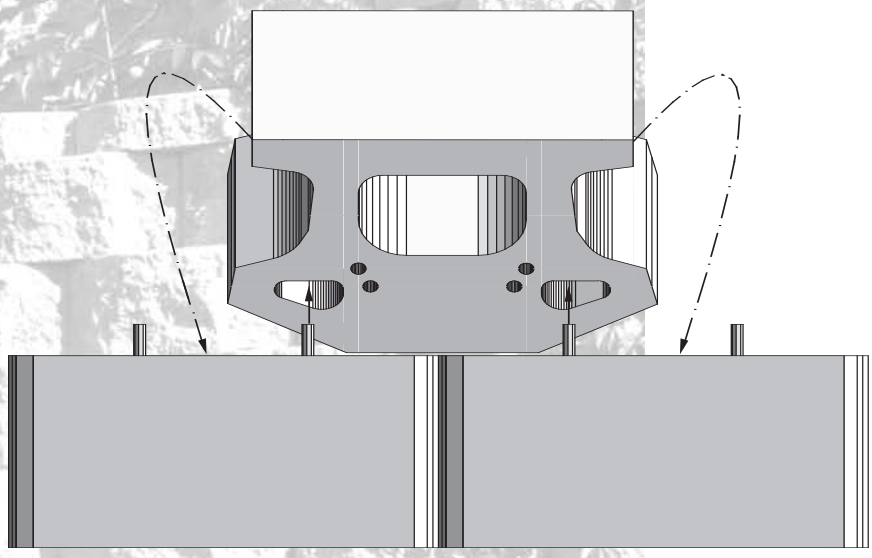
INSTALLATION



I N S T A L L A T I O N

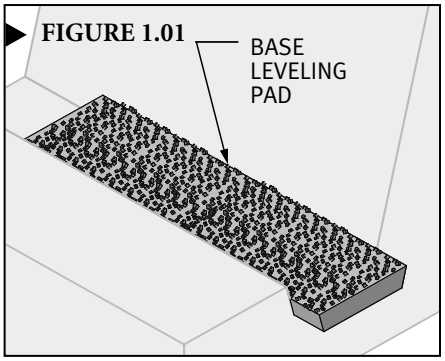
INSTALLATION - STEP BY STEP

With proper design methods, Keystone® Retaining Walls can be built to retain a variety of site conditions. Before construction begins, review standard design guidelines and engineering requirements. Will the retaining wall be a "non-critical" structure falling within basic design and construction methods or will it be a "critical" structure requiring strict engineering documentation? The following list describes site conditions which will require a full engineering study. Consult local building officials for specific requirements. For questions relating to the functionality of the Keystone® units in any of these conditions, contact a Keystone® representative.

- The wall height, including terraces, exceeds 6' (1.8m) for Standard Units, or 3' (0.9m) for Mini or Compac Units.
- The wall will be built on unstable soils, such as clays or organic materials.
- The wall will encounter hydrostatic loading or erosion from wave action, drainage or site runoff.
- The wall will encounter loading conditions resulting from slopes or structures behind or above the wall.
- The wall will use geogrid soil reinforcement or other mechanical anchoring devices.

The following construction procedures assume that all design or engineering issues have been addressed. These installation instructions apply to the Keystone® Standard, Compac, and Mini Units. Proceed with construction using tools common to the construction industry. At a minimum, you will need a level or transit and tools or equipment to dig a trench and place and compact the backfill.

FIGURE 1.01



STEP 1: PREPARE SITE

Remove all surface vegetation and debris. This material should not be used as backfill. If required, excavate site soils to allow for placement of the Keystone® units. If a wall is being built on fill, this step may not be necessary.

STEP 2: EXCAVATE BASE TRENCH

After selecting the location and length of the wall, excavate the Base Trench. This lowers the first course below grade creating a passive wedge of soil to resist sliding. In addition, it helps prevent erosion and scouring at the base of the wall. The Base Trench should be wide enough to allow for the Keystone® Unit and Drainage Zone. The Drainage Zone, an area of crushed stone material, promotes the release of hydrostatic pressures (see **STEP 6** for specific depth requirements).

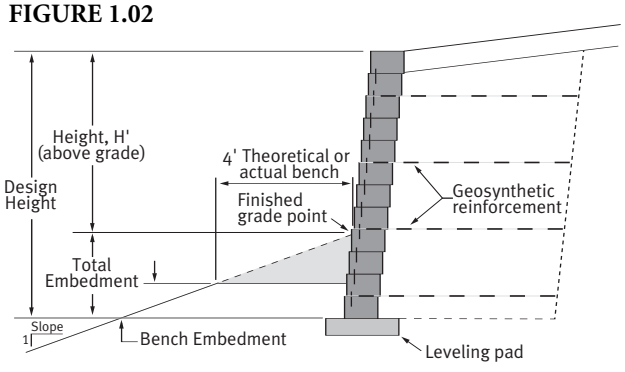
The Base Trench must be dug deep enough to allow for placement of the Base Leveling Pad and any buried Keystone® units. The combined depths of the Base Leveling Pad and buried units is the total depth of the Base Trench.

There are three exceptions to this rule for determining the proper depth of the Base Trench.

1. Poor soil conditions may require a much larger depth of Base Leveling Pad material or soil reinforcement.This extra material would be used to improve the bearing capacity of the sub grade to fully support the weight of the retaining wall. A Geotechnical engineer should evaluate such concerns.

2. Construction of a wall on a slope (Figure 1.02). When using the standard Base Trench guidelines, the amount of passive soil in front of a wall constructed on a slope is reduced significantly. This requires an increase in the Base Trench to meet minimum requirements.

FIGURE 1.02



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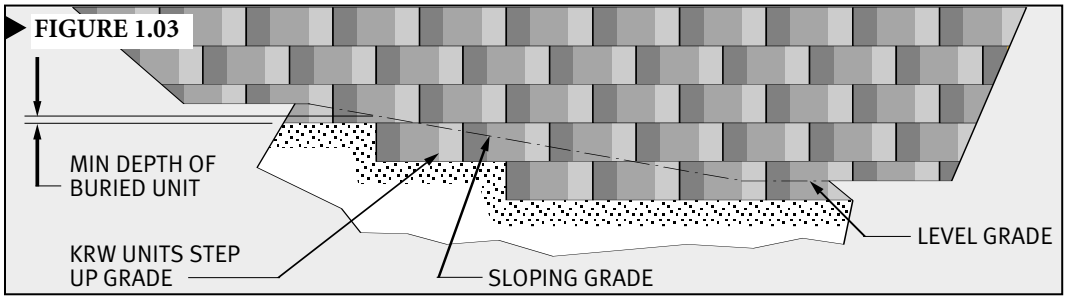
INSTALLATION - STEP BY STEP

3. Stepping units up along a sloping grade (figure 1.03). When the grade running parallel with the wall is not level with the top or bottom of the Keystone® units, the depth of the Base Trench and depth of the units below grade will vary. Maintain the minimum depth of buried Keystone® Units.

FIGURE 1.03



STEP 3: PLACE AND COMPACT BASE LEVELING PAD

Begin first by selecting the proper Base Leveling Pad material.

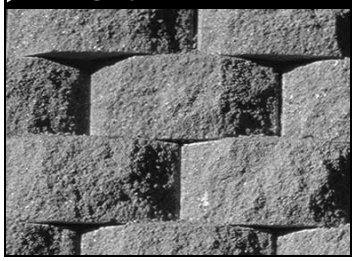
IMAGE 01

Place selected Base Leveling Pad material and compact with appropriate equipment to achieve proper density. Compact granular materials to 95% Standard Proctor or 90% Modified Proctor (soil testing standards to determine % of maximum soil density). Crushed stone should be compacted to yield (Proctor testing can not be performed on crushed stone material.). Requirements for the type of testing program, locations and frequency is the responsibility of the engineer of record or owner. Compact the Base Leveling Pad to a level condition (IMAGE 01). Check for accuracy using a level/transit or hand level. Use some sand or fine granular material for minor adjustments. If a concrete (non-reinforced) leveling pad is being used, set batter boards, pour concrete, and screed level.

When building on a level grade condition, the Base Leveling Pad is placed for the full length of the wall before Keystone® units are installed. Walls built on a sloping lateral grade may require a stepped base (Figure 1.03). In these conditions, the Base Leveling Pad and the first course of Keystone® Units are installed for each length of a step in grade (Figure 1.05). Beginning at the lowest elevation, place and compact the Base Leveling Pad material. Next, install the first course of Keystone® units. After leveling and alignment of these units is complete, place and compact the Base Leveling Pad for the next step in grade. While doing so, place the same material around the units closest to the step in grade to stabilize their position. The top of the last Keystone® unit becomes the grade level for the top of this Base Leveling Pad. This unit retains the Base Leveling Pad material for this next step in grade. If site conditions necessitate, building in the opposite direction, from a high to low elevation, is possible though significantly less efficient. This method will require greater skill to level and align the Base Leveling Pad with the last Keystone® unit of the preceding course.

STEP 4: SET AND ALIGN THE BASE COURSE

IMAGE 02



Begin at lowest wall elevation. Place all units parallel to the alignment line. The machined edges of adjoining units should contact each other (IMAGE 02). This procedure applies to straight walls (See section on "CURVES" for related information). If slag material protrudes past the corner, chip back to allow corners to contact properly. Be sure all units are set top side up. The top side has four pin holes centered between the two kidney receiving holes (Figure 1.04). All units should rest firmly on the Base Leveling Pad. If any rocking motion occurs, adjust base leveling pad material or units to achieve solid contact with this surface.

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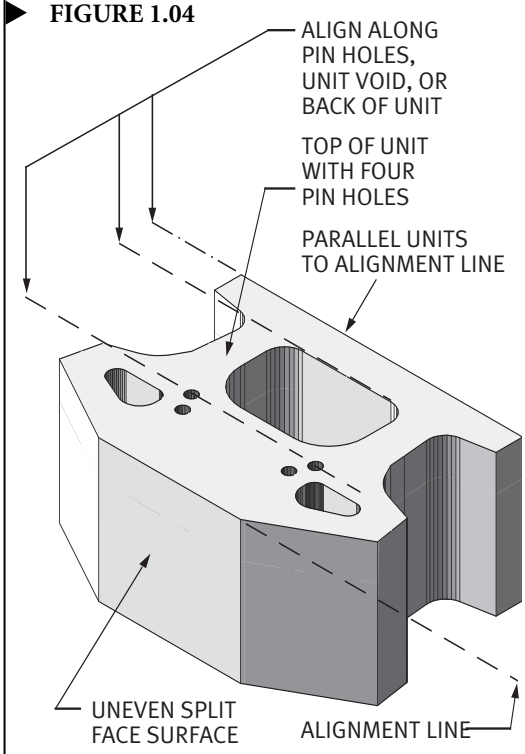
IMAGE 03

Check and adjust the level and alignment of all units. The position of the Base Course determines the alignment of all succeeding courses. Adjustments to alignment must be made at this time. Do not align the units using the split face surface. Instead, verify the proper position of all Keystone® units by examining a straight line across the back of the units or over the top of unit holes (Figure 1.04).

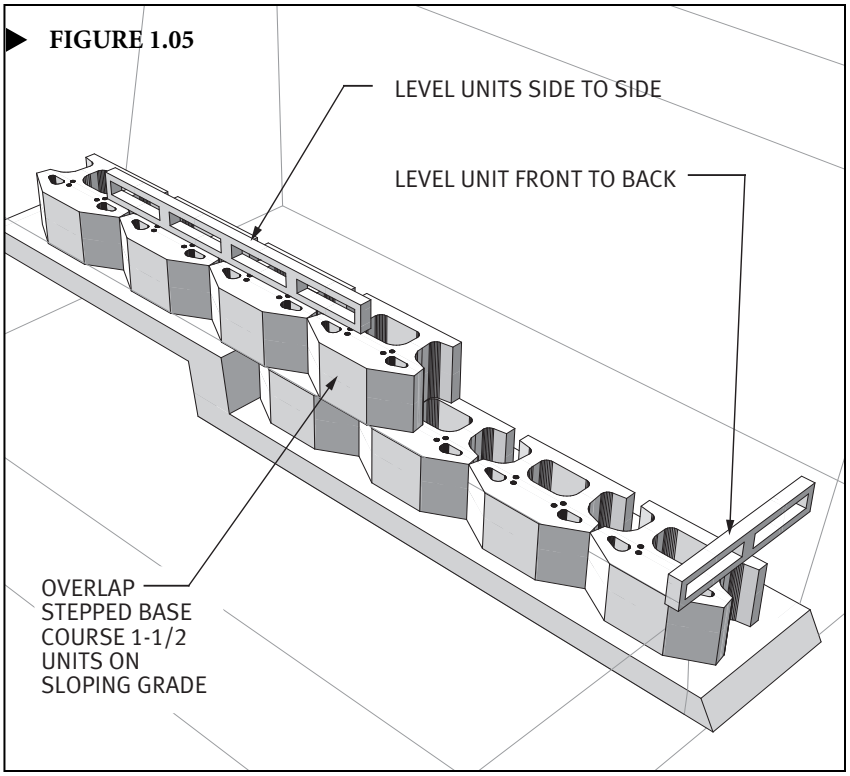
FIGURE 1.04



Level Keystone® units side to side using a 48" (122cm) or longer level. Units can be leveled front to back using a minimum 24" (61cm) level. If a level/ transit is used, spot check every 4th or 5th unit. The top surface of two adjoining units should align (+) or (-) 1/8" (3mm). Minor height adjustments can be made by tapping the unit with a rubber mallet or by placing small amounts of coarse sand under the units. Applying excessive vertical force in an attempt to adjust the height alignment could produce stress fractures. Placement of more than 3/4" (20mm) of loose material could lead to unacceptable settlement.

All Base Course units can be placed for an entire wall length or for a small segment of the full length. To reduce the movement of base units from construction equipment, place core material after placement and leveling of each ten units. When placing the Base Course for a wall with a stepping grade, set all units at the lowest grade elevation first. Secure the position of these units as described in STEP 2. Placement of the Base Course for the next step in grade should begin by placing a minimum of 1-1/2 overlapping units (Figure 1.05). This will ensure proper interlock position for additional units.

FIGURE 1.05



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INSTALLATION

INSTALLATION - STEP BY STEP

STEP 5: INSERT FIBERGLASS CONNECTING PINS

Before installing the pins, select a batter option. "Batter" is the slope of the face of a wall upward and backward so that the wall leans into the embankment being retained. With Keystone®, batter is mechanically controlled by the pin position. Units with four pin holes appearing in the top of the Keystone® unit have three batter options; 8.8° (1-1/4" [30mm]), 4.4° (5/8" [15mm]) or near vertical. Units with only two pin holes appearing in the top of the Keystone® unit result in a 4.4° batter (1.07).

Place two Keystone® pins into two of the preformed holes in the top of each Keystone® unit (Figure 1.06 and IMAGE 04). In some cases a light slag film may cover part or all of the hole. In these conditions, use a hammer to tap the pin through the concrete slag and into the opening. Once in position, a minimum 1-1/4" (30mm) segment of the pin should protrude out of the opening above the top surface of the unit.

IMAGE 04

FIGURE 1.06

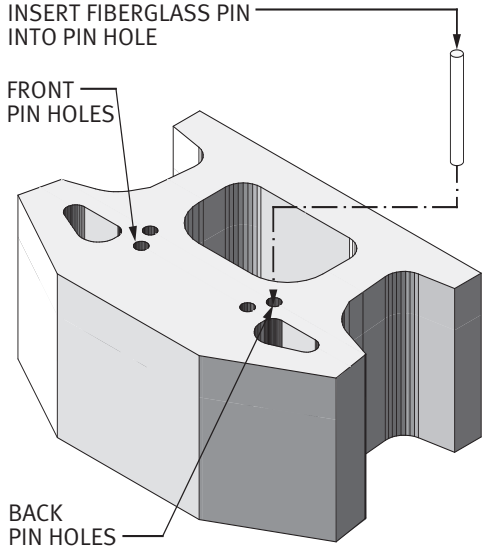
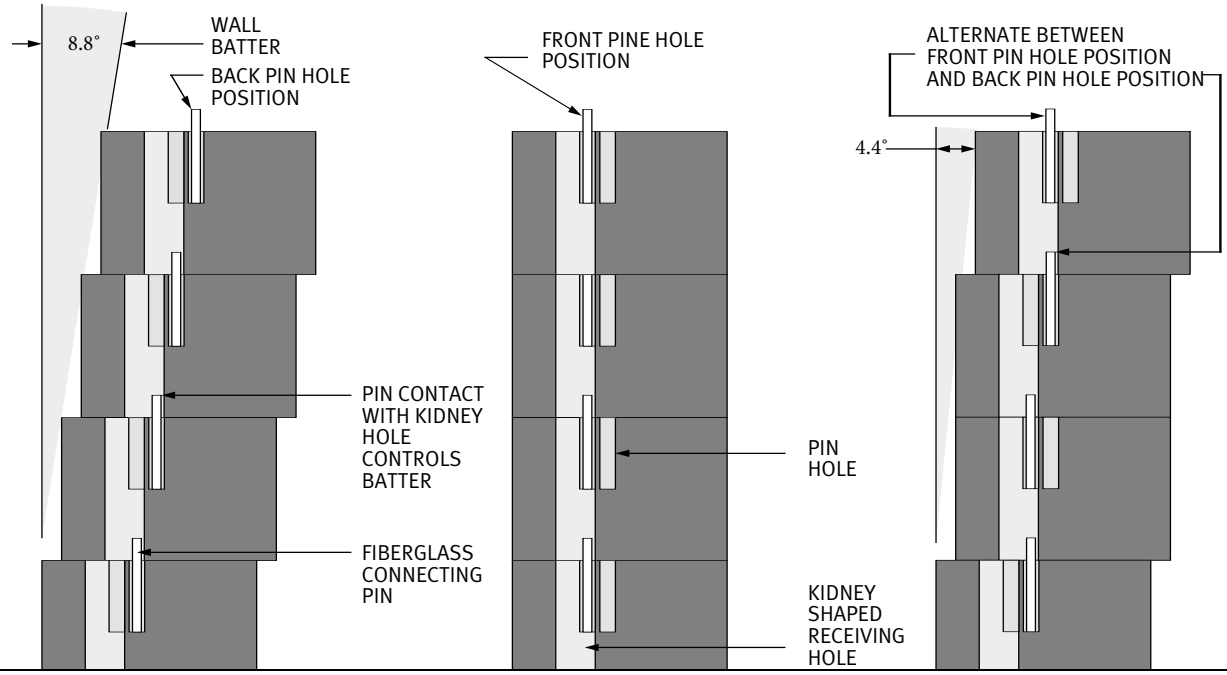


FIGURE 1.07



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INSTALLATION

INSTALLATION - STEP BY STEP

STEP 6: PLACE UNIT/DRAINAGE MATERIAL (IMAGE 05)

IMAGE 05

Fill the Keystone® unit voids and Drainage Zone with an inorganic free draining granular material (preferably 3/4" (20mm) crushed stone). The unit voids are the openings and spaces between units. The Drainage Zone is the combined area of the unit voids and/or additional area behind the unit. The width of Unit/Drainage material should be approximately 24"(61cm), measured from the wall face to the back of the trench (for specific volumes required to fill a Compac or Standard Unit, refer to the Standard or Compac Unit "Keynote"). Certain site conditions may require a greater width of this material. Place material into the specified area. A crushed stone material will consolidate naturally. Graded granular or coarse sand material may require hand compaction. Do not operate any automated compaction equipment directly over the Keystone® units in an attempt to compact this material. This may result in stress fractures.

Proper placement of the Unit/Drainage material serves three important purposes. First, placing this material between units on adjoining courses creates a positive interlock between units. If geogrid reinforcement is used, friction interlock with the wall face is significantly improved. In addition, this material will increase the overall weight of each Keystone® unit; a very important feature for simple gravity retaining walls. Finally, it will permit the release of hydrostatic pressures which build up behind the wall face. The Unit/Drainage material used in this procedure should be the same as is described in Step 3 (Points 1 & 2). If fine grain material is used (i.e. sand), water percolation may move some of these particles out of joints between units and over the wall. The presence of soil on the unit faces may cause some discoloration and an unacceptable appearance. To eliminate this problem, place a piece of filter fabric between each unit. This will allow moisture to flow out of the face while trapping soil fines. A larger aggregate material such as crushed stone will filter most soil fines found in retained site soils. This back-filling procedure should occur after placement of each Keystone® course. When building with the Standard Unit, an alternate technique may be used. The size of this unit and its voids will allow them to be laid up to three courses high prior to placement of the Unit/Drainage material. To use this construction procedure, the material must be clean 3/4" (20mm) crushed stone. Natural consolidation of this material will occur during construction. If geogrid reinforcement is used, backfill units before placing geogrid layers. Attempting to backfill through the geogrid openings will not allow the placement of the Unit/Drainage material into the unit voids.

NOTE: If drainage is required due to excess water, add drain tile behind the tails on the base course.

STEP 7: BACKFILL AND COMPACT SOILS.

The depth of this area will vary depending on the site conditions and construction procedures used. Walls constructed in a fill condition will require the placement of large volumes of this material. Walls built into cut conditions will require varying quantities of material depending on the amount of over excavation.

IMAGE 06

The same placement rules apply for each condition. In general, all soils should be placed in no more than 8" (20cm) thick lifts, the height of a single Keystone® unit. More specifically, the proper thickness of material placed in a single lift is dependent on the type of soils and compaction equipment being used. For example, crushed stone (used for Unit/Drainage) may be placed in maximum lifts and will compact with minimal effort. Most inorganic site soils, easily influenced by moisture levels, must be placed in shorter lifts and will require greater compaction effort.

What about compaction? The backfill soils need to be compacted to a minimum **95% Standard Proctor** (95% of the soil's maximum density). Both the type of material and the compaction equipment need to be considered when

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addressing this issue. Soils compacted with walk behind equipment will require the placement of thin layers of material. Using ride-on mechanical equipment will allow placement of thicker lifts of material. Consult an engineer for specific recommendations. The following are basic guidelines:

- Backfill material must have the proper moisture content for optimum performance when compacting.
- **Organic or heavy clay material should not be used**. These materials hold moisture and do not compact properly.
- Walk behind mechanical compaction equipment may be used to compact any soils placed beyond the Unit/Drainage zone.
- Ride-on mechanical compaction equipment should be operated no closer than within 3' (1m) of the Keystone® Unit back surface.
- Do not over compact or compact soils next to the back of the unit in an uncontrolled manner. This may drive drainage material under the unit, forcing the units out of level. If this continues, the wall may begin to lean forward.
- All soil testing should be performed by a qualified engineer. Soil tests should be taken no closer than three feet from the back surface of the Keystone® unit.

IMAGE 07

While placing backfill material behind the first course of Keystone® units, replace the passive soil wedge at the front of the units. This will secure the proper alignment of all units (See IMAGE 07).

STEP 8 : SWEEP TOP OF UNITS CLEAN

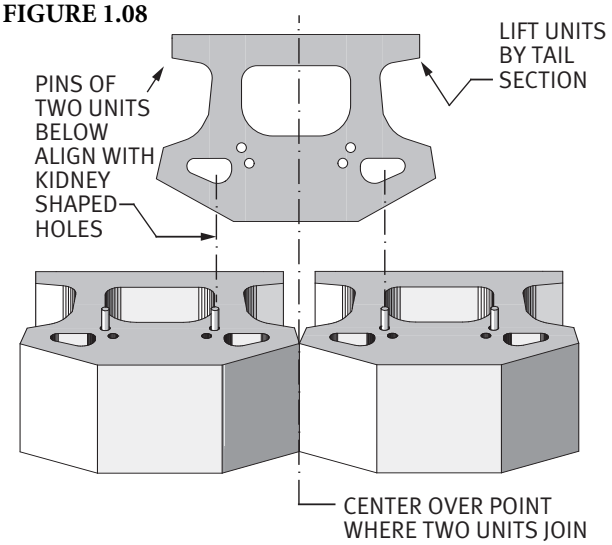
Remove all excess unit/drainage material from the top surface of all units. This allows a smooth surface for placement of the next course of Keystone® units. If small stones become sandwiched between units, point loading may occur resulting in stress fractures. This material may also leave units out of level, creating visual distortion. If due to the manufacturing process, ridges or slag material are present, remove by using a tool or use the next course unit being placed to rub the high spot off.

STEP 9: INSTALL ADDITIONAL COURSES OF KEYSTONE UNITS (Figures 1.08 - 1.11)

Place additional courses of Keystone® units. Each unit will be placed over two units below creating a running bond face pattern. Easiest placement of the Keystone® units is accomplished in the following steps:

- Lift each Keystone® unit by its back tail section to move it into position.
- Center the unit in front of the point where the two units below meet.
- Set the face of the unit onto the front edge of the two units below.

FIGURE 1.08



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I N S T A L L A T I O N

INSTALLATION - STEP BY STEP

FIGURE 1.09

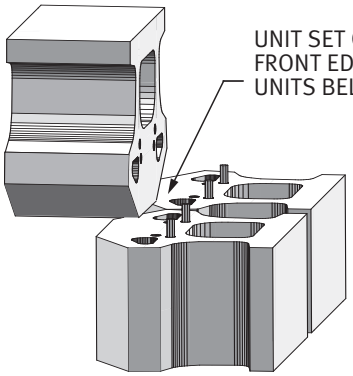
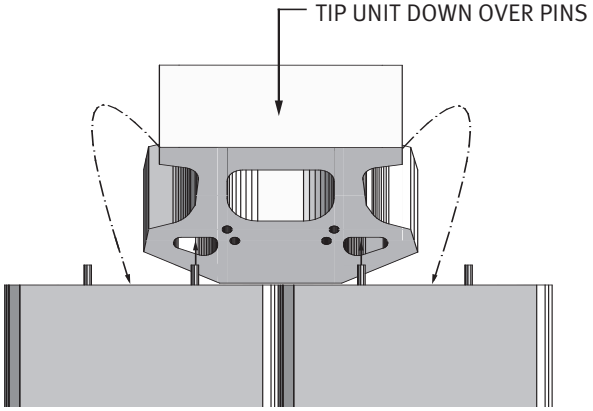


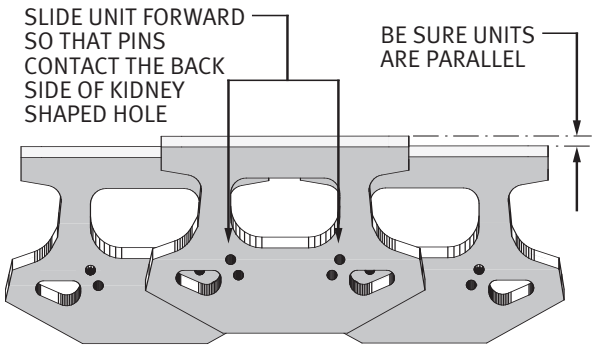
FIGURE 1.10



• With the Keystone® unit in this position, slowly lower it to contact the two units below. While lowering the unit, the two kidney receiving holes should slip over one fiberglass pin in the units below (open kidney will allow a visual check).

• Pull the unit forward to engage pins. The unit will be locked into a batter position. Visually check to see that the unit is parallel to the units below. After setting a length of Keystone® units, visually check the overall alignment. Make minor adjustments as necessary.

FIGURE 1.11



STEP 10: CONTINUE WITH STEPS 5-9 UNTIL ALL KEYSTONE UNITS ARE INSTALLED

STEP 11: POSITION AND SECURE CAP UNITS

Follow the same procedures described in **STEP 9** for proper placement and positioning of the Keystone® cap units. A variety of sizes and shapes, including 4" (100mm) and 8" (200mm) high units, have been designed to satisfy most installation needs. Availability of these units will vary from region to region. For cap unit descriptions and placement variations, see the section on, "WALL CAP: USING KEYSTONE UNITS" in this manual.

Cap units may be secured with a bonding material to prevent their removal. Final alignment at the top of the wall may also require this same procedure. If due to final alignment repositioned cap units do not properly meet pin connections, then remove the pins and secure these cap units with the bonding material. Due to the flexibility or non-rigid qualities of the Keystone® system, the bonding material must be able to tolerate some movement. **Keystone® KapSeal™** adhesive is designed for this use with a special formulation to withstand temperature and moisture extremes. If this material is unavailable, other flexible epoxy based adhesives designed to bond masonry to masonry may be used. Refer to manufacturer's instructions for complete details.

STEP 12: FINISHED GRADE AND LANDSCAPING

The Keystone® Retaining Wall is complete. Final grading, planting or other surface materials can now be put into place. 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 construction.

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INSTALLATION

INSTALLATION - STEP BY STEP

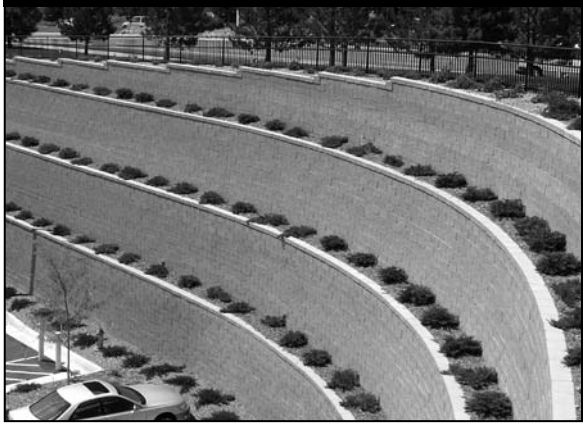
SPECIALIZED CONSTRUCTION TECHNIQUES

The following are a list of specific construction techniques that may be related to the construction of a Keystone® wall. See other sections in this manual for further details.

- Geogrid reinforcement
- Drainage issues
- Pipes and culverts through the wall face
- Guard rails
- Barriers
- Fences and poles
- Structures
- Curbs and copings
- Water applications
- Terraces
- Light fixtures and signage
- Mixing unit sizes.

IMAGE 08 - Guardrails

IMAGE 09 - Terraces



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INSTALLATION

GEOGRID - INSTALLATION

Many walls will require reinforcement (see "INSTALLATION STEP BY STEP" section to determine whether reinforcement is needed). Reinforced Keystone® retaining walls should be constructed in accordance with an engineered design. Contact your Keystone® representative to evaluate reinforcement needs and/or to locate engineering/design services and geogrid material suppliers.

The basic installation techniques for use of geogrid with a Keystone® retaining wall are outlined in the following steps. A variety of geogrid products are available. Consult the geogrid manufacturer for additional installation details, because there are variations among the commercially available geogrids.

IMAGE 09

IMAGE 10

1. Follow the instructions in the "INSTALLATION STEP BY STEP" section until you have reached the lowest wall elevation where a geogrid layer will be placed. This elevation, along with the elevation of any additional geogrid layers, will be specified in the engineering design for the wall. At this point, the Base Trench will have been excavated, the Base Leveling Pad will have been placed, the initial courses of Keystone® Units will have been installed and the core fill and drainage zone material and retained backfill will have been placed and compacted up to the first elevation where a geogrid layer is specified.

2. Measure and cut the geogrid material to the specified length. Refer to site specific engineering documents for length of geogrid layers and type of geogrid material. For information on proper placement of geogrid along curves or corners, consult the geogrid manufacturer's recommendations. Some wall designs may specify more than one type of geogrid or geogrid design strength and more than one length for the geogrid layers. It is critical to confirm this information before proceeding. If multiple types and/or lengths of geogrid will be used, pre-cutting and marking each geogrid piece (for example with colored spray paint) will make identification easier and reduce the chance of misplacement. In addition, verify the proper orientation of the geogrid to the wall face. Most geogrids have a design strength along one direction of the material. These are called uniaxial geogrids. The direction of design strength of a uniaxial geogrid can either be parallel or perpendicular to the direction of the roll of geogrid, though most frequently it is parallel to the roll direction. Some geogrids are biaxial; they have design strength in both directions. Check with the geogrid supplier to confirm which type of product is being used. Geogrid can either be field cut or pre-cut using a variety of tools. The type of geogrid being used will determine cutting procedures. For large installations, the geogrid is most efficiently cut off site in a controlled setting. In all cases, cut the geogrid in such a way so that the end of the layer that is nearest the front of the wall is trimmed close to the transverse bar. This will prevent unsightly pieces of geogrid from protruding out of the wall face.

3. Keystone® pins should be placed into all units. Hook the geogrid over the Keystone® pins (IMAGE 10). Lay the geogrid out flat. Follow the engineering design for geogrid placement. It will specify both the horizontal and vertical start/stop locations. In general, geogrid will be placed in pieces side by side in a continuous layer along the length of the wall unless a change in elevation is specified in the design. Check engineering documentation for details.

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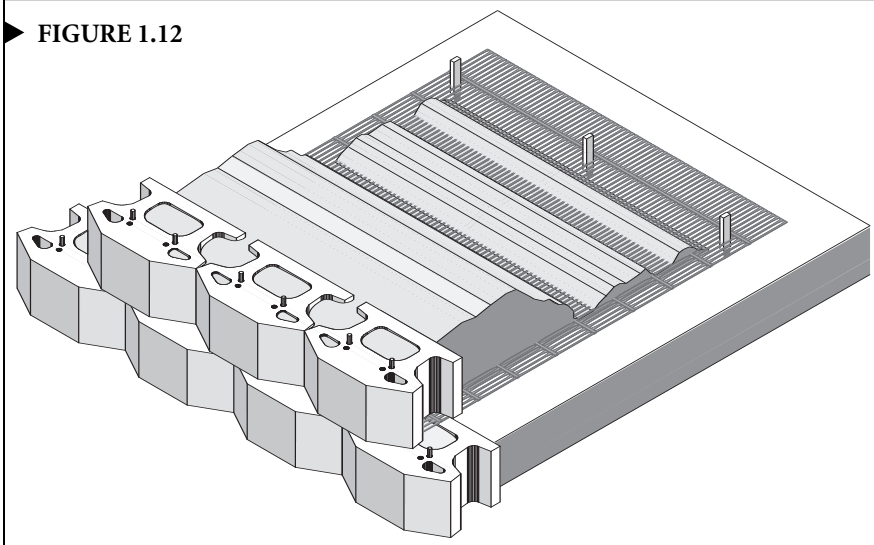
GEOGRID - INSTALLATION

4. Tension the geogrid by pulling it towards the embankment. Place a stake through the geogrid and into the ground. While using the stake as a lever and tensioning the geogrid, drive the stake into the ground to hold the position (IMAGE 11). Do not excessively tension geogrid. This may pull units out of their proper alignment. Install an additional course of Keystone® Units over the geogrid, and place pins in this course.

IMAGE 11

5. Proceed with placement of the unit fill/drainage zone crushed stone material and the backfill in the reinforced zone. Specifications for material used in the reinforced zone should be defined by the design engineer. Begin placement of this material near the Keystone® Units, moving progressively toward the cut embankment (Figure 1.12). This procedure will keep the geogrid under tension. After completing this backfill process, the tension stakes may be removed for reuse. Compact the backfill material to 95% Standard Proctor. Continue with construction according to the "Installation Step By Step" section until reaching the next wall elevation where a geogrid layer is to be placed. Repeat Steps 2-5.

FIGURE 1.12



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INSTALLATION

INSTALLATION Q & A

BASE TRENCH / LEVELING PAD

QUESTION:	*How wide does the Base Trench need to be?*
ANSWER:	A minimum 24" (610mm) wide for all units. NOTE: Additional excavation width may be required if geogrid or other mechanical reinforcement will be used.
QUESTION:	*What should be the depth of the Base Trench?*
ANSWER:	Depth of wall units below grade +Base Leveling Pad depth of the Base Trench (following above example) 12" + 6" = 18" (0.3m + 0.15m = 0.45m) depth of Base Trench below grade
QUESTION:	*What should be the depth of the Base Leveling Pad?*
ANSWER:	A depth of 6" (150mm) is standard. NOTE: Keystone® walls less than 3'-0" (1m) high, built on firm, inorganic original soils require no Base Leveling Pad. Level and compact soils in the Base Trench. Requirement for additional depth of leveling pad material must be determined by an engineer.
QUESTION:	*What should be the depth of the Base Trench for walls constructed on slopes?*
ANSWER:	Minimum distance from front of first course to daylight on the slope ÷ run of the slope = depth of units below grade + depth of Base Leveling Pad = depth of Base Trench below grade.
EXAMPLE:	5' (1.5m) ÷ 2 (run of slope) = 2.5' (0.75m)(depth of units below grade) + 6" (0.15m) = 3' (0.9m) depth of Base Trench below grade
QUESTION:	*What material should be used for the Base Leveling Pad?*
ANSWER:	Granular inorganic soil (i.e. Class #5, Burma, Road Base). Its maximum particle size is 3/4" (20mm). Its minimum particle size is no more than 10% of the volume passing a No. 200 sieve. Using larger material will make leveling more difficult.
QUESTION:	*Are concrete footings ever necessary or required?*
ANSWER:	Most Keystone® walls can be built directly on 4-6" (100-150mm) of well compacted granular base. However, there may be occasion to consider the use of a concrete leveling pad.
EXAMPLE:	Applications in or near water, a taller wall built on soft sub-soils, or a wall that is very long and by using a concrete footing, the contractor can speed up the installation process.
QUESTION:	*Can adjustments be made on a concrete leveling pad?*
ANSWER:	Minor inconsistencies on a concrete leveling pad will not usually create much of a problem. However, if there are noticeable differences in block height as the units are placed due to low spots in the leveling pad, a thin layer of sand or mortar may be used to help the leveling process. High point inconsistencies may require some grinding. Make all adjustments as gradual as possible. Before you begin laying the base course, be sure to check that the leveling pad is level front to back. Make corrections as needed, especially if the back of the footing is higher than the front. It is important to note, that taking the time to accurately level and finish off the concrete leveling pad will allow for minimal adjustment time and greatly speed up the installation process.

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INSTALLATION

INSTALLATION Q & A

BASE COURSE INSTALLATION

QUESTION:	*Can I use sand to help level the base units?*
ANSWER:	Yes. After the road base material has been leveled and compacted, a 1/2" (13mm) to 1" (25mm) of sand may be used to help speed up the leveling process.
QUESTION:	*How many Keystone® units should be placed below grade?*
ANSWER:	Wall Height (in feet) x 1.5 = depth of units (in inches) below grade.Wall Height (in meters) x .125 = depth of units (in meters)below grade. (1" (25mm) of wall buried below grade for each 8" (200mm) of wall above grade).
EXAMPLE:	8'H x 1.5 = 12" (2.4mH x 0.125 = 0.305m) of wall unit below grade. NOTE: The number of buried courses should not exceed three unless otherwise specified by engineering.
QUESTION:	*Should I always begin construction at one end of the wall or is it o.k. to start in the middle?*
ANSWER:	Construction of the wall should begin at your lowest point whenever possible. If the wall is going to tie into a building or structure, measure the distance from the corner of the Keystone unit to the edge of the building and make sure the distance is in an increment of 18" (455mm). (Full unit width.)

COREFILL / BACKFILL

QUESTION:	*What size rock is best suited for filling in and around the Keystone units in the drainage zone?*
ANSWER:	A clean, angular 3/4" (20mm) rock is best for corefill if available. Otherwise, use a clean rock material that is 1/2-1-1/2" (15-40mm) in diameter. Avoid aggregates that are round in nature. Angular material will provide the best interlocking strength. Also avoid material that contains a lot of fine grains in that these fines can flow with water through the wall and possibly stain the wall face.
QUESTION:	*How much rock do I need to use?*
ANSWER:	Adequately fill all open cores and 12" (305mm) behind the unit when using a Keystone Compac unit. The additional rock behind the unit provides better drainage and eliminates the need for compaction equipment directly behind the wall. For Keystone Standard units, core filling needs only to be placed in all open cores to the back of the tail. (See the section on Keystone Units in this Construction Manual)
QUESTION:	*How high can Keystone units be stacked before placing unit corefill and backfill?*
ANSWER:	Keystone recommends adding corefill and backfill after each consecutive course for the Compac units. This insures that all voids are properly filled with rock providing maximum interlocking strength. It also aids in keeping the wall straight and reduces the amount of waisted rock. Note: Because of the depth and size of open core areas on the Keystone Standard units, Keystone recommends that the Standard units can be stacked up to a maximum of 3 units before placing unit corefill and backfill.

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INSTALLATION

INSTALLATION Q & A

COREFILL / BACKFILL

QUESTION: *What type of material should be used to backfill?*

ANSWER: Granular materials such as rock and sand are best if available. These types of materials compact fairly easy and won't hold moisture that can increase the weight of the soil behind the wall. Keystone® walls can be effectively built with silty material and lean clays, but these types of soils require more compaction and care should be taken not to place these materials when they are wet. High clay soils that shrink and swell rapidly as well as organic soils should be avoided.

QUESTION: *How often do I need to compact the fill soils?*

ANSWER: Compacting backfill material in 8" to 12" (200mm-300mm) lifts allows you to effectively compact the entire area behind the wall without putting unnecessary pressure on the units. Thick lifts of soil require more compaction effort and create a greater force at the back of the wall which may cause potential alignment and rotation problems. Consult with a geotechnical engineer for further compaction criteria based on specific site soil.

EXAMPLE:

WALL SET BACK

QUESTION: *Which batter option should be used?*

ANSWER: A 4.4° or 8.8° batter may be used for any installation. Non-geogrid reinforced walls should use this batter for greatest stability. Straight walls are well suited for this batter option. A near vertical batter works well for tall geogrid reinforced walls with tight radius curves and corners. NOTE: See "CORNERS AND CURVES" section for the effect of batter on curved walls.

QUESTION: *Is there a way to figure how much setback there will be per course before construction of the wall begins?*

ANSWER: Yes. Level three units side by side and install the pins in the preferred set of pin holes. Set the next course of Keystone units on the three you just leveled and slide them forward toward the wall face so they are in full contact with he pins. Measure the distance the second course tails are overhanging the units below. This will give you your true setback per course.

TROUBLE SHOOTING

QUESTION: *How can I fix units that are out of level?*

ANSWER: If the units are leaning back towards the embankment, due to geogrid thickness or units being thicker in front than back, this is generally not a problem in that the batter is increased. However, if space is limited on top of the wall, this could be a problem because the wall is setting back faster than expected. To correct this problem, you may uniformly insert shims under the tails to bring the units back to level.The best material for this would be excess geogrid, pieces of asphalt shingles or other appropriate non-deteriorating materials. Avoid using wood or materials that will deteriorate over time. Care should be taken to make adjustment in small increments. If the units are rotating outward and higher toward the back of the unit, the problem should be addressed immediately. If the tails are higher than the fronts by more that 3/4" (20mm), disassembling and portion of the wall should be considered.The same guidelines and materials for shimming the back of units may be used for the fronts as well. For minor adjustment, tapping down the back of the units with a maul or dead blow hammer may also help.

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INSTALLATION

INSTALLATION Q & A

TROUBLE SHOOTING *(continued)*

QUESTION: *How can units that are out of alignment be fixed?*

ANSWER: To determine which units are out of alignment, run a stringline across the pin holes before the pins are placed. Adjust the misaligned units by sliding back and forth until the pin holes are in alignment with the stringline. If when looking down at the kidney shaped holes you see that these units are not in full contact with the pins below due to the adjustment, don't be alarmed. The gravel fill should adequately fill in around this area to secure the unit against the pin. If the unit type you are using has the dual pin option, either position may be used if it helps the alignment process.

GENERAL QUESTIONS

QUESTION: *How high can Keystone® walls be built without the use of geogrid?*

ANSWER: Keystone® walls can be constructed between 2' (.6m) and 6' (1.8m) high depending on the type of unit, soil conditions, amount of batter used, and surcharge on top of wall. The best way to determine if your wall will require the use of geogrid is to consult the Keystone® Gravity Wall and Soil Reinforced Wall charts in this Construction Manual.

QUESTION: *What advantages are there to using a pinned system?*

ANSWER: Unlike other retaining wall products, Keystone's pinned system offers the choice of near vertical or one inch setback options. It allows you to achieve tight corners and radii automatically without having to cut units while maintaining the running bond pattern. The Keystone® fiberglass pins also provide additional shear strength at the wall face and positive connection with geogrid which allows proper pre-tensioning and resistance to bulging during construction.

QUESTION: *How often should the wall's alignment be checked?*

ANSWER: Wall alignment should be checked at least every third course by visually looking down the wall or using a string line along the pin holes or tail positions. The wall should also be checked every 15-20' (4.6m-6.1m) to make sure the units are level from front to back. If the bubble on the level is high to the back, this means the wall is building to negative batter (leaning forward) and needs corrective measures.

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