

SECTION A

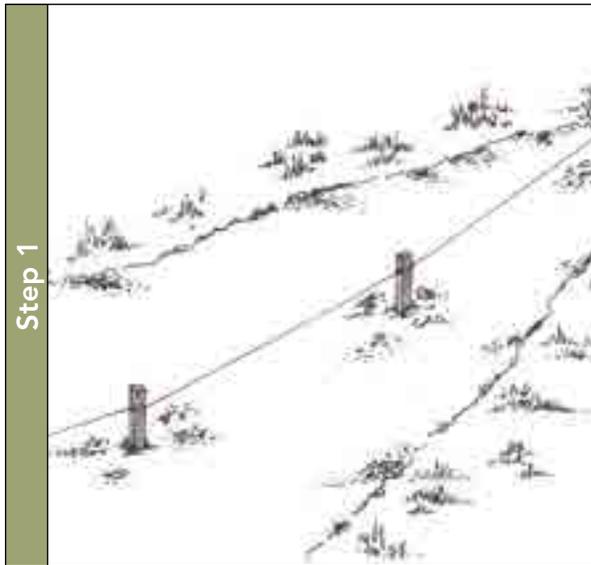
BASIC INSTALLATION

You have chosen your preferred Keystone unit, so now it is time to begin installation of your retaining wall. This section will take you through the step-by-step process of installing your retaining wall. Covered in this section is a basic gravity wall installation and also installation procedures for geogrid reinforced walls. While this section may not cover every construction issue you may encounter on your project, it gives a basic overview and helpful hints for the installation of a Keystone retaining wall.

Tools and materials that will be required:

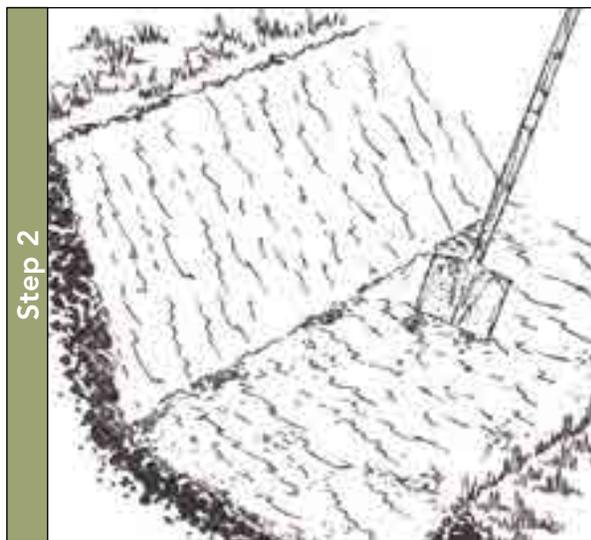
- 12 inch (305mm) and 48 inch (1.2m) levels
- Tape measure
- Shovel
- Excavating equipment
- Personal protective equipment
- 5 lb (2kg) dead blow hammer
- Keystone structural units, caps and fiberglass pins
- Structural geogrid, if required
- Unit drainage fill ($\frac{3}{4}$ [19mm] inch clean crushed stone)
- Backfill material
- Leveling pad material
- Exterior grade concrete adhesive

Installation: Step-by-Step



1. Site Examination / Permitting

Select the location and length for the retaining wall. Call before you dig! In the United States, calling 811 before every digging job gets your underground utility lines marked for free and helps prevent undesired consequences. Digging without calling can disrupt service to an entire neighborhood, harm you and those around you and potentially result in fines and repair costs. Take the necessary measurements, prepare plans, research zoning requirements for your area and obtain proper building permits for your project. Local permitting may require a soils investigation and/or engineered documentation and drawings.



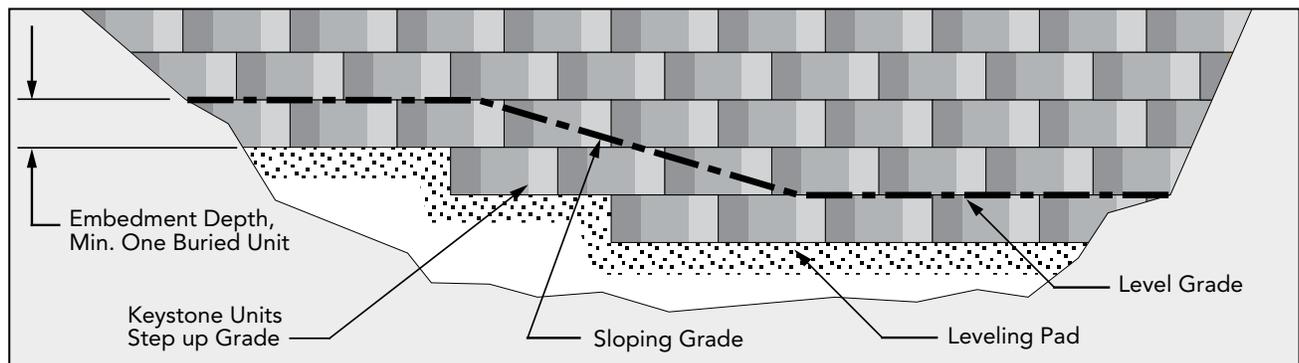
2. Excavation / Embedment

Verify that the layout dimensions are correct and excavate to the lines and grades shown on the construction drawings or to field dimensions. Remove all surface vegetation, organic soils and debris; verify that the foundation subgrade is in proper condition prior to leveling pad installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

Embedment Recommendations

For small Keystone gravity walls, a minimum 1" (25mm) of embedment is recommended for every unit of height (i.e., $H/8$) or 6" (152mm) minimum, which ever is greater. For reinforced soil Keystone walls, the minimum depth of embedment as a ratio to wall height may be determined in the following table from the NCMA Design Manual for Segmental Walls (2009):

FIGURE A:1



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Slope in Front of Wall	Min. Embedment
Minimum Requirement	0.5 ft (150mm)
Horizontal (walls)	H/20
Horizontal (Abutments)	H/10
3H:1V	H/10
2H:1V	H/7

Note:

Project plans, specifications, and design codes may require minimum embedments that exceed the minimums recommended by NCMA.

Sloping Toe

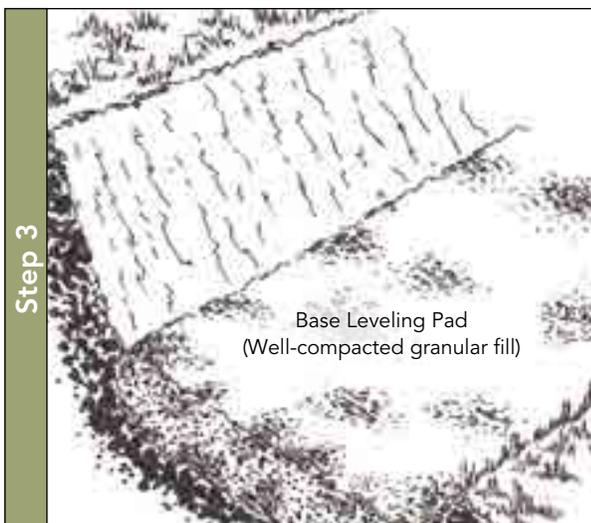
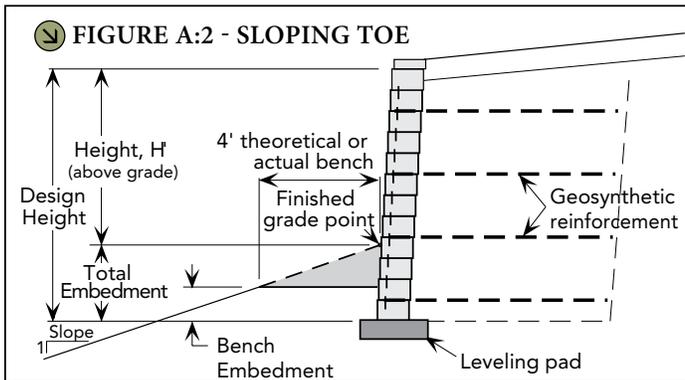
The minimum embedment required with a slope in front of the wall should be based on the establishment of a minimum 4 feet (1.2m) horizontal bench in front of the wall and establishing a minimum embedment from that point. Fill slopes usually have poor compaction near the edge of slope and all slopes are subject to erosion and surficial instability (see figure A:2).

The depth of embedment should be increased when any of the following conditions occur:

- Weak bearing soils
- Potential scour of wall toe
- Submerged wall applications
- Significant shrink/swell/frost properties of foundation soils

Note:

The required embedment depth for Keystone walls may become a controversial issue. The International Building Code (IBC) recommends a 1 foot (305mm) minimum or below prevailing frost depth, whichever ever is greater for foundations. AASHTO recommends a 2 foot (610mm) minimum or below prevailing frost depth which ever is greater for retaining structures. These minimum recommended depths are based on rigid foundation systems and are not totally applicable to flexible systems, which function properly with significantly less embedment. The proper embedment depth is a function of the structure size and type, the underlying soils, and the site geometry, especially toe slopes. It is significantly more important to properly inspect the foundation area when excavated, determine the limits of removal and replacement of unsuitable materials, and then confirm the final embedment depth for stability and bearing given the site conditions.

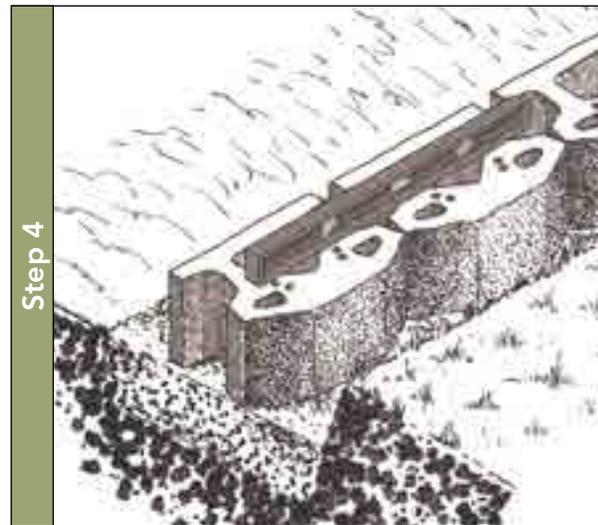


3. Prepare the Base Leveling Pad

Start the leveling pad at the lowest elevation along the wall alignment (see Figure A:1). The minimum leveling pad width shall be unit depth + 12 inches (305mm). The leveling pad shall consist of 6 inches (152mm) of well compacted (95% Standard Proctor or greater) angular granular fill (road base or ½ inch to ¾ inch [13-19mm] crushed stone). Concrete is also acceptable to use as a leveling pad. Step the leveling pad up in 8 inch (203mm) increments at the appropriate elevation change in the foundation. Do not use rounded material, i.e. PEA GRAVEL or SAND for leveling pad material.

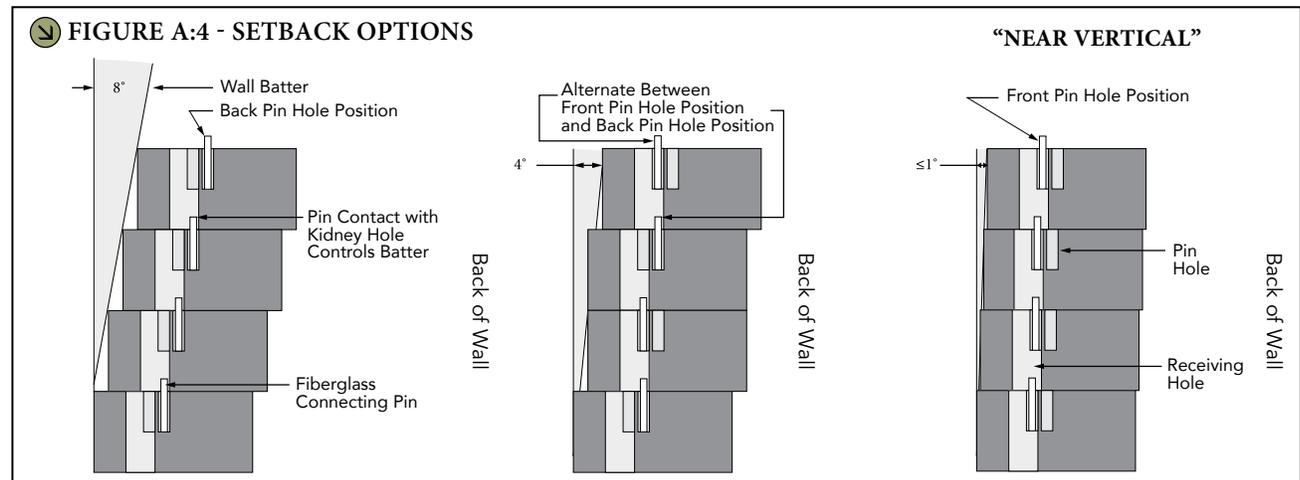
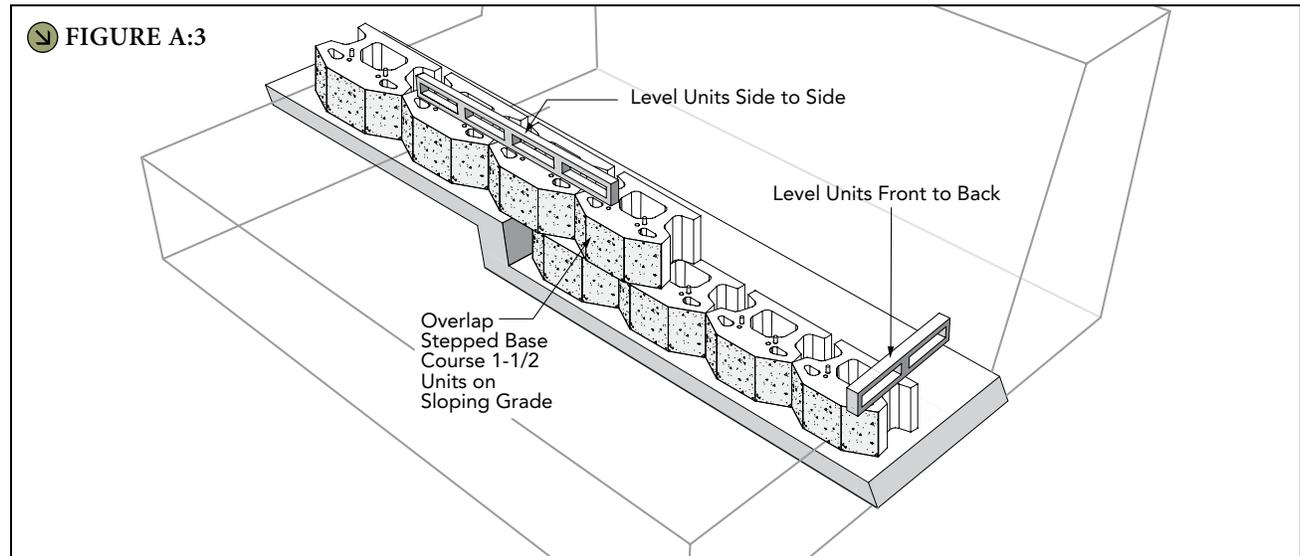
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Installation: Step-by-Step

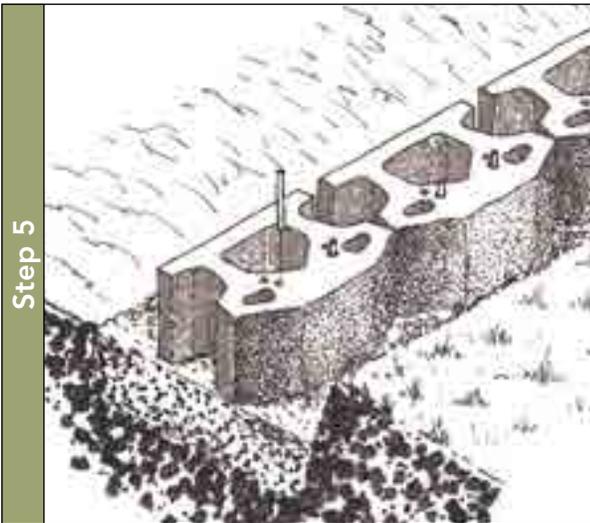


4. Install the Base Course

Place the first course of Keystone units (Keystone Compact units shown for illustrative purposes) end to end, with face of wall corners touching (do not leave gaps between units) on the prepared base. The pin holes should face upward, as shown. Ensure that all units are in full contact with the base and properly seated by gently pounding each block corner, and level as required. At base elevation changes (see Figure A:3) for installation reference. Leveling the first course is critical for accurate and acceptable results. Lay out corners and curves in accordance with the “Corners and Curves” section of this manual (p. 37).



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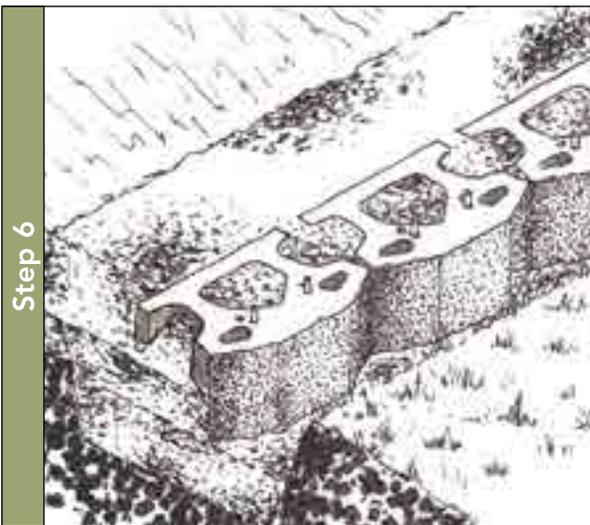


5. Insert the Fiberglass Pins/Drainage Pipe

Keystone units have 3 setback options, near vertical, ½ inch (13mm) setback and 1 inch (25mm) setback (see Figure A:4). For the near vertical option, place the pins in the front pin holes, or for the 1 inch (25mm) minimum setback, place the pins in the rear pin holes (see Figure A:5). Once placed, the pins create an automatic setback and alignment for the additional courses (see Figure A:6). When required, install drainage pipe behind wall unit and outlet drain to storm system or daylight. See drainage section for additional details (p. 66).

Note:

If drainage is required due to excess water or the design engineer's plans call for a drainage pipe to be installed, add the drain tile behind the tails on the base course. Drainage pipe should maintain positive drainage to daylight, outlet the drainpipe at low points, 50 to 75 feet (15 - 23m) on center and ends of wall.



6. Install Unit Drainage Fill/Backfill and Compaction

Once the pins have been installed, provide ½-¾ inch (13-19mm) crushed stone unit drainage material to a minimum total distance of 24 inches (610mm) from wall face. Fill all open spaces between units and open cavities/cores with the same unit drainage material. Place the wall backfill behind the unit drainage fill in maximum 8 inch (203mm) lifts and compact to 95% Standard Proctor Density or 92% Modified Proctor Density with the appropriate compaction equipment. Use only hand-operated equipment within 3 feet (1m) of the retaining wall face.

FIGURE A:5 - PIN INSTALLATION DIAGRAM

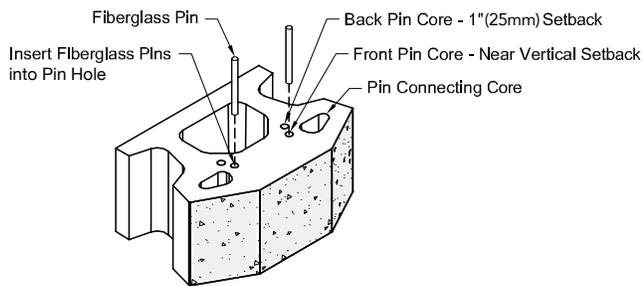
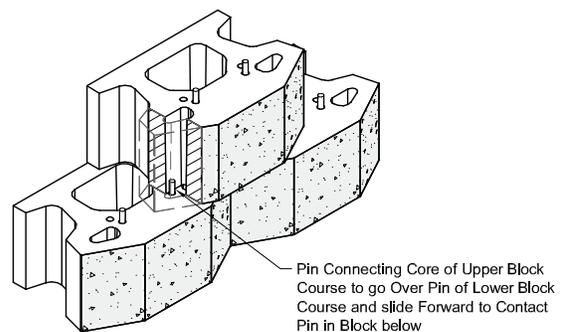
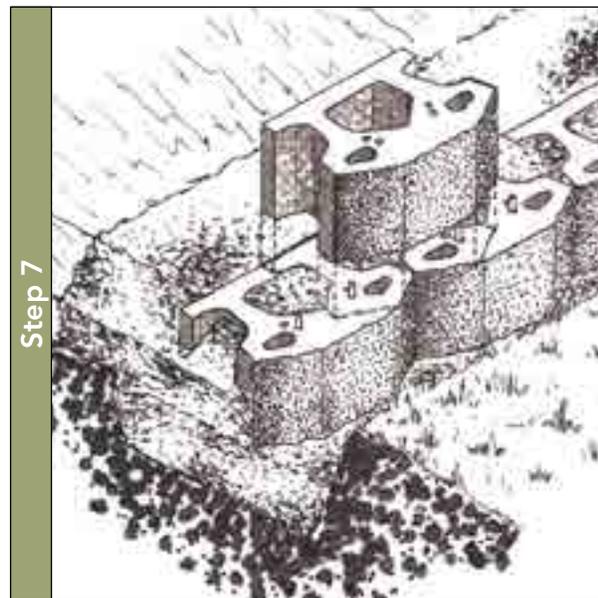


FIGURE A:6 - CONNECTION DIAGRAM



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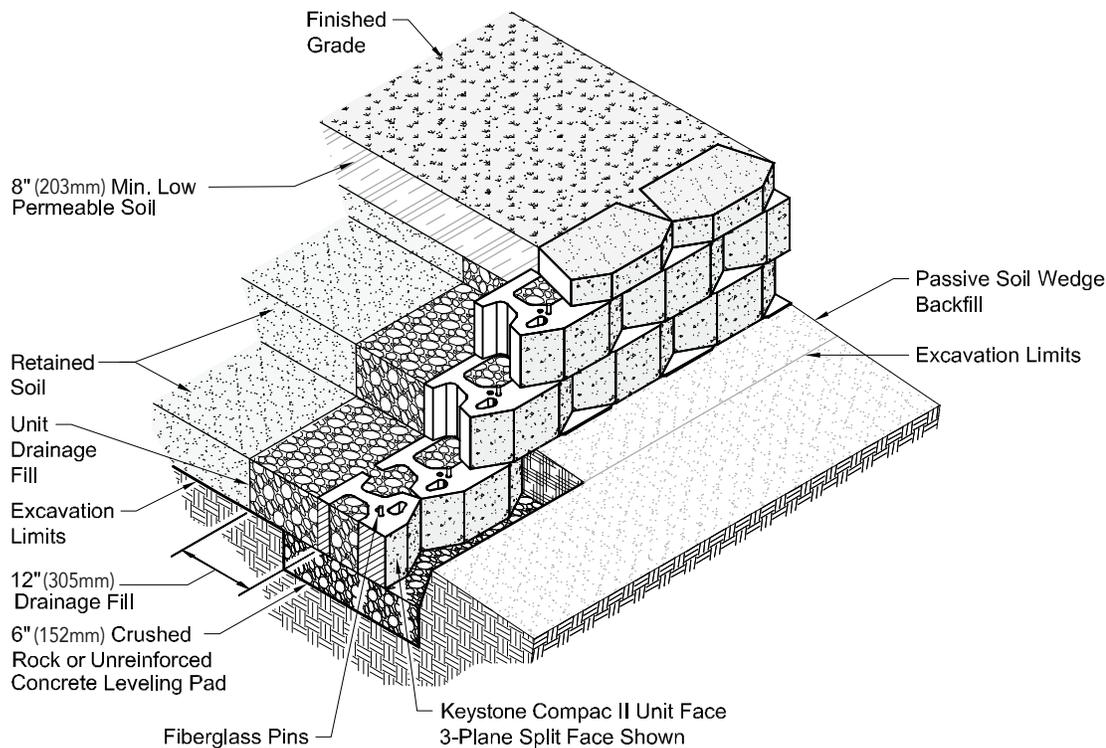
Installation: Step-by-Step



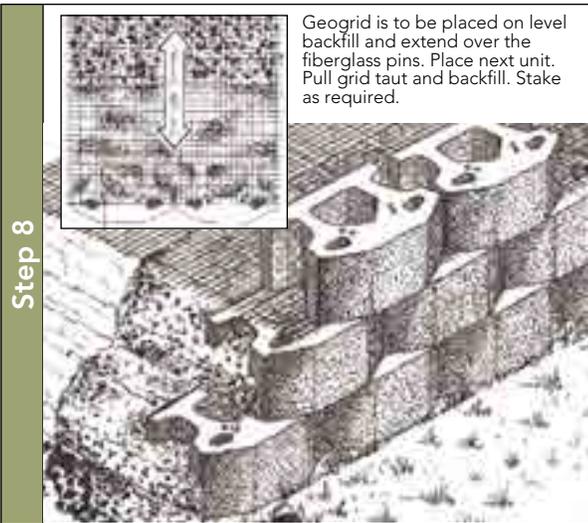
7. Install Additional Courses

Remove all excess unit drainage material from the top surface of the all units. Center the next unit in front of the point where the two units below meet, fitting the pins into the pin connecting core of the above unit. Push the units toward the face of the wall until they make full contact with the pins (see Figure A:6). Check level front to back and side to side, shim the units or grind as necessary. It is important to check level front to back and side to side on every course to maintain proper wall batter and alignment. Proper shimming materials can be any non-degradable material including but not limited to, asphalt shingles, scrap pieces of geogrid, etc... Continue backfilling, installing additional units and checking level to the desired top elevation (see Figure A:7). Follow wall unit and unit drainage fill installation closely with backfill. Maximum stacked vertical height of wall units prior to unit drainage fill and backfill placement and compaction shall not exceed 2 courses, unless special construction techniques are employed to insure complete filling of all units with unit drainage fill. For gravity walls continue this construction sequence to complete the wall, and proceed to Step 10. For geogrid reinforced walls, continue with Step 8 and Step 9.

FIGURE A:7 - 3D CROSS SECTION WITHOUT REINFORCEMENT

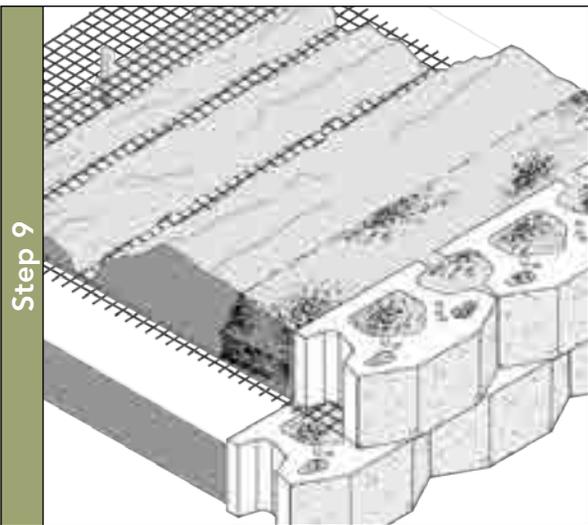


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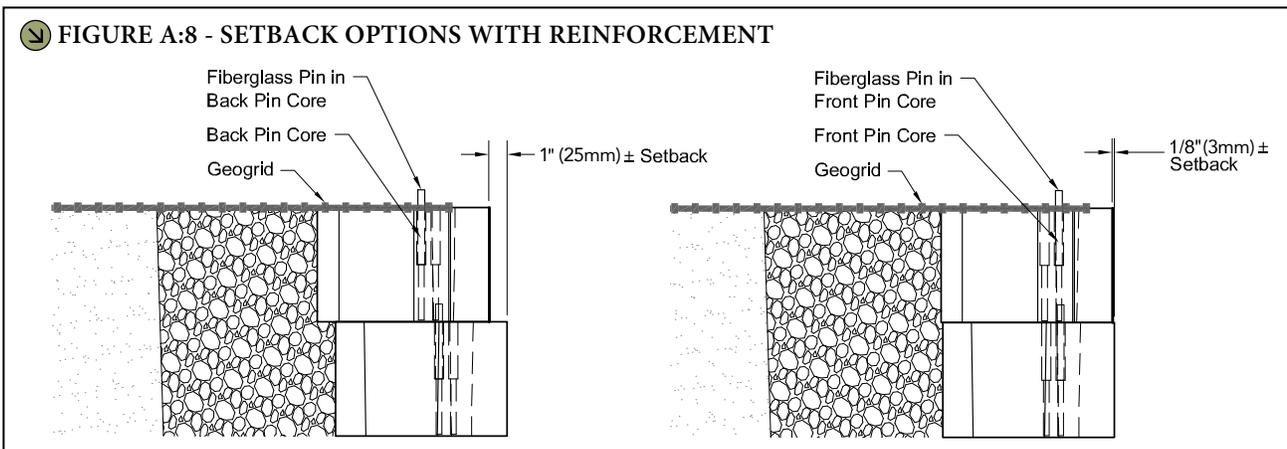
8. Structural Geogrid Installation

Start at the lowest wall elevation where a geogrid layer will be placed. The geogrid elevations, depths, and strength will be specified in the engineered design for the wall.* Measure and cut the geogrid material to the specified length. Orient geogrid with highest strength axis perpendicular to the wall alignment. Lay geogrid horizontally on compacted backfill and hook over the pins of the units to within 1" (25mm) of the face of the lower block (see Figure A:8). In general, geogrid will be placed in pieces side-by-side with no gapping, and in a continuous layer along the length of design geogrid elevation, unless a change in elevation is specified in the design. Install an additional course of units over the geogrid. Tension the geogrid by pulling it towards the embankment. Place a stake through the end of the geogrid into the ground or place fill over the back edge of geogrid to hold it taut and in place. Do not excessively tension geogrid: this may pull units out of proper alignment.



9. Reinforced Backfill Placement

Proceed with placement of the unit drainage fill and the backfill in the reinforced zone. Specifications for the material to be used as backfill in the reinforced zone should be defined in the engineered plans. Place this material nearest to the units, moving progressively toward the staked end of the geogrid. This procedure will keep the geogrid under tension. Compact the reinforced fill material to 95% Standard Proctor Density (ASTM D698), or 92% Modified Proctor Density (ASTM D1557) or to the compaction requirements in the engineered plans. Install additional courses as described in step 7, until the next reinforcement elevation. Repeat Step 8 and Step 9 (see Figure A:9, page 18). Only hand operated compaction equipment shall be allowed within 3 feet (1m) of the back surface of the units. At the end of each day's operation, grade the backfill away from the wall and direct runoff away from the wall face.



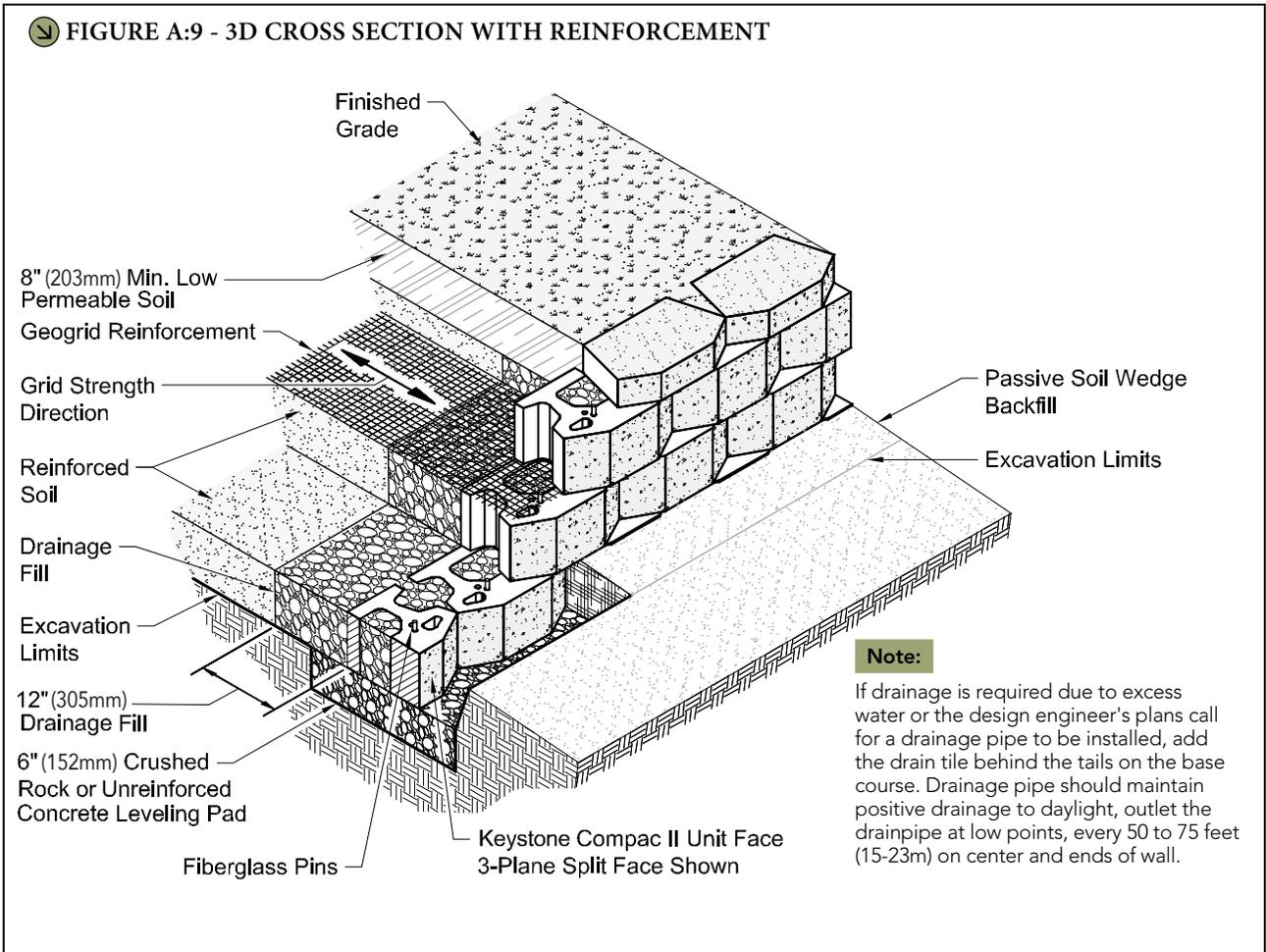
Note:

*For assistance in obtaining engineered drawings for your project, please contact your local Keystone representative.

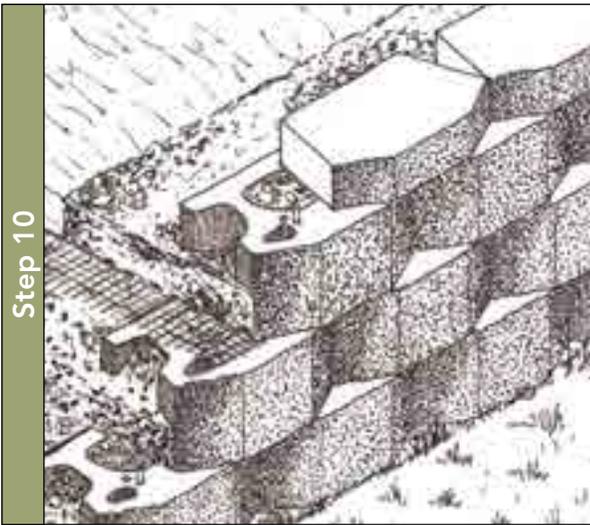
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Installation: Step-by-Step

FIGURE A:9 - 3D CROSS SECTION WITH REINFORCEMENT

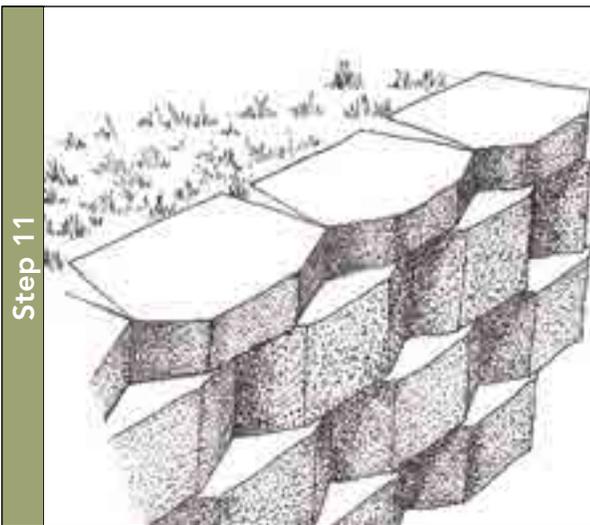


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10. Capping the Wall

Complete your wall with the appropriate Keystone capping units. These units are available in a variety of sizes and shapes, including 4 inch (102mm) and 8 inch (203mm) high units. Availability of these units will vary by region. For cap unit descriptions and placement variations see the section, “Wall Finishing” (p. 56) of this manual. Sweep the lower units clean and make sure they are dry. Use exterior grade concrete adhesive on the top surface of the last course before applying cap units (see Figure A:10).

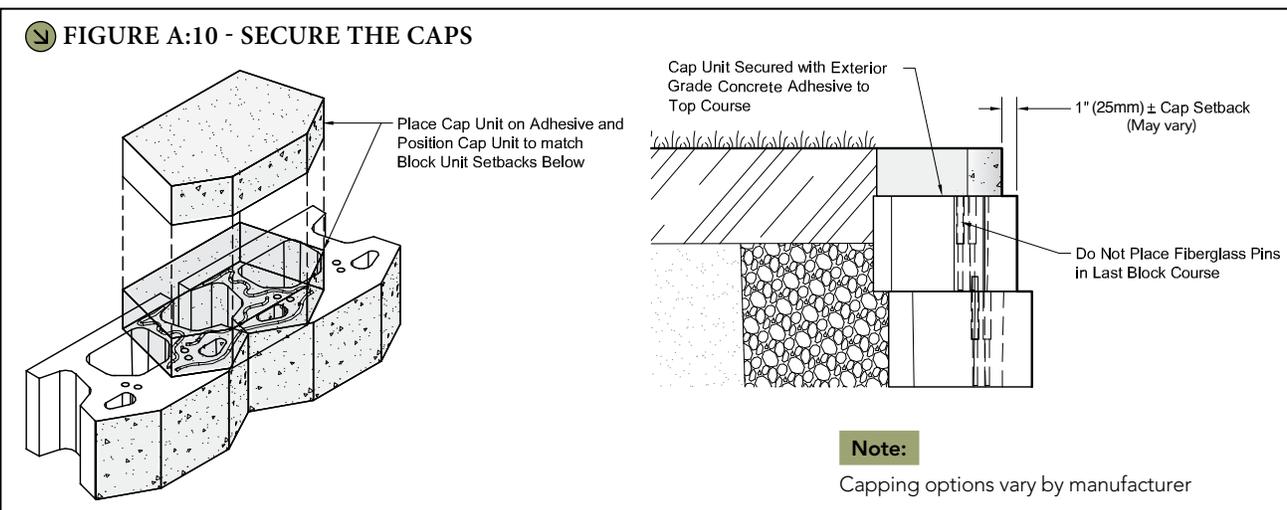


11. Finished Grade and Landscaping

The Keystone retaining wall is now complete. Final grading, planting or other surface material can now be put into place. Typically an 8 inch (203mm) thick layer of low permeable soil is installed as the final layer of material. This is to help prevent water infiltration to the retained or reinforced zone of the retaining wall. Remember that finished grade conditions affect the wall’s performance. Such conditions should not be altered from the original design. Loading with slopes, parking lots and buildings should be maintained as designed. Any changes to the top of wall finished grade must be evaluated prior to wall completion (see Figures A:11-A:13 for typical cross section details).

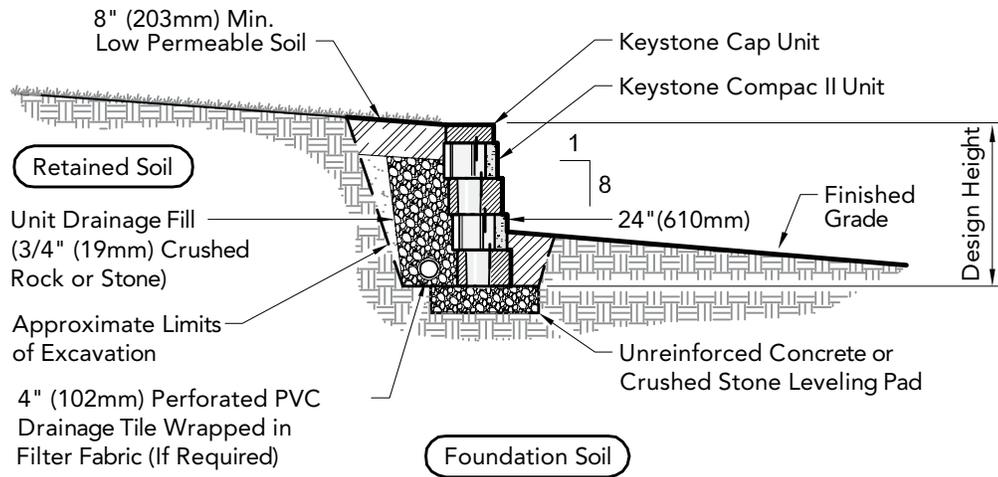
Note:

See SECTION F: Specialty - “Planting Guidelines” (p. 85) for details on proper planting installations for a Keystone retaining wall.



Completed Gravity Wall Section

FIGURE A:11 - (GRAVITY WALL) CROSS SECTION

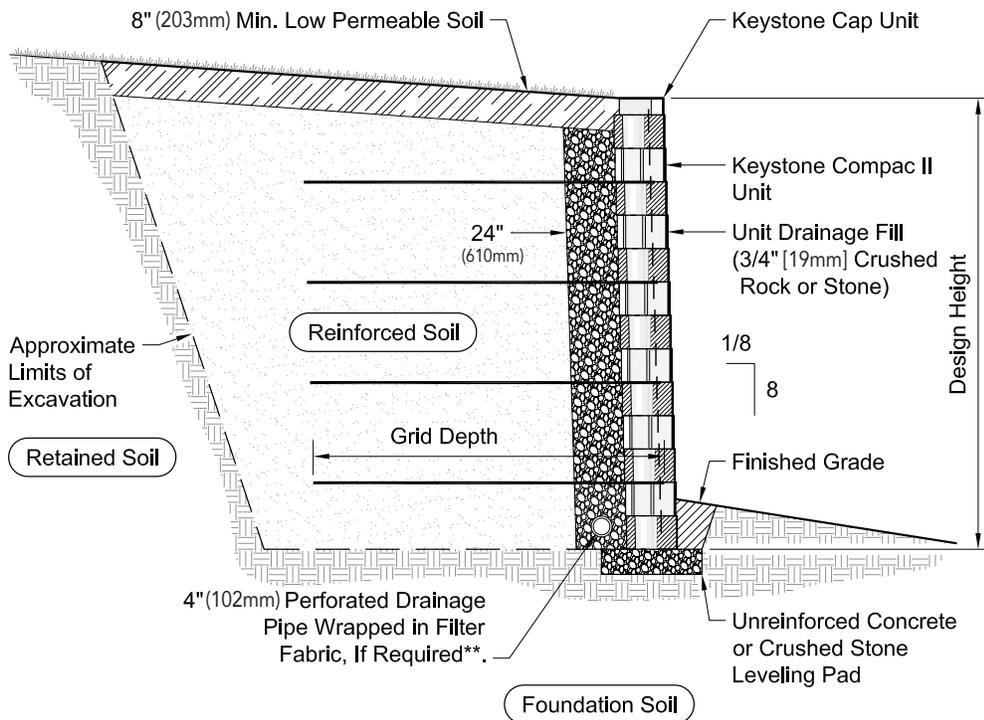


KEYSTONE COMPAC®

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Completed Reinforced Wall Sections

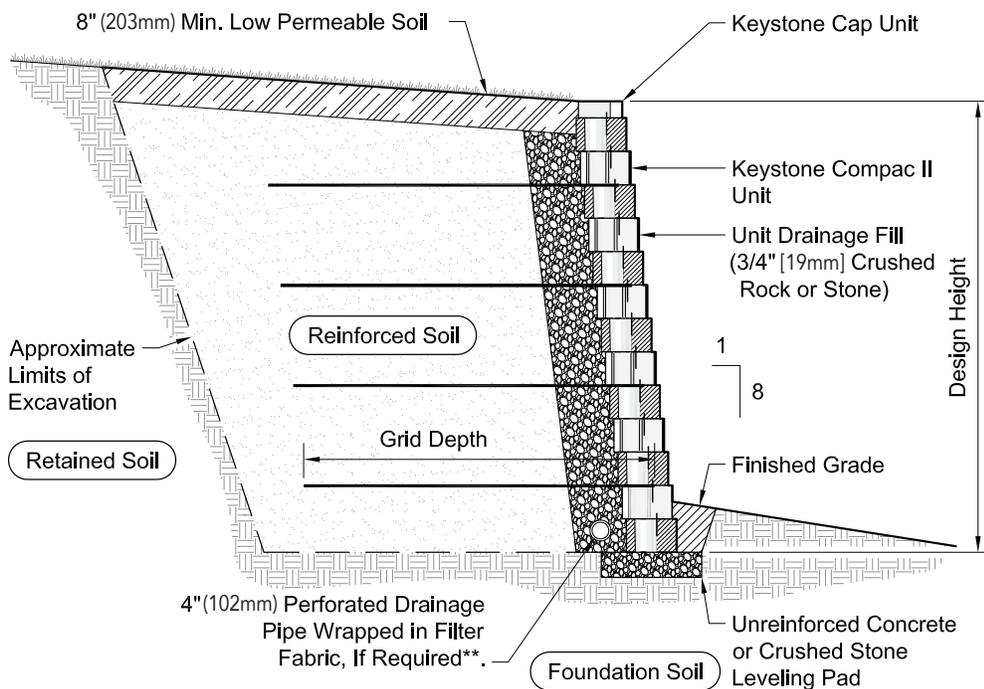
FIGURE A:12 - (REINFORCED WALL) NEAR VERTICAL SETBACK



Note:

** For most installations the site geotechnical engineer will direct a drainage pipe to be installed directly behind the wall face at the base of the wall. Piping shall outlet to project storm sewers or daylight at low points in the wall. For other potential drainage conditions that require additional drainage provisions for the wall, see Specialty - Water & Drainage section (pp. 62-65).

FIGURE A:13 - (REINFORCED WALL) 1" (25mm) SETBACK



Note:

** For most installations the site geotechnical engineer will direct a drainage pipe to be installed directly behind the wall face at the base of the wall. Piping shall outlet to project storm sewers or daylight at low points in the wall. For other potential drainage conditions that require additional drainage provisions for the wall, see Specialty - Water & Drainage section (pp. 62-65).

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