STANDARD UNIT - MINNETONKA, MN

CONSTRUCTION OF CORNERS AND CURVES

So far the discussion regarding the installation of a Keystone retaining wall has centered on the installation of units through the straight line sections of the wall. Equally important and one of the finer aspects for an aesthetically pleasing yet structurally sound wall is the construction of corners and curves.

A corner is typically constructed as either an outside 90° corner, inside 90° corner or acute outside corner (between 75° to 90°). When a wall needs to make a turn greater than 90° it is recommended to install a radius curve for the wall. For curves in the wall, Keystone units typically have a minimum radius depending on the face style, which is outlined later in this section by unit type. The flexibility of the Keystone units allows for the construction of multiple corners or curves within the same wall. The following information will provide a general explanation of construction techniques for building retaining walls with corner and curve conditions.

Tools and materials that will be required:

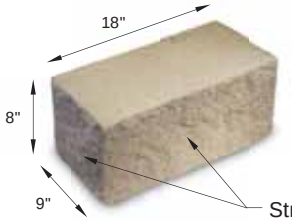
- 12 inch and 48 inch levels
- Tape measure
- Concrete saw
- Block splitter
- Masonry cold chisel
- 5 lb dead blow hammer
- Hammer drill with 5/8 inch masonry drill bit
- Keystone KapSeal™ concrete adhesive

90° Outside Corner : Standard Unit

For ease of construction of outside 90° corners, Keystone producers typically provide a corner unit specifically designed for this purpose. Corner unit options and product designs may vary by manufacturer, please contact your local manufacturer for availability before you begin your project planning. Details at right show a typical corner unit available in many locations.

If corner units are not available, Keystone recommends transitioning the wall from a corner to a radius curve in the wall and avoiding mitered corners. This will enable the wall to maintain its pin connection integrity and running bond wall configuration for continued wall stability and performance.

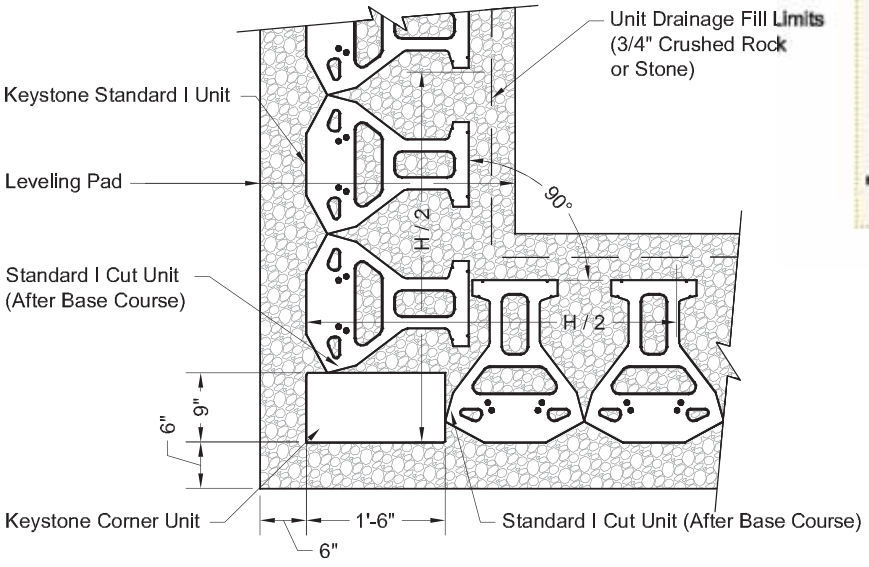
CORNER UNIT

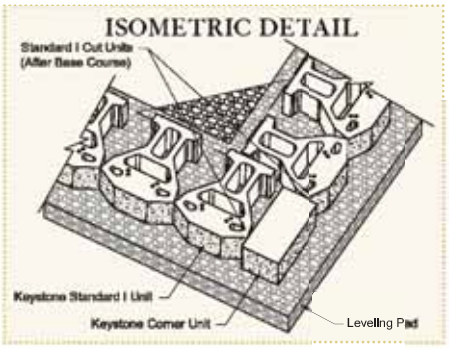


If creating a radius is not an option, the last resort is to miter the Keystone units to create the outside 90° corner. Unfortunately mitering a corner can result in undesirable wall performance issues in the corner, including gapping of the units, or an entire separation of the wall corner due to soil movement. Keystone recommends using an integration of the mitered Keystone units with rebar and grout or concrete to prevent the unwanted performance issues. Please contact your local Keystone representative for assistance when attempting to construct mitered outside corners.

Battered walls (8°) present an issue in outside corners, as the wall rises vertically, the wall will get smaller. See details on pages 42-43 for detailed installation and cutting instructions.

FIGURE M:1 - TYPICAL BASE (ODD COURSES)





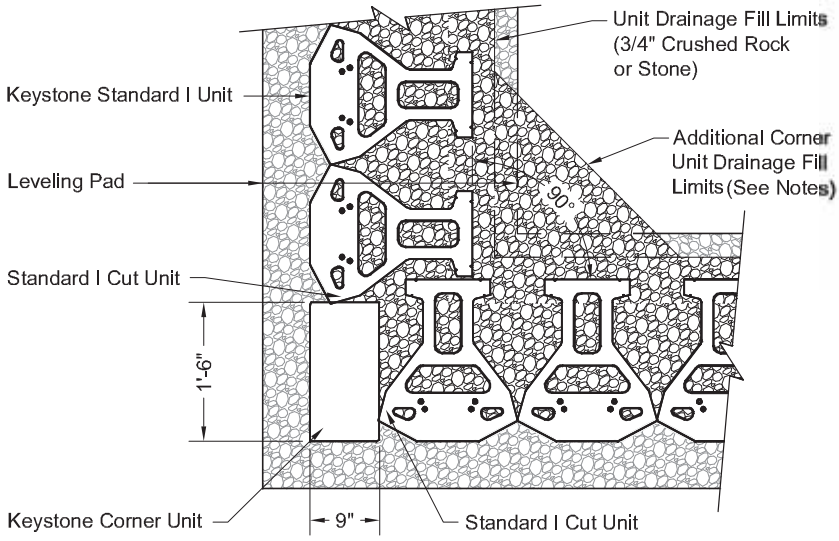
Notes:

Follow standard installation instructions for preparation of sub grade and leveling pad.

Tails of units near the corner may have to be trimmed to allow for a battered setback wall.

Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

FIGURE N:1 - TYPICAL SECOND (EVEN COURSES)



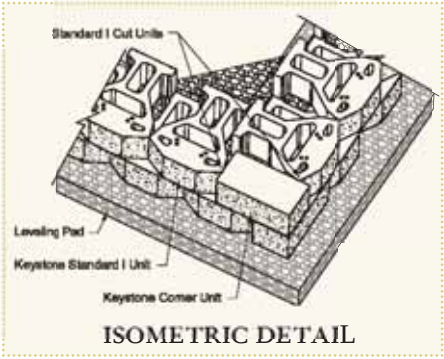
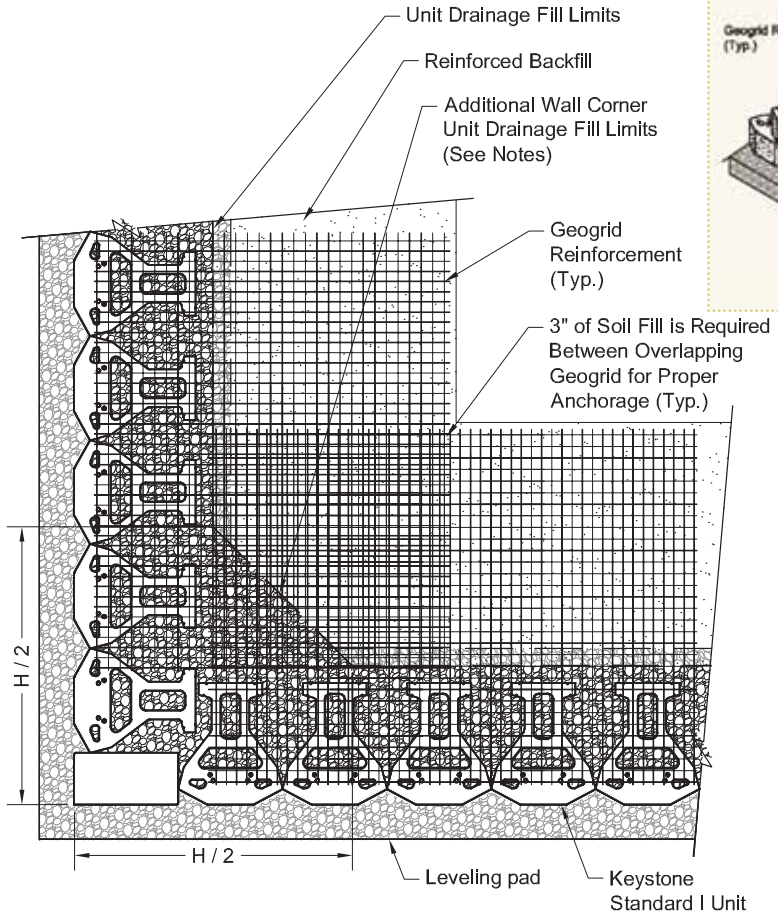
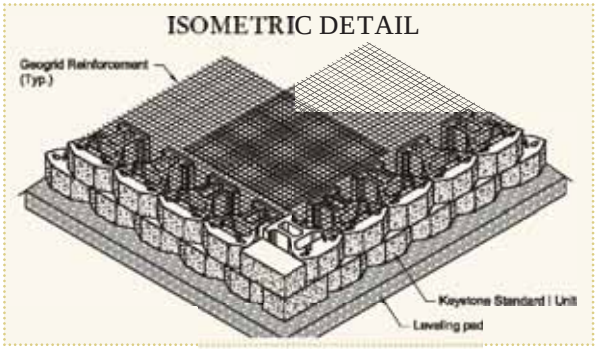


FIGURE O:1 - TYPICAL GEOGRID INSTALLATION FOR OUTSIDE CORNER





Notes:

Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

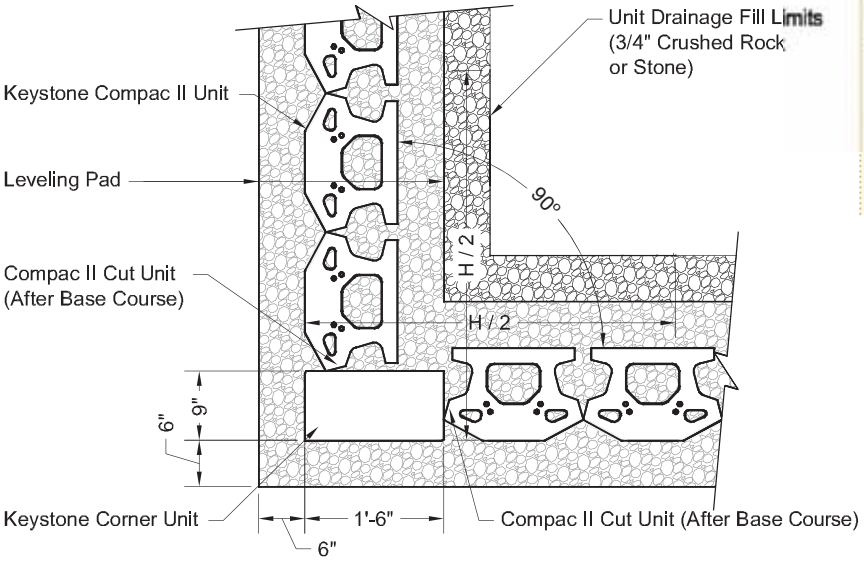
Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

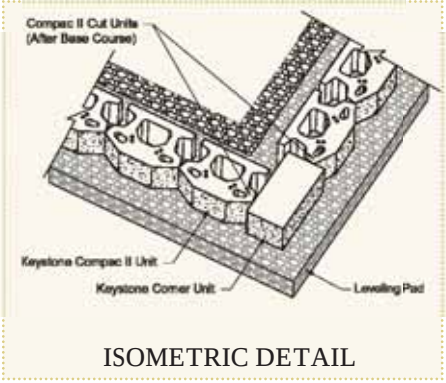
Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

90° Outside Corner : Compac Unit

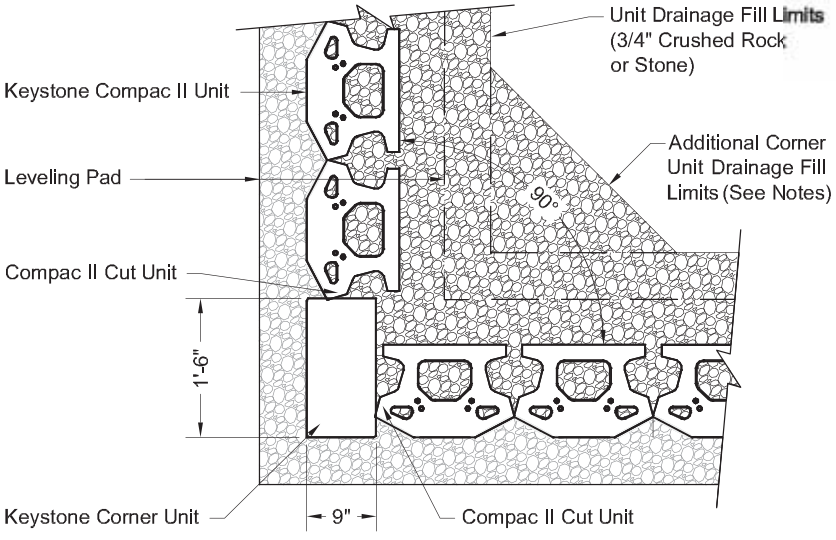
FIGURE P:1 - TYPICAL BASE (ODD COURSES)

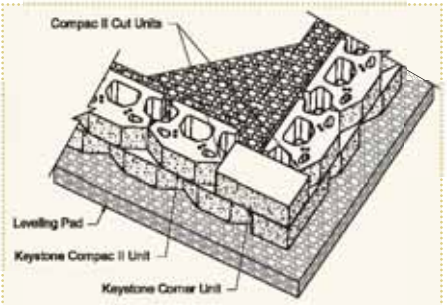




ISOMETRIC DETAIL

FIGURE Q:1 - TYPICAL SECOND (EVEN COURSES)



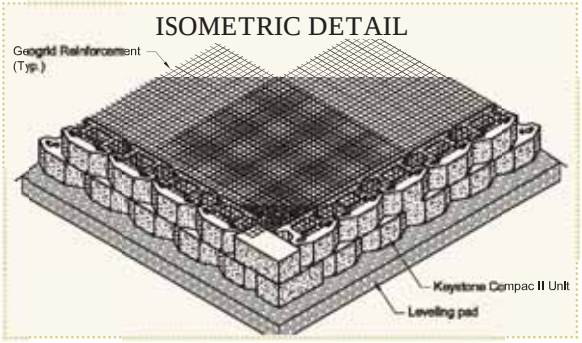


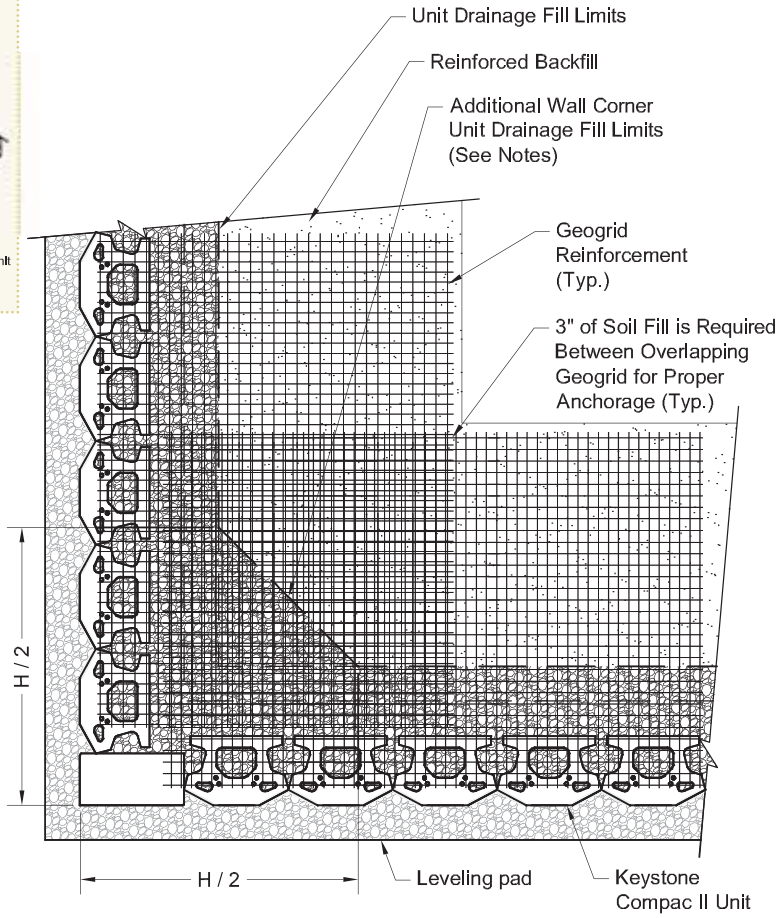
ISOMETRIC DETAIL

Notes:

Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

FIGURE R:1 - TYPICAL GEOGRID INSTALLATION FOR OUTSIDE CORNERS





Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

90° Outside Corner : 1" Setback

When constructing a battered wall (8°) there are construction issues at the corner as the wall rises vertically. Because the wall is setback 1 inch per course, it creates a need to cut the corner or structural units within 3 feet of either side of the corner to maintain a proper running bond pattern in the straight sections of the wall. Keystone has developed a typical trim pattern to follow. The pattern is repeatable for taller walls beyond the height shown in the illustration shown below (see Figure S:1). This illustration is based on a full running bond pattern on the base course, with no trimmed units. (In the case of two corners near each other, it is best to set each corner unit base first to establish corner location, and then set the base course of structural units running to the corners and trim units as necessary.)

FIGURE S:1 - BATTERED SETBACK AT 90º OUTSIDE CORNER

Notes:

Keystone Compac II units shown in 1 inch setback position.

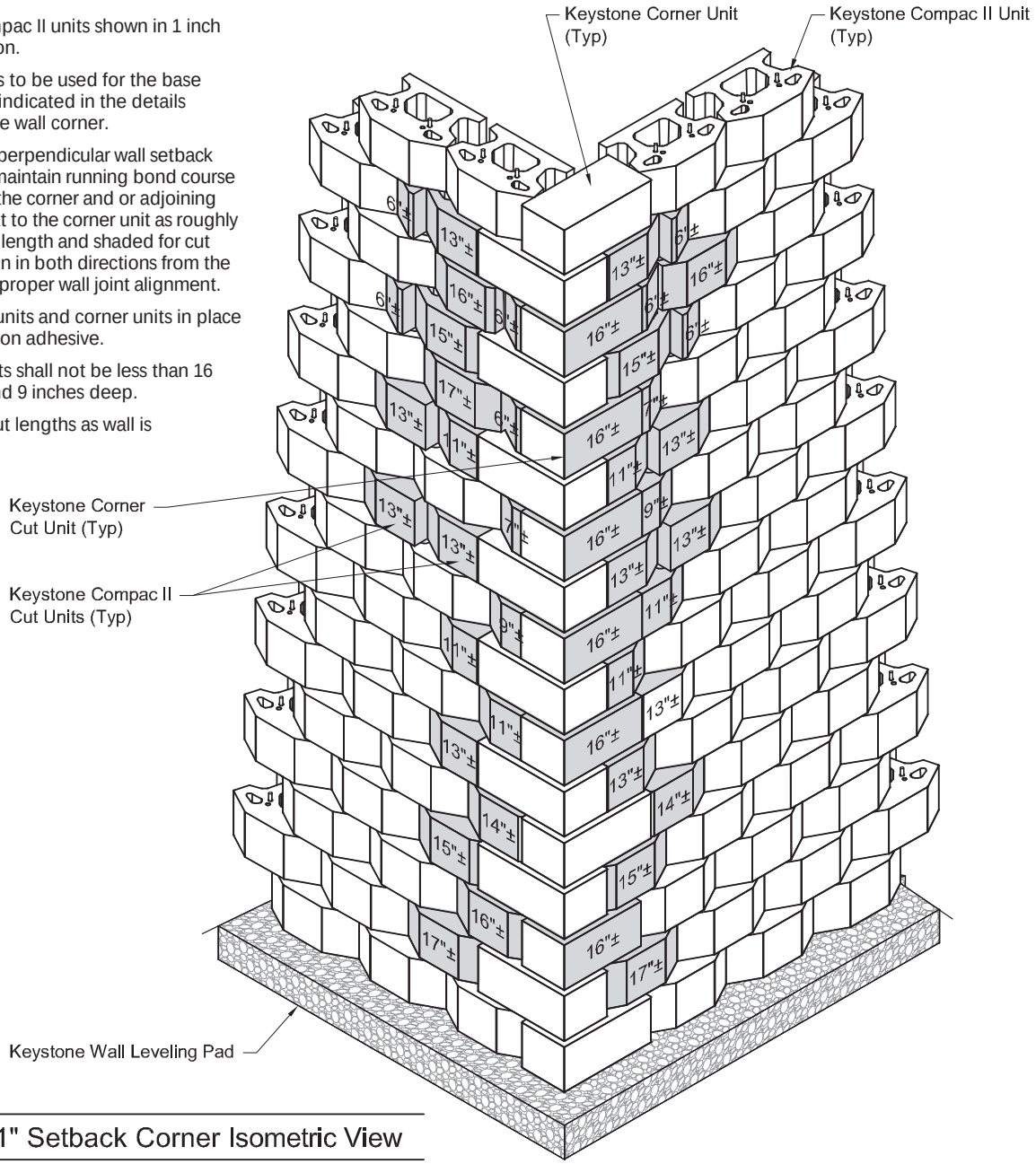
Full uncut units to be used for the base course and as indicated in the details vertically up the wall corner.

Due to corner perpendicular wall setback per course to maintain running bond course alignment cut the corner and or adjoining block units next to the corner unit as roughly labeled for cut length and shaded for cut unit designation in both directions from the wall corner for proper wall joint alignment.

Secure all cut units and corner units in place with construction adhesive.

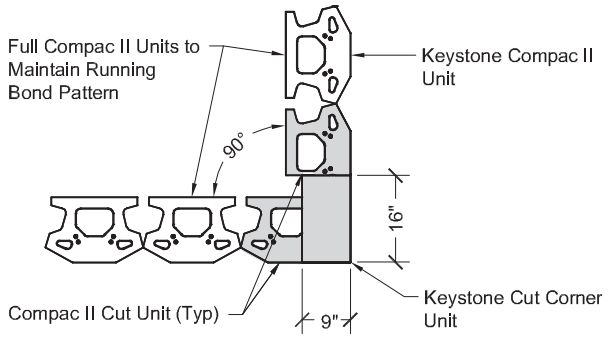
Cut corner units shall not be less than 16 inches wide and 9 inches deep.

Verify actual cut lengths as wall is constructed.



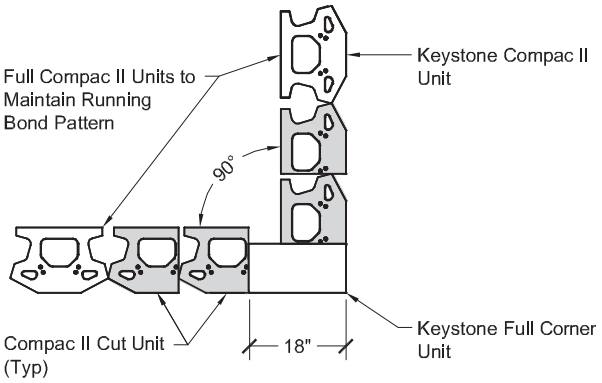
1" Setback Corner Isometric View

FIGURE T:1 - CUT CORNER UNIT COURSE

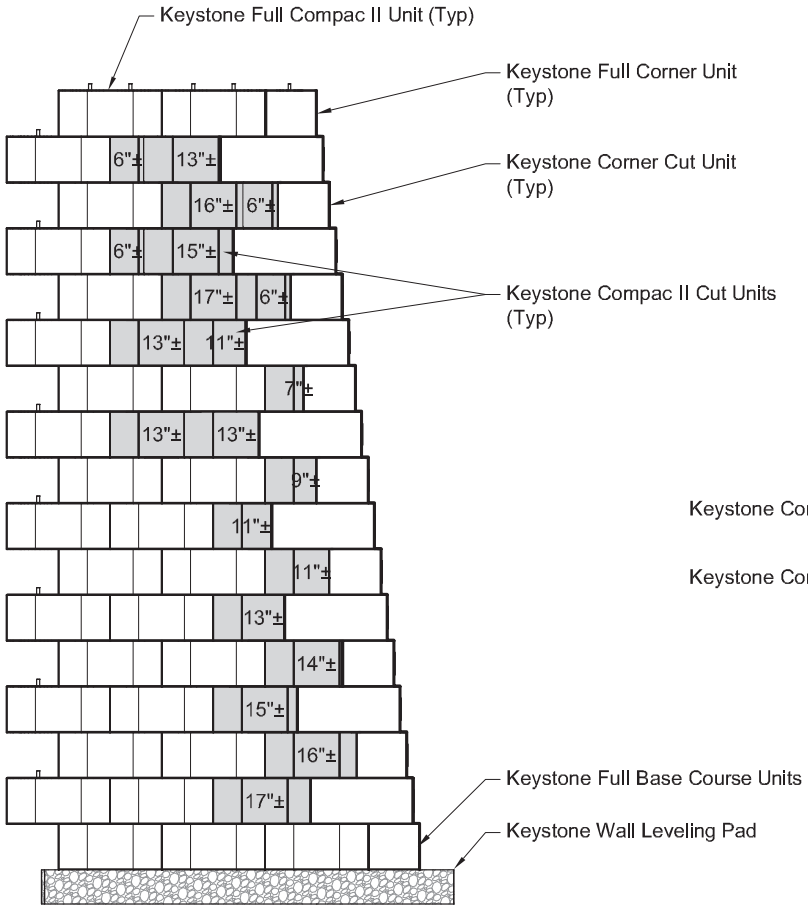


Cut Unit Course w/Cut Corner Unit Example

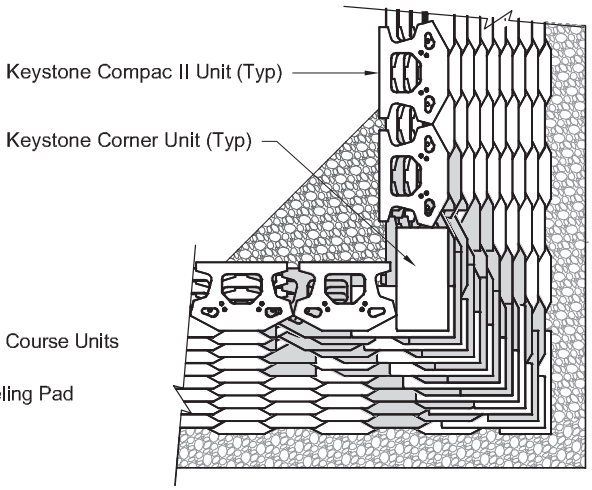
FIGURE U:1 - FULL CORNER UNIT COURSE



Cut Unit Course w/Full Corner Unit Example



1" Setback Corner Side Elevation View

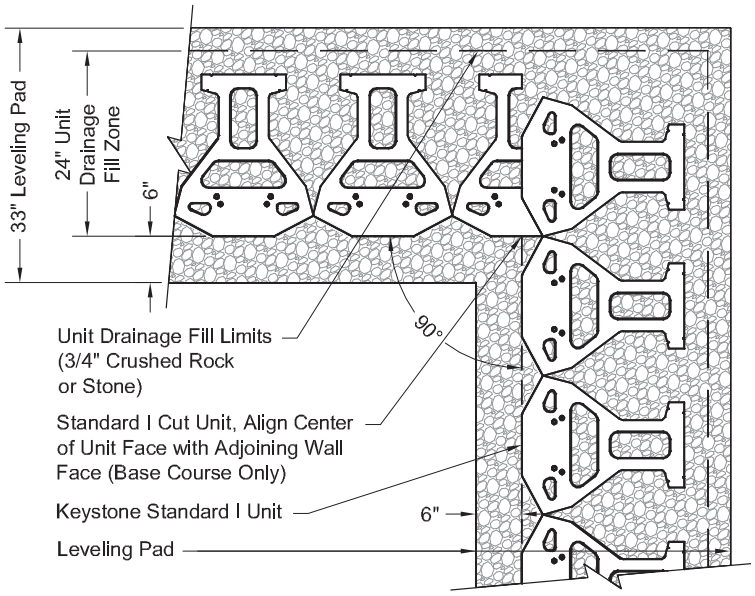


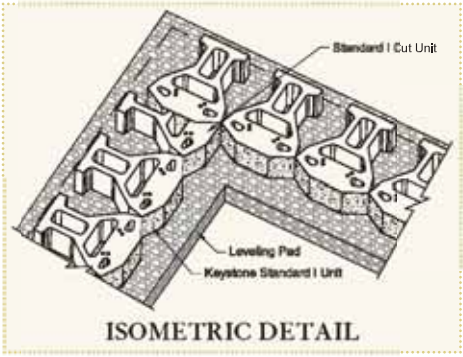
1" Setback Corner Plan View

90° Inside Corner : Standard Unit

The construction of inside corners is relatively simple, because no additional units are required. All you will need is your tape measure, concrete saw, block splitter blade or chisel and a level. There are two ways you can install an inside corner construction; you can butt one wall into the other wall, or you can use the interlocking method as shown below.

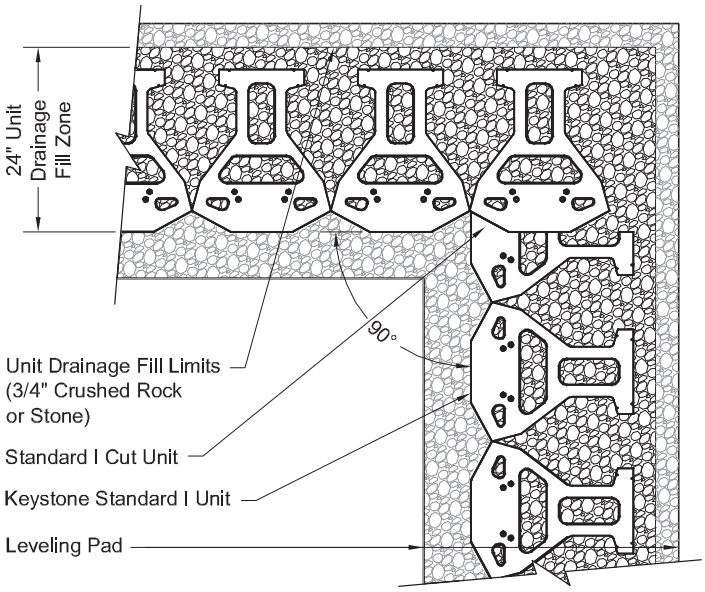
FIGURE V:1 - TYPICAL BASE (ODD COURSES)

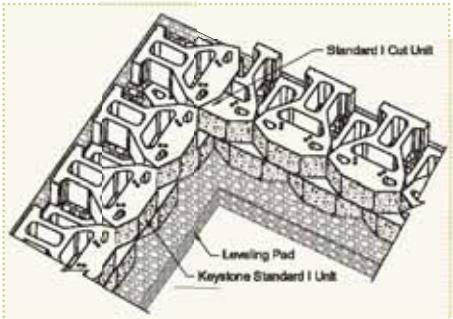




ISOMETRIC DETAIL

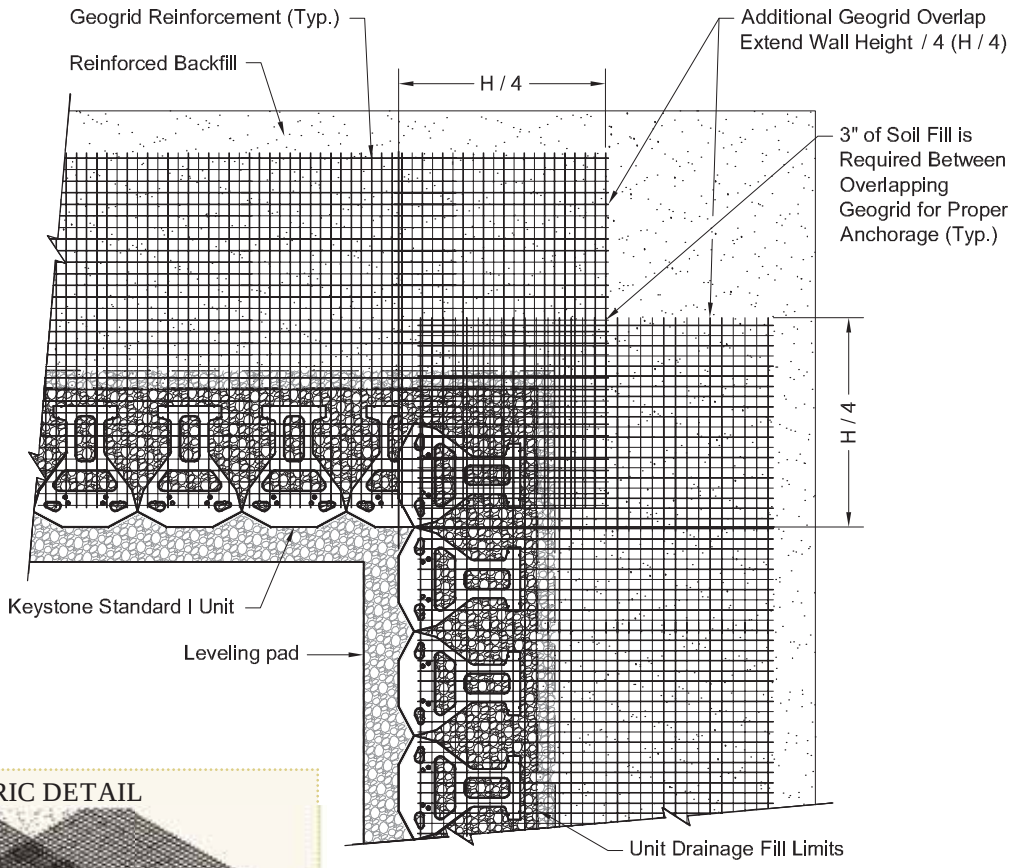
FIGURE W:1 - TYPICAL SECOND (EVEN COURSES)



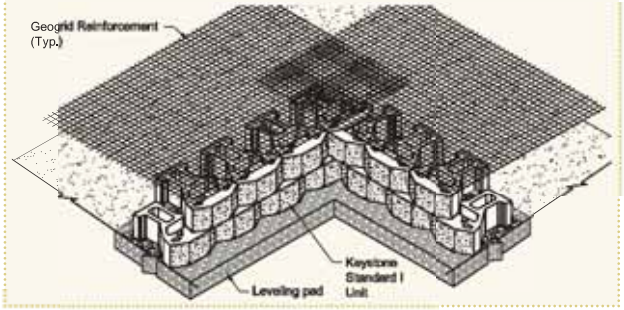


ISOMETRIC DETAIL

FIGURE X:1 - TYPICAL GEOGRID INSTALLATION FOR INSIDE CORNER



ISOMETRIC DETAIL



Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

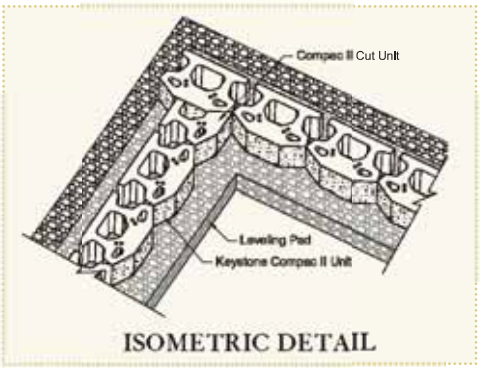
Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

Extend geogrid the wall height / 4 (H / 4) beyond the adjoining wall face at inside wall corners.

90° Inside Corner : Compac Unit

FIGURE Y:1 - TYPICAL BASE (ODD COURSES)



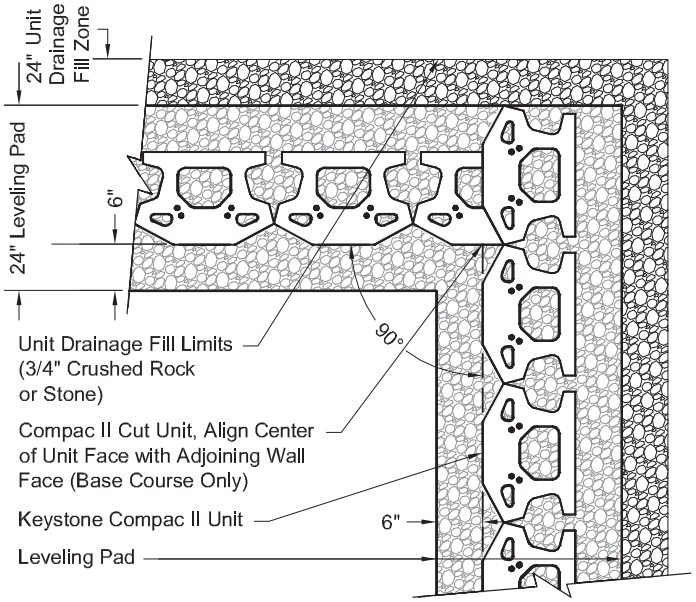
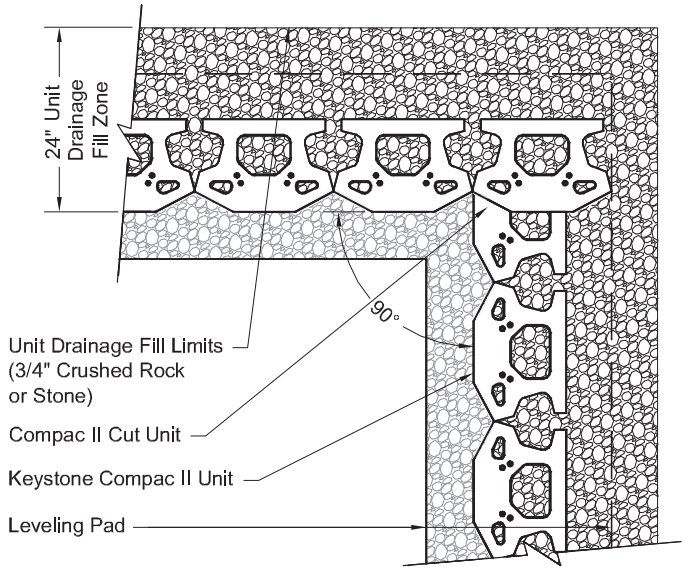


FIGURE Z:1 - TYPICAL SECOND (EVEN COURSES)



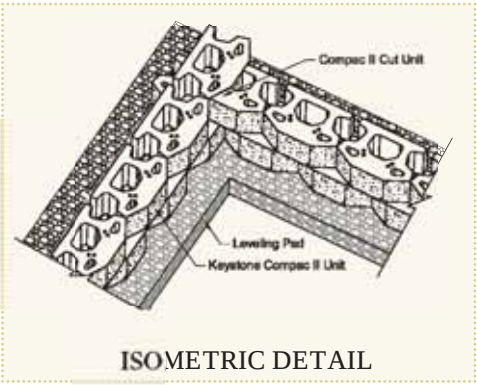


FIGURE A:2 - TYPICAL GEOGRID INSTALLATION FOR INSIDE CORNERS

Notes:

Drainage zone and backfill materials should be placed compacted and up to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

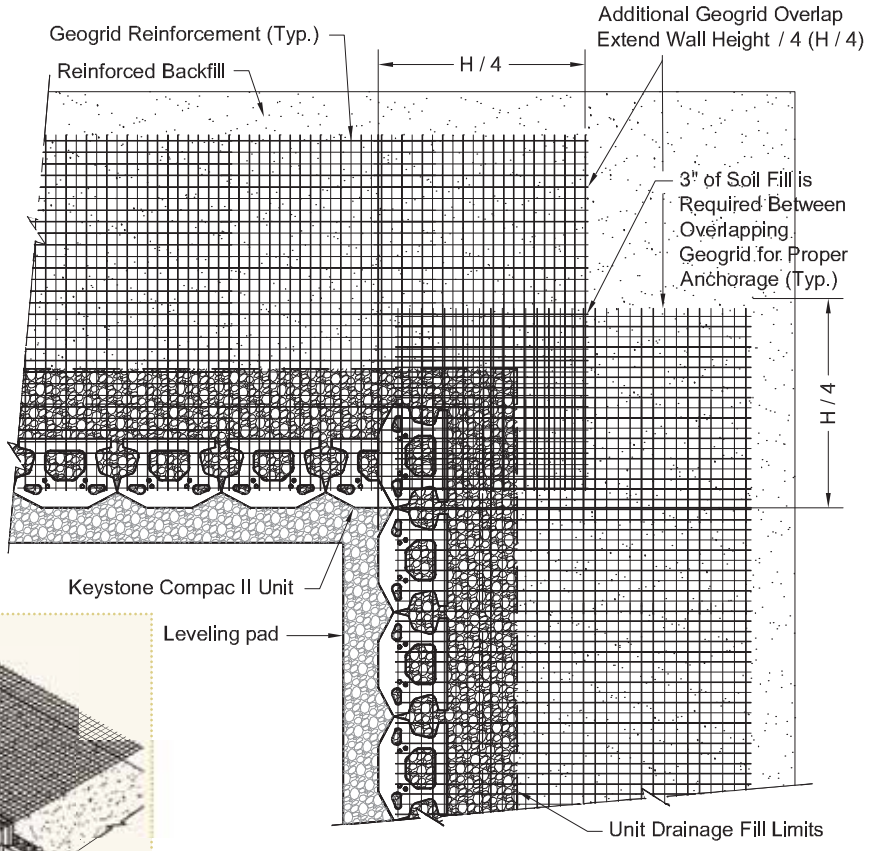
Measure, cut and orient the geogrid, as per the engineers design and the geogrid manufacturers specifications on correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

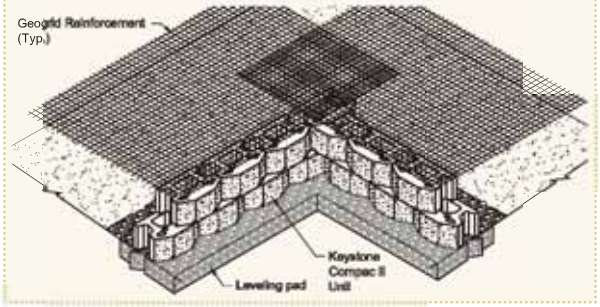
Proceed with placement of additional Keystone units then drainage zone and backfill material. Starting at the wall and moving back away from the wall place the drainage zone and backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process the tension stakes may be removed for reuse.

The backfill materials up to the next wall elevation where a geogrid is to be place.

Extend geogrid the wall height / 4 (H / 4) beyond the adjoining wall face at inside wall corners.



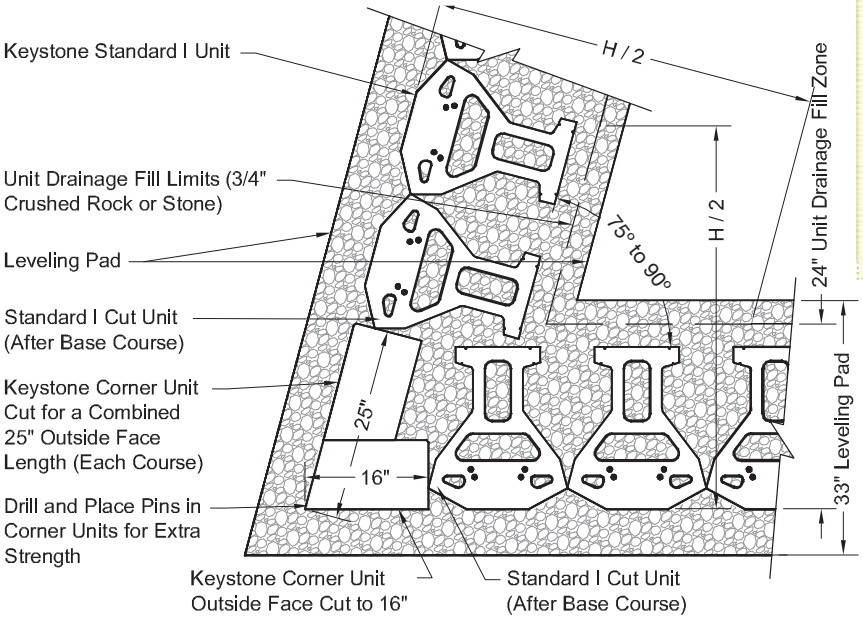
ISOMETRIC DETAIL



Acute Corner : Standard Unit

In special cases, an acute corner construction is needed. No special units are necessary for the construction of acute corners, you will just need to field split or cut the corner units. All you will need is your tape measure, concrete saw, splitter blade or chisel and a level. The following is the recommended installation procedure for acute corners.

FIGURE B:2 - TYPICAL BASE (ODD COURSES)



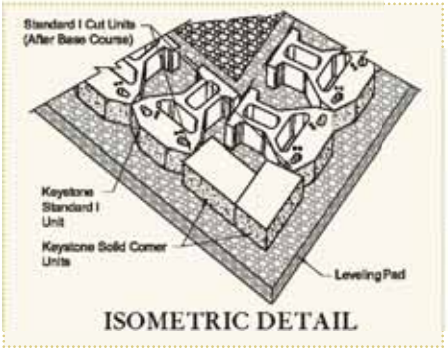
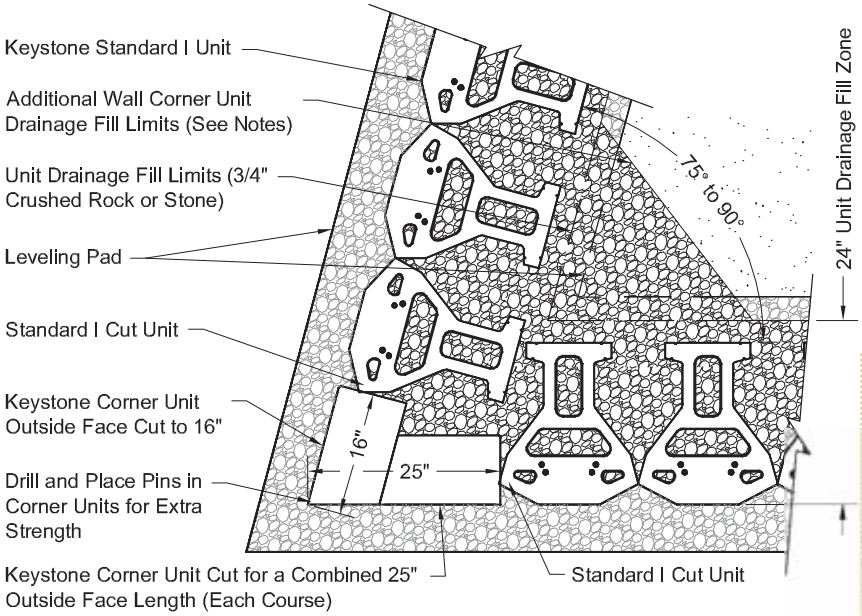


FIGURE C:2 - TYPICAL SECOND (EVEN COURSES)



Notes:

Cut corner piece units to be used for each odd or even course vertically up the wall corner. Corner units to be cut the same for each alternating odd or even course.

Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

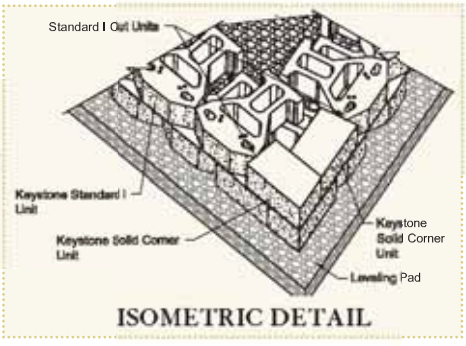
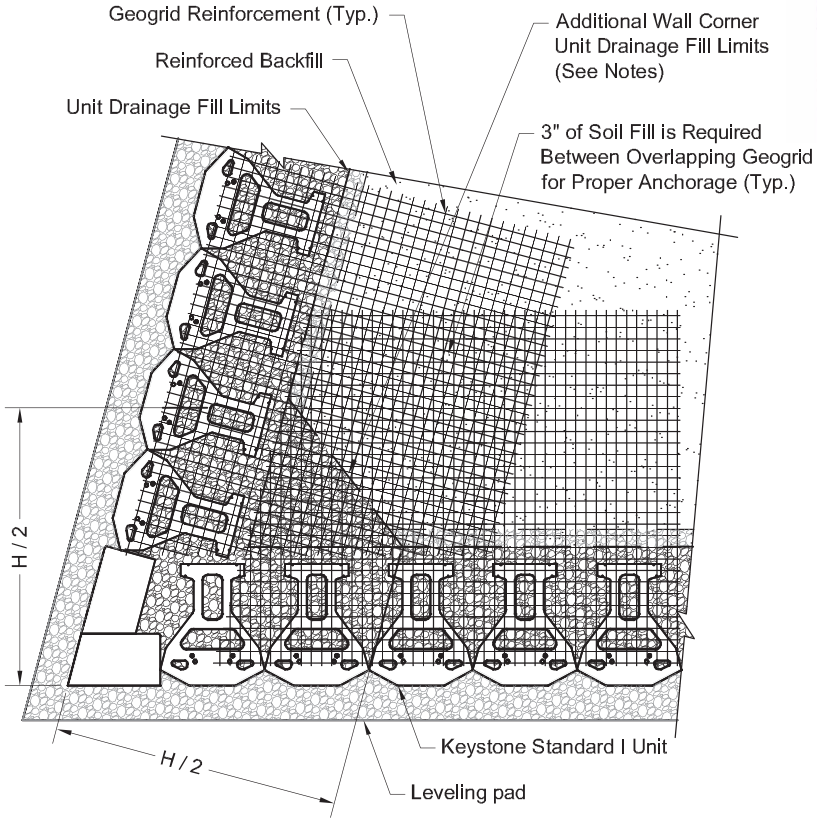
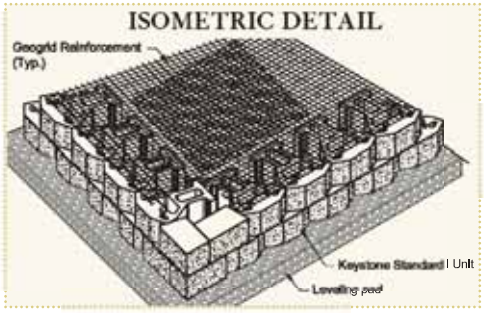


FIGURE D:2 - TYPICAL GEOGRID INSTALLATION FOR OUTSIDE ACUTE CORNERS





Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Place additional unit drainage fill at acute wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

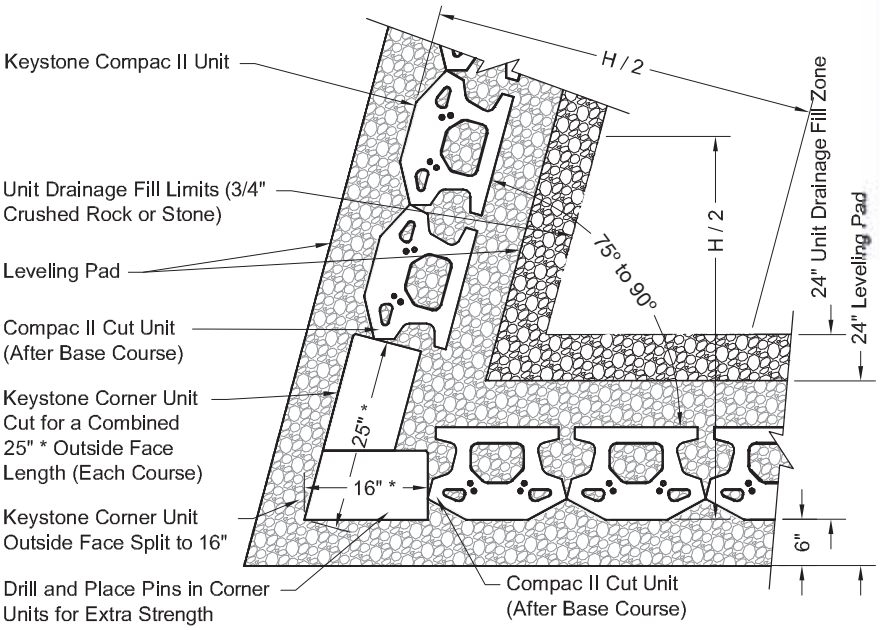
Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

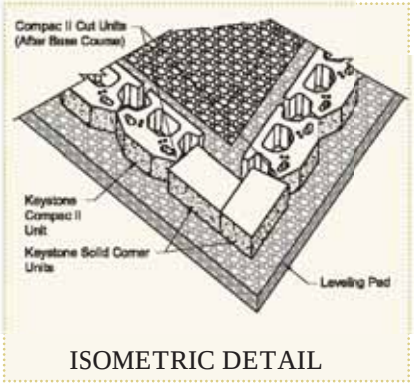
Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

Acute Corner : Compac Unit

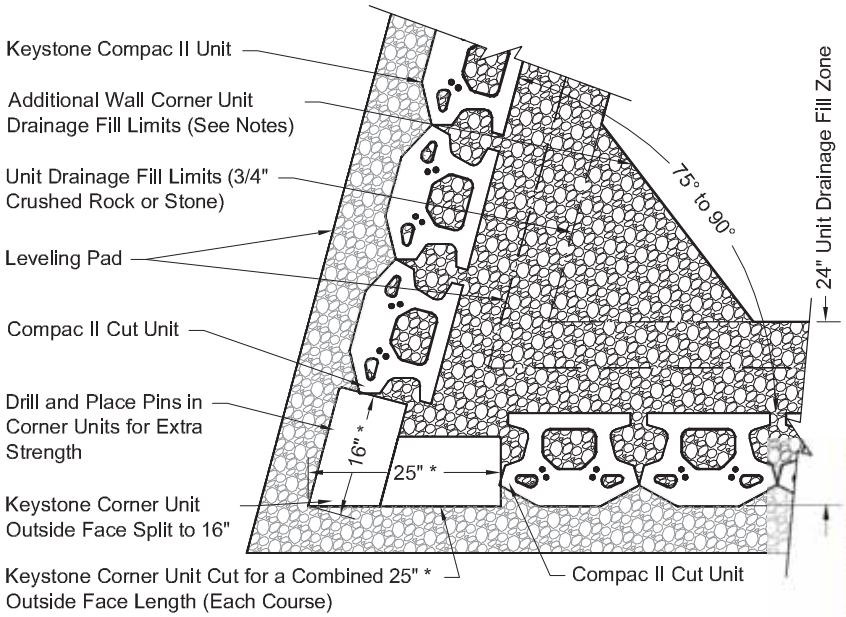
FIGURE E:2 - TYPICAL BASE (ODD COURSES)





ISOMETRIC DETAIL

FIGURE F:2 - TYPICAL SECOND (EVEN COURSES)

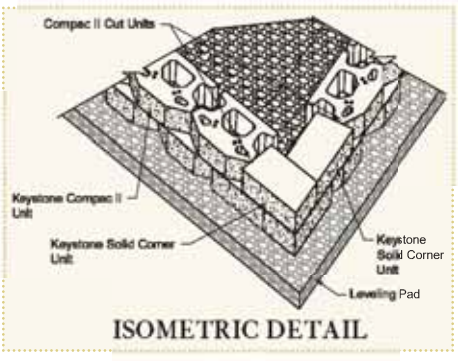


Notes:

Cut corner piece units to be used for each odd or even course vertically up the wall corner. Corner units to be cut the same for each alternating odd or even course.

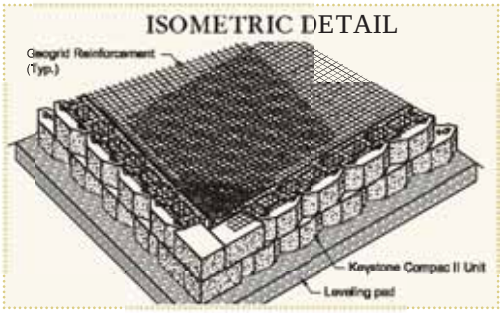
Additional crushed rock or stone drainage fill at outside wall corners to extend back from wall face each way at wall height / 2 (H / 2.).

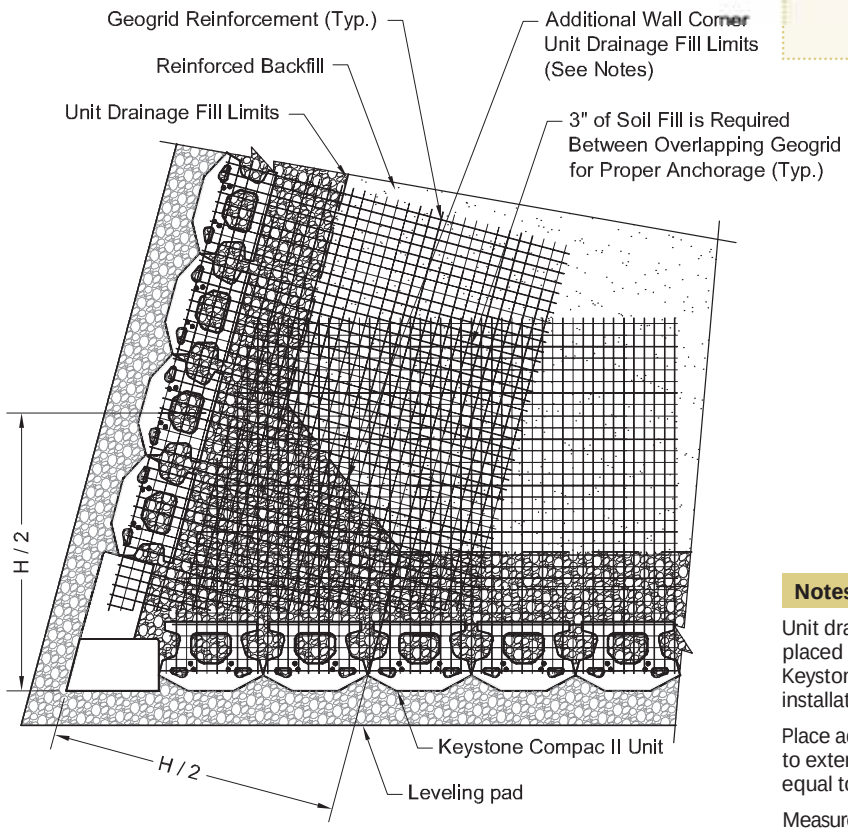
* Distance varies as angle increases.



ISOMETRIC DETAIL

FIGURE G:2 - TYPICAL GEOGRID INSTALLATION FOR OUTSIDE ACUTE CORNERS





Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Place additional unit drainage fill at acute wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

Concave Curves : Introduction

Concave curves for moderately tall Keystone walls are more difficult to construct than a straight wall due to the complex geometry resulting from a battered wall face in a curve. Inside curves allow good access for compaction and the wall face units tend to support each other like an arch when the soil strain associated with the active earth pressure condition develops.

For concave curves as the wall gets taller, the top of the wall becomes longer than the base. For wall systems that maintain the desired running bond configuration, gaps between units tend to form. In a wall in the near vertical pin position (<1°) the gapping is less significant than it is for a battered wall (8°).

When laying out wall geometry, several measures can be taken to minimize this issue or concentrate it to particular locations, which tend to make the issue easier to work with from a construction perspective. Use the following table to determine the amount of gapping (expansion) that will be tolerated at the design wall batter. The table will then provide the minimum radius through the curve based on the desired gap tolerance.

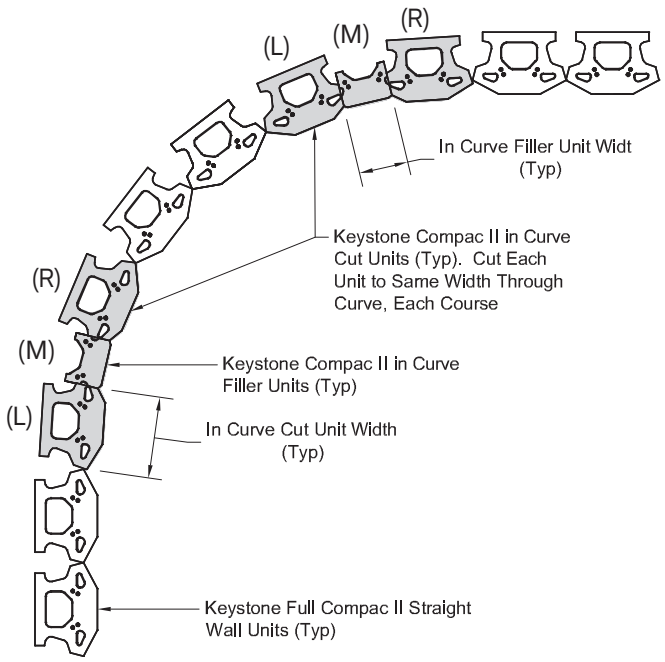
Minimum Radius Table to Reduce Block Expansion					
		Expansion per block per course in a curve			
		1/32"	1/16"	1/8"	1/4"
WALL SETBACK	1° (1/8")	6'	3'	-	-
	4° (9/16")	27'	13'	7'	4'
	8° (1")	54'	27'	13'	7'

Block gapping is expected, it is the amount of gapping that can controlled by increasing the radius of the curve

As the table indicates the minimum radius increases with an increase to the wall batter. The near vertical position is typically the best solution for tighter radius situations.

Unfortunately, the larger radii may not be achievable for a given wall. Therefore, filling the gaps between the units will be required when the gaps start to exceed ⅛ inch. See the illustration below:

Course	Width of Units		
	Left block cut (L)	Middle block cut (M)	Right block cut (R)
5th	15 3/16"	8 3/16"	15 3/16"
6th	15 3/8"	8 5/8"	15 3/8"
7th	15 9/16"	9 1/16"	15 9/16"
8th	15 11/16"	9 1/2"	15 11/16"
9th	15 7/8"	9 15/16"	15 7/8"
10th	16 1/16"	10 3/8"	16 1/16"
11th	16 1/4"	10 7/8"	16 1/4"
12th	15 1/2"	13"	15 1/2"



Notes:

Keystone Compac II units shown in 1 inch setback position.

Full uncut units to be used in the first three courses and as indicated in the details.

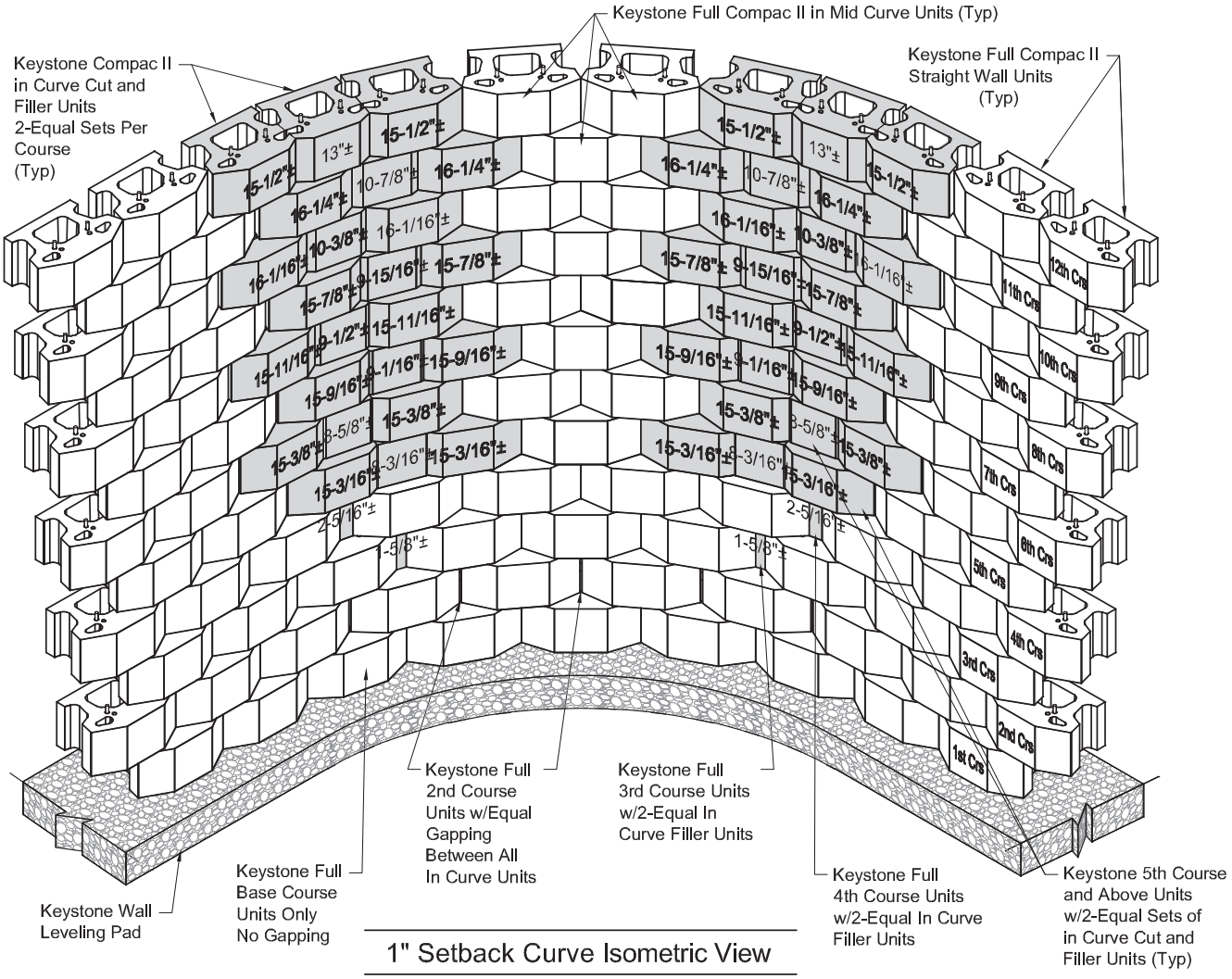
Due to per course perpendicular wall setback at both ends of the curve to maintain running bond course alignment at ends and center of curve, cut the units in the curve per course as roughly labeled for cut width and shaded for unit designation through the curve for proper wall joint alignment at ends and center of curve.

Place full base course units with no gapping between adjacent units. With the placement of each additional course of Keystone units the units batter, move or setback away from the point of radius. The rate of gapping is controlled by the severity of the batter (i.e. a 1 inch setback will gap more quickly than a near vertical setback). The distance between the pin holes on adjacent first course units should not exceed 12 inches on center.

Depending on wall height and radius, connecting pins may fall outside of connecting cores in additional units above, if this occurs re-drill new pin holes as needed using a 5/8 inch masonry bit and realign units and/or use Keystone KapSeal adhesive (or approved equal) to secure units together.

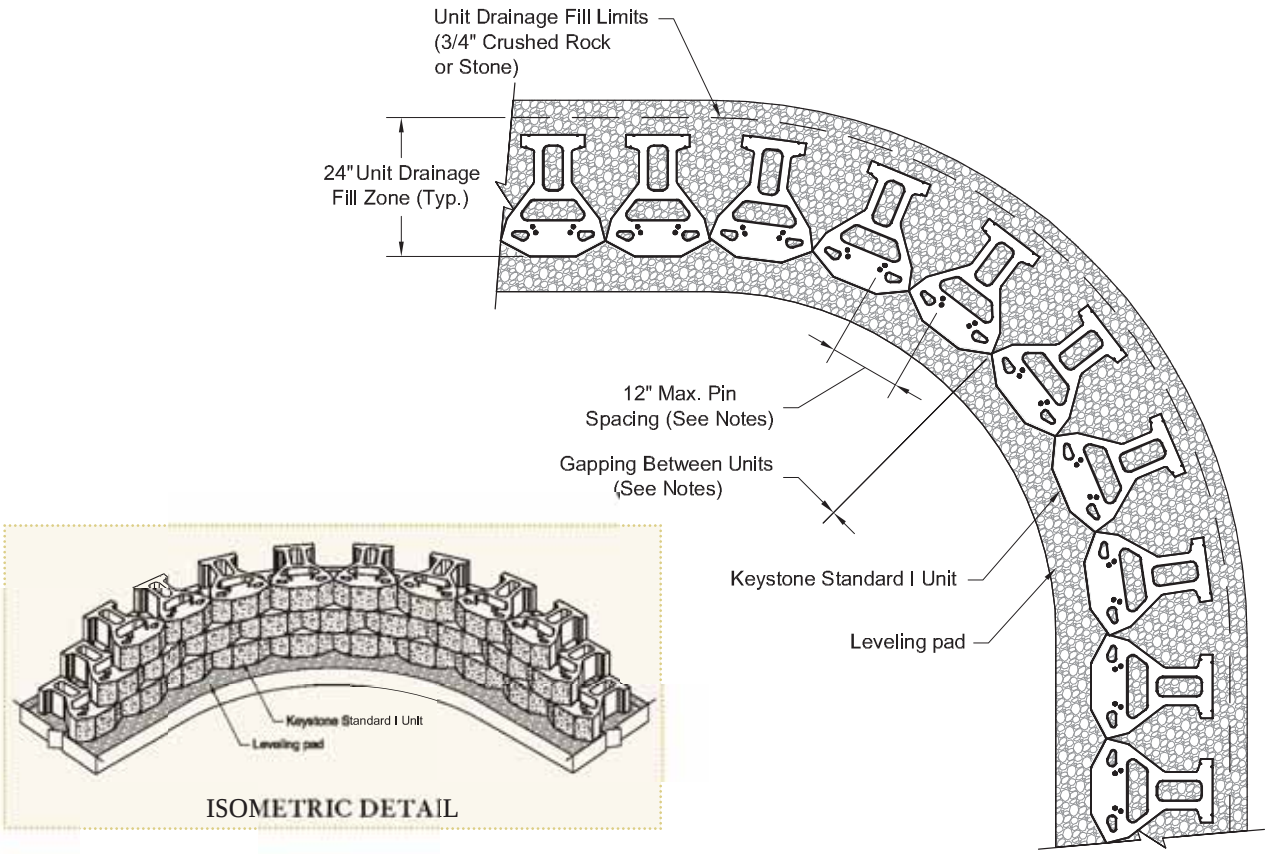
5 feet ± example radius shown, verify actual cut widths for each course as wall is constructed and for other radius sizes.

FIGURE H:2 - BATTERED SETBACK AT CONCAVE CURVES



1" Setback Curve Isometric View

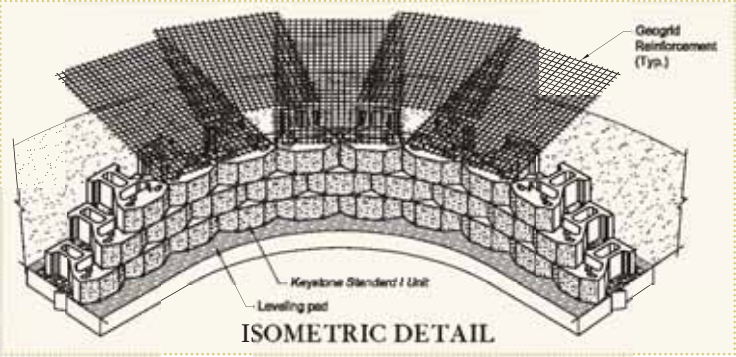
FIGURE I:2 - CONCAVE CURVE INSTALLATION (BASE COURSE)

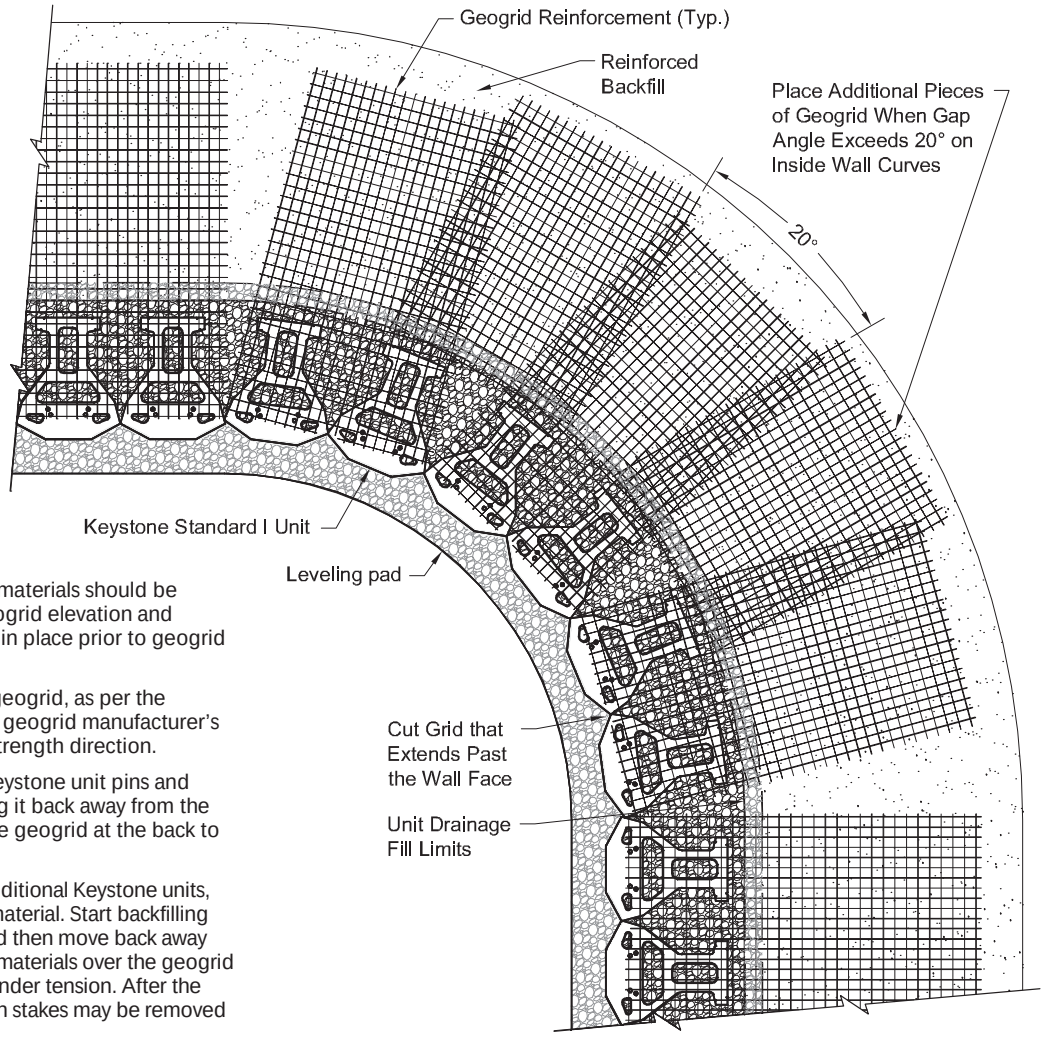


ISOMETRIC DETAIL

COMPAC UNIT -SIOUX CITY, IA

FIGURE J:2 - CONCAVE CURVE GEOGRID INSTALLATION





Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

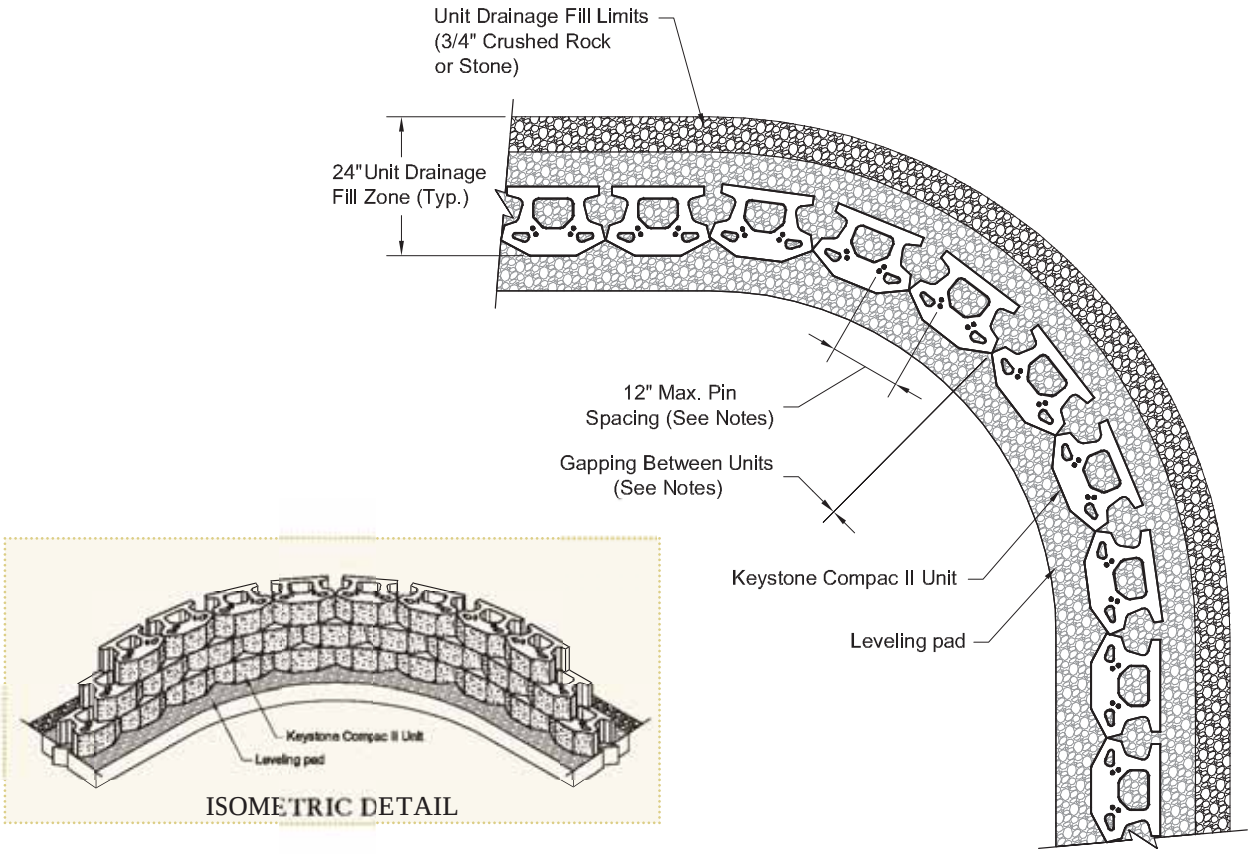
Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

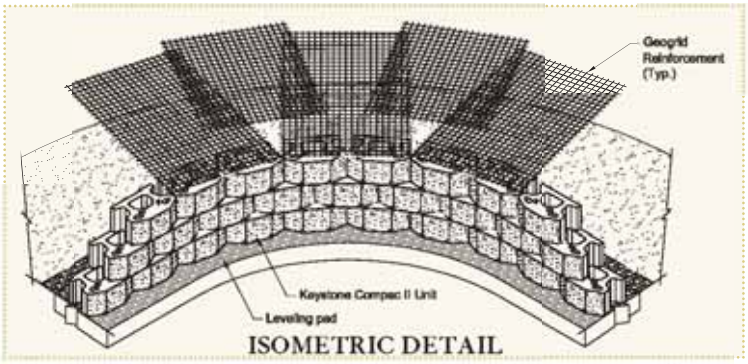
Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

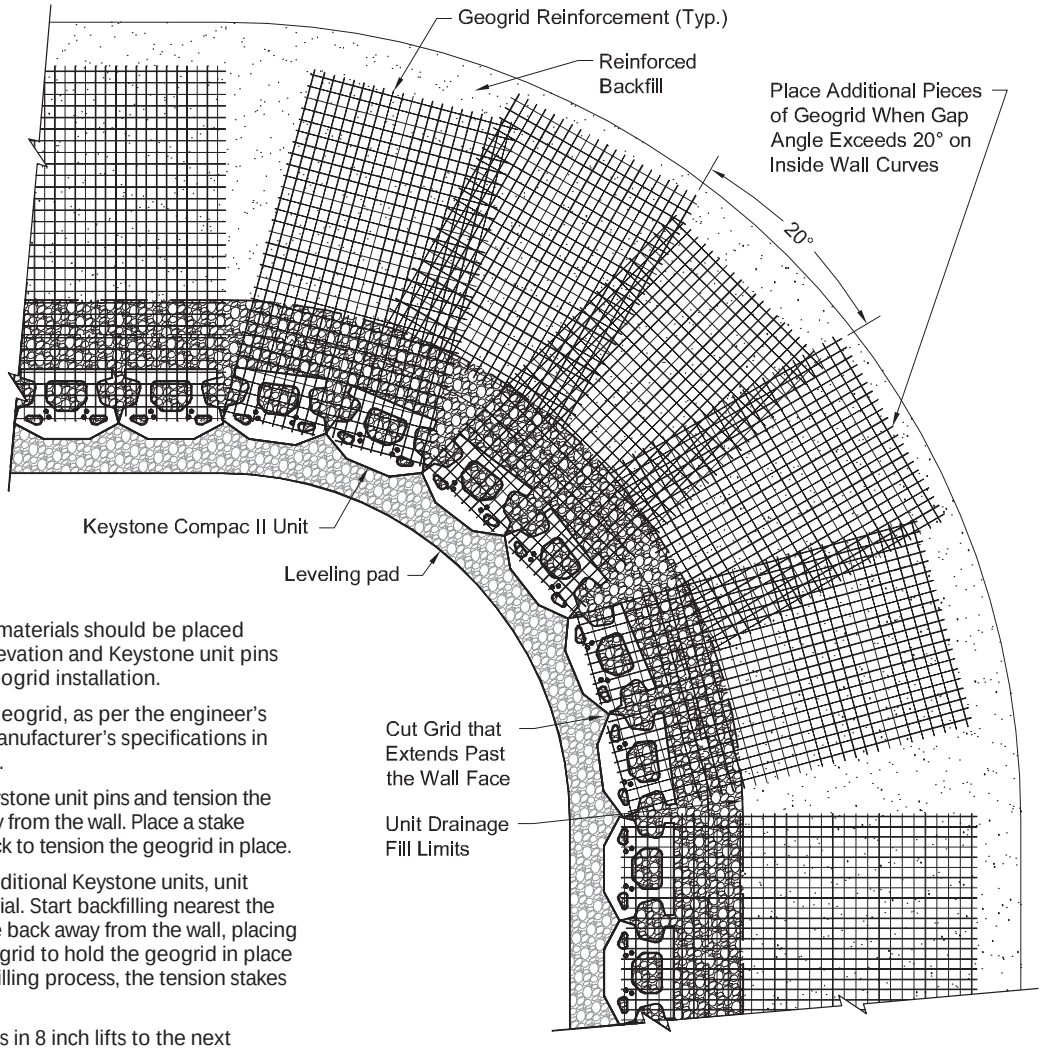
FIGURE K:2 - CONCAVE CURVE INSTALLATION (BASE COURSE)



COMPAC UNIT - CENTENNIAL, CO

FIGURE L:2 - CONCAVE CURVE GEOGRID INSTALLATION





Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

Convex Curves : Introduction

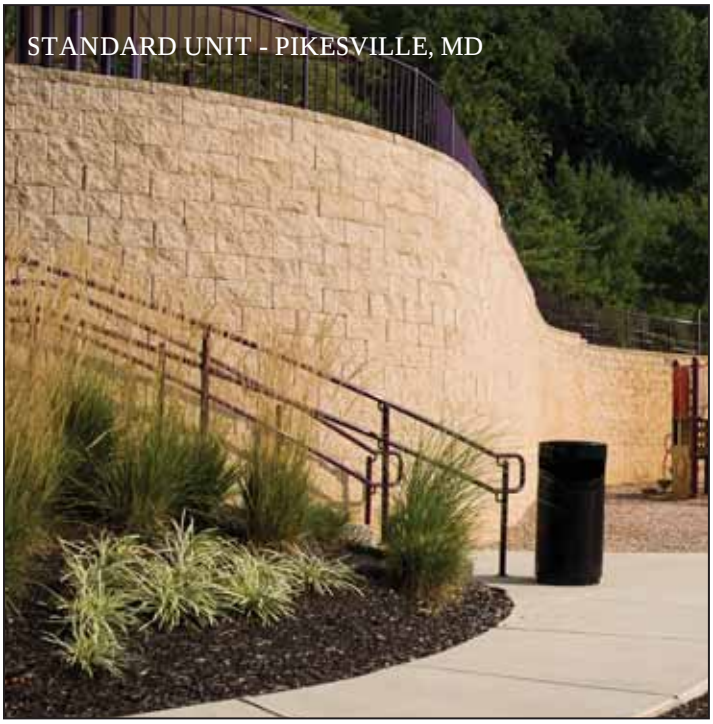
Convex curves are an aesthetically pleasing accent to any retaining wall. Keystone units can be easily integrated with multiple curves within the same wall. However, convex curves require attention to the small details when constructing these curves. Wall performance issues can result from installing too tight of radii, resulting in difficult compaction and many small cut pieces. Units tend to bind as the wall gets taller, thus using a concrete saw or splitter is required to trim some units as the wall is constructed to maintain the running bond configuration. Use the following table to determine the minimum radius of the curve to help reduce the amount of trimming that will be required at the design wall setback.

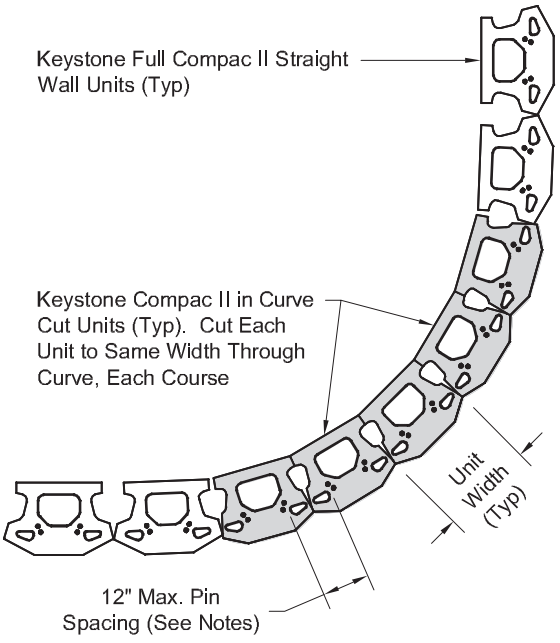
Minimum Radius Table to Reduce Block Trimming					
		Trimming per block per course in a curve			
		1/32"	1/16"	1/8"	1/4"
WALL SETBACK	1° (1/8")	6'	3'	-	-
	4° (9/16")	27'	13'	7'	4'
	8° (1")	54'	27'	13'	7'

Near Vertical Setback is recommended for walls with multiple curves.

As indicated in the above table, 1 inch setback walls require large radius curves to minimize the binding of the units. A wall in a near vertical setback requires minimal trimming of the units. When constructing an outside curve with a 1 inch setback and tight radius, we recommend performing the following steps to maintain pin integrity and running bond configuration. See the illustration below for additional details.

1. Trim unit corner sides equally using either a masonry chisel or concrete saw. Avoid trimming units in the same vertical location to avoid stack bonding and an aesthetically unpleasing look.
2. Push units back and realign. Re-drill new pin holes as needed using 5/8 inch masonry bit and hammer drill.





Notes:

Keystone Compac II units shown in 1 inch setback position.

Full uncut units to be used for the base course and as indicated in the details.

Place full base course units, with no gapping, between adjacent units. With the placement of each additional course of Keystone units the units batter, move or setback toward the point of radius. The rate of closure is controlled by the severity of the batter (i.e. a 1 inch setback will gap more quickly than a near vertical setback). The distance between the pin holes on adjacent first course units should not exceed 12 inches on center.

To maintain running bond configuration through the curve, cut the units equally as shown in the shaded units below. Cutting shown is for the example only and will vary by the radius of the curve.

Depending on wall height and radius, connecting pins may fall outside of connecting cores through the cut units. If this occurs, re-drill new pin holes as needed using a 5/8 inch masonry bit and realign units and/or use Keystone Kapseal adhesive (or approved equal) to secure units together.

6 foot ± example radius shown, verify actual cut widths for each course as wall is constructed and for other radius sizes.

FIGURE M:2 -BATTERED SETBACK AT CONVEX CURVE

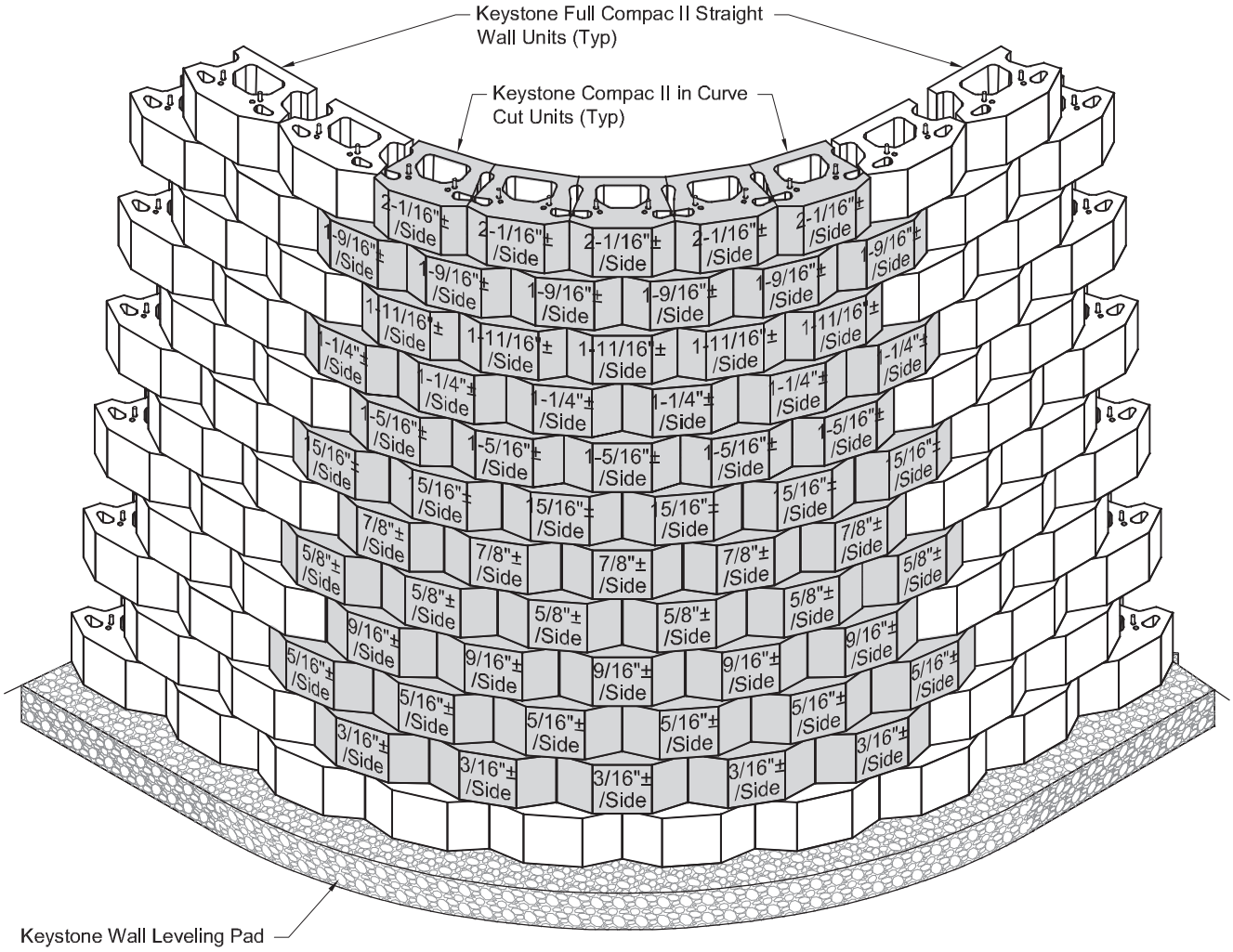
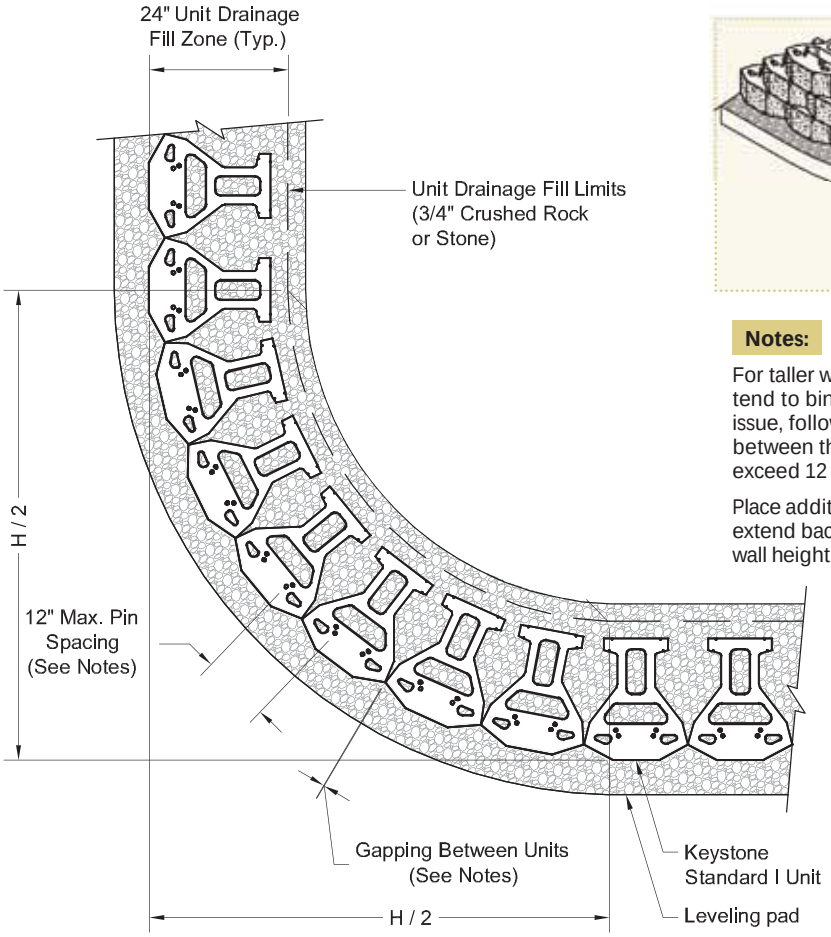
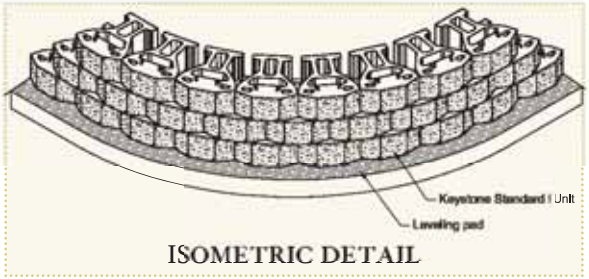


FIGURE N:2 - CONVEX CURVE INSTALLATION (BASE COURSE)



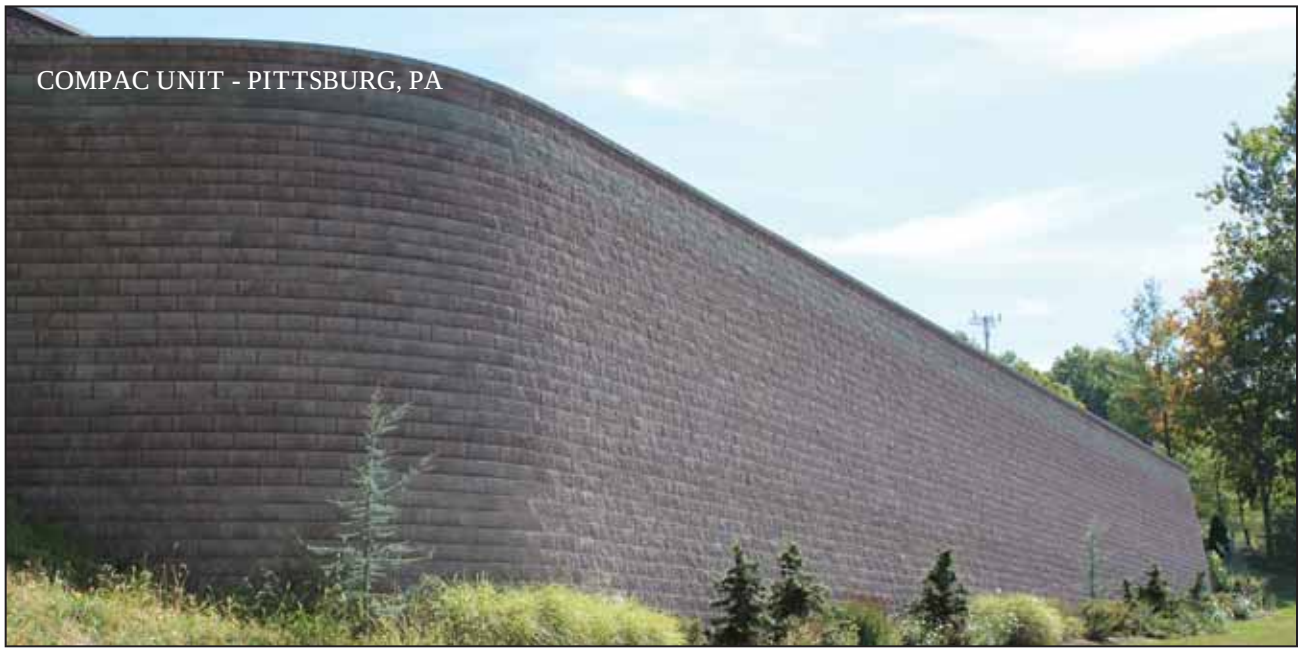


ISOMETRIC DETAIL

Notes:

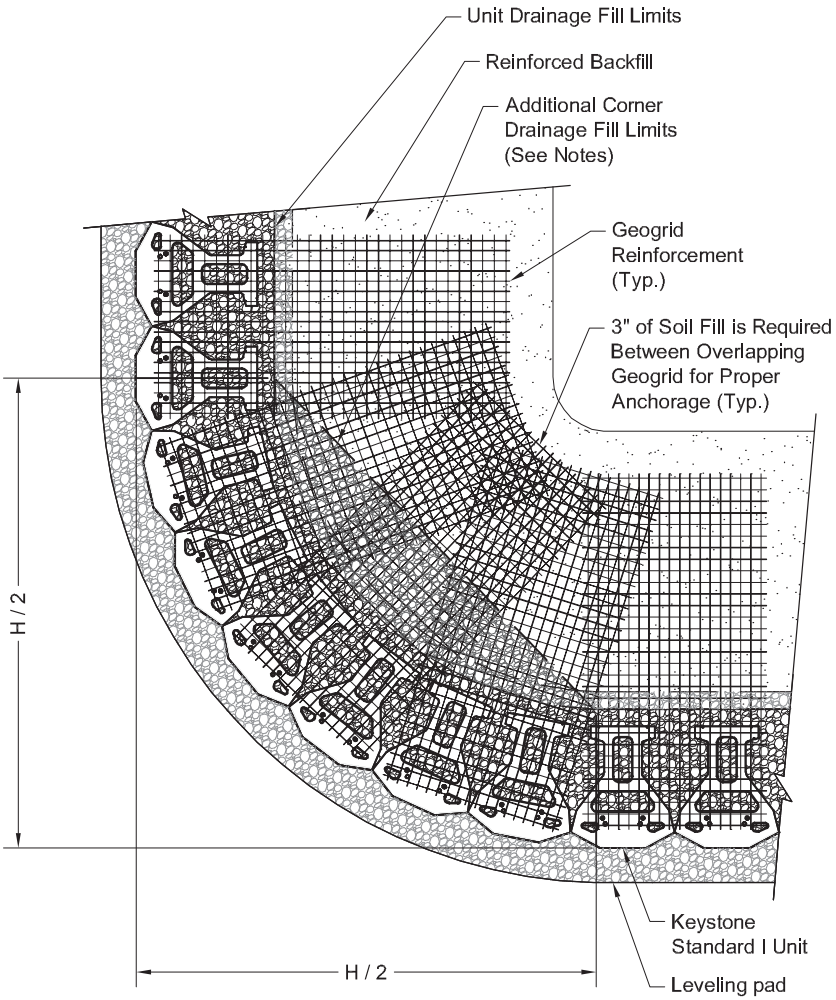
For taller walls, as the wall increases in height, the units will tend to bind on successive courses. To avoid this binding issue, follow the instructions noted above. The distance between the pin holes on adjacent course units should not exceed 12 inches on center.

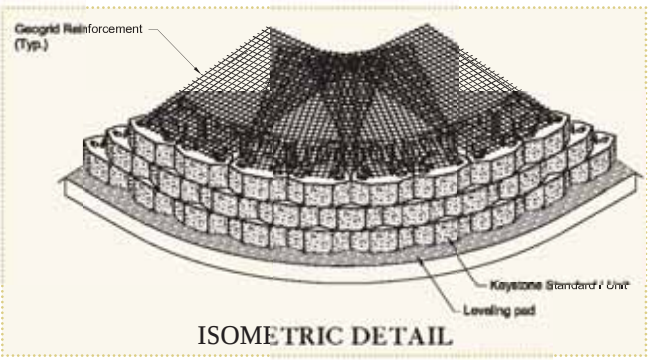
Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).



COMPAC UNIT - PITTSBURG, PA

FIGURE O:2 - CONVEX GEOGRID CURVE INSTALLATION





ISOMETRIC DETAIL

Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Place additional unit drainage fill at outside wall curve to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

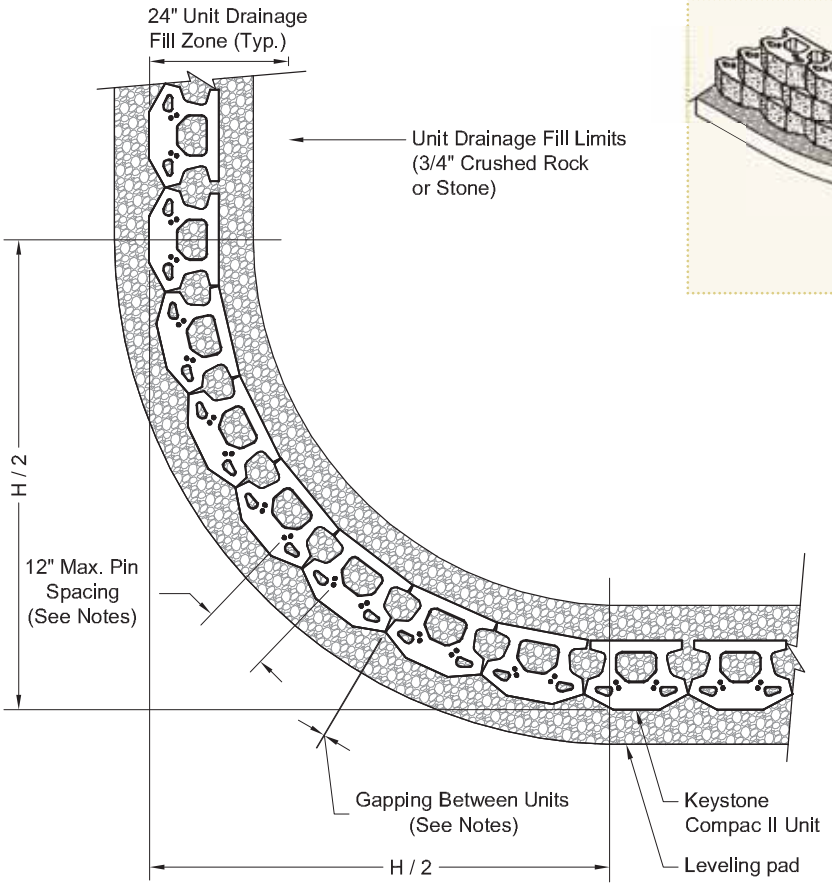
Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

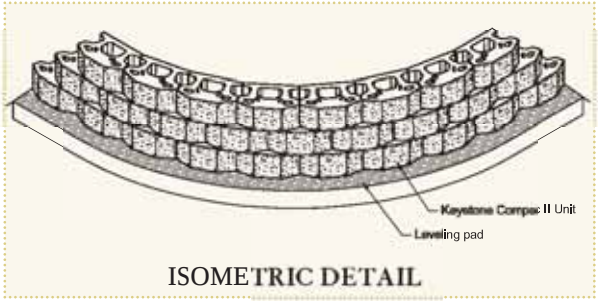
Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.

FIGURE P:2 - CONVEX CURVE INSTALLATION (BASE COURSE)





ISOMETRIC DETAIL

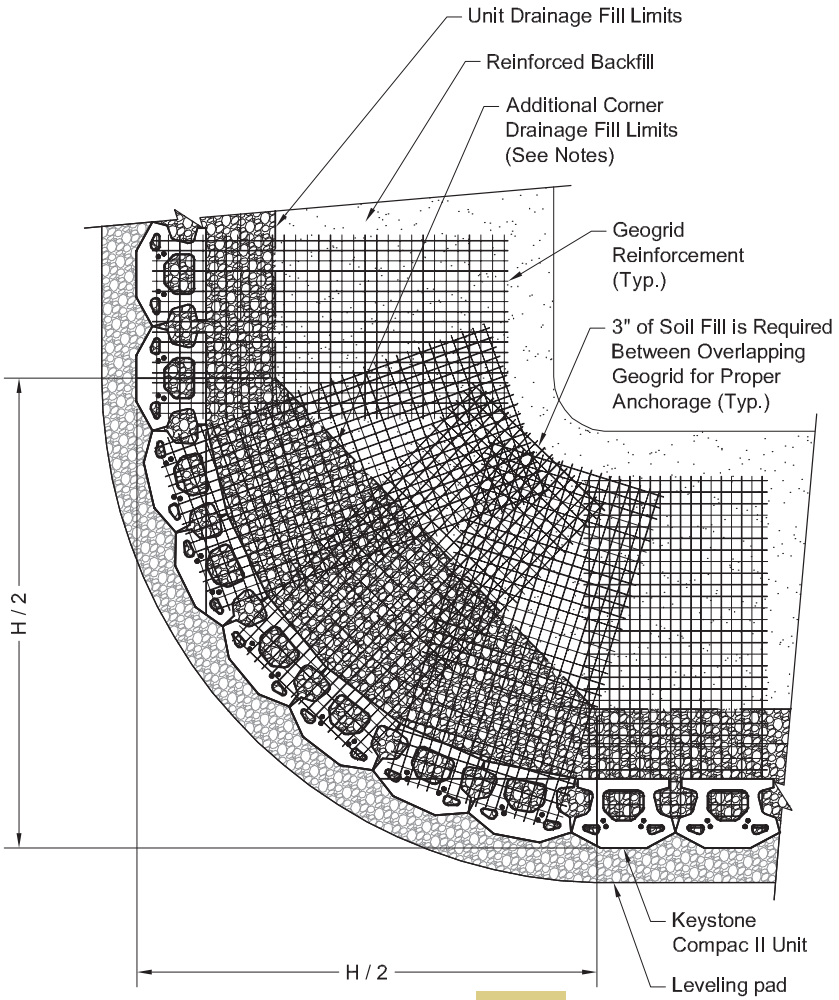
Notes:

For taller walls, as the wall increases in height, the units will tend to bind on successive courses. To avoid this binding issue, follow the instructions noted above. The distance between the pin holes on adjacent course units should not exceed 12 inches on center

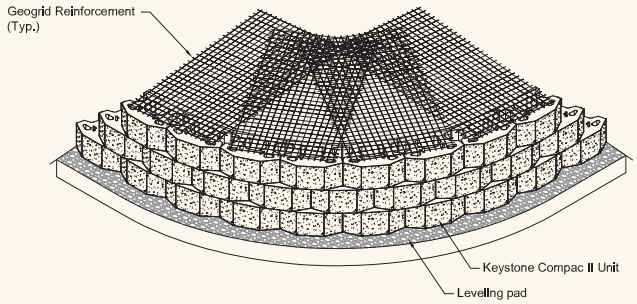
Place additional unit drainage fill at outside wall corner to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

COMPAC UNIT - REDDING, CA

FIGURE Q:2 - CONVEX CURVE GEOGRID INSTALLATION



ISOMETRIC DETAIL



Notes:

Unit drainage fill and backfill materials should be placed compacted to the geogrid elevation and Keystone unit pins should be in place prior to geogrid installation.

Place additional unit drainage fill at outside wall curve to extend back from wall face each way a distance equal to the wall height / 2 (H / 2).

Measure, cut and orient the geogrid, as per the engineer's design and/or the geogrid manufacturer's specifications in the correct strength direction.

Place the geogrid over the Keystone unit pins and tension the geogrid by pulling it back away from the wall. Place a stake through the geogrid at the back to tension the geogrid in place.

Proceed with placement of additional Keystone units, unit drainage fill and backfill material. Start backfilling nearest the Keystone units and then move back away from the wall, placing backfill materials over the geogrid to hold the geogrid in place under tension. After the backfilling process, the tension stakes may be removed for reuse.

Compact the backfill materials in 8 inch lifts to the next reinforcement elevation, and repeat.