W)	g	
Dry Weight (D)	g	
Moisture Content = $\frac{W-D}{D}$ x 100	T - 255 T - 265	%
Flakiness Index	ARIZ 233	% %
Carbonates	ARIZ 238	% %
pH	ARIZ 236 OR 237	
Resistivity (ohm-cm)	ARIZ 236	
Soluable Salts (PPM)	ARIZ 237	

A - ARIZ 225
C - ARIZ 226
D - ARIZ 226
AD - ARIZ 245
AI - ARIZ 232
ADI - ARIZ 246

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

WHITE ☒
YELLOW ☐
BLUE ☐

10-07-93 RECEIVED DATE

Joe Dogood 10-07-93 TEST OPERATOR & DATE

Ted Headman 10-08-93 SUPERVISOR & DATE

44-0353 R9/93

FIGURE 3

(h) Sieve the pass No. 4 material and record the weight retained for each sieve and in the pan.

(i) The sum of the individual weights retained for each sieve is compared to the weight of sample prior to sieving (fine sieve Total Dry Weight). Adjust or resieve as necessary.

(j) Determine the sieve analysis of the material. The coarse sieve factor is determined by dividing 100 by the "Coarse Sieve Total", (100/1137 = 0.087951). A fine sieve factor is not determined. The calculation of the percent passing each sieve is continuous through the entire sieve analysis.

ALTERNATE #4

5. Subjecting the entire sample to washing, and a minus No. 4 split for fine screening is required. An example of this procedure is given in Figure 4.

(a) A representative sample is obtained, dried to constant weight, allowed to cool, and the weight recorded as the "Coarse Sieve Total" and also as the "Unwashed Weight", (4893 in the example).

(b) Subject the sample to hand washing.

(c) Dry the sample to constant weight and allow to cool. The weight of the sample is recorded as the "Washed Wt", (4674).

(d) The elutriation of the total sample is determined by subtracting the "Washed Wt" from the "Unwashed Wt", (4893 - 4674 = 219).

(e) The sample shall be subjected to coarse screening and the weight retained on each sieve and in the pan is recorded, except the weight of pass No. 4 material is not recorded in the coarse sieve area, but rather as "Wt. of - #4" (2521).

(f) The sum of the individual weights retained for each sieve is compared to the weight of sample prior to sieving (Washed Wt.). Adjust or resieve as necessary.

(g) The passing No. 4 weight for coarse sieve analysis is the combination of the weight of pass No. 4 and the elutriation of the total sample, (2521 + 219 = 2740).

(h) The weight of the passing No. 4 material split for fine sieving is recorded as the fine sieve "Total Dry Weight", (665).

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER: 93-1111 | PROJ CODE: 7777 | ORG NUMBER: 8888 | MATL TYPE: TS | PURPOSE: A | TEST LAB: P | SIZE: - | SIZE %: +
TEST NO.: 8 | LOT OR SUFFIX: + | SAMPLED BY: A. JONES | MO DAY YEAR: 12 28 93 | TIME: 9:30 ☒ AM ☐ PM
SAMPLED FROM: STOCKPILE | LIFT NO.: + | RDWY: + | STATION: + | PLUS: IF MILEPOST, INPUT DECIMAL
ORIGINAL SOURCE: PIT # 3333 | PROJECT ENGINEER / SUPERVISOR: B. SMITH | PROJECT NUMBER: F-099-9(99) | TRACS NUMBER: H999901C
REMARKS: EXAMPLE WHEN ENTIRE SAMPLE IS WASHED AND A MINUS No. 4 SPLIT FOR FINE SIEVING IS REQUIRED - (ALTERNATE # 4).

ARIZ 201

% OVERSIZE: +3" ☐ +6" ☐ | COARSE FACTOR: .020437

WET SAMPLE PREWEIGHT = —
WET WT. OF -#4 = 2521
-#4 SPLIT WET WT. = —

2521 + 219 = 2740

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐					
2 1/2"					
2"				100	
1 1/2"					
1"					
3/4"	0		100		
1/2"	270	6	94	85-100	
3/8"	613	12	82		
1/4"	928	19	63		
#4	342	7			
-#4	2740	✓	56		
Total	4893	IF TOTAL SAMPLE IS WASHED:			

UNWASHED WT. = 4893
WASHED WT. = 4674
ELUTRIATION = 219

DRY WT. OF -#4 SPLIT: 723 | FINE FACTOR: .077455

852 x 219 = 812 x 1252 / 596

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.
#8	65	5	51	
#10	26	2	49	
#16	104	8	41	
#30	27	2	39	
#40	39	3	36	35-100
#50	181	14	22	
#100	117	9	13	
#200	103	8		
-#200	3	✓	4.7	
Total	665			
Elutriation	58			

Dry Weight

T = AASHTO Tests

			SPECS.
Liquid Limit (LL)	T - 89		
Plastic Limit (PL)	T - 90		
Plasticity Index (PI) = LL - PL	T - 90		
Abrasion Method (A,B,C,D)	T - 96		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%
Absorption, H_2O	T - 85 ARIZ 211	%	
Specific Gravity, SSD	T - 85 ARIZ 211		
Specific Gravity, OD	T - 85 ARIZ 211		
Proctor Method			A - ARIZ 225 C - ARIZ 226 D - ARIZ 226 AD - ARIZ 245 AI - ARIZ 232 ADI - ARIZ 248
Optimum Moisture		%	
Max. Dry Density		PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)		
Fractured Faces Weight (Wf)			
Total Sample Weight (Wa)			
Fractured Faces (FF) = Wf/Wa x 100	ARIZ 212	%	%
Wet Weight (W)		g	
Dry Weight (D)		g	
Moisture Content = (W-D)/D x 100	T - 255 T - 265	%	
Flakiness Index	ARIZ 233	%	%
Carbonates	ARIZ 236	%	%
pH	ARIZ 236 OR 237		
Resistivity (ohm-cm)	ARIZ 238		
Soluble Salts (PPM)	ARIZ 237		

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

WHITE ☒
YELLOW ☐
BLUE ☐

12-28-93 — RECEIVED DATE
Joe Dogood 12-28-93 — TEST OPERATOR & DATE
Ted Heidman 12-28-93 — SUPERVISOR & DATE

44-0333 R8/93

FIGURE 4

(i) The elutriation value for fine sieve analysis is determined as follows:

$$\text{Elutriation for Fine Sieve Analysis} = \frac{\left[\text{Wt. of Passing No. 4 Material Split for Fine Sieving, (Fine Sieve "Total Dry Weight"}\right]}{\left[\text{Wt. of - \#4}\right]} \times \left[\text{Elutriation of Total Sample}\right]$$

In the example in Figure 4:

Elutriation for Fine Sieve Analysis = (665/2521) x 219 = 58

(j) The "Dry Wt. of Pass #4 Split" is determined by adding the fine sieve total dry weight and the calculated elutriation for fine sieve analysis, (665 + 58 = 723).

(k) The pass No. 4 material is sieved and the weight retained for each sieve and in the pan is recorded.

(l) The sum of the individual weights retained for each sieve is compared to the weight of sample prior to sieving (fine sieve Total Dry Weight). Adjust or resieve as necessary.

(m) Determine the sieve analysis of the material.

ALTERNATE #5

6. Washing of coarse aggregate (Plus No. 4) to remove clinging particles and adjusting the fine sieve analysis. An example of this procedure is shown in Figures 5 and 6.

(a) A representative sample shall be prepared, screened, and the sieve analysis calculated as described in Arizona Test Method 201. (When this alternate procedure is used as a referee method, the sample shall be dried to constant weight prior to sieving.)

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER	PROJ CODE	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
93-9999	7777	8888	SB	+	A	P	-	+

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
12	+	A. JONES	11	15	93	4:25 ☐AM ☒PM

SAMPLED FROM: SITE
LIFT NO.: +
RDWY: EB
STATION: 11 52+50 (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
PIT # 3333	B. SMITH	F-099-9(99)	H999901C

REMARKS
EXAMPLE OF WASHING COARSE (PLUS No. 4) AGGREGATE
AND ADJUSTING FINE SIEVE ANALYSIS - (ALTERNATE #5).

ARIZ 201

% OVERSIZE: +3" ☐ +6" ☐
COARSE FACTOR: .004418

WET SAMPLE PREWEIGHT = 22960
WET WT. OF -#4 = 11400
-#4 SPLIT WET WT. = 558

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐				100	
2 1/2"	0		100		
2"	240	11	89		
1 1/2"	138	6	83		
1"	102	4	79		
3/4"	290	13	66	60-100	
1/2"	110	5	61		
3/8"	44	2	59		
1/4"	134	6	53		
#4	92	4			
-#4	1073	✓	49		
Total	2263				

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = —
WASHED WT. = —
ELUTRIATION = —

DRY WT. OF -#4 SPLIT: 542
FINE FACTOR: .090406

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8	101	9	40	35-80	
#10	20	2	38		
#16	53	5	33		
#30	87	8	25		
#40	46	4	21		
#50	42	4	17		
#100	33	3	14		
#200	35	2	12		
-#200	2	✓	H:3	0-12	
Total	419	Dry Weight	11.6		
Elutriate	123				

	T = AASHTO Tests		SPECS.
Liquid Limit (LL)	T - 89		
Plastic Limit (PL)	T - 90		
Plasticity Index (PI) = LL - PL	T - 90		
Abrasion Method (A,B,C,D)	T - 96		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%
Absorption, H_2O	T - 85 ARIZ 211	%	
Specific Gravity, SSD	T - 85 ARIZ 211	*	
Specific Gravity, OD	T - 85 ARIZ 211	*	
Proctor Method			A - ARIZ 225 C - ARIZ 226 D - ARIZ 228 AD - ARIZ 245 AI - ARIZ 232 ADI - ARIZ 246
Optimum Moisture		%	
Max. Dry Density		PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)		
Fractured Faces Weight (Wf)			
Total Sample Weight (Wa)			
Fractured Faces (FF) = $\frac{Wf}{Wa}$ x 100	ARIZ 212	%	%
Wet Weight (W)		g	
Dry Weight (D)		g	
Moisture Content = $\frac{W-D}{D}$ x 100	T - 255 T - 265	%	
Flakiness Index	ARIZ 233	%	%
Carbonates	ARIZ 238	%	%
pH	ARIZ 236 OR 237		
Resistivity (ohm-cm)	ARIZ 236		
Soluble Salts (PPM)	ARIZ 237		

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

WHITE ☒
YELLOW ☐
BLUE ☐

11-15-93 RECEIVED DATE
Joe Dasood 11-16-93 TEST OPERATOR & DATE
Ted Headman 11-16-93 SUPERVISOR & DATE

44-0353 R9/93

FIGURE 5

DETERMINATION OF PERCENT MINUS NO. 200 ON COARSE AGGREGATE AND TOTAL PERCENT PASS NO. 200 IN SAMPLE

Project No. F-099-9(99) / H999901C Lab. No. 93-9999

Unwashed Weight of Plus No. 4 = 4967

Washed Weight of Plus No. 4 = 4941

Calculate the "Percent Minus No. 200 on Coarse Aggregate" by the following, and record result to the nearest 0.01%:

$$\left[\text{Percent Minus No. 200 on Coarse Aggregate}\right] = \frac{\left[\text{Unwashed Weight of Plus No. 4}\right] - \left[\text{Washed Weight of Plus No. 4}\right]}{\left[\text{Unwashed Weight of Plus No. 4}\right]} \times 100$$

$$= \frac{(\ 4967\ ) - (\ 4941\ )}{(\ 4967\ )} \times 100$$

Percent Minus No. 200 on Coarse Aggregate = 0.52

Calculate the "Total Percent Pass No. 200 in Sample" by the following, and record result to the nearest 0.1%:

$$\left[\text{Total Percent Pass No. 200 in Sample}\right] = \left[\text{\% Pass No. 200 from Fine Sieving}\right] + \left[\frac{\left[100 - \left[\text{\% Pass No. 4}\right]\right] \times \left[\text{Percent Minus No. 200 on Coarse Aggregate}\right]}{100}\right]$$

$$= (\ 11.3\ ) + \left[\frac{\left[100 - (\ 49\ )\right] \times (\ 0.52\ )}{100}\right]$$

Total Percent Pass No. 200 in Sample = 11.6

FIGURE 6

(b) Either the entire amount, or a representative sample of approximately 5000 grams, whichever is less, of the Plus No. 4 material from screening shall be combined, dried to constant weight, allowed to cool, and the weight recorded as the "Unwashed Weight of Plus No. 4", (4967 in the example in Figure 6).

(c) Subject the sample to hand washing.

(d) Dry the sample to constant weight and allow to cool. Record the weight to at least the nearest gram as the "Washed Weight of Plus No. 4", (4941 in the example in Figure 6).

(e) Utilizing the equations shown in Figure 6, determine and record the "Percent Minus No. 200 on Coarse Aggregate" to the nearest 0.01%, (0.52); and the "Total Percent Pass No. 200 in Sample" to the nearest 0.1%, (11.6).

(f) Compare the percent Pass No. 200 from fine sieving with the "Total Percent Pass No. 200 in Sample". If the difference is less than or equal to 1.0, replace the percent Pass No. 200 from fine sieving with the "Total Percent Pass No. 200 in Sample" and, if necessary, adjust the value for percent retained on the No. 200 sieve. (In the example in Figure 5, the 11.3 percent Pass No. 200 from fine sieving has been replaced with the 11.6 "Total Percent Pass No. 200 in Sample", and the percent retained on the No. 200 sieve has been adjusted from 3 to 2.) If the difference is greater than 1.0, another sample shall be obtained and the entire sample subjected to washing and the gradation determined as specified in Section 4 or 5.

REPORT

7. (a) The sieve analysis shall be reported as shown in Figures 1 through 5 for the particular example which is applicable.

(b) When applicable, the determination of "Percent Minus No. 200 on Coarse Aggregate" and "Total Percent Pass No. 200 in Sample" is reported as shown in the example given in Figure 6.

(c) A blank Soils and Aggregate Tabulation laboratory card is provided in Figure 7.

(d) A blank form for the determination of "Percent Minus No. 200 on Coarse Aggregate" and "Total Percent Pass No. 200 in Sample" is provided in Figure 8.

ARIZONA DEPARTMENT OF TRANSPORTATION
SOIL AND AGGREGATE TABULATION

LAB NUMBER | PROJ CODE | ORG NUMBER | MATL. | TYPE | PURPOSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO | DAY | YEAR | TIME | AM | PM

SAMPLED FROM | LIFT NO. | RDWY | STATION | PLUS
IF MILEPOST, INPUT DECIMAL

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS

ARIZ 201

% OVERSIZE: +3" ☐ | +6" ☐ | COARSE FACTOR

WET SAMPLE PREWEIGHT = _____
WET WT. OF -#4 = _____
-#4 SPLIT WET WT. = _____

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	CUMULATIVE % RET. FINENESS MODULUS
3" ☐					
2 1/2"					
2"					
1 1/2"					
1"					
3/4"					
1/2"					
3/8"					
1/4"					
#4					
-#4					
Total					

IF TOTAL SAMPLE IS WASHED:
UNWASHED WT. = _____
WASHED WT. = _____
ELUTRIATION = _____

DRY WT. OF-#4 SPLIT | FINE FACTOR

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.	
#8					
#10					
#16					
#30					
#40					
#50					
#100					
#200					
-#200					
Total					
Elutriation					

Dry Weight

FINENESS MODULUS = TOTAL CUMULATIVE % RET. / 100

T = AASHTO Tests

			SPECS.
Liquid Limit (LL)	T - 89		
Plastic Limit (PL)	T - 90		
Plasticity Index (PI) = LL - PL	T - 90		
Abrasion Method (A,B,C,D)	T - 96		
@ 100 Revolutions		%	%
@ 500 Revolutions		%	%
Absorption, H_2O	T - 85 ARIZ 211	%	
Specific Gravity, SSD	T - 85 ARIZ 211		
Specific Gravity, OD	T - 85 ARIZ 211		
Proctor Method			A - ARIZ 225 C - ARIZ 226 D - ARIZ 226 AD - ARIZ 245 AI - ARIZ 232 ADI - ARIZ 246
Optimum Moisture		%	
Max. Dry Density		PCF	
Sand Equivalent	T - 176 ARIZ 242 (MAFC)		
Fractured Faces Weight (Wf)			
Total Sample Weight (Wa)			
Fractured Faces (FF) = $\frac{Wf}{Wa} \times 100$	ARIZ 212	%	%
Wet Weight (W)		g	
Dry Weight (D)		g	
Moisture Content = $\frac{W-D}{D} \times 100$	T - 255 T - 265	%	
Flakiness Index	ARIZ 233	%	%
Carbonates	ARIZ 238	%	%
pH	ARIZ 236 OR 237		
Resistivity (ohm-cm)	ARIZ 236		
Soluable Salts (PPM)	ARIZ 237		

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

44-0363 R9/93

FIGURE 7

DETERMINATION OF PERCENT MINUS NO. 200 ON COARSE AGGREGATE AND TOTAL PERCENT PASS NO. 200 IN SAMPLE

Project No. _____ Lab. No. _____

Unwashed Weight of Plus No. 4 = _____

Washed Weight of Plus No. 4 = _____

Calculate the "Percent Minus No. 200 on Coarse Aggregate" by the following, and record result to the nearest 0.01%:

$$\text{Percent Minus No. 200 on Coarse Aggregate} = \frac{\text{Unwashed Weight of Plus No. 4} - \text{Washed Weight of Plus No. 4}}{\text{Unwashed Weight of Plus No. 4}} \times 100$$

$$= \frac{(\quad) - (\quad)}{(\quad)} \times 100$$

Percent Minus No. 200 on Coarse Aggregate = _____

Calculate the "Total Percent Pass No. 200 in Sample" by the following, and record result to the nearest 0.1%:

$$\text{Total Percent Pass No. 200 in Sample} = \text{\% Pass No. 200 from Fine Sieving} + \frac{\left[100 - \text{\% Pass No. 4}\right] \times \text{Percent Minus No. 200 on Coarse Aggregate}}{100}$$

$$= (\quad) + \frac{\left[100 - (\quad)\right] \times (\quad)}{100}$$

Total Percent Pass No. 200 in Sample = _____

FIGURE 8

ARIZ 249
September 5, 1996
(7 Pages)

REMOLDED RING SAMPLES FOR DIRECT SHEAR, SWELL, AND CONSOLIDATION

(An Arizona Method)

SCOPE

1. (a) This procedure describes the method used to prepare remolded ring samples of soil for further testing of direct shear, swell, and consolidation. Samples are generally remolded at 95% or 97% of proctor maximum dry density and at minus 3% of optimum moisture. These values can be changed to suit the person ordering the test.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Brass ring(s) with an inside diameter of 61.47 ± 0.03 mm (2.420 ± 0.001 inches), a height of 25.40 ± 0.05 mm (1.000 ± 0.002 inch), and a nominal wall thickness of 1.02 mm (0.040 inches). The brass ring(s) shall fit snugly inside the loading cylinder with no discernible free play in any direction.

(b) Baseplate and loading cylinder, as shown in Figure 1.

(c) Metal ram with a nominal outside diameter of 63.5 mm (2.5 inches).

NOTE: The brass ring(s), baseplate, loading cylinder, and ram should be free of bumps, dents, scratches, rust, dirt, and corrosion.

(d) Rubber mallet.

(e) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

SAMPLING

3. (a) Obtain 34 to 45 kilograms (75 to 100 pounds) of material for a proctor density test.

(b) For the remolded ring samples, obtain 600 grams of minus 4.75 mm (No. 4) material from material for proctor density test. This amount of material is sufficient to remold 3 ring samples. Material should be split in accordance with AASHTO R 76.

NOTE: Direct shears require 3 rings. Swell and consolidation tests require only 1 ring.

(c) Obtain approximately 100 grams of the minus 4.75 mm (No. 4) material for determination of percent hydroscopic moisture content.

PROCEDURE

4. (a) Determine the percent hydroscopic moisture content of the minus 4.75 mm (No. 4) material in accordance with AASHTO T 265.

(b) Perform a Method A Proctor Density test in accordance with Arizona Test Method 225 or 232.

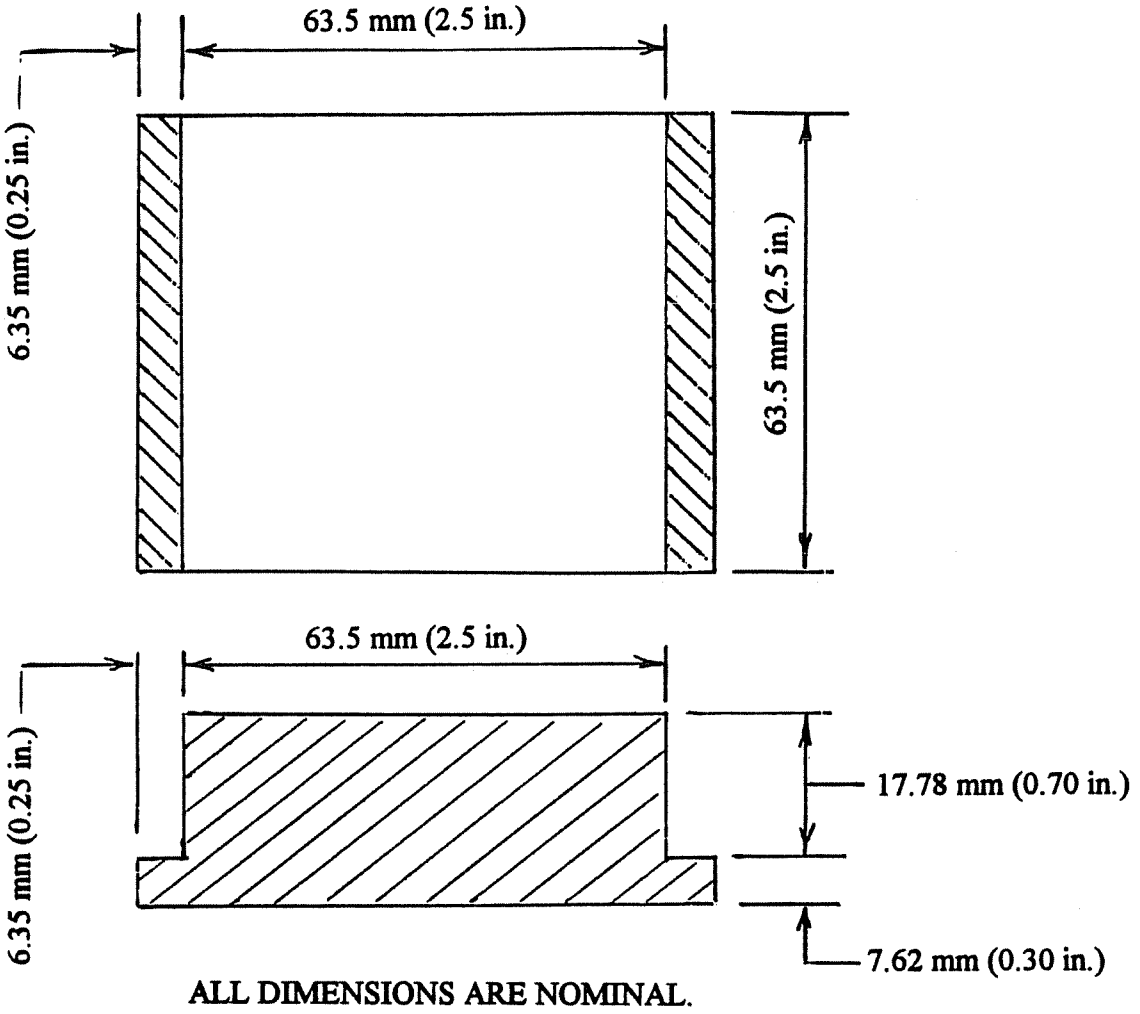
(c) When the weight of soil and water "W_2" has been calculated as shown in the examples given in Figure 2 and Figure 3 (a blank worksheet is given in Figure 4), the soil and water must be thoroughly mixed, put into a sealed container, and left to cure for at least 12 hours.

(d) After the soil has cured, the ring is ready to be loaded. Place ring in the bottom of the assembled baseplate and loading cylinder. Using a funnel, pour the soil mix into the cylinder. If it is necessary, gently tamp the material with your fingers. When all of the soil is loaded into the cylinder, insert the ram.

(e) Using the rubber mallet, strike the ram 3 or 4 times. Remove the ram from the cylinder and, using a spatula, clean the soil from edge of ring. Insert ram and strike it 2 or 3 times.

(f) Remove the ram from the cylinder and inspect the ring. If the ring is not showing, clean the soil from the edge of the ring using spatula, insert ram, and strike 2 or 3 times. If the ring is showing, remove loading cylinder from baseplate, and push the ring and soil gently out using the ram.

(g) From this point on, direct shears follow ASTM D 3080, swell tests follow ASTM D 4546, and consolidation tests follow ASTM D 2435.



ALL DIMENSIONS ARE NOMINAL.

Baseplate and Loading Cylinder

FIGURE 1

REMOLDED SHEAR / SWELL / CONSOLIDATION WORKSHEET

Lab No.: 96-999 Date: 10-25-96

Proctor Maximum Dry Density: 1884 kg/m^3 — lb./cu. ft.

Optimum Percent Moisture: 12.3

Maximum Dry Density at (95%) or 97% (D): 1789 kg/m^3 — lb./cu. ft.

Percent Optimum Moisture minus 3% (w_1): 9.3

Percent Hydroscopic Moisture Content (w): 1.9

Brass Ring Volume/Density Factor (F): (0.0754) (for density in kg/m^3) or
1.2074 (for density in lb./cu. ft.)

W =	Weight of Dry Soil, grams	$W = D \times F$	W = 134.9
W_1 =	Weight of Soil with Hydroscopic Moisture, grams	$W_1 = W \times (1.00 + w/100)$	W_1 = 137.5
W_2 =	Weight of Soil andWater, grams	$W_2 = W \times (1.00 + w_1/100)$	W_2 = 147.4
w_2 =	Weight of Water Added/Required, grams	$w_2 = W_2 - W_1$	w_2 = 9.9

Test Operator Joe Dogood

FIGURE 2

REMOLDED SHEAR / SWELL / CONSOLIDATION WORKSHEET

Lab No.: 96-999 Date: 10-25-96

Proctor Maximum Dry Density: — kg/m^3 117.6 lb./cu. ft.

Optimum Percent Moisture: 12.3

Maximum Dry Density at (95%) or 97% (D): — kg/m^3 111.7 lb./cu. ft.

Percent Optimum Moisture minus 3% (w_1): 9.3

Percent Hydroscopic Moisture Content (w): 1.9

Brass Ring Volume/Density Factor (F): 0.0754 (for density in kg/m^3) or (1.2074) (for density in lb./cu. ft.)

W =	Weight of Dry Soil, grams	W = D x F	W = 134.9
W_1 =	Weight of Soil with Hydroscopic Moisture, grams	W_1 = W x (1.00 + w/100)	W_1 = 137.5
W_2 =	Weight of Soil andWater, grams	W_2 = W x (1.00 + w_1 /100)	W_2 = 147.4
w_2 =	Weight of Water Added/Required, grams	w_2 = W_2 - W_1	w_2 = 9.9

Test Operator Joe Dogood

FIGURE 3

REMOLDED SHEAR / SWELL / CONSOLIDATION WORKSHEET

Lab No.: _____ Date: _____

Proctor Maximum Dry Density: _____kg/m^3 _____lb./cu. ft.

Optimum Percent Moisture: _____

Maximum Dry Density at 95% or 97% (D): _____kg/m^3 _____lb./cu. ft.

Percent Optimum Moisture minus 3% (w_1): _____

Percent Hydroscopic Moisture Content (w): _____

Brass Ring Volume/Density Factor (F): 0.0754 (for density in kg/m^3) or
1.2074 (for density in lb./cu. ft.)

W =	Weight of Dry Soil, grams	W = D x F	W = _____
W_1 =	Weight of Soil with Hydroscopic Moisture, grams	W_1 = W x (1.00 + w/100)	W_1 = _____
W_2 =	Weight of Soil andWater, grams	W_2 = W x (1.00 + w_1 /100)	W_2 = _____
w_2 =	Weight of Water Added/Required, grams	w_2 = W_2 - W_1	w_2 = _____

Test Operator _____

FIGURE 4

ARIZ 251a
March 31, 2010
(4 Pages)

COMBINED COARSE AND FINE AGGREGATE SPECIFIC GRAVITY AND ABSORPTION

(An Arizona Method)

1. SCOPE

(a) This procedure describes the method which is used to determine the combined coarse and fine aggregate specific gravity and absorption when the specific gravity and absorption of the fine aggregate and the coarse aggregate are known. Arizona Test Method 210 describes the procedure for determining the coarse aggregate specific gravity and absorption. Arizona Test Method 211 describes the procedure for determining the fine aggregate specific gravity and absorption.

(b) This procedure also contains provisions for calculating the combined specific gravity and combined absorption when it is desired to perform those calculations for coarse aggregate, fine aggregate, and mineral admixture.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. CALCULATIONS

(a) Combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity for coarse aggregate and fine aggregate is determined by the following:

$$\text{Combined Specific Gravity} = \frac{P_c + P_f}{\frac{P_c}{G_c} + \frac{P_f}{G_f}}$$

Where: P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
$P_c + P_f$ = 100
G_c = Specific Gravity of Coarse Aggregate
G_f = Specific Gravity of Fine Aggregate

Example:

$P_c = 41$
$P_f = 59$
$G_c = 2.597$
$G_f = 2.626$

$$\text{Combined Specific Gravity} = \frac{41 + 59}{\frac{41}{2.597} + \frac{59}{2.626}} = 2.614$$

(b) Combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity for coarse aggregate, fine aggregate, and mineral admixture, is determined by the following:

$$\text{Combined Specific Gravity} = \frac{P_c + P_f + P_{admix}}{\frac{P_c}{G_c} + \frac{P_f}{G_f} + \frac{P_{admix}}{G_{admix}}}$$

Where: P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
P_{admix} = Percent of Mineral Admixture, by weight of the mineral aggregate
$P_c + P_f + P_{admix}$ = 100 + % Mineral Admixture
G_c = Specific Gravity of Coarse Aggregate
G_f = Specific Gravity of Fine Aggregate
G_{admix} = Specific Gravity of Mineral Admixture
Type I or II Cement = 3.14
Type IP Cement = 3.00
Hydrated Lime = 2.20

Example:

$P_c = 41$
$P_f = 59$
$P_{admix} = 1.0\%$
$G_c = 2.597$
$G_f = 2.626$
Type of Mineral Admixture = Hydrated Lime
Mineral Admixture Specific Gravity = 2.20

$$\text{Combined Specific Gravity} = \frac{41 + 59 + 1.0}{\frac{41}{2.597} + \frac{59}{2.626} + \frac{1.0}{2.20}} = 2.609$$

(c) Combined absorption for coarse aggregate and fine aggregate is determined by the following:

$$\text{Combined Absorption} = \frac{(P_c \times A_c) + (P_f \times A_f)}{P_c + P_f}$$

Where: P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
$P_c + P_f$ = 100
A_c = Percent water absorption of coarse aggregate
A_f = Percent water absorption of fine aggregate

NOTE: The equation shown above for combined absorption differs from that currently shown in Arizona Test Methods 210 and 211. In the future, appropriate changes in these test methods will be made to reflect the above equation, but in the interim period the calculation shall be performed as shown above.

Example:

P_c = 41
P_f = 59
A_c = 1.51
A_f = 1.43

$$\text{Combined Absorption} = \frac{(41 \times 1.51) + (59 \times 1.43)}{41 + 59} = 1.46\%$$

(d) Combined absorption for coarse aggregate, fine aggregate, and mineral admixture, is determined by the following:

$$\text{Combined Absorption} = \frac{(P_c \times A_c) + (P_f \times A_f) + (P_{admix} \times A_{admix})}{P_c + P_f + P_{admix}}$$

Where: P_c = Percent of Coarse Aggregate
P_f = Percent of Fine Aggregate
P_{admix} = Percent of Mineral Admixture, by weight of the mineral aggregate
$P_c + P_f + P_{admix}$ = 100 + % Mineral Admixture
A_c = Percent water absorption of coarse aggregate
A_f = Percent water absorption of fine aggregate
A_{admix} = Percent water absorption of mineral admixture (assumed to be 0.0%)

Example:

P_c = 41
P_f = 59
P_{admix} = 1.0
A_c = 1.51
A_f = 1.43
A_{admix} = 0.0

$$\text{Combined Absorption} = \frac{(41 \times 1.51) + (59 \times 1.43) + (1.0 \times 0.0)}{41 + 59 + 1.0} = 1.45\%$$

3. REPORT

(a) Report combined Bulk (Oven Dry), Bulk (SSD), or Apparent specific gravity to the nearest 0.001, and indicate the type of specific gravity, whether Bulk (Oven Dry), Bulk (SSD), or Apparent.

(b) Report combined absorption to the nearest 0.01%.

(c) Report whether the combined specific gravity and absorption is for coarse aggregate and fine aggregate, or whether the combined specific gravity and absorption is for coarse aggregate, fine aggregate, and mineral admixture.

SERIES 300
CONCRETE

METHOD OF ADJUSTING CONCRETE MIXES FOR VARIATION IN AGGREGATE MOISTURE CONTENT
(An Arizona Method)

Scope

1. This method is intended for determining the field batch weights for a concrete mix on a Saturated Surface-Dry, or an Oven Dried basis.

The objective is to correct the field mix design for the percentage of moisture in the aggregates, either on an SSD or OD basis.

Apparatus and Procedure

2. If oven dried basis is desired refer to paragraph (a). For S.S.D. basis, paragraphs (b) and (c) shall be adhered to.

(a) Use the apparatus and follow the procedure for determining the percent total moisture content and the percent surface moisture content of coarse and fine aggregate on a oven dried basis. (AASHTO T 255)

(b) Determine the percent surface moisture of the coarse aggregate on a S.S.D. basis as shown below:

1) Weigh and record the weight of a representative sample of wet coarse aggregate as sampled from the stockpile. The sample should weigh at least 1500 g.

2) Place the sample on a towel or absorbent cloth and dry by rubbing or rolling until the sample still appears damp but no sheen caused by reflected light from free water on the surface of the particles. This is the "saturated surface-dry" state.

3) Weigh and record the weight of the "Saturated Surface Dry" sample. Care shall be taken during the weighing operation to prevent loss of moisture by evaporation.

4) The calculations are as follows:

$$\% \text{ Surface Moisture} = \frac{\text{Wet wt.} - \text{SSD wt.}}{\text{SSD wt.}} \times 100$$

Example:

Wet wt. = 2056 g.

SSD wt. = 2040 g.

$$\% \text{ Surface Moisture} = \frac{2056 - 2040}{2040} \times 100 = 0.8\%$$

(c) Determine the percent surface moisture of the fine aggregate (sand) on a S.S.D. basis as shown below:

1) Fill a Chapman flask with water to the 200 ml. mark on the lower neck. The temperature of the water shall be from 65° F to 85° F.

2) Pour a moist sample weighing exactly 500 g. down the neck of the flask.

3) Agitate or roll so as to remove all air bubbles.

4) After all air bubbles have been removed, record the level of the liquid on the scale on the upper neck of the flask.

5) The percent surface moisture shall be calculated as follows:

$$M = \frac{V - \left(\frac{Ww}{\text{Sp. Gr.}}\right) - Vw}{Ww + Vw - V} \times 100$$

Where:

M = Percent Surface Moisture

V = Volume of combined water and sand, ml.

Sp. Gr. = Bulk Specific Gravity of Sand (S.S.D.)

Ww = Wet wt. of sand = 500 g.

Vw = Volume of water = 200 ml.

Example:

Volume of water and sand = 399 ml.

Specific Gravity of Sand = 2.653

$$M = \frac{399 - \left(\frac{500}{2.653}\right) - 200}{500 + 200 - 399} \times 100 = \frac{10.5}{301} = 3.5\%$$

NOTE: The specific gravity of sand from any one source usually may be considered as constant; however, periodic determinations should be made to verify this. The specific gravity reported with the mix design may be used in the calculation. If no specific gravity has been recorded it may be determined for the sample in accordance with AASHTO T-84, Specific Gravity and absorption of fine aggregate.

Calculations and Example (for Oven-dry Basis)

3. The following serves to illustrate adjustments on an oven-dried (OD) basis:

(a) Moisture contents as determined in 2(a) on an oven dried basis:

Total: Sand = 5.9% water

Coarse = 3.0% water

Surface: Sand = 4.9% water

Coarse = 1.0% water

Asportion: Sand = 1.0%

Coarse = 2.0%

(b) Mix Design (Oven dry basis):

Cement = 94 lb. (one sack)

Sand = 203 lb.

Coarse = 301 lb.

Water = 7.6 gal. (@ 8.33 lb/gal) = 63 lbs.

(c) Batch weight adjustment:

Cement = 94 lb. (unchanged)

$$\text{Sand} = \frac{(\text{O.D. wt.})\ (100 + \%\ \text{total water})}{100}$$

$$= \frac{(203)\ (105.9)}{100} = 215 \text{ lb.}$$

$$\text{Coarse} = \frac{(\text{O.D. wt.})\ (100 + \%\ \text{total water})}{100}$$

$$= \frac{(301)\ (103.0)}{100} = 310 \text{ lb.}$$

$$\text{Surface moisture in sand} = \frac{(\%\ \text{surface water})\ (\text{O.D. wt.})}{100}$$

$$= \frac{(4.9)\ (203)}{100} = 10 \text{ lb.}$$

$$\text{Surface moisture in coarse} = \frac{(\%\ \text{surface water})\ (\text{O.D. wt.})}{100}$$

$$= \frac{(1.0)\ (303)}{100} = 3 \text{ lb.}$$

Total surface moisture = 10 + 3 = 13 lb.

$$\text{Gallons of surface moisture} = \frac{13 \text{ lb.}}{8.33 \text{ lb./gal.}} = 1.6 \text{ gals.}$$

Mix water required = 7.6 — 1.6 = 6.0 gals.

(d) Adjusted batch weights:

Cement = 94 lb.

Sand = 215 lb.

Coarse = 310 lb.

Water = 6.0 gals. (@8.33 lbs/gal) = 50 lbs.

Calculations and Example (for S.S.D. basis)

4. The following serves to illustrate adjustments, on a SSD basis:

(a) Percent surface moisture as determined in 2(b) and (c) on a SSD basis:

Sand = 3.5% water

Coarse = 0.8% water

(b) Mix Design (Saturated Surface-Dry basis):

Cement = 94 lb. (1 sack)

Sand = 205 lb.

Coarse = 307 lb.

Water = 6.5 gal. (@ 8.33 lb/gal) = 54 lbs.

(c) Batch weight adjustment:

Cement = 94 lb. (unchanged)

$$\text{Sand} = \frac{(\text{SSD wt.})\ (100 + \%\ \text{water})}{100}$$

$$= \frac{(205)\ (103.5)}{100} = 212 \text{ lb.}$$

$$\text{Coarse} = \frac{(\text{SSD wt.})\ (100 + \%\ \text{water})}{100}$$

$$= \frac{(307)\ (100.8)}{100} = 309 \text{ lb.}$$

Surface moisture in sand = 212 — 205 = 7 lb.

Surface moisture in coarse = 309 — 307 = 2 lb.

Total Surface Moisture = 7 + 2 = 9 lb.

$$\text{Gallons of surface moisture} = \frac{9 \text{ lb.}}{8.33 \text{ lb. gal.}} = 1.1 \text{ gal.}$$

Gallons of mixing water required = 6.5 — 1.1
= 5.4 gal.

(d) Adjusted batch weights:

Cement = 94 lb. (unchanged)

Sand = 212 lb.

Coarse = 309 lb.

Water = 5.4 gal. (@ 8.33 lb./gal/) = 45 lbs.

Report

5. Report adjusted batch weights to the nearest 1 lb., and water content to the nearest 0.1 gal.

TESTING IMPERVIOUS MATERIALS & COMPOUNDS FOR CURING CONCRETE

(A Modification of AASHO Designation T 155)

REFEREE TEST

Scope

1. This method is intended for use in determining the efficiency of liquid membrane-forming compounds for curing concrete, as measured by their ability to prevent loss of moisture during the early hardening period.

Apparatus

2. The apparatus shall consist of the following:

(a) Molds. – Molds shall be made of metal, glass, hard rubber, or plastic and shall be watertight, of such construction that distortion is prevented. Interior dimensions shall be: 6 x 12 in. at the top, 5¾ x 11¾ in. at the bottom, within ±¼ in., and 2 ±⅛ in. depth. A flat rim is required at the top and on all sides and shall be ¼ in. in width.

(b) Curing Cabinet. – A cabinet capable of a temperature of 100° ±2° F and relative humidity of 32 ±2%.

Specific Gravity Determination

3. (a) Fill a specific gravity flask with a well-stirred sample of curing compound.

(b) Gently lower a selected hydrometer into the compound, taking care the hydrometer does not touch the sides of the flask. If the trial hydrometer comes to rest and floats too high, a hydrometer of greater specific gravity is necessary; if the hydrometer sinks below the scale, a lighter hydrometer is required. Continue to change hydrometers until one is found which comes to rest on the scale.

(c) Allow the hydrometer to settle to a constant level. (For clear, wax and varnish compounds, this occurs in a very few minutes; but the heavy-pigmented types may require an hour or more). Read and record the specific gravity of the compound.

(d) From Table I which follows, find the quantity in grams of compound to use for the test. For unusual compounds which do not occur on the chart, consult the supervisor.

NOTE: *The amount of compound is calculated to represent 150 sq. ft. per gallon coverage. For clear type compounds this works out to 10.0 ml. per sample, but other types, and especially the pigmented types, may require more.*

NOTE: *To find the required grams of compound for any specific gravity values not listed on Table I, proceed as follows:*

1. *Determine specific gravity.*
2. *Obtain the specific gravity in the New and Revised Tag Manual for Inspectors of Petroleum and obtain the corresponding POUNDS PER GALLON.*
3. *Multiply POUNDS PER GALLON by factor 1.4385 to find the weight in grams of compound required to cover the specimen.*

Proportioning and Mixing Mortar

4. (a) Proportioning. – The proportions of cement and sand shall be determined by adding dry sand to a cement paste having a water-cement ratio of 0.40 by weight, to produce a flow of 35 ±5. The flow test shall be made as described in the Standard Method of Test for measuring Mortar-Making Properties of Fine Aggregate (AASHO Designation: T 71).

(b) Mixing. – The mortar shall be mixed at room temperature, preferably 73.4° ±3° F (23° ±1.7° C) if possible, and at a relative humidity of 40 to 60 percent. The temperature of the mortar at the time of molding shall be 73.4° ±3° F (23° ±1.7° C). The cement and water shall be placed in a nonabsorbent vessel and the cement permitted to absorb water for 1 minute. These materials shall then be mixed with a spoon into a smooth paste. The sand shall be added to the paste and final mixing shall be accomplished by continuous kneading and squeezing with the hands for 2 min. Rubber gloves shall be worn during the mixing operation. A suitable mortar-mixing machine may be used in lieu of hand mixing.

(c) Three specimens shall be molded for testing with a given curing compound.

(d) The mix used to determine the portion of sand to cement to produce the specified consistency shall be discarded and shall not be used for making test specimens.

Molding Specimens

4. (a) Coat the insides of the molds with a very thin coating of a light lubricating oil.

(b) Place a layer of mortar approximately 1 inch thick in the mold, and tamp 50 times with a wooden rod 1-in. square. Fill the mold with mortar and again tamp 50 times.

TABLE 1
GRAVITY CHART
For Use in Testing Curing Compounds

Range in Gravity	Grams of Compound	Range in Gravity	Grams of Compound
0.664 – 0.671	8.0	0.873 – 0.881	10.5
0.672 – 0.681	8.1	0.882 – 0.889	10.6
0.682 – 0.689	8.2	0.890 – 0.897	10.7
0.690 – 0.697	8.3	0.898 – 0.906	10.8
0.698 – 0.706	8.4	0.907 – 0.914	10.9
0.707 – 0.714	8.5	0.915 – 0.922	11.0
0.715 – 0.723	8.6	0.923 – 0.930	11.1
0.724 – 0.731	8.7	0.931 – 0.939	11.2
0.732 – 0.739	8.8	0.940 – 0.947	11.3
0.740 – 0.748	8.9	0.948 – 0.955	11.4
0.749 – 0.756	9.0	0.956 – 0.964	11.5
0.757 – 0.764	9.1	0.965 – 0.972	11.6
0.765 – 0.772	9.2	0.973 – 0.980	11.7
0.773 – 0.781	9.3	0.981 – 0.989	11.8
0.782 – 0.789	9.4	0.990 – 0.997	11.9
0.790 – 0.797	9.5	0.998 – 1.006	12.0
0.798 – 0.806	9.6	1.007 – 1.013	12.1
0.807 – 0.814	9.7	1.014 – 1.022	12.2
0.815 – 0.822	9.8	1.023 – 1.030	12.3
0.823 – 0.831	9.9	1.031 – 1.038	12.4
0.832 – 0.839	10.0	1.039 – 1.047	12.5
0.840 – 0.847	10.1	1.048 – 1.055	12.6
0.848 – 0.856	10.2	1.056 – 1.064	12.7
0.857 – 0.864	10.3	1.065 – 1.072	12.8
0.865 – 0.872	10.4	1.073 – 1.076+	12.9

(c) Immediately after completing the tamping, strike off the specimen level with the top of the mold, with a sawing motion of a wooden screed having a flat surface 1-inch in width. One pass only shall be made in the direction of the long axis of the mold.

Storage of Specimens

5. (a) Immediately after molding, weigh each full mold to the nearest 1 g. and place in the curing cabinet. Specimens shall be arranged so as to provide a clear space on all sides of from 2 to 7 inches.

NOTE: *The movement of conditioned air within the cabinet shall be such that the solvent from curing compounds will readily evaporate. During the first day of drying, sufficient fresh air shall be admitted into the cabinet to eliminate solvent vapors.*

Application of Curing Materials

7. (a) After approximately 1½ hours, check the specimens for surface water. If surface water is evident, leave the specimens in the cabinet until all surface water has disappeared. Then lightly brush the surface of the specimens with a stiff bristle brush. If surface water appears upon brushing, return the specimen to the curing cabinet. Remove the specimen immediately upon disappearance of the surface water brought to the surface, and brush again. Repeat the process until no surface water appears when the specimen is brushed.

(b) When the proper surface condition has been attained, form a V-shaped groove approximately ⅛ in. deep and not more than 1/16 in. wide between the edge of the mortar and the mold, extending all around the specimen. Fill the groove with a sealing compound that will not be affected by the curing material under test. This compound shall not extend more than ¼ in. from the mold onto the surface of the specimen.

(c) Weigh the specimen to the nearest 1 g. Then with a spray gun (for clear compounds), or with a soft-bristle brush 1 in. in width or a pipette (for pigmented compounds) apply the amount of curing compound determined from Section 3. Take care that the entire surface of the specimen is coated uniformly. Record the weight to the nearest 1 g. Place the specimen in the curing cabinet.

(d) After 3 hours, remove the specimens from the cabinet and weigh to the nearest 1 g. An unusually heavy loss in weight indicates a leaking mold or faulty seal. In such a case, the specimen shall be discarded. Return the specimens to the curing cabinet without delay.

Duration of Curing

8. The specimens shall be cured for 72 hours with occasional daily checks, and the amount of water lost shall be determined by weighing the specimen.

Corrections for Loss in Weight of Liquid Curing Materials During Test

9. (a) Take an identical quantity of curing compound and spread evenly over a clean, dry, tared metal pan approximately 6 in. x 12 in. x ⅛ in.

(b) Place the pan in the curing cabinet and dry it to constant weight. Reweigh to the nearest 0.1 g. Record the loss in weight of the curing compound as volatile matter.

Calculations

10. (a) Calculate the loss of water and volatiles in the specimen and curing compound by the following:

$$W = S - S_c$$

Where:

W = combined loss of water and volatile g.
S = original weight of mold and specimen, with curing compound, g.
S_c = weight of cured specimen, plus mold, plus curing compound, g.

(b) Calculate the net loss of water from the specimen by the following:

$$L = W - W_v$$

Where:

L = The net loss of water from specimen, g.
W_v = weight of volatile matter, as determined in section 9.(b), g.

(c) Measure the width of the mold in cm. in three areas and use the average with the length to acquire the surface area (A) of the mold.

(d) Calculate the weight of water lost per sq. cm. of surface area by the following:

$$W_u = L/A$$

Where:

W_u = weight of water lost per sq. cm. of area, g./cm.^{2}
A = surface area of mold (cm.^{2})

Example

11. The following shall serve to illustrate calculations:

Orig. wt., Mold + Sample + Compound (S)	= 5502 g.
Cured wt. of above (S_c)	= 5490 g.
Loss of water + Volatile (W)	= 12 g.
Volatile in 10 g. Curing Compound (W_v)	= 7.2 g.
Net loss of water (L)	= 4.8 g.
Avg. width of mold	= 14.08 cm.
Avg. length of mold	= 29.50 cm.
Surface Area of mold (A)	= 415.4 cm.^{2}

$$\text{Unit loss of water } (W_u) = \frac{L}{A} = \frac{4.8}{415.4} = 0.012 \text{ g./cm.}^2$$

Report

12. Report the following:

(a) Original weight of mold and specimen with curing compound, to nearest 1 g.

(b) Weight of mold, specimen and compound after curing, to nearest 1 g.

(c) Weight of loss of volatiles, to nearest 0.1 g.

(d) Loss of water and volatiles in cured specimen to the nearest 0.1 g.

(e) Net weight of water lost to the nearest 0.1 g.

(f) Average width of mold, to nearest 0.01 cm.

(g) Length of mold to nearest 0.01 cm.

(h) Surface area of mold, to nearest 1 sq. cm.

(i) Unit loss of water, to nearest 0.001 g. per sq. cm.

ALTERNATE METHOD

Scope

1. This method is a procedure for the determination of the non-volatile residue of curing compounds. It is applicable for all types of membrane-forming curing compounds. The percent residue is used in determining the moisture retention efficiency of the curing compound.

Apparatus

2. Apparatus shall consist of the following:

(a) Balance, accurate to 0.1 gram.

(b) Hot Plate, with a minimum of 3 heat variations.

(c) Ointment Tins, 6 oz.

Procedure

3. (a) Thoroughly stir the sample until it is completely free of lumps. Place 5 to 10 g. (weighed to the nearest 0.1 gram) into each of three 6 ounce ointment tins. Place the samples on a medium temperature hot plate (300° to 400° F) and heat until the volatile fraction is completely evaporated. This point can be determined when the formation of bubbles ceases and the residue starts to darken in color.

(b) Remove the cans from the hot plate and allow to cool to room temperature. Weigh each can to the nearest 0.1 gram and average the residue weights for the 3 cans.

Calculation

4. Using the average weight, calculate the percent non-volatiles with the following formula:

$$\text{Percent} = \frac{B}{A} \times 100$$

Where:

A = Weight of compound before heating.

B = Weight of residue.

Report

5. Report the result to the nearest 0.1 gram.

Notes

(1) *Pigmented compounds should be allowed to settle until the clear liquid can be decanted. The clear liquid is then tested as above.*

(2) *Emulsion types should be heated slowly to avoid spattering.*

MEASURING TEXTURE DEPTH OF PORTLAND CEMENT CONCRETE WITH METAL TINE FINISH

[A Modification of Louisiana Dept. of Hwys. Designation TR 229]

SCOPE

1. This method describes the procedure for measuring texture depth of fresh or hardened concrete finished with a metal tine.

APPARATUS

2. (a) A tire tread depth measuring gauge with 1/32 of an inch gradations similar to the one shown in Figure 1, or a similar device approved by the Engineer.

(b) Wire brush.

(c) Steel straightedge approximately 1/4" x 1" x 12".

PROCEDURE

3. (a) The depth of texture shall be measured from the original concrete surface. Any projections above the original surface shall be removed by wire brushing or with the steel straightedge prior to taking a measurement on hardened concrete. If measurements are being made on fresh concrete, the depth gauge shall be pressed down until substantially at the level of the original concrete surface. If measurements are being made on hardened concrete such that the depth gauge cannot be pressed down until substantially of the level of the original concrete surface, due to surface irregularities caused by the texturing operation, the height of these surface irregularities shall be measured and subtracted from the measured depth of texture.

(b) With the depth gauge guides in contact with the original concrete surface, the plunger is depressed until contact is made with the bottom of the groove in the concrete. The gauge is then removed from the surface with care being taken to prevent the plunger from being disturbed. The texture depth is then read to the nearest 1/32 of an inch on the calibrated plunger.

(c) The plunger is then re-zeroed and the procedure is repeated until the necessary measurements are completed.

(d) Sufficient measurements shall be taken at random locations along and across the paving width to ensure that the specification requirements are met. In most cases, one test per 12 foot width per 500 foot length should be sufficient. The results should be noted in the inspectors daily diary.

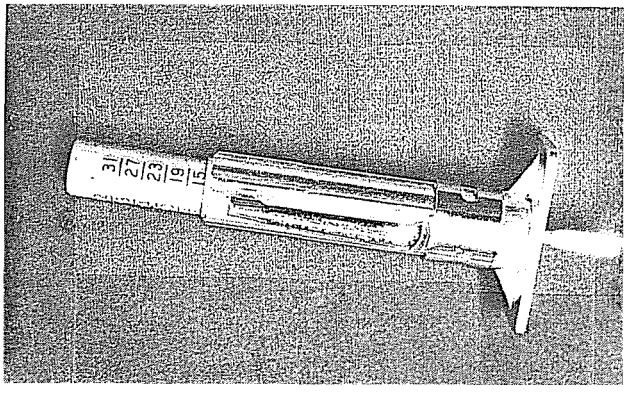


FIGURE 1

METHOD OF TEST FOR FLOW OF GROUT MIXTURES (FLOW CONE METHOD)

(A Modification of California Test Method 541)

SCOPE

1. (a) This method is intended to be used for determining the flow of grout mixtures as described in this test method.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Flow cone conforming to the dimensions indicated in Figure 1.

(b) Stop watch accurate to 0.1 second.

(c) Rubber stoppers.

(d) Sample container of four liter minimum capacity [a 152.4 mm x 304.8 mm (6 inch x 12 inch) concrete cylinder mold is adequate].

(e) Supporting ring for flow cone and stand [a 19 liter (5 gallon) bucket may be used], see figure 2.

SAMPLE

3. A representative sample shall be approximately 4 liters of grout.

PRECAUTIONS

4. (a) This test must be performed at a location that is free from vibration.

(b) The cone must be kept clean from cement build-up, especially in or near the orifice and nozzle.

PROCEDURE

5. (a) Determination of Efflux Time

1) Dampen flow cone and allow any excess water to drain. Place the cone in the supporting ring and insert the rubber stopper.

2) Level the cone, then pour the grout from the sample container into the cone until the grout Surface is level with the bottom of the holes in the side of the cone.

3) Remove the stopper and start the stopwatch simultaneously.

4) Stop the stopwatch at the first break or change in the continuous flow of grout from the discharge tube.

5) Dispose of the tested grout sample; rinse the equipment.

(b) Determination of Efflux After Quiescence

1) Fill cone with grout as previously described, using the remainder of the 4 liter sample.

2) Allow grout to rest in cone for 20 minutes ± 15 seconds from the instant the cone is filled. After the 20 minute quiescent period, remove the stopper and determine efflux time as described above.

EXAMPLE

6. Quiescent time (T_Q) is the amount of time that a sample of grout remains undisturbed (quiescent) in the flow cone and is expressed in minutes. Efflux time (T_E) is the amount of time that a sample of grout requires to run out of the flow cone after the plug is removed, expressed in seconds.

(a) Efflux time at the pump discharge:

$$T_E \geq 11 \text{ seconds (when } T_Q = 0 \text{ minutes)}$$

(b) Efflux time of grout sample at $T_Q = 20$ minutes:

$$T_E \text{ (at } T_Q = 20) \geq T_E \text{ (at } T_Q = 0) + 3 \text{ seconds,}$$

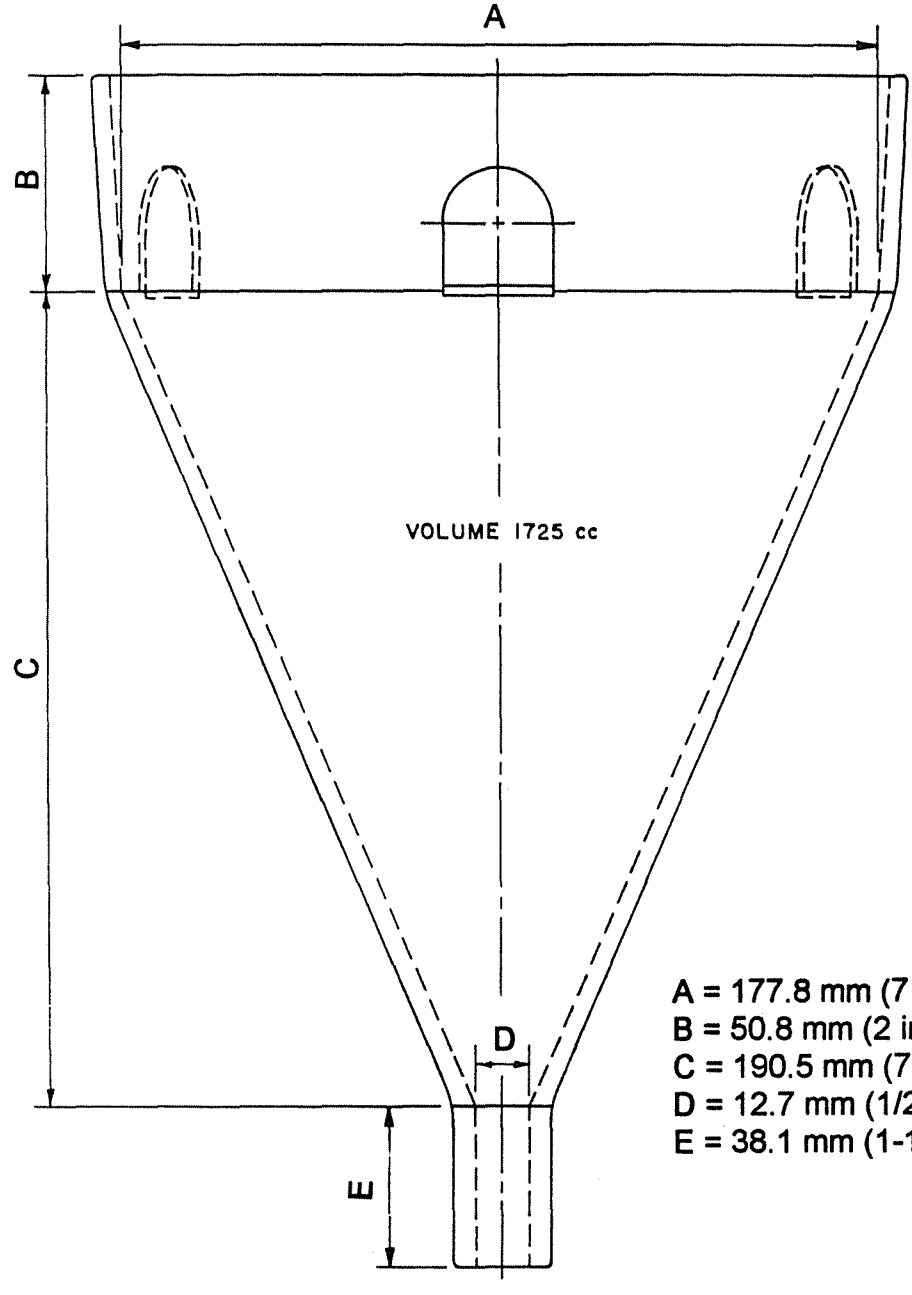
and

$$T_E \text{ (at } T_Q = 20) \leq T_E \text{ (at } T_Q = 0) + 8 \text{ seconds}$$

NOTE: The above mathematical expressions for quiescent time of 20 minutes are expressed as follows: "The efflux time after 20 minutes must be at least 3 seconds greater than the initial efflux time (Quiescent Time = Zero) and not more than 8 seconds greater than the initial efflux time."

REPORT

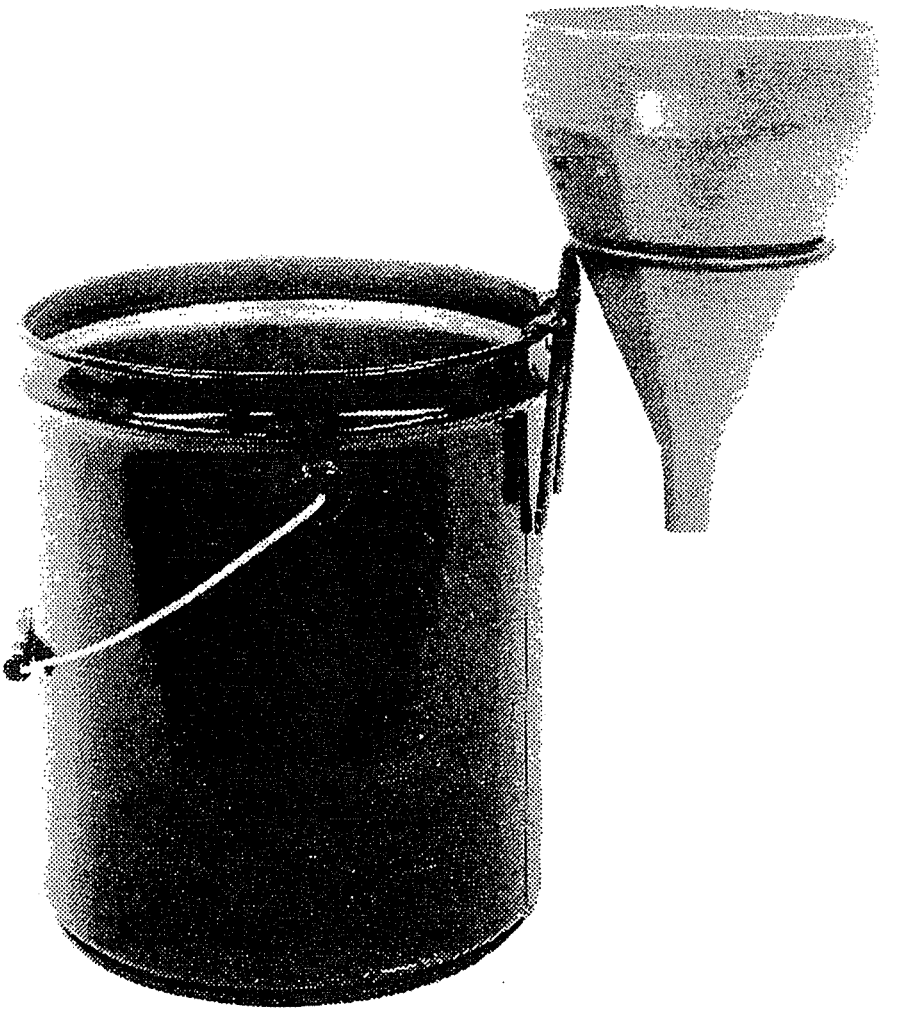
7. Report the efflux time to the nearest 0.1 seconds for both T_Q=0 and T_Q=20.



A = 177.8 mm (7 inches)
B = 50.8 mm (2 inches)
C = 190.5 mm (7-1/2 inches)
D = 12.7 mm (1/2 inch)
E = 38.1 mm (1-1/2 inches)

Grout Flow Cone

FIGURE 1



Grout Flow Test Apparatus

FIGURE 2

COMPRESSIVE STRENGTH OF CYLINDRICAL CONCRETE SPECIMENS

(A Modification of AASHTO Designation T 22 and ASTM Designation C 39)

1. This test procedure is the same as specified in AASHTO T 22 and ASTM C 39.

2. A blank ADOT "Concrete Test Report" laboratory card is provided in Figure 3 (front of card) and Figure 4 (back of card). An example of the use of the ADOT "Concrete Test Report" laboratory card is given in Figures 5 and 6.

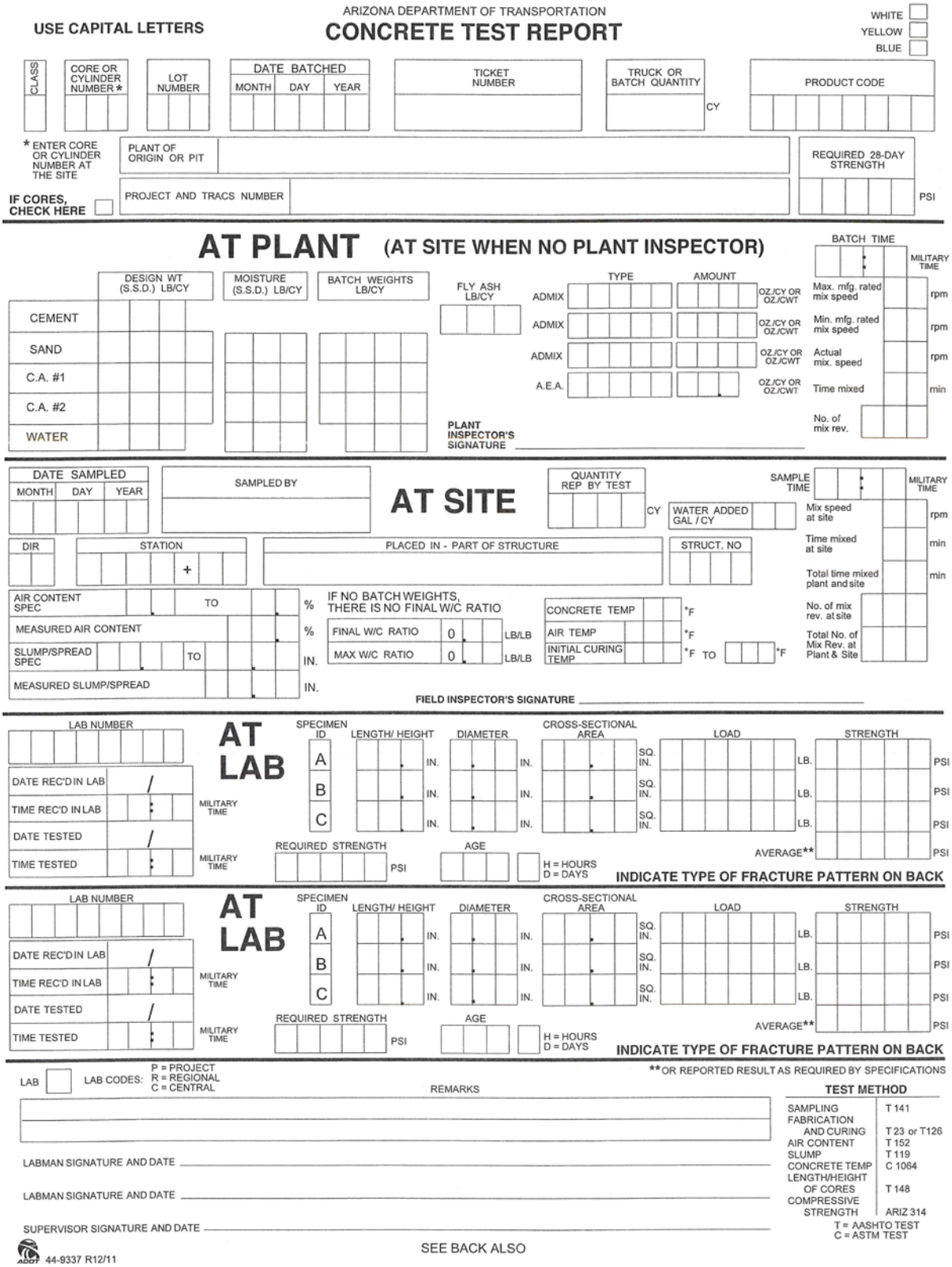
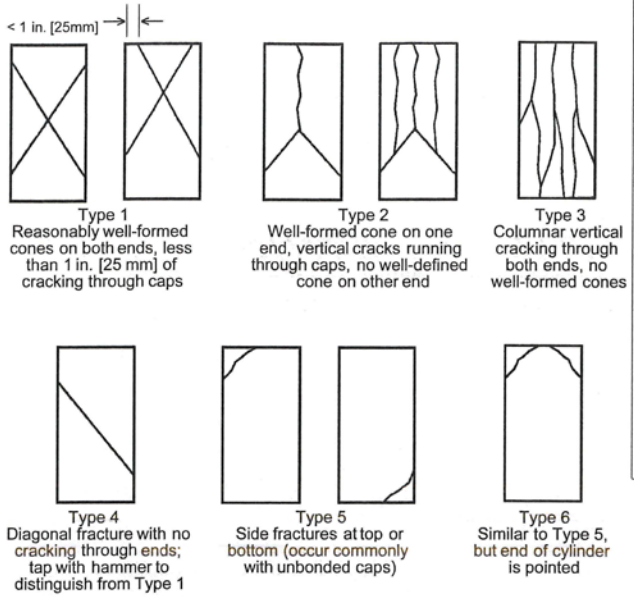

ARIZONA DEPARTMENT OF TRANSPORTATION
USE CAPITAL LETTERS
CONCRETE TEST REPORT
WHITE
YELLOW
BLUE
CLASS
CORE OR CYLINDER NUMBER *
LOT NUMBER
DATE BATCHED
MONTH DAY YEAR
TICKET NUMBER
TRUCK OR BATCH QUANTITY
CY
PRODUCT CODE
* ENTER CORE OR CYLINDER NUMBER AT THE SITE
PLANT OF ORIGIN OR PIT
REQUIRED 28-DAY STRENGTH
PSI
IF CORES, CHECK HERE
PROJECT AND TRACS NUMBER
AT PLANT (AT SITE WHEN NO PLANT INSPECTOR)
BATCH TIME
MILITARY TIME
DESIGN WT (S.S.D.) LB/CY
MOISTURE (S.S.D.) LB/CY
BATCH WEIGHTS LB/CY
FLY ASH LB/CY
TYPE
AMOUNT
CEMENT
SAND
C.A. #1
C.A. #2
WATER
ADMIX
ADMIX
ADMIX
A.E.A.
OZ./CY OR OZ./CWT
Max. mfg. rated mix speed
Min. mfg. rated mix speed
Actual mix. speed
Time mixed
No. of mix rev.
rpm
min
PLANT INSPECTOR'S SIGNATURE
AT SITE
DATE SAMPLED
MONTH DAY YEAR
SAMPLED BY
QUANTITY REP BY TEST
CY
WATER ADDED GAL / CY
SAMPLE TIME
Mix speed at site
Time mixed at site
Total time mixed plant and site
No. of mix rev. at site
Total No. of Mix Rev. at Plant & Site
DIR
STATION
PLACED IN - PART OF STRUCTURE
STRUCT. NO
AIR CONTENT SPEC
TO
%
MEASURED AIR CONTENT
SLUMP/SPREAD SPEC
IN.
MEASURED SLUMP/SPREAD
IF NO BATCH WEIGHTS, THERE IS NO FINAL W/C RATIO
FINAL W/C RATIO
MAX W/C RATIO
LB/LB
CONCRETE TEMP
AIR TEMP
INITIAL CURING TEMP
*F
FIELD INSPECTOR'S SIGNATURE
AT LAB
LAB NUMBER
DATE REC'D IN LAB
TIME REC'D IN LAB
DATE TESTED
TIME TESTED
SPECIMEN ID
LENGTH/ HEIGHT
DIAMETER
CROSS-SECTIONAL AREA
LOAD
STRENGTH
A
B
C
SQ. IN.
LB.
PSI
AVERAGE**
REQUIRED STRENGTH
AGE
H = HOURS
D = DAYS
INDICATE TYPE OF FRACTURE PATTERN ON BACK
AT LAB
LAB NUMBER
DATE REC'D IN LAB
TIME REC'D IN LAB
DATE TESTED
TIME TESTED
SPECIMEN ID
LENGTH/ HEIGHT
DIAMETER
CROSS-SECTIONAL AREA
LOAD
STRENGTH
REQUIRED STRENGTH
AGE
H = HOURS
D = DAYS
INDICATE TYPE OF FRACTURE PATTERN ON BACK
** OR REPORTED RESULT AS REQUIRED BY SPECIFICATIONS
LAB
LAB CODES: P = PROJECT R = REGIONAL C = CENTRAL
REMARKS
TEST METHOD
SAMPLING T 141
FABRICATION AND CURING T 23 or T126
AIR CONTENT T 152
SLUMP T 119
CONCRETE TEMP C 1064
LENGTH/HEIGHT OF CORES T 148
COMPRESSIVE STRENGTH ARIZ 314
T = AASHTO TEST
C = ASTM TEST
LABMAN SIGNATURE AND DATE
LABMAN SIGNATURE AND DATE
SUPERVISOR SIGNATURE AND DATE
ADOT 44-9337 R12/11
SEE BACK ALSO

FIGURE 3



[The space above is provided for recording testing charges when the testing is performed by the Central Materials Laboratory.]

AGE: _____

Were unbonded caps used? Yes ❑ No ❑ If Yes, what type of unbonded cap was used? Neoprene ❑ Other ❑ _____

SPECIMEN IDENTIFICATION	INDICATE TYPE OF FRACTURE PATTERN (✔)						
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	OTHER*
A							
B							
C							

* If the type of fracture pattern is other than Type 1 to Type 6, sketch and briefly describe the fracture pattern.

Remarks: _____

AGE: _____

Were unbonded caps used? Yes ❑ No ❑ If Yes, what type of unbonded cap was used? Neoprene ❑ Other ❑ _____

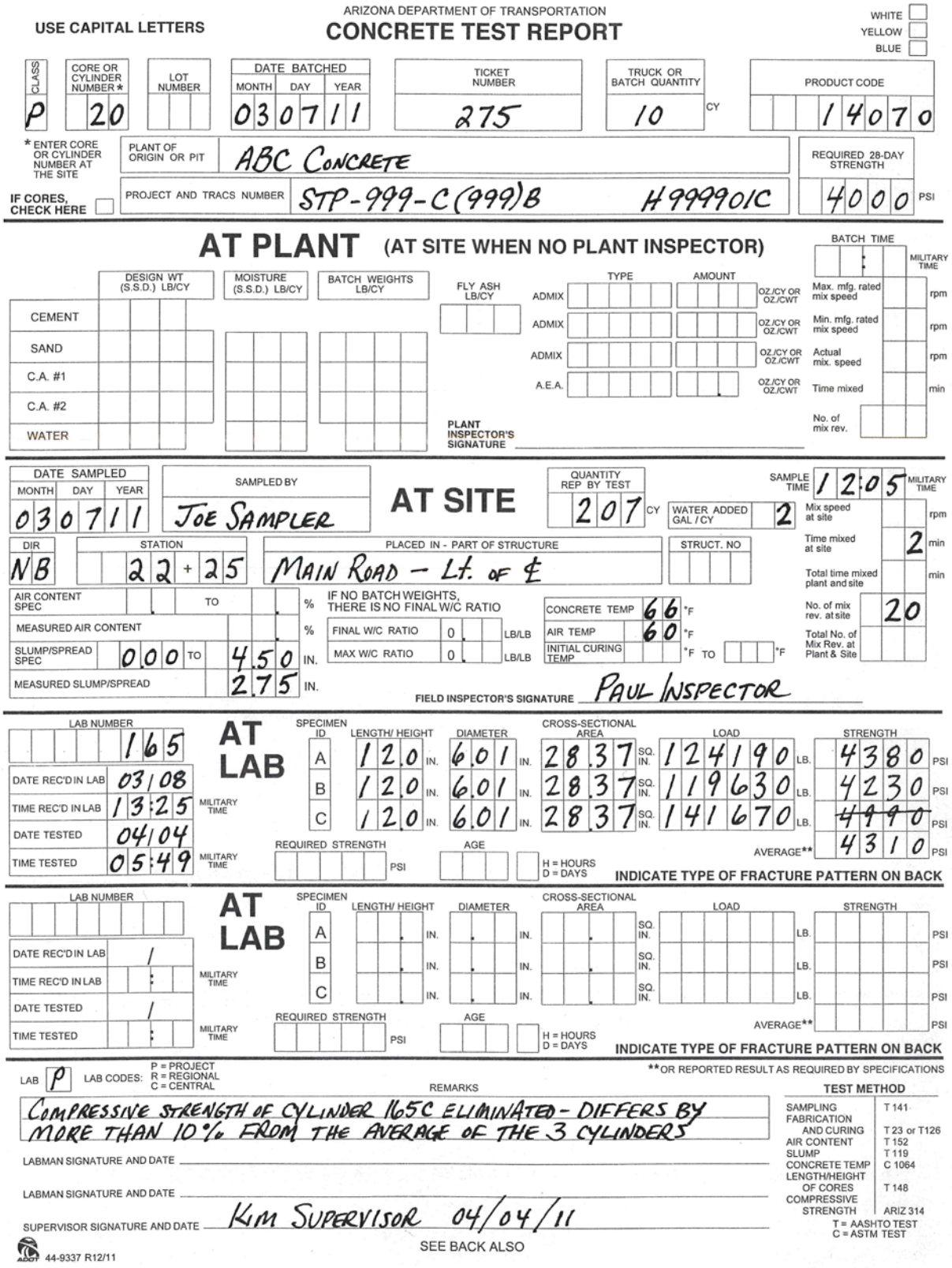
SPECIMEN IDENTIFICATION	INDICATE TYPE OF FRACTURE PATTERN (✔)						
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	OTHER*
A							
B							
C							

* If the type of fracture pattern is other than Type 1 to Type 6, sketch and briefly describe the fracture pattern.

Remarks: _____

ADOT 44-9337 R12/11 (Back)

FIGURE 4



USE CAPITAL LETTERS

ARIZONA DEPARTMENT OF TRANSPORTATION

CONCRETE TEST REPORT

WHITE ☐ YELLOW ☐ BLUE ☐

CLASS	CORE OR CYLINDER NUMBER *	LOT NUMBER	DATE BATCHED (MONTH DAY YEAR)	TICKET NUMBER	TRUCK OR BATCH QUANTITY	PRODUCT CODE
P	20		03 07 11	275	10 CY	14070

* ENTER CORE OR CYLINDER NUMBER AT THE SITE

PLANT OF ORIGIN OR PIT: ABC CONCRETE

REQUIRED 28-DAY STRENGTH: 4000 PSI

IF CORES, CHECK HERE ☐

PROJECT AND TRACS NUMBER: STP-999-C(999)B H999901C

AT PLANT (AT SITE WHEN NO PLANT INSPECTOR)

BATCH TIME ____ MILITARY TIME

	DESIGN WT (S.S.D.) LB/CY	MOISTURE (S.S.D.) LB/CY	BATCH WEIGHTS LB/CY
CEMENT			
SAND			
C.A. #1			
C.A. #2			
WATER			

FLY ASH LB/CY

	TYPE	AMOUNT
ADMIX		OZ./CY OR OZ./CWT
ADMIX		OZ./CY OR OZ./CWT
ADMIX		OZ./CY OR OZ./CWT
A.E.A.		OZ./CY OR OZ./CWT

Max. mfg. rated mix speed ____ rpm
Min. mfg. rated mix speed ____ rpm
Actual mix. speed ____ rpm
Time mixed ____ min
No. of mix rev. ____

PLANT INSPECTOR'S SIGNATURE ____

AT SITE

DATE SAMPLED (MONTH DAY YEAR): 03 07 11

SAMPLED BY: JOE SAMPLER

QUANTITY REP BY TEST: 207 CY

WATER ADDED GAL / CY: 2

SAMPLE TIME: 12:05 MILITARY TIME

Mix speed at site ____ rpm
Time mixed at site 2 min
Total time mixed plant and site ____ min
No. of mix rev. at site 20
Total No. of Mix Rev. at Plant & Site ____

DIR: NB

STATION: 22 + 25

PLACED IN - PART OF STRUCTURE: MAIN ROAD – Lt. of ℄

STRUCT. NO ____

AIR CONTENT SPEC	TO	%	IF NO BATCH WEIGHTS, THERE IS NO FINAL W/C RATIO
MEASURED AIR CONTENT		%	
SLUMP/SPREAD SPEC	0.00 TO 4.50	IN.	FINAL W/C RATIO 0. LB/LB; MAX W/C RATIO 0. LB/LB
MEASURED SLUMP/SPREAD	2.75	IN.	

CONCRETE TEMP 66 °F
AIR TEMP 60 °F
INITIAL CURING TEMP ____ °F TO ____ °F

FIELD INSPECTOR'S SIGNATURE: PAUL INSPECTOR

AT LAB

LAB NUMBER: 165

DATE REC'D IN LAB	03/08
TIME REC'D IN LAB (MILITARY TIME)	13:25
DATE TESTED	04/04
TIME TESTED (MILITARY TIME)	05:49

SPECIMEN ID	LENGTH/ HEIGHT	DIAMETER	CROSS-SECTIONAL AREA	LOAD	STRENGTH
A	12.0 IN.	6.01 IN.	28.37 SQ. IN.	124190 LB.	4380 PSI
B	12.0 IN.	6.01 IN.	28.37 SQ. IN.	119630 LB.	4230 PSI
C	12.0 IN.	6.01 IN.	28.37 SQ. IN.	141670 LB.	~~4990~~ PSI
				AVERAGE**	4310 PSI

REQUIRED STRENGTH ____ PSI

AGE ____ H = HOURS D = DAYS

INDICATE TYPE OF FRACTURE PATTERN ON BACK

AT LAB

LAB NUMBER ____

DATE REC'D IN LAB	/
TIME REC'D IN LAB (MILITARY TIME)	:
DATE TESTED	/
TIME TESTED (MILITARY TIME)	:

SPECIMEN ID	LENGTH/ HEIGHT	DIAMETER	CROSS-SECTIONAL AREA	LOAD	STRENGTH
A	IN.	IN.	SQ. IN.	LB.	PSI
B	IN.	IN.	SQ. IN.	LB.	PSI
C	IN.	IN.	SQ. IN.	LB.	PSI
				AVERAGE**	PSI

REQUIRED STRENGTH ____ PSI

AGE ____ H = HOURS D = DAYS

INDICATE TYPE OF FRACTURE PATTERN ON BACK

**OR REPORTED RESULT AS REQUIRED BY SPECIFICATIONS

LAB P LAB CODES: P = PROJECT R = REGIONAL C = CENTRAL

REMARKS

COMPRESSIVE STRENGTH OF CYLINDER 165C ELIMINATED - DIFFERS BY MORE THAN 10% FROM THE AVERAGE OF THE 3 CYLINDERS

TEST METHOD

SAMPLING	T 141
FABRICATION AND CURING	T 23 or T126
AIR CONTENT	T 152
SLUMP	T 119
CONCRETE TEMP	C 1064
LENGTH/HEIGHT OF CORES	T 148
COMPRESSIVE STRENGTH	ARIZ 314

T = AASHTO TEST
C = ASTM TEST

LABMAN SIGNATURE AND DATE ____

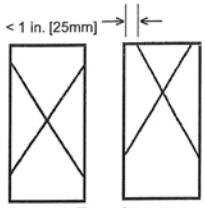
LABMAN SIGNATURE AND DATE ____

SUPERVISOR SIGNATURE AND DATE: KIM SUPERVISOR 04/04/11

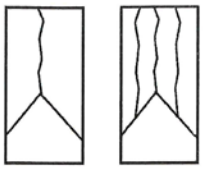
SEE BACK ALSO

ADOT 44-9337 R12/11

FIGURE 5

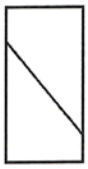


Type 1
Reasonably well-formed cones on both ends, less than 1 in. [25 mm] of cracking through caps

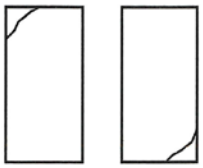


Type 2
Well-formed cone on one end, vertical cracks running through caps, no well-defined cone on other end

Type 3
Columnar vertical cracking through both ends, no well-formed cones



Type 4
Diagonal fracture with no cracking through ends; tap with hammer to distinguish from Type 1



Type 5
Side fractures at top or bottom (occur commonly with unbonded caps)

Type 6
Similar to Type 5, but end of cylinder is pointed

[The space above is provided for recording testing charges when the testing is performed by the Central Materials Laboratory.]

AGE: 28 DAY

Were unbonded caps used? Yes ☑ No ☐ If Yes, what type of unbonded cap was used? Neoprene ☑ Other ☐ _____

SPECIMEN IDENTIFICATION	INDICATE TYPE OF FRACTURE PATTERN (✔)						
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	OTHER*
A						✔	
B						✔	
C						✔	

* If the type of fracture pattern is other than Type 1 to Type 6, sketch and briefly describe the fracture pattern.

Remarks: _____

AGE: _____

Were unbonded caps used? Yes ☐ No ☐ If Yes, what type of unbonded cap was used? Neoprene ☐ Other ☐ _____

SPECIMEN IDENTIFICATION	INDICATE TYPE OF FRACTURE PATTERN (✔)						
	TYPE 1	TYPE 2	TYPE 3	TYPE 4	TYPE 5	TYPE 6	OTHER*
A							
B							
C							

* If the type of fracture pattern is other than Type 1 to Type 6, sketch and briefly describe the fracture pattern.

Remarks: _____

ADOT 44-9337 R12/11 (Back)

FIGURE 6

ARIZ 315
October 1, 1999
(4 Pages)

PRECAST MORTAR BLOCKS TEST

(An Arizona Test Method)

SCOPE

1. (a) This test method covers the accepted procedure for determining the compressive strength of precast mortar spacer blocks which are used to maintain the proper clearance on reinforcing steel bars. Precast mortar spacer blocks are prepared utilizing portland cement, aggregates, water, and admixtures.

(b) The compressive strength of the precast mortar spacer blocks shall be equal to or greater than the required twenty-eight day strength of the concrete that will encase the spacer blocks.

(c) The normal compressive strength of the precast mortar spacer blocks shall be in a range between 15 to 40 MPa (2000 to 6000 psi).

(d) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(e) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(f) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) A testing machine that conforms to the description given in AASHTO T 22, Section 5.

(b) A saw having a diamond or silicon-carbide cutting edge capable of cutting specimens which conform to the prescribed dimensions, without excessive heating or shock.

(c) Alignment devices and melting pots for sulfur mortars, conforming to the applicable sections of AASHTO T 231.

PREPARATION

3. (a) The length of the specimen, when capped, shall be as nearly as practical twice the diameter or least width. A specimen having a length which is less than the diameter or least width after capping shall not be tested.

(b) The ends of the specimens to be tested in compression shall be essentially smooth, perpendicular to the longitudinal axis, and of the same cross-sectional area as the body of the specimen. If necessary, saw or tool the ends of the specimens until the following requirements are met:

1) Projections, if any, shall not extend more than 5 mm (0.2 inch) above the end surfaces.

2) The end surfaces shall not depart from the perpendicular to the longitudinal axis by more than 5 degrees.

(c) Before making the compression test, cap the ends of the specimens in conformance with the procedure prescribed in the applicable section of AASHTO T 231. The capped surfaces of the specimens shall conform to the planeness requirements of AASHTO T 231.

(d) Prior to testing, measure the length of the capped specimen to the nearest 2.5 mm (0.1 inch) and use this length to compute the ratio of length to diameter or least width. Determine the dimension of the diameter or each width by averaging two measurements taken at the 1/3 points of the length of the specimen. Measure the diameter or each width and determine the average dimension to at least the nearest 2.5 mm (0.1 inch). If the ratio of length to diameter or least width of the specimen exceeds 2.10, the specimen shall be reduced in length to have a ratio of 1.94 to 2.10.

TEST PROCEDURE

4. (a) Test the specimens in accordance with the applicable provisions of AASHTO T 22.

Note: Short specimens fail at a greater load because the steel platens of the testing machine restrain lateral expansion throughout the specimen more effectively. The effect of end restraint is conventionally assumed to be negligible for a standard specimen with a ratio of length to diameter or least width of two. Short specimens are clearly defined in both AASHTO T 22 and T 24.

CALCULATIONS

5. (a) Calculate the compressive strength of each specimen using the computed cross-sectional area based on the average area of the specimen.

(b) Specimens which have a ratio of length to diameter or least width of 1.94 to 2.10 require no correction.

(c) If the ratio of length to diameter or least width of the specimen is less than 1.94, apply correction factors shown in the following table:

Ratio of Length to Diameter or Least Width	Strength Correction Factor
1.75	0.98
1.50	0.96
1.25	0.93
1.00	0.87
Values not given in the table shall be determined by interpolation.	

REPORT

6. (a) The compressive strength of the tested specimen at ultimate load shall be reported to the nearest 50 kPa (10 psi), after correction for length to diameter or least width ratio when appropriate.

OBTAINING AND TESTING DRILLED CORES AND SAWED BEAMS OF CONCRETE

(A Modification of AASHTO Designation T 24)

1. This test procedure is the same as specified in AASHTO T 24, with the following exceptions:

(a) Section 7.5 of AASHTO T 24 is revised to read:

7.5 *Measurement* – Prior to testing, measure the length of the capped specimen to the nearest 0.1 inch (2.5 mm) and use this length to compute the length-diameter ratio. Each test specimen shall be measured to determine its diameter. The diameter shall be the average of two measurements, taken using a caliper, at right angles to each other at about mid-height of the specimen. The individual diameter measurements shall be determined to the nearest 0.01 inch (0.25 mm). Determine and record the average of the two diameter measurements to the nearest 0.01 inch (0.25 mm). That value shall be the diameter used to calculate the cross-sectional area of the test specimen. Do not test the core if the difference between the largest diameter measurement and the smallest diameter measurement exceeds 5% of their average.

(b) Section 7.6 of AASHTO T 24 is revised to read:

7.6 *Testing* – Test the specimens in accordance with Arizona Test Method 314, except unbonded caps (neoprene or other elastomeric materials) with metal retainers shall not be used. Unless otherwise specified, the specimens shall be tested within seven days after coring.

(c) Section 7.8 of AASHTO T 24 is revised to read:

7.8 *Report* – Report the results as required by Arizona Test Method 314, with the addition of the following information:

(d) Section 7.8.1 of AASHTO T24 is revised to read:

7.8.1 The location where the core was obtained. The length of the core as drilled to the nearest 0.2 inch (5 mm),

(e) Section 7.8.2 of AASHTO T 24 is revised to read:

7.8.2 The length of the test specimen before and after capping or end grinding to the nearest 0.1 inch (2.5 mm), and the average diameter of the core to the nearest 0.01 inch (0.25 mm),

(f) Section 7.8.3 of AASHTO T 24 is revised to read:

7.8.3 The compressive strength of the test specimen to the nearest 10 psi (50 kPa), after correction for the length-diameter ratio when required. In addition, if the average compressive strength is determined for multiple specimens, the average compressive strength to the nearest 10 psi (50 kPa),

ESTIMATING THE DEVELOPMENT OF CONCRETE STRENGTH BY THE MATURITY METHOD

(An Arizona Method)

1. SCOPE

1.1 This test method provides a procedure for estimating the development of concrete strength by means of the maturity method.

1.2 This procedure is normally used, when desired, for Class S and Class P concrete; however, it may be used for other classes of concrete.

1.3 The concept of the maturity method is based on the combined effects of concrete age and temperature during the hydration process versus the rate of strength gain for a specific mix.

1.4 This method requires the establishment of a relationship curve between compressive strength and calculated maturity index for a specific concrete mixture (mix design) prior to placement of the mixture in the field.

1.5 This procedure may not be used to estimate the strength of mass concrete unless the strength-maturity relationship is developed at elevated temperatures. Mass concrete is defined as concrete which has a least dimension of three feet or more.

1.6 The maturity method shall not substitute for compressive strength acceptance testing (28-day test cylinder breaks).

1.7 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.8 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. REFERENCED DOCUMENTS

2.1 AASHTO Documents

- AASHTO T325 Estimating the Strength of Concrete in Transportation Construction by Maturity Tests
- AASHTO T23 Making and Curing Concrete Test Specimens in the Field
- AASHTO R39 Making and Curing Concrete Test Specimens in the Laboratory

2.2 ASTM Documents

- ASTM C 1074 Estimating Concrete Strength by the Maturity Method

2.3 Arizona Documents

- ARIZ 314 Compressive Strength of Cylindrical Concrete Specimens
- PPD No. 15 Submittal and Approval of Portland Cement Concrete Mix Designs

3. TERMINOLOGY

3.1 Maturity - The extent of development of concrete properties that are dependent on the hydration of cementitious materials.

3.2 Maturity Function - A mathematical expression that converts the temperature history of concrete to an index, which indicates its maturity.

3.3 Maturity Index - An index, calculated by using a maturity function, which can be used as an indicator of strength development in concrete.

3.4 Strength-Maturity Relationship - An empirical relationship between concrete strength and its maturity index, determined by comparing the strength of concrete cylinders, made from a specific concrete mix, to their maturity index at the time of strength testing.

4. SIGNIFICANCE AND USE

4.1 The estimated strength of in-place concrete determined by this procedure provides guidance useful in making decisions concerning:

4.1.1 Removal of formwork and reshoring.

4.1.2 Post-tensioning.

4.1.3 Opening of the roadways to traffic.

4.1.4 Initiation of strength tests, such as coring and pullout tests, on the in-place concrete.

4.2 The most critical limitations of the procedures presented are:

4.2.1 Concrete must be cured in a condition that supports the reaction of cementitious materials.

4.2.2 Batching or placement errors that are not detected.

4.2.3 Curing errors other than those that affect temperature that are not detected.

4.2.4 The actual strength of the concrete that is not measured.

4.3 This method provides technical personnel with a coordinated procedure for:

4.3.1 Developing a strength-maturity relationship for the approved concrete mix design in the laboratory.

4.3.2 Determining the temperature history of the in-place concrete.

4.3.3 Determining the maturity index of the in-place concrete.

4.3.4 Using the strength-maturity relationship and the maturity index to estimate the strength of the in-place concrete.

5. MATURITY METHOD

5.1 The temperature-time factor (Nurse-Saul) method shall be used to determine the maturity index.

5.2 Maturity digital data loggers shall be set at a datum factor of 0 °C.

5.3 The strength-maturity relationship shall be plotted using a linear chart or a logarithmic chart. In support of using either a linear chart or a logarithmic chart, a printout of the strength-maturity relationship test data shall be used.

6. APPARATUS

6.1 A maturity meter capable of reading a maturity digital data logger that has a secure method of collecting un-interruptible and un-alterable data, subsequent to the concrete pour and initial concrete set, for a minimum of 28 days. The system shall be accurate to at least ± 1 °C.

6.2 Maturity digital data loggers shall contain a real time clock and be capable of recording the current temperature and temperature history in real time with an associated time stamp.

6.3 Documentation shall be provided by the manufacturer that certifies the accuracy of the maturity meter and digital data loggers.

7. PROCEDURE TO DEVELOP STRENGTH-MATURITY RELATIONSHIP

7.1 A strength-maturity relationship curve shall be developed for a specific concrete mix prior to using this method on the project.

7.2 As described in Subsection 7.3 below, the strength-maturity relationship curve is developed utilizing compressive strength cylinders which have been fabricated, cured, and tested from a trial batch as described in ADOT Materials Policy and Procedure Directive No. 15, "Submittal and Approval of Portland Cement Concrete Mix Designs". The concrete mixture shall meet the specification (design mix) requirements in order to determine the strength-maturity relationship curve. The concrete mixture shall be at or above the target air content.

7.3 The compressive strength testing for the development of the strength-maturity relationship curve shall be performed as follows:

7.3.1 This procedure requires the initial casting of at least 17 compressive strength test cylinders. The test cylinders shall be fabricated in accordance with the requirements of AASHTO T23.

7.3.2 Two cylinders will be outfitted with maturity digital data loggers. Readings are taken from the data loggers in each of these cylinders. The readings are averaged, and the results are correlated with the compressive strength test results to establish the maturity curve.

7.3.3 A minimum of fifteen cylinders will be tested for compressive strength as described below.

7.3.3.1 Compressive strength tests shall be performed on three cylinders, at a minimum of five different ages encompassing the age at which the desired strength is needed. For example, compressive strength tests may be performed at 1, 2, 3, 5 and 7 days for Class S concrete or 12, 24, 36, 48 and 72 hours for Class P concrete. More cylinders may be fabricated, cured, and tested at additional ages if desired. Compressive strength testing shall be performed in accordance with the requirements of Arizona Test Method 314.

Note: Tests should be scheduled to result in approximately equal increments of strength gain between ages. Additionally, compressive strength tests should bracket the estimated target strength.

7.3.3.2 The compressive strength of each of the three test cylinders at each age and their average compressive strength shall be determined. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three test cylinders differ by more than 10 percent from the average of the three, the results of both will be discarded and the compressive strength shall be the strength of the remaining cylinder.

8. PLACEMENT OF DIGITAL DATA LOGGERS IN THE FIELD

8.1 Maturity digital data loggers shall be placed as follows, either prior to concrete placement (with maturity digital data loggers properly secured in their proper location) or into the fresh concrete following the placement of concrete.

Class of Concrete	Frequency of Logger Placement	Location of Logger Placement
Class P (PCCP)	Every 100 cubic yards	Mid-depth of pavement ≥ 12 inches from edge of pavement
Class S (Structural)	Every 50 cubic yards*	Critical locations per exposure and/or structural requirements
Other than Class S or Class P	Every 50 cubic yards*	Critical locations per exposure and/or structural requirements
* At least two additional maturity data loggers should be available for placement as needed		

8.2 Activate the maturity digital data loggers as soon as practicable after concrete placement, but not before the maturity digital data loggers are fully encapsulated in concrete.

9. FIELD VALIDATION OF STRENGTH-MATURITY RELATIONSHIP

9.1 The maturity method does not account for variations in strength due to proportioning, mixing, placing, and moisture conditions of the field-placed concrete. Proper curing of the concrete and minimizing moisture loss is critical in achieving reliable strength-maturity relationship results.

9.2 During the initial use of this method for the concrete mixture for which the strength-maturity relationship has been developed, a field validation of the strength-maturity relationship shall be performed. A minimum of three compressive strength test cylinders shall be fabricated, cured, handled, protected, and transported in accordance with the requirements of AASHTO T23. In addition, a minimum of one test cylinder shall be fabricated and cured in

the same manner as the three compressive strength test cylinders, and at least two maturity digital data loggers shall be embedded in the additional test cylinders, as close to the center (± 1/2 inch) of the cylinders as possible. The data logger readings are used in conjunction with the average compressive strength for validation of the strength-maturity relationship.

9.3 The three compressive strength cylinders shall be tested in accordance with the requirements of Arizona Test Method 314 at approximately the estimated temperature-time factor target. The average compressive strength of the three test cylinders shall be determined. However, if the compressive strength of any one of the three test cylinders differs by more than 10 percent from the average of the three, its result shall be discarded and the compressive strength shall be the average of the remaining two cylinders. Should the individual compressive strength of any two of the three test cylinders differ by more than 10 percent from the average of the three, the results of both will be discarded and the compressive strength shall be the strength of the remaining cylinder.

9.4 Compare the data logger readings and the average compressive strength of the field validation test cylinders to the original strength-maturity relationship curve at the estimated temperature-time factor target. The average compressive strength of the field validation cylinders is used only for comparison to the original strength-maturity relationship curve.

9.4.1 If the average compressive strength of the validation test cylinders is equal to or differs by less than ± 10 percent of the original strength-maturity relationship which has been developed for the concrete mixture, the development of a new strength-maturity relationship curve may not be required.

9.4.2 If the average compressive strength of the validation test cylinders differs by greater than ± 10 percent of the original strength-maturity relationship, the development of a new strength-maturity relationship curve is required.

9.5 During placement of the concrete mixture, field validations of the strength-maturity relationship curve shall be performed in accordance with the requirements of Subsections 9.2 through 9.4. The minimum frequency of field validations will be as follows:

9.5.1 For Class P concrete: every 10 days of concrete placement.

9.5.2 For Class S concrete: every 300 cubic yards of concrete placement.

9.5.3 For other than Class P or Class S: every 300 cubic yards of concrete placement.

10. REPORT FOR STRENGTH MATURITY RELATIONSHIP

10.1 Project number

10.2 Concrete Product Code and the source of each material (aggregate, cement, supplementary cementitious material, and admixtures).

10.3 Date(s) and times(s) that compressive strength testing of the cylinders is performed.

10.4 The air content, slump, water content, and the water/cementitious material ratio for each batch of concrete tested.

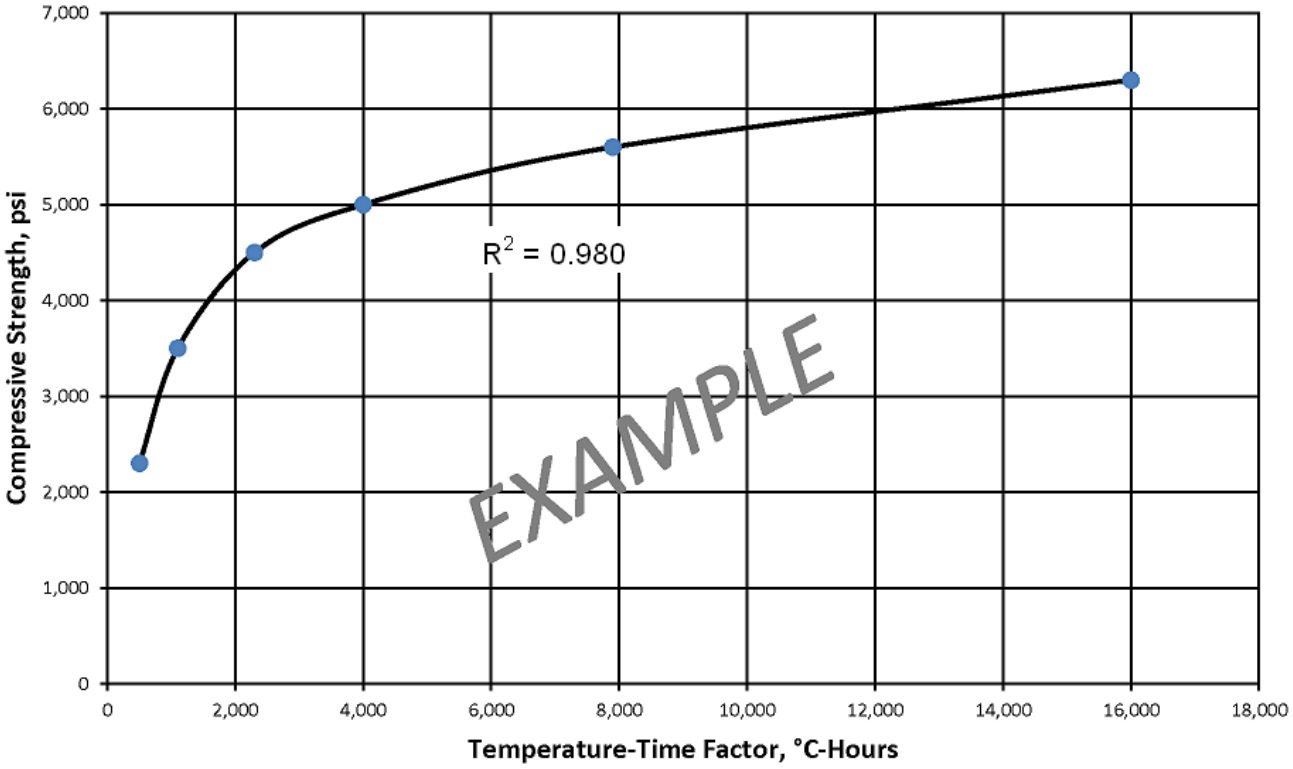
10.5 The amount and type of admixtures used in the concrete mixture.

10.6 The strength of each test cylinder and the average strength of the test cylinders at each test age.

10.7 The maturity index for each instrumented test cylinder and the average maturity index for the instrumented test cylinders at each test age.

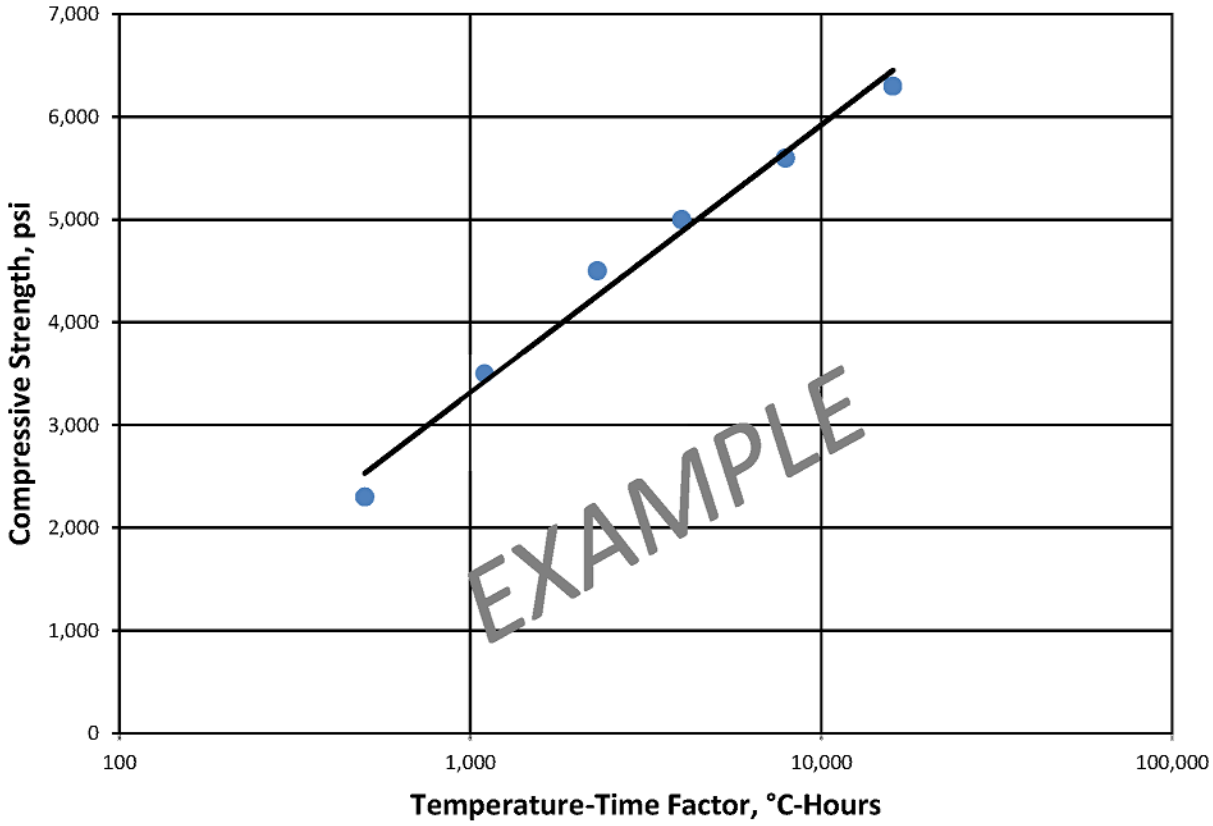
10.8 A graph of the plotted points, on either a linear chart or a logarithmic chart, for the average compressive strength at each age versus the average maturity index at each age, and the best-fit curve. An example of such a linear graph is shown in Figure 1. An example of a logarithmic graph is shown in Figure 2. To be acceptable, the plotted points shall produce a correlation coefficient (R2) of at least 0.90.

10.8.1 In support of providing either a linear chart or a logarithmic chart, a printout of the strength-maturity relationship test data used shall be provided. An example of such a printout is shown in Figure 3.



Example Strength-Maturity Relationship Curve
Linear Scale

FIGURE 1



Example Strength-Maturity Relationship Curve
(Logarithmic Scale)

FIGURE 2

Temperature-Time Factor, °C-Hours	Compressive Strength, psi
500	2,300
1,100	3,500
2,300	4,500
4,000	5,000
7,900	5,600
16,000	6,300

Example Printout of Strength-Maturity Relationship Test Data

FIGURE 3

SERIES 400
BITUMINOUS MIXTURES

MOISTURE CONTENT OF BITUMINOUS MIXTURES

(An Arizona Method)

1. SCOPE

1.1 This method is used to determine the percent moisture in bituminous mixtures. The option of using a conventional oven or a microwave oven is provided. In case of dispute, the conventional oven shall be utilized.

1.2 This test method may involve hazardous material, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Suitable sample containers for use in testing with the conventional oven or microwave oven.

2.3 Oven - A thermostatically controlled oven capable of maintaining a temperature of 290 $\pm$ 10 °F; or, a microwave oven capable of variable heat intensity settings.

2.4 A balance or scale capable of measuring the maximum weight to be determined, accurate to at least 0.1 gram.

3. PROCEDURE (CONVENTIONAL OVEN)

3.1 Obtain a representative 1000 $\pm$ 50 gram sample in accordance with ARIZ 416.

3.2 Record the tare weight of the container to the nearest 0.1 gram.

3.3 Place sample in the container and weigh. Determine and record the wet weight of sample to the nearest 0.1 gram as "f".

3.4 Place container and sample in a 290 ± 10 °F oven and initially dry for a minimum of 1 hour. Weigh the container and sample. Record the weight to the nearest 0.1 gram.

3.5 Continue drying and weighing until a constant weight is obtained; being the weight at which further drying does not alter the weight more than 0.1 gram at intervals of a minimum of 30 minutes.

3.6 After constant weight is obtained, cover sample and allow to cool 30 ± 10 minutes at room temperature. Weigh and determine and record the dry weight of sample to the nearest 0.1 gram as "g".

3.7 Proceed to section 5 for moisture content calculation.

4. PROCEDURE (MICROWAVE OVEN)

4.1 Obtain a representative 1000 ± 50 gram sample in accordance with ARIZ 416.

4.2 Record tare weight of the container to the nearest 0.1 gram.

4.3 Place sample in the container and weigh. Determine and record the wet weight of sample to the nearest 0.1 gram as "f".

4.4 Dry sample until a constant weight is obtained. The sample is considered to be at constant weight when further drying causes, or would cause, a difference in weight of not more than 0.1 gram. The sample shall be heated in such a manner that controls the intensity of heat generated to prevent splattering, aggregate breakage, and asphalt being "burned off". The method used with a microwave oven shall give results similar to those achieved with a conventional oven.

4.5 After constant weight is obtained, cover sample and allow to cool 30 ± 10 minutes at room temperature. Weigh and determine and record the dry weight of sample to the nearest 0.1 gram as "g".

5. CALCULATION

5.1 Calculate the percent moisture, "h", and record to the nearest 0.01% as shown below.

$$h = \frac{f - g}{f} \times 100$$

Where: h = Percent Moisture
f = Wet weight of sample
g = Dry weight of sample

COMPACTION AND TESTING OF BITUMINOUS MIXTURES UTILIZING FOUR INCH MARSHALL APPARATUS

(A Modification of AASHTO T 245)

1. SCOPE

1.1 This method covers the procedure for compacting and testing bituminous mixtures utilizing four inch Marshall apparatus.

1.2 This procedure is used for bituminous mixtures with a mix design gradation target of at least 85% passing the 3/4 inch sieve.

1.3 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Compaction Mold Assembly 4 inch diameter cylindrical mold, baseplate, and extension collar constructed of steel and conforming to the requirements of Figure 1. (Three compaction mold assemblies are normally utilized.)

2.3 Specimen Extruding Device - Extrusion jack or press for extruding specimens from molds.

2.4 Compaction Hammer:

2.4.1 The compaction hammer shall either be a mechanical or hand compaction hammer having a flat, circular tamping face with a nominal diameter of (3-7/8 inches), and a (10 ± 1/4 pound) sliding weight with a free fall of (18 ± 1/2 inches).

2.4.2 Compaction hammers must be monitored through the ADOT proficiency sample program. To be qualified, compaction hammers must produce specimens with an average density of no greater than ± 1.0 lb./cu. ft. from the average bulk density for the most recent set of proficiency samples. If two samples are required for the proficiency samples, both of the bulk density sets must meet the ± 1.0 lb./cu. ft. criteria, if not, the hammer is not qualified.

2.4.3 As an alternate to qualifying a compaction hammer through the proficiency sample program, a compaction hammer may be qualified by correlating with a hammer which has been approved through comparison with proficiency sample results. When qualified in this manner, results must be no greater than ± 0.5 lb./cu. ft.

2.4.4 Hammers which have had adjustments or repairs made to them after being qualified, must be requalified by correlating with another qualified hammer and yield results within ± 0.5 lb./cu. ft.

Note: Marshall compaction equipment can go out of calibration at any time, and each laboratory is encouraged to establish a method of ensuring that their equipment remains in calibration. Alternate methods that can be used include regular comparisons with other approved hammers or compaction of samples which have a known density.

2.4.5 Hammers which do not meet the above requirements may be adjusted by modifying the weight, or the height of fall, within the given criteria; by adjusting the number of blows a maximum of ± 10 from the specified 75 blows; or by a combination of adjustments to weight, height of fall, or number of blows.

2.4.6 Should a compacton pedestal be moved or replaced, the compaction hammer(s) shall be requalified.

2.5 Compaction pedestal - The compaction pedestal shall consist of a 8" x 8" x 18" wooden post capped with a 12" x 12" x 1" steel plate. The steel cap shall be firmly fastened to the post. The wooden post shall have a dry weight of 42 to 48 lbs./cu. ft. and shall rest squarely on, and be firmly secured to, a solid concrete slab. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

2.6 Specimen Mold Holder - Mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It shall hold the compaction mold, collar, and base plate securely in position during compaction of specimen.

2.7 Oven for heating bituminous mixtures and specimen mold assemblies at required temperature.

2.8 Hot plate for heating compaction hammer, spoon and spatula.

2.9 A flat spatula with blade approximately 1 inch wide and at least 6 inches long, stiff enough to penetrate the entire bituminous mixture.

2.10 Calibrated/verified thermometers, for determining temperatures of bituminous mixtures, with a range of 50 to 400 °F and increments of not greater than 5 °F. For digital thermometers, increments shall not be greater than 1 °F.

2.11 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least one gram.

2.12 If Marshall stability and flow are to be determined, the following additional apparatus is required:

2.12.1 Breaking Head and Water Bath, conforming to the requirements specified in AASHTO T 245.

2.12.2 Marshall stability and flow testing apparatus, with operating instruction manual. The apparatus shall be capable of applying a load with a constant rate of travel of 2.0 ± 0.1 inches per minute.

2.12.3 Height gauge capable of measuring the height of specimens to the nearest 0.001 inch.

3. PROCEDURE

3.1 Obtain three representative samples for Marshall specimens, as described in Arizona Test Method 416. If the Combined Aggregate Bulk (O.D.) Specific Gravity is known, the weight calculated by the following equation (± 50 grams) will normally give specimens which meet the height requirement of 2.300 to 2.700 inches. (1150 ± 50 grams is generally adequate.)

$$\left[\begin{array}{c}\text{Weight of}\\ \text{each Sample}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Combined Aggregate}\\ \text{Bulk (O.D.) Specific Gravity}\end{array}\right]}{2.520} \text{ x } 1150$$

3.2 Before placing the mixture in the mold, the mixture and a mold assembly (baseplate, mold, and collar) shall be at approximately 290 °F. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at approximately 290 °F. The temperature of the laboratory during compaction of the specimens shall be between 68 and 86 °F.

3.3 Place a 4-inch paper disc in the bottom of the mold before the mixture is introduced. Place the entire batch in the mold in one lift. Care should be taken to avoid segregation of material in the mold. Spade the mixture vigorously, penetrating the entire mix, with the heated spatula 15 times around the perimeter and 10 times at random into the mixture. Smooth the surface of the mix to a slightly rounded shape.

3.4 The compaction temperature shall be the laboratory compaction temperature shown on the mix design.

3.5 If necessary, the mixture and mold assembly shall be returned to an oven at the required temperature for the minimum time necessary to achieve the laboratory compaction temperature ± 5 °F; however, in no case shall the mixture be reheated longer than 60 minutes.

3.6 Place a 4-inch paper disc on top of material, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows [or adjusted number, as determined in Subsection 2.4] with the compaction hammer. When a hand hammer is utilized, the operator shall hold the handle by one hand so that the axis of the compaction hammer is as nearly perpendicular to the base of the mold assembly as possible while compaction is accomplished. Care shall be taken not to add body weight to the hammer by leaning or pressing down on the hammer. When using a hand hammer, no mechanical device of any kind is

to be used to restrict movement of the handle during compaction. Compaction shall be performed at a minimum rate of 40 blows per minute. The compaction hammer shall apply only one blow with each fall, that is, there shall not be a rebound impact. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 (or adjusted number) compaction blows to the face of the reversed specimen.

3.7 Remove collar, baseplate, and paper discs, and allow specimen to cool. Cooling may be accomplished at room temperature, in a 77 °F air bath, or if more rapid cooling is desired the mold and specimen may be placed in front of a fan until cool.

3.8 Extrude the specimen from the mold. Care shall be taken in extruding the specimen from the mold, so as not to develop tensile stresses in the specimen or tear the sides of the specimen.

4. SPECIMEN TESTING

4.1 If Marshall stability and flow are to be determined, measure height of specimens to the nearest 0.001 inch. Prior to measurement of height, excess material shall be brushed from the edges of the specimens. Compacted specimens shall be 2.300 to 2.700 inches in height. If this criteria is not met, the entire set of specimens shall be discarded and a new set prepared after necessary adjustments in sample weight have been made.

4.2 Determine the specific gravity of the specimens in accordance with Arizona Test Method 415, Method A. (Assume specimen is at constant weight after cooling.)

4.3 Determine the bulk density of each of the specimens, by multiplying the respective specific gravity by 62.3 lbs./cu. ft. Record the individual bulk densities to the nearest 0.1 lb./cu. ft. The densities of the three specimens shall not differ by more than 2.5 lbs./cu. ft. for 1/2", 3/4", or recycle mixes; and 3.0 lbs./cu. ft. for Base mixes. If this density requirement is not met, the entire set of specimens shall be discarded and a new set of specimens prepared.

4.4 Determine the average specific gravity of the specimens and record to the nearest 0.001. Calculate the average bulk density of the specimens, by multiplying the average specific gravity by 62.3 lbs./cu. ft. Record the average bulk density to the nearest 0.1 lb./cu. ft.

4.5 If the stability and flow are to be determined, the steps in Subsections 4.6 through 4.11 below are followed, utilizing the apparatus in accordance with the operating instructions for that apparatus.

4.6 Bring the specimens to 140 $\pm$ 2 °F by immersing in the water bath 30 to 40 minutes. Prior to testing, it shall be assured that the inside of the test heads are clean, and that the guide rods are clean and lubricated so that the upper test head slides freely over them.

4.7 The breaking head temperature shall be maintained between 70 to 100 °F, using a water bath when required. Remove the specimen from the water bath, quickly towel dry specimen and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine.

4.8 Apply the load to the specimen with a constant rate of 2.0 $\pm$ 0.1 inches per minute until the maximum load is reached and the load decreases. The maximum load is defined as the last point in the load/time curve before the load decreases. The elapsed time for the test from removal of the test specimen from water bath to maximum load determination shall not exceed 30 seconds.

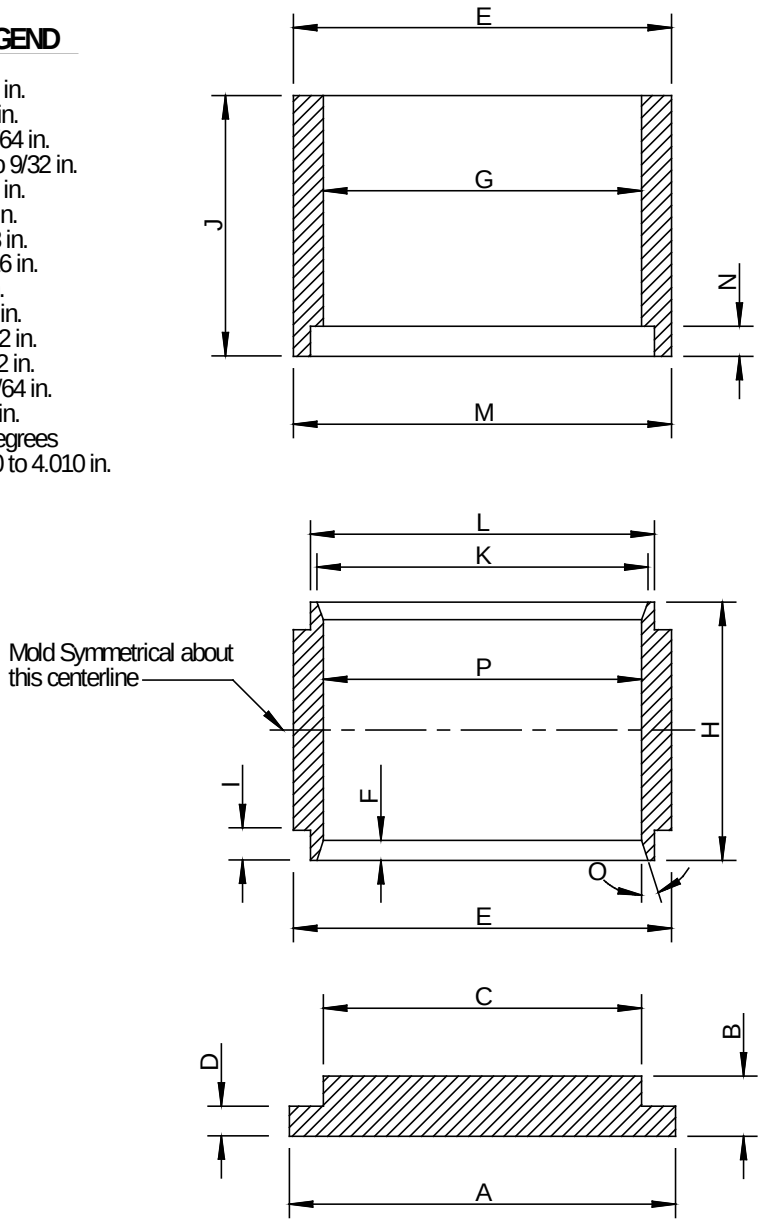
4.9 Record the stability of each specimen to the nearest 10 pounds force, and the flow to the nearest 0.01 inch.

4.10 Correct the stability obtained for each specimen, for the height of the specimen, by the table in Figure 2. Record the corrected stability to the nearest 10 pounds force.

4.11 Determine and record the average corrected stability to the nearest 10 pounds force, and the average flow to the nearest 0.01 inch.

LEGEND

A: 4-3/4 in.
B: 9/16 in.
C: 3-63/64 in.
D: 1/8 to 9/32 in.
E: 4-1/2 in.
F: 3/16 in.
G: 4-1/8 in.
H: 3-7/16 in.
I: 1/4 in.
J: 2-3/4 in.
K: 4-5/32 in.
L: 4-9/32 in.
M: 4-19/64 in.
N: 9/32 in.
O: 20 degrees
P: 3.990 to 4.010 in.



All dimensions are nominal, except where tolerances are indicated.

Four Inch Compaction Mold, Extension Collar, and Baseplate

FIGURE 1

STABILITY CORRELATION RATIOS*

For 4 inch Diameter Specimens

Height of Specimen (Inches)	Correlation Ratio
2.300 - 2.306	1.15
2.307 - 2.319	1.14
2.320 - 2.332	1.13
2.333 - 2.344	1.12
2.345 - 2.357	1.11
2.358 - 2.369	1.10
2.370 - 2.381	1.09
2.382 - 2.393	1.08
2.394 - 2.405	1.07
2.406 - 2.417	1.06
2.418 - 2.430	1.05
2.431 - 2.445	1.04
2.446 - 2.461	1.03
2.462 - 2.477	1.02
2.478 - 2.492	1.01
2.493 - 2.507	1.00
2.508 - 2.522	0.99
2.523 - 2.537	0.98
2.538 - 2.553	0.97
2.554 - 2.573	0.96
2.574 - 2.594	0.95
2.595 - 2.615	0.94
2.616 - 2.634	0.93
2.635 - 2.649	0.92
2.650 - 2.663	0.91
2.664 - 2.679	0.90
2.680 - 2.697	0.89
2.698 - 2.700	0.88

* The measured stability of a specimen multiplied by the correlation ratio for the height of the specimen equals the corrected stability for a 2-1/2 inch specimen.

FIGURE 2

DETERMINATION OF BITUMINOUS DISTRIBUTOR TRUCK TRANSVERSE SPREAD RATE

(A Modification of California Test 339)

1. SCOPE

1.1 This procedure describes the method for determining the transverse spread rate, in gallons per square yard, of bituminous distributor trucks. **This procedure is applicable for all bituminous materials other than asphalt-rubber and cutback asphalts.**

Note: Three Alternate Sampling Procedures are outlined in this test method.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

2.1.2 Oven - An oven capable of maintaining a temperature of 140 ± 5 °F.

2.1.3 Metal Sheets (20 gauge galvanized) - 7-7/8 inches in width and with a length to accommodate a sixteen foot spray bar. Any combination of lengths of metal plates may be used. (For example, three plates each 68

inches long; or two plates each 84 inches long and one plate 36 inches long.)

2.1.4 Testing Machine (when Alternate Sampling Procedure #1 is used.) - A device with a sliding platform which holds the test plates as they are moved under and through the bituminous material while it is being sprayed. See Figure 4 for an illustration of a typical "sliding platform" device.

2.1.5 When Alternate Sampling Procedures #2 or #3 are used, a provision to raise the plates and pads off the surface must be provided. (For example, 2” x 4” or 1” x 6” boards in any combination of lengths for a total length of 17 feet.)

2.1.6 Stapler - For fastening cotton pads to paper strips.

3. MATERIALS

3.1 100% cotton gauze pads - 4” x 8", 12 ply.

3.2 5" x 12" strips cut from heavy wrapping paper.

3.3 Masking tape, minimum 1" width.

3.4 Scotch tape, 3/4" width

4. PREPARATION OF TEST PADS AND TEST PLATES

4.1 Prepare each test pad by attaching two cotton pads (laid on top of each other) to each paper strip with a staple at each corner of the cotton pads. The cotton pads are attached to the paper strips as shown in Figure 1.

4.2 Place a strip of scotch tape along each end of the paper strip as shown in Figure 1. This will allow the masking tape to be easily removed from the paper strip during the removal of the test pad from the test plate.

4.3 Place an identification number on the paper back of each test pad. To facilitate the assembly of the test plates at the test site, it is helpful to also place the identification number in the middle of either end on the front of each test pad. (Fifty-one consecutively numbered test pads are required to fabricate the three test plates for each test.)

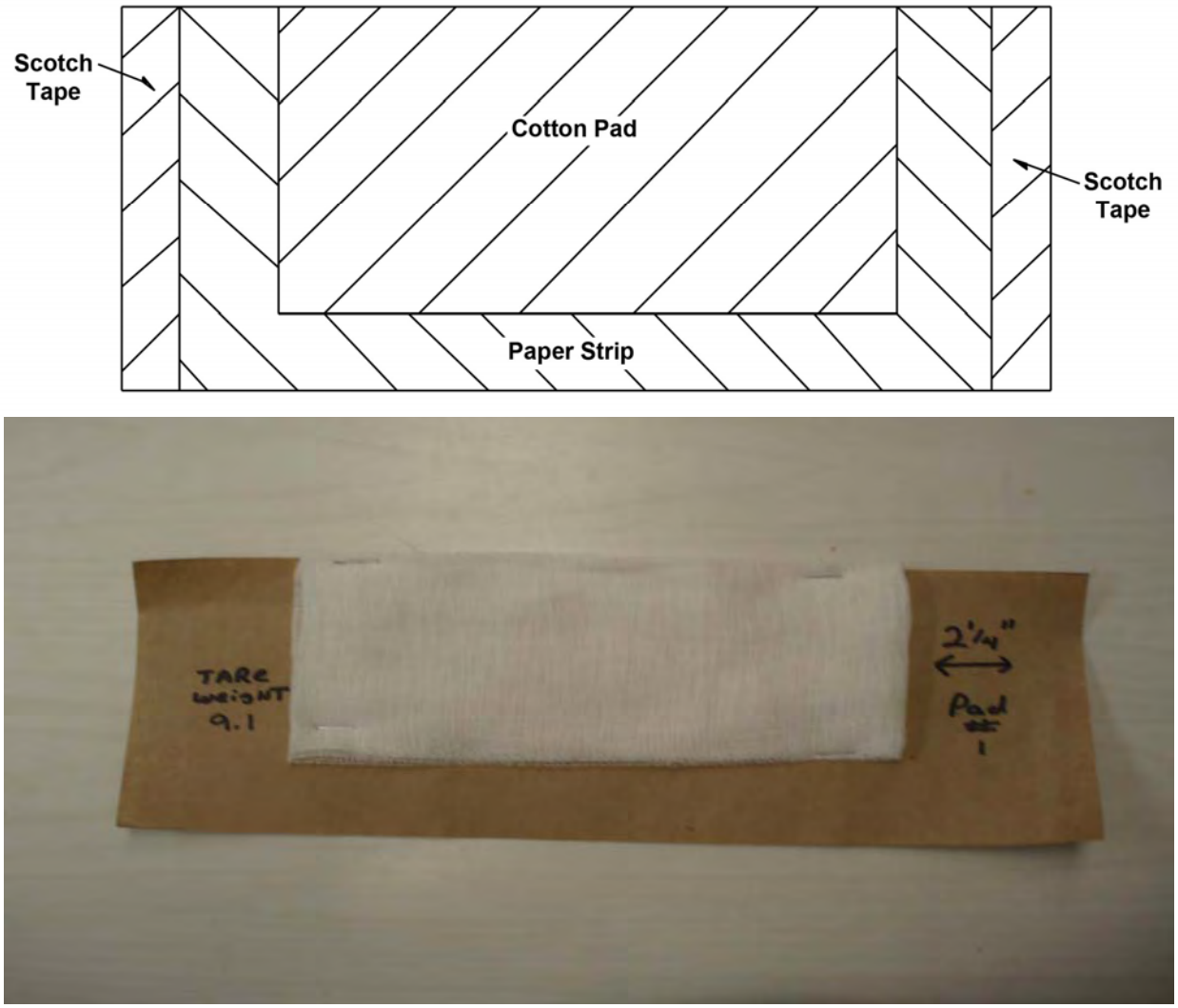
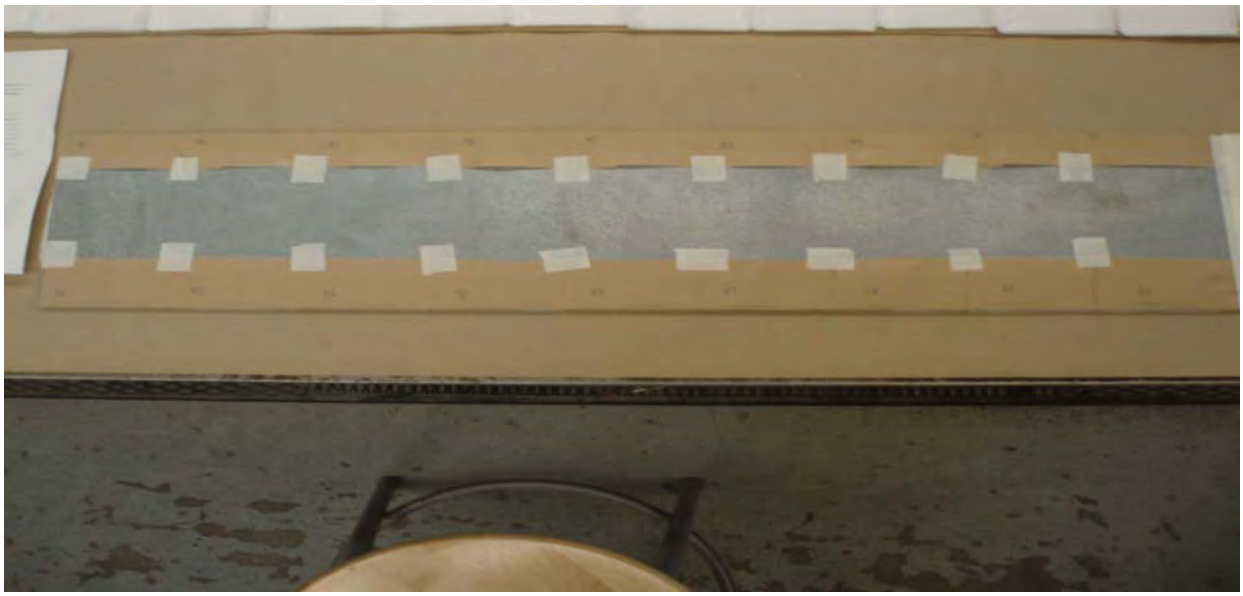


Figure 1 – Test Pad

4.4 Weigh each test pad and record its tare weight to the nearest 0.1 gram on the test record shown in Figure 7.

4.5 The test pads are attached to the metal sheet in numerical order so that the cotton pads are snug against each other by overlapping the adjacent strips 1 inch. Figure 2 provides an illustration of test pads attached to the test plate. Twenty-one test pads are required to fabricate an 84-inch test plate. Nine test pads are required to fabricate a 36-inch test plate. Each end of the test pad is folded over to the backside of the test plate and secured with masking tape.

Front of Test Plate



Back of Test Plate

Figure 2 – Test Pads Attached To Test Plate

4.6 Stack the assembled test plates on one another, with the corresponding test record containing the test pad tare weights. Wrap the bundle in heavy wrapping paper, as shown in Figure 3, for protection and to keep them clean while being stored or transported to the test site.

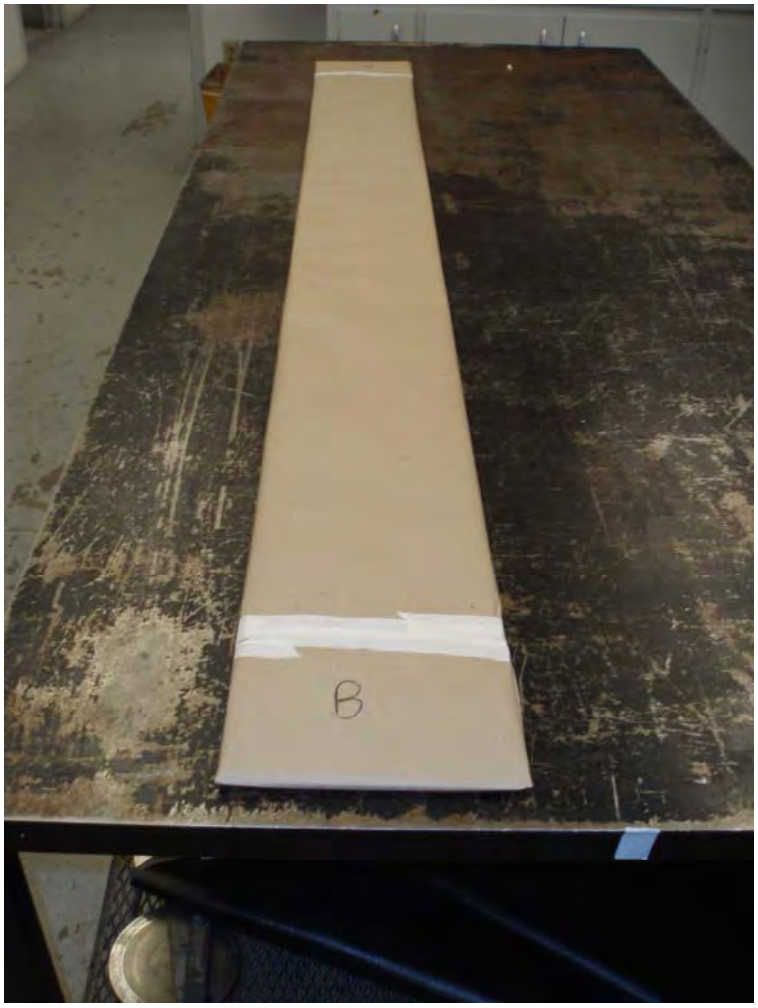


Figure 3 – Wrapped Test Plates

5. ALTERNATE SAMPLING PROCEDURE #1

5.1 Alternate Sampling Procedure #1 utilizes the sliding platform testing machine described in Subsection 2.1.4. In this procedure, the distributor truck remains stationary while the test is being performed. Side shields shall not be used when testing is performed under this procedure.

5.1.1 Securely attach the test plates to the testing machine platform by wire tying. The test plates are placed end-to-end so that the test pads are in numerical order with test pad No. 1 being on the driver's side of the truck.

5.1.2 Position the distributor truck so that its spray bar is over the testing machine, but far enough away from the test plates to prevent any bituminous material being sprayed on the test pads. Initiate the spraying. When the spray is judged to be normal, energize the platform so that it moves under and through the spray, as illustrated in Figure 4. Terminate the spray and pull the distributor truck away from the testing machine.

5.1.3 Proceed to Section 8.

Typical "Sliding Platform" Testing Machine With Bituminous Material Being Sprayed

Figure 4

6. ALTERNATE SAMPLING PROCEDURE #2

6.1 If desired, Alternate Sampling Procedure #2 may be used instead of Alternate Sampling Procedure #1 described in Section 5 or Alternate Sampling Procedure #3 described in Section 7. Side shields shall not be used when testing is performed under this procedure.

6.1.1 Place the boards used to raise the plates off the surface in a suitable location.

Note: The boards should be protected from the bituminous material by wrapping them in heavy paper.

6.1.2 Place the test plates end-to-end on top of the boards so that the test pads are in numerical order with test pad No. 1 being on the driver's side of the truck.

6.1.3 Back the distributor truck up to test plates so that the back wheels of the truck are a few inches from the test plates.

6.1.4 Drive the distributor truck forward at a constant speed and spray bituminous material across the test plates.

6.1.5 Proceed to Section 8.

7. ALTERNATE SAMPLING PROCEDURE #3

7.1 If desired, Alternate Sampling Procedure #3 may be used instead of Alternate Sampling Procedure #1 described in Section 5 or Alternate Sampling Procedure #2 described in Section 6. Side shields shall not be used when testing is performed under this procedure.

7.1.1 Place the boards used to raise the plates off the surface in a suitable location, which will facilitate the distributor truck backing up at a constant speed with the ability to stop prior to its wheels hitting the test plates.

Note: The boards should be protected from the bituminous material by wrapping them in heavy paper.

7.1.2 Place the test plates end-to-end on top of the boards so that the test pads are in numerical order with test pad No. 1 being on the driver's side of the truck.

7.1.3 With the distributor truck starting at an adequate distance in front of the test plates, it is backed up at a constant speed so that the bituminous material is sprayed across the test plates. The distributor truck must be stopped prior to its wheels hitting the test plates.

7.1.4 Proceed to Section 8.

8. REMOVAL OF TEST PADS FROM THE TEST PLATES

8.1 After the spraying operation is complete, leave the test plates in place a short time to allow the bituminous material to set up enough to prevent running.

8.2 Remove the test plates and transport them to the laboratory.

8.3 Place each test plate in turn on an adequate size work area. Starting with the highest number test pad and proceeding to the lowest number, remove each test pad taking care to not remove any of the paper when removing the masking tape. Fold each test pad, and stack them in a drying pan as shown in Figure 5.

8.4 Dry the test pads to constant weight at 140 ± 5°F. Allow them to cool to room temperature prior to weighing.

Note: If PG asphalt binder is used, drying of the test pads at 140 °F is not required.

8.5 Weigh each test pad and record its weight to the nearest 0.1 gram on the test record shown in Figure 8.

9. CALCULATIONS

9.1 Omit end test pads that are outside the spray bar width.

9.2 Determine the weight of bituminous material on each of the remaining test pads, by subtracting the corresponding test pad tare weight, and record the weight to the nearest 0.1 gram on the test record shown in Figure 7.

Folded and Stacked Test Pads

Figure 5

9.3 Multiply the weight of bituminous material on each test pad by 0.0107, or use the table found in Figure 6, to determine the spread rate to the nearest 0.001 gal./sq. yd. for each test pad.

9.4 Determine the average spread rate to the nearest 0.001 gal./sq. yd.

9.5 Determine the acceptable range as shown below:

9.5.1 Acceptable Range = Average spread rate ± 10%, or
± 0.020 gal/sq. yd., whichever is less.

9.6 Determine the number of test pads that are outside the acceptable range. More than three pads outside the acceptable range constitutes a failing test. Three or fewer test pads outside the acceptable range constitutes a passing test.

10. REPORT AND EXAMPLE

10.1 Report the following:

10.1.1 The spread rate, to the nearest 0.001 gal./sq. yd., for each test pad used in the spread rate calculations.

10.1.2 The average spread rate, to the nearest 0.001 gal./sq. yd.

10.1.3 Any test pads outside the acceptable range.

10.1.4 The person performing the test, the test date, the contractor's name, and identifying information on the truck tested (the license plate number and the truck number).

10.1.5 The Alternate Sampling Procedure used.

10.1.6 Whether the test result indicates a passing result or a failing result.

10.2 A blank test report form is shown in Figure 7. An example of a completed test report is given in Figure 8.

CONVERSION TABLE

(Weight of bituminous material on a 4" by 8" cotton pad to gals./sq. yd.)

grams	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
8	0.086	0.087	0.088	0.089	0.090	0.091	0.092	0.093	0.094	0.095
9	0.096	0.097	0.098	0.099	0.100	0.102	0.103	0.104	0.105	0.106
10	0.107	0.108	0.109	0.110	0.111	0.112	0.113	0.114	0.116	0.117
11	0.118	0.119	0.120	0.121	0.122	0.123	0.124	0.125	0.126	0.127
12	0.128	0.129	0.131	0.132	0.133	0.134	0.135	0.136	0.137	0.138
13	0.139	0.140	0.141	0.142	0.143	0.144	0.146	0.147	0.148	0.149
14	0.150	0.151	0.152	0.153	0.154	0.155	0.156	0.157	0.158	0.159
15	0.160	0.162	0.163	0.164	0.165	0.166	0.167	0.168	0.169	0.170
16	0.171	0.172	0.173	0.174	0.175	0.177	0.178	0.179	0.180	0.181
17	0.182	0.183	0.184	0.185	0.186	0.187	0.188	0.189	0.190	0.192
18	0.193	0.194	0.195	0.196	0.197	0.198	0.199	0.200	0.201	0.202
19	0.203	0.204	0.205	0.206	0.208	0.209	0.210	0.211	0.212	0.213
20	0.214	0.215	0.216	0.217	0.218	0.219	0.220	0.221	0.223	0.224
21	0.225	0.226	0.227	0.228	0.229	0.230	0.231	0.232	0.233	0.234
22	0.235	0.236	0.237	0.239	0.240	0.241	0.242	0.243	0.244	0.245
23	0.246	0.247	0.248	0.249	0.250	0.251	0.252	0.254	0.255	0.256
24	0.257	0.258	0.259	0.260	0.261	0.262	0.263	0.264	0.265	0.266
25	0.267	0.269	0.270	0.271	0.272	0.273	0.274	0.275	0.276	0.277
26	0.278	0.279	0.280	0.281	0.282	0.284	0.285	0.286	0.287	0.288
27	0.289	0.290	0.291	0.292	0.293	0.294	0.295	0.296	0.297	0.298
28	0.300	0.301	0.302	0.303	0.304	0.305	0.306	0.307	0.308	0.309
29	0.310	0.311	0.312	0.313	0.315	0.316	0.317	0.318	0.319	0.320
30	0.321	0.322	0.323	0.324	0.325	0.326	0.327	0.328	0.330	0.331
31	0.332	0.333	0.334	0.335	0.336	0.337	0.338	0.339	0.340	0.341
32	0.342	0.343	0.344	0.346	0.347	0.348	0.349	0.350	0.351	0.352
33	0.353	0.354	0.355	0.356	0.357	0.358	0.359	0.361	0.362	0.363
34	0.364	0.365	0.366	0.367	0.368	0.369	0.370	0.371	0.372	0.373
35	0.374	0.376	0.377	0.378	0.379	0.380	0.381	0.382	0.383	0.384

Figure 6

ARIZONA DEPARTMENT OF TRANSPORTATION

BITUMINOUS DISTRIBUTOR TRUCK TRANSVERSE SPREAD RATE

(Arizona Test Method 411)

OWNER/CONTRACTOR: _____ **TESTED BY:** _____ **DATE:** _____

TRUCK #: _____ **TRUCK LICENSE PLATE #:** _____ **SPRAY WIDTH** _____ FT.

AVERAGE SPREAD RATE: _____ **GALS./SQ. YD.** **ACCEPTABLE RANGE:** **UPPER** _____ **LOWER:** _____

TYPE OF BITUMINOUS MATERIAL USED IN TEST: _____ **TEST RESULT:** **PASS** _____ **FAIL** _____

PAD #	WT. PAD + BIT. MAT'L.	PAD TARE	WT. BIT. MAT'L.	* SPREAD RATE	PAD OUT	REMARKS	PAD #	WT. PAD + BIT. MAT'L.	PAD TARE	WT. BIT. MAT'L.	* SPREAD RATE	PAD OUT	REMARKS
1							27						
2							28						
3							29						
4							30						
5							31						
6							32						
7							33						
8							34						
9							35						
10							36						
11							37						
12							38						
13							39						
14							40						
15							41						
16							42						
17							43						
18							44						
19							45						
20							46						
21							47						
22							48						
23							49						
24							50						
25							51						
26													

* SPREAD RATE = GALS/SQ.YD.

REMARKS: _____

Figure 7

ARIZONA DEPARTMENT OF TRANSPORTATION

BITUMINOUS DISTRIBUTOR TRUCK TRANSVERSE SPREAD RATE

(Arizona Test Method 411)

OWNER/CONTRACTOR: ACME ASPHALT TRANSPORT **TESTED BY:** JOHN DOE **DATE:** 09/28/12

TRUCK #: 960 **TRUCK LICENSE PLATE #:** C 4568 A2 **SPRAY WIDTH** 16 FT.

AVERAGE SPREAD RATE: 0.139 **GALS./SQ. YD.** **ACCEPTABLE RANGE:** **UPPER** 0.153 **LOWER:** 0.125

TYPE OF BITUMINOUS MATERIAL USED IN TEST: SS-1 **TEST RESULT:** **PASS** X **FAIL**

PAD #	WT. PAD + BIT. MAT'L.	PAD TARE	WT. BIT. MAT'L.	* SPREAD RATE	PAD OUT	REMARKS	PAD #	WT. PAD + BIT. MAT'L.	PAD TARE	WT. BIT. MAT'L.	* SPREAD RATE	PAD OUT	REMARKS
1		12.3					27	23.2	12.0	11.2	0.120	X	
2		12.3					28	25.9	12.3	13.6	0.146		
3	25.4	11.9	13.5	0.144			29	25.6	12.5	13.1	0.140		
4	26.0	12.0	14.0	0.150			30	25.0	12.0	13.0	0.139		
5	25.0	12.3	12.7	0.136			31	24.8	12.2	12.6	0.135		
6	25.1	12.0	13.1	0.140			32	24.7	11.9	12.8	0.137		
7	25.0	11.7	13.3	0.142			33	24.6	11.8	12.8	0.137		
8	24.8	11.7	13.1	0.140			34	24.3	11.8	12.5	0.134		
9	24.5	11.6	12.9	0.138			35	24.8	11.8	13.0	0.139		
10	23.6	11.6	12.0	0.128			36	24.2	11.8	12.4	0.133		
11	25.0	11.9	13.1	0.140			37	[illegible]	11.6	13.4	0.143		
12	23.9	11.6	12.3	0.132			38	[illegible]5.1	11.7	13.4	0.143		
13	25.9	11.7	14.2	0.152			39	[illegible]4.8	11.9	12.9	0.138		
14	25.2	12.8	12.4	0.133			40	[illegible]5.2	11.0	14.2	0.152		
15	23.9	11.5	12.4	0.133			41	25.2	11.7	13.5	0.144		
16	24.6	11.6	13.0	0.139			42	25.2	11.7	13.5	0.144		
17	24.5	11.7	12.8	0.137			43	24.7	12.0	12.7	0.136		
18	24.3	11.8	12.5	0.134			44	25.0	11.6	13.4	0.143		
19	25.8	13.0	12.8	0.137			45	25.0	11.5	13.5	0.144		
20	23.6	11.5	12.1	0.129			46	23.2	11.4	11.8	0.126		
21	24.3	11.4	12.9	0.138			47	23.7	11.3	12.4	0.133		
22	26.6	11.9	14.7	0.157	X		48	23.1	11.6	11.5	0.123	X	
23	25.5	11.8	13.7	0.147			49	26.1	12.0	14.1	0.151		
24	25.3	11.9	13.4	0.143			50		11.8				
25	23.9	11.8	12.1	0.129			51		11.6				
26	24.4	11.7	12.7	0.136									

* SPREAD RATE = GALS/SQ.YD.

REMARKS:

EXAMPLE

Figure 8

ARIZ 412b
November 14, 2008
(4 Pages)

DENSITY OF COMPACTED BITUMINOUS MIXTURES - NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This method is used to determine the in-place density of compacted layers of bituminous mixtures by use of nuclear apparatus.

(b) This test method involves hazardous materials, operations, and equipment. This test method does not purport to address all of the safety problems associated with its use. It is the responsibility of whoever uses this test method to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) Safety procedures for operation, transport and storage of nuclear gauges shall be in accordance with the manufacturer's recommendations and the applicable regulations of the Arizona Radiation Regulatory Agency (ARRA).

APPARATUS

2. The apparatus shall consist of the following:

(a) Moisture/Density Nuclear gauge capable of determining densities by the backscatter method. Calibration of the gauge shall be performed in accordance with AASHTO T310, Annexes A1, A2 and A3, on an annual basis.

(b) Reference standard block or test stand to obtain standard counts for moisture and density which are used to check the gauge stability.

(c) Nuclear gauge transport case and labels which comply with A.R.R.A. Regulations.

(d) Charging cord, if applicable.

(e) Radiation exposure badge (if required by license .with A.R.R.A.)

(f) Information packet for the nuclear gauge which shall contain the following items:

(g) Moisture/Density Calibration Tables (if required), and a standard count log book.

(h) Manufacturer's Gauge Operation Manual for the nuclear gauge.

(i) Applicable documentation necessary to meet requirements of ARRA for gauge safety.

(j) Blank test forms for use on the applicable nuclear gauge.

(k) Calculator for necessary computations.

(l) Miscellaneous equipment including watch, pencils, writing paper, ruler, eraser, clip board, and hand cart as required.

GAUGE STABILITY CHECK

3. A density standard count and moisture standard count shall be taken at the beginning of each day of testing at the project where the field density testing is to be performed. The gauge stability check shall be performed as follows:

(a) Place the reference standard block on any asphalt, concrete, compacted aggregate or similar surface which is dry and level. The reference standard block should be at least at least 15 feet away from any large object, or vehicle, and at least 50 feet away from another nuclear gauge.

(b) Seat the nuclear gauge on the reference block in accordance with the gauge operation manual. It is very important that the gauge is seated properly on the standard reference block.

(c) Remove the lock on the source handle and make sure the source handle is in the safe or stored position (the top notch on the index rod).

(d) Turn the gauge on (in standby power condition) and allow it to warm-up, if necessary, for the recommended time as given in the gauge operation manual.

(e) After the warm-up period, take a standard moisture count and a standard density count in accordance with the gauge operation manual.

(f) Record the moisture and density standard counts in the proper columns of the standard count log book along with the appropriate additional information, such as date, time, temperature, and location.

(g) Return the gauge to the standby power condition. The gauge should be left in the standby mode for subsequent testing.

(h) Determine if the standard counts are within the limits for normal operation in accordance with the gauge operation manual. This is usually done by comparing the standard counts to the average of the four previous standard counts or utilizing an internal statistical test which is available on some gauges. Additional standard counts may be necessary if initially the gauge does not appear to be operating properly. If the gauge does not meet the normal operating parameters as specified by the Standard Count procedure in the gauge operation manual, the gauge should not be used for testing. It should be sent in for servicing to determine the problem.

NOTE: Some gauges will store standard counts for later use in calculations performed by the gauge itself. The most recent standard counts will usually be stored automatically over pre-existing standard counts

(i) On a weekly basis, compare the average of the four most recent standard counts with the average of four standard counts immediately after gauge calibration or at least three months previous, whichever is shorter. If the accumulative shift in standard count exceeds 2% for moisture or 3% for density, the nuclear gauge should be recalibrated.

PROCEDURE

4. (a) At each location to be tested, two one-minute readings shall be obtained by taking the first reading and recording the wet density to the nearest 0.1 lb. per cu./ft. then rotating the gauge 180° (making sure that the gauge is set in the same footprint as the first reading) and taking another reading and again recording the wet density to the nearest 0.1 lb. per cu./ft. The two reading are then averaged.

(b) Normally the preparation of the surface for taking readings at each location shall not include the removal of any material for the purpose of making it more

smooth, except that particles which are completely unattached and merely lying loose on top of the compacted and bound mixture shall be brushed away. Not more than one pound of dry fine sand (minus #10 material) shall be spread over each location and then scraped away with a straightedge so that the mixture is visible over the majority of the surface.

PRECAUTIONS

5. (a) Except when actually in use performing tests, the gauge and its accessories are to be kept within the A.R.R.A. (Arizona Radiation Regulatory Agency) approved carrying case, to protect it from damage and to provide better radiation shielding for persons in its vicinity

BULK SPECIFIC GRAVITY AND BULK DENSITY OF COMPACTED BITUMINOUS MIXTURES

(A Modification of AASHTO Designation T 166 and PP 75)

1. SCOPE

1.1 This procedure covers the determination of bulk specific gravity and bulk density of specimens of compacted bituminous mixtures.

1.2 This test procedure consists of three methods for determining bulk specific gravity and bulk density. These methods are referred to as "Method A", "Method C (Rapid Test)", and “Vacuum Method”.

Note: If it is desired to use "Method B", which is not included in this procedure, AASHTO T 166 shall be referred to. Method B should not be used with samples that contain open or interconnecting voids and/or absorb more than 2.0 percent water by volume. Method B is not acceptable for specimens that have more than six percent air voids.

1.3 Method A should not be used with samples that contain open or interconnecting voids and/or absorb more than 2.0 percent water by volume as determined in Subsection 7.4. If the percent water absorbed by the specimen exceeds 2.0 percent, either Method C, Vacuum Method, or AASHTO T 275 “Bulk Specific Gravity (G_{mb}) of Compacted Hot Mix Asphalt (HMA) Using Paraffin-Coated Specimens” shall be used.

1.4 Referee testing shall be performed in accordance with "Method C".

1.5 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.6 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. TEST SPECIMENS

2.1 Test specimens may be either laboratory molded specimens or samples from an existing bituminous pavement.

2.2 Size of specimens - It is recommended that: (1) the diameter of cylindrically molded or cored specimens, or the length of the sides of sawed specimens, be at least four times the maximum size of the aggregate and, (2) the thickness of specimens be at least one and one half times the maximum size of the aggregate.

2.3 Specimens obtained from bituminous pavements shall be taken with a core drill, diamond or carborundum saw, or by other suitable means.

2.4 Care shall be taken to avoid distortion, bending, or cracking of specimens during and after the removal from the pavement or mold. Specimens shall be stored in a safe, cool place.

2.5 Test specimens shall be free from paper, tape, soil, and other foreign materials not intended to be tested as part of the specimen.

2.6 If desired, specimens may be separated from other pavement layers by sawing or other suitable means. Care shall be exercised to ensure that specimens are not damaged during the separation process.

3. APPARATUS

3.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

3.1.1 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram. The balance shall be equipped with a suitable suspension apparatus and holder to permit weighing the specimen while suspended from the center of the balance.

3.1.2 Suspension Apparatus - The wire(s) suspending the holder shall be the smallest practical size to minimize any possible effects of a variable immersed length. The suspension apparatus shall be constructed to enable the container to be immersed to a depth sufficient to cover it and the test sample during weighing.

3.1.3 Water bath - The water bath for immersing the specimen in water while suspended under the balance shall be equipped with an overflow outlet or a clearly marked “fill line” for maintaining a constant water level. The level of the water shall be adjusted before testing each specimen, if necessary, to maintain a constant water level.

3.1.4 Oven - An oven capable of drying specimens at either 125 ± 5 °F (Method A) or 290 ± 10 °F (Method C).

3.1.5 Vacuum Drying Device (For Vacuum Method) – Conforming to the requirements of AASHTO PP 75. Automatic controls of the unit shall be calibrated by the manufacturer prior to initial use.

METHOD A

4. PROCEDURE

4.1 Dry the specimen to constant mass. Constant mass shall be defined as the mass at which further drying at 125 ± 5 °F does not alter the mass by more than 0.1 gram. Samples saturated with water shall initially be dried overnight at 125 ± 5 °F and then weighed at two-hour drying intervals. Recently molded laboratory samples, which have not been exposed to moisture, do not require drying.

4.2 Cool the specimen to room temperature at 77 ± 9 °F and record the dry mass to the nearest 0.1 gram as "A".

4.3 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

4.4 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry

weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

Note: A terry cloth towel has been found to work well. Damp is considered to be when no water can be wrung from the towel.

Note: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass, "C", can be taken, then the surface-dry mass, "B", and finally the dry mass, "A".

4.5 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

METHOD C (RAPID TEST)

5. PROCEDURE

5.1 This procedure can be used for testing specimens which are not required to be saved and which contain a substantial amount of moisture. Specimens obtained by methods that introduce moisture, such as wet coring or sawing, can generally be tested the same day by this method.

5.2 Ensure the specimen is at room temperature (77 ± 9 °F).

5.3 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

5.4 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

5.5 Place the specimen in a large, flat-bottom drying pan of known weight. Place the pan and specimen in a 290 ± 10 °F oven. Leave the specimen in the oven until it can be easily separated to the point where particles of the fine aggregate portion are not larger than 1/4 inch. During separation of material, ensure that no material is lost. Place the separated specimen in the 290 ± 10 °F oven and dry to constant mass. (Constant mass shall be determined as follows: Dry the sample for a minimum of 1 hour at 290 ± 10 °F. Record the weight of the sample to the nearest 0.1 gram. Continue drying and weighing until the weight does not change more than 0.1 gram at drying intervals of a minimum of 30 minutes.)

5.6 Cool the pan and specimen to room temperature at 77 ± 9 °F. Weigh the pan and specimen, subtract the mass of the pan, and record the dry mass of the specimen to the nearest 0.1 gram as "A".

Note: For Method C, the drying of specimens to constant weight may be accomplished in a microwave oven, as described in Arizona Test Method 719.

5.7 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

VACUUM METHOD

6. PROCEDURE

6.1 This procedure can be used for testing specimens, which are to be saved, and which contain a substantial amount of moisture. Specimens obtained by methods that introduce moisture, such as wet coring or sawing, can generally be tested the same day by this method.

6.2 Turn on the vacuum drying device. Follow the manufacturer's recommendations for warm up and self-test procedures.

6.3 Run the vacuum drying device without any specimens. The pressure reading on the display should indicate a known dry point value as recommended by the manufacturer. If the indicated dry point is not achieved, refer to the manufacturer's trouble shooting instructions.

6.4 Ensure the specimen is at room temperature (77 ± 9 °F).

6.5 Remove any standing water from the surface of the specimen by using a paper towel or an absorptive cloth.

6.6 Dry the cold trap and the specimen chamber. Place the specimen inside the vacuum chamber.

Note: Two 4-inch diameter specimens, that are less than 3-inches in thickness can be placed side-by-side in the chamber during a single drying cycle. Larger specimens shall be placed in the chamber individually.

Note: Water and/or ice may buildup in the moisture trap during a drying cycle. Wipe off any free standing water in the moisture trap between drying specimens. This will expedite specimen drying.

6.7 Place the lid on the vacuum chamber and press the lid down to ensure secure contact between the lid and the chamber. Press the appropriate key on the vacuum drying device to begin the drying process.

6.8 The vacuum drying device will automatically stop when the specimen is dry. The unit shall be calibrated to sense the “dry specimen condition”. The “dry specimen condition” shall be determined from the calibrated pressure at which no water remains in the chamber. The pressure is monitored throughout the drying process to ensure that the “dry specimen condition” pressure is achieved in the device.

6.9 Remove the specimen from the vacuum drying device. Weigh the specimen and record the dry mass of the specimen to the nearest 0.1 gram as "A".

6.10 Immerse the specimen in water at 77 ± 2 °F for 4 ± 1 minutes and record the immersed mass to the nearest 0.1 gram as "C". Care shall be exercised to ensure that no trapped air bubbles exist under the specimen.

6.11 Remove the specimen from the water, quickly damp dry the specimen surface by blotting with a damp towel, and as quickly as possible determine and record the surface-dry mass to the nearest 0.1 gram as "B". Any water that seeps from the specimen during the surface-dry weighing operation is considered as part of the specimen. The determination of the immersed mass and surface-dry mass of each specimen will be completed before the next specimen is submerged for its immersed mass determination.

Note: If desired, the sequence of testing operations may be changed to expedite the test results. For example, first the immersed mass, "C", can be taken, then the surface-dry mass, "B", and finally the dry mass, "A".

6.12 Calculate the bulk specific gravity, bulk density, and percent water absorption by volume in accordance with Section 7.

7. CALCULATION

7.1 Calculate and record the bulk specific gravity of the specimen to the nearest 0.001 as follows:

$$\text{Bulk Specific Gravity} = \frac{A}{B - C}$$

Where: A = mass of dry specimen
B = mass of surface-dry specimen
C = mass of immersed specimen

7.2 Calculate and record the bulk density of the specimen to the nearest 0.1 lb/cu ft by multiplying the bulk specific gravity by 62.3 lbs/cu ft.

7.3 For laboratory molded specimens of 1/2-inch or 3/4-inch asphaltic concrete mixes, the range of bulk density results for three replicate specimens shall not differ by more than 2.5 lbs/cu ft. For laboratory molded specimens of asphaltic concrete Base Mixes, the range of bulk density results for three replicate specimens shall not differ by more than 3.0 lbs/cu ft. If the respective requirement is not met, the entire set of specimens shall be discarded and a new set of specimens shall be prepared and tested.

7.4 Calculate and record the percent water absorbed by the specimen to the nearest 0.01 percent (on volume basis) as follows:

$$\text{Percent Water Absorption by Volume} = \frac{B - A}{B - C} \times 100$$

8. REPORT

8.1 The method that was used.

8.2 The bulk specific gravity to the nearest 0.001.

8.3 The bulk density to the nearest 0.1 lb/cu ft.

8.4 The absorption to the nearest 0.01 percent.

PREPARING AND SPLITTING FIELD SAMPLES OF BITUMINOUS MIXTURES FOR TESTING

(An Arizona Method)

1. SCOPE

1.1 This procedure describes the preparation and splitting of field samples of bituminous mixtures for testing.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.3 Oven capable of maintaining a temperature of 290 $\pm$ 10 °F.

2.4 Closed-end samplers as illustrated in Figure 1 (or similiar), constructed of 16 to 18 gauge sheet metal, having a height of 3 inches, a minimum length of 13 inches, and widths of approximately 2-1/2 inches, 3 inches, or 3-1/2 inches.

2.5 A concrete trowel or hand float. If desired, a straightedge of sufficient length to span the final diameter of the circular mass may be used.

2.6 Small scoop, spatulas, and suitable size containers.

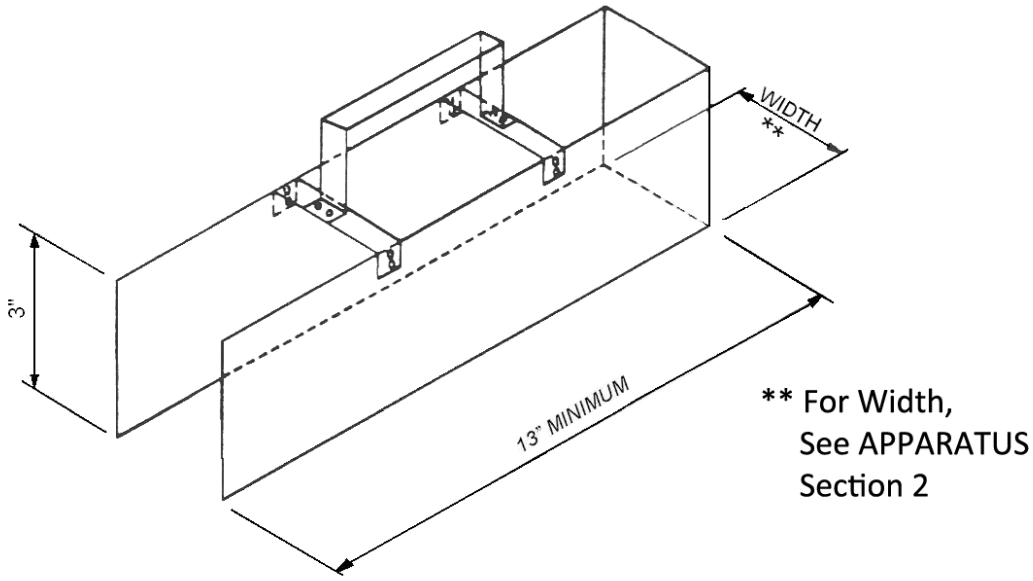


FIGURE 1

3. PREPARATION OF SAMPLE

3.1 Samples may be stored for indefinite periods of time at temperatures not exceeding 140 °F.

3.2 The material shall be easily workable and pliable when splitting. If necessary, the sample may be heated at 290 ± 10 °F for a maximum of 3 hours. The 3-hour time period begins when the oven reaches the specified temperature.

3.3 If necessary, the material shall be reduced in size to provide a workable amount of material from which to obtain all required samples by thoroughly mixing and quartering, splitting with a mechanical (clam-shell) splitter, or using a four-way splitter such as a "Quartermaster". When utilizing a mechanical (clam-shell) splitter, the width of the individual chute openings shall be approximately 1-1/2 to 2-1/2 times larger than the largest particles in the sample to be split. Generally it will only be necessary to reduce the material one time by quartering or splitting. A light coat of vegetable cooking spray may be sprayed on the equipment to help shed the asphaltic concrete. In no case shall diesel fuel or similar solvent be used. Individual samples for testing shall not be obtained by quartering or splitting, but rather as described in Section 4.

3.4 Place the hot material on a tarp or a sheet of heavy paper large enough to manipulate the sample. In a rolling motion thoroughly mix the material. Leave the mound in a circular shape after rolling is completed.

3.5 Spread the material into a circular mass. Spreading may be accomplished either by leveling the mound of material with a concrete trowel or hand float; or by placing a straightedge of sufficient length to span the final diameter of the circular mass over the center of the material and rotating it until the desired height is obtained. Whichever method is utilized, the operator shall assure that the material is evenly distributed with as little segregation as possible. The thickness of the circular mass shall not exceed 3 inches. Generally a depth of 1-1/2 to 2 inches will provide acceptable size samples.

3.6 At any time during obtaining test samples, the material may be reheated for a maximum of 1 hour at a temperature not exceeding 300 °F to restore pliability.

4. OBTAINING TEST SAMPLES

4.1 The required samples for testing, with the exception of moisture content, shall be obtained as described in Subsections 4.2 through 4.6 below. For obtaining test samples for moisture content, see Subsection 4.7 below. The samples may be obtained in any sequence as long as the sample for moisture content is taken immediately before or after the sample for determination of asphalt content. The width of sampler to be used is dependent upon the size of aggregate in the sample and/or the amount of material needed.

4.2 The samples shall be obtained by placing the closed end of the sampler as near the center of the mass as possible with the open end of the sampler extending beyond the edge of the circular mass (see Figure 2). Force the sampler down to the bottom of the pile and remove the contents that are captured by sliding the sampler out of the pile, and placing the contents into a tared container.

4.3 Obtain additional material, as necessary, by repeating the procedure in Subsection 4.2, at a different location in the pile so that a cut does not overlap a previous cut (see Figure 3).

4.4 If small amounts of material are needed, slide the sampler out and to the side of the pile. Lift the sampler up and turn it perpendicular to the material. Force the sampler down through the full width of the material, starting at the closed end portion of the material. (Figure 4 provides an illustration of this procedure.) If necessary, additional material may be obtained by taking multiple cuts. Utilize the entire portion(s) taken and do not attempt to obtain an exact weight.

4.5 If excess material is obtained, the sample shall be returned to a place not disturbing the rest of the circular mass. If the remaining mass is large enough, and is undisturbed, obtain another sample for the test, if necessary utilizing a smaller width sampler. Alternatively, the sample may be returned to the circular mass and the material re-rolled and spread to a thinner depth.

4.6 If the remaining mass is not large or uniform enough to obtain required samples, re-roll and spread the material in the same manner described in Subsection 3.5.

4.7 Test samples for determining moisture content may be obtained by use of the sampler as described in Subsections 4.2 through 4.6 above, or by taking several small portions with a small scoop at random locations throughout the mass.

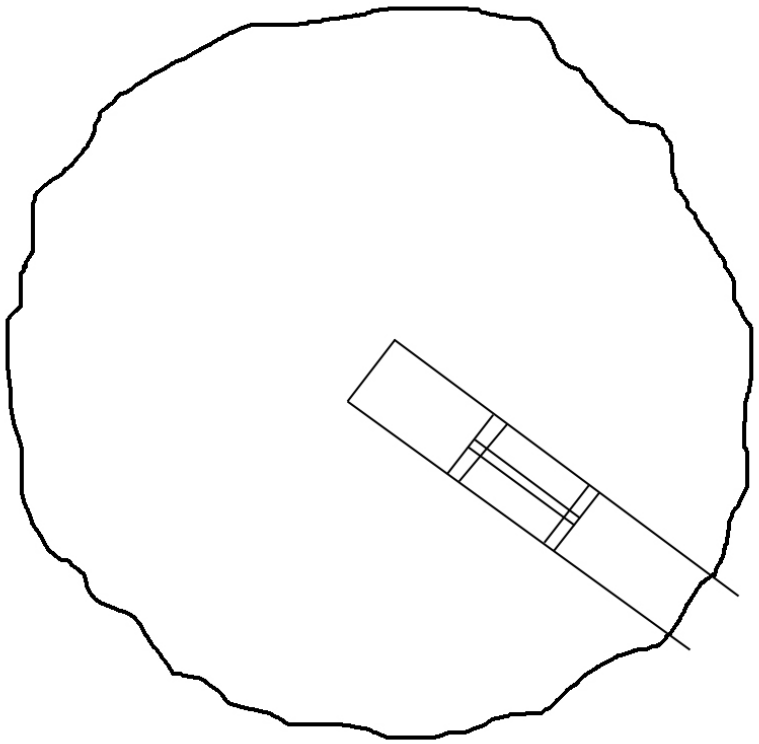


FIGURE 2

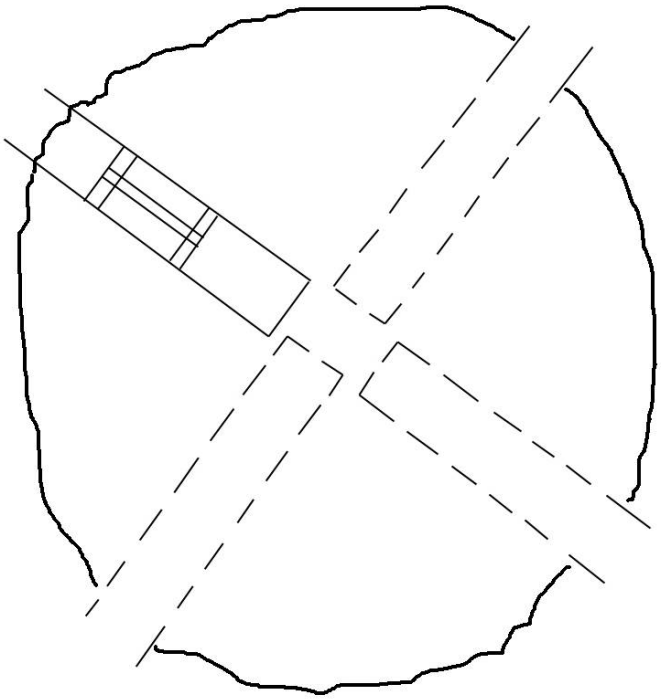


FIGURE 3

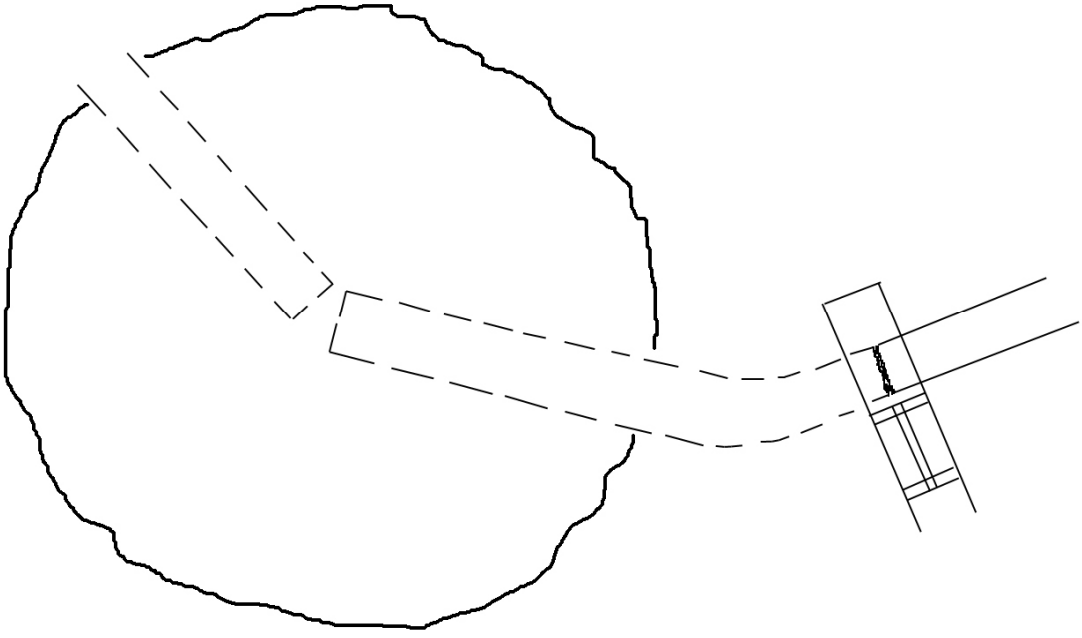


FIGURE 4

MAXIMUM THEORETICAL SPECIFIC GRAVITY AND DENSITY OF FIELD PRODUCED BITUMINOUS MIXTURES (RICE TEST)

(A Modification of AASHTO T 209)

1. SCOPE

1.1 This method of test is intended for determining the maximum specific gravity and density of uncompacted bituminous mixtures that have been field produced.

Note: Two methods are provided for determining the maximum specific gravity. The method given in Section 6 is for determining results without fan drying the samples. Section 7 describes the procedure which is used when fan drying is necessary. For the first four samples taken at the beginning of production on a project the maximum specific gravity shall be determined in accordance with Section 6 and also shall be fan dried and maximum specific gravity determined in accordance with Section 7. If the difference in resultant air voids, when determined as described in Arizona Test Method 424 is greater than 0.2% subsequent samples will be subjected to fan drying. During the course of the project comparisons should be made on approximate 10 sample intervals to determine need for fan drying. In case of dispute, fan drying shall be used.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Balance - A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

2.3 Container - A heavy walled Erlenmeyer flask having a capacity of at least 1500 mL and strong enough to withstand a partial vacuum; the cover shall consist of a rubber stopper with a tight hose connection. A small piece of No. 200 wire mesh covering the hose opening shall be used to minimize the possibility of loss of fine material.

Note: If a procedure which subjects multiple flasks to a vacuum simultaneously is used, the vacuum gauge shall be placed beyond the last bottle to insure that all the bottles are being subjected to the same amount of vacuum.

2.4 Flat glass plate large enough to cover mouth of the flask.

2.5 Vacuum pump for evacuating air from the container.

2.6 All water used in this procedure shall be distilled or de-mineralized water.

3. CALIBRATION OF FLASK

3.1 Record the weight of the flask and flat glass plate separately to the nearest 0.1 gram on the work card. Using water at a temperature of 77 ± 1 °F, fill the flask with water to approximately one inch below the top of the flask. Using a long narrow rod, remove air bubbles adhering to the walls of the flask. Confirm that the temperature of the water is at 77 ± 1 °F. Fill to the top and slide the flat glass plate over the mouth of the flask. Verify that no air is trapped under the flat glass plate. Dry the outside of the flask and glass plate and weight to the nearest 0.1 gram. Subtract the weight of the glass plate and record the weight of the “flask and water” as "B".

4. PREPARATION OF SAMPLES

4.1 Obtain 3 representative 1050 ± 50 gram samples of the material, as described in Arizona Test Method 416.

Note: If necessary, heat the sample for not more than one hour at a maximum temperature of 285 °F ONLY until it is pliable enough to allow separation of the coated aggregate.

4.2 Spread each sample on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled, separate the particles of the mixture, taking care not to fracture the coarse aggregate particles, so that the particles of the fine aggregate portion are not larger than 1/4 inch. Allow the samples to cool to room temperature.

5. PROCEDURE

5.1 Place the sample in the flask and determine the weight to the nearest 0.1 gram. Subtract the weight of the flask and record the “weight of sample in air" as "Wmm".

5.2 Add sufficient water to cover the sample. The water shall be at a temperature of approximately 77 °F and shall have been treated with a wetting agent.

Note: Aerosol OT in a concentration of 0.01%, or one mL of 10% solution per 1000 mL of water, has been found to be a suitable wetting agent and shall be used to facilitate the release of entrapped air.

5.3 Remove entrapped air by subjecting the contents of the flask to a partial vacuum with a minimum of 20 inches of mercury (gauge) for 15 ± 2 minutes, agitating the contents of the flask four times at evenly spaced intervals throughout this period.

CAUTION: Do not agitate the sample too frequently or vigorously, as that can cause stripping of the asphalt film from some particles, resulting in erroneous specific gravities.

5.4 After the evacuation period, fill the flask with water to approximately one inch below the top of the flask. Gently stir the sample with a long narrow rod in such

a way to release any trapped air bubbles, avoiding breakage of the aggregates. Using the long narrow rod, carefully remove any air bubbles adhering to the walls of the flask. Fill completely to the top and confirm that the temperature is at 77 ± 2 °F. Slide the pre-weighed flat glass plate over the mouth of the flask. Verify that no air is trapped under the flat glass plate. Dry the outside of the flask and glass plate and weigh immediately to the nearest 0.1 gram. Subtract the weight of the glass plate and record the weight of the "flask + water + sample" as "C".

6. CALCULATIONS

6.1 The Volume of Voidless Mix, "Vvm", in mL, and Maximum Specific Gravity, “Gmm” is determined for each sample by the following:

$$Vvm = Wmm + B - C$$

$$Gmm = \frac{Wmm}{Vvm}$$

Where: Wmm = Wt. of Sample in Air
B = Wt. of Flask + Water
C = Wt. of Flask + Water + Sample

6.2 Compare the three individual values for maximum specific gravity. If the range of the three is within 0.024, all are used to determine the average maximum specific gravity as shown in Subsection 6.4. If the range is greater than 0.024, the average of two may be used if they are within a range of 0.012. If values are not achieved within the above criteria, the samples shall be discarded and a set of three new samples shall be tested. If material is not available, results should be used cautiously in the analysis of the bituminous mix. If results are used for specification compliance, additional material must be obtained for retesting.

6.3 The average maximum specific gravity of the bituminous mix is determined for the samples with acceptable maximum specific gravity values, and recorded to the nearest 0.001.

6.4 To determine the maximum density, the average maximum specific gravity is multiplied by 62.3 lbs./cu. ft.

7. PROCEDURE FOR FAN DRYING SAMPLES

7.1 The entire contents of the flask shall be poured into a nest of sieves consisting of a No. 40 and a No. 200 screen.

Note: If stripping has occurred, as evidenced by discoloration of water in the flask, significant loss of Minus No. 200 material may be expected. Provisions for the recovery and addition of this material to the Plus No. 200 material shall be made.

7.2 Allow the mix to drain through the sieves until excess moisture is removed from the mix. Separate the sieves and place both sieves in a tared pan. Place the pan in front of a fan (see Note below) and dry the material retained on the No. 40 and No. 200 sieves until the material can be easily removed from the sieves. Remove the material from the sieves and spread it in the pan. Determine and record the initial weight of the pan and the material.

Note: The air through the fan shall be at room temperature and no heat shall be used to dry the material.

7.3 Continue fan drying the material, determining and recording the weight of the pan and the material at 15 minute intervals. When the weight loss is 0.5 gram or less for a 15 minute interval, the mix is considered to be surface dry. Record the surface dry weight as "Wsd". Intermittent stirring of the sample is required during the drying period. Conglomerations of the mix shall be broken by hand. Care must be taken to prevent loss of particles of the mixture.

Note: If the "Wsd" weight for any of the three samples is less than its corresponding "Wmm" weight, the samples shall be discarded and a set of three new samples shall be tested. If material is not available, the maximum specific gravity shall be determined utilizing the "Wmm" weight and results should be used cautiously in the analysis of the bituminous mix. If results are used for specification compliance, additional material must be obtained for retesting.

7.4 To calculate the fan dried "Vvm" and maximum specific gravity, "Gmm", of each sample, the surface dry weight, "Wsd", is substituted for "Wmm" in the equation given for "Vvm" in Subsection 6.1, as shown in the example below.

$$Vvm = Wsd + B - C$$

$$G_{mm} = \frac{W_{mm}}{V_{vm}}$$

Where: Wmm = Wt. of Sample in Air
Wsd = Wt of Fan Dried Sample
B = Wt. of Flask + Water
C = Wt. of Flask + Water + Sample

8. EXAMPLE

8.1 An example of the completed form is shown in Figure 1 and an example of the blank form is shown in Figure 2.

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Lab#: 15-3456	Date: 08/05/2015	Project #: F-111-1(1)	TRACS#: H999901C	**If samples were fan dried, the maximum density is determined utilizing the "Wsd" weight as shown below:**	
Project Name: Big Gulch - Bug Mountain		Material Type: 3/4" AC			
Lot#: 1	Sample #: 4	Maximum Specific Gravity Range: 0.003			
Tested By: Lisa Tester		Checked By: A. A.			

Flask Number or I. D.	"Wf" Wt. of Flask	"Wmm" Wt. of Sample in Air (Wfs - Wf)	"B" Wt. of Flask + Water	"C" Wt. of Flask + Sample + Water (Wa - Wp)	Vvm" Volume of Voidless Mix (Wmm + B - C)	"Gmm" Maximum Specific Gravity (Wmm / Vvm)	Maximum Density (lbs./cu. ft.) (Gmm X 62.3)	"Wsd" Surface Dry Weight (See Below)	Vvm" Volume of Voidless Mix (Wsd + B - C)	"Gmm" Maximum Specific Gravity (Wmm / Vvm)	Maximum Density (lbs./cu. ft.) (Gmm X 62.3)
1	998.7	1064.9	3215.7	3848.7	431.9	2.466		1067.7	434.7	2.450	
2	977.6	1076.5	3178.7	3819.2	436.0	2.469		1080.5	440.0	2.447	
3	~~994.3~~	~~1067.4~~	~~3194.1~~	~~3825.1~~	~~436.4~~	~~2.446~~		~~1071.2~~	~~440.2~~	~~2.425~~	
AVERAGE						*2.468*	*153.8*			*2.449*	*152.6*

Remarks: *Flask #3 eliminated from the average due to Specific Gravity being outside specified 0.024 allowable range*

Flask Number or I. D.	1	2	3
Wt. of Flask + Sample, **"Wfs"**	2063.6	2054.1	2061.7
Wt. of Flask + Sample Water + Glass Plate, **"Wa"**	3931.1	3901.6	3907.5
Wt. of Glass Plate, **"Wp"**	82.4	82.4	82.4

Specific Gravity Range:	**Range of 3:**	**Range of 2:**
Non Fan Dried:	0.023	0.003
Fan Dried:	0.025	0.003

Maximum Specific Gravity (Rice) Fan Dry Weigh backs

Flask Numer or I.D.	1	2	3
Tare weight of Pan	453.7	502.4	499.6
Weight of Pan and Sample	1536.3	1597.8	1585.7
Weight of Pan and Sample	1529.2	1590.7	1578.6
Weight of Pan and Sample	1523.2	1584.7	1572.6
Weight of Pan and Sample	1522.5	1584.0	1571.9
Weight of Pan and Sample	1521.9	1583.4	1571.2
Weight of Pan and Sample	1521.4	1582.9	1570.8
Weight of Pan and Sample			
Weight of Pan and Sample			
Surface Dry Weight (Wsd)	*1067.7*	*1080.5*	*1071.2*

Air Voids Calculations

$$\left[1 - \frac{\text{A.C. Mix Bulk Density}}{\text{Maximum Density From Rice Test}}\right] \times 100 =$$

Non Fan Dried $\left[1 - \frac{145.5}{153.8}\right] \times 100 =$ **5.4** %

Fan Dried $\left[1 - \frac{145.5}{152.6}\right] \times 100 =$ **4.6** %

Difference in Air Voids = [Air Voids (Sample Not Fan Dried)] - [Air Voids (Sample Fan Dried)] = **0.8** %

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FIGURE 1

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ARIZONA TEST METHOD 417

Lab#: _____ Date: _____ Project #: _____ TRACS#: _____
Project Name: _____ Material Type: _____
Lot#: _____ Sample #: _____ Maximum Specific Gravity Range: _____
Tested By: _____ Checked By: _____

If samples were fan dried, the maximum density is determined utilizing the "Wsd" weight as shown below:

Flask Number or I. D.	**"Wf"** Wt. of Flask	**"Wmm"** Wt. of Sample in Air Wfs - Wf	**"B"** Wt. of Flask + Water	**"C"** Wt. of Flask + Sample + Water Wa - Wp	**Vvm** Volume of Voidless Mix Wmm + B - C	**"Gmm"** Maximum Specific Gravity Wmm / Vvm	Maximum Density (lbs./cu. ft.) Gmm X 62.3	**"Wsd"** Surface Dry Weight (See Below)	**Vvm** Volume of Voidless Mix Wsd + B - C	**"Gmm"** Maximum Specific Gravity Wmm / Vvm	Maximum Density (lbs./cu. ft.) Gmm X 62.3
AVERAGE											

				Remarks:
Flask Number or I. D.				
Wt. of Flask + Sample, **"Wfs"**				**Specific Gravity Range: Range of 3: Range of 2:**
Wt. of Flask + Sample Water + Glass Plate, **"Wa"**				Non Fan Dried:
Wt. of Glass Plate, **"Wp"**				Fan Dried:

Maximum Specific Gravity (Rice) Fan Dry Weigh backs

Flask Numer or I.D.			
Tare weight of Pan			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Weight of Pan and Sample			
Surface Dry Weight (Wsd)			

Air Voids Calculations

$$\left[1 - \frac{\text{A.C. Mix Bulk Density}}{\text{Maximum Density From Rice Test}}\right] \times 100 =$$

Non Fan Dried $\left[1 - \text{———}\right] \times 100 =$ _____ %

Fan Dried $\left[1 - \text{———}\right] \times 100 =$ _____ %

Difference in Air Voids = [Air Voids (Sample Not Fan Dried)] - [Air Voids (Sample Fan Dried)] = _____ %

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FIGURE 2

ARIZ 421
September 5, 1996
(14 Pages)

BITUMINOUS MATERIAL CONTENT OF ASPHALTIC CONCRETE MIXTURES BY THE NUCLEAR METHOD

(An Arizona Method)

SCOPE

1. (a) This procedure describes a method for determining the percent bituminous material content of asphaltic concrete mixtures, by testing a sample with a device that utilizes neutron thermalization techniques.

(b) Modifications to this procedure for Asphaltic Concrete Friction Course, Asphaltic Concrete (Asphalt-Rubber), and Asphaltic Concrete Friction Course (Asphalt-Rubber) are given in Section 7.

(c) This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(d) Safety procedures for operation, transport, and storage of nuclear gauges shall be in accordance with the manufacturer's recommendations and the applicable regulations of the Arizona Radiation Regulatory Agency (ARRA).

(e) If recommended by the manufacturer, equipment operators should wear an approved form of radiation dosimetry film badge capable of monitoring the occupational radiation exposure.

(f) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(g) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with

applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Nuclear asphalt content gauge and manufacturer's instruction manual. While exact details of the manufacture of the apparatus may vary, the system shall consist of the following items and meet the criteria for variability given below. The equipment shall be so constructed as to be licensable in accordance with applicable health and safety regulations.

1) Neutron Source - An encapsulated and sealed radioactive source such as "Americium-241: Beryllium", or "Californium-252".

2) Detectors - Any type of thermal neutron detector, such as helium-3 or boron tri-floride.

3) Read-Out Instrument, such as a scaler or a direct-reading digital device calibrated in percent asphalt cement.

4) A minimum of four standard stainless steel sample pans [approximately 230 mm long by 185 mm wide by 100 mm deep (9" x 7-1/4" x 4")].

5) The variability of the gauge shall be no greater than $\pm$ 0.05 percent asphalt for a four-minute count. The variability shall be determined utilizing a three point calibration for a conventional asphaltic concrete mix with a design asphalt content of approximately five percent. The variability of the gauge is determined from the slope of the calibration curve and the standard deviation of the measured counts of the calibration sample at the mix design percent asphalt. If the gauge fails to meet the variability requirement shown above for a four-minute count, the variability may be determined utilizing either 8-minute or 16-minute counts as necessary. If the variability is determined using an increased count time, that count time is the minimum that is to be used for testing subsequent field samples [See paragraphs 6(g) and 6(i)]. In lieu of an increased count time, a new set of calibration samples may be prepared and tested with greater care. If the gauge fails to meet the variability requirement after increased count times or preparation of additional calibration samples, the gauge must be returned to the manufacturer for necessary repair and recalibration. Variability is

calculated as shown below. The variablity of the gauge should be checked at minimum 12 month intervals. Documentation of the variability determination shall be kept on file.

$$V = \frac{S.D.}{S}$$

Where: V = apparatus variability, in percent asphalt.
S = slope of the calibration curve, in counts (y-axis) per percent asphalt cement (x-axis). [See note below.]
S.D. = standard deviation, in counts. The standard deviation is calculated from 20 individual four-minute readings (8-minute or 16-minute counts if used) taken on the calibration sample at the mix design percent asphalt content.

NOTE: The slope of the calibration curve, as calculated and given by the gauge may <u>not</u> be the actual numerical value for the slope, and in addition, the slope may <u>not</u> be given in counts (y-axis) per percent asphalt (x-axis). For instance, the Troxler Nuclear Asphalt Content Gauge (Model 3241-C) gives a numerical value for slope which is actually 1000 times the actual slope, and in addition, the value given by the Troxler gauge is given for percent asphalt (y-axis) per counts (x-axis). The following is an example of the slope of the calibration curve as given by the Troxler gauge and the determination of the corrected slope value to be used in the Apparatus Variability equation given above:

Troxler gauge reported slope = 5.220075
[Slope based on percent asphalt (y-axis) per counts (x-axis).]

Determination of corrected slope:

$$\frac{5.220075}{1000} =$$

0.005220075 (percent asphalt/counts)

Reciprocal of slope to obtain slope based on counts (y-axis) per percent asphalt (x-axis):

$$\frac{1}{0.005220075} =$$

191.568 (counts/percent asphalt)

In this case, the value of 191.568 is the slope of the calibration curve and is the value which is to be used for "S" in the equation for Apparatus Variability given above.

(b) Scale(s) or balance(s) capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be as shown below:

1) The scale or balance to be used for preparing calibration samples shall have a readability and sensitivity of at least 1 gram.

2) The scale or balance to be used for testing field samples shall have a readability and sensitivity of at least 5 grams.

(c) Oven(s), capable of heating and maintaining temperatures to 177 °C (350 °F). Two ovens may be required.

(d) Steel straightedge, approximately 300 mm (12 inches) in length.

(e) Either a piece of plywood of at least 20 mm (3/4 inch) nominal thickness, or a metal plate of at least 6 mm (1/4 inch) nominal thickness, having an area slightly larger than the top of the sample pans.

(f) Mixing apparatus - Mechanical mixing is recommended; 19 liter (20 quart) capacity mixer is required. (Hand mixing may be performed if desired.)

(g) Miscellaneous pans, bowls, spoons, and spatulas.

(h) Thermometer with temperature range 10 to 260 °C (50 to 500 °F).

(i) Hot plate(s) capable of heating and maintaining temperatures to 177 °C (350 °F).

(j) Flat bottom metal scoop at least 50 mm wide by 150 mm long (2 inches x 6 inches).

PRECAUTIONS

3. (a) Since nuclear equipment measures the total amount of hydrogen in the sample, this procedure is sensitive to changes in moisture content. It must be remembered that both bituminous material and water contain hydrogen.

(b) Keep any other source of neutron radiation at least 10 meters (30 feet) from the equipment.

(c) Do not place the equipment where the amount of hydrogenous material may change during the calibration or testing procedures. Hydrogenous materials are those containing hydrogen, for example, water or plastic materials.

(d) Moving the gauge to a new location may have an effect on the results. Therefore, a new background count and/or calibration is required if the gauge is moved. If the original calibration specimens are retested, they shall be heated in an oven at 121 to 149 °C (250 to 300 °F) for at least one hour to drive out any condensation or absorbed moisture and to bring them to testing temperature.

SAMPLING

4. (a) For preparing calibration samples, aggregate samples are obtained in accordance with Arizona Test Method 105. Samples shall be adequately dried, if necessary, to a free-flowing condition in the portion passing the 4.75 mm (No. 4) sieve. A maximum of approximately 45 kg (100 pounds) of aggregate, representative of the mix design gradation, will normally be required.

(b) When testing field samples of Asphaltic Concrete, a sample of the freshly produced mix is obtained in accordance with Arizona Test Method 104.

CALIBRATION

5. (a) A calibration must be performed for each asphaltic concrete mixture that is to be used on the project. Test results on asphaltic concrete mixtures may vary with changes in the type and gradation of aggregate, (percentage and source of

mineral admixture, if used), and percentage and source of bituminous material. Accordingly, a calibration curve must be developed for each mix design. The calibration curve shall be established with three or more points. The calibration procedure consists of preparing and testing one dry aggregate blank sample, and a minimum of three asphaltic concrete calibration samples at varying bituminous material contents.

(b) Before a calibration is performed, a 16-minute background count shall be taken and recorded.

(c) For the dry aggregate blank sample, weigh up one approximate 10 kg (22 pound) aggregate sample representative of the mix design aggregate gradation. Thoroughly blend the aggregate and dry to constant weight at 121 to 149 °C (250 to 300 °F), and then place in a tared sample pan in at least two approximately equal depth layers. After placing each layer in the pan, gently spade the aggregate with the scoop or wide blade-like tool. The coarse and fine material shall be uniformly distributed. Too much manipulation of the material can result in segregation of the material, causing the fines to migrate to the bottom. Fill the pan slightly above the top rim. Place the straightedge firmly across the rim and, using a sawing motion, strike off the surface of the sample so that it is flush with the rim. Gaps between the straightedge and the sample shall be filled with fine aggregate and the sample leveled. Do not further compact the sample. Determine and record the weight of the dry aggregate blank sample to the nearest 5 grams.

(d) Place the dry aggregate blank sample in an oven at 121 to 149 °C (250 to 300 °F). A count will be determined on this sample, as described in paragraph 5(l), at the completion of the testing of the asphaltic concrete calibration samples.

(e) For the asphaltic concrete calibration samples, weigh up a minimum of three aggregate samples representative of the mix design aggregate gradation. These aggregate samples shall weigh at least 500 grams more than the dry aggregate blank sample weight determined in paragraph 5(c). If mineral admixture is used, the appropriate type and amount shall be added to the aggregate and thoroughly blended. Dry the samples to constant weight at the mixing temperature required as shown in paragraph (g) below.

(f) Bituminous material of the same source, grade, and type as that which will be used in production of the asphalt concrete mixture shall be used in the calibration samples. Normally three samples are prepared; one at the design bituminous material content, one at 1.0% above, and one at 1.0% below. The percent of bituminous material is based on the weight of total mix. The weight of bituminous material to be added for each percent of bituminous material is determined by the following:

$$\left[\begin{array}{c}\text{Weight of}\\ \text{Bituminous}\\ \text{Material}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Weight of Aggregate}\\ \text{(and mineral admixture when used)}\end{array}\right]}{100 - \left[\begin{array}{c}\text{Percent of}\\ \text{Bituminous}\\ \text{Material}\end{array}\right]} \times \left[\begin{array}{c}\text{Percent of}\\ \text{Bituminous}\\ \text{Material}\end{array}\right]$$

(g) All bowls, sample pans, and mixing tools shall be heated to approximately 149 °C (300 °F). It is recommended that a "butter mix" be utilized to condition the mixing equipment. If a "butter mix" is utilized, the mixing equipment shall be scraped consistently clean with a spatula after each batch. As an alternate to a "butter mix", the mixing equipment shall be scraped as clean as possible with a spatula after each batch. All samples shall be mixed at the same mixing temperature, ± 6 °C (10 °F). During mixing, a hot plate shall be placed under the mixing bowl to reduce loss of heat while mixing. The sample shall be sufficiently mixed to ensure thorough coating. Unless otherwise indicated on the mix design, the temperature of the bituminous material and aggregate (and mineral admixture when used) at the time mixing begins shall be in accordance with the following:

BITUMINOUS MATERIAL	TEMPERATURE RANGE
AC 10, AC-20	149 ± 6 °C (300 ± 10 °F)
AC-30, AC-40	152 ± 6 °C (305 ± 10 °F)
PG 58-XX, PG 64-XX	149 ± 6 °C (300 ± 10 °F)
PG 70-XX, PG 76-XX	152 ± 6 °C (305 ± 10 °F)
Polymer Modified Asphalt	160 ± 6 °C (320 ± 10 °F)
Asphalt-Rubber	163 ± 6 °C (325 ± 10 °F)

(h) At the time of beginning the fabrication of each asphaltic concrete calibration sample, the mixture shall be 121 to 149 °C (250 to 300 °F). The mix with the lowest bituminous material content shall be prepared first. Fill the tared sample pan in approximately equal depth layers (two layers minimum), uniformly distributing the sample in the pan. After placing each layer in the pan, gently spade the mix with a spatula, wide blade-like tool, or scoop and lightly press the mix down. Add mix until the top of the material is mounded approximately 25 to 38 mm (1 to 1-1/2 inches) above the top of the pan. Using a spatula or trowel, round the top of the mixture so that it is at the interior edges of the pan but not on the top rim of the pan. Use the metal plate or plywood to consolidate the asphaltic concrete mixture. If necessary, this can be done by placing the pan on a clean floor, placing the metal plate or plywood on top of the sample pan and standing on the plate. If desired, a piece of waxed paper or other suitable material may be placed on the top of the mix to avoid sticking. If necessary, fill any voids and consolidate the mix with the metal plate of plywood until the pan is

completely full and the mix is even with the top of the pan. Determine and record the weight of this asphaltic concrete calibration sample to the nearest gram. This weight is identified as the asphaltic concrete calibration sample weight and is used (± 5 grams) for the remaining calibration samples.

(i) Place the sample in the gauge and take a 16-minute count. Record the measured count.

(j) Repeat steps in paragraphs 5(h) and 5(i) to fabricate and test the remaining calibration samples. These samples shall be fabricated in the same manner as the first calibration sample and shall be within ± 5 grams of the asphaltic concrete calibration sample weight. If samples are not able to be tested immediately after fabrication, they shall be placed in an oven at 121 to 149 °C (250 to 300 °F) until they can be tested.

(k) Prepare a calibration curve in accordance with the manufacturer's calibration instructions. On some gauges this curve may be generated internal to the gauge. To be considered acceptable, a calibration curve should have a correlation coefficient greater than or equal to 0.995.

$$\text{Correlation Coefficient} = \sqrt{1 - \frac{\Sigma (y - y')^2}{\Sigma (y - \overline{y})^2}}$$

Where: y = Actual percent bituminous material value for each sample.
y' = Calculated percent bituminous material value for each sample, from curve.
$\overline{y}$ = Mean of the actual percent bituminous material values for all samples.

(l) Remove the dry aggregate blank sample from the oven. Place in the gauge take a minimum four-minute count. This count is recorded and may be used to determine if significant changes occur in the aggregate during asphaltic concrete production. [See paragraph 6(i).]

(m) Once a calibration has been performed for the asphaltic concrete mixture, other gauges from the same manufacturer may use a cross calibration for testing of the same asphaltic concrete mixture. Cross calibrations shall be performed in accordance with the gauge manufacturer's recommendations, and shall have been done within the preceding 12 months. In cases of dispute, the gauge derived calibration shall be the referee method. A new cross calibration is required after any gauge repair.

PROCEDURE (FIELD TEST SAMPLE)

6. (a) A 16-minute background count shall be taken and recorded each day before any test samples are run.

(b) Obtain a representative sample for determining the bituminous material content. Generally 8 kg (18 pounds) should be adequate.

(c) If desired, the entire sample for determining the bituminous material content may be dried to constant weight in an oven at 143 ± 6 °C (290 ± 10 °F) in lieu of obtaining a moisture content sample as described in paragraph (d) or (h) below. If a moisture sample is obtained, the percent moisture is determined in accordance with Arizona Test Method 406. The percent moisture is subtracted from the gauge percent bituminous material to obtain the corrected (actual) percent bituminous material.

(d) If the entire sample for determining the bituminous material content has not been dried to constant weight as described in paragraph (c) above, or the moisture content sample is not to be taken at the completion of testing of the bituminous material content sample as described in paragraph (h) below, a moisture content sample is taken immediately after the fabrication of the bituminous material content test sample as described in paragraph (e) below.

(e) If the field sample is at fabrication temperature at the time of obtaining the bituminous material content test sample, the bituminous material content test sample is fabricated immediately. If the field sample is not at fabrication temperature, enough material for both the bituminous material content test sample, and a moisture content sample when necessary, shall be obtained and placed in a single pan and brought to fabrication temperature.

(f) At the time of beginning the fabrication of the bituminous material test sample, the mixture shall be at a temperature of 121 to 149 °C (250 to 300 °F). Fill the tared sample pan in approximately equal depth layers, using the same number of layers as was used in fabrication of the calibration samples. Uniformly distribute each layer of the sample in the pan. After placing each layer in the pan, gently spade the mix with a spatula, wide blade-like tool, or scoop and lightly press the mix down. When the pan is nearly full, weigh the sample. Add enough mix until the sample weight is within ± 10 grams of the asphaltic concrete calibration sample weight as determined in paragraph 5(h). If necessary, the mix may be pressed down using the metal plate or plywood during addition of material. Using a spatula or trowel, round the top of the mixture so that it is at the interior edges of the pan but not on the top rim of the pan. Use the metal plate or plywood to consolidate the asphaltic concrete mixture until it is even with the top rim of the pan. If necessary, this can be done by placing the pan on a

clean floor, placing the metal plate or plywood on top of the sample pan and standing on the plate. If desired, a piece of waxed paper or other suitable material may be placed on the top of the mix to avoid sticking. Reweigh the sample, and assure the weight is within ± 10 grams of the asphaltic concrete calibration sample weight. Record the weight of the test sample to at least the nearest 5 grams.

(g) Immediately after fabrication place the sample in the gauge. Take and record a minimum four-minute count, and determine the gauge percent bituminous material. If an increased count time (8-minute or 16-minute) was used to determine the variability of the gauge [paragraph 2(a)(5)], that count time is the minimum that is to be used.

(h) If the bituminous material content sample has not been dried to constant weight prior to testing, or if the moisture content sample has not been taken at the time of fabrication of the bituminous material content test sample, a representative 1000 ± 50 gram moisture content sample shall be immediately taken from the bituminous material content test sample upon determination of the bituminous material percent in the gauge.

NOTE: Generally the samples taken for bituminous material content and moisture content are obtained from a larger field sample from which material for other tests, e.g., Marshall and Rice is also split out. In case there is a need for additional testing, it may be desirable to save material from the bituminous material content test sample along with excess material from the field sample.

(i) If desired during asphaltic concrete production, a dry aggregate blank sample may be prepared and tested to ensure that changes in aggregate do not occur unnoticed. Testing may be performed at any time that a change in the aggregate is suspected. This sample shall be dried to constant weight and fabricated in the manner described in paragraph 5(c). The weight of this sample shall be within ± 10 grams of the weight of the dry aggregate blank sample as determined in paragraph 5(c). Place sample in the gauge and take and record a minimum four-minute count. If an increased count time (8-minute or 16-minute) was used to determine the variability of the gauge [paragraph 2(a)(5)], that count time is the minimum that is to be used. If a significant change is noted in this count [greater than ± 1.0% of the calibration blank count determined in paragraph 5(l)], a new calibration may be warranted. The project supervisor should be notified immediately of a possible change in aggregate, pit conditions, and/or moisture retained in the aggregate.

MODIFICATIONS FOR ASPHALTIC CONCRETE FRICTION COURSE, ASPHALTIC CONCRETE (ASPHALT-RUBBER), AND ASPHALTIC CONCRETE FRICTION COURSE (ASPHALT-RUBBER)

7. The following modifications apply for Asphaltic Concrete Friction Course, Asphaltic Concrete (Asphalt-Rubber), and Asphaltic Concrete Friction Course (Asphalt-Rubber).

(a) In paragraph 3(d), the last sentence is changed to read: If the original calibration specimens are retested, they shall be heated in an oven at 104 ± 11 °C (220 ± 20 °F) for Asphaltic Concrete Friction Course, or at 149 ± 14 °C (300 ± 25 °F) for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), for at least one hour to drive out any condensation or absorbed moisture and to bring them to testing temperature.

(b) In the calbration procedure given in Section 5, the following changes are made:

1) In paragraph 5(g), a "butter mix" shall be used for preparing calibration samples.

2) In paragraph 5(h):

a) At the time of beginning the fabrication of calibration samples for Asphaltic Concrete Friction Course, the temperature of the mixture shall be 104 ± 11 °C (220 ± 20 °F).

b) At the time of beginning the fabrication of calibration samples for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), the temperature of the mixture shall be 149 ± 14 °C (300 ± 25 °F).

c) For Asphaltic Concrete Friction Course or Asphaltic Concrete Friction Course (Asphalt-Rubber), instead of adding mix until the top of the material is mounded approximately 25 to 38 mm (1 to 1-1/2 inches) above the top of the pan, mix shall be added so that the top of the mix is mounded slightly above the top of the pan.

3) In paragraph 5(j), the last sentence is changed to read: If samples are not able to be tested immediately after fabrication, they shall be placed in an oven at 104 ± 11 °C (220 ± 20 °F) for Asphaltic Concrete Friction Course, or at 149 ± 14 °C (300 ± 25 °F), for Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber).

(c) Paragraph 4 (b) is changed to read: When sampling Asphaltic Concrete Friction Course or Asphaltic Concrete Friction Course (Asphalt-Rubber), an adequate amount of material shall be taken from the truck at the mixing plant and placed into a 19 liter (5 gallon) bucket, or other suitable container, which has been conditioned with a "butter mix". The sample shall be taken at random locations, approximately 300 mm (12 inches) below the surface, within 5 minutes from the time the loading of the truck is completed. Representative samples of Asphaltic Concrete (Asphalt-Rubber) may be obtained either from the truck at the mixing plant, the windrow, or in accordance with Arizona Test Method 104.

(d) In the procedure for testing field samples (Section 6), the following changes are made:

1) At the beginning of the fabrication of field samples of Asphaltic Concrete Friction Course, the temperature of the mixture shall be 104 ± 11 °C (220 ± 20 °F).

2) At the beginning of the fabrication of field samples of Asphaltic Concrete (Asphalt-Rubber) or Asphaltic Concrete Friction Course (Asphalt-Rubber), the temperature of the mixture shall be 149 ± 14 °C (300 ± 25 °F).

CALIBRATION REPORT

8. The calibration report shall contain, as a minimum, the following information:

(a) Make, model, and serial number of the asphalt content gauge.

(b) ADOT project number.

(c) Type of mix.

(d) Calibration number.

(e) Name of test operator.

(f) Identification (type and source) of bituminous material and aggregate materials, (and mineral admixture when used).

(g) Calibration date and background count.

(h) Correlation coefficient of the calibration curve (Fit Coeff.).

(i) Weight and measured count of the dry aggregate blank sample prepared and tested during the calibration prodedure.

(j) Mix design percent bituminous material content.

(k) Percent of mineral admixture if used.

(l) Percentages of bituminous material in calibration samples.

(m) Weight of asphaltic concrete calibration samples.

(n) Measured count of each asphaltic concrete calibration sample.

FIELD SAMPLE TEST REPORT

9. The field sample test report shall, as a minimum, contain the following information:

(a) ADOT project number.

(b) Type of mix.

(c) Calibration number.

(d) Mix design percent bituminous material content.

(e) Date and location of field test sample.

(f) Test number and lot number, if applicable.

(g) Field sample test date and name of test operator.

(h) Background count.

(i) Weight of test sample.

(j) Count time (minutes) of test.

(k) Measured count of test sample.

(l) Gauge measured percent bituminous material.

(m) Percent moisture.

(n) Corrected (actual) percent bituminous material.

(o) When a dry aggregate blank sample is prepared and tested, the following information is also reported:

1) Weight and measured count of the dry aggregate blank sample prepared and tested during the calibration prodedure.

2) Weight and measured count of dry aggregate blank sample prepared and tested during production.

3) Percentage change in counts from the calibration dry aggregate blank sample count.

ARIZ 422
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(9 Pages)

COMPACTION AND TESTING OF BITUMINOUS MIXTURES UTILIZING 152.4 mm (SIX INCH) MARSHALL APPARATUS

(A Modification of ASTM D 5581)

SCOPE

1. (a) This method covers the procedure for compacting and testing bituminous mixtures utilizing 152.4 mm (six inch) Marshall apparatus.

(b) This procedure is used for bituminous mixtures with a mix design gradation target of less than 85% passing the 19.0 mm (3/4 inch) sieve.

(c) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(d) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(e) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Compaction Mold Assembly [152.4 mm (six inch) diameter] - Cylindrical mold, baseplate, and extension collar; constructed of steel and conforming to the requirements of Figure 1. (Three compaction mold assemblies are normally utilized.)

(b) Specimen Extruding Device - Extrusion jack or press for extruding specimens from molds.

(c) Compaction Hammer.

1) A mechanical compaction hammer having a flat, circular tamping face with a nominal diameter of 149.4 mm (5-7/8 inches), and a 10.21 ± 0.01 kg (22.50 ± 0.02 pound) sliding weight with a free fall of 457.2 ± 2.5 mm (18.0 ± 0.1 inches).

2) For calibration purposes, the density of a 152.4 mm (six inch) diameter specimen of a 19 mm (3/4") AC mix compacted with the 152.4 mm (six inch) mechanical hammer utilizing approximately 112 blows per side shall not vary by more than 16.0 kg/m^3 (1.0 lb./cu. ft.) from the density of a 101.6 mm (four inch) diameter specimen of the same mix compacted with a compaction hammer meeting the requirements of Arizona Test Method 410. The number of blows may be varied from 112 in order to obtain calibration. If changes or adjustments to the compaction hammer or pedestal are made, a recalibration may be warranted.

(d) Compaction pedestal - The compaction pedestal shall consist of a 203.2 mm by 203.2 mm by 457.2 mm (8" x 8" x 18") wooden post capped with a 304.8 mm by 304.8 mm by 25.4 mm (12" x 12" x1") steel plate. The steel cap shall be firmly fastened to the post. The wooden post shall have a dry weight of 673 to 769 kg/m^3 (42 to 48 lbs./cu. ft.) and shall rest squarely on, and be firmly secured to, a solid concrete slab. The pedestal assembly shall be installed so that the post is plumb and the cap is level.

(e) Specimen Mold Holder - Mounted on the compaction pedestal so as to center the compaction mold over the center of the post. It shall hold the compaction mold, collar, and base plate securely in position during compaction of specimen.

(f) Oven for heating bituminous mixtures and specimen mold assemblies at required temperature.

(g) Hot plate for heating compaction hammer, spoon, and spatula.

(h) A flat spatula with blade approximately 25 mm (1 inch) wide and at least 150 mm (6 inches) long, stiff enough to penetrate the entire bituminous mixture.

(i) Thermometers for determining temperatures of bituminous mixtures. Armored glass thermometers or dial-type with metal stem with a range of 10 to 200 °C (50 to 400 °F) are recommended. Thermometers shall have increments of not greater than 2.8 °C (5 °F).

(j) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least one gram.

(k) Large spoon for placing mixtures in specimen molds.

(l) If Marshall stability and flow are to be determined, the following additional apparatus is required:

1) Breaking head consisting of upper and lower cylindrical segments or test heads. The lower segment shall be mounted on a base having two perpendicular guide rods or posts extending upward. Guide sleeves in the upper segment shall be in such a position as to direct the two segments together without appreciable binding or loose motion the guide rods. When a 152.4 ± 3.1 mm (6.000 ± 0.120 inch) diameter by 100 mm (4 inch) thick metal block is placed between the two segments, the breaking head shall conform to the requirements of Figure 2.

2) Water bath of sufficient depth to provide for the complete immersion of specimens and thermostatically controlled so as to maintain the bath at 60 ± 1 °C (140° ± 1.8 °F). The tank shall have a perforated false bottom or be equipped with a shelf for supporting specimens 50.8 mm (2 inches) above the bottom of the bath.

3) Marshall stability and flow testing apparatus, with operating instruction manual. The apparatus shall be capable of applying a load with a constant rate of travel of 50.8 ± 2.5 mm (2.0 ± 0.1 inches) per minute.

4) Height gauge capable of measuring the height of specimens to the nearest 0.1 mm (0.001 inch).

PROCEDURE

3 (a) A set of three 4000 gram (approximate) representative samples of bituminous mixture shall be obtained. The weight utilized will be such that compacted specimens for Marshall stability and flow testing meet the height requirement of 88.9 to 101.6 mm (3.500 to 4.000 inches).

(b) Before placing in the mold, the mixture and a mold assembly (baseplate, mold and collar) shall be at approximately 143 °C (290 °F). The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at approximately 143 °C (290 °F). The temperature of the laboratory during compaction of the specimens shall be between 20 and 30 °C (68 and 86 °F).

(c) Place a 152.4 mm (6 inch) paper disc in the bottom of the mold before the mixture is introduced. Place approximately one-half of the batch in the mold with a heated spoon. Spade the mixture vigorously, penetrating the entire mixture, with the heated spatula 15 times around perimeter and 10 times over the interior. Place the second half of the batch in the mold and repeat the spading procedure. Smooth the surface of the mix to a slightly rounded shape.

(d) Unless otherwise indicated on the mix design, the compaction temperature range (except for recycle mixes and bituminous mixtures containing asphalt-rubber) shall be as shown in Table 1 below for the specified type of bituminous material. For asphalt-rubber mixes, the compaction temperature range shall be 163 ± 6 °C (325 ± 10 °F). For recycle mixes, the compaction temperature range shall be 141 ± 6 °C (285 ± 10 °F).

TABLE 1

Bituminous Material	Compaction Temperature Range
AC 10, AC 20	138 ± 6 °C (280 ± 10 °F)
AC 30, AC 40	141 ± 6 °C (285 ± 10 °F)
PG 58-XX, PG 64-XX	138 ± 6 °C (280 ± 10 °F)
PG 70-XX, PG 76-XX	141 ± 6 °C (285 ± 10 °F)
Polymer Modified Asphalts	143 ± 6 °C (290 ± 10 °F)

(e) If necessary, the mixture and mold shall be returned to an oven at the required temperature for the minimum time necessary to achieve the required compaction temperature.

(f) Place a 152.4 mm (six inch) paper disc on top of material, place the mold assembly on the compaction pedestal in the mold holder, and apply the calibrated number of blows (approximately 112) with the mechanical compaction hammer. Compaction shall be performed at a minimum rate of 40 blows per minute. The compaction hammer shall apply only one blow with each fall, that is, there shall not be a rebound impact. Remove the base plate and collar, and reverse and reassemble the mold. Apply the calibrated number of compaction blows to the face of the reversed specimen.

(g) Remove collar, baseplate, and paper discs, and allow specimen to cool. Cooling may be accomplished at room temperature, in a 25 °C (77 °F) air bath, or if more rapid cooling is desired the mold and specimen may be placed in front of a fan until cool.

(h) Extrude the specimen from the mold. Care shall be taken in extruding the specimen from the mold, so as not to develop tensile stresses in the specimen or tear the sides of the specimen.

SPECIMEN TESTING

4. Specimens prepared as above shall be tested by some or all of the following procedures, as applicable due to testing requirements and availability of apparatus.

(a) If Marshall stability and flow are to be determined, measure height of specimens to the nearest 0.1 mm (0.001 inch). Prior to measurement of height, excess material shall be brushed from the edges of the specimens. Compacted specimens shall be 88.9 to 101.6 mm (3.500 to 4.000 inches) in height. If this criteria is not met, the entire set of specimens shall be discarded and a new set prepared after necessary adjustments in sample weight have been made.

(b) Determine the specific gravity of the specimens in accordance with Arizona Test Method 415, Method A. (Assume specimen is at constant weight after cooling.)

(c) Determine the bulk density of each of the specimens, by multiplying the respective specific gravity by 998 kg/m^3 (62.3 lbs./cu. ft.). Record the individual bulk densities to the nearest 1 kg/m^3 (0.1 lb./cu. ft.). The densities of the three specimens shall not differ by more than 48 kg/m^3 (3.0 lbs./cu. ft.). If this density

requirement is not met, the entire set of specimens shall be discarded and a new set of specimens prepared.

(d) Determine the average specific gravity of the specimens and record to the nearest 0.001. Calculate the average bulk density of the specimens, by multiplying the average specific gravity by 998 kg/m^3 (62.3 lbs./cu. ft.). Record the average bulk density to the nearest 1 kg/m^3 (0.1 lb./cu. ft.).

(e) If the stability and flow are to be determined, the steps in paragraphs (f) through (l) below are followed, utilizing apparatus in accordance with the operating instructions for that apparatus.

(f) Bring the specimens to 60 ± 1 °C (140° ± 1.8 °F) by immersing in the water bath 45 to 60 minutes. Prior to testing, it shall be assured that the inside of the test heads are clean, and that the guide rods are clean and lubricated so that the upper test head slides freely over them.

(g) The breaking head temperature shall be maintained between 21 to 38 °C (70 to 100 °F), using a water bath when required. Remove the specimen from the water bath, quickly towel dry specimen and place in the lower segment of the breaking head. Place the upper segment of the breaking head on the specimen, and place the complete assembly in position on the testing machine.

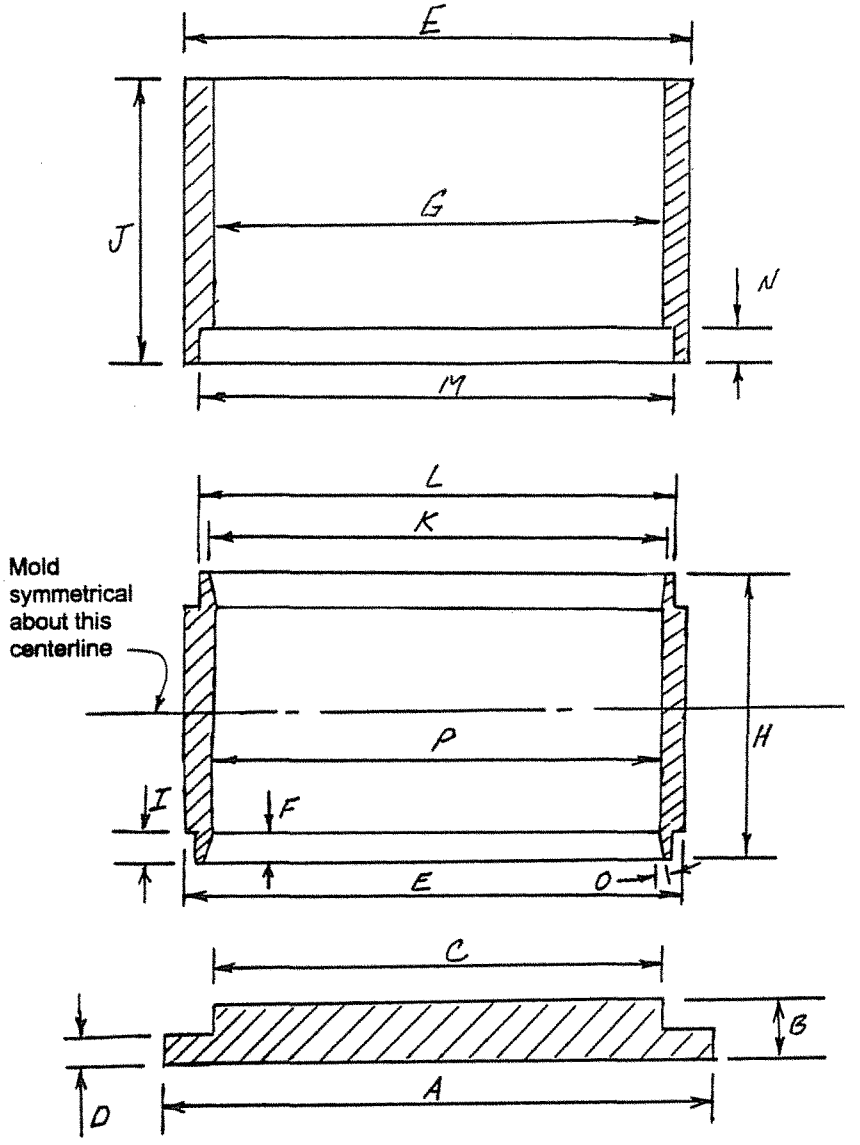
(h) Apply the load to the specimen with a constant rate of 50.8 ± 2.5 mm (2.0 ± 0.1 inches) per minute until the maximum load is reached and the load decreases. The maximum load is defined as the last point in the load/time curve before the load decreases. The elapsed time for the test from removal of the test specimen from water bath to maximum load determination shall not exceed 30 seconds.

(i) Record the stability of each specimen to the nearest 50 newtons (10 pounds force), and the flow to the nearest 0.1 mm (0.01 inch).

(j) Correct the stability obtained for each specimen, for the height of the specimen, by the table in Figure 3. Record the corrected stability to the nearest 50 newtons (10 pounds force).

(k) Determine and record the average corrected stability to the nearest 50 newtons (10 pounds force), and the average flow to the nearest 0.1 mm (0.01 inch).

(l) The average stability shall be corrected to correspond to a 101.6 mm (four inch) specimen by dividing the average test result by 2.0.

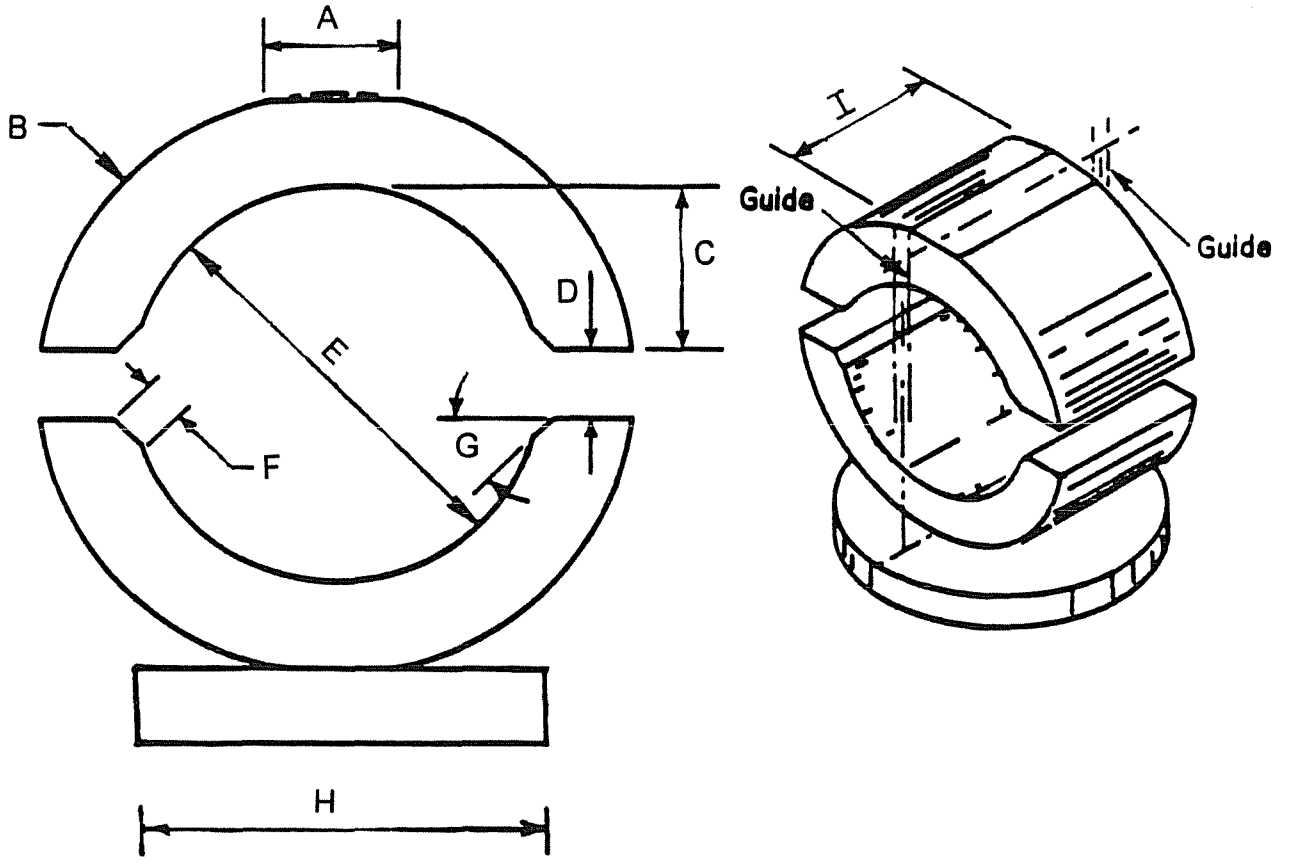


A	171.5 mm (6-3/4 in.)	H	114.3 mm (4-1/2 in.)
B	12.7 mm (1/2 in.)	I	6.4 mm (1/4 in.)
C	151.6 mm (5-31/32 in.)	J	82.6 mm (3-1/4 in.)
D	6.4 mm (1/4 in.)	K	155.6 mm (6-1/8 in.)
E	165.1 mm (6-1/2 in.)	L	159.1 mm (6-17/64 in.)
F	6.4 mm (1/4 in.)	M	159.6 mm (6-9/32 in.)
G	155.6 mm (6-1/8 in.)	N	7.1 mm (9/32 in.)
O	14°		
P	152.2 to 152.6 mm (5.992 to 6.008 in.)		

All dimensions are nominal, except where tolerances are indicated.

152.4 mm (Six Inch) Compaction Mold, Extension Collar, and Baseplate

FIGURE 1



A	50 mm (2 in.)
B	22 mm (0.87 in.) minimum
C	66.7 ± 1.3 mm (2.625 ± 0.050 in.)
D	19.0 ± 0.5 mm (0.750 ± 0.020 in.)
E	152.4 ± 3.1 mm (6.000 ± 0.120 in.)
F	13.5 ± 0.3 mm (0.53 ± 0.01 in.)
G	45°
H	152.4 (6 in.) nominal
I	108 mm (4.25 in.)

Breaking Head

FIGURE 2

STABILITY CORRELATION RATIOS*
For 152.4 mm (6 inch) Diameter Specimens

Height of Specimen (millimeters)	Height of Specimen (inches)	Correlation Ratio
88.9 - 89.1	3.500 - 3.511	1.12
89.2 - 89.6	3.512 - 3.532	1.11
89.7 - 90.2	3.533 - 3.553	1.10
90.3 - 90.7	3.554 - 3.574	1.09
90.8 - 91.2	3.575 - 3.594	1.08
91.3 - 91.7	3.595 - 3.615	1.07
91.8 - 92.3	3.616 - 3.636	1.06
92.4 - 92.8	3.637 - 3.657	1.05
92.9 - 93.3	3.658 - 3.678	1.04
93.4 - 93.9	3.679 - 3.699	1.03
94.0 - 94.4	3.700 - 3.719	1.02
94.5 - 94.9	3.720 - 3.739	1.01
95.0 - 95.5	3.740 - 3.760	1.00
95.6 - 96.0	3.761 - 3.782	0.99
96.1 - 96.5	3.783 - 3.803	0.98
96.6 - 97.2	3.804 - 3.831	0.97
97.3 - 97.9	3.832 - 3.858	0.96
98.0 - 98.6	3.859 - 3.886	0.95
98.7 - 99.2	3.887 - 3.907	0.94
99.3 - 99.7	3.908 - 3.928	0.93
99.8 - 100.4	3.929 - 3.956	0.92
100.5 - 101.1	3.957 - 3.983	0.91
101.2 - 101.6	3.984 - 4.000	0.90

* The measured stability of a specimen multiplied by the correlation ratio for the height of the specimen equals the corrected stability for a 95.25 mm (3-1/2 inch) specimen.

FIGURE 3

DETERMINATION OF AIR VOIDS IN COMPACTED BITUMINOUS MIXTURES

(A Modification of AASHTO Designation T 269)

1. SCOPE

1.1 This procedure is used to determine the air voids in compacted bituminous mixtures. It is applicable for specimens which are either laboratory compacted or field compacted (for example, cores).

1.2 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. CALCULATION

2.1 For specimens which are either Marshall laboratory compacted or field compacted (e.g., cores), the percent air voids shall be calculated using the bulk density of the compacted bituminous mixture (Arizona Test Method 415) and maximum density of the mixture from the Rice Test (Arizona Test Method 417).

2.1.1 The percent air voids are calculated by the following equation:

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Bulk Density}}{\text{Maximum Density}}\right] \times 100$$

2.1.1.1 An example of the calculations is given in Figure 1.

2.1.1.2 A blank form for perfoming the calculations is given in Figure 3.

2.2 For specimens which are gyratory laboratory compacted, the percent air voids shall be calculated using the average relative density of the compacted bituminous mixture at N_{design} (AASHTO T 312).

2.2.1 The percent air voids are calculated by the following equation:

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{design})

2.2.1.1 An example of the calculations is given in Figure 2.

2.2.1.2 A blank form for perfoming the calculations is given in Figure 4.

3. REPORT

3.1 The percent air voids shall be reported to the nearest 0.1%.

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☒ 4 inch ☒ 6 inch ☐; Core ☐

Specimen I.D.	1	2	3	Average
Specimen Height	2.516	2.515	2.519	
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air	1155.9	1155.4	1158.2	
B = Mass in grams of SSD specimen in Air	1156.9	1156.3	1159.2	
C = Mass in grams of specimen in Water	647.9	649.6	651.8	
G_{mb} = Bulk Specific Gravity = A/(B – C)	2.271	2.280	2.283	2.278
% Absorption = [(B – A)/(B – C)] x 100	0.20	0.18	0.20	
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)	141.5	142.0	142.2	
Range of Bulk Density values (lbs./cu. ft.)	0.7			
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)				141.9
Maximum Density (lbs./cu. ft.) [from Rice Test]	149.4			

Notes:

The Individual specimen heights are reported to the nearest 0.001 inch.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Average Bulk Density}}{\text{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{141.9}{149.4}\right] \times 100 = 5.0\%$$

EXAMPLE AIR VOIDS CALCULATION FOR MARSHALL LABORATORY COMPACTED SPECIMENS

FIGURE 1

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.	1	2	Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)	128.7	129.3	
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)	117.0	117.4	
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)	115.6	116.0	
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air	4747.4	4744.6	
B = Mass, in grams, of SSD specimen at N_{max} in Air	4759.4	4756.0	
C = Mass, in grams, of specimen at N_{max} in Water	2752.7	2751.2	
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B-C}$	2.366	2.367	
% Absorption = [(B – A)/(B – C)] x 100	0.60	0.57	
G_{mm} = Maximum Specific Gravity [from Rice Test]	2.449		
*Relative Density, $\%G_{mm}$, of specimen at N_{ini}	86.8	86.7	86.8
*Relative Density, $\%G_{mm}$, of specimen at N_{des}	95.5	95.5	95.5
*Relative Density, $\%G_{mm}$, of specimen at N_{max}	96.6	96.7	96.7

$$*\text{Relative Density}, \%G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The Individual specimen heights are reported to the nearest 0.1 mm.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})

= (100) – (95.5) = 4.5%

EXAMPLE AIR VOIDS CALCULATION FOR GYRATORY LABORATORY COMPACTED SPECIMENS

FIGURE 2

CALCULATION OF AIR VOIDS FOR MARSHALL LABORATORY COMPACTED SPECIMENS OR FIELD COMPACTED SPECIMENS

Specimens Compacted by: Hand ☐ Mechanical ☐ 4 inch ☐ 6 inch ☐; Core ☐

Specimen I.D.				Average
Specimen Height				
Bulk Specific Gravity, Bulk Density, and Absorption (Arizona Test Method 415: Method A ☒, Method C ☐, or Vacuum Method ☐)				
A = Mass in grams of specimen in Air				
B = Mass in grams of SSD specimen in Air				
C = Mass in grams of specimen in Water				
G_{mb} = Bulk Specific Gravity = A/(B – C)				
% Absorption = [(B – A)/(B – C)] x 100				
Bulk Density = (G_{mb} x 62.3 lbs./cu. ft.)				
Range of Bulk Density values (lbs./cu. ft.)				
Average Bulk Density = (Average G_{mb} x 62.3 lbs./cu. ft)				
Maximum Density (lbs./cu. ft.) [from Rice Test]				

Notes:

The Individual specimen heights are reported to the nearest 0.001 inch.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The average bulk specific gravity is calculated, and reported to the nearest 0.001, using the individual bulk specific gravities which have been reported to the nearest 0.001.

The individual bulk densities are reported to the nearest 0.1 lb./cu. ft.

The average bulk density is reported to the nearest 0.1 lb./cu. ft.

The maximum density [from Rice Test] is reported to the nearest 0.1 lb./cu. ft.

$$\text{Percent Air Voids} = \left[1 - \frac{\text{Average Bulk Density}}{\text{Maximum Density from Rice Test}}\right] \times 100 = \left[1 - \frac{(\quad)}{(\quad)}\right] \times 100 = \quad\%$$

FIGURE 3

CALCULATION OF AIR VOIDS FOR GYRATORY LABORATORY COMPACTED SPECIMENS

Specimen I.D.			Average
h_{ini} = Height, in mm, of specimen at N_{ini} (8 gyrations)			
h_{des} = Height, in mm, of specimen at N_{des} (100 gyrations)			
h_{max} = Height, in mm, of specimen at N_{max} (160 gyrations)			
Bulk Specific Gravity and Absorption (Arizona Test Method 415: Method A ☐, Method C ☐, or Vacuum Method ☐)			
A = Mass, in grams, of specimen at N_{max} in Air			
B = Mass, in grams, of SSD specimen at N_{max} in Air			
C = Mass, in grams, of specimen at N_{max} in Water			
G_{mb} = Bulk Specific Gravity of specimen at N_{max} $= \frac{A}{B - C}$			
% Absorption = [(B – A)/(B – C)] x 100			
G_{mm} = Maximum Specific Gravity [from Rice Test]			
*Relative Density, $\%G_{mm}$, of specimen at N_{ini}			
*Relative Density, $\%G_{mm}$, of specimen at N_{des}			
*Relative Density, $\%G_{mm}$, of specimen at N_{max}			

$$*\text{Relative Density}, \%G_{mmx} = \frac{(G_{mb}) \times (h_{max})}{(G_{mm}) \times (h_x)} \times 100$$

Where: $\%G_{mmx}$ = Relative Density, $\%G_{mm}$, of specimen at N_{ini}, N_{des}, or N_{max}
G_{mb} = Bulk Specific Gravity of specimen at N_{max}
h_{max} = Height, in mm, of specimen at N_{max}
G_{mm} = Maximum Specific Gravity [from Rice Test]
h_x = Height of specimen, in mm, at N_{ini}, N_{des}, or N_{max}

Notes:

The Individual specimen heights are reported to the nearest 0.1 mm.

The Individual specimen masses are reported to the nearest 0.1 gram.

The Indivdual bulk specific gravities are reported to the nearest 0.001.

The maximum specific gravity [from Rice Test] is reported to the nearest 0.001.

The individual relative densities are reported to the nearest 0.1 percent.

The average relative density for each set of specimens (at N_{ini}, N_{des}, and N_{max}) is calculated, and reported to the nearest 0.1 percent, using the corresponding individual relative densities which have been reported to the nearest 0.1 percent.

Three specimens are used when referee testing is performed.

Percent Air Voids = (100) – (Average Relative Density, % G_{mm}, at N_{des})

= (100) – (_____) = _____%

FIGURE 4

ASPHALT BINDER CONTENT OF ASPHALTIC CONCRETE MIXTURES BY THE IGNITION FURNACE METHOD

(A Modification of AASHTO T 308)

1. SCOPE

1.1 This procedure describes the method for determining the percent asphalt binder content of asphaltic concrete mixtures, by use of an ignition furnace. The aggregate remaining after ignition can be used for sieve analysis, as indicated in Section 6.

1.1.1 This procedure does not address the use of reclaimed asphalt pavement (RAP) in asphaltic concrete mixtures. **See Arizona Test Method 428 when testing is to be performed on asphaltic concrete mixtures containing RAP.**

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure #	Title	Page #
Section 2	Apparatus	2
Section 3	Sampling	3
Section 4	Calibration	4
Section 5	Procedure	7
Section 6	Sieve Anaylsis of Aggregate	9
Section 7	Report and Example	12
Figure 1	Example Completed Asphaltic Concrete Tabulation - Ignition Furnace Laboratory Card (for the testing performed on a field sample)	14
Figure 2	Blank Asphaltic Concrete Tabulation - Ignition Furnace Laboratory Card	15

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 Ignition Furnace - a forced-air ignition furnace that heats the sample by the convection method. The furnace must be capable of heating to temperatures up to 538 °C (1000 °F), and able to maintain a given temperature at ± 5 °C (± 9 °F). The furnace shall have an internal weighing system thermally isolated from the furnace chamber and accurate to 0.1 gram. The balance shall be capable of weighing a 3500 gram sample in addition to the sample baskets. A data collection system shall also be included so that the sample mass loss can be automatically determined to an accuracy of 0.1 gram and displayed during a test. The furnace shall provide a printout that includes, as a minimum, the initial sample mass, sample mass loss, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive one minute intervals. A filter capable of reducing emissions to an acceptable level shall also be incorporated into the furnace. The furnace shall be vented into a hood or to the outside and be set up properly so that there are no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability to pull air through the furnace to expedite the test and to reduce escape of smoke into the laboratory. The furnace shall be equipped so that the door cannot be opened until testing is complete.

2.1.2 Stainless Steel Perforated Baskets - the baskets shall be an appropriate size that allow the samples to be a thickness which allows air to flow up through and around the sample particles. The sample shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material. Screen mesh or other suitable material with openings of No. 8 has been found to perform well.

2.1.3 Stainless Steel Catch Pan - of sufficient size to hold the sample baskets so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

2.1.4 Oven(s) - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at the tolerances specified herein.

2.1.5 Scale(s) or balance(s) - capable of measuring the maximum mass to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.1.6 Safety Equipment - safety glasses or face shield, high temperature gloves, and long sleeve jacket. Additionally, a heat resistant surface capable of withstanding 1200 °F and a protective cage capable of surrounding the sample baskets shall be provided.

2.1.7 Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring samples after ignition, spatulas, bowls, spoons, and wire brushes.

2.1.8 Mixing apparatus - Mechanical mixing is recommended; 20 quart capacity mixer is required. (Hand mixing may be performed if desired.)

2.1.9 Thermometer - with a temperature range of 50 to 500 °F.

2.1.10 Hot plate - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at ± 5 °F.

2.1.11 For performing sieve analysis, apparatus as specified in Arizona Test Method 201.

3. SAMPLING

3.1 For preparing calibration samples, obtain representative samples of aggregates in accordance with Arizona Test Method 105. Samples shall be sufficiently large to provide enough material for calibration testing. The samples shall be adequately dried, if necessary, to a free-flowing condition in the portion passing the 4.75 mm (No. 4) sieve.

3.2 For testing field samples of asphaltic concrete, obtain a representative sample of the freshly produced mix in accordance with Arizona Test Method 104. Obtain representative test samples, in accordance with the appropriate sections of Arizona Test Method 416, for the determination of moisture content (if required) and asphalt binder content.

3.2.1 The size of the asphalt binder content test sample shall be within ± 150 grams of the sample size used for calibration and must also conform to the mass requirement shown in Table 1. When the mass of the test sample exceeds the capacity of the equipment used, the test sample shall

be divided into suitable increments, tested, and the results appropriately combined.

TABLE 1	
Size of Test Sample	
Nominal Maximum Aggregate Size (See Note)	**Mass of Sample, grams**
1-1/2 in.	4000 – 4500
1 in.	3000 – 3500
3/4 in.	2000 – 2500
1/2 in.	1500 – 2000
3/8 in.	1200 – 1700
No. 4	1200 – 1700
Note: The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.	

4. CALIBRATION

4.1 Asphalt binder content results may be affected by the type of aggregate and binder in the mixture. A calibration factor for the asphalt binder content must be established for each mix design. Certain aggregate types may result in an unusually high calibration factor and erroneous gradation results due to aggregate breakdown. Such mixes should be calibrated and tested at a lower temperature as described in Subsection 4.14.

4.2 Dry the aggregate samples to constant mass at 290 ± 10 °F. Allow the material to cool.

4.3 Screen the aggregate stockpile samples and separate into individual sizes for No. 8 and larger, and minus No. 8 material.

Note: In lieu of screening the aggregate sample for each individual stockpile, a bulk-batched sample may be used as described in Subsection 4.3.1.

4.3.1 Using the aggregate stockpile percentages shown in the mix design composite, the material from the individual stockpiles may be bulk-batched in a single sample of an adequate amount of material necessary to prepare the required calibration samples. Screen the bulk-batched material and separate into individual sizes for No. 8 and larger, and minus No. 8 material.

4.4 Using the individual sizes of aggregate for No. 8 and larger, and minus No. 8 material, as obtained either by screening the material from the individual aggregate stockpiles or by screening the the bulk-batched sample, weigh up four aggregate samples representative of the mix design gradation without mineral admixture. These samples will be used for a gradation check, two calibration samples, and a butter mix. The appropriate type and quantity of mineral admixture (by weight of aggregate) shall be added to the aggregate, and thoroughly blended. The weight of the gradation check sample shall conform to the requirements of Table 1. The weight of the two calibration samples and the butter mix shall be such that when the required amount of asphalt binder is added, they conform to the requirements of Table 1.

4.5 Using the aggregate and mineral admixture sample prepared for the gradation check, perform a gradation analysis according to Section 6 to determine the actual gradation. The gradation shall be representative of the mix design gradation with mineral admixture. If the gradation is not representative of the mix design, four new aggregate and mineral admixture samples shall be prepared.

4.6 Using the remaining three aggregate and mineral admixture samples, two calibration samples and a butter mix are prepared as described below at the design asphalt binder content. The asphalt binder grade and type shall be the same as will be used in the asphalt concrete mixture to be tested during production. Heat the samples to the laboratory mixing temperature prescribed in the mix design. (See Note following Subsection 4.7). Allow the samples to cool. Weigh and determine the mass of each sample to the nearest 0.1 gram. If mass is lost during the heating of the samples, do not add make-up material, as this will change the gradation of the samples. The percent asphalt binder content is based on the mass of total mix. For each sample, the weight of asphalt binder to be used is determined by the following:

$$\left[\begin{array}{c}\text{Weight of}\\ \text{Asphalt Binder}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Weight of Aggregate}\\ \text{and Mineral Admixture}\end{array}\right]}{100 - \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]} \times \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]$$

4.7 All bowls, sample pans, and mixing tools shall be preheated to approximately the laboratory mixing temperature prescribed in the mix design. At the time mixing of the samples begins, the temperature of the asphalt binder, aggregate, and mineral admixture shall be in accordance with the prescribed laboratory mixing temperature $\pm$ 5 °F. Each individual

sample shall be thoroughly mixed. All samples shall be mixed at the same mixing temperature ± 5 °F.

Note: If the mix design laboratory mixing temperature is not specified, a temperature of 300 ± 5 °F shall be used for mixes which do not use asphalt-rubber, and 325 ± 5 °F for asphalt-rubber mixes.

4.8 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F), or as modified in Subsection 4.14. Do not preheat the sample basket.

4.9 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

4.10 The freshly mixed samples may be placed directly in the sample basket assembly. If the samples are allowed to cool, they must be reheated in a 290 ± 10 °F oven for 25 minutes.

4.11 Test samples in accordance with Subsections 5.6 through 5.14.

4.12 If the difference between the measured asphalt binder content of the two samples exceeds 0.07, repeat the test using two additional samples, and from the four results discard the high and the low values.

4.13 Subtract the actual asphalt binder content for each of the two samples from their respective measured asphalt binder content. The asphalt binder content calibration factor is the average of the two resultant values expressed in percent by mass of the asphalt mixture.

4.14 If the asphalt binder content calibration factor exceeds ± 1.0 percent, lower the test temperature to 482 ± 5 °C (900 ± 9 °F) and repeat the test to determine a new calibration factor. If the calibration factor continues to exceed ± 1.0 percent, lower the test temperature to 427 ± 5 °C (800 ± 9 °F) and repeat the test to determine a new calibration factor. Use the calibration factor obtained at 427 ± 5 °C (800 ± 9 °F) even if it exceeds ± 1.0 percent.

4.15 Perform a gradation analysis on the residual aggregate as indicated in Section 6. Subtract the actual percent passing the No. 200 sieve for each sample from the measured percent passing the No. 200 sieve (as determined in Subsection 4.5). Determine the average of the two values. If the resultant average value is greater than ± 0.50, an aggregate gradation correction factor (equal to the resultant average value) for the

passing No. 200 material may be applied to the production field sample test results.

5. PROCEDURE

5.1 The moisture content of the asphaltic concrete shall be determined in accordance with Arizona Test Method 406. The moisture content sample shall be obtained at the same time and subjected to the same treatment prior to testing as the asphalt binder content test sample. As an alternate to performing the moisture determination, the test sample may be dried to a constant mass in an oven at 290 ± 10 °F.

5.2 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F), or to the alternate temperature determined during the calibration (Subsection 4.14). Do not preheat the sample basket. Record the furnace temperature set point prior to the initiation of the test.

5.3 Record the asphalt binder content calibration factor, determined in accordance with Subsections 4.12 through 4.14, for the specific mix to be tested.

5.4 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

5.5 Obtain the asphalt binder content test sample in accordance with Subsection 3.2, ensuring that the size of the test sample is within ± 150 grams of the sample size used for calibration and that the test sample conforms to the requirements shown in Table 1.

5.6 Evenly distribute the test sample over the center of the sample basket(s) and level the material. Use a spatula or trowel to pull material approximately one inch away from the outside edge of basket(s).

5.7 Weigh and record the mass of the sample and basket assembly to the nearest 0.1 gram.

5.8 Calculate and record the initial mass of the sample to the nearest 0.1 gram.

5.9 Set the ignition furnace controller print mode to give a printout of the test data required in Subsection 2.1.1. Input the initial mass of the sample into the ignition furnace controller. Verify that the correct mass has been entered.

5.10 Open the furnace door and place the sample and basket assembly so that it is centered in the chamber. After assuring that the sample basket assembly is not in contact with any wall, close the door. Initiate the test by pressing the start button. This will lock the furnace door and start testing.

5.11 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. The test is deemed complete when the measured mass loss does not exceed 0.01 percent of the sample mass for three consecutive one minute intervals. If required, press the stop button. This will unlock the furnace door and cause the printer to print out the test results.

5.12 Open the furnace door and remove the sample and basket assembly. Allow the sample to cool 30 ± 5 minutes in the basket assembly. Weigh and record the mass of the sample and basket assembly after ignition to the nearest 0.1 gram.

5.13 Calculate and record the mass of sample after ignition to the nearest 0.1 gram.

5.14 Calculate and record the corrected asphalt binder content of the sample, to the nearest 0.01%, as follows:

$$\%AC = \left[\frac{W_i - W_A}{W_i} \times 100 \right] - C_F - \%M$$

Where: %AC = measured (corrected) asphalt binder content in percent by mass of the sample
W_i = mass of the sample prior to ignition
W_A = mass of the sample after ignition
C_F = asphalt binder content calibration factor, percent by mass of the sample
%M = percent moisture in the sample

Note: During calibration, C_F and %M are zero.

5.14.1 If an ignition furnace correction (tank stab correction) is made, the %AC determined in Subsection 5.14 is adjusted by that correction.

5.15 Attach the original printed ticket to the back of the card.

5.16 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the

baskets. Take care not to lose any material, as this will affect gradation results.

5.17 If needed, perform a gradation analysis of the residual aggregate according to Section 6.

6. SIEVE ANALYSIS OF AGGREGATE

6.1 If required, the aggregate shall be subjected to sieve analysis as described below. The coarse sieving shall be performed in accordance with Subsection 6.2, and the fine sieving in accordance with Subsection 6.3. The quantity of material on a given sieve at the completion of sieving shall not exceed the amount shown in Table 2.

TABLE 2

Sieve Size	Maximum Mass Allowed (grams/sq. in.)	Maximum Mass Allowed (grams)	
		8 inch Diameter Sieve	12 inch Diameter Sieve
1-1/2”	25	---	2827
1”	18	---	2036
3/4”	14	---	1583
1/2”	10	---	1131
3/8”	8	---	905
1/4”	6	---	679
No. 4	5	---	565
No. 8 and smaller	4	201	452

6.2 The coarse sieving of the aggregate shall be performed as follows:

6.2.1 Weigh and record the mass of the sample to be sieved to the nearest gram. Place sample on the top sieve of a nest of 12 inch sieves. The nest of sieves shall consist of sieves starting with the smallest size sieve that 100% of the material will pass, down through and including the No. 8 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.2.2 Weigh and record separately, to the nearest gram, the mass of the material retained on the individual sieves and in the pan. The material retained in the pan is recorded as the minus No. 8 material.

6.2.3 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 8 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.2.4 Determine the coarse sieve factor by dividing 100 by the total mass sieved. Record the factor to six decimal places.

6.2.5 The percent passing for each sieve in the coarse sieve analysis is determined by multiplying the mass retained on that sieve by the coarse sieve factor, and subtracting the result from the unrounded % passing for the next larger sieve. Values for "mass retained multiplied by the coarse sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent.

6.2.6 As a check on the coarse sieve analysis, multiply the mass of minus No. 8 material by the coarse sieve factor. The result of this calculation, rounded to the nearest percent, should be the same as the value for percent passing the No. 8 sieve determined in Subsection 6.2.5 above.

6.2.7 The material passing the No. 8 sieve is split, if necessary, to obtain a minimum 500 gram sample for fine sieving; however, the sample size may be less than 500 grams if a minimum of 500 grams is not obtained from coarse sieving. If less than 800 grams passes the No. 8 sieve, the entire amount shall be subjected to fine sieving. The mass of the sample for fine sieving is recorded to the nearest gram as mass of pass No. 8 split.

6.3 The elutriation and fine sieving of the pass No. 8 material shall be performed as follows:

6.3.1 Subject sample to elutriation through a No. 200 screen either by hand or mechanical washing.

6.3.2 Dry sample to constant mass, allow to cool, then weigh and record the dry mass to the nearest gram.

6.3.3 Place sample on the top sieve of a nest of fine sieves. The nest of sieves shall consist of sieves starting with the No. 10 sieve, down through and including the No. 200 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.3.4 Weigh and record separately, to the nearest gram, the mass of material retained on the individual sieves and in the pan.

6.3.5 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 200 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.3.6 Determine and record elutriation to nearest gram by determining the difference between the dry mass and the mass of the pass No. 8 split.

6.3.7 Determine a factor for calculating the fine sieve analysis by dividing the percent passing the No. 8 sieve (recorded to the nearest percent) by the mass of pass No. 8 split. Record the factor to six decimal places. If all the pass No. 8 material from coarse sieving was subjected to elutriation and fine sieving, a fine sieve factor is not determined. Rather, the coarse sieve factor is utilized and the calculation of the percent passing each sieve is continuous through the entire sieve analysis.

6.3.8 The percent passing for each sieve in the fine sieve analysis is determined by multiplying the mass retained on that sieve by the fine sieve factor, and subtracting the result from the unrounded % passing the next larger sieve, with the exception of the percent passing the No. 8 which has previously been recorded to the nearest percent. Values for "mass retained multiplied by the fine sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent, except the percent passing the No. 200 sieve is recorded to the nearest 0.1 percent.

6.3.9 As a check on the fine sieve analysis, the mass of material passing the No. 200 sieve is added to the elutriation mass, and this total is multiplied by the fine sieve factor. The result of this calculation, rounded to the nearest 0.1 percent, should be the same as the value for the percent passing the No. 200 sieve determined in Subsection 6.3.8 above.

6.3.10 If an aggregate gradation correction factor is utilized, the percent passing the No. 200 sieve shall be adjusted by subtracting the correction factor determined in Subsection 4.15.

6.4 Other methods may be used that differ from that specified in Subsections 6.2 and 6.3 above to determine % passing each sieve, so long as the method utilized has been proven to give equivalent results. However, any procedure which includes recording percent retained values prior to completing the calculation of all percent passing values is not allowed.

7. REPORT AND EXAMPLE

7.1 Report test information on the Asphaltic Concrete Tabulation – Ignition Furnace laboratory card. An example for the testing performed on a field sample is shown in Figure 1. Only the portion of the laboratory card relevant to the ignition furnace test is used for the example. A blank Asphaltic Concrete Tabulation – Ignition Furnace laboratory card is shown in Figure 2.

7.1.1 Mass of basket assembly.

7.1.2 Mass of sample and basket assembly.

7.1.3 Calculated initial mass of the sample.

7.1.4 Mass of sample and basket assembly after ignition.

7.1.5 Calculated mass of sample after ignition.

7.1.6 Asphalt binder content calibration factor.

7.1.7 Percent moisture from moisture test, if one was performed.

7.1.8 Corrected percent asphalt binder content.

7.1.9 Elapsed time of test.

7.1.10 Name of the operator.

7.1.11 Sample test date.

7.1.12 Design percent asphalt binder content.

7.2.13 Ignition furnace set temperature.

7.2.14 If determined, the sieve analysis of the residual aggregate (corrected for passing the No. 200 sieve if applicable).

ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PUR-POSE	TEST LAB	SIZE	SIZE %
13-0098	7777	AC	34	A	P		

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
4	3	A. JONES	04	22	13	1525 MILITARY TIME

SAMPLED FROM	LIFT NO.	RDWY	STATION
ROADWAY - 8' Lt. of ℄	2	EB	5550 IF MILEPOST, INPUT DECIMAL

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
BLUE RIVER PIT	B. Smith	F-088-8 (88)	H088801C

REMARKS

416 Special Mix

EXAMPLE

COARSE FACTOR 045455 = 100 / COARSE SIEVE TOTAL

WEIGHTS RETAINED		% RET	% PASS	SPECS
3"				
2 1/2"				
2"				
1 1/2"				
1"		0	100	
3/4"	96	4	96	
1/2"	439	20	76	
3/8"	132	6	70	
1/4"	172	8	62	
#4	160	7	55	
#8	207	10		
-#8	994	✓	45	
Total	2200	= i (Rounded)		

Weight of Pass # 8 Split 509 = p

FINE FACTOR 088409 = % Pass #8 / Wt. of Pass #8 Split

WEIGHTS RETAINED		% RET	% PASS	SPECS
#10	56	5	40	
#16	34	3	37	
#30	101	9	28	
#40	127	7	21	
#50	19	2	19	
#100	83	10	9	
#200	29	4		
-#200	2	✓ r	5.3	
Total	451	q = Dry Weight		
Elutri-ation	58	= p - q		

r - s = 5.9 Corrected % Pass No. 200

% Pass No. 200 Correction Factor (±) − 0.6 s

IGNITION FURNACE
ARIZ. 427 ☒ ARIZ. 428 ☐

a. Wet Mass of Moisture Sample	1026.2	g
b. Dry Mass of Moisture Sample	1024.0	g
c. Moisture Content (ARIZ 400) [(a - b) / a] x 100	0.21	%
d. Mass of Basket Assembly	4473.6	g
e. Mass of Sample and Basket Assembly	6790.3	g
f. Initial Mass of Sample (e - d)	2316.7	g
g. Ignition Furnace Set Temperature	538	°C
h. Mass of Sample and Basket Assembly After Ignition	6674.0	g
i. Mass of Sample After Ignition (h - d)	2200.4	g
j. Uncorrected Asphalt Binder Content [(f - i) /f] x 100	5.02	%
k. Asphalt Binder Content Calibration Factor (±)	+ 0.28	%
l. Ignition Furnace Correction (Tank Slab Correction) (±)	− 0.30	%
m. Corrected Asphalt Binder Content (j - k - c - l)	4.83	%
n. Design Asphalt Binder Content	4.70	%
o. Elapsed Time of Test (minutes)	79	

COMPACTION
Marshall = M Gyratory = G Core = C ☐

RICE
Sample Max. Sp. Gr. (Gmm)
Sample Max. Density [(Gmm) x (62.3)] pcf

MARSHALL
Average Bulk O.D. Sp. Gr. (Gmb)
Average Bulk Density [(Gmb) x (62.3)] pcf
Air Voids = %
[1 - (Average Bulk Density / Max Density From Rice Test)] x 100
Stability lbs
Flow 0.01 in

GYRATORY
Average Relative Density (% Gmm) at Ndesign pcf
Air Voids = %
100 - [Average Relative Density % (Gmm) at Ndesign]

WHITE ☐
YELLOW ☐
BLUE ☐

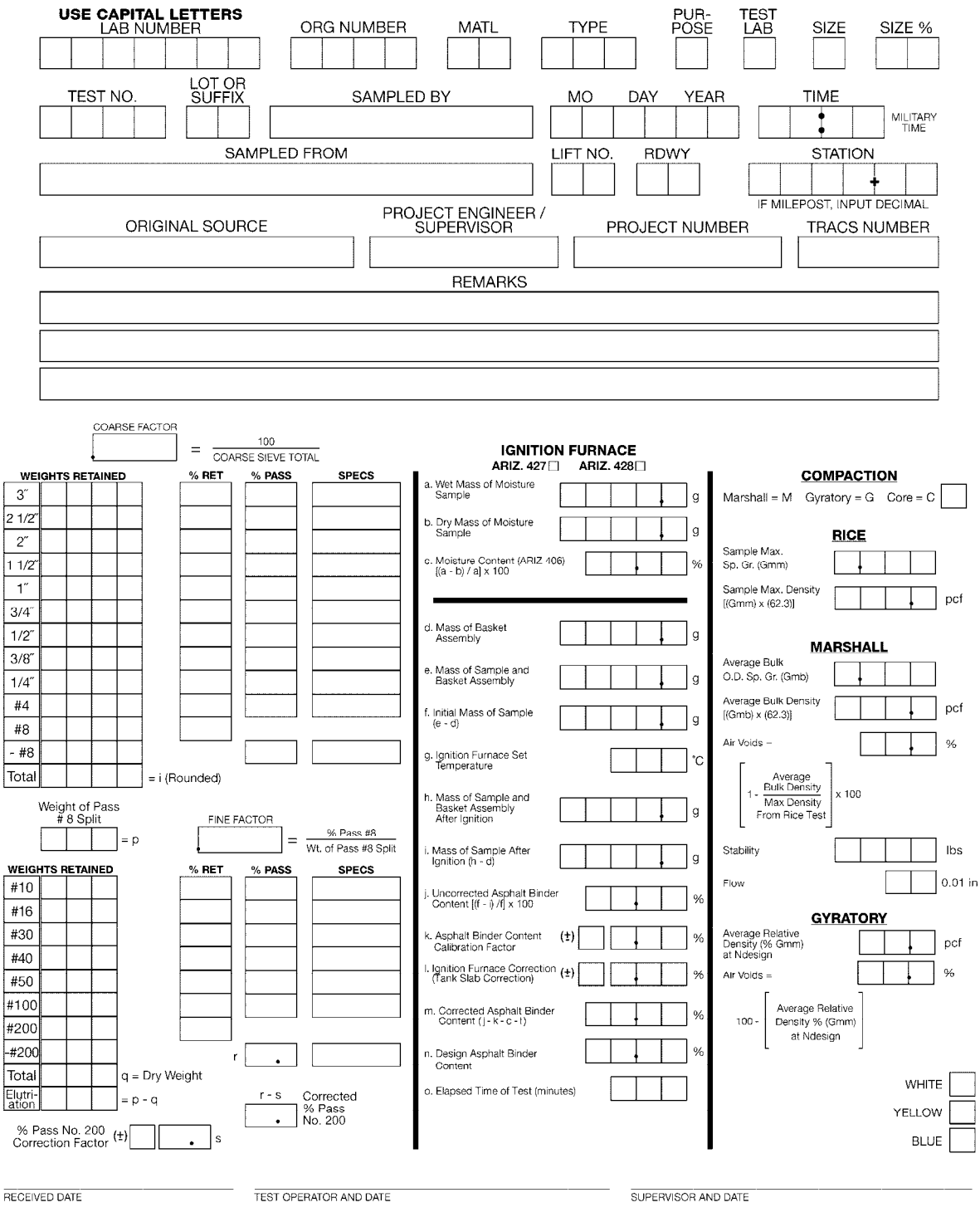
RECEIVED DATE	TEST OPERATOR AND DATE	SUPERVISOR AND DATE
04-22-13	S. Clement 04-23-13	H. Finn 04-23-13

44-9372 R03/13

SEE BACK ALSO

FIGURE 1

ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE



RECEIVED DATE | TEST OPERATOR AND DATE | SUPERVISOR AND DATE

44-9372 R03/13

SEE BACK ALSO

FIGURE 2

ASPHALT BINDER CONTENT OF ASPHALTIC CONCRETE MIXTURES CONTAINING RECLAIMED ASPHALT PAVEMENT (RAP) BY THE IGNITION FURNACE METHOD

(A Modification of AASHTO T 308)

1. SCOPE

1.1 This procedure describes the method for determining the percent asphalt binder content of asphaltic concrete mixtures containing reclaimed asphalt pavement (RAP), by use of an ignition furnace. The aggregate remaining after ignition can be used for sieve analysis, as indicated in Section 6.

1.1.1 The gradation, moisture content, and binder content of the RAP material are determined as described in Appendix A of this test method. The determination of the RAP aggregate gradation is also discussed in Appendix A. The procedure for determining the RAP binder content correction factor is described in Appendix B.

1.1.2 This procedure addresses the use of reclaimed asphalt pavement (RAP) in asphaltic concrete mixtures. **See Arizona Test Method 427 when testing is to be performed on asphaltic concrete mixtures which do not contain RAP.**

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure #	Title	Page #
Section 2	Apparatus	2
Section 3	Sampling	4
Section 4	Calibration	4
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2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 Ignition Furnace - a forced-air ignition furnace that heats the sample by the convection method. The furnace must be capable of heating to temperatures up to 538 °C (1000 °F), and able to maintain a given temperature at ± 5 °C (± 9 °F). The furnace shall have an internal weighing system thermally isolated from the furnace chamber and accurate to 0.1 gram. The balance shall be capable of weighing a 3500 gram sample in addition to the sample baskets. A data collection system shall also be included so that the sample mass loss can be automatically determined to an accuracy of 0.1 gram and displayed during a test. The furnace shall provide a printout that includes, as a minimum, the initial sample mass, sample mass loss, test time, and test temperature. The furnace shall provide an audible alarm and indicator light when the sample mass loss does not exceed 0.01 percent of the total sample mass for three consecutive one minute intervals. A filter capable of reducing

emissions to an acceptable level shall also be incorporated into the furnace. The furnace shall be vented into a hood or to the outside and be set up properly so that there are no noticeable odors escaping into the laboratory. The furnace shall have a fan with the capability to pull air through the furnace to expedite the test and to reduce escape of smoke into the laboratory. The furnace shall be equipped so that the door cannot be opened until testing is complete.

2.1.2 Stainless Steel Perforated Baskets - the baskets shall be an appropriate size that allow the samples to be a thickness which allows air to flow up through and around the sample particles. The sample shall be completely enclosed with screen mesh, perforated stainless steel plate, or other suitable material. Screen mesh or other suitable material with openings of No. 8 has been found to perform well.

2.1.3 Stainless Steel Catch Pan - of sufficient size to hold the sample baskets so that aggregate particles and melting asphalt binder falling through the screen mesh are caught.

2.1.4 Oven(s) - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at the tolerances specified herein.

2.1.5 Scale(s) or balance(s) - capable of measuring the maximum mass to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.1.6 Safety Equipment - safety glasses or face shield, high temperature gloves, and long sleeve jacket. Additionally, a heat resistant surface capable of withstanding 1200 °F and a protective cage capable of surrounding the sample baskets shall be provided.

2.1.7 Miscellaneous Equipment - a pan larger than the sample basket(s) for transferring samples after ignition, spatulas, bowls, spoons, and wire brushes.

2.1.8 Mixing apparatus - Mechanical mixing is recommended; 20 quart capacity mixer is required. (Hand mixing may be performed if desired.)

2.1.9 Thermometer - with a temperature range of 50 to 500 °F.

2.1.10 Hot plate - capable of heating to temperatures up to 350 °F, and able to maintain a given temperature at ± 5 °F.

2.1.11 For performing sieve analysis, apparatus as specified in Arizona Test Method 201.

3. SAMPLING

3.1 For preparing calibration samples, obtain representative samples of virgin aggregate and RAP material in accordance with Arizona Test Method 105. Samples of virgin aggregate and RAP material shall be sufficiently large to provide enough material for calibration testing.

3.2 For testing field samples of asphaltic concrete, obtain a representive sample of the freshly produced mix in accordance with Arizona Test Method 104. Obtain representative test samples, in accordance with the appropriate sections of Arizona Test Method 416, for the determination of moisture content (if required) and asphalt binder content.

3.2.1 The size of the asphalt binder content test sample shall be within $\pm$ 150 grams of the sample size used for calibration and must also conform to the mass requirement shown in Table 1. When the mass of the test sample exceeds the capacity of the equipment used, the test sample shall be divided into suitable increments, tested, and the results appropriately combined.

4. CALIBRATION

4.1 Asphalt binder content results may be affected by the type of aggregate and binder in the mixture. A calibration factor for the asphalt binder content must be established for each mix design. Certain aggregate types may result in an unusually high calibration factor and erroneous gradation results due to aggregate breakdown. Such mixes should be calibrated and tested at a lower temperature as described in Subsection 4.13.

TABLE 1

Size of Test Sample

Nominal Maximum Aggregate Size (See Note)	Mass of Sample, grams
1-1/2 in.	4000 – 4500
1 in.	3000 – 3500
3/4 in.	2000 – 2500
1/2 in.	1500 – 2000
3/8 in.	1200 – 1700
No. 4	1200 – 1700

Note: The smallest sieve opening through which the entire amount of material, by specification, is permitted to pass.

4.2 Spread the RAP material from each individual RAP stockpile to be used for the calibration in separate pans at 1 to 1-1/2 inches in depth and dry overnight at 140 ± 10 °F, and continue drying until the mass, after successive one-half hour periods of drying, indicates no change in mass. Allow the material to cool. Screen the RAP material from the individual stockpiles and separate into individual sizes for No. 8 and larger sieves, and minus No. 8 material. The RAP material shall be screened for 5 minutes ± 15 seconds per Arizona Test Method 240 to prevent excessive breakdown of the RAP agglomerations.

4.3 Dry the individual virgin aggregate stockpile samples to constant mass at 290 ± 10 °F. Allow the material to cool. Screen the virgin aggregate from the individual stockpiles and separate into individual sizes for No. 8 and larger sieves, and minus No. 8 material.

Note: In lieu of drying and screening the virgin aggregate samples for each individual stockpile, a bulk-batched sample may be used as described in Subsection 4.3.1.

4.3.1 Using the adjusted stockpile percentages shown in Mix Design Composite #2 (Virgin Aggregate Composite), the material from the individual stockpiles may be bulk-batched into a single sample of an adequate amount of material necessary to prepare the required calibration samples. Dry the bulk-batched sample to constant mass at 290 ± 10 °F. Allow the material to cool. Screen the bulk-batched material and separate into individual sizes for No. 8 and larger sieves, and minus No. 8 material.

4.4 The RAP aggregate [extracted aggregate (AASHTO T 164 - Method A) from the RAP material] shall be dried to constant mass at 290 ± 10 °F. Allow the material to cool. Screen the RAP aggregate material from the individual stockpiles and separate into individual sizes for No. 8 and larger sieves, and minus No. 8 material.

Note: The batching of samples described below in Subsection 4.5 and Subsection 4.6 is based on the mix design weigh-up information, as shown in the example in Figure 1.

4.5 A gradation check sample is batched using:

- The virgin mineral aggregate component (individual stockpile material or bulk-batched material), which has been screened into individual sizes for No. 8 and larger sieves, and minus No. 8 material.

- The RAP aggregate component, which has been screened into individual sizes for No. 8 and larger sieves, and minus No. 8 material.

- Mineral admixture.

4.5.1 Batch the virgin aggregate portion to Mix Design Composite #2 (Virgin Aggregate Composite). If the individual virgin aggregate stockpiles were screened, batch to the individual accumulative weights required for each individual stockpile, as shown in the example in Figure 2. If bulk-batched virgin aggregate material is used, batch to the accumulative weights required for the total batch weight as shown in the example in Figure 2.

4.5.1.1 The weight of the virgin aggregate portion is determined as follows:

$$W_{va} = \left(\frac{100 - T_{pra}}{100} \right) \text{ x } (W_{ta})$$

Where:

W_{va} = Weight of virgin aggregate
T_{pra} = Total percent of RAP aggregate in mix design
W_{ta} = Weight of total aggregate desired (combined virgin aggregate and RAP aggregate)

Example:

$$W_{va} = \left(\frac{100 - (15 + 10)}{100} \right) \text{ x } (2200) = 1650 \text{ grams}$$

4.5.2 Batch the RAP aggregate portion to Mix Design Composite #1 (Virgin Aggregate and RAP Aggregate Composite), utilizing the accumulative weights required for each individual RAP aggregate material, as shown in the example in Figure 2.

4.5.2.1 The weight of RAP aggregate portion required for each RAP stockpile is determined as follows:

$$W_{ra} = \left(\frac{P_{ra}}{100} \right) \text{ x } (W_{ta})$$

Where:

W_{ra} = Weight of RAP aggregate for each RAP stockpile
P_{ra} = Percent of RAP aggregate used in mix design
W_{ta} = Weight of total aggregate desired (combined virgin aggregate and RAP aggregate)

Example (for fine RAP aggregate):

$$W_{ra} = \left(\frac{15}{100} \right) \text{ x } (2200) = 330.0 \text{ grams}$$

Example (for coarse RAP aggregate):

$$W_{ra} = \left(\frac{10}{100} \right) \text{ x } (2200) = 220.0 \text{ grams}$$

4.5.3 Add the required type and amount of mineral admixture to the virgin aggregate and RAP aggregate and blend thoroughly.

4.5.3.1 The weight of mineral admixture is determined as follows:

$$W_{ad} = \left(\frac{P_{ad}}{100} \right) \text{ x } (W_{ta})$$

Where:

W_{ad} = Weight of mineral admixture
P_{ad} = Percent mineral admixture
W_{ta} = Weight of total aggregate desired (combined virgin aggregate and RAP aggregate)

Example:

$$W_{ad} = \left(\frac{1.0}{100} \right) \text{ x } (2200) = 22 \text{ grams}$$

4.5.4 The weight of the combined virgin aggregate, RAP aggregate, and mineral admixture for the gradation check sample shall conform to the requirements of Table 1.

4.5.5 Perform a gradation analysis on the gradation check sample in accordance with Section 6 to determine the actual gradation.

4.6 Two calibration (burn) samples and also a “butter mix” sample are batched using:

- The virgin mineral aggregate component (individual stockpile material or bulk-batched material), which has been screened into individual sizes for No. 8 and larger sieves, and minus No. 8 material.
- The RAP material (dry screened RAP) component, which has been screened into individual sizes for No. 8 and larger sieves, and minus No. 8 material.
- Mineral admixture.

4.6.1 Batch the virgin aggregate portion to Mix Design Composite #2 (Virgin Aggregate Composite). If the individual virgin aggregate stockpiles were screened, batch to the individual accumulative weights required for each individual stockpile, as shown in the example in Figure 3. If bulk-batched virgin aggregate material is used, batch to the accumulative weights required for the total batch weight as shown in as shown in the example in Figure 3.

4.6.1.1 The weight of the virgin aggregate portion is detemined as shown in Subsection 4.5.1.1.

4.6.2 Add the required type and amount of mineral admixture to each of the batched virgin aggregate samples and blend thoroughly.

4.6.2.1 The weight of the mineral admixture is detemined as shown in Subsection 4.5.3.1.

4.6.3 Form a shallow crater in the center of each of the blended virgin aggregate/mineral admixture samples.

4.6.4 Batch the dry screened RAP portion to Mix Design Composite #3 (Virgin Aggregate and Dry Screened RAP Composite), utilizing the accumulative weights required for each individual dry screened RAP material, as shown in the example in Figure 3.

4.6.4.1 The weight of the dry screened RAP portion from each RAP stockpile is determined as follows:

$$W_{rap} = \left(\frac{W_{ra}}{1 - \frac{P_{br}}{100}} \right)$$

Where:

W_{rap} = Weight of dry screened RAP from each RAP stockpile
W_{ra} = Weight of RAP aggregate for each RAP stockpile
P_{br} = Percent binder content of each RAP stockpile

Example (for fine RAP stockpile):

$$W_{rap} = \left(\frac{330.0}{1 - \frac{5.82}{100}} \right) = 350.4 \text{ grams}$$

Example (for coarse RAP stockpile):

$$W_{rap} = \left(\frac{220.0}{1 - \frac{3.43}{100}} \right) = 227.8 \text{ grams}$$

4.6.5 Place the dry screened RAP material in the crater formed in each of the blended virgin aggregate/mineral admixture samples.

4.6.6 The weight of the combined virgin aggregate, dry screened RAP, and mineral admixture for each calibration sample and the “butter mix” sample shall be such that when the required amount of virgin asphalt binder is added, they conform to the requirements of Table 1.

Note: It is recommended that an initial calibration sample be prepared and tested in accordance with the requirements of Subsection 4.6.7 prior to the preparation of additional samples. Doing so may help avoid the waste of the limited amount of dry screened RAP material.

4.6.7 Prior to the addition of the virgin binder, record the weight of the combined virgin aggregate, dry screened RAP, and mineral admixture for each calibration sample to the nearest 0.1 gram as the “Weight of Initial Charge Before Drying”. Dry each charge to constant mass at 290 ± 10 °F, allow to cool, and record the weight to the nearest 0.1 gram as the “Weight of Initial Charge After Drying”. If the loss from drying is greater than

25 grams, discard the charge and prepare a new charge using the same procedure, except the dry screened RAP shall be initially dried overnight at 160° ± 3 °F, and drying continued at 160° ± 3 °F until the mass, after successive one-half hour periods of drying, indicates no change in mass. Do not add make-up material to account for any loss from drying, as doing so will change the gradation of the samples.

Note: The extended drying at the increased temperature (from 140 ± 10 °F to 160° ± 3 °F) specified above is to ensure that all moisture is removed from the dry screened RAP material.

4.6.8 Two calibration samples and the butter mix are prepared as described below at the design total asphalt binder content. The asphalt binder grade and type shall be the same as will be used in the asphalt concrete mixture to be tested during production. The percent total asphalt binder content is based on the mass of the total mix. For each sample, the weight of virgin asphalt binder to be added is determined using the calculations in Subsections 4.5.1.1, 4.5.3.1, and 4.5.6.1 in conjunction with Subsections 4.6.8.1, 4.6.8.2, and 4.6.8.3.

4.6.8.1 The weight of binder contributed by the RAP material from each RAP stockpile is determined as follows:

$$W_{rb} = \left(\frac{P_{br}}{100} \right) \text{ x } \left(W_{rap} \right)$$

Where:

W_{rb} = Weight of binder contributed by each RAP stockpile
P_{br} = Percent binder content of each RAP stockpile
W_{rap} = Weight of RAP from each RAP stockpile

Example (for fine RAP stockpile):

$$W_{rb} = \left(\frac{5.82}{100} \right) \text{ x } (350.4) = 20.39 \text{ grams}$$

Example (for coarse RAP stockpile):

$$W_{rb} = \left(\frac{3.43}{100} \right) \text{ x } (227.8) = 7.81 \text{ grams}$$

4.6.8.2 The weight of total binder is determined as follows:

$$W_{tb} = \left(\frac{W_{va} + T_{wra} + W_{ad}}{100 - P_{tb}} \right) \text{ x } (P_{tb})$$

Where:

W_{tb} = Weight of total binder
W_{va} = Weight of virgin aggregate
T_{wra} = Total weight of RAP aggregate
W_{ad} = Weight of mineral admixture
P_{tb} = Percent total binder (mix design percent binder content)

Example:

$$W_{tb} = \left(\frac{1650 + (330 + 220) + 22}{100 - 5.4} \right) \text{ x } (5.4) = 126.84 \text{ grams}$$

4.6.8.3 The weight of virgin asphalt binder to be added is determined as follows:

$$W_{vb} = (W_{tb}) - (W_{trb})$$

Where:

W_{vb} = Weight of virgin asphalt binder to be added
W_{tb} = Weight of total binder
W_{trb} = Total weight of binder contributed by RAP stockpiles

Example:

$$W_{vb} = (126.84) - (20.39 + 7.81) = 98.6 \text{ grams}$$

Note: If desired, the percent of the total binder which is contributed by RAP can be calculated as follows:

$$\left[\begin{array}{c} \text{Percent of Total} \\ \text{Binder Contributed} \\ \text{by RAP} \end{array} \right] = \left(\frac{W_{trb}}{W_{tb}} \right) \text{ x } (100)$$

Where:

W_{trb} = Total weight of binder contributed by RAP stockpiles
W_{tb} = Weight of total binder required

Example:

$$\begin{bmatrix} \text{Percent of Total} \\ \text{Binder Contributed} \\ \text{by RAP} \end{bmatrix} = \left(\frac{(20.39 + 7.81)}{126.84} \right) \text{ x } (100) = 22.23\%$$

4.6.8.4 All bowls, sample pans, and mixing tools shall be preheated to approximately the laboratory mixing temperature prescribed in the mix design. At the time mixing of the samples begins, the temperature of the asphalt binder, virgin aggregate, RAP, and mineral admixture shall be in accordance with the prescribed laboratory mixing temperature $\pm$ 5 °F. Each individual sample shall be thoroughly mixed. All samples shall be mixed at the same mixing temperature $\pm$ 5 °F.

Note: If the mix design laboratory mixing temperature is not specified, a temperature of 300 $\pm$ 5 °F shall be used.

4.7 Preheat the ignition furnace to 538 $\pm$ 5 °C (1000 $\pm$ 9 °F), or as modified in Subsection 4.13. Do not preheat the sample basket.

4.8 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

4.9 The freshly mixed samples may be placed directly in the sample basket assembly. If the samples are allowed to cool, they must be reheated in a 290 $\pm$ 10 °F oven for 25 minutes.

4.10 Test samples in accordance with Subsections 5.6 through 5.14.

4.11 If the difference between the measured asphalt binder content of the two samples exceeds 0.07, repeat the test using two additional samples, and from the four results discard the high and the low values.

4.12 Subtract the actual asphalt binder content for each of the two samples from their respective measured asphalt binder content. The asphalt binder content calibration factor is the average of the two resultant values expressed in percent by mass of the asphalt mixture.

4.13 If the asphalt binder content calibration factor exceeds ± 1.25 percent, lower the test temperature to 482 ± 5 °C (900 ± 9 °F) and repeat the test to determine a new calibration factor. If the calibration factor continues to exceed ± 1.25 percent, lower the test temperature to 427 ± 5 °C (800 ± 9 °F) and repeat the test to determine a new calibration factor. Use the calibration factor obtained at 427 ± 5 °C (800 ± 9 °F) even if it exceeds ± 1.25 percent.

4.14 Perform a gradation analysis on the residual aggregate as indicated in Section 6. Subtract the actual percent passing the No. 200 sieve for each sample from the measured percent passing the No. 200 sieve (as determined in Subsection 4.5.5). Determine the average of the two values. If the resultant average value is greater than ± 0.50, an aggregate gradation correction factor (equal to the resultant average value) for the passing No. 200 material may be applied to the production field sample test results.

5. PROCEDURE

5.1 The moisture content of the asphaltic concrete shall be determined in accordance with Arizona Test Method 406. The moisture content sample shall be obtained at the same time and subjected to the same treatment prior to testing as the asphalt binder content test sample. As an alternate to performing the moisture determination, the test sample may be dried to a constant mass in an oven at 290 ± 10 °F.

5.2 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F), or to the alternate temperature determined during the calibration (Subsection 4.13). Do not preheat the sample basket. Record the furnace temperature set point prior to the initiation of the test.

5.3 Record the asphalt binder content calibration factor, determined in accordance with Subsections 4.11 through 4.13, for the specific mix to be tested.

5.4 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

5.5 Obtain the asphalt binder content test sample in accordance with Subsection 3.2, ensuring that the size of the test sample is within ± 150 grams of the sample size used for calibration and that the test sample conforms to the requirements shown in Table 1.

5.6 Evenly distribute the test sample over the center of the sample basket(s) and level the material. Use a spatula or trowel to pull material approximately one inch away from the outside edge of basket(s).

5.7 Weigh and record the mass of the sample and basket assembly to the nearest 0.1 gram.

5.8 Calculate and record the initial mass of the sample to the nearest 0.1 gram.

5.9 Set the ignition furnace controller print mode to give a printout of the test data required in Subsection 2.1.1. Input the initial mass of the sample into the ignition furnace controller. Verify that the correct mass has been entered.

5.10 Open the furnace door and place the sample and basket assembly so that it is centered in the chamber. After assuring that the sample basket assembly is not in contact with any wall, close the door. Initiate the test by pressing the start button. This will lock the furnace door and start testing.

5.11 Allow the test to continue until the stable light and audible stable indicator indicates the test is complete. The test is deemed complete when the measured mass loss does not exceed 0.01 percent of the sample mass for three consecutive one minute intervals. If required, press the stop button. This will unlock the furnace door and cause the printer to print out the test results.

5.12 Open the furnace door and remove the sample and basket assembly. Allow the sample to cool 30 ± 5 minutes in the basket assembly. Weigh and record the mass of the sample and basket assembly after ignition to the nearest 0.1 gram.

5.13 Calculate and record the mass of sample after ignition to the nearest 0.1 gram.

5.14 Calculate and record the corrected asphalt binder content of the sample, to the nearest 0.01%, as follows:

$$\%AC = \left[\frac{W_i - W_A}{W_i} \times 100 \right] - C_F - \%M$$

Where: %AC = measured (corrected) asphalt binder content in percent by mass of the sample
W_i = mass of the sample prior to ignition
W_A = mass of the sample after ignition
C_F = asphalt binder content calibration factor, percent by mass of the sample
%M = percent moisture in the sample

Note: During calibration, C_F and %M are zero.

5.14.1 If an ignition furnace correction (tank stab correction) is made, the %AC determined in Subsection 5.14 is adjusted by that correction.

5.15 Attach the original printed ticket to the back of the card.

5.16 Empty the contents of the baskets into a flat pan. Use a small wire sieve brush to ensure that any residual fines are removed from the baskets. Take care not to lose any material, as this will affect gradation results.

5.17 If needed, perform a gradation analysis of the residual aggregate according to Section 6.

6. SIEVE ANALYSIS OF AGGREGATE

6.1 If required, the aggregate shall be subjected to sieve analysis as described below. The coarse sieving shall be performed in accordance with Subsection 6.2, and the fine sieving in accordance with Subsection 6.3. The quantity of material on a given sieve at the completion of sieving shall not exceed the amount shown Table 2.

6.2 The coarse sieving of the aggregate shall be performed as follows:

6.2.1 Weigh and record the mass of the sample to be sieved to the nearest gram. Place sample on the top sieve of a nest of 12 inch sieves. The nest of sieves shall consist of sieves starting with the smallest size sieve that 100% of the material will pass, down through and including the No. 8 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.2.2 Weigh and record separately, to the nearest gram, the mass of the material retained on the individual sieves and in the pan. The material retained in the pan is recorded as the minus No. 8 material.

TABLE 2			
Sieve Size	**Maximum Mass Allowed (grams/sq. in.)**	**Maximum Mass Allowed (grams)**	
		8 inch Diameter Sieve	**12 inch Diameter Sieve**
1-1/2”	25	---	2827
1”	18	---	2036
3/4”	14	---	1583
1/2”	10	---	1131
3/8”	8	---	905
1/4”	6	---	679
No. 4	5	---	565
No. 8 and smaller	4	201	452

6.2.3 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 8 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.2.4 Determine the coarse sieve factor by dividing 100 by the total mass sieved. Record the factor to six decimal places.

6.2.5 The percent passing for each sieve in the coarse sieve analysis is determined by multiplying the mass retained on that sieve by the coarse sieve factor, and subtracting the result from the unrounded % passing for the next larger sieve. Values for "mass retained multiplied by the coarse sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent.

6.2.6 As a check on the coarse sieve analysis, multiply the mass of minus No. 8 material by the coarse sieve factor. The result of this calculation, rounded to the nearest percent, should be the same as the value for percent passing the No. 8 sieve determined in Subsection 6.2.5 above.

6.2.7 The material passing the No. 8 sieve is split, if necessary, to obtain a minimum 500 gram sample for fine fine sieving; however, the sample size may be less than 500 grams if a minimum of 500 grams is not obtained from coarse sieving. If less than 800 grams passes the No. 8 sieve, the entire amount shall be subjected to fine sieving. The mass of the sample for fine sieving is recorded to the nearest gram as mass of pass No. 8 split.

6.3 The elutriation and fine sieving of the pass No. 8 material shall be performed as follows:

6.3.1 Subject sample to elutriation through a No. 200 screen either by hand or mechanical washing.

6.3.2 Dry sample to constant mass, allow to cool, then weigh and record the dry mass to the nearest gram.

6.3.3 Place sample on the top sieve of a nest of fine sieves. The nest of sieves shall consist of sieves starting with the No. 10 sieve, down through and including the No. 200 sieve and pan. Place lid on nested sieves and screen the material by either mechanical or hand shaking, until not more than 0.5 percent by mass of sample passes any sieve during one minute.

6.3.4 Weigh and record separately, to the nearest gram, the mass of material retained on the individual sieves and in the pan.

6.3.5 Do not discard any of the sieved material until the sum of the individual masses is compared to the mass of the sample prior to sieving. If the difference between the two masses is less than or equal to 1.0% of the mass of the sample prior to sieving, an adjustment in mass shall be made on the sieve which has the largest mass retained, except no adjustment shall be made on the minus No. 200 material. If the difference is greater than 1.0%, the sample shall be recombined, resieved, and carefully reweighed.

6.3.6 Determine and record elutriation to nearest gram by determining the difference between the dry mass and the mass of the pass No. 8 split.

6.3.7 Determine a factor for calculating the fine sieve analysis by dividing the percent passing the No. 8 sieve (recorded to the nearest percent) by the mass of pass No. 8 split. Record the factor to six decimal places. If all the pass No. 8 material from coarse sieving was subjected to elutriation and fine sieving, a fine sieve factor is not determined. Rather, the coarse

sieve factor is utilized and the calculation of the percent passing each sieve is continuous through the entire sieve analysis.

6.3.8 The percent passing for each sieve in the fine sieve analysis is determined by multiplying the mass retained on that sieve by the fine sieve factor, and subtracting the result from the unrounded % passing the next larger sieve, with the exception of the percent passing the No. 8 which has previously been recorded to the nearest percent. Values for "mass retained multiplied by the fine sieve factor" and "percent passing each sieve" shall be determined and used in the calculations to six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest percent, except the percent passing the No. 200 sieve is recorded to the nearest 0.1 percent.

6.3.9 As a check on the fine sieve analysis, the mass of material passing the No. 200 sieve is added to the elutriation mass, and this total is multiplied by the fine sieve factor. The result of this calculation, rounded to the nearest 0.1 percent, should be the same as the value for the percent passing the No. 200 sieve determined in Subsection 6.3.8 above.

6.3.10 If an aggregate gradation correction factor is utilized, the percent passing the No. 200 sieve shall be adjusted by subtracting the correction factor determined in Subsection 4.14.

6.4 Other methods may be used that differ from that specified in Subsections 6.2 and 6.3 above to determine % passing each sieve, so long as the method utilized has been proven to give equivalent results. However, any procedure which includes recording percent retained values prior to completing the calculation of all percent passing values is not allowed.

7. REPORT AND EXAMPLE

7.1 Report test information on the Asphaltic Concrete Tabulation – Ignition Furnace laboratory card. An example for the testing performed on a field sample is shown in Figure 4. Only the portion of the laboratory card relevant to the ignition furnace test is used for the example. A blank Asphaltic Concrete Tabulation – Ignition Furnace laboratory card is shown in Figure 5.

7.1.1 Mass of basket assembly.

7.1.2 Mass of sample and basket assembly.

7.1.3 Calculated initial mass of the sample.

7.1.4 Mass of sample and basket assembly after ignition.

7.1.5 Calculated mass of sample after ignition.

7.1.6 Asphalt binder content calibration factor.

7.1.7 Percent moisture from moisture test, if one was performed.

7.1.8 Corrected percent asphalt binder content.

7.1.9 Elapsed time of test.

7.1.10 Name of the operator.

7.1.11 Sample test date.

7.1.12 Design percent asphalt binder content.

7.1.13 Ignition furnace set temperature.

7.1.14 If determined, the sieve analysis of the residual aggregate (corrected for passing the No. 200 sieve if applicable).

Ignition Furnace Calibration
Mix Design Weigh-Up Information

Weight of Total Virgin Aggregate Required if Bulk Batching is Used (grams) (Furnace Calibration, Aggregate Properties Testing, etc.)	10000
Total Weight of Aggregate Charge (grams) (Virgin + RAP Aggregate needed for each Gradation Check and Burn)	2200

EXAMPLE

Total Binder Content (% by wt of total mix)	5.40	
Virgin Binder Content (% by wt of total mix)	4.20	
RAP Binder Content (% by wt of total mix)	1.20	
Total Virgin Aggregate (% by weight of total aggregate)		75.0
Total RAP Aggregate (% by weight of total aggregate)		25.0
	Total	100.0
Admixture (% by weight of total aggregate)		1.0

	Virgin Aggregate Stockpiles (Composite #2)					
	Sieve Analysis (Percent Passing)					Adjusted
Stockpile Description	WCF	CF	3/8	3/4	Total	Virgin Composite
Percent Used (w/o Admix)*	35.0	13.0	8.0	19.0	75.0	100.00
Adjusted Percent Used	46.67	17.33	10.67	25.33	100.00	
Sieve Size						
1.5"	100.0	100.0	100.0	100.0		100.00
1"	100.0	100.0	100.0	100.0		100.00
3/4"	100.0	100.0	100.0	82.0		95.44
1/2"	100.0	100.0	100.0	13.6		78.11
3/8"	100.0	100.0	100.0	4.0		75.68
1/4"	100.0	100.0	59.0	1.6		70.70
#4	97.1	98.8	22.5	1.6		65.24
#8	60.8	70.1	1.3	1.5		41.04
	* If unadjusted percent virgin agggregate stockpile use is not shown in Compostite #2, see Composite #1.					

Total Weight Required from each Stockpile if Bulk Batching Virgin Aggregates					Total
	4666.7	1733.3	1066.7	2533.3	10000.0

	Dry Screened RAP (Composite #3)		RAP Aggregate (Composite #1)		
	Sieve Analysis (Percent Passing)		Sieve Analysis (Percent Passing)		
Stockpile Description	Fine	Coarse	Fine	Coarse	Total
Percent Used (w/o Admix)			15.0	10.0	25.0
Adjusted Percent Used			60.0	40.0	100.0
Sieve Size					
1.5"	100.0	100.0	100.0	100.0	
1.25"	100.0	100.0	100.0	100.0	
1"	100.0	100.0	100.0	100.0	
3/4"	100.0	94.4	100.0	100.0	
1/2"	100.0	57.1	100.0	63.0	
3/8"	100.0	13.7	100.0	10.5	
1/4"	68.1	8.0	93.3	8.0	
#4	54.5	4.9	77.6	6.0	
#8	24.8	2.2	66.1	5.0	
	NOTE: Overall, Composite #2 (RAP Aggregate) will be finer than Composite #3 (Dry Screened RAP).				
RAP Mat'l Binder Content (%)	5.82	3.43			

FIGURE 1

Ignition Furnace Calibration
Weigh-Up Requirements for Gradation Check

Stockpile Description	Virgin Aggregate Stockpiles (Composite #2)				
	WCF	CF	3/8	3/4	Total
Percent Used (w/o Admix)	35.0	13.0	8.0	19.0	75.0
Adjusted Percent Used	46.67	17.33	10.67	25.33	100.00
Sieve Size	Accumulative Weights Required (grams)				
1.5"	0.0	0.0	0.0	0.0	0.0
1"	0.0	0.0	0.0	0.0	0.0
3/4"	0.0	0.0	0.0	75.2	75.2
1/2"	0.0	0.0	0.0	361.2	361.2
3/8"	0.0	0.0	0.0	401.3	401.3
1/4"	0.0	0.0	72.2	411.3	483.5
#4	22.3	3.4	136.4	411.3	573.5
#8	301.8	85.5	173.7	411.7	972.8
-#8	770.0	286.0	176.0	418.0	1650.0

NOTE: Use individual stockpile accumulative weights if Virgin Aggregate is not Bulk Batched. Use total accumulative weights if Virgin Aggregate is Bulk Batched prior to sieving.

Stockpile Description	Dry Screened RAP (Composite #3)	
	Fine	Coarse
Percent Used (w/o Admix)		
Adjusted Percent Used		
Sieve Size	Accumulative Weights Required (grams)	
1.5"	N/A	N/A
1.25"	N/A	N/A
1"	N/A	N/A
3/4"	N/A	N/A
1/2"	N/A	N/A
3/8"	N/A	N/A
1/4"	N/A	N/A
#4	N/A	N/A
#8	N/A	N/A
-#8	N/A	N/A
RAP Mat'l Binder Content (%)	5.82	3.43

RAP Aggregate (Composite #1)		
Fine	Coarse	Total
15.0	10.0	25.0
60.0	40.0	100.0
Accumulative Weights Required (grams)		
0.0	0.0	
0.0	0.0	
0.0	0.0	
0.0	0.0	
0.0	81.4	
0.0	196.9	
22.1	202.4	
73.9	206.8	
111.9	209.0	
330.0	220.0	

EXAMPLE

Gradation Check Material Requirements

Total Virgin Aggregate Weight Required (grams)	1650.0
Total RAP Aggregate Weight Required (grams)	550.0
Admixture Weight Required (grams)	22.0
Final Charge Weight (grams)	2222.0

FIGURE 2

Ignition Furnace Calibration
Weigh-Up Requirements for Burn 1 & 2

	Virgin Aggregate Stockpiles (Composite #2)				
Stockpile Description	WCF	CF	3/8	3/4	Total
Percent Used (w/o Admix)	35.0	13.0	8.0	19.0	75.0
Adjusted Percent Used	46.67	17.33	10.67	25.33	100.00
Sieve Size	Accumulative Weights Required (grams)				
1.5"	0.0	0.0	0.0	0.0	0.0
1"	0.0	0.0	0.0	0.0	0.0
3/4"	0.0	0.0	0.0	75.2	75.2
1/2"	0.0	0.0	0.0	361.2	361.2
3/8"	0.0	0.0	0.0	401.3	401.3
1/4"	0.0	0.0	72.2	411.3	483.5
#4	22.3	3.4	136.4	411.3	573.5
#8	301.8	85.5	173.7	411.7	972.8
-#8	770.0	286.0	176.0	418.0	1650.0
NOTE: Use individual stockpile accumulative weights if Virgin Aggregate is Bulk Batched. Use total accumulative weights is Virgin Aggregate is Batched prior to sieving.					

	Dry Screened RAP (Composite #3)		RAP Aggregate (Composite #1)	
Stockpile Description	Fine	Coarse	Fine	Coarse
Percent Used (w/o Admix)			N/A	N/A
Adjusted Percent Used			N/A	N/A
Sieve Size	Accumulative Weights Required (grams)		Accumulative Weights Required (grams)	
1.5"	0.0	0.0	N/A	N/A
1.25"	0.0	0.0	N/A	N/A
1"	0.0	0.0	N/A	N/A
3/4"	0.0	12.8	N/A	N/A
1/2"	0.0	97.7	N/A	N/A
3/8"	0.0	196.6	N/A	N/A
1/4"	111.8	209.6	N/A	N/A
#4	159.4	216.7	N/A	N/A
#8	263.5	222.8	N/A	N/A
-#8	350.4	227.8	N/A	N/A
RAP Mat'l Binder Content (%)	5.82	3.43		
Total Wt. of RAP Mat'l (grams)	350.4	227.8		
			Total	
Weight of RAP Binder (grams)	20.39	7.81	28.20	

Weight of Total Binder (grams)	126.84
RAP Binder Content (% by weight of total binder)	22.23
Total RAP Aggregate (% by weight of total aggregate)	25.00

EXAMPLE

Burn 1 & 2 Material Requirements

Total Virgin Aggregate Weight Required (grams)	1650.0
Total RAP Material Weight Required (grams)	578.2
Admixture Weight Required (grams)	22.0
Virgin Binder Weight Required (grams)	98.6
Final Charge Weight (grams)	2348.8

FIGURE 3

ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
13-0079	5555	AC	RC	A	P		

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
3	5	BETTY BOOP	05	02	13	1415 (MILITARY TIME)

SAMPLED FROM	LIFT NO.	RDWY	STATION
ROADWAY - 10' Rt. of ℄	1	NB	999+00 (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
RED RIVER VALLEY PIT	Bob Heidman	F-099-9(99)	H099901C

REMARKS
416 3/4" SPECIAL MIX (WITH RAP)

EXAMPLE

COARSE FACTOR 043860 = 100 / COARSE SIEVE TOTAL

WEIGHTS RETAINED		% RET	% PASS	SPECS
3″				
2 1/2″				
2″				
1 1/2″				
1″		0	100	
3/4″	91	4	96	
1/2″	319	14	82	
3/8″	160	7	75	
1/4″	182	8	67	
#4	137	6	61	
#8	433	19		
-#8	958	✓	42	
Total	2280	= i (Rounded)		

Weight of Pass #8 Split: 493 = p

FINE FACTOR 085193 = % Pass #8 / Wt. of Pass #8 Split

WEIGHTS RETAINED		% RET	% PASS	SPECS
#10	46	4	38	
#16	162	14	24	
#30	81	7	17	
#40	39	3	14	
#50	24	2	12	
#100	33	3	9	
#200	45	4		
-#200	31	r	5.4	
Total	461	q = Dry Weight		
Elutriation	32	= p - q		

r - s = 4.8 Corrected % Pass No. 200

% Pass No. 200 Correction Factor (±) + 0.6 s

IGNITION FURNACE ARIZ. 427☐ ARIZ. 428☒

a. Wet Mass of Moisture Sample	1023.2 g
b. Dry Mass of Moisture Sample	1020.5 g
c. Moisture Content (ARIZ 406) [(a - b) / a] x 100	0.26 %
d. Mass of Basket Assembly	3057.3 g
e. Mass of Sample and Basket Assembly	5471.5 g
f. Initial Mass of Sample (e - d)	2414.2 g
g. Ignition Furnace Set Temperature	538 °C
h. Mass of Sample and Basket Assembly After Ignition	5337.3 g
i. Mass of Sample After Ignition (h - d)	2280.0 g
j. Uncorrected Asphalt Binder Content [(f - i) /f] x 100	5.56 %
k. Asphalt Binder Content Calibration Factor (±)	+ 0.23 %
l. Ignition Furnace Correction (Tank Slab Correction) (±)	- 0.17 %
m. Corrected Asphalt Binder Content (j - k - c - l)	5.24 %
n. Design Asphalt Binder Content	5.40 %
o. Elapsed Time of Test (minutes)	67

COMPACTION
Marshall = M Gyratory = G Core = C ☐

RICE
Sample Max. Sp. Gr. (Gmm)
Sample Max. Density [(Gmm) x (62.3)] pcf

MARSHALL
Average Bulk O.D. Sp. Gr. (Gmb)
Average Bulk Density [(Gmb) x (62.3)] pcf
Air Voids = %
[1 - (Average Bulk Density / Max Density From Rice Test)] x 100
Stability lbs
Flow 0.01 in

GYRATORY
Average Relative Density (% Gmm) at Ndesign pcf
Air Voids = %
100 - [Average Relative Density % (Gmm) at Ndesign]

WHITE ☐
YELLOW ☐
BLUE ☐

05-02-13
RECEIVED DATE

M. Twain 05-03-13
TEST OPERATOR AND DATE

T. Sawyer 05-03-13
SUPERVISOR AND DATE

44-9372 R03/13

SEE BACK ALSO

FIGURE 4

ARIZONA DEPARTMENT OF TRANSPORTATION
ASPHALTIC CONCRETE TABULATION – IGNITION FURNACE

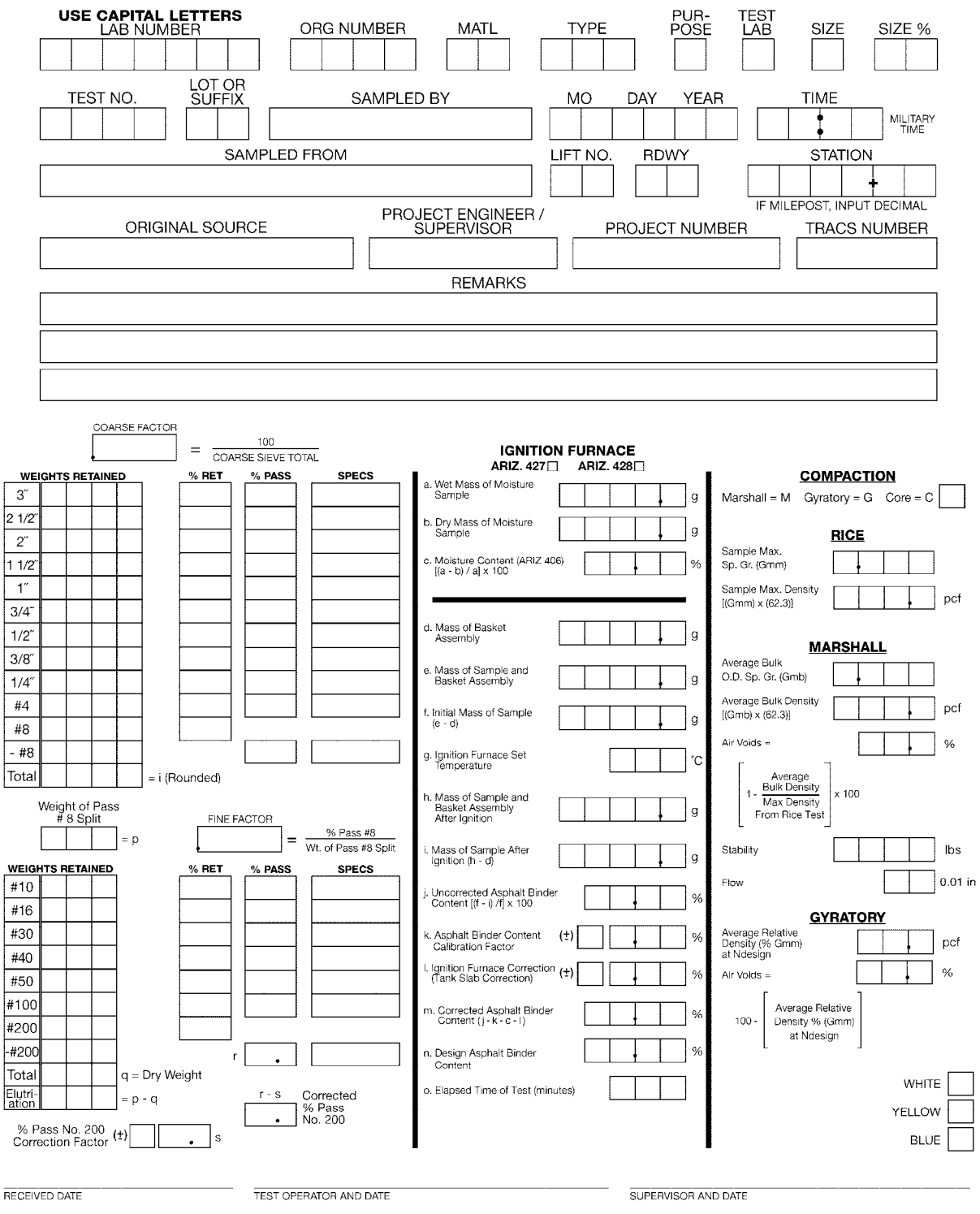


FIGURE 5

APPENDIX A

DETERMINATION OF GRADATION, MOISTURE CONTENT, AND BINDER CONTENT OF THE RAP MATERIAL

A.1 Obtain a representative sample of the RAP material in accordance with Arizona Test Method 105. When multiple RAP stockpiles are used, a separate representative sample shall be obtained from each stockpile.

A.1.1 The sample shall be split to provide a sufficient amount of material for gradation testing, moisture content testing, and binder content testing.

A.2 The entire split sample of RAP material from each stockpile is dried at 140 °F and the percent moisture content determined as described below.

Note: A higher drying temperature is not appropriate because it will soften the binder causing the RAP material to break into smaller particles and adhere to the drying pan.

A.2.1 The weight of the RAP material from each stockpile is determined and recorded to the nearest 0.1 gram.

A.2.2 The material is dried to constant weight at 140 ± 10 °F.

Note: Drying to constant weight at 140 °F will typically take overnight.

A.2.3 After drying to constant weigtht at 140 ± 10 °F, cover the material and allow to cool 30 ± 10 minutes at room temperature. The weight of the RAP material is then determined and recorded to the nearest 0.1 gram.

A.2.4 The percent moisture content of the RAP material from each stockpile is determined and recorded to the nearest 0.01 percent by the following:

$$\left[\begin{array}{c}\text{Percent Moisture} \\ \text{Content}\end{array}\right] = \left[\frac{\left(\begin{array}{c}\text{Weight of Material} \\ \text{Prior to Drying}\end{array}\right) - \left(\begin{array}{c}\text{Weight of Material} \\ \text{After Drying}\end{array}\right)}{\left(\begin{array}{c}\text{Weight of Material} \\ \text{After Drying}\end{array}\right)}\right] \text{ x } 100$$

A.3 After drying and determining the moisture content at 140 °F, the RAP material shall be tested for gradation, moisture content (at 290 °F), and binder content.

A.3.1 The gradation of the RAP material from each stockpile shall be determined as described below.

A.3.1.1 Split out a representative sample of the RAP material from each stockpile which conforms to the size specified in Table 3.

TABLE 3

Maximum Size of Particle (See Note)	Minimum Weight of Sample, grams
3/4 in. and larger	5000
1/2 in.	2000
3/8 in.	1000

Note: The smallest sieve opening through which the entire amount of material will pass.

A.3.1.2 Dry sieve the material in accordance with Arizona Test Method 240, with the exception that the No. 8 sieve shall be used as the smallest sieve. (Arizona Test Method 240 limits the time for shaking the sample to 5 minutes ± 15 seconds to control breakdown of the particles of RAP material into smaller size fractions.) The gradation of the RAP material from each stockpile is then determined in accordance with Arizona Test Method 248, Alternate #2.

A.3.2 The percent moisture content of the RAP material from each stockpile shall be determined by drying at 290 °F as described below.

Note: The sample for determining the moisture content at 290 °F shall be obtained at the same time and subjected to the same treatment prior to testing as the sample obtained for determining the RAP binder content.

A.3.2.1 Split out a representative 1000 ± 50 gram sample of the RAP material from each stockpile. The weight of each sample is determined and recorded to the nearest 0.1 gram.

A.3.2.2 Each sample is dried at 290 ± 10 °F to constant weight. Constant weight is defined as the weight at which further drying does not alter the weight more than 0.1 gram at intervals of a minimum of 30 minutes.

A.3.2.3 After drying to constant weight at 290 ± 10 °F, cover the sample and allow to cool 30 ± 10 minutes at room temperature. The weight of the sample is then determined and recorded to the nearest 0.1 gram.

A.3.2.4 The percent moisture content of the RAP material from each stockpile is determined and recorded to the nearest 0.01 percent by the following:

$$\left[\begin{array}{c}\text{Percent Moisture} \\ \text{Content}\end{array}\right] = \left[\frac{\left(\begin{array}{c}\text{Weight of Material} \\ \text{Prior to Drying}\end{array}\right) - \left(\begin{array}{c}\text{Weight of Material} \\ \text{After Drying}\end{array}\right)}{\left(\begin{array}{c}\text{Weight of Material} \\ \text{Prior to Drying}\end{array}\right)}\right] \text{ x } 100$$

A.3.3 The total percent moisture content of the RAP material from each stockpile is determined by adding the percent moisture content by drying at 140 °F (Subsection A.2) to the percent moisture content by drying at 290 °F (Subsection A.3.2).

A.3.4 The binder content of the RAP material from each stockpile shall be determined as described below.

A.3.4.1 Split out a representative sample of the RAP material from each stockpile which conforms to the size specified in Table 4.

TABLE 4

Nominal Maximum RAP Aggregate Size (See Notes)	Mass of Sample, grams
1 in.	2500 – 3000
3/4 in.	2000 – 2500
1/2 in.	1500 – 2000
3/8 in.	1200 – 1700
No. 4	1200 – 1700

Note: The nominal maximum RAP aggregate size is defined as: One size larger than the first sieve that retains more than 10 percent RAP aggregate.

Note: To determine the nominal maximum RAP aggregate size, the RAP aggregate gradation of each RAP stockpile, as shown in the mix design or as detemined from previous testing, may provide information.

A.3.4.2 Preheat the ignition furnace to 538 ± 5 °C (1000 ± 9 °F). Do not preheat the sample basket.

A.3.4.3 Weigh and record the mass of the basket assembly to the nearest 0.1 gram.

A.3.4.4 Perform ignition furnace testing on the RAP material from each stockpile in accordance with Subsections 5.6 through 5.13.

A.3.4.5 Calculate and record the binder content of the material from each RAP stockpile, to the nearest 0.01%, as follows:

$$\%AC = \left[\frac{W_i - W_A}{W_i} \times 100 \right] - \%M$$

Where:
- %AC = measured RAP binder content in percent by mass of the sample
- W_i = mass of the sample prior to ignition
- W_A = mass of the sample after ignition
- %M = percent moisture in the sample (determined by drying at 290 °F, per Subsection A.3.2)

A.3.4.5.1 Retain the original printed ticket and save with other test documentation.

A.3.4.6 Each measured binder content test result, as determined in Subsection A.3.4.5, is adjusted by the appropriate RAP binder content correction factor (See Appendix B). This adjustment is made by adding the RAP binder correction factor to each measured binder content. The corrected RAP binder content is recorded to the nearest 0.01%.

A.4 If needed, determine the RAP aggregate gradation by performing a sieve analysis of the residual aggregate in accordance with Section 6.

Note: Subsection 6.3.10 does not apply when determining the RAP aggregate gradation.

A.5 Report test information on the “RAP Material Tabulation - Ignition Furnace” laboratory card. An example is shown in Figure 6. A blank “RAP Material Tabulation - Ignition Furnace” laboratory card is shown in Figure 7.

ARIZONA DEPARTMENT OF TRANSPORTATION
RAP MATERIAL TABULATION – IGNITION FURNACE
(Arizona Test Method 428 - Appendix A)

WHITE ☐ YELLOW ☐ BLUE ☐

USE CAPITAL LETTERS

LAB NUMBER	ORG NUMBER	MATL	TYPE	PURPOSE	TEST LAB	SIZE	SIZE %
13-0027	5555	RP	C	A	P		

TEST NO.	LOT OR SUFFIX	SAMPLED BY	MO	DAY	YEAR	TIME
		BETTY BOOP	04	29	13	1035 MILITARY TIME

SAMPLED FROM	LIFT NO.	RDWY	STATION
STOCKPILE			+ (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE	PROJECT ENGINEER / SUPERVISOR	PROJECT NUMBER	TRACS NUMBER
EXISTING ROADWAY MILLINGS	Bob Heidman	F-099-9(99)	H099901C

REMARKS

EXAMPLE

RAP Material Moisture Content @ 140°F

p. Wet Mass of RAP Material	10185.5	g
q. Dry Mass of RAP Material	10134.8	g
r. Moisture Content @ 140°F [(p - q) / q] x 100	0.50	%

RAP Material Gradation (ARIZ 240 / ARIZ 248, Alt. #2)

FACTOR 015293 = 100 / TOTAL

	WEIGHTS RETAINED	% RET	% PASS	SPECS
3"				
2 1/2"				
2"				
1 1/2"				
1 1/4"		0	100	100
1"	134	2	98	
3/4"	455	7	91	
1/2"	1942	30	61	
3/8"	2977	45	16	0-25
1/4"	585	9	7	
#4	129	2	5	
#8	140	2		
- #8	177	✓	3	
Total	6539			

Total RAP Material Moisture Content

r. Moisture Content @ 140°F	0.50	%
c. Moisture Content @ 290°F	0.16	%
s. Total Moisture Content (r + c)	0.66	%

Ignition Furnace

a. Wet Mass of Moisture Sample	989.3	g
b. Dry Mass of Moisture Sample	987.7	g
c. Moisture Content @ 290°F [(a - b) / a] x 100	0.16	%
d. Mass of Basket Assembly	3045.7	g
e. Mass of Sample and Basket Assembly	5631.3	g
f. Initial Mass of Sample (e - d)	2585.6	g
g. Ignition Furnace Set Temperature	538	°C
h. Mass of Sample and Basket Assembly After Ignition	5525.3	g
i. Mass of Sample After Ignition (h - d)	2479.6	g
j. Measured RAP Binder Content {[(f - i) /f] x 100} - c	3.94	%
k. RAP Binder Content Correction Factor	(±) - 0.37	%
l. Corrected RAP Binder Content (j + k)	3.57	%
m. Elapsed Time of Test (minutes)	43	

RAP Aggregate Gradation

COARSE FACTOR 040323 = 100 / Total [i (Rounded)]

	WEIGHTS RETAINED	% RET	% PASS
3"			
2 1/2"			
2"			
1 1/2"			
1"		0	100
3/4"	24	1	99
1/2"	794	32	67
3/8"	1287	52	15
1/4"	75	3	12
#4	49	2	10
#8	102	4	
- #8	149	✓	6
Total	2480	= i (Rounded)	

Weight of Pass # 8 Split ___ = n ; FINE FACTOR ___ = % Pass #8 / n

	WEIGHTS RETAINED	% RET	% PASS
#10	29	1	5
#16	13	1	4
#30	9	0	4
#40	20	1	3
#50	7	0	3
#100	16	1	2
#200	20	1	
-#200	17	✓	1.4
Total	131	o = Dry Weight	
Elutriation	18	= n - o	

04-29-13
RECEIVED DATE

M. TWAIN 04-30-13
TEST OPERATOR AND DATE

T. SAWYER 04-30-13
SUPERVISOR AND DATE

44-9379 03/13

FIGURE 6

ARIZONA DEPARTMENT OF TRANSPORTATION
RAP MATERIAL TABULATION – IGNITION FURNACE
(Arizona Test Method 428 - Appendix A)

WHITE ☐
YELLOW ☐
BLUE ☐

USE CAPITAL LETTERS
LAB NUMBER | ORG NUMBER | MATL | TYPE | PUR-POSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO | DAY | YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS

RAP Material Moisture Content @ 140°F

p. Wet Mass of RAP Material ____ g
q. Dry Mass of RAP Material ____ g
r. Moisture Content @ 140°F [(p - q) / q] x 100 ____ %

RAP Material Gradation (ARIZ 240 / ARIZ 248, Alt. #2)

FACTOR ____ = 100 / TOTAL

WEIGHTS RETAINED		% RET	% PASS	SPECS
3″				
2 1/2″				
2″				
1 1/2″				
1 1/4″				
1″				
3/4″				
1/2″				
3/8″				
1/4″				
#4				
#8				
- #8				
Total				

Total RAP Material Moisture Content

r. Moisture Content @ 140°F ____ %
c. Moisture Content @ 290°F ____ %
s. Total Moisture Content (r + c) ____ %

Ignition Furnace

a. Wet Mass of Moisture Sample ____ g
b. Dry Mass of Moisture Sample ____ g
c. Moisture Content @ 290°F [(a - b) / a] x 100 ____ %

d. Mass of Basket Assembly ____ g
e. Mass of Sample and Basket Assembly ____ g
f. Initial Mass of Sample (e - d) ____ g
g. Ignition Furnace Set Temperature ____ °C
h. Mass of Sample and Basket Assembly After Ignition ____ g
i. Mass of Sample After Ignition (h - d) ____ g
j. Measured RAP Binder Content {[(f - i) /f] x 100} - c ____ %
k. RAP Binder Content Correction Factor (±) ____ %
l. Corrected RAP Binder Content (j + k) ____ %
m. Elapsed Time of Test (minutes) ____

RAP Aggregate Gradation

COARSE FACTOR ____ = 100 / Total [i (Rounded)]

WEIGHTS RETAINED		% RET	% PASS
3″			
2 1/2″			
2″			
1 1/2″			
1″			
3/4″			
1/2″			
3/8″			
1/4″			
#4			
#8			
- #8			
Total			= i (Rounded)

Weight of Pass # 8 Split ____ = n
FINE FACTOR ____ = % Pass #8 / n

WEIGHTS RETAINED		% RET	% PASS
#10			
#16			
#30			
#40			
#50			
#100			
#200			
-#200			.
Total		o = Dry Weight	
Elutri-ation		= n - o	

RECEIVED DATE | TEST OPERATOR AND DATE | SUPERVISOR AND DATE

44-9379 03/13

FIGURE 7

APPENDIX B

DETERMINATION OF THE RAP BINDER CORRECTION FACTOR

B.1 A RAP binder content correction factor is determined for each RAP stockpile used in the asphaltic concrete mixture.

B.2 At the start of asphaltic concrete production, the first two samples of RAP material from each stockpile are split and tested for asphalt binder content; one split is tested by ignition furnace as described in Subsections A.3.4.2 through A.3.4.5.1, and the other split is tested by solvent extraction in accordance with AASHTO T 164.

Note: Generally, 9000 grams of RAP material from each stockpile will be adequate to obtain the split samples for determining the RAP binder content correction factor.

Note: At the discretion of the Engineer, the RAP binder correction factor may be determined prior to the start of asphaltic concrete production provided representative RAP samples are available.

B.3 The average asphalt binder content determined by ignition furnace is recorded to the nearest 0.001%.

B.4 The average asphalt binder content determined by solvent extraction is recorded to the nearest 0.001%.

B.5 The RAP binder content correction factor is determined by subtracting the average ignition furnace result from the average solvent extraction result. The RAP binder content correction factor is recorded to the nearest 0.01%.

B.6 A new RAP binder correction factor may be determined at any time the Engineer believes it is necessary due to a change in material or other circumstances.

B.7 Report the determination of the RAP binder content correction factor on the “RAP Binder Content Correction Factor” laboratory card. An example is shown in Figure 8. A blank “RAP Binder Content Correction Factor” laboratory card is shown in Figure 9.

ARIZONA DEPARTMENT OF TRANSPORTATION

RAP BINDER CONTENT CORRECTION FACTOR

(Arizona Test Method 428 - Appendix B)

Project Number: F-099-9(99)

TRACS Number: H099901C

RAP Material Type: COARSE

Sample # : 1 Sampled By: JACK B. NIMBLE Sampled From: STOCKPILE

Date Sampled: 04-23-13 Time Sampled: 8:28

Sample # : 2 Sampled By: MARY MUFFETT Sampled From: STOCKPILE

Date Sampled: 04-24-13 Time Sampled: 14:26

RAP BINDER CONTENT CORRECTION FACTOR
(Ignition Furnace vs. Solvent Extraction)

Sample #	RAP Binder Content (%)		RAP Binder Content Correction Factor
	Ignition Furnace (ARIZ 428)	Solvent Extraction (AASHTO T 164)	(Average Solvent Extraction Value) Minus (Average Ignition Furnace Value)
1	3.81	3.39	
2	3.96	3.65	
Average	3.885	3.520	(±) − 0.37

Remarks: EXAMPLE

04-24-13
Received Date

M. TWAIN
Test Operator and Date

T. SAWYER
Supervisor and Date

44-9380 03/13

FIGURE 8

ARIZONA DEPARTMENT OF TRANSPORTATION

RAP BINDER CONTENT CORRECTION FACTOR

(Arizona Test Method 428 - Appendix B)

Project Number: _____

TRACS Number: _____

RAP Material Type: _____

Sample # : _____ Sampled By: _____ Sampled From: _____

Date Sampled: _____ Time Sampled: _____

Sample # : _____ Sampled By: _____ Sampled From: _____

Date Sampled: _____ Time Sampled: _____

RAP BINDER CONTENT CORRECTION FACTOR
(Ignition Furnace vs. Solvent Extraction)

Sample #	RAP Binder Content (%)		RAP Binder Content Correction Factor
	Ignition Furnace (ARIZ 428)	Solvent Extraction (AASHTO T 164)	(Average Solvent Extraction Value) Minus (Average Ignition Furnace Value)
	.	.	
	.	.	
Average	.	.	(±) .

Remarks:

Received Date

Test Operator and Date

Supervisor and Date

44-9380 03/13

FIGURE 9

Field Shear Vane Test for Cold Recycled Asphalt

(Modification of Utah Shear Vane Test)

1. SCOPE

1.1 This method covers a method for performing shear vane testing on cold recycled asphalt, whether cold in-place recycled or cold central plant recycled, to determine the progress of curing after compaction.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

2. APPARATUS

2.1 Sledge Hammer – A minimum of 5 lbs

2.2 Torque Wrench – Capable of recording torque to 0.5 ft-lb increments within the range of 25 to 150 ft-lb

2.3 Shear Vane – See Figures 1 and 2

2.4 15/16 Inch Socket with a 1/2 Drive

2.5 Protective Shear Vane Cover (optional) – A metal cover of any configuration used during the shear vane driving process which facilitates hammering and protects the shear vane during hammering.

FIGURE 1

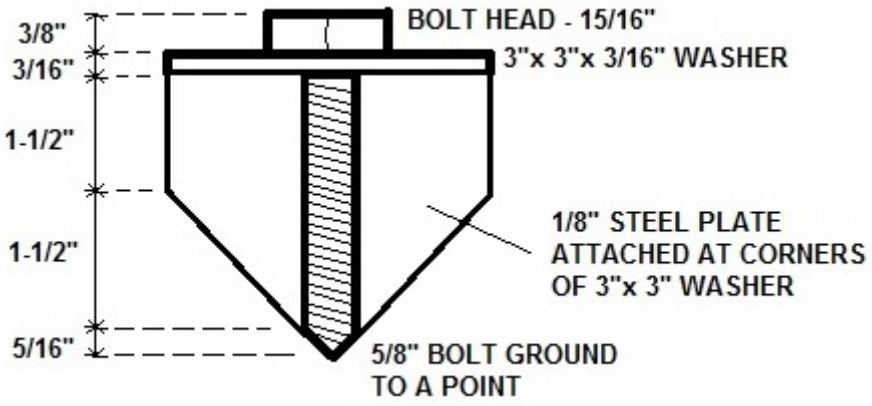


FIGURE 2

3. PROCEDURE

3.1 Select a test location according to project specifications and at least 1 foot from the edge of the cold recycled asphalt and other test sites.

3.2 Using the hammer, drive the shear vane into the cold recycled asphalt, keeping the shear vane vertical, until the washer sits flush on the surface.

Note: The socket or a protective shear vane cover must be on the bolt head before striking with the hammer so that the shear

vane is not damaged. Care must be taken to keep the device as vertical as possible to minimize damage to the cold recycled asphalt before testing.

3.3 Place the torque wrench onto the head of the shear vane bolt. Apply slight downward pressure to ensure that the shear vane does not lift during the test.

3.4 Evenly apply pressure to the torque wrench (90 degrees in 10 seconds) while watching the dial closely. Apply increasing pressure until the cold recycled asphalt is broken loose by the shear vane.

3.5. Record the highest torque value reached during test.

3.6 Determine and record the pavement temperature at two inches below the surface with an infrared thermometer.

3.7 The test will leave a hole in the mat. Repair by pressing loose material into the hole and coating the location with emulsion.

4. REPORT

4.1 Record the following information:

4.1.1 Time and date of the test

4.1.2 Location including stationing and offset

4.1.3 Maximum torque value achieved in ft-lb

4.1.4 Pavement temperature at a depth of two inches

Determining In-Place Flow of Cold Recycled Asphalt Using the Marshall Hammer

1. SCOPE

1.1 This procedure provides a quick evaluation of flow characteristics of cold recycled asphalt, whether cold in-place recycled or cold central plant recycled, to determine appropriate hold time for cold recycling mixes before finishing compactive efforts and releasing to traffic.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

2. APPARATUS

2.1 Marshall Hammer - A Marshall compaction hammer meeting the dimensional requirements of Arizona Test Method 410.

2.2 Caliper or Tape Measure – Capable of measuring depth and measuring in millimeters.

3. PROCEDURE

3.1 This test is to be performed on an initially compacted cold recycled mat.

3.2 Place the Marshall hammer with its head flat on the mat. Do not move the hammer or rock the head.

3.3 Pick up the sliding weight until it reaches the upper stop. Drop the weight. Repeat 50 times. The operator shall hold the handle by one hand so that the axis of the compaction hammer is as nearly perpendicular to the base of the mold assembly as possible while compaction is accomplished. Care shall be taken not to add body weight to the hammer by leaning or pressing down on the hammer. No mechanical device of any kind is to be used to restrict movement of the handle during compaction. Compaction shall be performed at a minimum rate

of 40 blows per minute. The compaction hammer shall apply only one blow with each fall, that is, there shall not be a rebound impact.

3.4 All measurements are from the level of the undisturbed mat.

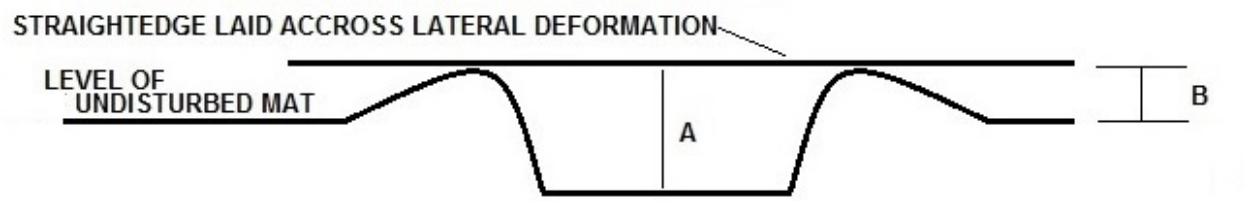


FIGURE 1

3.4.1 Measure the depth of the depression made by the hammer, in mm. The depth is determined by the following equation.

$$\text{Depth of Depression} = A - B$$

Where: A = Distance between Straightedge and Bottom of Depression
B = Distance between Straightedge and Undisturbed Mat

3.4.2 Measure the height of lateral deformation, if any, in mm. The height of lateral deformation, measured from the level of the undisturbed mat, is represented as "B" in Figure 1.

3.5 Determine the moisture condition of the mat; whether there is water bleeding from the mat, or if it is dry. Visible water on the surface of the mat, which is not from rolling operations, may indicate possible bleeding from the mat.

3.6 Determine temperature of the mat to the nearest 1 degree F.

4. REPORT

4.1 Record the following information:

4.1.1 Time and date of the test

4.1.2 Depth of depression, in mm.

4.1.3 Height of lateral deformation, in mm.

4.1.4 Mat temperature

4.1.5 Location of the test including stationing and offset

SERIES 500
BITUMINOUS MATERIALS

PERCENTAGE OF UNCOATED PARTICLES USING ASPHALT EMULSIONS

(An Arizona Method)

1. SCOPE

1.1 This method describes a procedure for determining percentage of uncoated particles based on the failure of emulsions to coat a specific mixture of Standard Sand and Type III portland cement.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Mixing Bowl or Pan - A mixing bowl or round bottom pan with a surface which is non-reactive with the emulsion (e.g., stainless steel, glass, or plastic) of approximately 3 liter (3 quart) capacity.

2.3 Mixing Tool - A stainless steel spoon approximately ten inches long.

2.4 Thermometer - A thermometer accurate to 1 °F.

2.5 Balance - A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the

readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.6 Stopwatch or other timing device.

2.7 No. 20 sieve conforming to the requirements of ASTM E11.

3. MATERIALS

3.1 Standard Sand (20-30) conforming to ASTM C778.

3.2 Type III Portland cement conforming to ASTM C150 and having a minimum specific surface of 1900 cm^2 /gram.

4. PROCEDURE

4.1 Thoroughly mix a representative sample of the emulsion to be tested. If any large particles are present, the emulsion shall be strained through a single layer of damp cheesecloth or the No. 20 sieve.

4.2 Screen approximately 500 grams of the Standard Sand through the No. 20 sieve.

4.3 Weigh 461 ± 0.1 grams of the screened sand into the tared mixing bowl or pan.

4.4 Add 4 ± 0.1 grams of the cement to the sand.

4.5 Mix the sand and cement for one minute, using the mixing spoon to obtain a uniform mixture.

4.6 Bring the emulsion to a temperature of 77 ± 3 °F.

4.7 Weigh 35 $\pm$ 0.1 grams of the emulsion into the sand-cement mixture.

4.8 Mix vigorously with the spoon for 2-1/2 minutes, using a stirring and kneading motion.

4.9 Empty the contents of the mixing bowl or pan onto absorbent paper so that the mixture covers an area approximately 10 inches in diameter.

4.10 Allow to dry thoroughly (approximately two hours).

4.11 Pour the dried mixture into the No. 20 sieve and shake and vibrate the sieve until all of the uncoated particles have passed through the sieve.

4.12 Pour sand which has passed the No. 20 sieve into a tared pan and weigh to the nearest 0.1 gram.

5. CALCULATIONS

5.1 Calculate the percent of uncoated sand using the following formula:

$$U = \frac{W_p}{465} \times 100$$

Where: U = Percent of uncoated sand
Wp = Weight of Sand passing No. 20 sieve.

6. REPORT

6.1 Report percentage of uncoated sand to the nearest one percent.

VACUUM RECOVERY OF ASPHALT EMULSION RESIDUE
(An Arizona Method)

Scope

1. This method describes a low temperature vacuum procedure for recovery of the asphalt residue from asphalt emulsions. It is is not suitable for quantitative recovery of solvents from emulsions containing low boiling range distillates.

Apparatus

2. The apparatus shall consist of the following:

(a) Brass stirring rod.

(b) 8 oz. ointment can.

(c) 100 ml. stainless steel beaker.

(d) No. 20 sieve conforming to AASHTO designation M 92.

(e) Vacuum recovery apparatus as shown assembled in Fig. 1.

1) Vacuum source capable of producing an absolute vacuum within the system of approximately 710 mm (28 in.) mercury.

2) Thermometer — shall have a range of -5° to +200°C (23°F to 392°F). The overall length shall be 600 mm (24 in.) and the distance from the bottom of the bulb to the zero point shall be 300 mm (12 in.)

3) Stirrer hot plate.

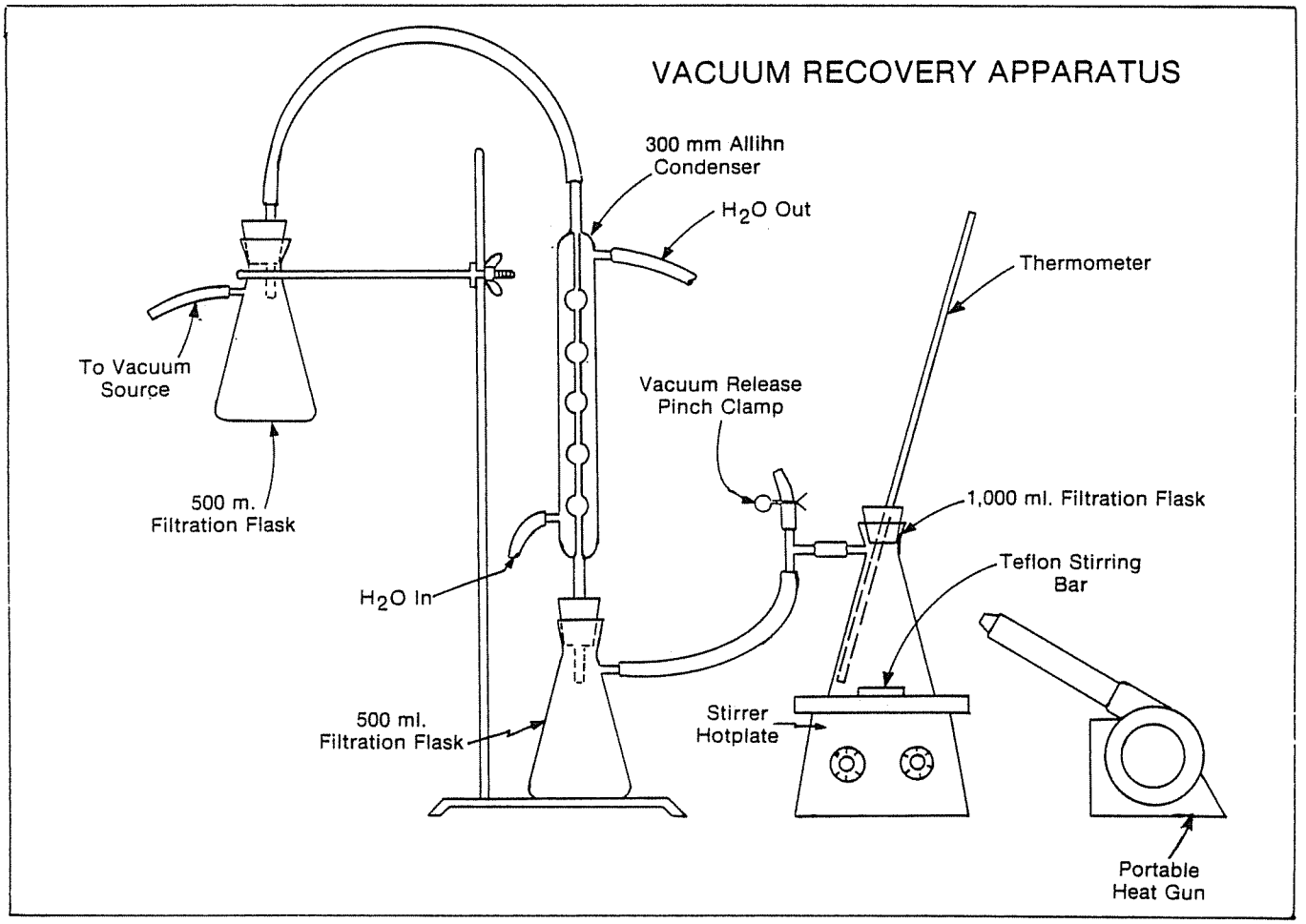


FIGURE 1

4) Teflon covered stirring bar.

5) 1000 ml. and two 500 ml. filtering flasks with tubulation.

6) 300 mm Allihn condensor.

7) Portable heat gun.

8) Miscellaneous rubber stoppers and connecting hose.

9) Vacuum release clamp.

(f) Additional vacuum recovery apparatus for alternate test procedure.

1) 8" waterbath — hemispherical.

2) 500 ml. Separatory Funnel — pear shape.

Material

3. Isopropyl alcohol, technical grade.

Sample Preparation

4. Emulsion shall be thoroughly stirred and strained through a No. 20 sieve just prior to use.

Test Procedure

5. (a) Pour 750 ± 25 ml. of the strained emulsion into a 1000 ml. stainless steel beaker.

(b) Cool the emulsion to approximately 25°C (77°F).

(c) Add isopropyl alcohol (approximately 25 to 100 ml.) in sufficient quantity to break the emulsion.

(d) Knead lumps with brass stirring rod against the sides of the beaker to expel the water from the broken asphalt.

(e) Apply a film of soap around neck of the 1000 ml. vacuum flask to prevent asphalt from sticking to the flask.

(f) Wet hands thoroughly with distilled water. Remove the stirring rod on which the broken asphalt emulsion (now asphalt) is clinging, and with the wet hands gently squeeze out all entrained water while washing asphalt under a constant flow of distilled water. Form asphalt into a rope and drop into the 1000 ml. flask containing the Teflon stirring bar. (Amount of asphalt to be added should be enough to cover bottom of flask approx. 1" in depth). Wash soap off of flask and rinse soap from sample and flask with distilled water making sure water is drained from flask before it is placed on hot plate.

(g) Insert the stoppered themometer (positioned in the stopper at an angle to prevent contact with stirring bar) into the flask and set on hot plate at a medium high heat setting (#4). The bulb of the thermometer should be 6 mm. (¼ inch) from the bottom of the flask.

(h) Turn on the water to the condenser, start the stirring bar and open the vacuum line to establish a vacuum of approximately 710 mm (28 in.) mercury in the apparatus.

(i) Turn on the portable heat gun to medium high heat (#6) and use wherever needed to keep condensation from forming inside the vacuum flask.

(j) Allow temperature to rise until it reaches approximately 90° C., turn hot plate down to setting #2 and then allow the temperature of the residue to rise until it reaches 115° C. ± 3° C. (239° F. ±5° F). Hold at this temperature for at least 1 minute (if possible).

NOTE: The hot plate temperature will need to be regulated during heating of residue to allow for complete removal of water. (This removal is complete when there is no longer foaming in the residue.) If the 115° C temperature is reached and there is still water present, the flask should be removed from the hot plate, allowed to cool a short time, and then heating resumed at a reduced temperature. As the residue heats up, soap bubbles will form up into the vacuum line and condense in the filtering flask. Some emulsions may react violently between 60° C (140° F) and 105° C (221° F) and rise up in the flask. Use the vacuum release clamp as often as needed to control the asphalt. DO NOT let asphalt escape into the vacuum line.

(k) Turn off vacuum and slowly release vacuum through apparatus using release clamp. Stop stirrer, remove thermometer, and pour residue into a 8 oz. ointment can. Residue is now ready for specified tests.

Alternate Test Procedure

6. This procedure is recommended for use with emulsions that will not break using isopropyl alcohol.

(a) Pour 350 ml. to 400 ml. of the strained emulsion into the separatory funnel.

(b) Place the stoppered funnel into the 1000 ml. flask and carefully set the unit into the preheated water bath (Setting #6).

(c) With the water circulating through condenser, open the vacuum line to establish a vacuum of approximately 710 mm (28 in.) mercury in the apparatus.

(d) Start the stirring bar at slow speed and slowly add the emulsion at a rate which allows the emulsion to break as it leaves the funnel. (This is indicated by the presence of foaming at the end of the funnel.

CAUTION: If the emulsion is added to the flask too rapidly, it may react violently and rise up in the flask. If this happens quickly return addition of emulsion to proper rate and use the vacuum release clamp to prevent asphalt from entering into the vacuum line.

(e) Continue adding emulsion to flask until all of it is removed from the funnel.

(f) Close the vacuum line and slowly release vacuum from unit. Stop the stirring bar.

(g) Remove the separatory funnel and the water bath. Wipe bottom of flask dry, insert the thermometer as in 5 (g) and follow original method to completion.

ARIZ 505a
September 5, 1996
(3 Pages)

ASPHALT REJUVENATING AGENT RESIDUE INSOLUBLE IN PETROLEUM ETHER

(An Arizona Method)

SCOPE

1. (a) This method of test is intended for determining the percent of insoluble matter in an asphalt rejuvenating agent using petroleum ether.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Erlenmeyer flask, 125 mL capacity, with stopper.

(b) Drying oven, adequately ventilated, capable of maintaining a temperature of 110 ± 5 °C (230 ± 9 °F).

(c) Desiccator of adequate size to hold several crucibles.

(d) Analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.001 gram.

(e) Filtering apparatus, including:

(1) Vacuum pump

(2) Filtering flask, 250 mL capacity

(3) Filter tube with molded rubber gasket to hold Gooch crucible.

(4) Rubber tubing.

(5) Glass fiber pad conforming to AASHTO T 44.

(6) Gooch crucible, 4 cm high, 3.5 cm top diameter and 2.1 cm bottom diameter, prepared in accordance with AASHTO T 44.

MATERIALS

3. Petroleum either, 30 to 60 °C, reagent grade.

CAUTION: Always work under a hood, avoid breathing petroleum ether fumes, and keep material away from flame. It is highly flammable and toxic.

TEST PROCEDURE

4. (a) Measure approximately 1 gram of asphalt rejuvenating agent residue into the tared Erlenmeyer flask and weigh to the nearest 0.001 gram.

(b) Pour half of a 100 mL portion of petroleum ether into the flask and swirl the contents until all the residue has dissolved.

(c) Add the balance of the 100 mL portion of petroleum ether and swirl the flask to mix the contents thoroughly. Place a stopper in the flask and set aside for 30 minutes.

(d) Place the tared Gooch crucible and filter mat into position on the filtering flask. Wet the mat with a small portion of petroleum ether.

(e) Apply light suction as decantation through crucible is begun. Use suction sparingly because it tends to clog the filter mat. Exercise utmost care in making the filtration to avoid stirring up any precipitate, in order that the filter mat may not be clogged and that the first decantation may be as complete as possible.

(f) Wash the flask with petroleum ether and pour the bulk of the insoluble material on the filter mat after the crucible has drained. Transfer all insoluble material from the flask to the crucible, using a rod with flattened rubber tip (a.k.a. "policeman") if necessary. Rinse the flask and policeman thoroughly with petroleum ether.

(g) Wash the insoluble matter in the crucible until the filtrate is substantially colorless, then apply strong suction to remove the remaining petroleum ether.

(h) Remove crucible from flask and wipe bottom of crucible clean.

(i) Dry the crucible in a 110 ± 5 °C (230 ± 9 °F) oven for 15 to 20 minutes, cool in desiccator for 15 to 20 minutes and weigh to the nearest 0.001 gram.

NOTE: The crucible shall be cooled in the desiccator for the same amount of time that it is dryed in the oven.

CALCULATIONS

5. Calculate the percentage of the total sample which is insoluble in petroleum ether. The formula is as follows:

$$\text{Insoluble Residue, percent} = \frac{A}{B} \times 100$$

Where: A = total weight insoluble

B = total weight of sample

REPORT

6. Report the total insoluble residue to the nearest 0.01 percent.

ARIZ 509a
September 5, 1996
(6 Pages)

RAPID DETERMINATION OF ASPHALTENES AND CHEMICAL REACTIVITY OF ASPHALTS

(An Arizona Method)

SCOPE

1. (a) This method describes a procedure for the determination of Asphaltene, (A), content and Chemical Reactivity Ratio, (CRR), of asphalts. It is not intended to supplant the complete asphalt analytical methods, but should be used when only the A and CRR values are needed.

(b) This test method involves hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Erlenmeyer flasks with glass stoppers, 125 mL capacity.

(b) Analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.0001 gram.

(c) Glass funnels, 75 mm top diameter.

(d) Hot plate, with variable heat control.

(e) Beakers, Griffin type, 250 mL capacity.

(f) Funnel support.

(g) Infra-red heat lamp, variable intensity.

MATERIALS

3. (a) Filter paper, Whatman Glass Microfibre, 12.5 cm, Grade GF/A.

(b) Normal pentane, (nC_5H_{12}), practical grade.

(c) Petroleum Ether, 30 to 60 °C, reagent grade

(d) Concentrated Sulfuric Acid, reagent grade, (H_2SO_4 Assay: 95-98%)

(e) Sodium Hydroxide, pellets, reagent grade.

CAUTION: Pentane and Petroleum Ether are extremely flammable solvents. Smoking or open flames should not be permitted in the area while they are in use. With the exception of weighing, all operations should be carried out in a functioning fume hood. Protective goggles, gloves and laboratory apron shall be worn.

PROCEDURE

4. (a) Weigh approximately 1 gram of the asphalt into a tared 125 mL Erlenmeyer flask. Weigh to the nearest 0.1 mg and record as S_f (weight of sample and flask).

(b) Add 75 mL of normal pentane to the flask and dissolve the asphalt completely. Frequent shaking during the first 15 minutes will aid in dissolving the asphalt. If it does not dissolve, warm cautiously until the asphalt is in solution.

(c) Allow the solution to settle overnight.

(d) Stir vigorously with a glass stirring rod to initiate precipitation, and allow to settle until clear.

(e) Carefully decant liquid through filter paper into a 250 mL beaker, using the Glass Microfibre filter paper. Wash the precipitate remaining in the flask 3 times with 15-20 mL portions of pentane, each time decanting liquid into filter paper. Thoroughly wash flask with pentane and add washings to filter paper. Thoroughly wash precipitate on filter paper with pentane until discoloration is removed from the filter paper. Discard paper containing the precipitate.

NOTE: It is very important that the filter paper be kept wet throughout the washing and filtering process in step (e).

(f) Thoroughly wash and dry the flask used in this operation. Methylene Chloride washing is recommended.

(g) Using the heat lamp, evaporate the solution in the beaker until approximately 25 mL remains. Pour solution into the 125 mL flask previously used. Wash the beaker with pentane until clean, adding the washings to the flask.

(h) Evaporate the contents of the flask with the heat lamp until all the solvent has been removed. Then place on the hot plate and heat cautiously until a white vapor is noticed at the top of the flask.

(i) Remove the flask from the hot plate. Cool and weigh to the nearest 0.1 mg. Record this weight as B_p (weight of flask and residue).

(j) Add 75 mL of Petroleum Ether to the flask containing the residue and dissolve ALL the residue.

(k) Pour the solution into a 250 mL beaker and thoroughly wash the flask with Petroleum Ether. Add the washings to the solution in the beaker. If necessary, reduce the volume of the solution to 100 - 125 mL by evaporation with the heat lamp.

(l) Thoroughly wash and dry the flask. Methylene Chloride washing is recommended.

(m) Slowly add 10 ± 0.5 mL concentrated sulfuric acid to the solution in the beaker while stirring vigorously. Continue stirring for at least 3 minutes.

(n) Allow the solution to settle until clear.

(o) Cover bottom of a 250 mL beaker with Sodium Hydroxide pellets, then immediately filter the liquid through a filter paper into the 250 mL beaker containing the Sodium Hydroxide pellets. Do not allow the sludge to leave the beaker. Wash the sludge in the beaker 3 times, using 15 - 20 mL portions of Petroleum Ether. Filter the washings into the pellets in the beaker, then discard filter paper.

CAUTION: Do not touch the pellets with bare hands.

CAUTION: Sludge contains large amounts of unreacted acid. Contact with Sodium Hydroxide pellets may cause explosion.

(p) Using the heat lamp, evaporate this solution to approximately 50 mL, then filter into the 125 mL Erlenmeyer flask previously used, thoroughly washing beaker and pellets into filter paper, using a 30-40 mL portion of Petroleum Ether.

(q) Discard the filter paper containing the Sodium Hydroxide pellets.

(r) Evaporate the contents of the flask with heat lamp until all the solvent has been removed. Then place on the hot plate and heat cautiously until a white vapor is noticed at the top of the flask.

(s) Remove the flask from the hot plate. Cool and weigh to the nearest 0.1 mg. Record this weight as "C" (weight of flask and residue).

CALCULATIONS AND REPORT

5. (a) Percent Asphaltenes:

$$A = \frac{S_f - B_p}{S} \times 100$$

Where: S = Weight of sample, $S_f - T_f$
S_f = Weight of sample and flask, grams
T_f = Tare weight of flask, grams
A = Percent Asphaltenes.
B_p = Weight of flask and residue from Pentane washing, grams

(b) Percent Unreacteds:

$$U = \frac{C - T_f}{S} \times 100$$

Where: U = Percent Unreacteds.
C = Weight of flask and residue from Petroleum Ether washing, grams
S = Weight of Sample, grams
T_f = Tare weight of flask, grams

(c) CRR (Chemical Reactivity Ratio) Value:

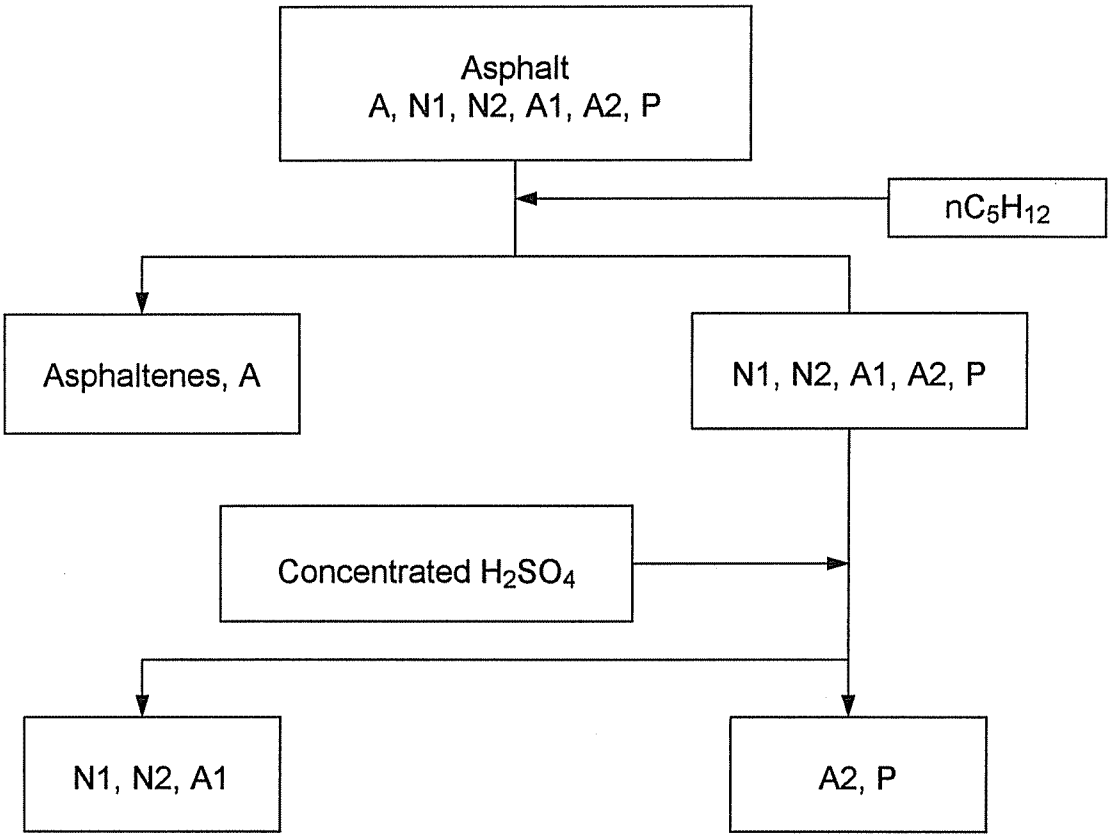
$$CRR = \frac{100 - (A + U)}{U}$$

Where: CRR = Chemical Reactivity Ratio
A = Percent Asphaltenes
U = Percent Unreacteds.

(d) Report Asphaltenes as a percentage of the asphalt sample, to the nearest 0.01%.

(e) Report CRR Value as a ratio of the Reacted and Unreacted asphalt components, to the nearest 0.01 unit, if this value is required.

FLOW SHEET - MODIFIED ROSTLER-STERNBERG ANALYSIS



NOTE:

A	=	Asphaltenes	Insoluable in nC_5H_{12}
*N1	=	1st Nitraffins	Precipitated by concentrated H_2SO_4
*N2	=	2nd Nitraffins	Precipitated by concentrated H_2SO_4
A1	=	1st Acidaffins	Precipitated by concentrated H_2SO_4
A2	=	2nd Acidaffins	Unreacted by concentrated H_2SO_4
P	=	Paraffins	Unreacted by concentrated H_2SO_4

* 1st and 2nd Nitraffins are Nitrogen Bases

RESIDUE BY EVAPORATION

(An Arizona Method)

1. SCOPE

1.1 This method describes a rapid procedure for determining the percent of asphaltic residue in all types of emulsified bituminous materials.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Small glass beaker or similar container.

2.3 Ointment tins [180 mL (6 oz.)].

2.4 Hot plate capable of maintaining temperatures of 163 °C (325 °F) maximum.

2.5 Glass or metal stirring rod.

2.6 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 gram.

3. PRECAUTION

3.1 Care must be exercised in the use of apparatus and the handling of the tin so that material is neither lost nor additional material picked up. The use of the ointment tin lid serves as well as a clean place for resting the tin.

4. PROCEDURE

4.1 Thoroughly mix the sample using stirring rod.

Note: It is very important that the sample be completely mixed, making certain to mix material clinging to bottom and sides of container into sample. A sample that has "separated" may be rendered homogeneous through continued stirring. Never mix the sample by shaking. If a sample is received which has "broken", it shall be discarded and another sample obtained for testing.

4.2 Pour approximately 25 grams of the mixed material into the glass beaker or similar container.

4.3 Record weight of a 180 mL (6 oz.) ointment tin to the nearest 0.01 gram and place 5 $\pm$ 0.3 grams of material into the tin. Record weight of material in tin to the nearest 0.01 gram, as "A".

4.4 Repeat procedure in Subsection 4.3 for 2 additional samples.

4.5 Place the three samples on hot plate and slowly heat to a temperature that will prevent spattering or overcooking. (See Note in Subsection 4.7)

4.6 Heat samples at this temperature until the residue stops bubbling and appears smooth. This is an indication that the sample is nearing the end point (complete removal of water).

Note: Air bubbles should be removed occasionally by tapping tin on the hot plate or other hard surface and rotating the sample around the bottom of the tin. (Use of tongs or needle-nose pliers to handle tin is recommended.)

4.7 Raise the temperature of samples to 163 °C (325 °F) maximum. This may be accomplished by raising the temperature of the hot plate or by placing samples on another hot plate. If an additional hot plate is used and bubbling occurs the samples shall be placed back on the lower temperature hot plate for a short period of time and then returned to the higher temperature hot plate.

Note: The temperatures required vary with the type of material being tested. When testing the "ERA" grade materials and emulsions with low viscosities the temperatures used will normally be near the boiling point of water. When testing higher viscosity materials the temperatures may approach the 163 °C (325 °F) maximum allowed. Care must be exercised for all materials to prevent spattering and overheating.

4.8 Heat the samples until the first indication of smoking is detected, which shall be the determination of the removal of all water. The use of a black background is useful in observing the point of smoking.

Note: When testing "ERA - 1" grade materials, the determination of end point described in Subsection 4.8 shall not be used, rather when the material is free of all bubbles and has a completely translucent appearance.

4.9 Remove samples from hot plate and allow to cool.

4.10 Record the weight of each sample to the nearest 0.01 gram, as "B".

5. CALCULATION

5.1 Determine percent residue of each sample by the equation below, and record results to the nearest 0.1%:

$$\text{Percent Residue} = \frac{B}{A} \times 100$$

Where: A = Weight of Sample Before Heating
B = Weight of Sample After Heating

Example:

$$\%\,\text{Residue} = \frac{3.18}{5.02} \times 100 = 63.35\%$$

5.2 Determine the average percent residue of the material being tested by the equation below, and record the results to the nearest 0.1%.

$$\text{Average \% Residue} = \frac{(\text{Sum of the 3 individual samples Percent Residue})}{3}$$

Example:

(For 3 samples of 63.4 %, 63.5%, and 63.7% residue)

$$\text{Average \% Residue} = \frac{(63.4 + 63.5 + 63.7)}{3} = 63.5\%$$

Reported Example = 64%

6. REPORT

6.1 The average percent residue shall be reported to the nearest whole percent.

SERIES 700
CHEMICAL AND SPECIALTY

TESTING OF PAINT, VARNISH, LACQUER, AND RELATED MATERIAL

(A Modification of Federal Test Method Standard 141)

SCOPE

1. (a) This group of tests describes the procedures for routine chemical and/or physical testing of paints and the raw materials used in the manufacture of these organic protective coatings for surface preservation or marking of wood, metal, and/or masonry installations.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS & REAGENTS

2. (a) Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. All apparatus shall conform to those specifications given in the respective tests.

(b) All reagents shall conform to the specifications of the Committee on Analytical Reagents of the American Chemical Society, where such specifications are available.

GENERAL

3. (a) Consistency - The determination of consistency of paint shall be as specified in ASTM Designation D 562, "Consistency of Paints Using the Stormer Viscosimeter."

(b) Drying Time - Determine the dry-to-touch and dry-hard times of paints by following the procedures specified in ASTM Designation D 1640, "Drying, Curing, or Film Formation of Organic Coatings at Room Temperature."

(c) Pigment Content - Follow ASTM Designation D 2371, "Pigment Content of Solvent-Reducible Paints," to determine percentage by weight. The remaining percentage may be considered as vehicle.

(d) Vehicle Composition - Follow ASTM Designation D 2621, "Infrared Identification of Vehicle Solids from Solvent-Reducible Paints."

(e) Density, kilograms per liter (pounds per gallon)

1) The apparatus shall consist of a smoothly finished aluminum, brass, stainless steel or plated cup provided with a snug-fitting, plug type cover having a small hole in its center. The capacity of the cup at 25.0 ± 0.5 °C shall be 83.2 ± 0.1 mL. The inside of the bottom of the cup shall be rounded. A convenient size for the apparatus is about 76 mm high by 38 mm in diameter. The cup shall be tared.

2) Pour the well-mixed paint, brought to a temperature of 25.0 ± 0.5 °C, into the cup until it is nearly full, put on the cover, rotate it firmly into place. Wipe off excess paint that exudes through the hole. Determine the weight of the sample to the nearest 0.1 gram. Multiply this weight by 0.012 to obtain the density in kilograms per liter (divide the weight of the sample by 10 to obtain the density in pounds per gallon).

3) This same procedure is applied for paste and semipaste, with care that all air pockets are removed from the material.

RAW MATERIALS, PIGMENTS

4. (a) White Pigments - Follow ASTM Designation D 34, "Chemical Analysis of White Pigments."

(b) Magnesium Silicate Pigments - Follow ASTM Designation D 717, "Analysis of Magnesium Silicate Pigment."

(c) Diatomaceous Silica - Follow ASTM Designation D 719, "Analysis of Diatomaceous Silica Pigment."

(d) Dry Red Lead - Follow ASTM Designation D 49, "Chemical Analysis of Dry Red Lead."

(e) Iron Oxide - Follow ASTM Designation D 50, "Chemical Analysis of Yellow, Orange, Red, and Brown Pigments Containing Iron and Manganese." Refer to Section 11 and 12 of same.

ALUMINUM PASTE

5. Follow ASTM Designation D 480, "Sampling and Testing of Flaked Aluminum Powders and Pastes," for the tests given below.

(a) Coarse Particles

(b) Easily Extracted Fatty and Oil Matter

(c) Nonvolatile Matter

SAMPLING AND SIEVING OF CRUMB RUBBER

(An Arizona Method)

1. SCOPE

1.1 This method describes the procedure for sampling and determining the sieve analysis of crumb rubber.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2 Sieves for fine screening conforming to ASTM E11, with a diameter of 8 inches, nested in sizes: #8, #10, #16, #30, #40, #50, #100, #200, and bottom pan.

2.3 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 grams.

2.4 Oven capable of maintaining a temperature of 140 ± 5 °F.

2.5 A small riffle splitter with one-half inch openings.

2.6 Mechanical sieve shaker which imparts a vertical, or lateral and vertical, motion to the sieves, causing the particles thereon to bounce and turn so as to present different orientations to the sieving surface.

2.7 Splitting blanket of adequate size for approximately 1500 grams of crumb rubber.

2.8 Talc (Talcum Powders) – Usually some mixture of magnesium silicate, silica, magnesium oxide, or magnesium-aluminum silicate. 100 percent of the particles shall pass a No. 200 sieve.

2.9 A one-quart glass jar with large opening, and lid.

2.10 Scoop, shovel, "sample thief" or other suitable device for obtaining samples.

3. SAMPLING

3.1 Samples shall be obtained at the hot plant or CRA (Crumb Rubber Asphalt) blending unit from bags selected by the Engineer.

3.2 The sample shall be obtained from the top of a randomly selected bag of crumb rubber, taken at a minimum of three random locations at least 3" below the surface, using a scoop, shovel, "sample thief", or other suitable device. The combined sample size shall be approximately 1500 grams.

3.3 If the contractor suspects that segregation of the crumb rubber has occurred in the bag, the contractor may propose that the sample be obtained in a method which differs from that specified in Subsection 3.2 above. The proposed method of sampling must be approved by the Engineer and must render a representative sample. The sample shall be obtained by the contractor and witnessed by the Engineer.

4. SAMPLE PREPARATION

4.1 Dry the approximate 1500 gram sample to constant mass at a temperature of 140 ± 5 °F.

4.2 Spread the sample on the splitting blanket and break up clumps so that the material is free flowing.

4.3 Mix the material thoroughly by turning the entire sample over several times in the splitting blanket.

4.4 Obtain a representative 100 ± 10 gram test sample of the crumb rubber by splitting the entire sample through the splitter.

4.5 Place the test sample in the jar, breaking up any clumps of material. Weigh the sample to the nearest 0.1 gram and record as “Preweight of Crumb Rubber”.

4.6 Add 5.0 grams of talc to the jar. Place the lid on the jar and mix sample thoroughly by manually shaking until the rubber and talc are uniformly mixed (a minimum of one minute). Weigh the combined rubber and talc to the nearest 0.1 gram and record as “Preweight of Crumb Rubber and Talc”. Do not record this weight as “Corrected Dry Weight”.

4.7 Empty the sample of combined rubber and talc into the nest of sieves, thoroughly removing any material clinging to the jar and lid.

5. PROCEDURE

5.1 Subject the test sample to mechanical sieving for 10 ± 0.5 minutes. In no case shall fragments be turned or manipulated through the sieves by hand. If there are clumps of material retained on any of the screens, break these apart, and recombine the rubber and talc from all the sieves and bottom pan; place the material in the jar, reshake, reweigh (recording new weight of combined rubber and talc), and resieve.

5.2 Determine the weight retained on each sieve and the bottom pan and record to the nearest 0.1 gram. Any material adhering to the bottom of a screen shall be brushed into the next finer screen.

5.3 Do not discard any of the sieved material until the sum of the individual weights retained is compared to the weight of the combined rubber and talc prior to sieving (“Preweight of Crumb Rubber and Talc”). If the difference between the two weights is less than or equal to 1.0% of the "Preweight of Crumb Rubber and Talc”, an adjustment in weight shall be made on the sieve which has the largest weight retained, except no adjustment shall be made on the minus #200 material. If the difference is greater than 1.0%, discard this test sample and obtain another 100 ± 10 gram sample as specified in Subsection 4.4 and repeat the test.

6. CALCULATION

6.1 If the weight of minus #200 material from sieving is 5.0 grams or less, record a zero as the minus #200 weight corrected for talc.

6.2 If the weight of minus #200 material from sieving is greater than 5.0 grams, subtract 5.0 grams from it and record this difference as the minus #200 weight corrected for talc.

NOTE: The adjustments made in Subsections 6.1 and 6.2 above are to account for the 5.0 grams of talc added to the sample.

6.3 After determining the minus #200 weight corrected for talc as described above, determine the “Corrected Dry Weight” by adding the weights retained on sieve size #8, #10, #16, #30, #40, #50, #100, #200 and the minus #200 corrected for talc. Record this sum as the "Corrected Dry Weight".

6.4 Determine the sieve factor for calculating the sieve analysis by dividing 100 by the "Corrected Dry Weight". Record the factor to at least six decimal places.

6.5 The percent passing for each sieve is determined by multiplying the weight retained on that sieve by the factor, and subtracting the result from the unrounded % passing the next larger sieve. Values for "weight retained times the factor" and "percent passing each sieve" shall be determined and used in the calculations to at least six decimal places. The percent passing value for each sieve is recorded in the sieve analysis to the nearest whole percent, except the percent passing the #200 sieve (corrected for talc) is recorded to the nearest 0.1 percent.

6.6 As a check on the sieve analysis, the weight of material passing the #200 (corrected for talc) is multiplied by the factor. The result of this calculation, rounded to the nearest 0.1 percent, should be the same as the value for the percent passing the #200 determined in the paragraph above.

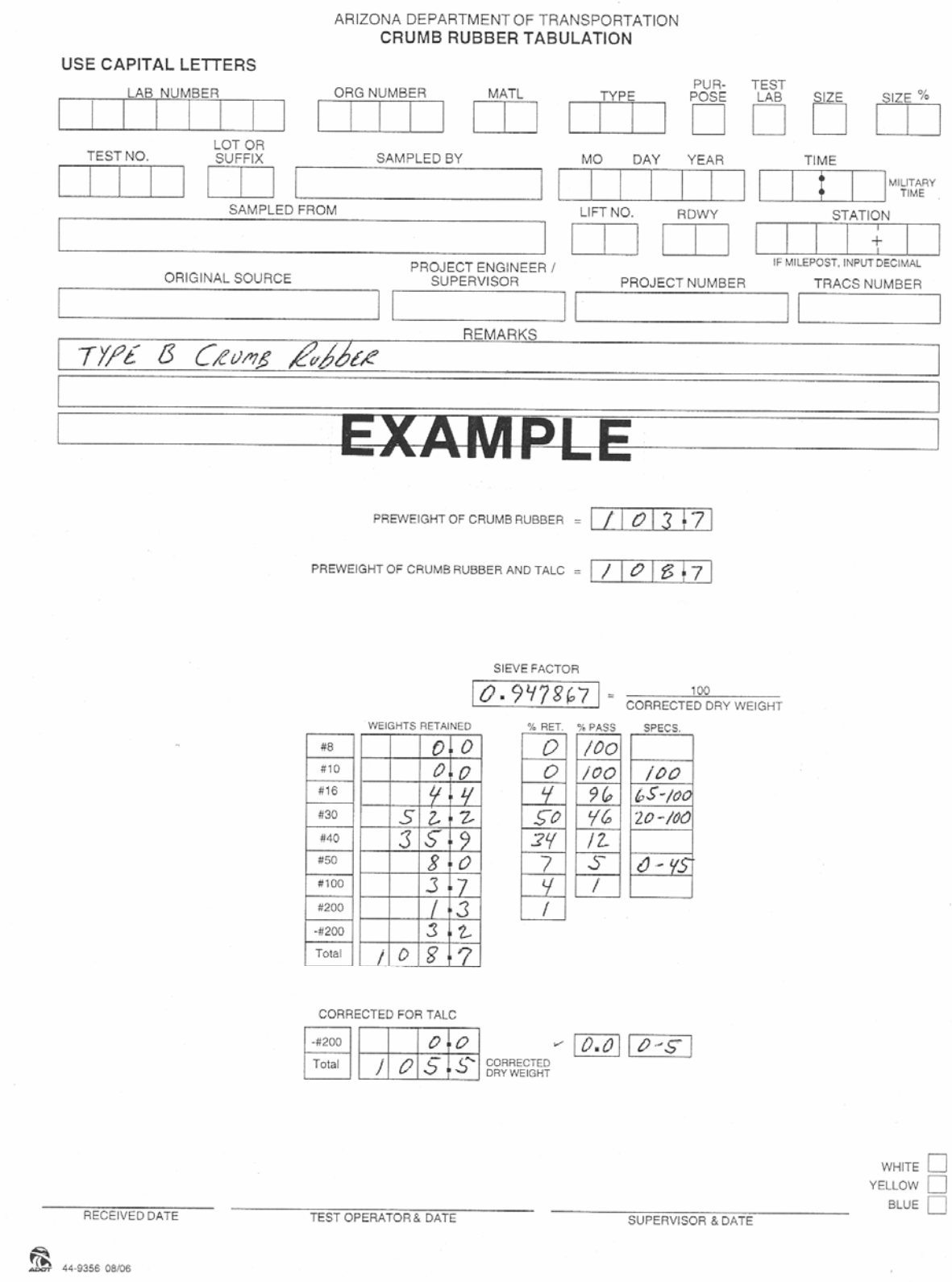
6.7 If desired, obtain the percent retained on each sieve by subtracting the rounded % passing value for that sieve from the rounded % passing value for the next higher sieve.

7. EXAMPLE

7.1 Figure 1 is an example of the calculations when the weight of minus #200 material is 5.0 grams or less.

7.2 Figure 2 is an example of the calculations when the weight of minus #200 material exceeds 5.0 grams.

7.3 A blank Crumb Rubber Tabulation laboratory card is provided in Figure 3.



ARIZONA DEPARTMENT OF TRANSPORTATION
CRUMB RUBBER TABULATION

USE CAPITAL LETTERS

LAB NUMBER | ORG NUMBER | MATL | TYPE | PUR-POSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO DAY YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS: TYPE B Crumb Rubber

EXAMPLE

PREWEIGHT OF CRUMB RUBBER = 103.7

PREWEIGHT OF CRUMB RUBBER AND TALC = 108.7

SIEVE FACTOR = 0.947867 = 100 / CORRECTED DRY WEIGHT

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.
#8	0.0	0	100	
#10	0.0	0	100	100
#16	4.4	4	96	65-100
#30	52.2	50	46	20-100
#40	35.9	34	12	
#50	8.0	7	5	0-45
#100	3.7	4	1	
#200	1.3	1		
-#200	3.2			
Total	108.7			

CORRECTED FOR TALC

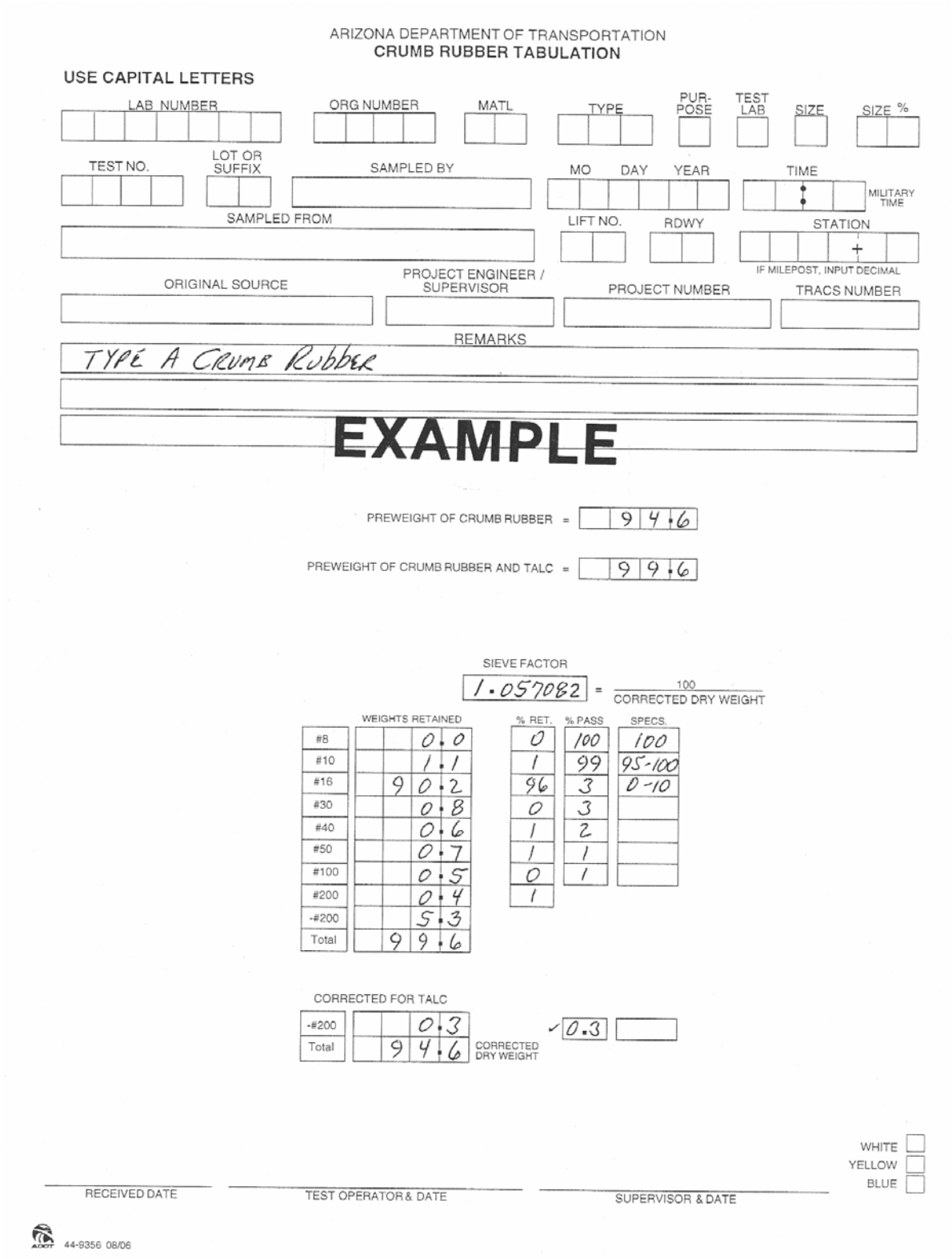
-#200	0.0	0.0	0-5
Total	105.5	CORRECTED DRY WEIGHT	

WHITE
YELLOW
BLUE

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

44-9356 08/06

FIGURE 1



ARIZONA DEPARTMENT OF TRANSPORTATION
CRUMB RUBBER TABULATION

USE CAPITAL LETTERS

LAB. NUMBER | ORG NUMBER | MATL | TYPE | PUR-POSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO DAY YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS: TYPE A CRUMB RUBBER

EXAMPLE

PREWEIGHT OF CRUMB RUBBER = 94.6

PREWEIGHT OF CRUMB RUBBER AND TALC = 99.6

SIEVE FACTOR = 1.057082 = 100 / CORRECTED DRY WEIGHT

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.
#8	0.0	0	100	100
#10	1.1	1	99	95-100
#16	90.2	96	3	0-10
#30	0.8	0	3	
#40	0.6	1	2	
#50	0.7	1	1	
#100	0.5	0	1	
#200	0.4	1		
-#200	5.3			
Total	99.6			

CORRECTED FOR TALC

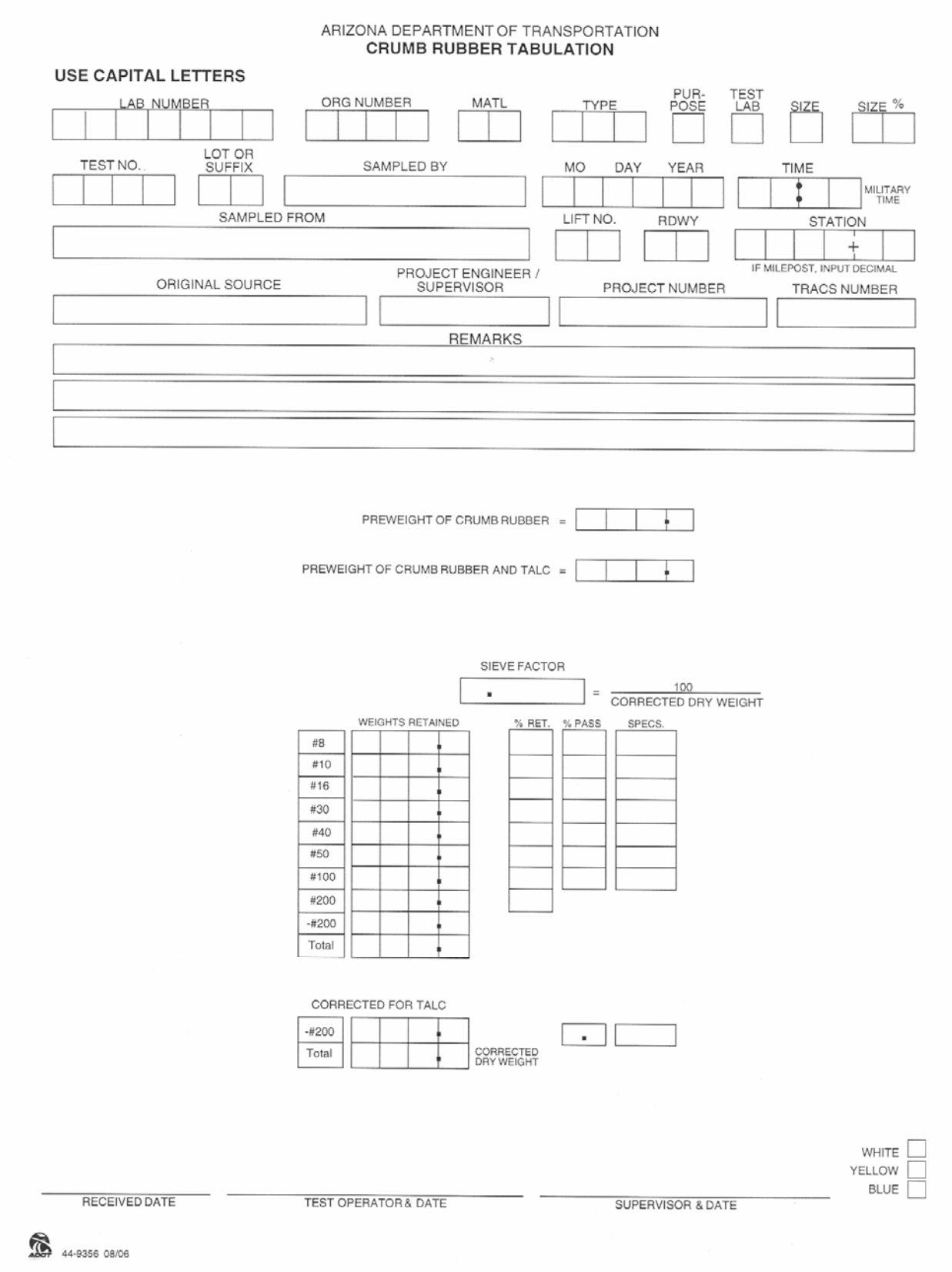
-#200	0.3	✓ 0.3
Total	94.6	CORRECTED DRY WEIGHT

WHITE ☐
YELLOW ☐
BLUE ☐

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

ADOT 44-9356 08/06

FIGURE 2


ARIZONA DEPARTMENT OF TRANSPORTATION
CRUMB RUBBER TABULATION

USE CAPITAL LETTERS

LAB NUMBER | ORG NUMBER | MATL | TYPE | PUR-POSE | TEST LAB | SIZE | SIZE %

TEST NO. | LOT OR SUFFIX | SAMPLED BY | MO DAY YEAR | TIME (MILITARY TIME)

SAMPLED FROM | LIFT NO. | RDWY | STATION (IF MILEPOST, INPUT DECIMAL)

ORIGINAL SOURCE | PROJECT ENGINEER / SUPERVISOR | PROJECT NUMBER | TRACS NUMBER

REMARKS

PREWEIGHT OF CRUMB RUBBER = ____.__

PREWEIGHT OF CRUMB RUBBER AND TALC = ____.__

SIEVE FACTOR ____.__ = 100 / CORRECTED DRY WEIGHT

	WEIGHTS RETAINED	% RET.	% PASS	SPECS.
#8				
#10				
#16				
#30				
#40				
#50				
#100				
#200				
-#200				
Total				

CORRECTED FOR TALC

-#200		
Total		CORRECTED DRY WEIGHT

WHITE
YELLOW
BLUE

RECEIVED DATE | TEST OPERATOR & DATE | SUPERVISOR & DATE

ADOT 44-9356 08/06

FIGURE 3

HEATING AND DRYING MATERIALS IN MICROWAVE OVEN

(An Arizona Method)

SCOPE

1. (a) This method describes the procedure for the heating, drying, and/or determining moisture content of soils and aggregates, and bituminous mixtures utilizing a microwave oven.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding number to the required degree of accuracy.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Microwave oven capable of variable heat intensity settings. When heating and drying aggregates that have been extracted from bituminous mixtures, proper ventilation of fumes from oven exhaust fan shall be provided. The microwave oven shall be operated in accordance with the manufacturer's instructions.

(b) Sample containers suitable for microwave use.

(c) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

HEATING AND DRYING SOILS AND AGGREGATE SAMPLES

3. The heating and drying of soils and aggregates is controlled by the intensity of heat generated that prevents aggregate breakage and sample splattering. When the percent moisture is determined, the method used with a microwave oven shall give results similiar to those achieved with a conventional oven. In case of dispute, a conventional oven shall be utilized in accordance with the applicable AASHTO test method, T 255 "Total Moisture Content of Aggregate by Drying", or T 265 "Laboratory Determination of Moisture Content of Soils".

(a) The following describes the method for drying samples of soils and aggregates to constant weight.

1) Record the tare weight of a suitable size container to the nearest 0.1 gram. Place sample in container and determine and record the wet weight of sample to the nearest 0.1 gram.

2) Dry sample until a constant weight is obtained. The sample is considered to be at constant weight when further drying causes, or would cause, a difference in weight of not more than 0.1 gram.

(b) After the sample has been dried to constant weight, the percent moisture, if desired, is determined as follows:

1) Cool container and sample to room temperature. Determine and record the dry weight of sample to the nearest 0.1 gram.

2) Calculate and record the percent moisture to the nearest 0.1% by the following:

$$\% \text{ moisture} = \frac{(\text{wet weight}) - (\text{dry weight})}{(\text{dry weight})} \times 100$$

HEATING AND DRYING BITUMINOUS MIXTURES

4. Bituminous mixtures shall be heated in such a manner that controls the intensity of heat generated to prevent splattering, aggregate breakage, and asphalt being "burned off".

(a) The determination of constant weight and percent moisture, if desired, shall be determined in accordance with Arizona Test Method 406.

TENSILE PROOF DOWEL TEST

(An Arizona Method)

SCOPE

1. (a) This test method covers the determination of the tensile force necessary to break the bond between a steel reinforcing bar and portland cement concrete when utilizing an epoxy adhesive, under defined procedures for preparation, conditioning, and testing.

(b) Tensile strength is the maximum tensile load carried by the test specimen during a tension or pull-out test. The results are expressed in Newtons (pounds force).

(c) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(d) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(e) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) A rotary hammer drill with a 25.4 mm (1 inch) drill bit.

(b) Testing Machine, capable of maintaining a specified rate of loading and comprised of essentially the following:

1) Fixed Member - The upper member of the machine has grips for holding the test specimen in the machine. These grips shall secure the reinforcing bar in such a way that the concrete cylinder shall move into a seating alignment as soon as a load is applied.

2) Movable Member - This seating alignment shall bring the concrete cylinder into a uniform bearing against a steel plate that bears against the bottom of the movable or lower member.

MATERIALS

3. (a) The concrete cylinder shall be a 152.4 x 304.8 mm (6 x 12 inch) concrete cylinder fabricated according to AASHTO T 23 (ASTM C 31). The concrete utilized to fabricate the cylinder shall have a minimum compressive strength of 40 MPa (6000 psi) when tested in accordance with Arizona Test Method 314.

(b) The reinforcing bar shall be No. 20M (No. 6), conforming to the requirements of AASHTO M 31 (ASTM A 615) Grade 60, with a length of 815 mm (32 inches).

(c) The epoxy adhesive product, prepared according to the manufacturer's recommendations.

PREPARATION

4. (a) A 25.4 mm (1 inch) diameter hole is drilled in the center and parallel to the principal axis of the cylinder to a depth that will accommodate a full 150 mm (6 inches) of reinforcing bar. Compressed oil-free air shall be used to purge drill dust from the hole. Then, water under pressure along with a bottle brush will be used to flush out any remaining particles. Water under pressure will be continuously applied to the hole until the rinse water turns clear. Then the cylinder is moved to a storage area and set up side down to allow any free moisture to drain away. The cylinder will be dry before any epoxy adhesive is applied in fabricating the test specimen.

(b) If a low or medium viscosity epoxy is used, pour a sufficient quantity of epoxy into the hole, such that when a square end of reinforcing bar is pushed to the full depth of the drilled hole, the epoxy shall reach the top of the hole. A small amount of excess material extruded will be acceptable. The reinforcing bar should be rotated approximately one to three revolutions in an effort to more uniformly distribute the epoxy adhesive over the reinforcing bar and the wall of the drill hole.

(c) If a high viscosity or non-sag epoxy is used, use a spatula or putty knife in the application of the epoxy to place a sufficient quantity of the material into the drill hole. In addition, the length of reinforcing bar that is to be embedded, should be coated with epoxy before the square end of the reinforcing bar is inserted into the drill hole. A small amount of excess material extruded will be acceptable. The reinforcing bar should be rotated approximately one to three revolutions in an effort to more uniformly distribute the epoxy adhesive over the reinforcing bar and the wall of the drill hole.

(d) If a glass self-contained epoxy adhesive capsule is used, one end of the reinforcing bar shall be chisel pointed. The other end of the bar will have a square end, which shall be fitted into an attachent on a rotary hammer drill. The glass capsule shall be inserted into the drill hole and the reinforcing bar with the chisel point is then driven into the drill hole. The reinforcing bar shall be driven to the full depth of the drilled hole or refusal.

TEST SPECIMEN

5. Each test specimen shall consist of a fully assembled 152.4 mm (6 inch) diameter concrete cylinder with the rebar bonded within utilizing the epoxy adhesive product submitted for evaluation. The test shall consist of performing testing on two test specimens; one being tested at one day, and the other at three days, unless other time periods are agreed upon.

CONDITIONING

6. The conditioning of the test specimens shall be maintained, until such time as the tests are conducted, at a temperature of 24 ± 4 °C (75 ± 7 °F) and a relative humidity of 50 ± 2 percent.

PROCEDURE

7. (a) Place the test specimen in the test machine so the grips fully engage the reinforcing bar, while taking care to align the concrete cylinder and the bearing plate so that they will bear uniformly against the lower or movable member. The application of the tensile loading should begin as quickly as possible. An initial loading of 22 kN (5000 pounds force) shall be applied to the test sample. Loading shall then be applied at a rate of movement which corresponds to a loading rate within the range of 22 to 27 kN/minute (5000 to 6000 pounds force/minute) to failure.

(b) Record the maximum load carried by the test specimen at failure, to the nearest 450 N (100 pounds force).

(c) Record the type of failure that occurred. This will be based on a visual inspection. (See Note below).

NOTE: Adhesive failure refers to the lack of bond obtained by observing how much of a failure has occurred in the epoxy adhesive being in contact with the surfaces to be bonded, poor distribution of epoxy material. Concrete tensile failure could be described as being a complete failure that is preceded by developing a shallow surface cone.

ARIZ 726a
September 5, 1996
(5 Pages)

REFLECTANCE, DRY OPACITY, AND YELLOWNESS INDEX OF TRAFFIC PAINT

(An Arizona Method)

SCOPE

1. (a) This method is used for integrated testing of traffic paints for their reflectance properties. It is applied primarily in testing water-borne white and yellow traffic paints. Yellowness Index is determined on white traffic paints.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Black and white opacity charts - Leneta, form 2C.

(b) 0.25 mm (10 mil) doctor blade, 101.6 mm (4 inch) width.

(c) 0.38 mm (15 mil) doctor blade, 101.6 mm (4 inch) width.

(d) Photovolt 577 reflectance meter with "T" search unit.

PREPARATION OF TEST SPECIMENS (PAINT FILMS)

3. Two test films, on separate charts, are prepared for each paint sample as follows:

(a) Apply a bead of paint approximately 50.8 mm (2 inches) long and 5 milliliters in volume across the top of the upper (black) portion of a chart.

(b) Draw the paint down across both portions of the chart (black and white) using the 0.25mm (10 mil) doctor blade.

(c) Repeat, steps 3(a) and 3(b) using a bead of approximately 10 milliliters volume and the 0.38 (15 mil) doctor blade.

(d) Prior to testing, allow the test specimens to dry for a minimum of 24 hours at 25 ± 5 °C (77 ± 9 °F).

SETUP AND CALIBRATION OF REFLECTANCE METER

4. After an initial warmup time of a minimum of 30 minutes, calibrate the meter for use on the applicable filter channels (green "G", amber "A", and/or blue "B") as follows:

(a) Load the green filter in the filter rack of the "T" search unit and rotate the rack until the filter is in front of the lens.

(b) Select the green memory location by depressing the "G" button on the front face of the meter.

(c) Place the black cavity standard on the head of the search unit.

(d) Set the dark current (zero offset) by depressing first the "CHANGE" button and then the "ZERO" button on the face of the meter.

(e) Place the Photovolt ceramic reflectance standard plaque on the head of the search unit.

(f) Enter the standard reflectance value for the green filter on the meter display, by depressing first the "CHANGE" button, then the "STD" button, and finally, the "A", "B", and "G" buttons as necessary to increment the tens, units, and tenths digits respectively until the value is displayed. Then depress the "STD" button again. The standard reflectance value for the green filter is now stored in the memory, and the meter is now calibrated on the green filter channel.

(g) If reflectance data is to be obtained for a white paint sample, repeat steps 4(a) through 4(f) for the amber filter channel and again for the blue filter channel.

(h) For each channel used, immediately prior to obtaining reflectance data for paint samples, the calibration will be checked and, if necessary, corrected. First replace the black cavity standard on the head of the search unit and if drift has occurred, depress the "CHANGE" button and then the "ZERO" button. Next replace the standard plaque on the head of the search unit and if drift has occurred, depress the "CHANGE" button, and then depress the "STD" button twice.

MEASURING AND RECORDING REFLECTANCE DATA

5. (a) Obtain reflectance data for a white paint sample as follows:

1) After set up of the meter on the green filter channel, check and correct the calibration as described in paragraph 4(h). Measure the reflectance of the 0.25 mm (10 mil) specimen over the black and white portions of the chart. Record the results in the appropriate boxes of the reflectance data worksheet. (See Figure 1 for an illustration of a blank worksheet.) Then measure the reflectances of the 0.38 mm (15 mil) specimen over both portions of the chart and record similarly.

2) After set up of the meter on the amber filter channel, check and correct the calibration as described in paragraph 4(h). Measure and record reflectances of the 0.38 (15 mil) specimen over both the black and the white portion of the chart.

3) Repeat step 5(a)(2), on the blue channel.

(b) Obtain reflectance data for a yellow paint sample as in step 5(a)(1).

CALCULATING AND REPORTING REFLECTANCE PROPERTIES

6. (a) Report "Reflectance" of a white or yellow paint as the reflectance of the 0.38 mm (15 mil) specimen on the green channel over the white portion of the chart.

(b) Calculate and report "Dry Opacity" of a white or yellow paint as the ratio of reflectance of the 0.25 mm (10 mil) specimen over the black portion of the chart to the reflectance of the same over the white portion, both reflectances being measured on the green channel.

(c) Calculate and report "Yellowness Index" of a white paint according to the following formula: (Yellowness Index does not apply to a yellow paint.)

$$\text{Yellowness Index} = \frac{\text{Amber - Blue}}{\text{Green}} \times 100$$

Where: Amber, Blue, and Green are the measured reflectances of the 0.38 mm (15 mil) specimen over the white portion of the chart on the respective filter channels.

NOTE: Any reflectance and yellowness index properties derived from measurements made over the black portions of the charts are for informational purposes only.

REFLECTANCE DATA WORKSHEET

DATE _____ OPERATOR _____

SERIAL #	1		2		3		4		5		6	
BATCH #												
COLOR												
BACKGROUND	BLACK	WHITE	BLACK	WHITE	BLACK	WHITE	BLACK	WHITE	BLACK	WHITE	BLACK	WHITE
0.25 mm (10 mil) GREEN (G_1)												
DRY OPACITY (BLACK/WHITE)												
0.38 mm (15 mil) GREEN (G_2) REFLECTANCE												
0.38 mm (15 mil) AMBER (A)												
0.38 mm (15 mil) BLUE (B)												
YELLOWNESS INDEX (ON WHITE PAINT) $\frac{A - B}{G_2}(100)$												

FIGURE 1

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September 5, 1996
(6 Pages)

CHLORIDE IN HARDENED CONCRETE

(An Arizona Method)

SCOPE

1. (a) This method covers the determination of chloride in concrete by a standard addition technique using a chloride electrode. Use of the standard addition technique minimizes the effects of interferences in the samples. "Total Chloride" is obtained by an acid digestion, and "Available Chloride" by water leaching of the concrete sample.

(b) This test method involves hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

REAGENTS

2. (a) Chloride standard solution, 1.000 mg/mL, (weigh 1.648 grams dried primary standard Sodium Chloride, and dilute to 1 liter with deionized water).

(b) Nitric acid, 12%. **Caution must be exercised in preparing this solution.** Measure 120 mL concentrated Nitric acid, slowly pour into a 1 liter (1000mL) beaker or flask with approxiamately 500 mL deionized water. Then, fill with deionized water to make 1 liter solution.

(c) Deionized water.

APPARATUS

3. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) 300 mL Tall-Form beakers, calibrated to indicate 100 mL volume, with watch glasses.

(b) An analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.001 gram.

(c) Whatman # 43 filter paper, or equivalent.

(d) Low temperature hot plate.

(e) Magnetic stirrer and stirring bar.

(f) Orion 94-17 chloride electrode with Orion 90-01 reference electrode, or equivalent combination.

(g) Orion EA 940 specific ion meter, or equivalent.

(h) 1 mL pipette, accurate to 0.01 mL.

(i) Thermometer, accurate to at least 0.5 °C.

PROCEDURE

4. (a) Weigh a 1.000 gram representative homogeneous sample of finely pulverized concrete into a beaker. The sample should preferably pass a 75 μm (No. 200) sieve. If "ΔE", as calculated in paragraph 4(j), is less than 18 millivolts (or if "C_0", as calculated in paragraph 5(a), is equal to or greater than 0.010 mg/mL), the procedure shall be repeated using a smaller sample, recording the sample weight to the nearest 0.001 gram.

(b) To the beaker, add 25 mL nitric acid for "Total Chloride" or 25 mL deionized water for "Available Chloride", and cover with watch glass.

(c) Heat at a temperature just below the boiling point for 20 minutes, occasionally swirling solution. Do not allow solution to boil.

(d) Filter into a clean beaker and wash thoroughly using approximately 50 mL of deionized water.

(e) Dilute filtrate to 100 mL with deionized water. This is the "reading solution". Adjust solution temperature to 25 ± 0.5 °C and maintain at that temperature throughout remainder of test.

(f) Place stirring bar in beaker, place beaker on magnetic stirrer, insert electrodes, and initiate stirring. Stirring shall be at a constant moderate rate, such that the vortex created by stirring does not expose the tips of the immersed electrodes. The rate of stirring and the temperature (25 ± 0.5 °C) shall be constant throughout the remainer of the procedure, until the final reading has been obtained in paragraph (i) below.

(g) After reading has stabilized, record initial reading to the nearest millivolt as "E_1".

(h) Add 1.00 mL chloride standard solution.

(i) After reading has stabilized, record final reading to the nearest millivolt as "E_2".

(j) Calculate $\Delta E = E_1 - E_2$.

(k). Repeat steps (b) through (j) on a reagent blank in a clean beaker.

CALCULATIONS AND REPORT

5. (a) Calculate chloride concentration, "C_o" in sample reading solution and "C_b" in reagent blank reading solution, and record each to the nearest 0.001 mg/mL, by the following. (The formula is derived from the Nernst equation for a specific ion electrode. The relation holds in dilute solutions. See Appendix.)

$$C_o \text{ or } C_b = \frac{1}{(101)\,10^{(\Delta E/S)} - 100}$$

Where: $\Delta E = E_1 - E_2$

S = Electrode slope at 25 ± 0.5 °C as determined in accordance with manufacturer's recommendations. (The slope "S" should equal approximately 59 millivolts for a properly functioning electrode. See Section 6, Appendix.)

(b) Calculate percent chloride concentration in concrete, "C" (Total Chloride or Available Chloride), and report to the nearest 0.001%, by the following:

$$C = \frac{10\ (C_o - C_b)}{\text{Sample Wt.}}$$

APPENDIX

6. (a) The derivation of the formula for "C_o" and "C_b", the concentration of chloride in the reading solutions, is as follows:

(1) The chloride sensing electrode's behavior is given by the Nernst equation:

$$E = E_o - S\,[\log (kC)] = E_o - 2.303\frac{RT}{F}[\log (kC)]$$

Where: E = the measured electrode potential in volts (difference of potential between chloride electrode and reference electrode).

E_o = the standard electrode potential.

S = 2.303RT/F = the electrode slope. The theoretical value of "S" is given by:

$$2.303\ \frac{8.314\frac{\text{volt}\cdot\text{coul}}{°K}298\ °K}{96500\ \text{coul}} = 0.059\ \text{volt}$$

C = the chloride concentration in the reading solution in mg/mL.

k = a constant which converts concentration to activity.

(2) For initial reading "E_1" = E_o - S [log (kC_1)]
and final reading "E_2" = E_o - S [log (kC_2)]

$$\Delta E = E_1 - E_2 = S\,[\log (C_2/C_1)]$$

or $$\frac{C_2}{C_1} = 10^{(\Delta E/S)}$$

Since $$C_2 = \frac{C_1V_1 + C_SV_S}{V_1 + V_S}$$

Where:
C_2 = final chloride concentration in mg/mL
C_1 = initial chloride concentration in mg/mL
V_1 = initial volume = 100 mL
C_S = standard chloride concentration = 1 mg/mL
V_S = volume of chloride standard solution added = 1 mL

then $$\frac{C_2}{C_1} = \frac{C_1 V_1 + C_S V_S}{C_1(V_1 + V_S)} = 10^{(\Delta E/S)}$$

or $$C_1 V_1 + C_S V_S = C_1 (V_1 + V_S) 10^{(\Delta E/S)}$$

or $$C_S V_S = C_1 \left[(V_1 + V_S) 10^{(\Delta E/S)} - V_1 \right]$$

Therefore $$C_1 = \frac{C_S V_S}{(V_1 + V_S)\, 10^{(\Delta E/S)} - V_1}$$

and $$C_o \text{ or } C_b = \frac{1}{(101)\, 10^{(\Delta E/S)} - 100}$$

(b) The formula for "C" (percent "Total Chloride" or "Available Chloride" concentration in concrete) is as follows:

$$C = \frac{[C_o\ (mg/mL) - C_b\ (mg/mL)]\ (100\ mL)\left[\frac{1\ g}{1000\ mg}\right]}{\text{Sample Weight (g)}} \times 100$$

$$C = \frac{10\ (C_o - C_b)}{\text{Sample Wt.}}$$

ARIZ 729b
March 31, 2010
(4 Pages)

EXCHANGEABLE SODIUM IN TOPSOIL

(An Arizona Method)

1. SCOPE

(a) This test method is used to compare or qualify topsoil for cultivation of plants insofar as the proportion of exchangeable sodium among the four major cations (Sodium, Potassium, Calcium, and Magnesium) is related to plant welfare. "Exchangeable" is defined by the method itself and is based on the exchange of ammonium ion from the reagent Ammonium Acetate Solution with the four major cations under the conditions given by the method. The four cations are brought into solution by the reagent and their concentrations in solution are determined by Atomic Absorption or Flame Emission Spectrophotometry.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

(a) Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(1) No. 12 sieve.

(2) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 gram.

(3) Plastic vials, 1-1/4 inches in diameter and 4 inches in length, with caps.

(4) Reciprocating shaker capable of 180 cycles per minute, with carrier for holding vials in place.

(5) Sodium-free quantitative filter paper, 11 cm diameter.

(6) Atomic Absorption or Flame Emission Spectrophotometer capable of determining Sodium, Potassium, Calcium, and Magnesium.

3. REAGENTS

(a) Ammonium Acetate Solution, 1 Normal. (Measure 57 mL reagent glacial acetic acid into a 1 liter volumetric flask and dilute to 500 mL with deionized water. Add 69 mL reagent concentrated ammonium hydroxide. Dilute to approximately 950 mL with deionized water and mix. Adjust pH to 7.0 using glacial acetic acid or ammonium hydroxide dropwise as necessary. Dilute to the mark with deionized water.)

(b) Sodium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(c) Potassium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(d) Calcium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(e) Magnesium Stock Solution, 1000 mg/liter. (Available as calibrated standard solution from chemical suppliers).

(f) Hydrochloric Acid Solution, 50%. (Dilute concentrated reagent grade hydrochloric acid 1:1 with deionized water.)

(g) Lanthanum Chloride Reagent Solution, 0.26%. (Weigh 1.30 grams anhydrous reagent grade lanthanum chloride into a 500 mL volumetric flask. Dilute to the mark with deionized water.)

4. PROCEDURE

(a) Weigh 2.00 grams of soil, passing a No. 12 sieve into a plastic vial.

(b) Pipette 40.0 mL Ammonium Acetate Solution into the vial, and cap it.

(c) Place vial into carrier of reciprocating shaker. Shake at 180 cycles per minute for exactly 5 minutes.

(d) Immediately filter into a clean vial. (The folded filter paper can be placed onto the rim of the vial instead of using a funnel.) Cap the vial. This is the Original Extract Solution.

(e) Prepare a diluted solution by transferring a suitable aliquot from the Original Extract Solution to a volumetric flask, adding hydrochloric acid to 1% and lanthanum chloride to 26 mg/liter. (If a 50 mL flask is used, 1.0 mL of Hydrochloric Acid Solution and 0.5 mL of Lanthanum Chloride Reagent Solution is required.) The dilution is made with deionized water. This is the Diluted Extract Solution. The dilution should be sufficient to bring the absorbances of the four elements to values below those of the Standard Solution.

(f) Prepare a solution with concentrations of 1.00 mg/liter of sodium, 2.00 mg/liter of potassium, 5.00 mg/liter of calcium, and 0.50 mg/liter of magnesium. This solution should have 1% strength hydrochloric acid and 26 mg/liter lanthanum chloride. The dilution is made with deionized water. This is the Standard Solution.

(g) Prepare a solution with 1% Hydrochloric Acid and 26 mg/liter Lanthanum Chloride in deionized water. This is the Reagent Blank Solution.

(h) Perform an Atomic Absorption or Flame Emission Spectrophotometric analysis using the Diluted Extract Solution, the Standard Solution, and the Reagent Blank Solution. (The instrumental parameters, given in the table below are recommended for the analysis.) Determine the concentration of each of the four cations in the Original Extract Solution to the nearest 0.1 mg/liter. If the concentration of any element in the Diluted Extract Solution is higher than that in the Standard Solution, a more dilute Diluted Extract Solution should be prepared as in paragraph 4(e).

ELEMENT	WAVELENGTH	FLAME
Sodium	589.2	Air-Acetylene
Potassium	766.5	Air-Acetylene
Calcium	422.7	Air-Acetylene
Magnesium	285.2	Air-Acetylene

5. CALCULATIONS

(a) Calculate the concentration of exchangeable cations in milliequivalents per 100 grams (meq /100 g) of soil using the following formulas:

$$C'_{Na}\ (\text{in meq/100 g}) = (0.087)\ x\ (C_{Na})$$

$$C'_{K}\ (\text{in meq/100 g}) = (0.051)\ x\ (C_{K})$$

$$C'_{Ca}\ (\text{in meq/100 g}) = (0.100)\ x\ (C_{Ca})$$

$$C'_{Mg}\ (\text{in meq/100 g}) = (0.165)\ x\ (C_{Mg})$$

Where: C_{Na}, C_K, C_{Ca}, or C_{Mg} is the concentration of each cation, in mg/liter, respectively in the Original Extract Solution.

(b) Compute the total Cation Exchange Capacity (CEC) of the soil, which is the sum of the four exchangeable cation concentrations, as follows:

$$CEC\ (\text{in meq/100 g}) = C'_{Na} + C'_{K} + C'_{Ca} + C'_{Mg}$$

(c) Compute the Exchangeable Sodium Percentage (ESP), which is the exchangeable sodium proportion of the total Cation Exchange Capacity, as follows:

$$ESP = \frac{C'_{Na}}{CEC} \times 100$$

(d) Compute the Exchangeable Sodium (ES) in the soil, in parts per million, using the following formula:

$$ES\ (\text{in ppm}) = (20)\ x\ (C_{Na})$$

6. REPORT

(a) Report Exchangeable Sodium Percentage (ESP) to the nearest 0.1 percent.

(b) Report Exchangeable Sodium (ES) to the nearest 1.0 ppm.

CALCIUM CARBONATE IN TOPSOIL (NEUTRALIZATION POTENTIAL OF TOPSOIL)

(An Arizona Method)

1. SCOPE

1.1 This test method is used to determine the acid-consumption capacity or alkalinity of a topsoil as defined by the conditions of the test itself. The principal mineral components of the topsoil which give rise to this alkalinity are generally taken to be alkali and alkaline earth metal carbonates. They are represented by calcium carbonate, the most abundant member of the group.

1.2 A large excess of Hydrochloric Acid Standard Solution is added to ensure complete decomposition of the Calcium Carbonate. Then, the residual acid is backtitrated out with Sodium Hydroxide Standard Solution.

1.3 This test method involves hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.4 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 25 mL, volumetric pipette, accurate to $\pm$ 0.05 mL.

2.1.2 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 gram.

2.1.3 Filter paper equivalent to Whatman No. 40.

2.1.4 Filtration funnel, 7.5 cm, 60°, long stem.

2.1.5 300 mL beaker, tall form, graduated.

2.1.6 25 mL burette, accurate to $\pm$ 0.01 mL.

2.1.7 Stirring rod (glass or plastic).

3. REAGENTS

3.1 1.00 $\pm$ 0.10 Normal Hydrochloric Acid Standard Solution. Label this solution "Reagent 1" or "R_1" on the bottle. This reagent is available from laboratory chemical suppliers as a standardized solution. Its normality should be checked regularly against "Reagent 2" below, as required by frequency of use. Record the actual normality of this solution as "N_1".

3.2 1.00 $\pm$ 0.10 Normal Sodium Hydroxide Standard Solution. Label this solution "Reagent 2" or "R_2" on the bottle. This reagent is available from laboratory chemical suppliers as a standardized solution. Its normality should be checked regularly against primary standard Potassium Biphthalate, as required by frequency of use. Record the actual normality of this solution as "N_2".

3.3 Phenolphthalein Indicator (1% Phenolphthalein in 50% Isopropyl Alcohol).

3.4 Demineralized Water.

4. PROCEDURE

4.1 Weigh 1.00 $\pm$ 0.01 gram of soil passing a No. 12 sieve into a 300 mL beaker.

4.2 Pipette 25.00 $\pm$ 0.05 mL Hydrochloric Acid Solution (Reagent 1) into the 300 mL beaker.

4.3 Stir thoroughly with a stirring rod.

4.4 Let the mixture stand undisturbed for 15 minutes, or, if significant bubbling is observed, 30 minutes.

4.5 Filter the entire contents of the 300 mL beaker into another 300 mL beaker and rinse three times with demineralized water, being careful to keep the total volume at or under 100 mL.

4.6 Dilute to 100 mL, if necessary, with demineralized water, and add one drop of Phenolphthalein Indicator.

4.7 Backtitrate the residual Hydrochloric Acid with Sodium Hydroxide Solution (Reagent 2) to a Phenolphthalein endpoint.

4.8 Record the volume of Reagent 2 delivered, to the nearest 0.05 mL, as "V_2".

5. CALCULATIONS AND REPORT

5.1 Calculate Calcium Carbonate, in percent, using the following formula:

$$\text{Calcium Carbonate, \%} = 5 \times \left[25 - \frac{N_2 \times V_2}{N_1} \right] \times N_1$$

5.2 Report Calcium Carbonate to the nearest 0.1%.

SULFATE IN SOILS

(An Arizona Method)

1. SCOPE

1.1 This test method describes a procedure for determining sulfate content in soil using a turbidimeter. The sulfate content determined is defined in terms of the method and may be called water soluable sulfate.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 The extraction procedure, Subsections 4.1 through 4.4, is the same as is used in Arizona Test Method 736, “Chloride In Soils”.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 Turbidimeter - with at least ± 2% accuracy to 1000 NTU (nephelometric turbidity units) and at least ± 5% accuracy to 4000 NTU, with sample cuvettes.

2.1.2 Balances or scales:

2.1.2.1 One balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity shall be at least 0.1 gram.

2.1.2.2 An analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity shall be at least 0.1 milligram.

2.1.3 Beaker(s) - three, 200 mL capacity each.

2.1.4 Erlenmeyer flask - 500 mL capacity with stopper.

2.1.5 Volumetric flask - 1000 mL capacity, accurate to 0.3 mL.

2.1.6 Reagent dispensing bottle - 500 mL capacity, capable of repeatedly dispensing 5 mL of reagent.

2.1.7 Reagent storage bottles - three, one-liter capacity, each with cap.

2.1.8 Dropping bottle - 60 mL, with dispensing tip or dropper.

2.1.9 Centrifuge tube - 50 mL, with cap.

3. REAGENTS

3.1 Conditioning Reagent.

3.1.1 Into a reagent storage bottle, add 300 mL demineralized water, 30 mL Reagent Grade Concentrated Hydrochloric Acid, 100 mL Reagent Grade Isopropyl Alcohol, 75 grams Reagent Grade Sodium Chloride, and 50 mL Reagent Grade Glycerol. Mix well. Transfer to a reagent dispensing bottle as needed.

3.2 Sulfate Standard Solution, 0.100 mg/mL (100 ppm).

3.2.1 Into a 1000 mL volumetric flask, add 147.9 mg Reagent Grade Anhydrous Sodium Sulfate. Fill the flask to the 1000 mL mark with demineralized water. Mix well. Transfer to a reagent storage bottle.

3.3 Barium Chloride Reagent Solution, 1%.

3.3.1 Into a 1000 mL volumetric flask, add 10 grams of Reagent Grade Barium Chloride Powder, Anhydrous. Fill the flask to the 1000 mL mark with demineralized water. Mix well. Transfer to a reagent dispensing bottle as needed, and the remainder to a reagent storage bottle.

3.4 Nitric Acid, 20%.

3.4.1 Measure 10 mL concentrated nitric acid into a suitable size beaker containing approximately 40 mL demineralized water and mix well. Transfer to a dropping bottle.

CAUTION: Exercise extreme caution in preparing and using the Nitric Acid solution. It must be properly labeled and treated as a hazardous material.

3.5 Demineralized water.

4. PROCEDURE

4.1 Weigh 100.0 ± 0.1 grams of soil passing a No. 10 sieve into a 500 mL Erlenmeyer flask.

4.2 Weigh 300.0 ± 0.1 grams demineralized water into the flask.

4.3 Stopper the flask, shake vigorously, and let the mixture stand undisturbed for one hour.

4.4 Carefully, with minimal disturbance of the sediment, decant 50 mL of the extract solution into a centrifuge tube.

4.4.1 If the decanted extract solution is clear, proceed to Subsection 4.5.

4.4.2 If the decanted extract solution is not clear, place the tube into the centrifuge and centrifuge at a minimum of 5000 RPM for 10 minutes. If the solution is still not clear, add 2 drops of 20% Nitric Acid solution to the tube and centrifuge again. Repeat until the centrifugate is clear.

4.5 Transfer 20.0 mL of the clear extract solution (or centrifugate) into a 200 mL beaker. This is the sample aliquot, “ALSAM.”

4.5.1 Dispense 5 mL of Conditioning Reagent and 5 mL of Barium Chloride Reagent Solution into the beaker, and dilute to 100 mL. This is the “Sample Solution.”

4.6 Transfer 20.0 mL of Sulfate Standard Solution into a second 200 mL beaker. This is the standard aliquot “ALSTD.”

4.6.1 Dispense 5 mL of Conditioning Reagent and 5 mL of Barium Chloride Reagent Solution into this beaker, and dilute to 100 mL. This is the "Standard Solution."

4.7 Dispense 5 mL of Conditioning Reagent and 5 mL of Barium Chloride Reagent Solution into a third 200 mL beaker, and dilute to 100 mL. This is the "Reagent Blank Solution."

4.8 Stir the three solutions and let them stand undisturbed for at least 15 minutes.

4.9 Rinse a sample cuvette with demineralized water and then with freshly stirred Reagent Blank Solution. Immediately transfer enough Reagent Blank Solution to fill the cuvette to the mark.

4.9.1 Place the cuvette into the turbidimeter and read the turbidity to the nearest 0.1 NTU. The turbidity of the Reagent Blank Solution is recorded as "TBBNK".

4.10 Rinse a sample cuvette with demineralized water and then with freshly stirred Sample Solution. Immediately transfer enough Sample Solution to fill the cuvette to the mark.

4.10.1 Place the cuvette into the turbidimeter and read the turbidity to the nearest 0.1 NTU. Record the turbidity of the Sample Solution as "TBSAM."

4.11 Rinse a sample cuvette with demineralized water and then with freshly stirred Standard Solution. Immediately transfer enough Standard Solution to fill the cuvette to the mark.

4.11.1 Place the cuvette into the turbidimeter and read the turbidity to the nearest 0.1 NTU. Record the turbidity of the Standard Solution as "TBSTD."

4.12 Compare the values of "TBSAM" and "TBSTD." If "TBSAM" is larger than "TBSTD", repeat Subsections 4.5 and 4.5.1 using a suitably smaller sample aliquot. Record this volume, to the nearest 0.1 mL, as "ALSAM." Repeat Subsections 4.10 and 4.10.1.

5. CALCULATION AND REPORT

5.1 Calculate sulfate content in the soil in parts per million, "S", and report to the nearest 10 ppm as follows:

$$S = 300 \times \left[\frac{ALSTD \times TBSAM}{ALSAM \times TBSTD} \right]$$

Where:

ALSTD = 20.0 mL (Size of the standard aliquot).
TBSTD = Turbidity corresponding to ALSTD.
ALSAM = Size of the sample aliquot, mL.
TBSAM = Turbidity corresponding to ALSAM.

Note: If the turbidity of the Reagent Blank Solution “TBBNK” is 0.40 or higher, for greater accuracy, the value of “TBBNK” shall be subtracted from “TBSAM” and from “TBSTD” before calculating S above.

DETERMINATION OF PORTLAND CEMENT CONTENT IN CEMENT TREATED BASE MATERIAL

(An Arizona Method)

SCOPE

1. (a) This test procedure covers a method for the determination of the percentage of portland cement in cement treated base material.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

(a) Burette - 50 mL capacity with teflon stopcock and burette cover.

(b) Burette clamps.

(c) Ring stand.

(d) Pipette - 10 mL capacity, accurate to 0.05 mL.

(e) Plastic dropper dispenser - 100 mL.

(f) Plastic wash bottles - 100 mL capacity, 500 mL capacity, 1000 mL capacity.

(g) Graduated cylinders - (transparent plastic), 100 mL capacity, 500 mL capacity, 1000 mL capacity.

(h) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

(i) An analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.0001 gram.

(j) Beakers - (plastic), 300 mL capacity, 2000 mL capacity, 4000 mL capacity.

(k) Stirring rods - stainless steel, 305 mm (12") long; glass, not over 150 mm (6 inches) long.

(l) Erlenmeyer flasks - (plastic), 500 mL capacity with stoppers.

(m) Variable control hot plate.

(n) Spatulas, cleaning brushes, watch glasses.

(o) Stop watch or equally efficient timing device.

(p) Plastic bottles - 3.8 liter (1 gal.), 1 liter (1 qt.).

(q) 19.0 liter (5 gallon) polyethylene jug.

REAGENTS

3. Reagents shall be prepared as described below. Distilled or de-ionized water shall be used in their preparation.

(a) 2-Propanol (Analyzed Reagent)

(b) Tartaric Acid 72% Solution (TAS).

1) For a 19.0-liter (5 gallon) batch, weigh 13680 grams of reagent grade D-Tartaric Acid into a 19.0 liter (5 gallon) polyethylene jug, or other suitable non-reactive container, precalibrated to indicate a 19.0 liter (5 gallon) volume.

2) Add boiling water to fill the jug to the 19.0 liter (5 gallon) mark. Mix thoroughly and let set overnight.

3) Filter into another 19.0 liter (5 gallon) jug and dilute to the 19.0 liter (5 gallon) mark.

(c) Potassium Hydroxide 1-Normal Titrating Solution (TS).

1) Weigh 56.1 grams reagent grade Potassium Hydroxide into a one liter polyethylene jug, or other suitable non-reactive container, precalibrated to indicate a one liter volume. The Potassium Hydroxide shall not be placed in a glass container.

2) Add sufficient water to dissolve the Potassium Hydroxide. Mix thoroughly and allow to come to room temperature. Dilute to the one liter mark. This solution shall not be stored in a glass container.

(e) 1% Methyl Red Indicator.

1) For a 50 mL batch, weigh 0.5 gram methyl red dye into a 100 mL beaker.

2) Add 25 mL 2-propanol and dissolve.

3) Fill to 50 mL mark with distilled water.

4) Transfer to the dropper dispenser.

PREPARATION OF STANDARD SAMPLES

4. (a) Standard samples shall be prepared using the same materials and mix design formula as the job from which field samples will be taken. A representative minimum 3000 grams of soil/aggregate material with no added cement shall be used to prepare the standard samples. From this, three representative portions to be used for preparing standard samples shall be obtained using a standard reduction method such as given in AASHTO R 76. The standard samples shall be prepared with differing cement contents bracketing the mix design cement content as follows:

(1) 0.0% cement content.

(2) The mix design cement content, expressed to the nearest 0.1%.

(3) 5.0% more cement than the design content.

(b) The three components of the standard samples are cement, soil/aggregate material, and water. The total sample weight shall be 300 grams. The weight of water from the job is 30 grams. The dry components of the standard sample are cement and soil/aggregate material with a combined weight of 270 grams. The state of dryness of the soil/aggregate material used in preparing standard samples may be either saturated-surface-dry, air-dry, or oven-dry. It is important that the same state of dryness be obtained for all standard samples and for field test samples, [See paragraph 8(a)]. Use the following formulas to determine the dry components of each standard sample:

$$W_C = 300 \times \frac{C}{100}$$

$$W_{S/A} = 270 - W_C$$

Where: W_C = Weight of cement, grams
$W_{S/A}$ = Weight of soil/aggregate, grams
C = Cement content, % of total sample

NOTE: In case a large quantity of large aggregate is present in a cement treated base job, a minimum of 15,000 grams of soil/aggregate material should be obtained for preparation of standard samples, and the following procedure followed:

(1) For each standard sample, 5000 grams of soil/aggregate material is obtained using the standard reduction method and separated into coarse and fine fractions.

(2) The coarse fraction is washed with distilled water and its adhering fines are added to the fine fraction.

(3) From the resulting combined fine fraction, a representative portion is obtained using the standard reduction method.

TEST PROCEDURE FOR STANDARD SAMPLES

5. (a) Transfer the dry components to the 2000 mL plastic beaker.

NOTE: It is preferable to weigh the cement as accurately as possible. Use an analytical balance to weigh the desired amount of cement. Then transfer the cement to the aggregate already in the plastic beaker.

(b) Mix thoroughly. AVOID PRODUCING DUST.

(c) Add 30 grams of water that is used on the job for mixing the batch.

NOTE: At this point it may be desirable to thoroughly mix the standard sample and transfer it to a suitable container and allow it to cure for a sufficient time to approximate the expected condition of the field sample at the time it is tested, after which the standard sample must be broken down as necessary to facilitate mixing and intimate contact with the reagent (TAS). An apparatus such as the one described in AASHTO T 87 may be utilized for this purpose. Care should be taken to avoid reducing the size of individual natural particles. Quantitatively transfer the standard sample to the 2000 mL beaker.

(d) Add 400 ± 0.1 mL of distilled water to the beaker.

(e) Stir thoroughly and vigorously for 3 ± 1 minutes.

(f) Cover the 2000 mL beaker with a watch glass. Keep the beaker covered with a watch glass at all times, except when actually in use.

(g) Let stand undisturbed for 40 ± 5 minutes.

(h) Stir thoroughly and vigorously for 2 minutes. Let stand undisturbed for 1 to 2 minutes.

(i) Accurately measure 300 mL Tartaric Acid 72% Solution (TAS) into a 500 mL graduated cylinder.

NOTE: Keep all containers of all reagents covered when not in use. Keep all stock containers sealed.

(j) Add TAS slowly and with continued stirring to the beaker.

NOTE: If effervescence occurs, stop addition of TAS and stir vigorously until bubbling ceases, complete the addition of TAS, then stir at least 2 minutes continuously.

(k) Let the sample stand undisturbed for 10 minutes.

(l) Accurately measure 710 mL of 2-propanol into a 1000 mL graduated cylinder.

(m) Add the 2-propanol, all at once, to the beaker, completely draining the cylinder. Immediately stir, rapidly and thoroughly, for exactly 2 minutes, so that all the contents of the beaker are washed with 2-propanol. Cover with a watch glass, and let the beaker stand undisturbed until a clear liquid layer forms.

(n) Carefully pour only the clear liquid into a 500 mL plastic Erlenmeyer flask. Tightly stopper and seal the flask.

TITRATION PROCEDURE

6. (a) Fill the 50 mL burette completely with Potassium Hydroxide 1-Normal Titrating Solution (TS). Open the stopcock and let the burette drain completely.

(b) Refill the burette with TS, and adjust the bottom of the meniscus to read 0.0 mL.

NOTE: Make sure that there are no air bubbles anywhere in the system. Always check just below the stopcock for air bubbles when the burette is draining. Keep the top of the burette covered.

(c) Transfer an aliquot of 10.00 ± 0.05 mL of the clear liquid from the flask to a 300 mL plastic beaker using a 10 mL pipette.

(d) Add 100 mL distilled water to the beaker, using a 100 mL graduated cylinder.

(e) Stir the contents of the beaker with a glass stirring rod. Do not remove the stirring rod until the titration is completed.

(f) Add 2 drops of 1% Methyl Red Indicator and stir the solution. The test solution should now be a clear, dark-red color. The color change is as follows:

Start: Clear, dark-red solution.
To: Clear, pure orange solution.
End: Clear, pure lemon-yellow solution.

(g) Rapidly, with stirring, add TS until the solution turns to an orange color.

(h) Stir the solution.

(i) Set the burette stopcock to deliver the TS one drop at a time, with stirring between each addition. As the end point is approached, the solution should turn to a clear red-orange or clear yellow-orange color.

(j) Decrease the rate of addition of TS, and stop addition when one drop produces a pure lemon-yellow clear solution. Allow the solution to stand undisturbed for one minute to check for color fading.

(k) If the color fades, add one more drop and again allow to stand undisturbed for one minute. Repeat until the color does not fade.

(l) Read the volume of TS used to the nearest 0.1 mL at the bottom of the meniscus.

(m) If time is available, run at least two titrations for each sample and obtain the average volume of TS used.

PREPARATION OF THE STANDARD CURVE

7. (a) The standard curve is prepared using linear graph paper.

(b) Plot the number of mL of TS, along the X-axis.

(c) Plot the percentages of portland cement, along the Y-axis.

(d) Draw the straight line of best fit for the three points.

TEST PROCEDURE FOR FIELD SAMPLE

8. (a) From a representive minimum 1000 gram field sample of the cement treated base material to be tested, at the same state of dryness as the standard samples, obtain a 270 ± 0.1 gram test sample using the standard reduction method used with the standard samples and transfer it to a 2000 mL plastic beaker.

NOTE: As necessary, the field sample must be broken down to facilitate weighing, mixing, and intimate contact with the reagent (TAS). An apparatus such as the one described in AASHTO T 87 may be utilized for this purpose. Care should be taken to avoid reducing the size of individual natural particles.

NOTE: If much large aggregate is present, a representative minimum of 5000 gram field sample should be used. It should be separated into coarse and fine fractions and the coarse fraction washed with distilled water to obtain a combined fine fraction from which the test sample is prepared as above. [See note following paragraph 4(b).]

(b) Add 400 ± 0.1 mL of distilled water to the beaker.

(c) Stir thoroughly and vigorously for 3 ± 1 minutes.

(d) Cover the beaker with a watch glass. Keep the beaker covered with a watch glass at all times, except when actually in use.

(e) Let the beaker stand undisturbed for 40 ± 5 minutes.

(f) Follow the procedure as described in paragraphs 5(h) through 5(n).

TITRATION PROCEDURE

9. Titrate in accordance with Section 6.

REPORT

10. Read results directly from the Standard Curve as percent portland cement in the field sample. Report the result to the nearest 0.1%.

TESTING OF THERMOPLASTIC PAVEMENT MARKING MATERIAL

(An Arizona Method)

SCOPE

1. (a) Thermoplastics to be tested according to the procedures given herein are mixtures of resins, mineral fillers, pigments, organic additives, and reflective glass spheres.

(b) All testing is done on hot melt test specimens made from the commercial products. These include field test specimens obtained from highway striping operations and specimens produced according to Part I of this method.

(c) This method is divided into two parts: Part I gives a procedure for producing hot melt test specimens. Part I also gives an alternate procedure for producing hot melt test specimens in accordance with AASHTO T 250. Part II gives the procedures for testing specimens.

(d) This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(e) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(f) Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

PART I - PROCEDURE FOR PRODUCING HOT MELTS

APPARATUS

2. (a) Heating mantle - Glas-Col Model 620 or equivalent, capable of accepting a 4000 mL beaker.

(b) Stainless steel beaker - 4000 mL, Vollrath No. 84000 or equivalent, for use with heating mantle.

(c) Mixer - Variable-speed, air-driven, Cole-Parmer No. E-04685-00 or equivalent.

(d) Mixer stand - Cole-Parmer No. E-04546-00 or equivalent with 60 cm height and capability of holding mixer.

(e) Adjustable chuck - Cole-Parmer No. E-04423-00 or equivalent, capable of coupling mixer shaft to impeller assembly shaft.

(f) Impeller assembly - Any assembly with a 35-40 cm shaft of 0.5 cm minimum diameter, dual impellers of 8-10 cm diameter spaced 4-6 cm apart with one at the end of the shaft, capable of efficient mixing of 3000-3500 mL of fluid at 700-800 rpm. Alternatively, a heavy-duty "Jiffy" type impeller for one gallon paint containers is suitable.

(g) Temperature controller with thermocouple probe - Glas-Col Digitroll II, No. 104A PL612, with 6 in. type "J" iron-constantan thermocouple or equivalent, capable of controlling mixture temperature in conjunction with heating mantle at 218 °C.

(h) Ladles - Stainless steel, 30 mL and 60 mL capacity with long handles for sampling hot melts.

(i) Aluminum or stainless steel lid to cover beaker, with holes for impeller shaft and thermocouple, and turned-down edges for holding in place over beaker.

PROCEDURE

3. (a) Mount the mixer, with impeller assembly and lid, onto the mixer stand and note position of mixer which locates bottom of impeller assembly about 2-3 cm from bottom of beaker. Secure the mantle to the mixer stand in such a position as to permit the impeller assembly to be placed over the center of the beaker and to prevent relative movement between the impeller assembly and the beaker. Plug the mantle cord into the controller. Plug the controller into a wall outlet.

(b) Remove the mixer with impeller assembly and lid. Split out a 6000 gram sample of thermoplastic material and add enough to the beaker to come to within 5-6 cm of the top. Replace the mixer, impeller, and lid. (It may be necessary to first work the impeller assembly into the thermoplastic, and then replace the lid and mixer). Place the thermocouple in position through its hole in the lid, making sure it penetrates

into the thermoplastic. Set the controller parameters for automatic control of temperature at 218 °C, and start the heating cycle.

(c) When the thermoplastic has melted sufficiently, start the mixer at a low speed. As the temperature continues to rise, increase the mixer speed until it is evident that the entire mass of thermoplastic in the beaker is being turned over continuously. (Note this mixer speed for future use). Continue heating and mixing while periodically checking the level of thermoplastic in the beaker. If the level drops below 5-6 cm from the top of the beaker, add more thermoplastic as necessary. Continue this process for four hours after the material has reached the final temperature of 218 °C.

(d) At the end of the four hour period, turn the mixer off and remove it with the lid and impeller assembly. Immediately use the ladles to transfer enough of the melt to fill a set of suitable can lids, usually a one-gallon can lid and two one-quart can lids. Set the lids with the test specimens aside for cooling. These will be used for all of the tests of the thermoplastic material.

(e) Use heat resistant gloves to remove the beaker from the mantle and discard the remainder of the thermoplastic. Allow the beaker to drain completely while the material is hot.

Note: Alternatively, the procedure for producing hot melt test specimens for Reflectance, Color, and Yellowness Index as given in AASHTO T 250 may be used, if desired. If AASHTO T 250 is used, the amount of material specified may be increased to approximately 500 grams.

PART II - TESTS

REFLECTANCE AND YELLOWNESS INDEX

4. The apparatus and procedure for determining reflectance and yellowness is given in Sections 5 through 8.

APPARATUS

5. Reflectance and gloss meter - Photovolt 577 or equivalent, with "T" search head.

CALIBRATION OF METER

6. After an initial warmup time of a minimum of 30 minutes, calibrate the meter for use on the applicable filter channels (green "G", amber "A", and/or blue "B") as follows:

(a) Load the green filter in the filter rack of the "T" search unit and rotate the rack until the filter is in front of the lens.

(b) Select the green memory location by depressing the "G" button on the front face of the meter.

(c) Place the black cavity standard on the head of the search unit.

(d) Set the dark current (zero offset) by depressing first the "CHANGE" button and then the "ZERO" button on the face of the meter.

(e) Place the Photovolt ceramic reflectance standard plaque on the head of the search unit.

(f) Enter the standard reflectance value for the green filter on the meter display, by depressing first the "CHANGE" button, then the "STD" button, and finally, the "A", "B", and "G" buttons as necessary to increment the tens, units, and tenths digits respectively until the value is displayed. Then depress the "STD" button again. The standard reflectance value for the green filter is now stored in the memory, and the meter is now calibrated on the green filter channel.

(g) If reflectance data is to be obtained for a white test specimen, repeat steps 6(a) through 6(f) for the amber filter channel and again for the blue filter channel.

(h) For each channel used, immediately prior to obtaining reflectance data the calibration should be checked and, if necessary, corrected. First replace the black cavity standard on the head of the search unit and if drift has occurred, depress the "CHANGE" button and then the "ZERO" button. Next replace the standard plaque on the head of the search unit and if drift has occurred, depress the "CHANGE" button, and then depress the "STD" button twice.

MEASURING AND RECORDING REFLECTANCE DATA

7. (a) Obtain reflectance data for a white test specimen as follows:

(1) After calibration of the meter on the green filter channel, measure the reflectance of the specimen. Record the result as “Green.”

(2) Repeat step 7(a)(1) for the amber channel. Record the result as "Amber."

(3) Repeat step 7(a)(1) for the blue channel. Record the result as "Blue."

(b) Obtain reflectance data for a yellow test specimen as in step 7(a)(1) for the green channel only.

CALCULATING AND REPORTING REFLECTANCE PROPERTIES

8. (a) Report "Reflectance" of a white or yellow test specimen as the reflectance value "Green" obtained as in 7(a)(1) or 7(b) above, respectively.

(b) Calculate and report "Yellowness Index" of a white test specimen according to the following formula:

$$\text{Yellowness Index} = \frac{\text{Amber - Blue}}{\text{Green}} \times 100$$

BINDER AND GLASS BEAD CONTENT

9. The apparatus, reagents, and procedure for determining binder content and glass bead content is given in Sections 10 through 13.

APPARATUS

10. (a) A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.01 gram.

(b) Porcelain crucibles, 30 mL capacity.

(c) Muffle furnace, capable of holding a constant temperature of 538 °C and having a sufficiently large chamber for several crucibles.

(d) Drying oven, capable of holding a constant temperature of 100 °C.

(e) Mortar, 75-100 mL capacity, with pestle.

(f) Dessicator.

(g) Beakers, 400 mL capacity.

(h) Aluminum dishes, 57 mm diameter.

(i) Small spatula.

(j) Balance brush.

(k) Hot plate.

REAGENT

11. Hydrochloric acid solution, 50%, prepared by adding (cautiously) 500 mL concentrated hydrochloric acid to 500 mL demineralized water.

PROCEDURE

12. (a) Break up a test specimen into pieces sufficiently small to permit weighing of material into a crucible.

(b) Weigh a crucible to the nearest 0.01 gram. Record the weight as "C".

(c) Zero the balance and weigh 10.00 ± 0.10 gram of test specimen into the crucible. Record the weight as "S".

(d) Preheat the furnace to 538 °C.

(e) Place the crucible **(cautiously)** into the furnace.

(f) After one hour, remove the crucible from the furnace and place it into the dessicator for cooling.

(g) After cooling, remove the crucible and weigh it, with its contents, to the nearest 0.01 gram. Record the weight as "R".

(h) Use the spatula to scrape the inside of the crucible and quantitatively transfer all of the residue into the mortar.

(i) Using the pestle, gently grind the residue to a fine powder, taking care not to crush the glass beads.

(j) Using the brush, quantitatively transfer all of the powdered residue to a beaker.

(k) Slowly add 150 mL of acid solution to the beaker, taking care to minimize possible splattering due to generation of carbon dioxide.

(l) Stir the mixture by swirling, place the beaker on the hot plate, and heat to boiling with frequently stirring.

(m) Remove the beaker from the hot plate and add 150 mL of demineralized water.

(n) Let stand until the beads settle and decant the suspension, being careful not to lose any beads.

(o) Add about 100 ml of water and repeat step 12(n) until the decanted water is clear.

(p) Place the beaker into the drying oven.

(q) When completely dried, remove the beaker, with beads, from the oven.

(r) Allow the beaker and beads to cool. Weigh to the nearest 0.01 gram and record the weight as "B_1".

(s) Using the brush, quantitatively transfer the beads to a suitable receptacle for microscopic examination, if desired, or to a waste container.

(t) Reweigh the empty beaker to the nearest 0.01 gram. Record the weight as "B_2".

CALCULATIONS AND REPORT

13. (a) Calculate and report the binder content, to the nearest 0.1%, using the following formula:

$$\text{Binder Content, \%} = \frac{C + S - R}{S} \times 100$$

(b) Calculate and report the bead content, to the nearest 0.1%, using the following formula:

$$\text{Bead Content, \%} = \frac{B_1 - B_2}{S} \times 100$$

CHLORIDE IN SOILS

(An Arizona Method)

1. SCOPE

1.1 This test method describes a procedure for determining chloride content in soil by a standard addition technique using a chloride electrode. The chloride content is defined in terms of the method and may be called water soluable chloride.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 The extraction procedure, Subsections 4.1 through 4.4, is the same as is used in Arizona Test Method 733, “Sulfate In Soils”.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus shall consist of the following:

2.1.1 Tall-form beakers - two, 200 mL each (Pyrex #1060 or equivalent), calibrated to indicate 100 mL volume.

2.1.2 An analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity of any balance utilized shall be at least 0.001 gram.

2.1.3 Magnetic stirrer and stirring bar.

2.1.4 Erlenmeyer flask(s) - 500 mL capacity with stopper(s).

2.1.5 Chloride electrode system - (Orion Ionplus #9617 combination chloride electrode or equivalent), suitable for use in a 200 mL tall-form beaker.

2.1.6 Specific ion meter - (Orion EA 940 or equivalent), suitable for use with the chloride electrode system.

2.1.7 Thermometer - accurate to at least 0.5 $^{\circ}$C.

2.1.8 Pipettes - 1 mL, 5 mL, and 10 mL capacity, accurate to 1%.

2.1.9 Sample bottle - 200 mL capacity or larger, with cap.

2.1.10 Dropping bottle - 60 mL, with dispensing tip or dropper.

2.1.11 Centrifuge tube - 50 mL, with cap.

3. REAGENTS

3.1 Chloride Standard Solution, 1.000 mg/mL (1000 ppm).

3.1.1 Fisher Scientific # LC13000-1 or equivalent. Alternatively, the Chloride Standard Solution may be made by transferring 1.648 gram dried primary standard sodium chloride into a 1000 mL volumetric flask and diluting to 1000 mL with demineralized water.

3.2 Nitric Acid, 20%.

3.2.1 Measure 10 mL concentrated nitric acid into a suitable size beaker containing approximately 40 mL demineralized water and mix well. Transfer to a dropping bottle.

CAUTION: Exercise extreme caution in preparing and using the Nitric Acid solution. It must be properly labeled and treated as a hazardous material.

3.3 Demineralized Water.

4. PROCEDURE

4.1 Weigh 100.0 ± 0.1 grams of soil passing a No. 10 sieve into a 500 mL Erlenmeyer flask.

4.2 Weigh 300.0 ± 0.1 grams demineralized water into the flask.

4.3 Stopper the flask, shake vigorously, and let the mixture stand undisturbed for one hour.

4.4 Carefully, with minimal disturbance of the sediment, decant 50 mL of the extract solution into a 50 mL centrifuge tube.

4.4.1 If the decanted extract solution is not cloudy, proceed to Subsection 4.5.

Note: The decanted extract solution does not have to be clear, as it is required to be in Arizona Test Method 733.

4.4.2 If the decanted extract solution is cloudy, place the tube into the centrifuge and centrifuge at a minimum of 5000 RPM for 10 minutes.

4.5 Pipette a 10.0 mL aliquot of the extract solution (or centrifugate) into a 200 mL beaker. Record this volume as “A”. Dilute to the 100 mL mark with demineralized water and add three drops of Nitric Acid, 20%. This is the “Sample Reading Solution.”

4.6 Place a stirring bar into the beaker, place the beaker onto the magnetic stirrer, insert the electrodes, and initiate stirring. Stirring shall be at a constant moderate rate, such that the vortex created by stirring does not expose the tips of the immersed electrodes. The rate of stirring shall be constant throughout the procedure.

4.7 After the reading has stabilized, record the initial reading to the nearest millivolt, as "E_1".

4.8 Add 1.00 mL of Chloride Standard Solution.

4.9 After the reading has stabilized, record the final reading to the nearest millivolt, as "E_2".

4.10 Calculate ΔE. ($\Delta E = E_1 - E_2$).

Note: "ΔE" is calculated and recorded initially as "ΔEo" for the Sample Reading Solution. It is subsequently also calculated and recorded as "ΔEb for the Reagent Blank Reading Solution.

4.11 If "ΔEo" (for the Sample Reading Solution) is less than 18, repeat Subsections 4.5 through 4.10 with a suitably smaller size aliquot, recording this aliquot volume as "A."

4.12 Prepare a Reagent Blank Reading Solution by placing 100 mL of demineralized water into a second 200 mL beaker and adding 3 drops of Nitric Acid 20%. Repeat Subsections 4.6 through 4.10, calculating and recording "ΔEb" (for the Reagent Blank Reading Solution).

5. CALCULATIONS AND REPORT

5.1 Calculate chloride concentration, "C_o" in the Sample Reading Solution and "C_b" in the Reagent Blank Reading Solution, and record each to the nearest 0.001 mg/mL, as follows:

$$C_o = \frac{1}{\left[101 \times 10^{[(\Delta Eo)/S]}\right] - 100}$$

$$C_b = \frac{1}{\left[101 \times 10^{[(\Delta Eb)/S]}\right] - 100}$$

Where:

S = Electrode slope, as determined in accordance with the manufacturer's recommendations. (The slope should equal approximately 59 millivolts for a properly functioning electrode.)

5.2 Calculate chloride concentration in the soil in parts per million, "C", and report to the nearest 10 ppm as follows:

$$C = \frac{300{,}000 \times (C_o - C_b)}{A}$$

CHLORIDE IN CONCRETE ADMIXTURES

(An Arizona Method)

SCOPE

1. (a) This test method describes a procedure for determining the chloride content of products used as admixtures in Portland cement concrete. The method employs a standard addition technique using a chloride electrode.

(b) This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

APPARATUS

2. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus shall consist of the following:

(a) 300 mL tall-form beaker (Pyrex #1060 or equivalent), calibrated to indicate 100 mL volume.

(b) An analytical balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M231, except the readability and sensitivity of any balance utilized shall be at least 0.001 gram.

(c) Suitable magnetic stirrer and stirring bar.

(d) Chloride electrode system (Orion Ionplus #9617 combination chloride electrode or equivalent) suitable for use in the 300 mL beaker.

(e) Specific ion meter (Orion EA 940 or equivalent) suitable for use with the chloride electrode system.

(f) 3 mL disposable syringe with cap (Beckton Dickinson # 301112 or equivalent).

(g) 1.000 mL pipette or pipetter accurate to ± 0.001 mL.

REAGENTS

3. (a) Chloride standard solution, 1.000 mg/mL (1000 PPM), (Fisher Scientific #LC13000-1, or equivalent, or made by transferring 1.648 gram dried primary standard sodium chloride into a 1 liter volumetric flask and diluting to 1000 mL with demineralized water).

(b) Nitric acid, 8% (made by transferring 80 mL of concentrated nitric acid into a 1 liter volumetric flask containing approximately 500 mL demineralized water and diluting to 1000 mL with demineralized water. **Caution must be exercised in preparing and using this solution! It should be properly labelled and treated as a hazardous material.**

PROCEDURE

4. (a) Weigh 1.000 ± 0.010 gram sample of admixture into a beaker. (If liquid, weigh by difference using a syringe). Record the sample weight to the nearest 0.001 gram as "A."

(b) Transfer 25 mL nitric acid, 8% into the beaker and swirl to mix with the sample.

(c) Dilute to 100 mL with demineralized water.

(d) Place a stirring bar into the beaker, place the beaker onto the magnetic stirrer, insert the electrode(s) into the solution, and initiate stirring. Stir at a constant moderate rate such that the vortex created by stirring does not expose the tip(s) of the electrode(s) to the air. The rate of stirring and the temperature (25.0 ± 1.0 °C) shall be held constant throughout the procedure.

(e) After the reading has stabilized, record it to the nearest millivolt, as "E_1."

(f) Pipette 1.000 ± 0.001 mL chloride standard solution into the beaker.

(g) After the reading has stabilized, record it to the nearest millivolt, as "E_2."

(h) Calculate $\Delta E = E_1 - E_2$.

(i) If ΔE is less than 18 mV, repeat steps (a) through (h) with a smaller size sample.

(j) Prepare a reagent blank solution by transferring 25 mL of Nitric Acid, 8% into a 300 mL beaker and diluting to 100 mL with demineralized water. Repeat steps (d) through (h).

CALCULATIONS AND REPORT

5. (a) Calculate chloride concentration, "C_o" in the sample reading solution and "C_b" in the reagent blank reading solution, and record each to the nearest 0.010 mg/mL, as follows:

$$C_o \text{ or } C_b = \frac{1}{(101)\,10^{(\Delta E/S)} - 100}$$

Where: S = Electrode slope at 25 ± 1.0 °C as determined in accordance with manufacturer's recommendations. (The slope should equal approximately 59 millivolts for a properly functioning electrode.)

(b) Calculate chloride concentration in the admixture in parts per million, "C", and report to the nearest 10 PPM as follows:

$$C = \frac{10^5 (C_o - C_b)}{A}$$

MEAN MACROTEXTURE DEPTH OF MILLED PAVEMENT

(A Modification of Indiana Test Method 812-03T and ASTM E 965)

1. SCOPE

(a) This test method describes the procedure to determine the Mean Macrotexture Depth of a milled pavement surface.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

(a) The apparatus shall consist of the following:

(1) Filler - Type 1 glass beads conforming to the requirements of AASHTO M 247.

(2) Spreader - A flat, stiff, hard disk made from methyl methacrylate (Plexiglas) with a thickness of 0.5 ± 0.1 inch, and a diameter of 8 inches ± 1/4 inch, with a handle attached to the top of the disk.

(3) Graduated Cylinder - Class B or better, Style III, 250 mL capacity graduated cylinder conforming to the requirements of ASTM E 1272, used to measure the amount of filler required for the test.

(4) Brushes - A stiff wire brush and a soft bristle brush, used to clean the pavement.

(5) Container - Small container, with a secure and easily removable cover, used to store 200 mL of filler.

(6) Wind Screen - A shield used to protect the test area from air turbulence created from wind or traffic.

(7) Measuring device - A tape measure, or ruler at least 12 inches long, graduated in at least 1/8 inch increments. A tape measure, or ruler at least 300 millimeters long, graduated in millimeter increments may be used if desired.

3. PREPARATION OF FILLER MATERIAL

(a) For each test location, one container with 200 mL of filler is prepared as follows:

(1) Fill the graduated cylinder to the 200 mL mark and gently tap the base of the cylinder several times on a rigid surface. Add more material to fill the graduated cylinder to the 200 mL mark. Gently tap the side of the cylinder to level the material. As necessary, add additional material, tap, and level until the filler is at the 200 mL mark.

(2) Place the measured amount of filler in the container.

4. PROCEDURE

(a) Randomly select a test location.

(b) Inspect the selected test location and ensure that it is dry, uniform, and free of unique or localized features such as cracks, joints, stripping, and patching. Clean the test location using the brushes to remove any residue, debris, or loosely bonded material. Position the wind screen around the test location.

(c) Holding the container above the test location at a height not greater than 4 inches from the pavement surface, pour the measured amount of filler into a conical pile on the test area.

(d) Lightly place the spreader on top of the conical pile, being careful not to compact the filler.

(e) Using the spreader, carefully spread the material into a circular patch filling the surface voids flush with the top of the milled pavement.

(f) Measure and record the diameter of the circular patch at four locations (intervals of 45º) to the nearest 1/8 inch. Convert each reading to the nearest millimeter (1 inch = 25.4 millimeters). If desired, measurements may be taken directly in millimeters and recorded to the nearest millimeter.

Example: (For a reading of 9-3/8")

9-3/8" = 9.375"
9.375" x 25.4 = 238.125 millimeters =
238 millimeters (rounded to the nearest millimeter)

5. CALCULATIONS

(a) Calculate the average diameter of the circular patch as follows:

$$D_a = \frac{D_1 + D_2 + D_3 + D_4}{4}$$

Where:

D_a = Average diameter of the circular patch, nearest millimeter
D_1, D_2, D_3, D_4 = Individual diameters of the circular patch, nearest millimeter

(b) Using the average diameter of the circular patch, determine the Mean Macrotexture Depth by referencing Figure 1. The values for Mean Macrotexture Depth shown in Figure 1 have been determined using the equation for Mean Macrotexture Depth shown below. When necessary, use the equation to determine the Mean Macrotexture Depth for average diameters outside the range of values given in Figure 1.

Since: Volume = (Area) x (Height, or Depth)

Therefore: $\text{Height, or Depth} = \frac{\text{Volume}}{\text{Area}}$

so: $\text{Mean Macrotexture Depth, mm} = \frac{V}{(\pi) \text{ x } \left(\frac{D_a}{2}\right)^2}$

Where: V = Volume of glass beads, 200,000 mm^3 (200 mL)
D_a = Average diameter of the circular patch, mm

6. REPORT AND EXAMPLE

(a) An example of a completed Mean Macrotexture Depth test report is provided in Figure 2.

(b) A blank Mean Macrotexture Depth test report form is provided in Figure 3.

MEAN MACROTEXTURE DEPTH (Based on 200 mL of Glass Beads and Average Diameter)					
Average Diameter (mm)	**Mean Macrotexture Depth (mm)**	**Average Diameter (mm)**	**Mean Macrotexture Depth (mm)**	**Average Diameter (mm)**	**Mean Macrotexture Depth (mm)**
185	7.44	222	5.17	259	3.80
186	7.36	223	5.12	260	3.77
187	7.28	224	5.08	261	3.74
188	7.20	225	5.03	262	3.71
189	7.13	226	4.99	263	3.68
190	7.05	227	4.94	264	3.65
191	6.98	228	4.90	265	3.63
192	6.91	229	4.86	266	3.60
193	6.84	230	4.81	267	3.57
194	6.77	231	4.77	268	3.55
195	6.70	232	4.73	269	3.52
196	6.63	233	4.69	270	3.49
197	6.56	234	4.65	271	3.47
198	6.50	235	4.61	272	3.44
199	6.43	236	4.57	273	3.42
200	6.37	237	4.53	274	3.39
201	6.30	238	4.50	275	3.37
202	6.24	239	4.46	276	3.34
203	6.18	240	4.42	277	3.32
204	6.12	241	4.38	278	3.29
205	6.06	242	4.35	279	3.27
206	6.00	243	4.31	280	3.25
207	5.94	244	4.28	281	3.22
208	5.89	245	4.24	282	3.20
209	5.83	246	4.21	283	3.18
210	5.77	247	4.17	284	3.16
211	5.72	248	4.14	285	3.14
212	5.67	249	4.11	286	3.11
213	5.61	250	4.07	287	3.09
214	5.56	251	4.04	288	3.07
215	5.51	252	4.01	289	3.05
216	5.46	253	3.98	290	3.03
217	5.41	254	3.95	291	3.01
218	5.36	255	3.92	292	2.99
219	5.31	256	3.89	293	2.97
220	5.26	257	3.86	294	2.95
221	5.21	258	3.83	295	2.93

FIGURE 1

MEAN MACROTEXTURE DEPTH
ARIZONA TEST METHOD 742

TRACS Number: H999901C Roadway: Heraz Canyon – Lee's Bluff Contractor: Happy Days Construction

Test #	Date	Station	Offset	D_1 (mm)	D_2 (mm)	D_3 (mm)	D_4 (mm)	D_a (mm)	Mean Macrotexture Depth	Spec.	Pass (✓)	Fail (✓)
1	03-25-08	351+62	4' Rt. of CL	248	239	245	236	242	4.35	≤4.50	✓	
2	03-25-08	373+16	6' Rt. of CL	255	263	250	259	257	3.86	"	✓	
3	03-25-08	402+42	10' Rt. of CL	241	246	237	248	243	4.31	"	✓	
4	03-25-08	429+53	7' Rt. of CL	247	259	251	254	253	3.98	"	✓	
5	03-25-08	456+87	3' Rt. of CL	263	260	257	253	258	3.83	"	✓	

EXAMPLE

(03/18/08)

FIGURE 2

MEAN MACROTEXTURE DEPTH
ARIZONA TEST METHOD 742

TRACS Number: _____ Roadway: _____ Contractor: _____

Test #	Date	Station	Offset	D_1 (mm)	D_2 (mm)	D_3 (mm)	D_4 (mm)	D_a (mm)	Mean Macrotexture Depth	Spec.	Pass (✓)	Fail (✓)

(03/18/08)

FIGURE 3

TITANIUM DIOXIDE IN PAINTS AND THERMOPLASTICS

(An Arizona Method)

1. SCOPE

1.1 This test method may be used to make a rapid estimation of the amount of Titanium Dioxide pigment in paints and thermoplastics, particularly those of white color used for traffic control markings.

1.2 The method is a non-instrumental, gravimetric method, which involves removing, successively, all accompanying constituents of the material, leaving only the Titanium Dioxide analyte. The isolated analyte is weighed directly.

1.3 The method is applicable for paints and for thermoplastics, with or without glass beads.

1.4 **The procedure in this method consists of two parts. Part A is for paints; Part B is for thermoplastics.**

1.5 This test method involves hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.6 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 600 mL beaker, graduated.

2.1.2 Whatman No. 40 ashless filter paper, 125 mm, or equivalent.

2.1.3 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except that the readability and sensitivity of any balance or scale utilized shall be at least 0.0001 gram.

2.1.4 50 mL porcelain crucible.

2.1.5 Filtration funnel, 7.5 cm, 60°, long stem.

2.1.6 Watch glass, 3 inch.

2.1.7 Glass stirring rod.

2.1.8 Muffle furnace, capable of maintaining a constant temperature of 450 °C.

2.1.9 Drying oven, capable of maintaining a constant temperature of 110 °C.

2.1.10 Dessicator.

2.1.11 Hot plate.

3. REAGENTS

3.1 Concentrated Hydrochloric Acid Solution.

3.2 Concentrated Nitric Acid Solution.

3.3 Demineralized water.

4. PROCEDURE

4.1 **PART A (FOR PAINTS):**

4.1.1 Weigh 5.0000 ± 0.2500 grams of paint into a crucible. Record the weight of the paint specimen as “B” to the nearest 0.0001 gram.

4.1.2 Place crucible and specimen into the drying oven at temperature of 110 °C.

4.1.3 After 2 hours, remove crucible, place into cold muffle furnace, and set the temperature to 450 °C.

4.1.4 Ignite specimen at 450 °C for 1 hour after the temperature of 450 °C is attained.

4.1.5 Remove crucible with ignition residue and allow to cool to room temperature.

4.1.6 Place crucible with residue into 300 mL beaker.

4.1.7 Cautiously, dropwise, add 30 mL Concentrated Hydrochloric Acid to crucible.

4.1.8 Cautiously add 10 mL Concentrated Nitric Acid to crucible.

4.1.9 After digestion of the residue is complete, add 250 mL of demineralized water to beaker, add 1 boiling chip, cover with watchglass, and place on the hot plate.

4.1.10 Heat beaker contents to boiling and boil for 15 minutes.

4.1.11 Remove beaker from hotplate and filter contents, carefully washing and decanting titanium dioxide, leaving boiling chip and glass beads, if any, in the beaker. Wash thoroughly with demineralized water.

4.1.12 Tightly fold filter and place into tared crucible. Record crucible weight as “A,” to the nearest 0.0001 gram.

4.1.13 Place crucible and contents into cold furnace and set temperature to 450 °C.

4.1.14 Ignite specimen at 450 °C for 1 hour after temperature of 450 °C is attained.

4.1.15 Remove crucible and allow to cool to room temperature in dessicator.

4.1.16 Weigh crucible and contents. Record weight as “C,” to the nearest 0.0001 gram.

4.2 **PART B (FOR THERMOPLASTICS):**

4.2.1 Weigh 5.0000 ± 0.2500 grams of thermoplastic into a crucible. Record the weight of the thermoplastic specimen as "B" to the nearest 0.0001 gram.

4.2.2 Place crucible and specimen into cold muffle furnace and set the temperature to 450 °C.

4.2.3 Proceed as specified in Subsections 4.1.4 through 4.1.16.

5. CALCULATIONS AND REPORT

5.1 Calculate Titanium Dioxide, in percent, using the following formula:

$$\text{Titanium Dioxide, \%} = \frac{C - A}{B} \times 100$$

5.2 Report Titanium Dioxide to the nearest 0.001%.

ROCK SALT IN CRASH BARREL SAND

(An Arizona Method)

1. SCOPE

1.1 This test method is used to determine the amount of rock salt which has been mixed with sand for use in crash barrel cushions.

1.2 The method is a non-instrumental, gravimetric method, which involves removing the salt from the sand/salt mixture by dissolution and washing away the salt using demineralized water. The salt content is then determined by weight loss after drying.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. APPARATUS

2.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. Apparatus for this test procedure shall consist of the following:

2.1.1 1000 mL heavy-duty glass beaker, graduated; KIMAX No. 14005, or equivalent.

2.1.2 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except that the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.1.3 Stirring rod (glass, steel, or plastic).

2.1.4 Drying oven, capable of maintaining a constant temperature of 110 °C.

2.1.5 Spot plate (black).

3. REAGENTS

3.1 Silver Nitrate Test Solution, 1%. Weigh approximately 0.5 gram of Silver Nitrate crystals into a 100 mL beaker and dilute to 50 mL. Stir to dissolve, and transfer contents to an amber dropping bottle.

3.2 Demineralized water.

4. PROCEDURE

4.1 Weigh a clean beaker. Record the weight as "A" to the nearest 0.1 gram.

4.2 Weigh 500.0 ± 5.0 grams of sand/salt mixture into the beaker. Record the weight of the sand/salt mixture as "B" to the nearest 0.1 gram.

4.3 Add enough demineralized water to cover the specimen and fill the beaker to the 750 mL mark.

4.4 Stir the contents of the beaker vigorously and let the mix stand for one hour.

4.5 Decant and discard the supernatant extract solution.

4.6 Repeat Subsections 4.3 and 4.4, and then continue to Subsection 4.7.

4.7 Test two drops of the extract solution for the presence of chloride with two drops of the silver nitrate solution, in the spot plate.

4.8 If the test indicates the presence of chloride (by a white cloudy solution), repeat Subsections 4.3, 4.4, and 4.7. If the test indicates the absence of chloride, decant and discard the extract solution.

4.9 Place the beaker and wet sand residue into the drying oven. Dry thoroughly at 110 °C.

4.10 After drying, remove the beaker with dry sand residue from the oven and allow to cool to room temperature.

4.11 Weigh the beaker and contents. Record the weight as "C" to the nearest 0.1 gram.

5. CALCULATIONS AND REPORT

5.1 Calculate the salt content, in percent, using the following formula:

$$\text{Salt, \%} = \frac{(A + B) - C}{B} \times 100$$

5.2 Report as Percent Rock Salt, to the nearest 0.1%.

SERIES 800
DESIGN

EVALUATION OF PROFILES

(A Modification of California Test 526)

SCOPE

1. This method describes the procedure for determining the Profile Index from profilograms of pavements made with a California type profilograph. Also described is the procedure used to locate individual high areas when their reduction is required by the contract documents. The same requirements apply to both the mechanical and the electronic profilograph, except that the electronic type will compute the profile index and high points directly, in lieu of manual reduction, and will print a summary of data for the test section.

SUMMARY OF METHOD

2. The profilogram is recorded on a scale of one inch equal to 25 feet longitudinally and one inch equal to one inch, or full scale, vertically. The determination of the Profile Index involves measuring "scallops" that appear outside a "blanking band". The determination of individual high areas involves the use of a special template.

PART I
DETERMINATION OF PROFILE INDEX

APPARATUS

3. The only special equipment needed to determine the Profile Index is a plastic scale 1.70 inches wide and 21.12 inches long representing a pavement length of 528 feet, or one tenth of a mile, at a scale of 1 inch = 25 feet. Near the center of the scale is an opaque band 0.2 inch wide extending the entire length of 21.12 inches. On either side of this band are scribed lines 0.1 inch apart parallel to the opaque band. These lines serve as a convenient scale to measure deviations or excursions of the graph above or below the blanking band. These are called "scallops".

METHOD OF COUNTING

4. The methodology described below pertains to the use a mechanical profilograph. If an electronic profilograph is used, this counting is performed automatically (see Part III).

(a) Place the plastic scale over the profile in such a way as to "blank out" as much of the profile as possible. When this is done, scallops above and below the blanking band usually will be approximately balanced. (See Figure 1)

(b) The profile trace will move from a generally horizontal position when going around superelevated curves, making it impossible to blank out the central portion of the trace without shifting the scale. The profile under such conditions should be broken in short sections and the blanking band repositioned on each section while counting. (See Figure 2A)

(c) Starting at the right end of the scale, measure and total the height of all the scallops appearing both above and below the blanking band, measuring each scallop to the nearest 0.05 inch. Write this total on the profile sheet near the left end of the scale together with a small mark to align the scale when moving to the next section. Short portions of the profile line may be visible outside the blanking band, but unless they project 0.03 inch or more, and extend longitudinally for two feet (0.08 inch on the profilogram) or more, they are not included in the count. (See Figure 1 for illustration of these special conditions.)

(d) When scallops occurring in the first 0.1 mile are totaled, slide the scale to the left, aligning the right end of the scale with the small mark previously made, and proceed with the counting in the same manner. The last section counted may or may not be an even 0.1 mile. If not, its length should be scaled to determine its length in miles.

CALCULATIONS

5. The Profile Index, "PrI", is determined as "inches per mile in excess of the 0.2 inch blanking band", but is simply called the Profile Index.

(a) The procedure for converting counts to Profile Index is given below. If an electronic profilograph is used, this calculation is performed automatically (see Part III).

$$PrI = \frac{1}{\text{Length of profile (miles)}} \times \frac{\text{Total count (Tenths of an Inch)}}{10}$$

(b) Profile Indexes may be averaged for two or more profiles of the same section of road if the profiles are the same length. Generally the same profiles shall be taken along the path of the wheel tracks within each lane, or at 3 ft. from the edge of the pavement and at every 6-ft. interval after that across the pavement.

EXAMPLE

6. The following is an illustration of the calculations:

Section Length (Miles)	Counts (Tenths of an inch)
0.10	5.0
0.10	4.0
0.10	3.5
400 ft. = 0.076	2.0
Total = 0.376	Total = 14.5

$$PrI = \frac{1}{0.376} \times \frac{14.5}{10} = 3.9$$

LIMITATIONS OF COUNT IN 0.1 MILE SECTIONS

7. When the specifications limit the amount of roughness in any one-tenth mile section, the scale is moved along the profile and counts made at various intervals to find those sections that do not conform to specifications.

LIMITS OF COUNTS - JOINTS

8. When counting profiles, a day's paving is considered to include the last portion of the previous day's work, which includes the daily joint. The last 15 to 30 feet of a day's paving cannot usually be obtained until the following day. In general, the paving contractor is responsible for the smoothness of joints if he places the concrete pavement on both sides of the joint. On the other hand, the contractor is responsible only for the pavement placed by him if the work abuts a bridge or a pavement placed under another contract. Profilograph readings when approaching such joints should be taken in conformance with the contract documents.

AVERAGE PROFILE INDEX FOR THE WHOLE JOB

9. When averaging Profile Indexes to obtain an average for the job, the average for each day must be "weighted" according to its length. This is most easily done by totaling the counts for the 0.1-mile sections of a given line or lines and using the total length of the line in the computation for determining the Profile Index.

PART II
DETERMINATION OF HIGH POINTS IN EXCESS OF 0.3 INCH

APPARATUS

10. The only special equipment needed is a plastic template having a line one inch long scribed on one face with a small hole or scribed mark at either end, and a slot 0.3 inch from the parallel to the scribed line (see Figure 2). The one-inch line corresponds to a horizontal distance of 25 feet on the horizontal scale of the profilogram.

LOCATING HIGH POINTS IN EXCESS OF 0.3 INCH

11. The procedure for locating high points in excess of 0.3 inch is given below. If an electronic profilograph is used, these locations are determined automatically (see Part III).

(a) At each prominent peak or high point on the profile trace, place the template so that the small holes or scribe marks at each end of the scribed line intersect the profile trace to form a chord across the base of the peak or indicated bump. The line on the template need not be horizontal. With a sharp pencil, draw a line using the narrow slot in the template as a guide. Any portion of the trace extending above this line will indicate the approximate length and height of the deviation in excess of 0.3 inch.

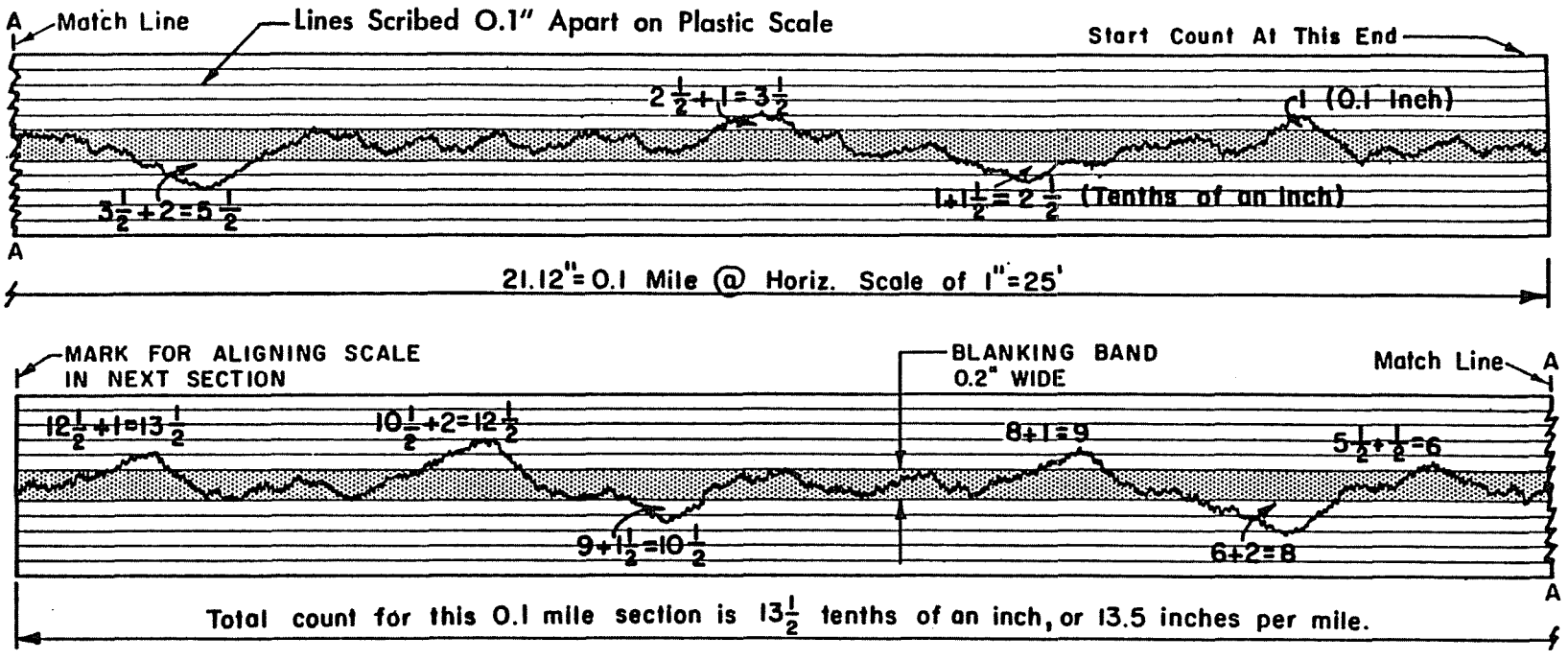
(b) There may be instances where the distance between easily recognizable low points is less than one inch (25 feet). In such cases, a shorter chord length shall be used in making the scribed line on the template tangent to the trace at the low points. It is the intent however, of this requirement that the baseline for measuring the height of bumps will be as nearly 25 feet (1 inch) as possible, but in no case to exceed this value. When the distance between prominent low points is greater than 25 feet (1 inch) make the ends of the scribed line intersect the profile trace when the template is in a nearly horizontal position. A few examples of the procedure are shown in the lower portion of Figure 2.

PART III
SPECIAL REQUIREMENTS FOR
ELECTRONIC TYPE PROFILOGRAPH

APPARATUS

12. The Cox electronic profilograph is the only brand approved for use on Arizona Department of Transportation projects. This apparatus shall be operated in accordance with the manufacturers instructions. The use of the manufacturers recommended settings of 80 for the null band filter, and 8000 for the data filter are mandatory.

EXAMPLE SHOWING METHOD OF DERIVING PROFILE INDEX FROM PROFILOGRAMS



TYPICAL CONDITIONS

SPECIAL CONDITIONS

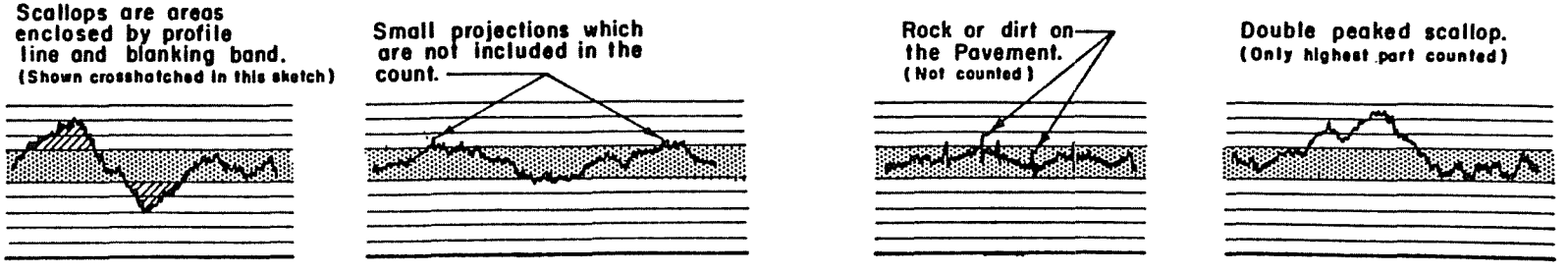
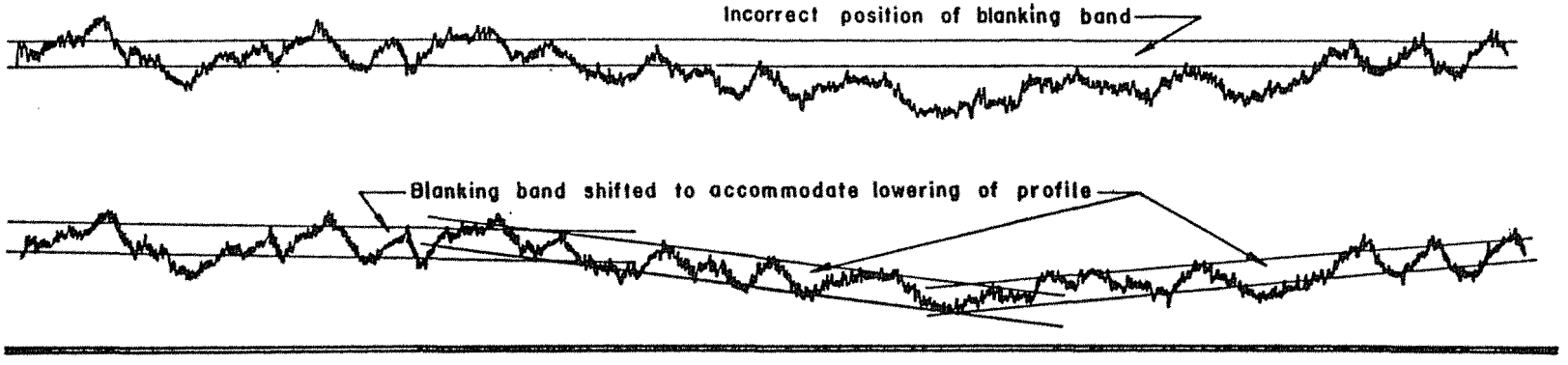


FIGURE 1

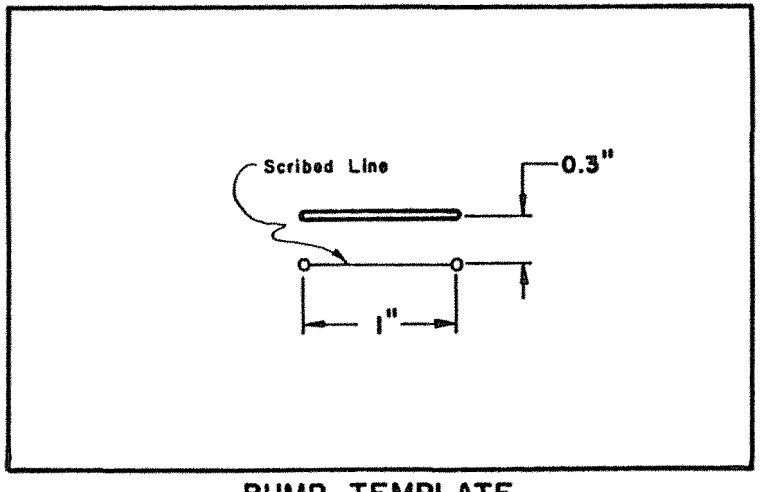
METHOD OF COUNTING WHEN POSITION OF PROFILE SHIFTS AS IT MAY WHEN ROUNDING SHORT RADIUS CURVES WITH SUPERELEVATION

A



B

METHOD OF PLACING TEMPLATE WHEN LOCATING BUMPS TO BE REDUCED



BUMP TEMPLATE

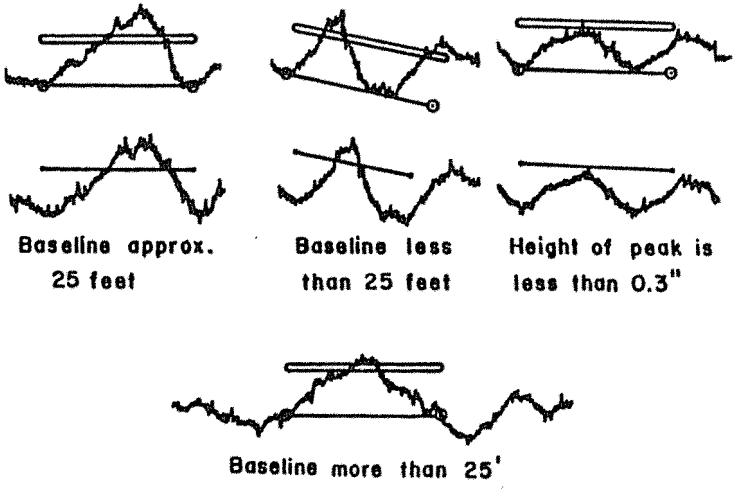


FIGURE 2

EFFECT OF WATER ON STRENGTH OF COMPACTED, TREATED AND UNTREATED BITUMINOUS MIXTURES (IMMERSION COMPRESSION TEST)

(A Modification of AASHTO Designation T 167 and ASTM D 1075)

1. SCOPE

1.1 This method covers measurement of the loss of strength resulting from the effect of water on compacted bituminous mixtures. A numerical index of retained strength is obtained by comparing the compressive strength of freshly molded and cured specimens with the compressive strength of duplicate specimens that have been immersed in water under prescribed conditions. Provisions are also given for testing specimens which have been treated with a mineral admixture. With some modifications this procedure may be used in testing recycled bituminous mixtures or emulsion mixes.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

2. REFERENCED DOCUMENTS

2.1

ARIZ 415	Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
ARIZ 815	Marshall Mix Design Method for Asphaltic Concrete

2.2

AASHTO M 231	Weighing Devices Used in the Testing of Materials
AASHTO T 167	Compressive Strength of Hot Mix Asphalt
AASHTO T 316	Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.3	ASTM D 1075	Effect of Water on Compressive Strength of Compacted Bituminous Mixtures
	ASTM D 2493	Standard Viscosity-Temperature Chart for Asphalt

3. APPARATUS

3.1 Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

3.2 Molds and Plungers – Molds and plungers conforming to the requirements of AASHTO T 167.

3.3 Support Bars – Steel bars to hold the mold cylinder one inch above the baseplate during molding operation.

3.4 Testing Machine – A testing machine conforming to the requirements of AASHTO T 167.

3.5 Ovens – A minimum of two ovens that are controllable to within ± 5 °F of any temperature specified in this method.

3.6 Hot Plate – A small controllable hot plate shall be provided under the mixing bowl to maintain the mix at the desired temperature during mixing.

3.7 Hot Water Bath – An automatically controlled water bath of sufficient size to permit total immersion of the test specimens. It shall have a perforated false bottom or be equipped with a shelf. Either one shall support the specimens at least 1 inch above the bottom of the bath. The bath and shelf or false bottom shall be either lined with or constructed of a non-reactive material. It shall provide accurate and uniform control of a temperature of 140 ± 2 °F.

3.8 Water Bath – A separate water bath conforming to Section 3.7 above and which provides accurate and uniform control for bringing immersed specimens to a temperature of 77 ± 2 °F for the compression test.

Note: The water used in both of the above baths shall be distilled water. Only one set of specimens shall be in the 140 °F bath at a time. The 140 °F bath shall be emptied, cleaned, and refilled with fresh distilled water for each set of specimens. The 77 °F water bath shall be drained and cleaned on a regular basis.

3.9 Air Bath – An automatically controlled air bath for storing the specimens at 77 ± 2 °F.

3.10 Balance – A balance capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance utilized shall be at least 0.1 gram.

3.11 Mixer – A commercial grade mixer conforming to the requirements of AASHTO T 167.

3.12 Miscellaneous Equipment – A flexible spatula for scraping the mixing bowl and a stiff spatula, approximately 1" wide and 8" long, for spading the mix in the mold. A supply of transfer plates approximately 5" x 5" made of glass or non-reactive material for transferring the molded specimens.

4. PREPARING AGGREGATE-MINERAL ADMIXTURE SAMPLES

4.1 Based on the stockpile composite aggregate gradation, the aggregate samples needed for the immersion compression (IMC) test are prepared as follows.

4.2 Dry the mineral aggregate from each individual stockpile at a temperature not exceeding any temperature restrictions in Section 5. Drying shall be performed until no further weight loss is obtained from continued drying.

4.3 Representative samples of aggregate material which are retained on the individual No. 8 and larger sieve sizes and the Minus No. 8 Material from each stockpile are used to prepare the samples for mix design testing.

4.4 Weigh up three 3400 gram samples of mineral aggregate plus the required percent of mineral admixture, by dry weight of the aggregate, to yield three sets of two IMC specimens.

Note: Generally the weight of mineral aggregate will provide specimens of acceptable heights, but adjustments may be necessary in some cases. Use the following equation below to adjust the weight of aggregate as necessary to conform to specimen height requirements of 4.000 ± 0.100 inches for IMC specimens.

$$\begin{pmatrix}\text{Adjusted Weight}\\ \text{of Aggregate}\end{pmatrix} = \frac{\begin{pmatrix}\text{Combined Bulk OD}\\ \text{Agg. Specific Gravity}\end{pmatrix}}{2.650} \text{ X } (3400 \text{ grams})$$

4.5 The aggregate-mineral admixture samples shall be dried to constant weight within ± 5 °F of the laboratory mixing temperature and shall be at this temperature at the time of mixing with the asphalt binder. If necessary, a small amount of proportioned Minus No. 8 aggregate make-up material shall be added to bring samples to the desired weight.

5. LABORATORY MIXING TEMPERATURES AND BATCHING PROCEDURE

5.1 The rotational viscosity of the asphalt binder at 275 °F and 350 °F shall be determined in accordance with AASHTO T 316, and a viscosity-temperature curve developed in accordance with ASTM D 2493.

5.2 The laboratory mixing temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds. The actual laboratory mixing temperature used is normally selected at or near the mid-point of the range.

5.3 Alternatively, the viscosity-temperature curve may be found in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 °F or for modified asphalt binder, refer to the binder manufacturer to establish appropriate mixing temperature ranges. In no case shall the mixing temperature exceed 350 °F.

Note: When IMC testing is performed with Warm Mix Asphalt (WMA) technology, testing shall be performed with and without the WMA technology. The test results, both with and without the WMA technology, shall meet the minimum requirements of the specifications.

The WMA technology must be added to the mix before testing in accordance with the WMA technology manufacturer's recommendations. The WMA technology shall be added at the rate anticipated to be used in the production of the asphaltic concrete.

The mixing temperature for the laboratory prepared samples shall be per the WMA technology manufacturer's recommendations, but shall not exceed the maximum anticipated mixing temperature during field production. In making laboratory mixing temperature recommendations, the WMA technology manufacturer should consider the mixing temperature based on the viscosity-temperature curve for the asphalt which has been modified with the WMA technology as well as the minimum mixing temperature required for adequate coating.

5.4 Before each batch of asphaltic concrete is mixed, the asphalt binder shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to bring the asphalt binder to within ± 5 °F of the laboratory mixing temperature. (Avoid prolonged heating of the binder.)

5.5 Calculate the weight of asphalt binder to be used as determined by the following equation:

$$\left[\begin{array}{c}\text{Weight of}\\ \text{Asphalt Binder}\end{array}\right] = \left[\frac{\left(\begin{array}{c}\text{Weight of Aggregate and}\\ \text{Mineral Admixture}\end{array}\right)}{100 - \left(\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right)}\right] X \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]$$

Percent of asphalt binder is based on the mix design asphalt binder content.

5.6 Preheat the mixing bowl and whip to within ± 5 °F of the laboratory mixing temperature. The aggregate-mineral admixture blend and the appropriate amount of asphalt binder shall be mechanically mixed together for 90 to 120 seconds within ± 5 °F of the required laboratory mixing temperature. After mechanical mixing, hand mixing shall be used as necessary to produce a well-coated homogeneous mixture.

5.7 Immediately after mixing, place the hot material on a tarp or a sheet of heavy paper large enough to manipulate the sample. Thoroughly scrape the bowl and whip and add this material to the sample. In a rolling motion, thoroughly mix the material. Leave the mound in a circular shape after rolling is completed. Spread the material into a circular mass. Spreading may be accomplished either by leveling the mound of material with a concrete trowel or hand float; or by placing a straightedge of sufficient length to span the final diameter of the circular mass over the center of the material and rotating it until the desired

height is obtained. Whichever method is utilized, the operator shall assure that the material is evenly distributed with as little segregation as possible. The thickness of the circular mass shall not exceed 3 inches. The circular mass shall be cut into 4 equal pie-shaped segments. Take opposite segments for each individual sample and use the entire batch.

6. MOLDING AND CURING TEST SPECIMENS

6.1 Place the mixtures in an oven maintained at 255 ± 5 °F for 2 hours ± 10 minutes. A mold and bottom plunger for each mixture shall also be heated to 255 ± 5 °F.

Note: For mixtures with WMA technology, the samples shall be at a compaction temperature of 255 ± 5 °F, unless an alternative compaction temperature is recommended by the WMA technology manufacturer and approved by the Engineer.

For WMA water foaming processes, if laboratory water foaming equipment is not available, the specimens for IMC testing may be fabricated from plant produced mix. The specimens shall be tested as described above except the specimens shall be compacted without allowing the mixture to cool after the sample is obtained. Reheating, aging, or curing will not be allowed.

6.2 Remove the bottom plunger and mold cylinder from the oven, and place the mold assembly on the baseplate (bottom plunger in place with the mold cylinder supported on the two steel bars). Place the paper disc on the bottom plunger to prevent material from adhering to the plunger. Place 1/2 of the mixture into the molding cylinder and spade the mixture vigorously with a heated, flat, metal spatula with a blade approximately 1" wide and 8" long, stiff enough to penetrate an entire layer of material, 15 times around the edge of the mold and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Place the remaining half of the mixture into the mold and repeat the spading process, penetrating into the first lift of the mixture. The top of the mixture should be slightly rounded to aid in firm seating of the upper plunger.

6.3 Place a paper disc and then the upper plunger (which has been preheated) on the sample and compress the mixture under an initial load of 150 psi, to set it against the sides of the mold. Remove the support bars and permit full double-plunger action. Apply the load to the mixture at a rate of 0.2 inches per minute until a load of 2750 psi is reached. Hold the load at 2750 psi for 2 minutes.

Note: A load of 2750 psi will generally produce specimens that meet the criteria specified for air voids in Section 7. The loading may be varied, if necessary, to a minimum of 2000 psi. However, in all cases the requirements for air voids must be met. Record the load at which the specimens are prepared.

6.4 Remove the specimen from the mold. During and after extrusion from the mold, take care to maintain the specimen's shape and prevent tensile stresses in the specimen. Place the specimen on a transfer plate.

Note: The specimen may be allowed to cool for a maximum of 10 minutes before removal from the mold.

6.5 Place the specimen and plate in an oven at 140 ± 5 °F.

6.6 Repeat Sections 6.2 through 6.5 for the other mixtures.

6.7 Cure the specimens for 18 ± 0.5 hours at 140 ± 5 °F.

7. BULK DENSITY DETERMINATION

7.1 After removal from the 140 °F oven, allow the specimens to cool on the plate to room temperature.

Note: Cooling may be accomplished in a 77 °F air bath or if more rapid cooling is desired the specimen may be placed in front of a fan until cooled to room temperature.

7.2 Determine and record the bulk density in accordance with ARIZ 415 (Method A) and record the height of each specimen to the nearest 0.001 inches.

Note: The bulk densities between specimens shall not differ by more than 2.5 lbs/cu ft. If this criterion is not met the entire set of specimens shall be discarded and a new set prepared.

Note: The mixture shall be compacted to 7.0 +/- 1.0 percent air voids based on the mix design maximum specific gravity. The standard molding load of 2750 psi may be increased or decreased to achieve a target air voids.

7.3 Sort the six specimens into two groups of three specimens each, so that the average bulk density of the specimens in group 1 is essentially the same as for group 2. Test the specimens in group 1 as specified in Section 8. Test the specimens in group 2 as specified in Section 9.

8. DETERMINATION OF DRY STRENGTH

8.1 Bring the test specimens to testing temperature by storing in an air bath maintained at 77 ± 2 °F for 4 to 5 hours.

8.2 Remove each specimen from the air bath and test each specimen in axial compression without lateral support at a uniform rate of vertical deformation of 0.2 inches per minute. Record the load failure point for each specimen and the average load failure point. Determine the dry strength by converting the average load failure point to pounds per square inch.

Note: At least two of the individual load failure points shall be within ± 10% of the average load failure point for the three specimens. If this criterion is not met the entire set of 6 specimens shall be discarded and a new set prepared. If only two of the three specimens meet this criterion, a new average load failure point is determined using the two values.

9. DETERMINATION OF WET STRENGTH

9.1 Immerse the test specimens in a water bath maintained at 140 ± 2 °F, at least 1 inch below the top of the water, on a transfer plate, for 24 ± 0.5 hours.

9.2 Transfer the specimens to a 77 ± 2 °F water bath for 2 hours keeping them on the plates and making sure all specimens are totally immersed.

9.3 Remove each specimen from the water bath and test each specimen in axial compression without lateral support at a uniform rate of vertical deformation of 0.2 inches per minute. Record the load failure point for each specimen and the average load failure point. Determine the wet strength by converting the average load failure point to pounds per square inch.

Note: At least two of the individual load failure points shall be within ± 10% of the average load failure point for the three specimens. If

this criterion is not met the entire set of 6 specimens shall be discarded and a new set prepared. If only two of the three specimens meet this criterion, a new average load failure point is determined using the two values.

10. CALCULATIONS

10.1 The index of retained strength shall be expressed as the percentage of "dry strength" of the specimens. It shall be calculated as follows:

$$\left(\begin{array}{c}\text{Index of}\\ \text{Retained Strength}\end{array}\right) = \frac{\left(\begin{array}{c}\text{Wet Strength}\\ \text{of Specimens}\end{array}\right)}{\left(\begin{array}{c}\text{Dry Strength}\\ \text{of Specimens}\end{array}\right)} \text{ X } (100)$$

10.2 The index of retained strength shall be reported to the nearest whole percent.

Arizona Department of Transportation

ARIZ 802 Workcard

LAB. #: 16-1045 PROJECT #: X1234 01Z DATE: 4/19/2016

GRADE OF ASPHALT: PG 70-22 % ASPHALT: 4.6 ADMIXTURE: 1% LIME

DENSITY DETERMINATION OF DRY IMC SPECIMENS:

SPEC. #	HEIGHT	SSD WT.	H_20 WT.	AIR WT.	SP. GR.	DENSITY	AVERAGE SP. GR.	AVG. IMC DENSITY
1	3.988	1830.8	1017.5	1823.4	2.242	139.7	2.242	139.7
2	3.988	1827.3	1015.2	1819.5	2.240	139.6		
3	3.986	1828.6	1015.2	1821.5	2.239	139.5		
4	3.981	1829.5	1016.8	1820.6	2.240	139.6		
5	3.988	1833.6	1020.5	1824.7	2.244	139.8		
6	3.991	1837.1	1024.3	1826.9	2.248	140.0		

MIX DESIGN MAXIMUM DENSITY = 150.5

$$\% \text{ AIR VOIDS} = 1-\left(\frac{\text{AVG IMC DENSITY}}{\text{MIX DESIGN MAX DENSITY}}\right) \times 100 = 1-\left(\frac{139.7}{150.5}\right) \times 100 = 7.2\%$$

LOAD: ☑ 2750 psi ☐ Other: _____ psi

COMPRESSIVE STRENGTH OF DRY SPECIMENS:

SPEC. #	LOAD FAILURE POINT	AVG. LOAD FAILURE POINT	PSI
3	4170	4260	338.9
4	4280		
6	4330		

COMPRESIVE STRENGTH OF WET SPECIMENS:

SPEC. #	LOAD FAILURE POINT	AVG. LOAD FAILURE POINT	PSI
1	3610	3780	300.7
2	3840		
5	3890		

$$\text{INDEX OF RETAINED STRENGTH} = \frac{\text{PSI (WET)}}{\text{PSI (DRY)}} \times 100 = \left(\frac{300.7}{338.9}\right) = 89\%$$

FIGURE 1

CENTRIFUGE KEROSENE EQUIVALENT OF AGGREGATE INCLUDING K-FACTOR

(A Modification of Test No. Calif. 303)

Scope

1. This method of test furnishes a measure of the surface capacity, including absorption, of both coarse and fine aggregates used in bituminous mixtures. The K-factor is an index that indicates the relative particle roughness or degree of porosity.

Apparatus

2. The apparatus shall consist of the following:

(a) Centrifuge. - A hand or power-driven centrifuge with cover, capable of exerting a force of 400 times gravity (400 G) on a 100-g. sample (See Figs. 1 and 2). The required rpm necessary to achieve this force is determined from the following formula:

$$\text{Required rpm of centrifuge head} = \sqrt{\frac{14{,}000{,}000}{r}}$$

Where: R = Radius in inches to center of gravity of sample

(b) Centrifuge Cups. - Aluminum cups 2-13/16 in. in height and 2-1/16 in. in diameter (Fig. 3) with a perforated brass plate containing a minimum

FIGURE 1

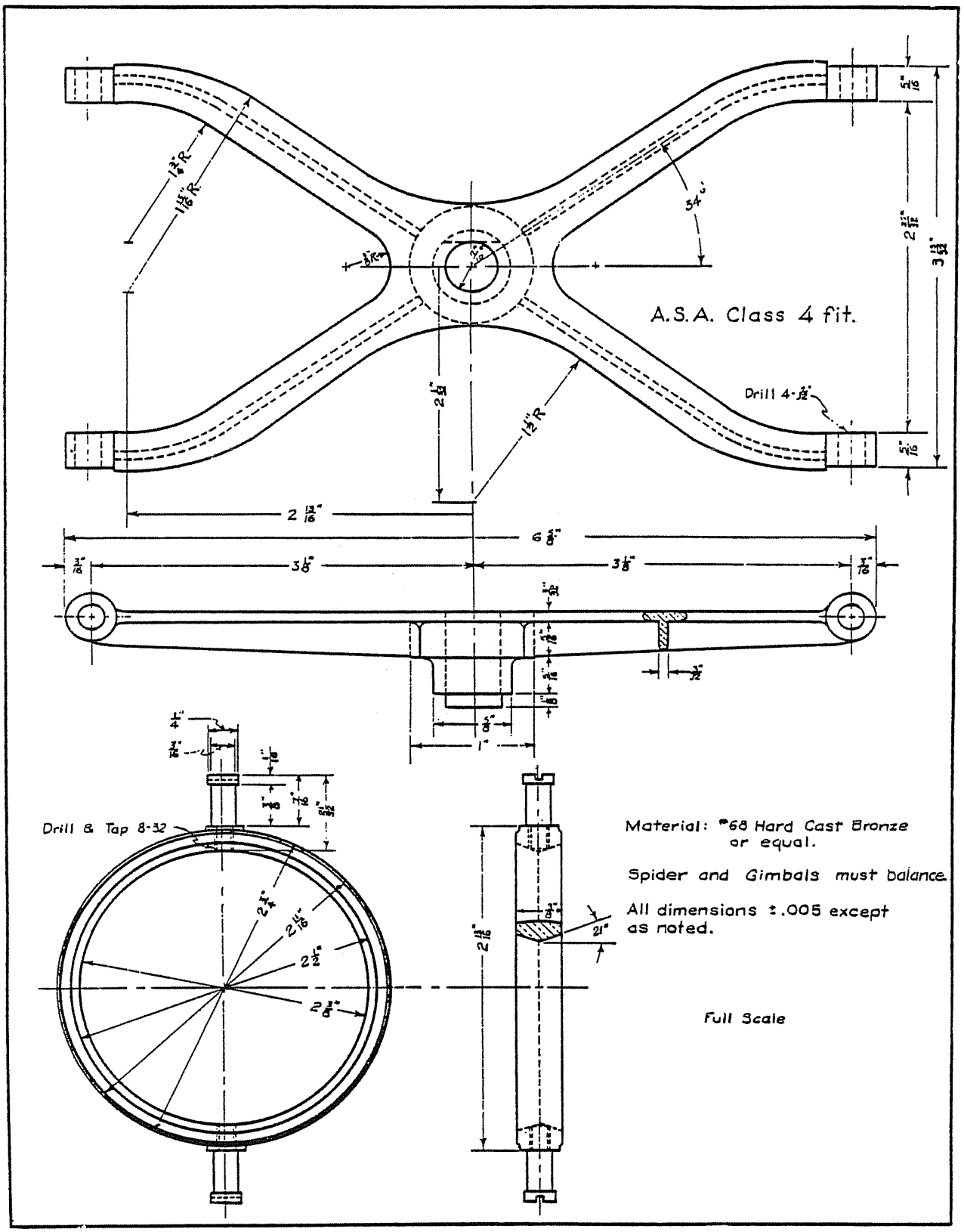


FIGURE 2

DETAILED PLAN OF CENTRIFUGE PARTS

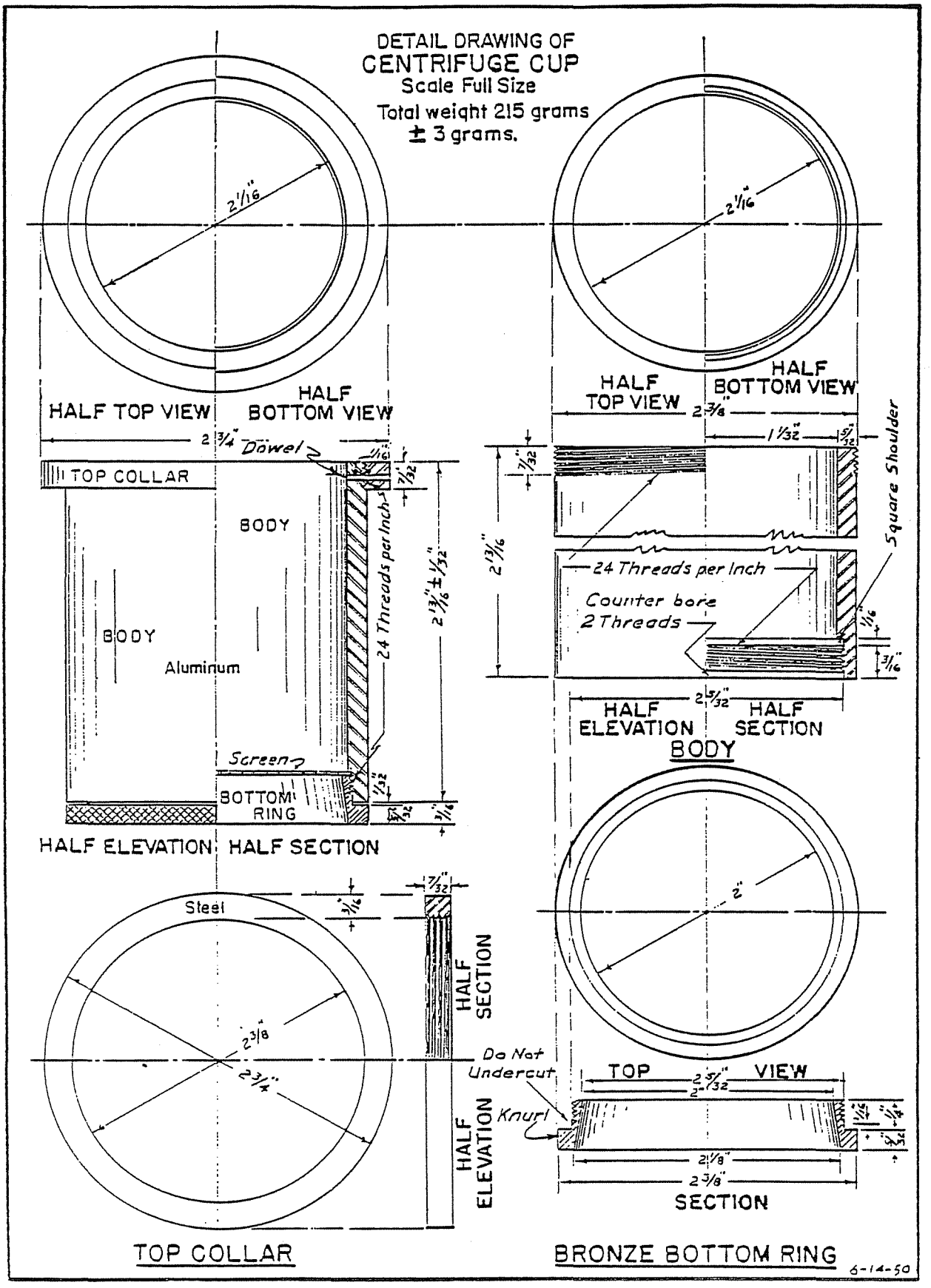

DETAIL DRAWING OF
CENTRIFUGE CUP
Scale Full Size
Total weight 215 grams
± 3 grams.
HALF TOP VIEW
HALF BOTTOM VIEW
2 1/16"
2 3/4"
Dowel
TOP COLLAR
BODY
BODY
Aluminum
24 Threads per Inch
2 13/16" ± 1/32"
Screen
BOTTOM RING
HALF ELEVATION
HALF SECTION
Steel
HALF SECTION
2 3/8"
2 3/4"
HALF ELEVATION
TOP COLLAR
HALF TOP VIEW
HALF BOTTOM VIEW
2 3/8"
1 1/32"
Square Shoulder
2 13/16"
24 Threads per Inch
Counter bore
2 Threads
HALF ELEVATION
HALF SECTION
BODY
2"
Do Not Undercut
Knurl
TOP VIEW
2 1/8"
2 3/8"
SECTION
BRONZE BOTTOM RING
6-14-50

FIGURE 3

of 100 holes, .062 inches in diameter, per square inch.

(c) Balance. - A torsion balance, 500 g. capacity, accurate to 0.1 g.

(d) Metal funnels. - Top diameter 3.5 in., height 4.15 in., orifice 0.5 in., with a piece of No. 10 sieve soldered to the top of the orifice.

(e) Glass Beakers, 1500 ml. capacity.

(f) Timer with sweep second hand.

(g) Pans, 4.5 in. in diameter, 1 in. deep.

(h) Ovens. - One oven capable of maintaining a temperature of 230° F ± 5° F; and an oven capable of maintaining a temperature of 140° F.

Materials

3. (a) Kerosene, 1 gallon.

(b) S.A.E. No. 10 lubricating oil.

NOTE: *Kerosene and S.A.E. No. 10 lubricating oil shall be supplied as "standard" materials by Central Lab.*

(c) Filter paper, 5.5 cm. diameter, Eaton Dikeman No. 613.

Preparation of Sample

4. (a) Separate the aggregate into two size groups; "C" material, used for K_c determination, passing the 3/8" sieve and retained on the No. 4 sieve; "F" material for K_f determination, all passing the No. 4 sieve.

(b) Determine bulk O.D. specific gravity for fine aggregate ("F" material) by ARIZ 211 - Specific Gravity and Absorption of Fine Mineral Aggregate, and for coarse aggregate ("C" material) by AASHTO T 85 - Specific Gravity and Absorption of Coarse Aggregates.

NOTE: *Bulk O.D. specific gravity which has been determined for plus No. 4 material using additional sizes may be used in lieu of running specific gravity for "C" material as described below.*

(c) The gradation of the aggregate employed is used to calculate the surface area of the aggregates. This calculation consists of multiplying the total percent passing each sieve by a "surface area factor" as set forth in Table 1, and dividing by 100. The sum of all the results represents the equivalent surface area of the sample in terms of square feet per pound.

NOTE: *All surface area factors must be used in the calculation. If a different series of sieves is used, different surface-area factors are necessary. An example of calculations is given in Table II, section 13.*

Procedure

5. Fine aggregate shall be tested as follows:

(a) Obtain a representative minimum 210 g. sample of Pass No. 4 material, place in an oven at 230° ± 5° F, and dry to constant weight.

(b) Allow the sample to cool to room temperature and place exactly 100 g. in weighed centrifuge cup fitted with the perforated metal disk underlying a disk of filter paper.

(c) Prepare the other centrifuge cup in the same manner, with another 100 g. of the same material.

(d) Place the centrifuge cups in a pan containing sufficient kerosene (1/2 in. deep) to saturate the samples by capillary action.

(e) When the samples are saturated, place the cups in the centrifuge, and spin for 2 minutes at a force of 400 G (for hand operated centrifuges this force can be developed by turning the handle about 45 revolutions per minute).

(f) Reweigh the cups with the samples to the nearest 0.1 g. and subtract the original weight. The difference is the percent of kerosene retained (based on 100 g. of dry aggregate). Record the average of the two values for duplicate samples.

NOTE: *If the difference between the two samples exceeds 0.20 grams the test should be run again, taking greater care in obtaining duplicate aggregate samples.*

6. Coarse aggregate shall be tested as follows:

(a) Split out two 105 gram minimum representative samples of the passing 3/8 and retained No. 4 sieve material. (If a 1/4 in. sieve was employed in the coarse sieve analysis, the material retained

TABLE I

SURFACE AREA FACTORS

Total Percent Passing Sieve No.	3/4"	3/8"	4	8	16	30	50	100	200
Surface Area Factor	*	*	2	4	8	14	30	60	160

*Assume surface area for all of plus No. 4 material = 2 sq. ft./lb.

on the 1/4 in. and No. 4 sieve shall be graded in proportion with the weight % retained on the respective sieves.) Place in an oven at 230° F ± 5° F. and dry to constant weight.

(b) Allow to cool at room temperature, then weigh out exactly 100 grams from one of the 105 gram samples and transfer to the funnel. Immerse material in S.A.E. No. 10 lubricating oil for 5 minutes by placing funnel in holder (a 500 ml. glass beaker works very well) and pouring adequate amount of oil over aggregate until sample is entirely covered.

(c) Remove funnel and place in a metal quart can. Drain for 2 minutes, then place can with funnel in an oven set at 140° F. for 15 minutes of additional draining.

(d) Obtain the tare weight of a pan, remove the sample from the oven and pour into the pan, allow to cool and then weigh to the nearest 0.1 gram. The difference between the original sample weight (100 grams) and the final sample weight (weight minus the tare weight of pan) is the percent oil retained.

(e) Subject the other 105 gram sample to the same procedure as shown in paragraphs (b), (c) and (d).

(f) Record the average of the two values for duplicate samples.

NOTE: *If the difference between the two samples exceeds 0.30 grams the test should be run again, taking greater care in obtaining duplicate aggregate samples.*

Calculations

7. K_f

(a) K_f is determined from the following factors:

1) Percent of kerosene retained, which represents the total effect of superficial area, the aggregate's absorptive properties, and surface roughness.

2) Computed surface area, based on particle size.

3) Percent passing No. 4 sieve.

(b) If the specific gravity for "F" is greater than 2.70 or less than 2.60, make corrections for percent of kerosene retained with the following formula:

$$\text{Corrected CKE} = (\%\ \text{kerosene ret.}) \times \frac{\text{Sp. Gr. "F"}}{2.65}$$

(c) Start in the lower left hand corner of the chart in Fig. 4 with the value for CKE corrected for specific gravity; follow the straightedge horizontally to the right to the intersection with calculated surface area; hold the point, move vertically upward to the intersection with the percent passing the No. 4 sieve, hold the point, and follow the straightedge horizontally to the right. The value obtained will be the surface constant for the passing No. 4 fraction "F", or "K_f".

8. K_c

(a) K_c is determined from the percent of S.A.E. No. 10 oil retained, which represents the total effect of superficial area, the aggregate's absorptive properties, and surface roughness.

(b) If the specific gravity for "C" is greater than 2.70 or less than 2.60 apply the correction to oil retained by the following formula:

$$\%\ \text{oil ret. corrected} = (\%\ \text{oil ret.}) \times \frac{\text{Sp. Gr. "C"}}{2.65}$$

(c) Start at the bottom of the chart in Fig. 5 with the corrected percent oil retained, follow the straightedge vertically upward to the intersection with the diagonal line, hold the point, and follow the straightedge horizontally to the left. This value is the surface constant for the retained coarse fraction "C", or "K_c".

9. K_m

(a) K_m represents the mean value of K for a given combination of coarse and fine materials on which K_c and K_f have already been determined.

(b) Use the chart in Fig. 6 to combine K_f and K_c for determination of "K_m".

(c) Start in the lower left hand corner of the chart in Fig. 6 with the value of the total Surface Area, follow straightedge horizontally to the right to the percentage of coarse aggregate (+ No. 4), hold point, and follow straightedge vertically upward to the intersection with the difference between K_c and K_f, hold point, and move horizontally to the right to the "correction to K_f". If ($K_c - K_f$) is positive K_m is calculated by $K_m = K_f$ + corr. to K_f; if ($K_c - K_f$) is negative K_m is calculated by $K_m = K_f$ - corr. to K_f. If $K_c = K_f$, the correction is zero, and the chart does not have to be used, K_m simply equals K_f.

10. Bitumen Ratio

(a) The chart in Fig. 7 is used, provided the following factors are known:

1) K_m

2) S.A. (Surface Area of Aggregate)

3) Combined Specific Gravity

$$\text{Combined Sp. Gr.} = \frac{100}{\frac{\%\ \text{coarse}}{\text{sp. gr. coarse}} + \frac{\%\ \text{fine}}{\text{sp. gr. fine}}}$$

(b) Start in the upper left-hand corner with S.A., follow a straightedge horizontally to the right to the intersection with the combined sp. gr., hold point, and move vertically downward to the intersection with known K_m; hold point, and move horizontally to the right. This value is for liquid asphalt SC-250, MC-250, and RC-250 only.

(c) If a heavier asphalt is used, refer to the chart in Fig 8. By means of a straightedge, connect the point on Scale "A" which represents the grade of bitumen to be used with the point on Scale "B" representing the S.A. of the aggregate. Through the point of intersection on line "C" place the straightedge to connect with the previously determined bitumen ratio value on Scale "D". The intersection with Scale "E" represents the bitumen ratio corrected for viscosity of the bitumen.

11. Percentage of Recommended Bitumen

To convert bitumen ratio to percentage of bitumen on the basis of total mix, use the following formula:

$$\% \text{ recommended bitumen} = \frac{\text{Bitumen Ratio}}{100 + \text{Bitumen Ratio}} \times 100$$

Report

12. Report the % bitumen recommended. Also record K_c, K_f, K_m, the grade of bitumen used, specific gravity of coarse and fine aggregate, CKE values, and bitumen ratio.

Example

13. Using the information given in Table II, and that supplied in (a), the data in paragraph (b), (c), (d) and (e) was calculated by the procedure outlined above.

(a) Percent coarse = 38

Percent fine (pass #4) = 62

Bulk O.D. Sp. Gr. coarse = 2.589

Bulk O.D. Sp. Gr. fine = 2.613

Combined Bulk O.D. Sp. Gr. = $\dfrac{100}{\frac{38}{2.589} + \frac{62}{2.613}} = 2.604$

CKE Results

Fines - uncorrected ret. = 4.3
corrected ret. = 4.3 (No correction: 2.7<sp.gr.>2.6)

Coarse - uncorrected ret. = 3.7
corrected ret. = 3.6

(b) $K_f = 1.25$
$K_c = 1.54$
$(K_c - K_f) = 1.54 - 1.24 = 0.30$
"Correction to K_f" = 0 1
$K_m = K_f$ + correction to K_f ($K_c - K_f$ is positive)
$K_m = 1.24 + 0.1 = 1.34$

(c) Bitumen Ratio = 5.4

(d) Corrected Bitumen Ratio = 6.3
(Corrected using AC-20 grade asphalt)

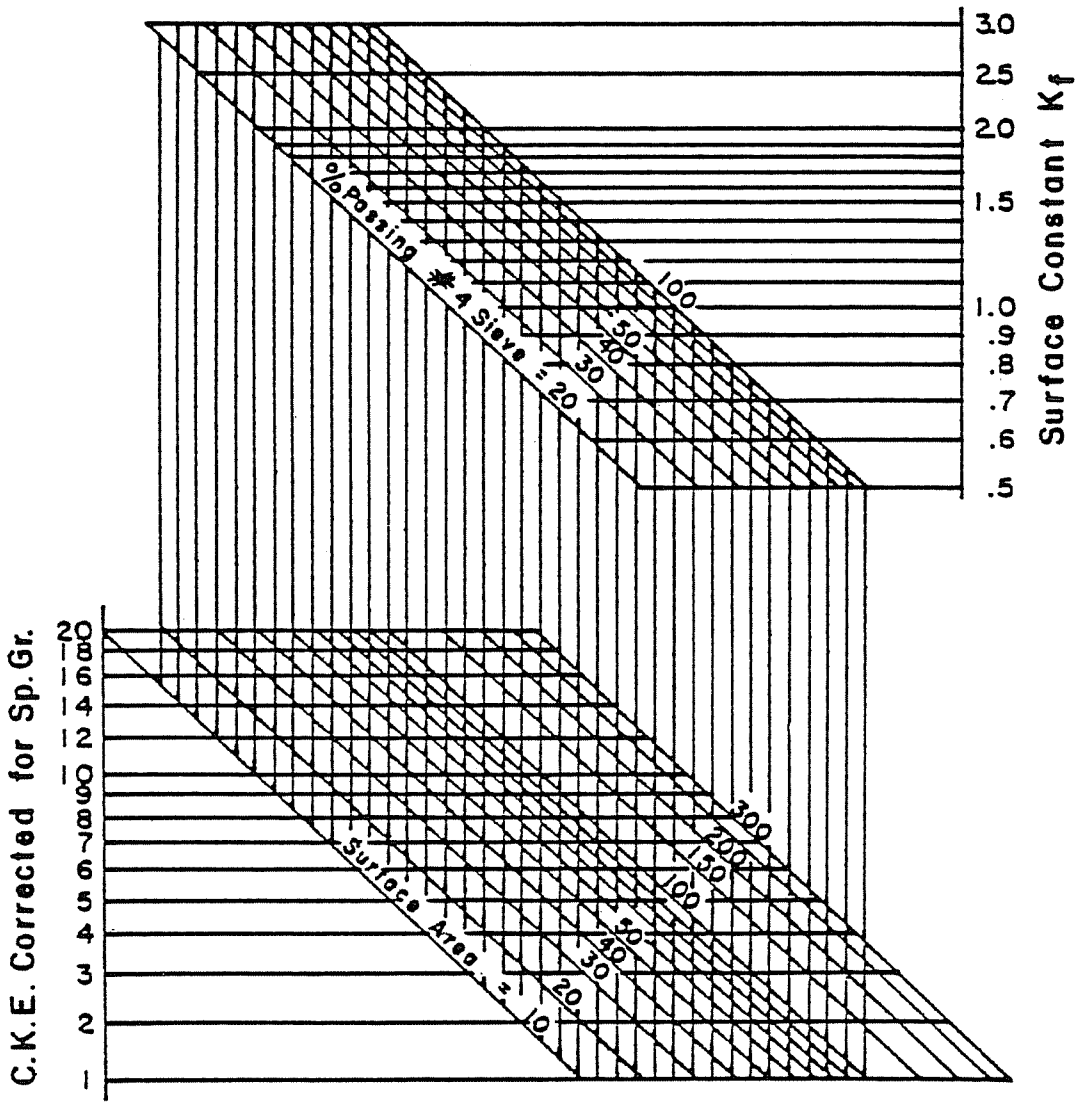
(e) Percent Bitumen recommended = 5.9%

TABLE II

TOTAL SURFACE AREA CALCULATION

Sieve Size	Percent Passing	x	S.A. Factor	÷	100	=	Surface Area (S.A.)
3/4"	100		-				2.0
3/8"	96		-				
No. 4	62		2				1.24
No. 8	31		4				1.24
No. 16	22		8				1.76
No. 30	16		14				2.24
No. 50	14		30				4.20
No. 100	12		60				7.20
No. 200	9.6		160				15.36
					Total Surface Area =		35.24 sq. ft./lb.

CHART FOR DETERMINING K_f FROM C.K.E.



$$\text{C.K.E. Corrected} = \text{C.K.E.} \times \frac{\text{sp. gr. fine}}{2.65}$$

FIGURE 4

CHART FOR DETERMINING K_c FROM COARSE AGGREGATE ABSORPTION

Material Used { Aggregate passing $\frac{3}{8}$", ret.#4 sieve
Oil SAE 10

$$\% \text{ oil ret. corrected} = \% \text{ oil ret.} \times \frac{\text{sp. gr. of aggregate}}{2.65}$$

K_c may also be determined by the following:

$$K_c = [(0.4)(C)] + [(C - 2)(0.01)] + (0.1)$$

Where: C = Percent Oil Retained (Corrected for Sp. Gr.)

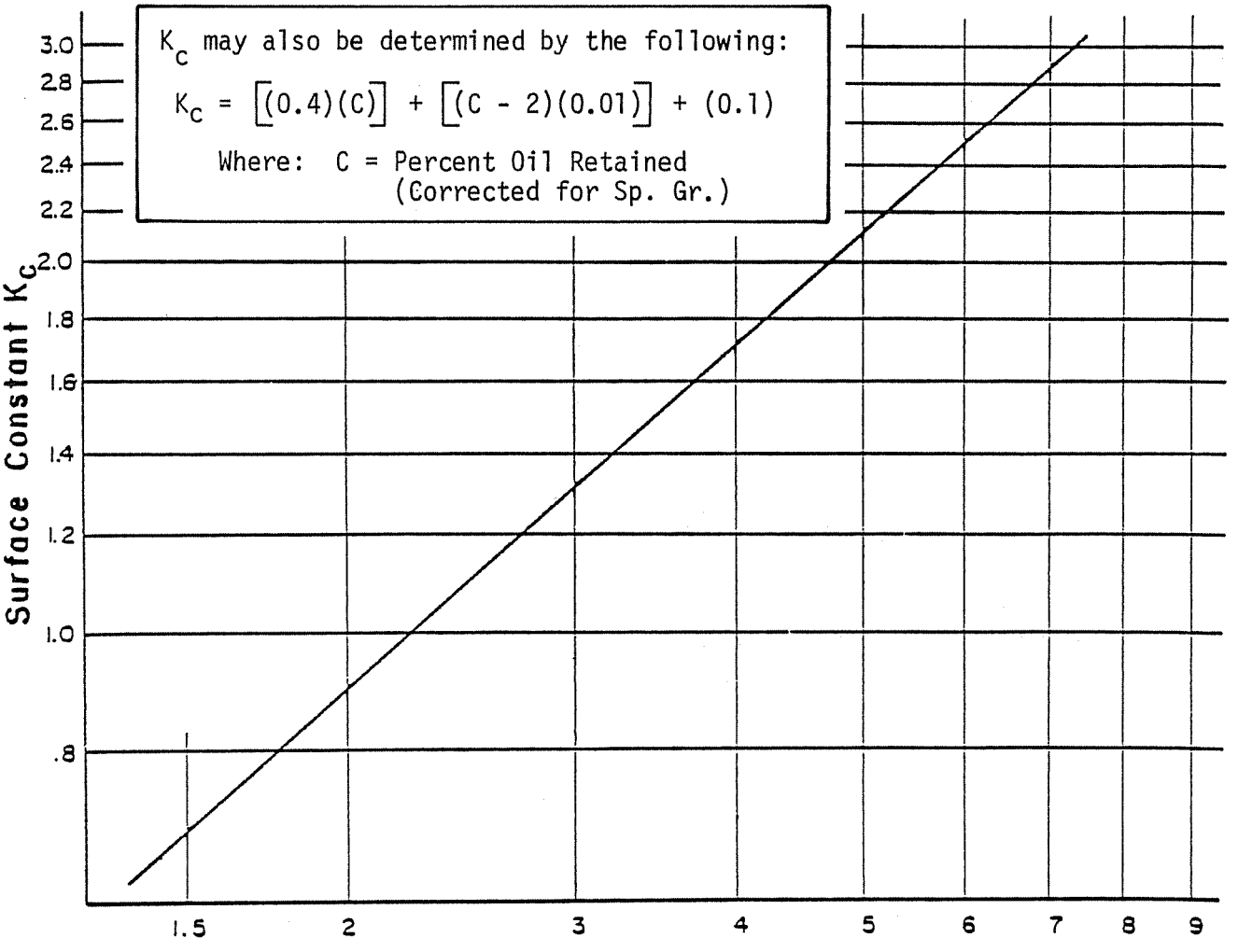


FIGURE 5

CHART FOR COMBINING K_f AND K_c TO DETERMINE K_m

If $(K_c - K_f)$ is negative,
$K_m = K_f$ - correction to K_f
If $(K_c - K_f)$ is positive,
$K_m = K_f$ + correction to K_f
If $K_c = K_f$, $K_m = K_f$

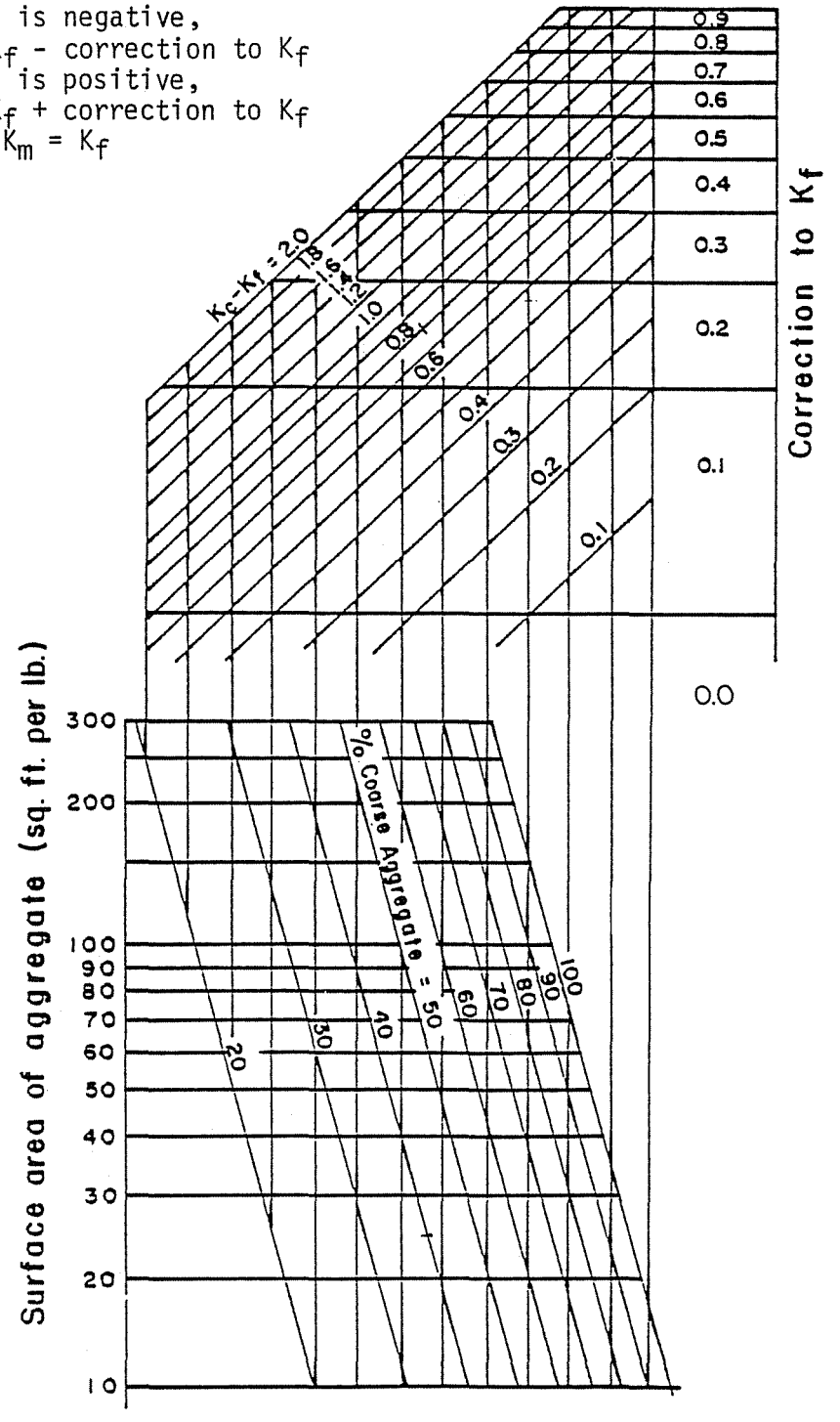


FIGURE 6

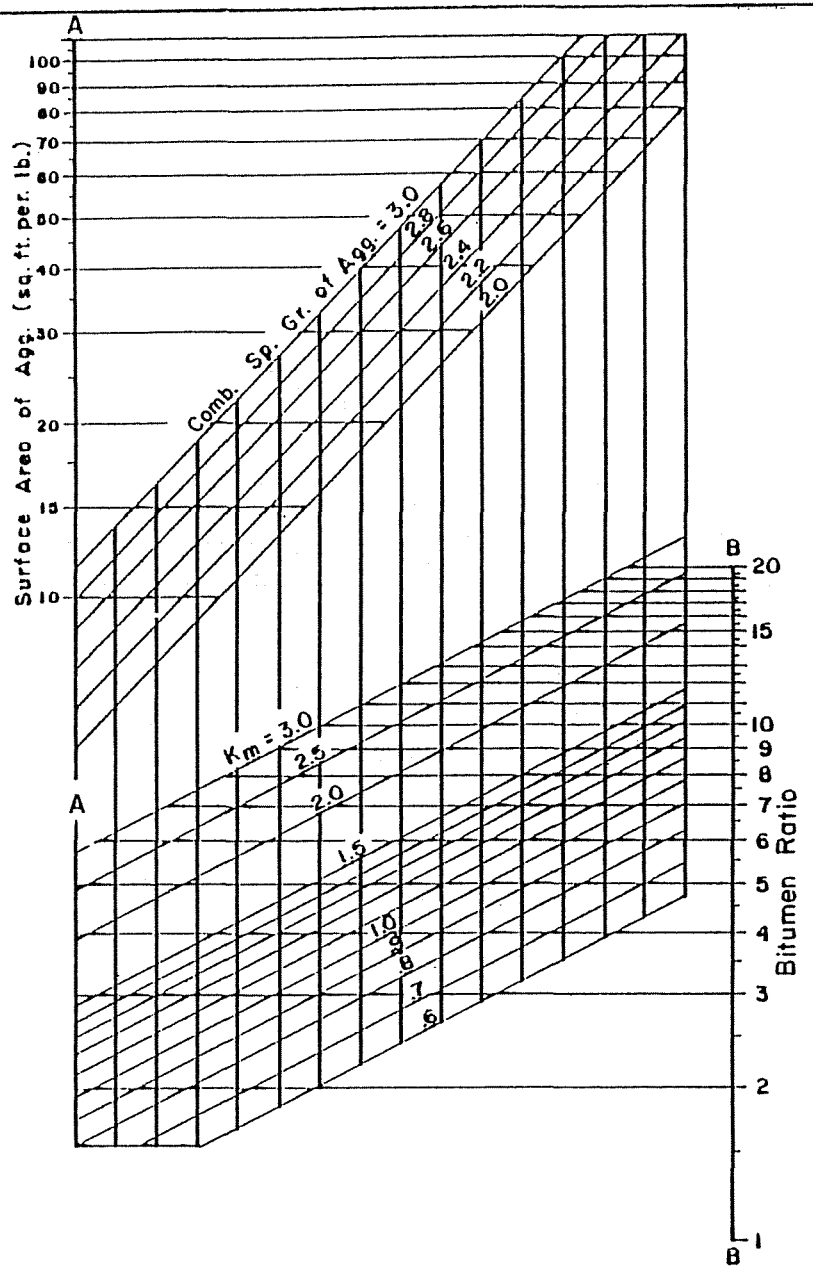


CHART FOR DETERMINING BITUMEN RATIO

PROCEDURE

Given surface area, combined sp. gr., and K_m of aggregate.

Find surface area on scale A. Proceed horizontally to line corresponding to combined sp. gr. of aggregate. Then down to line corresponding to K_m. Then horizontally to scale B for Bitumen Ratio.

Bitumen Ratio = lbs. of bitumen per 100 lbs. of aggregate and applies directly to asphalt of SC 250, MC 250, and RC 250 grades. The bitumen ratio is converted to percent bitumen (based on total mix) by the following:

$$\% \text{ Bitumen} = \frac{\text{Bitumen Ratio}}{100 + \frac{\text{Bitumen}}{\text{Ratio}}} \times 100$$

When heavier liquid or paving asphalts are used a correction must be made to the bitumen ratio. See Figure 8.

FIGURE 7

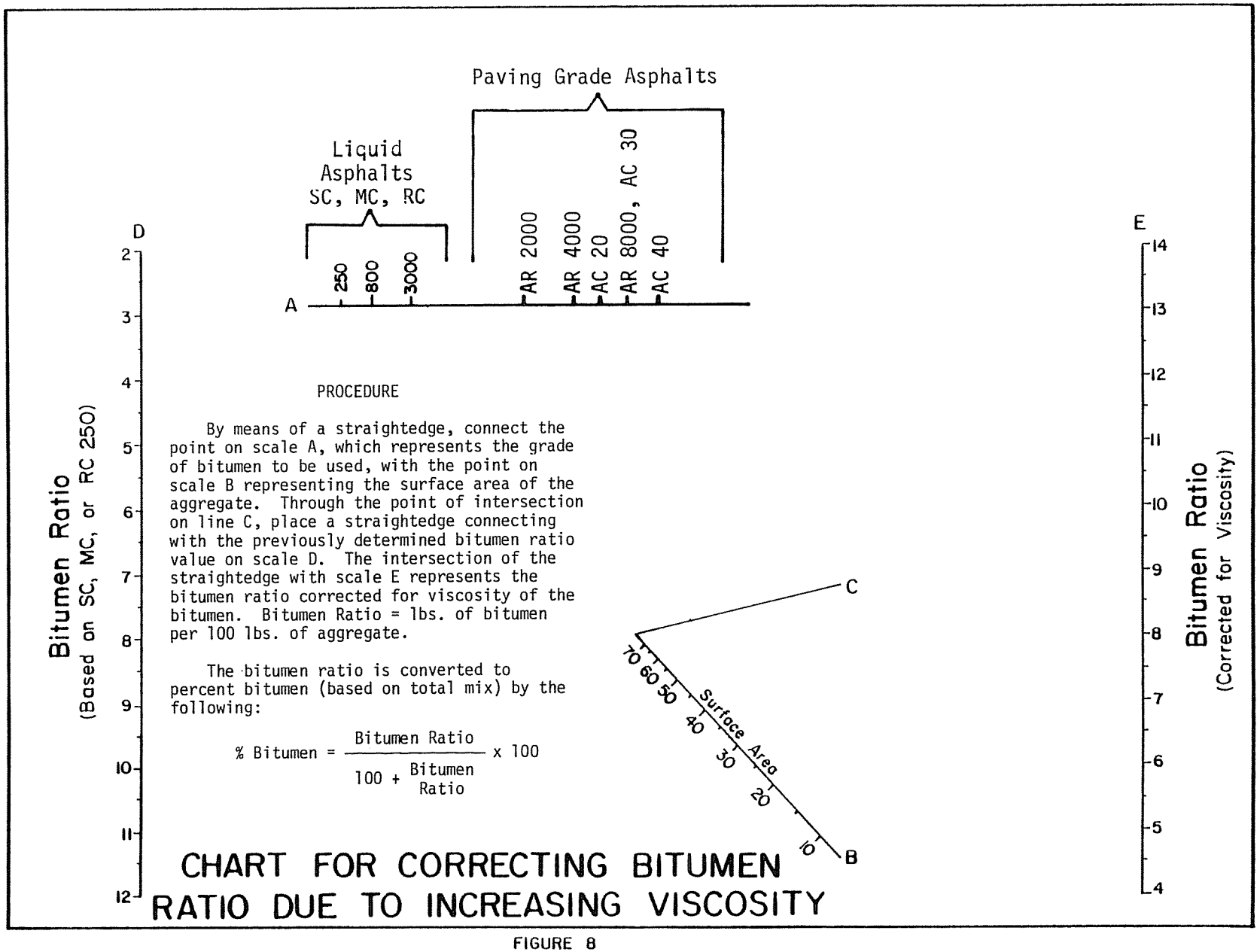

Paving Grade Asphalts
Liquid Asphalts SC, MC, RC
250
800
3000
AR 2000
AR 4000
AC 20
AR 8000, AC 30
AC 40
A
D
E
Bitumen Ratio
(Based on SC, MC, or RC 250)
Bitumen Ratio
(Corrected for Viscosity)
C
B
Surface Area
10
20
30
40
50
60
70
PROCEDURE
By means of a straightedge, connect the point on scale A, which represents the grade of bitumen to be used, with the point on scale B representing the surface area of the aggregate. Through the point of intersection on line C, place a straightedge connecting with the previously determined bitumen ratio value on scale D. The intersection of the straightedge with scale E represents the bitumen ratio corrected for viscosity of the bitumen. Bitumen Ratio = lbs. of bitumen per 100 lbs. of aggregate.
The bitumen ratio is converted to percent bitumen (based on total mix) by the following:
% Bitumen = Bitumen Ratio / (100 + Bitumen Ratio) x 100
CHART FOR CORRECTING BITUMEN RATIO DUE TO INCREASING VISCOSITY

FIGURE 8

MAXIMUM THEORETICAL SPECIFIC GRAVITY OF LABORATORY PREPARED BITUMINOUS MIXTURES (RICE TEST)

(A Modification of AASHTO T 209)

SCOPE

1. This method of test is intended for determining the maximum specific gravity of uncompacted bituminous mixtures which have been prepared in the laboratory.

APPARATUS

2. The apparatus shall consist of the following:

(a) Balance - A balance accurate to 0.1 gram at the maximum weight to be determined.

(b) Container - A heavy walled Erlenmeyer flask having a capacity of at least 1500 ml. strong enough to withstand a partial vacuum; the cover shall consist of a rubber stopper with a tight hose connection. A small piece of No. 200 wire mesh covering the hose opening shall be used to minimize the possibility of loss of fine material.

NOTE: If a procedure which subjects multiple flasks to a vacuum simultaneously is used, the vacuum gauge shall be placed beyond the last bottle to insure that all the bottles are being subjected to the same amount of vacuum.

(c) Glass cover plate large enough to cover mouth of the flask.

(d) Vacuum pump for evacuating air from the container.

(e) Ovens - One oven capable of maintaining a temperature of 255° ± 5°F and one capable of maintaining approximately 300°F.

(f) Distilled water - All water used in this procedure shall be distilled water.

(g) Mixer - A mechanical commercial dough mixer with a minimum 10 quart capacity and equipped with a wire whip.

CALIBRATION OF FLASK

3. Calibrate the flask by accurately determining the weight of water at 77° ± 1°F required to fill it completely. Use of a glass cover plate is required to ensure accurate filling. Record the weight of the flask + water to the nearest 0.1 gram as "B".

PREPARATION OF SAMPLES

4. (a) One aggregate sample of 3000 grams, proportioned in that grading determined by design, is required for each test. The 3000 gram aggregate sample will provide 3 test samples when mixed and split as described below.

(b) To minimize stripping of the asphalt from the aggregate, pre-weigh a 300 to 500 gram sample of asphalt and add to this 1.0% of a suitable anti-stripping agent by weight of asphalt. This mixture will be designated as "binder" in this test.

NOTE: Pave Bond Special is the preferred anti-stripping agent.

(c) The percent binder used shall normally be 6.0%.

NOTE: A binder content of 6.0% will normally give satisfactory results, although aggregate characteristics and gradation may require adjustment in percentage of binder to be used.

(d) The temperature of the asphalt and aggregate at the time mixing begins shall be in accordance with the following:

Asphalt Grade	Temperature Range
AC 20	300° ± 10°F
AC 30, AC 40	305° ± 10°F

(e) The aggregate shall be dried to a constant weight, at the temperature required as shown in paragraph 4 (d). Bring samples to desired weight by adding a small amount of proportioned Pass No. 8 makeup material.

(f) The aggregate and asphalt shall be mixed mechanically for 90 to 120 seconds and then hand mixed as necessary to ensure thorough coating.

NOTE: Before each batch is mixed, the mixing bowl and whip shall be at approximately the temperature specified in 4 (d).

(g) The mixed sample shall be placed on a tarp or sheet of heavy paper and in a rolling motion thoroughly mixed. The material shall be spread into a circular mass 1 1/2 to 2 inches thick. The circular mass shall be cut into 6 equal segments taking opposite segments for each individual sample.

(h) Place samples in an oven maintained at 255° ± 5°F and cure for 2 hours ± 5 minutes. After curing, spread each sample on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled separate the particles of the mixture, taking care not to fracture the mineral particles, so that the particles of the fine aggregate portion are not larger than 1/4 inch. Allow the samples to cool to room temperature.

PROCEDURE

5. For each sample the procedure below shall be followed:

(a) Place the sample in the flask and determine weight of sample to the nearest 0.1 gram. This is designated as the "weight of sample in air", or "Wmm".

NOTE: Care should be taken in mixing and transferring of the samples to the flask so that there is no more than an 18 gram difference between the total weight of aggregate and binder before mixing and the total "weight of the samples in air".

(b) Add sufficient water, which has been treated with a wetting agent, to cover the sample.

NOTE: A suitable wetting agent such as Aerosol OT in a concentration of 0.01%, or 1 ml. of 10% solution per 1000 ml. of water, shall be used to facilitate the release of entrapped air.

(c) Remove entrapped air by subjecting the contents of the flask to a partial vacuum, with a minimum of 20 inches mercury for 15 ± 2 minutes. Agitate the contents three or four times within this period, to dislodge trapped air bubbles.

CAUTION: Do not agitate the sample too frequently or vigorously; this can cause stripping of the film from some particles, resulting in erroneous specific gravities.

(d) After the evacuation period, fill the flask completely with water, slide a preweighed glass cover plate over the mouth of the flask, and weigh immediately to the nearest 0.1 gram. The temperature of the flask, water, and sample shall be between 72°F and 80°F. Record as the weight of the "flask + water + sample", or "C".

(e) The entire contents of the flask shall be poured into a nest of sieves consisting of a No. 40 and a No. 200 screen.

NOTE: If stripping has occurred, as evidenced by discoloration of water in the flask, significant loss of minus No. 200 material may be expected. Provisions for the recovery and addition of this material to the Plus No. 200 material shall be made.

(f) Allow mix to drain through the sieves until excessive moisture is removed from mix. Spread the material retained on the No. 40 and No. 200 sieves in a pan and place before an electric fan to remove surface moisture. The air through the fan shall be at room temperature and no heat shall be used to dry the mix.

(g) After evaporation of excess moisture is observed, weigh mix at 15 minute intervals and when the weight loss is less than 0.5 gram for this interval the mix is considered to be surface dry. Record the surface dry weight as "Wsd". Intermittent stirring of the sample is required during the drying period. Conglomerations of mix shall be broken by hand. Care must be taken to prevent loss of particles of mixture.

NOTE: If the "Wsd" weight for any of the three samples is less than its corresponding "Wmm" weight the samples shall be discarded and a set of three new samples shall be prepared and tested.

CALCULATIONS

6. (a) The Volume of Voidless Mix, "Vvm", in ml. is determined for each sample by the following:

$$Vvm = Wsd + B - C$$

Where: Wsd = Surface Dry Weight
B = Weight of Flask + Water
C = Weight of Flask + Water + Sample

(b) The Maximum Specific Gravity, "Gmm", is determined for each sample by the following:

$$Gmm = \frac{Wmm}{Vvm}$$

(c) Compare the three individual values for maximum specific gravity. If the range of the three is within 0.014, all are used to determine the average maximum specific gravity as

shown in paragraph (d) below. If the range is greater than 0.014, the average of two may be used if they are within a range of 0.007. If values are not achieved within the above criteria, the samples shall be discarded and a set of three new samples shall be prepared and tested.

NOTE: For recycle mixes the above criteria shall be replaced with 0.024 for the range of three and 0.012 for two.

(d) The average maximum specific gravity of the bituminous mix is determined for the samples with acceptable maximum specific gravity values, and recorded to the nearest 0.001 unit.

(e) To determine the maximum density, the average maximum specific gravity is multiplied by 62.3 lbs/cu ft.

EXAMPLE

7. An example of the calculations is shown in Figure 1.

NOTE: The form shown in Figure 1 contains equations which shall be used to determine the combined bulk oven dry specific gravity of aggregate, the effective specific gravity of aggregate, and the asphalt absorption. These values are utilized in determining the voids relationships for the bituminous mixture. The areas provided on the form in Figure 1 may be conveniently used to perform these calculations.

ARIZONA 806

LAB. NO.: 88-999B PROJECT NO.: F-099-9(11) DATE: 1-12-88
PROJECT NAME: CHRISTMAS CANYON - CLAUS T.I. MATERIAL TYPE: 3/4" A.C.
GRADE OF ASPHALT: AC 40 SPECIFIC GRAVITY OF ASPHALT: 1.023 PERCENT OF ASPHALT: 6.0
TESTED BY: JOE TESTER CHECKED BY: S.C.

FLASK NUMBER	WEIGHT OF FLASK	"Wmm" WEIGHT OF SAMPLE IN AIR	(B) FLASK + WATER	(C) FLASK + WATER + SAMPLE	"Wsd" SURFACE DRY WEIGHT	"Vvm" VOLUME OF VOIDLESS MIX (Wsd+B-C)	"Gmm" MAX. SP. GR. "Wmm" / "Vmm"	MAXIMUM DENSITY LBS. PER CU. FT. "Gmm"x 62.3
1	1185.9	1057.6	3429.9	4046.7	1058.4	441.6	2.395	
2	1280.0	1059.2	3499.2	4116.1	1060.3	443.4	2.389	
~~3~~	~~1178.1~~	~~1057.2~~	~~3436.1~~	~~4053.6~~	~~1057.1~~	~~439.6~~	~~2.405~~	
AVERAGE							2.392	149.0

MIX WT. - TOTAL SAMPLE WT. = LOSS OF GRAMS = 8.4

FLASK NUMBER:	1	2	3
WT. OF SAMPLE AND FLASK	2243.5	2339.2	2235.3
WT. OF SAMPLE, FLASK, WATER AND GLASS PLATE	4201.8	4271.2	4208.7
WT. OF GLASS PLATE	155.1	155.1	155.1

% COARSE AGG. = 41 % FINE AGG. = 59
COARSE AGG. BULK O.D. SP. GR. = 2.558 FINE AGG. BULK O.D. SP. GR. = 2.589
COMBINED AGG. BULK O.D. SP. GR. (Gsb) =

$$= \frac{100}{\frac{(41)}{(2.558)} + \frac{(59)}{(2.589)}} = 2.576$$

EFFECTIVE SPECIFIC GRAVITY OF AGGREGATE (Gse) =

$$= \frac{(100) - (6.0)}{\frac{(100)}{(2.392)} - \frac{(6.0)}{(1.023)}} = 2.615$$

ASPHALT ABSORPTION (Pba) =

$$\left[\frac{(Gse) - (Gsb)}{(Gse) \times (Gsb)}\right] \times (\text{ASPHALT SP. GR.}) \times (100) =$$

$$= \left[\frac{(2.615) - (2.576)}{(2.615) \times (2.576)}\right] \times (1.023) \times (100) = 0.59$$

REMARKS: FLASK #3 ELIMINATED DUE TO BEING OUTSIDE 0.014 ALLOWABLE RANGE.

FIGURE 1

DESIGN OF SLURRY SEAL

(A Modification of Test No. Calif. 355)

Scope

1. This method is intended for use in determining the total liquid content for proper workability and the optimum asphalt content for a slurry seal. This test method also furnishes an index of the slurry seal mixture's resistance to abrasion in the presence of water.

Apparatus

2. The apparatus shall consist of the following:

(a) Centrifuge, hand or power driven, capable of exerting a force of 400 times gravity (400 G) on a 100 g. sample.

$$\text{Required rpm of centrifuge head} = \sqrt{\frac{14{,}000{,}000}{r}}$$

Where:

r = radius in inches to center of gravity of sample.

(b) Centrifuge cups, 2 13/16 in. in height, 2 1/16 in. in diameter, complete with perforated brass plate 0.031 in. thick with minimum of 100 holes, 0.062 in. in diameter, per square inch.

(c) Balance, 500 g. capacity, accurate to 0.1 g.

(d) Drying oven or hot plate.

(e) Assortment of round metal pans.

(f) Scale, 2 kg. capacity, accurate to 1 g.

(g) Circular metal rings, 10 in. in inside diameter with vertical sides ¼ in. deep.

(h) Abrasion apparatus, as shown in Fig. 2.

(i) Mechanical mixer (bituminous mix) or other power device capable of driving abrasion apparatus at 33 rpm (Fig. 1).

(j) Special plastic cylinder, 500 ml., with valve at bottom (see Fig. 4).

(k) Kerosene.

(l) Filter paper, Eaton Dikemann Co., size 5½ cm., No. 611.

(m) Roofing Felt, 50-60 lb. weight.

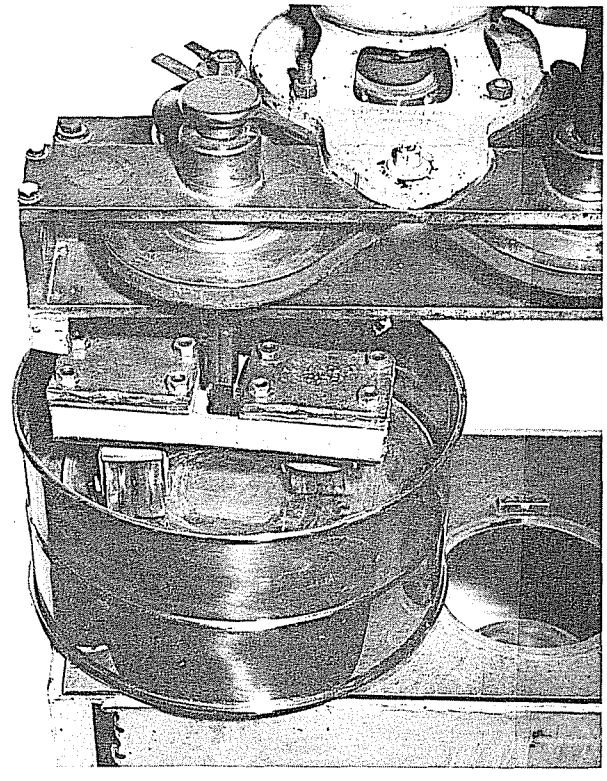


FIGURE 1

Preparation of the Sample

3. (a) Weigh out approximately 105 g. of representative aggregates.

(b) Dry to constant weight and allow to cool to room temperature.

Determination of Surface Area and Absorption

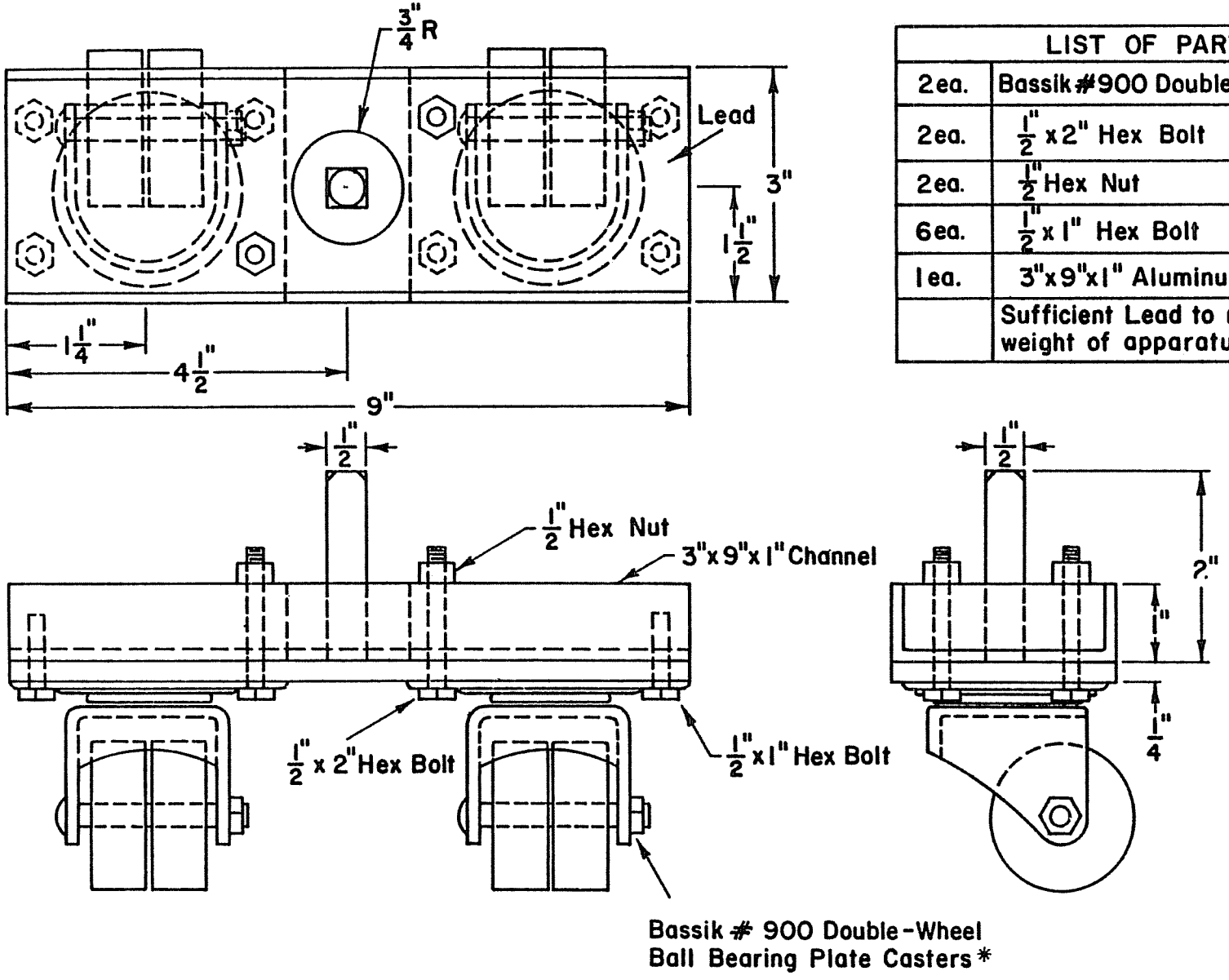
4. (a) Place sample in a tared centrifuge cup containing filter paper and adjust the weight of the material to exactly 100 g.

(b) Place the cup and sample in the centrifuge, quickly pour about 20 ml. of kerosene over the sample and immediately centrifuge for 2 minutes at a force of 400 G.

NOTE: *The centrifuge must be in operation within 5 seconds after adding kerosene, as an additional time allows the kerosene to be absorbed by the aggregate and will not represent true surface area.*

(c) Weigh centrifuged sample to the nearest 0.1 g. and record the amount of kerosene retained. Correct for specific gravity as follows:

ABRADING ASSEMBLY



LIST OF PARTS	
2ea.	Bassik #900 Double Wheel Casters
2ea.	1/2" x 2" Hex Bolt
2ea.	1/2" Hex Nut
6ea.	1/2" x 1" Hex Bolt
1ea.	3"x9"x1" Aluminum Channel
	Sufficient Lead to make total weight of apparatus 13.5 lbs.

* Wheels machined for true flat surface.

FIGURE 2

$$\text{Correction} = \frac{\text{(g. kerosene ret.)} \times \text{avg. sp. gr. agg.}}{2.65}$$

(d) Use the surface area chart in Fig. 3. Place the straightedge on the horizontal line representing the corrected amount of kerosene retained; follow straightedge horizontally to the right to the point of intersection with the diagonal line and then move vertically downward to the intersection with the bottom scale to obtain the surface area.

(e) After step (c), place the sample and cup in a small pan containing a ½-in. depth of kerosene and pour approximately 35 ml. of kerosene over the sample. Allow to soak for 10 minutes.

(f) Remove the sample from the bath and centrifuge for 2 minutes at a force of 400 G.

(g) Reweigh and record the amount of kerosene retained. Make a correction for specific gravity as in step (c).

(h) Subtract the correction result in (c) above from the result of (g) and record the difference as the absorption.

Total Liquid Content of Mixture

5. (a) Pour 500 g. of quartered aggregate into the tared plastic cylinder (Fig. 4). Add water slowly from the bottom by attaching a length of hose between a water faucet and the valve at the bottom of the graduate until free water appears on the surface of the sample.

(b) Record the total weight of the water.

NOTE: *If the aggregate column breaks up during addition of water, rod with a small metal rod until the column goes back together.*

(c) The above procedure will establish the maximum amount of liquid (emulsion plus water) that the aggregate can accommodate.

Optimum Asphalt Content

6. (a) Quarter out 3 separate 500-g. samples of aggregate for fabrication of test specimens.

(b) Add 5.0 percent water by weight of the dry material, to the first test sample and mix thoroughly. Plot the surface area of the material on Fig. 5 or Table 1 to determine the amount of emulsion required to give an asphalt film thickness of 9 microns. Add this amount of emulsion plus sufficient water to bring to the previously established total liquid content (section 5). This added amount of water will be in addition to the 5.0 percent added for initial mixing. Mix thoroughly.

TABLE 1
CONVERSION TABLE *

	PER CENT ASPHALT TO FILM THICKNESS(μ)									
Surface Area	2.0%	4.0	6.0	8.0	10.0	12.0	14.0	16.0	18.0	20.0
45	2.2μ	4.4	6.5	8.7	10.9	13.1	15.2	17.4	19.6	21.8
50	2.0	3.9	5.9	7.8	9.0	11.8	13.7	15.7	17.8	19.6
55	1.8	3.6	5.4	7.1	8.9	10.7	12.5	14.3	16.1	17.8
60	1.6	3.3	4.9	6.5	8.2	9.8	11.5	13.1	14.8	16.3
65	1.5	3.0	4.6	6.0	7.5	9.1	10.6	12.1	13.6	15.1
70	1.4	2.8	4.2	5.6	7.0	8.4	9.8	11.2	12.6	14.0
75	1.3	2.6	3.9	5.2	6.5	7.8	9.1	10.4	11.8	13.1
80	1.2	2.4	3.7	4.9	6.1	7.3	8.6	9.8	11.0	12.3
85	1.2	2.3	3.5	4.6	5.7	6.9	8.1	9.2	10.4	11.5
90	1.1	2.2	3.3	4.4	5.4	6.5	7.6	8.7	9.8	10.9
95	1.0	2.1	3.1	4.1	5.2	6.2	7.2	8.2	9.3	10.3
100	1.0	1.9	2.9	3.9	4.9	5.9	6.9	7.8	8.8	9.8

* Based on 60% asphalt in the emulsion.

(c) Place a metal ring on a disk cut from roofing felt to the outside diameter of the ring, and flow the mixed material into the ring. Strike off excess material flush with the top of the ring and allow to stand at room temperature for 15 minutes.

(d) Remove the metal ring and place the test specimen with supporting disk in a 140° F oven to dry to constant weight. Record the weight, after allowing specimen to cool to room temperature.

(e) In order to provide a range for visual inspection and evaluation of the abrasion test, repeat the above procedure on the other 2 samples using appropriate percentages of asphalt required (Fig. 5) to provide about 1 micron film thickness above and below the 9 micron level.

Resistance to Abrasion

7. (a) Place the 3 specimens that were prepared in section 6 in pans and cover each with 350 ml. of water at room temperature. Allow to soak for 1 hour.

(b) Place the pan with specimen and water in abraiding unit and abraid for 15 minutes.

(c) Remove the specimen from the bath and dry in a 140° F oven to constant weight. Subtract this weight from the oven-dry weight before the abrasion test (section 6.(d) above). This difference represents abrasion loss.

(d) Repeat steps (b) and (c) for the other 2 specimens. Multiply the grams lost in abrasion by 6.20. This equal grams abraided per square foot. The quantity 6.20 is a constant designating the area enencompassed by the wheel track (1/6.20 sq. ft.). If the dimensions of the wheels are changed, this factor must be adjusted.

NOTE: *Determining optimum asphalt content for a slurry seal mixture will depend on the judgment of the individual. This mixture after curing should present a dense, voidless mastic-like appearance, black in color, with no visible signs of free asphalt. Excessive loss in the abrasion test will normally be indication of insufficient asphalt and an excess of asphalt will usually be evidenced by the mixture picking up on the rubber wheels of the abrasion apparatus.*

An abrasion loss in excess of 100 g. per square foot of surface on the specimen determined to have optimum asphalt content will be cause for rejection of the mixture. Causes of the excessive abrasion loss for this specimen can usually be attributed to hydrophylic aggregates or possibly to a faulty emulsion which tends to separate and inadequately coat the aggregate particles. Additional mixtures should be tested in which the emulsion in question is mixed with an aggregate of known non-hydrophylic characteristics. In addition, the aggregates in question should be tested with an emulsion from a different source to isolate the cause of the abrasion loss.

SURFACE AREA CHART

$$\text{Corrected Amount Kero. Ret.} = \frac{\text{Grams Kero. Ret. by Sample x average Sp. Gr. of Agg.}}{2.65}$$

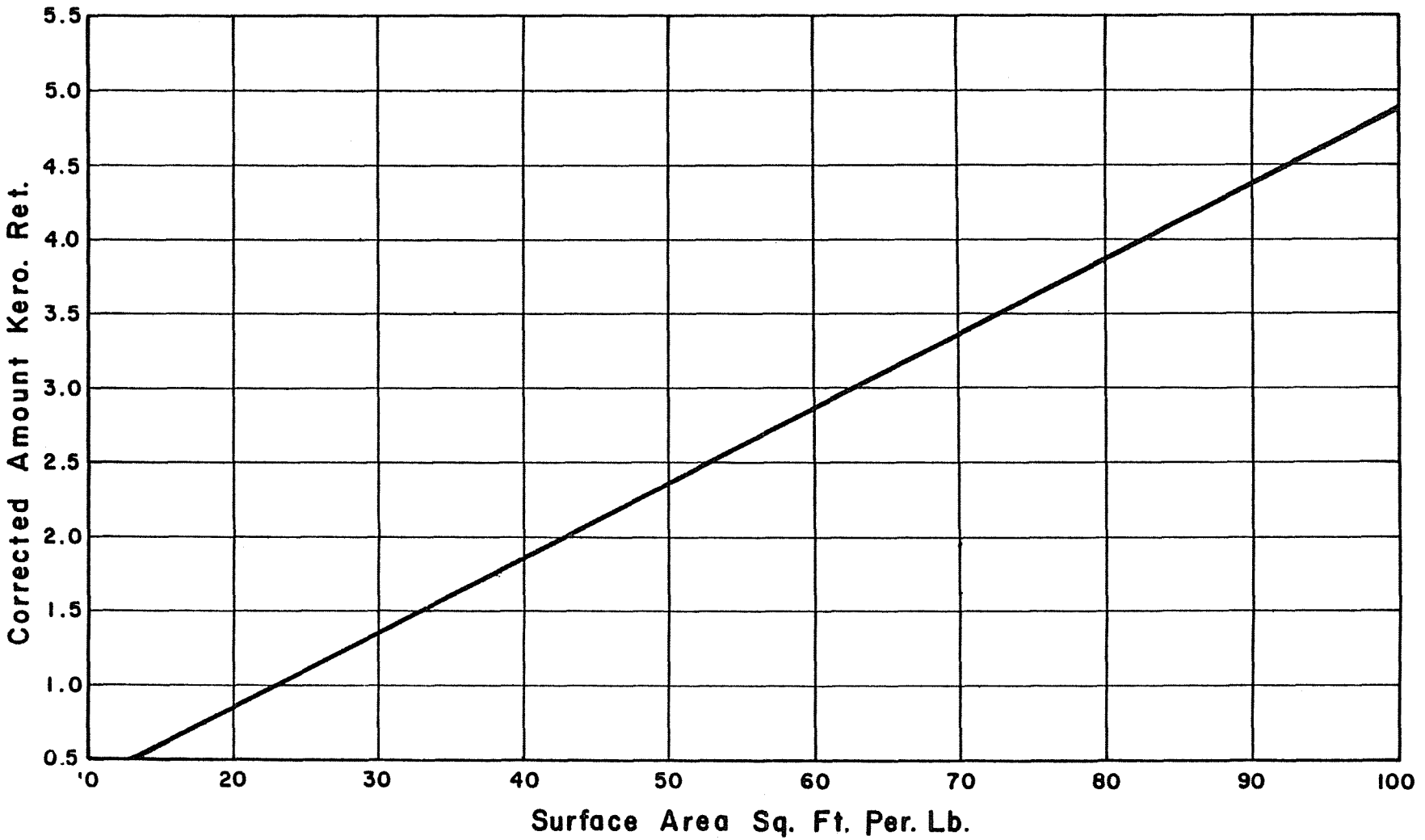
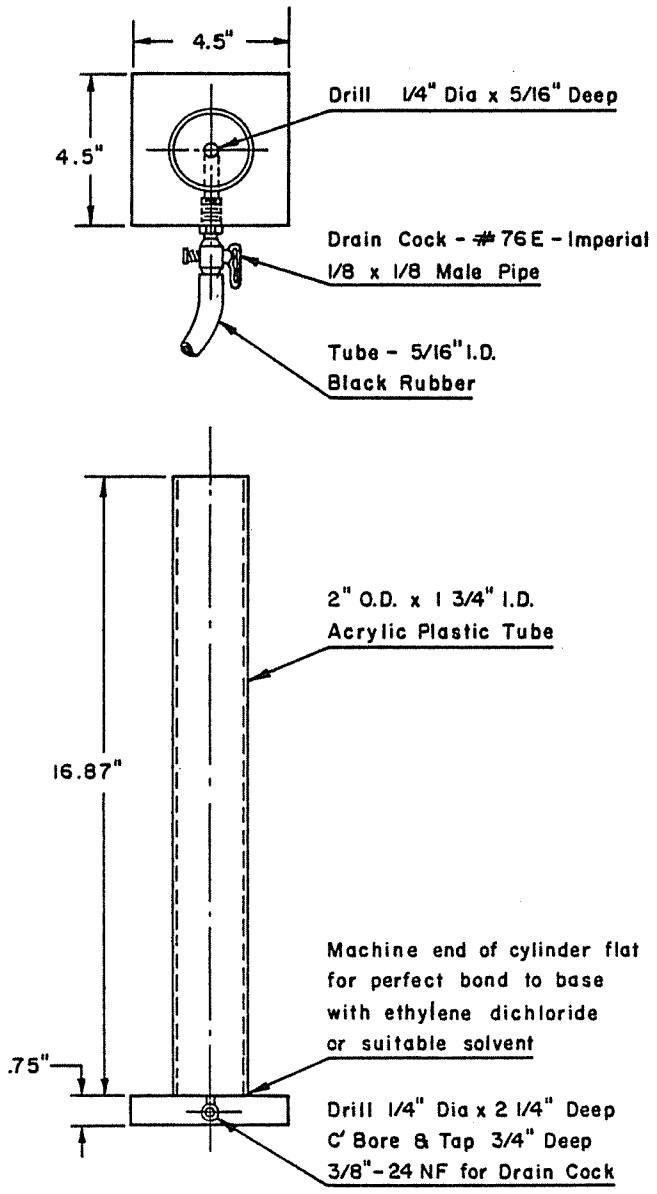


FIGURE 3



NOTE: CYLINDER & BASE TO BE OF MOULDED TRANSPARENT ACRYLIC PLASTIC

500 ML CYLINDER

FIGURE 4

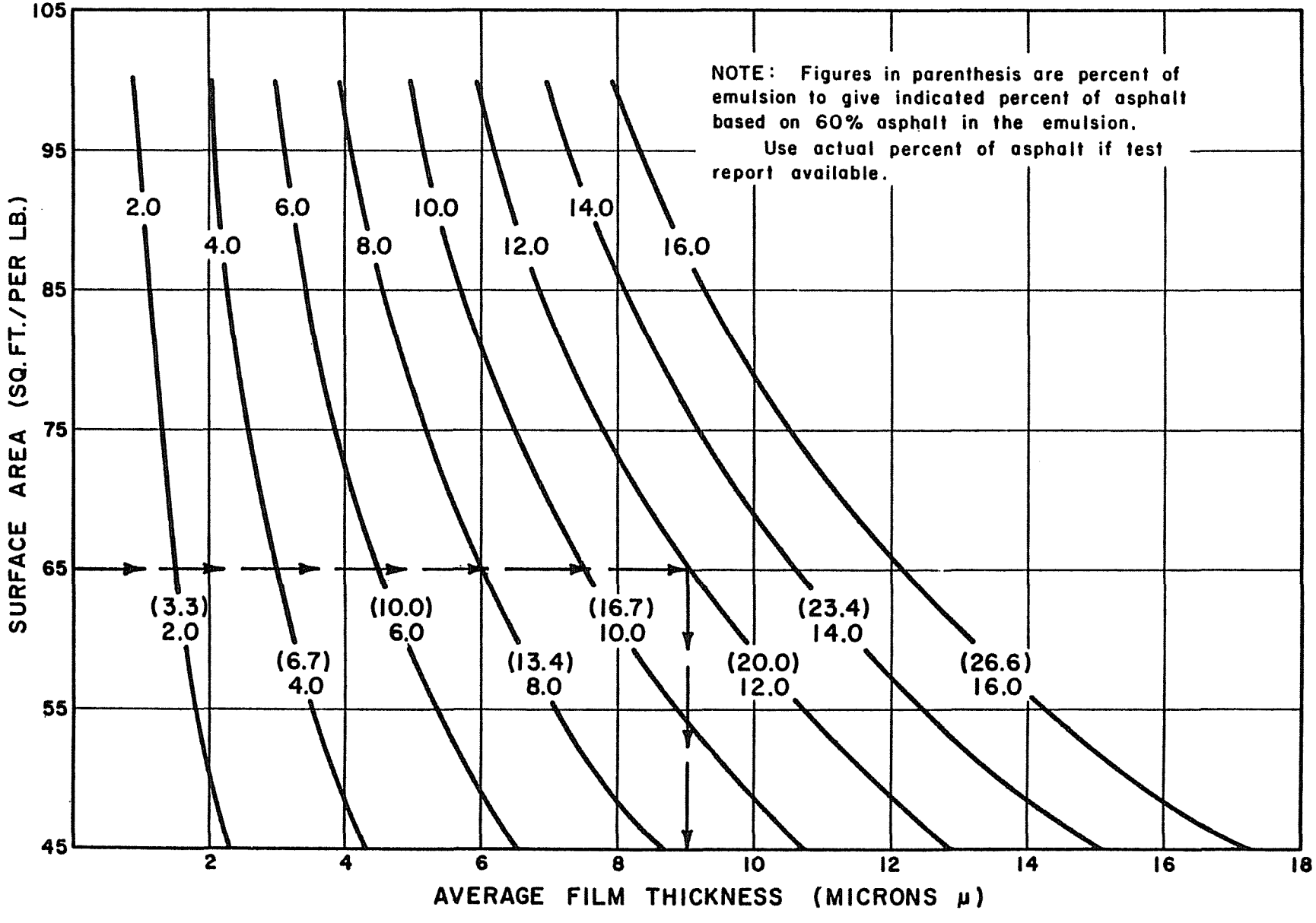

NOTE: Figures in parenthesis are percent of emulsion to give indicated percent of asphalt based on 60% asphalt in the emulsion.
Use actual percent of asphalt if test report available.
2.0
4.0
6.0
8.0
10.0
12.0
14.0
16.0
(3.3)
2.0
(6.7)
4.0
(10.0)
6.0
(13.4)
8.0
(16.7)
10.0
(20.0)
12.0
(23.4)
14.0
(26.6)
16.0
105
95
85
75
65
55
45
SURFACE AREA (SQ.FT./PER LB.)
2
4
6
8
10
12
14
16
18
AVERAGE FILM THICKNESS (MICRONS μ)

FIGURE 5

DESIGN OF ASPHALTIC CONCRETE FRICTION COURSE

(An Arizona Method)

1. SCOPE

1.1 This test method provides a standard methodology to be used for the development of an asphaltic concrete friction coarse mix design. It includes a means of determining the density and design binder content.

1.2 This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure	Title	Page
Section 2	Test Methods and Apparatus	2
Section 3	Materials	4
Section 4	Determination of Composite Gradation	5
Section 5	Preparing Samples for Mix Designs Using Stockpile Materials	7
Section 6	Aggregate Specific Gravities and Absorption	9
Section 7	Asphalt Mixture Testing Temperature Requirements	11
Section 8	Determination of Maximum Theoretical Specific Gravity	12
Section 9	Determination of Design Asphalt Content	13

Section 10	Draindown Determination	15
Section 11	Bulk Density Determination	16
Section 12	Example and Report	19
Figure 1	Mix Design Composite (With and Without Mineral Admixture)	21
Figure 2	Mix Design Composite Adjusted (With and Without Mineral Admixture)	22
Figure 3	Determination of Percent Pass No. 200 On Coarse Aggregate	23
Figure 4	Example Weigh Up Sheet	24
Figure 5	Draindown Determination Example	25
Figure 6	Example Mix Design Summary	26

2. TEST METHODS AND APPARATUS

2.1 This test method is used in conjunction with the test methods listed below. The required apparatus is shown in the individual test methods, as appropriate. This test method also requires specific apparatus for the draindown and unit weight procedure, as listed in Subsection 2.5. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual.

2.2

ARIZ 201	Sieving of Coarse and Fine Graded Soils and Aggregates
ARIZ 205	Composite Grading
ARIZ 210	Specific Gravity and Absorption of Coarse Aggregate
ARIZ 211	Specific Gravity and Absorption of Fine Aggregate
ARIZ 212	Percentage of Fractured Coarse Aggregate Particles
ARIZ 233	Flakiness Index of Coarse Aggregate
ARIZ 238	Percent Carbonates in Aggregate
ARIZ 242	Sand Equivalent Test for Mineral Aggregate for Asphaltic Concrete Friction Course
ARIZ 248	Alternate Procedures for Sieving of Coarse and Fine Graded Soils and Aggregates
ARIZ 251	Combined Coarse and Fine Specific Gravity and Absorption
ARIZ 714	Sieving of Granulated Rubber
ARIZ 806	Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)

2.3 AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
AASHTO T 228 Specific Gravity of Semi-Solid Bituminous Materials

Note: Perform testing by AASHTO T 228 at 77 °F.

AASHTO M 231 Weighing Devices Used in the Testing Materials
AASHTO T 316 Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.4 ASTM D 7741 Measurement of Apparent Viscosity of Asphalt-Rubber or Other Asphalt Binders by Using a Rotational Hand Held Viscometer

2.5 Apparatus for Draindown and Unit Weight Procedure

2.5.1 Oven – An oven capable of maintaining constant temperatures between 220 and 335 °F.

2.5.2 Compression Testing Machine – A testing machine conforming to the requirements of AASHTO T 167.

2.5.3 Molds – Molding cylinders, and top and bottom molding plungers; the cylinders shall be 4.000 ± 0.005 inches inside diameter by approximately 6 inches in height. The top and bottom plungers shall be 3.985 ± 0.005 inches in diameter, the bottom plunger shall be approximately 2 inches in height and the top plunger shall be approximately 6 inches in height. A baseplate approximately 8”x 8” shall be provided to hold the mold and plunger assembly.

Note: Identify the molding cylinders and record the tare weight to the nearest 0.1 gram, and the inside diameter recorded to the nearest 0.001 inch. Check the tare weight and inside diameter of the cylinders periodically to assure they have not changed due to use.

2.5.4 Support Bars – Steel bars to hold the mold cylinder one inch above the baseplate during the molding operation.

2.5.5 A balance or scale capable of measuring the maximum weight to be determined and conforming to the requirements of AASHTO M 231, except the readability and sensitivity of any balance or scale utilized shall be at least 0.1 gram.

2.5.6 Hot Plate – Capable of maintaining a temperature of up to 325 ± 5 °F.

2.5.7 Miscellaneous mixing bowls, spoons, spatulas, scoops, pans, etc.

2.5.8 Thermometers – Dial type with glass face, or digital, capable of reading to the nearest 1 °F with a range of 50 to at least 350 °F.

2.5.9 1,000 ml Glass Beakers.

2.5.10 Glass Plate or Watch Glass large enough to cover Glass Beaker.

3. MATERIALS

3.1 Mineral Aggregate – The mineral aggregate used in the design shall be produced material from the source(s) for the project.

3.1.1 The composited gradation of the aggregate without admixture, and the composited gradation of the aggregate-mineral admixture blend shall comply with the grading limits of the specifications.

3.1.2 The composited mineral aggregate shall conform to the requirements of the specifications for Combined Bulk Oven Dry Specific Gravity (ARIZ 251), Combined Water Absorption (ARIZ 251), Sand Equivalent (ARIZ 242), Fractured Coarse Aggregate Particles (ARIZ 212), Flakiness Index (ARIZ 233), Percent Carbonates (ARIZ 238), and Abrasion (AASHTO T 96) when applicable.

3.2 Bituminous Material – The bituminous material used in the design shall be an asphalt binder, conforming to the requirements of Section 1005 of the specifications, which is to be used in the production of the asphaltic concrete. The specific gravity of the asphalt binder shall be determined in accordance with AASHTO T 228 (at 77 °F).

3.3 Mineral Admixture – Mineral admixture is required. The mineral admixture used in the design shall be the same type of material from the same supplier to be

used in production of friction course. The mineral admixture shall conform to the requirements of the specifications.

Note: The mineral admixture used for mix design testing should be stored in an airtight container and be no older than 3 months.

3.4 Crumb Rubber Asphalt (CRA) – The Crumb Rubber Asphalt shall be tested and conform to the specifications of ADOT Specifications Section 1009.

3.5 Crumb Rubber – The crumb rubber shall be tested for sieve analysis in accordance with ARIZ 714. It shall conform to ADOT Specifications Sections 414 & 1009.

4. DETERMINATION OF COMPOSITE GRADATION

4.1 Perform a coarse and a fine sieve analysis for the aggregate from each stockpile in accordance with ARIZ 201. The fine sieve sample size may be reduced if the minimum of 500 grams is not obtained from coarse sieving, or if there is insufficient material for performing other desired tests which utilizes the Minus No. 4 Material.

4.2 Compare the Percent Pass No. 8 from the Sieve Analysis to the actual Percent Pass No. 8 as follows:

4.2.1 The Minus No. 4 Material from each stockpile is separated into Retained No. 8 Material and Minus No. 8 Material, and the weights for each recorded.

4.2.2 Determine the actual Percent Pass No. 8 by dividing the weight of Minus No. 8 Material by the combined total weight of the Plus No. 8 and Minus No. 8 Material that was determined in Subsection 4.2.1.

4.2.3 Multiply this value by the Percent Pass No. 4 from the sieve analysis. Record the result to the nearest whole percent. This is the actual Percent Pass No. 8.

4.2.4 Compare the actual Percent Pass No. 8 to the Percent Pass No. 8 from the sieve analysis. If the difference between the two results is greater than 4.0%, a new fine sieve analysis must be performed. If the difference between the two results is still greater than 4.0% after performing a new fine sieve analysis, adjust the

fine sieve analysis by multiplying the Percent Pass for each sieve smaller than the No. 8 sieve by a factor obtained by dividing the actual Percent Pass No. 8 by the Percent Pass No. 8 from the sieve analysis.

4.3 Determine the mineral aggregate composite in accordance with ARIZ 205. This is used to establish the mix design gradation which is then compared to the specifications. If the gradation falls outside of the specification band, the stockpile percentages will be adjusted until the composite is within the band. (An example is given in Figure 1 & 2).

Note: Adjustments of stockpile percentages greater than 5% for any stockpile should not be made without the agreement of the supplier in writing.

4.4 The aggregate-mineral admixture blend composite is determined by adjusting the mineral aggregate composite (Percent Passing) for mineral admixture by performing the calculation for each sieve:

$$\left(\begin{array}{c}\text{\% Pass}\\ \text{Each Sieve}\\ \text{[Adjusted for}\\ \text{Mineral Admixture]}\end{array}\right) = \frac{\left(\begin{array}{c}\text{\% Pass Each Sieve in}\\ \text{the Aggregate Composite}\end{array}\right) + \left(\begin{array}{c}\text{\% Mineral}\\ \text{Admixture}\end{array}\right)}{(100) + (\text{\% Mineral Admixture})} \text{ x } 100$$

4.5 The composited gradation of the aggregate and the composited gradation of the aggregate-mineral admixture blend shall be shown on the design report, along with the percentage of each material.

4.6 The design gradation is adjusted for Minus No. 200 Material adhering to the coarse aggregate by washing a composited sample of Plus No. 4 Material in accordance with ARIZ 248, alternate #5 (Referee Method). Figure 3 gives an illustration of the calculations and the adjustment to the Minus No. 200 Material from washing.

If adjustments to the gradation are necessary due to the increase in Minus No. 200 Material, a maximum of a one percent change may be made for the Percent Retained on No. 200. If the adjusted Percent Pass No. 200 results in a greater amount of change, wash a composited sample as specified in ARIZ 248 Section 5 (Alternate #4) to determine the actual design gradation.

Note: It is recommended that the composited dust correction sample be tested before additional mix design testing is performed to assure that the design gradation meets governing specifications.

5. PREPARING SAMPLES FOR MIX DESIGNS USING STOCKPILE MATERIAL

5.1 Representative aggregate samples for each test are prepared utilizing the information from the composite for individual size fractions for No. 8 sieve size and larger from each stockpile; and the Minus No. 8 Material from each stockpile.

Note: Aggregate retained on the No. 8 and larger sized sieves may be weighed up by hand for each size fraction. The individual Minus No. 8 Materials may be obtained by first splitting each Minus No. 8 Material into pans of adequate size to hold approximately 1500 grams of material, and then using the split portions for weighing up samples by stirring and scooping out the required amount with a small scoop.

5.2 Table 1 shows the aggregate sample sizes, the number of samples required for each test listed, and which samples include mineral admixture. The aggregate weight shown for Maximum Theoretical Specific Gravity will provide three Rice test specimens. An example weigh-up sheet is shown in Figure 4.

Table 1		
Sample Type	**Sample Size**	**No. of Samples**
Coarse Aggregate Specific Gravity/ Absorption (ARIZ 210)	Required grams of Mineral Aggregate as determined by the Nominal Maximum Aggregate Size [Excludes mineral admixture]	2
Fine Aggregate Specific Gravity/ Absorption (ARIZ 211)	1200 grams of Mineral Aggregate [Excludes mineral admixture]	2
Dust (ARIZ 248)	1000 grams Refer to Figure 4. [Excludes mineral admixture]	1
Sand Equivalent (ARIZ 242)	500 to 750 grams of Mineral Aggregate [Excludes mineral admixture]	1
Fractured Coarse Aggregate Particles (ARIZ 212)	Required grams of Mineral Aggregate as determined by test method [Excludes mineral admixture]	1
Flakiness Index (ARIZ 233)	#¼" Sieve 200g #4 Sieve 100g #8 Sieve 50g [Excludes mineral admixture]	1 1 1
Percent Carbonates (ARIZ 238)	300 grams of Mineral Aggregate [Excludes mineral admixture]	1
Abrasion (AASHTO T 96)	5000 grams of Mineral Aggregate as per test method for grading type [Excludes mineral admixture]	1
Maximum Theoretical Specific Gravity (Rice Test) (ARIZ 806, as modified in Section 11)	3030 grams of Mineral Aggregate [Includes mineral admixture]	1 [Yields 3 test specimens]
Draindown	960 grams Refer to Section 10. [Includes mineral admixture]	3
Bulk Unit Weight	960 grams Refer to Section 11. [Includes mineral admixture]	3

Minus No. 8 Make-Up Material	An adequate amount (normally 600 grams) of Mineral Aggregate [Excludes mineral admixture]	1

6. AGGREGATE SPECIFIC GRAVITIES AND ABSORPTION

6.1 Determine the bulk oven dry (OD) specific gravity, bulk saturated surface dry (SSD) specific gravity, apparent specific gravity, and absorption of the fine and coarse mineral aggregates in accordance with Arizona Test Method 211 and Arizona Test Method 210.

Note: Two samples of both the fine aggregate and coarse aggregate are to be tested and the results must not exceed the maximum range as listed below in Table 2. Additional samples are to be run as necessary until results fall within these ranges.

Table 2

Fine Specific Gravity	**Acceptable Range of 2 Results**
Bulk Sp. Gr.(OD)	0.032
Bulk Sp. Gr.(SSD)	0.027
Apparent Sp. Gr.	0.027
Absorption, %	0.31
Coarse Specific Gravity	**Acceptable Range of 2 Results**
Bulk Sp. Gr.(OD)	0.250
Bulk Sp. Gr.(SSD)	0.020
Apparent Sp. Gr.	0.020
Absorption, %	0.25

6.2 The individual averages for the fine and coarse specific gravities are then utilized in calculating the final combined specific gravities.

6.3 The combined bulk (OD) specific gravity, bulk saturated surface dry (SSD) specific gravity, apparent specific gravity, and combined absorption for the coarse and fine mineral aggregates are calculated by the following:

$$\begin{bmatrix}\text{Combined}\\ \text{Bulk (OD)}\\ \text{Specific Gravity}\end{bmatrix} = \frac{100}{\frac{P_c}{G_c} + \frac{P_f}{G_f}}$$

Where: P_c and P_f = Percent of Coarse Aggregate (Plus No. 8) from the composite and Percent of Fine Aggregate (Minus No. 8), respectively. (Use the nearest whole percent in calculations.).

G_c and G_f = Specific gravity of coarse and fine aggregate respectively.

$$\text{Example}: \begin{bmatrix} P_c = 86 \\ P_f = 14 \\ G_c\,(OD) = 2.741 \\ G_f\ (OD) = 2.704 \end{bmatrix}$$

$$\begin{bmatrix}\text{Combined}\\ \text{Bulk (OD)}\\ \text{Specific Gravity}\end{bmatrix} = \frac{100}{\frac{86}{2.741} + \frac{14}{2.704}} = 2.736$$

$$\text{Example}: \begin{bmatrix} \text{Combined Bulk (SSD) Specific Gravity} = 2.798 \\ \text{Combined Bulk (OD) Specific Gravity} = 2.736 \end{bmatrix}$$

$$(\text{Combined \% Absorption}) = \frac{(2.798) - (2.736)}{(2.736)} \text{ x } 100 = 2.27\%$$

6.4 The combined aggregate bulk specific gravity (OD) must be adjusted for admixture (G_{sb} adj). The calculations for this are as follows:

$$G_{sb\,adj} = \frac{100 + P_{admix}}{\frac{100}{G_{sb}} + \frac{P_{admix}}{G_{admix}}}$$

Where: P_{admix} = Percent of Mineral Admixture, by weight of the mineral aggregate (typically 1.0%)

G_{sb} = Combined Bulk OD Specific Gravity
G_{admix} = Specific Gravity of Mineral Admixture
Type I or II Cement = 3.14
Type IP Cement = 3.00
Hydrated Lime = 2.20

$$\text{Example}: \begin{bmatrix} P_{admix} = 1.0\% \\ G_{sb} = 2.736 \\ G_{admix} = 3.14 \end{bmatrix}$$

$$G_{sb\,adj} = \frac{100 + 1.0}{\frac{100}{2.736} + \frac{1.0}{3.14}} = 2.739$$

7. ASPHALT MIXTURES TESTING TEMPERATURE REQUIREMENTS

7.1 Maximum Theoretical Specific Gravity (ARIZ 806), Draindown Determination, and Bulk Density Determination of friction course must be performed to complete the development of a mix design. Mix and cure samples for these tests at the temperatures specified below in Table 3. The Engineer will specify the laboratory mixing and curing temperatures for all the binders not listed in Table 3.

Table 3

Asphalt Binder Type	Mixing Temperature	Curing Temperature for Rice and Draindown Test	Curing and Compaction Temperature for Unit Weight
CRA	325 ± 5 °F	325 ± 10 °F	230 ± 5 °F
ALL PG's & TR+	300 ± 5 °F	300 ± 10 °F	230 ± 5 °F

8. DETERMINATION OF MAXIMUM THEORETICAL SPECIFIC GRAVITY (with mineral admixture)

8.1 Determine the maximum theoretical specific gravity (G_{mm}) of the friction course mixture in accordance with ARIZ 806 and the temperature guidelines specified in Section 7. For design purposes the binder content will be 4.0% by weight of total mix.

Note: The final binder content selected for a friction course design is typically much higher than the 4.0% mandated above. However, using high asphalt percentages in conjunction with open-graded mixes often results in erroneous values when performing ARIZ 806. Occasionally, 4.0% binder does not provide an adequate asphalt film coating on the aggregate which results in a negative asphalt absorption calculation. If this happens, increase the percent of binder in increments of 0.5% until satisfactory test results are obtained.

8.2 Calculate the Effective Specific Gravity of the Aggregate/Admixture (Gse) using the following formula:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where:
- G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
- P_b = Asphalt binder content at which the Rice test was performed (Rice P_b).
- G_{mm} = Measured maximum theoretical specific gravity of the mix at Rice P_b.
- G_b = Specific gravity of the asphalt binder.

$$\text{Example}: \begin{bmatrix} P_b = 4.0 \\ G_{mm} = 2.628 \\ G_b = 1.034 \end{bmatrix}$$

$$G_{se} = \frac{100 - 4.0}{\frac{100}{2.628} - \frac{4.0}{1.034}} = 2.808$$

8.3 Calculate the percent asphalt absorption (P_{ba}) by the following:

$$P_{ba} = \left(\frac{G_{se} - G_{sb}}{G_{sb} \text{ x } G_{se}} \right) \text{ x } G_b \text{ x } 100$$

Where:
- P_{ba} = Absorbed asphalt, percent by total weight of mix.
- G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
- G_{sb} = Bulk oven dry specific gravity of the combined aggregate and mineral admixture.
- G_b = Specific gravity of the asphalt binder.

$$\text{Example}: \begin{bmatrix} Gse = 2.808 \\ Gsb = 2.739 \\ Gb = 1.034 \end{bmatrix}$$

$$P_{ba} = \left(\frac{2.808 - 2.739}{2.808 \text{ x } 2.739} \right) \text{x } 1.034 \text{ x } 100 = 0.93$$

Report the asphalt absorption to the nearest 0.01%.

9. DETERMINATION OF DESIGN ASPHALT CONTENT

9.1 Design binder content is based on the binder draindown procedure as described in Section 10. The target percent of binder draindown is 0.25% and the intent is to determine a percent of binder as close as possible to the target draindown percent without exceeding it.

Note: Often draindown tests for AR-ACFC will indicate a design binder content that is over 10%. It is current ADOT practice not to issue a friction course design over 9.9%, regardless of what draindown test results indicate.

9.2 An initial binder percent for draindown testing is calculated using one of the two following formulas:

For ACFC and ACFC Special mixes:

$$\text{ACFC Binder Content} = (0.20)(W) + \left(\frac{(61+P)}{5}\right)\left(\frac{1}{C}\right) + 0.1$$

Where: W = Percent Water Absorption
P = Percent Pass #8
C = Combined Bulk OD Specific Gravity

Example: W = 2.27
P = 14
C = 2.736

$$\text{ACFC Binder Content} = (0.20)(2.27) + \left(\frac{(61+14)}{5}\right)\left(\frac{1}{2.736}\right) + 0.1 = 6.0\%$$

For AR-ACFC mixes:

$$\text{AR ACFC Binder Content} = [(0.80)(W) + 8.6]\left(\frac{2.620}{C}\right)$$

Where: W = Percent Water Absorption
C = Combined Bulk OD Specific Gravity

Example: W = 2.27
C = 2.736

$$\text{AR ACFC Binder Content} = [(0.80)(2.27) + 8.6]\left(\frac{2.620}{2.736}\right) = 10.0\%$$

Note: The equations above are used to give an initial binder content value only. This binder content will need to be adjusted based on the actual draindown test results. A minimum of three draindown tests will be run for the mix design; one at the design asphalt content, one at approximately 0.2% below the design content, and one at approximately 0.2% above the design content. Refer to Subsection 9.1.

10. DRAINDOWN DETERMINATION

10.1 Prepare a composited aggregate-admixture sample of approximately 960 grams and dry the sample to a constant weight.

10.2 Heat the composited sample, binder, metal mixing bowl, spoons, and scrapers to the temperature specified in Section 7. Determine the weight of a 1,000 milliliter glass beaker. Record the weight to the nearest 0.1 gram.

10.3 Once the binder and aggregate have reached the proper mixing temperature remove the mixing bowl from the oven and apply a light coat of aerosol based vegetable oil to the inner surface, and wipe any excess with a towel. Place the mixing bowl on a balance and zero the balance. Carefully add the heated aggregate into the mixing bowl. Determine the weight of the aggregate and, if needed, add Minus No. 8 Make-Up Material (See Table 1) to the sample to bring the weight back to 960 grams.

10.4 Create a small crater in the center of the aggregate and add the heated binder to the sample until the total weight of mix is reached.

Note: The total weight of mix is calculated by the following formula:

$$\text{Total Weight of Mix} = \frac{\text{Wt. of Composited Aggregate (with Admixture)} \times 100}{100 - P_b}$$

Where: P_b = Asphalt Binder Content

10.5 Place the mixing bowl on a hot plate and quickly and thoroughly hand mix the sample using a heated spoon. Transfer the sample into the glass beaker taking care to transfer as much of the mixture as possible. Use a scraper to remove mix material adhering to the bowl and spoon, and transfer it into the beaker.

10.6 Weigh and record the weight of the beaker and mixture to the nearest 0.1 gram. Place a glass plate or watch glass over the sample and return it to the oven at mix temperature for 1 hour ± 10 minutes.

10.7 Determine the weight of a sample pan and record the weight to the nearest 0.1 gram.

10.8 After the 1 hour curing, remove the glass beaker from the oven and remove the glass plate or watch glass. Flip the beaker over and quickly empty the asphalt

mixture into the sample pan. This must be done without shaking or tapping the glass beaker, nor allowing the beaker to drain for an extended time.

10.9 Place the beaker and the pan containing the sample in front of a fan and cool to room temperature. Weigh the beaker with the asphalt residue. Then determine the final weight of the pan and asphalt mixture. Record these values to the nearest 0.1 grams.

10.10 Determine the percent draindown by the following equation:

$$\text{Percent Draindown} = \frac{(C - A) \times 100}{(C - A) + (D - B)}$$

Where:
- A = Weight of Glass Beaker
- B = Weight of Sample Pan
- C = Final Weight of Beaker and Mixture Residue
- D = Final Weight of Pan and Mixture

Report the draindown value to the nearest 0.01%. An example of the calculations is shown in Figure 5.

11. BULK DENSITY DETERMINATION

11.1 Prepare a minimum of three composited aggregate-admixture samples of approximately 960 grams each and dry the samples to a constant weight.

11.2 Heat the composited samples, asphalt binder, metal mixing bowl, and spoons to the temperature specified in Section 7.

11.3 Once the binder and aggregate have reached the proper mixing temperature, remove the mixing bowl from the oven and apply a light coat of aerosol based vegetable oil to the inner surface, and wipe any excess with a towel. Place the mixing bowl on a balance and zero the balance. Carefully add the heated aggregate into the mixing bowl. Determine the weight of the aggregate and add Minus No. 8 Make-Up Material to the sample to bring the weight back to 960 grams.

11.4 Create a small crater in the center of the aggregate sample and add enough asphalt binder to the sample to bring the asphalt content up to the design binder content that was determined in Section 10.

11.5 Place the mixing bowl on a hot plate and quickly and thoroughly mix the sample using a heated spoon.

11.6 Place the mixed sample into a 230 ± 5 °F oven until a constant temperature is attained (approximately 1 hour). Also place a calibrated mold, bottom, and a top plunger in the oven.

11.7 Repeat steps 11.3 through 11.6 for the remaining two samples.

11.8 Remove the bottom plunger and mold cylinder from oven, place mold assembly on baseplate (bottom plunger in place with mold cylinder supported on the two steel bars). Apply a light coat of aerosol based vegetable oil to the mold and bottom plunger, and wipe any excess with a towel. Place all of the mixture into molding cylinder and spade mixture vigorously with heated flat metal spatula (approximately 1" wide and 8" long, stiff enough to penetrate the entire layer of material), 15 times around the edge of the mold and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of the mix to a slightly rounded shape.

11.9 Apply a light coat of aerosol based vegetable oil to the upper plunger, and wipe any excess with a towel. Place the upper plunger (which has been preheated) on the sample and compress the mixture under an initial load of 150 psi, to set it against the sides of the mold. Remove the support bars to permit full double-plunger action. Apply the load to the mixture at a rate of 0.2 inches per minute until a load of 2,000 psi is reached. Hold the load at 2,000 ± 100 psi for 2 minutes.

11.10 After compaction, the top plunger is removed, leaving the bottom plunger in place to support the specimen until the sample has cooled sufficiently to be handled safely with bare hands.

Note: Cooling may be achieved by the use of a 77 °F air bath or, if more rapid cooling is desired, fans may be used.

11.11 Repeat the procedure as described in Subsections 11.8 through 11.10 above, for the other two samples.

11.12 After the specimens have cooled, remove the bottom plunger and determine the weight of each mold with specimen to the nearest 0.1 gram. The weight of each

specimen is calculated by subtracting the weight of the corresponding mold cylinder.

11.13 While the specimens are still in the molds, the heights of each of the three specimens are determined to the nearest 0.001 inch.

11.14 The inside diameters of the molds used for each of the three specimens is recorded to the nearest 0.001 inch.

11.15 The bulk density is determined for each specimen by the following:

$$\text{Bulk Density} = \frac{\text{Weight of Specimen (grams)}}{(d/2)^2\,(h)\,(50.86)} \text{ X } 62.3$$

Where: d = Inside Diameter of Mold (inches)
h = Height of Specimen (inches)

Report the densities to the nearest 0.1 lbs./cu.ft.

$$\text{Example}: \begin{bmatrix} \text{Weight of Specimen} = 1002.7 \text{ grams} \\ \text{Inside Diameter of Mold} = 4.002 \text{ inches} \\ \text{Height of Specimen} = 2.489 \text{ inches} \end{bmatrix}$$

$$\text{Bulk Density} = \frac{1002.7}{(4/2)^2 \text{x} (2.489) \text{x} (50.86)} \text{ X } 62.3 = 123.2 \text{ lbs./cu. ft.}$$

Note: The range of densities between all 3 samples shall not differ by more than 2.0 lbs./cu.ft. If this density requirement is not met, discard the entire set of specimens and prepare a new set of specimens.

11.16 The average bulk density of the three specimens is determined and recorded to the nearest 0.1 lbs./cu.ft.

12. EXAMPLE AND REPORT

12.1 Report the test results and data obtained on the appropriate form. Liberal use of the remarks area to clarify and/or emphasize any element of the design is

strongly recommended. Information required in the mix design report is shown in the items listed below.

12.2 Name of the testing organization and the signature of the mix design engineer responsible for the mix design.

12.3 Aggregate:

- Source and identification
- Individual stockpile gradations
- Aggregate blend proportions and composite gradation, with and without mineral admixture
- Fine and coarse aggregate bulk (OD) specific gravity, bulk (SSD) specific gravity, and absorption
- Combined aggregate bulk (OD) specific gravity
- Combined aggregate absorption
- LA Abrasion at both 100 and 500 revolutions
- Sand Equivalent
- Fractured Coarse Aggregate Particles (percent with two fractured faces)
- Carbonates

12.4 Mineral Admixture:

- Type and source
- Percentage used
- Specific gravity

12.5 Combined Mineral Aggregate and Mineral Admixture:

- Combined bulk (OD) specific gravity (with admix)

12.6 CRA Binder Design for AR-ACFC only (from supplier), including:

- Source and grade of base asphalt cement
- Source and type of crumb rubber
- Crumb rubber gradation
- Proportions of asphalt cement and crumb rubber
- Percentage of crumb rubber, by weight of asphalt cement
- CRA binder properties, in compliance with Section 1009 of the ADOT Specifications

- CRA binder specific gravity at 77° F

12.7 Asphalt Cement for ACFC, ACFC Special, and AR-ACFC mixes:

- Source and grade of asphalt cement
- Asphalt cement properties, in compliance with Section 1005 of the ADOT Specifications
- Asphalt cement specific gravity at 77 °F

12.8 Maximum Theoretical Specific Gravity of Asphaltic Mix:

- The binder content at which the Rice test was performed
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf) at the binder and mineral admixture content at which the Rice was performed
- Effective specific gravity of the combined aggregate and mineral admixture (G_{se})

12.9 Asphaltic Mix Properties:

- Design binder content
- Bulk density (pcf)
- Asphalt absorption

12.10 Mix Design Summary:

- An example of a mix design summary report is shown in Figure 6

Arizona Department of Transportation
ARIZONA TEST METHOD 814

Initial Composite Gradation

Project Number: XM122 01X Design: 15-09015 Type: 407 SPECIAL

% Admix: 1.0 % Dust: N/A

Material	3/8" Coarse	3/8" Fine	W.C.F.	Composite		Specifications for 407 Special	
Lab #	2015-00119	2015-00118	2015-00120				
% Used	42	42	16	Without Admix	With Admix	Without Admix	With Admix
Sieve #							
	Gradation Percent Passing						
1 1/2"	100	100	100	100.0	100.0		
1"	100	100	100	100.0	100.0		
3/4"	100	100	100	100.0	100.0		
1/2"	100	100	100	100.0	100.0		
3/8"	100	100	100	100.0	100.0	100	100
1/4"	50	62	100	63.0	63.4		
#4	15	27	100	*33.6	*34.3	35 - 55	36 - 55
#8	3	3	63	12.6	13.5	9 - 14	10 - 15
#10	2	2	57	10.8	11.7		
#16	2	2	40	8.1	9.0		
#30	1	1	23	4.5	5.5		
#40	1	1	18	3.7	4.7		
#50	1	1	14	3.1	4.0		
#100	1	1	7	2.0	2.9		
#200	0.6	0.7	4.0	1.2	2.2	0.0 - 2.0	1.0 - 3.0

* Stockpile composite out of specification

FIGURE 1

Arizona Department of Transportation
ARIZONA TEST METHOD 814

Adjusted Composite Gradation

Project Number: XM122 01X Design: 15-09015 Type: 407 Special

% Admix: 1.0 % Dust: N/A

Material	3/8" Coarse	3/8" Fine	W.C.F.	Composite		Specifications for 407 Special	
Lab #	2015-00119	2015-00118	2015-00120				
% Used	40	42	18	Without Admix	With Admix	Without Admix	With Admix
Sieve Size	Gradation Percent Passing						
1 1/2"	100	100	100	100.0	100.0		
1"	100	100	100	100.0	100.0		
3/4"	100	100	100	100.0	100.0		
1/2"	100	100	100	100.0	100.0		
3/8"	100	100	100	100.0	100.0	100	100
1/4"	50	62	100	64.0	64.4		
#4	15	27	100	35.3	36.0	35 - 55	36 - 55
#8	3	3	63	13.8	14.7	9 - 14	10 - 15
#10	2	2	57	11.9	12.8		
#16	2	2	40	8.8	9.7		
#30	1	1	23	5.0	5.9		
#40	1	1	18	4.1	5.0		
#50	1	1	14	3.3	4.3		
#100	1	1	7	2.1	3.1		
#200	0.6	0.7	4.0	1.3	2.2	0.0 - 2.0	1.0 - 3.0

FIGURE 2

Arizona Department of Transportation
ARIZONA TEST METHOD 814

**Determination Of Percent Pass No. 200 On Coarse Aggregate
And Total Percent Pass No. 200 In Composite
Using Arizona 248 Alternate Procedures for Sieving of
Coarse and Fine Graded Soils and Aggregates Alternate #5**

Lab #: 15-09015 Project #: XM122 01X Date: 08/19/2015

O D Weight of Unwashed Plus No. 4 =	993.9
O D Weight of Washed Plus No. 4 =	990.9

Calculate the "% Pass No. 200 on the Coarse Aggregate" by the following, and record result to the nearest 0.01%

$$\frac{\text{(O D Weight of Unwashed Plus No. 4) - (O D Weight of Washed Plus No. 4)}}{\text{O D Weight Unwashed Plus No. 4}} \times 100 =$$

$$\frac{(993.9) - (990.9)}{993.9} \times 100 =$$

0.30 % Pass No. 200 on Coarse Aggregate

Calculate Total Percent Pass No. 200 in Sample by the following, and record to the nearest 0.1 %:

$$\begin{pmatrix}\text{Total \% Pass}\\ \text{No. 200 in Sample}\end{pmatrix} = \begin{pmatrix}\text{\% Pass No. 200}\\ \text{from fine Sieving}\end{pmatrix} + \frac{\left(100 - \begin{pmatrix}\text{\% Pass}\\ \text{No. 4}\end{pmatrix}\right) \times \begin{pmatrix}\text{\% Pass No. 200}\\ \text{Coarse Agg}\end{pmatrix}}{100}$$

Total % Pass No. 200 in Sample = $\frac{(\ 1.3\ ) + (\ 100 - (\ 35.34\ )) \times (\ 0.30\ )}{100}$

= 1.5 % Total Pass #200

FIGURE 3

Arizona Department of Transportation
ARIZONA TEST METHOD 814

Weigh UP Sheet

Material	3/8" Coarse	3/8" Fine	WCF
Percent	40	42	18

Number of Sets			1	3	1	2	1	1	1	3	1	1	2	1
Material	Sieve Size	Accum. % Ret.	Rice (3030 g)	Bulk Unit Wt. (960 g)	Dust (1000 g)	Coarse Specific Gravity [Plus #8] (2000 g)	Fractured Faces [Plus # 8] (300 g)	Abrasion (5000 g)	Percent Carbonates [Plus # 4] (300 g)	Drain Down (960 g)	Flakiness Index (200 gr., 100 gr., & 50 g)	Sand Equivalent [Minus #8] (600 g)	Fine Specific Gravity [Minus #8] (1200 g)	Make-up Material [Minus #8] (600 g)
3/8" Coarse	1/4"	20	600	190	309	464	69	1390	92	190				
3/8" Coarse	# 4	34	1020	323	772	788	118	2610	157	323				
3/8" Fine	1/4"	50	1498	474	1000	1159	173	3720	231	474				
3/8" Fine	# 4	64.7	1939	614		4500	225	5000	300	614				
3/8" Coarse	# 8	69.5	2083	659		1611	241			659				
3/8" Fine	# 8	79.5	2386	755		1845	276			755				
WCF	# 8	86.2	2586	818		2000	300			818				
3/8" Coarse	- # 8	87.4	2622	830						830		52	104	52
3/8" Fine	- # 8	88.7	2659	842						842		106	213	106
WCF	- # 8	100	3000	950						950		600	1200	600
Admix		101	3030	960						960				

3/8" Coarse	1/4"
3/8" Fine	1/4"
3/8" Coarse	# 4
3/8" Coarse	# 4
3/8" Fine	# 8
3/8" Fine	# 8
WCF	# 8

111
200
48
100
11
34
50

FIGURE 4

Arizona Department of Transportation
Arizona Test Method 814

A.C.F.C. DESIGN WORKSHEET

Lab.No.: 15-09015 Tracs.No.: XM122 01X Date: 08/21/2015

BULK DENSITY EQUATION:

$$BD = \frac{(\text{Weight of Specimen})}{((d/2)^2 \ (\text{Height of Specimen}) \ (50.86))} \times 62.3$$

% Binder	Mold Spec.#	$(d/2)^2$	Height Of Spec.	Wt.of Spec / Mold	Wt.of Mold	Wt. of Spec.	Sp. Gr.	Bulk Dens.	Avg.Sp. Gr.	Avg. Bulk Dens.
6.4	1	4	2.339	3563.8	2543.3	1020.5	2.145	133.6	2.136	133.1
	8	4	2.353	3615.1	2595.6	1019.5	2.13	132.7		
	4	4	2.352	3607.5	2586.8	1020.7	2.133	132.9		

BINDER DRAIN DOWN TEST

% Binder: 6.4

$$\text{Percent Draindown} = \frac{(C - A) \times 100}{(C - A) + (D - B)}$$

A= Wt. of Beaker: 402.0 B = Wt. of Pan : 213.6

C = Wt. of Beaker (After) : 404.5 D = Wt. of Pan & Binder: 1213.3

$$\text{Percent Drain Down} = \frac{(404.5 - 402.0) \times 100}{(404.5 - 402.0) + (1213.3 - 213.6)} = 0.25\ \%$$

FIGURE 5

ARIZONA DEPARTMENT OF TRANSPORTATION
CONSTRUCTION MATRIALS GROUP

407 Special ACFC Mix Design | Lab # 2015-09015 | Date: 8/19/2015

This design meets ADOT specifications

Tracs #: XM12201X | Project #: 011-D(211)T | Project Name: I 11– VULTURE FLAT TI
Resident Engineer: Doe, John | Contractor: Easy Contracting, Inc..

General Design Information

lab #	2015-16030	PG Grade	PG70-22 TR+	PG Source	Acme Asphalt	PG Specific Gravity	1.034
Admixture Type	TYPE II DRY	Design %	1.0	Admix Source	Sugarville Products	Admix Specific Gravity	3.140
						Total number of stockpiles:	3

Aggregate:	lab #	Description	Site #	Design %
1.	2015-00119	3/8`` Coarse Agg	CM 9888	40
2.	2015-00118	3/8`` Fine Agg	CM 9888	42
3.	2015-00120	W.C.F.	CM 9888	18
4.				
5.				
6.				
7.				
			Total	100 %

Composite Gradation

Sieve #	Specification band		Gradation w/o admix	Gradation w/ admix	Field Target Band	
	% passing		% passing	% passing	% passing	
	min	max			min	max
1 1/2"			100	100		
1 "			100	100		
3/4"			100	100		
1/2"			100	100		
3/8"	100		100	100		
1/4"			64	64		
#4	35	55	35	36		
#8	9	14	14	15		
#10			12	13		
#16			9	10		
#30			5	6		
#40			4	5		
#50			3	4		
#100			2	3		
#200	0.0	2.0	1.5	2.5		

Composite Aggregate Properties

Property	Test Value	min	max
L.A. Abrasion % at 100 revolutions (AASHTO T96)	4		9
L.A. Abrasion % at 500 revolutions (AASHTO T96)	17		40
Sand Equivalent (AZ 242)	74	55	
Two Fractured Faces, % (AZ 212)	99	85	
Flakiness Index, % (AZ 233)	21		25
Carbonates, % (AZ 238)	2.0		20
Combined O.D. Specific Gravity (AZ 210)	2.736	2.35	2.85
Corrected Combined O.D. Specific gravity (with admix)	2.739		
Combined Water Absorption, % (AZ 814)	2.27		2.50

Calculated Mix Properties Results

Description	Design Values	Specification Limits
Design Binder Content	6.4	
Bulk Density pcf	133.1	
Asphalt Absorption %	0.93	< 1.0

FIGURE 6

Stockpile Gradations

sieve #	2015-00119 3/8`` Coarse Agg	2015-00118 3/8`` Fine Agg	2015-00120 W.C.F.
1 1/2"	100	100	100
1 "	100	100	100
3/4"	100	100	100
1/2"	100	100	100
3/8"	100	100	100
1/4"	50	62	100
#4	15	27	100
#8	3	3	63
#10	2	2	57
#16	2	2	40
#30	1	1	23
#40	1	1	18
#50	1	1	14
#100	1	1	7
#200	0.6	0.7	4.0

Laboratory Aggregate Specific Gravity Test Results

Type	O.D. Sp. Gr.	SSD SP. Gr.	Water Absorption %	Tested On
Fine (AZ 211)	2.704	2.773	2.57	-#8
Coarse (AZ 210)	2.741	2.802	2.23	+#8

Laboratory Rice Data (AZ 806)

% Asphalt	Maximum Specific Gravity	Maximum Density - pcf	Effective Specific Gravity
4.00	2.628	163.7	2.808

This design has been prepared and submitted under the direction of:

Lab Supervisior: Bossman, Joe Bituminous Engineer Engineer, Ima

Remarks:

Designed approved by: _____

FIGURE 6 (continued)

MARSHALL MIX DESIGN METHOD FOR ASPHALTIC CONCRETE

(An Arizona Method)

1. SCOPE

1.1 This method is used to design Asphaltic Concrete mixes using 4-inch diameter Marshall apparatus.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure #	Title	Page #
Section 2	Test Methods and Apparatus	2
Section 3	Materials	3
Section 4	Determination of Composite Gradation	4
Section 5	Preparing Aggregate/Mineral Admixture Samples for Mix Design Testing	5
Section 6	Aggregate Specific Gravities and Absorption	7
Section 7	Laboratory Mixing and Compaction Temperatures	9
Section 8	Preparation of Specimens for Bulk Specific Gravity/Bulk Density and Marshall Stability/Flow Determination	10
Section 9	Bulk Specific Gravity/Bulk Density of Specimens	13
Section 10	Marshall Stability and Flow Determination	13
Section 11	Maximum Theoretical Specific Gravity (Rice Test)	14
Section 12	Determination of Design Percent Asphalt Binder Content	16
Section 13	Immersion Compression (IMC) Test	20
Section 14	Mix Design Gradation Target Values	20
Section 15	Report	20
Figure 1	Example Mix Design Composite (With and Without Mineral Admixture)	23
Figure 2	Example Weigh Up Sheet #1	24
Figure 3	Example Weigh Up Sheet #2	25
Figure 4	Example Plots of Effective Voids, VMA, Dust/Bitumen Ratio, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent Asphalt Binder Content	26
Figure 5	Example Mix Design Summary	27

2. TEST METHODS AND APPARATUS

2.1 This test method is used in conjunction with the test methods listed below. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. The required apparatus is shown in the individual test methods, as appropriate.

2.2 Arizona Test Methods:

- ARIZ 201 Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 205 Composite Grading
- ARIZ 210 Specific Gravity and Absorption of Coarse Aggregate
- ARIZ 211 Specific Gravity and Absorption of Fine Aggregate
- ARIZ 212 Percentage of Fractured Coarse Aggregate Particles
- ARIZ 238 Percent Carbonates in Aggregate
- ARIZ 247 Particle Shape and Texture of Fine Aggregate Using Uncompacted Void Content
- ARIZ 248 Alternate Procedures for Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 251 Combined Coarse and Fine Aggregate Specific Gravity and Absorption
- ARIZ 410 Compaction and Testing of Bituminous Mixtures Utilizing Four Inch Marshall Apparatus
- ARIZ 415 Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
- ARIZ 416 Preparing and Splitting Field Samples of Bituminous Mixtures for Testing
- ARIZ 802 Effect of Water on Strength of Compacted Treated and Untreated Bituminous Mixtures (Immersion Compression Test)
- ARIZ 806 Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)

2.1.2 AASHTO Test Methods:

- AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- AASHTO T 228 Specific Gravity of Semi-Solid Bituminous Materials

Note 1: Testing by AASHTO T 228 shall be performed at 77 °F.

- AASHTO T 316 Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.1.3 ASTM Standard:

- ASTM D 2493 Standard Viscosity-Temperature Chart for Asphalts

3. MATERIALS

3.1 Mineral Aggregate - The mineral aggregate used in the design shall be produced material from the source(s) for the project.

3.1.1 The composited gradation of the aggregate without admixture, and the composited gradation of the aggregate-mineral admixture blend shall comply with the grading limits of the specifications.

3.1.2 The composited mineral aggregate shall conform to the requirements of the specifications for Sand Equivalent (AASHTO T 176), Combined Bulk Oven Dry Specific Gravity (ARIZ 251), Combined Water Absorption (ARIZ 251), Fractured Coarse Aggregate Particles (ARIZ 212), Uncompacted Void Content (ARIZ 247), and Percent Carbonates (ARIZ 238) when applicable.

3.1.3 Mineral aggregate from each source shall be tested separately for compliance to the project requirements for Abrasion (AASHTO T 96).

3.2 Bituminous Material - The bituminous material used in the design shall be an asphalt binder, conforming to the requirements of Section 1005 of the specifications, which is to be used in the production of the asphaltic concrete. The specific gravity of the asphalt binder shall be determined in accordance with AASHTO T 228 (at 77 °F).

3.3 Mineral Admixture - Mineral admixture is required. The mineral admixture used in the design shall be the same type of material to be used in production of the asphaltic concrete. The mineral admixture shall conform to the requirements of the specifications.

3.4 Batch Plants - Mix designs developed for asphaltic concrete which is to be produced in a batch plant shall be prepared in accordance with this procedure, modified as follows:

3.4.1 Aggregate samples will be obtained from the hot bins for all testing except Sand Equivalent. Testing for Sand Equivalent will be performed on aggregate stockpile samples proportioned and composited to meet the

mix design composite without admixture. Any method may be used to combine the aggregate stockpile samples for Sand Equivalent testing as long as the resultant gradation is representative of the mix design composite gradation without admixture.

3.4.2 The mix design shall provide component percentages and composite gradations for both stockpile and hot bin materials.

4. DETERMINATION OF COMPOSITE GRADATION

4.1 The gradation of the aggregate from each individual component stockpile or bin shall be determined in accordance with ARIZ 248 using washed sieve analysis Alternate #3, Alternate #4, or Alternate #5. For Alternate #5, washing of the coarse aggregate may be performed on the composite Plus No. 4 material and applied to the composite percent pass the minus No. 200 determined from the unwashed coarse sieving and washed fine sieving of the individual stockpiles.

4.2 The composite gradation of the mineral aggregate is determined using desired percentages of each component based on washed sieve analysis. Mix designs may be developed based on bin or stockpile material, as appropriate for the respective mix production facility to be used.

4.3 The mineral aggregate composite shall be determined in accordance with ARIZ 205, paragraph 2(e).

4.4 The aggregate-mineral admixture blend composite is determined by adjusting the mineral aggregate composite (percent passing) for mineral admixture by performing the calculation in Equation 1 for each sieve:

Equation 1:

$$\left(\begin{array}{c}\text{\% passing each sieve [Adjusted for Mineral Admixture]}\end{array}\right) = \frac{\left(\begin{array}{c}\text{\% passing each sieve in the aggregate composite}\end{array}\right) + \left(\begin{array}{c}\text{\% Mineral Admixture}\end{array}\right)}{(100) + (\%\ \text{Mineral Admixture})} \times 100$$

4.5 The composited gradation of the aggregate and the composited gradation of the aggregate-mineral admixture blend shall be shown on the design report, along with the percentage of each material.

5. PREPARING AGGREGATE/MINERAL ADMIXTURE SAMPLES FOR MIX DESIGN TESTING

5.1 Based on the stockpile or bin composite aggregate gradation, the aggregate samples needed for mix design tests are prepared as follows.

5.1.1 Dry the mineral aggregate from each individual stockpile at a temperature not exceeding any temperature restrictions specified in subsequent test procedures. Drying shall be performed until no further weight loss is obtained from continued drying.

5.1.2 Representative samples of aggregate material which is retained on the individual No. 8 and larger sieve sizes and the minus No. 8 material from each stockpile or bin are used to prepare the samples for mix design testing.

5.1.3 Table 1 shows the aggregate sample sizes, the number of samples required for each test listed, and which samples include mineral admixture. The aggregate weight shown for Maximum Theoretical Specific Gravity will provide three Rice test specimens. the amount shown for Density-Stability/Flow will produce three Marshall specimens, and the amount shown for Immersion Compression (IMC) will produce two specimens. Example weigh-up sheets are shown in Figures 2 and 3.

Table 1

Sample Type	Sample Size	Number of Samples
Fractured Coarse Aggregate Particles (ARIZ 212)	Required grams of Mineral Aggregate as determined by test method [No mineral admixture]	1
Percent Carbonates (ARIZ 238) (When required)	300 grams of Mineral Aggregate [No mineral admixture]	1
Abrasion (AASHTO T 96)	5000 grams of Mineral Aggregate as per test method for grading type [No mineral admixture]	1
Fine Aggregate Specific Gravity/ Absorption (ARIZ 211)	1200 grams of Mineral Aggregate [No mineral admixture]	1
Coarse Aggregate Specific Gravity/Absorption (ARIZ 210)	Required grams of Mineral Aggregate as determined by the Nominal Maximum Aggregate Size [No mineral admixture]	1

Table 1 (Continued)		
Sand Equivalent (AASHTO T 176)	500 to 750 grams of Mineral Aggregate [No mineral admixture]	1
Uncompacted Void Content (ARIZ 247)	Minimum 500 grams of Mineral Aggregate [No mineral admixture]	1
Minus No. 8 Make-Up Material	An adequate amount (normally 500 grams) of Mineral Aggregate [No mineral admixture]	1
Marshall Density-Stability/Flow (ARIZ 415 and ARIZ 410, as modified in Sections 9 and 10 respectively)	3300 grams of Mineral Aggregate (See Note 2) [Plus mineral admixture, by percent required by ARIZ 802 (as modified in Section 13)]	3 (See Note 3) [Each sample yields 1 set of 3 Marshall Specimens]
Maximum Theoretical Specific Gravity (Rice Test) (ARIZ 806, as modified in Section 11)	3000 grams of Mineral Aggregate [Plus mineral admixture, by percent required by ARIZ 802 (as modified in Section 13)]	1 [Yields 3 test specimens]
Immersion Compression (IMC) (ARIZ 802, as modified in Section 13)	3400 grams of Mineral Aggregate (See Note 2) [Plus required percent of mineral admixture]	3 [Each sample yields 1 set of 2 IMC Specimens]

Note 2: Generally the weight of mineral aggregate will provide specimens of acceptable heights, but adjustments may be necessary in some cases. Use Equation 2 to adjust the weight of aggregate as necessary to conform to specimen height requirements of 2.500 ± 0.200 inches for Marshall Density-Stability/Flow specimens and 4.000 ± 0.100 inches for IMC specimens.

***Equation 2*:**

$$\begin{bmatrix}\text{Adjusted Weight}\\ \text{of Aggregate}\end{bmatrix} = \frac{\begin{pmatrix}\text{Combined Bulk O.D.}\\ \text{Agg. Specific Gravity}\end{pmatrix}}{2.650} \times \begin{pmatrix}\text{3300 grams (for Marshall}\\ \text{Density - Stability/Flow)}\\ \text{or 3400 grams (for}\\ \text{Immersion Compression)}\end{pmatrix}$$

Note 3: Requires one sample for each asphalt binder content to be tested (minimum of 3 asphalt binder contents, with 3 Marshall specimens at each asphalt binder content).

5.1.4 After the aggregate samples for the Marshall, Rice, and IMC specimens have been composited, add the required amount of mineral admixture, by dry weight of the aggregate, and mix thoroughly. Add 3% water, by dry weight of the aggregate, to each sample and mix thoroughly to wet the mineral admixture and aggregate surfaces.

5.1.5 Testing utilizing the prepared virgin aggregate-mineral admixture samples for Marshall, Rice, and IMC will be performed as specified in Sections 8-10, 11, and 13, respectively.

6. AGGREGATE SPECIFIC GRAVITIES AND ABSORPTION

6.1 Determine the Bulk Oven Dry, S.S.D., Apparent Specific Gravities and Absorption for the fine aggregate (minus No. 4) and the coarse aggregate (plus No. 4) in accordance with ARIZ 211 and ARIZ 210, respectively.

6.2 Determine the combined bulk oven dry specific gravity of the fine aggregate and the coarse aggregate without mineral admixture and also the combined water absorption of the fine aggregate and the coarse aggregate without mineral admixture, in accordance with ARIZ 251.

6.2.1 The combined aggregate bulk oven dry specific gravity without mineral admixture and the combined aggregate water absorption without mineral admixture are used only to determine compliance with specification requirements.

6.3 Using Equation 3, calculate the Combined Bulk Oven Dry (Gsb), S.S.D., and Apparent Specific Gravities of the aggregate-mineral admixture blend.

Equation 3:

$$\begin{pmatrix}\text{Combined Specific Gravity}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{pmatrix} = \frac{P_f + P_c + P_{admix}}{\frac{P_f}{G_f} + \frac{P_c}{G_c} + \frac{P_{admix}}{G_{admix}}}$$

Where:

P_f, P_c	=	Weight percent of fine aggregate (minus No. 4) and coarse aggregate (plus No. 4) respectively. Determined from the aggregate composite without mineral admixture.
P_{admix}	=	Percent mineral admixture by weight of the aggregate.
$P_f + P_c$	=	100
$P_f + P_c + P_{admix}$	=	100 + % Mineral Admixture
G_f, G_c	=	Bulk Oven Dry, S,S.D., or Apparent specific gravity of the fine aggregate and the coarse aggregate respectively.

G_{admix} = Specific gravity of the mineral admixture.
Type I or II Cement = 3.14
Type IP Cement = 3.00
Hydrated Lime = 2.20

Example [for combined Bulk Oven Dry Specific Gravity (G_{sb})]:

P_f = 59
P_c = 41
G_f = 2.593
G_c = 2.634
G_{admix} = 3.14 (Type II Cement)
P_{admix} = 1.0

$$\left[\begin{array}{l}\text{Example of Combined}\\ \text{Bulk Oven Dry Specific}\\ \text{Gravity } (G_{sb}) \text{ of Aggregate}\\ \text{and Mineral Admixture}\end{array}\right] = \frac{59 + 41 + 1.0}{\frac{59}{2.593} + \frac{41}{2.634} + \frac{1.0}{3.14}} = 2.614$$

6.4 Using Equation 4, calculate the Combined Water Absorption of the aggregate-mineral admixture blend.

Equation 4:

$$\left(\begin{array}{l}\text{Combined Water Absorption}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{array}\right) = \frac{(P_f \text{ x } A_f) + (P_c \text{ x } A_c) + (P_{admix} \text{ x } A_{admix})}{P_f + P_c + P_{admix}}$$

Where: P_f, P_c = Weight percent of fine aggregate (minus No. 4) and coarse aggregate (plus No. 4) respectively. Determined from the aggregate composite without mineral admixture.
P_{admix} = Percent mineral admixture by weight of the aggregate.
$P_f + P_c$ = 100
$P_f + P_c + P_{admix}$ = 100 + % Mineral Admixture
A_f, A_c = Percent water absorption of the coarse aggregate and the fine aggregate respectively.
A_{admix} = Percent water absorption of mineral admixture (assumed to be 0.0%).

Example:

$P_f = 59$
$P_c = 41$
$A_f = 1.28$
$A_c = 0.79$
$P_{admix} = 1.0$
$A_{admix} = 0.00$

$$\begin{bmatrix}\text{Combined Water}\\ \text{Absorption of}\\ \text{Aggregate and}\\ \text{Mineral Admixture}\end{bmatrix} = \frac{(59 \times 1.28) + (41 \times 0.79) + (1.0 \times 0.00)}{59 + 41 + 1.0} = 1.07$$

7. LABORATORY MIXING AND COMPACTION TEMPERATURES

7.1 The rotational viscosity of the asphalt binder at 275 °F and 350 °F shall be determined in accordance with AASHTO T 316, and a viscosity - temperature curve developed in accordance with ASTM D 2493.

7.2 The laboratory mixing temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds. The actual laboratory mixing temperature used is normally selected at or near the mid-point of the range.

7.3 The laboratory compaction temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.28 ± 0.03 Pascal·seconds. The actual laboratory compaction temperature used is normally selected at or near the mid-point of the range.

7.4 The viscosity - temperature curve shall be included in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 ^{o}F or a maximum laboratory compaction temperature exceeding 300 ^{o}F, the laboratory mixing and compaction temperature ranges shall be specified in writing by the asphalt binder supplier. A viscosity-temperature curve will meet this requirement for written documentation if the viscosity-temperature curve is developed and submitted by the binder supplier and includes language that the recommended laboratory mixing and compaction temperatures are within acceptable ranges, and shall include a statement indicating the maximum laboratory mixing temperature to which the binder can be heated without damage. The laboratory mixing and compaction temperature ranges, as

well as the actual laboratory mixing and compaction temperatures used, shall be reported on the mix design.

8. PREPARATION OF SPECIMENS FOR BULK SPECIFIC GRAVITY/BULK DENSITY AND MARSHALL STABILITY/FLOW DETERMINATION

8.1 Specimens shall be prepared as described herein, utilizing the apparatus specified in ARIZ 410.

Note 4: Normally a range of 3 different asphalt binder contents at 0.5% increments will provide sufficient information, although in some cases it may be necessary to prepare additional sets of samples at other asphalt binder contents.

8.2 The aggregate-mineral admixture samples, prepared as specified in Section 5, shall be dried to constant weight at the laboratory mixing temperature $\pm$ 5 ºF and shall be at this temperature at the time of mixing with the asphalt binder. If necessary, a small amount of proportioned minus No. 8 aggregate make-up material shall be added to bring samples to the desired weight.

8.3 Before each batch of asphaltic concrete is mixed, the asphalt binder shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to bring the asphalt binder to the laboratory mixing temperature $\pm$ 5 ºF.

8.4 Using Equation 5, calculate the weight of asphalt binder to be used for each asphalt binder content:

Equation 5:
$$\left[\begin{array}{c}\text{Weight of}\\ \text{Asphalt Binder}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Weight of Aggregate}\\ \text{and Mineral Admixture}\end{array}\right]}{100 - \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]} \times \left[\begin{array}{c}\text{Percent of}\\ \text{Asphalt Binder}\end{array}\right]$$

Example (for Marshall specimens with 4.5% Asphalt Binder) (See Note 4):

$$\left[\begin{array}{c}\text{Weight of}\\ \text{Asphalt Binder}\end{array}\right] = \frac{3333}{100 - 4.5} \times 4.5 = 157.1 \text{ grams}$$

Note 5: Before each batch is mixed, the mixing bowl and whip shall be heated to the laboratory mixing temperature ± 5 ºF.

8.5 The aggregate-mineral admixture blend and the appropriate amount of asphalt binder shall be mixed together for 90 to 120 seconds at the required laboratory mixing temperature ± 5 ºF. **Mechanical mixing is required.**

Note 6: Although a wide range of mixers may provide the desired well-coated homogeneous mixture, commercial dough mixers with whips are often used. Minimum recommended capacity of the mixing bowl is 12 quarts.

Note 7: After mechanical mixing, hand mixing shall be used as necessary to produce a well-coated homogeneous mixture.

8.6 Immediately after mixing, each batch of asphaltic concrete shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual specimen and use up the entire batch.

8.7 Each individual specimen shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The specimens shall be oven-cured for 2 hours ± 10 minutes at the laboratory compaction temperature ± 5 ºF.

8.8 A mold assembly (base plate, mold, and collar) shall be heated to the laboratory compaction temperature ± 5 ºF. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at the laboratory compaction temperature ± 5 ºF. A suitable shield, baffle plate, or sand bath shall be used on the surface of the hot plate to minimize localized overheating of the face of the hammer.

8.9 Place a 4-inch diameter paper disc in the bottom of the mold before the mixture is introduced. Quickly place the mixuture into the mold using a transfer bowl or other suitable device. Spade the mixture vigorously with a heated flat metal spatula, with a blade approximately 1-inch wide and 6-inches long and stiff enough to penetrate the entire layer of material, 15 times around the perimeter and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of mix to a slightly rounded shape.

8.10 Before compaction, put the mold containing the mixture in an oven as necessary to heat the mixture to the required laboratory compaction temperature ± 5 ºF. The specimen shall not be heated for more than one hour after being placed in the mold. Prior to compaction, it shall be verified that the mixture is at the required temperature. An electronic temperature probe with a digital display or a long-stem metal thermometer with a dial face shall be used. The use of an infrared temperature gun is not allowed.

8.11 Immediately upon removing the mold assembly loaded with mix from the oven, place a paper disc on top of mixture, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows with the compaction hammer. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 compaction blows to the face of the reversed specimen.

Note 8: The compaction hammer shall apply only one blow after each fall, that is, there shall not be a rebound impact. The compaction hammer shall meet the requirements specified in Subsection 2.4 of ARIZ 410.

8.12 Remove the collar and top paper disc. Remove the base plate and remove the bottom paper disc while the specimen is still hot.

Note 9: Paper discs need to be removed while the specimen is hot. The discs are difficult to remove after the specimens have cooled.

8.13 Allow each compacted specimen to cool until they are cool enough to be extruded without damaging the specimen.

Note 10: Generally specimens can be extruded without damage when they are at a temperature of approximately 77 to 90 ºF.

Note 11: Cooling may be accomplished at room temperature, or in a 77 ºF air bath. If more rapid cooling is desired, the mold and specimen may be placed in front of a fan until cool.

8.14 Extrude the specimen by orienting the mold so that the ram pushes on the bottom face (base plate face) of the specimen. If any specimen is deformed or damaged during extrusion, the entire set of specimens at that asphalt binder content shall be discarded and a new set prepared.

8.15 Immediately upon extrusion, measure and record the height of the specimen to the nearest 0.001 inch and determine and record its weight in air to the nearest 0.1 gram. Compacted specimens shall be 2.500 $\pm$ 0.200 inches in height. If this criteria is not met for the specimens at each asphalt binder content, the entire set of specimens at that asphalt binder content shall be discarded and a new set prepared after necessary adjustments in the weight of aggregate have been made using Equation 2 (see Note 2 in Table 1).

8.16 Repeat the procedures in Subsections 8.4 through 8.15 for the required specimens.

9. BULK SPECIFIC GRAVITY/BULK DENSITY OF SPECIMENS

9.1 Determine the bulk specific gravity and bulk density of the three compacted specimens at each asphalt binder content in accordance with Method A of ARIZ 415. The determination of the “Weight in Water” and “S.S.D. Weight" of each specimen will be completed before the next specimen is submerged for its "Weight in Water" determination.

Note 12: Specimens fabricated in the laboratory that have not been exposed to moisture do not require drying after extrusion from the molds. The specimen weight in air obtained in Subsection 9.1 is its dry weight.

9.2 For each asphalt binder content, the densities of individual compacted specimens shall not differ by more than 2.0 pcf. If this density requirement is not met, the entire set of specimens at that asphalt binder content shall be discarded and a new set of specimens prepared.

9.3 For each set of three specimens, determine the average bulk specific gravity (G_{mb}), and using that value calculate the average bulk density (G_{mb} multiplied by 62.3 lb./cu. ft.).

10. MARSHALL STABILITY AND FLOW DETERMINATION

10.1 Specimens shall be tested for Marshall Stability and Flow utilizing the apparatus specified in ARIZ 410.

10.2 For each specimen, determine the uncorrected stability, the stability (corrected for height), and the flow according to ARIZ 410, Subsections 4.6 through 4.11. In addition, determine the average stability (corrected for height) and average flow for each set of specimens prepared at each asphalt binder content.

11. MAXIMUM THEORETICAL SPECIFIC GRAVITY (RICE TEST)

11.1 The maximum theoretical specific gravity of the mixture shall be determined in accordance with ARIZ 806 with the following modifications:

11.1.1 Prepare the specimens including mineral admixture according to the procedures described in Section 5 and Subsections 8.2 through 8.5 using 5.5% or 6.0% asphalt binder by total mix weight. A liquid anti-stripping agent is not used.

11.1.2 Immediately after mixing, the material shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual test sample and use up the entire batch.

11.1.3 Each individual test sample shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The test samples shall be oven-cured for 2 hours ± 10 minutes at the laboratory compaction temperature ± 5 °F.

11.1.4 After curing, each test sample shall be spread on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled, separate the particles of the mixture, taking care not to fracture the mineral aggregate particles, so that the particles of the fine aggregate portion are not larger than ¼ inch. Allow the test samples to cool to room temperature.

11.1.5 Using Equation 6, calculate the effective specific gravity of the combined aggregate and mineral admixture (G_{se}).

Equation 6:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where:
- G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
- P_b = Asphalt binder content at which the Rice test was performed (Rice P_b).
- G_{mm} = Measured maximum theoretical specific gravity of the mix at Rice P_b.
- G_b = Specific gravity of the asphalt binder.

Example: $P_b = 5.5$
$G_{mm} = 2.436$
$G_b = 1.032$

$$G_{se} = \frac{100 - 5.5}{\frac{100}{2.436} - \frac{5.5}{1.032}} = 2.645$$

11.1.6 Using Equation 7, calculate the maximum theoretical specific gravity (G_{mm}) for each asphalt binder content.

Note 13: G_{se} is considered constant regardless of the asphalt binder content.

Equation 7: $$G_{mm} = \frac{100}{\frac{P_{sa}}{G_{se}} + \frac{P_b}{G_b}}$$

Where:
G_{mm} = Calculated maximum theoretical specific gravity of the mix at each asphalt binder content P_b.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).
P_b = Percent asphalt binder content, by total weight of mix, for each asphalt binder content.
G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
G_b = Specific gravity of the asphalt binder.

Example (for 4.5% asphalt binder content) (See Note 4):

$P_{sa} = 95.5$
$P_b = 4.5$
$G_{se} = 2.645$
$G_b = 1.032$

$$G_{mm} = \frac{100}{\frac{95.5}{2.645} + \frac{4.5}{1.032}} = 2.471$$

12. DETERMINATION OF DESIGN PERCENT ASPHALT BINDER CONTENT

12.1 The design percent asphalt binder content is determined as follows in Subsections 12.2 through 12.3.

12.2 For each asphalt binder content used, calculate effective voids (V_a), percent absorbed asphalt (P_{ba}), voids in mineral aggregate (VMA), percent effective asphalt binder content (P_{be}), and the ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt binder content (Dust/Bitumen Ratio) using the following equations.

12.2.1 Using Equation 8, calculate the effective voids (V_a). The calculated G_{mm} values for the respective asphalt binder contents are used to determine the corresponding effective voids content of the compacted Marshall specimens at each asphalt binder content.

Equation 8: $$V_a = \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100$$

Where: V_a = Effective voids in the compacted mixture, percent of total volume.
G_{mm} = Calculated maximum theoretical specific gravity of the mix at each asphalt binder content P_b.
G_{mb} = Bulk specific gravity of compacted mixture specimens.

Example (for 4.5% asphalt binder content) (See Note 4):

$$G_{mm} = 2.471$$
$$G_{mb} = 2.290$$

$$V_a = \frac{2.471 - 2.290}{2.471} \times 100 = 7.3$$

12.2.2 Using Equation 9, calculate the percent absorbed asphalt (P_{ba}).

Note 14: The percent absorbed asphalt (P_{ba}) is the same for all asphalt binder contents.

Equation 9: $$P_{ba} = \left(\frac{G_{se} - G_{sb}}{G_{sb} \times G_{se}} \right) \times G_b \times 100$$

Where: P_{ba} = Absorbed asphalt, percent by total weight of mix.
G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
G_{sb} = Bulk oven dry specific gravity of the combined aggregate and mineral admixture.
G_b = Specific gravity of the asphalt binder.

Example: $G_{se} = 2.645$
$G_{sb} = 2.614$
$G_b = 1.032$

$$P_{ba} = \frac{2.645 - 2.614}{2.614 \times 2.645} \times 1.032 \times 100 = 0.46$$

12.2.3 Using Equation 10, calculate voids in mineral aggregate (VMA) of the compacted Marshall specimens at each asphalt binder content.

Equation 10: $$VMA = 100 - \left(\frac{G_{mb} \times P_{sa}}{G_{sb}} \right)$$

Where: VMA = Voids in the mineral aggregate, percent of bulk volume.
G_{mb} = Bulk specific gravity of compacted mixture specimens.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix ($100-P_b$).
G_{sb} = Bulk oven dry specific gravity of the combined aggregate and mineral admixture.

Example (for 4.5% asphalt binder content) (See Note 4):

$G_{mb} = 2.290$
$P_{sa} = 95.5$
$G_{sb} = 2.614$

$$VMA = 100 - \frac{2.290 \times 95.5}{2.614} = 16.3$$

12.2.4 Using Equation 11, calculate the percent effective asphalt binder content (P_{be}) of the compacted Marshall specimens at each asphalt binder content.

Equation 11: $$P_{be} = P_b - \left(\frac{P_{ba} \times P_{sa}}{100} \right)$$

Where: P_{be} = Percent effective asphalt binder content of the mixture (free binder not absorbed).
P_b = Asphalt binder content, percent by total weight of mix.
P_{ba} = Absorbed asphalt, percent by total weight of mix.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix ($100-P_b$).

Example (for 4.5% asphalt binder content) (See Note 4):

$P_b = 4.5$
$P_{ba} = 0.46$
$P_{sa} = 95.5$

$$P_{be} = 4.5 - \frac{0.46 \times 95.5}{100} = 4.06$$

12.2.5 Using Equation 12, calculate the the ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt binder content (Dust/Bitumen Ratio) of the compacted Marshall specimens at each asphalt binder content.

Equation 12: $$\text{Dust / Bitumen Ratio} = \frac{\left[\begin{array}{c} \text{Mix Design} \\ \text{Passing No. 200} \\ \text{(Including Mineral Admix.)} \end{array} \right]}{P_{be}}$$

Where: P_{be} = Percent effective asphalt binder content of the mixture (free binder not absorbed).

Example (for 4.5% asphalt binder content) (See Note 4):

$$P_{be} = 4.06$$

$$\text{Dust / Bitumen Ratio} = \frac{5.0}{4.06} = 1.23$$

12.3 If the specified value for effective voids (V_a) falls between the resultant V_a values determined for two of the asphalt binder contents used, straight-line interpolation shall be used to calculate the bulk specific gravity (G_{mb}) at each 0.1% asphalt binder content increment between the two corresponding measured values of G_{mb}. Using equations 7 and 8, determine the values for G_{mm} and V_a at each interpolated asphalt binder content. Select the asphalt binder content which results in V_a being as close as possible to the specified value.

12.3.1 Using equations 10, 11, and 12, calculate VMA, P_{be}, and the Dust/Bitumen Ratio at the selected asphalt binder content. Using straight-line interpolation, determine the values for stability and flow that correspond to the selected asphalt binder content. If the values for VMA, Dust/Bitumen Ratio, stability, and flow are within the limits of the specifications, the selected asphalt binder content shall be the design asphalt binder content.

12.3.2 On separate graphs (using the same scale for percent asphalt binder for each graph), plot the values for bulk specific gravity, effective voids, VMA, Dust/Bitumen Ratio, stability, and flow for each set of three specimens and at the design asphalt binder content, versus the percent asphalt binder. Draw a smooth “best fit” curve based on the plotted points, as shown in Figure 4. The graphs in Figure 4 are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 12.3 and 12.3.1, is used for mix design calculations.

12.3.3 If it is not possible to obtain specification compliance within the range of asphalt binder contents used, a determination must be made to either redesign the mix (different aggregate gradation and/or source) or prepare additional specimens at other asphalt binder contents for testing and volumetric analyses.

13. IMMERSION COMPRESSION (IMC) TEST

13.1 The Immersion Compression Test shall be performed in accordance with ARIZ 802, modified as follows:

13.1.1 Prepare the asphaltic concrete sample including mineral admixture according to the procedures described in Section 5 and Subsections 8.2 through 8.5 at the design asphalt binder content.

13.1.2 Immediately after mixing, each batch of asphaltic concrete shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 4 equal pie-shaped segments. Take opposite segments for each individual sample and use up the entire batch.

13.1.3 Each individual sample shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The samples shall be oven-cured for 2 hours $\pm$ 10 minutes at 255 $\pm$ 5 ºF.

13.1.4 Compacted specimens shall be 4.000 $\pm$ 0.100 inches in height.

14. MIX DESIGN GRADATION TARGET VALUES

14.1 The target values for the aggregate composite without mineral admixture, and the aggregate-mineral admixture blend composite, for the asphaltic concrete mixture shall be expressed as percent passing particular sieve sizes as required by the specifications for the project. An example mix design composite, with and without mineral admixture, is shown in Figure 1.

15. REPORT

15.1 Report the test results and data obtained on the appropriate form. Liberal use of the remarks area to clarify and/or emphasize any element of the design is strongly recommended. Information required in the mix design report includes the items listed below:

15.1.1 Name and address of the testing organization and the signature and seal of the mix design engineer responsible for the mix design.

15.1.2 Aggregate:

- Source and identification
- Individual stockpile or bin gradations
- Aggregate blend proportions and composite gradation, with and without mineral admixture
- Fine and coarse aggregate specific gravities (Bulk Oven Dry, SSD, Apparent) and absorption
- Combined aggregate specific gravities (Bulk Oven Dry, SSD, Apparent)
- Combined aggregate absorption
- Aggregate quality
    - LA Abrasion
    - Sand Equivalent
    - Fractured Coarse Aggregate Particles (percentage with one fractured face and percentage with two fractured faces)
    - Uncompacted Void Content (when applicable)
    - Carbonates (when applicable)

15.1.3 Mineral Admixture:

- Type and source
- Percentage used
- Specific gravity

15.1.4 Combined Mineral Aggregate and Mineral Admixture

- Combined specific gravities [Bulk Oven Dry (G_{sb}), SSD, Apparent] and absorption of the combined aggregate and mineral admixture
- Effective specific gravity of the combined aggregate and mineral admixture (G_{se})

15.1.5 Asphalt Binder:

- Source and grade
- Specific gravity (at 77 °F)
- Viscosity - Temperature Curve and the following:
    - Laboratory mixing temperature range and actual laboratory mixing temperature used.
    - Laboratory compaction temperature range and actual laboratory compaction temperature used.

15.1.6 Maximum theoretical specific gravity (G_{mm}) and density (pcf) at the asphalt binder content at which the Rice test was performed (Rice P_b)

15.1.7 Mixture Compaction Trials:

- Percent asphalt binder content (P_b), by weight of the bituminous mixture
- Aggregate and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Percent absorbed asphalt (P_{ba})
- Percent effective asphalt binder content (P_{be})
- Marshall stability (nearest 10 pounds)
- Marshall flow (0.01 inch)

15.1.8 Plots of the following properties versus percent asphalt binder content (See examples in Figure 4):

- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Bulk specific gravity (G_{mb})
- Marshall stability
- Marshall flow

15.1.9 Mixture Properties at Design Percent Asphalt Binder Content:

- Percent asphalt binder content (P_b), by weight of the bituminous mixture
- Aggregate and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Percent absorbed asphalt (P_{ba})
- Percent effective asphalt binder content (P_{be})
- Marshall stability (nearest 10 pounds)
- Marshall flow (0.01 inch)
- Immersion Compression wet strength (psi)
- Immersion Compression dry strength (psi)
- Index of retained strength

15.1.10 Mix Design Summary. The mix design summary shall contain the information shown in Figure 5. [An example Mix Design Summary for an Asphaltic Concrete Marshall Mix Design.]

Example Mix Design Composite
(With and Without Mineral Admixture)

Material	Crusher Fines	Washed Crusher Fines	3/8" Aggregate	3/4" Aggregate	Composite		Specifications ADOT 416 (3/4 Inch Special Mix)	
Percent used in composite	10	27	30	33	Without Admix	With Admix*	Without Admix	With Admix
Sieve	Gradation – Percent Passing							
1"	100.0	100.0	100.0	100.0	100	100	100	100
3/4"	100.0	100.0	100.0	82.5	94	94	90 - 100	90 - 100
1/2"	100.0	100.0	100.0	33.3	78	78		
3/8"	100.0	100.0	96.1	15.7	71	71	62 - 77	62 - 77
1/4"	100.0	99.9	81.0	5.3	63	63		
#4	91.6	98.8	73.1	4.1	59	59		
#8	58.0	76.9	54.2	2.8	44	45	37 - 46	38 - 47
#10	52.0	68.9	50.2	2.7	40	41		
#16	37.9	48.5	39.0	2.2	29	30		
#30	26.9	30.9	28.4	1.9	20	21		
#40	21.9	22.0	23.1	1.8	16	17	10 - 18	11 - 19
#50	17.8	15.2	18.9	1.6	12	13		
#100	11.7	5.1	12.7	1.3	7	8		
#200	7.6	1.8	8.2	0.9	4.0	5.0	1.5 - 4.5	2.5 – 6.0

* 1.0 percent admixture, by weight of dry mineral aggregate, is used.

FIGURE 1

Example Weigh Up Sheet #1

MATERIAL	SIEVE	INDIV. % RET.	ACCUM. % RET.	FRACTURED COARSE AGGREGATE PARTICLES [Plus #4] (500 grams)	COARSE AGGREGATE SPECIFIC GRAVITY/ ABSORPTION [Plus #4] (4000 grams)	FINE AGGGREGATE SPECIFIC GRAVITY/ ABSORPTION [Minus #4] (1200 grams)	SAND EQUIVALENT [Minus #4] (600 grams)	UNCOMPACTED VOID CONTENT [Minus #8] (500 grams)	ABRASION [Type B] (5000 grams)
				ACCUMULATIVE WEIGHT (grams)					
Crusher Fines	#4	0.840	0.840	10	82	---	---	---	---
	#8	3.360	4.200	---	---	68	34	---	---
	- #8	5.800	10.000	---	---	186	93	66	---
Washed Crushed Fines	1/4"	0.027	10.027	11	85	---	---	---	---
	#4	0.297	10.324	14	114	---	---	---	---
	#8	5.913	16.237	---	---	306	153	---	---
	- #8	20.763	37.000	---	---	727	364	304	---
3/8" Aggregate	3/8"	1.170	38.170	29	228	---	---	---	419
	1/4"	4.530	42.700	84	672	---	---	---	---
	#4	2.370	45.070	113	904	---	---	---	---
	#8	5.670	50.740	---	---	842	421	---	---
	- #8	16.260	67.000	---	---	1173	586	489	---
1/2" Aggregate	3/4"	5.775	72.775	184	1469	---	---	---	---
	1/2"	16.236	89.011	382	3057	---	---	---	2919
	3/8"	5.808	94.819	453	3625	---	---	---	5000
	1/4"	3.432	98.251	495	3961	---	---	---	---
	#4	0.396	98.647	500	4000	---	---	---	---
	#8	0.429	99.076	---	---	1181	590	---	---
	- #8	0.924	100.000	---	---	1200	600	500	---

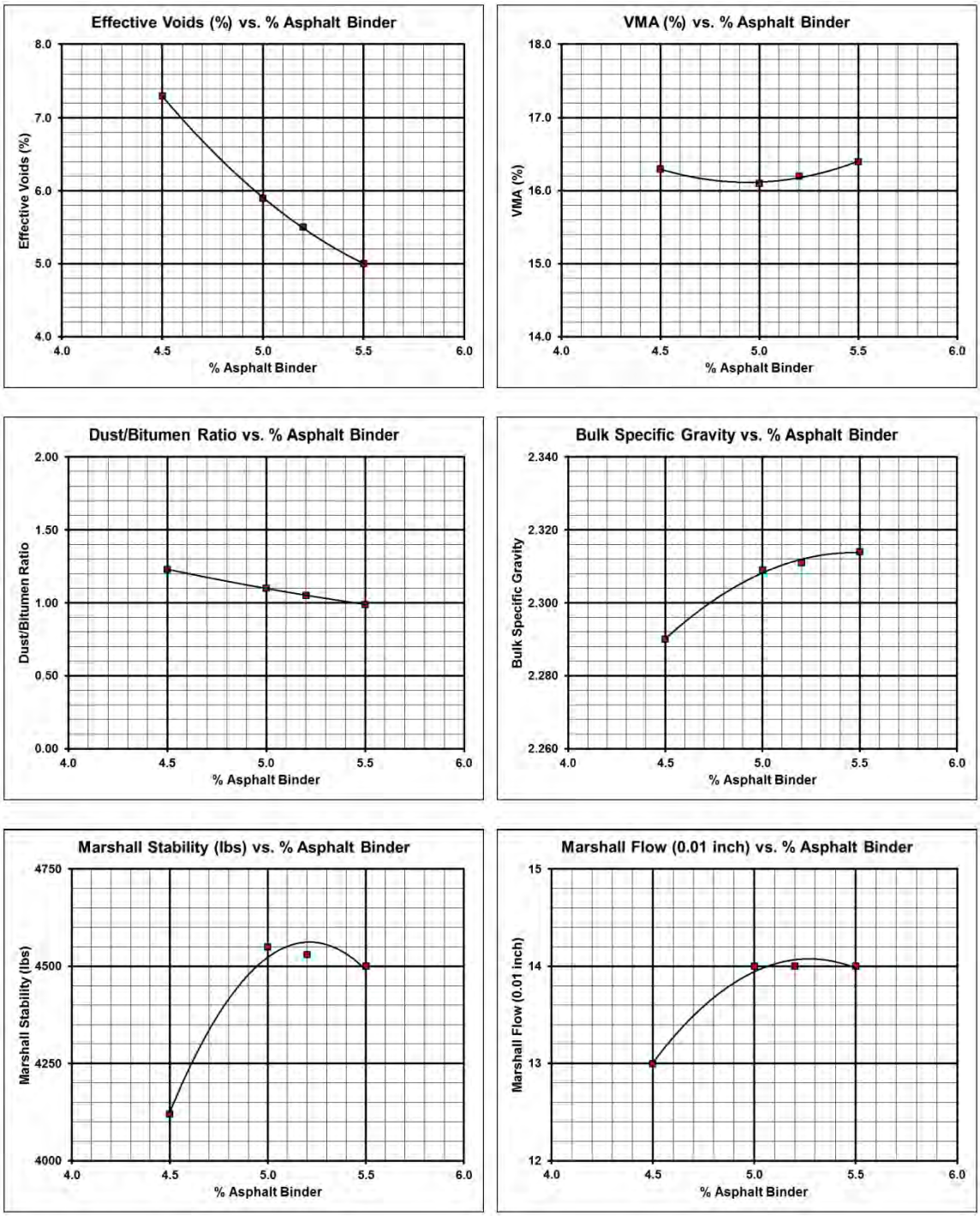
FIGURE 2

Example Weigh Up Sheet #2

MATERIAL	SIEVE	INDIV. PERCENT RETAINED	ACCUM. PERCENT RETAINED	RICE (3000 grams)	MARSHALL (3300 grams)	IMMERSION COMPRESSION (3400 grams)	MINUS NO. 8 MAKE-UP MATERIAL (500 grams)
				ACCUMULATIVE WEIGHT (grams)			
Crusher Fines	#4	0.840	0.840	25	28	29	---
	#8	3.360	4.200	126	139	143	---
	- #8	5.800	10.000	300	330	340	66
Washed Crusher Fines	1/4"	0.027	10.027	301	331	341	---
	#4	0.297	10.324	310	341	351	---
	#8	5.913	16.237	487	536	552	---
	- #8	20.763	37.000	1110	1221	1258	304
3/8" Aggregate	3/8"	1.170	38.170	1145	1260	1298	---
	1/4"	4.530	42.700	1281	1409	1452	---
	#4	2.370	45.070	1352	1487	1532	---
	#8	5.670	50.740	1522	1674	1725	---
	- #8	16.260	67.000	2010	2211	2278	489
3/4" Aggregate	3/4"	5.775	72.775	2183	2402	2474	---
	1/2"	16.236	89.011	2670	2937	3026	---
	3/8"	5.808	94.819	2845	3129	3224	---
	1/4"	3.432	98.251	2948	3242	3341	---
	#4	0.396	98.647	2959	3255	3354	---
	#8	0.429	99.076	2972	3270	3369	---
	- #8	0.924	100.000	3000	3300	3400	500
Weight of Mineral Admixture (Type II Cement) [1.0%, by weight of Dry Mineral Aggregate]				30	33	34	---
Total weight of Mineral Aggregate and Mineral Admixture				3030	3333	3434	---

FIGURE 3

Example Plots of Effective Voids, VMA, Dust/Bitumen Ratio, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent Asphalt Binder Content



The above graphs are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 12.3 and 12.3.1, is used for mix design calculations.

FIGURE 4

Asphaltic Concrete Marshall Mix Design
Example Mix Design Summary

Date: February 22, 2013

Contractor: Best Paving Contractors, Inc.	**Mix Designation:** ADOT 416 (3/4 Inch Special Mix)
ADOT Project Number: STP-888-Z(888)A	**Mix Design Laboratory:** XYZ Testing Laboratories
ADOT TRACS Number: H888801C	**Mix Design Engineer:** Joe Designer
Project Name: Anywhere - Everywhere	**Grade/Specific Gravity of Asphalt Binder:** PG 70-10/1.032 @

COMPOSITE GRADATION:

Mineral Aggregate	Percent Used
Crusher Fines	10
Washed Crusher Fines	27
3/8" Aggregate	30
3/4" Aggregate	33
Mineral Admixture	
Type II Cement	1.0

Sieve Size	Percent Passing w/o Admix	Percent Passing w/ Admix	Specifications: Without Admix	Specifications: With Admix
1"	100	100	100	100
3/4"	94	94	90 - 100	90 - 100
1/2"	78	78		
3/8"	71	71	62 - 77	62 - 77
1/4"	63	63		
#4	59	59		
#8	44	45	37 - 46	38 - 47
#10	40	41		
#16	29	30		
#30	20	21		
#40	16	17	10 - 18	11 - 19
#50	12	13		
#100	7	8		
#200	4.0	5.0	1.5 - 4.5	2.5 - 6.0

DESIGN DATA:

% Asphalt Binder	4.5	5.0	**5.2**	5.5	Spec.
Bulk Specific Gravity	2.290	2.309	**2.311**	2.314	
Bulk Density (lb./cu. ft)	142.7	143.9	**144.0**	144.2	
Stability (lb.)	4120	4550	**4530**	4500	2000 Min.
Flow (0.01 inch)	13	14	**14**	14	8 - 16
Effective Voids (%)	7.3	5.9	**5.5**	5.0	5.5 ± 0.2
VMA (%)	16.3	16.1	**16.2**	16.4	15.0 - 18.0
Effective Asphalt, Total Mix (%)	4.06	4.56	**4.76**	5.06	
Dust/Bitumen Ratio	1.23	1.10	**1.05**	0.99	0.6 – 1.2
Absorbed Asphalt (%)	0.46				0 – 1.0
Max. Theoretical Specific Gravity at 5.2% Asphalt Binder = 2.446					
Max. Theoretical Density at 5.2% Asphalt Binder = 152.4 lb/cu. ft.					

IMMERSION COMPRESSION – ARIZ 802: 5.2% Asphalt Binder, 1.0% Type II Cement		Spec.
Dry Strength (psi)	728	-----
Wet Strength (psi)	627	150 Min.
Index of Retained Strength (%)	86	60 Min.

AGGREGATE PROPERTIES:

Test Characteristic	Fine	Coarse	Combined	Spec.
Bulk O.D. Specific Gravity	2.593	2.634	2.610	2.350 – 2.850
SSD Specific Gravity	2.626	2.655	2.638	-----
Apparent Specific Gravity	2.682	2.690	2.685	-----
Absorption	1.28	0.79	1.08	0 - 2.5%
Sand Equivalent	75			Min. 55
Uncompacted Void Content	47.4			Min. 45.0%
Carbonates	N/A			-----
Fractured Coarse Aggregate Particles				
At least one fractured face	100			Min. 92%
At least two fractured faces	95			Min. 85%
Abrasion	(Type B)			
100 Rev., % Loss	4			9% Max.
500 Rev. ,%Loss	22			40% Max.

RECOMMENDED ASPHALT BINDER CONTENT: (By weight of total mix)	**5.2%**

COMBINED AGGREGATE AND MINERAL ADMIXTURE PROPERTIES:

Bulk O.D.Specific Gravity	2.614
SSD Specific Gravity	2.642
Apparent Specific Gravity	2.689
Water Absorption	1.07
Effective Specific Gravity	2.645

ADDITIONAL DATA / INFORMATION:

Source of Mineral Aggregate: Excellent Aggregate Materials, Inc.
Source of Asphalt Binder: Superb Asphalt Suppliers
Source of Mineral Admixture: Superior Cement Company, Inc.
Mineral Admixture Type/Specific Gravity: Type II Cement/3.14
Laboratory Mixing Temperature Range: 320 °F to 331 °F
Laboratory Compaction Temperature Range: 298 °F to 307 °F
Actual Laboratory Mixing Temperature Used: 325 °F
Actual Laboratory Compaction Temperature Used: 300 °F

REMARKS:

FIGURE 5

DESIGN OF EXPOSED AGGREGATE SEAL COATS

(An Arizona Method)

SCOPE

1. (a) This method describes the procedure for calculating design quantities of materials for exposed aggregate seal coats utilizing cover aggregates and emulsified asphalt. The resultant quantities are to be adjusted for field conditions, as necessary.

(b) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(c) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

DATA

2. The following values are to be determined by the method indicated:

H = Average least dimension of cover aggregate (Median Aggregate size modified for Flakiness Index - Arizona Test Method 233).

G = Bulk Specific Gravity (Arizona Test Method 210 - Saturated surface dry basis).

R = Residual bitumen of emulsified asphalt, expressed as a decimal (AASHTO T 59).

T = Traffic factor from the following:

When the ADT is less than or equal to 2000,
T = 0.85 - [0.0001(ADT)]

When the ADT is more than 2000, T = 0.65

NOTE: Traffic must be considered by lanes - for instance on a divided highway, the passing lane and distress lanes should have a higher traffic factor than the travel lane.

E = Wastage factor due to cover aggregate lost to whip off by traffic and to variation in spread (1 + Estimated Waste, for example, 1.05 for 5% wastage).

V = Voids in Aggregate by the following:

Metric:

$$V = 1 - \frac{W_L}{(998)\,(G)}$$

Where: W_L = Loose unit weight of aggregate in kg/m^3 by AASHTO T 19 (Shoveling Procedure).

English:

$$V = 1 - \frac{W_L}{(62.3)\,(G)}$$

Where: W_L = Loose unit weight of aggregate in lbs./cu. ft. by AASHTO T 19 (Shoveling Procedure).

S = Surface Texture Correction from below:

Surface Texture	Surface Texture Correction	
	liters/square meter	gals./sq. yd.
Very Porous	0.41	0.09
Rough and Porous	0.27	0.06
Slightly Rough, Black	0.14	0.03
Black and Smooth (Hard, no aggregate embedment predicted)	0.00	0.00
Soft and Rich (Aggregate embedment predicted)	-0.05* to -0.23*	-0.01* to -0.05*
	* Depending upon aggregate embedment estimation.	

CALCULATIONS

3. The required amount of cover material and bituminous material shall be calculated by the following:

(a) Cover Material Requirement:

Metric:

For 100% pass 9.5 mm sieve,

$$C = [0.6163\ (G)\ (H)\ (E)]\ (2 - V)$$

For 100 % pass 12.5 mm sieve,

$$C = [0.5078\ (G)\ (H)\ (E)]\ (2 - V)$$

Where: C = Cover Material in kg/m^2

Convert cover material from kg/m^2 to m^3/m^2 by the following equation:

$$\frac{C(\text{in } kg/m^2)}{W_L\ (\text{in } kg/m^3)} = C\ (\text{in } m^3/m^2)$$

English:

For 100% pass 3/8" sieve,

$$C = [28.4\ (G)\ (H)\ (E)]\ (2 - V)$$

For 100 % pass 1/2" sieve,

$$C = [23.4\ (G)\ (H)\ (E)]\ (2 - V)$$

Where: C = Cover Material in lbs./sq. yd

Convert cover material from lbs./sq. yd. to cubic yards per square yard by the following equation:

$$\frac{C \text{ (in lbs./sq. yd.)}}{[W_L \text{ (in lbs./cu. ft.)}] \times 27}$$

(b) Bituminous Material Requirement:

Metric:

$$B = \frac{0.3622\ (H)\ (T)}{R} + S$$

Where: B = Bituminous Material in L/m^2

English:

$$B = \frac{2\ (H)\ (T)}{R} + S$$

Where: B = Bituminous Material in gals./sq. yd.

EXAMPLE

4. The following example will serve to illustrate the calculations:

(a) Data:

H = 5.50 mm
G = 2.630
R = 0.65
T (for 1500 ADT) = 0.85 - [0.0001 (1500)] = 0.70
E = 1.06

$V = 0.46$ ($W_L = 1418$ kg/m^3)
S = Rough and Porous = 0.27 L/m^2

(b) Cover Material Requirement:

For 100% pass 12.5 mm sieve,

$$C = [0.5078\ (G)\ (H)\ (E)]\ (2 - V)$$
$$= [0.5078\ (2.630)\ (5.50)\ (1.06)]\ (2 - 0.46)$$
$$= 11.99\ \text{kg/m}^2$$

Convert 11.99 kg/m^2 to m^3/m^2 by:

$$\frac{11.99\ \text{kg/m}^2}{1418\ \text{kg/m}^3} = 0.008\ \text{m}^3/\text{m}^2$$

(c) Bituminous Material Requirement:

$$B = \frac{0.3622\ (H)\ (T)}{R} + S$$

$$= \frac{0.3622\ (5.50)\ (0.70)}{0.65} + 0.27$$

= 2.42 liters per square meter

REPORT

5. Report the following:

(a) The amount of cover material required, in kg/m^2 (lbs./sq. yd.), to the nearest 0.01 kg/m^2 (0.1 lbs./sq. yd.).

(b) The amount of cover material required, in m^3/m^2 (cubic yards per square yard), to the nearest 0.001 m^3/m^2 (0.001 cubic yards per square yard).

(c) The amount of bituminous material required, to the nearest 0.01 L/m^2 (0.01 gals./sq. yd.).

METHOD OF TEST FOR DETERMINING THE QUANTITY OF ASPHALT REJUVENATING AGENT REQUIRED FOR AN ASPHALTIC PAVEMENT

(A Modification of California Test No. 345)

SCOPE

1. (a) This method of test describes the procedure for determining the quantity of asphalt rejuvenating agent an asphaltic pavement will absorb in a specified period of time.

NOTE: This test is used primarily for maintenance purposes.

(b) This test method may involve hazardous material, operations, or equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of any regulatory limitations prior to use.

(c) See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

(d) Metric (SI) units and values are shown in this test method with English units and values following in parentheses. Values given for metric and English units may be numerically equivalent (soft converted) for the associated units, or they may be given as rounded or rationalized values (hard converted). Either the metric or English units along with their corresponding values shall be used in accordance with applicable specifications. See Appendix A2 of the Materials Testing Manual for additional information on the metric system.

APPARATUS

2. Apparatus for this test procedure shall consist of the following:

(a) 1 - Aluminum template 152 mm (6") diameter with handle.

(b) 1 - Caulking gun with a 127 mm (5") piece of 6.35 mm (1/4") copper tubing with cap.

(c) 1 - 25 mL graduated cylinder (plastic or glass).

(d) 1 - 127 mm (5") inch trowel.

(e) 2 - small stiff bristle brushes.

(f) 2 - 3.8 liter (1 gallon) friction top cans. One for new medium weight chassis grease. One for used grease.

(g) 1 - 203 mm (8") spatula.

(h) 2 - pieces of yellow lumber crayon.

(i) 1 - stop watch with 60 second dial.

MATERIAL

3. The following materials are required:

(a) Medium weight chassis grease.

(b) A liter (quart) can containing a dilution of 2 parts rejuvenating agent and one part distilled water.

PROCEDURE

4. (a) With lumber crayon and template, draw a 152 mm (6") diameter circle on the pavement.

(b) Extrude grease from the caulking gun on the circle. The diameter of the grease should be about 6 mm (1/4").

(c) Run finger around the outside of the grease ring, pushing a small amount of grease into the pavement. This will form a sealed reservoir for the asphalt rejuvenating agent (2:1 dilution).

(d) Measure 8.3 mL of asphalt rejuvenating agent, 2:1 dilution, in the graduate and pour into grease ring. Start stop watch and quickly brush agent uniformly over the area within the grease ring.

(e) Record the time required for the rejuvenating agent to completely penetrate the surface. Complete penetration is generally indicated by a loss in color of the rejuvenating agent, giving a dull dark appearance to the surface.

NOTE: Loss of color can also occur when evaporation of the water takes place leaving a thin film of the residue on the surface of the pavement giving a shiny appearance. In this case penetration has not occurred.

(f) If 8.3 mL is absorbed within a 15 minute interval, make a new grease ring and repeat test with additional testing solution in increments of 8.3 mL until time of penetration just exceeds 15 minutes.

(g) If 8.3 mL is not absorbed within the 15 minute period, repeat the test using 4.1 mL.

NOTE: 4.1 mL is equivalent to 0.23 L/m^2 (0.05 gal./sq. yd.) spread rate.
8.3 mL is equivalent to 0.45 L/m^2 (0.10 gal./sq. yd.) spread rate.
16.6 mL is equivalent to 0.91 L/m^2 (0.20 gal./sq. yd.) spread rate.

(h) If an application rate of 0.91L/m^2 (0.20 gal./sq. yd.) [16.6 mL] is exceeded, the effect of rejuvenating agent on the properties of the asphaltic pavement (for example, stability/flow, voids, etc.) shall be evaluated.

(i) Graduate can be easily cleaned with water.

(j) Pick up grease with trowel and place in 3.8 liter (1 gallon) can for used grease. Do not mix used grease with new grease.

PROCEDURE FOR DETERMINING PAVEMENT REQUIREMENTS

5. The following procedure is recommended for obtaining the average absorption rate or quantity of rejuvenating agent required for a given section of highway.

(a) In any travel lane, determine the absorption at 8 meter (25 foot) intervals in the outer wheel path, inner wheel path, and between wheel paths, respectively. The three readings should be averaged to obtain the reading for the test area.

(b) This procedure should be repeated at intervals of approximately 600 meters (2000 feet).

REFERENCE

6. "Method of Test for Determining Quantity and Rate of Absorption of Reclamite into an Asphalt Pavement" by Golden Bear Oil Company, Bakersfield, California.

EVALUATION OF PAVEMENT SMOOTHNESS

(An Arizona Method)

SCOPE

1. This test method describes the procedure for determining the smoothness of pavements. Profile measurements are taken on designated area(s) of the pavement. Those measurements are analyzed and reported as International Roughness Index (IRI) values, inches per mile (in/mi).

APPARATUS

2. The equipment used to perform profile testing shall be a General Motors Research (GMR)-type Inertial Profiler, meeting the requirements of ASTM E 950.

METHOD OF MEASURING

3. The test vehicle is driven in the wheel paths of each lane a sufficient number of times to collect two valid individual sets of profile measurements. The speed at which profile measurements are taken shall be a constant speed (± 2 mph), between 30 and 65 mph.

CALCULATIONS

4. (a) Profile measurements taken using the GMR-type Inertial Profiler will be reduced to IRI smoothness values, in accordance with the requirements of ASTM E 1926. IRI smoothness values will be recorded to the nearest 0.1 in/mi for each 0.1 mile increment.

(b) For each individual set of IRI smoothness values, the average value will be determined.

(c) The set of IRI smoothness values with the lowest average value will be used for acceptance purposes.

(d) If necessary, 0.1 mile increment IRI values used for acceptance purposes shall be adjusted to account for any exception areas required by the contract documents.

REPORT

5. A report will be prepared showing:

(a) The date of test.

(b) The name of the test operator(s).

(c) Identification of test vehicle.

(d) Speed of test vehicle during testing.

(e) Project number, if applicable.

(f) The individual IRI value, adjusted as necessary per paragraph 4(d), and recorded to the nearest 0.1 in/mi for each 0.1 lane-mile increment (Actual Smoothness Value "AS").

(g) The location of each 0.1 lane-mile increment for the corresponding individual IRI value.

MARSHALL MIX DESIGN METHOD FOR ASPHALTIC CONCRETE (ASPHALT-RUBBER) [AR-AC]

(An Arizona Method)

1. SCOPE

1.1 This method is used to design Asphaltic Concrete (Asphalt-Rubber) [AR-AC] mixes using 4-inch diameter Marshall apparatus.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure #	Title	Page #
Section 2	Test Methods and Apparatus	2
Section 3	Materials	3
Section 4	Determination of Composite Gradation	4
Section 5	Preparing Aggregate/Mineral Admixture Samples for Mix Design Testing	4
Section 6	Aggregate Specific Gravities and Absorption	7
Section 7	Preparation of Specimens for Bulk Specific Gravity/Bulk Density and Marshall Stability/Flow Determination	9
Section 8	Bulk Specific Gravity/Bulk Density of Specimens	13
Section 9	Marshall Stability and Flow Determination	14
Section 10	Maximum Theoretical Specific Gravity (Rice Test)	14
Section 11	Determination of Design Percent CRA Binder Content	16
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Figure 1	Example Mix Design Composite (With and Without Mineral Admixture)	23
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Figure 4	Example Plots of Effective Voids, VMA, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent CRA Binder Content	26
Figure 5	Example Mix Design Summary	27 & 28

2. TEST METHODS AND APPARATUS

2.1 This test method is used in conjunction with the test methods listed below. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. The required apparatus is shown in the individual test methods, as appropriate.

2.2 Arizona Test Methods:

- ARIZ 201 Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 205 Composite Grading
- ARIZ 210 Specific Gravity and Absorption of Coarse Aggregate
- ARIZ 211 Specific Gravity and Absorption of Fine Aggregate
- ARIZ 212 Percentage of Fractured Coarse Aggregate Particles
- ARIZ 238 Percent Carbonates in Aggregate
- ARIZ 247 Particle Shape and Texture of Fine Aggregate Using Uncompacted Void Content
- ARIZ 248 Alternate Procedures for Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 251 Combined Coarse and Fine Aggregate Specific Gravity and Absorption
- ARIZ 410 Compaction and Testing of Bituminous Mixtures Utilizing Four Inch Marshall Apparatus
- ARIZ 415 Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
- ARIZ 416 Preparing and Splitting Field Samples of Bituminous Mixtures for Testing
- ARIZ 806 Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)

2.1.2 AASHTO Test Methods:

- AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- AASHTO T 228 Specific Gravity of Semi-Solid Bituminous Materials

Note 1: Testing by AASHTO T 228 shall be performed at 77 °F.

3. MATERIALS

3.1 Mineral Aggregate - The mineral aggregate used in the design shall be produced material from the source(s) for the project. Use of natural sand is not permitted in AR-AC mixtures.

3.1.1 The composited gradation of the aggregate without admixture, and the composited gradation of the aggregate-mineral admixture blend shall comply with the grading limits of the specifications.

3.1.2 The composited mineral aggregate shall conform to the requirements of the specifications for Sand Equivalent (AASHTO T 176), Combined Bulk Oven Dry Specific Gravity (ARIZ 251), Combined Water Absorption (ARIZ 251), Fractured Coarse Aggregate Particles (ARIZ 212), Uncompacted Void Content (ARIZ 247), and Percent Carbonates (ARIZ 238) when applicable.

3.1.3 Mineral aggregate from each source shall be tested separately for compliance to the project requirements for Abrasion (AASHTO T 96).

3.2 Bituminous Material - The bituminous material used in the design shall be asphalt-rubber material [hereinafter Crumb Rubber Asphalt (CRA)], conforming to the requirements of Section 1009 of the specifications, which is to be used in the production of the AR-AC. The specific gravity of the CRA and of the asphalt cement used in the CRA shall be determined in accordance with AASHTO T 228 (at 77 °F).

3.3 Mineral Admixture - Mineral admixture is required. The mineral admixture used in the design shall be the same type of material to be used in production of the AR-AC. The mineral admixture shall conform to the requirements of the specifications.

3.4 Batch Plants - Mix designs developed for asphaltic concrete which is to be produced in a batch plant shall be prepared in accordance with this procedure, modified as follows:

3.4.1 Aggregate samples will be obtained from the hot bins for all testing except Sand Equivalent. Testing for Sand Equivalent will be performed on aggregate stockpile samples proportioned and composited to meet the mix design composite without admixture. Any method may be used to combine the aggregate stockpile samples for Sand Equivalent testing as long as the resultant gradation is representative of the mix design composite gradation without admixture.

3.4.2 The mix design shall provide component percentages and composite gradations for both stockpile and hot bin materials.

4. DETERMINATION OF COMPOSITE GRADATION

4.1 The gradation of the aggregate from each individual component stockpile or bin shall be determined in accordance with ARIZ 248 using washed sieve analysis Alternate #3, Alternate #4, or Alternate #5. For Alternate #5, washing of the coarse aggregate may be performed on the composite Plus No. 4 material and applied to the composite percent pass the minus No. 200 determined from the unwashed coarse sieving and washed fine sieving of the individual stockpiles.

4.2 The composite gradation of the mineral aggregate is determined using desired percentages of each component based on washed sieve analysis. Mix designs may be developed based on bin or stockpile material, as appropriate for the respective mix production facility to be used.

4.3 The mineral aggregate composite shall be determined in accordance with ARIZ 205, paragraph 2(e).

4.4 The aggregate-mineral admixture blend composite is determined by adjusting the mineral aggregate composite (percent passing) for mineral admixture by performing the calculation in Equation 1 for each sieve:

Equation 1:

$$\begin{pmatrix} \text{\% passing each sieve [Adjusted for Mineral Admixture]} \end{pmatrix} = \frac{\begin{pmatrix} \text{\% passing each sieve in the aggregate composite} \end{pmatrix} + \begin{pmatrix} \text{\% Mineral Admixture} \end{pmatrix}}{(100) + (\text{\% Mineral Admixture})} \times 100$$

4.5 The composited gradation of the aggregate and the composited gradation of the aggregate-mineral admixture blend shall be shown on the design report, along with the percentage of each material.

5. PREPARING AGGREGATE/MINERAL ADMIXTURE SAMPLES FOR MIX DESIGN TESTING

5.1 Based on the stockpile or bin composite aggregate gradation, the aggregate samples needed for mix design tests are prepared as follows.

5.1.1 Dry the mineral aggregate from each individual stockpile at a temperature not exceeding any temperature restrictions specified in subsequent test procedures. Drying shall be performed until no further weight loss is obtained from continued drying.

5.1.2 Representative samples of aggregate material which is retained on the individual No. 8 and larger sieve sizes and the minus No. 8 material from each stockpile or bin are used to prepare the samples for mix design testing.

5.1.3 Table 1 shows the aggregate sample sizes, the number of samples required for each test listed, and which samples include mineral admixture. The aggregate weight shown for Maximum Theoretical Specific Gravity will provide three Rice test specimens and the amount shown for Density-Stability/Flow will produce three Marshall specimens. Example weigh-up sheets are shown in Figures 2 and 3.

Table 1

Sample Type	Sample Size	Number of Samples
Fractured Coarse Aggregate Particles (ARIZ 212)	Required grams of Mineral Aggregate as determined by test method [No mineral admixture]	1
Percent Carbonates (ARIZ 238) (When required)	300 grams of Mineral Aggregate [No mineral admixture]	1
Abrasion (AASHTO T 96)	5000 grams of Mineral Aggregate as per test method for grading type [No mineral admixture]	1
Fine Aggregate Specific Gravity/ Absorption (ARIZ 211)	1200 grams of Mineral Aggregate [No mineral admixture]	1
Coarse Aggregate Specific Gravity/Absorption (ARIZ 210)	Required grams of Mineral Aggregate as determined by the Nominal Maximum Aggregate Size [No mineral admixture]	1
Sand Equivalent (AASHTO T 176)	500 to 750 grams of Mineral Aggregate [No mineral admixture]	1

Table 1 (Continued)		
Uncompacted Void Content (ARIZ 247)	Minimum 500 grams of Mineral Aggregate [No mineral admixture]	1
Minus No. 8 Make-Up Material	An adequate amount (normally 500 grams) of Mineral Aggregate [No mineral admixture]	1
Marshall Density-Stability/Flow (ARIZ 415 and ARIZ 410, as modified in Sections 8 and 9 respectively)	3000 grams of Mineral Aggregate (See Note 2) [Plus 30 grams of mineral admixture]	3 (See Note 3) [Each sample yields 1 set of 3 Marshall Specimens]
Maximum Theoretical Specific Gravity (Rice Test) (ARIZ 806, as modified in Section 10)	3000 grams of Mineral Aggregate [Plus 30 grams of mineral admixture]	1 [Yields 3 test specimens]

Note 2: Generally 3000 grams of mineral aggregate will provide Marshall Density-Stability/Flow specimens of acceptable heights, but adjustments may be necessary in some cases. Use Equation 2 to adjust the weight of aggregate as necessary to conform to specimen height requirements of 2.500 ± 0.200 inches.

***Equation 2*:** $$\text{Adjusted Weight of Aggregate} = \frac{\left(\begin{array}{l}\text{Combined Bulk O.D.}\\ \text{Agg. Specific Gravity}\end{array}\right)}{2.650} \times 3000$$

Note 3: Requires one sample for each CRA binder content to be tested (minimum of three CRA binder contents, with three Marshall specimens at each CRA binder content).

5.1.4 After the aggregate samples for the Marshall and Rice specimens have been composited, add 1% mineral admixture, by dry weight of the aggregate, and mix thoroughly. Add 3% water, by dry weight of the aggregate, to each sample and mix thoroughly to wet the mineral admixture and aggregate surfaces.

5.1.5 Testing utilizing the prepared virgin aggregate-mineral admixture samples for Marshall and Rice will be performed as specified in Sections 7-9 and 10, respectively.

6. AGGREGATE SPECIFIC GRAVITIES AND ABSORPTION

6.1 Determine the Bulk Oven Dry, S.S.D., Apparent Specific Gravities and Absorption for the fine aggregate (minus No. 4) and the coarse aggregate (plus No. 4) in accordance with ARIZ 211 and ARIZ 210, respectively.

6.2 Determine the combined bulk oven dry specific gravity of the fine aggregate and the coarse aggregate without mineral admixture and also the combined water absorption of the fine aggregate and the coarse aggregate without mineral admixture, in accordance with ARIZ 251.

6.2.1 The combined aggregate bulk oven dry specific gravity without mineral admixture and the combined aggregate water absorption without mineral admixture are used only to determine compliance with specification requirements.

6.3 Using Equation 3, calculate the Combined Bulk Oven Dry (Gsb), S.S.D., and Apparent Specific Gravities of the aggregate-mineral admixture blend.

Equation 3:

$$\begin{pmatrix}\text{Combined Specific Gravity}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{pmatrix} = \frac{P_f + P_c + P_{admix}}{\frac{P_f}{G_f} + \frac{P_c}{G_c} + \frac{P_{admix}}{G_{admix}}}$$

Where:

P_f, P_c = Weight percent of fine aggregate (minus No. 4) and coarse aggregate (plus No. 4) respectively. Determined from the aggregate composite without mineral admixture.

P_{admix} = Percent mineral admixture by weight of the aggregate.

$P_f + P_c$ = 100

$P_f + P_c + P_{admix}$ = 100 + % Mineral Admixture

G_f, G_c = Bulk Oven Dry, S,S.D., or Apparent specific gravity of the fine aggregate and the coarse aggregate respectively.

G_{admix} = Specific gravity of the mineral admixture.

- Type I or II Cement = 3.14
- Type IP Cement = 3.00
- Hydrated Lime = 2.20

Example [for combined Bulk Oven Dry Specific Gravity (G_{sb})]:

P_f = 38
P_c = 62
G_f = 2.732
G_c = 2.772
G_{admix} = 2.20 (Hydrated Lime)
P_{admix} = 1.0

$$\left[\begin{array}{l}\text{Example of Combined}\\ \text{Bulk Oven Dry Specific}\\ \text{Gravity } (G_{sb}) \text{ of Aggregate}\\ \text{and Mineral Admixture}\end{array}\right] = \frac{38 + 62 + 1.0}{\frac{38}{2.732} + \frac{62}{2.772} + \frac{1.0}{2.20}} = 2.750$$

6.4 Using Equation 4, calculate the Combined Water Absorption of the aggregate-mineral admixture blend.

Equation 4:

$$\left(\begin{array}{l}\text{Combined Water Absorption}\\ \text{of Aggregate and Mineral}\\ \text{Admixture Blend}\end{array}\right) = \frac{(P_f \text{ x } A_f) + (P_c \text{ x } A_c) + (P_{admix} \text{ x } A_{admix})}{P_f + P_c + P_{admix}}$$

Where:
P_f, P_c = Weight percent of fine aggregate (minus No. 4) and coarse aggregate (plus No. 4) respectively. Determined from the aggregate composite without mineral admixture.
P_{admix} = Percent mineral admixture by weight of the aggregate.
$P_f + P_c$ = 100
$P_f + P_c + P_{admix}$ = 100 + % Mineral Admixture
A_f, A_c = Percent water absorption of the coarse aggregate and the fine aggregate respectively.
A_{admix} = Percent water absorption of mineral admixture (assumed to be 0.0%).

Example:

$P_f = 38$
$P_c = 62$
$A_f = 2.42$
$A_c = 1.68$
$P_{admix} = 1.0$
$A_{admix} = 0.00$

$$\begin{bmatrix}\text{Combined Water}\\ \text{Absorption of}\\ \text{Aggregate and}\\ \text{Mineral Admixture}\end{bmatrix} = \frac{(38 \times 2.42) + (62 \times 1.68) + (1.0 \times 0.00)}{38 + 62 + 1.0} = 1.94$$

7. PREPARATION OF SPECIMENS FOR BULK SPECIFIC GRAVITY/BULK DENSITY AND MARSHALL STABILITY/FLOW DETERMINATION

7.1 Specimens shall be prepared as described herein, utilizing the apparatus specified in ARIZ 410.

Note 4: Normally a range of 3 different CRA binder contents at 1.0% increments will provide sufficient information, although in some cases it may be necessary to prepare additional sets of samples at other CRA binder contents. Two series of CRA binder contents are customarily used: either 6.0%, 7.0%, and 8.0% CRA by total mix weight; or 6.5%, 7.5%, and 8.5% CRA by total mix weight.

7.2 The aggregate-mineral admixture samples, prepared as specified in Section 5, shall be dried to constant weight at 325 ± 5 ºF and shall be at this temperature at the time of mixing with the CRA. If necessary, a small amount of proportioned minus No. 8 aggregate make-up material shall be added to bring samples to the desired weight.

7.3 Before each batch of AR-AC is mixed, the CRA shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to reach a temperature of 325 ± 5 ºF (See ***CAUTION*** below). Upon removal from the oven, the CRA shall be thoroughly stirred to uniformly distribute the rubber particles throughout the CRA before adding the designated proportion to the aggregate-mineral admixture blend. If there is any delay before beginning of mixing the CRA with the aggregate-mineral admixture blend, thoroughly stir the CRA again immediately before pouring.

CAUTION: ***To avoid damage to the CRA, a hot plate or open flame is not used to bring it to the specified temperature. Once the CRA temperature has reached 325 ± 5 ºF, the container may briefly be moved to a hot plate for no more than 5 minutes at at time to maintain that temperature. If a hot plate is utilized, a suitable shield, baffle plate, or sand bath shall be used on the surface of the hot plate to minimize localized overheating. The CRA shall be constantly stirred to avoid sticking or scorching. Do not heat the CRA longer than necessary to complete batching and mixing operations (approximately three hours total heating time), or damage may occur.***

7.4 Using Equation 5, calculate the weight of CRA to be used for each CRA binder content:

Equation 5:

$$\left[\begin{array}{c}\text{Weight of}\\ \text{CRA}\end{array}\right] = \frac{\left[\begin{array}{c}\text{Weight of Aggregate}\\ \text{and Mineral Admixture}\end{array}\right]}{100 - \left[\begin{array}{c}\text{Percent of}\\ \text{CRA}\end{array}\right]} \times \left[\begin{array}{c}\text{Percent of}\\ \text{CRA}\end{array}\right]$$

Example (for Marshall specimens with 7.5% CRA) (See Note 4):

$$\left[\begin{array}{c}\text{Weight of}\\ \text{CRA}\end{array}\right] = \frac{3030}{100 - 7.5} \times 7.5 = 245.7 \text{ grams}$$

Note 5: Before each batch is mixed, the mixing bowl and whip shall be heated to 325 ± 5 ºF.

7.5 The aggregate-mineral admixture blend and the appropriate amount of CRA shall be mixed together for 90 to 120 seconds at the required mixing temperature of 325 ± 5 ºF. **Mechanical mixing is required.**

Note 6: Although a wide range of mixers may provide the desired well-coated homogeneous mixture, commercial dough mixers with whips are often used. Minimum recommended capacity of the mixing bowl is 12 quarts.

Note 7: After mechanical mixing, hand mixing shall be used as necessary to produce a well-coated homogeneous mixture.

7.6 Immediately after mixing, each batch of AR-AC shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual specimen and use up the entire batch.

7.7 Each individual AR-AC specimen shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The specimens shall be oven-cured for 2 hours ± 10 minutes at 325 ± 5 ºF.

7.8 A mold assembly (base plate, mold, and collar) shall be heated to approximately 325 ± 5 ºF. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at 325 ± 5 ºF. A suitable shield, baffle plate, or sand bath shall be used on the surface of the hot plate to minimize localized overheating of the face of the hammer.

7.9 Place a 4-inch diameter paper disc in the bottom of the mold before the mixture is introduced. Quickly place the mixuture into the mold using a transfer bowl or other suitable device. Spade the mixture vigorously with a heated flat metal spatula, with a blade approximately 1-inch wide and 6-inches long and stiff enough to penetrate the entire layer of material, 15 times around the perimeter and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of mix to a slightly rounded shape.

Note 8: To ease removal of the end papers after compaction, they may be sprayed with a light application of aerosol based vegetable oil. PAM® cooking spray has been found to work well for this application.

7.10 Before compaction, put the mold containing the mixture in an oven as necessary to heat the mixture to the proper compaction temperature of 325 ± 5 ºF. The specimen shall not be heated for more than one hour after being placed in the mold. Prior to compaction, it shall be verified that the mixture is at the required temperature. An electronic temperature probe with a digital display or a long-stem metal thermometer with a dial face shall be used. The use of an infrared temperature gun is not allowed.

7.11 Immediately upon removing the mold assembly loaded with mix from the oven, place a paper disc on top of mixture, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows with the

compaction hammer. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 compaction blows to the face of the reversed specimen.

Note 9: The compaction hammer shall apply only one blow after each fall, that is, there shall not be a rebound impact. The compaction hammer shall meet the requirements specified in Subsection 2.4 of ARIZ 410.

7.12 Remove the collar and top paper disc. Remove the base plate and remove the bottom paper disc while the specimen is still hot. Replace the base plate immediately, making sure to keep the mold and specimen oriented so that the bottom face of the compacted specimen remains directly in contact with, and is fully supported by, the base plate.

Note 10: Paper discs need to be removed while the AR-AC specimen is hot. The discs are very difficult to remove after the specimens have cooled.

7.13 If any part of the top surface of a compacted specimen is visually observed to increase in height (rise or swell in the mold) after compaction, stop testing and discard the prepared specimens. Adjust the gradation of the aggregate-mineral admixture blend to provide additional void space to accommodate the CRA, then batch and compact new trial AR-AC specimens. If no visible increase in height occurs, proceed with Subsections 7.14 through 7.17.

7.14 Allow each compacted specimen to cool in a vertical position in the mold (with the base plate on the bottom and the top surface exposed to air) until they are cool enough to be extruded without damaging the specimen. Rotate the base plate occasionally to prevent sticking.

Note 11: Generally specimens can be extruded without damage when they are at a temperature of approximately 77 to 90 ºF.

Note 12: Cooling may be accomplished at room temperature, or in a 77 ºF air bath. If more rapid cooling is desired, the mold and specimen may be placed in front of a fan until cool, ***but do not turn the mold on its side***.

7.15 Extrude the specimen by orienting the mold so that the ram pushes on the bottom face (base plate face) of the specimen. If any specimen is deformed or damaged during extrusion, the entire set of specimens at that CRA binder content shall be discarded and a new set prepared.

7.16 Immediately upon extrusion, measure and record the height of the specimen to the nearest 0.001 inch and determine and record its weight in air to the nearest 0.1 gram. Compacted specimens shall be 2.500 ± 0.200 inches in height. If this criteria is not met for the specimens at each CRA binder content, the entire set of specimens at that CRA binder content shall be discarded and a new set prepared after necessary adjustments in the weight of aggregate have been made using Equation 2 (see Note 2 in Table 1).

7.17 Repeat the procedures in Subsections 7.4 through 7.16 for the required specimens.

8. BULK SPECIFIC GRAVITY/BULK DENSITY OF SPECIMENS

8.1 Determine the bulk specific gravity and bulk density of the three compacted AR-AC specimens at each CRA binder content in accordance with Method A of ARIZ 415, except the paraffin method shall not be used. The determination of the “Weight in Water” and “S.S.D. Weight" of each specimen will be completed before the next specimen is submerged for its "Weight in Water" determination.

Note 13: Specimens fabricated in the laboratory that have not been exposed to moisture do not require drying after extrusion from the molds. The specimen weight in air obtained in Subsection 8.1 is its dry weight.

8.2 For each CRA binder content, the densities of individual compacted specimens shall not differ by more than 2.0 pcf. If this density requirement is not met, the entire set of specimens at that CRA binder content shall be discarded and a new set of specimens prepared.

8.3 For each set of three specimens, determine the average bulk specific gravity (G_{mb}), and using that value calculate the average bulk density (G_{mb} multiplied by 62.3 lb./cu. ft.).

9. MARSHALL STABILITY AND FLOW DETERMINATION

9.1 Specimens shall be tested for Marshall Stability and Flow utilizing the apparatus specified in ARIZ 410.

Note 14: Marshall Stability and Flow values are determined and recorded for information only.

9.2 For each specimen, determine the uncorrected stability, the stability (corrected for height), and the flow according to ARIZ 410, Subsections 4.6 through 4.11. In addition, determine the average stability (corrected for height) and average flow for each set of specimens prepared at each CRA binder content.

Note 15: Flow values may be high compared to conventional asphaltic concrete mixtures.

10. MAXIMUM THEORETICAL SPECIFIC GRAVITY (RICE TEST)

10.1 The maximum theoretical specific gravity of the mixture shall be determined in accordance with ARIZ 806 with the following modifications:

10.1.1 Prepare the AR-AC specimens including mineral admixture according to the procedures described in Section 5 and Subsections 7.2 through 7.5 using 6.0% or 6.5% CRA by total mix weight. A liquid anti-stripping agent is not used.

10.1.2 Immediately after mixing, the material shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual test sample and use up the entire batch.

10.1.3 Each individual test sample shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The test samples shall be oven-cured for 2 hours $\pm$ 10 minutes at 325 $\pm$ 5 °F.

10.1.4 After curing, each test sample shall be spread on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled, separate the particles of the mixture, taking care not to fracture the mineral aggregate particles, so that the particles of the fine aggregate portion are not larger than ¼ inch. Allow the test samples to cool to room temperature.

10.1.5 Using Equation 6, calculate the effective specific gravity of the combined aggregate and mineral admixture (G_{se}).

Equation 6:

$$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where:
G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
P_b = CRA binder content at which the Rice test was performed (Rice P_b).
G_{mm} = Measured maximum theoretical specific gravity of the mix at Rice P_b.
G_b = Specific gravity of the CRA.

Example:
$P_b = 6.0$
$G_{mm} = 2.547$
$G_b = 1.037$

$$G_{se} = \frac{100 - 6.0}{\frac{100}{2.547} - \frac{6.0}{1.037}} = 2.808$$

10.1.6 Using Equation 7, calculate the maximum theoretical specific gravity (G_{mm}) for each CRA binder content.

Note16: G_{se} is considered constant regardless of the CRA binder content.

Equation 7:

$$G_{mm} = \frac{100}{\frac{P_{sa}}{G_{se}} + \frac{P_b}{G_b}}$$

Where:
G_{mm} = Calculated maximum theoretical specific gravity of the AR-AC at each CRA binder content P_b.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).
P_b = Percent CRA binder content, by total weight of mix, for each CRA binder content.

G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
G_b = Specific gravity of the CRA.

Example (for 7.5% CRA binder content) (See Note 4):

P_{sa} = 92.5
P_b = 7.5
G_{se} = 2.808
G_b = 1.037

$$G_{mm} = \frac{100}{\frac{92.5}{2.808} + \frac{7.5}{1.037}} = 2.489$$

11. DETERMINATION OF DESIGN PERCENT CRA BINDER CONTENT

11.1 The design percent CRA binder content is determined as follows in Subsections 11.2 through 11.3.

11.2 For each CRA binder content used, calculate effective voids (V_a), percent absorbed CRA (P_{ba}), and voids in mineral aggregate (VMA) using the following equations.

11.2.1 Using Equation 8, calculate the effective voids (V_a). The calculated G_{mm} values for the respective CRA binder contents are used to determine the corresponding effective voids content of the compacted Marshall specimens at each CRA binder content.

Equation 8: $$V_a = \left(\frac{G_{mm} - G_{mb}}{G_{mm}} \right) \times 100$$

Where: V_a = Effective voids in the compacted mixture, percent of total volume.
G_{mm} = Calculated maximum theoretical specific gravity of the AC-AR at each CRA binder content P_b.
G_{mb} = Bulk specific gravity of compacted mixture specimens.

Example (for 7.5% CRA binder content) (See Note 4):

$$G_{mm} = 2.489$$
$$G_{mb} = 2.263$$

$$V_a = \frac{2.489 - 2.263}{2.489} \times 100 = 9.1$$

11.2.2 Using Equation 9, calculate the percent absorbed CRA (P_{ba}).

Note17: The percent absorbed CRA (P_{ba}) is the same for all CRA binder contents.

Equation 9: $$P_{ba} = \left(\frac{G_{se} - G_{sb}}{G_{sb} \times G_{se}} \right) \times G_b \times 100$$

Where:
- P_{ba} = Absorbed CRA, percent by total weight of mix.
- G_{se} = Effective specific gravity of the combined aggregate and mineral admixture.
- G_{sb} = Bulk oven dry specific gravity of the combined aggregate and mineral admixture.
- G_b = Specific gravity of the CRA.

Example:
$$G_{se} = 2.808$$
$$G_{sb} = 2.750$$
$$G_b = 1.037$$

$$P_{ba} = \frac{2.808 - 2.750}{2.750 \times 2.808} \times 1.037 \times 100 = 0.78$$

11.2.3 Using Equation 10, calculate voids in mineral aggregate (VMA) of the compacted Marshall specimens at each CRA binder content.

Equation 10: $$VMA = 100 - \left(\frac{G_{mb} \times P_{sa}}{G_{sb}} \right)$$

Where: VMA = Voids in the mineral aggregate, percent of bulk volume.
G_{mb} = Bulk specific gravity of compacted mixture specimens.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).
G_{sb} = Bulk oven dry specific gravity of the combined aggregate and mineral admixture.

Example (for 7.5% CRA binder content) (See Note 4):

$G_{mb} = 2.263$
$P_{sa} = 92.5$
$G_{sb} = 2.750$

$$VMA = 100 - \frac{2.263 \times 92.5}{2.750} = 23.9$$

11.3 If the specified value for effective voids (V_a) falls between the resultant V_a values determined for two of the CRA binder contents used, straight-line interpolation shall be used to calculate the bulk specific gravity (G_{mb}) at each 0.1% CRA binder content increment between the two corresponding measured values of G_{mb}. Using equations 7 and 8, determine the values for G_{mm} and V_a at each interpolated CRA binder content. Select the CRA binder content which results in V_a being as close as possible to the specified value.

11.3.1 Using equation 10, calculate VMA at the selected CRA binder content. Using straight-line interpolation, determine the values for stability and flow that correspond to the selected CRA binder content. (Stability and flow values are detemined for information only.) If the value for VMA is within the limits of the specifications, the selected CRA binder content shall be the design CRA binder content.

11.3.2 On separate graphs (using the same scale for percent CRA binder for each graph), plot the values for bulk specific gravity, effective voids, VMA, stability, and flow for each set of three specimens and at the design CRA binder content versus the percent CRA binder. Draw a smooth “best fit” curve based on the plotted points, as shown in Figure 4. The graphs in Figure 4 are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 11.3 and 11.3.1, is used for mix design calculations. (Values for stability and flow are plotted for information only.)

11.3.3 If it is not possible to obtain specification compliance within the range of CRA binder contents used, a determination must be made to either redesign the mix (different aggregate gradation and/or source) or prepare additional specimens at other CRA binder contents for testing and volumetric analyses.

11.4 Using Equation 11, calculate the percent effective CRA binder content (P_{be}) at each percent CRA binder content, including the design percent CRA binder content.

Equation 11: $$P_{be} = P_b - \left(\frac{P_{ba} \text{ x } P_{sa}}{100} \right)$$

Where: P_{be} = Percent effective CRA binder content of the mixture (free binder not absorbed).
P_b = CRA binder content, percent by total weight of mix.
P_{ba} = Absorbed CRA, percent by total weight of mix.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).

Example (for 9.3% CRA design binder content):

$P_b = 9.3$
$P_{ba} = 0.78$
$P_{sa} = 90.7$

$$P_{be} = 9.3 - \frac{0.78 \text{ x } 90.7}{100} = 8.59$$

12. MIX DESIGN GRADATION TARGET VALUES

12.1 The target values for the aggregate composite without mineral admixture, and the aggregate-mineral admixture blend composite, for the AR-AC mixture shall be expressed as percent passing particular sieve sizes as required by the specifications for the project. An example mix design composite, with and without mineral admixture, is shown in Figure 1.

13. REPORT

13.1 Report the test results and data obtained on the appropriate form. Liberal use of the remarks area to clarify and/or emphasize any element of the design is strongly recommended. Information required in the mix design report includes the items listed below:

13.1.1 Name and address of the testing organization and the signature and seal of the mix design engineer responsible for the mix design.

13.1.2 Aggregate:

- Source and identification
- Individual stockpile or bin gradations
- Aggregate blend proportions and composite gradation, with and without mineral admixture
- Fine and coarse aggregate specific gravities (Bulk Oven Dry, SSD, Apparent) and absorption
- Combined aggregate specific gravities (Bulk Oven Dry, SSD, Apparent)
- Combined aggregate absorption
- Aggregate quality
    - LA Abrasion
    - Sand Equivalent
    - Fractured Coarse Aggregate Particles (percentage with one fractured face and percentage with two fractured faces)
    - Uncompacted Void Content
    - Carbonates (when applicable)

13.1.3 Mineral Admixture:

- Type and source
- Percentage used
- Specific gravity

13.1.4 Combined Mineral Aggregate and Mineral Admixture

- Combined specific gravities [Bulk Oven Dry (G_{sb}), SSD, Apparent] and absorption of the combined aggregate and mineral admixture
- Effective specific gravity of the combined aggregate and mineral admixture (G_{se})

13.1.5 CRA Binder Design (from supplier), including:

- Source and grade of base asphalt cement
- Source and type of crumb rubber
- Crumb rubber gradation
- Proportions of asphalt cement and crumb rubber
  - Percentage of crumb rubber, by weight of asphalt cement
  - Percentages of crumb rubber and asphalt cement, by weight of total binder
- CRA binder properties, in compliance with Section 1009 of the ADOT Specifications
- CRA binder specific gravity (G_b) (at 77 °F)
- Asphalt cement specific gravity (at 77 °F)

13.1.6 Maximum theoretical specific gravity (G_{mm}) and density (pcf) at the CRA binder content at which the Rice test was performed (Rice P_b)

13.1.7 Mixture Compaction Trials:

- Percent CRA binder content (P_b), by weight of the bituminous mixture
- Aggregate and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Percent absorbed CRA (P_{ba})
- Percent effective CRA binder content (P_{be})
- Marshall stability (nearest 10 pounds) (recorded for information only)
- Marshall flow (0.01 inch) (recorded for information only)

13.1.8 Plots of the following properties versus percent CRA binder content (See examples in Figure 4.):

- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Bulk specific gravity (G_{mb})
- Marshall stability (for information only)
- Marshall flow (for information only)

13.1.9 Mixture Properties at Design Percent CRA Binder Content:

- Percent CRA binder content (P_b), by weight of the bituminous mixture
- Aggregate and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Percent absorbed CRA (P_{ba})
- Percent effective CRA binder content (P_{be})
- Marshall stability (nearest 10 pounds) (recorded for information only)
- Marshall flow (0.01 inch) (recorded for information only)

13.1.10 Mix Design Summary. The mix design summary shall contain the information shown in Figure 5. [Pages 1 and 2 of an example Mix Design Summary for an Asphaltic Concrete (Asphalt-Rubber) Marshall Mix Design.]

Example Mix Design Composite
(With and Without Mineral Admixture)

Material	3/16" Washed Crusher Fines	1/4" Washed Crusher Fines	3/8" Aggregate	1/2" Aggregate	Composite		Specifications ADOT 415 [Asphaltic Concrete (Asphalt-Rubber)]	
Percent used in composite	15	9	30	46	Without Admix	With Admix*	Without Admix	With Admix
Sieve	Gradation – Percent Passing							
3/4"	100.0	100.0	100.0	100.0	100	100	100	100
1/2"	100.0	100.0	100.0	92.1	96	96	80 - 100	80 - 100
3/8"	100.0	100.0	95.4	48.1	75	75	65 - 80	65 - 80
1/4"	100.0	100.0	73.4	7.6	50	50		
#4	99.8	92.2	41.1	4.4	38	39	28 - 42	29 - 43
#8	75.0	50.9	6.6	2.9	19	20	14 - 22	15 - 23
#10	67.3	43.6	5.5	2.6	17	18		
#16	46.5	26.3	3.8	2.3	12	13		
#30	26.5	14.1	3.0	2.1	7	8		
#40	18.3	9.8	2.8	2.0	5	6		
#50	12.9	7.0	2.5	1.9	4	5		
#100	6.7	3.9	2.2	1.7	3	4		
#200	4.0	2.5	1.9	1.4	2.0	3.0	0 - 2.5	0 – 3.5

* 1.0 percent admixture, by weight of dry mineral aggregate, is used.

FIGURE 1

Example Weigh Up Sheet #1

MATERIAL	SIEVE	INDIV. % RET.	ACCUM. % RET.	FRACTURED COARSE AGGREGATE PARTICLES [Plus #4] (500 grams)	PERCENT CARBONATES [Plus #4] (300 grams)	COARSE AGGREGATE SPECIFIC GRAVITY/ ABSORPTION [Plus #4] (4000 grams)	FINE AGGGREGATE SPECIFIC GRAVITY/ ABSORPTION [Minus #4] (1200 grams)	SAND EQUIVALENT [Minus #4] (600 grams)	UNCOMPACTED VOID CONTENT [Minus #8] (500 grams)	ABRASION [Type C] (5000 grams)
				ACCUMULATIVE WEIGHT (grams)						
3/16" Washed Crusher Fines	#4	0.030	0.030	---	---	2	---	---	---	6
	#8	3.720	3.750	---	---	---	119	59	---	---
	-#8	11.250	15.000	---	---	---	477	239	294	---
1/4" Washed Crushed Fines	#4	0.702	15.702	6	4	47	---	---	---	154
	#8	3.717	19.419	---	---	---	596	298	---	---
	-#8	4.581	24.000	---	---	---	742	371	413	---
3/8" Aggregate	3/8"	1.380	25.380	17	10	135	---	---	---	---
	1/4"	6.600	31.980	70	42	559	---	---	---	808
	#4	9.690	41.670	148	89	1180	---	---	---	2845
	#8	10.350	52.020	---	---	---	1072	536	---	---
	-#8	1.980	54.000	---	---	---	1135	568	465	---
1/2" Aggregate	1/2"	3.634	57.634	177	106	1413	---	---	---	---
	3/8"	20.240	77.874	339	203	2711	---	---	---	---
	1/4"	18.630	96.504	488	293	3906	---	---	---	4691
	#4	1.472	97.976	500	300	4000	---	---	---	5000
	#8	0.690	98.666	---	---	---	1157	579	---	---
	-#8	1.334	100.00	---	---	---	1200	600	500	---

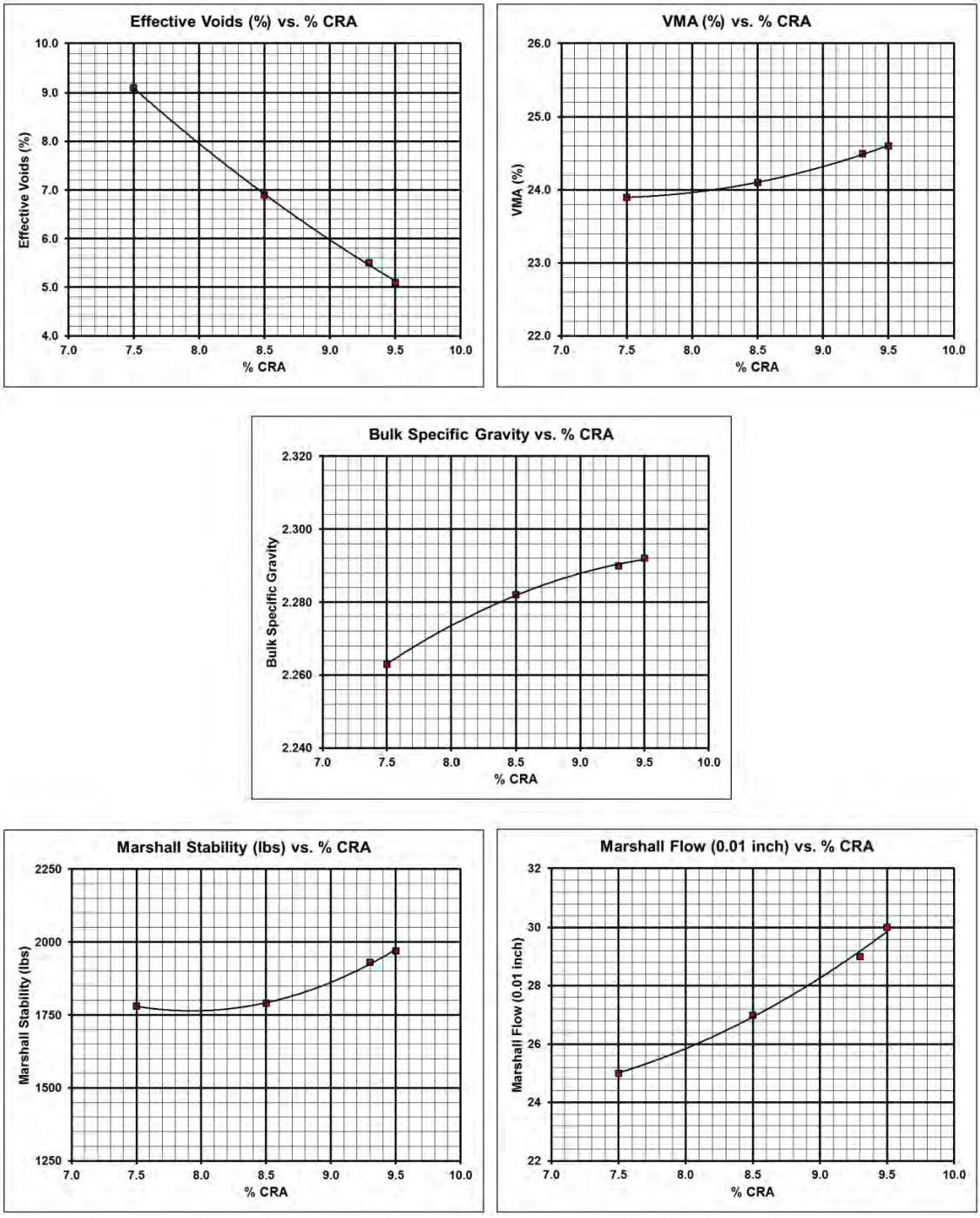
FIGURE 2

Example Weigh Up Sheet #2

MATERIAL	SIEVE	INDIVIDUAL PERCENT RETAINED	ACCUMULATIVE PERCENT RETAINED	RICE (3000 grams)	MARSHALL (3000 grams)	MINUS NO. 8 MAKE-UP MATERIAL (500 grams)
				ACCUMULATIVE WEIGHT (grams)		
3/16" Washed Crusher Fines	#4	0.030	0.030	1	1	---
	#8	3.720	3.750	113	113	---
	- #8	11.250	15.000	450	450	294
1/4" Washed Crusher Fines	#4	0.702	15.702	471	471	---
	#8	3.717	19.419	583	583	---
	- #8	4.581	24.000	720	720	413
3/8" Aggregate	3/8"	1.380	25.380	761	761	---
	1/4"	6.600	31.980	959	959	---
	#4	9.690	41.670	1250	1250	---
	#8	10.350	52.020	1561	1561	---
	- #8	1.980	54.000	1620	1620	465
1/2" Aggregate	1/2"	3.634	57.634	1729	1729	---
	3/8"	20.240	77.874	2336	2336	---
	1/4"	18.630	96.504	2895	2895	---
	#4	1.472	97.976	2939	2939	---
	#8	0.690	98.666	2960	2960	---
	- #8	1.334	100.000	3000	3000	500
Weight of Mineral Admixture (Hydrated Lime) [1.0%, by weight of Dry Mineral Aggregate]				30	30	---
Total weight of Mineral Aggregate and Mineral Admixture				3030	3030	---

FIGURE 3

Example Plots of Effective Voids, VMA, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent CRA Binder Content (Marshall Stability and Marshall Flow are plotted for information only.)



The above graphs are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 11.3 and 11.3.1, is used for mix design calculations.

FIGURE 4

Asphaltic Concrete (Asphalt-Rubber) Marshall Mix Design
Example Mix Design Summary (Page 1 of 2)

Date: February 22, 2013

Contractor: Best Paving Contractors, Inc.	**Mix Designation:** ADOT 415 [Asphaltic Concrete (Asphalt-Rubber)]
ADOT Project Number: STP-777-Z(777)A	**Mix Design Laboratory:** XYZ Testing Laboratories
ADOT TRACS Number: H777701C	**Mix Design Engineer:** Frank Dogood
Project Name: Uptown - Downtown	**Grade of Asphalt-Rubber Binder:** CRA Type 2

COMPOSITE GRADATION:

Mineral Aggregate	Percent Used
3/16" Washed Crusher Fines	15
1/4" Washed Crusher Fines	9
3/8" Aggregate	30
1/2" Aggregate	46
Mineral Admixture	
Hydrated Lime	1.0

Sieve Size	Percent Passing w/o Admix	Percent Passing w/ Admix	Specifications: Without Admix	Specifications: With Admix
3/4"	100	100	100	100
1/2"	96	96	80 - 100	80 - 100
3/8"	75	75	65 - 80	65 - 80
1/4"	50	50		
#4	38	39	28 - 42	29 - 43
#8	19	20	14 - 22	15 - 23
#10	17	18		
#16	12	13		
#30	7	8		
#40	5	6		
#50	4	5		
#100	3	4		
#200	2.0	3.0	0 – 2.5	0 – 3.5

AGGREGATE PROPERTIES:

Test Characteristic	Fine	Coarse	Combined	Spec.
Bulk O.D. Specific Gravity	2.732	2.772	2.757	2.350 – 2.850
SSD Specific Gravity	2.798	2.819	2.811	-----
Apparent Specific Gravity	2.925	2.907	2.914	-----
Absorption	2.42	1.68	1.96	0 – 2.5%
Sand Equivalent	97			Min. 55
Uncompacted Void Content	47.8			Min. 45.0%
Carbonates	2			Max. 20%
Fractured Coarse Aggregate Particles				
At least one fractured face	99			Min. 92%
At least two fractured faces	97			Min. 85%
Abrasion	(Type C)			
100 Rev., % Loss	3			9% Max.
500 Rev. ,%Loss	14			40% Max.

DESIGN DATA:

% CRA	7.5	8.5	**9.3**	9.5	Spec.
Bulk Specific Gravity	2.263	2.282	**2.290**	2.292	
Bulk Density (lb./cu. ft)	141.0	142.2	**142.7**	142.8	
Stability (lb.)	1780	1790	**1930**	1970	
Flow (0.01 inch)	25	27	**29**	30	
Effective Voids (%)	9.1	6.9	**5.5**	5.1	5.5 ± 0.5
VMA (%)	23.9	24.1	**24.5**	24.6	19.0 Min.
Effective CRA, Total Mix (%)	6.78	7.79	**8.59**	8.79	
Absorbed CRA (%)	0.78				0 – 1.0
Max. Theoretical Specific Gravity at 9.3% CRA = 2.423					
Max. Theoretical Density at 9.3% CRA = 151.0 lb/cu. ft.					

RECOMMENDED CRA BINDER CONTENT: (By weight of total mix)	**9.3%**

COMBINED AGGREGATE AND MINERAL ADMIXTURE PROPERTIES:

Bulk O.D.Specific Gravity	2.750
SSD Specific Gravity	2.803
Apparent Specific Gravity	2.905
Water Absorption	1.94
Effective Specific Gravity	2.808

ADDITIONAL DATA / INFORMATION:

Source of Mineral Aggregate: Excellent Aggregate Materials, Inc.
Source of Mineral Admixture: Superior Lime Company, Inc.
Mineral Admixture Type/Specific Gravity: Hydrated Lime/2.20

CRA BINDER DESIGN: (SEE PAGE 2)

REMARKS:

FIGURE 5 (Continued on Next Page)

Asphaltic Concrete (Asphalt-Rubber) Marshall Mix Design
Example Mix Design Summary (Page 2 of 2)

CRA BINDER DESIGN

Source of Base Asphalt Cement: Supreme Asphalt Suppliers, Inc.
Source of Crumb Rubber: Rubber Suppliers, Inc.
Grade of Base Asphalt Cement: PG 58-22
Type of Crumb Rubber: Type B
Grade of Asphalt-Rubber Binder: CRA Type 2
Specific Gravity of Base Asphalt Cement: 1.009 (at 77 °F)
Specific Gravity of CRA Binder: 1.037 (at 77 °F)
Crumb Rubber (by weight of asphalt cement): 20.5% (Minimum 20% required)
Proportions of Asphalt Cement and Crumb Rubber (by weight of total binder):
83.0% Asphalt Cement
17.0% Crumb Rubber

CRA Binder Properties (ADOT Specifications Section 1009):

Property	Test Result	Requirements (CRA Type 2)
Rotational Viscosity: 177 °C (350 °F); (Rion Model VT-04, No. 1 Rotor); Pascal·seconds	2.1	1.5 – 4.0
Penetration: 4 °C (39.2 °F), 200 g, 60 sec. (ASTM D 5); 0.1 mm	26	15 Minimum
Softening Point: (AASHTO T 53); °C	61	54 Minimum
Resilience: 25 °C (77 °F) (ASTM D 5329); %	47	20 Minimum

Crumb Rubber Gradation (Arizona Test Method 714):

Sieve Size	Percent Passing	Requirements (Type B)
No. 10	100	100
No. 16	90	65 – 100
No. 30	30	20 – 100
No. 50	7	0 – 45
No. 200	0.3	0 - 5

FIGURE 5 (Continued from Previous Page)

MARSHALL MIX DESIGN METHOD FOR ASPHALTIC CONCRETE WITH RECLAIMED ASPHALT PAVEMENT (RAP)

(An Arizona Method)

1. SCOPE

1.1 This method is used to design Asphaltic Concrete mixes with Reclaimed Asphalt Pavement (RAP) using 4-inch diameter Marshall apparatus.

1.2 This test method involves hazardous material, operations, and equipment. This test method does not purport to address all of the safety concerns associated with its use. It is the responsibility of the user to consult and establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

1.3 See Appendix A1 of the Materials Testing Manual for information regarding the procedure to be used for rounding numbers to the required degree of accuracy.

1.4 A listing of subsequent Sections and Figures in this procedure is given below:

Section or Figure #	Title	Page #
Section 2	Test Methods and Apparatus	2
Section 3	Materials	3
Section 4	Determination of Composite Gradation	5
Section 5	Preparing Aggregate/RAP/Mineral Admixture Samples for Mix Design Testing	7
Section 6	Virgin Aggregate and RAP Aggregate Specific Gravities and Absorption	12
Section 7	Asphalt Binder Selection	20
Section 8	Laboratory Mixing and Compaction Temperatures	23
Section 9	Preparation of Specimens for Bulk Specific Gravity/Bulk Density and Marshall Stability/Flow Determination	25
Section 10	Bulk Specific Gravity/Bulk Density of Specimens	29
Section 11	Marshall Stability and Flow Determination	30
Section 12	Maximum Theoretical Specific Gravity (Rice Test)	30
Section 13	Determination of Design Asphalt Binder Content	32
Section 14	Immersion Compression (IMC) Test	36
Section 15	Mix Design Gradation Target Values	37
Section 16	Report	37
Figure 1	Example of Composite #1 (Vrigin Aggregate and RAP Aggregate)	41
Figure 2	Example of Batch Sheet #1 (For Compostite #1) (Virgin Aggregate and RAP Aggregate)	42

Section 17	Adjusted Percentage for Each Virgin Aggregate Stockpile	43
Figure 3	Example of Composite #2 (Vrigin Aggregate)	45
Figure 4	Example of Batch Sheet #2 (For Compostite #2) (Virgin Aggregate)	46
Section 18	Adjusted Percentage for Each RAP Stockpile	47
Figure 5	Example of Composite #3 (Vrigin Aggregate and Dry Screened RAP)	48
Figure 6	Example of Batch Sheet #3 (For Compostite #3) (Virgin Aggregate and Dry Screened RAP)	49
Figure 7	Example Plots of Effective Voids, VMA, Dust/Bitumen Ratio, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent Total Asphalt Binder Content	50
Figure 8	Example Mix Design Summary	51 & 52

2. TEST METHODS AND APPARATUS

2.1 This test method is used in conjunction with the test methods and standards listed below. Requirements for the frequency of equipment calibration and verification are found in Appendix A3 of the Materials Testing Manual. The required apparatus is shown in the individual test methods and standards listed below, as appropriate.

2.1.1 Arizona Test Methods:

- ARIZ 201 Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 205 Composite Grading
- ARIZ 210 Specific Gravity and Absorption of Coarse Aggregate
- ARIZ 211 Specific Gravity and Absorption of Fine Aggregate
- ARIZ 212 Percentage of Fractured Coarse Aggregate Particles
- ARIZ 238 Percent Carbonates in Aggregate
- ARIZ 240 Sieve Analysis and Separation of Salvaged AC Pavement Particles for Recycled Asphaltic Concrete
- ARIZ 247 Particle Shape and Texture of Fine Aggregate Using Uncompacted Void Content
- ARIZ 248 Alternate Procedures for Sieving of Coarse and Fine Graded Soils and Aggregates
- ARIZ 251 Combined Coarse and Fine Aggregate Specific Gravity and Absorption
- ARIZ 406 Moisture Content of Bituminous Mixtures
- ARIZ 410 Compaction and Testing of Bituminous Mixtures Utilizing Four Inch Marshall Apparatus
- ARIZ 415 Bulk Specific Gravity and Bulk Density of Compacted Bituminous Mixtures
- ARIZ 416 Preparing and Splitting Field Samples of Bituminous Mixtures for Testing

- ARIZ 417 Maximum Theoretical Specific Gravity of Field Produced Bituminous Mixtures
- ARIZ 802 Effect of Water on Strength of Compacted Treated and Untreated Bituminous Mixtures (Immersion Compression Test)
- ARIZ 806 Maximum Theoretical Specific Gravity of Laboratory Prepared Bituminous Mixtures (Rice Test)

2.1.2 AASHTO Standards:

- AASHTO M 320 Standard Specification for Performance-Graded Asphalt Binder
- AASHTO R 29 Grading or Verifying the Performance Grade of an Asphalt Binder
- AASHTO T 96 Resistance to Degradation of Small-Size Coarse Aggregate by Abrasion and Impact in the Los Angeles Machine
- AASHTO T 164 Quantitative Extraction of Asphalt Binder from Hot-Mix Asphalt (HMA) – Method A
- AASHTO T 170 Recovery of Asphalt from Solution by Abson Method
- AASHTO T 176 Plastic Fines in Graded Aggregates and Soils by Use of the Sand Equivalent Test
- AASHTO T 228 Specific Gravity of Semi-Solid Bituminous Materials

Note 1: Testing by AASHTO T 228 shall be performed at 77 °F.

- AASHTO R 76 Reducing Samples of Aggregate to Testing Size
- AASHTO T 316 Viscosity Determination of Asphalt Binder Using Rotational Viscometer

2.1.3 ASTM Standards:

- ASTM D 2493 Standard Viscosity-Temperature Chart for Asphalts
- ASTM D 5404 Standard Practice of Recovery of Asphalt from Solution Using the Rotary Evaporator

3. MATERIALS

3.1 Mineral Aggregate - The mineral aggregate used in the design shall be produced material from the source(s) for the project. Mineral aggregate shall consist of a combination of virgin aggregate and aggregate from RAP (RAP aggregate). When the terms “mineral aggregate” or

"aggregate" are used without being further described as "virgin" or "RAP", the intended meaning is the total aggregate material used in the mixture.

3.1.1 RAP aggregate used for mix design purposes shall be extracted aggregate from AASHTO T 164 (Method A), except RAP aggregate used for Abrasion testing may be obtained using an ignition furnace.

3.1.2 The composited gradation of the virgin aggregate and RAP aggregate, and the composited gradation of the virgin aggregate-RAP aggregate-mineral admixture blend, shall comply with the grading limits of the specifications.

3.1.3 The composited virgin mineral aggregate shall conform to the requirements of the specifications for Sand Equivalent (AASHTO T 176), Combined Bulk Oven Dry Specific Gravity (ARIZ 251), Combined Water Absorption (ARIZ 251), and when applicable, Uncompacted Void Content (ARIZ 247).

3.1.4 The composited virgin aggregate and RAP aggregate shall conform to the requirements of the specifications for Fractured Coarse Aggregate Particles (ARIZ 212) and when applicable, Percent Carbonates (ARIZ 238).

3.1.5 Virgin mineral aggregate and RAP aggregate from each source shall be tested separately for compliance to the project requirements for Abrasion (AASHTO T 96). If multiple RAP stockpiles are utilized, and if the stockpiles are from different sources, an abrasion test will be necessary for each source. If the RAP is obtained from one source and is fractionated, one abrasion test will suffice.

3.2 Reclaimed Asphalt Pavement (RAP) - RAP consists of salvaged, milled, pulverized, broken, or crushed asphalt pavement. RAP contains "RAP aggregate" and bituminous materials hereinafter referred to as "RAP Binder". The gradation of the RAP material shall conform to the requirements of the specifications.

3.3 Bituminous Material - The bituminous material used in the design shall be the total asphalt binder which is to be used in the production of the asphaltic concrete. Bituminous material shall consist of a combination of virgin asphalt binder and asphalt binder from RAP (RAP binder). When the terms "bituminous material" or "asphalt binder" or "binder" are used without being further described as "virgin" or "RAP", the intended meaning is the total bituminous material used in the mixture.

3.3.1 If ≤15% RAP binder is being used, the virgin binder must conform to the requirements of Section 1005 of the specifications for the specific grade of

binder shown in the Special Provisions. The specific gravity of the virgin asphalt binder used in the asphaltic concrete shall be determined in accordance with AASHTO T 228 (at 77 °F). (See Section 7.)

3.3.2 If >15% RAP binder is being used, the blended RAP binder and virgin binder must conform to the requirements of Section 1005 of the specifications for the specific grade of binder shown in the Special Provisions. The specific gravity of the virgin asphalt binder, the specific gravity of the RAP binder from each RAP stockpile, and the specific gravity of the blended RAP binder and virgin binder shall be determined in accordance with AASHTO T 228 (at 77 °F). (See Section 7.) As an alternate to determining the specific gravity of the recovered RAP binder from each RAP stockpile, the specific gravity of proportionally blended recovered RAP binder may be determined. (See Note 9.)

3.4 Mineral Admixture - Mineral admixture is required. The mineral admixture used in the design shall be the same type of material which is to be used in production of the asphaltic concrete. The mineral admixture shall conform to the requirements of the specifications.

3.5 Batch Plants - Mix designs developed for asphaltic concrete which is to be produced in a batch plant shall be prepared in accordance with this procedure, modified as follows:

3.5.1 Virgin aggregate samples will be obtained from the hot bins for all testing except Sand Equivalent. Testing for Sand Equivalent will be performed on virgin aggregate stockpile samples proportioned and composited to meet Composite #2 without admixture. Any method may be used to combine the virgin aggregate stockpile samples for Sand Equivalent testing as long as the resultant gradation is representative of the composite gradation without admixture shown in Composite #2.

3.5.2 The mix design shall provide component percentages and composite gradations for both stockpile and hot bin materials.

4. DETERMINATION OF COMPOSITE GRADATION

4.1 The gradation of the aggregate from each individual component stockpile, bin, or RAP aggregate, shall be determined in accordance with ARIZ 248 using washed sieve analysis Alternate #3, Alternate #4, or Alternate #5. The RAP aggregate gradation shall be determined using the aggregate from solvent extraction testing of the RAP. For Alternate #5, washing of the coarse aggregate may be performed on the composite plus No. 4 material and applied to the composite percent pass the

minus No. 200 determined from the unwashed coarse sieving and washed fine sieving of the individual stockpiles.

4.2 The composite gradation of the virgin aggregate and RAP aggregate blend is determined using desired percentages of each component based on washed sieve analysis. Mix designs may be developed based on bin or stockpile material, as appropriate for the respective mix production facility to be used.

4.3 The virgin aggregate and RAP aggregate blend composite shall be determined in accordance with ARIZ 205, paragraph 2(e).

4.4 The virgin aggregate-RAP aggregate-mineral admixture blend composite is determined by adjusting the virgin aggregate and RAP aggregate blend composite (percent passing) for mineral admixture by performing the calculation in Equation 1 for each sieve:

Equation 1:

$$\left[\begin{array}{l}\text{\% passing}\\ \text{each sieve}\\ \text{(Adjusted for}\\ \text{Mineral}\\ \text{Admixture)}\end{array}\right] = \frac{\left(\begin{array}{l}\text{\% passing each}\\ \text{sieve in the}\\ \text{virgin aggregate}\\ \text{and RAP aggregate}\\ \text{blend composite}\end{array}\right) + \left(\begin{array}{l}\text{\% Mineral}\\ \text{Admixture}\end{array}\right)}{(100) + (\text{\% Mineral Admixture})} \text{ x } 100$$

4.5 The composite gradations of the components and the percentage of each will be included in the design report for each of the composite types listed below.

4.5.1 Composite #1 - Virgin Aggregate and RAP Aggregate (with and without mineral admixture).

4.5.2 Composite #2 - Virgin Aggregate (with and without mineral admixture)

4.5.3 Composite #3 - Virgin Aggregate and Dry Screened RAP (without mineral admixture)

5. PREPARING AGGREGATE/RAP/MINERAL ADMIXTURE SAMPLES FOR MIX DESIGN TESTING

5.1 Preparation of Mineral Aggregate:

5.1.1 Dry the mineral aggregate from each individual stockpile at a temperature not exceeding any temperature restrictions specified in subsequent test procedures. Drying shall be performed until no further weight loss is obtained from continued drying.

5.1.2 Based on the virgin mineral aggregate stockpile or bin gradations and composite percentages, virgin mineral aggregate material which is retained on the individual No. 8 and larger sieve sizes, and the minus No. 8 material, is used to prepare samples for mix design testing.

5.1.3 Based on the RAP aggregate gradation(s) and composite percentage(s), RAP aggregate material which is retained on the individual No. 8 and larger sieve sizes, and the minus No. 8 material, is used to prepare samples for mix design testing.

5.2 Preparation of Reclaimed Asphalt Pavement (RAP):

5.2.1 Drying/Processing of RAP:

5.2.1.1 Based on the amount of RAP used in the composite gradation, determine the minimum weight of RAP from each stockpile needed for mix design, then increase it by 100% to be sure enough is available for possible retesting.

5.2.1.2 Spread the material from each individual RAP stockpile to be used for mix design testing in separate pans at 1 to 1½ inches in depth and dry in an oven at 140 ± 5 °F such that no further weight loss is obtained from continued drying at 140 ± 5 °F. Allow the material to cool. Split or quarter samples of RAP material from each stockpile, in accordance with AASHTO R 76, as necessary to perform the remainder of the testing and batching required in Section 5.

5.2.1.3 Determine the RAP binder content of material from each RAP stockpile, by weight of RAP, in accordance with AASHTO T 164 – Method A (Centrifuge Extraction) and the gradation of the extracted RAP aggregate in accordance with ARIZ 248. Determine the moisture content in accordance with ARIZ 406.

Note 2: For mixes utilizing >15% RAP binder, the extract from the solvent extraction is saved for testing as specified in Subsection 7.2. Specific time frames related to binder recovery must be followed. (See Subsection 7.4.1.)

5.2.1.4 The binder content of RAP material from each individual stockpile is recorded as "P_{br}" ("P_{br1}" and "P_{br2}", if two RAP stockpiles are used).

5.2.2 Dry Gradation of RAP (into individual sizes for No. 8 and larger sieves, and minus No. 8 material):

5.2.2.1 Determine the appropriate size test sample of each individual RAP stockpile as shown in Table 1.

Table 1

Maximum Size of Particle	Minimum Weight of Sample, grams (lbs)
1¼”	10000 (22)
3/4”	5000 (11)
1/2”	2000 (4.4)
3/8”	1000 (2.2)

5.2.2.2 Dry sieve each test sample in accordance with ARIZ 240, but utilizing the No. 8 sieve as the smallest sieve. Compute the unwashed gradation in accordance with ARIZ 248, Alternate #2. This gradation is used only for batching test specimens for Batch Sheet #3. (See Subsection 5.3.3.)

5.2.3 Screening of dry RAP into individual sizes for use in mix design batching:

5.2.3.1 Screen the RAP material from the individual stockpiles and separate into individual sizes for No. 8 and larger sieves, and minus No. 8 material. The RAP shall be screened for 5 minutes ± 15 seconds per ARIZ 240 to prevent excessive breakdown of the RAP agglomerations. The screened RAP will be used in Batch Sheet #3.

5.3 Batching of Test Samples: Multiple batch sheets, as described below, will be necessary due to the use of RAP. Batch Sheet #1 is for samples which include virgin aggregate and RAP aggregate. Batch Sheet #2 is for samples where only the virgin aggregate is used. Batch Sheet #3 is for samples that include virgin aggregate, RAP, and mineral admixture; where the virgin aggregate and mineral admixture must be wet treated prior to incorporating the RAP. Each virgin mineral aggregate, RAP aggregate, and RAP component which has been screened into individual sizes for No. 8 and larger sieves, and minus No. 8 material, will be used in the batching process.

5.3.1 Batch Sheet #1:

5.3.1.1 This batch sheet will utilize the individual virgin aggregate gradations and the RAP aggregate gradation(s) determined from solvent extraction (except RAP aggregate used for abrasion testing may be obtained using an ignition furnace). The component proportions will be based on Composite #1.

5.3.1.2 Samples for Fractured Coarse Aggregate Particles, Percent Carbonates (if required), and Abrasion (each separate source of virgin aggregate and RAP aggregate) will be prepared using Batch Sheet #1.

5.3.1.3 Examples of Composite #1 and corresponding Batch Sheet #1 are shown in Figures 1 and 2, respectively.

5.3.2 Batch Sheet #2:

5.3.2.1 This batch sheet will utilize the individual virgin aggregate gradations. The individual virgin stockpile proportions will be based on Composite #2. The percentage of material from each virgin aggregate stockpile is adjusted, as shown in Equations 18 and 19 (prior to Figure 3), so that the sum of the virgin aggregate stockpile percentages equal 100 percent.

5.3.2.2 Samples for Coarse and Fine Aggregate Specific Gravity and Absorption, Sand Equivalent, and Uncompacted Void Content (when required) will be prepared using Batch Sheet #2. In addition, minus No. 8 virgin aggregate make-up material is prepared using Batch Sheet #2.

5.3.2.3 Examples of Composite #2 and corresponding Batch Sheet #2 are shown in Figures 3 and 4, respectively.

5.3.3 Batch Sheet #3:

5.3.3.1 This batch sheet will utilize the individual virgin aggregate gradations and the gradation of the dry screened RAP material from each stockpile. The individual component stockpile proportions will be based on Composite #3. The percent of RAP material from each stockpile is adjusted to account for the RAP binder contained in the RAP material, as shown in Section 18. Marshall, Maximum Theoretical Specific Gravity (Rice Test), and Immersion Compression (IMC) samples will be prepared using Batch Sheet #3. Also using Batch Sheet #3, samples of dry screened RAP material are prepared for performing the Rice Test for each individual RAP stockpile. (See Subsection 6.3.1.4.)

5.3.3.2 Examples of Composite #3 and corresponding Batch Sheet #3 are shown in Figures 5 and 6, respectively.

5.3.3.3 The virgin aggregate samples for the Marshall, Rice, and Immersion Compression (IMC) specimens are batched separately from the RAP. Add the required percentage of mineral admixture to the virgin aggregate samples, by dry weight of the total aggregate (virgin aggregate and RAP aggregate), and mix thoroughly. Add 3% water, by dry weight of virgin aggregate, to each batched virgin aggregate/mineral admixture sample and mix thoroughly to wet the mineral admixture and virgin aggregate surfaces.

5.3.3.3.1 After mixing, place the wet treated virgin aggregate in a suitable pan, form a shallow crater in the center of the aggregate, and place the RAP material from each stockpile in the crater (do not allow the RAP material to touch the pan).

5.3.3.4 Testing utilizing the prepared virgin aggregate-RAP-mineral admixture samples for Marshall, Rice, and Immersion Compression will be performed as specified in Sections 9-11, 12, and 14, respectively.

5.3.4 Table 2 summarizes the test samples required for each batch sheet.

Table 2

Sample Type	Sample Size	Number of Samples	Batch Sheet #
Fractured Coarse Aggregate Particles (ARIZ 212)	Required grams of Virgin Mineral Aggregate and RAP Aggregate as determined by test method [No mineral admixture]	1	1
Percent Carbonates (ARIZ 238) (When required)	300 grams of Virgin Mineral Aggregate and RAP Aggregate [No mineral admixture]	1	1
Abrasion (AASHTO T 96)	5000 grams of Virgin Mineral Aggregate as per test method for grading type [No mineral admixture]	1	1
Abrasion (AASHTO T 96)	5000 grams of RAP Aggregate as per test method for grading type [No mineral admixture]	1	1
Fine Aggregate Specific Gravity/Absorption (ARIZ 211)	1200 grams of Virgin Mineral Aggregate [No mineral admixture]	1	2

Table 2 (Continued)			
Coarse Aggregate Specific Gravity/Absorption (ARIZ 210)	Required grams of Virgin Mineral Aggregate as determined by the Nominal Maximum Aggregate Size [No mineral admixture]	1	2
Sand Equivalent (AASHTO T 176)	500 to 750 grams of Virgin Mineral Aggregate [No mineral admixture]	1	2
Uncompacted Void Content (ARIZ 247) (When required)	Minimum 500 grams of Virgin Mineral Aggregate [No mineral admixture]	1	2
Minus No. 8 Make-Up Material	An adequate amount (normally 500 grams) of Virgin Mineral Aggregate [No mineral admixture]	1	2
Maximum Theoretical Specific Gravity (Rice Test) (ARIZ 806, as modified in Section 12)	3000 grams of Virgin Mineral Aggregate and RAP Aggregate (See Note 3.) [Plus mineral admixture, by percent required by ARIZ 802 (as modified in Section 14)]	1 [Yields 3 test specimens]	3
Maximum Theoretical Specific Gravity (Rice Test) [ARIZ 417, as modified in Subsection 6.3.1.4]	3150 grams of Dry Screened RAP Material [No mineral admixture]	1 (for each RAP stockpile) [Yields 3 test specimens]	3
Marshall Density-Stability/Flow (ARIZ 415 and ARIZ 410, as modified in Sections 9 through 11)	3300 grams of Virgin Mineral Aggregate and RAP Aggregate (See Notes 3 and 4.) [Plus mineral admixture, by percent required by ARIZ 802 (as modified in Section 14)]	3 (See Note 5.) [Each sample yields 1 set of 3 Marshall Specimens]	3
Immersion Compression (ARIZ 802, as modified in Section 14)	3400 grams of Virgin Mineral Aggregate and RAP Aggregate (See Notes 3 and 4.) [Plus required percent of mineral admixture]	3 [Each sample yields 1 set of 2 IMC Specimens]	3

Table 2 (Continued)

Note 3: Samples are prepared with Virgin Mineral Aggregate and Dry Screened RAP material, however the amount shown for each sample is actually the amount of Virgin Mineral Aggregate and RAP Aggregate in the sample. Due to the asphalt binder in the RAP material, the required amount of RAP material necessary to provide the required samples of Virgin Mineral Aggregate and RAP Aggregate will be greater than that shown, as illustrated in Figure 6. The adjusted percent of RAP material from each stockpile to be used is determined as shown in Section 18.

Note 4: Generally the weight of virgin aggregate and RAP shown will provide specimens of acceptable heights, but adjustments may be necessary in some cases. Use Equation 2 to adjust sample size as necessary to conform to specimen height requirements of 2.500 ± 0.200 inches for Marshall Density-Stability/Flow specimens and 4.000 ± 0.100 inches for IMC specimens.

Equation 2:

$$[\text{Adjusted Sample Size}] = \frac{\left(\begin{array}{l}\text{Combined Bulk O.D.}\\ \text{Agg. Specific Gravity}\end{array}\right)}{2.650} \text{ x } \left(\begin{array}{l}\text{3300 grams (for Marshall}\\ \text{Density - Stability/Flow)}\\ \text{or 3400 grams (for}\\ \text{Immersion Compression)}\end{array}\right)$$

Note 5: Requires one (1) sample for each asphalt binder content to be tested (minimum of 3 binder contents, with 3 Marshall specimens at each binder content).

6. VIRGIN AGGREGATE AND RAP AGGREGATE SPECIFIC GRAVITIES AND ABSORPTION

6.1 Determine the Bulk Oven Dry, S.S.D., Apparent Specific Gravities and Absorption for the virgin fine aggregate (minus No. 4) and the virgin coarse aggregate (plus No. 4) in accordance with ARIZ 211 and ARIZ 210, respectively.

6.2 Determine the combined bulk oven dry specific gravity of the virgin fine aggregate and the virgin coarse aggregate without mineral admixture and also the combined water absorption of the virgin fine aggregate and the virgin coarse aggregate without mineral admixture, in accordance with ARIZ 251. The composite of virgin aggregate materials is determined by Composite #2.

6.2.1 The combined virgin aggregate bulk oven dry specific gravity without mineral admixture and the combined virgin aggregate water absorption

without mineral admixture are used to determine compliance with specification requirements.

6.2.2 The combined virgin aggregate water absorption without mineral admixture is recorded as "A_v" and used in Equations 4b, 4c, and 6.

6.3 Estimate the Bulk Oven Dry Specific Gravity of the RAP aggregate from each RAP stockpile as follows.

6.3.1 For each RAP stockpile, the following items are used in the calculations.

6.3.1.1 The estimated binder absorption of the RAP aggregate.

Note 6: The binder absorption of the RAP aggregate (P_{bar}) is normally estimated to be 0.50 percent. An exception is made when the binder content of the RAP material is less than 1.00 percent, in which case the binder absorption of the RAP aggregate is estimated to be one-half of the binder content of the RAP material.

6.3.1.2 The tested specific gravity of the recovered RAP binder (when >15% RAP binder is used) or an estimated specific gravity of 1.050 for the RAP binder (when ≤15% RAP binder is used).

6.3.1.3 The binder content of the RAP material.

6.3.1.4 The maximum theoretical specific gravity and the effective specific gravity of the RAP aggregate determined in accordance with ARIZ 417, modified as follows:

6.3.1.4.1 From each RAP stockpile, weigh up a 3150 gram sample of dry screened material for individual No. 8 and larger sieves, and minus No. 8 material per the “As-Received” gradation. For an example, see the right side of Figure 6. Each 3000 gram sample is split into three individual approximate 1000 gram samples. Alternatively, individual 1000 gram samples may be weighed up separately.

6.3.1.4.2 Spread each sample in a large pan at nominal single stone thickness.

6.3.1.4.3 Place the sample in an oven at 230 ± 5 °F for 30 ± 5 minutes.

6.3.1.4.4 Immediately upon removal from the oven, break up fine particle agglomerations so that they are not larger than 1/4-inch, taking care not to fracture the aggregate particles.

6.3.1.4.5 Care must be taken not to lose minus No. 200 material while removing the sample from the flask following the evacuation of air from the sample. A recovery container must be provided to capture the water and minus No. 200 material while the contents of the flask are poured into a nest of No. 40 and No. 200 sieves.

6.3.1.4.6 After the minus No. 200 material has settled in the recovery container, carefully decant the water so that no minus No. 200 material is lost.

6.3.1.4.7 Dry the recovered minus No. 200 material to constant weight at a temperature that will not cause material to be lost due to splattering. Determine and record the weight of the recovered minus No. 200 material to the nearest 0.1 gram.

6.3.1.4.8 Combine the material retained on the No. 40 and No. 200 sieves and perform fan drying.

6.3.1.4.9 The weight of the recovered minus No. 200 material is added to the W_{sd} weight.

6.3.1.4.10 Using Equation 3, calculate the effective specific gravity of each RAP aggregate (G_{ser}).

Equation 3:
$$G_{ser} = \frac{100 - P_{brn}}{\frac{100}{G_{mmr}} - \frac{P_{brn}}{G_{brn}}}$$

Where: G_{ser} = Effective specific gravity of each RAP aggregate.
P_{brn} = Binder content of material from each RAP stockpile.
G_{mmr} = Maximum theoretical specific gravity of material from each RAP stockpile.
G_{brn} = When >15% RAP binder is used, the tested specific gravity of the recovered RAP binder from each RAP stockpile. Alternatively, blended RAP binder from each RAP stockpile may be tested. (See Note 9.) When ≤15% RAP binder is used, an estimated specific gravity of 1.050 is used for the RAP binder.

Example [for RAP Aggregate 1 (Fine RAP)]:

P_{br1} = 5.82
G_{mmr} = 2.469
G_{br1} = 1.049

$$G_{ser} = \frac{100 - 5.82}{\frac{100}{2.469} - \frac{5.82}{1.049}} = 2.694$$

Example [for RAP Aggregate 2 (Coarse RAP)]:

$P_{br2} = 3.43$
$G_{mmr} = 2.326$
$G_{br2} = 1.052$

$$G_{ser} = \frac{100 - 3.43}{\frac{100}{2.326} - \frac{3.43}{1.052}} = 2.431$$

6.3.2 Using Equation 4a, calculate the Bulk Oven Dry Specific Gravity (G_{sbr}) of each RAP aggregate as a function of the estimated Binder Absorption of the RAP aggregate and the calculated Effective Specific Gravity.

Equation 4a: $$G_{sbr} = \frac{G_{ser}}{\frac{P_{bar} \times G_{ser}}{100 \times G_{brn}} + 1}$$

Where: G_{sbr} = Bulk oven dry specific gravity of each RAP aggregate.
P_{bar} = Estimated binder absorption of the RAP aggregate. (See Note 6.)

Example [for RAP Aggregate 1 (Fine RAP)]:

$G_{ser} = 2.694$
$P_{bar} = 0.50$
$G_{br1} = 1.049$

$$G_{sbr} = \frac{2.694}{\frac{0.50 \times 2.694}{100 \times 1.049} + 1} = 2.660$$

Example [for RAP Aggregate 2 (Coarse RAP)]:

$G_{ser} = 2.431$
$P_{bar} = 0.50$
$G_{br2} = 1.052$

$$G_{sbr} = \frac{2.431}{\frac{0.50 \text{ x } 2.431}{100 \text{ x } 1.052} + 1} = 2.403$$

6.4 Using Equation 4b, calculate the corresponding estimated S.S.D. specific gravity of each RAP aggregate.

Equation 4b: $$\begin{bmatrix}\text{S.S.D. Specific Gravity} \\ \text{of each RAP aggregate}\end{bmatrix} = G_{sbr} \text{ x } \left(1 + \frac{A_v}{100}\right)$$

Where: G_{sbr} = Bulk oven dry specific gravity of each RAP aggregate.
A_v = Combined virgin aggregate water absorption without mineral admixture.

Note 7: The water absorption of the RAP aggregates is assumed to be the same as the combined virgin aggregate water absorption.

Example [for RAP Aggregate 1 (Fine RAP)]:

G_{sbr} = 2.660
A_v = 1.13

$$\begin{bmatrix}\text{S.S.D. Specific Gravity of} \\ \text{RAP aggregate 1 (Fine RAP)}\end{bmatrix} = 2.660 \text{ x } \left(1 + \frac{1.13}{100}\right) = 2.690$$

Example [for RAP Aggregate 2 (Coarse RAP)]:

G_{sbr} = 2.403
A_v = 1.13

$$\begin{bmatrix}\text{S.S.D. Specific Gravity of} \\ \text{RAP aggregate 2 (Coarse RAP)}\end{bmatrix} = 2.403 \text{ x } \left(1 + \frac{1.13}{100}\right) = 2.430$$

6.5 Using Equation 4c, calculate the corresponding estimated Apparent specific gravity of each RAP aggregate.

Equation 4c: $$\begin{bmatrix}\text{Apparent Specific Gravity} \\ \text{of each RAP aggregate}\end{bmatrix} = \frac{1}{\frac{1}{G_{sbr}} - \frac{A_v}{100}}$$

Where: G_{sbr} = Bulk oven dry specific gravity of each RAP aggregate.
A_v = Combined virgin aggregate water absorption without mineral admixture. (See Note 7.)

Example [for RAP Aggregate 1 (Fine RAP)]:

$G_{sbr} = 2.660$
$A_v = 1.13$

$$\left[\begin{array}{l}\text{Apparent Specific Gravity of} \\ \text{RAP aggregate 1 (Fine RAP)}\end{array}\right] = \frac{1}{\frac{1}{2.660} - \frac{1.13}{100}} = 2.742$$

Example [for RAP Aggregate 2 (Coarse RAP)]:

$G_{sbr} = 2.403$
$A_v = 1.13$

$$\left[\begin{array}{l}\text{Apparent Specific Gravity of} \\ \text{RAP aggregate 2 (Coarse RAP)}\end{array}\right] = \frac{1}{\frac{1}{2.403} - \frac{1.13}{100}} = 2.470$$

6.6 Using Equation 5, calculate the combined Bulk Oven Dry (G_{sb}) specific gravity, combined S.S.D. specific gravity, and combined Apparent specific gravity of the virgin aggregate, RAP aggregate, and mineral admixture.

Equation 5:

$$\left[\begin{array}{l}\text{Combined Specific Gravity} \\ \text{of Virgin Aggregate, RAP} \\ \text{Aggregate, and Mineral} \\ \text{Admixture}\end{array}\right] = \frac{P_f + P_c + P_{ra1} + P_{ra2} + P_{admix}}{\frac{P_f}{G_f} + \frac{P_c}{G_c} + \frac{P_{ra1}}{G_{ra1}} + \frac{P_{ra2}}{G_{ra2}} + \frac{P_{admix}}{G_{admix}}}$$

Where: P_f = Weight percent of total virgin fine aggregate (minus No. 4), determined from Composite #1. [Calculated by multiplying the percentage of each virgin aggregate material used in the composite by the respective percent passing No. 4, and summing the individual results.]

P_c = Weight percent of total virgin coarse aggregate (plus No. 4), determined from Composite #1. [Calculated by subtracting P_f from the total percent virgin aggregate used in the composite.]

P_{ra1}, P_{ra2} = Weight percent of each RAP aggregate, determined from Composite #1.

P_{admix} = Percent mineral admixture by weight of the aggregate.

$P_f + P_c + P_{ra1} + P_{ra2}$ = 100

$P_f + P_c + P_{ra1} + P_{ra2} + P_{admix}$ = 100 + % Mineral Admixture

G_f, G_c, G_{ra1}, G_{ra2} = Bulk Oven Dry, SSD, or Apparent specific gravity of the virgin fine aggregate, virgin coarse aggregate, and RAP aggregate(s) respectively.

G_{admix} = Specific gravity of the mineral admixture.

- Type I or II Cement = 3.14
- Type IP Cement = 3.00
- Hydrated Lime = 2.20

Example [for combined Bulk Oven Dry Specific Gravity (G_{sb})]:

G_f = 2.797
G_c = 2.789
G_{ra1} = G_{sbr} [for RAP Aggregate 1 (Fine RAP)] = 2.660
G_{ra2} = G_{sbr} [for RAP Aggregate 2 (Coarse RAP)] = 2.403
G_{admix} = 3.00 (Type IP Cement)
P_f = (0.35 x 97.1) + (0.13 x 98.8) + (0.08 x 22.5) + (0.19 x 1.6) = 48.93
P_c = (75 – 48.93) = 26.07
P_{ra1} = 15.0 [for RAP Aggregate 1 (Fine RAP)]
P_{ra2} = 10.0 [for RAP Aggregate 2 (Coarse RAP)]
P_{admix} = 1.0

Example of Combined Bulk Oven Dry Specific Gravity (G_{sb}) of Virgin Aggregate, RAP Aggregate, and Mineral Admixture

$$= \frac{48.93 + 26.07 + 15.0 + 10.0 + 1.0}{\frac{48.93}{2.797} + \frac{26.07}{2.789} + \frac{15.0}{2.660} + \frac{10.0}{2.403} + \frac{1.0}{3.00}} = 2.732$$

6.7 Using Equation 6, calculate the combined water absorption of the virgin aggregate, RAP aggregate, and mineral admixture.

***Equation 6*:**

$$\begin{bmatrix}\text{Combined Water Absorption of Virgin Aggregate, RAP Aggregate, and Mineral Admixture}\end{bmatrix} = \frac{(P_f \text{ x } A_f) + (P_c \text{ x } A_c) + (P_{ra} \text{ x } A_v) + (P_{admix} \text{ x } A_{admix})}{P_f + P_c + P_{ra} + P_{admix}}$$

Where: P_f, P_c, = Weight percent of virgin fine aggregate (minus No. 4) and virgin coarse aggregate (plus No. 4), respectively, as determined for P_f and P_c for use in Equation 5.

P_{ra} = Total percent of RAP aggregate (Determined from Composite #1).

A_v = Combined virgin aggregate water absorption without mineral admixture. (See Note 7.)

P_{admix} = Percent mineral admixture by weight of the aggregate.

$P_f + P_c + P_{ra}$ = 100

$P_f + P_c + P_{ra} + P_{admix}$ = 100 + % Mineral Admixture

A_f, A_c = Percent water absorption of the virgin fine aggregate and the virgin coarse aggregate respectively.

A_{admix} = Percent water absorption of mineral admixture (assumed to be 0.0%).

Example:

P_f = 48.93
P_c = 26.07
A_f = 1.11
A_c = 1.17
P_{ra} = 25.0
A_v = 1.13
P_{admix} = 1.0
A_{admix} = 0.00

$$\left[\begin{array}{l}\text{Combined Water}\\ \text{Absorption of}\\ \text{Virgin Aggregate,}\\ \text{RAP Aggregate,}\\ \text{and Mineral}\\ \text{Admixture}\end{array}\right] = \frac{(48.93 \times 1.11) + (26.07 \times 1.17) + (25.0 \times 1.13) + (1.0 \times 0.00)}{48.93 + 26.07 + 25.0 + 1.0} = 1.13$$

7. ASPHALT BINDER SELECTION

7.1 Estimate the total binder content that will be needed in the mix design and determine whether the RAP binder content is lower or higher than the estimated total binder content.

Note 8: Estimating the total binder content relative to the RAP binder content may assist the designer in estimating the amount of RAP material which can be used in the mix.

7.2 For mixes utilizing >15% RAP binder, the extract obtained from the solvent extraction of material from each RAP stockpile, performed in Subsection 5.2.1.3, is used for additional testing. Determine and remove mineral matter from the extract using AASHTO T 164, Annex Method A1.2 (Centrifuge).

7.3 For mixes utilizing ≤15% RAP binder, the virgin binder used in the mix design shall be the grade called for in the Special Provisions. Determine the specific gravity [AASHTO T 228 (at 77 °F)] of the virgin binder.

7.4 For mixes utilizing >15% RAP binder, the virgin binder used in the mix design will be the grade determined as follows:

7.4.1 Recover the RAP binder from the extract solvent from each RAP stockpile using either AASHTO T 170 or ASTM D 5404. The solvent used in the extraction process shall not contain stabilizers that act as acid scavengers. The entire procedure, from the start of the extraction to the final recovery, must be completed within eight hours.

7.4.2 Perform PG grading (AASHTO R 29) on the recovered RAP binder from each RAP stockpile. Rotational viscosity, flash point, and mass loss tests are not required. Use PAV aging temperature for grade specified in the Special Provisions. Determine the specific gravity [AASHTO T 228 (at 77 °F)] of the recovered RAP binder from each RAP stockpile.

Note 9: Alternatively, the recovered binder from each RAP stockpile may be proportionally blended and the PG grading and specific gravity determined on the blended RAP binder.

7.4.3 Perform PG verification (AASHTO R 29) and determine the specific gravity [AASHTO T 228 (at 77 °F)] of the virgin binder, or use PG verification and specific gravity provided by the virgin asphalt binder supplier.

7.4.4 Blend RAP binder and virgin binder using the following procedure.

7.4.4.1 Using Equation 7, calculate the percent of RAP binder to blend with virgin binder. The percent of RAP binder, by weight of the total binder in the mix, shall not exceed the allowable maximum specified.

Equation 7:

$$P_{rb} = \frac{\left(\frac{\frac{P_{ra1}}{100}}{100 - P_{br1}} \times P_{br1}\right) + \left(\frac{\frac{P_{ra2}}{100}}{100 - P_{br2}} \times P_{br2}\right)}{\frac{1 + \frac{P_{admix}}{100}}{100 - P_b} \times P_b} \times 100$$

Where: P_{rb} = Percent of RAP Binder to blend with Virgin binder (Percent of RAP binder, by weight of total binder, in the mix).

P_{ra1}, P_{ra2} = Percent of RAP aggregate from each RAP stockpile (from Composite #1).

P_{br1}, P_{br2} = Binder content of the material from each RAP stockpile.

P_{admix} = Percent mineral admixture used.

P_b = Total asphalt binder content (percent by total weight of the bituminous mixture).

Note 10: The total asphalt binder content estimated in Subsection 7.1 is initially used for the value of P_b in Equations 7, 7a, and 7b. Subsequently, the actual total asphalt binder content from the mix design shall be used for the value of P_b.

Example:

$$P_{ra1} = 15.0$$
$$P_{ra2} = 10.0$$
$$P_{br1} = 5.82$$
$$P_{br2} = 3.43$$
$$P_{admix} = 1.0$$
$$P_b = 5.40$$

$$P_{rb} = \frac{\left(\frac{\frac{15.0}{100}}{100 - 5.82} \times 5.82\right) + \left(\frac{\frac{10.0}{100}}{100 - 3.43} \times 3.43\right)}{\frac{1 + \frac{1.0}{100}}{100 - 5.40} \times 5.40} \times 100 = 22.24\%$$

7.4.4.2 The proportional amount of RAP binder from each RAP stockpile can be calculated using Equations 7a and 7b.

Equation 7a: $$P_{rb1} = \frac{\frac{\frac{P_{r1}}{100}}{100 - P_{br1}} \times P_{br1}}{\frac{1 + \frac{P_{admix}}{100}}{100 - P_b} \times P_b} \times 100$$

Example (for Equation 7a) [for RAP Stockpile 1 (Fine RAP)]:

$$P_{rb1} = \frac{\frac{\frac{15.0}{100}}{100 - 5.82} \times 5.82}{\frac{1 + \frac{1.0}{100}}{100 - 5.4} \times 5.4} \times 100 = 16.08\%$$

Equation 7b: $$P_{rb2} = \frac{\frac{\frac{P_{r2}}{100}}{100 - P_{br2}} \times P_{br2}}{\frac{1 + \frac{P_{admix}}{100}}{100 - P_b} \times P_b} \times 100$$

Example (for Equation 7b) [for RAP Stockpile 2 (Coarse RAP)]:

$$P_{rb2} = \frac{\frac{\frac{10.0}{100}}{100 - 3.43} \times 3.43}{1 + \frac{\frac{1.0}{100}}{100 - 5.4} \times 5.4} \times 100 = 6.16\%$$

7.4.4.3 Blend the required amount of RAP binder (proportional amounts from each RAP stockpile if necessary) with the required amount of virgin binder. The RAP binder and the virgin binder shall be heated sufficiently to pour and thoroughly stirred prior to blending. The blended material shall be thoroughly stirred prior to testing.

7.4.5 Perform PG verification (AASHTO R 29) on the blend of RAP and virgin binder. Flash point and mass loss tests are not required.

Note 11: If the total binder content, estimated in Subsection 7.1, deviates by more than 0.30 percent from the total binder content established by mix design, the PG grading must be verified on a binder blended at the blend percentages established by the mix design.

7.4.6 If the blended binder does not meet the specified grade, a different virgin binder grade, or a different proportion of RAP and virgin binder, must be selected. An iterative process may be required in order to obtain a final blend of RAP and virgin binder that meets the specified binder grade.

Note 12: The virgin binder grade may only be changed one PG grade (6 °C on either or both the high and low temperatures) from that shown in the bid documents.

7.4.7 Determine the specific gravity [AASHTO T 228 (at 77 °F)] of the blended binder. Develop a viscosity - temperature curve (ASTM D 2493) for the blended binder.

8. LABORATORY MIXING AND COMPACTION TEMPERTURES

8.1 For mixes containing ≤15% RAP binder, the laboratory mixing and compaction temperatures shall be determined based on the specified virgin binder utilized. These temperatures are determined in accordance with Subsections 8.1.1 through 8.1.4 below.

8.1.1 The rotational viscosity of the asphalt binder at 275 °F and 350 °F shall be determined in accordance with AASHTO T 316, and a viscosity - temperature curve developed in accordance with ASTM D 2493.

8.1.2 The laboratory mixing temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.17 ± 0.02 Pascal·seconds. The actual laboratory mixing temperature used is normally selected at or near the mid-point of the range.

8.1.3 The laboratory compaction temperature range is defined as the range of temperatures where the un-aged asphalt binder has a rotational viscosity of 0.28 ± 0.03 Pascal·seconds. The actual laboratory compaction temperature used is normally selected at or near the mid-point of the range.

8.1.4 The viscosity - temperature curve shall be included in the mix design report. For PG asphalt binders that have a maximum laboratory mixing temperature exceeding 325 ^{o}F or a maximum laboratory compaction temperature exceeding 300 ^{o}F, the laboratory mixing and compaction temperature ranges shall be specified in writing by the asphalt binder supplier. A viscosity-temperature curve will meet this requirement for written documentation if the viscosity-temperature curve is developed and submitted by the binder supplier and includes language that the recommended laboratory mixing and compaction temperatures are within acceptable ranges, and shall include a statement indicating the maximum laboratory mixing temperature to which the binder can be heated without damage. The laboratory mixing and compaction temperature ranges, as well as the actual laboratory mixing and compaction temperatures used, shall be reported on the mix design.

8.2 For mixes containing >15% RAP binder, the laboratory mixing and compaction temperatures shall be determined from a viscosity - temperature curve developed for the blended binder. These temperatures are determined in accordance with Subsections 8.2.1 through 8.2.5 below.

8.2.1 The rotational viscosity of the blended binder at 275 °F and 350 °F shall be determined in accordance with AASHTO T 316, and a viscosity - temperature curve developed in accordance with ASTM D 2493.

8.2.2 Determine the laboratory mixing temperature range and the laboratory compaction temperature range, along with the actual laboratory mixing

and compaction temperatures, in accordance with Subsections 8.1.2 and 8.1.3.

8.2.3 If the maximum laboratory mixing temperature exceeds 350 ^{o}F, a temperature of 350 ^{o}F shall be used.

8.2.4 If the maximum laboratory compaction temperature exceeds 325 ^{o}F, a temperature of 325 ^{o}F shall be used.

8.2.5 The viscosity - temperature curve shall be included in the mix design report. The laboratory mixing and compaction temperature ranges, as well as the actual laboratory mixing and compaction temperatures used, shall be reported on the mix design.

9. PREPARATION OF SPECIMENS FOR BULK SPECIFIC GRAVITY/BULK DENSITY AND MARSHALL STABILITY/FLOW DETERMINATION

9.1 Specimens shall be prepared as described herein, utilizing the apparatus specified in ARIZ 410.

Note 13: A minimum of three different asphalt binder contents at 0.5% increments is required, although in some cases it may be necessary to prepare additional sets of samples at other asphalt binder contents.

9.2 The virgin aggregate-RAP-mineral admixture samples, prepared as specified in Section 5, shall be dried to constant weight at the laboratory mixing temperature $\pm$ 5 ºF and shall be at this temperature at the time of mixing with the virgin asphalt binder. If necessary, a small amount of proportioned minus No. 8 virgin aggregate make-up material shall be added to bring samples to the desired weight.

9.3 Before each batch of asphaltic concrete is mixed, the virgin asphalt binder shall be heated in a loosely covered container in a forced draft oven for approximately 2 hours or as necessary to bring the asphalt binder to the laboratory mixing temperature $\pm$ 5 ºF.

9.4 The weight of virgin asphalt binder required to provide the desired total binder content shall be calculated as follows.

9.4.1 The total binder content of a mix design sample is the total of the added virgin asphalt binder plus the RAP binder. Using Equations 8 through 10, calculate the weight of virgin asphalt binder (W_{vb}) to be added to the virgin aggregate-dry screened RAP-mineral admixture sample.

Equation 8: $$W_b = \frac{W_s + W_a}{100 - P_b} \times P_b$$

Equation 9: (Calculated for each RAP stockpile)

$$W_{rbn} = \frac{\frac{P_{ran}}{100} \times W_s}{100 - P_{brn}} \times P_{brn}$$

Equation 10: $$W_{vb} = W_b - \left[W_{rb1} + W_{rb2} \right]$$

Where:
- W_b = Weight of Total Binder (virgin asphalt binder + RAP binder).
- W_s = Weight of Total Aggregate (virgin aggregate + RAP aggregate).
- W_a = Weight of Mineral Admixture.
- P_b = Percent Total Binder (virgin asphalt binder + RAP binder) for each asphalt binder content, by total weight of mix.
- W_{rbn} = Weight of RAP binder for each RAP stockpile.
- P_{ran} = Percent of each RAP aggregate used (Determined from Composite #1).
- P_{brn} = Binder content of the material from each RAP stockpile.
- W_{vb} = Weight of virgin asphalt binder.

Example (for 5.0% asphalt binder content) (See Note 13.):

W_s = 3300 g
W_a = 33 g
P_b = 5.0%
P_{ra1} = 15.0%
P_{ra2} = 10.0%
P_{br1} = 5.82%
P_{br2} = 3.43%

$$W_b = \frac{3300 + 33}{100 - 5.0} \times 5.0 = 175.4 \text{ grams}$$

For RAP Stockpile 1 (Fine RAP): $$W_{rb} = \frac{\frac{15.0}{100} \times 3300}{100 - 5.82} \times 5.82 = 30.6 \text{ grams}$$

For RAP Stockpile 2 (Coarse RAP): $W_{rb} = \dfrac{\dfrac{10.0}{100} \text{ x } 3300}{100 - 3.43} \text{ x } 3.43 = 11.7 \text{ grams}$

$$W_{vb} = 175.4 - [30.6 + 11.7] = 133.1 \text{ grams}$$

Note 14: Before each batch is mixed, the mixing bowl and whip shall be heated to the laboratory mixing temperature $\pm$ 5 ºF.

9.5 The virgin aggregate-RAP-mineral admixture blend and the appropriate amount of virgin asphalt binder shall be mixed together for 90 to 120 seconds at the required laboratory mixing temperature $\pm$ 5 ºF. **Mechanical mixing is required.**

Note 15: Although a wide range of mixers may provide the desired well-coated homogeneous mixture, commercial dough mixers with whips are often used. Minimum recommended capacity of the mixing bowl is 12 quarts.

Note 16: After mechanical mixing, hand mixing shall be used as necessary to produce a well-coated homogeneous mixture.

9.6 Immediately after mixing, each batch shall be thoroughly blended and spread according to ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual specimen and use up the entire batch.

9.7 Each individual specimen shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The specimens shall be oven-cured for 2 hours $\pm$ 10 minutes at the laboratory compaction temperature $\pm$ 5 ºF.

9.8 A mold assembly (base plate, mold, and collar) shall be heated to the laboratory compaction temperature $\pm$ 5 ºF. The face of the compaction hammer shall be thoroughly cleaned and heated on a hot plate set at the laboratory compaction temperature $\pm$ 5 ºF. A suitable shield, baffle plate, or sand bath shall be used on the surface of the hot plate to minimize localized overheating of the face of the hammer.

9.9 Place a 4-inch diameter paper disc in the bottom of the mold before the mixture is introduced. Quickly place the mixture into the mold using a

transfer bowl or other suitable device. Spade the mixture vigorously with a heated flat metal spatula, with a blade approximately 1-inch wide and 6-inches long and stiff enough to penetrate the entire layer of material, 15 times around the perimeter and 10 times at random into the mixture, penetrating the mixture to the bottom of the mold. Smooth the surface of mix to a slightly rounded shape.

9.10 Before compaction, put the mold containing the mixture in an oven as necessary to heat the mixture to the laboratory compaction temperature $\pm$ 5 ºF. The specimen shall not be heated for more than one hour after being placed in the mold. Prior to compaction, it shall be verified that the mixture is at the required temperature. An electronic temperature probe with a digital display or a long-stem metal thermometer with a dial face shall be used. The use of an infrared temperature gun is not allowed.

9.11 Immediately upon removing the mold assembly loaded with mix from the oven, place a paper disc on top of mixture, place the mold assembly on the compaction pedestal in the mold holder, and apply 75 blows with the compaction hammer. Remove the base plate and collar, and reverse and reassemble the mold. Apply 75 compaction blows to the face of the reversed specimen.

Note 17: The compaction hammer shall apply only one blow after each fall, that is, there shall not be a rebound impact. The compaction hammer shall meet the requirements specified in Subsection 2.4 of ARIZ 410.

9.12 Remove the collar and top paper disc. Remove the base plate and remove the bottom paper disc while the specimen is still hot.

Note 18: Paper discs need to be removed while the specimen is hot. The discs are difficult to remove after the specimens have cooled.

9.13 Allow each compacted specimen to cool until they can be extruded without damaging the specimen.

Note 19: Generally, specimens can be extruded without damage when they are at a temperature of approximately 77 to 90 ºF.

Note 20: Cooling may be accomplished at room temperature, or in a 77 °F air bath. If more rapid cooling is desired, the mold and specimen may be placed in front of a fan until cool.

9.14 Extrude the specimen by orienting the mold so that the ram pushes on the bottom face (base plate face) of the specimen. If any specimen is deformed or damaged during extrusion, the entire set of specimens at that asphalt binder content shall be discarded and a new set prepared.

9.15 Immediately upon extrusion, measure and record the height of the specimen to the nearest 0.001 inch and determine and record its weight in air to the nearest 0.1 gram. Compacted specimens shall be 2.500 ± 0.200 inches in height. If this criteria is not met for the specimens at each asphalt binder content, the entire set of specimens at that asphalt binder content shall be discarded and a new set prepared after necessary adjustments in the sample size have been made using Equation 2. (See Note 4 in Table 2.)

9.16 Repeat the procedures in Subsections 9.4 through 9.15 for the required specimens.

10. BULK SPECIFIC GRAVITY/BULK DENSITY OF SPECIMENS

10.1 Determine the bulk specific gravity and bulk density of the three compacted specimens at each asphalt binder content in accordance with ARIZ 415, Method A. The determination of the “Weight in Water” and “S.S.D. Weight" of each specimen will be completed before the next specimen is submerged for its "Weight in Water" determination.

Note 21: Specimens fabricated in the laboratory that have not been exposed to moisture do not require drying after extrusion from the molds. The specimen weight in air obtained in Subsection 10.1 is its dry weight.

10.2 For each asphalt binder content, the densities of individual compacted specimens shall not differ by more than 2.0 pcf. If this density requirement is not met, the entire set of specimens at that asphalt binder content shall be discarded and a new set of specimens prepared.

10.3 For each set of three specimens, determine the average bulk specific gravity (G_{mb}), and using that value calculate the average bulk density (G_{mb} multiplied by 62.3 lb./cu. ft.).

11. MARSHALL STABILITY AND FLOW DETERMINATION

11.1 Specimens shall be tested for Marshall Stability and Flow utilizing the apparatus specified in ARIZ 410.

11.2 For each specimen, determine the uncorrected stability, the stability (corrected for height), and the flow according to ARIZ 410, Subsections 4.6 through 4.11. In addition, determine the average stability (corrected for height) and average flow for each set of specimens prepared at each asphalt binder content.

12. MAXIMUM THEORETICAL SPECIFIC GRAVITY (RICE TEST)

12.1 The maximum theoretical specific gravity of the mixture shall be determined in accordance with ARIZ 806, with the following modifications:

12.1.1 Prepare the specimens including mineral admixture according to the procedures described in Section 5 and Subsections 9.2 through 9.5 using 5.5% or 6.0% total asphalt binder (virgin binder plus RAP binder) by total mix weight. A liquid anti-stripping agent is not used.

12.1.2 Immediately after mixing, the material shall be thoroughly blended and spread according to the procedures described in ARIZ 416. The circular mass shall be cut into 6 equal pie-shaped segments. Take opposite segments for each individual test sample and use up the entire batch.

12.1.3 Each individual test sample shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The test samples shall be oven-cured for 2 hours $\pm$ 10 minutes at the laboratory compaction temperature $\pm$ 5 °F.

12.1.4 After curing, each test sample shall be spread on a sheet of heavy paper or in a large flat bottom pan. Before the samples are completely cooled, separate the particles of the mixture, taking care not to fracture the mineral aggregate particles, so that the particles of the fine aggregate portion are not larger than ¼ inch. Allow the test samples to cool to room temperature.

12.1.5 Using Equation 11, calculate the effective specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture (G_{se}).

Equation 11: $$G_{se} = \frac{100 - P_b}{\frac{100}{G_{mm}} - \frac{P_b}{G_b}}$$

Where:
- G_{se} = Effective specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture.
- P_b = Total asphalt binder content (virgin binder + RAP binder) at which the Rice test was performed (Rice P_b).
- G_{mm} = Measured maximum theoretical specific gravity of the mix at Rice P_b.
- G_b = When >15% RAP binder is used, the specific gravity of the blended virgin and RAP binder. (When ≤15% RAP binder is used, the specific gravity of the virgin binder is used for the value of G_b.)

Example:

$P_b = 6.0$
$G_{mm} = 2.526$
$G_b = 1.031$

$$G_{se} = \frac{100 - 6.0}{\frac{100}{2.526} - \frac{6.0}{1.031}} = 2.784$$

12.1.6 Using Equation 12, calculate the maximum theoretical specific gravity (G_{mm}) for each asphalt binder content.

Note 22: G_{se} is considered constant regardless of asphalt binder content.

Equation 12: $$G_{mm} = \frac{100}{\frac{P_{sa}}{G_{se}} + \frac{P_b}{G_b}}$$

Where:
- G_{mm} = Calculated maximum theoretical specific gravity of the mix at each asphalt binder content P_b.
- P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix (100-P_b).

P_b = Percent asphalt binder, by total weight of mix, for each asphalt binder content.

G_{se} = Effective specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture.

G_b = When >15% RAP binder is used, the specific gravity of the blended virgin and RAP binder. (When ≤15% RAP binder is used, the specific gravity of the virgin binder is used for the value of G_b.)

Example (for 5.0% asphalt binder content) (See Note 13.):

$P_{sa} = 95.0$
$P_b = 5.0$
$G_{se} = 2.784$
$G_b = 1.031$

$$G_{mm} = \frac{100}{\frac{95.0}{2.784} + \frac{5.0}{1.031}} = 2.566$$

13. DETERMINATION OF DESIGN ASPHALT BINDER CONTENT

13.1 The design percent asphalt binder content is determined as follows in Subsections 13.2 and 13.3.

13.2 For each asphalt binder content used, calculate effective voids (V_a), percent absorbed asphalt (P_{ba}), voids in mineral aggregate (VMA), percent effective asphalt binder content (P_{be}), and the ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt binder content (Dust/Bitumen Ratio) using the following equations.

13.2.1 Using Equation 13, calculate the effective voids (V_a). The calculated G_{mm} values for the respective asphalt binder contents are used to determine the corresponding effective voids content of the compacted Marshall specimens at each asphalt binder content.

Equation 13: $$V_a = \frac{G_{mm} - G_{mb}}{G_{mm}} \times 100$$

Where: V_a = Effective voids in the compacted mixture, percent of total volume.
G_{mm} = Calculated maximum theoretical specific gravity of the mix at each asphalt binder content P_b.
G_{mb} = Bulk specific gravity of compacted mixture specimens.

Example (for 5.0% asphalt binder content) (See Note 13.):

$G_{mm} = 2.566$
$G_{mb} = 2.400$

$$V_a = \frac{2.566 - 2.400}{2.566} \times 100 = 6.5$$

13.2.2 Using Equation 14, calculate the percent absorbed asphalt (P_{ba}).

Note 23: The percent absorbed asphalt (P_{ba}) is the same for all binder contents.

Equation 14:
$$P_{ba} = \frac{G_{se} - G_{sb}}{G_{sb} \times G_{se}} \times G_b \times 100$$

Where: P_{ba} = Absorbed asphalt, percent by total weight of mix.
G_{se} = Effective specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture.
G_{sb} = Bulk oven dry specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture.
G_b = When >15% RAP binder is used, the specific gravity of the blended virgin and RAP binder. (When ≤15% RAP binder is used, the specific gravity of the virgin binder is used for the value of G_b.)

Example:

$G_{se} = 2.784$
$G_{sb} = 2.732$
$G_b = 1.031$

$$P_{ba} = \frac{2.784 - 2.732}{2.732 \times 2.784} \times 1.031 \times 100 = 0.70$$

13.2.3 Using Equation 15, calculate voids in mineral aggregate (VMA) of the compacted Marshall specimens at each asphalt binder content.

Equation 15: $$VMA = 100 - \frac{G_{mb} \times P_{sa}}{G_{sb}}$$

Where: VMA = Voids in the mineral aggregate, percent of bulk volume.
G_{mb} = Bulk specific gravity of compacted mixture specimens.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix ($100-P_b$).
G_{sb} = Bulk oven dry specific gravity of the combined virgin aggregate, RAP aggregate, and mineral admixture.

Example (for 5.0% asphalt binder content) (See Note 13.):

$G_{mb} = 2.400$
$P_{sa} = 95.0$
$G_{sb} = 2.732$

$$VMA = 100 - \frac{2.400 \times 95.0}{2.732} = 16.5$$

13.2.4 Using Equation 16, calculate the percent effective asphalt binder content (P_{be}) of the compacted Marshall specimens at each asphalt binder content.

Equation 16: $$P_{be} = P_b - \frac{P_{ba} \times P_{sa}}{100}$$

Where: P_{be} = Percent effective asphalt binder content of the mixture (free binder not absorbed).
P_b = Asphalt binder content, percent by total weight of mix.
P_{ba} = Absorbed asphalt, percent by total weight of mix.
P_{sa} = Aggregate and mineral admixture content, percent by total weight of mix ($100-P_b$).

Example (for 5.0% asphalt binder content) (See Note 13.):

$$P_b = 5.0$$
$$P_{ba} = 0.70$$
$$P_{sa} = 95.0$$

$$P_{be} = 5.0 - \frac{0.70 \times 95.0}{100} = 4.34$$

13.2.5 Using Equation 17, calculate the the ratio of the mix design composite gradation target for the No. 200 sieve, including mineral admixture, to the effective asphalt binder content (Dust/Bitumen Ratio) of the compacted Marshall specimens at each asphalt binder content.

Equation 17: $$\text{Dust / Bitumen Ratio} = \frac{\left[\begin{array}{c}\text{Mix Design} \\ \text{Passing No. 200} \\ \text{(Including Mineral Admix.)}\end{array}\right]}{P_{be}}$$

Where: P_{be} = Percent effective asphalt binder content of the mixture (free binder not absorbed).

Example (for 5.0% asphalt binder content) (See Note 13.):

$$P_{be} = 4.34$$

$$\text{Dust / Bitumen Ratio} = \frac{5.2}{4.34} = 1.20$$

13.3 If the specified value for effective voids (V_a) falls between the resultant V_a values determined for two of the asphalt binder contents used, ~~line~~ straight-line interpolation shall be used to calculate the bulk specific gravity (G_{mb}) at each 0.1% asphalt binder content increment between the two corresponding measured values of G_{mb}. Using equations 12 and 13, determine the values for G_{mm} and V_a at each interpolated asphalt binder content. Select the total asphalt binder content which results in V_a being as close as possible to the specified value.

13.3.1 Using equations 15, 16, and 17, calculate VMA, P_{be}, and the Dust/Bitumen Ratio at the selected asphalt binder content. Using straight-line interpolation, determine the values for stability and flow that correspond to the selected asphalt binder content. If the values for VMA, Dust/Bitumen Ratio, stability, and flow are within the limits of the

specifications, the selected asphalt binder content shall be the design asphalt binder content.

13.3.2 On separate graphs (using the same scale for percent total asphalt binder for each graph), plot the values for bulk specific gravity, effective voids, VMA, Dust/Bitumen Ratio, stability, and flow for each set of three specimens and at the design asphalt binder content, versus the percent total asphalt binder. Draw a smooth "best fit" based on the plotted points, as shown in Figure 7. The graphs in Figure 7 are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 13.3 and 13.3.1, is used for mix design calculations.

13.3.3 If it is not possible to obtain specification compliance within the range of asphalt binder contents used, a determination must be made to either redesign the mix (different aggregate gradation and/or source) or prepare additional specimens at other asphalt binder contents for testing and volumetric analyses.

14. IMMERSION COMPRESSION (IMC) TEST

14.1 The Immersion Compression Test shall be performed in accordance with ARIZ 802, modified as follows:

14.1.1 Prepare the asphaltic concrete sample including mineral admixture according to the procedures described in Section 5 and Subsections 9.2 through 9.5 at the design asphalt binder content.

14.1.2 Immediately after mixing, each batch shall be thoroughly blended and spread according to ARIZ 416. The circular mass shall be cut into 4 equal pie-shaped segments. Take opposite segments for each individual specimen and use up the entire batch.

14.1.3 Each individual sample shall be spread in a large pan at nominal single-stone thickness. Avoid stacking particles as feasible. The samples shall be oven-cured for 2 hours $\pm$ 10 minutes at 255 $\pm$ 5 ºF.

14.1.4 Compacted specimens shall be 4.000 $\pm$ 0.100 inches in height.

15. MIX DESIGN GRADATION TARGET VALUES

15.1 The target values for the combined virgin aggregate and RAP aggregate without mineral admixture (Composite #1), and the combined virgin aggregate-RAP aggregate-mineral admixture blend (Composite #1), in the mixture shall be expressed as percent passing particular sieve sizes as required by the specifications for the project.

16. REPORT

16.1 Report the test results and data obtained on the appropriate form. Liberal use of the remarks area to clarify and/or emphasize any element of the design is strongly recommended. Information required in the mix design report includes the items listed below. In addition, all composites and batch sheets/weigh-ups (examples are given in Figures 1 through 6) are to be included in the mix design report.

16.1.1 Name and address of the testing organization and the signature and seal of the mix design engineer responsible for the mix design.

16.1.2 Virgin Aggregate:

- Source and identification
- Individual stockpile or bin gradations
- Aggregate blend proportions and composite gradation with and without mineral admixture (See example in Figure 3.)
- Fine and coarse aggregate specific gravities (Bulk Oven Dry, SSD, Apparent) and absorption
- Combined Bulk Oven Dry Specific Gravity
- Combined Absorption
- Aggregate quality:
  - LA Abrasion
  - Sand Equivalent
  - Uncompacted Void Content (when applicable)

16.1.3 Mineral Admixture:

- Type and source
- Percentage used
- Specific gravity

16.1.4 RAP (each stockpile):

- Source and identification
- Anticipated gradation
- Binder content (P_{brn})
- Maximum theoretical specific gravity

16.1.5 RAP Aggregate (each stockpile):

- Percentage used
- Gradation
- Estimated binder absorption (P_{bar}) (normally 0.50 percent) (See Note 6.)
- Estimated Bulk Oven Dry, S.S.D., and Apparent specific gravities
- Aggregate quality:
  - LA Abrasion

16.1.6 Combined Virgin Aggregate and RAP Aggregate:

- Composite gradation with and without mineral admixture (See example in Figure 1.)
- Aggregate quality:
  - Fractured Coarse Aggregate Particles (percentage with one fractured face and when required, percentage with two fractured faces)
  - Carbonates (when applicable)

16.1.7 Virgin Asphalt Binder:

- Source and grade
- Specific gravity (at 77 °F)
- Viscosity - Temperature Curve and the following:
  - Laboratory mixing temperature range and actual laboratory mixing temperature used.
  - Laboratory compaction temperature range and actual laboratory compaction temperature used.
- Virgin asphalt binder content (by weight of total binder and by weight of total mix)
- PG verification results (if RAP binder content is greater than 15 percent)

16.1.8 RAP Binder:

- RAP binder content (by weight of total binder and by weight of total mix)
- PG grading results (Standard PG Grade and Actual Grade), including specific gravity (G_{brn}) (at 77 °F), on recovered RAP binder from each RAP stockpile (if RAP binder content is greater than 15 percent)

16.1.9 Virgin Asphalt Binder and RAP Binder Blend:

- Total Binder Content (P_b)
- PG verification results, including specific gravity (G_b) (at 77 °F), (if RAP binder content is greater than 15 percent)

16.1.10 Combined Virgin Aggregate and Dry Screened RAP:

- Individual stockpile or bin gradations
- Percentage of virgin aggregates used
- Percentage of RAP materials used (adjusted for RAP binder content)

16.1.11 Combined Aggregate (virgin aggregate and RAP aggregate) and Mineral Admixture:

- Combined specific gravities [Bulk Oven Dry (G_{sb}), SSD, and Apparent]
- Combined absorption

16.1.12 Maximum theoretical specific gravity (G_{mm}) and density (pcf) at the total asphalt binder content at which the Rice test was performed (Rice P_b).

16.1.13 Mixture Compaction Trials:

- Percent virgin asphalt binder, by weight of total binder in the mix
- Percent RAP binder, by weight of total binder in the mix
- Total asphalt binder content (P_b), by weight of the bituminous mixture
- Combined aggregate (virgin aggregate and RAP aggregate) and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Percent absorbed asphalt (P_{ba})
- Effective specific gravity of the combined aggregate (virgin aggregate and RAP aggregate) and mineral admixture (G_{se})
- Percent effective asphalt binder content (P_{be})
- Marshall stability (nearest 10 pounds)
- Marshall flow (0.01 inch)

16.1.14 Plots of the following properties versus percent total asphalt binder (See examples in Figure 7.):

- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Bulk specific gravity (G_{mb})
- Marshall stability
- Marshall flow

16.1.15 Mixture Properties at Design Asphalt Binder Content:

- Percent virgin asphalt binder, by weight of total binder in the mix
- Percent RAP binder, by weight of total binder in the mix
- Total asphalt binder content (P_b), by weight of the bituminous mixture
- Combined aggregate (virgin aggregate and RAP aggregate) and mineral admixture content (P_{sa})
- Calculated maximum theoretical specific gravity (G_{mm}) and density (pcf)
- Bulk specific gravity (G_{mb}) and bulk density (pcf) of Marshall specimens
- Percent effective voids (V_a)
- Percent voids in mineral aggregate (VMA)
- Dust/Bitumen Ratio
- Percent absorbed asphalt (P_{ba})
- Effective specific gravity of the combined aggregate (virgin aggregate and RAP aggregate) and mineral admixture (G_{se})
- Percent effective asphalt binder content (P_{be})
- Marshall stability (nearest 10 pounds)
- Marshall flow (0.01 inch)
- Immersion Compression wet strength (psi)
- Immersion Compression dry strength (psi)
- Index of retained strength

16.1.16 Mix Design Summary [The Mix Design Summary shall contain the information shown in Figure 8. (Pages 1 and 2 of an example Mix Design Summary for an Asphaltic Concrete Marshall Mix Design with RAP.)]

Example of Composite #1
(Virgin Aggregate and RAP Aggregate)

Material	Virgin Aggregate (75.0%)				RAP Aggregate (25.0%)		Composite		Specifications ADOT 416 (3/4 Inch Special Mix)	
	Washed Crusher Fines	Crusher Fines	3/8 Inch	3/4 inch	RAP 1 (Fine)	RAP 2 (Coarse)				
Percent used in composite	35.0	13.0	8.0	19.0	15.0	10.0	Without Admix	With Admix *	Without Admix	With Admix
Sieve	Gradation – Percent Passing									
1”	100.0	100.0	100.0	100.0	100.0	100.0	100	100	100	100
3/4”	100.0	100.0	100.0	82.0	100.0	100.0	97	97	90 - 100	90 - 100
1/2”	100.0	100.0	100.0	13.6	100.0	63.0	80	80		
3/8”	100.0	100.0	100.0	4.0	100.0	10.5	73	73	62 - 77	62 - 77
1/4”	100.0	100.0	59.0	1.6	93.3	8.0	68	68		
#4	97.1	98.8	22.5	1.6	77.6	6.0	61	62		
#8	60.8	70.1	1.3	1.5	66.1	5.0	41	42	37 - 46	38 - 47
#10	58.8	68.1	1.2	1.5	43.6	4.5	37	37		
#16	33.3	45.1	1.0	1.5	40.3	4.0	24	25		
#30	19.4	31.3	1.0	1.5	31.4	3.5	16	17		
#40	13.9	25.9	0.9	1.4	23.7	3.0	12	13	10 - 18	11 - 19
#50	10.0	22.0	0.9	1.4	20.0	2.5	10	11		
#100	5.5	17.0	0.8	1.4	16.6	2.0	7	8		
#200	3.3	8.4	0.7	1.2	10.8	1.5	4.3	5.2	1.5 - 4.5	2.5 - 6.0

* 1.0 percent admixture, by weight of the total aggregate (virgin aggregate and RAP aggregate), is used in this example.

FIGURE 1

Example of Batch Sheet #1
(For Composite #1)
(Virgin Aggregate and RAP Aggregate)

MATERIAL	SIEVE	INDIV. % RET.	ACCUM. % RET.	FRACTURED COARSE AGGREGATE PARTICLES [Plus #4] (Virgin Agg. and RAP Agg.) (500 grams)	PERCENT CARBONATES [Plus #4] (Virgin Agg. and RAP Agg.) (300 grams)	ABRASION [Type B] (Virgin Agg.) (5000 grams)	ABRASION [Type B] (RAP Agg.) (5000 grams)
				ACCUMULATIVE WEIGHT (grams)			
Virgin Aggregate Washed Crusher Fines (35.0%)	#4	1.015	1.015	13	8	---	---
	#8	12.705	13.720	---	---	---	---
	- #8	21.280	35.000	---	---	---	---
Virgin Aggregate Crusher Fines (13.0%)	#4	0.156	35.156	15	9	---	---
	#8	3.731	38.887	---	---	---	---
	- #8	9.113	48.000	---	---	---	---
Virgin Aggregate 3/8 Inch (8.0%)	1/4”	3.280	51.280	57	34	---	---
	#4	2.920	54.200	95	57	---	---
	#8	1.696	55.896	---	---	---	---
	- #8	0.104	56.000	---	---	---	---
Virgin Aggregate 3/4 Inch (19.0%)	3/4”	3.420	59.420	139	83	---	---
	1/2”	12.996	72.416	306	184	2500	---
	3/8”	1.824	74.240	330	198	5000	---
	1/4”	0.456	74.696	336	201	---	---
	#8	0.019	74.715	---	---	---	---
	- #8	0.285	75.000	---	---	---	---
RAP Aggregate 1 (Fine RAP) (15.0%)	1/4”	1.005	76.005	349	209	---	---
	#4	2.355	78.360	379	227	---	---
	#8	1.725	80.085	---	---	---	---
	- #8	9.915	90.000	---	---	---	---
RAP Aggregate 2 (Coarse RAP) (10.0%)	1/2”	3.700	93.700	427	256	---	2500
	3/8”	5.250	98.950	494	297	---	5000
	1/4”	0.250	99.200	497	298	---	---
	#4	0.200	99.400	500	300	---	---
	#8	0.100	99.500	---	---	---	---
	- #8	0.500	100.000	---	---	---	---

FIGURE 2

17. ADJUSTED PERCENTAGE FOR EACH VIRGIN AGGREGATE STOCKPILE

17.1 In order to develop the data for Composite #2, Equations 18 and 19 are used to calculate the adjusted percentage for each virgin aggregate stockpile, as shown in Figure 3.

Equation 18: $P_{sv} = P_{sv1} + P_{sv2} + ... + P_{svn}$

Where: P_{sv} = Sum of the original individual virgin aggregate stockpile percentages from Composite #1.

$P_{sv1}, P_{sv2}, P_{svn}$ = The original individual virgin aggregate stockpile percentages from Composite #1.

Example:

$P_{sv1} = 35.0$
$P_{sv2} = 13.0$
$P_{sv3} = 8.0$
$P_{sv4} = 19.0$

$P_{sv} = 35.0 + 13.0 + 8.0 + 19.0 = 75.0$

Equation 19: $P_{svcn} = \frac{P_{svn}}{P_{sv}} \times 100$

Where: P_{svcn} = Adjusted individual virgin aggregate stockpile percentages in Composite #2 (as a percentage of virgin aggregates only).

P_{svn} = The original individual virgin aggregate stockpile percentages from Composite #1.

P_{sv} = Sum of the original individual virgin aggregate stockpile percentages from Composite #1.

Example: (for Washed Crusher Fines)

$P_{sv} = 75.0$
$P_{sv1} = 35.0$

$$P_{svc1} = \frac{35.0}{75.0} \times 100 = 46.667$$

Example: (for Crusher Fines)

$P_{sv} = 75.0$
$P_{sv2} = 13.0$

$$P_{svc2} = \frac{13.0}{75.0} \times 100 = 17.333$$

Example: (for 3/8 Inch)

$P_{sv} = 75.0$
$P_{sv3} = 8.0$

$$P_{svc3} = \frac{8.0}{75.0} \times 100 = 10.677$$

Example: (for 3/4 Inch)

$P_{sv} = 75.0$
$P_{sv4} = 19.0$

$$P_{svc4} = \frac{19.0}{75.0} \times 100 = 25.333$$

Example of Composite #2
(Virgin Aggregate)

Material	Washed Crusher Fines	Crusher Fines	3/8 Inch	3/4 inch	Composite	
Original individual virgin aggregate stockpile percentages used in Composite #1.	35.0	13.0	8.0	19.0		
	(Total = 75.0%)					
Adjusted individual virgin aggregate stockpile percentages.	46.667	17.333	10.667	25.333	Without Admix	With Admix *
	(Total = 100%)					
Sieve	Gradation – Percent Passing					
1”	100.0	100.0	100.0	100.0	100	100
3/4”	100.0	100.0	100.0	82.0	95	95
1/2”	100.0	100.0	100.0	13.6	78	78
3/8”	100.0	100.0	100.0	4.0	76	76
1/4”	100.0	100.0	59.0	1.6	71	71
#4	97.1	98.8	22.5	1.6	65	65
#8	60.8	70.1	1.3	1.5	41	42
#10	58.8	68.1	1.2	1.5	40	41
#16	33.3	45.1	1.0	1.5	24	25
#30	19.4	31.3	1.0	1.5	15	16
#40	13.9	25.9	0.9	1.4	11	12
#50	10.0	22.0	0.9	1.4	9	10
#100	5.5	17.0	0.8	1.4	6	7
#200	3.3	8.4	0.7	1.2	3.4	4.7

* The weight of admixture used in the mix is based on the weight of the total aggregate (virgin aggregate and RAP aggregate). As shown in Composite #1, the percent admixture, by weight of the total aggregate, used in this example is 1.0 percent. However, since Composite #2 is for virgin aggregate only (but will contain all of the admixture), to correctly calculate the composite gradation with admixture the percent of admixture must be adjusted for the percent of RAP aggregate used in the mix (25.0% in this example). The adjusted percent of admixture is determined by dividing “100” by the percent of virgin aggregate (75.0 in this example). The resultant value (1.33 for this example) is the adjusted percent of admixture used to calculate the composite gradation with admixture.

$$\%\,\text{passing (with admix)} = \left[\frac{(\%\,\text{passing without admix}) + (\text{adjusted percent of admixture})}{100 + (\text{adjusted percent of admixture})}\right] \text{x } 100$$

Example for the No. 200 sieve:

$$\%\,\text{passing (with admix)} = \left[\frac{3.4 + 1.33}{100 + 1.33}\right] \text{ x } 100 = 4.7$$

FIGURE 3

Example of Batch Sheet #2
(For Composite #2)
(Virgin Aggregate)

MATERIAL	SIEVE	INDIV. % RET.	ACCUM. % RET.	COARSE SPECIFIC GRAVITY [Plus #4] (4000 grams)	FINE SPECIFIC GRAVITY [Minus #4] (1200 grams)	SAND EQUIVALENT [Minus #4] (600 grams)	UNCOMPACTED VOID CONTENT [Minus #8] (500 grams)	MINUS NO. 8 MAKE-UP MATERIAL (500 grams)
				ACCUMULATIVE WEIGHT (grams)				
Virgin Aggregate Washed Crusher Fines (Adjusted = 46.667%)	#4	1.353	1.353	156	---	---	---	---
	#8	16.940	18.293	---	312	156	---	---
	- #8	28.374	46.667	---	833	417	346	346
Virgin Aggregate Crusher Fines (Adjusted = 17.333%)	#4	0.208	46.875	180	---	---	---	---
	#8	4.975	51.850	---	925	463	---	---
	- #8	12.150	64.000	---	1148	574	494	494
Virgin Aggregate 3/8 Inch (Adjusted = 10.667%)	1/4”	4.374	68.374	683	---	---	---	---
	#4	3.893	72.267	1131	---	---	---	---
	#8	2.261	74.528	---	1190	595	---	---
	- #8	0.139	74.667	---	1193	596	495	495
Virgin Aggregate 3/4 Inch (Adjusted = 25.333%)	3/4”	4.560	79.227	1656	---	---	---	---
	1/2”	17.328	96.555	3650	---	---	---	---
	3/8”	2.432	98.987	3930	---	---	---	---
	1/4	0.608	99.595	4000	---	---	---	---
	#8	0.025	99.620	---	---	---	---	---
	- #8	0.380	100.000	---	1200	600	500	500

FIGURE 4

18. ADJUSTED PERCENTAGE FOR EACH RAP STOCKPILE

18.1 In order to develop the data for Composite #3, Equation 20 is used to calculate the adjusted percentage for each RAP stockpile, as shown in Figure 5.

Equation 20: $$P_{rcn} = \frac{P_{ran}}{1 - \frac{P_{brn}}{100}}$$

Where: P_{rcn} = Adjusted individual RAP stockpile percentages (includes RAP binder).
P_{ran} = Percent of each RAP aggregate used (Determined from Composite #1).
P_{brn} = Binder content of the material from each RAP stockpile.

Example: For RAP Stockpile 1 (Fine RAP)

$P_{ra1} = 15.0$
$P_{br1} = 5.82$

$$P_{rc1} = \frac{15.0}{1 - \frac{5.82}{100}} = 15.927$$

Example: For RAP Stockpile 2 (Coarse RAP)

$P_{ra2} = 10.0$
$P_{br2} = 3.43$

$$P_{rc2} = \frac{10.0}{1 - \frac{3.43}{100}} = 10.355$$

Example of Composite #3
(Virgin Aggregate and Dry Screened RAP)

Material	Virgin Aggregate (75.0%)				Dry Screened RAP (26.282%)		Composite Without Admix **
	Washed Crusher Fines	Crusher Fines	3/8 Inch	3/4 inch	RAP 1 (Fine) (% Binder = = 5.82) *	RAP 2 (Coarse) (% Binder = 3.43) *	
Percent used in composite	35.0	13.0	8.0	19.0	15.927	10.355	Total = 101.282
Sieve	Gradation - Percent Passing						
1”	100.0	100.0	100.0	100.0	100.0	100.0	101
3/4”	100.0	100.0	100.0	82.0	100.0	94.4	97
1/2”	100.0	100.0	100.0	13.6	100.0	57.1	80
3/8”	100.0	100.0	100.0	4.0	100.0	13.7	74
1/4”	100.0	100.0	59.0	1.6	68.1	8.0	65
#4	97.1	98.8	22.5	1.6	54.5	4.9	58
#8	60.8	70.1	1.3	1.5	24.8	2.2	35

* By weight of Dry Screened RAP

** The composite gradation without admixture includes the contribution of binder in the Dry Screened RAP [as indicated by the total percent of Dry Screened RAP (26.282%), the total percent of Virgin Aggregate and Dry Screened RAP used in the composite (101.282%), and the percent passing the 1 inch sieve (101%)].

FIGURE 5

Example of Batch Sheet #3
(For Composite #3)
(Virgin Aggregate and Dry Screened RAP)

MATERIAL	SIEVE	INDIVIDUAL PERCENT RETAINED	ACCUMULATIVE PERCENT RETAINED	RICE (3000 grams) [1]	MARSHALL (3300 grams) [1]	IMC (3400 grams) [1]
				ACCUMULATIVE WEIGHT (grams) [2] and [3]		
VIRGIN AGGREGATE (75.0%)						
Washed Crusher Fines (35.0%)	#4	1.015	1.015	30	33	35
	#8	12.705	13.720	412	453	466
	- #8	21.280	35.000	1050	1155	1190
Crusher Fines (13.0%)	#4	0.156	35.156	1055	1160	1195
	#8	3.731	38.887	1167	1283	1322
	- #8	9.113	48.000	1440	1584	1632
3/8 Inch (8.0%)	1/4"	3.280	51.280	1538	1692	1744
	#4	2.920	54.200	1626	1789	1843
	#8	1.696	55.896	1677	1845	1900
	- #8	0.104	56.000	1680	1848	1904
3/4 Inch (19.0%)	3/4"	3.420	59.420	1783	1961	2020
	1/2"	12.996	72.416	2172	2390	2462
	3/8"	1.824	74.240	2227	2450	2524
	1/4"	0.456	74.696	2241	2465	2540
	#8	0.019	74.715	---	2466	---
	- #8	0.285	75.000	2250	2475	2550
Weight of Mineral Admixture (Type IP Cement) [1.0%, by weight of Virgin Aggregate and RAP Aggregate]				30	33	34
Total weight of Virgin Aggregate and Mineral Admixture				2280	2508	2584
DRY SCREENED RAP (26.282%)						
RAP 1 (Fine) (15.927%)	1/4"	5.081	5.081	152	168	173
	#4	2.166	7.247	217	239	246
	#8	4.730	11.977	359	395	407
	- #8	3.950	15.927	478	526	542
RAP 2 (Coarse) (10.355%)	3/4"	0.580	16.507	495	545	561
	1/2"	3.862	20.369	611	672	693
	3/8"	4.494	24.863	746	820	845
	1/4"	0.590	25.453	764	840	865
	#4	0.321	25.774	773	851	876
	#8	0.280	26.054	782	860	886
	- #8	0.228	26.282	788	867	894
Total weight of Virgin Aggregate and Dry Screened RAP				3038	3342	3444
Total weight of Virgin Aggregate, Dry Screened RAP, and Mineral Admixture				3068	3375	3478

RICE (3150 grams from each Dry Screened RAP stockpile)		
Accumulative Percent Retained	Accumulative Percent Retained (Adjusted to 100%)	**Accumulative Weight (grams) [4]**
5.081	31.902	1005
7.247	45.501	1433
11.977	75.199	2369
15.927	100.000	3150
0.580	5.601	176
4.442	42.897	1351
8.936	86.296	2718
9.526	91.994	2898
9.847	95.094	2995
10.127	97.798	3081
10.355	100.000	3150

[1] Desired Weight of Virgin Aggregate and RAP Aggregate.

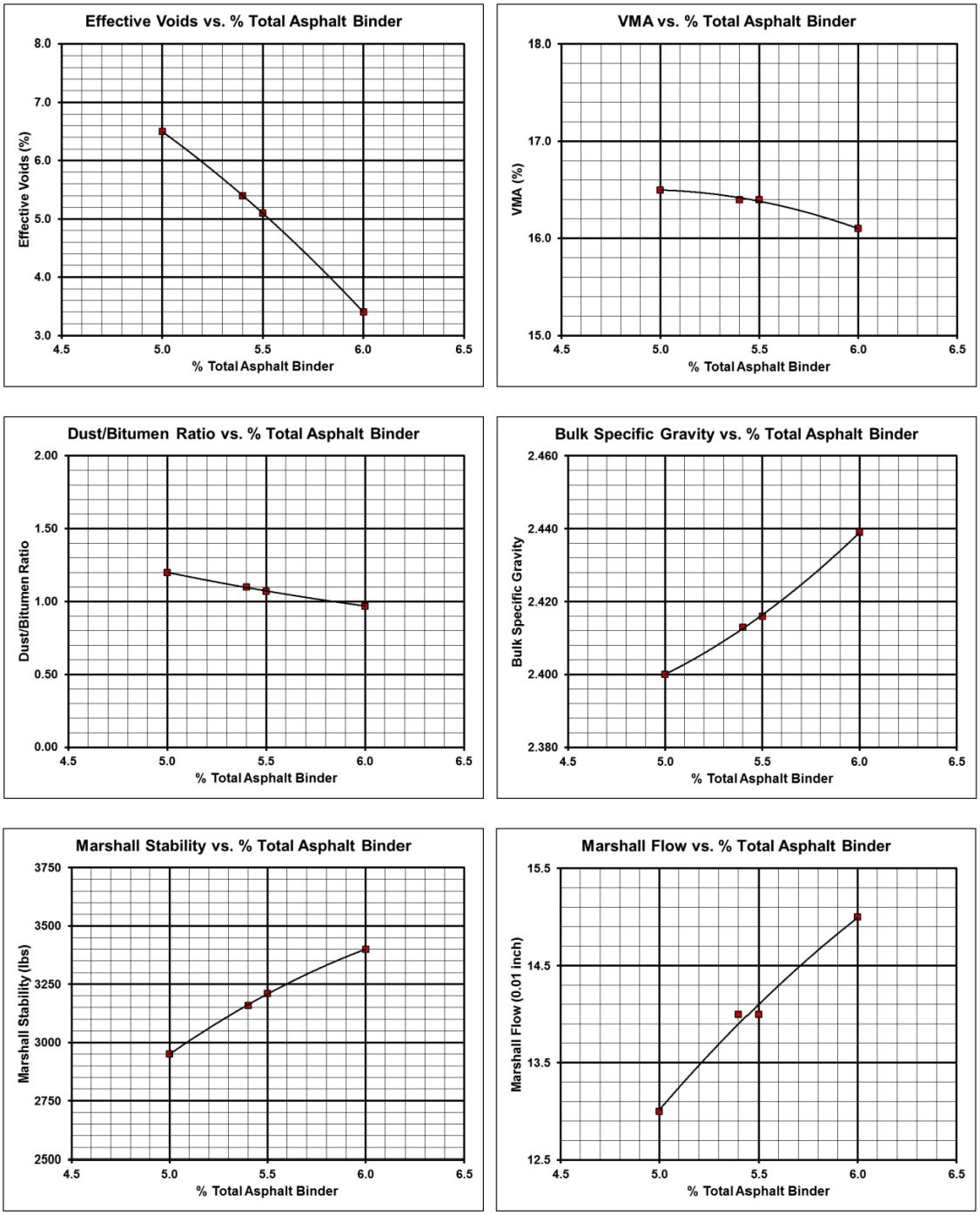
$$[2]\quad \begin{bmatrix}\text{Accumulative Wt.}\\ \text{for each sieve}\\ \text{(Virgin Agg.)}\end{bmatrix} = \begin{pmatrix}\text{Desired Weight}\\ \text{of Virgin Agg.}\\ \text{and RAP Agg.}\end{pmatrix} \times \left(\frac{\text{Accumlative \% Retained for each sieve (Virgin Agg.)}}{100}\right)$$

$$[3]\quad \begin{bmatrix}\text{Accumulative Wt.}\\ \text{for each sieve}\\ \text{(Dry Screened RAP)}\end{bmatrix} = \begin{pmatrix}\text{Desired Weight}\\ \text{of Virgin Agg.}\\ \text{and RAP Agg.}\end{pmatrix} \times \left(\frac{\text{Accumlative \% Retained for each sieve (Dry Screened RAP)}}{100}\right)$$

$$[4]\quad \begin{bmatrix}\text{Accumulative Wt. for each sieve}\\ \text{for Rice from each Dry}\\ \text{Screened RAP Stockpile}\end{bmatrix} = \begin{pmatrix}\text{Accumulative \% Retained (Adjusted}\\ \text{to 100\%) for each sieve from each}\\ \text{Dry Screened RAP Stockpile}\end{pmatrix} \times 3000$$

FIGURE 6

Example Plots of Effective Voids, VMA, Dust/Bitumen Ratio, Bulk Specific Gravity, Marshall Stability, and Marshall Flow versus Percent Total Asphalt Binder Content



The above graphs are for illustrative purposes only. Straight-line interpolation, as specified in Subsections 13.3 and 13.3.1, is used for mix design calculations.

FIGURE 7

Asphaltic Concrete Marshall Mix Design with RAP
Example Mix Design Summary (Page 1 of 2)

Contractor: Best Paving Contractors, Inc.	**Date:** February 22, 2013
ADOT Project Number: STP-999-Z(999)A	**Mix Design Laboratory:** XYZ Testing Laboratories
ADOT TRACS Number: H999901C	**Mix Design Engineer:** Raul "RAP MAN" Raponi
Project Name: Nowhere - Somewhere	**Asphalt Binder Specified in Special Provisions:** PG 76-16
Mix Designation: ADOT 416 (3/4 Inch Special Mix with RAP)	**Virgin Asphalt Binder Required by Mix Design:** PG 76-22

COMPOSITE GRADATION:

Virgin Aggregate (75.0%)	Percent Used
Washed Crusher Fines	35.0
Crusher Fines	13.0
3/8 Inch	8.0
3/4 Inch	19.0
RAP Aggregate (25.0 %)	
RAP 1 (Fine)	15.0
RAP 2 (Coarse)	10.0
Mineral Admixture (1.0%)	
Type IP Cement	1.0

Sieve Size	Percent Passing w/o Admix	Percent Passing w/ Admix	Specifications	
			Without Admix	With Admix
1"	100	100	100	100
3/4"	97	97	90 - 100	90 - 100
1/2"	80	80		
3/8"	73	73	62 - 77	62 - 77
1/4"	68	68		
#4	61	62		
#8	41	42	37 - 46	38 - 47
#10	37	37		
#16	24	25		
#30	16	17		
#40	12	13	10 - 18	11 - 19
#50	10	11		
#100	7	8		
#200	4.3	5.2	1.5 – 4.5	2.5 – 6.0

DESIGN DATA:

% Total Binder	5.0	**5.4**	5.5	6.0	Spec.
Bulk Specific Gravity	2.400	**2.413**	2.416	2.439	
Bulk Density (lb./cu. ft)	149.5	**150.3**	150.5	151.9	
Stability (lb.)	2950	**3160**	3210	3400	2000 Min.
Flow (0.01 inch)	13	**14**	14	15	8 - 16
Effective Voids (%)	6.5	**5.4**	5.1	3.4	5.3 – 5.7
VMA (%)	16.5	**16.4**	16.4	16.1	15.0 – 18.0
Effective Asphalt, Total Mix (%)	4.34	**4.74**	4.84	5.34	
Dust/Bitumen Ratio	1.20	**1.10**	1.07	0.97	0.6 – 1.2
Absorbed Asphalt (%)	0.70				0 – 1.0

Max. Theoretical Specific Gravity at 5.4% Total Binder = 2.550

Max. Theoretical Density at 5.4% Total Binder = 158.9 lb/cu. ft.

RECOMMENDED TOTAL BINDER CONTENT:	**5.40%***
ADDED VIRGIN BINDER CONTENT:	**4.20%***
CONTRIBUTED RAP BINDER CONTENT:	**1.20%***

*By weight of total mix

PERCENT RAP BINDER (Equation 7)**:**	**22.24%***
PERCENT VIRGIN BINDER (100 - % RAP Binder)**:**	**77.76%***

*By weight of total binder in the mix

IMMERSION COMPRESSION – ARIZ 802: 5.4% Total Binder, 1.0% Type IP Cement		Spec.
Dry Strength (psi)	269	-----
Wet Strength (psi)	197	150 Min.
Index of Retained Strength (%)	73	60 Min.

PERCENT RAP AGGREGATE:	**25.0%***
PERCENT VIRGIN AGGREGATE:	**75.0%***

*By weight of total aggregate in the mix

RAP 1 (FINE) PERCENT RAP BINDER:	5.82%
RAP 2 (COARSE) PERCENT RAP BINDER:	3.43%

RAP 1 (FINE) RAP BINDER GRADE (ACTUAL):	93-8
RAP 2 (COARSE) RAP BINDER GRADE (ACTUAL):	91-9

RAP 1 (FINE) RAP BINDER SPECIFIC GRAVITY:	1.049 @ 77°F
RAP 2 (COARSE) RAP BINDER SPECIFIC GRAVITY:	1.052 @ 77°F

AGGREGATE PROPERTIES: (See page 2.)

ADDITIONAL DATA / INFORMATION:

Source of RAP: Existing Project Roadway

Source of Virgin Aggregate: Excellent Aggregate Materials, Inc.

Source of Virgin Asphalt Binder: Supreme Asphalt Suppliers, Inc.

Source of Mineral Admixture: Superior Hydraulic Cements, Inc.

Virgin Asphalt Binder Type/Specific Gravity: PG 76-22/1.026 @ 77°F

Mineral Admixture Type/Specific Gravity: Type IP Cement/3.00

Blended Virgin Binder and RAP Binder Grade: PG 76-16

Blended Virgin Binder and RAP Binder Specific Gravity: 1.031 @ 77°F

Laboratory Mixing Temperature Range: 304 °F to 314 °F

Laboratory Compaction Temperature Range: 286 °F to 293 °F

Actual Laboratory Mixing Temperature Used: 309 °F

Actual Laboratory Compaction Temperature Used: 290 °F

REMARKS:

FIGURE 8 (Continued on Next Page)

Asphaltic Concrete Marshall Mix Design with RAP
Example Mix Design Summary (Page 2 of 2)

AGGREGATE PROPERTIES:

Test Characteristic	Virgin Aggregate				RAP Aggregate				Combined Virgin Aggregate and RAP Aggregate		
	Fine	Coarse	Combined	Spec.	RAP 1 (Fine)	RAP 2 (Coarse)	Combined	Spec.	Without Admixture.	With Admixture.	Spec.
Bulk OD Specific Gravity	2.797	2.789	2.794	2.350 - 2.850	2.660	2.403	---	---	---	2.732	---
SSD Specific Gravity	2.828	2.821	2.826	---	2.690	2.430	---	---	---	2.762	---
Apparent Specific Gravity	2.887	2.883	2.885	---	2.742	2.470	---	---	---	2.818	---
Absorption	1.11	1.17	1.13	0 -2.5%	1.13		---	---	---	1.13	---
Effective Specific Gravity	---	---	---	---	2.694	2.431	---	---	---	2.784	---
Sand Equivalent	76			55 Min.	---	---	---	---	---	---	---
Uncompacted Void Content	48.6			45.0 Min.	---	---	---	---	---	---	---
Carbonates	---	---	---	---	---	---	---	---	4	---	20% Max.
Fractured Coarse Aggregate Particles											
At least one fractured face	---	---	---	---	---	---	---	---	98	---	92% Min
At least two fractured faces	---	---	---	---	---	---	---	---	97	---	85% Min.
Abrasion	(Type B)				(Type B)						
100 Rev., % loss	3			9 Max.	5			9 Max.	---	---	---
500 Rev., % loss	14			40 Max.	28			40 Max.	---	---	---

FIGURE 8 (Continued from Previous Page)

APPENDIX

ROUNDING PROCEDURE

The following describes the rounding procedure which is to be used for rounding numbers to the required degree of accuracy:

1. Except as specified in Section 2 below, the following procedure will apply. This procedure correlates with the "built-in" rounding method normally utilized by calculators and computers.

1.1 When the figure next beyond the last figure or place to be retained is less than 5, the figure in the last place retained is left unchanged.

Examples:
Rounding 2.6324 to the nearest thousandth is 2.632
Rounding 7843.343 to the nearest hundredth is 7843.34
Rounding 4928.22 to the nearest tenth is 4928.2
Rounding 7293.1 to the nearest whole number is 7293
Rounding 2042 to the nearest units of 10 is 2040
Rounding 3548 to the nearest units of 100 is 3500
Rounding 8436 to the nearest units of 1000 is 8000

1.2 When the figure next beyond the last figure or place to be retained is 5 or larger, the figure in the last place retained is increased by 1.

Examples:
Rounding 4839.4575 to the nearest thousandth is 4839.458
Rounding 9347.215 to the nearest hundredth is 9347.22
Rounding 8420.35 to the nearest tenth is 8420.4
Rounding 1728.5 to the nearest whole number is 1729
Rounding 3685 to the nearest units of 10 is 3690
Rounding 6650 to the nearest units of 100 is 6700
Rounding 2500 to the nearest units of 1000 is 3000

Rounding 2.6326 to the nearest thousandth is 2.633
Rounding 7843.347 to the nearest hundredth is 7843.35
Rounding 4928.28 to the nearest tenth is 4928.3
Rounding 7293.9 to the nearest whole number is 7294
Rounding 2046 to the nearest units of 10 is 2050
Rounding 3572 to the nearest units of 100 is 3600
Rounding 8634 to the nearest units of 1000 is 9000

1.3 No result shall be rounded more than once.

Example: 3024.5 rounded to the nearest units of 10 will be 3020;

not

3024.5 rounded to 3025, and then rounded again to 3030.

2. The rounding procedure specified in Section 1 above shall be used for all calculations and recording of data in performing materials testing, except when a specific test method cites a method of rounding which differs from this procedure, for example, the sand equivalent test (AASHTO T 176 or Arizona Test Method 242).

3. Compliance will be based upon interpreting the reported results as though they are rounded to the terms (whole numbers, decimals, or fractions reduced to decimals) of the specifications. For example, a value reported as 8.4% shall be considered as having no deviation from specifications that require 4 – 8%. It would however be a deviation for specifications requiring 4.0 – 8.0%.

4. Computers and most electronic calculators automatically carry several decimal places beyond the point of desired accuracy. At times, results of calculations utilizing these values are different than that achieved when calculations are performed utilizing values that have been rounded to the desired degree of accuracy by the above rules. The user is cautioned that the use of a computer or electronic calculator without re-entry of values after rounding, and discarding any figures beyond those needed, may cause unacceptable variations in final results.

METRIC GUIDE

The following information is provided as a guide for utilizing the International System of Units (SI), generally referenced as "metric units". Related information can be found in AASHTO R1 "Metric Practice Guide", and ASTM E380, "Use of the International System of Units (SI)(The Modernized Metric System)".

Included herein are commonly used equivalents and conversions for U.S. Customary Units and Metric Units. It is not the intention of this guide to provide a detailed compilation of such equivalents and conversions. Such lists are available in many publications, including those referenced above.

One common conversion, which is found in many test procedures, is to determine an equivalent temperature in units of either degrees Celsius or degrees Fahrenheit.

Convert degrees Fahrenheit to degrees Celsius by:

$$°C = \frac{5}{9} \times (°F - 32)$$

Convert degrees Celsius to degrees Fahrenheit by:

$$°F = \left[\frac{9}{5} \times °C\right] + 32$$

Under the SI (Metric) system, the base unit for mass is the "kilogram". (Although not technically correct, "weight" is often used in common practice to mean "mass".) The base unit for length is the "meter". The base unit for time is the "second". Primary metric units for area and volume are the "square meter" and the "cubic meter", respectively.

In addition to expressing values in the base or primary metric units, other associated metric units are identified and determined by varying the magnitude of the base metric unit by powers of 10. Metric values are commonly shown in scientific notation form, (for example, $1 \times 10^4 = 10{,}000$; $1 \times 10^{-4} = 0.0001$).

Table 1 below gives a listing of prefixes used in the metric system, with their associated powers of ten, and their symbol.

TABLE 1

Prefix	Power of ten	Symbol
*deci	10^{-1}	d
*centi	10^{-2}	c
milli	10^{-3}	m
micro	10^{-6}	μ
nano	10^{-9}	n
pico	10^{-12}	p
femto	10^{-15}	f
atto	10^{-18}	a
*deka	10^{1}	da
*hecto	10^{2}	h
kilo	10^{3}	k
mega	10^{6}	M
giga	10^{9}	G
tera	10^{12}	T
peta	10^{15}	P
exa	10^{18}	E

* Use is to be avoided where practical. When expressing a quantity by a numerical value and a unit, a prefix should preferably be chosen so that the numerical value lies between 0.1 and 1000. In expressing area and volume, the prefixes hecto, deka, deci, and centi may be required, for example, square hectometer, cubic centimeter.

Table 2 below gives the symbols commonly used for various metric units.

TABLE 2

kg = kilogram
g = gram
mg = milligram
m = meter
km = kilometer
cm = centimeter
mm = millimeter
μm = micrometer (micron)
s = second
m^2 = square meter
cm^2 = square centimeter
mm^2 = square millimeter
m^3 = cubic meter
cm^3 or cc = cubic centimeter
mm^3 = cubic millimeter
L = liter
mL = milliliter
Pa = pascal
N = newton
kPa = kilopascal
MPa = megapascal

Table 3 below includes common conversions from the base and primary metric units (kilogram, meter, square meter, and cubic meter) to other associated metric units. Also listed are some common derived metric units.

TABLE 3

1 gram = 0.001 kilogram
1 milligram = 1 x 10^{-6} kilogram
1 milligram = 0.001 gram
1 kilogram = 1000 grams
1 metric ton = 1000 kilograms
1 kilometer = 1000 meters
1 centimeter = 0.01 meter
1 millimeter = 0.001 meter
1 micron (micrometer) = 1 x 10^{-6} meter
1 square kilometer = 1 x 10^{6} square meters
1 square centimeter = 1 x 10^{-4} square meter
1 square millimeter = 1 x 10^{-6} square meter
1 cubic centimeter = 1 x 10^{-6} cubic meter
1 cubic millimeter = 1 x 10^{-9} cubic meter
1 liter = 0.001 cubic meter
1 milliliter = 1 x 10^{-6} cubic meter
1 milliliter = 1 cubic centimeter
1 newton = 1 kg·m/s^2
1 pascal = 1 N/m^2
1 kilopascal = 1000 pascals
1 megapascal = 1 x 10^{6} pascals
1 poise (absolute viscosity) = 0.10 Pa·s
1 centistoke (kinematic viscosity) = 1 mm^2/s or 1 x 10^{-6} m^2/s

Some common U.S Customary units, with their corresponding base and primary metric unit equivalents, are given below in Table 4.

TABLE 4

1 pound (avoirdupois) = 0.453 5924 kilogram
1 ton (2000 lbs.) = 907.1847 kilograms
* 1 inch = 0.0254 meter
* 1 foot = 0.3048 meter
* 1 yard = 0.9144 meter
* 1 mile (5280 feet) = 1609.344 meters
* 1 square inch = 6.4516×10^{-4} square meter
* 1 square foot = 0.092 903 04 square meter
1 square yard = 0.836 1274 square meter
1 cubic inch = $1.638\ 706 \times 10^{-5}$ cubic meter
1 cubic foot = 0.028 316 85 cubic meter
1 cubic yard = 0.764 5549 cubic meter
1 pint (U.S. liquid) = $4.731\ 765 \times 10^{-4}$ cubic meter
1 quart (U.S. liquid) = $9.463\ 529 \times 10^{-4}$ cubic meter
1 gallon (U.S. liquid) = 0.003 785 412 cubic meter

(Exact equivalents are noted with an asterisk.)

Table 5 below lists commonly used conversions for U.S. Customary Units and metric units. Values are shown to the degree of accuracy which generally may be used to achieve satisfactory results. If more accuracy is desired, the values may be derived by using Tables 3 and 4.

TABLE 5

1 kilogram = 2.205 pounds
1 pound = 453.6 grams
1 ounce (avoirdupois) = 28.35 grams
1 ton (2000 lbs) = 0.9072 metric ton
1 meter = 39.37 inches or 3.281 feet
1 kilometer = 0.62 miles
* 1 mil = 0.0254 millimeters or 25.4 micrometers
* 1 inch = 2.54 centimeters or 25.4 millimeters
* 1 foot = 0.3048 meters
* 1 yard = 0.9144 meters
1 mile = 1.61 kilometers
1 square inch = 6.452 cm^2 or 645.16 mm^2
1 square foot = 0.0929 square meters
1 square yard = 0.836 square meters
1 cubic inch = 16.39 cm^3 or 16386 mm^3
1 cubic foot = 0.028 m^3 or 28317 cm^3
1 cubic yard = 0.765 cubic meters
1 liter = 1.06 quarts (U.S. liquid)
1 ounce (U.S. fluid) = 29.574 milliliter
1 pint (U.S. liquid) = 0.47 liter
1 quart (U.S. liquid) = 0.95 liter
1 gallon (U.S. liquid) = 3.79 liters
1 lb/ft^3 = 16.02 kg/m^3
1 kilometer/hour = 0.62 mile/hour
1 mile/hour = 1.61 km/hour
1 pound/square inch = 6.895 kPa
1 pound force = 4.448 newton
1 gallon/square yard = 4.527 $liters/m^2$
1 gallon/ton (2000 lbs.) = 4.173 liters/metric ton
1 gallon/cubic yard = 4.951 $liters/m^3$
1 pound/square yard = 0.542 kg/m^2
1 pound/cubic yard = 0.593 kg/m^3
1 pound/gallon = 0.120 kg/liter
1 cubic yard/square yard = 0.914 m^3/m^2
1 inch/mile = 0.0158 meter/kilometer

(Exact equivalents are noted with an asterisk.)

Table 6 below is from information contained in AASHTO M92 and ASTM E11 "Wire-Cloth Sieves for Testing Purposes", and shows Standard (Metric) and Alternative (U.S. Customary) sieve size designations. As shown, metric size designations are given in mm or μm. (1,000 μm = 1 millimeter)

8 inch diameter sieve = 203.2 mm diameter sieve
12 inch diameter sieve = 304.8 mm diameter sieve

TABLE 6

Sieve Designation		Sieve Designation	
Standard	Alternate	Standard	Alternate
125 mm	5 in.	2.36 mm	No. 8
106 mm	4.24 in.	2.00 mm	No. 10
100 mm	4 in.	1.70 mm	No. 12
90 mm	3-1/2 in.	1.40 mm	No. 14
75 mm	3 in.	1.18 mm	No. 16
63 mm	2-1/2 in.	1.00 mm	No. 18
53 mm	2.12 in.	850 μm	No. 20
50 mm	2 in.	710 μm	No. 25
45 mm	1-3/4 in.	600 μm	No. 30
37.5 mm	1-1/2 in.	500 μm	No. 35
31.5 mm	1-1/4 in.	425 μm	No. 40
26.5 mm	1.06 in.	355 μm	No. 45
25.0 mm	1 in.	300 μm	No. 50
22.4 mm	7/8 in.	250 μm	No. 60
19.0 mm	3/4 in.	212 μm	No. 70
16.0 mm	5/8 in.	180 μm	No. 80
13.2 mm	0.530 in.	150 μm	No. 100
12.5 mm	1/2 in.	125 μm	No. 120
11.2 mm	7/16 in.	106 μm	No. 140
9.5 mm	3/8 in.	90 μm	No. 170
8.0 mm	5/16 in.	75 μm	No. 200
6.7 mm	0.265 in.	63 μm	No. 230
6.3 mm	1/4 in.	53 μm	No. 270
5.6 mm	No. 3-1/2	45 μm	No. 325
4.75 mm	No. 4	38 μm	No. 400
4.00 mm	No. 5	32 μm	No. 450
3.35 mm	No. 6	25 μm	No. 500
2.80 mm	No. 7	20 μm	No. 635

TABLE 7

SI* (METRIC) CONVERSION FACTORS

(Approximate equivalents, except as noted)**

CONVERSIONS TO SI UNITS					CONVERSIONS FROM SI UNITS				
Abbrev./Symbol	*When you know*	*Multiply by*	*To find*	*Symbol*	*Symbol*	*When you know*	*Multiply by*	*To find*	*Abbrev./Symbol*
LENGTH					**LENGTH**				
in.	inches	25.4**	millimeters	mm	mm	millimeters	0.03937	inches	in.
ft.	feet	0.3048**	meters	m	m	meters	3.28	feet	ft.
yd.	yards	0.9144**	meters	m	m	meters	1.09	yards	yd.
mi.	miles	1.61	kilometers	km	km	kilometers	0.621	miles	mi.
AREA					**AREA**				
sq. in. or in^2	square inches	645.2	square millimeters	mm^2	mm^2	square millimeters	0.0016	square inches	sq. in. or in^2
sq. ft. or ft^2	square feet	0.093	square meters	m^2	m^2	square meters	10.764	square feet	sq. ft. or ft^2
sq. yd. or yd^2	square yards	0.836	square meters	m^2	m^2	square meters	1.19	square yards	sq. yd. or yd^2
	acres	0.405	hectares	ha	ha	hectares	2.47	acres	
sq. mi. or mi^2	square miles	2.59	square kilometers	km^2	km^2	square kilometers	0.386	square miles	sq. mi. or mi^2
VOLUME					**VOLUME**				
fl. oz.	fluid ounces	29.57	milliliters	mL	mL	millimeters	0.034	fluid ounces	fl. oz.
gal.	gallons (liquid)	3.7854	liters***	L	L	liters***	0.264	gallons (liquid)	gal.
cu. ft. or ft^3	cubic feet	0.028	cubic meters	m^3	m^3	cubic meters	35.315	cubic feet	cu. ft. or ft^3
cu. yd. or yd^3	cubic yards	0.765	cubic meters	m^3	m^3	cubic meters	1.31	cubic yards	cu. yd. or yd^3
MASS					**MASS**				
oz.	ounces	28.35	grams	g	g	grams	0.035	ounces	oz.
lb.	pounds	0.454	kilograms	kg	kg	kilograms	2.205	pounds	lb.
T	short tons (2000 lb)	0.907	metric tons****	t	t	metric tons****	1.102	short tons (2000 lb)	T
T	short tons (2000 lb)	0.907	megagrams****	Mg	Mg	megagrams****	1.102	short tons (2000 lb)	T

* SI is the symbol for the International System of Units.

** Exact equivalent.

*** Metric volumes greater than 1000 liters should be shown in m^3. The following conversion factors are helpful in making necessary conversions:
1 liter = 0.001 cubic meter; 1 cubic meter = 264.17 gallons (liquid).

**** 1 metric ton = 1000 kilograms = 1,000,000 grams = 1 Mg.

EQUIPMENT CALIBRATION AND VERIFICATION

Equipment and apparatus used in testing materials must be calibrated or verified for accuracy on a regular basis to assure the equipment is giving reliable results.

Materials Group, Quality Assurance Section, has developed a listing of requirements, frequency, and the applicable test methods for the calibration and verification of various types of equipment. The listing provided is not intended to address the calibration or verification of all equipment. Appendix A3 contains the following figures:

Figure Number	Figure Title
1	General Laboratory Testing Equipment
2	Aggregates Testing Equipment
3	Asphalt Binder/Cutback Asphalt/Emulsified Asphalt Testing Equipment
4	Asphalt Mixtures Testing Equipment
5	Soils Testing Equipment
6	Soils Testing Equipment (Continued)
7	Portland Cement Concrete Testing Equipment
8	Metal Testing Equipment
9	Equipment Maintenance

Test methods and standards referenced in the figures contained in Appendix A3 are identified as follows:

AZ	Arizona Test Methods
T, M, and R	AASHTO Test Methods and Standards
C, D, and E	ASTM Test Methods and Standards

Related information on the calibration and verification of apparatus can be found in AASHTO R 18, "Establishing and Implementing a Quality System for Construction Materials Testing Laboratories".

Maximum frequency intervals shown in the following figures may be reduced based on specific laboratory conditions, deterioration of equipment, frequency of use, and other contributing factors.

Equipment and apparatus that may be affected by movement must be recalibrated after relocation.

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GENERAL LABORATORY TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)
Mechanical Shakers	Check Sieving Thoroughness.	12
Ovens	Standardize Thermometric Device.	12
Sieves	Fine Sieves (openings < No.4) Check Physical Condition --- Coarse Sieves (openings ≥ No.4) Check Physical Condition and Dimensions of Openings.	12
Specimen Molds	Check Critical Dimensions.	12
General Purpose Balances and Masses	Standardize	12
Thermometers, including Digital Thermistors	Standardize	12
Analytical Balances and Masses	Calibrate	12
Calipers	Standardize	12
Vacuum/Pressure Measurement Devices (Bourdon Gauges, Pressure Manometer, and Electronic Pressure Transducers)	Standardize	12
Length Measurement Devices (Dial Indicators, LDT's, LVDT's, and Extensometers)	Standardize	12
Compression, Loading, or Tensile Testing Devices	Standardize	12
Constant Temperature Baths	Check Temperature Settings.	12

FIGURE 1

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AGGREGATES TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Unit Weight Apparatus	Standardize	12	T 19, C 29
Sulfate Oven	Check Rate of Evaporation.	12	T 104, C 88
Sulfate Soundness Sample Containers	Check Physical Condition.	12	T 104, C 88
L.A. Abrasion Machine	Check RPM and Critical Dimensions.	24	T 96, C 131
Steel Balls for Abrasion Machine	Check Individual Weight and Charge Weight.	24	T 96, C 731
Conical Mold and Tamper	Check Critical Dimensions.	24	AZ 211, T 84, C 128

FIGURE 2

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ASPHALT BINDER/CUTBACK ASPHALT/EMULSIFIED ASPHALT TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Saybolt Viscometer	Standardize	36	T 59, D 244, T 72
Timing Devices	Standardize	12	T 49, D 5
Penetrometer Needle	Check Condition and Critical Dimensions.	12	T 49, D 5
Penetrometer	Standardize for Penetration Depth.	12	T 49, D 5
Ductility Apparatus	Check Speed of Travel.	12	T 51, D 113
Elastic Recovery Apparatus	Check Speed of Travel.	12	T 301, D 6084
RTFO Carriage	Check Rotation Speed.	12	T 240, D 2872
Brass Rings and Assembly	Check Critical Dimensions.	12	T 53, D 36
Pycnometers	Check Physical Condition and Standardize Volume.	12	T 228, D 70
Collars and Floats	Check Critical Dimensions.	12	T 50, D 139
Pressurized Aging Vessel	Standardize Temperature and Pressure.	6	R 28, D 6521
Rotational Viscometer	Standardize with Reference Fluid.	6	T 316, D 4402
Dynamic Shear Rheometer (DSR)	Standardize with Reference Fluid.	6	T 315, D 7175
Bending Beam Rheometer (BBR)	Calibrate Masses.	12	T 313, D 6648
Kinematic Viscometer Tubes	Calibrate with Reference Fluid.	36	T 201, D 2170

FIGURE 3

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ASPHALT MIXTURES TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Mechanical Compaction Hammers, Breaking Heads	Check Critical Dimensions, Check Mass of Hammer.	12	AZ 410, AZ 815, T 245, T 283, D 4867, D 6926, D 6927
	Monitor Through Proficiency Sample Program.	Per proficiency sample frequency.	
Manual Compaction Hammers, Breaking Heads	Check Critical Dimensions, Check Mass of Hammer.	12	AZ 410, AZ 815, T 245, T 283, D 4867, D 6926, D 6927
Marshall Stability/Flow Testing Machine	Check Speed of Travel, Verify Load Cell.	12	AZ 410, AZ 422, AZ 815, T 245, T 283, D 4867, D 5581, D 6926, D 6927
Plungers	Check Critical Dimensions.	12	AZ 802, T 165, T 176, D 1074
Gyratory Compactor	Standardize Ram Pressure, Frequency of Gyration, LVDT.	12	T 312, D 6925
Gyratory Compactor	Standardize External or Internal Angle of Gyration.	12	T 312, D 6925
Ram Face, Base Plate Face	Check Critical Dimensions.	12	T 312, D 7115
Ignition Oven Internal Balance	Standardize	12	AZ 427, T 308, D 6307
Rice Flasks	Calibrate Volume.	12	AZ 417, AZ 806, T 209
Nuclear Asphalt Content Gauge	Check Variability using 3 - Point Calibration.	12	AZ 421

FIGURE 4

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SOILS TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Mechanical Compactor	Check Rammer Face Diameter and Height of Drop.	12	AZ 225, AZ 226, AZ 232, AZ 245, AZ 246, T 99, T 134, T 135, T 180, D 558, D 559, D 698, D 1557
	Monitor Through Proficiency Sample Program.	Per proficiency sample frequency.	
Manual Hammer	Check Critical Dimensions.	12	AZ 225, AZ 226, AZ 232, AZ 245, AZ 246, T 99, T 134, T 135, T 180, D 558, D 559, D 698, D 1557
Liquid Limit Device	Check Wear and Critical Dimensions.	12	T 89, D 4318
Grooving Tool	Check Critical Dimensions.	12	T 89, D 4318
Hydrometers	Check Critical Dimensions.	24	T 88, D 422
Straightedge	Check Dimensions and Planeness of Edge.	12	AZ 225, AZ 245, T 99, T 134, T 135, T 136, T 180, D 558, D 559, D 560, D 698, D 1557
Weighted Foot Assembly	Check Mass.	12	AZ 242, T 176, D 2419
CA Kneading Compactor	Standardize	24	T 190, D 2844
Standard Metal Specimen	Check Outside Diameter.	12	T 190, D 2844
Metal Follower	Check Diameter.	12	T 190, D 2844

FIGURE 5

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SOILS TESTING EQUIPMENT (CONTINUED)

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Vertical Load	Standardize	12	AZ 249, T 216, T 236, D 2435, D 3080, D 4829
Uncompacted Void Content Apparatus	Check Critical Dimensions and Calibrate Volume.	12	AZ 247, C 1252
Resistivity Apparatus	Check Resistivity.	12	AZ 236
pH Meter	Standardize	12	AZ 236, AZ 237
Flat and Elongated Proportional Caliper Device	Check Critical Dimensions.	12	D 4791
Flakiness Index Slotted Sieves	Check Critical Dimensions.	12	AZ 233
Fine Aggregate Specific Gravity Flask	Calibrate Volume.	12	AZ 211, T 84, C 128
Coarse Aggregate Specific Gravity Apparatus	Check Wire Diameter, Basket Type, and Water Tank.	12	AZ 210, T 85, C 127
Speedie Moisture Tester	Verify Scale and Gauge.	6	T 217
Standard Sand	Check Each New Shipment for Conformance to C 778.	- - -	C 778
Sand Cone Density Apparatus	Standardize	12	AZ 229, AZ 230

FIGURE 6

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PORTLAND CEMENT CONCRETE TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Unit Weight Measures	Standardize	12	T 121, C 138
Air Meters (Pressure Type)	Standardize	3 (See Note)	T 152, C 231
Air Meters (Volumetric Type)	Standardize	12 (See Note)	C 173
Note: The individual test methods specify conditions that require restandardization, such as changes in elevation and rough handling.			
Capping Material	Check Strength.	3	T 231, C 617
Slump Cones and Rods	Check Critical Dimensions.	12	T 119, C 143
Single-Use Concrete Cylinder Molds	Check Critical Dimensions of each Shipment.	- - -	T 22, T 23, C 31, C 39
Cylinder Capping Plates	Check Critical Dimensions.	12	T 231, C 617
Recording Thermometer	Standardize	6	C 31, C 39
Autoclave Apparatus	Check Critical Dimensions, Calibrate Valve and Gauge.	12	T 107, M 210, C 151
Rebound Hammer (Swiss Hammer)	Standardize	6	C 805
Moist Room (Fog Room)	Verify Temperature and Humidity with Recording Thermometer.	6	M 201, C 511
Cube Modes and Tampers	Check Critical Dimensions and Physical Condition	30	T 106, C 109

FIGURE 7

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METAL TESTING EQUIPMENT

EQUIPMENT	REQUIREMENT	MAX. INTERVAL (Months)	TEST METHOD
Rockwell Hardness Tester	Standardize	12	E 18

FIGURE 8

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EQUIPMENT CALIBRATION AND VERIFICATION

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EQUIPMENT MAINTENANCE

EQUIPMENT	MAX. INTERVAL (Months)	TEST METHOD
Performance-Graded Binder Equipment	12	R 58, T 240, T 313, T 314, T 315, D 2872, D 6521, D 6648, D 6723, D 7175
Ductilometers	12	T 51, T 300, T 301, D 113, D 6084
Mechanical Marshall Compactors	12	T 245
California Kneading Compactors	12	T 247, T 190, D 1561, D 2844
Gyratory Compactors	12	T 312, D 6925
Mechanical Compactors	12	T 99, T 180, D 698, D 1557
Mechanical Shakers	12	Where Applicable.

NOTE: There may be more items added to the laboratory's list of equipment that require maintenance. Maintenance activities will typically involve lubricating, tightening fittings, cleaning, replacing fluids, checking and replacing damaged or worn parts, etc. These activities will vary based on the type of equipment, how often the equipment is used, the manufacturer's recommendations, etc.

FIGURE 9