COMPAC UNIT - CRANBERRY TWP, PA

ADDITIONAL WALL CONSTRUCTION DETAILS

Keystone has been the segmental retaining wall design leader for over 25 years. This section covers a variety of the most common wall details and/or issues that may be confronted when constructing a Keystone wall. Some of the details presented in the section have been developed specifically based on industry design standards. Other details have been developed through our years of experience in the segmental retaining wall industry.

Items that are covered in this section:

- Retaining wall drainage
- Water applications
- Barriers
- Fencing
- Parapets
- Steps and stairs
- Terraced and wall applications
- Wall repair
- Tree planting guidelines
- Creative options

Retaining Wall Drainage Options

Poor drainage is a leading cause of retaining wall failures. Hydrostatic pressure can accumulate behind a wall and add an increased load on the wall if drainage provisions are not installed or not adequate for the conditions. The Keystone system has superior drainage features. The techniques below should be considered where the specified drainage issues are present.

1. Basic drainage/Unit drainage fill
Keystone's mortarless, interlocking system, with a free draining gravel drainage zone and corefill (See "Installation: Step-by-Step" section), allow proper drainage under most circumstances. No weep holes are necessary.

2. Surface run-off
Divert surface drainage at the top of the retaining wall by placing a impermeable soil cap (i.e. clay) or formed swale (i.e. soil or concrete) along the back surface of the Keystone units. This will help direct run-off away from the retaining wall.

3. Embankment flow
When embankment ground water flow behind the wall is likely, place a drainage composite or chimney drain over the cut soil (see product suppliers for recommended coverage and installation instructions or drainage composite). The drainage composite or chimney drain should drain to an outflow pipe (i.e. drain tile) to remove water. Numerous cost-effective products are available to serve this purpose.

4. Ground water flow
The effects of seasonally fluctuating ground water, at the base of the retaining wall, can be offset by placing an outflow pipe (i.e. drain tile) behind the lowest unit, along with a drain behind the reinforced fill.

GENERAL NOTES:

*Rear drainage pipe should be included when:

- » Groundwater or seepage is present in retained soils
- » Springs or seasonal seepage potential is noted in geotechnical report
- » Reinforced soil of lower permeability than retained soils
- » Generally, additional drainage material such as aggregate drains & fabrics and/or drainage composite nets are used in conjunction with rear drainage pipe as directed.
- » When above conditions are not present or groundwater conditions are not a factor, the rear drainage pipe may be omitted or alternately located behind units at the base of the drainage fill.

FIGURE B:3 - DRAINAGE SWALE

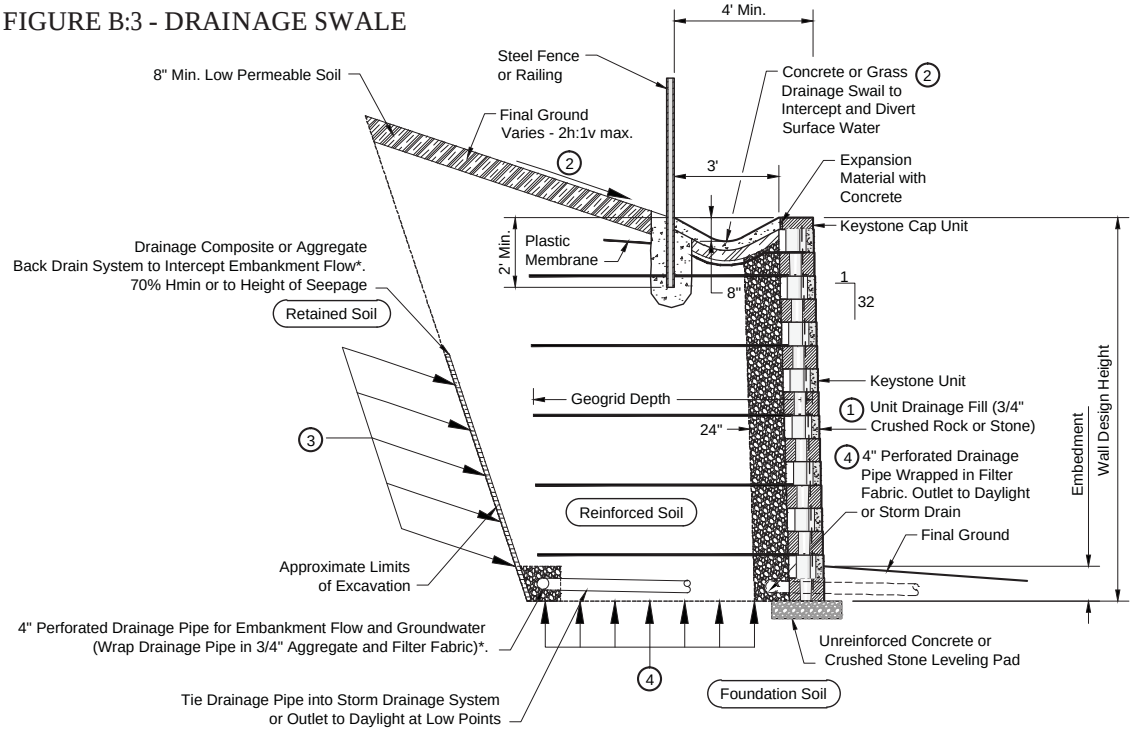
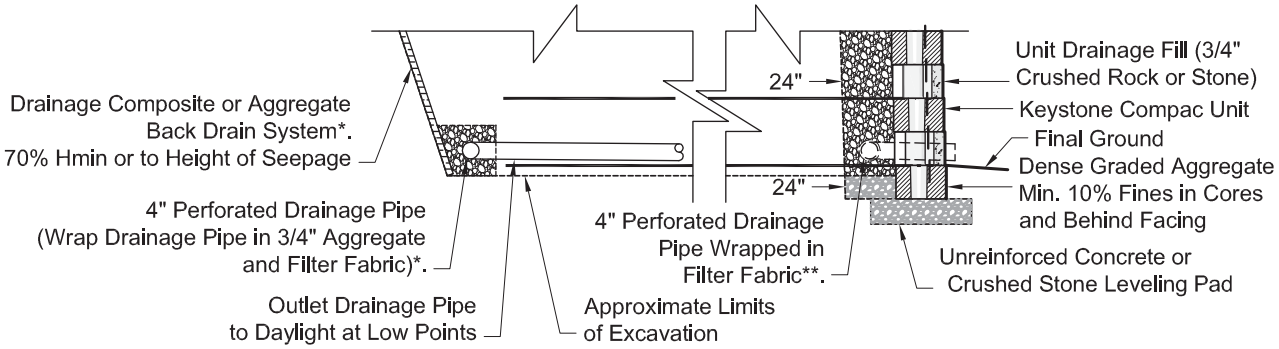


FIGURE C:3 - ALTERNATE RAISED DRAINAGE PIPE LOCATIONS



NOTE:

Alternate raised drain pipe locations may only be used when:

» Grading at base does not allow gravity outlet of pipe.

» There is no storm sewer system to outlet pipe directly into.

Only used when site geometry requires drain pipe to be raised in order to outlet at face

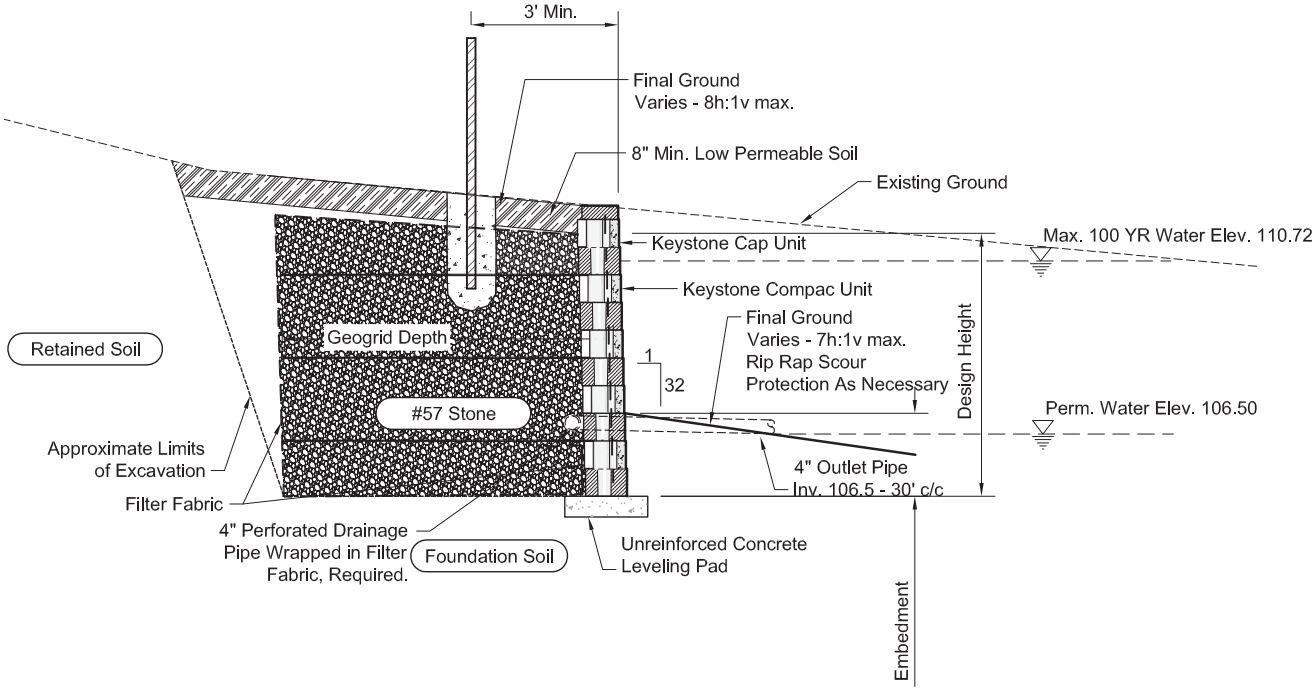
*See general notes (p. 72) for drainage requirements.

When considering a water application for the Keystone wall system, the following areas need to be analyzed and designed to maintain structural integrity of the wall under normal, high wave and flooding water conditions:

- » Start by analyzing the wall under normal design criteria. (i.e. WALL HEIGHT, BASE CONDITIONS, SURCHARGE LOADS, SOILS DATA, REINFORCEMENT REQUIREMENTS, DRAINAGE, ETC…)
- » Determine the water level on the wall under normal and adverse conditions.
- » Determine flow rate for streams, channels, etc…
- » Determine degree of wave action; minor, major or boat wake.
- » Determine the potential for flooding and inundation of the wall.

Always contact a professional engineer to assist you in your water application design.

FIGURE D:3 - WATER APPLICATION




COMPAC UNIT - ANN ARBOR, MI

FIGURE E:3 - PIPE IN REINFORCED ZONE

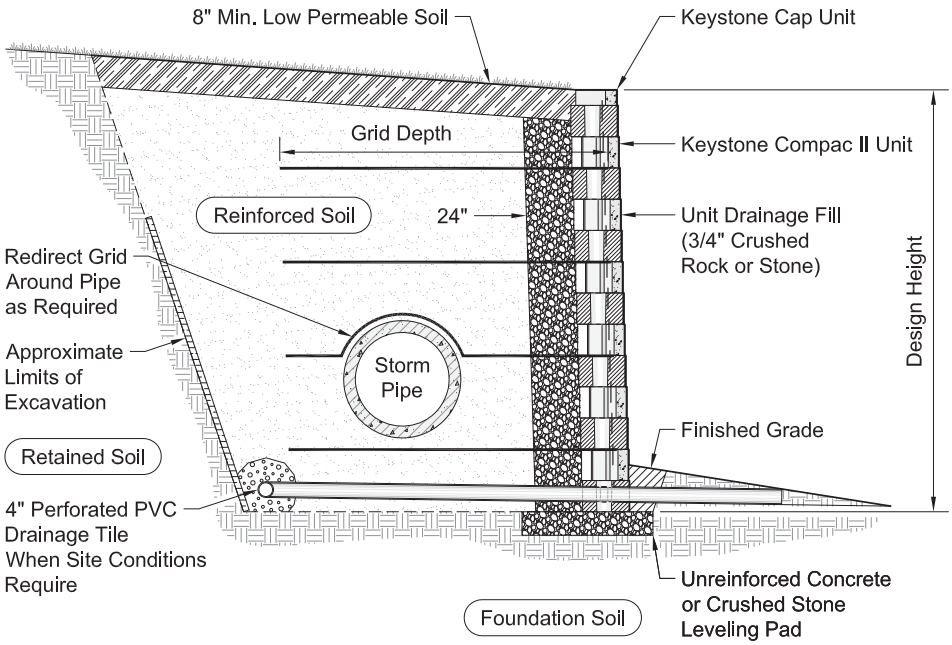
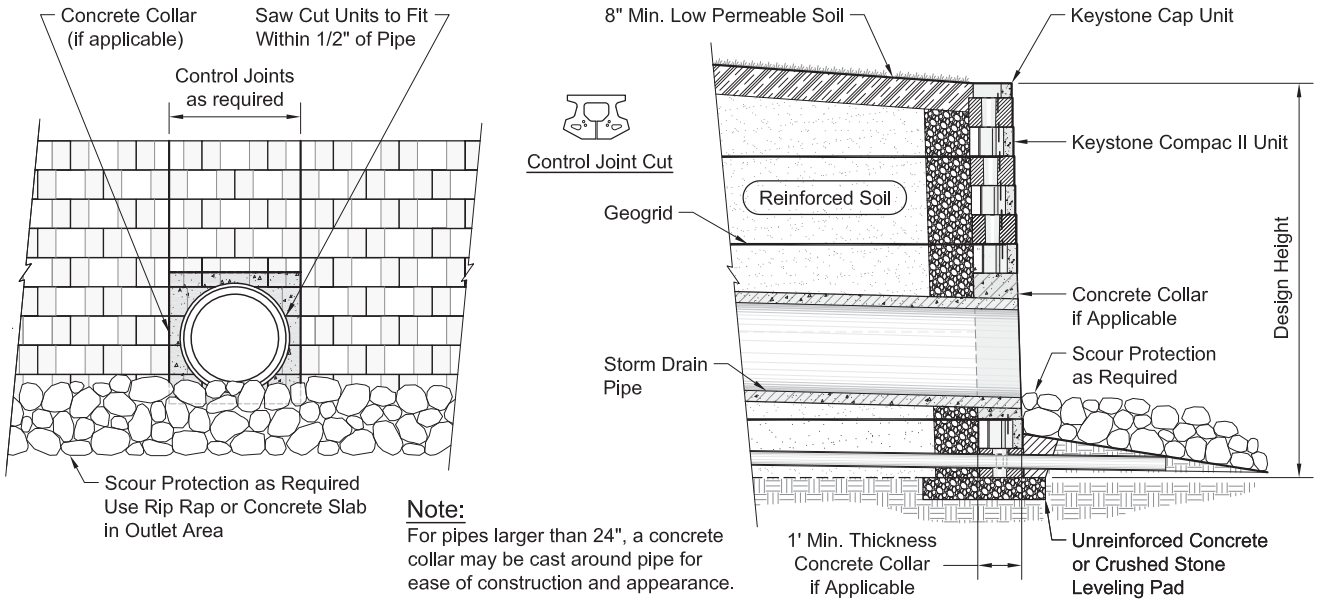


FIGURE F:3 - TYPICAL PIPE OUTLET



Note:
For pipes larger than 24", a concrete collar may be cast around pipe for ease of construction and appearance.

Headwall Application

Keystone retaining walls are an economical and effective headwall system for many types of multi-plate arches, precast concrete panel arches, and various types of culverts:

NOTE:

Total width of headwall face must be in full or half width unit increments.

Fascia plate shown is 6"x 4"x 5/16" hot rolled steel angle (galvanized finish) or as specified. Use if desired to conceal rough cut Keystone unit edges for an aesthetic appearance.

Cut Keystone units to conform to arch or box culvert. Grout between block and plate using non-shrink type grout conforming to ASTM C1107. Maximum 3/4 inch gap to be grouted with non-shrink grout.

When building the Keystone wall, backfill in equal lifts on each side of culvert. Measure for exact course height and unit running bond pattern on each side of arch or box culvert so they meet correctly at top of culvert.

Pipe Zone Separation Notes:

1. Drainage aggregate fill in the pipe zone is 3/8 inch to 3/4 inch crushed stone.
2. Geotextile must be selected so it is not blinded by the pipe backfill material.

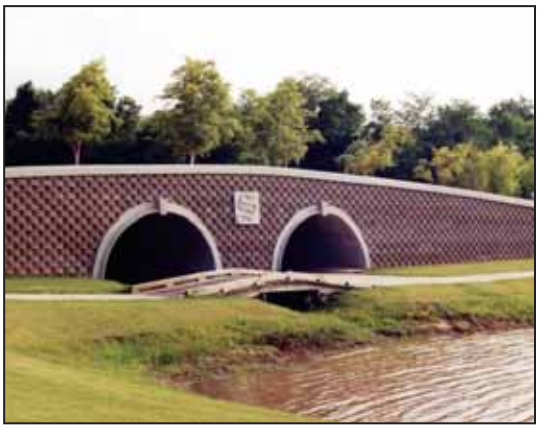


FIGURE G:3 - TYPICAL DRAINAGE STRUCTURE

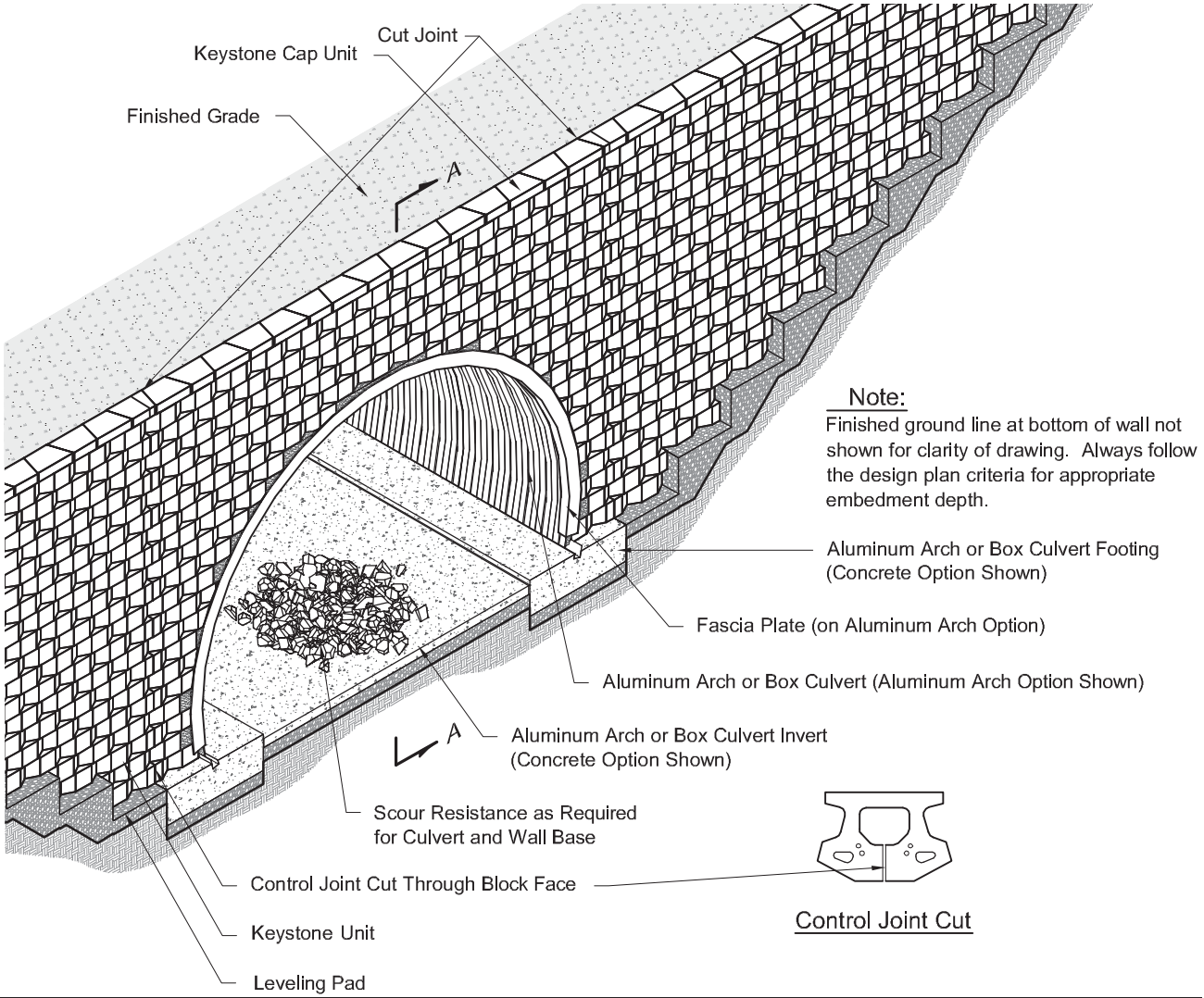
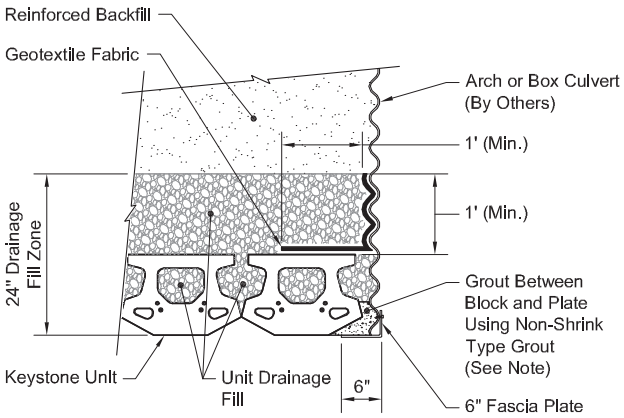
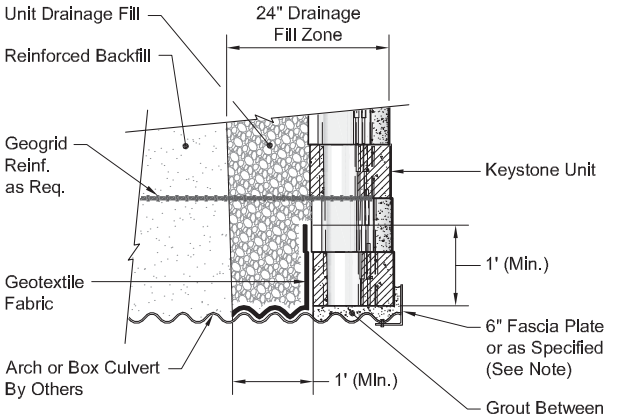


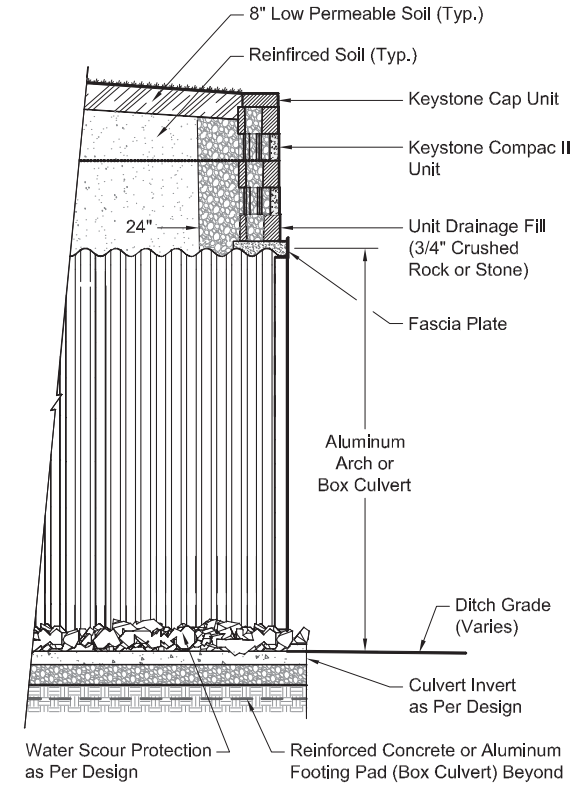
FIGURE H:3 - TYPICAL DRAINAGE STRUCTURE DETAILS



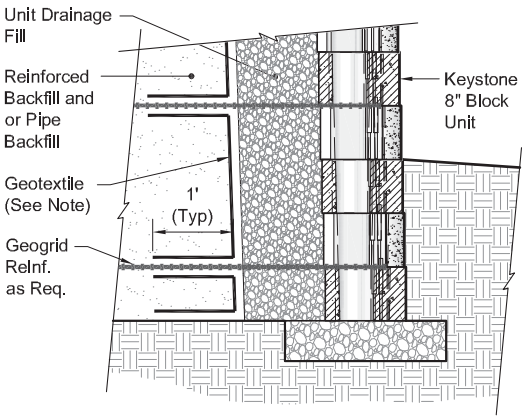
Wall Vertical
Connection Joint Plan
No Scale



Wall Horizontal
Connection Joint Plan
No Scale



Typical Reinforced Wall Section A-A at Culvert
Compac II Unit - Near Vertical Setback Shown



Modular Block Headwall
Pipe Zone Separation Detail
No Scale


COMPAC UNIT - PUEBLO, CO

SPECIALTY INSTALLATIONS

Barriers : Introduction

Keystone walls can readily be installed with many various types of barrier systems. There are two main types of barriers that can be installed at the top of Keystone wall system: vehicular barrier devices, and pedestrian fall protection devices.

Vehicular barrier devices typical fall into two categories, flexible and rigid. Flexible barriers are the most common traffic impact barrier device due to the simplicity of installation and the fact that they are typically more cost effective than a rigid option.

When a flexible barrier is not an option, due to insufficient room to install a guardrail at the top of a wall, often times a rigid cast in place (CIP) concrete traffic barrier is the next best solution. CIP concrete traffic barriers are most commonly used in DOT applications, but can also be specified in private application roadways with heavy traffic areas. CIP concrete traffic barriers can vary greatly by the application type, location, or design codes. Refer to the engineered design for specific design criteria.

Pedestrian fall protection devices come in various forms such as, railings, fences or parapets. Most public design codes require some form of fall protection when a retaining wall reaches a specified height. Please contact your local building officials for code requirements in your area to determine if and when a fall protection device is required for your retaining wall. Keystone recommends fall protection be installed for all walls over 3 feet in height.

COMPAC UNIT - PROVO CANYON, UT

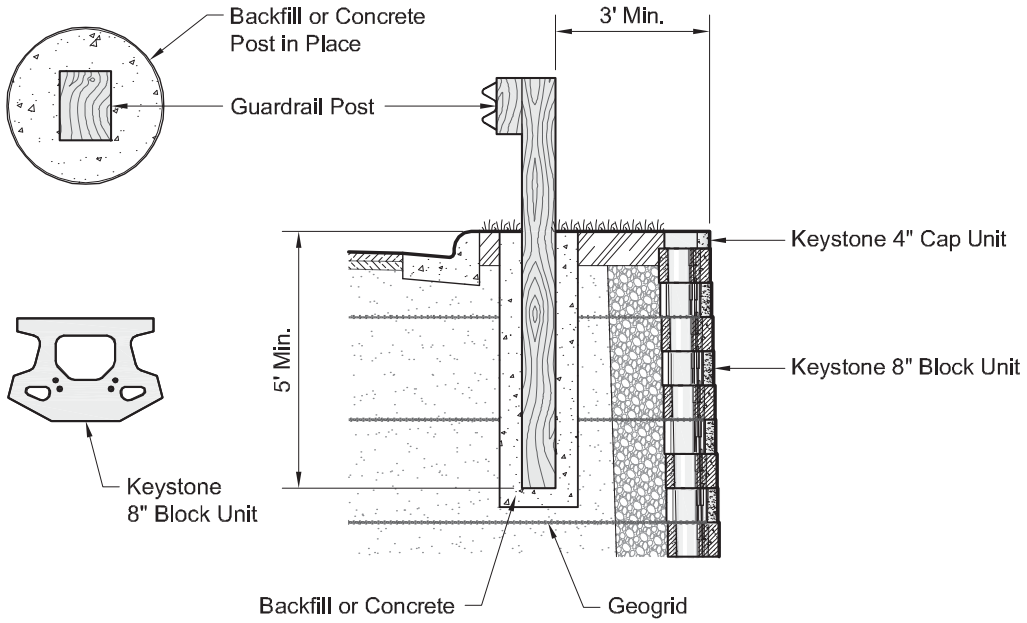
When installing a guardrail with a Keystone wall, there are three important guidelines that must be met as mandated by The American Association of State Highway Transportation Officials (AASHTO).

1. The guardrail must be located a minimum of 3 feet from a wall face.
2. The guardrail post shall be augered or driven a minimum 5 feet into the ground.
3. The guardrail needs to pass through a minimum of 2 geogrid layers.

There are a number of installation methods for a guardrail with a Keystone wall. Always reference the project engineered drawings for the preferred installation method.

1. Sonotubes can be installed during wall construction for the guardrail foundation posts.
2. Wooden posts can be augered into the ground after wall construction.
3. Steel posts can be driven into the ground after wall construction.

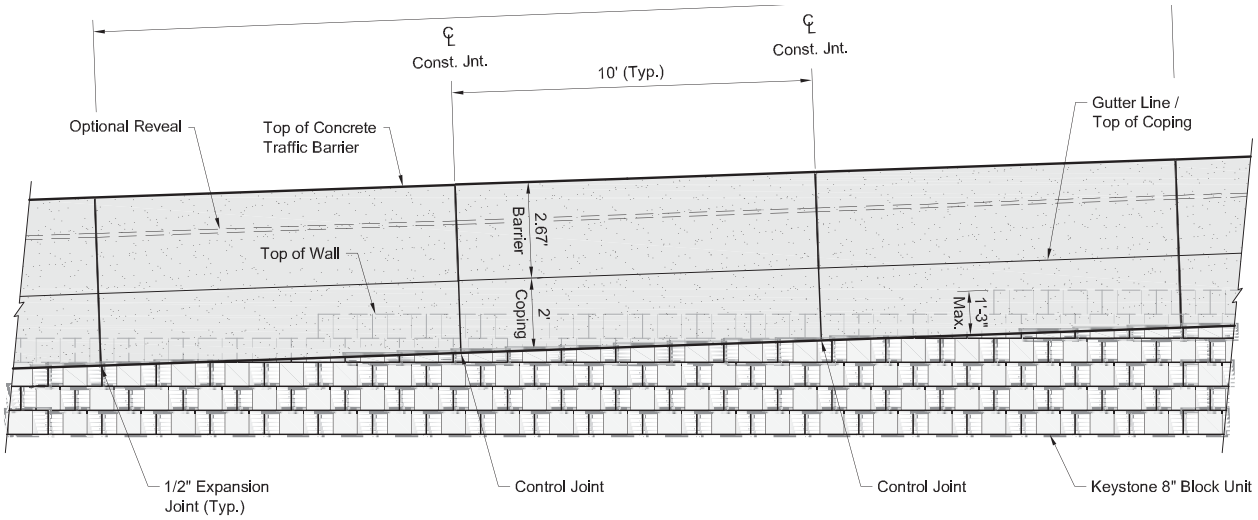
FIGURE W:2 - TYPICAL GUARDRAIL CROSS SECTION



Keystone walls can readily be capped with a reinforced CIP concrete traffic barrier. The following details are provided for reference as a typical "Jersey Barrier." Always follow the project plan details for installation details.

1. Install the Keystone wall per project installation instructions or as outlined in this manual.
2. Set and secure forming materials along the top course of the Keystone wall using standard forming procedures. Pour and finish traffic barrier as by the project engineered design. Insert control joints at a maximum 10 feet on center along the length of the barrier, or as specified by engineer.

FIGURE I:3 - PARTIAL CAST IN PLACE TRAFFIC BARRIER



NOTE:

1. If short CIP barrier sections are to be constructed adjacent to precast barrier sections, then this section's dimensions shall be adjusted to conform to the precast dimensions.
2. Elevations shown are at the labeled gutter point.

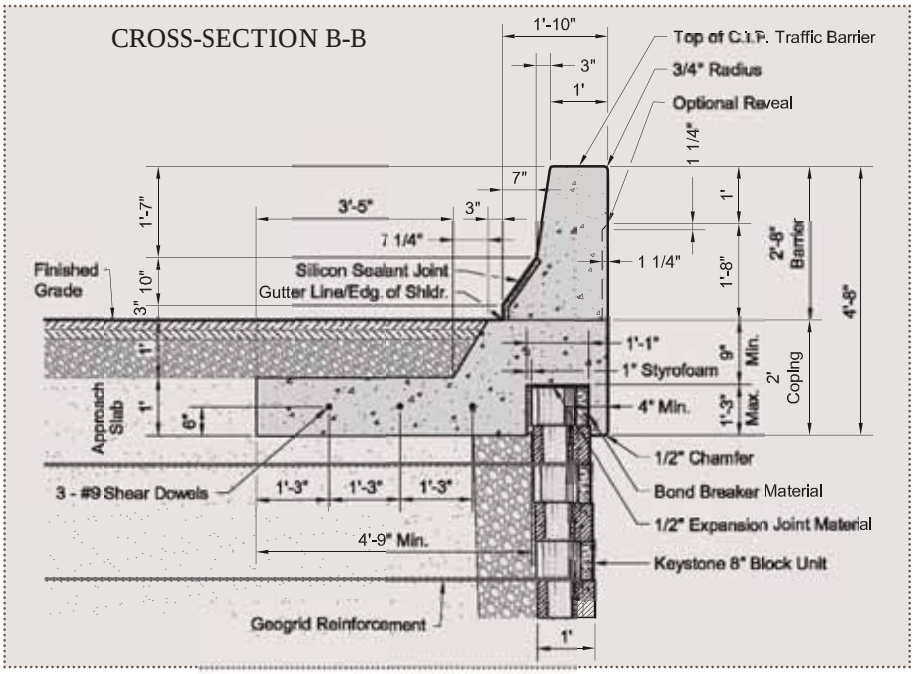
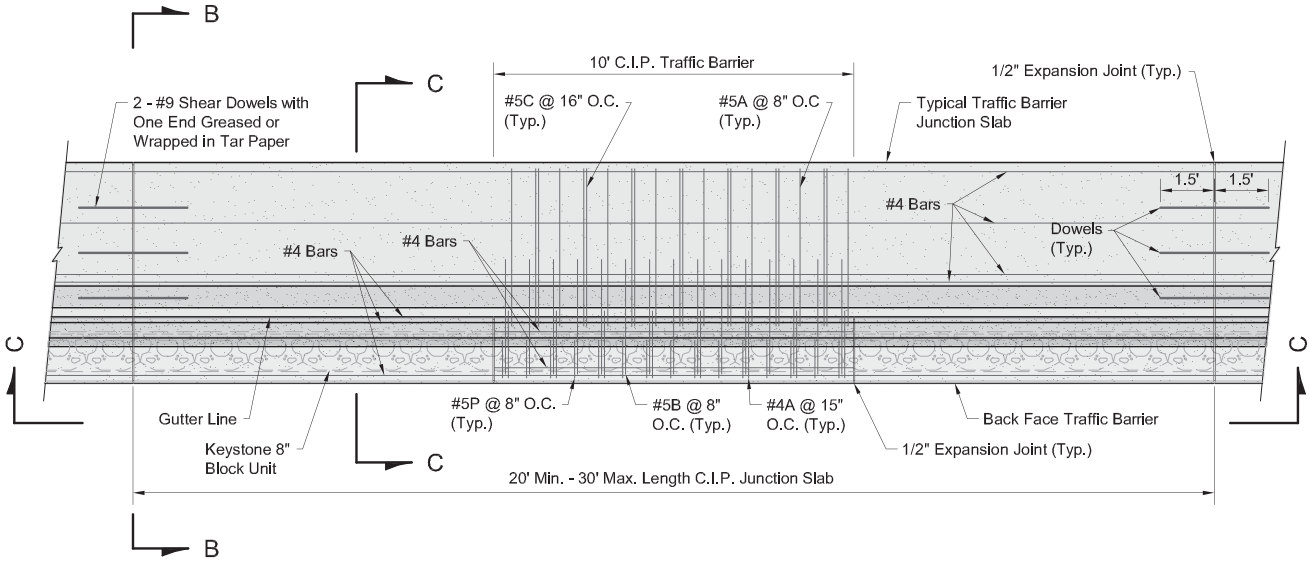
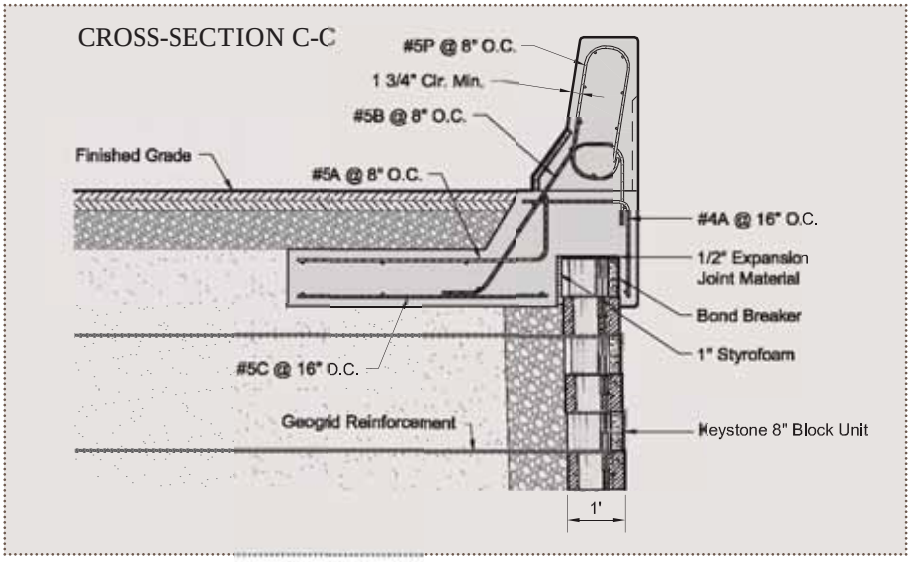


FIGURE J:3 - PARTIAL CAST IN PLACE REINFORCED TRAFFIC BARRIER





NOTE:

1. All longitudinal bars are #4 as shown.
2. Concrete cover 2 inch (Typ.)

Fences can be placed at the top of a Keystone wall with fence posts placed behind the Keystone units. The choice, location, and compliance to local codes of the appropriate fall protection system, is the responsibility of the owner and site engineer. Follow these procedures for proper installation of fence posts with Keystone walls.

1. Install the Keystone wall per general installation instructions.
2. Fence posts positioned behind the Keystone units may be installed and anchored using a variety of installation methods.
3. These details can also be used for Keystone Standard units.

FIGURE K:3 - TYPICAL FENCE POST OFFSET

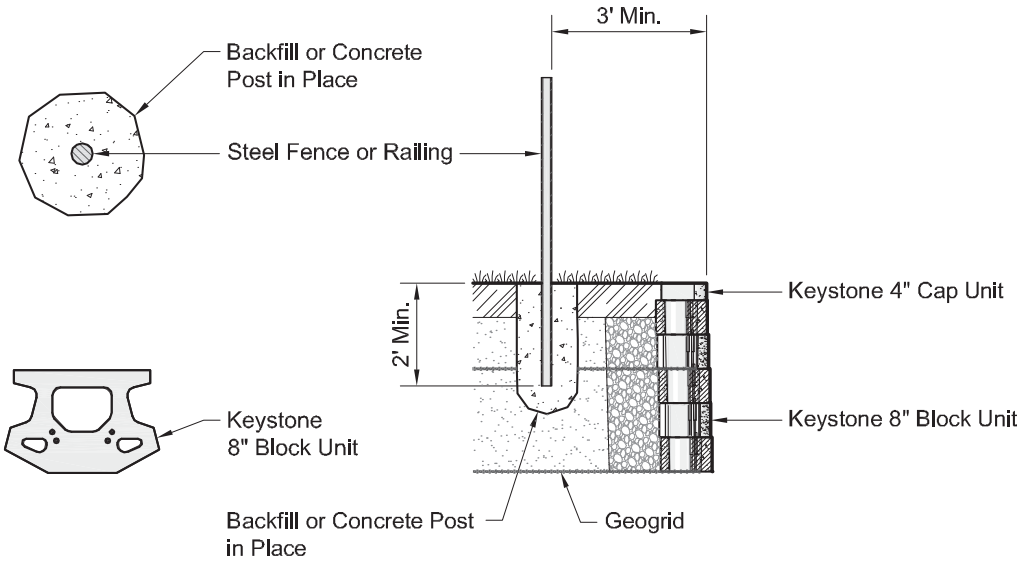


FIGURE L:3 - INTEGRATED SIDEWALK & FENCE

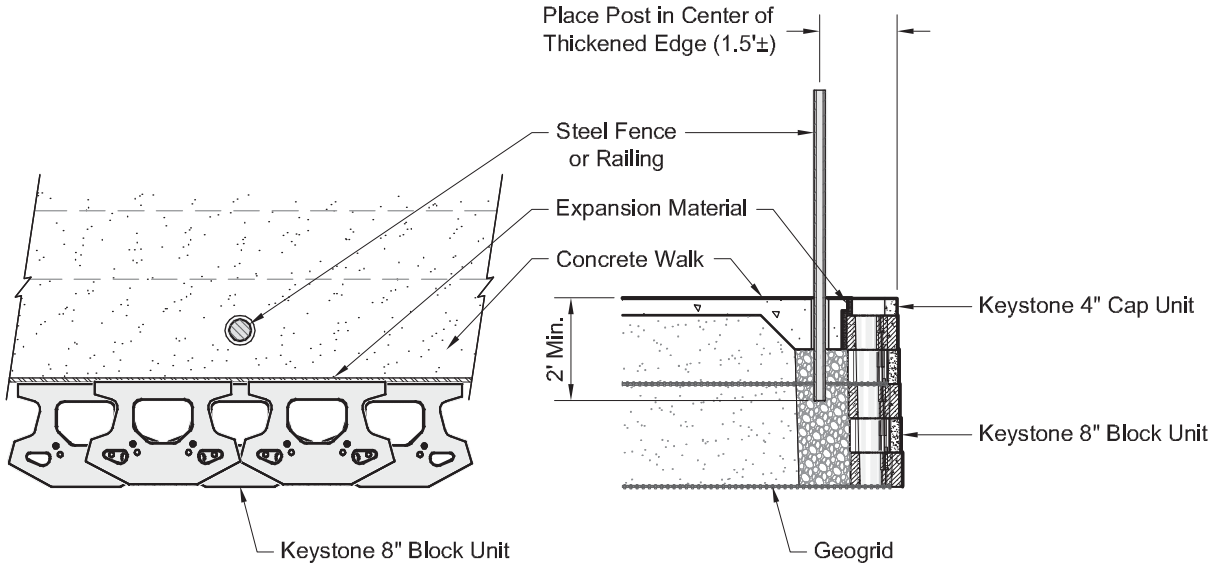
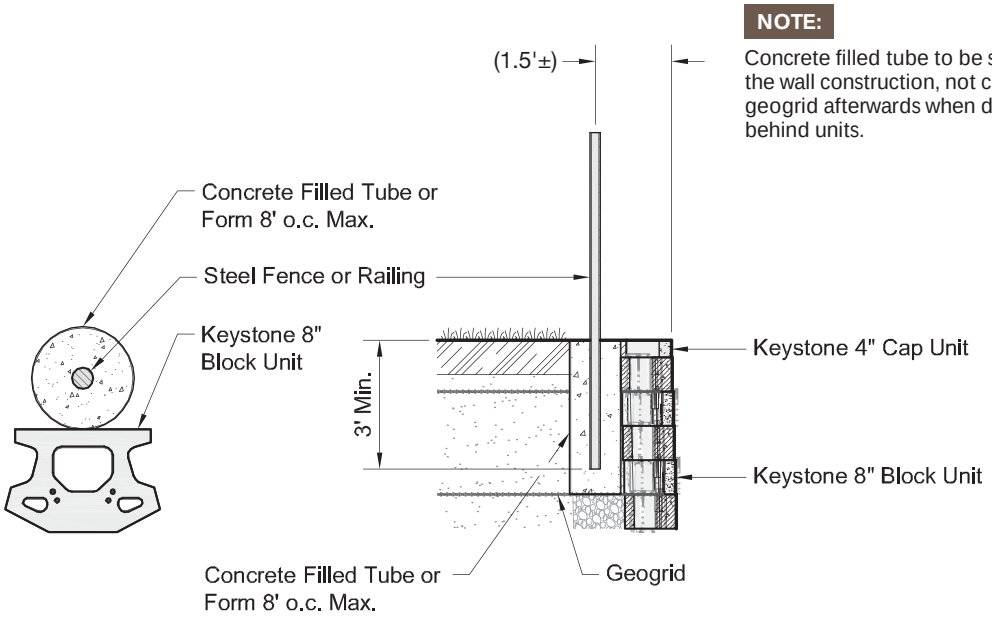


FIGURE M:3 - MINIMUM FENCE OFFSET



STANDARD UNIT - MINNETRISTA, MN

Special Fence Installation : Standard Unit Only

Keystone Standard units are always recommended in situations where railings are considered for direct mounting on the wall system. It is difficult for a railing design to satisfy structural design requirements when considering the direct mounting on, or into, the Keystone modular wall system. The small unit size and mass provides minimal resistance to overturning by itself so a number of units must be engaged to provide the required resistance. The Keystone Standard unit is typically large enough to satisfy a 20 plf or 200lb post minimum IBC loading, provided that the post is grouted into the upper three courses as shown below. Shear resistance of Standard units (>1000plf) exceeds the driving forces (20plf) by a wide margin in a gravity wall application and is not critical evaluation. Railing shall not exceed maximum height of 42 inches above the units.

FIGURE N:3 - DIRECT MOUNT RAILING IN STANDARD UNIT WALL - NEAR VERTICAL

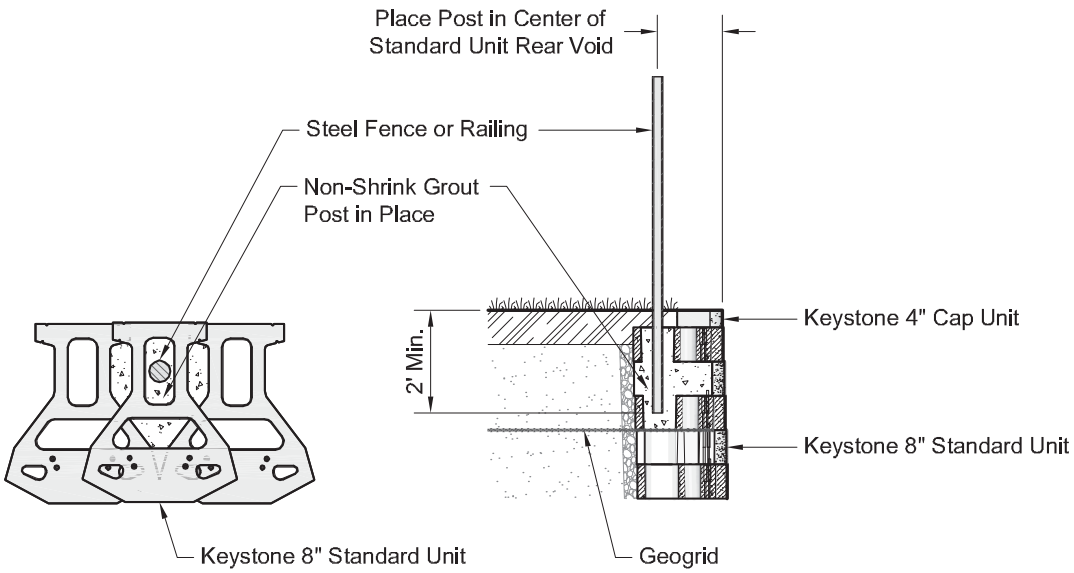


FIGURE O:3 - DIRECT MOUNT RAILING IN STANDARD UNIT WALL - 1" SETBACK

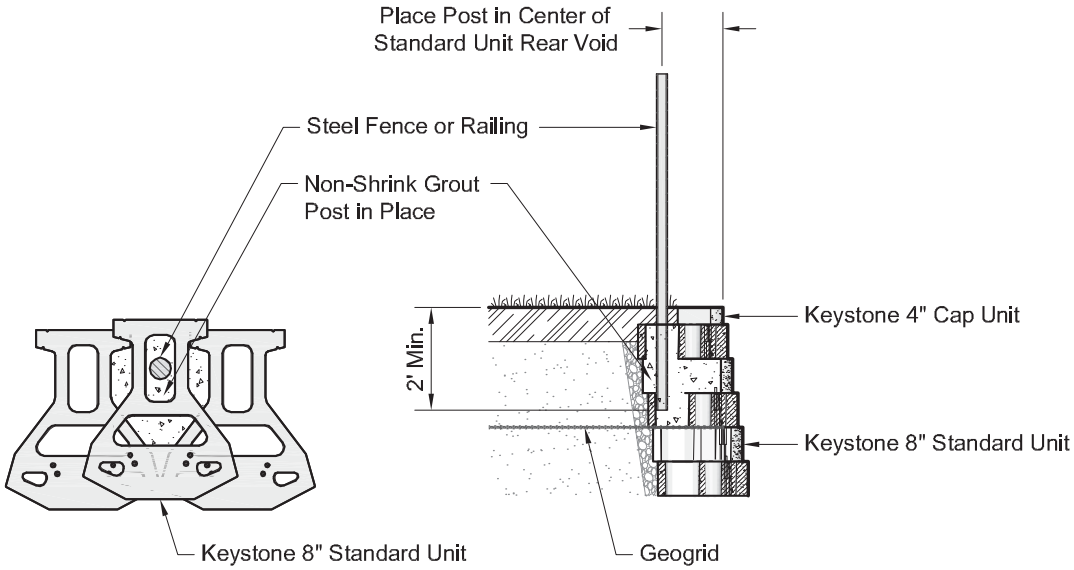


FIGURE P:3 - ROUND POST
(post size shall not exceed 3" diameter)

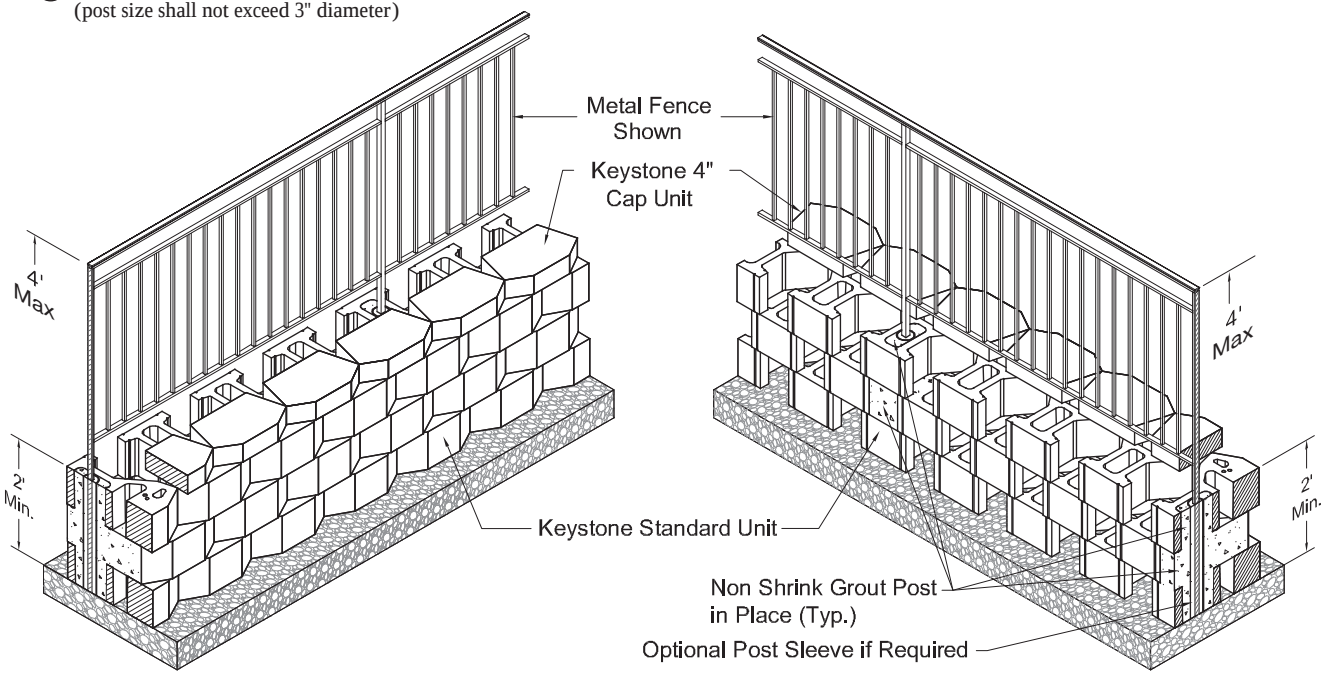
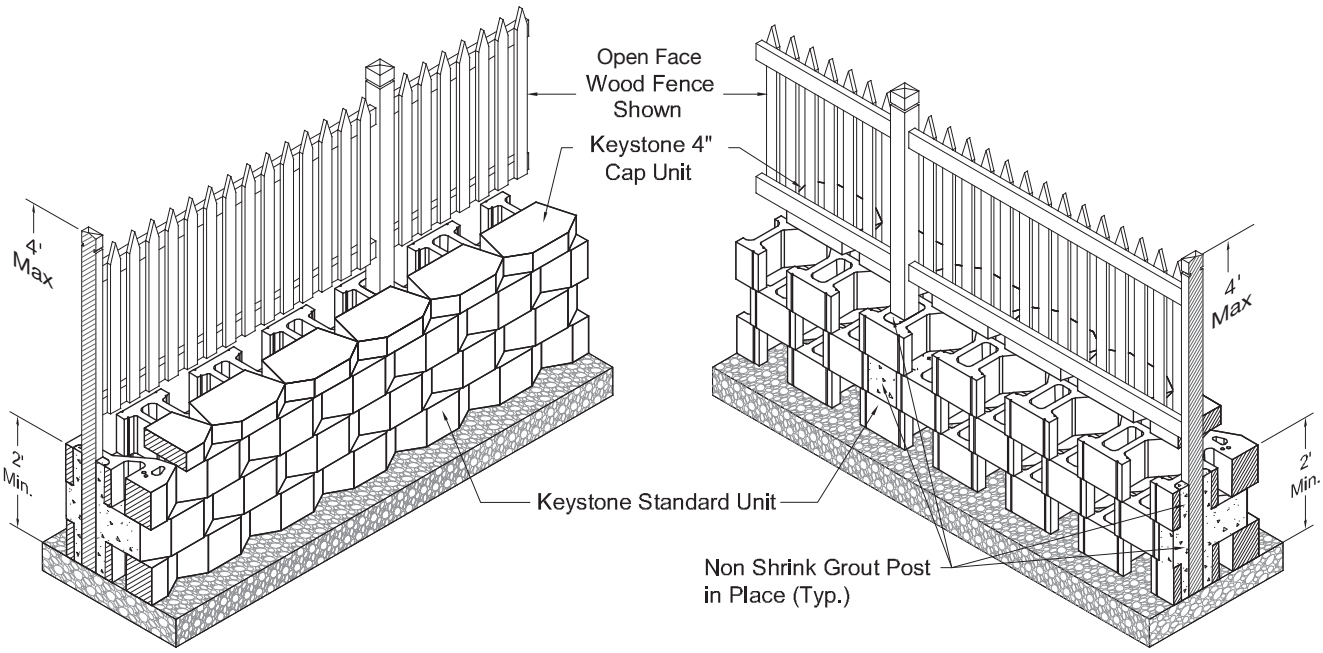


FIGURE Q:3 -SQUARE POST
(post size embedded in units shall not exceed 3" x 3")



SPECIALTY INSTALLATIONS

FIGURE R:3 - TYPICAL PARAPET COURSE PLANS

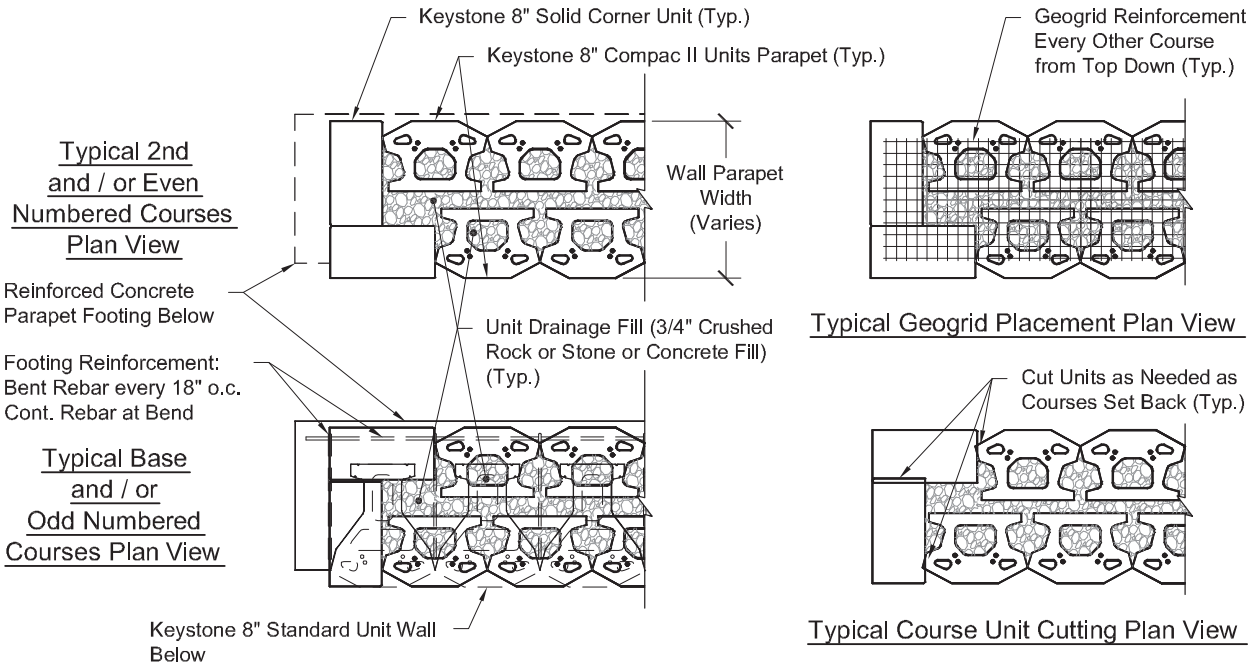


FIGURE S:3 - WALL/PARAPET SECTION VIEW (STANDARD & COMPAC UNITS)

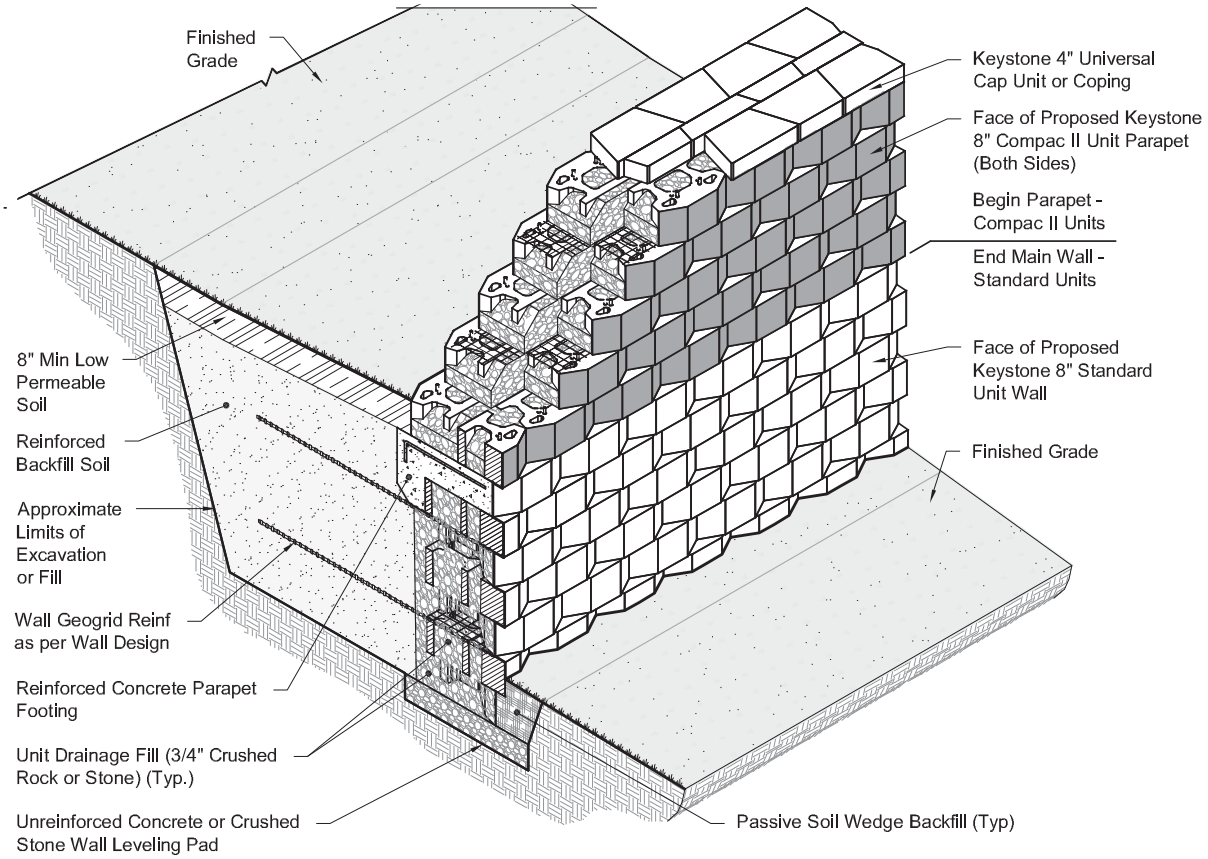


FIGURE T:3 - WALL/PARAPET CAPPING & END SECTION VIEW (STANDARD & COMPAC UNITS)

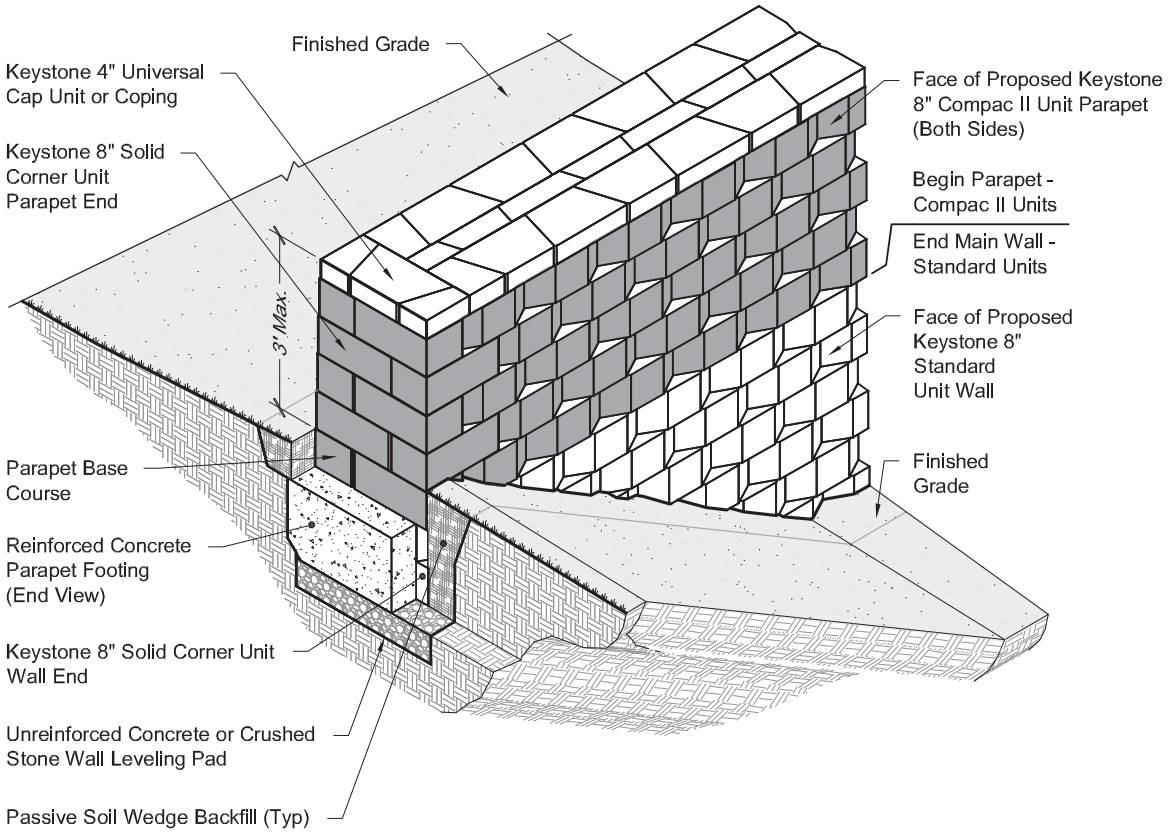
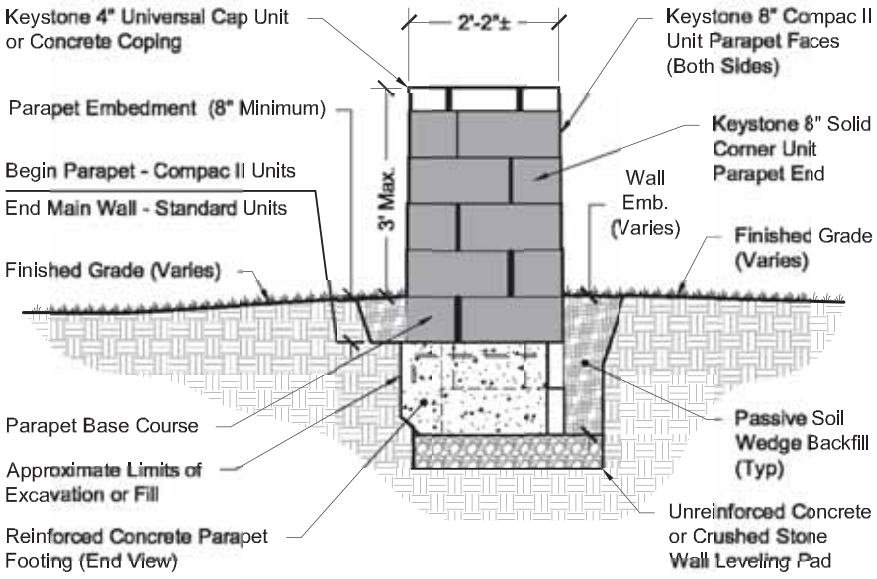


FIGURE U:3 - PARAPET END SECTION VIEW

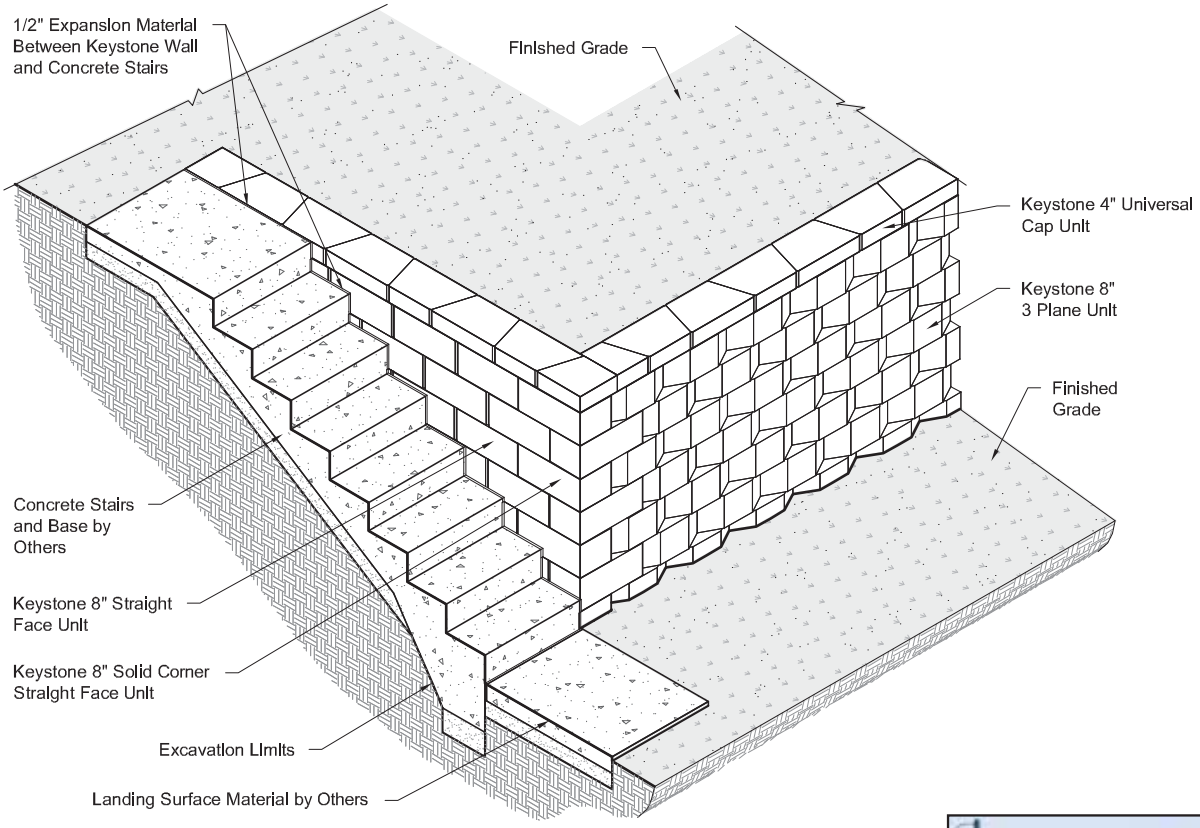


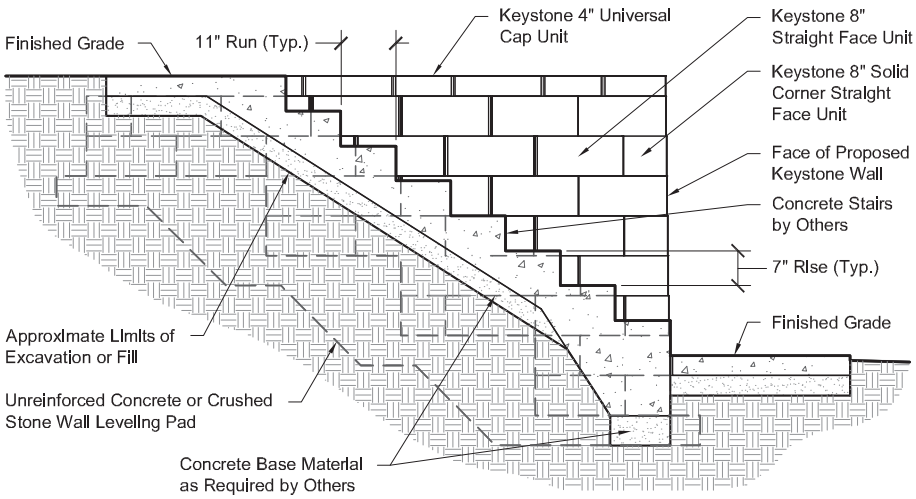
Keystone walls can easily be constructed to incorporate CIP concrete stairs within the wall systems. The stairways can be designed to be incorporated into reinforced soil of the wall (see Figure V:3), or project out from the wall face (see Figure Y:3). Construct the Keystone wall as per design. Where a stairway is proposed, create a 90° outside corner with Keystone straight face and corner units. Construct the CIP concrete stairs as the project plans, making sure the include a ½ inch expansion joint between the stairs and the Keystone units.

NOTE:

International Building Code (IBC) indicates that stair facilities shall have a minimum riser height of 4 inches and a maximum height of 7 ¼ inches. Keystone Compac and Standard units are 8 inches high, therefore will not meet IBC code for stair riser use.

FIGURE V:3 - INSET STAIRWAY DETAILS





STANDARD UNIT - MINNEAPOLIS, MN

FIGURE W:3 - STAIR IN WALL DETAIL PLAN VIEWS

NOTE:

Use Compac straight face units in return walls along concrete stair for ease of stair installation and for placement of bond breaker material between stair and wall.

Tread depths and riser heights may vary depending on design and or local codes.

Install hand railing as per local codes.

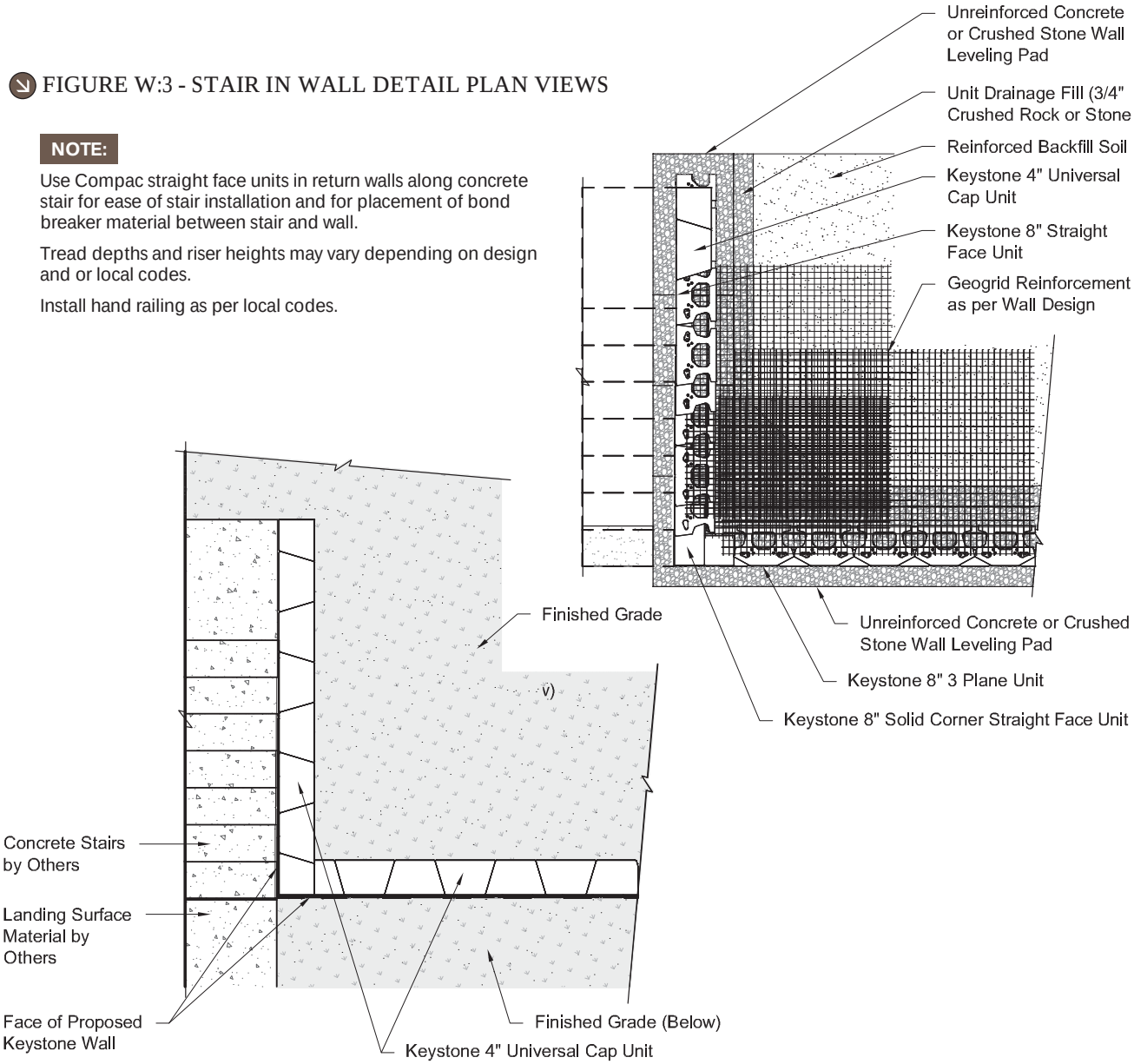


FIGURE X:3 - STAIR IN WALL DETAIL ELEVATION

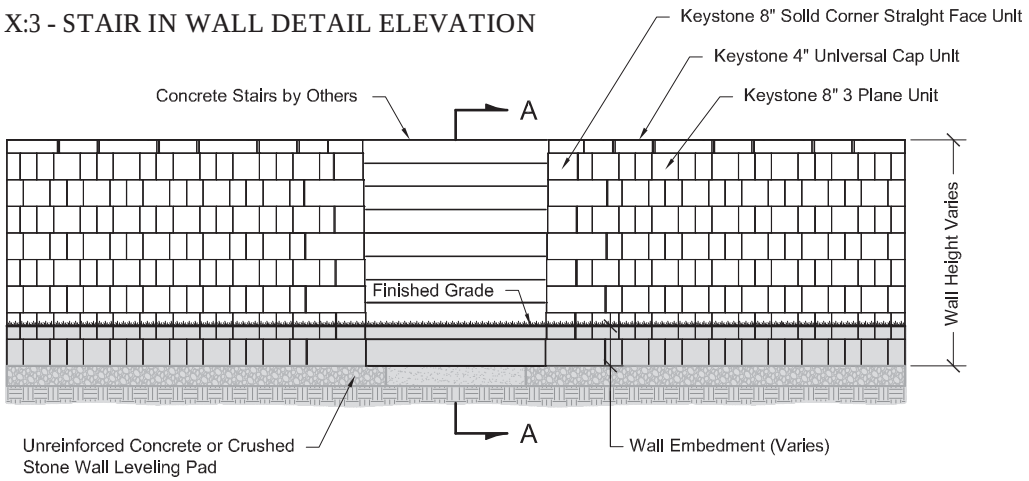


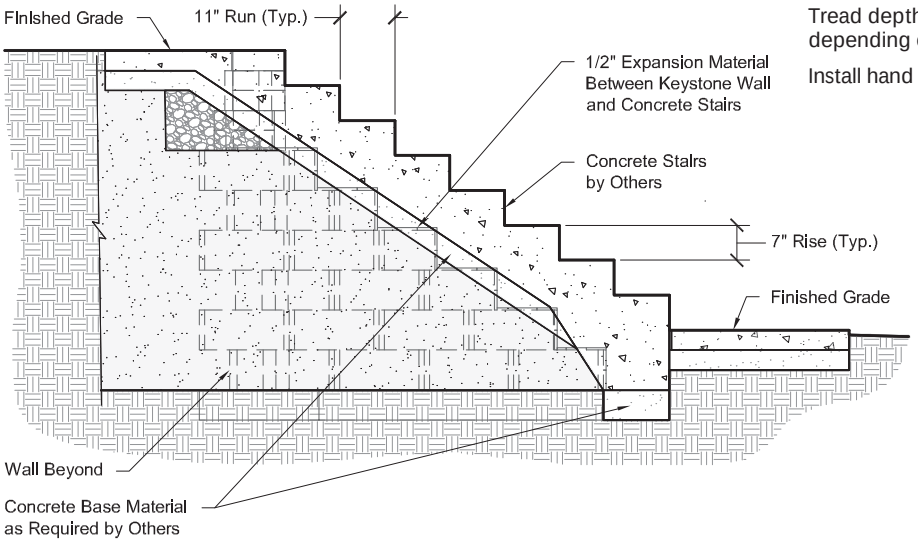
FIGURE Y:3 - PROJECTED STAIRWAY DETAIL

NOTE:

Place bond breaker material between Keystone units and concrete stair. Stair designs may vary.

Tread depths and riser heights may vary depending on design and or local codes.

Install hand railing as per local codes.



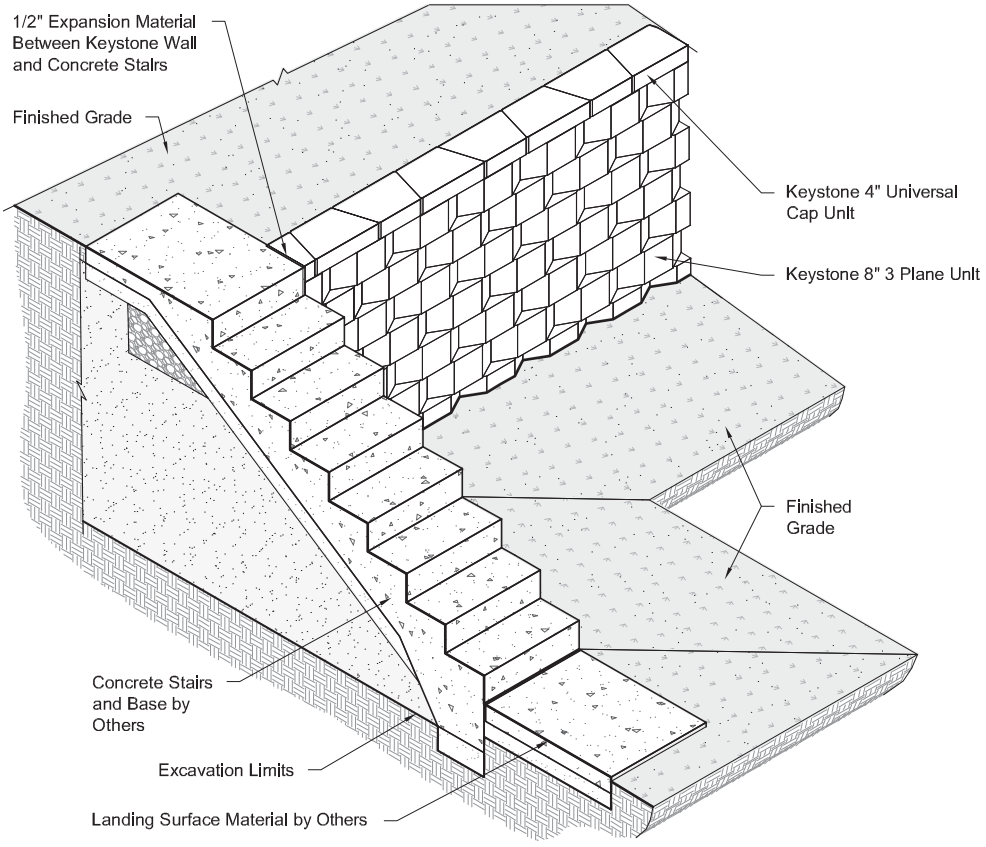
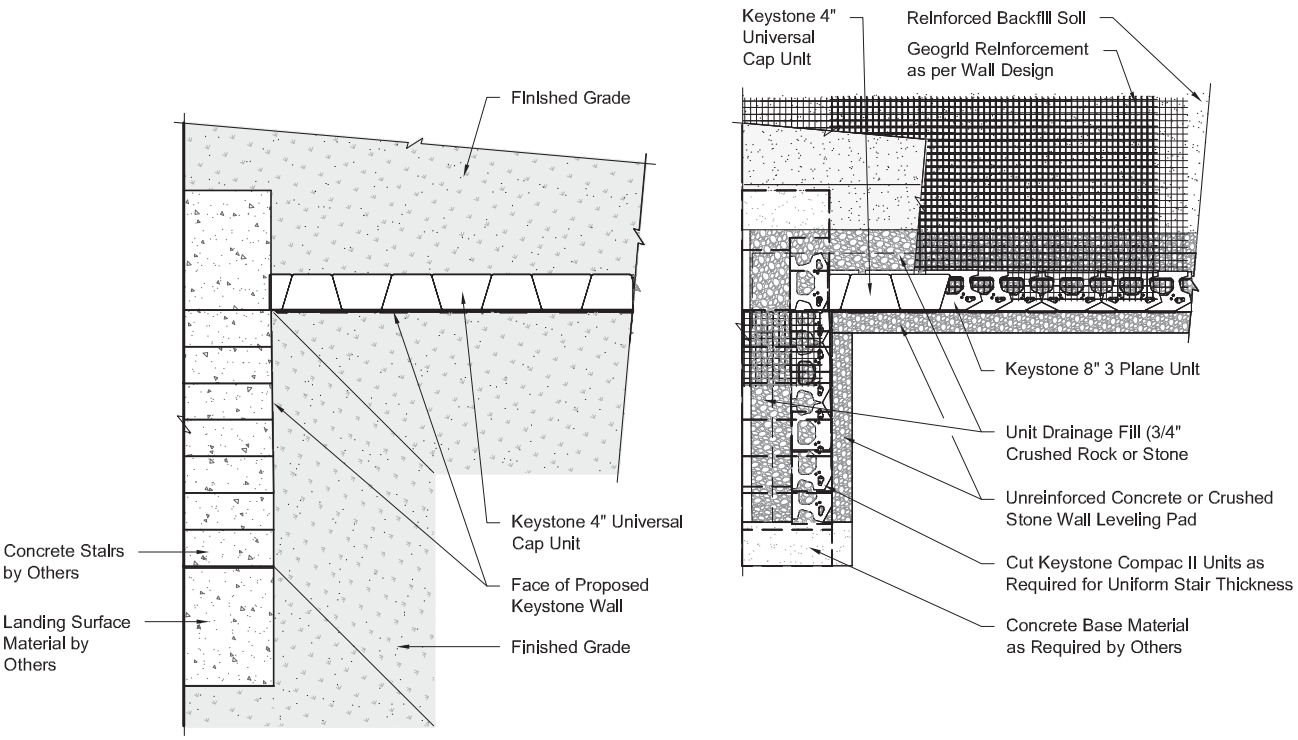


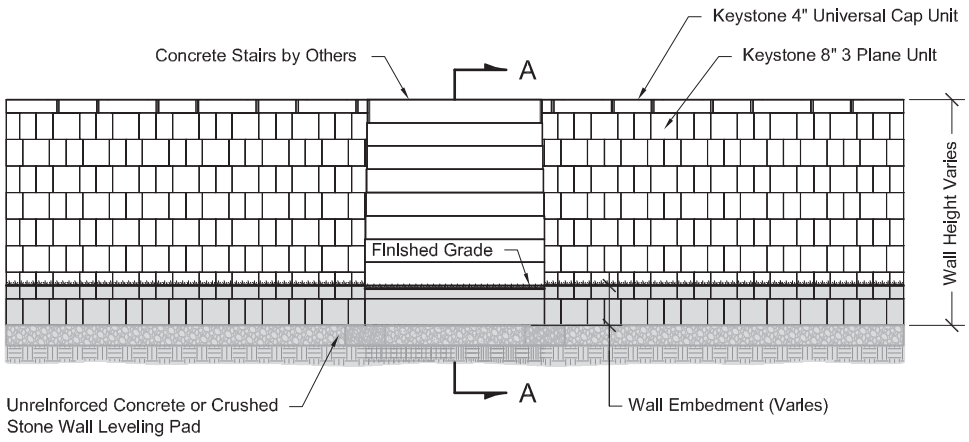
FIGURE Z:3 - STAIR IN FRONT OF WALL DETAIL PLAN VIEWS



Typical Stair Section Plan View - Final
Near Vertical Setback Shown

Typical Stair Section Plan View - Partial
Near Vertical Setback Shown

FIGURE A:4 - STAIR IN FRONT OF WALL DETAIL ELEVATION



Terrace Wall Application

An area of design that affects many site applications is the use of terraced walls. The upper terrace wall can put pressure on the lower terrace if the walls are too close together. Multiple terrace walls in close proximity to each other, can have structural stability issues related to the lower walls not having the capacity to carry the loads developed by the upper walls. Always consult with a qualified professional for assistance with terraced walls.

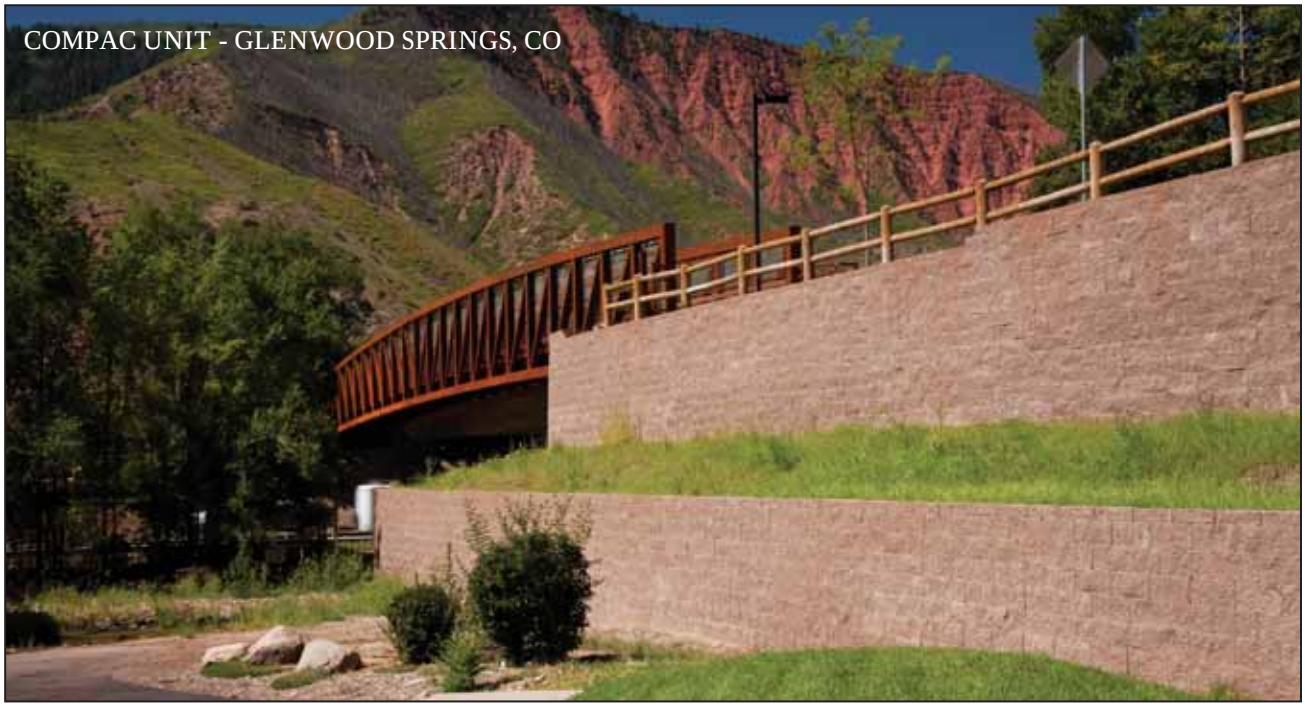
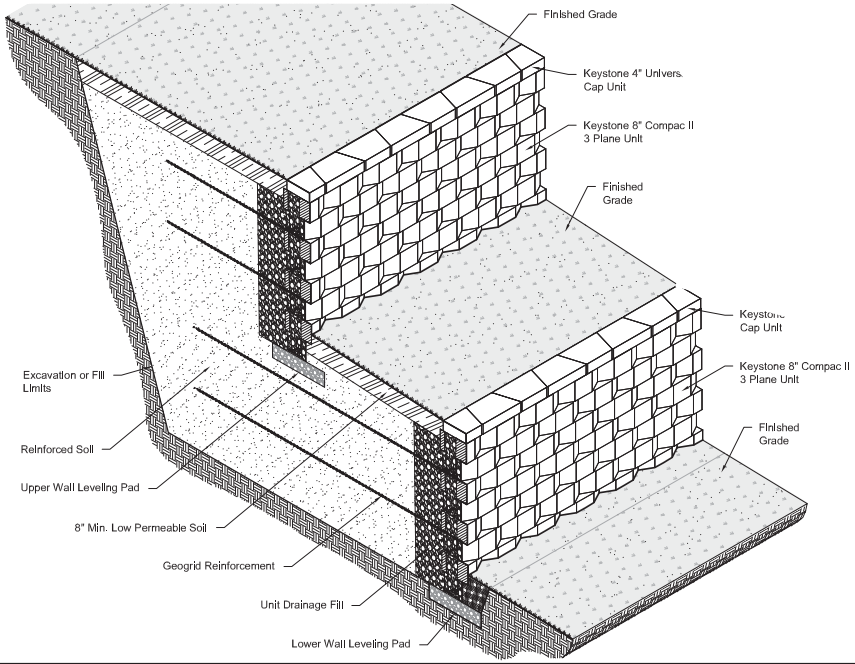


FIGURE B:4 - TYPICAL TERRACED WALL ISOMETRIC .



COMPAC UNIT - CHILLIWACK, BRITISH COLUMBIA

COMPAC UNIT - BLUFFDALE, UT

Wall Repair

PROBLEM: Damaged or cracked unit in wall.

SOLUTION: For minor cracks, fill opening with construction epoxy and dust lightly with concrete material of similar color. Use a ground up piece from another Keystone unit.

For low height walls, dismantle units down to broken unit(s), replace with new unit(s). Rebuild wall placing corefill and backfill with necessary light compaction until capping of wall as shown in above detail.

For taller walls or where it is not practical to dismantle the wall, follow steps shown in the details below. (see Figure D:4)

FIGURE C:4 - REPLACE CRACKED UNIT

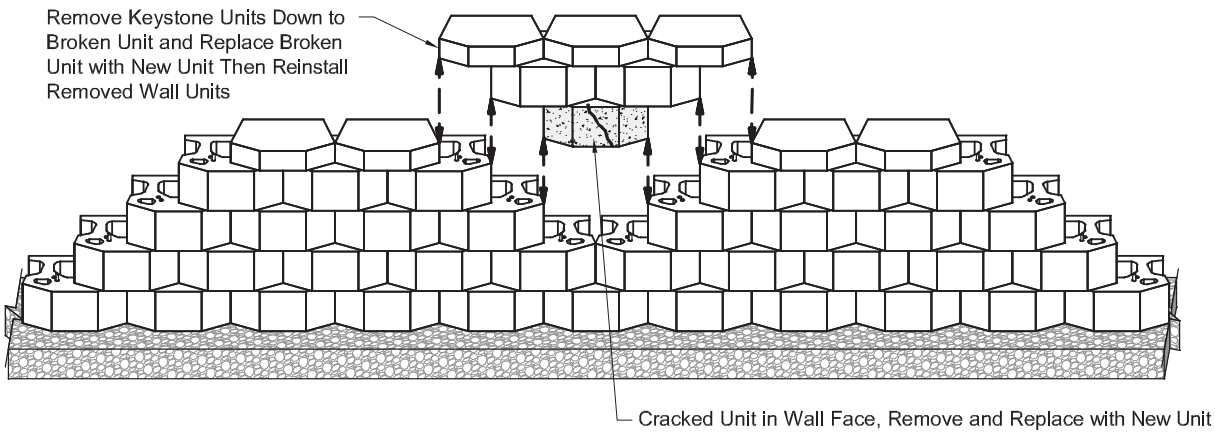
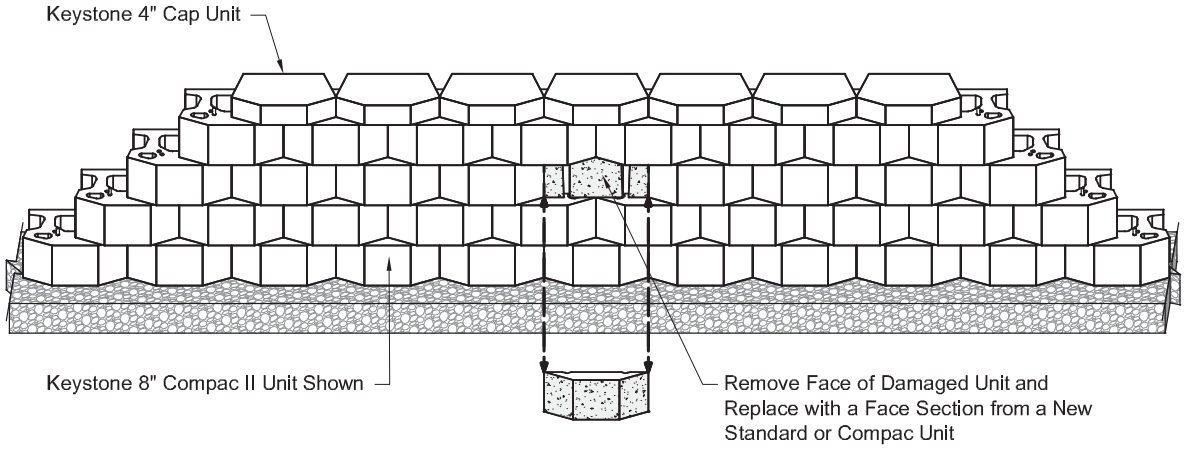
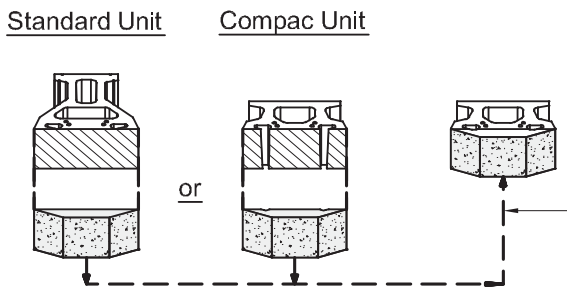


FIGURE D:4- REPLACE UNIT FACE ONLY - FOR TALLER WALLS





NOTES:

Solution allows wall to remain intact. Wall structure with geogrid soil reinforcement is not interrupted.

Cut off face section from a Standard or Compac unit for use as a replacement face veneer and insert into removed space provided. Adhere face section to cut unit with Keystone KapSeal™ adhesive or equal.

SPECIALTY INSTALLATIONS

FIGURE E:4 - TYPICAL PLANTING LIMITS

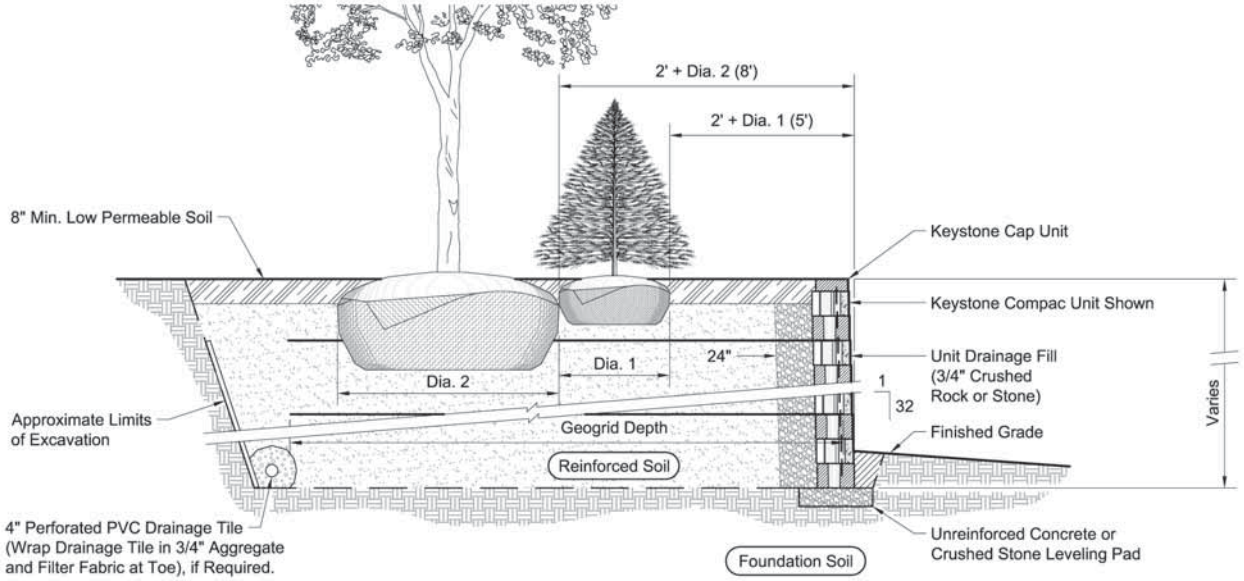
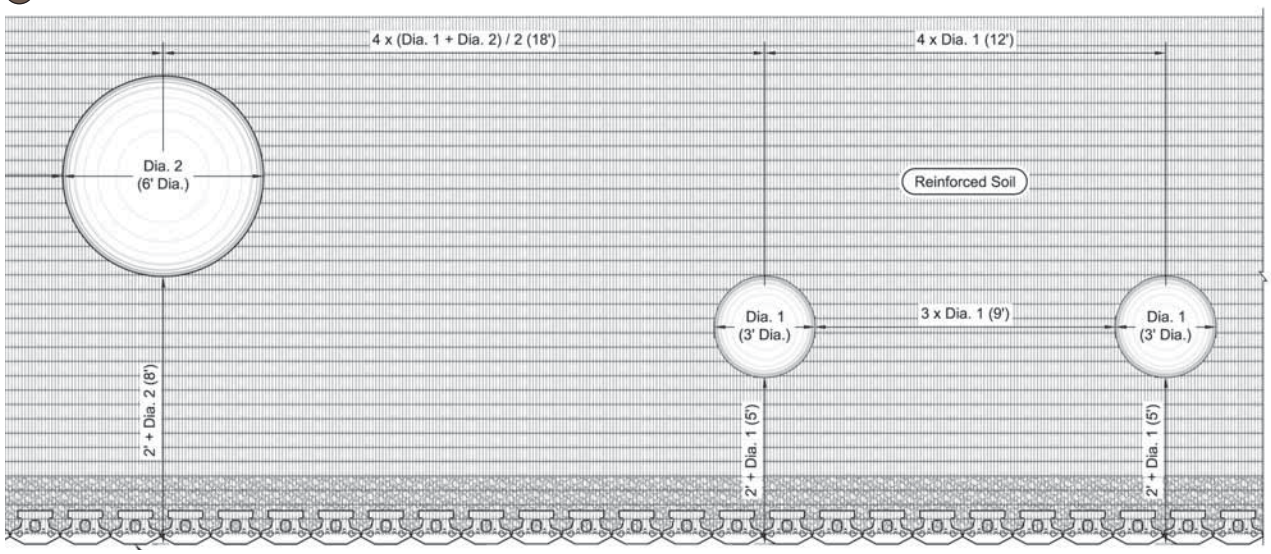


FIGURE F:4 - TYPICAL PLANTING LIMITS



NOTES:

All planting offsets shall be a minimum of 2 feet + the opening diameter as measured from face of wall.

Lateral spacing between openings shall be a minimum of 3 x opening diameter.

Only top two layers of geogrid may be cut to allow planting of tree ball. Avoid disturbance of adjacent reinforcement.

If trees are spaced closely together and cutting of geogrid becomes excessive, consult with your Keystone representative.

Extreme care shall be taken if installing irrigation systems directly behind the wall so as to not damage the soil reinforcement during installation or have potential leakage into the retaining wall system. Leaking irrigation lines can saturate the backfill and create hydrostatic pressure and wall movement.

Utilize a root control barrier as required to avoid root pressures or growth through the Keystone concrete units.

Numbers in parenthesis are for example only.

Creative Options

Add distinctive detail to any Keystone retaining wall. For subtle design accents vary the texture of units in geometric patterns while maintaining the Keystone unit color choice. Texture combinations can be sculptured rockface mixed with straight split units, smooth face units or corduroy units. Dramatic accents can occur when combining units of complimentary and or contrasting color schemes. Consult your local manufacturer/distributor for standard colors, custom color availability, pricing and unit texture options available by region.

Additional options:
» Mixture of units of different heights. (i.e. 8 inch (200mm) & 4 inch (100mm) combinations)
» Specific graphic emblem. (i.e. State shape logo - Texas, Illinois, etc…)
» Various bonds (Flemish), diagonal bars, geometric repeats, horizontal bands, stair step bands, etc…

Use these features to coordinate the site landscape retaining walls with accents on building architecture (i.e. belt courses, bands and geometric details).

BANDING

COMPAC UNIT - CENTENNIAL, CO

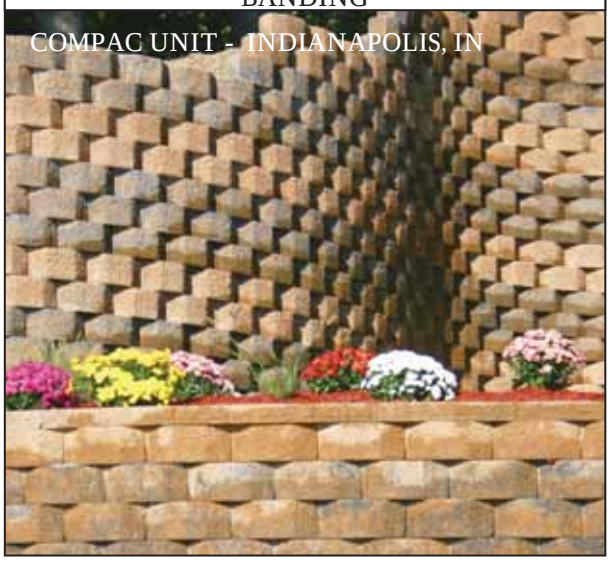
BANDING

COMPAC UNIT - KELOWNA, BRITISH COLUMBIA

FLEMISH BOND

COMPAC UNIT - LITTLETON, CO

BANDING



COMPAC UNIT - INDIANAPOLIS, IN

GRAPHIC EMBLEM

COMPAC UNIT - EGYPT

GEOMETRIC PATTERN

COMPAC UNIT - EGYPT

GRAPHIC EMBLEM

COMPAC UNIT - HOUSTON, TX