ARIZONA DEPARTMENT OF TRANSPORTATION MATERIALS GROUP

1221 NORTH 21ST AVENUE PHOENIX, ARIZONA 85009-3740 PHONE (602) 712- 7231

PRACTICE AND PROCEDURE DIRECTIVE

TO: ALL MANUAL HOLDERS	PPD No. 20a
SUBJECT: GUIDANCE ON THE USE OF RECLAIMED ASPHALT PAVEMENT (RAP) IN ASPHALTIC CONCRETE	EFFECTIVE DATE: April 19, 2013

1. GENERAL

1.1 Reclaimed asphalt pavement (RAP) may be used in asphaltic concrete provided it is allowed per Specification.

1.2 This Practice and Procedure Directive was developed to provide guidance to those involved in the production of asphaltic concrete containing RAP. It assumes the reader has a general understanding of the requirements for mixtures which do not contain RAP.

1.3 References contained herein to "A R I Z 428" are defined as "Arizona Test Method 428".

2. TERMS

2.1 Asphaltic concrete with RAP consists of a mixture of virgin aggregate, virgin binder, RAP, and mineral admixture.

2.1.1 Virgin aggregate consists of mineral aggregate not previously used.

2.1.2 Virgin binder consists of asphalt cement not previously used.

2.1.3 RAP consists of salvaged, milled, pulverized, broken, or crushed asphalt pavement. For purposes of the Specification, RAP is made up of two main components: RAP aggregate and RAP binder.

2.1.3.1 RAP aggregate consists of the aggregate portion of the reclaimed asphalt pavement.

2.1.3.2 RAP binder consists of the binder, or asphalt cement, portion of the reclaimed asphalt pavement.

2.2 When the term "aggregate" is used without being further described as "RAP" or "Virgin", the intended meaning is the total aggregate used in the mixture. Also note that the term "aggregate" is used interchangeably with "mineral aggregate".

2.3 When the term "binder" is used without being further described as "RAP" or "Virgin", the intended meaning is the total binder used in the mixture. Also note that the term "binder" is use interchangeably with "bituminous material", "asphalt cement", and "asphalt".

2.4 The specifications are very deliberate in their use of the terms "RAP" and "Virgin" when describing aggregate or binder. Therefore, it is important that the user be familiar with these definitions and read the specifications carefully.

3. LIMITS ON RAP USAGE

3.1 The amount of RAP material allowed in asphaltic concrete is limited by both a maximum RAP aggregate contribution and a maximum RAP binder contribution to the mixture. In addition, production and testing requirements vary depending on the amount of RAP aggregate and RAP binder in the mixture.

3.1.1 A maximum of 25% RAP aggregate, by weight of total aggregate in the mix, may be used in mixes placed in a lower lift (minimum 2" below finished surface). A maximum of 20% RAP aggregate, by weight of total aggregate in the mix, may be used at all other locations.

3.1.2 A maximum of 25% RAP binder, by weight of total binder in the mix, may be used in mixes placed in a lower lift (minimum 2" below finished surface). A maximum of 20% RAP binder, by weight of total binder in the mix, may be used at all other locations.

3.2 When less than or equal to 15% RAP aggregate is used, by weight of the total aggregate in the mix, all RAP material must pass the 1¼ inch sieve.

3.3 When more than 15% RAP aggregate is used, by weight of the total aggregate in the mix, the RAP must be processed into uniform coarse and fine stockpiles meeting the gradation requirements of the specifications, and such that there will be a minimum amount of fines.

3.4 When less than or equal to 15% RAP binder is used, by weight of the total binder in the mix, no testing is required on the RAP binder properties during the mix design process.

3.5 When more than 15% RAP binder is used, by weight of the tota l binder in the mix, the RAP binder must be extracted, recovered, and tested during the mix design process. Depending on the results of these tests, the grade of virgin binder supplied to the project may need to be different than the grade specified in the bid documents. A different virgin binder

grade may be required to ensure the blend of virgin and RAP binder meets the grade specified in the bid documents. The virgin binder grade delivered to the project shall be as specified in the approved mix design.

3.6 There are no specific restrictions on the source of RAP material for a project. However, the contractor is responsible to determine the suitability of the RAP proposed for use regardless of its source.

4. SAMPLING AND TESTING

4.1 The sampling and testing of asphaltic concrete containing RAP is similar to non-RAP mixtures, with some important differences. These differences deal primarily with aggregate properties and asphalt cement content. For mixtures containing RAP, the RAP binder must be tracked separately from the virgin binder. This requires additional sampling, testing, data collection, and calculations.

4.2 During production of asphaltic concrete, sampling and testing is required on the following materials:

4.2.1 Mineral Aggregates (See Section 5 for details.)

4.2.2 Virgin Binder (See Section 6 for details.)

4.2.3 RAP Material (See Sections 7 and 8 for details.)

4.2.4 Asphaltic Concrete (See Section 9 for details.)

4.3 Additional contractor quality control is required for an asphaltic concrete mixture containing RAP. See the project specifications for specific requirements.

5. SAMPLING AND TESTING OF MINERAL AGGREGATES

5.1 Virgin mineral aggregate will be sampled in accordance with Arizona Test Method 105.

5.2 Requirements for the sand equivalent and uncompacted void content are on the composite of the virgin aggregates only. Samples will be obtained from the cold feed belt prior to the addition of admixture, or from the stockpiles when sampling from the cold feed belt is not possible.

5.3 The requirement for fractured coarse aggregate particles is on the composite of the virgin aggregate and RAP aggregate material. The aggregate material for determining fractured coarse aggregate particles will normally come from an asphaltic concrete sample taken and tested for binder content and gradation in accordance with ARIZ 428. However, if the

engineer determines that excessive breakdown of the aggregate has occurred due to the use of the ignition furnace, the fractured coarse aggregate particles testing will be performed on a composite of RAP aggregate obtained in accordance with ARIZ 428, and virgin mineral aggregate. The virgin mineral aggregate will be obtained from the cold feed belt prior to the addition of admixture, or from the stockpiles when sampling from the cold feed belt is not possible. The virgin aggregate and RAP aggregate shall be batched per Composite #1 in the mix design.

6. SAMPLING AND TESTING OF VIRGIN BINDER

6.1 Virgin binder will be sampled and tested in the same way as it is done for non-RAP mixtures. However, as mentioned in Subsection 3.5, the virgin binder grade required may be different than what is specified in the bid documents to ensure the blend of virgin and RAP binder meet the grade specified. This will be determined during the mix design process. Sample labels shall indicate the actual grade of virgin binder provided to the project.

7. SAMPLING AND TESTING OF RAP MATERIAL FORGRADATION, MOISTURE CONTENT, AND BINDER CONTENT

7.1 RAP material must be sampled and tested to ensure it meets the gradation requirements in the specifications. The intent of the RAP material gradation requirements is to prohibit the use of oversized (+ 1¼ inch) material, improve consistency, and minimize segregation. RAP material must also be sampled and tested for moisture content and RAP binder content. Virgin binder and RAP binder contents must be tracked separately in order to determine correction factors, validate and/or determine payments for asphalt cement, and to properly apply asphalt price adjustments.

7.2 RAP material will be sampled in accordance with Arizona Test Method 105. The sample shall be split to provide a sufficient amount of material for gradation testing, moisture content testing, and binder content testing. When multiple RAP stockpiles are used, RAP material shall be sampled separately from each stockpile.

7.3 Each RAP stockpile will be sampled and tested for gradation, moisture content, and binder content at a minimum frequency of one sample per lot of asphaltic concrete production. When more than one RAP sample is tested for moisture content and binder content, for a given lot and stockpile, the average of the results will be used.

7.4 Prior to testing the RAP material for gradation and binder content, the weight of the RAP material is recorded and the material is then dried at 140 °F to a constant weight. A higher temperature is not appropriate because it will soften the binder causing the RAP material to break into smaller particles and adhere to the pan. Drying to a constant weight at 140 °F will typically take overnight. The percent moisture content by drying at 140 °F shall be determined and recorded. After drying and determining the moisture content at 140 °F, the material shall be allowed to cool and then be tested for gradation and binder content.

7.5 The gradation of the RAP material will be determined by first dry sieving the material in accordance with Arizona Test Method 240, but utilizing the No. 8 sieve as the smallest sieve. To control breakdown of the particles of salvaged material into smaller size fractions, Arizona Test Method 240 limits the time for shaking the sample to 5 minutes ± 15 seconds. The gradation of the RAP material is then determined in accordance with Arizona Test Method 248 (Alternate #2).

7.6 The RAP binder content, including the determination of moisture content at 290 °F, of each RAP stockpile will be determined in accordance with ARIZ 428.

7.7 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 7.4) to the percent moisture content by drying at 290 °F (Subsection 7.6).

7.8 The total moisture content and RAP binder content results will be used to determine the total quantity of RAP binder used in each lot, as well as in the calculation of a tank stab correction (See Subsection 9.2.2).

8. RAP BINDER CONTENT CORRECTIONFACTOR

8.1 A RAP binder content correction factor will be applied to each RAP binder content result determined in accordance with Subsection 7.6. A correction factor is required for each RAP stockpile and is determined as follows:

8.1.1 At the start of asphaltic concrete production, the first two samples of RAP material from each stockpile will be split and tested for binder content; one split is tested in accordance with ARIZ 428 (Ignition Furnace) and the other split is tested in accordance with AASHTO T 164 (Solvent Extraction). A RAP binder content correction factor will be determined by subtracting the average ignition furnace result from the average solvent extraction result. The appropriate correction factor shall be added to each RAP binder content test result determined on the material from each RAP stockpile in accordance with ARIZ 428 to determine the RAP binder content. At the discretion of the Engineer, the correction factor may be determined prior to the start of asphaltic concrete production provided representative RAP samples are available. A new correction factor may be determined at any time the Engineer believes it is necessary due to a change in material or other circumstances. See Attachment #1 for an example calculation for determining the RAP binder content correction factor.

8.1.2 When splitting RAP material to determine the RAP binder content correction factor for the respective stockpile, it is extremely important that a representative split be obtained because the correction factor will be applied to all RAP binder content test results for that RAP stockpile. To help ensure a good split is obtained the sample should first be reduced to the approximate size required to perform both procedures (ARIZ 428 and AASHTO T 164). 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. The sample shall be split and each half visually observed to verify that both halves appear similar in composition. One half of the split is then tested by the acceptance laboratory in accordance with ARIZ 428. The other half is sent to the Central Laboratory to have tested accordance with AASHTO T 164. Split samples must be sent to the Central Laboratory as quickly as possible to ensure that the RAP binder correction factor for each RAP stockpile and a subsequent ignition furnace correction (tank stab correction) can be calculated in a timely manner.

Note: ADOT does not currently perform AASHTO T 164. Therefore, the Central Laboratory will send their split of the RAP material to an on-call independent laboratory for the required testing.

9. SAMPLING AND TESTING OF ASPHALTICCONCRETE

9.1 Asphaltic concrete containing RAP is sampled in the same manner as asphaltic concrete without RAP.

9.2 Testing for gradation, total asphalt content by ignition furnace, effective voids, stability, and compaction for asphaltic concrete containing RAP is done in the same manner as asphaltic concrete without RAP with the following exceptions:

9.2.1 The ignition furnace calibration is performed in accordance with ARIZ 428.

9.2.2 An ignition furnace correction (tank stab correction) must be determined by the Engineer for all mixtures containing RAP. If the correction is greater than 0.1%, it shall be applied to the ignition furnace results. Applying the correction is not optional as is the case for mixtures that do not contain RAP. The tank stab correction is defined as the average difference between the asphalt cement content as measured by the ignition furnace testing and the actual asphalt cement content for the first five lots of production. The "actual" asphalt cement content is determined by adding the virgin asphalt cement content to the RAP binder content, both expressed as a percent of the total mix. See Attachment #2 for an example calculation for determining the tank stab correction when one RAP stockpile is used. See Attachment #3 for an example calculation for determining the tank stab correction when two RAP stockpiles are used.

9.2.3 Asphalt content results for mixtures containing RAP are not subject to referee testing because a tank stab correction cannot be established for referee results.

10. MEASUREMENTAND PAYMENT FOR ASPHALT CEMENT

10.1 Asphaltic cement will be measured by the ton, for each lot of asphaltic concrete accepted, in one of the following ways:

10.1.1 Asphalt cement may be measured by multiplying the average asphalt cement content (from the Mix/Compaction Report) by the total tons of asphaltic concrete in that lot.

10.1.2 Asphalt cement may be measured by adding invoice quantities for virgin binder to the RAP binder used, adjusted as necessary for waste. The invoice quantities should be shown on the hot plant reports and substantiated by certified weights. RAP binder used shall be determined by multiplying the RAP binder content determined in Subsection 7.6 by the number of tons of dry RAP materials used in that lot. The tons of RAP material shall be a measured value (i.e., from a belt scale) rather than a calculated value. The measured tons of RAP material shall be shown on the hot plant report. When multiple RAP stockpiles are used, the RAP quantities and RAP binder contents must be determined separately for each stockpile.

10.2 In no case shall the measured amount of asphalt cement for payment be greater than the quantity determined in Subsection 10.1.2 above, adjusted for waste.

11. OTHER CONSIDERATIONS

11.1 Asphalt cement penalties and price adjustments only apply to the virgin binder in the mixture.

11.2 During production, the percent RAP aggregate shall be maintained to within plus 2 percent and minus 5 percent of the mix design values, not to exceed the maximum allowed by specification. When more than one RAP stockpile is used, this tolerance shall apply to the total percent RAP aggregate in the mixture, as well as the percent RAP aggregate from each stockpile.

11.3 For mixes containing RAP, an asphalt cement tank shall be dedicated to the project for each shift of asphalt concrete production. This is necessary in order to accurately track virgin binder usage for the project and to establish an accurate tank stab correction.

11.4 At least five days prior to the start of asphaltic concrete production, a copy of the mix design and representative samples of the virgin mineral aggregate, RAP aggregate, mineral admixture, and asphalt cement used in the mix design must be submitted by the contractor for calibration of the ignition furnace, and determination of aggregate properties. A minimum of 40 pounds of representative RAP material and a minimum of 10 pounds of solvent extracted RAP aggregate shall be submitted. If the RAP is fractionated, the RAP material and RAP aggregate from each stockpile shall be kept separate. All materials must be submitted in sufficient quantity to perform an ignition furnace calibration by both the acceptance lab and a referee lab if

necessary. If referee testing is performed, the referee testing laboratory will only be required to perform the ignition furnace calibration to determine a minus No. 200 correction factor.

11.5 The contractor shall provide daily documentation of the weight, determined by a belt scale, and proportion of material from each individual RAP stockpile incorporated into the mix. The percent moisture content of the RAP material from each stockpile shall also be determined and provided daily by the contractor.

11.6 A pre-activity meeting shall be held approximately two weeks prior to the start of paving. The agenda should include discussion items dealing with the production of asphaltic concrete containing RAP.

Bill Hurguy, P.E.
Assistant State Engineer
Materials Group

Attachments (3)

Project Number: F-011-1(11)

TRACS Number: H011101C

RAP Material Type: Fine

Sample # 1 Sampled By: Barb B.Que Sampled From: Stockpile
Date Sampled: 04/22/13 Time Sampled: 9:25

Sample # 2 Sampled By: Jack Frost Sampled From: Stockpile
Date Sampled: 04/23/13 Time Sampled: 14:50

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 T164)	(Average Solvent Extraction Value) Minus (Average Ignition Furnace Value)
1	7.73	6.51	
2	8.31	7.28	
Average	**8.020**	**6.895**	**- 1.13**

Notes:
1) Shaded fields contain data input by the user. All other numerical fields are calculated values.
2) The RAP binder contents and RAP binder content correction factor in this example are high due to the recycling of ARAC.

EXAMPLE RAP BINDER CONTENT CORRECTION FACTOR DETERMINATION

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
							Only if two RAP stockpiles are used								
Lot #	Tons of Asphaltic Concrete in the Lot (including waste)	Tons of Virgin Binder in the Lot	Tons of Fine RAP Material in the Lot	Total Percent Moisture Content of Fine RAP Material	Tons of Dry Fine RAP Material used in the Lot	Fine RAP percent binder content from lab (corrected)	Tons of Coarse RAP Material in the Lot	Total Percent Moisture Content of Coarse RAP Material	Tons of Dry Coarse RAP Material used in the Lot	Coarse RAP percent binder content from lab (corrected)	Percent Binder Content from Ignition Furnace (Lot average from Pay Factor report)	Tons of RAP Binder used in the Lot	Actual Tons of Total Binder used in the Lot (RAP plus Virgin)	Calculated Total Actual Percent RAP Binder and Virgin Binder used in the Lot	Difference between the Percent Binder Content from the Ignition Furnace Pay Factor Report and the Calculated Total Actual Percent Binder
1	1370.78	59.76	205.47	3.14	199.02	6.60					5.20	13.14	72.90	5.32	-0.12
2	2483.52	114.10	371.27	2.98	360.21	7.18					5.43	25.86	139.96	5.64	-0.21
3	1679.76	78.11	252.96	3.57	243.93	7.27					5.05	17.73	95.84	5.71	-0.66
4	1349.10	54.94	202.40	3.42	195.48	6.89					4.91	13.47	68.41	5.07	-0.16
5	3280.36	135.20	489.01	3.86	470.13	6.87					4.95	32.30	167.50	5.11	-0.16
													Tank Stab Correction =		**-0.26**

Notes:

1) Shaded columns contain data input by the user. All other columns are calculated values.
2) Column B is the tons of asphaltic concrete produced for the given lot.
3) Column C is the tons of virgin binder in the lot (per the hot plant report, verified by certified weights).
4) Column D is the tons of fine RAP material used in the lot (if only one RAP stockpile is used, the tons of RAP used is entered in Column D).
5) Colunm E is the total percent moisture content of the fine RAP material (the sum of percent moisture contents from drying at 140 °F and 290 °F).
6) Column F is the tons of dry fine RAP material used in the given lot. F = D x [(100-E) / 100]
7) Column G is the percent binder content of the fine RAP material, as determined by ARIZ 428 and corrected by the RAP binder content correction factor (see Attachment #1).
8) Columns H, I, J and K are used in the same way as columns D, E, F and G when a second RAP stockpile is used (See Attachment #3).
9) Column L is the average percent binder content in the lot as measured by the ignition furnace (ARIZ 428).
10) Column M is the tons of RAP binder used in the lot. M = [{(G x F) / 100} + {(K x J) / 100}]
11) Column N is the actual tons of total binder (tons of RAP binder plus tons of virgin binder) used in the lot. N = C + M
12) Column O is the calculated total actual percent binder content used in the lot. O = (N / B) X 100
13) Column P is the difference between the percent binder content measured by the ignition furnace and the calculated total actual percent binder content. P = L - O
14) The tank stab correction is the average of the five values in Column P.
15) The above values include waste at the plant and grade. Waste must be deducted prior to payment for binder and mix.
16) This example is for a mixture with one RAP stockpile. An example of a tank stab correction when two RAP stockpiles are used is given in Attachment #3.

EXAMPLE IGNITION FURNACE CORRECTION (TANK STAB CORRECTION) DETERMINATION

(WHEN ONE RAP STOCKPILE IS USED)

A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
							Only if two RAP stockpiles are used								
Lot #	Tons of Asphaltic Concrete in the Lot (including waste)	Tons of Virgin Binder in the Lot	Tons of Fine RAP Material in the Lot	Total Percent Moisture Content of Fine RAP Material	Tons of Dry Fine RAP Material used in the Lot	Fine RAP percent binder content from lab (corrected)	Tons of Coarse RAP Material in the Lot	Total Percent Moisture Content of Coarse RAP Material	Tons of Dry Coarse RAP Material used in the Lot	Coarse RAP binder content from lab (corrected)	Percent Binder Content from Ignition Furnace (Lot average from Pay Factor report)	Tons of RAP Binder used in the Lot	Actual Tons of Total Binder used in the Lot (RAP plus Virgin)	Calculated Total Actual Percent RAP Binder and Virgin Binder used in the Lot	Difference between the Percent Binder Content from the Ignition Furnace Pay Factor Report and the Calculated Total Actual Percent Binder
1	1390.19	62.31	145.53	2.07	142.52	4.65	144.90	0.57	144.07	3.57	5.12	11.77	74.08	5.33	-0.21
2	1896.32	86.12	191.88	3.34	185.47	4.51	191.89	1.26	189.47	3.58	5.24	15.15	101.27	5.34	-0.10
3	1099.05	48.30	109.68	3.37	105.98	4.53	111.61	1.58	109.85	3.49	5.04	8.63	56.93	5.18	-0.14
4	2195.36	98.48	218.50	2.83	212.32	4.47	220.03	1.39	216.97	3.85	5.21	17.84	116.32	5.30	-0.09
5	2248.38	102.02	217.15	2.99	210.66	4.73	228.20	1.60	224.55	4.01	5.19	18.97	120.99	5.38	-0.19
													Tank Stab Correction =		-0.15

Notes:

1) Shaded columns contain data input by the user. All other columns are calculated values.
2) Column B is the tons of asphaltic concrete produced for the given lot.
3) Column C is the tons of virgin binder in the lot (per the hot plant report, verified by certified weights).
4) Column D is the tons of fine RAP material used in the lot (if only one RAP stockpile is used, the tons of RAP used is entered in Column D).
5) Column E is the total percent moisture content of the fine RAP material (the sum of percent moisture contents from drying at 140 °F and 290 °F).
6) Column F is the tons of dry fine RAP material used in the given lot. F = D x [(100-E) / 100]
7) Column G is the percent binder content of the fine RAP material, as determined by ARIZ 428 and corrected by the RAP binder content correction factor (see Attachment #1).
8) Columns H, I, J and K are used in the same way as columns D, E, F and G when a second RAP stockpile is used.
9) Column L is the average percent binder content in the lot as measured by the ignition furnace (ARIZ 428).
10) Column M is the tons of RAP binder used in the lot. M = [{(G x F) / 100} + {(K x J) / 100}]
11) Column N is the actual tons of total binder (tons of RAP binder plus tons of virgin binder) used in the lot. N = C + M
12) Column O is the calculated total actual percent binder content used in the lot. O = (N / B) X 100
13) Column P is the difference between the percent binder content measured by the ignition furnace and the calculated total actual percent binder content. P = L - O
14) The tank stab correction is the average of the five values in Column P.
15) The above values include waste at the plant and grade. Waste must be deducted prior to payment for binder and mix.
16) This example is for a mixture with two RAP stockpiles. An example of a tank stab correction when one RAP stockpile is used is given in Attachment #2.

EXAMPLE IGNITION FURNACE CORRECTION (TANK STAB CORRECTION) DETERMINATION

(WHEN TWO RAP STOCKPILES ARE USED)

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