ADOT Specific Requirements for Keystone's KeySystem I Wall System

ADOT Vendor	Keystone Retaining Wall Systems 4444 W, 78th Street Minneapolis, MN 55435
General Information	ADOT Product ID No. 10093 Approval Date: 11/09/2011 Approval Renewed Date: 05/2018 Re-evaluation due: 05/2023
Design Standards	More Stringent of the following: 1. 2008 ADOT Standard Specifications for Road and Bridge Construction 2. Latest ADOT MSE Wall LRFD Based Special Provisions [Contact ADOT for latest version at the time of the application of the system to a given project.] 3. FHWA (2009), "Design and Construction of Mechanically Stabilized Earth Walls and Reinforced Soil Slopes," Publication No. FHWA-NHI-09-083; Authors: Berg, R.R., Christopher, B.R. and Samtani, N.C. 4. AASHTO (2012 or latest Specification or Interims) LRFD Bridge Design Specifications
HITEC Evaluation	Highway Innovative Technology Evaluation Center (HITEC) evaluation was completed in 2000. Civil Engineering Research Foundation (CERF) Report No. 40478. Report available on file..
Facing Evaluated	• Modular KeySystem I Units - straight split face and tri-planar split face. Both units are 12 inches deep, 18 inches wide (measurement parallel to face) and 8 inches high. The mini/cap units are half-height units (4 inches high). See attached drawings for facing details.
Facing Connector	• Positive connection using a patented pin/kidney configuration wherein a 9/16 inch diameter by 8 inch galvanized steel pin is used for units that are connected to the steel reinforcing elements. Where the soil reinforcement does not connect to the modular facing units, a 1/2 inch by 5-1/4 inch fiberglass pin is used for alignment. See attached drawings for connector details.
Soil Reinforcement Evaluated	• Proprietary "Keystrip" soil reinforcement which is steel grid reinforcement with two longitudinal wires fabricated from W7.5, W11, W14, and W17 steel wire. The longitudinal wires are spaced at 7 inches on center, and the transverse (cross) wires are spaced from 6 to 24 inches on center depending on wall and design conditions. Since the steel grid configuration of two longitudinal wires with transverse wires resembles a "ladder" it is sometimes referred to as ladder reinforcement. The transverse wires are 9 inches long. The longitudinal wires taper from 7 inches on centers to 6 inches on centers at the connection within the facing unit. See attached drawings for details.

Notes/Constrains	In addition to the general design requirements provided in the Design Standards listed above, the following specific requirements apply: 1. For any project, use of the system evaluated herein is subject to ADOT approval based on project- and site-specific evaluation. 2. Only the system components evaluated as noted above are to be used. Details in the HITEC report are considered to be superseded by the figures, tables and typical details in this evaluation. Tolerances shall be the more stringent of those noted in Keystone's attached drawings and the Design Standards listed above. 3. The submittal indicates that in 2001 KeySystem I wall was successfully constructed up to 65 in height in Puerto Rico. However, the maximum wall height would be a function of the foundation soils in terms of bearing capacity (resistance), tolerable settlements and global stability. 4. Use of soil reinforcements not connected to the wall face is not allowed. 5. The vertical obstruction detail shown on Drawing No. 7 (attached) which indicates a single wire connection to achieve splay is not approved. At all times, both longitudinal wires shall be fully connected to the modular facing unit. 6. Soil reinforcement length measured from back of the facing unit to the last transverse wire. 7. The transverse wires on the grid shall be uniformly distributed along the complete length of the grid. 8. In accordance with Design Standards 3 and 4 listed above, the width of the Keystrip shall be considered to be equal to the center to center distance between longitudinal wires and not equal to the 9-inch length of the transverse wire. 9. Reinforcement pullout shall be calculated based on the default values for steel grid reinforcement provided in the latest AASHTO design specification (Design Standard 4 listed above). 10. Keystone proposes a coefficient of lateral stress, K, value of 2.0 at the top of the wall rather than 2.5. The K value at the top of the wall shall be 2.5 to be consistent with AASHTO design specifications (Design Standard 4 listed above). 11. Keystone proposes use of the coherent gravity method for internal stability analysis. As per Design Standard 2, the simplified method shall be used for internal stability analysis on all ADOT projects. 12. Keystone proposes the use of a resistance factor value of 0.75 of the tensile capacity of the 2 longitudinal wire ladder style Keystrip. The value of 0.75 is acceptable since the soil reinforcement is connected to a relatively flexible facing system in comparison with a precast panel reinforced concrete facing system. 13. For skewed panel connection, a splay angle more than 5 degrees is not allowed as per Design Standard 2 listed above. Splay angle is defined as the deviation from the normal to the face of the wall in the horizontal plane at a reinforcing level. Reduction in tensile capacity perpendicular to the wall face due to splay shall be accounted for in the analysis.

14. The maximum vertical spacing of soil reinforcement shall be 2-ft in accordance with AASHTO design specifications (Design Standard 4 listed above).
15. For horizontal spacing of soil reinforcement, the soil reinforcement shall be located at spacing no greater than every other block in accordance with AASHTO design specifications (Design Standard 4 listed above).
16. The modular facing dry cast concrete blocks shall meet the requirements for modular block as noted in Design Standard 2 listed above.
17. Bending of the steel ladder grid (Keystrip) soil reinforcement shall be minimized during transport to the site and handling at the project site. As shipped to the wall site, the Keystrip soil reinforcements must meet the tolerance requirement of ASTM A185, i.e., the permissible variation of the center-to-center distance between longitudinal wires shall not exceed ±0.5 inch of the specified distance.
18. Facing connectors shall be designed to have adequate life considering corrosion loss based on the design (service) life of the structure noted on the plans or specifications with a minimum of 75 years design life for permanent structures.
19. The computations for design capacities (i.e., factored resistances) of facing connections noted in the submittal package shall be provided on each project for project-specific approval. The factored resistances approved for the project shall be compared to factored loads consistent with all applicable strength limit states.
20. The acute angle corner detail is not approved on standard basis but shall be reviewed on a project by project basis.
21. The joint filler requirements (geotextile or graded granular) shall be in conformance with Section 5.3.3 ("Filtration and Drainage System Component Requirements") of Design Standard 3 listed above and in accordance with the gradation for unit (core) fill in Design standard 2 listed above. When a geotextile is used it shall meet the requirements of moderate survivability AASHTO M 288.
22. All details for penetration of culverts or other objects through the wall face shall be evaluated on a project- and site-specific basis.
23. All details for penetration of vertical and horizontal obstructions through the reinforced soil zone shall be evaluated on a project- and site-specific basis. Examples of these obstructions include foundation elements, catch basins, slotted drains, etc.
24. Drainage details shall be modified as appropriate to meet project- and site- specific requirements.
25. End-bent details shall be modified as appropriate to meet project- and site- specific requirements.
26. Because of the steel grid reinforcement, facing construction tolerances for precast facing panels in Design Standard #2 listed above (i.e., ADOT Special Provisions), shall be applicable to KeySystem I wall systems. Any adjustment to the facing batter needed during wall construction shall be done in a manner that prevents additional stress to the reinforcement-facing connection and that also prevents significant stress concentration between facing blocks which could cause cracking of the facing blocks as additional modular blocks are placed. In general, any shims used between blocks to adjust facing batter shall be no more than 1/8-

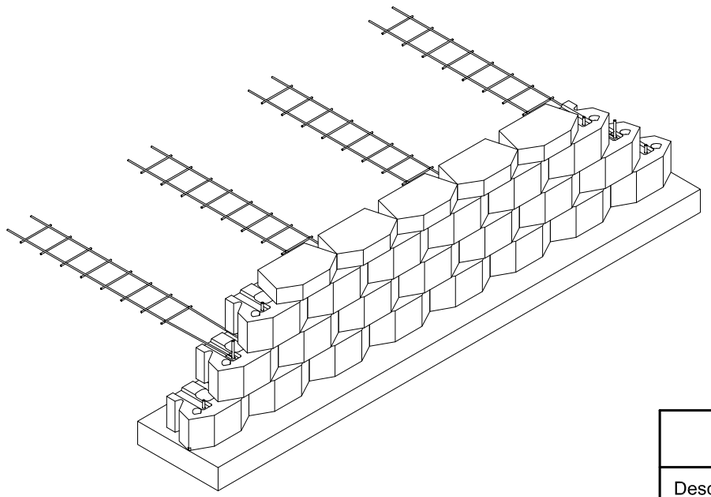
	inch thick, shall minimize the creation of local stress concentrations, and shall be made of material that is durable and does not degrade over the design life of the wall. Use of degradable materials such as a rope shall not be allowed as a means to adjust the facing batter.
Assumptions	• Vendor will submit a copy of this Specific Requirements with its project- and site-specific design to ADOT and its representatives for review and approval consideration for a specific construction project. • Vendor submittals shall be in accordance with the design standards and other requirements listed herein. • ADOT and its design representatives will evaluate the project- and site- specific application of Keystone's KeySystem I system and review submittals for approval consideration in strict accordance with the design standards, limitations, and requirements listed herein. Typical details in this package may not be applicable to a given project and will be modified, based on site-specific considerations, as necessary by the designer in consultation with the vendor. • During construction of the Keystone's KeySystem I system, ADOT and it's representatives will enforce project- and site-specific acceptance requirements in accordance with the plans and specifications.

TYPICAL DETAILS

(Total 12 pages)

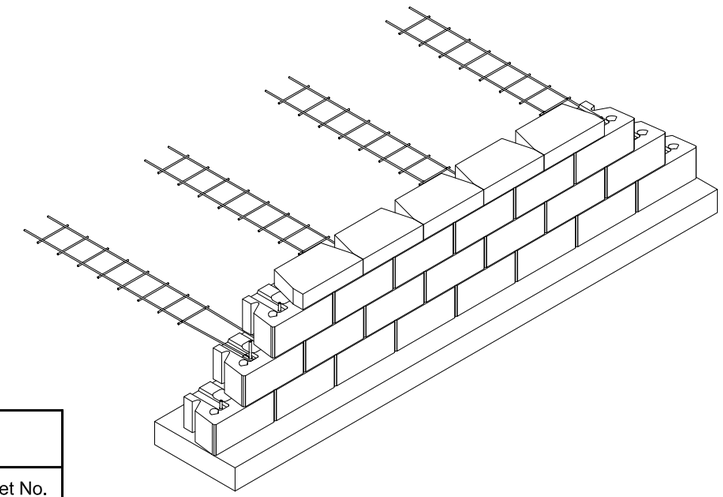
Typical details submitted to ADOT as part of the product approval process are attached. These represent generic details that must be evaluated by the designer based on project and site specific requirements. The designer shall also be responsible for ensuring conformance to the constraints and design standards noted in this evaluation.

Keystone Retaining Wall Systems
Keysystem I Details



Tri-Planer Split Face Treatment

DRAWING INDEX	
Description	Sheet No.
Title Sheet	Sheet 1
Keysystem I Unit Details	Sheet 2
Keysystem I Unit & Keystrip Details	Sheet 3
Keysystem I C.I.P. Coping Details	Sheet 4
Keysystem I C.I.P. Traffic Barrier Details	Sheet 5
Keysystem I Typical Sections Details	Sheet 6
Keysystem I Inlet Obstruction Details	Sheet 7
Keysystem I Pier / Pile Obstruction Details	Sheet 8
Keysystem I Slip Joint / Cut Joint Details	Sheet 9
Keysystem I Wall Drain Details	Sheet 10
Keysystem I Wall Backfill Procedure Details	Sheet 11
Keysystem I Wall Structure Connection Appurtenances Details	Sheet 12



Straight Split Face Treatment

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4444 W 78th Street
Minneapolis, MN 55435
952-897-1040

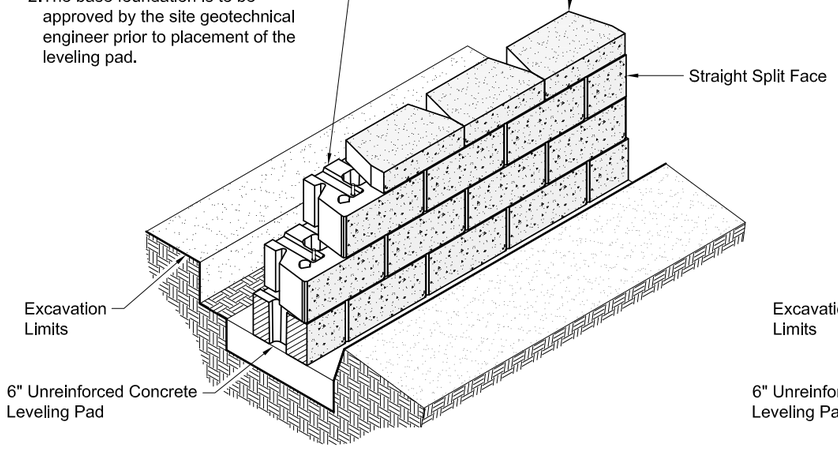
Designed By: RKM	Title: Title Sheet	Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details	Drawing No: 1
Scale: No Scale		

Base Leveling Pad Notes:

1. The leveling pad is to be constructed of class B (2,400 psi) unreinforced concrete
2. The base foundation is to be approved by the site geotechnical engineer prior to placement of the leveling pad.

Keysystem I Unit	
Width:	18"
*Depth:	12"
Height:	8"
*Weight:	95 lbs

Cap Unit	
Width:	18"
*Depth:	10 1/2"
Height:	4"
*Weight:	50 lbs

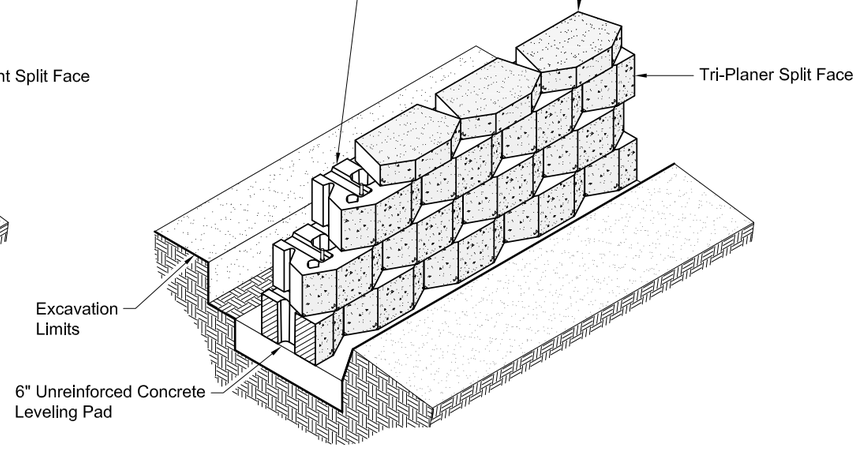


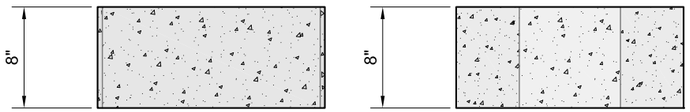
Keysystem I Unit/Base Pad Isometric Section View

*Dimensions & Weight May Vary by Region

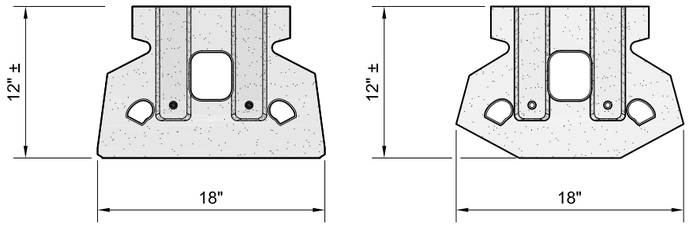
Keysystem I Unit	
Width:	18"
*Depth:	12"
Height:	8"
*Weight:	85 lbs

Cap Unit	
Width:	18"
*Depth:	10 1/2"
Height:	4"
*Weight:	50 lbs





Keysystem I Elevation



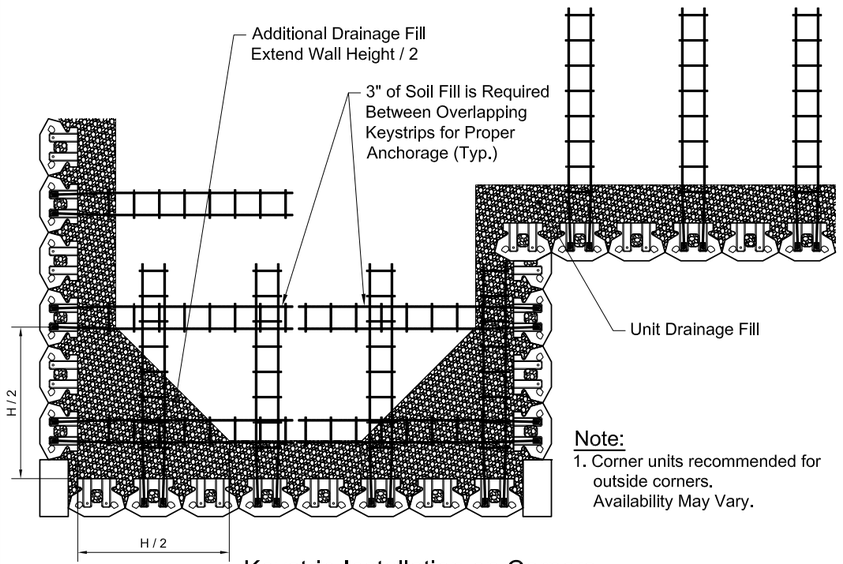
Straight Split Face

Tri-Planer Split Face

Keysystem I Plan

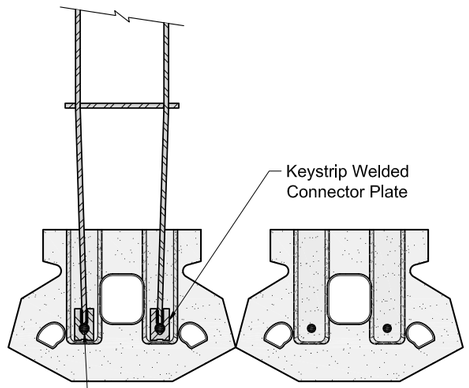
Keysystem I Unit

*Dimensions & Weight May Vary by Region

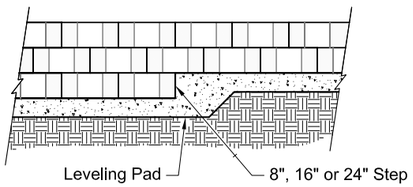


Note:
1. Corner units recommended for outside corners. Availability May Vary.

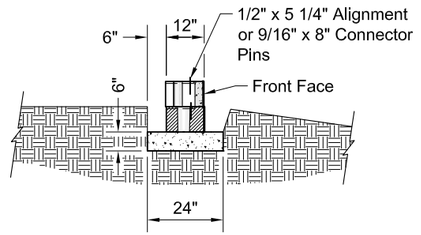
Keystrip Installation on Corners



Keystrip & Pin Connection



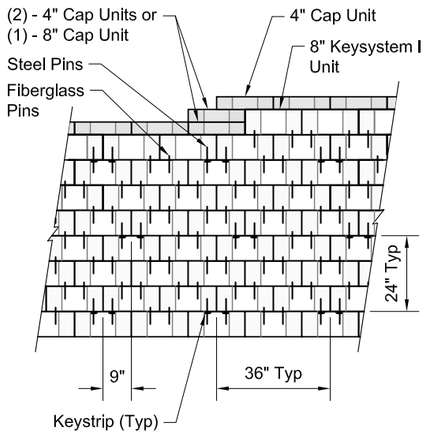
Elevation



Section

Leveling Pad Detail

Note:
1. Secure all cap units with Keystone Kapseal or equal.



Top of Wall Steps & Typical Keystrip Layout

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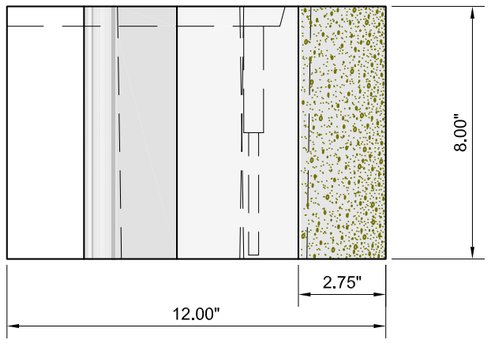
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040

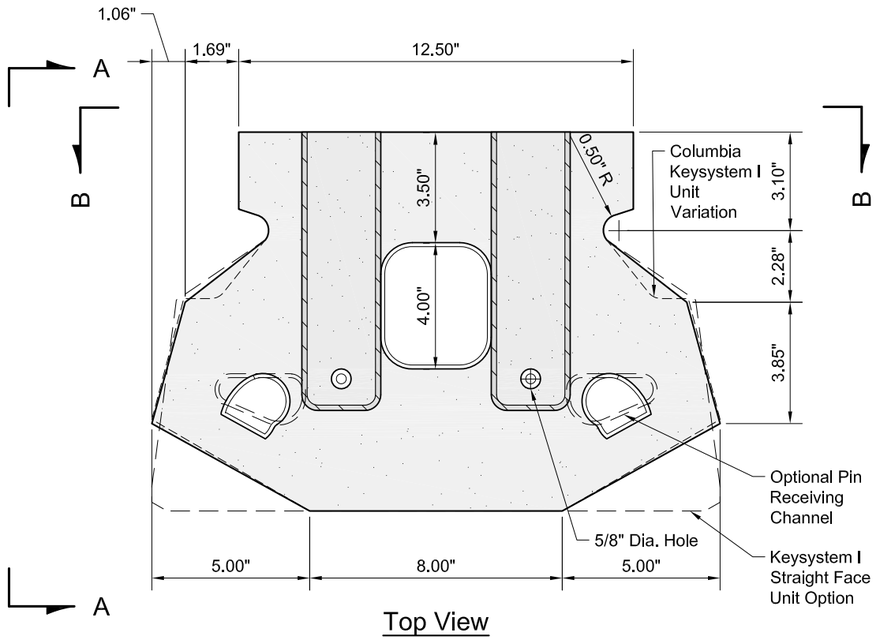
Designed By:	RKM
Checked By:	CDM
Scale:	No Scale
Title:	Keysystem I Unit Details
Project:	ADOT LRFD Submital Keysystem Details
Date:	01/2018
Drawing No:	2

Notes :

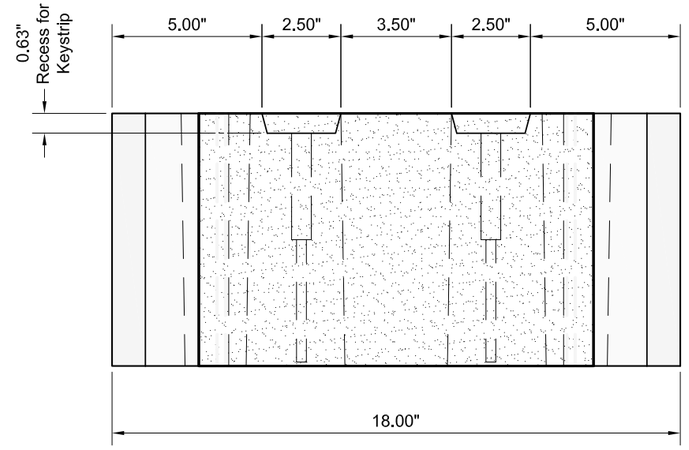
1. Wire is welded on one side of plate only.
2. Plate is fabricated from 3/8" thick ASTM A36 steel plate.
3. The Keystrips are shop fabricated from cold drawn steel wire conforming to minimum requirements and fabricated in accordance with ASTM A1064.
4. The Keystrips are hot dipped galvanized in accordance with ASTM A123 after fabrication.



Side View



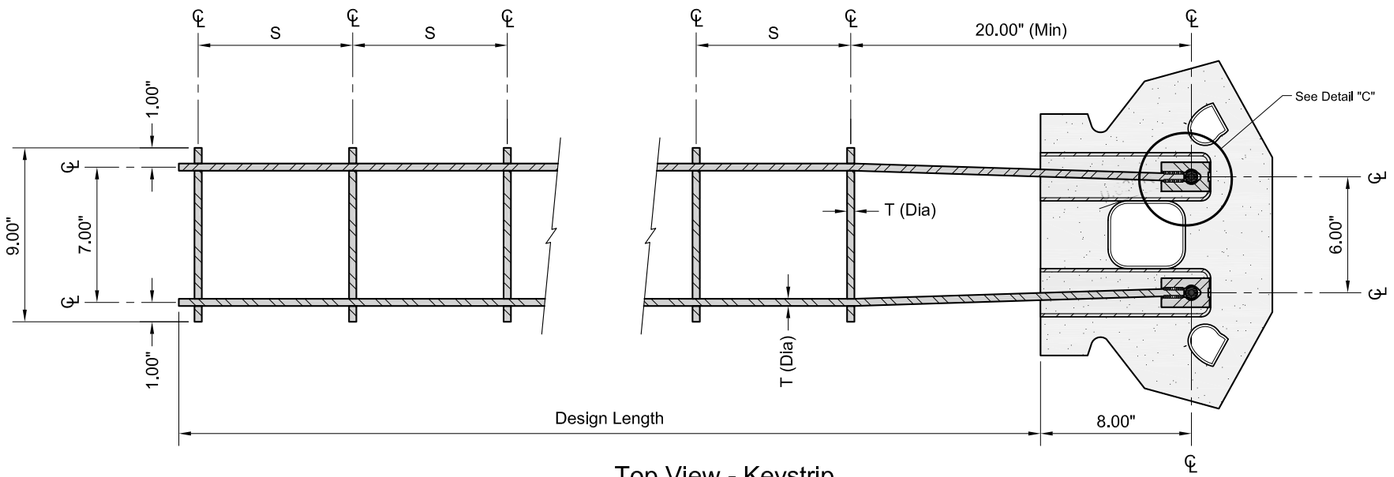
Top View



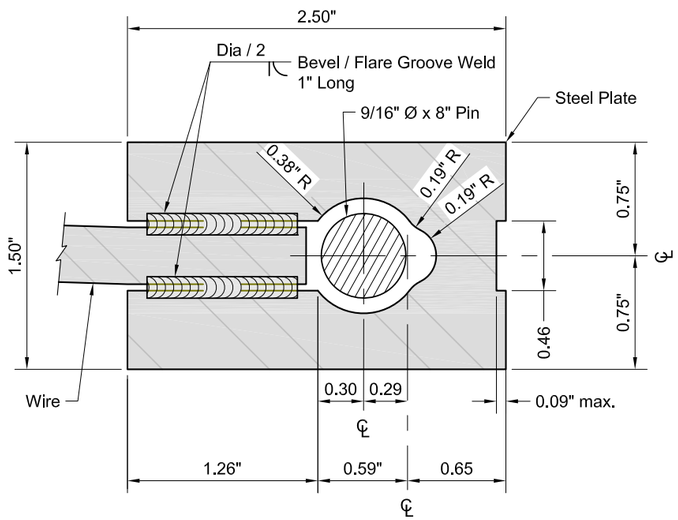
End View

	Typical Wire Code			
	A	B	C	D
	W7.5	W11	W14	W17
S	6"	12"	18"	24"
DIA	0.309"	0.375"	0.422"	0.465"

Note: Wire sizes and spacings vary for different design criteria.



Top View - Keystrip



Detail "C"

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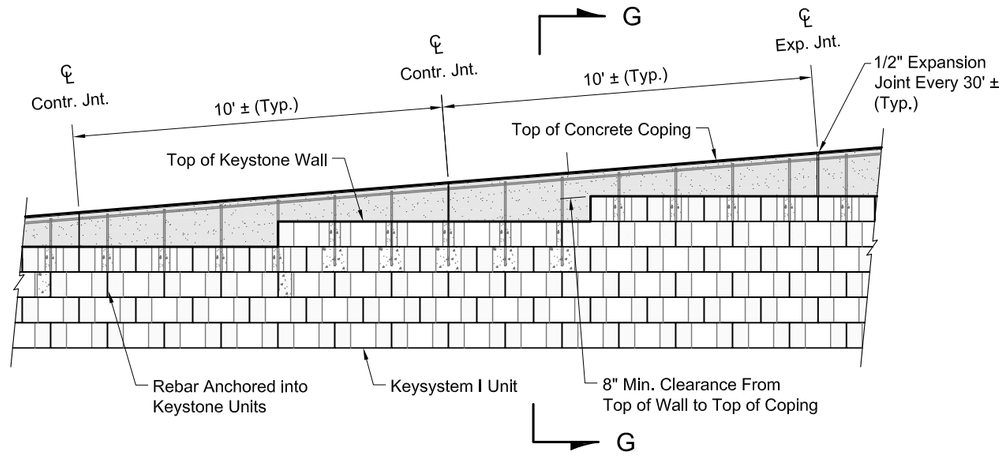
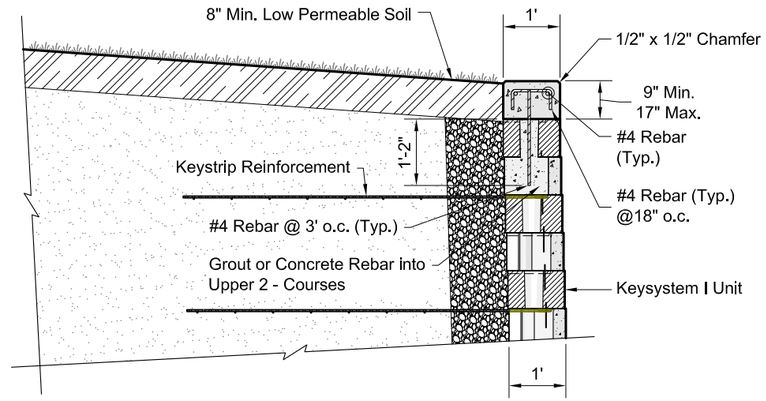
Minneapolis, MN 55435
952-897-1040

Designed By: RKM	Title: Keysystem I Unit & Keystrip Details	Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details	Drawing No: 3
Scale: No Scale		



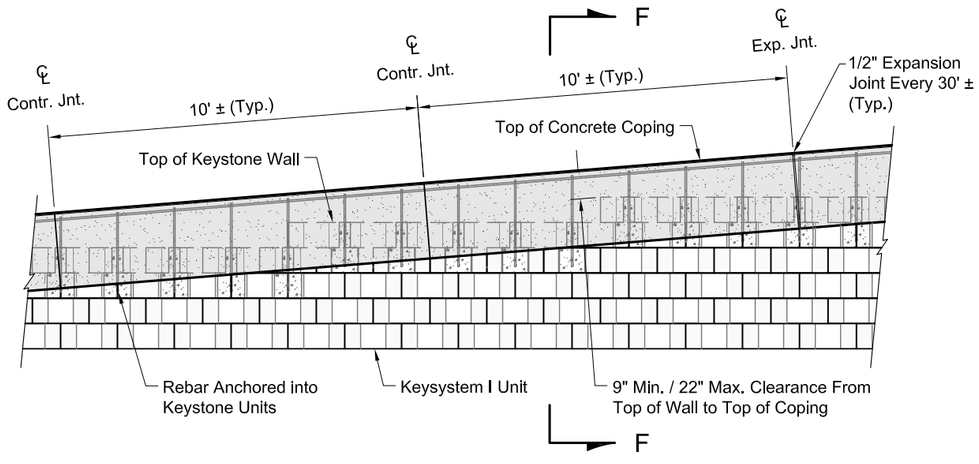
Partial C.I.P Top Concrete Coping Elevation



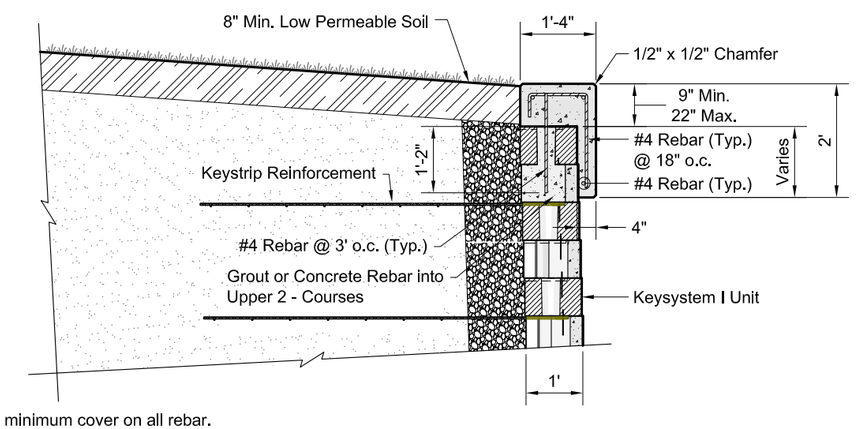
Note:

1. Maintain 2" minimum cover on all rebar.
2. Full expansion joints shall be placed every 3rd joint and at all wall radius and bend points.

Section G - G
C.I.P. Top Concrete Coping



Partial C.I.P Concrete Coping Elevation



Note:

1. Maintain 2" minimum cover on all rebar.
2. Full expansion joints shall be placed every 3rd joint and at all wall radius and bend points.
3. Insure that all top of wall steps are completely covered by overhang of concrete coping (2" min.).

Section F - F
C.I.P. Concrete Coping

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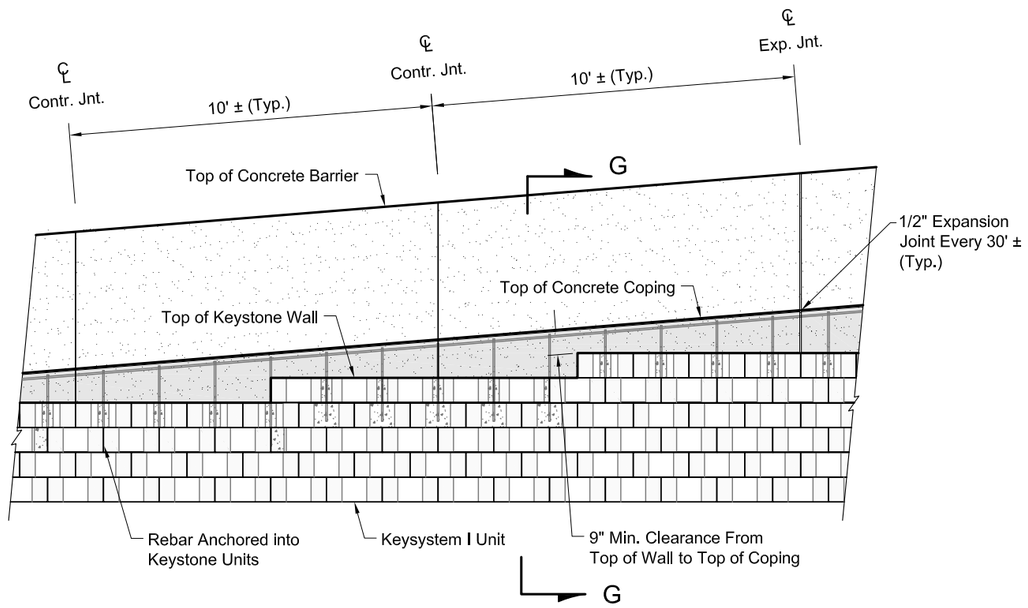
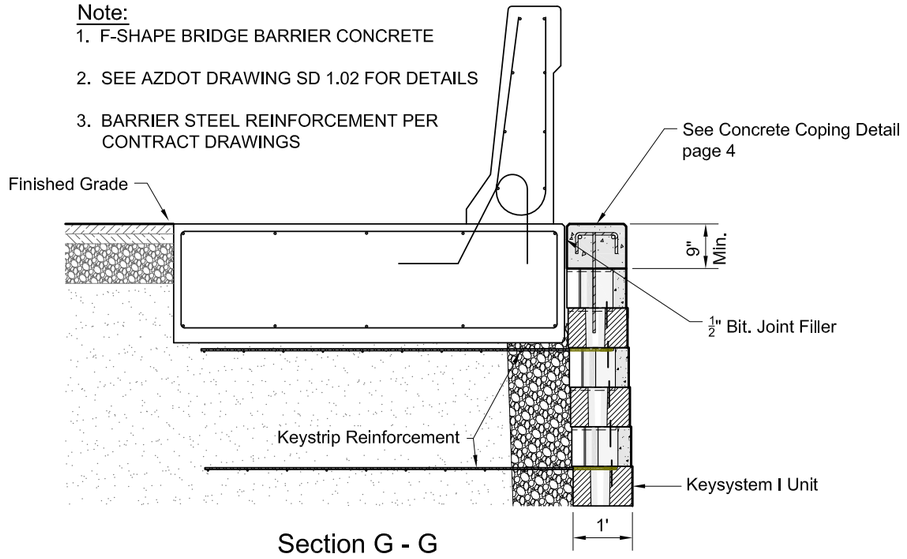
Minneapolis, MN 55435
952-897-1040

Designed By: RKM	Title: Keysystem I C.I.P. Coping Details		Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details		Drawing No: 4
Scale: No Scale			



Partial C.I.P Top Concrete Coping Elevation

Note:
1. F-SHAPE BRIDGE BARRIER CONCRETE
2. SEE AZDOT DRAWING SD 1.02 FOR DETAILS
3. BARRIER STEEL REINFORCEMENT PER CONTRACT DRAWINGS



Section G - G

C.I.P. Traffic Barrier Reinforcement

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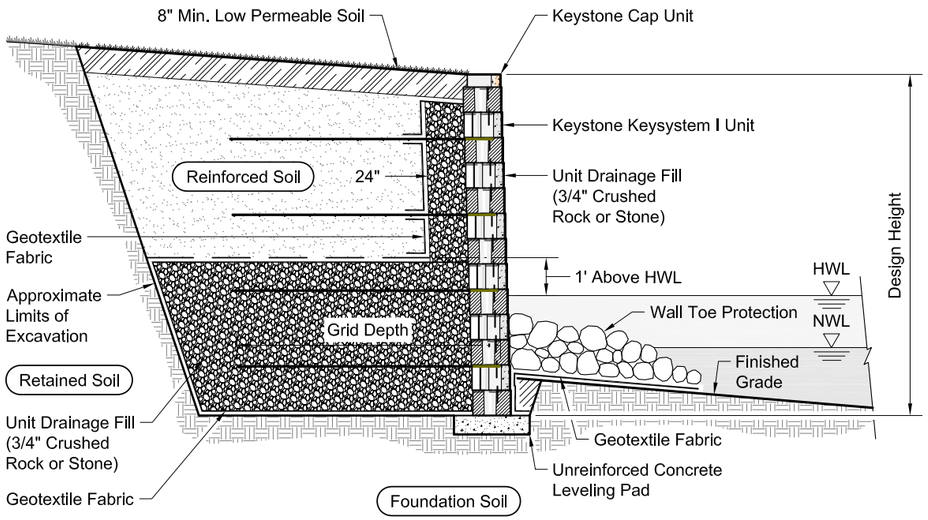
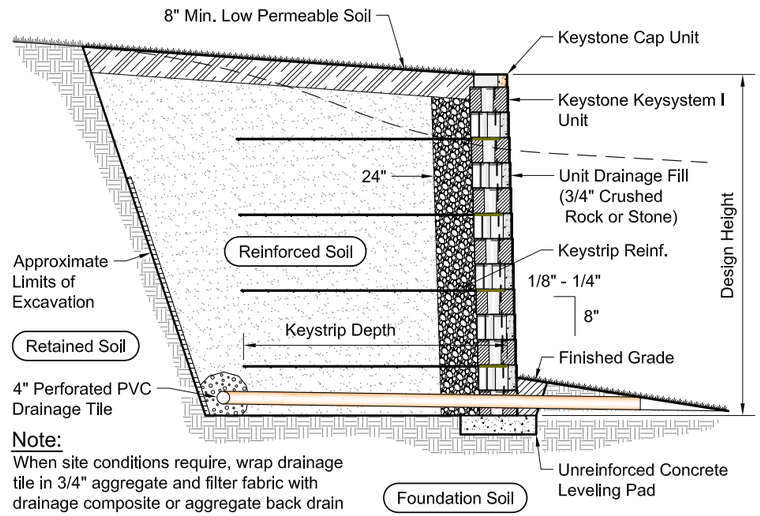
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040

Designed By: RKM	Title: Keysystem I C.I.P. Traffic Barrier Details
Checked By: CDM	Date: 01/2018
Scale: No Scale	Project: ADOT LRFD Submital Keysystem Details
	Drawing No: 5



Typical Reinforced Water Wall Section

Keysystem I Unit - Near Vertical Setback

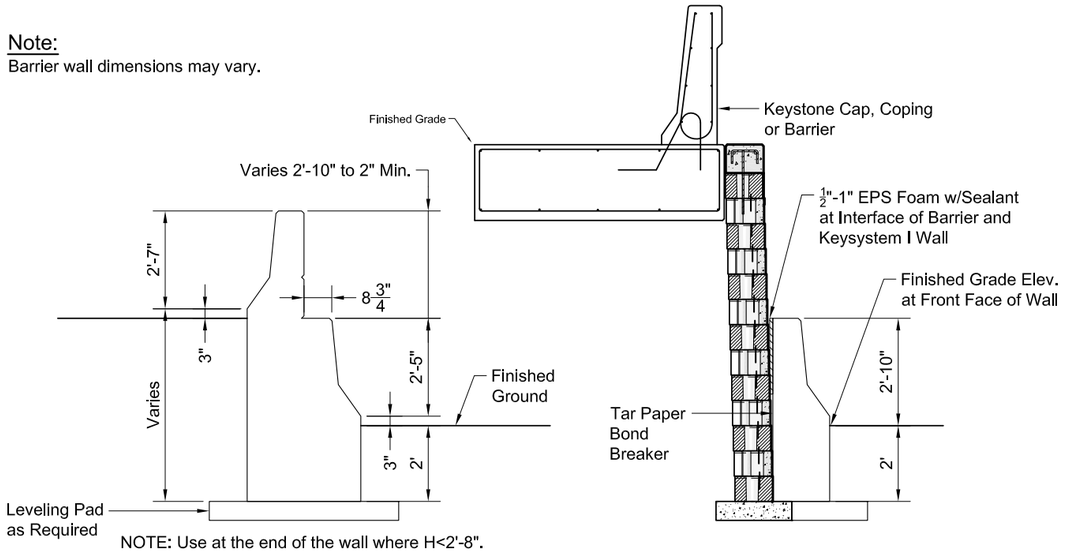


Note:
When site conditions require, wrap drainage tile in 3/4" aggregate and filter fabric with drainage composite or aggregate back drain system, as directed by geotechnical engineer.

Typical Reinforced Wall Cut Section

Keysystem I Unit - Near Vertical Setback

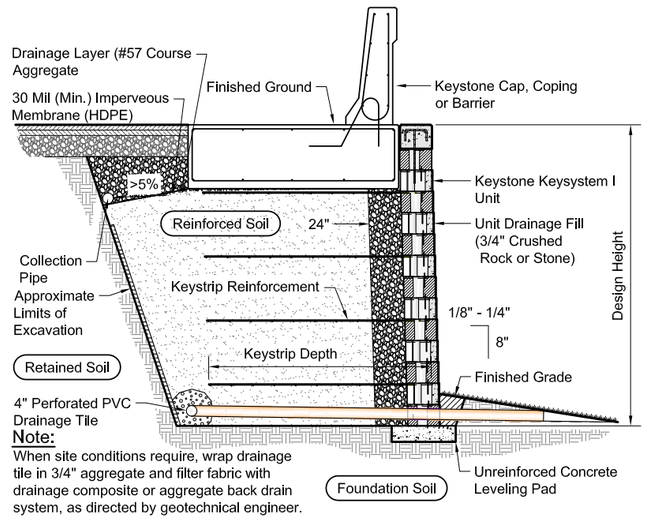
Note:
Barrier wall dimensions may vary.



NOTE: Use at the end of the wall where H<2'-8".

MSE Barrier, Moment Slab and Concrete Barrier Wall Details

Keysystem I Unit - Near Vertical Setback



Note:
When site conditions require, wrap drainage tile in 3/4" aggregate and filter fabric with drainage composite or aggregate back drain system, as directed by geotechnical engineer.

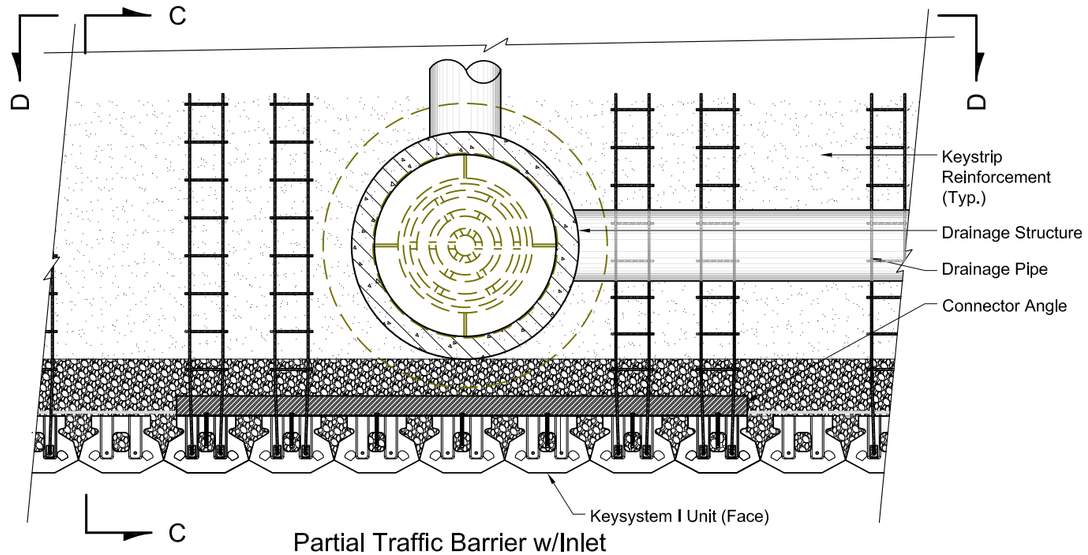
Typical Reinforced Wall Fill Section

Keysystem I Unit - Near Vertical Setback

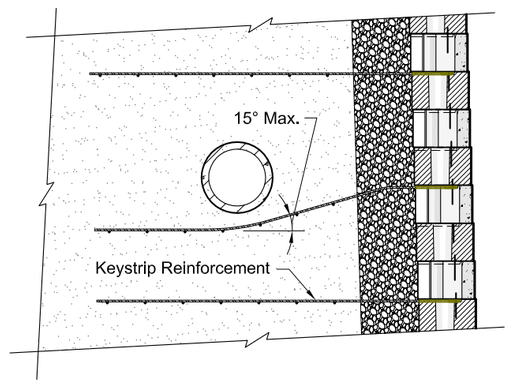
KEYSTONE® RETAINING WALL SYSTEMS
A CONTECH COMPANY

4444 W 78th Street
Minneapolis, MN 55435
952-897-1040

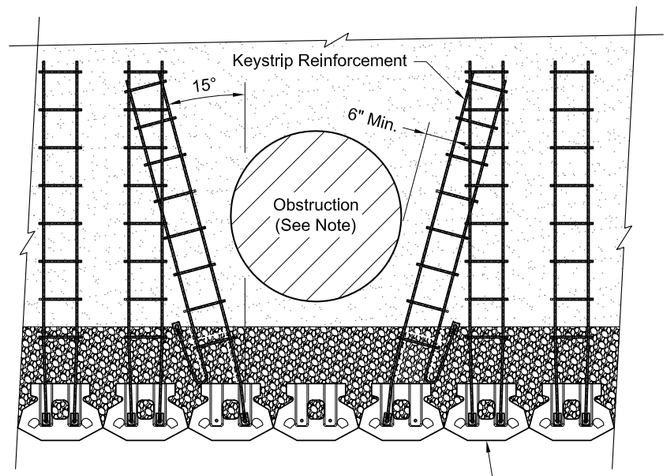
Designed By: RKM	Title: Keysystem I Typical Sections Details
Checked By: CDM	Date: 01/2018
Scale: No Scale	Project: ADOT LRFD Submital Keysystem Details
	Drawing No: 6



Partial Traffic Barrier w/Inlet Behind Wall Plan



Horizontal Obstruction Detail

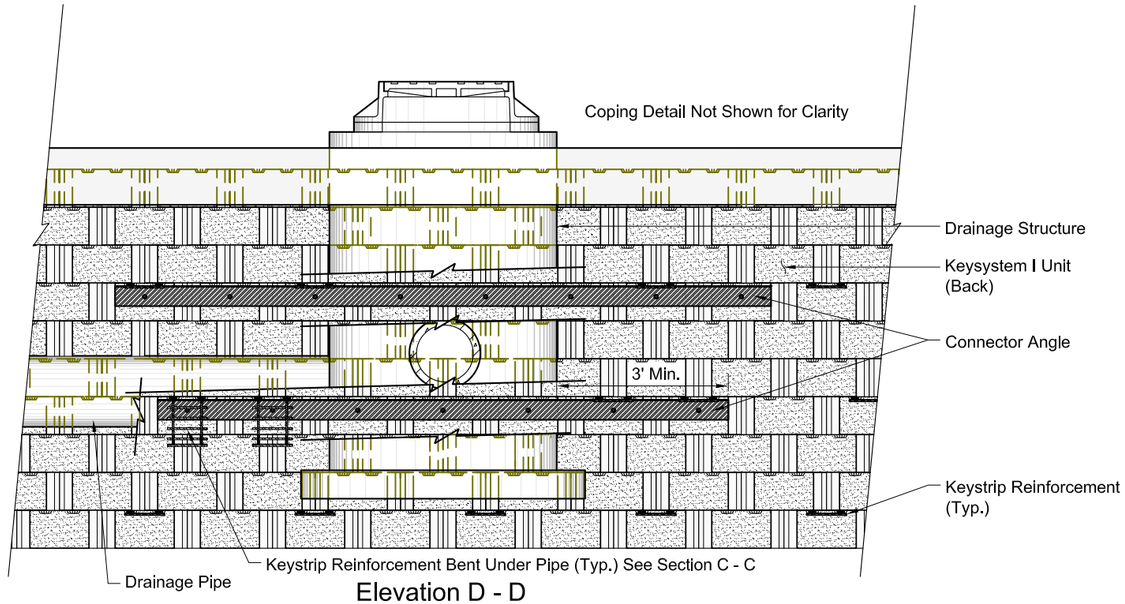


Vertical Obstruction Detail

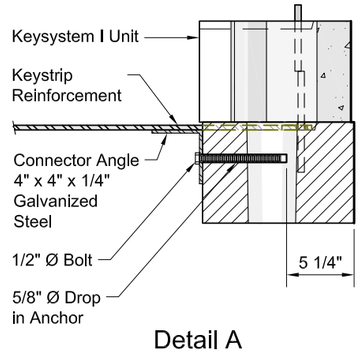
Note:

1. The Keystrips are to be field cut and welded as required. All cut and welded surfaces are to be coated with a cold tar epoxy or zinc rich paint.
2. The size of the tube is limited by the minimum clearance and strip inclination limits shown.

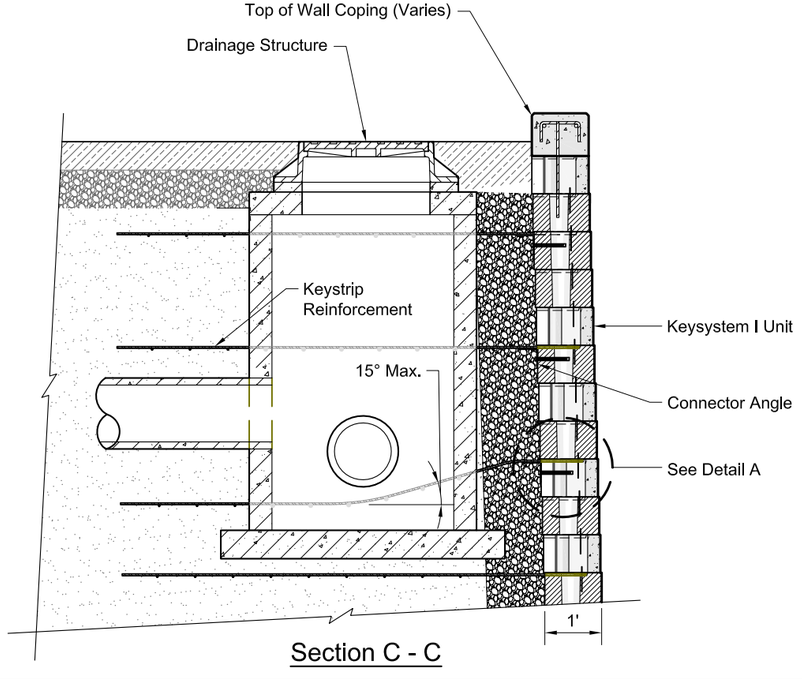
Keystrip Skew Details



Elevation D - D



Detail A



Section C - C

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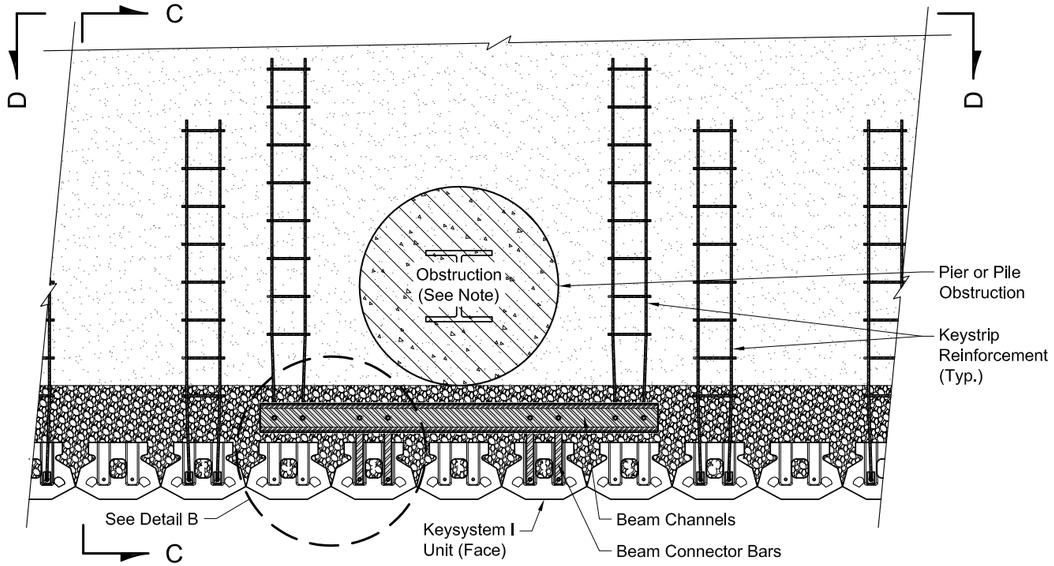
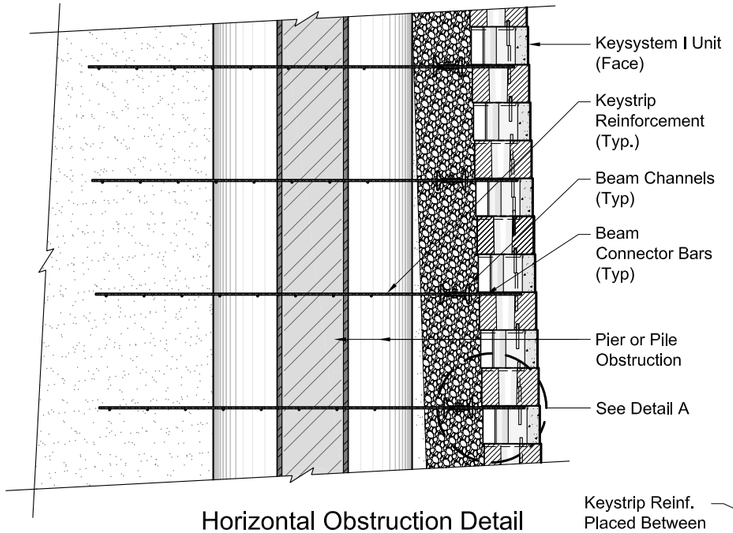
Minneapolis, MN 55435
952-897-1040

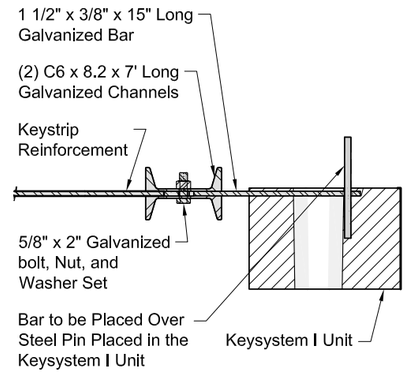
Designed By: RKM	Title: Keysystem I Inlet Obstruction Details		Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details		Drawing No: 7
Scale: No Scale			



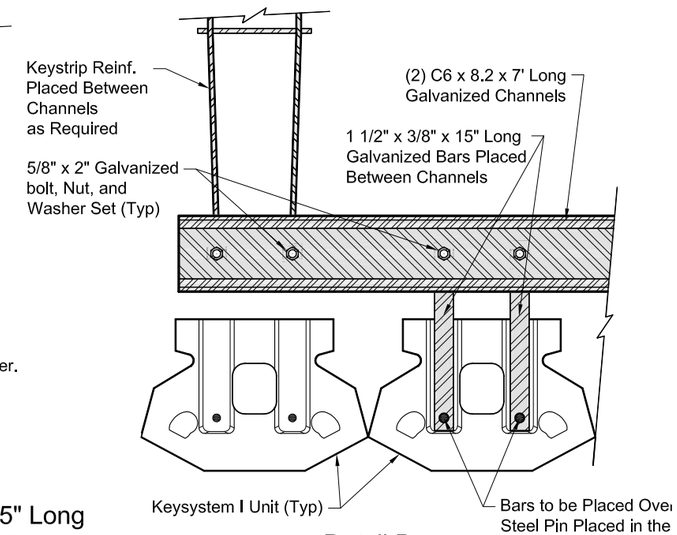
Vertical Pier or Pile Obstruction Behind Wall Plan Detail



Horizontal Obstruction Detail



Detail A



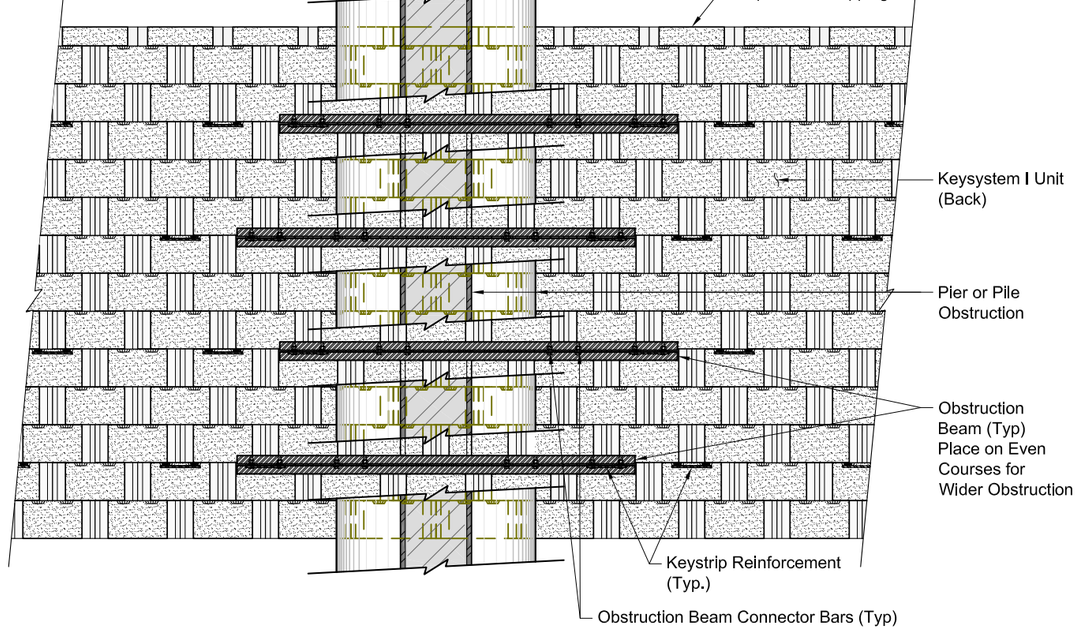
Detail B

Layout Procedure Note:

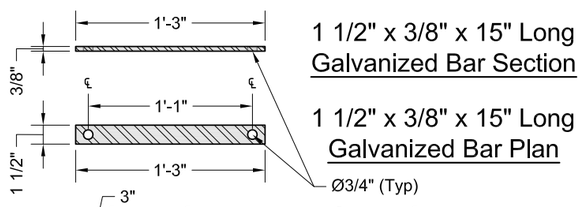
1. Install beam centered ± on pier or pile obstruction. Connect to blocks that fit best.
2. Install Keystrips on each end of the beam.
3. Install two Keystrips between frames as shown unless there is only space for one (1) Keystrip based on beam layout.

Steel Note:

1. Channels and bars shall conform to ASTM A36 steel or better.
2. Bolts shall conform to ASTM A307 or better.
3. Galvanization shall conform to ASTM A123.

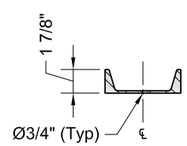


Elevation D - D

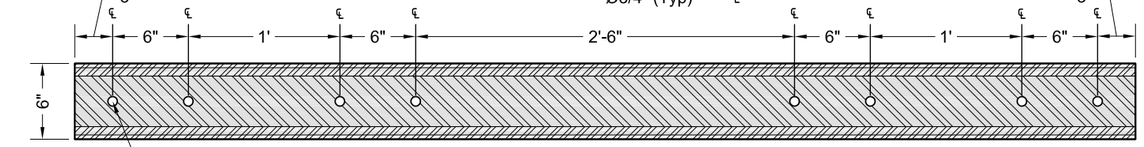


1 1/2" x 3/8" x 15" Long Galvanized Bar Section

1 1/2" x 3/8" x 15" Long Galvanized Bar Plan



C6 x 8.2 x 7' Long Galvanized Channel Section



C6 x 8.2 x 7' Long Galvanized Channel Plan

KEYSTONE® RETAINING WALL SYSTEMS
A CONTECH COMPANY

4444 W 78th Street
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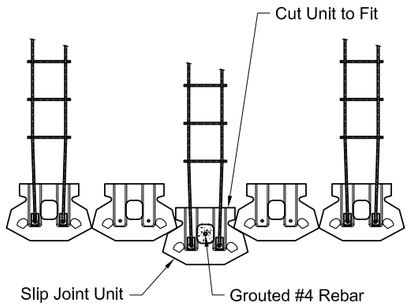
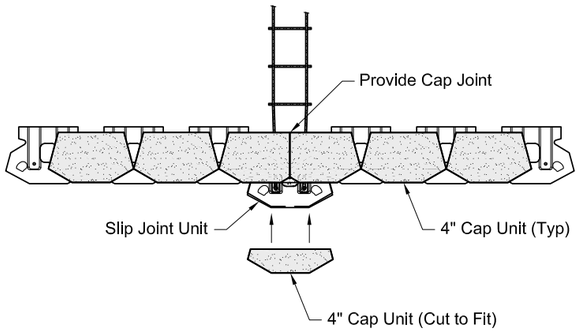
Designed By: RKM	Title: Keysystem I Pier / Pile Obstruction Details
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details
Scale: No Scale	Date: 01/2018
	Drawing No: 8

Slip Joint Notes:

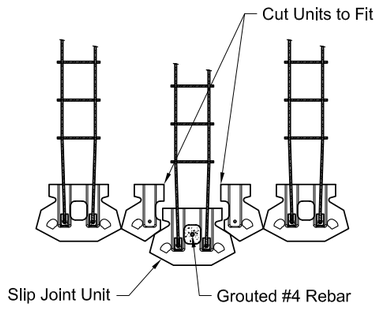
1. The core of the slip joint unit is to have a grouted #4 rebar extending from keystrip level to keystrip level (24" nominal height).
2. Drill out holes in the bottom of each slip joint unit to allow the steel or fiberglass pins to protrude into the units above.
3. Cut the tails off the slip joint unit to accomodate adjoining units as required.
4. Cut adjoining units to fit as required (see second course).
5. Cut 4" cap unit to cover exposed slip joint unit. Use kapseal adhesive to secure.



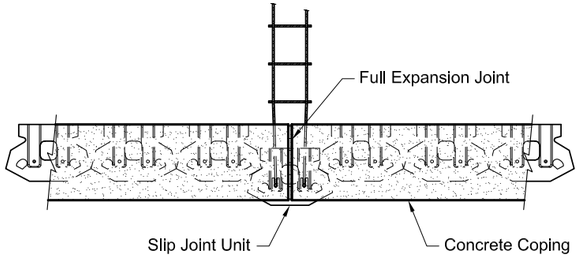
First Course



4" Cap Unit at Slip Joint



Second Course

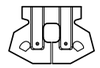


Concrete Coping at Slip Joint

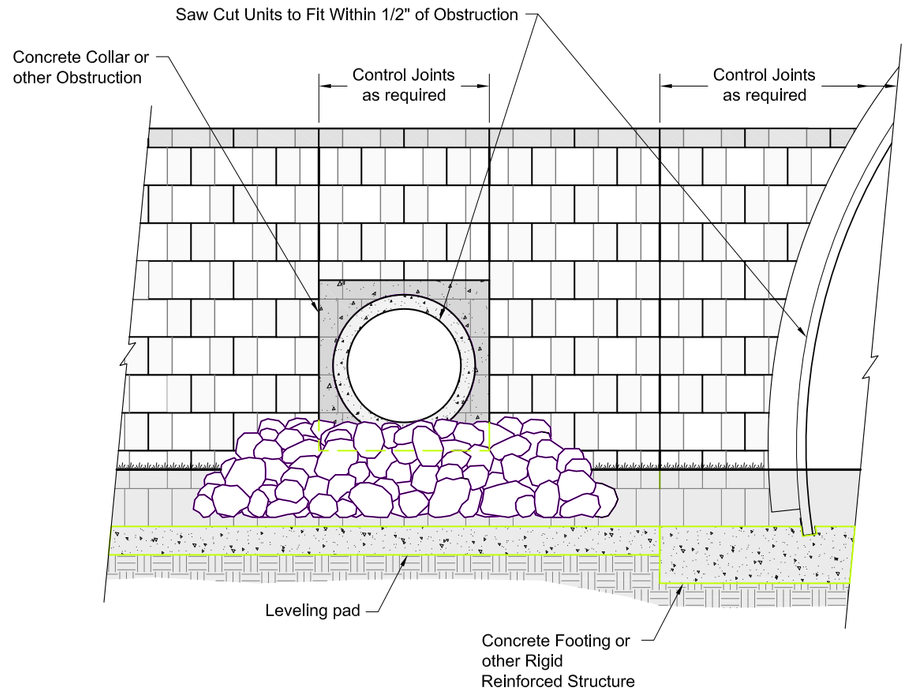
Typical Slip Joint Details

Control Joint Notes:

1. Vertical settlement control joints to be located at transition from the footing to the leveling pad and at the outside edges of obstructions that go through wall face.
2. Make control joint cuts at centerline of block face and cut through to center core of the unit.



Control Joint Cut



Typical Cut Joint Details

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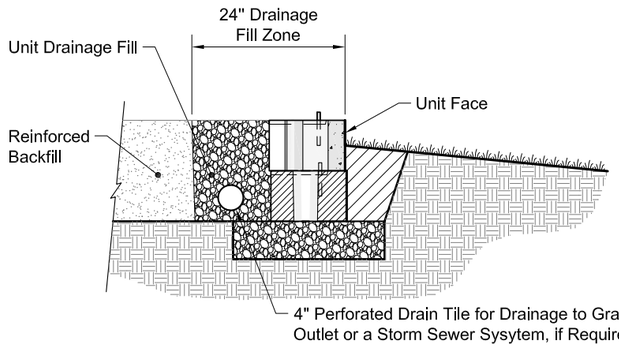
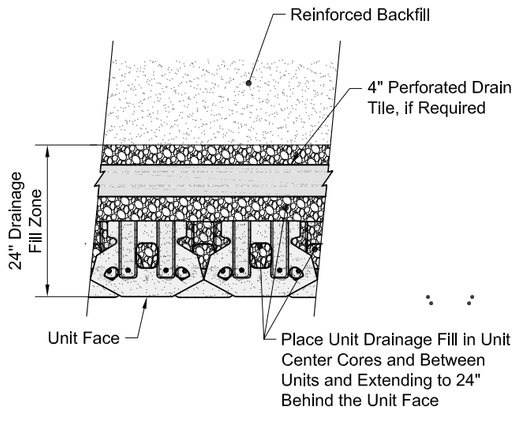
Designed By: RKM	Title: Keysystem I Slip Joint / Cut Joint Details	Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details	Drawing No: 9
Scale: No Scale		

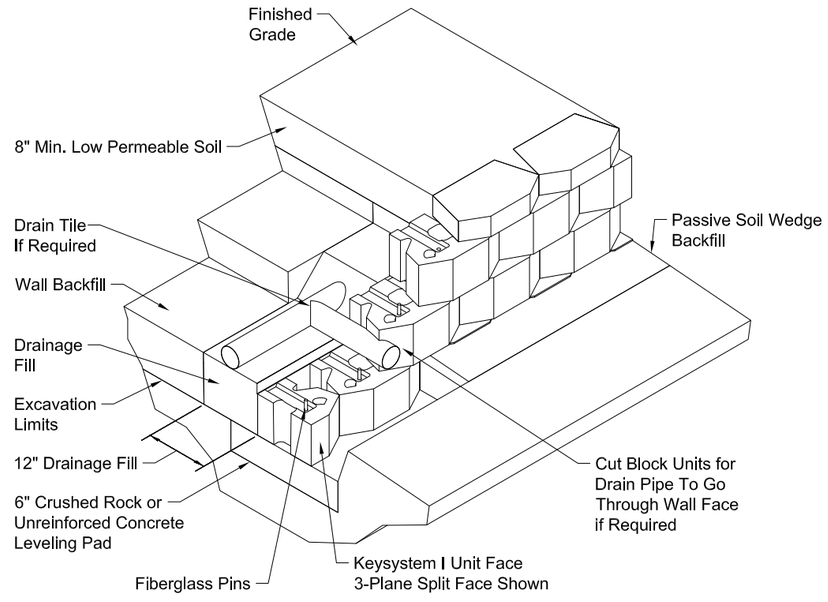


Drain / Unit Drainage Fill Section

Note:
Drainage tile is not required directly behind the wall units for conventional wall construction where retained soils are not a source of groundwater such as fill wall construction or cut walls into relatively dry banks. When required, the size, location, and type of specific drainage materials should be completed as directed by the onsite geotechnical engineer.



Drain / Unit Drainage Fill Plan



Keysystem I Unit / Wall System Isometric Cut Section View

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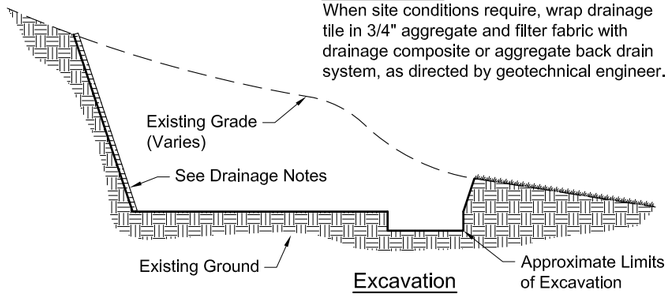
4444 W 78th Street
Minneapolis, MN 55435
952-897-1040

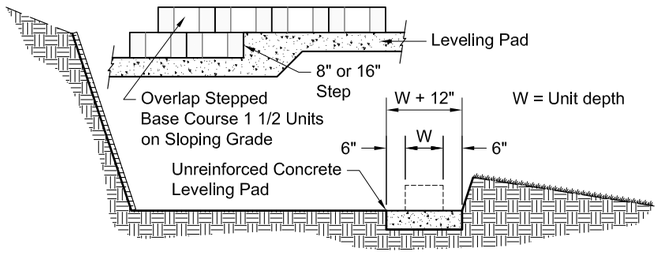
Designed By: RKM	Title: Keysystem I Wall Drain Details	Date: 01/2018
Checked By: CDM	Project: ADOT LRFD Submital Keysystem Details	Drawing No: 10
Scale: No Scale		

Drainage Notes:
When site conditions require, wrap drainage tile in 3/4" aggregate and filter fabric with drainage composite or aggregate back drain system, as directed by geotechnical engineer.



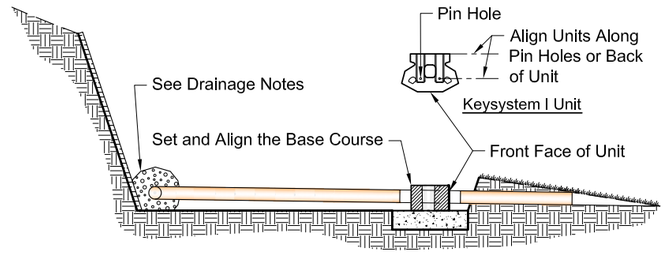
Excavation

Assembly Section Step 1



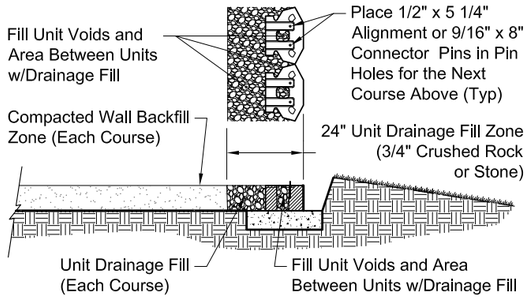
Place and Compact Leveling Pad / Drainage

Assembly Section Step 2



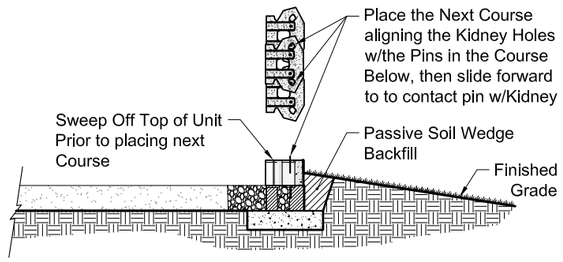
Place and Align Base Course / Drainage

Assembly Section Step 3



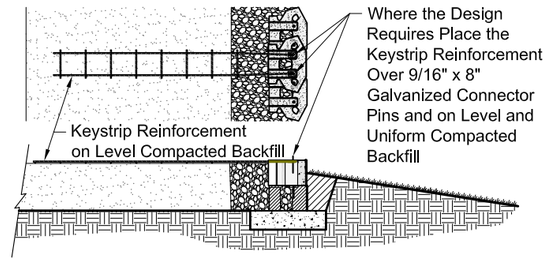
Place Pins, Unit / Drainage Material, Compacted Backfill

Assembly Section Step 4



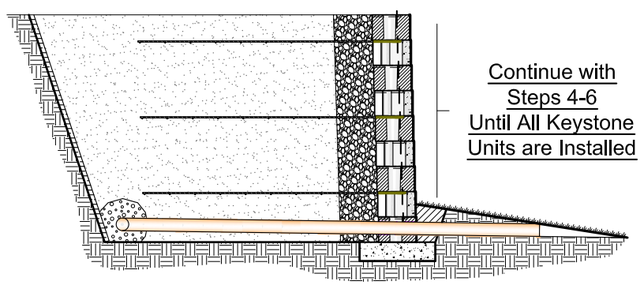
Place Additional Courses

Assembly Section Step 5

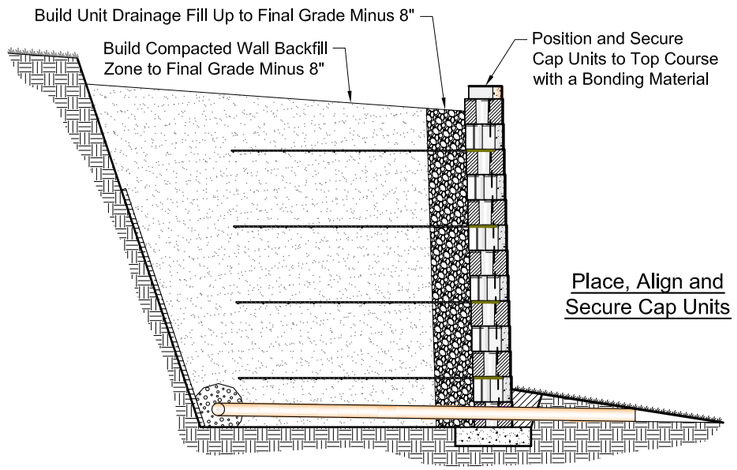


Place Reinforcement, as Required

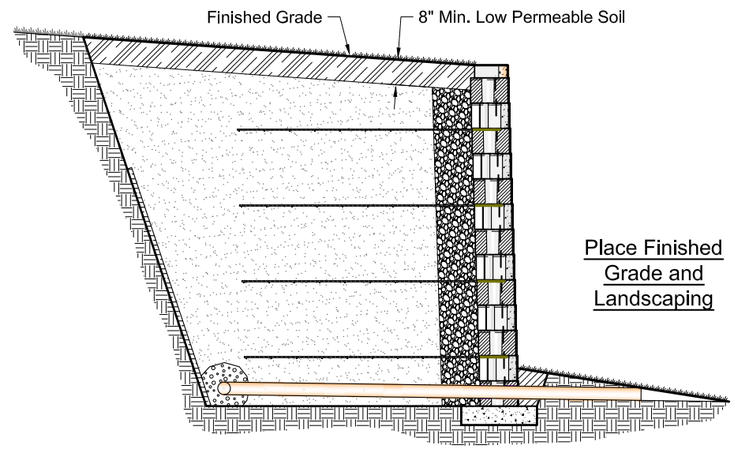
Assembly Section Step 6



Assembly Section Step 7



Assembly Section Step 8



Assembly Section Step 9

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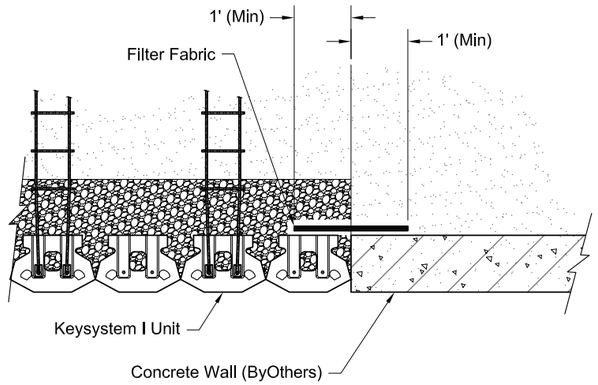
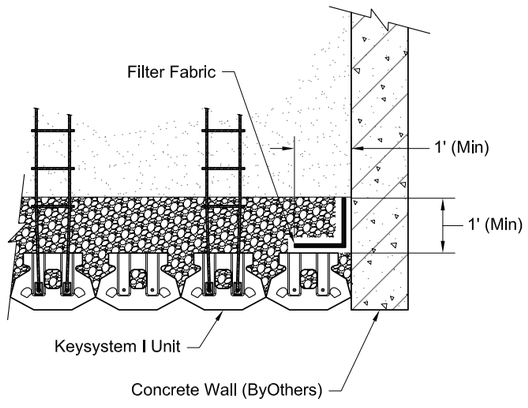
Designed By:	RKM
Checked By:	CDM
Scale:	No Scale
Title:	Keysystem I Wall Backfill Procedure Details
Project:	ADOT LRFD Submital Keysystem Details
Date:	01/2018
Drawing No:	11

Filter Fabric Notes:

1. Attach filter fabric to Keysystem I units and Obstructions with construction adhesive.



Parallel Connection Detail



Perpendicular Connection Detail

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4444 W 78th Street
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Designed By: RKM	Title: Keysystem I Wall Structure Connection Appurtenances Details
Checked By: CDM	Date: 01/2018
Scale: No Scale	Project: ADOT LRFD Submital Keysystem Details
	Drawing No: 12