

KEYSTONE CONSTRUCTION M A N U A L



KEYSTONE[®]
RETAINING WALL SYSTEMS
A CONTECH COMPANY

Retaining Excellence[™]

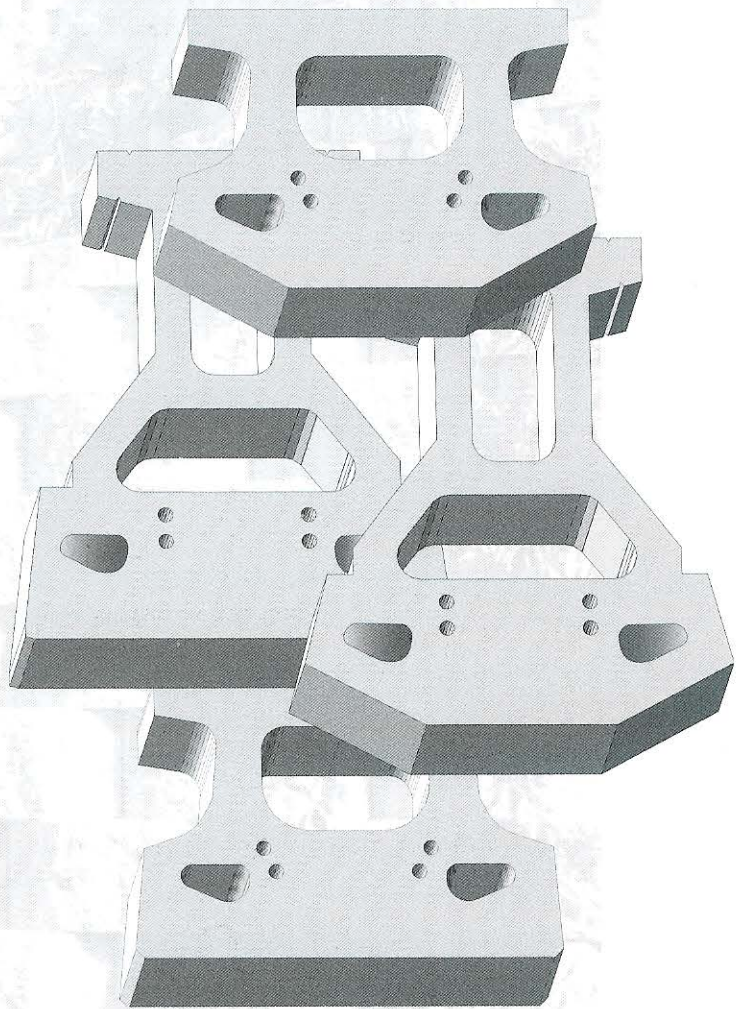
I N D E X

- ▶ A. KEYSTONE UNITS
 - Standard Units
 - Compac Units
- ▶ B. SPECIFICATIONS
- ▶ C. INSTALLATION
 - Installation Step By Step
 - Geogrid Installation
 - Installation Q & A
- ▶ D. CORNERS AND CURVES
 - 90° Inside Corner - Using 1" setback
 - 90° Inside Corner - Using near vertical setback
 - 90° Outside Corner - Using 1" setback
 - 90° Outside Corner - Using near vertical setback
 - Convex Curves
 - Concave Curves
 - Corners and Curves Q & A
- ▶ E. STEPS AND STAIRS
 - Steps and Stairs Installation
 - Option 1 - Steps In Walls
 - Option 2 - Steps In Front Of Walls
 - Option 3 - Steps In Wall; 10" (25cm) Tread
 - Option 4 - Step Parallel To Wall
 - Steps and Stairs Q & A
- ▶ F. CAPPING AND COPING
 - Wall Cap Using Keystone Units
 - Wall Termination Detail
 - Coping Option For Keystone Wall
- ▶ G. BARRIERS
 - Traffic Barrier
 - Guard Rails
 - Fences With Metal Posts
 - Fences Using the Sleeve-It™ System
 - Barrier/Fence Rail Option
 - Parapet Options
- ▶ H. WATER AND DRAINAGE ISSUES
 - Drainage Around Walls
 - Water Applications
 - Drainage Structures
 - Water and Drainage Q & A
- ▶ I. MISCELLANEOUS DETAILS
 - Lighting Options
 - Creative Options
 - Wall Repair
 - Tree Planting Detail
 - Terrace Applications
 - Miscellaneous Q & A
- ▶ J. DESIGN CHARTS

KEYSTONE UNITS

Standard Unit ◀

Compac Unit ◀



A

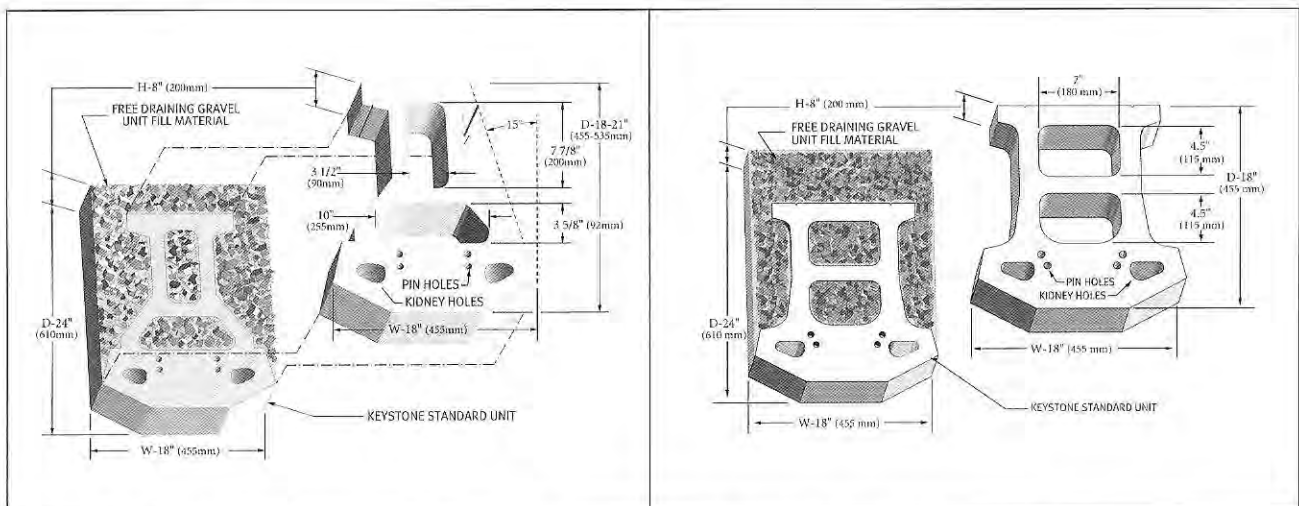
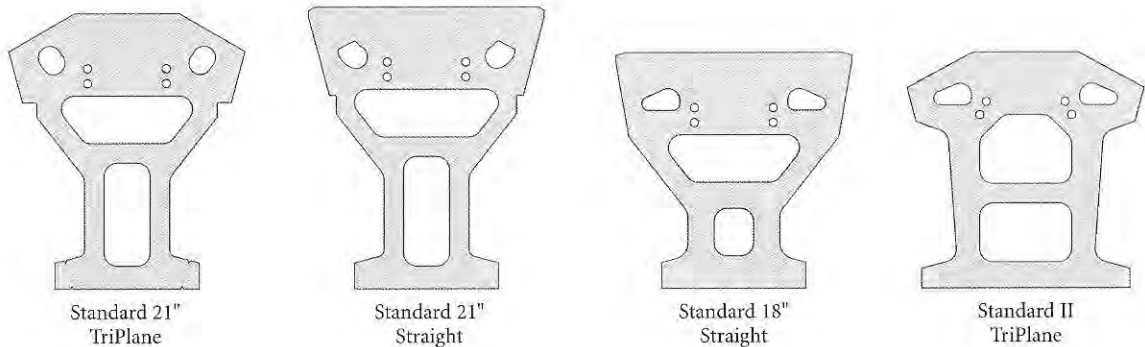
KEYSTONE UNITS

STANDARD UNITS

Keystone retaining wall units have evolved from the original Standard unit created in 1985 to a wide range of structural and landscaping products to accommodate most architectural, structural, and constructibility requirements. Keystone producers have a wide selection of Keystone products to choose from and generally manufacture those product lines that sell best in their local marketplace and can be produced efficiently with their production equipment. However, this has resulted in not all products, colors, and finishes being available in every market and minor fabrication differences occurring in products fabricated at different plant locations.

The Construction Manual addresses Keystone structural products which can be divided into two basic groups: Standard sized units, depth $\geq 18"$ (455mm) and Compac size units, depth = 12" (305mm). The Standard units can provide more design options and stability due to the larger unit size as described in the Manual, while the smaller Compac size units have some performance restrictions but are generally available at a lesser unit cost.

	Standard 21"	Standard 18"	Standard II
Unit Height	8" (200mm)	8" (200mm)	8" (200mm)
Unit Width	18" (455mm)	18" (455mm)	18" (455mm)
Unit Depth	21.5" (545mm)	18" (455mm)	18" (455mm)
Face Area per Unit	1SF (.093m ²)	1SF (.093m ²)	1SF (.093m ²)
Unit Weight	95-125lbs(43-56kg)	90-115lbs (41-53kg)	90-115lbs (41-53kg)
Volume of Voids to Tail	0.90 ft ³ /ft ² (0.27m ³ /m ²)	0.70 ft ³ /ft ² (0.21m ³ /m ²)	0.70 ft ³ /ft ² (0.21m ³ /m ²)
Volume of Voids to 24" depth	1.16 ft ³ /ft ² (0.36m ³ /m ²)	1.20 ft ³ /ft ² (0.37m ³ /m ²)	1.20 ft ³ /ft ² (0.37m ³ /m ²)



NOTE: Unit weights, dimensions and availability vary by manufacturer. Please contact your local representative.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

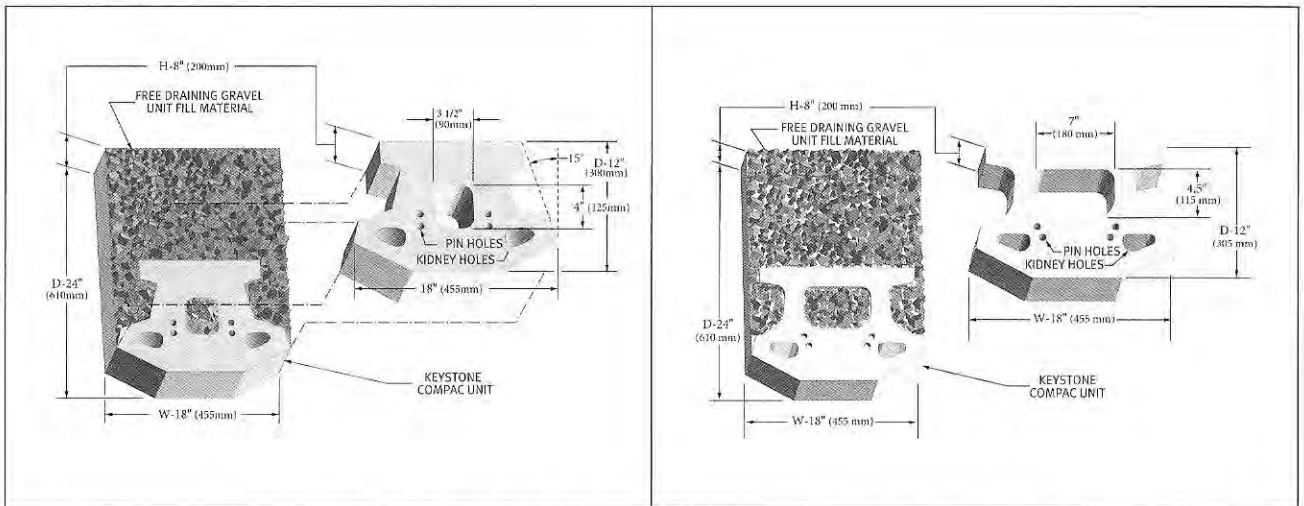
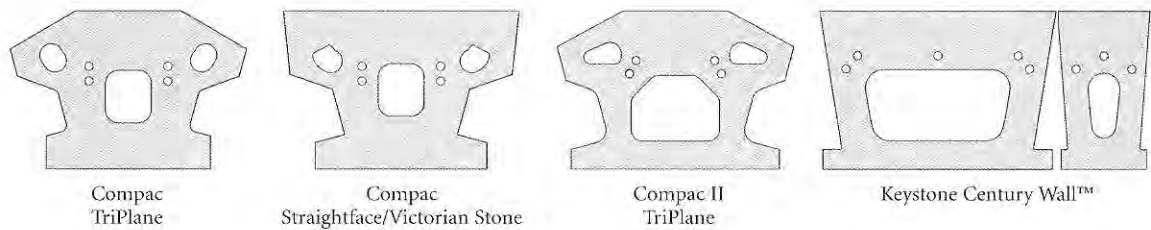
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

KEYSTONE UNITS

► **COMPAC UNITS**

	Compac	Compac II	KS Century Wall
Unit Height	8" (200mm)	8" (200mm)	8" (200mm)
Unit Width	18" (455mm)	18" (455mm)	7"-18" (175-455mm)
Unit Depth	12" (300mm)	12" (300mm)	12" (300mm)
Face Area per Unit	1SF (.093m ²)	1SF (.093m ²)	0.39 - 1SF
Unit Weight	85lbs (39kg)	79lbs (36kg)	37-90lbs (17-41kg)
Volume of Voids to Tail	0.30 ft ³ /ft ² (0.09m ³ /m ²)	0.35 ft ³ /ft ² (0.11m ³ /m ²)	0.40 ft ³ /ft ² (0.12m ³ /m ²)
Volume of Voids to 24" depth	1.30 ft ³ /ft ² (0.40m ³ /m ²)	1.35 ft ³ /ft ² (0.41m ³ /m ²)	1.40 ft ³ /ft ² (0.43m ³ /m ²)

KS = Keystone



NOTE: Unit weights, dimensions and availability vary by manufacturer. Please contact your local representative.



S P E C I F I C A T I O N S

B

S P E C I F I C A T I O N S

SPECIFICATION GUIDELINES ◀

SECTION 02834
MODULAR CONCRETE RETAINING WALLS

PART ONE: GENERAL

1.1 SECTION INCLUDES

- A. Work includes furnishing and installing concrete modular block retaining wall units with fiberglass shear/alignment pins to the lines and grades shown on the construction drawings, within a reasonable field tolerance, and as specified herein.
- B. Work includes preparing foundation soil, furnishing and installing leveling pad, unit fill and backfill to the lines and grades shown on the construction drawings.
- C. Work includes furnishing and installing geogrid reinforcement and backfill to the lines and grades designated on the construction drawings.

1.2 RELATED SECTIONS

- A. Section 02300 - Earthwork.
- B. Section 03300 - Cast-In-Place Concrete.

1.3 REFERENCES

- A. ASTM C 1372 - Standard Specification for Segmental Retaining Wall Units; 2004.
- B. ASTM D 422 - Standard Test Method for Particle-Size Analysis of Soils; 1963 (Reapproved 2002).
- C. ASTM D 698 - Standard Method of Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft³ 600kN-m/m³); 2000.
- D. ASTM D 3034 - Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings; 2004.
- E. ASTM D 4318 - Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils; 2000.
- F. ASTM D 4595 - Standard Test Method for Tensile Properties of Geotextiles by the Wide Strip Method; 2001
- G. ASTM D 5262 - Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics; 2004.
- H. ASTM F 405 - Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings; 1997.
- I. GRI-GG4 - Determination of Long Term Design Strengths of Geogrids; Geosynthetic Research Institute.
- J. GRI-GG5 - Determination of Geogrid (Soil) Pullout; Geosynthetic Research Institute.
- K. NCMA SRWU-1 - Test Method for Determining Connection Strength of SRW; National Concrete Masonry Association.
- L. ASTM D4475-02 - Standard Test Method for Horizontal Shear (Short-Beam Method) of Pultruded Reinforced Plastic Rods.
- M. ASTM D4476-03 - Standard Test Method for Flexural Properties of Fiber Reinforced Pultruded Plastic Rods.
- N. ASTM D3916-02 - Standard Test Method for Tensile Properties of Pultruded Glass-Fiber-Reinforced Plastic Rods.
- O. ASTM D570-98 - Standard Test Method for Water Absorption of Plastics.
- P. ASTM D3917-02 - Standard Specification for Dimensional Tolerance of Thermosetting Glass-Reinforced Plastic Pultruded Shapes.

1.4 DEFINITIONS

- A. Modular Unit: A concrete retaining wall element machine made from Portland cement, water, and aggregates.
- B. Unit Fill: A drainage aggregate which is placed within and immediately behind the modular concrete units.
- C. Reinforced Backfill: A compacted soil which is placed within the reinforced soil volume as outlined on the plans.
- D. Structural Geogrid: A structural element formed by a regular network of integrally connected tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, or earth and to function primarily as reinforcement.
- E. Shear/Alignment Pin: A pultruded high strength isophthalic polyester resin glass reinforced pin which fits in manufactured holes in the concrete units and interconnects units and courses.

1.5 SUBMITTALS

- A. Submit under provisions of Section 01300.
- B. Shop Drawings: Dimensioned plans, sections, and design calculations prepared and stamped by a professional engineer registered in the state of the project location; provide engineering designs, techniques, and material evaluations performed in accordance with the KEYSTONE Design Manual, NCMA Design Guidelines For Segmental Retaining Walls, or the AASHTO Standard Specifications for Highway Bridges, Section 5.8, 1993 Interim, whichever is applicable.
- C. Product Data: Submit manufacturer's product data for proposed materials and method of installation.
- D. Samples: Submit samples of each product used in the work of this section.
- E. Certifications: Submit a manufacturer's certification, prior to start of work, that the retaining wall system components meet the requirements of this specification and that the retaining wall system (modular concrete units and specific geogrid):
 1. Has been successfully utilized on a minimum of five (5) similar projects, i.e., height, soil fill types, erection tolerances, etc.; and
 2. Has been successfully installed on a minimum of 1 million (1,000,000) square feet (92,000 sq m) of retaining walls.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S P E C I F I C A T I O N S

► SPECIFICATIONS GUIDELINES

- F. Test Reports: Submit test reports documenting strength of specific modular concrete unit and geogrid reinforcement connection. The maximum design tensile load of the geogrid shall be equal to the laboratory tested ultimate strength of geogrid/concrete retaining wall unit connection at a maximum normal force limited by the "Hinge Height" of the structure divided by a safety factor of 1.5. The connection strength evaluation shall be performed in accordance with NCMA SRWU-1.

1.6 QUALITY ASSURANCE

- A. Design Engineer Qualifications: Minimum of five years documentable experience in the design of reinforced soil structures and able to provide proof of current professional liability insurance with an aggregate coverage limit of not less than \$2,000,000.
B. Installer Qualifications: Able to provide a list of 5 previously constructed successful projects of similar size and magnitude using the retaining wall system specified, with contact names and telephone numbers.

1.7 DELIVERY, STORAGE AND HANDLING

- A. Check materials upon delivery to assure that proper materials have been received.
B. Prevent excessive mud, wet cement, epoxy, and similar materials (which may affix themselves) from coming in contact with the materials.
C. Protect materials from damage; do not use damaged materials.

PART 2: PRODUCTS

2.1 MANUFACTURER

- A. Provide modular concrete retaining wall units and accessory materials fabricated by authorized licensed manufacturers of Keystone Retaining Wall Systems, Inc., 4444 West 78th Street, Minneapolis, MN 55435. Tel: (952) 897-1040. Fax: (952) 897-3858.
1. Substitutions will not be acceptable.

2.2 MATERIALS

- A. Modular Concrete Retaining Wall Units: Comply with ASTM C 1372 and the following:
1. Color: Manufacturer's standard color palette.
 2. Face Finish: Sculptured rock face in angular tri-planar configuration for Standard and Compac units. Weathered straight face for Keystone Century Wall and Country Manor units. Other face finishes not be allowed without written approval.
 3. Bond Configuration: Running, with bonds nominally located at midpoint vertically adjacent units, in both straight and curved alignments.
 4. Exposed surfaces free of chips, cracks or other imperfections when viewed from a distance of 10 feet (3050mm) under diffused lighting.
 5. Compressive strength: 3000 pounds per square inch (20MPa) minimum.
 6. Alignment and Grid Positioning Mechanism: Fiberglass pins, typically two per unit unless using small units that have provision for only one.
 7. Design to provide installed vertical setback of 1/8 inch (3 mm) plus/minus per course (near vertical) or 1.25 inches (31.75 mm) plus per course per the design drawings.

**** NOTE TO SPECIFIER ** Delete one of the following two paragraphs. 6 percent absorption should be specified in northern states.**

9. Absorption: 8 percent maximum for standard weight aggregates.

10. Absorption: 6 percent maximum for standard weight aggregates.

**** NOTE TO SPECIFIER ** Select appropriate unit type and delete others.**

11. Keystone Standard Units:

- a. Width: 18 inches (457 mm), plus/minus 1/8 inch (3 mm).
- b. Depth: 18 – 24 inches (508 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
- c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
- d. Weight: 100 pounds (45 kg) per unit minimum using standard weight aggregates.
- e. Inter-Unit Shear Strength: 1500 pounds per linear foot (21,000 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
- f. Geogrid/Unit Peak Connection Strength: 1000 pounds per linear foot (14600 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.

12. Keystone Compac Units:

- a. Width: 18 inches (457 mm), plus/minus 1/8 inch (3 mm).
- b. Depth: 12 inches (305 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
- c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
- d. Weight: 75 pounds (34 kg) per unit minimum using standard weight aggregates.
- e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
- f. Geogrid/Unit Peak Connection Strength: 500 pounds per linear foot (7250 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.



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

SPECIFICATION GUIDELINES

13. Keystone Century Wall Units:
 - a. Width: Varies – 7 to 18 inches (178-457 mm), plus/minus 1/8 inch (3 mm).
 - b. Depth: 12 inches (305 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
 - c. Height: 8 inches (203 mm), plus/minus 1/16 inch measured to top and bottom planes.
 - d. Weight: 35 - 90 pounds (16 - 40 kg) per unit minimum using standard weight aggregates.
 - e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
 - f. Geogrid/Unit Peak Connection Strength: 500 pounds per linear foot (7250 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
14. Keystone Country Manor Units:
 - a. Width: 4 - 16 inches (102 - 406 mm), plus/minus 1/8 inch (3 mm).
 - b. Depth: 10 inches (254 mm) minimum, plus/minus 1/8 inch (3 mm), not including rough split face.
 - c. Height: 6 inches (152 mm), plus/minus 1/16 inch measured to top and bottom planes.
 - d. Weight: 25 - 60 pounds (11 - 27 kg) per unit minimum using standard weight aggregates.
 - e. Inter-Unit Shear Strength: 600 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
 - f. Geogrid/Unit Peak Connection Strength: 300 pounds per linear foot (4300 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
15. Accessory Units: Provide matching units.
 - a. Corners: Provide 90 degree corners, finished two sides, where indicated.
 - b. Cap units: Provide solid cap units with parallel sides for straight walls and convex walls, angular sides for concave walls. Caps may be solid or have 1/2 depth voids for connection to alignment/shear pins from course below.
- B. Shear Connectors:
 1. Non-Shouldered Pins: 1/2 inch (13 mm) diameter x 5.25 inches (133 mm) long thermoset isophthalic polyester resin-pultruded fiberglass reinforcement rods.
 2. Shouldered Pins: Similar to pin noted above, except this pin has a 3/4" diameter cap/shoulder for specific unit connection.
 - a. Flexural Strength: 128,000 pounds per square inch (882 MPa), minimum.
 - b. Short Beam Shear: 6,400 pounds per square inch (44 MPa), minimum.
 - c. Provide products that are capable of maintaining strength over design temperature range of minus 10 degrees F (minus 23 degrees C) to plus 100 degrees F (plus 38 degrees C).
 - d. Provide products that are capable of holding the geogrid in the proper design position during grid pre-tensioning and backfilling.
 - e. All pins to be supplied by "Approved Vendors" with verification notice issued by Keystone Retaining Wall Systems, Inc.
- C. Construction Adhesive: Keystone KapSeal as supplied by manufacturer of modular concrete units.
- D. Base Leveling Pad Material: Compacted crushed stone base or non-reinforced concrete as shown on the drawings.
- E. Unit Drainage Fill: Clean 1-inch minus crushed stone or crushed gravel meeting the gradation listed below.
 1. 1 inch (25 mm) sieve, 100 percent passing.
 2. 3/4 inch (19 mm) sieve, 75-100 percent passing.
 3. No. 4 (4.75 mm) sieve, 0 - 10 percent passing.
 4. No. 50 (300 micro-m) sieve, 0 - 5 percent passing.
- F. Pea rock rounded stone is not acceptable.
- G. Reinforced Backfill: Free of debris and meet the following gradation requirements:
 1. 2 inch (50 mm) sieve, 100-75 percent passing.
 2. 3/4 inch (19 mm) sieve, 100-75 percent passing.
 3. No. 4 (4.75 mm) sieve, 100-20 percent passing.
 4. No. 40 (425 micro-m) sieve, 0-60 percent passing.
 5. No. 200 (75 micro-m) sieve, 0-35 percent passing.
 6. Plasticity Index (PI) less than 10 and liquid limit less than 40.
 7. Maximum Aggregate Size: 3/4 inch (19 mm), unless field tests have been or will be performed to evaluate potential strength reductions to the geogrid design due to damage during construction.
 8. Material may be site excavated soils where the above requirements can be met.
 9. Do not use unsuitable soils (high plastic clays or organic soils) for backfill or in the reinforced soil mass.
 10. Shall submit reinforced fill sample and laboratory test results to the Architect/Engineer for approval prior to the use of any proposed reinforced fill material.
- H. Geogrid: Geotextile fabric of high tenacity polyester yarn or high density polyethylene specifically fabricated for use as soil reinforcement.
 1. Polyester: Knitted from high tenacity polyester filament yarn with a molecular weight exceeding 25,000 Meg/m and a carboxyl end group values less than 30; coated with an impregnated PVC coating that resists peeling, cracking, and stripping.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

► SPECIFICATIONS GUIDELINES

2. T_a , Long Term Allowable Tensile Design Load, shall be determined as follows:
 - a. $T_a = T_{ult}/(RF_{cr} \times RF_d \times RF_{id} \times FS)$
 - b. T_a shall be evaluated based on a 75 year design life.
 3. RF_{cr} , Reduction Factor for Creep Limited Tensile Load: Determined from 10,000 hour creep testing performed in accordance with ASTM D 5262; 1.60 minimum.
 4. RF_d , Reduction Factor for Durability/Aging: Determined from polymer specific durability testing covering the range of expected soil environments; 1.10 minimum.
 5. RF_{id} , Reduction Factor for Installation Damage: Determined from product specific construction damage testing performed in accordance with GRI-GG4; 1.05 minimum. Test results shall be provided for each product to be used with project specific or more severe soil type.
 6. FS , Overall Factor of Safety: 1.5 unless otherwise noted.
 7. Maximum Design Tensile Load: Not more than the laboratory tested ultimate strength of the geogrid/facing unit connection as limited by the "Hinge Height" divided by a factor of safety of 1.5, using connection strength testing and computation procedures in accordance with NCMA SRWU-1.
 8. Soil Interaction Coefficient, C_i : Determined in accordance with GRI-GG5 at maximum 0.75 inch (19 mm) displacement.
 9. Manufacturing Quality Control: Test each 40,000 square feet (3700 sq m) of production, each lot, or each production day; include tensile strength testing, melt flow index (HDPE), and molecular weight (polyester).
- ** NOTE TO SPECIFIER ** Delete the following if not required.**
- I. Drainage Pipe: Perforated or slotted PVC pipe complying with ASTM D 3034 or corrugated high density polyethylene pipe complying with ASTM F 405.

PART THREE: EXECUTION

3.1 EXAMINATION

- A. Verify that layout dimensions are correct and substrate is in proper condition for installation. Do not proceed with installation until unsatisfactory conditions have been corrected.

3.2 EXCAVATION

- A. Excavate to the lines and grades shown on the construction drawings. Obtain the Architect/Engineer's approval of excavation prior to placement of leveling material or fill soils. Proof roll foundation area as directed to determine if remedial work is required.
- B. Over-excavation of deleterious soils and replacement with suitable fill, when approved in advance by the Architect/Engineer, will be paid at unit cost rates.
- C. Be careful not to disturb embankment and foundation materials beyond lines shown.

3.3. BASE LEVELING PAD

- A. Place leveling pad material to the lines and grades shown on the construction drawings. Extend leveling pad minimum of 6 inches (150 mm) in beyond front and back faces of units and minimum of 6 inches (150 mm) thick.
- B. Compact granular leveling pad material to a minimum of 95 percent Standard or 90 percent Modified Proctor.
- C. Prepare leveling pad to ensure full contact to the base surface of the concrete units.

3.4 MODULAR UNIT INSTALLATION

- A. Place first course of units on leveling pad and check alignment and level. Use pins or molded surfaces of modular concrete units for alignment control; do not attempt alignment from rockface split surface, due to its irregular split finish.
- B. Ensure that all units are in full contact with base and properly seated.
- C. Place fronts of units side-by-side. Do not leave gaps between units. Lay out corners and curves in accordance with manufacturer's recommendations.
- D. Install shear connectors. Verify specified setback position as indicated on drawings.
- E. Place and compact drainage fill within and behind units. Place minimum of 1 cubic foot (0.03 cu m) per unit of drainage fill within the cores of the units, between units, and behind units.
- F. Place and compact backfill soil behind drainage fill.
- G. Follow wall and drainage fill installation closely with backfill. Maximum stacked vertical height of wall units prior to drainage fill and backfill placement and compaction not to exceed 2 courses.

3.5 STRUCTURAL GEOGRID INSTALLATION

- A. Orient geogrid with the highest strength axis perpendicular to the wall alignment.
- B. Place geogrid reinforcement at the elevations and to the extent shown on the construction drawings or as directed by the Engineer.
- C. Lay geogrid horizontally on compacted backfill and attached to the wall units. Place the next course of modular concrete units over geogrid. Pull geogrid taut and anchor prior to backfill placement on the geogrid.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S P E C I F I C A T I O N S**SPECIFICATIONS** ◀

D. Install geogrid reinforcements continuous throughout embedment lengths and side-by-side for 100 percent coverage at each level. Do not splice shorter pieces of geogrid or leave gaps between ends of pieces.

3.6 REINFORCED BACKFILL PLACEMENT

- A. Place, spread, and compact backfill in such a manner that minimizes the development of slack in the geogrid and other damage.
- B. Place and compact reinforced backfill in lifts not to exceed 6 inches (150 mm) where hand compaction is used, or 8 to 10 inches (200 to 250 mm) where heavy compaction equipment is used. Decrease lift thickness where necessary to achieve required density.
- C. Compact reinforced backfill to 95 percent of the maximum density as determined by ASTM D 698. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer and shall be within +0/-3 percentage points dry of optimum.
- D. Allow only lightweight hand-operated equipment within 3 feet (900 mm) from the tail of the modular concrete unit.
- E. Do not operate tracked construction equipment directly upon the geogrid reinforcement. A minimum fill thickness of 6 inches (152 mm) is required prior to operation of tracked vehicles over the geogrid. Tracked vehicle turning should be kept to a minimum to prevent tracks from displacing the fill and damaging the geogrid.
- F. Rubber tired equipment may pass over geogrid reinforcement at slow speeds, less than 10 miles per hour (16 kph). Sudden braking and sharp turning shall be avoided.
- G. At the end of each day's operation, slope the last lift of reinforced backfill away from the wall units to direct runoff away from wall face. Do not allow surface runoff from adjacent areas to enter the wall construction site.

3.7 CAP INSTALLATION

- A. Glue cap units to underlying units with an all-weather adhesive recommended by the manufacturer.

3.8 FIELD TOLERANCES

- A. Vertical Alignment: Plus/minus 1.5 inches over any 10 foot (37.5 mm in 3 m) distance.
- B. Wall Batter: Within 2 degrees of design batter.
- C. Horizontal Alignment: Plus/minus 1.5 inches over any 10 foot (37.5 mm in 3 m) distance; corners, bends, and curves plus/minus 1 ft (305 mm) to theoretical location.
- D. Maximum Horizontal Gap Between Erected Units: 1/2 inch (12 mm).

3.9 FIELD QUALITY CONTROL

**** NOTE TO SPECIFIER **** Delete this article entirely if the Owner will not be providing field testing or inspection. Testing and inspections services should only be performed by qualified and experienced technicians and engineers. As a minimum, quality assurance testing should include foundation soil inspection, soil and backfill testing, verification of design parameters, and observation of construction for general compliance with design drawings and specifications.

- A. The Owner will engage inspection and testing services, including independent laboratories, to provide quality assurance and testing services during construction. This does not relieve the Contractor from securing the necessary construction control testing during construction.

END OF SECTION



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

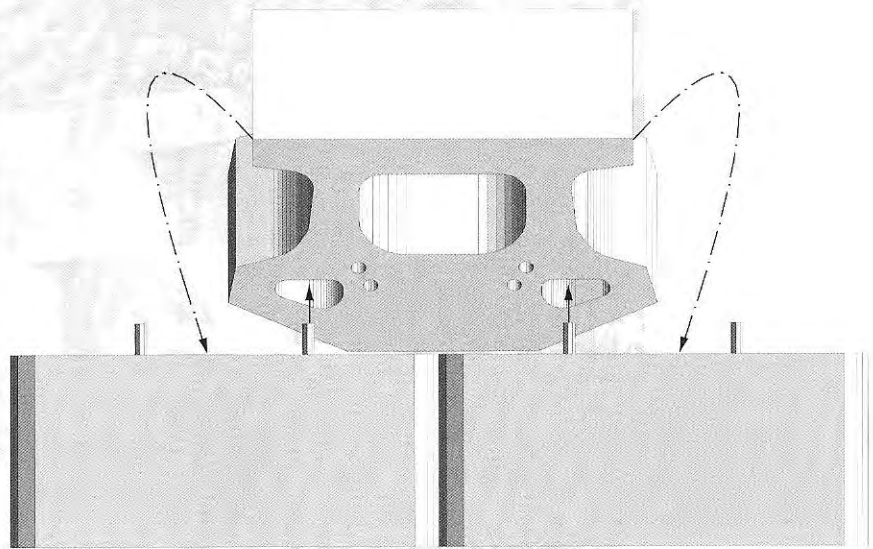
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

INSTALLATION

Installation Step By Step ◀

Geogrid Installation ▶

Installation Q & A ▶



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

INSTALLATION - STEP BY STEP

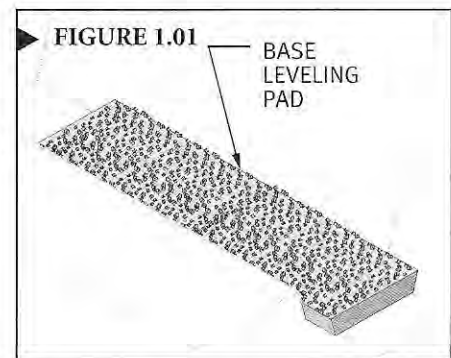
With proper design methods, Keystone® Retaining Walls can be built to retain a variety of site conditions. Before construction begins, review standard design guidelines and engineering requirements. Will the retaining wall be a “non-critical” structure falling within basic design and construction methods 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.

▶ 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.



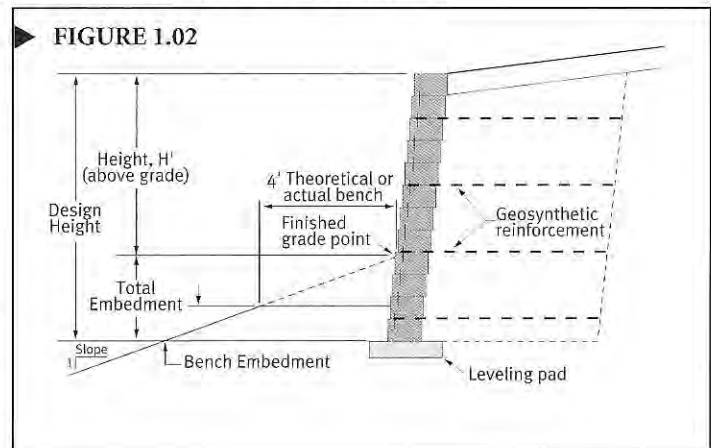
▶ STEP 2: EXCAVATE BASE TRENCH

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.



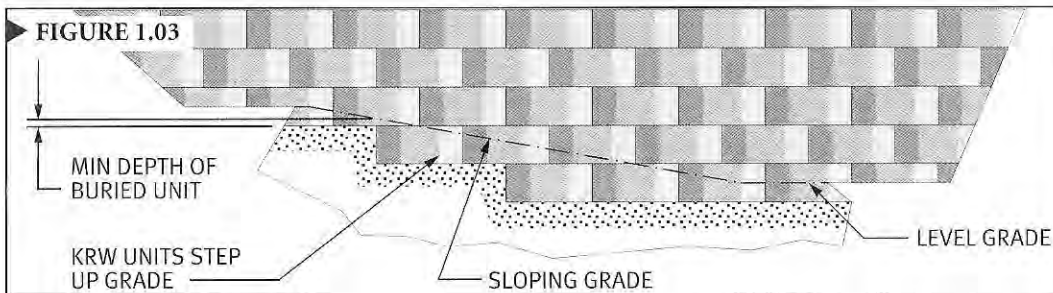
© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

► 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.



► STEP 3: PLACE AND COMPACT BASE LEVELING PAD

Begin first by selecting the proper Base Leveling Pad material.

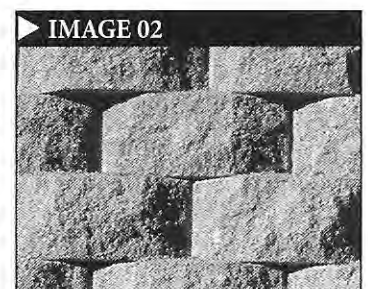
Place selected Base Leveling Pad material and compact with appropriate equipment to achieve proper density. Compact granular materials to 95% Standard Proctor or 90% Modified Proctor (soil testing standards to determine % of maximum soil density). Crushed stone should be compacted to yield (Proctor testing 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

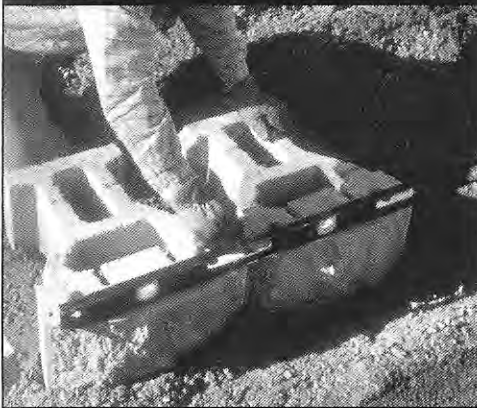
Begin at lowest wall elevation. Place all units parallel to the alignment line. The machined edges of adjoining units should contact each other (IMAGE 02). This procedure applies to straight walls (See section on "CURVES" for related information). If slag material protrudes past the corner, chip back 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.



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

INSTALLATION - STEP BY STEP

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).

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.

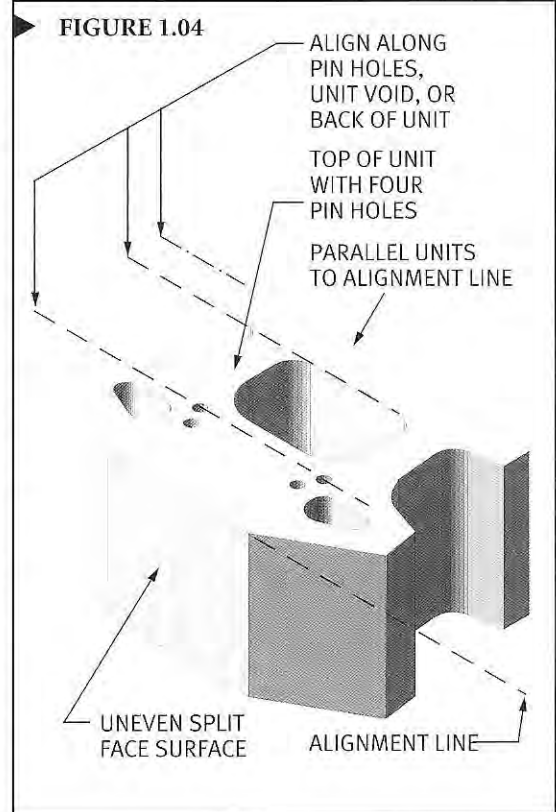
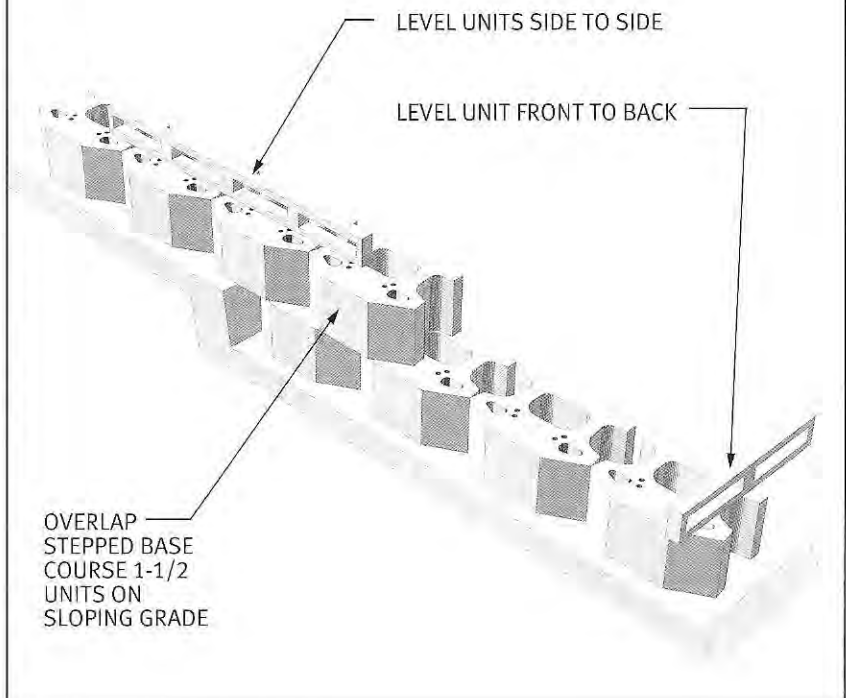


FIGURE 1.05



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

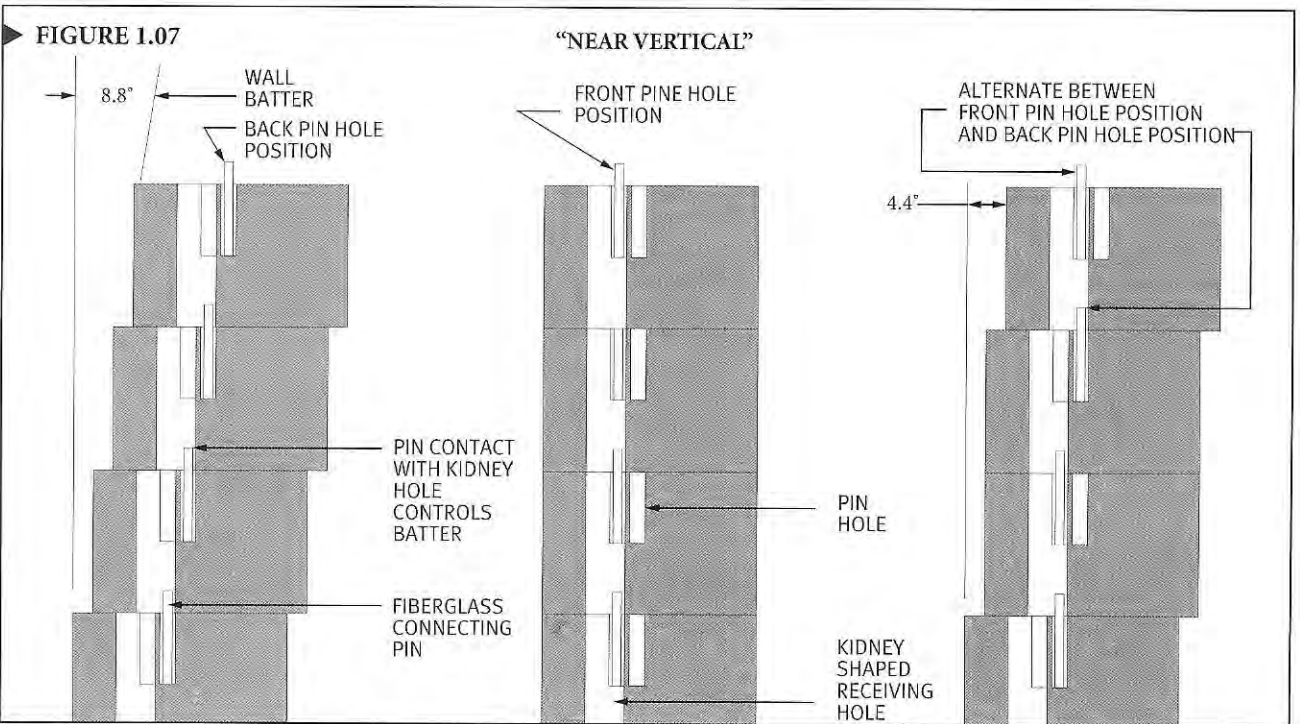
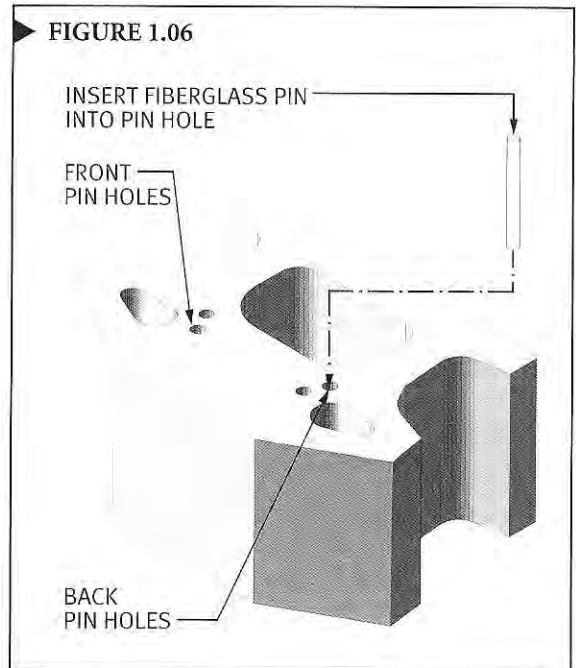
I N S T A L L A T I O N

► **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.



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

INSTALLATION - STEP BY STEP

► **STEP 6: PLACE UNIT/DRAINAGE MATERIAL (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.

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

► **IMAGE 05**



► **IMAGE 06**



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

► INSTALLATION - STEP BY STEP

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.



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).

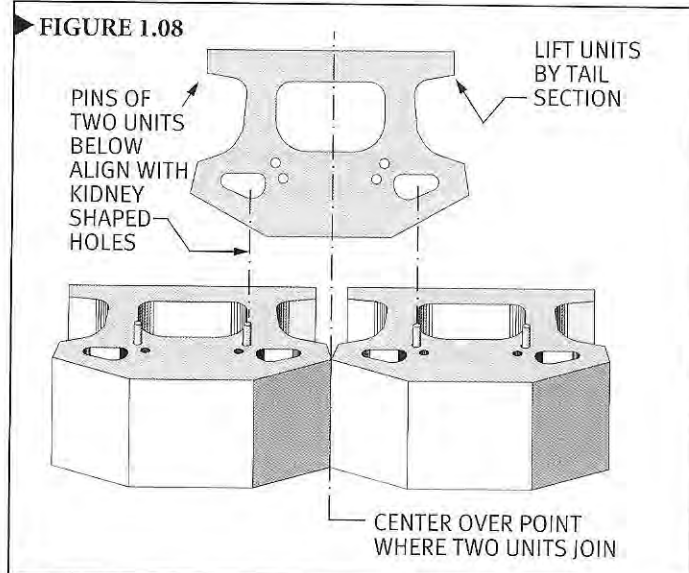
► **STEP 8 : SWEEP TOP OF UNITS CLEAN**

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)

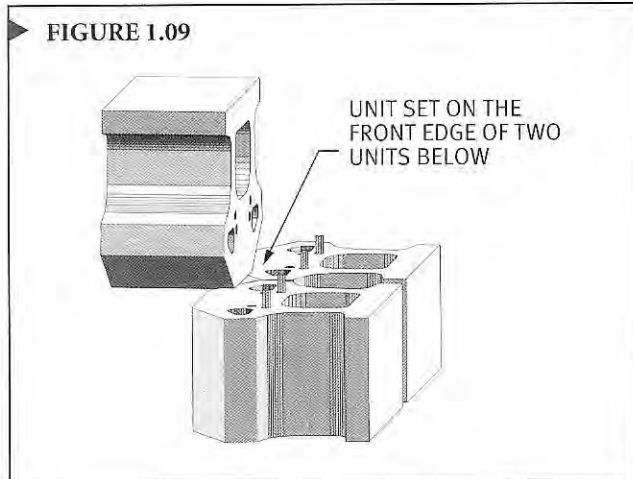
Place additional courses of Keystone® units. Each unit will be placed over two units below creating a running bond face pattern. Easiest placement of the Keystone® units is accomplished in the following steps:

- 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.



INSTALLATION

INSTALLATION - STEP BY STEP



- 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.

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

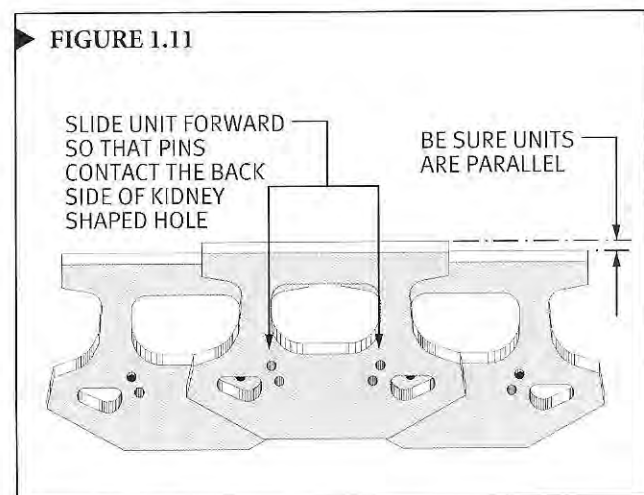
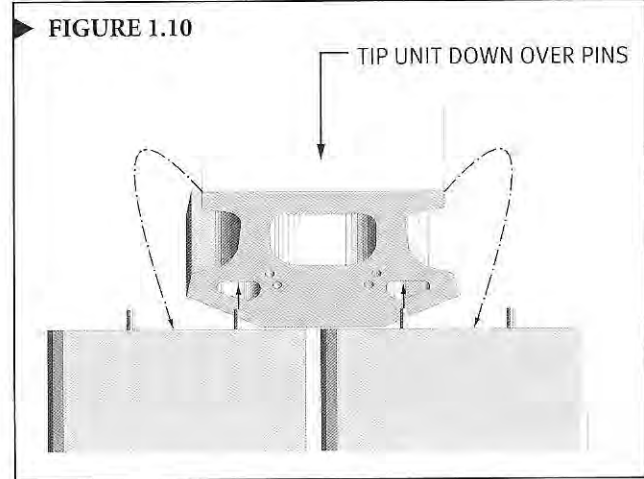
► **STEP 11: POSITION AND SECURE CAP UNITS**

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.



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

► 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



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

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.

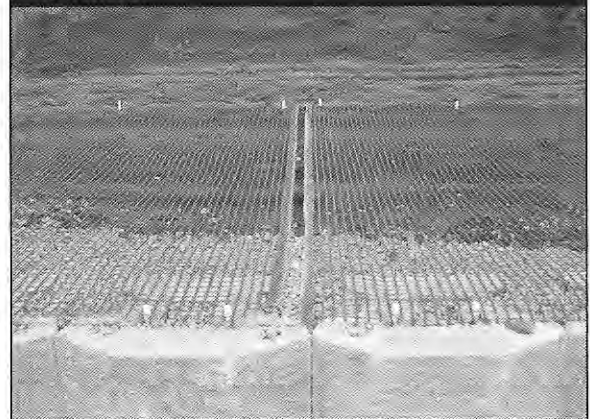
The basic installation techniques for use of geogrid with a Keystone® retaining wall are outlined in the following steps. A variety of geogrid products are available. Consult the geogrid manufacturer for additional installation details, because there are variations among the commercially available geogrids.

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.

▶ IMAGE 09



▶ IMAGE 10



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

► GEOGRID - INSTALLATION

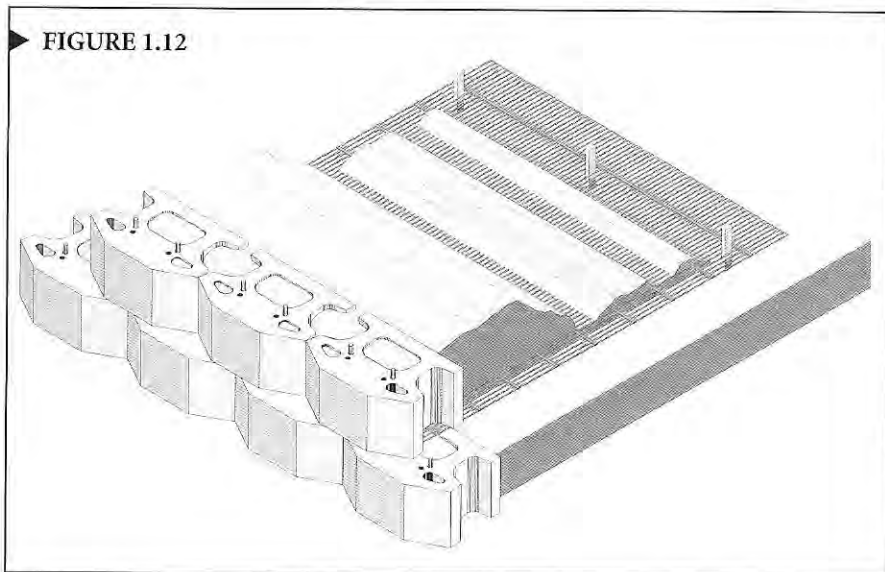
4. Tension the geogrid by pulling it towards the embankment. Place a stake through the geogrid and into the ground. While using the stake as a lever and tensioning the geogrid, drive the stake into the ground to hold the position (IMAGE 11). Do not excessively tension geogrid. This may pull units out 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



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

INSTALLATION Q & A

BASE TRENCH / LEVELING PAD	
QUESTION:	<i>How wide does the Base Trench need to be?</i>
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:	<i>What should be the depth of the Base Trench?</i>
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:	<i>What should be the depth of the Base Leveling Pad?</i>
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:	<i>What should be the depth of the Base Trench for walls constructed on slopes?</i>
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:	<i>What material should be used for the Base Leveling Pad?</i>
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:	<i>Are concrete footings ever necessary or required?</i>
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:	<i>Can adjustments be made on a concrete leveling pad?</i>
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.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

▶ INSTALLATION Q & A

BASE COURSE INSTALLATION

QUESTION:	<i>Can I use sand to help level the base units?</i>
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:	<i>How many Keystone® units should be placed below grade?</i>
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:	<i>Should I always begin construction at one end of the wall or is it o.k. to start in the middle?</i>
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:	<i>What size rock is best suited for filling in and around the Keystone units in the drainage zone?</i>
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:	<i>How much rock do I need to use?</i>
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:	<i>How high can Keystone units be stacked before placing unit corefill and backfill?</i>
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.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

INSTALLATION Q & A ◀

COREFILL / BACKFILL	
<p>QUESTION:</p>	<p><i>What type of material should be used to backfill?</i></p>
<p>ANSWER:</p>	<p>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.</p>
<p>QUESTION:</p>	<p><i>How often do I need to compact the fill soils?</i></p>
<p>ANSWER:</p>	<p>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.</p>
<p>EXAMPLE:</p>	<p></p>
WALL SET BACK	
<p>QUESTION:</p>	<p><i>Which batter option should be used?</i></p>
<p>ANSWER:</p>	<p>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.</p>
<p>QUESTION:</p>	<p><i>Is there a way to figure how much setback there will be per course before construction of the wall begins?</i></p>
<p>ANSWER:</p>	<p>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 the pins. Measure the distance the second course tails are overhanging the units below. This will give you your true setback per course.</p>
TROUBLE SHOOTING	
<p>QUESTION:</p>	<p><i>How can I fix units that are out of level?</i></p>
<p>ANSWER:</p>	<p>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 than 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.</p>



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

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

▶ INSTALLATION Q & A

TROUBLE SHOOTING (continued)

QUESTION:	<i>How can units that are out of alignment be fixed?</i>
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:	<i>How high can Keystone® walls be built without the use of geogrid?</i>
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:	<i>What advantages are there to using a pinned system?</i>
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:	<i>How often should the wall's alignment be checked?</i>
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.

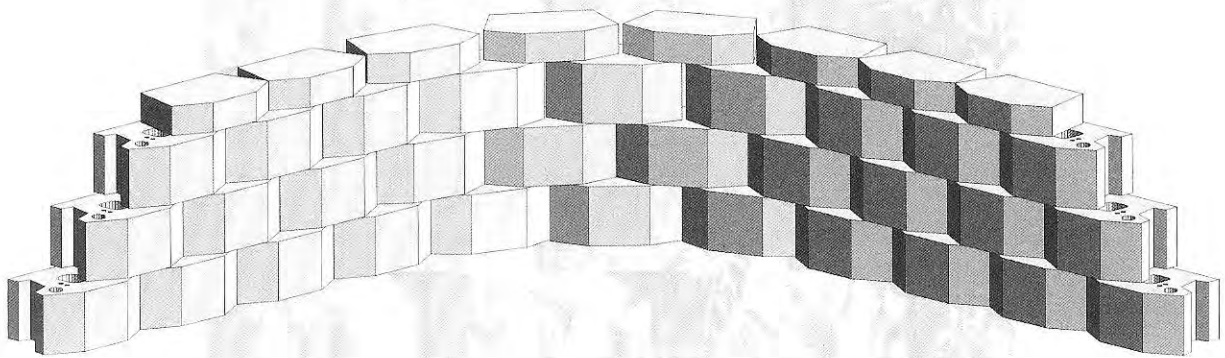


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

CORNERS AND CURVES

- 90° Inside Corner - Using 1" setback ◀
- 90° Inside Corner - Using Near Vertical setback ◀
- 90° Outside Corner - Using 1" setback ◀
- 90° Outside Corner - Using Near Vertical setback ◀
- Convex Curves ◀
- Concave Curves ◀
- Corners and Curves Q & A ◀



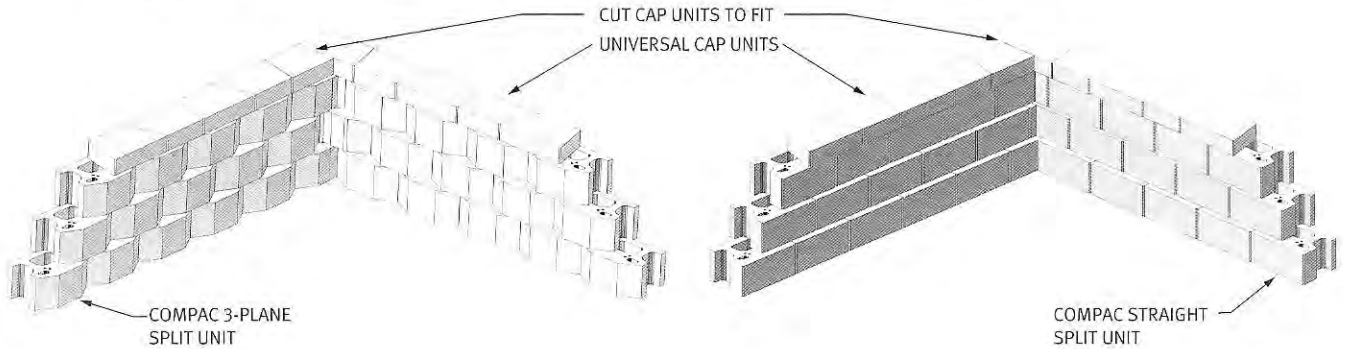
C O R N E R S A N D C U R V E S

90° INSIDE CORNER - USING 1" SETBACK ◀

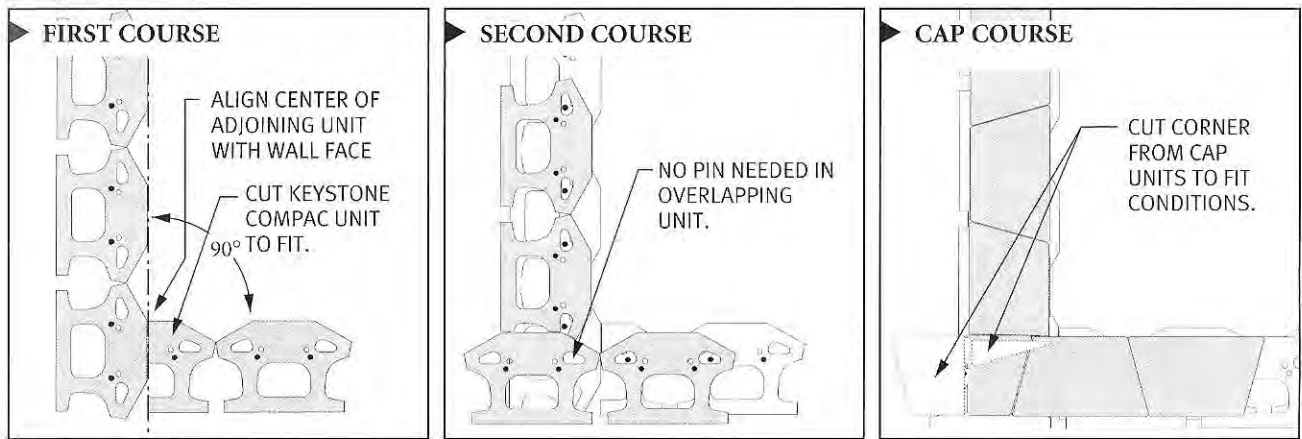
The following information will provide a general explanation of construction techniques for building retaining walls with these conditions.

INSTALLATION PROCEDURES:

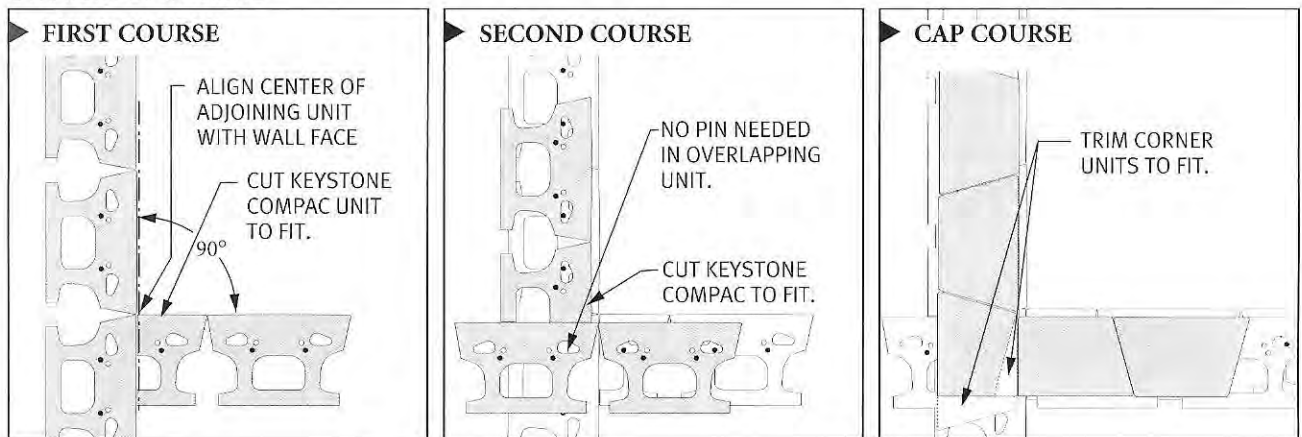
- ▶ Follow standard installation instructions for preparation of sub grade and leveling pad.
- ▶ Construction can start at the corner and work away from this point or with the method shown below, the wall can be started elsewhere and worked into the corner. This detail gives the builder flexibility.



3-PLANE SPLIT UNITS



STRAIGHT SPLIT UNITS



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

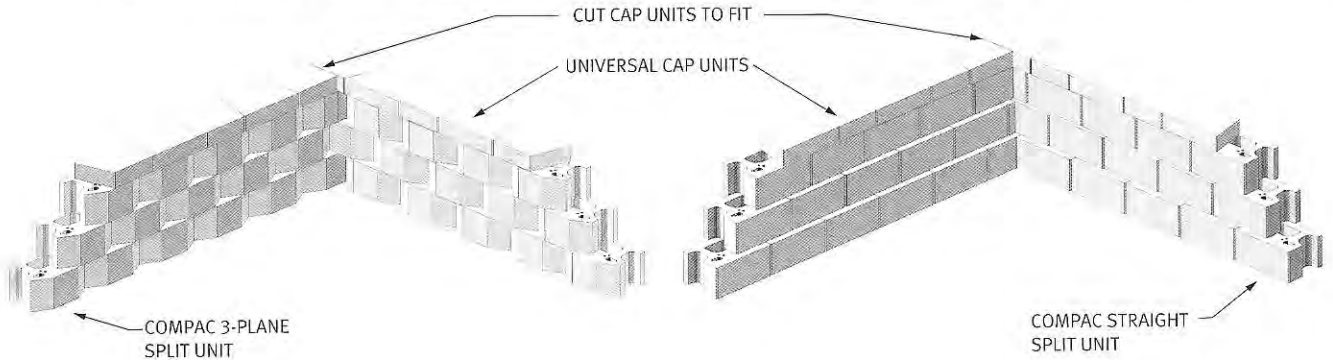
C O R N E R S A N D C U R V E S

► **90° INSIDE CORNER - USING NEAR VERTICAL SETBACK**

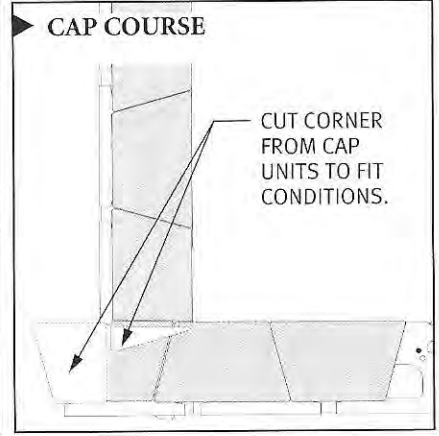
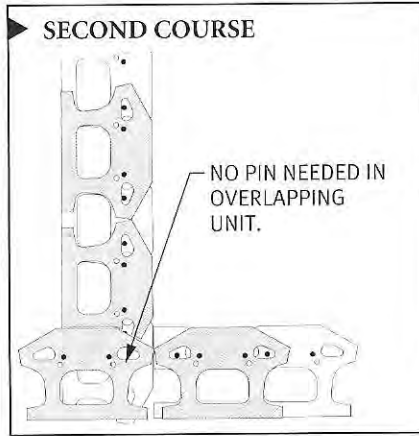
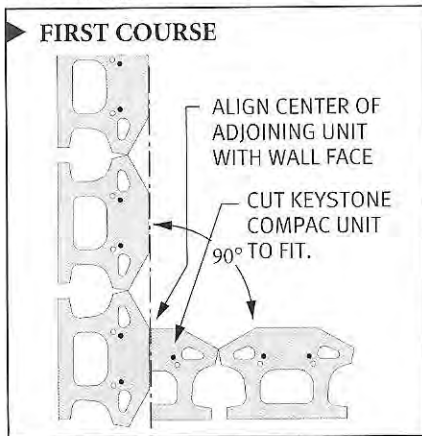
The following information will provide a general explanation of construction techniques for building retaining walls with these conditions.

INSTALLATION PROCEDURES:

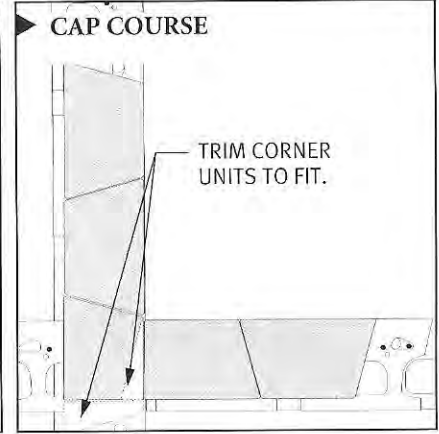
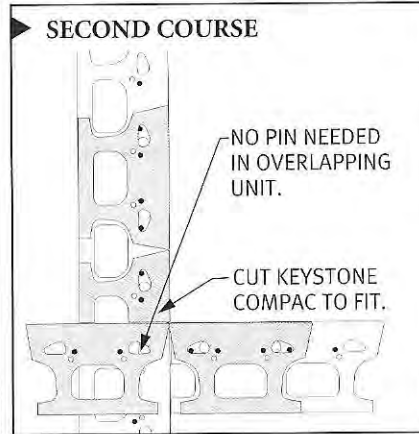
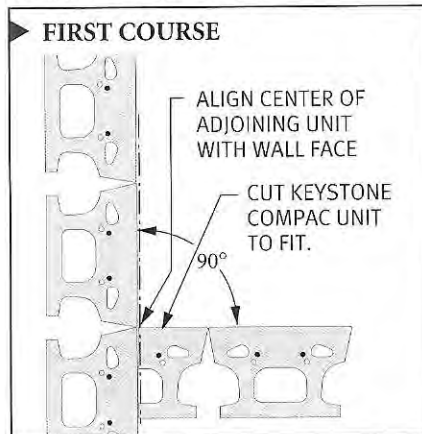
- Follow standard installation instructions for preparation of sub grade and leveling pad.
- Construction can start at the corner and work away from this point or with the method shown below, the wall can be started elsewhere and worked into the corner. This detail gives the builder flexibility.



3-PLANE SPLIT UNITS



STRAIGHT SPLIT UNITS



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

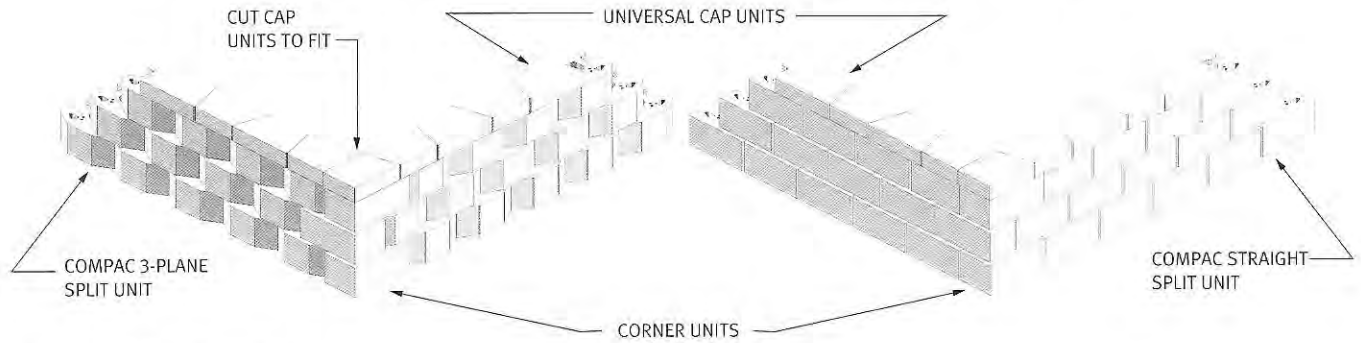
I N S T A L L A T I O N

90° OUTSIDE CORNER - USING 1" SETBACK ◀

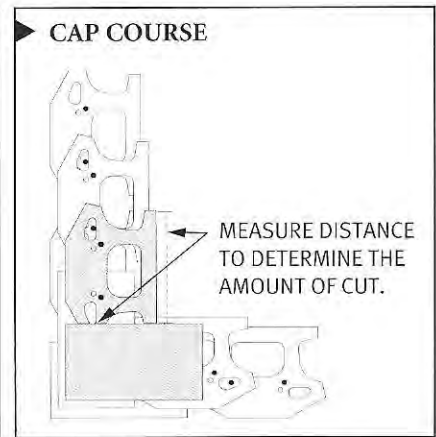
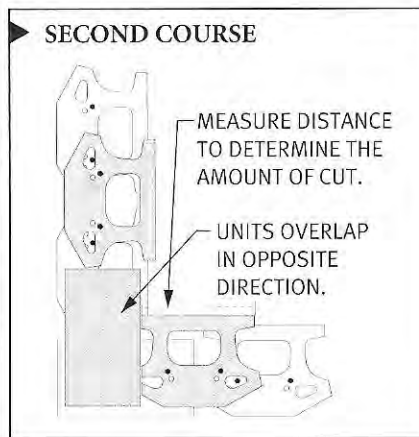
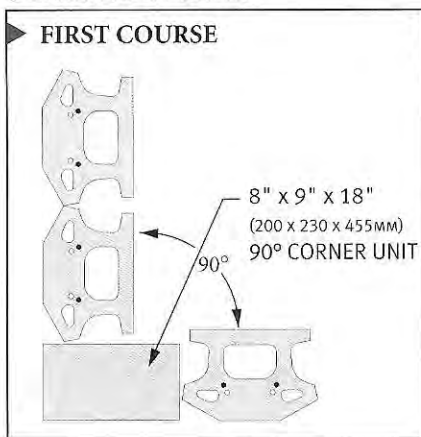
The following information will provide a general explanation of construction techniques for building retaining walls with these conditions.

INSTALLATION PROCEDURES:

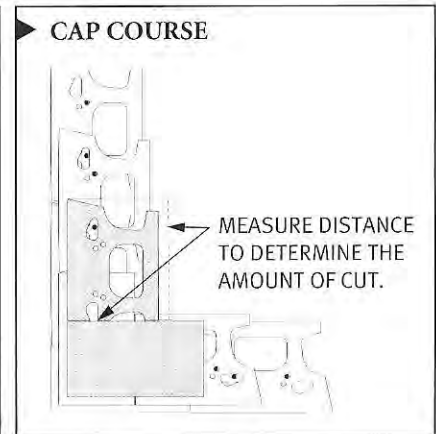
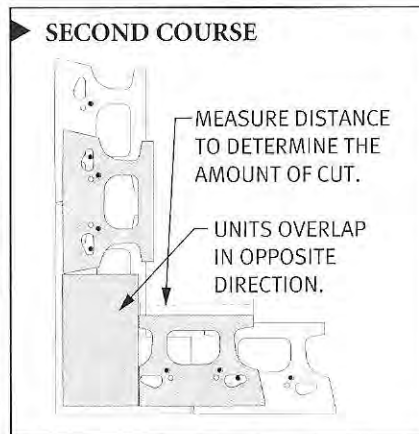
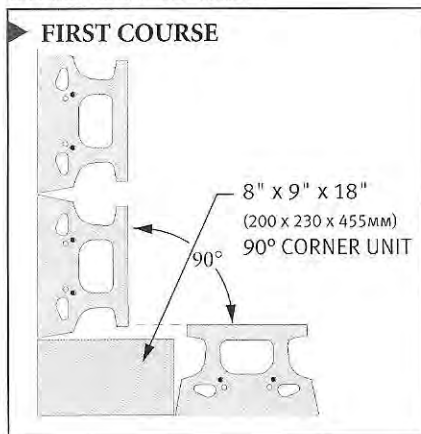
- ▶ Follow standard installation instructions for preparation of sub grade and leveling pad.
- ▶ Construction can start at the corner and work away from this point or with the method shown below, the wall can be started elsewhere and worked into the corner. This detail gives the builder flexibility.



3-PLANE SPLIT UNITS



STRAIGHT SPLIT UNITS



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

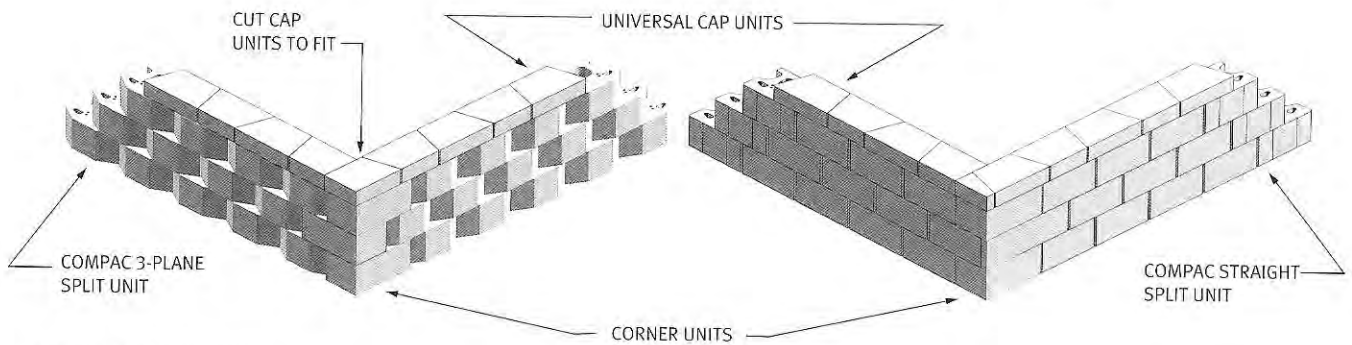
C O R N E R S A N D C U R V E S

► **90° OUTSIDE CORNER - USING NEAR VERTICAL SETBACK**

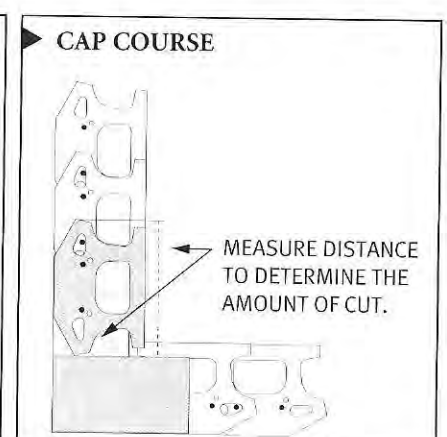
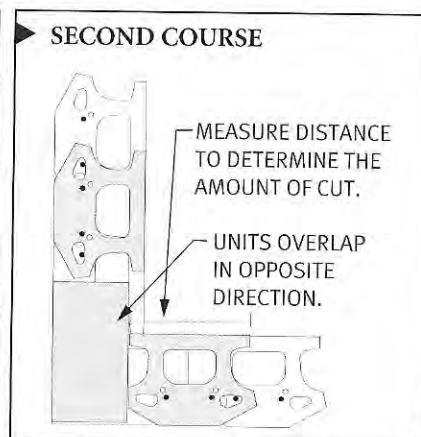
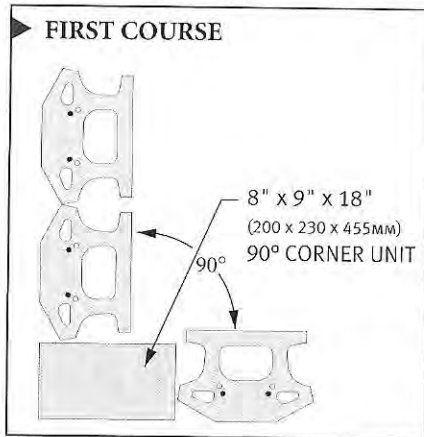
The following information will provide a general explanation of construction techniques for building retaining walls with these conditions.

INSTALLATION PROCEDURES:

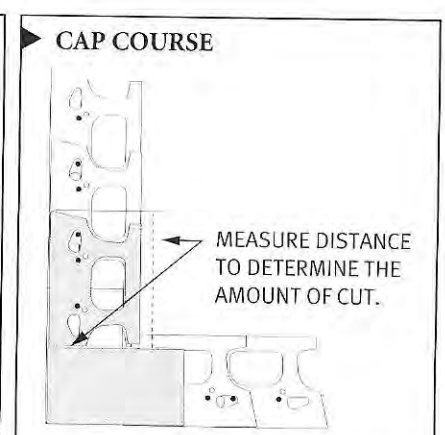
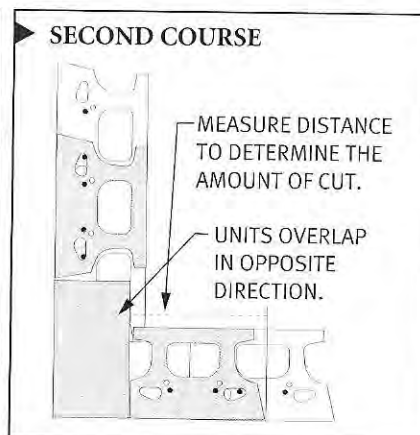
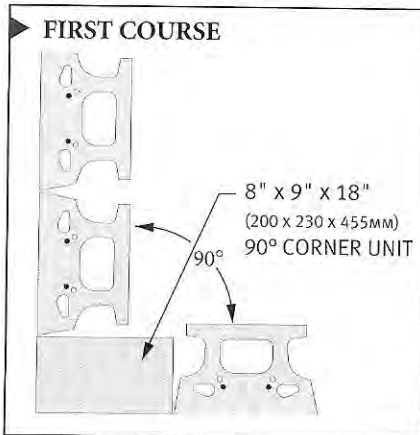
- Follow standard installation instructions for preparation of sub grade and leveling pad.
- Construction can start at the corner and work away from this point or with the method shown below, the wall can be started elsewhere and worked into the corner. This detail gives the builder flexibility.



3-PLANE SPLIT UNITS



STRAIGHT SPLIT UNITS



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.kestonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

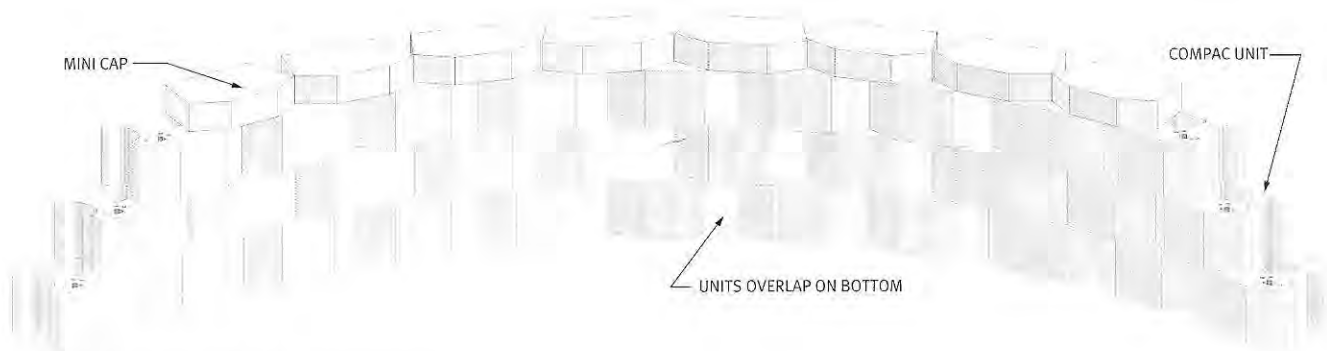
C O R N E R S A N D C U R V E S

CONCAVE CURVES

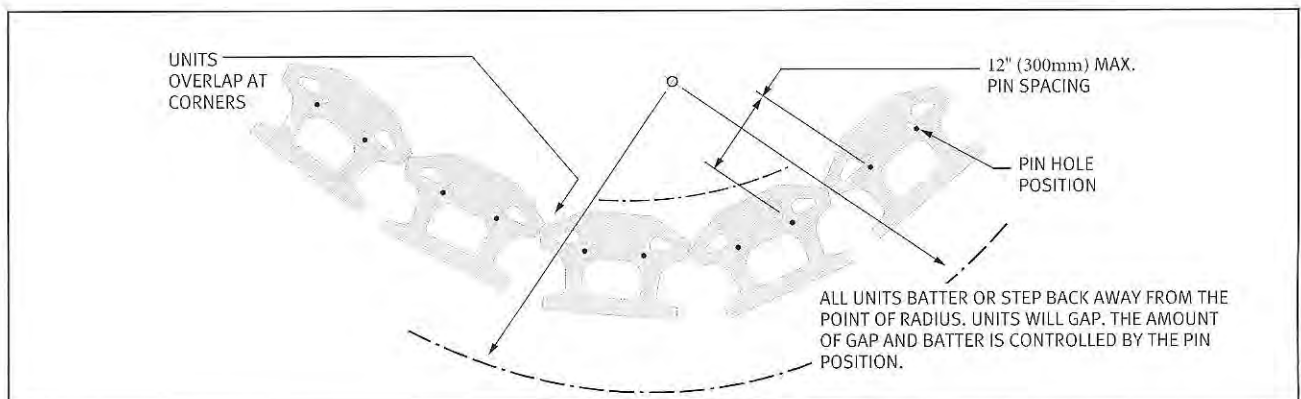
Concave curves are constructed using typical wall units. The following information will provide a complete explanation of construction techniques for building retaining walls with these conditions.

INSTALLATION PROCEDURES:

- ▶ Follow standard installation instructions for preparation of subgrade and leveling pad.
- ▶ Overlap corners of base course if building with the 8.8° or 4.4° batter options. The amount of overlap will vary based on size of curve. Gapping will occur as the units batter or move away from the point of radius. The rate of gapping is controlled by the severity of the batter (i.e. a 8.8° batter will gap more quickly than a near vertical batter). The distance between the pin holes on adjacent first course units should not exceed 12" (30cm) on center. For best visual appearance, a maximum 1/2" to 3/4" (15 -20mm) gap is recommended.
- ▶ Follow standard installation instructions for back filling and placement of additional courses.
- ▶ If geogrid reinforcement is used, refer to manufacturer's recommendations for proper placement of this material along concave curves and corners.
- ▶ Depending on wall height, radius and batter selection some gapping between units may occur. If gaps exceed acceptable limits, re-drill new pin holes as needed using a 5/8" (15mm) masonry bit and realign units to close gaps.



NOTE: All units shown with Sculptured Rock Face finish



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.kestonewalls.com

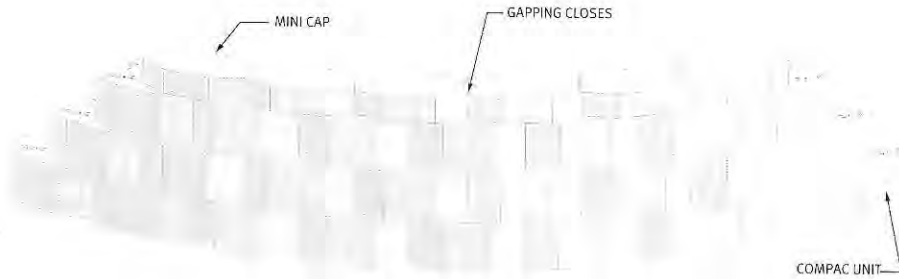
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

C O R N E R S A N D C U R V E S

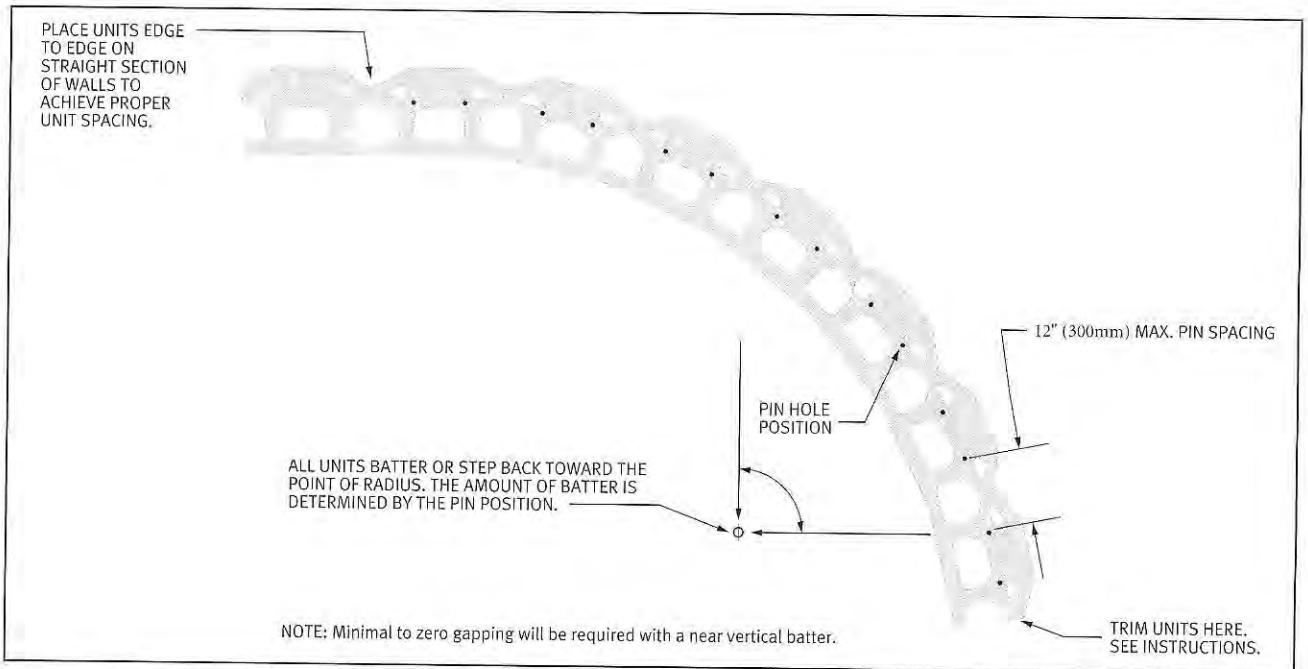
► CONVEX CURVES

INSTALLATION PROCEDURES:

- Follow standard installation instructions for preparation of sub grade and leveling pad.
- Place base course units with a small gap between adjacent units. This gap will close with the placement of each additional course of Keystone® units as the units batter and converge toward the point of radius. The rate of closure is controlled by the severity of the batter (i.e. a 8.8° batter will close more quickly than a near vertical batter). A maximum of 1/2" to 3/4" (15-20mm) gap is recommended for best visual appearance. To achieve this, the distance between the pin holes on adjacent first course units should not exceed 12" (30cm) on center.
- Follow standard installation instructions for back filling and placement of additional courses.
- If geogrid reinforcement is used, refer to manufacturers recommendations for proper placement of this material along convex curves.
- Depending on wall height, radius and batter selection some binding between units may occur. If this prohibits proper placement of additional units, try one of the following suggestions.
 - Trim unit corners using either a masonry cold chisel or concrete saw.
 - Push units back and realign. Re-drill new pin holes as needed using a 5/8" (15mm) masonry bit.



NOTE: All units shown with Sculptured Rock Face finish



NOTE: Minimal to zero gapping will be required with a near vertical batter.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.kestonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

C O R N E R S A N D C U R V E S

QUESTIONS AND ANSWERS

CORNERS & CURVES	
<p>QUESTION: <i>When building an inside 90° corner, how much should be cut off the first course?</i></p> <p>ANSWER:</p>	<p>A good place to start is approximately at the half unit range. This will result in field cutting the caps to finish the top of wall in the corner. If it is important to finish the wall with full cap units versus a cut unit as shown below, you will need to know how much setback occurs in your wall from base course to cap course to determine the starting location of the last full unit (uncut) at the base. To determine setback, follow this simple method: Place 3 units on a smooth level surface. Place fiberglass pins in desired setback option. Place next course of units in running bond pattern over base units. Pull upper unit forward towards face of wall. Now measure distance from tail surface of lower and upper courses. This is your setback dimension! Multiply this measurement times the total number of vertical courses. This will then give you the projected horizontal shift required to handle the setback of the two 90° walls away from the starting point.</p>
<p>QUESTION: <i>How do I determine the smallest concave radius I can construct before unacceptable gapping between units may occur?</i></p> <p>ANSWER:</p> <p>EXAMPLE:</p>	<p>Multiply the height of wall by two. The result is the smallest radius dimension.</p> <p>Wall Height (4') (1.2m) x 2 = Smallest Radius (8') (2.4m)</p> <p>NOTE: This formula applies to installations using the 8.8° batter. For the 4.4° batter use a multiple of 1.5. For the near vertical batter, no radius limitations are expected. No minimum radius applies. The near vertical batter is recommended for walls with multiple curves.</p>
<p>QUESTION: <i>How do I determine the smallest convex radius I can construct before binding between units may occur?</i></p> <p>ANSWER:</p> <p>EXAMPLE:</p>	<p>Multiply the height of wall by two. The result is the smallest radius dimension.</p> <p>Wall Height (4') (1.2m) x 2 = Smallest Radius (8') (2.4m)</p> <p>NOTE: This formula applies to installations using the 8.8° batter. For the 4.4° batter use a multiple of 1.5. For the near vertical batter, no radius limitations are expected. Minimum overall radius is 3.5' (1m).</p>
<p>QUESTION: <i>How do I determine how many Keystone® units will be required for a given radius or for a complete circle?</i></p> <p>ANSWER:</p> <p>EXAMPLE:</p>	<p>Multiply the diameter of the circle (the measurement of a line passing through the center from one side of the circle to the other or 2 x the radius) by 3.146. Divide the result by 1.5. The result is the number of units for a complete circle.</p> <p>Diameter (10') x 3.146 = 31.46 ÷ 1.5 = 21 units for a 10' circle or 5 units for a 90°-5' radius arc within a wall (3.05m x 3.146 = 9.6m x 2.19 units/m = 21 units)</p>



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

STEPS AND STAIRS

Steps And Stairs Installation ◀

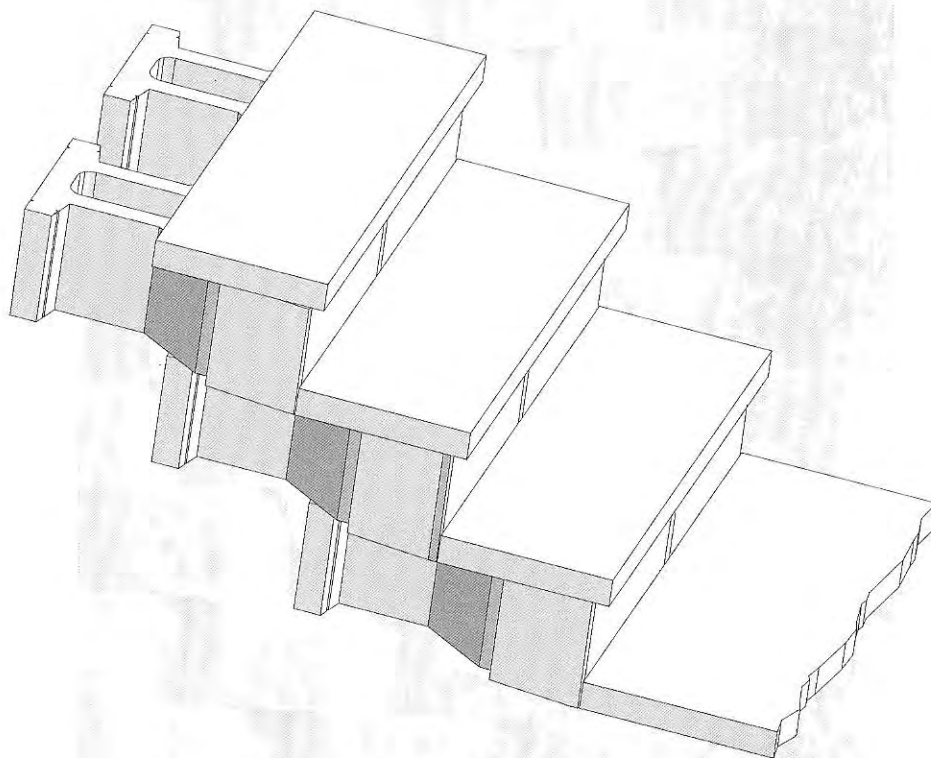
Steps In Wall - Option 1 ◀

Steps In Front of Walls - Option 2 ◀

Steps In Wall; 10" (25cm) Tread - Option 3 ◀

Step Parallel to Wall - Option 4 ◀

Steps and Stairs Q & A ◀

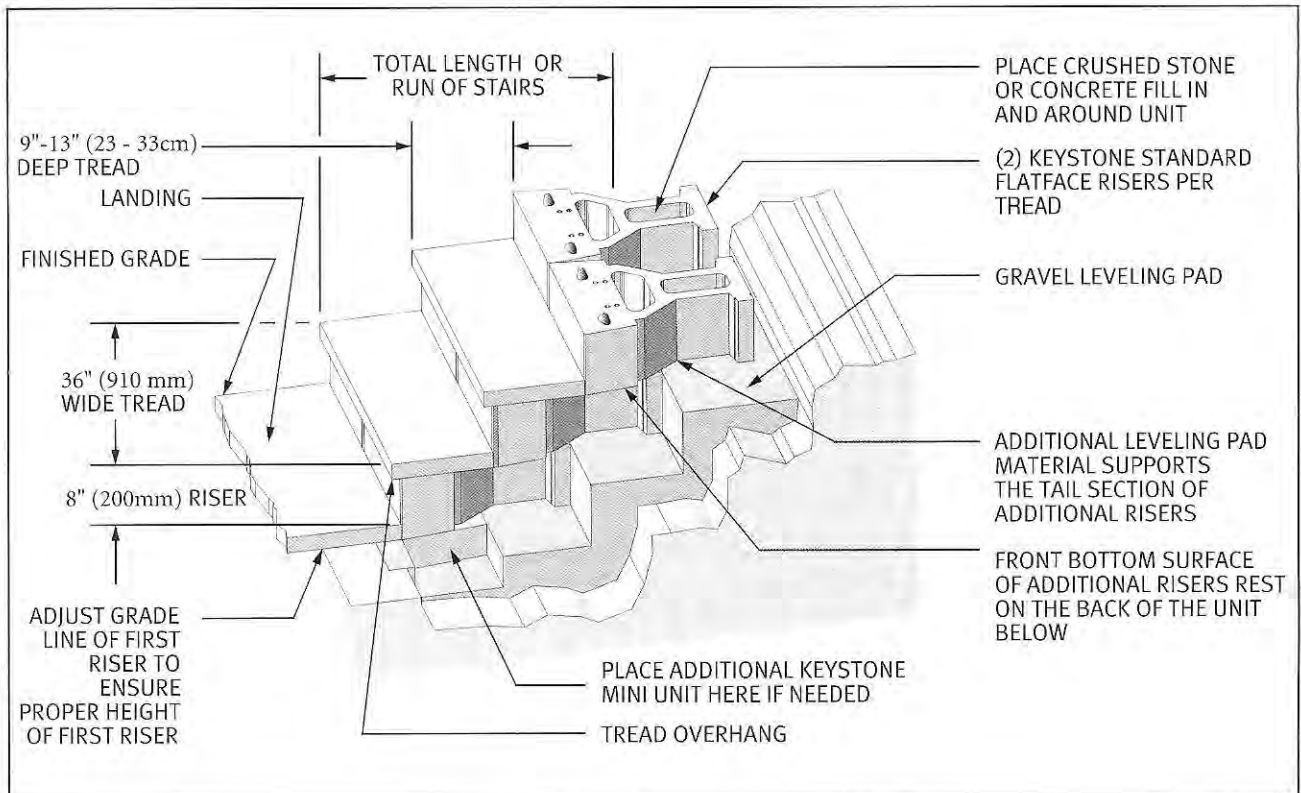


STEPS AND STAIRS

STEPS & STAIR INSTALLATION

The Keystone® Retaining Wall System not only provides a great deal of flexibility in wall construction but also in step design. Steps and stairs can be customized to fit a variety of applications. This document will discuss the various placement options available, surface materials and installation procedures for construction of steps and stairs using the Keystone® units. Steps can either be constructed prior to construction, while construction is underway or after construction is complete. This means that no matter the state of a particular site, steps and (or) a Keystone® Retaining Wall can be built without a great deal of complication. Each step illustration can be built independent of the adjoining retaining wall if none is required. Steps and stairs of other materials (i.e. poured concrete, natural stone) can be integrated successfully with a Keystone® wall in lieu of the step illustrations shown. **Steps constructed using Keystone® units are not recommended for high traffic usage (i.e. commercial installations).** All illustrations demonstrate the most popular methods currently used for step construction. Steps are shown with a 36" x 10" - 13" (915 x 255 - 330mm) wide tread and an 8" (200mm) riser. Other dimension combinations are possible and will be discussed later in this document. Step risers are shown as Keystone® Standard Straight Face Units. Sculptured Rock Face units may also be used. The flexibility of Keystone® allows for further design options. The following is a list of tools and supplies that may be necessary when building Keystone® steps:

- Square and round nosed shovels
- Compactor (hand and/or power)
- Level-3' (1m) or wider
- Rubber or small sledge hammer
- Tape measure
- 3" - 4" (75 - 100mm) backset/chisel
- Concrete saw
- Caulking gun
- Broom
- Keystone® KapSeal™



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S**► STEPS & STAIR INSTALLATION**

Follow these step by step procedures for a successful residential installation of Keystone® steps and stairs. Refer to STEP OPTIONS 1 thru 7 for more detail.

► STEP 1: DETERMINE WHICH TYPE OF STEP AND STAIR MATERIAL WILL BE USED
(See STEP 14 for tread material options)

► STEP 2: SPECIFY THE WIDTH OF STEPS

When using the Keystone® units, various incremental dimensions are possible without unit modification. Each Keystone® unit is 18" (457mm) wide. A multiple of this equals step widths of 36" (0.9m), 54" (1.4m), 72" (1.8m) (etc. Additional width should be added if a planting space will be provided between the sides of the steps and the retaining wall (See Option 2).

► STEP 3: CALCULATE THE HEIGHT OF THE RISER AND THE DEPTH OF THE TREAD

Most municipal building departments have code requirements regarding dimensions for steps and stairs used in site construction. CHECK WITH LOCAL OFFICIALS FOR REQUIREMENTS. If the steps and stairs will be built using the Keystone® units, use the height of a Keystone® unit (8"H) (200mm) as the standard riser dimension. Any uniformly dimensioned tread material placed on top of the Keystone® risers will maintain the 8" (200mm) riser dimension. Step tread dimensions should be 9"-13" (25-35mm) wide. (General rule for exterior stairs: 2 risers + tread = 26" (660mm). If step landings will be used instead of stairs, tread dimensions should be multiples of 18" (455mm) (i.e. 36" (915mm), 54" (1.4m)) for comfortable passage from one landing to another.

► STEP 4: LAY OUT WALL AND STEP LOCATION

Taking the above calculations into account, design and lay out where steps are to be located.

► STEP 5: EXCAVATE THE BASE TRENCH FOR PLACEMENT OF THE FIRST KEYSTONE® RISER UNITS

If the steps and stairs are being built adjoining a Keystone® Retaining Wall, use the same grade lines as used for the wall so that the horizontal plane of the step and wall units align. If not, excavate the Base Trench to a depth that will allow placement of a 6" (150mm) Base Leveling Pad. The finished grade of the Base Leveling Pad should be on the same grade line as the bottom of the landing material (typically the same material used as tread surfaces). This will ensure that the rise of the first step will be the same as the remaining steps. If no landing material will be used (i.e. steps from a gravel walk or a grass lawn), an additional Keystone® Mini Unit will need to be placed below the first Keystone® riser. This provides the necessary interlock with the soil at the base of the steps. Join the first riser and the Mini Unit using the same bonding procedures recommended for attaching the treads (STEP 14). Keystone® pins are not used to join the units since they will be stacked directly above one another instead of the normal running bond pattern.

► STEP 6: PLACE AND COMPACT THE BASE LEVELING PAD MATERIAL

This should be the same material as used in Keystone® Retaining Wall construction. See STEP 2 of INSTALLATION STEP BY STEP for further detail. Level the Base Leveling Pad with a square nosed shovel left to right and front to back. Hand or machine compact this material to 95% of Standard Proctor (95% of the soil's maximum density).

► STEP 7: SET THE FIRST KEYSTONE® RISER

Stability is as important an issue for steps as it is for retaining walls. For this reason, the Keystone® Standard Unit is recommended for use as the step riser. Its proportional height to width ratio (8"H x 18"W x 21-1/2"D) (200 x 455 x 545mm) creates a stable platform. Its depth provides a solid platform for placement of additional step risers. Position and align the first Keystone® risers.

► STEP 8: POSITION RETAINING WALL UNITS IF APPLICABLE

If a Keystone® Retaining Wall is adjoining the steps and stairs, position and align the units on the same course as the first step. For specific details, see STEP OPTIONS 1 THRU 7.

► STEP 9: PLACE UNIT FILL MATERIAL

If units will be back filled with concrete, skip to the next step (See placement of tread material for a complete explanation). If not, fill in and around units with Drainage Backfill Material (3/8"-3/4" (10-20mm) crushed stone). Gently compact this material to permanently position the first Keystone® risers.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S**STEPS & STAIR INSTALLATION** ◀▶ **STEP 10: POSITION THE NEXT KEYSTONE RISER**

Having determined the depth of the tread, measure this dimension from the face of the first riser back to the face of the second riser. Mark a line for position. If the tread will overhang the front of the riser, move the position of the second riser forward in the amount of the overhang dimension. The front surface of the second step will rest firmly on the risers below them. The tail section of these units will be supported on grade. Level and prepare this material using the same procedures as in STEP 6.

▶ **STEP 11: REPEAT BACKFILL PROCEDURES**

Backfill in and around the Keystone® riser as in STEP 9 to fix the position of the units. To eliminate potential movement caused by placement of succeeding risers during backfill and construction, join units using the same bonding procedures recommended for attaching treads (STEP 14).

▶ **STEP 12: CONTINUE WITH STEPS 9 & 10 UNTIL ALL RISERS ARE IN PLACE**▶ **STEP 13: PLACE CONCRETE FILL**

If Keystone® risers will be filled with concrete, backfill with this material at this time. Filling units with concrete joins all Keystone® step risers into one monolithic structure. Concrete passes between units joining them to each other.

▶ **STEP 14: APPLY TREAD MATERIAL**

Most tread materials can be used with Keystone® units. Step treads are attached using Keystone® KapSeal™ adhesive, mortar or epoxy adhesive. A monolithic concrete tread should be poured at the same time units are filled. This interlocks the tread with the Keystone® unit. If a 1/2"-3/4" (15-20mm) concrete skim coat is used as the step tread, use a concrete additive to reduce cracking and chipping. When using manufactured treads (i.e. pavers), consult the supplier or a masonry dealer for specific bonding material recommendations.



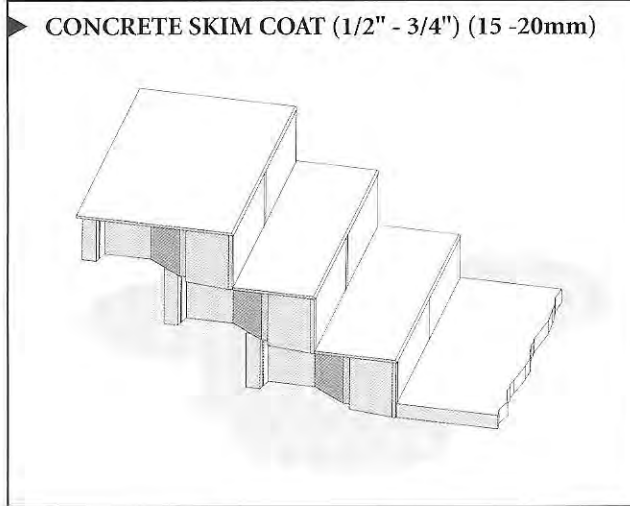
© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

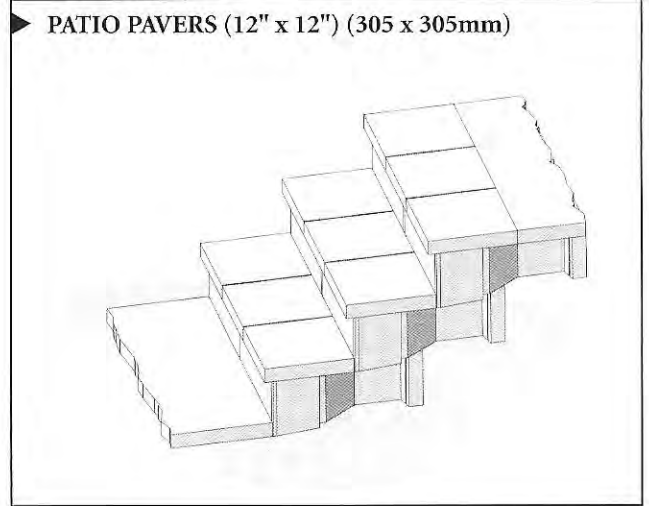
S T E P S A N D S T A I R S

► **STEPS & STAIRS INSTALLATION**

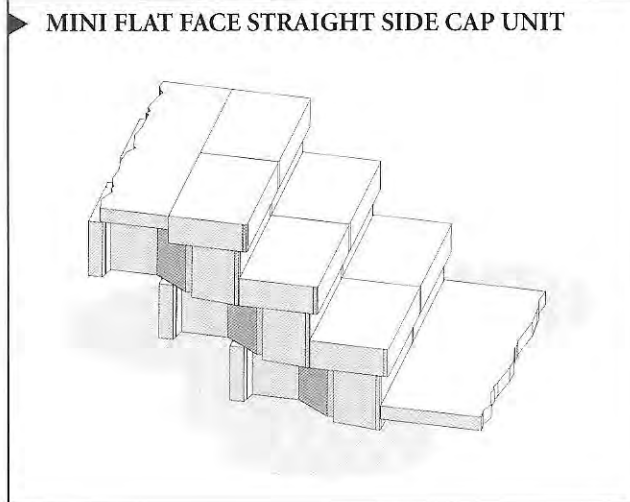
► **CONCRETE SKIM COAT (1/2" - 3/4") (15 -20mm)**



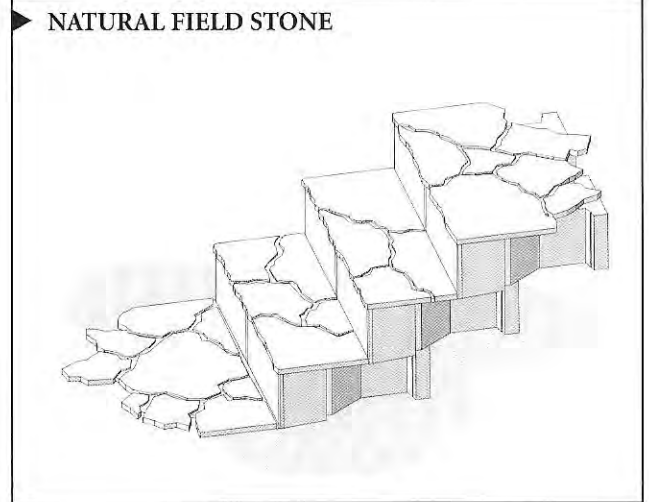
► **PATIO PAVERS (12" x 12") (305 x 305mm)**



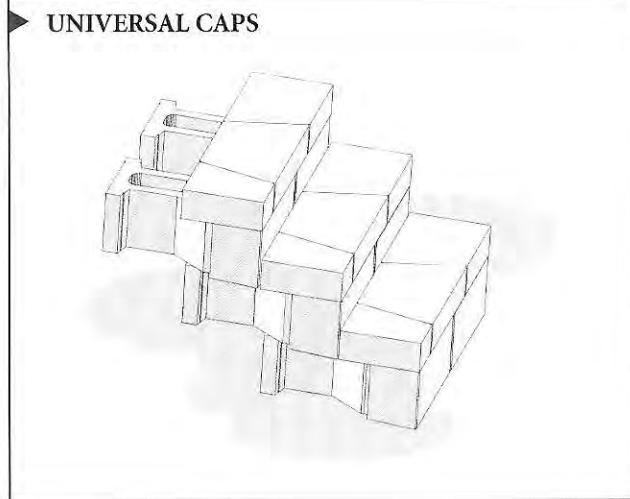
► **MINI FLAT FACE STRAIGHT SIDE CAP UNIT**



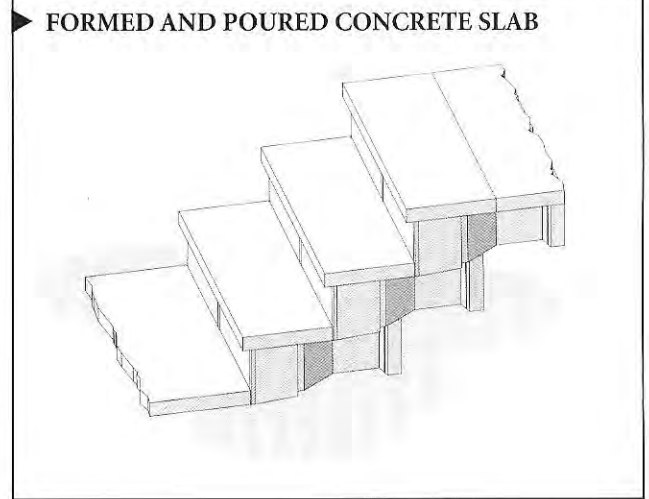
► **NATURAL FIELD STONE**



► **UNIVERSAL CAPS**

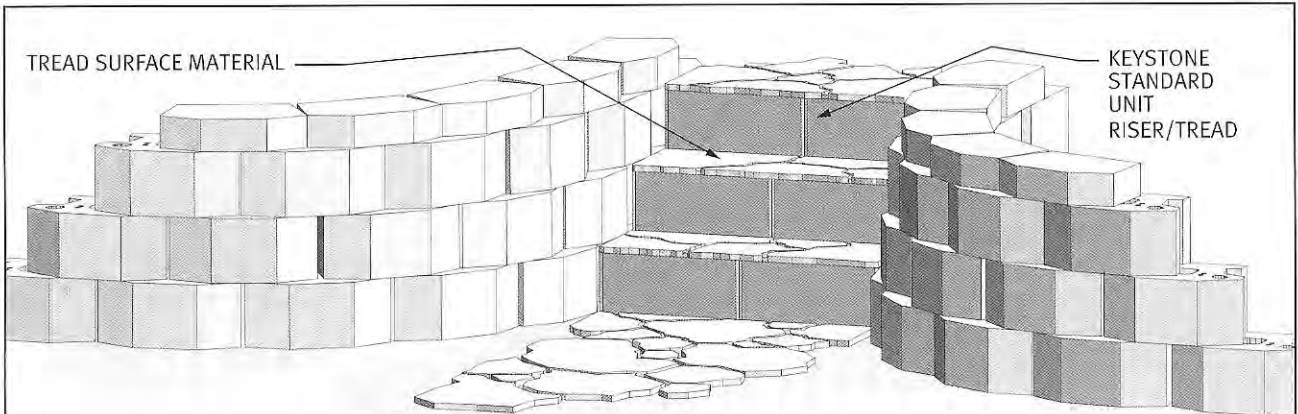


► **FORMED AND POURED CONCRETE SLAB**

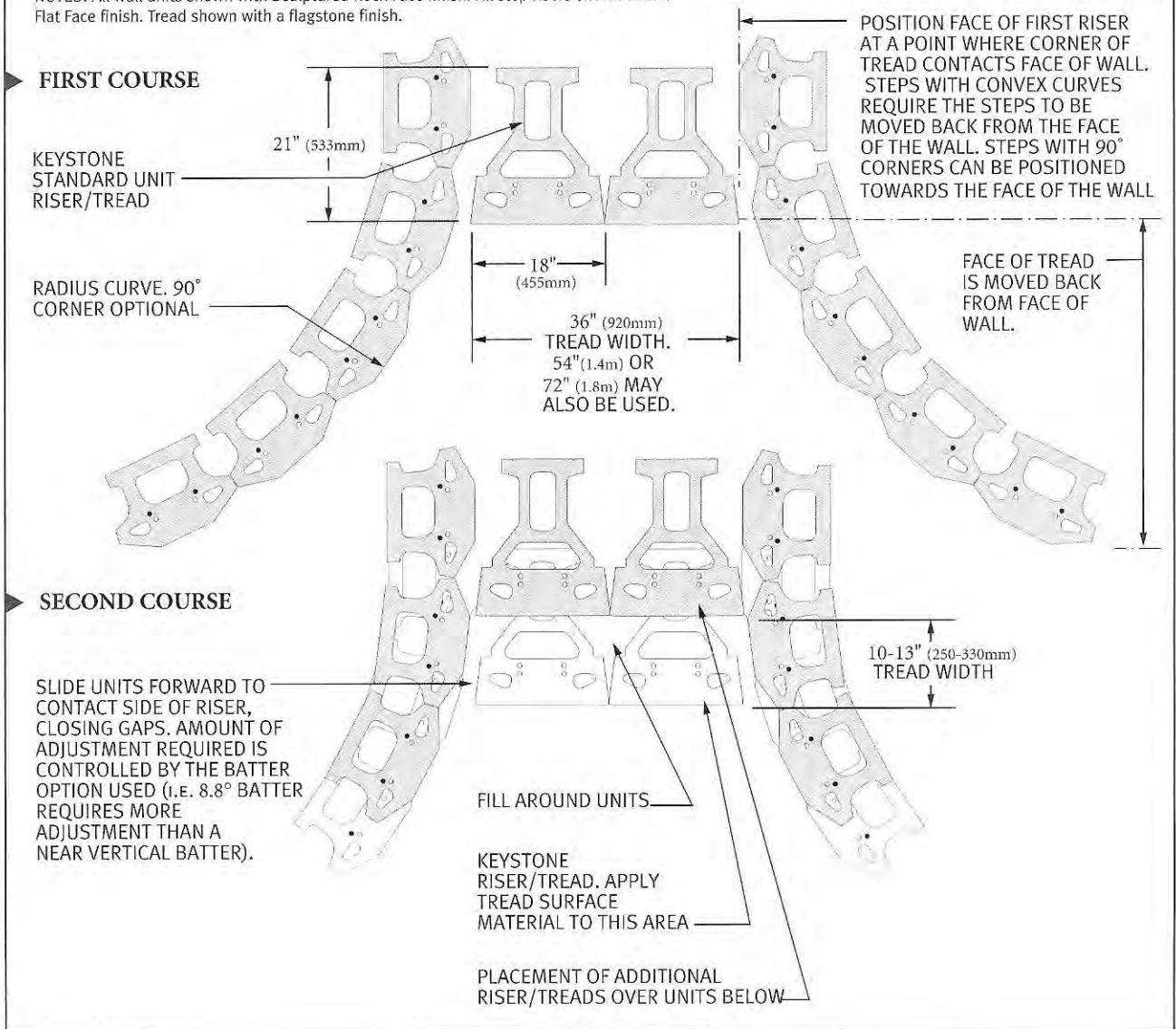


STEPS AND STAIRS

OPTION 1 - STEPS IN WALL



NOTES: All wall units shown with Sculptured Rock Face finish. All step risers shown with a Flat Face finish. Tread shown with a flagstone finish.

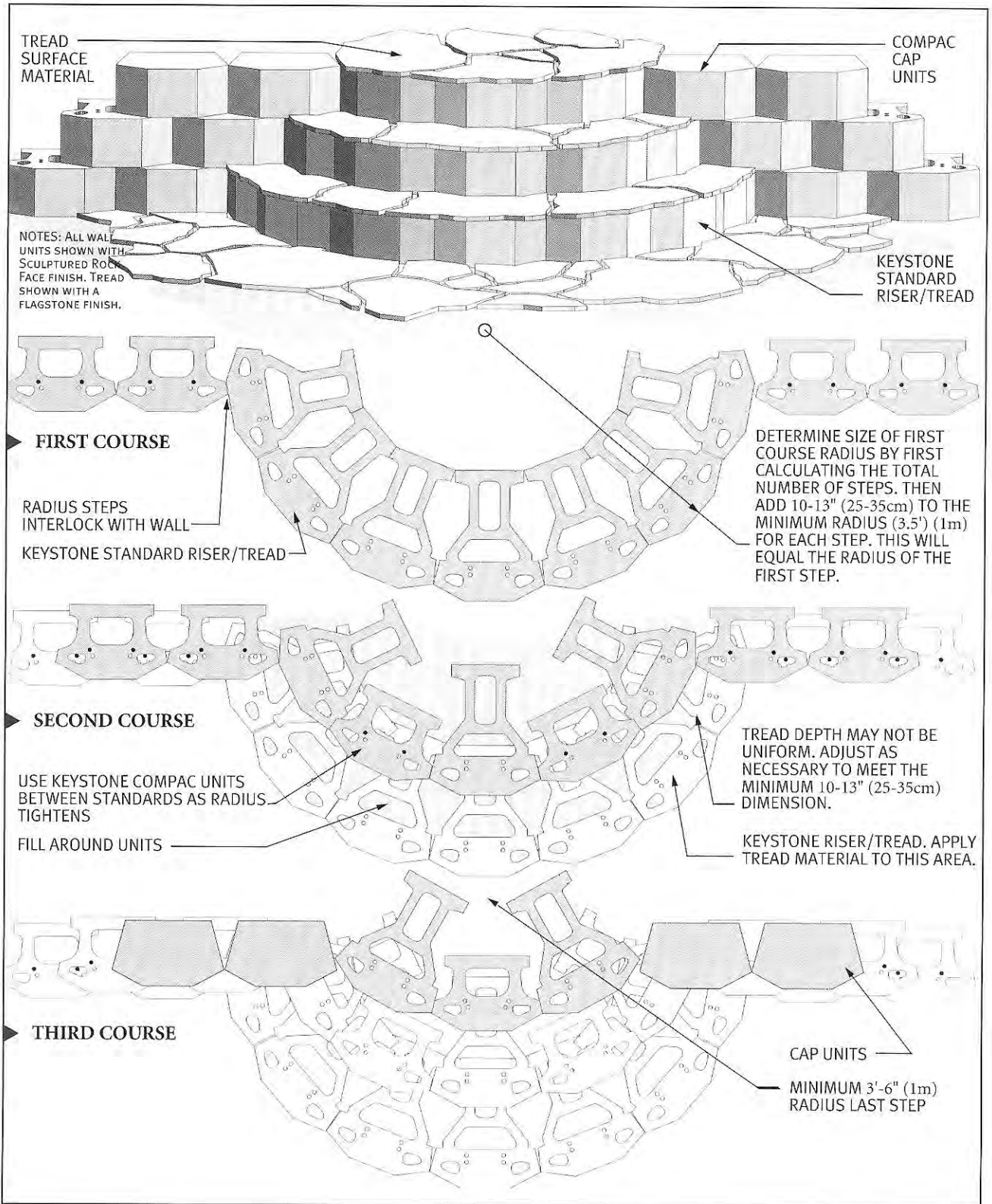


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S

▶ **OPTION 2 - STEPS IN FRONT OF WALLS**

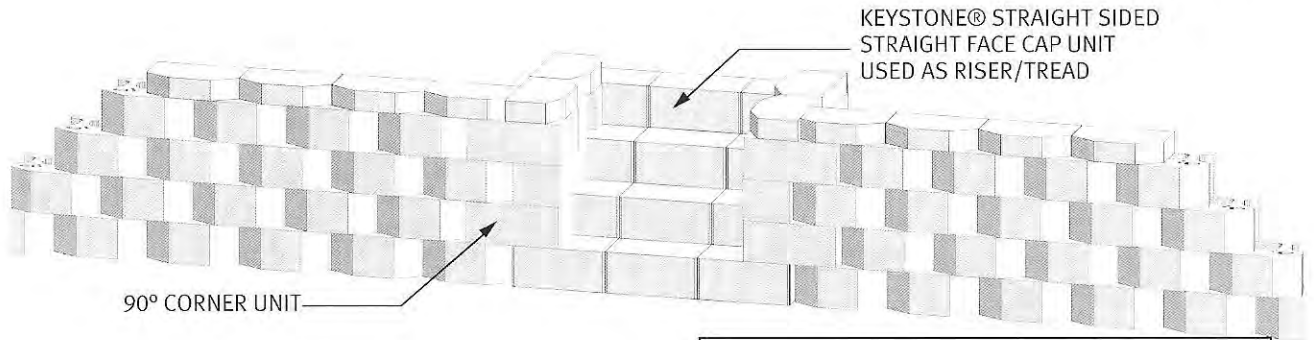


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

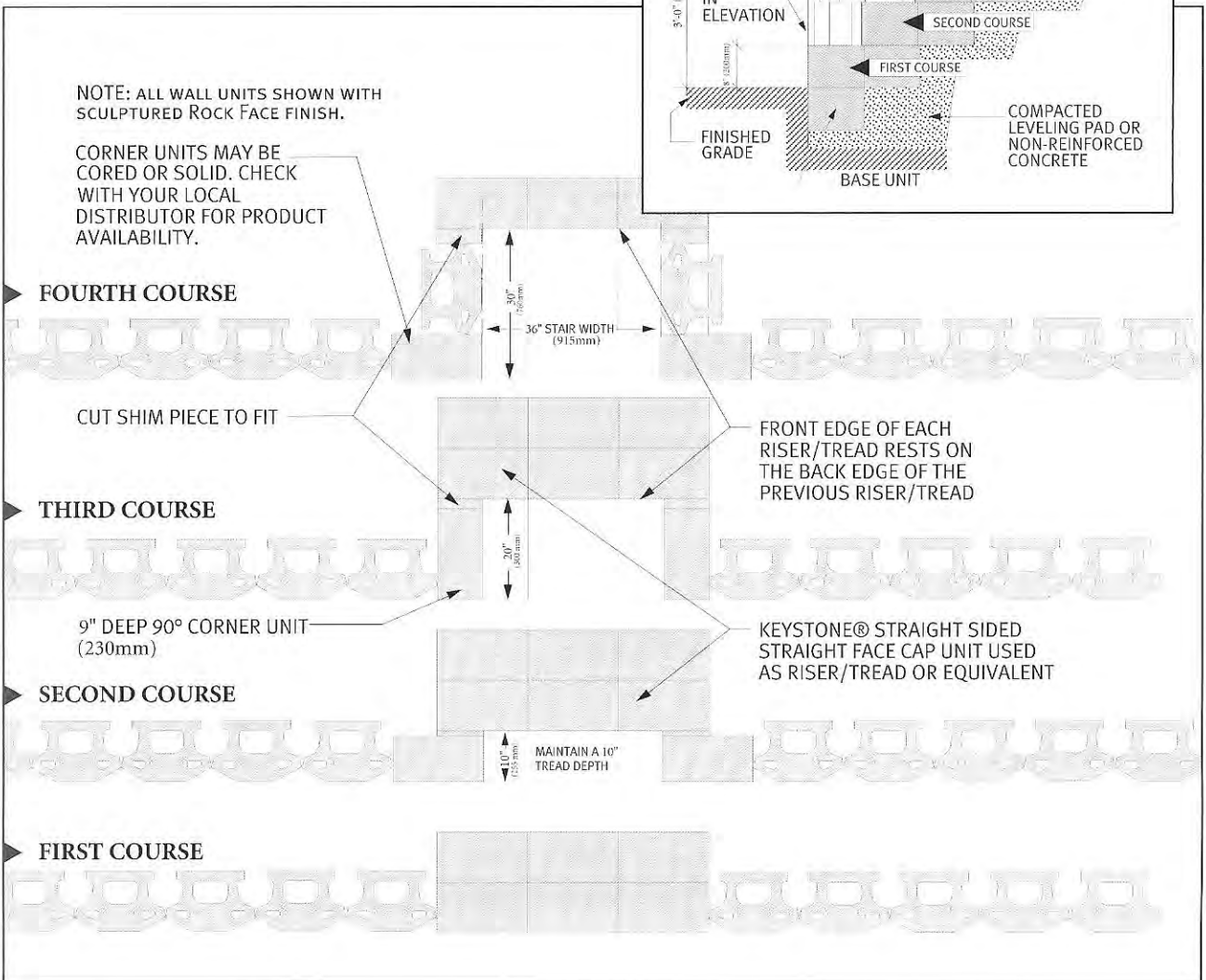
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S

OPTION 3 - STEPS IN WALL; 10" TREAD



▶ 10" (25cm) TREAD DEPTH

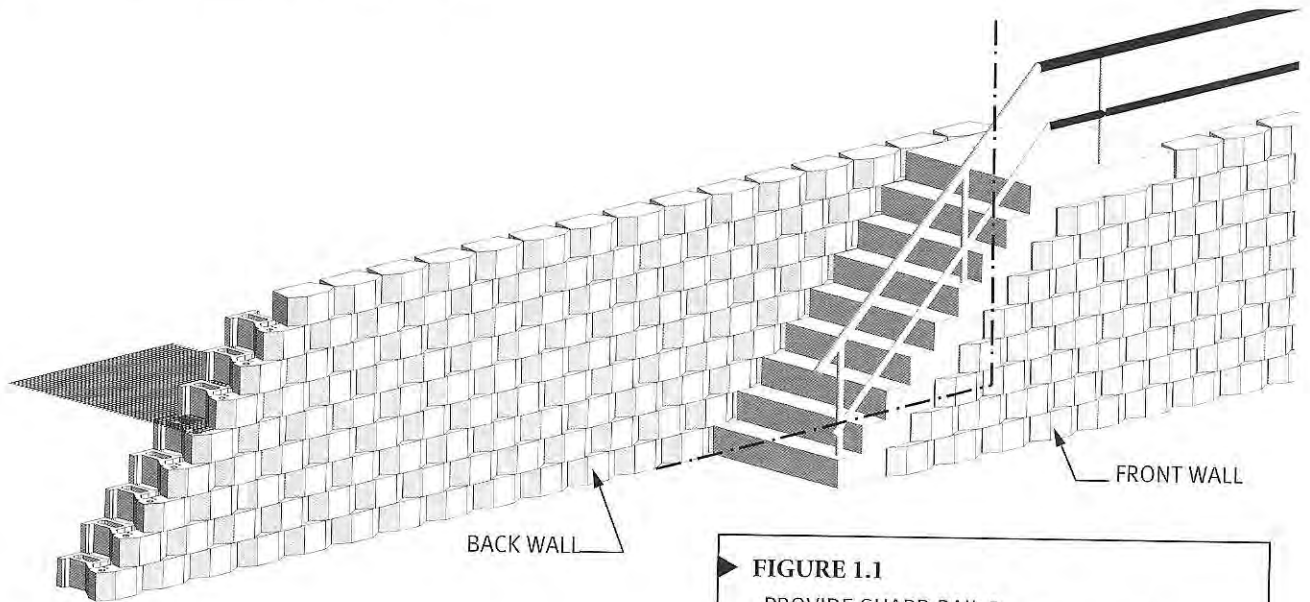


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

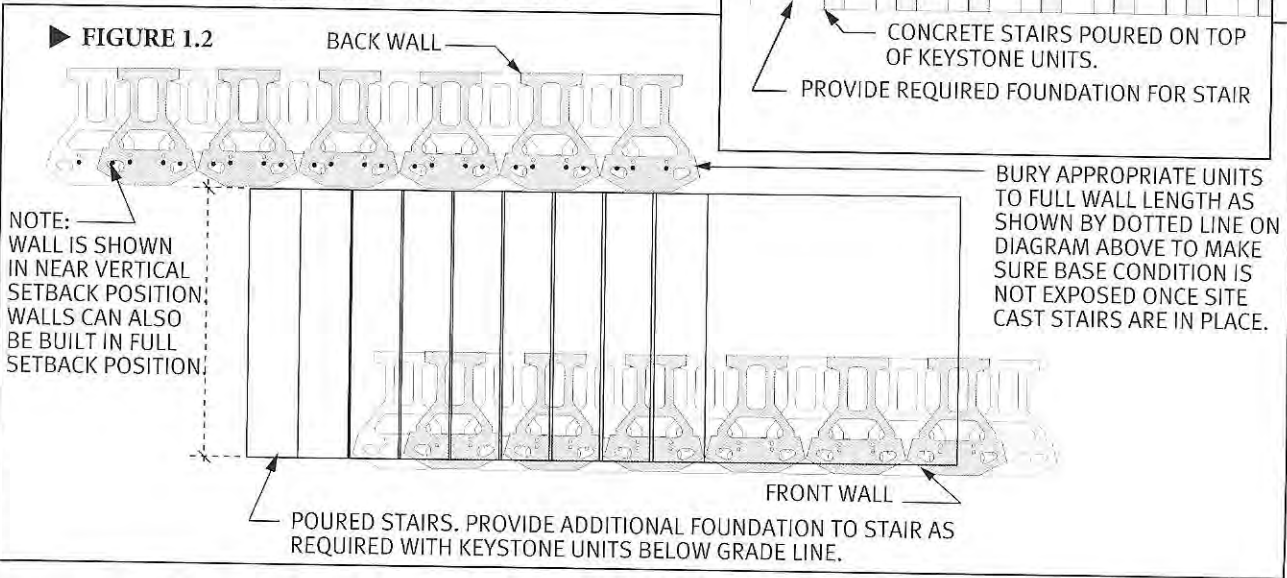
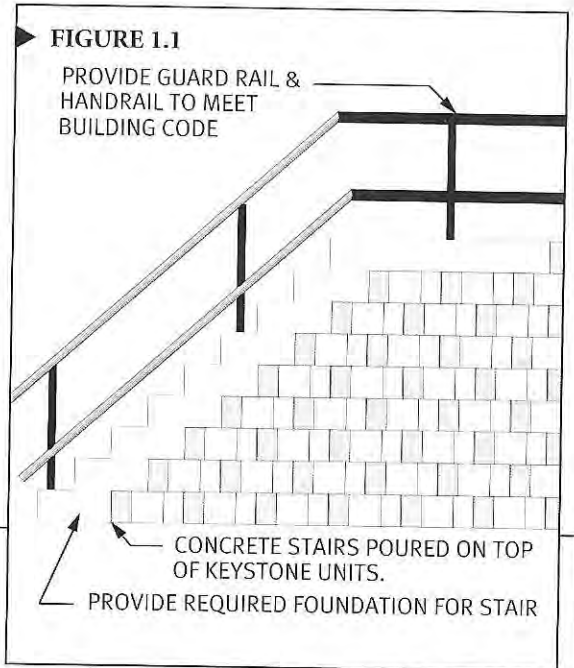
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S

▶ **OPTION 4 - STEP PARALLEL TO WALL**



When building stairs on a project, a great design feature can include running the stairway parallel to the retaining wall as shown. This solution can minimize the area needed for a typical stair which runs perpendicular to the wall. The construction is typical to normal installation. Build the Keystone walls with proper soil reinforcement as per design. Offset the front wall by the desired stair width. The back wall only needs to be buried so that the cast in place stair hides the base condition of all units (See figure 1.2). Determine staircase rise and run requirements based on applicable building codes. Figure 1.1 shows cast in place stair poured over the Keystone units in a uniform dimension. If rise and run for stair require modifying the layout, Keystone units can be cut to allow for a change in horizontal dimensions.



NOTE:
WALL IS SHOWN
IN NEAR VERTICAL
SETBACK POSITION;
WALLS CAN ALSO
BE BUILT IN FULL
SETBACK POSITION.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

S T E P S A N D S T A I R S

QUESTIONS & ANSWERS ◀

STEPS AND STAIRS	
QUESTION:	<i>How do I calculate how many steps will be needed to scale a specific grade?</i>
ANSWER:	Total height of the slope ÷ 8"(200mm) (Keystone® riser height) = Number of risers (round to the nearest full riser)
EXAMPLE:	12' ÷ 8" (.67') = 18 risers (0.305m x 18 = 5.5m)
QUESTION:	<i>How do I calculate the distance the steps will travel into the embankment?</i>
ANSWER:	Tread width x Number of risers = Total length of stairs
EXAMPLE:	12" x 18 = 216" (18') (0.305m x 18 = 5.5m)



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

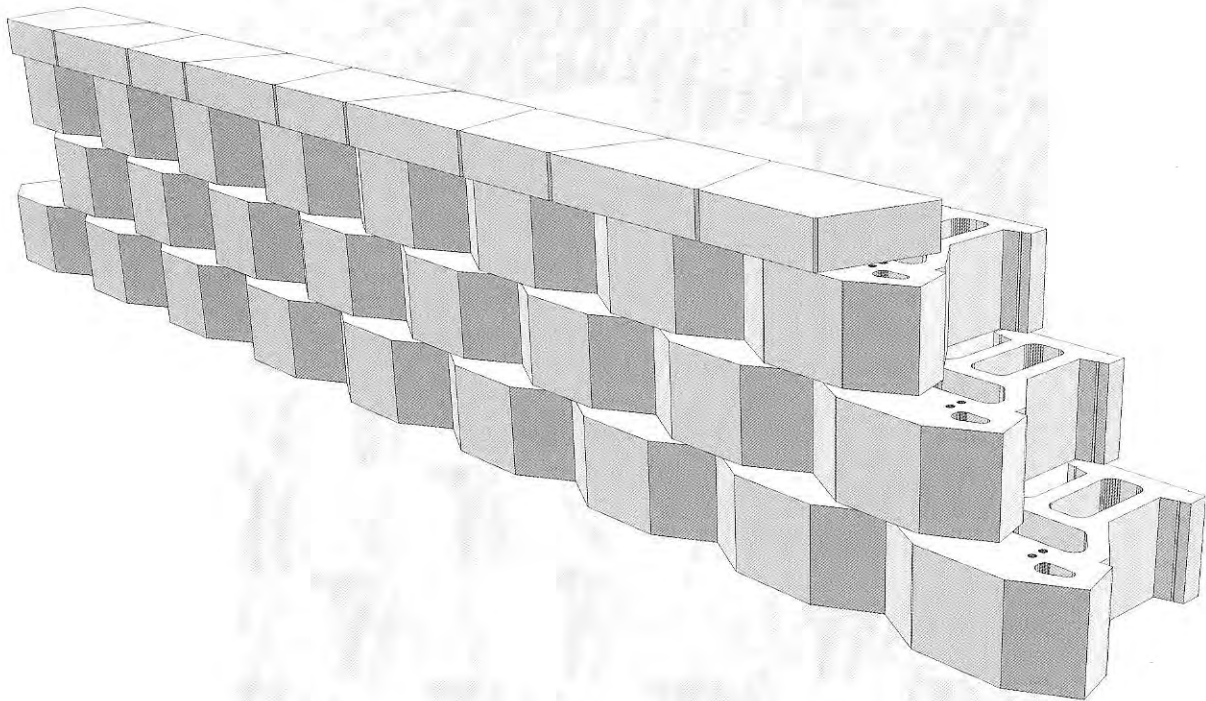
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

CAPPING & COPING

Wall Cap Using Keystone Unit ◀

Wall Termination Detail ◀

Coping Option for Keystone Wall ◀

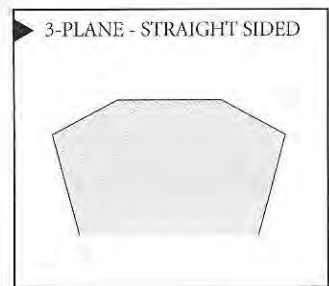
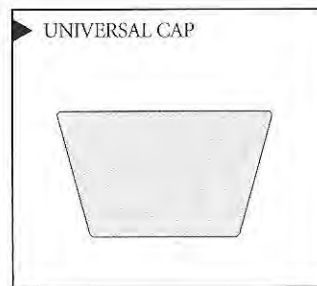
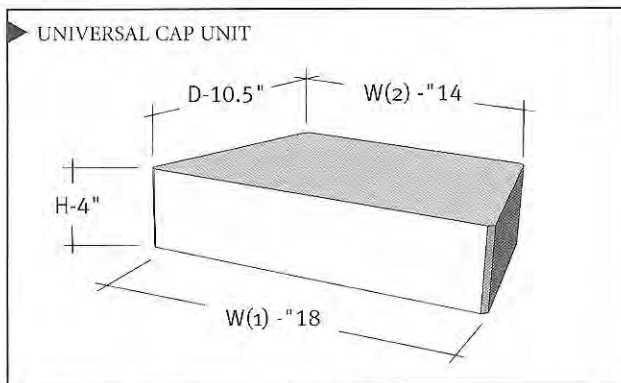


C A P P I N G & C O P I N G

WALL CAP USING KEYSTONE UNITS

A Keystone® Retaining Wall is not complete without the “capping touch”. The two primary wall units, the Standard and Compac Units, both have open voids, making them an unsuitable finish to the top of the wall. In some situations this may be acceptable. In most cases, a more attractive finish is required. Once again Keystone® provides a simple solution, the family of Keystone® Cap Units - the Mini Cap (4"H)(100mm) and Compac Cap (8"H)(200mm). Each unit is available in various combinations of facial finish and degrees of angled sides*. The following information will clearly explain the uses of these units in a variety of finishing techniques.

► **CAP UNITS**



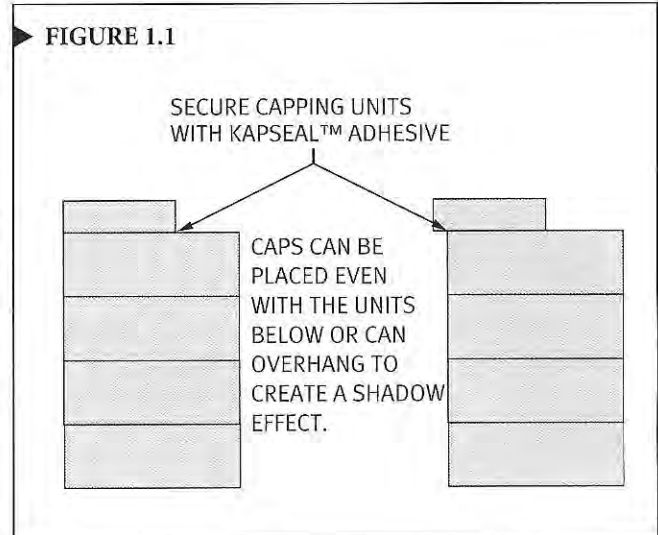
* Check with local manufacturers for product availability.

NOTE: Capping is not required to guarantee structural stability. It's only an aesthetic adornment.

Like other Keystone® units, all cap units can be used interchangeably. Depending on the wall contour, some cap units will work more effectively than others (i.e. angled side units for concave curves). In any given installation, if binding occurs between units, the units can be modified to fit using a concrete saw, chisel or other device.

Installation of the cap units is a simple one step operation. Secure all capping units with KapSeal™ (or equivalent) adhesive.

The following illustrations demonstrate the most common uses of the Keystone® cap units.

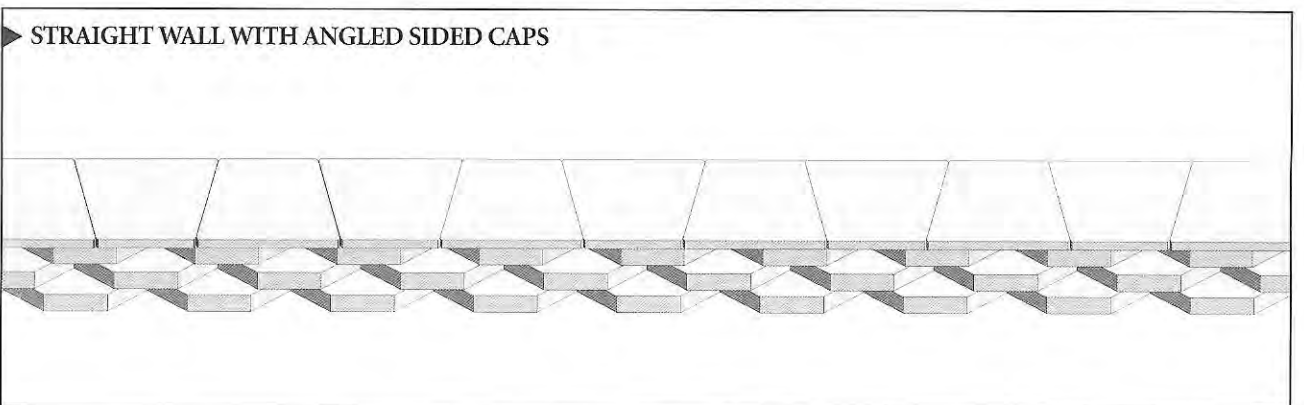
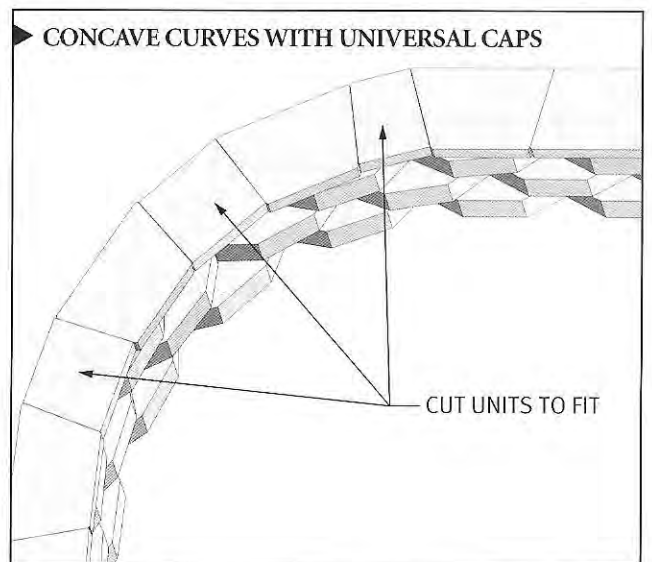
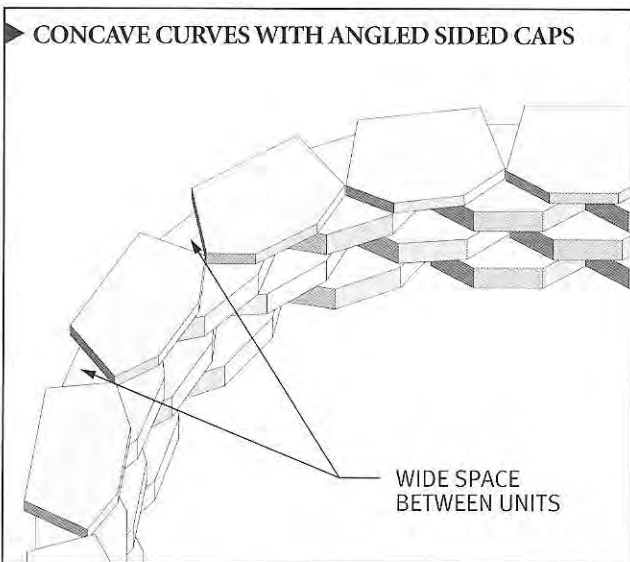
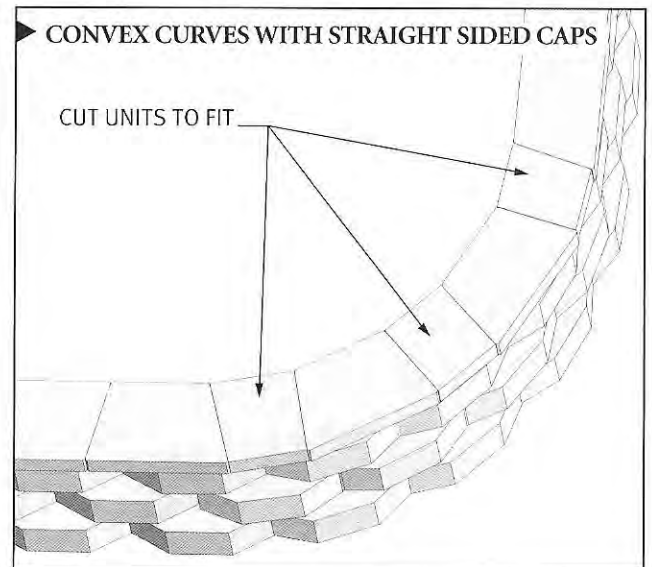
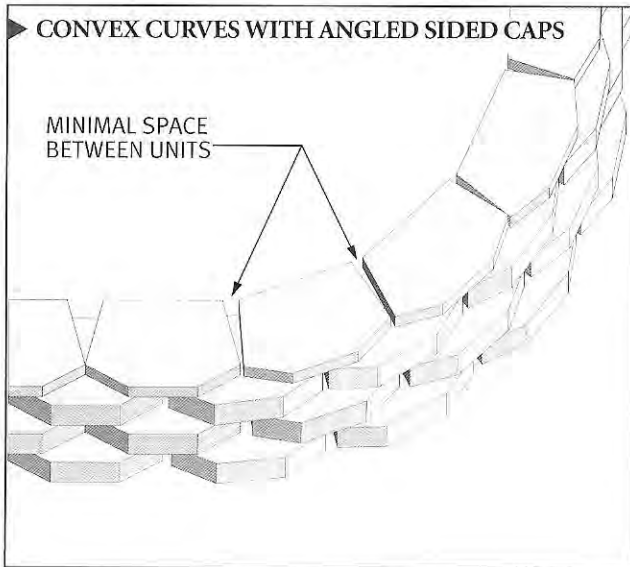


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

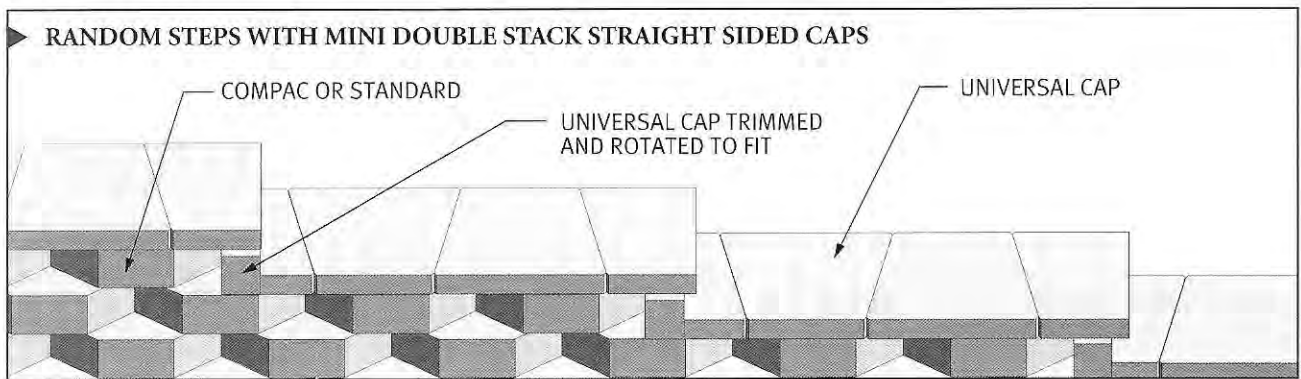
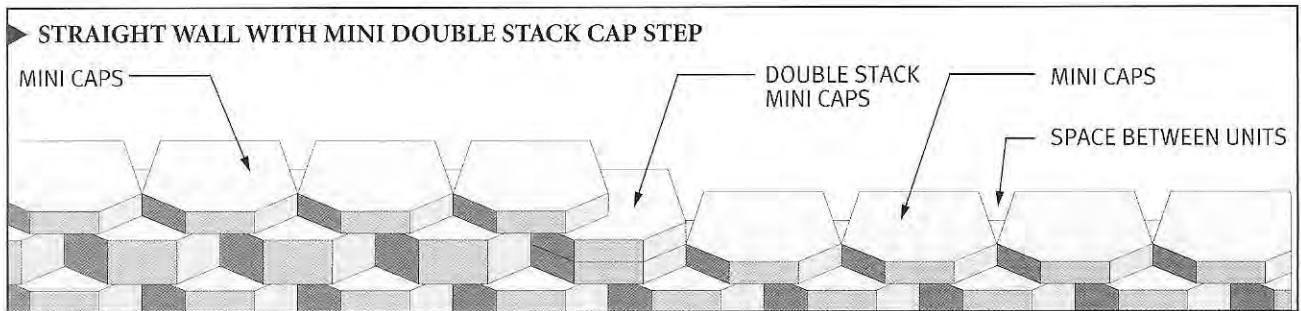
C A P P I N G & C O P I N G

▶ WALL CAP USING KEYSTONE UNITS



C A P P I N G & C O P I N G

WALL CAP USING KEYSTONE UNITS



The size of each Keystone® unit makes this system very adaptable to grade changes. A Keystone® wall can be constructed with a top of wall grade in increments between 0° and a 42° slope. These grade changes may occur along the length of a wall or at its points of origin. As cap units step up and down grades, an additional installation procedure is required to firmly fix some cap units in position. So that no unit voids in a Keystone® unit (Standard or Compac) are exposed, the last unit in each course should be Mini double stacked caps. Each additional cap unit is offset 9" (23cm) to maintain the running bond wall pattern. The caps should be attached using a 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. Apply this material to an area where the two units make contact.

The following illustrations demonstrate typical methods used for adjusting to grade changes and the corresponding use of cap units.

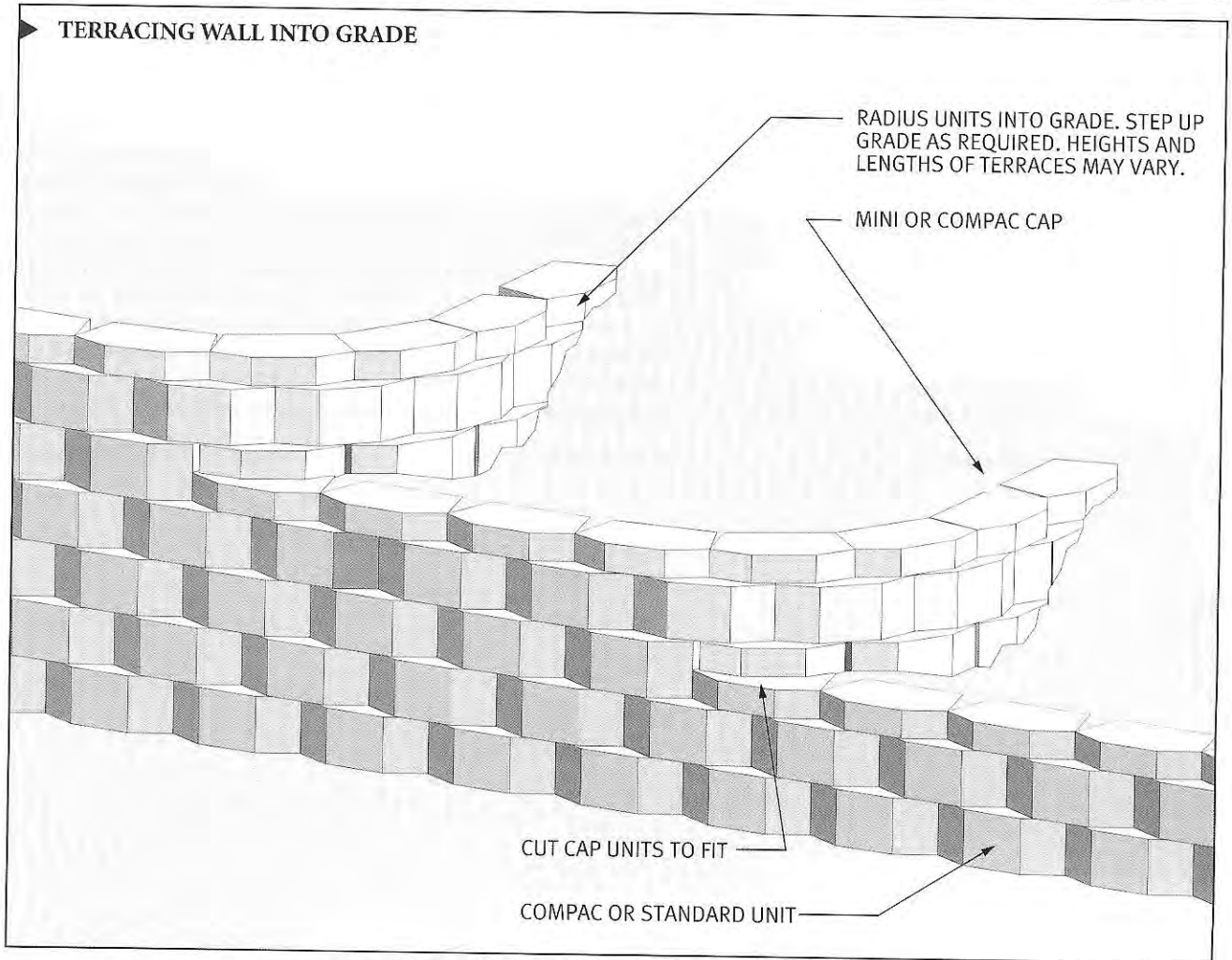
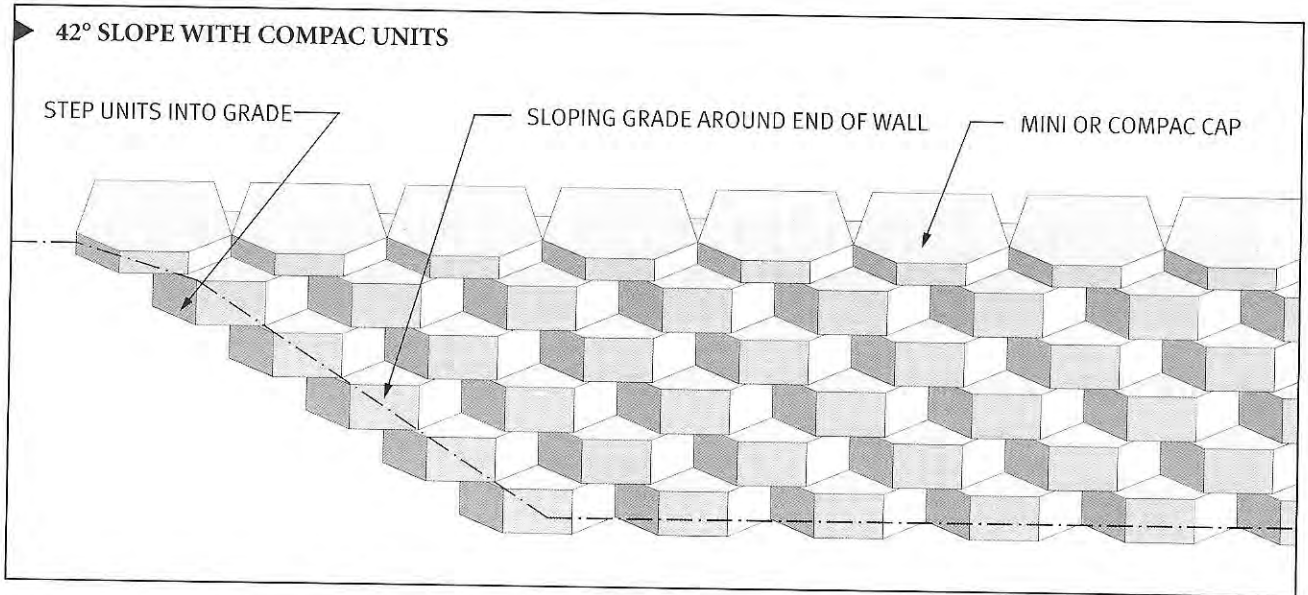


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

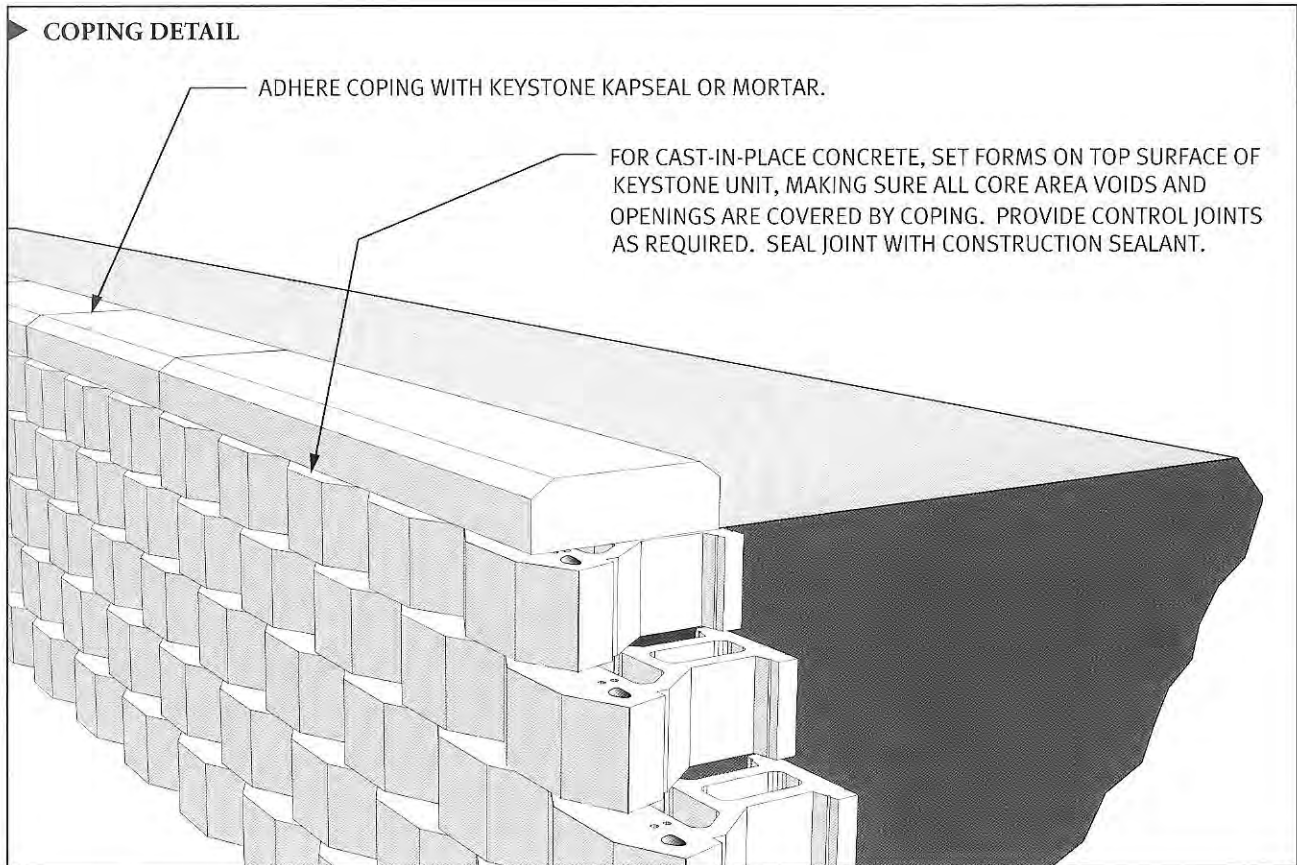
C A P P I N G & C O P I N G

▶ WALL TERMINATION DETAILS



C A P P I N G & C O P I N G

COPING OPTION FOR KEYSTONE WALL



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

BARRIERS

Traffic Barrier ◀

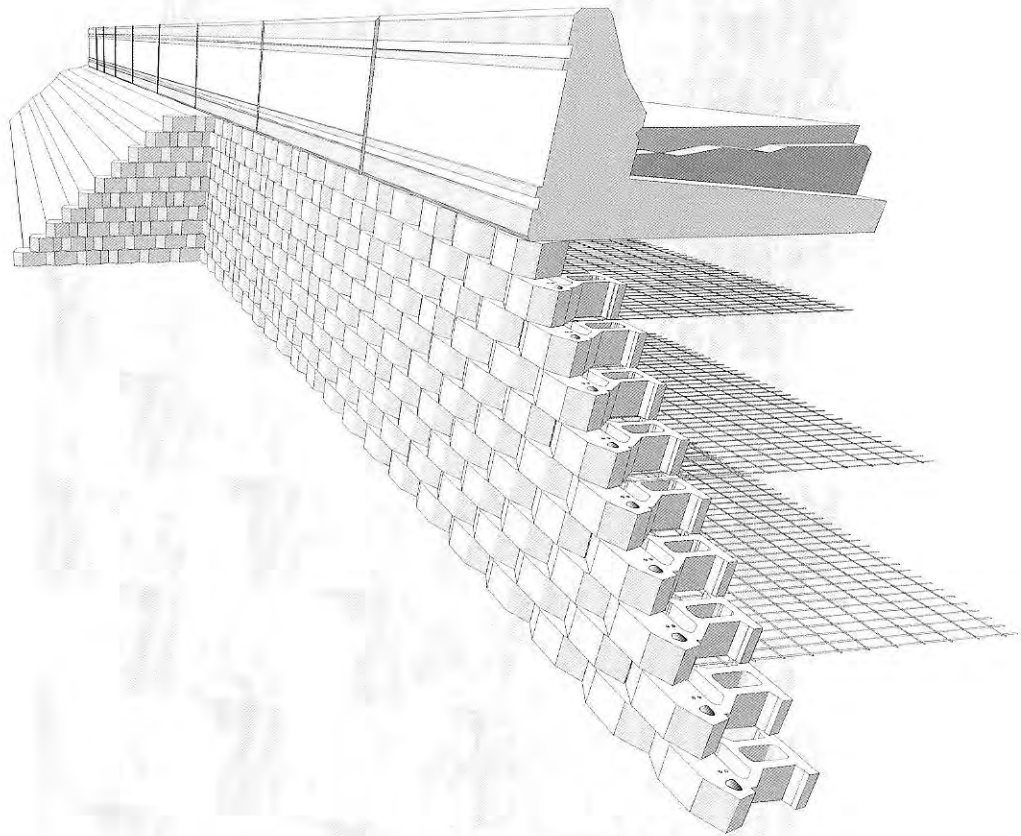
Guard Rails ◀

Fence With Metal Posts ◀

Fences Using the Sleeve-It™ System ◀

Barrier/Fence Rail Option ◀

Parapet Options ◀

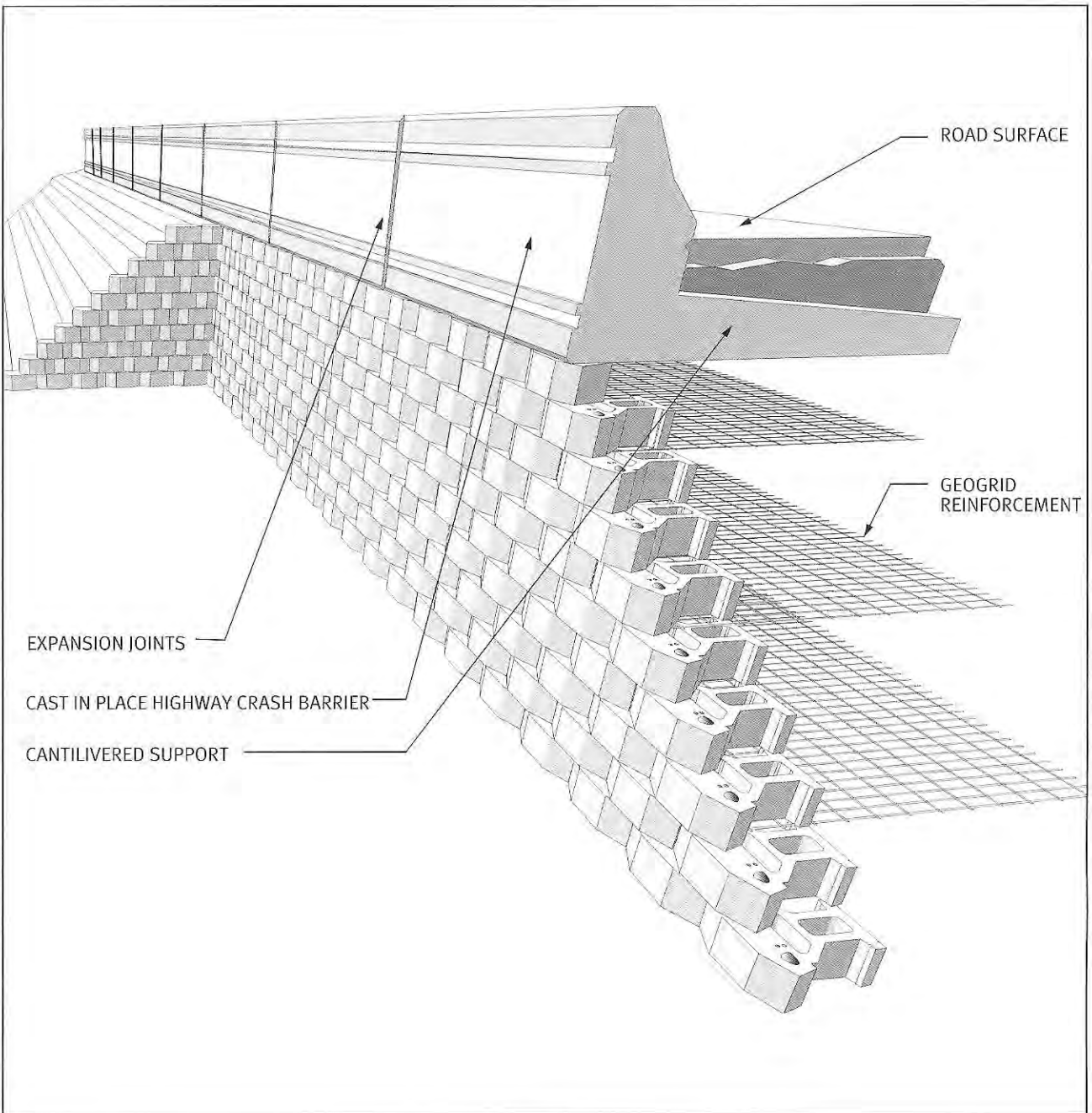


B A R R I E R S

TRAFFIC BARRIER ◀

Keystone® walls can readily be capped with a reinforced traffic barrier. Follow these procedures to install a poured concrete coping.

1. Install the Keystone® wall per general installation instructions.
2. Set and secure forming materials along the top course of the Keystone® wall using standard forming procedures. If the design requires an overhanging coping, form the edge using an "L" shaped galvanized iron or plastic forming material. Fasten this material to the top courses of the Keystone® wall. Pour and finish traffic barrier as by engineered design. Insert control joints at a maximum nine feet on center along the length of the coping, or as specified by engineer.

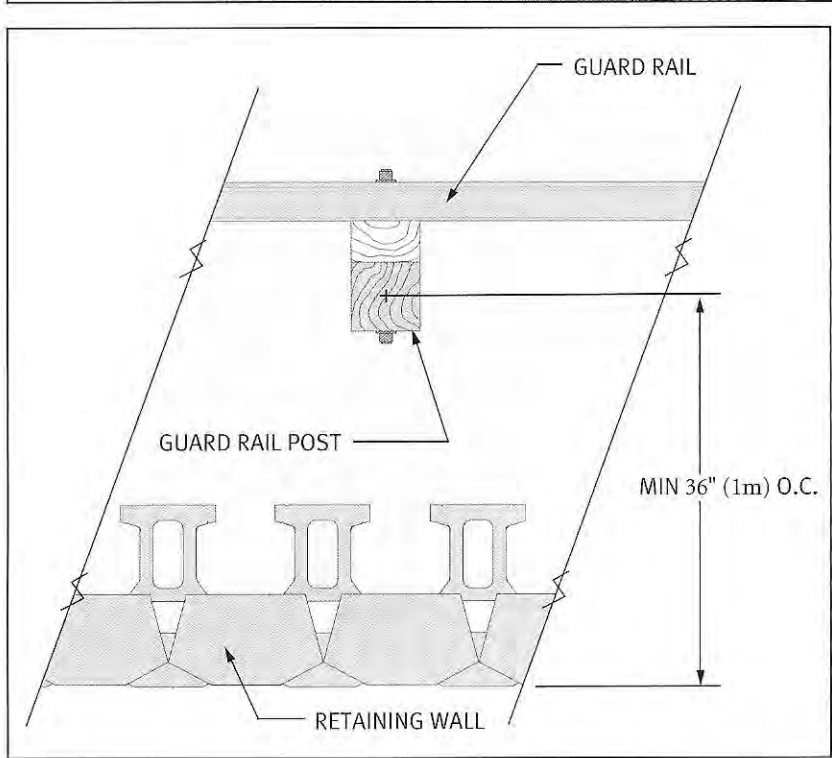
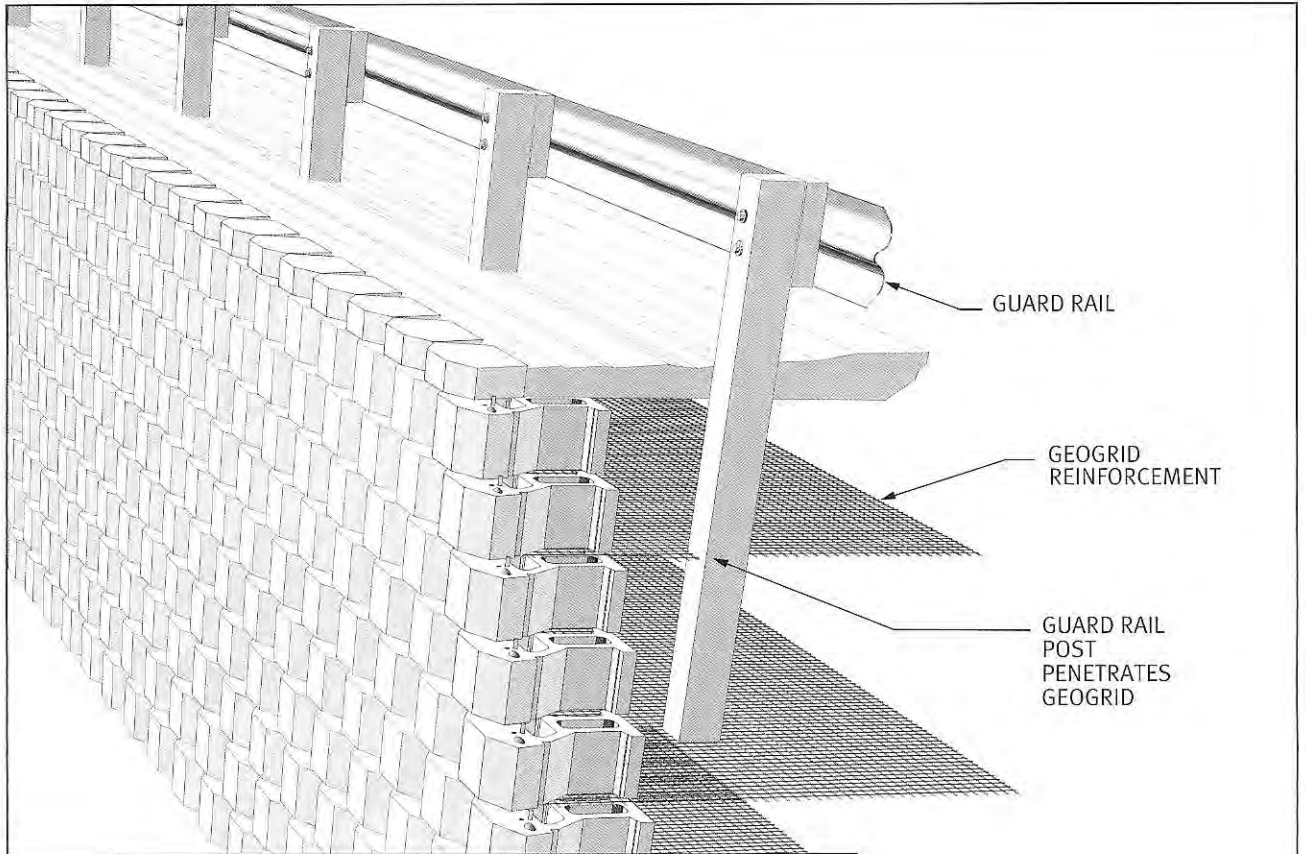


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

B A R R I E R S

► **GUARD RAILS**



Guard rails can easily be placed along the top of a Keystone® wall using standard procedures. Posts may be of wood or steel sections. Post positions should be a minimum of 36" (0.9m) behind the wall face to provide anchoring of post into the reinforced soil area. If the wall is reinforced with geogrid, the guard rail post may be placed by cutting holes in the geogrid layers as needed per the recommendations of the geogrid manufacturer. Typically, the project engineer will provide design recommendations for this detail.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

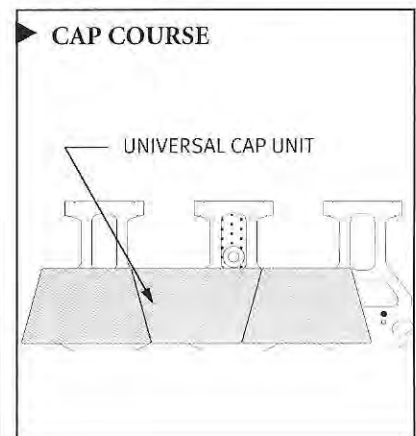
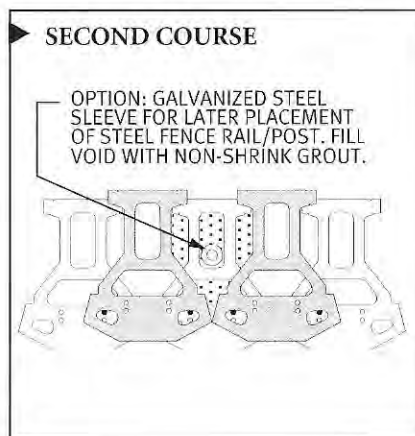
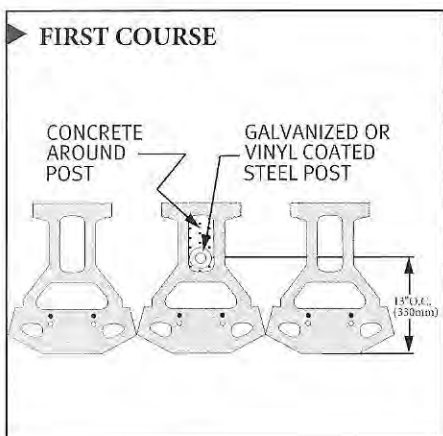
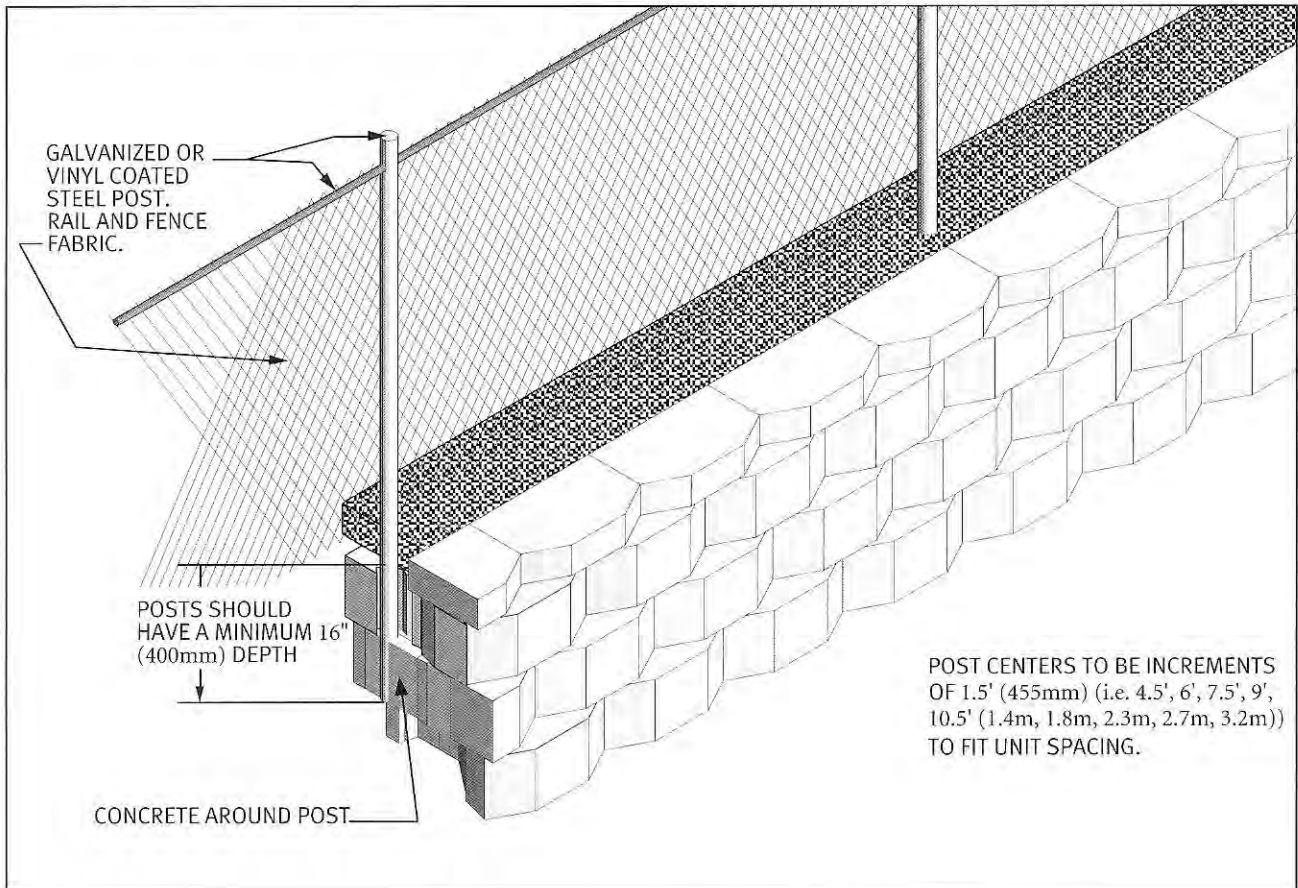
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

BARRIERS

FENCES WITH METAL POSTS

Fences can be placed at the top of a Keystone® wall with fence posts placed behind the Keystone® units. Follow these procedures for proper installation of fence posts.

1. Install the Keystone® wall per general installation instructions.
2. Fence posts positioned behind the Keystone® units may be installed and anchored using standard installation methods. This position is recommended for retaining walls constructed using the Keystone® Compac Unit. Posts would be placed by normal construction methods for anchoring. If the wall is reinforced with geogrid, the guard rail post may be placed by cutting holes in the geogrid layers as needed per the recommendations of the geogrid manufacturer.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

B A R R I E R S

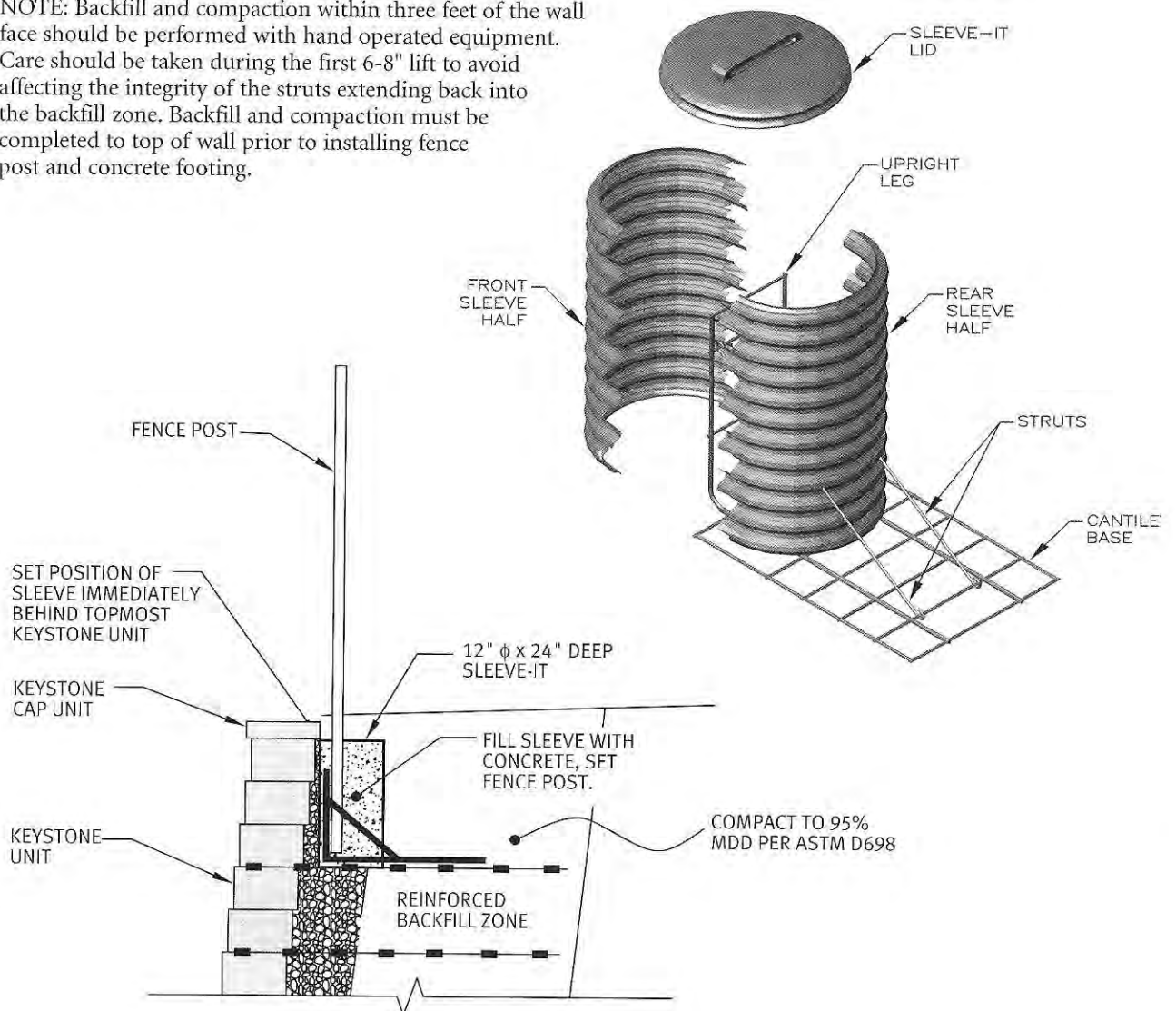
► FENCES USING THE SLEEVE-IT™ SYSTEM

Total's building codes require fencing behind most retaining walls. With the Sleeve-It™ System, fence integration problems are easily solved.

Features and Benefits:

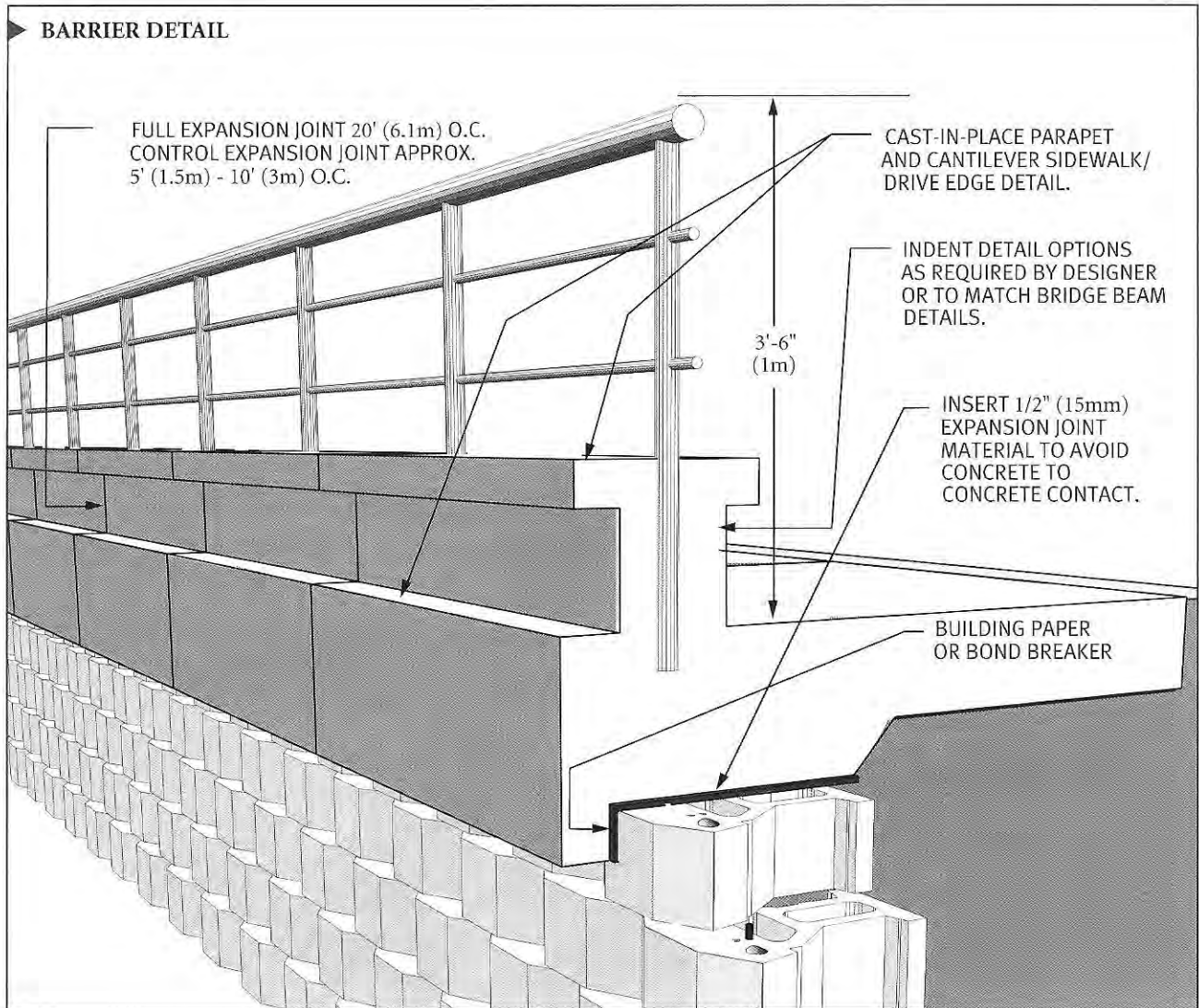
- Easy assembly and installation by wall installer eliminates schedule coordination with fence installer
- Universal sizes to accommodate all your fencing needs
- Engineered fence post foundation system designed to meet building code requirements
- System designed specifically to integrate with Keystone's® design and construction sequence
- Keeps fence contractor from tearing through geogrid layers and affecting integrity of wall system
- Placement of system in the 12" drainage layer allows backfill and compaction to proceed unobstructed

NOTE: Backfill and compaction within three feet of the wall face should be performed with hand operated equipment. Care should be taken during the first 6-8" lift to avoid affecting the integrity of the struts extending back into the backfill zone. Backfill and compaction must be completed to top of wall prior to installing fence post and concrete footing.



B A R R I E R S

BARRIER/FENCE RAIL OPTION

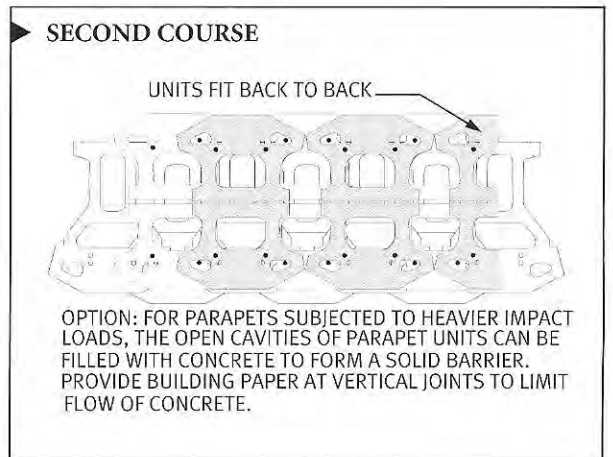
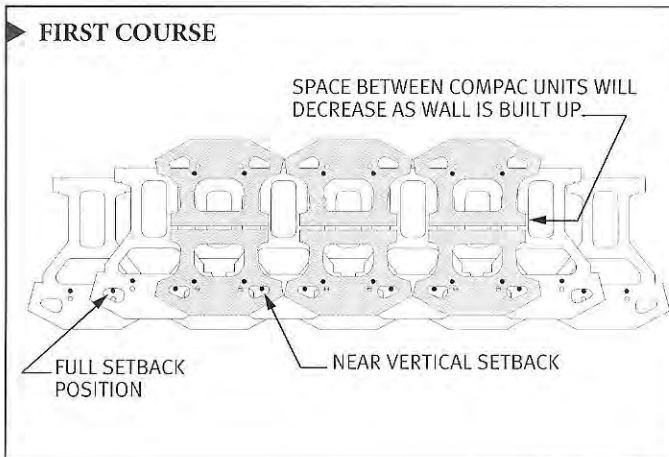
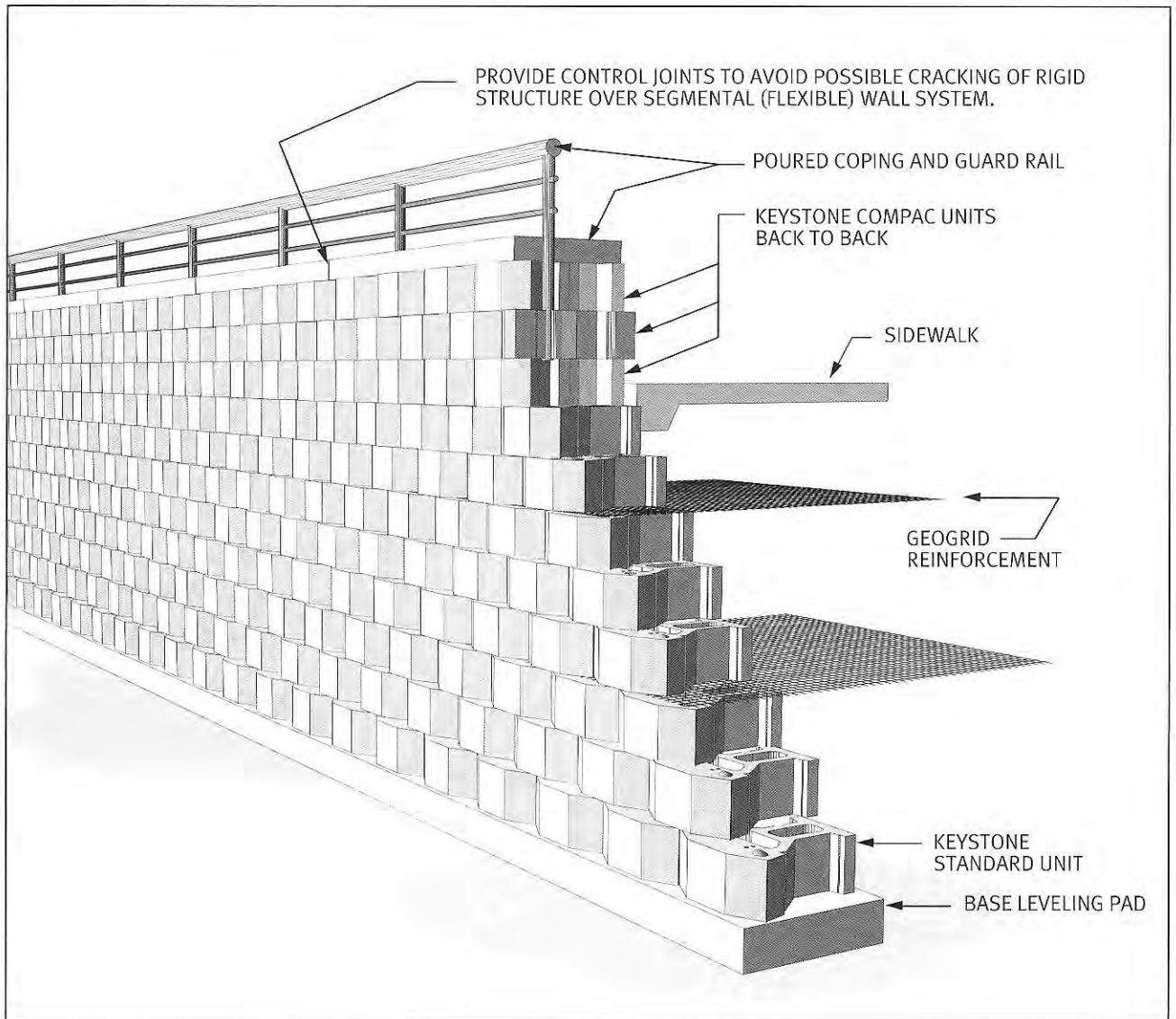


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

B A R R I E R S

► **PARAPET OPTIONS**

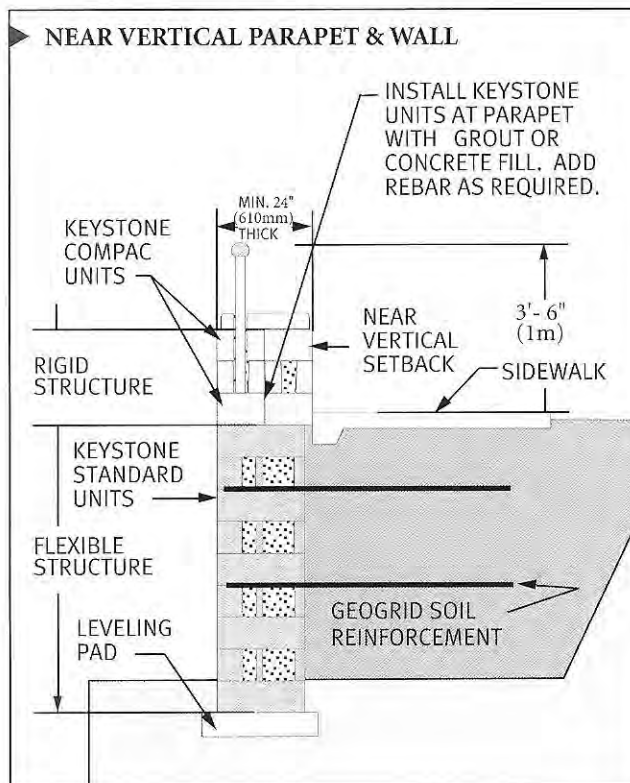
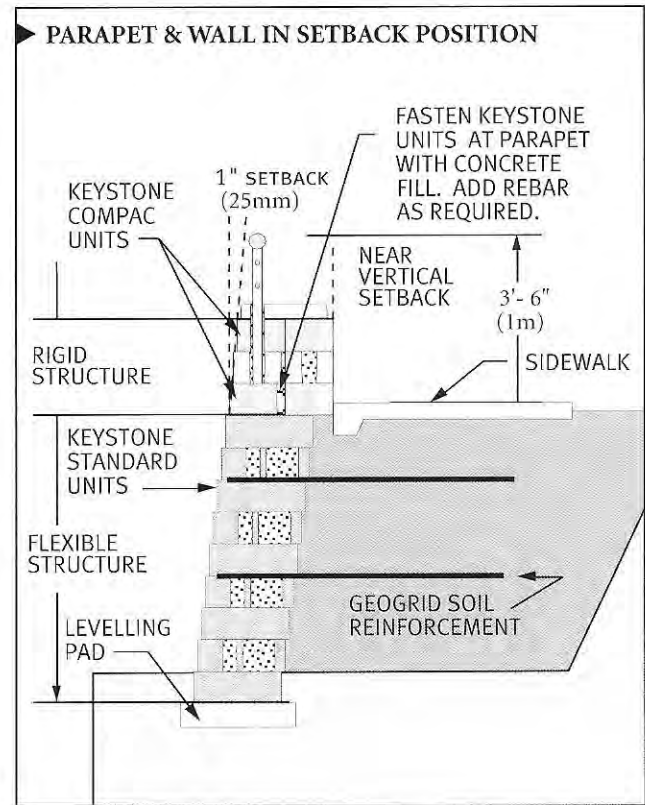
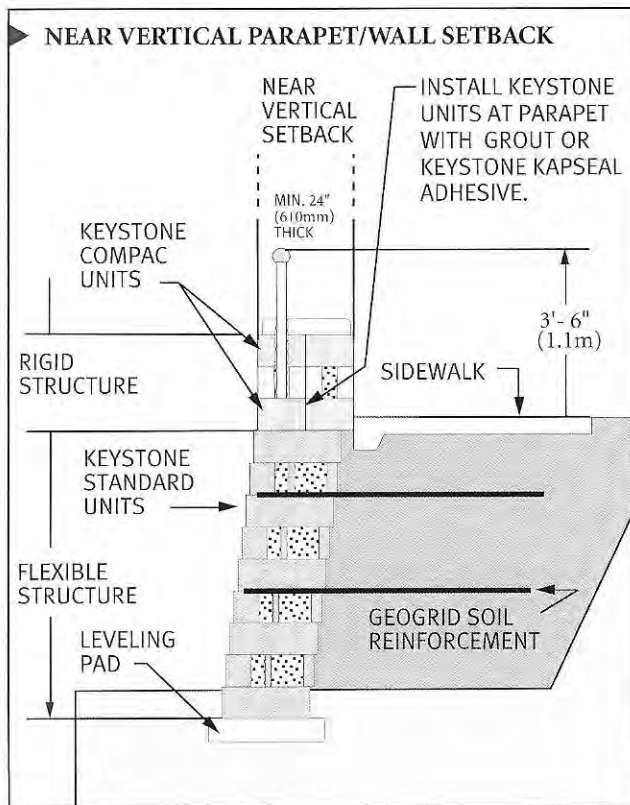


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

B A R R I E R S

PARAPET OPTIONS



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

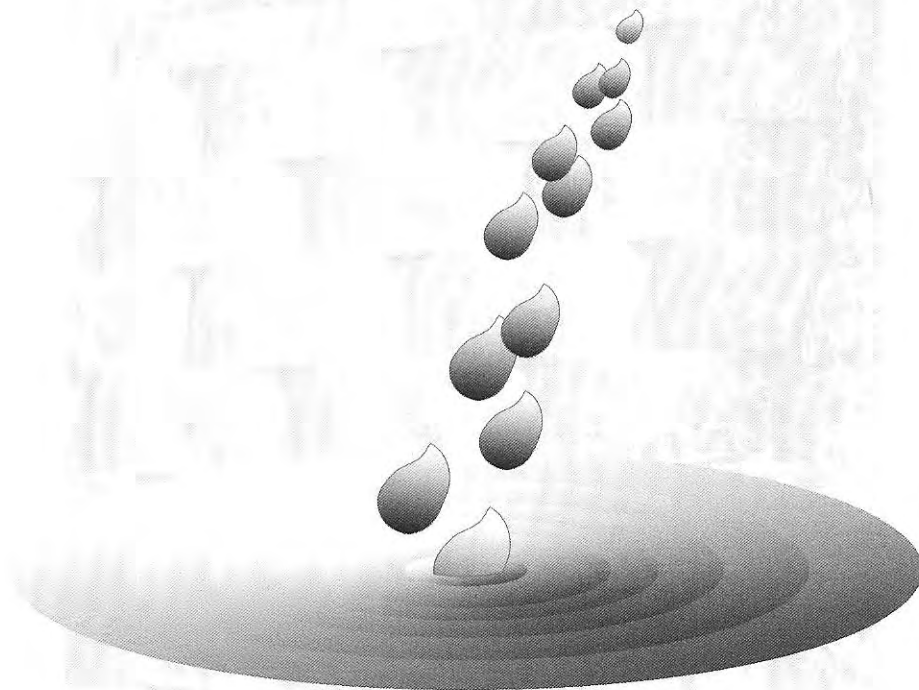
WATER AND DRAINAGE

Drainage Around Walls ◀

Water Applications ◀

Drainage Structures ◀

Water and Drainage Q & A ◀

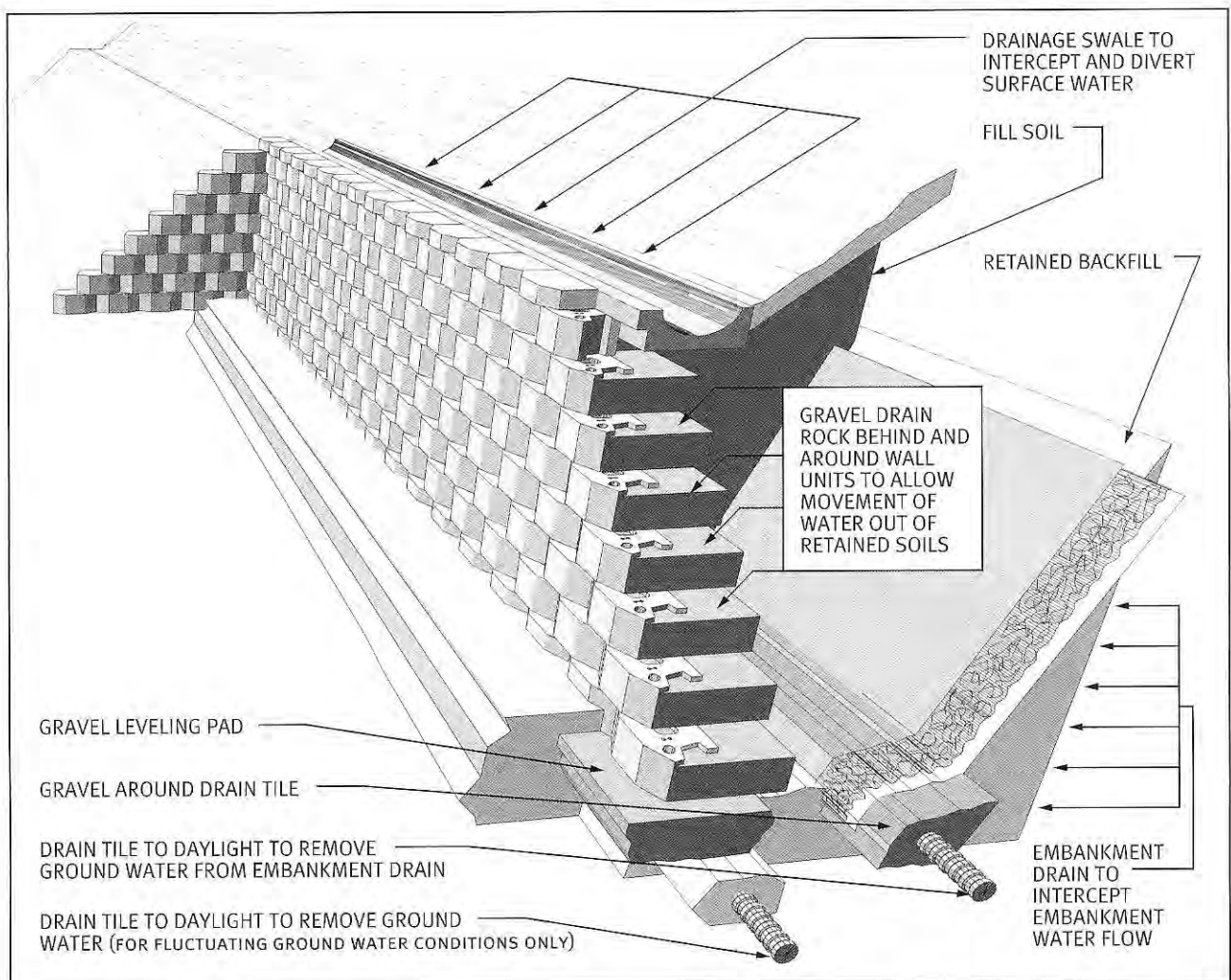


W A T E R A N D D R A I N A G E

DRAINAGE AROUND WALLS

Poor drainage is a leading cause of retaining wall failures. Hydrostatic pressure can accumulate behind a wall if drainage is inadequate and add an increased load on the wall. The Keystone® system has superior drainage features. The techniques below should be considered where the specified drainage issues are present.

1. **BASIC DRAINAGE.** Keystone's® mortarless, interlocking system, with a free draining gravel drainage zone and corefill (See "INSTALLATION STEP BY STEP" section), allow proper drainage under most circumstances. No weep holes are necessary.
2. **SURFACE RUN-OFF.** Divert surface drainage at the top of the retaining wall by placing a plastic soil cap (i.e. clay) or formed swale (i.e. soil or concrete) along the back surface of the Keystone® units. Direct run-off away from the reinforced wall structure where possible.
3. **EMBANKMENT FLOW.** When embankment ground water flow behind the wall is likely, place an embankment drainage membrane over the cut soil (see product suppliers for recommended coverage and installation instructions). The embankment membrane should drain to an outflow pipe (i.e. drain tile) to remove water. Numerous cost-effective products are available to serve this purpose.
4. **GROUND WATER FLOW.** The effects of seasonally fluctuating ground water at the base of the retaining wall can be offset by placing a drainage zone of gravel with an outflow pipe (i.e. drain tile) beneath the leveling pad.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.kestonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

W A T E R A N D D R A I N A G E

► WATER APPLICATIONS

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

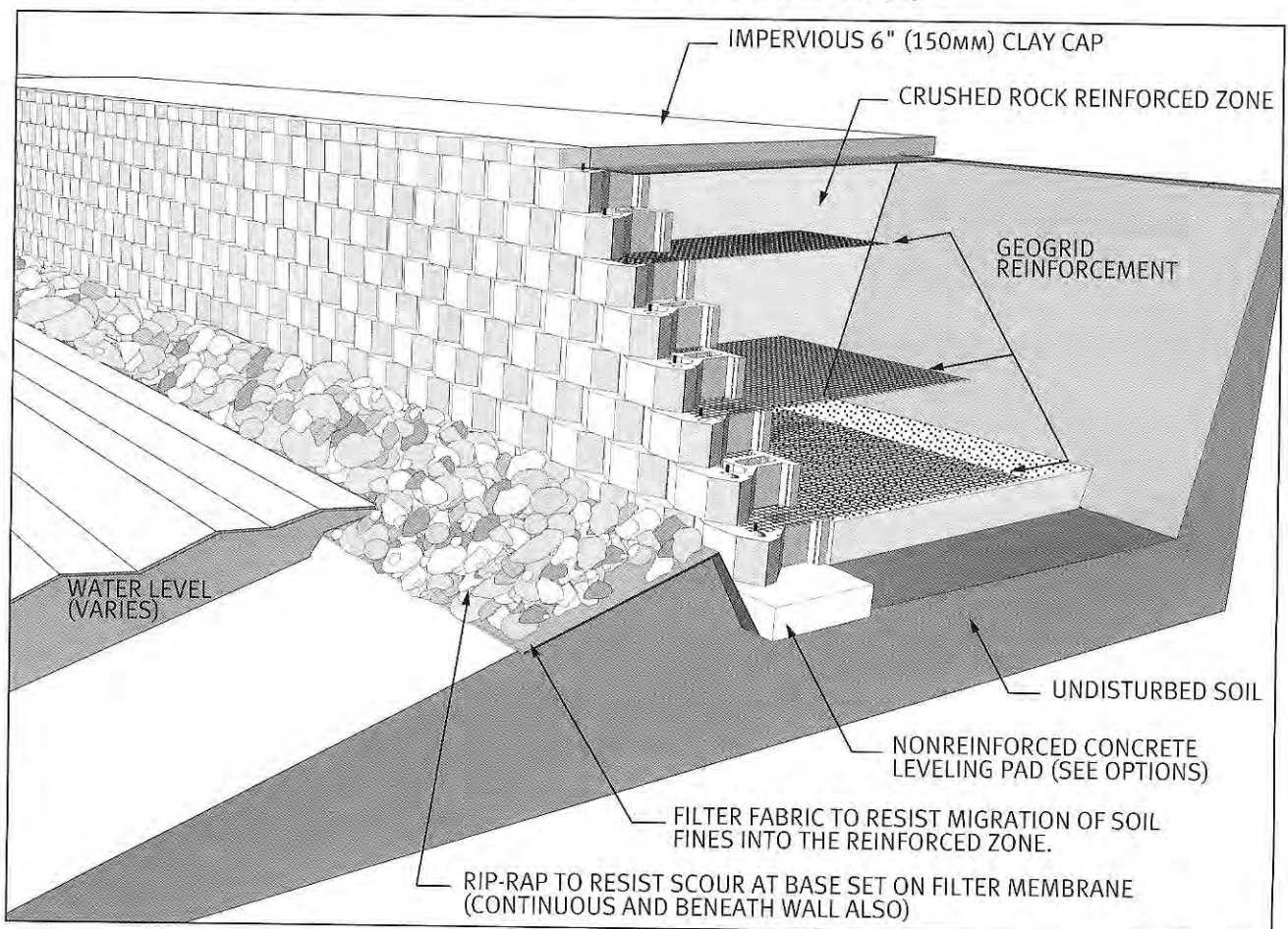
- Start by analyzing the wall under normal design criteria. (i.e. WALL HEIGHT, BASE CONDITIONS, SURCHARGE LOADS, SOILS DATA, REINFORCEMENT REQUIREMENTS, DRAINAGE, ETC.)
- Determine the water level on wall under normal and adverse conditions.
- Determine flow rate for streams, channels, etc.
- Determine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

Once these items have been evaluated, design options to handle these conditions can be selected.

CONDITION: Soft base soils subject to settlement and erosion.

OPTIONS: A foundation mattress constructed of filter membrane, crushed stone and geogrid reinforcement will support wall and reinforced zone over soft base conditions. Filter membrane prohibits migration of fines into stone of mattress area. The mattress is free draining and resists erosion from under the wall. This solution also permits construction where base of wall is below the water elevation (See detail on following page).

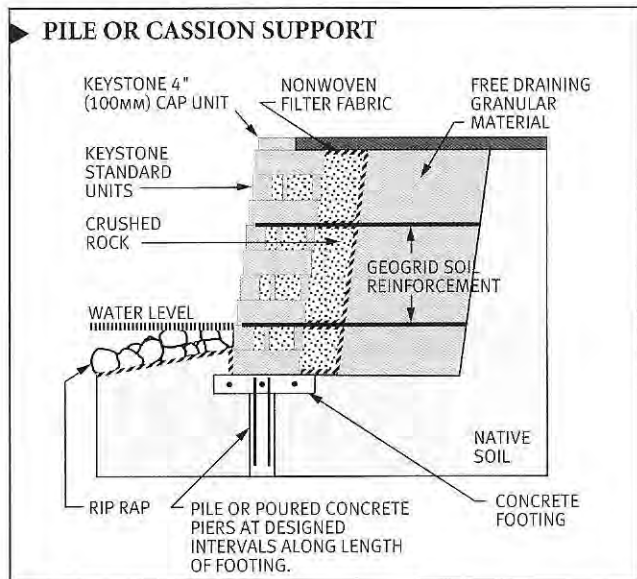
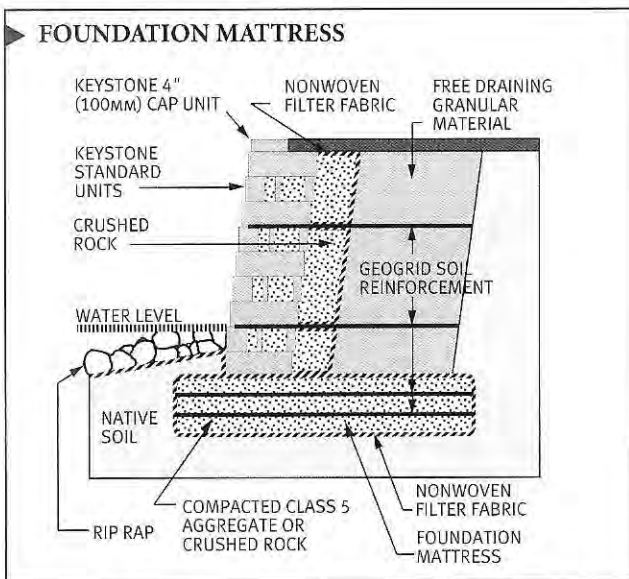
In more extreme conditions, a continuous reinforced concrete footing may be required to avoid settlement. This can be additionally structured to combine with pile or concrete cussions for support by more capable soils at a deeper elevation (See detail on following page).



W A T E R A N D D R A I N A G E

WATER APPLICATIONS

- CONDITION:** Scour potential at toe of wall due to water flow and wave action.
- OPTION:** The use of natural stone rip rap on a filter membrane is a possible solution depending on degree of flow and wave action. Distance out from wall toe and size of rip rap will be determined by degree of water flow.
- In more extreme cases, the use of cable tied articulated concrete revetment systems along the sloped base and beneath the wall can resist the heavy water flow and wave action (See detail below).
- CONDITION:** Rapid draw down after flooding or waves going over wall and adding hydrostatic surcharge to wall loading.
- OPTION:** Design using hydrostatic loads as well as normal loads in determining the reinforcement requirements. Use free draining crushed stone in reinforced zone to permit rapid outflow of water through the wall. Provide filter membrane on top of reinforced zone below turf soils or clay cap to allow drainage without migration of organic fines into free draining reinforced zone crushed rock (See detail on previous page).

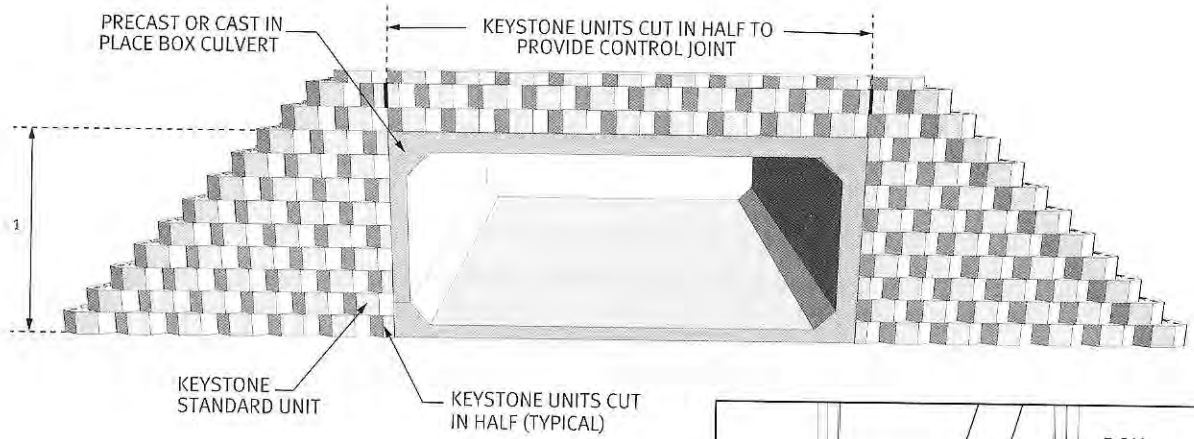


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

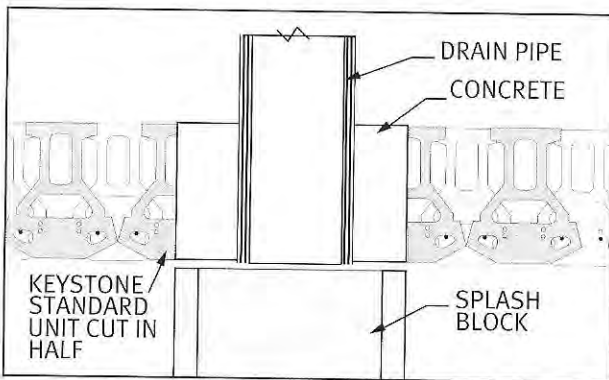
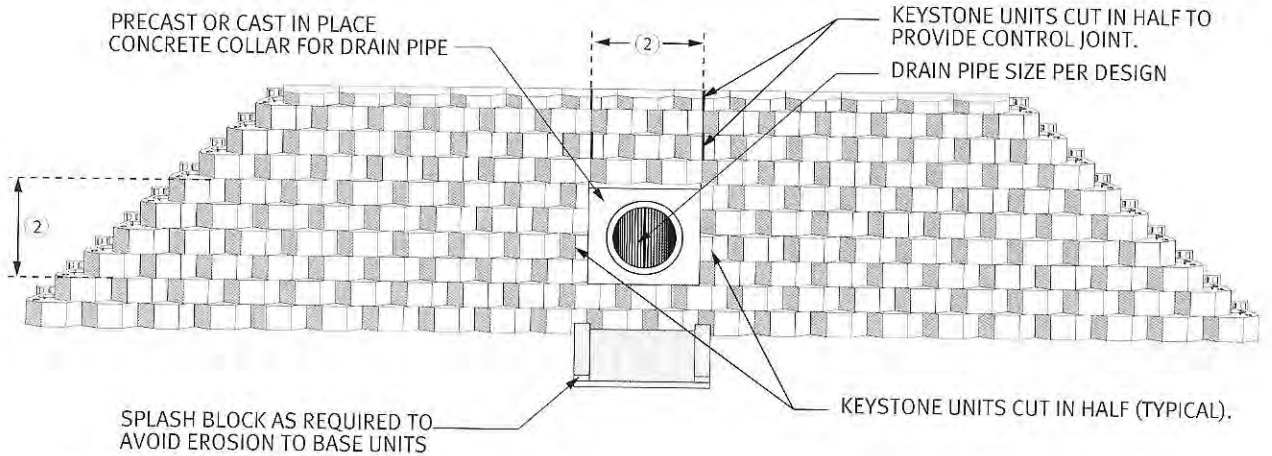
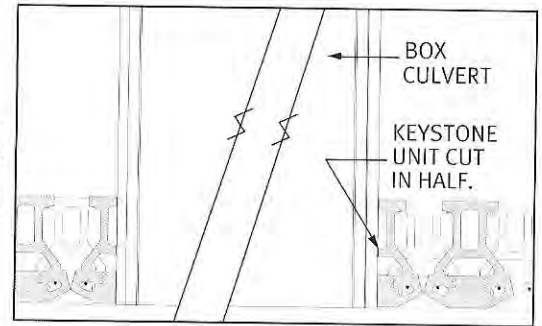
The Information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

W A T E R A N D D R A I N A G E

► **DRAINAGE STRUCTURES**



① NOTE: Design of box culvert with Keystone® Retaining Wall units works best if culvert height is in even 8" (200mm) increments to line up with Keystone® coursing and width aligns with full increments of Keystone® units (18")(455mm). Pre-plan courses to make sure course on top of drainage structure is a full unit.



② NOTE: Design of drain pipe with Keystone® Retaining Wall units works best if culvert height is in even 8" (200mm) increments to line up with Keystone® coursing and width aligns with full increments of Keystone® units (18") (455mm).

OPTION: On smaller scale drainage structures, the designer or contractor may choose to field cut the Keystone® units to conform to the shape of the pipe. Voids between units and pipe can be filled in with mortar or sealant material.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

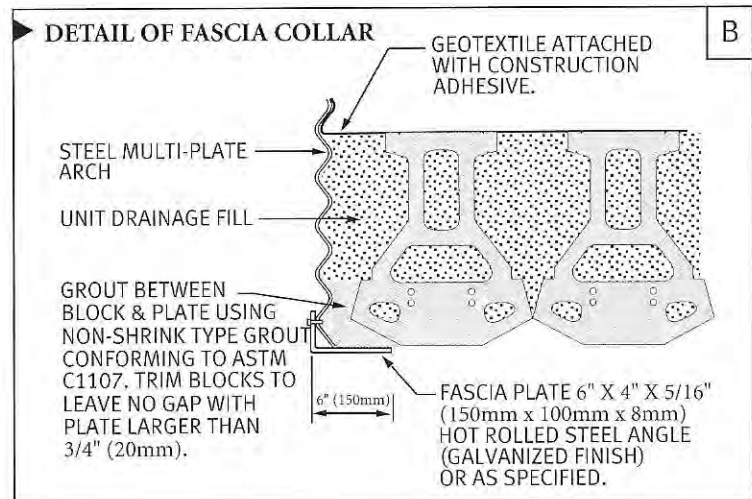
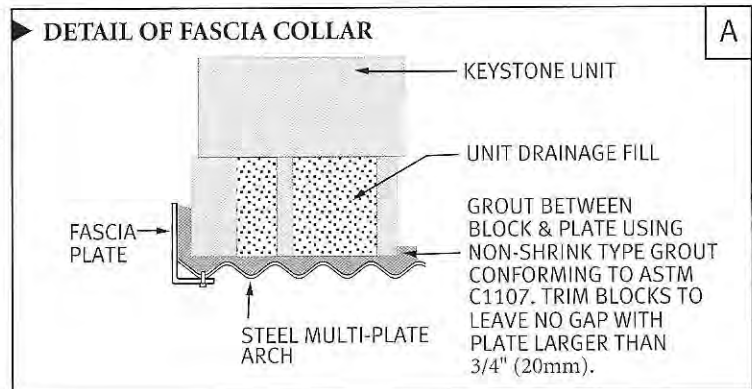
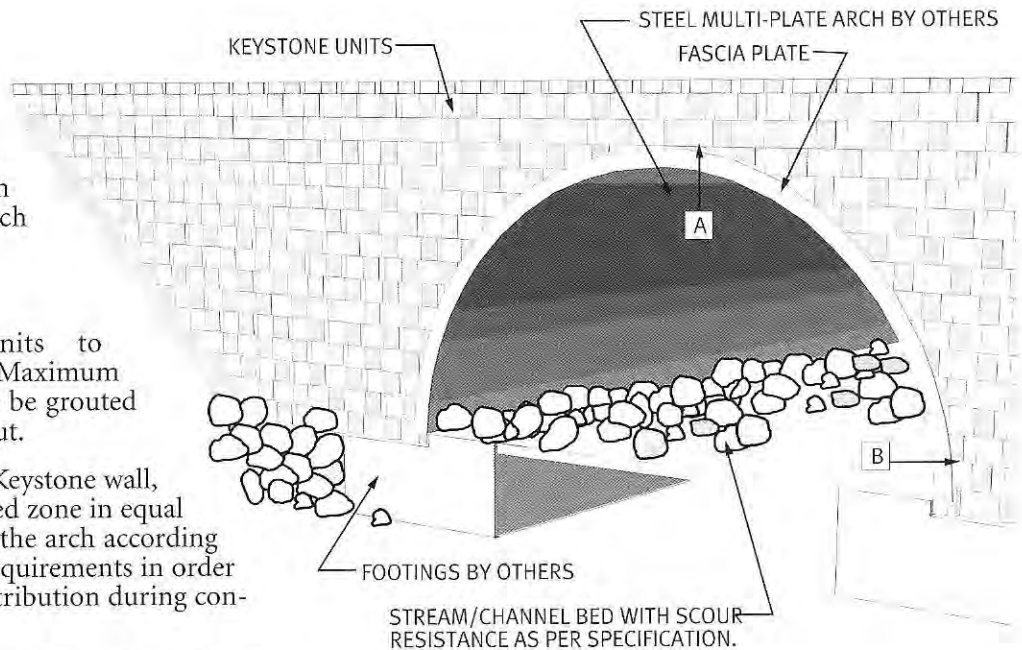
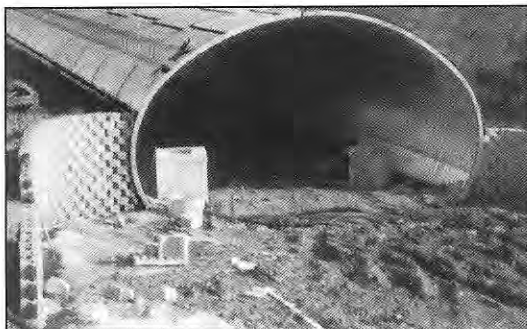
WATER AND DRAINAGE

DRAINAGE STRUCTURES

Keystone Retaining Walls are an ideal system for economical and effective use with steel multi-plate arch design:

INSTALLATION:

- ▶ Cut Keystone units to conform to arch. Maximum gap 3/4" (15mm) to be grouted with low shrink grout.
- ▶ When building the Keystone wall, backfill the reinforced zone in equal lifts on each side of the arch according to manufacturer's requirements in order to even out load distribution during construction.
- ▶ Measure for exact course height and unit bonding on each side of arch so they meet correctly at top of arch.
- ▶ Fascia collar of hot rolled steel angle section will help conceal rough cut Keystone edges and give an aesthetically appealing final finish.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

W A T E R A N D D R A I N A G E**▶ QUESTIONS & ANSWERS****DRAINAGE STRUCTURES**

QUESTION:	<i>When building around a structure or culvert, how do I know if the courses will match on top?</i>
ANSWER:	Make sure that your Keystone units on either side of the culvert are at the same elevation and in an increment of 18" (457mm) apart. Depending on the distance, you may want to allow a 1/4" (6mm) or more for adjustments. When you get to the top, you may need to use mortar or grout on top of the culvert structure to continue the course of units across at the proper elevation. Also, it is important to create a cold joint at each side of the culvert to allow for differential settlement possibilities from the culvert on a rigid foundation to the Keystone on a flexible foundation.
QUESTION:	<i>When cutting for a round culvert or multi-plate arch, is it necessary for the whole Keystone unit to remain intact, and what is the best way to secure the unit?</i>
ANSWER:	On many cuts, it is nearly impossible to keep the whole unit intact (i.e. having small pieces of units). After the cut has been made, pin the unit if possible and apply a liberal amount of Keystone KapSeal™ adhesive to secure. It is also important to use additional clean rock fill behind these units to ease compaction efforts, provide additional drainage, and to prevent fine material from migrating through any existing gaps. An additional solution is to design in a collar for the front edge of the culvert or multi-plate in order to conceal visually the construction joint where the Keystone units are cut to fit the curved structure.

MISCELLANEOUS DETAILS

Lighting Options ◀

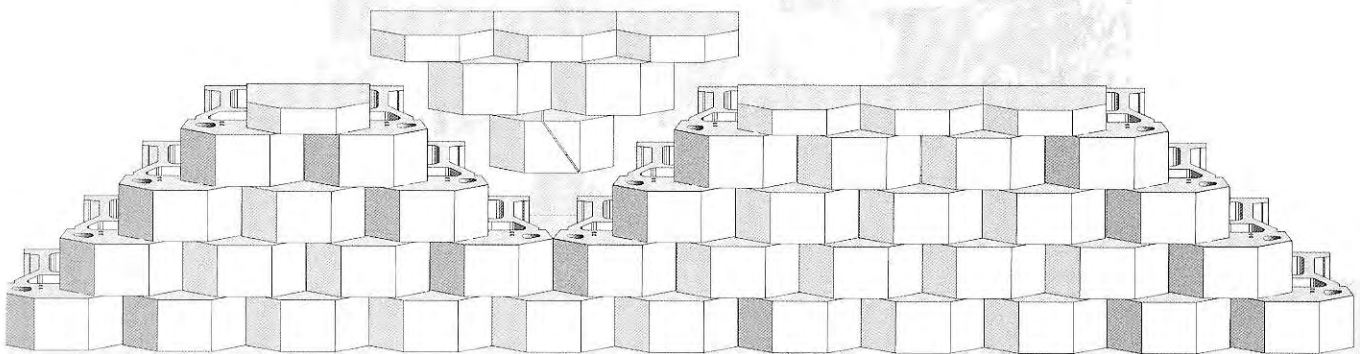
Creative Options ◀

Wall Repair ◀

Tree Planting Detail ◀

Terrace Applications ◀

Miscellaneous Q & A ◀



M I S C E L L A N E O U S D E T A I L S**LIGHTING OPTIONS** ◀

Light fixtures can add a dramatic affect to the nighttime aesthetics of the KEYSTONE Retaining Wall System. Light can be used to wash the wall surface with distinctive shadows and highlights on the sculptured rockface texture.

By placing light fixtures in the wall as shown in these details, pathway and stairway lighting can be achieved for illumination and safety/security at pedestrian walkways.

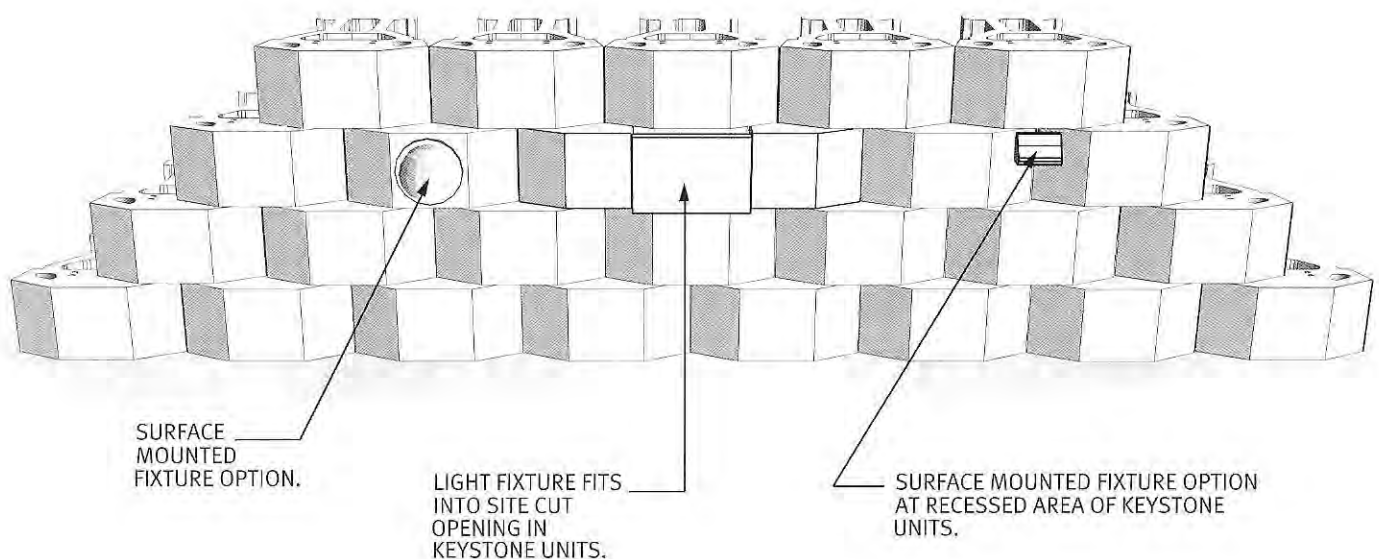
OPTIONS:

- ▶ Light fixtures can be conveniently placed into the Keystone® wall by cutting the Keystone® concrete units with a mason saw. It is best to size the fixture to fit within the unit vertical height space of 8" (200mm). Width may vary up to a maximum 12" (305mm) wide. Electrical connection should be supplied from behind the wall using industry standard exterior use circuit and wiring. Locate supply wiring for potential maintenance and service needs (See details on following page).
- ▶ Wall fixtures can be surface mounted onto the face of the Keystone® wall if desired. A convenient method is to provide a smooth surface using a mechanical grinder if the Keystone® Unit does not have a manufactured smooth surface. Drill hole for wiring from face of unit into unit cavity (See Surface Mounted Fixture Detail).
- ▶ Washing the Keystone® wall in light can be accomplished by using ground mounted landscape light fixtures shining towards the wall.

LENS OPTIONS:

- ▶ **DOWN LOUVER:** Hides light source and directs light where desired along the pathway, wall or stairway.
- ▶ **TINTED:** Adds color accent or minimizes source light.
- ▶ **TRANSLUCENT OR CLEAR (no louver):** Light source glare potential when light shines from wall toward object.

NOTE: For convenience of maintenance or service, run wiring below grade at minimum depth (follow electrical industry standards) directly behind the KEYSTONE units to location above light fixture for vertical drop and connection.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

M I S C E L L A N E O U S D E T A I L S

► **LIGHTING OPTIONS**

► FIXTURE IN CUT POCKET

ELECTRICAL CONDUIT OR UNDERGROUND FLEXIBLE CABLE AS PER ELECTRICAL STANDARDS FOR EXTERIOR USE.

LIGHT FIXTURE TO MEET REQUIREMENTS FOR EXTERIOR USE. CUT KEYSTONE UNITS WITH MASON SAW TO FIT FIXTURE. IDEAL DIMENSIONS- 8" (200mm) MAX. HEIGHT, 12" (305mm) MAX. WIDTH.

LIGHT FIXTURE FITS INTO SITE CUT OPENING

8" (200mm) MAX. HEIGHT

12" (305mm) MAX. WIDTH

ELECTRICAL CONDUIT OR FLEXIBLE CABLE (EXTERIOR USE).

► SURFACE MOUNTED FIXTURE

SEALANT AT JOINT AS REQUIRED FOR WEATHER PROTECTION.

LIGHT FIXTURE MOUNTED INTO RECESSED AREA OF KEYSTONE UNITS.

LOW VOLTAGE FIXTURE OPTION.

LIGHT SHINES DOWN ON FACE OF WALL.

► SURFACE MOUNTED FIXTURE

DRILL THROUGH UNIT FROM FACE TO CAVITY THEN RISE VERTICALLY TO MAIN HORIZONTAL RUN.

PROVIDE SMOOTH SURFACE FOR MOUNTING WITH MASONRY ANCHOR SCREWS OR ADHESIVE.

PROVIDE SMOOTH SURFACE FOR MOUNTING.

SURFACE MOUNTED FIXTURE.

M I S C E L L A N E O U S D E T A I L S

CREATIVE OPTIONS ◀

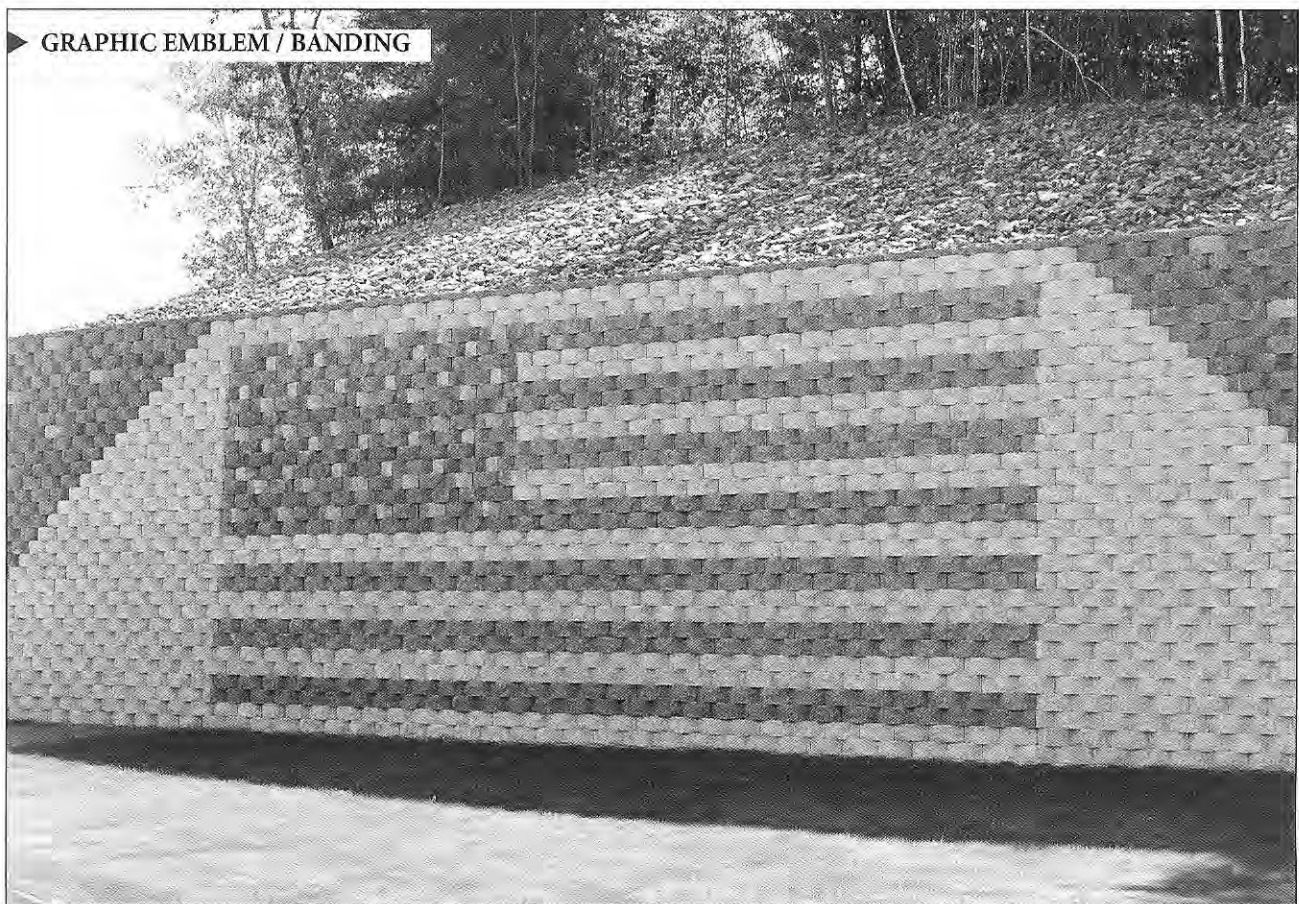
As a distinctive detail to any retaining wall, the Keystone® Retaining Wall System allows for creative options in color or texture geometries in the wall.

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

Additional options:

- ▶ Mixture of units of different heights. (i.e. 8" (200mm) & 4" (100mm) combinations)
- ▶ Specific graphic emblem. (i.e. State shape logo - Texas, Illinois, etc.)
- ▶ Various bonds (Flemish), diagonal bars, geometric repeats, horizontal bands, stairstep bands, etc.

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

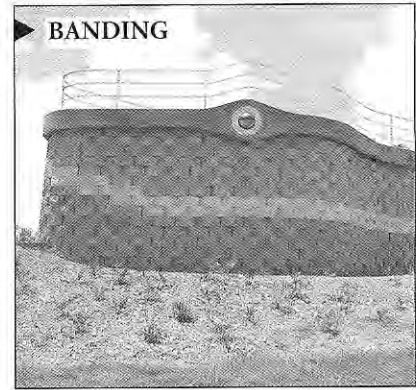
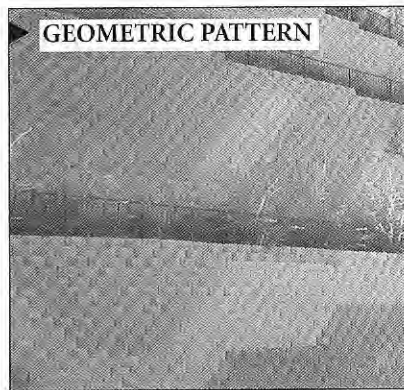
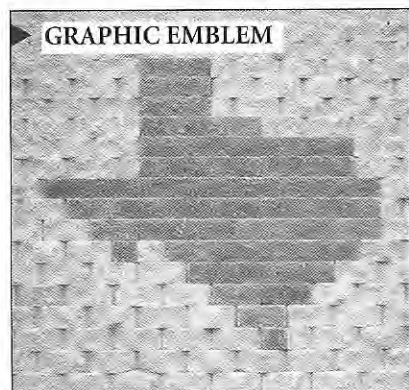
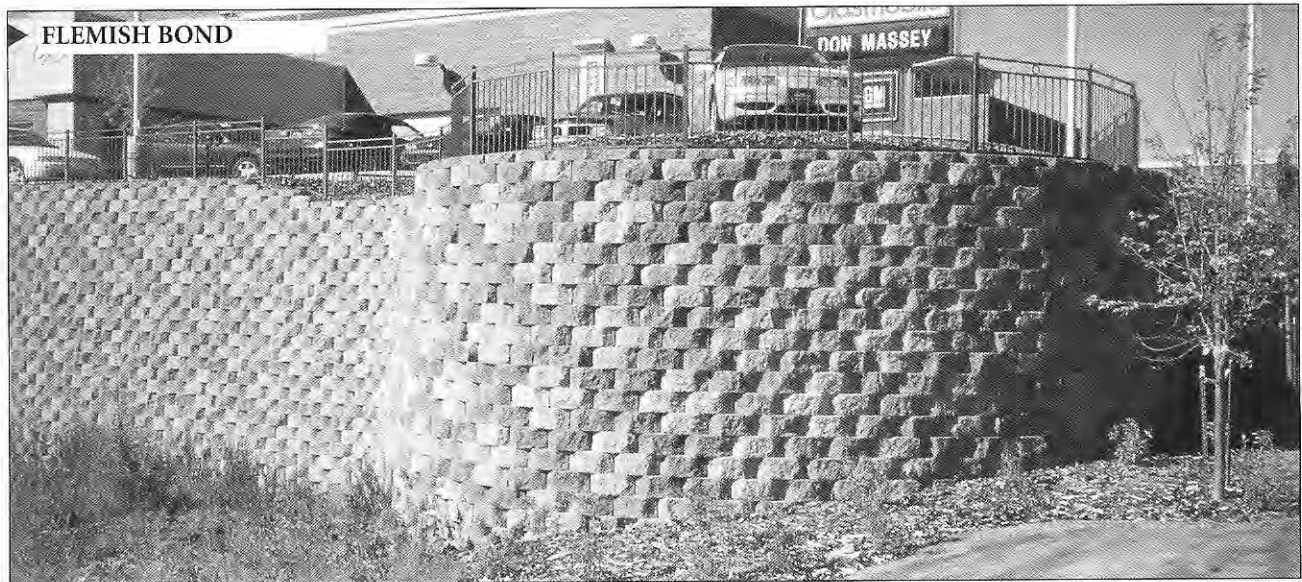
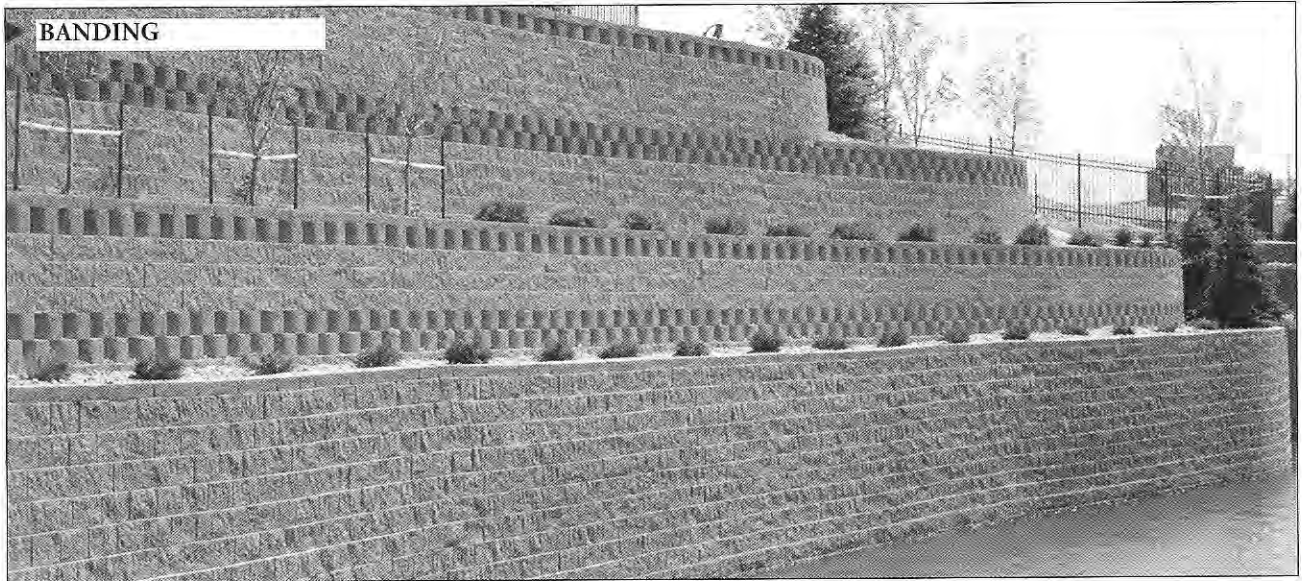


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

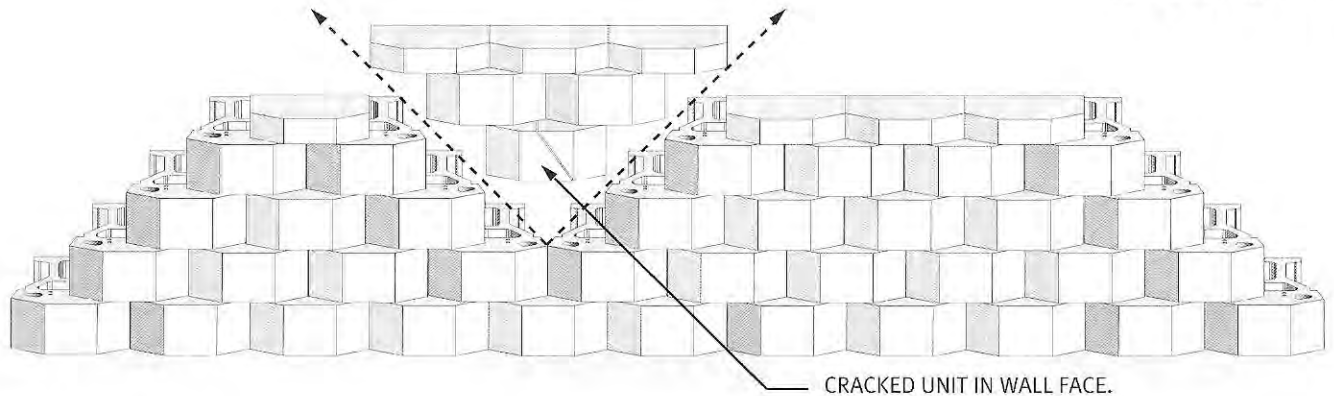
M I S C E L L A N E O U S D E T A I L S

▶ CREATIVE OPTIONS



M I S C E L L A N E O U S D E T A I L S

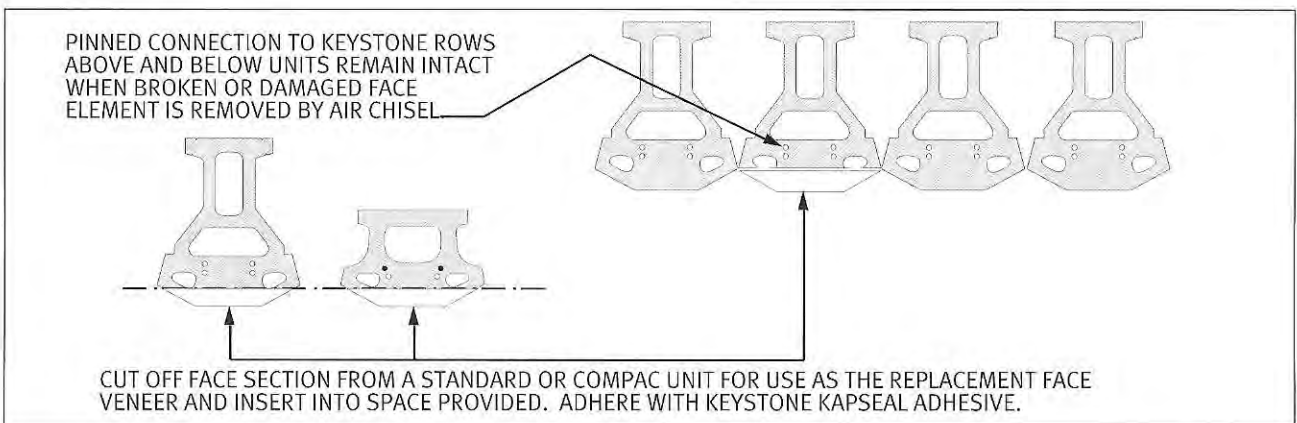
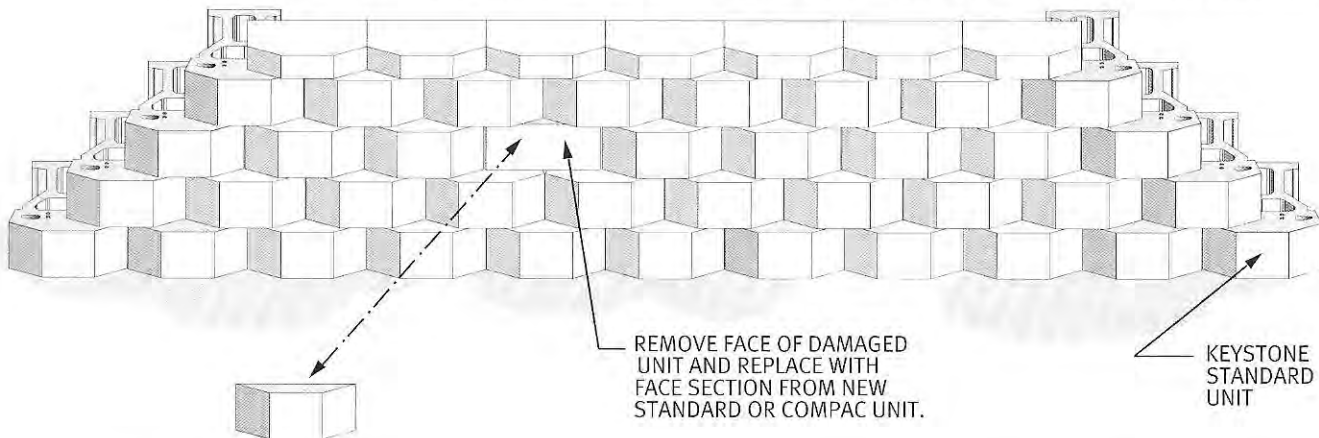
WALL REPAIR ◀



PROBLEM: Damaged or cracked unit in wall.

SOLUTION:

- ▶ For minor cracks, fill opening with construction epoxy and dust lightly with concrete material of similar color. Use a ground up piece from another Keystone® unit.
- ▶ For low height walls, dismantle units down to broken unit(s), replace with new unit(s). Rebuild wall placing core-fill and backfill with necessary light compaction until capping of wall as shown in above detail.
- ▶ For taller walls or where it is not practical to dismantle the wall, follow steps shown in the details below.
Note: Solution allows wall to remain intact. Wall structure with geogrid soil reinforcement is not interrupted.

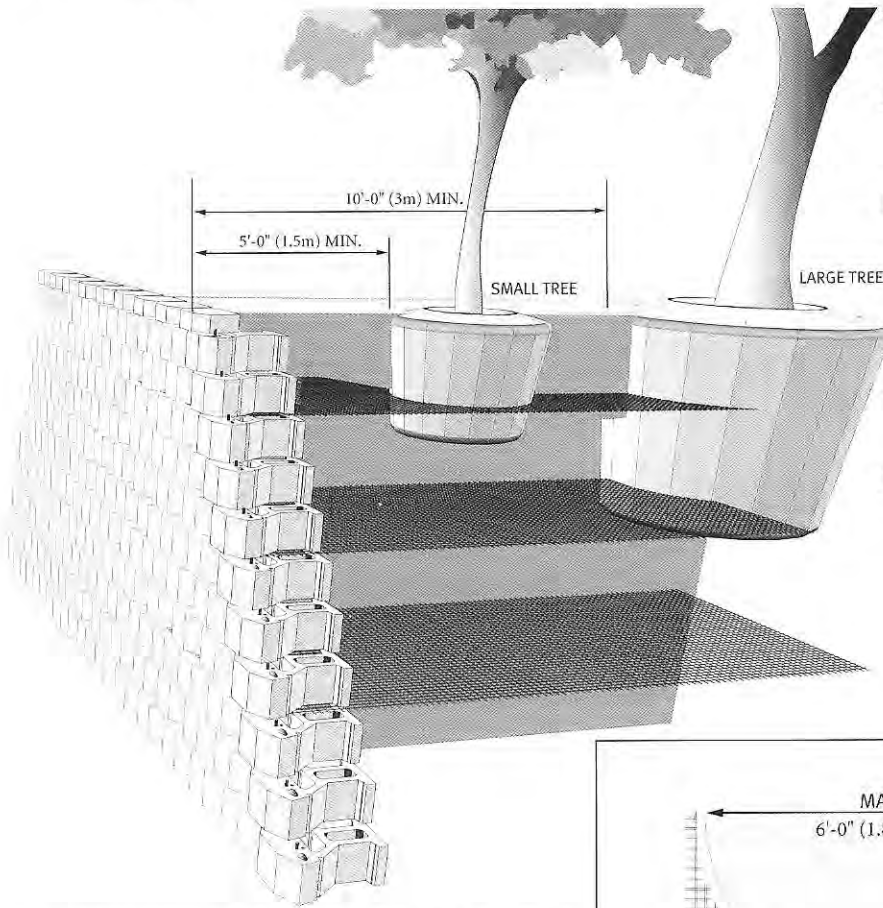


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

MISCELLANEOUS DETAILS

▶ TREE PLANTING DETAIL



NOTES:

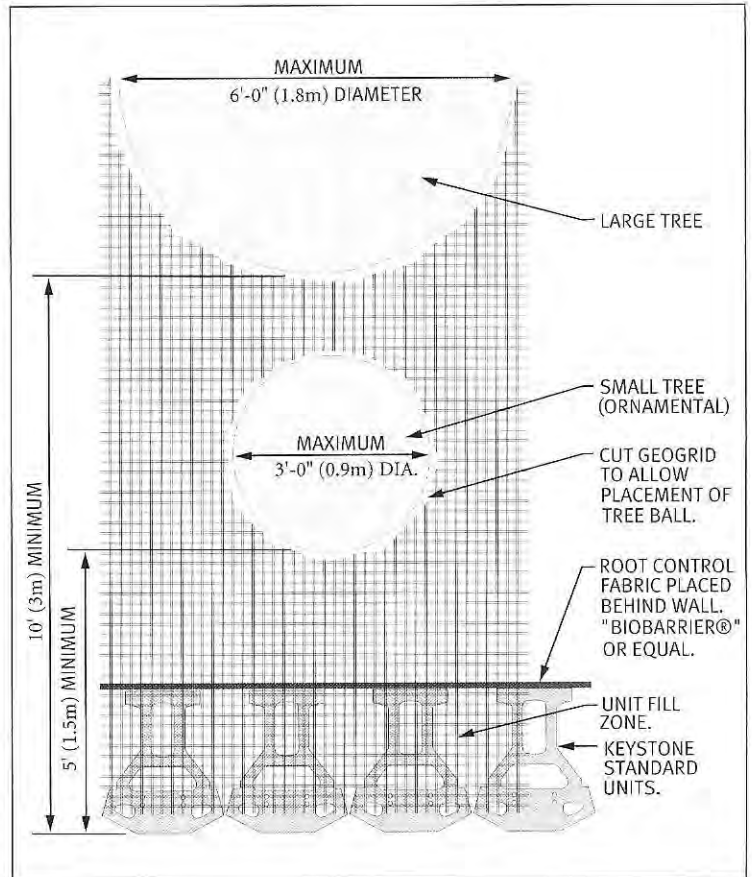
- ▶ Only top two layers of geogrid should be cut to allow planting of tree ball.
- ▶ Uniform geogrid layers may be interrupted periodically with openings for trees. If trees are spaced closely together and cutting of geogrid becomes excessive, consult with your Keystone® representative.
- ▶ Cut holes cleanly in geogrid for root ball.
- ▶ This process can work for small shrubs as well. In most cases, shrub root balls typically will not be deep enough to affect the first layer of geogrid.

Planting trees or shrubs behind the Keystone® wall can be accomplished with a few simple considerations.

- ▶ Plant small ornamental trees approximately 5'-0" (1.5m) minimum from face of wall to avoid root growth into drainage zone or surcharge loading developed by wind load acting on the tree.
- ▶ Plant large trees approximately 10'-0" (3m) minimum from face of wall.
- ▶ Utilize a root control barrier as required to avoid root pressures or growth thru the Keystone concrete units.

NOTE: If root growth pushes on Keystone wall during growth life of tree, Keystone units can be dismantled and relocated if property limits permit.

- ▶ If the design includes irrigation lines, locate these lines directly behind wall units. In this location, if there is a break in the line, the water will be noticed on the wall face and the path of excess water will be draining through the wall versus saturating the reinforced fill zone and adding hydrostatic load to the wall.

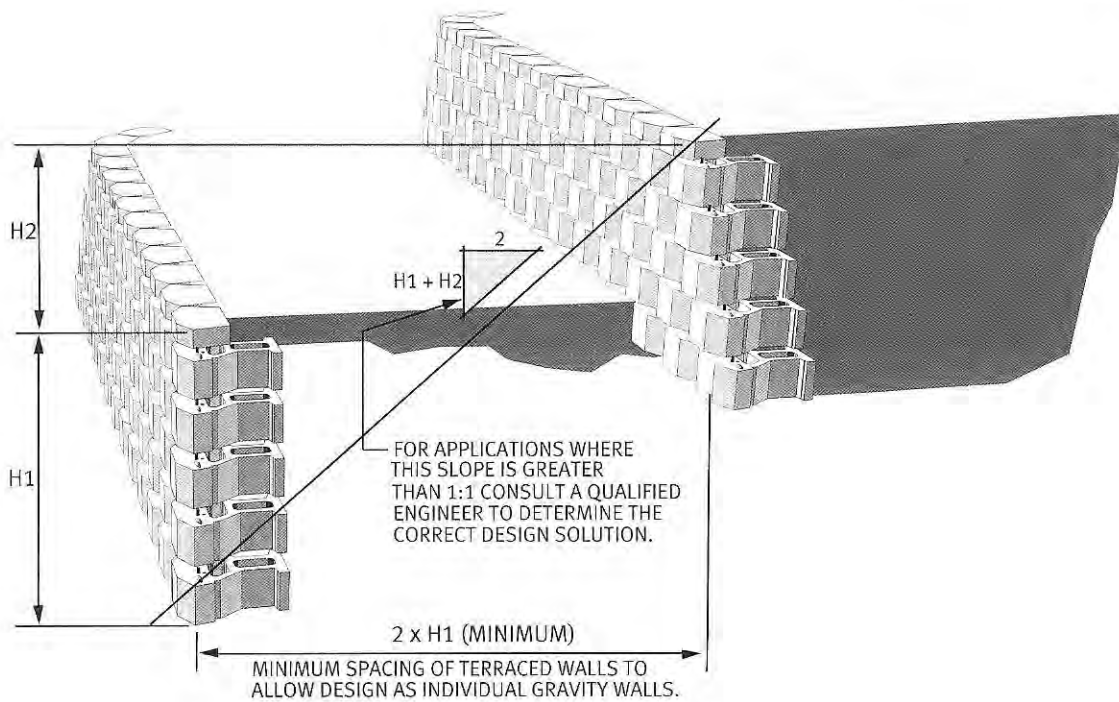


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
 Minneapolis, Minnesota
 (952) 897-1040
 (952) 897-3858-fax
 www.keystonewalls.com

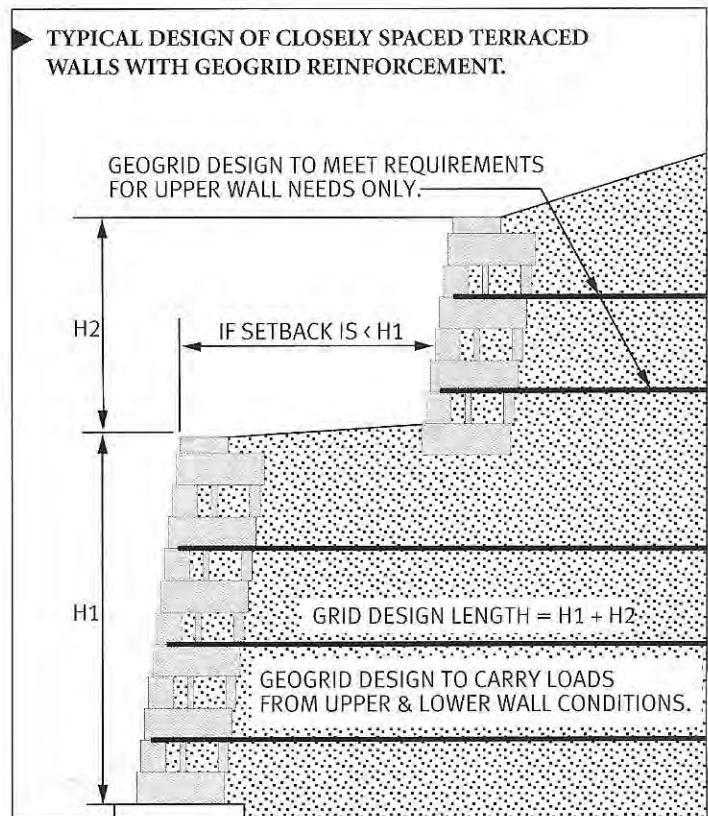
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

M I S C E L L A N E O U S D E T A I L S

TERRACE APPLICATIONS



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



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

M I S C E L L A N E O U S D E T A I L S

► QUESTIONS AND ANSWERS

TERRACES	
QUESTION:	<i>When building gravity walls with terraces, what is the recommended distance between the terraced walls where the upper wall does not affect the loading condition on the lower wall?</i>
ANSWER:	The distance between terraces (face of wall to face of wall) should be greater than or equal to two times the lower wall height. Typically this can also work for lower height soil reinforced walls. With higher reinforced walls or walls built on a slope, the issue of global stability must be considered by a qualified engineer in analyzing the terrace situation.
QUESTION:	<i>What are the recommended methods to avoid settlement when building a wall that has terraces converging into a single wall?</i>
ANSWER:	If at all possible, build on bench cut virgin soil conditions. If this is difficult to achieve, the next best solution is to build the base course of the terrace as it approaches the single wall, to a deeper elevation (either stepping down to the same level as the single wall or to virgin soil at a higher elevation). This provides for a deeper and more stable base condition.
QUESTION:	<i>How far apart do the terrace walls have to be to perform as individual gravity walls?</i>
ANSWER:	As a rule of thumb, the minimum distance between the wall terraces must be at least equal to twice the height of the lower wall.
EXAMPLE:	If the lower gravity wall is 5 feet (1.5m) tall, then the minimum recommended spacing between terraces is 10 feet (3m). This rule also applies to walls with more than two terraces. The distance between any two terraces must be at least equal to twice the height of the lower adjacent terrace wall. Note: This simple rule of thumb does not address global stability where walls are built on steep slopes or over poor soils of low friction strength. If these conditions exist, then contact your local Keystone representative or a local engineer.
QUESTION:	<i>What if there isn't enough room to space the terraces according to this rule? (2 x H1 MIN.)</i>
ANSWER:	The wall can still be built, but the effect of the upper terrace on the lower terrace and overall stability must be taken into account when designing the wall(s). When the terraces are close together, the design analysis may model the structure as a single taller wall to account for the added load from the upper terrace wall on the lower wall(s).

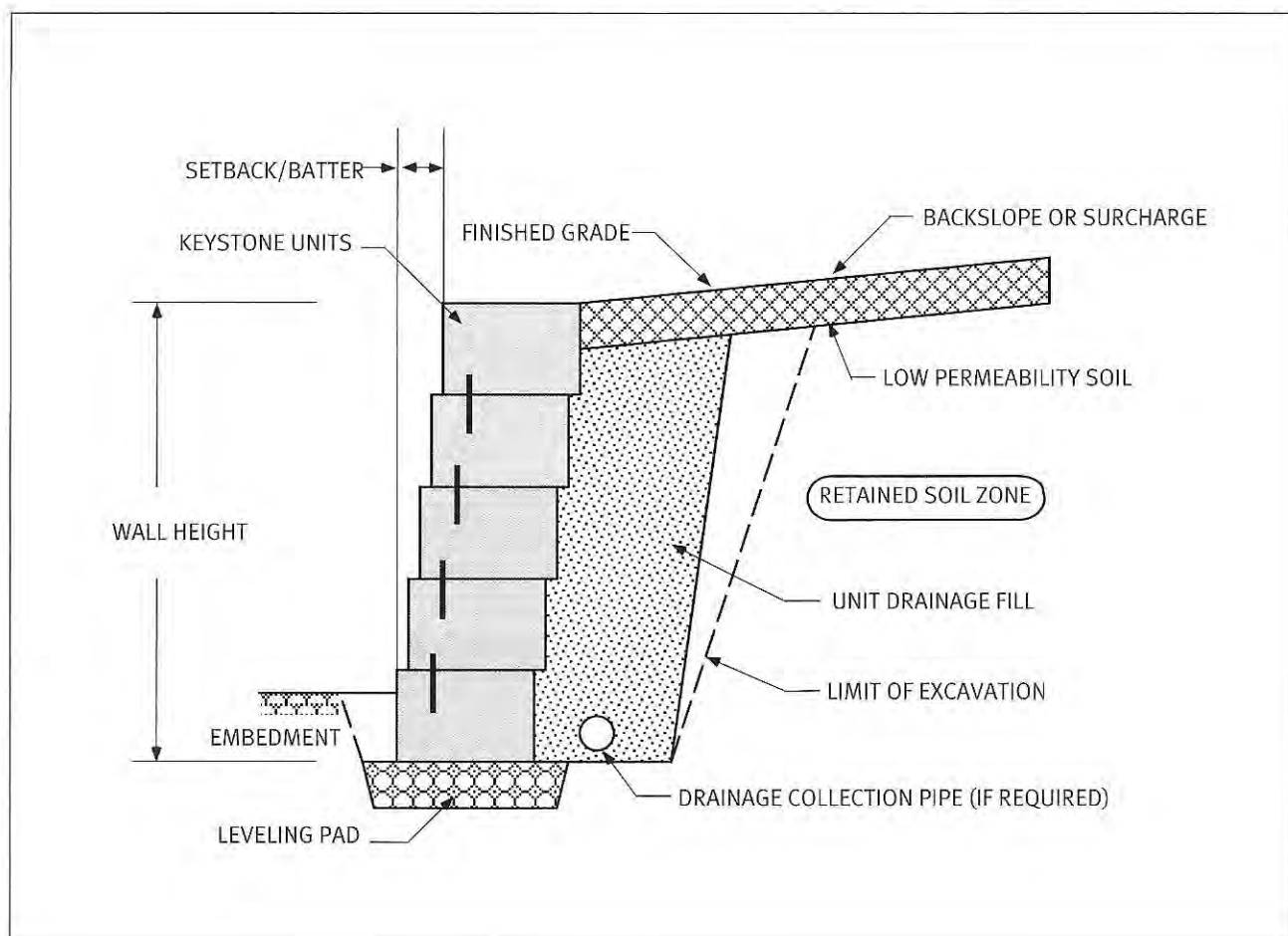


DESIGN CHARTS

J

DESIGN CHARTS

GRAVITY WALL SCHEMATIC

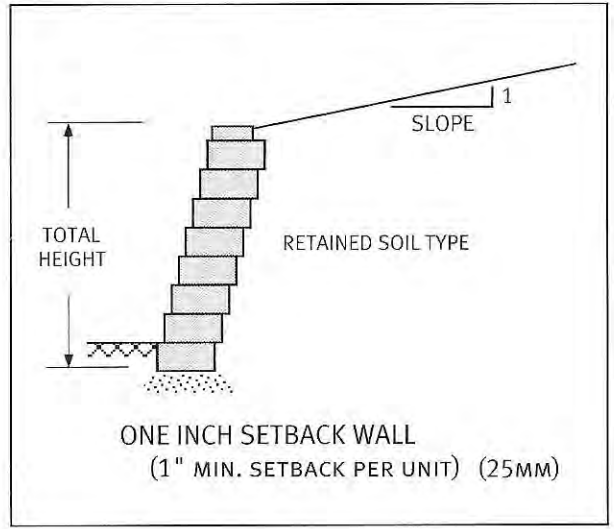
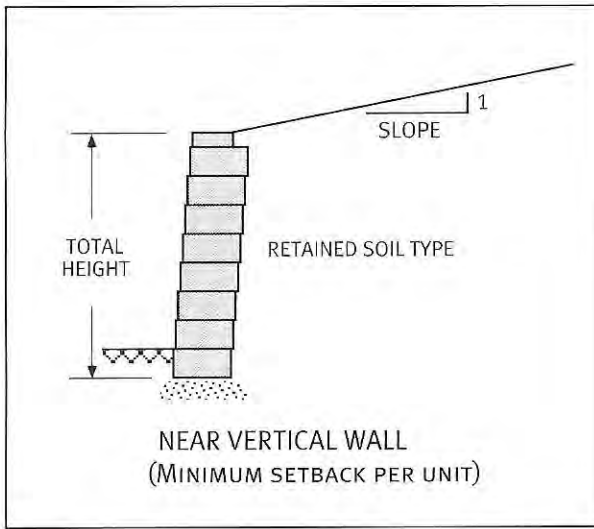


NOTES:

- ▶ Wall Height (H) is the total height from top to bottom.
- ▶ Minimum wall embedment is 6" (150mm) or Height/20, whichever is greater for level toe.
- ▶ Subsurface soils must be capable of supporting wall system.
- ▶ Unit drainage fill is 3/4" (20mm) clean crushed stone.
- ▶ Leveling pad is crushed stone base material.
- ▶ All backfill materials are compacted to 95% max. density.
- ▶ Finished grade must provide positive drainage.
- ▶ The symbol — 5.0' — indicates location and length of geogrid as measured from the connection pins to the end of the geogrid.

D E S I G N C H A R T S

► **GRAVITY WALL TABLES**



► **STANDARD/STANDARD II UNITS (18")**

MAX. HGT.	BACKSLOPE				
	SOIL TYPE	LEVEL	4H:1V	3H:1V	2H:1V
SAND/GRAVEL	4.3' (1.3M)	4.0' (1.2M)	3.8' (1.2M)	3.4' (1.0M)	3.4' (1.0M)
SILTY SAND	4.0' (1.2M)	3.6' (1.1M)	3.4' (1.0M)	3.0' (0.9M)	3.0' (0.9M)
SILT/LEAN CLAY	3.6' (1.1M)	3.2' (1.0M)	3.1' (0.9M)	2.1' (0.6M)	2.1' (0.6M)

► **STANDARD/STANDARD II UNITS (18")**

MAX. HGT.	BACKSLOPE				
	SOIL TYPE	LEVEL	4H:1V	3H:1V	2H:1V
SAND/GRAVEL	5.7' (1.7M)	5.2' (1.6M)	5.0' (1.5M)	4.5' (1.4M)	4.5' (1.4M)
SILTY SAND	5.1' (1.6M)	4.6' (1.4M)	4.3' (1.3M)	3.7' (1.1M)	3.7' (1.1M)
SILT/LEAN CLAY	4.6' (1.4M)	4.0' (1.2M)	3.8' (1.1M)	2.5' (0.7M)	2.5' (0.7M)

► **STANDARD UNITS (21.5")**

MAX. HGT.	BACKSLOPE				
	SOIL TYPE	LEVEL	4H:1V	3H:1V	2H:1V
SAND/GRAVEL	5.2' (1.6M)	4.7' (1.5M)	4.6' (1.4M)	4.1' (1.2M)	4.1' (1.2M)
SILTY SAND	4.7' (1.4M)	4.3' (1.3M)	4.1' (1.2M)	3.6' (1.1M)	3.6' (1.1M)
SILT/LEAN CLAY	4.4' (1.3M)	3.9' (1.2M)	3.7' (1.1M)	2.9' (0.9M)	2.9' (0.9M)

► **STANDARD UNITS (21.5")**

MAX. HGT.	BACKSLOPE				
	SOIL TYPE	LEVEL	4H:1V	3H:1V	2H:1V
SAND/GRAVEL	6.8' (2.1M)	6.2' (1.9M)	5.9' (1.8M)	5.3' (1.6M)	5.3' (1.6M)
SILTY SAND	6.1' (1.9M)	5.5' (1.7M)	5.2' (1.6M)	4.4' (1.3M)	4.4' (1.3M)
SILT/LEAN CLAY	5.3' (1.6M)	4.5' (1.4M)	4.1' (1.2M)	3.2' (1.0M)	3.2' (1.0M)

NOTES: CALCULATIONS ASSUME A UNIT WEIGHT OF 120 LBS/CF (19kN/SQM) FOR ALL SOIL TYPES. ASSUMED ϕ ANGLES FOR EARTH PRESSURE CALCULATIONS ARE: SAND/GRAVEL=34°, SILTY SAND=30°, AND SANDY SILT/LEAN CLAY=26°. NON CRITICAL STRUCTURES WITH SF>1.5. NO SURCHARGE LOADINGS ARE INCLUDED. SURCHARGES OR SPECIAL LOADING CONDITIONS WILL REDUCE MAXIMUM WALL HEIGHTS. SLIDING CALCULATIONS ASSUME A 6" (150MM) CRUSHED STONE LEVELLING PAD AS COMPACTED FOUNDATION MATERIAL. THE INFORMATION PROVIDED IS FOR PRELIMINARY DESIGN USE ONLY. A QUALIFIED PROFESSIONAL SHOULD BE CONSULTED. KEYSTONE ACCEPTS NO LIABILITY FOR THE IMPROPER USE OF THESE TABLES.

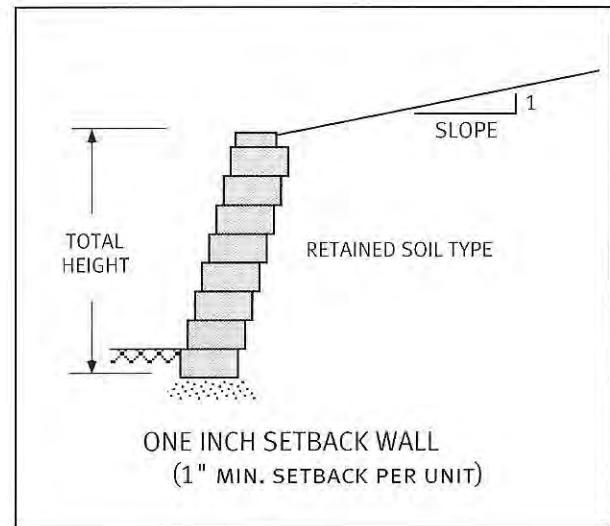
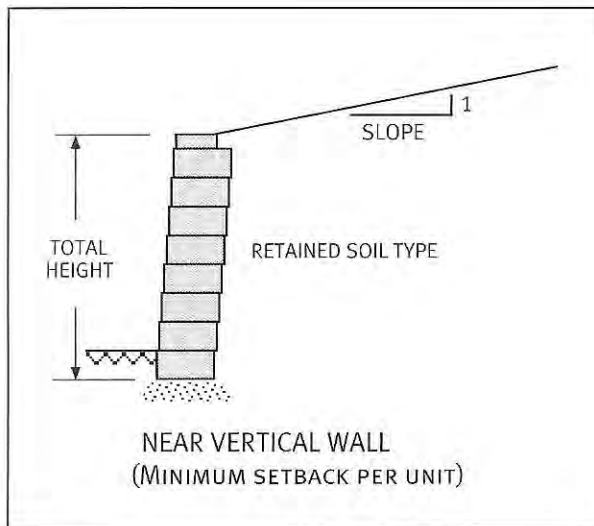


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

DESIGN CHARTS

GRAVITY WALL TABLES



► COMPAC/COMPAC II UNITS

MAX. HGT.	BACKSLOPE			
	LEVEL	4H:1V	3H:1V	2H:1V
SOIL TYPE				
SAND/GRAVEL	2.9' (0.9M)	2.6' (0.8M)	2.5' (0.8M)	2.3' (0.7M)
SILTY SAND	2.6' (0.8M)	2.4' (0.7M)	2.3' (0.7M)	2.0' (0.6M)
SILT/LEAN CLAY	2.4' (0.7M)	2.1' (0.6M)	2.0' (0.6M)	1.7' (0.5M)

► COMPAC/COMPAC II UNITS

MAX. HGT.	BACKSLOPE			
	LEVEL	4H:1V	3H:1V	2H:1V
SOIL TYPE				
SAND/GRAVEL	3.8' (1.2M)	3.4' (1.0M)	3.3' (1.0M)	2.9' (0.9M)
SILTY SAND	3.4' (1.0M)	3.0' (0.9M)	2.9' (0.9M)	2.4' (0.7M)
SILT/LEAN CLAY	3.0' (0.9M)	2.7' (0.8M)	2.5' (0.8M)	2.1' (0.6M)

NOTE: The Keystone Compac charts above can also be used for Keystone Century Wall™.

NOTES: CALCULATIONS ASSUME A UNIT WEIGHT OF 120 LBS/CF (19KN/SQM) FOR ALL SOIL TYPES. ASSUMED ϕ ANGLES FOR EARTH PRESSURE CALCULATIONS ARE: SAND/GRAVEL=34°, SILTY SAND=30°, AND SANDY SILT/LEAN CLAY=26°. NON CRITICAL STRUCTURES WITH SF>1.5. NO SURCHARGE LOADINGS ARE INCLUDED. SURCHARGES OR SPECIAL LOADING CONDITIONS WILL REDUCE MAXIMUM WALL HEIGHTS. SLIDING CALCULATIONS ASSUME A 6" (150MM) CRUSHED STONE LEVELLING PAD AS COMPACTED FOUNDATION MATERIAL. THE INFORMATION PROVIDED IS FOR PRELIMINARY DESIGN USE ONLY. A QUALIFIED PROFESSIONAL SHOULD BE CONSULTED. KEYSTONE ACCEPTS NO LIABILITY FOR THE IMPROPER USE OF THESE TABLES.

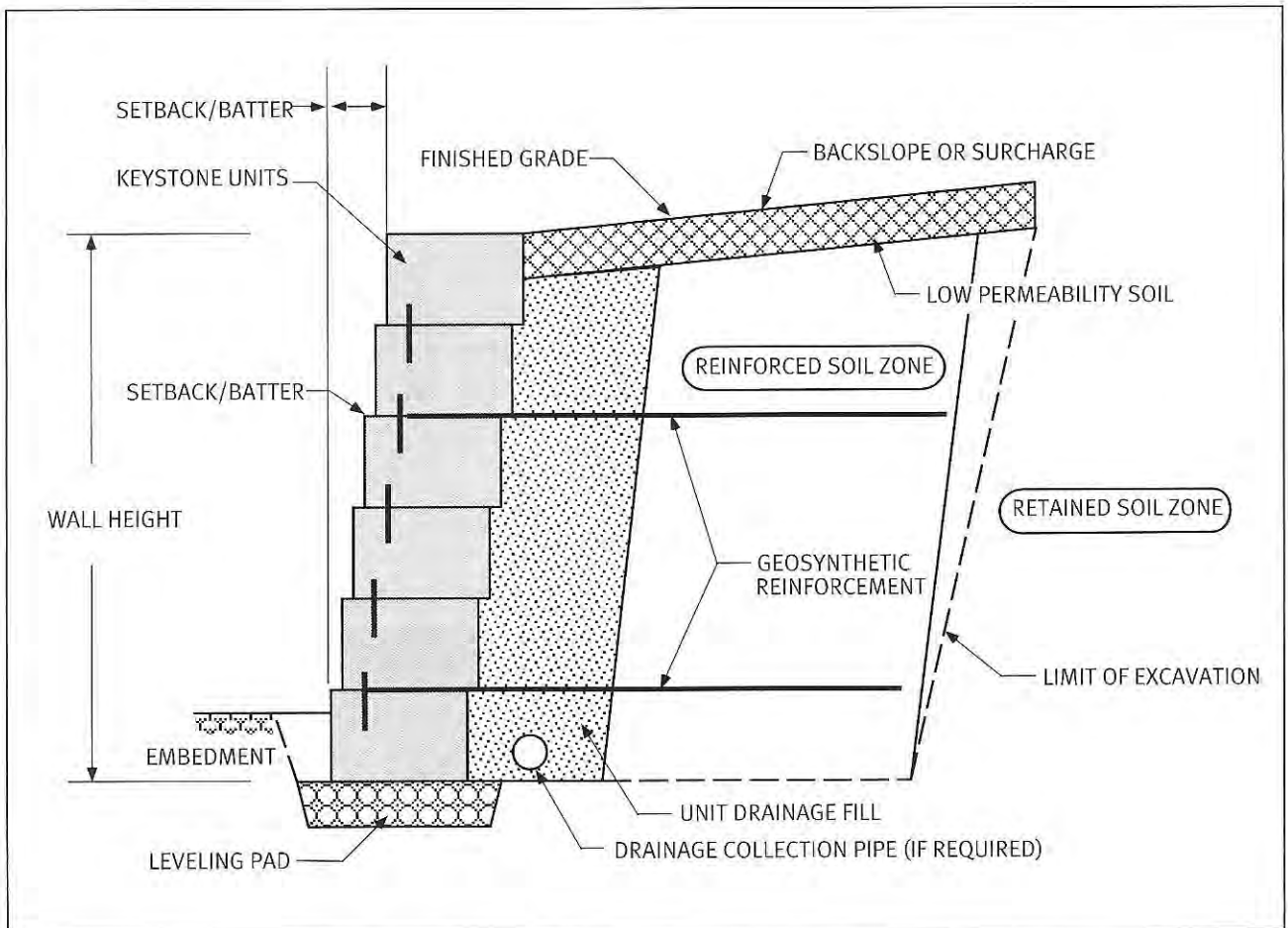


© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

DESIGN CHARTS

▶ REINFORCED WALL SCHEMATIC



NOTES:

- ▶ Wall Height (H) is the total height from top to bottom.
- ▶ Minimum wall embedment is 6" (150mm) or Height/20, whichever is greater for level toe.
- ▶ Subsurface soils must be capable of supporting wall system.
- ▶ Unit drainage fill is 3/4" (20mm) clean crushed stone.
- ▶ Leveling pad is crushed stone base material.
- ▶ All backfill materials are compacted to 95% max. density.
- ▶ Geogrids must be of appropriate type and length per the design.
- ▶ Finished grade must provide positive drainage.
- ▶ The symbol — 5.0' — indicates location and length of geogrid as measured from the connection pins to the end of the geogrid.

D E S I G N C H A R T S**GEOGRID CHART NOTES** ◀

The KEYSTONE geogrid charts are graphically presented to show the proper orientation and lengths of geogrids used with Standard and Compac Units at the near vertical and 1" (25mm) setback batter.

Heights were set in two block increments beginning at 4.3' (1.3m) and ending 11' (3.4m). Engineering judgement should be used when interpolating between heights. Heights under the 4.3' (1.3m) height shown may require geogrid reinforcement depending upon the units used, soil types, and surcharge loadings.

Soil ranges were selected to approximate good, medium and poor soil conditions to concisely cover the typical design range. Wall height is the total height of the wall from leveling pad to top of wall.

The charts assume the use of a lower strength geogrid and can be used safely with the following materials:

Miragrid 3XT by TC Mirafi

Stratagrid 200 by Strata Systems

UX1400 SB or UXK1100 by Tensar Corporation

55/30-20 by Huesker Inc.

All geogrid lengths shown are the actual lengths of geogrid required as measured from the connection pins to the end of the geogrid.

The Design Charts assume that the walls are constructed in accordance with KEYSTONE specifications and good construction practice. All soils must be compacted in 8 inch (200mm) lifts to 95% Standard Proctor density as determined by laboratory testing.

The information contained in the Design Charts is for preliminary design use only. A qualified professional should be consulted for final design assistance. KEYSTONE accepts no liability for the improper use of these charts.



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

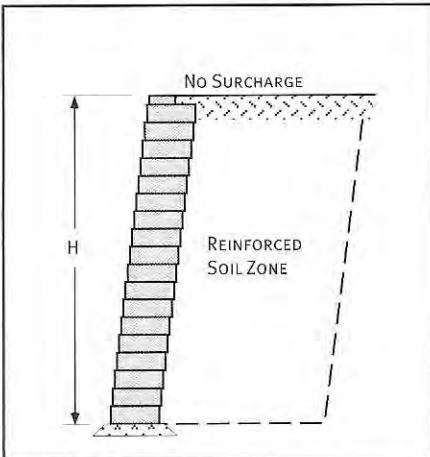
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

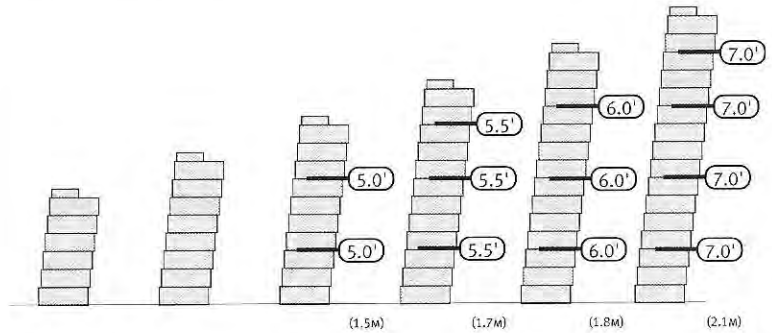
► **REINFORCED WALL CHARTS**

► **STANDARD UNITS - 1-1/4" (25mm) SET BACK**

► **SAND/GRAVEL: $\phi=34^\circ$, $\gamma=120$ pcf (19kN/m³)**

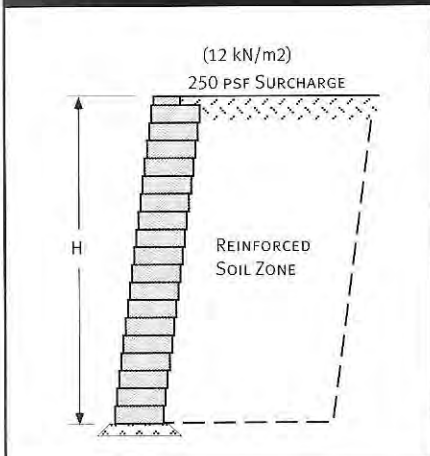


► Geogrid Placement

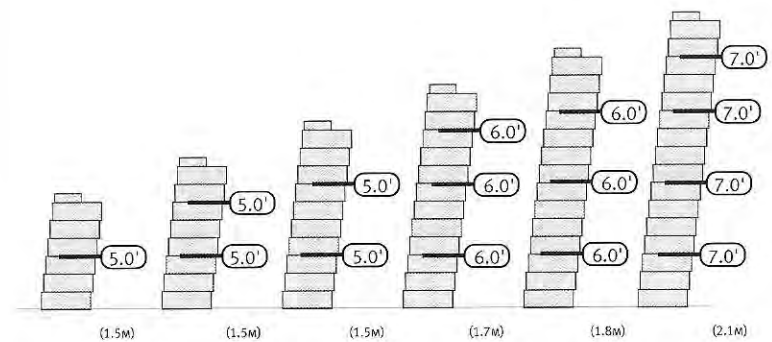


CASE 1

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)

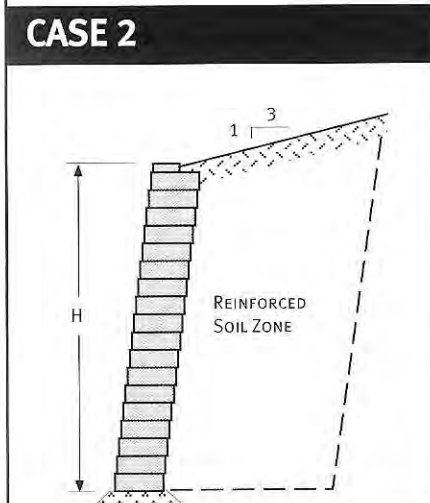


► Geogrid Placement

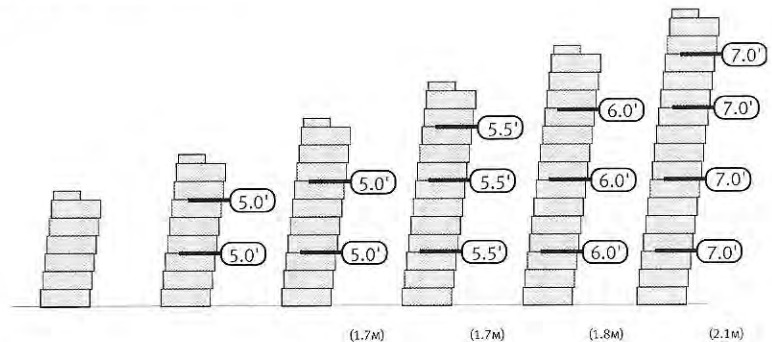


CASE 2

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



► Geogrid Placement



CASE 3

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

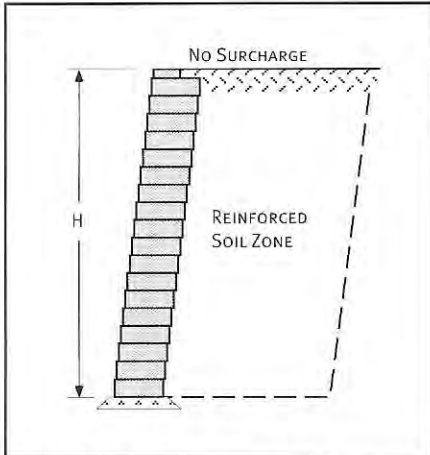
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

DESIGN CHARTS

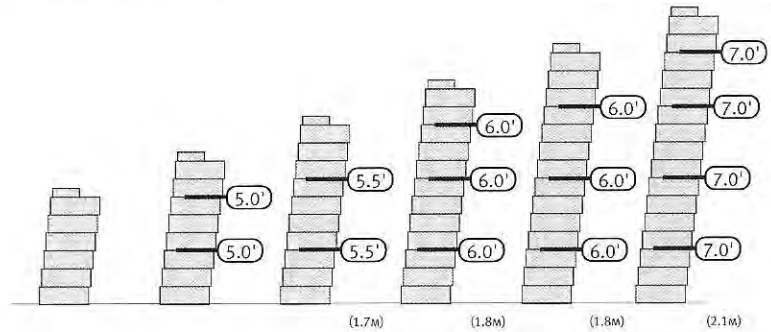
REINFORCED WALL CHARTS

▶ STANDARD UNITS - 1-1/4" (25mm) SET BACK

▶ SILTY SAND: $\phi=30^\circ$, $\gamma=120$ pcf (19kN/m³)

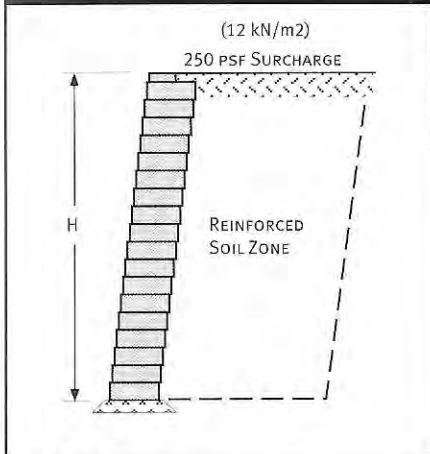


▶ Geogrid Placement

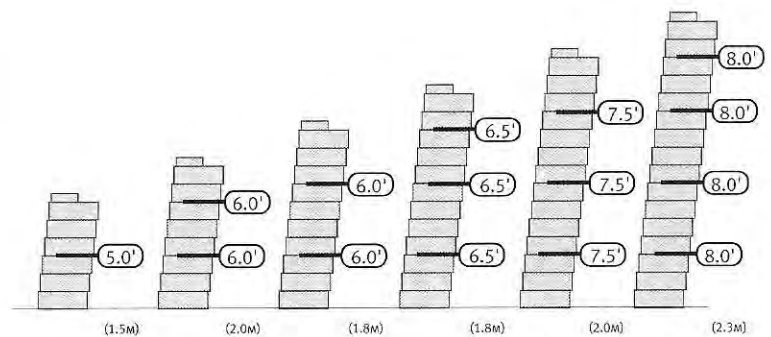


CASE 1

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)

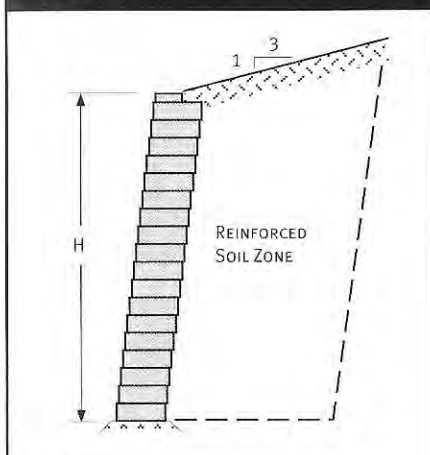


▶ Geogrid Placement

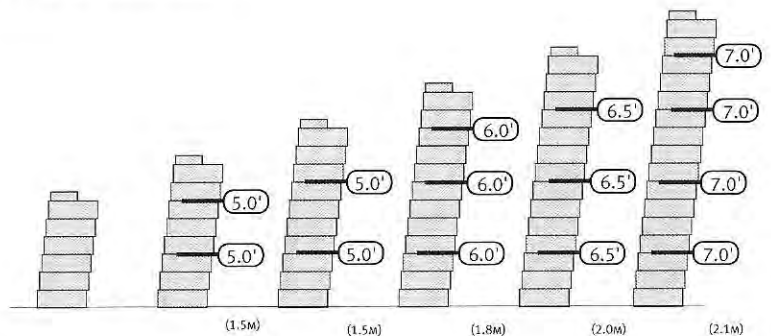


CASE 2

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



▶ Geogrid Placement



CASE 3

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

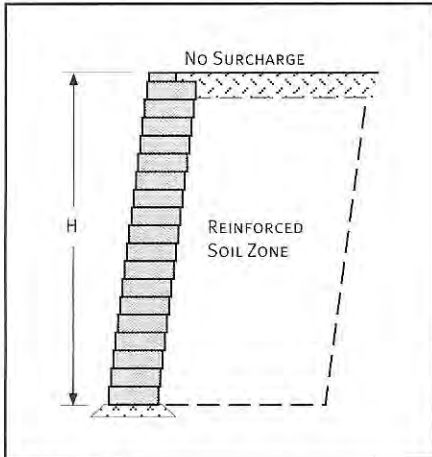
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

► REINFORCED WALL CHARTS

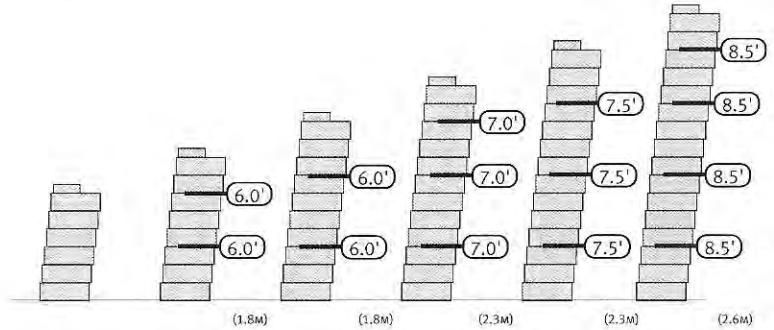
► STANDARD UNITS - 1-1/4" (25MM) SET BACK

► SILT/LEAN CLAY: $\phi=26^\circ$, $\gamma=120$ pcf (19kN/m³)

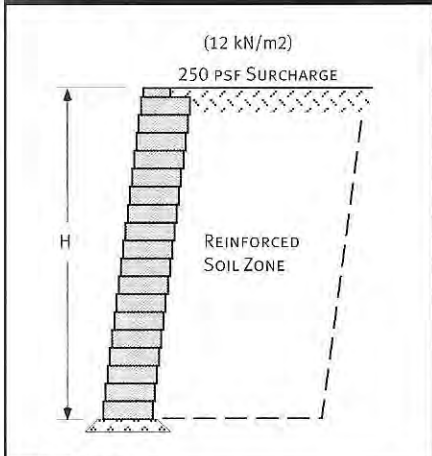


CASE 1

► Geogrid Placement

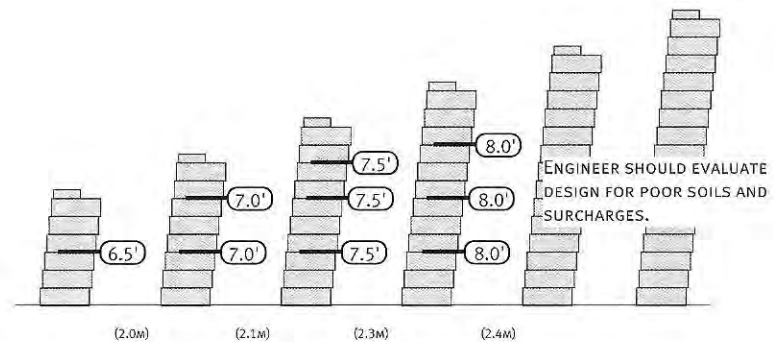


HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

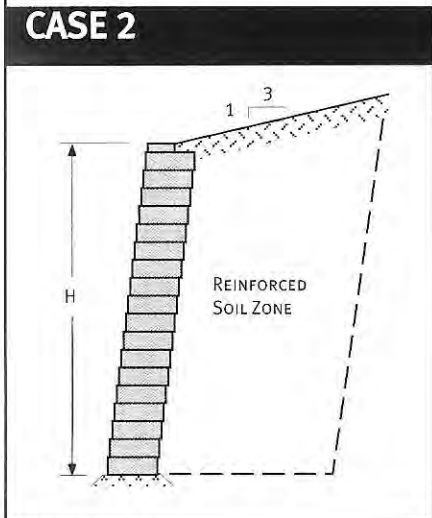


CASE 2

► Geogrid Placement

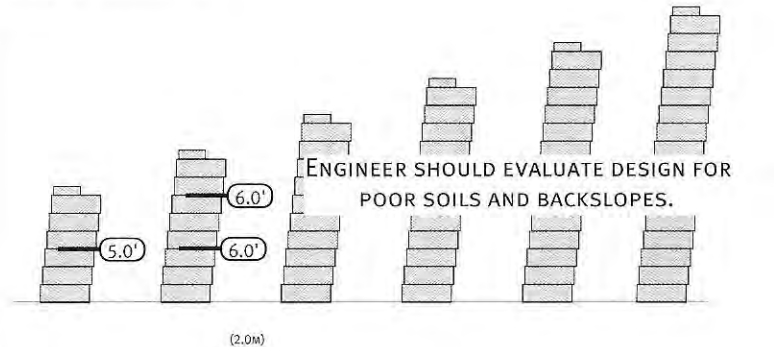


HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



CASE 3

► Geogrid Placement



HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

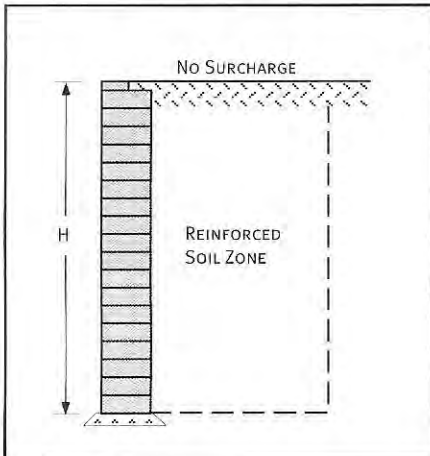
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

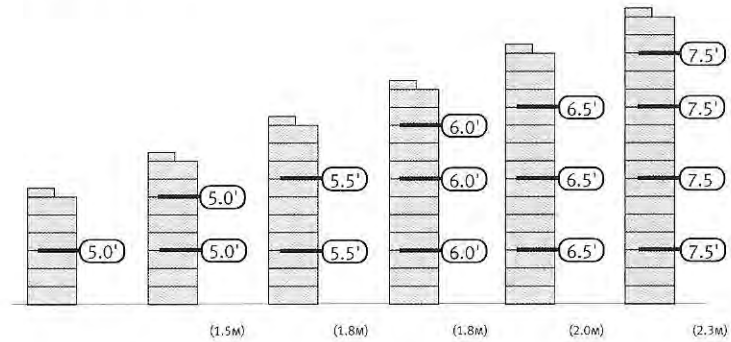
REINFORCED WALL CHARTS

▶ STANDARD UNITS - NEAR VERTICAL

▶ SAND/GRAVEL: $\phi=34^\circ$, $\gamma=120$ pcf (19kN/m³)

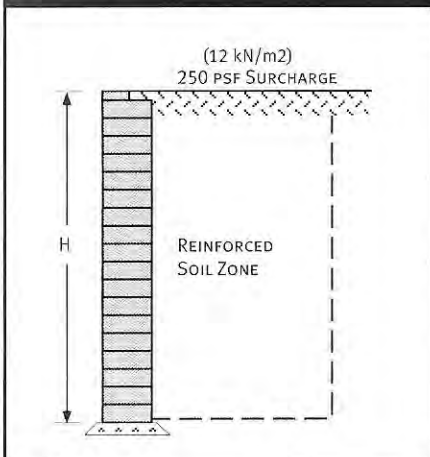


▶ Geogrid Placement

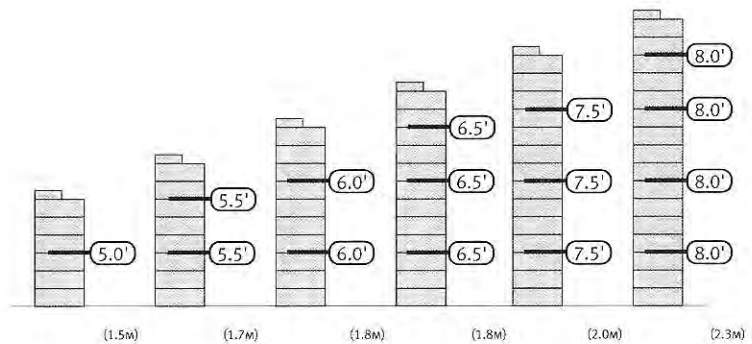


CASE 1

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

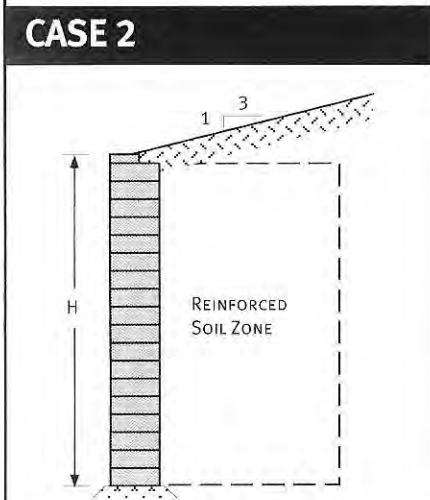


▶ Geogrid Placement

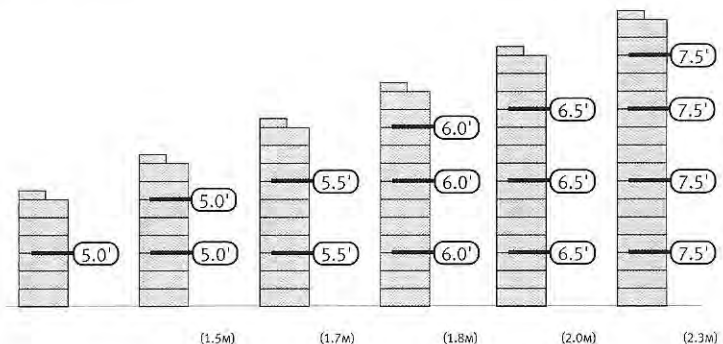


CASE 2

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



▶ Geogrid Placement



CASE 3

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

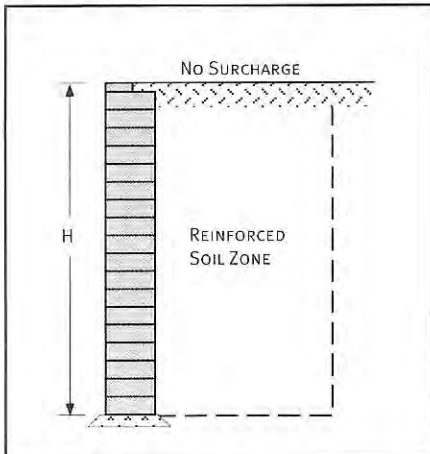
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

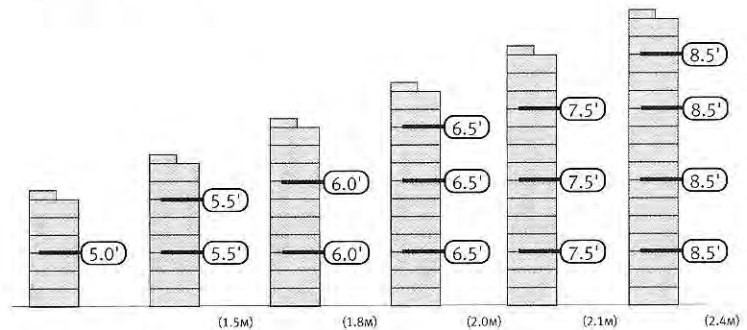
► REINFORCED WALL CHARTS

► STANDARD UNITS - NEAR VERTICAL

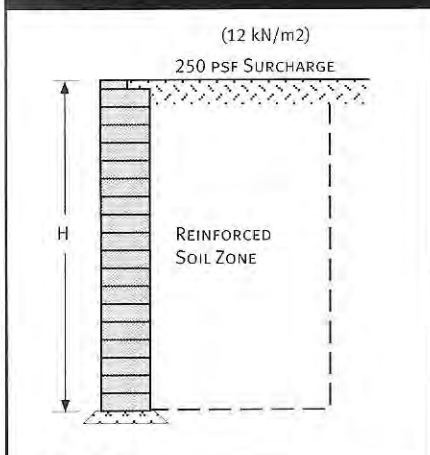
► SILTY SAND: $\phi=30^\circ$, $\gamma=120$ pcf (19kN/m³)



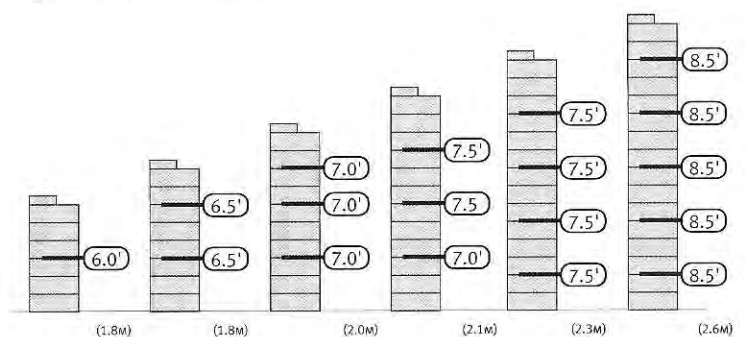
► Geogrid Placement



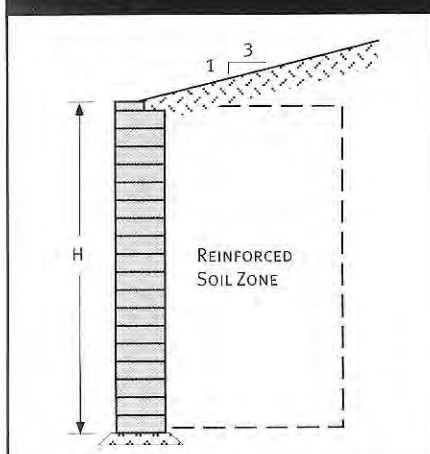
CASE 1



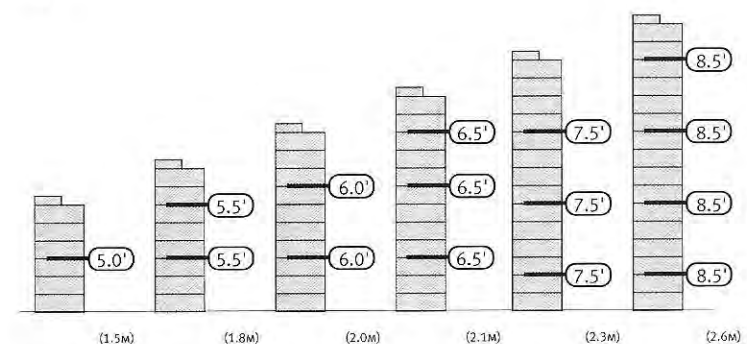
► Geogrid Placement



CASE 2



► Geogrid Placement



CASE 3



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

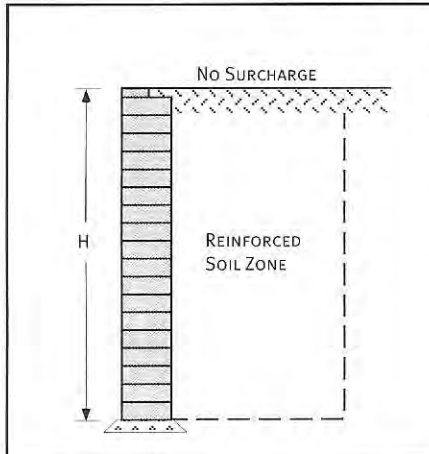
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

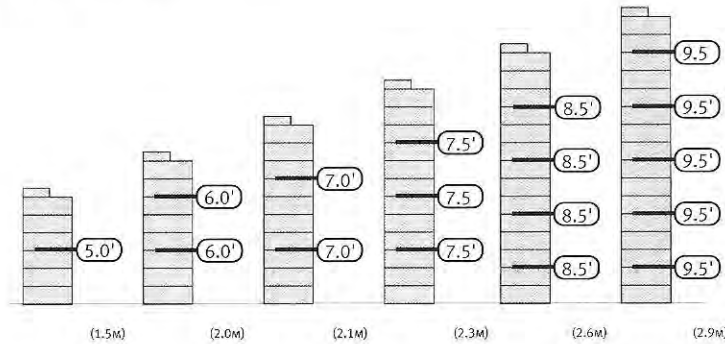
REINFORCED WALL CHARTS

► STANDARD UNITS - NEAR VERTICAL

► SILT/LEAN CLAY: $\phi=26^\circ$, $\gamma=120$ pcf (19kN/m³)

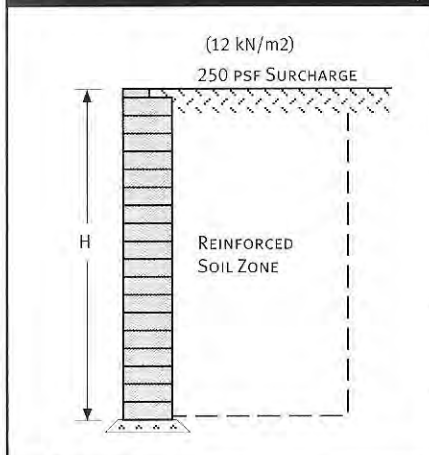


► Geogrid Placement

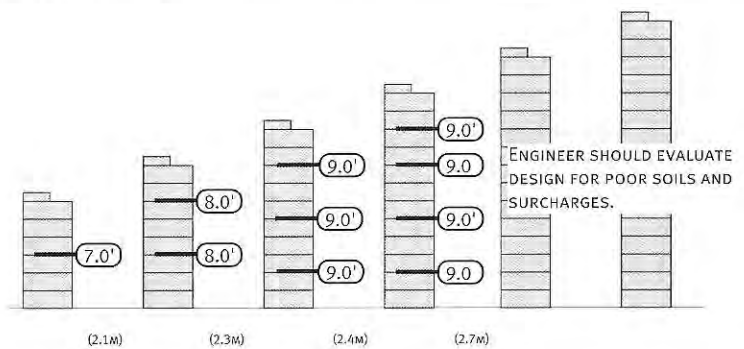


CASE 1

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

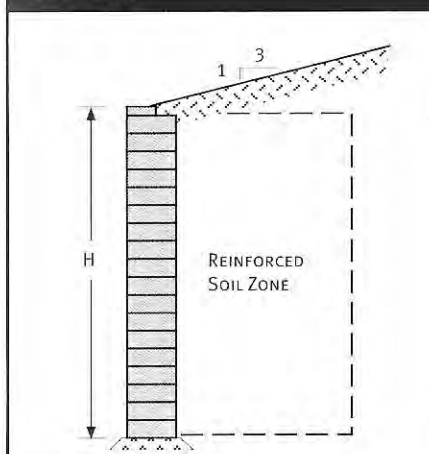


► Geogrid Placement

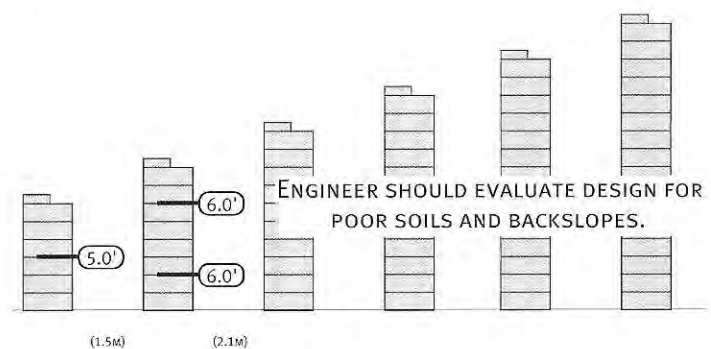


CASE 2

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



► Geogrid Placement



CASE 3

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

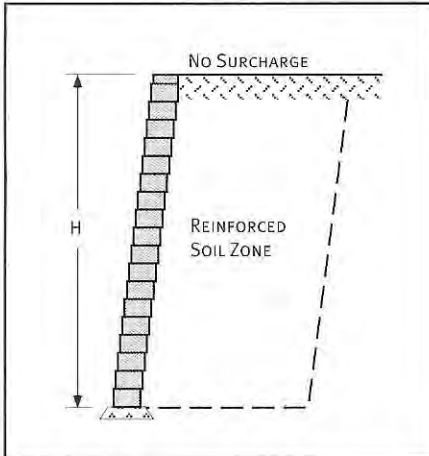
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

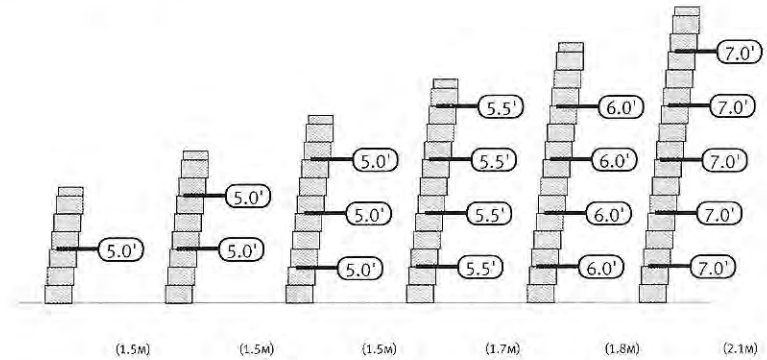
► REINFORCED WALL CHARTS

► COMPAC UNITS - 1-1/4" (25MM) SET BACK

► SAND/GRAVEL: $\phi=34^\circ$, $\gamma=120$ pcf (19kN/m³)

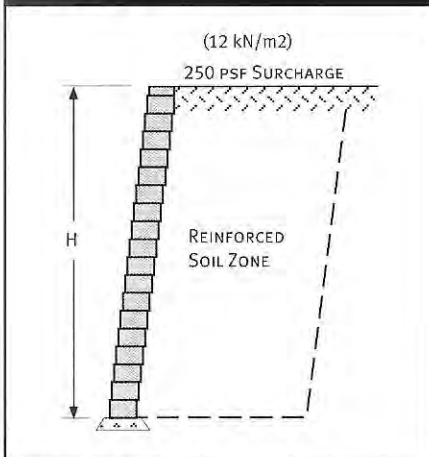


► Geogrid Placement

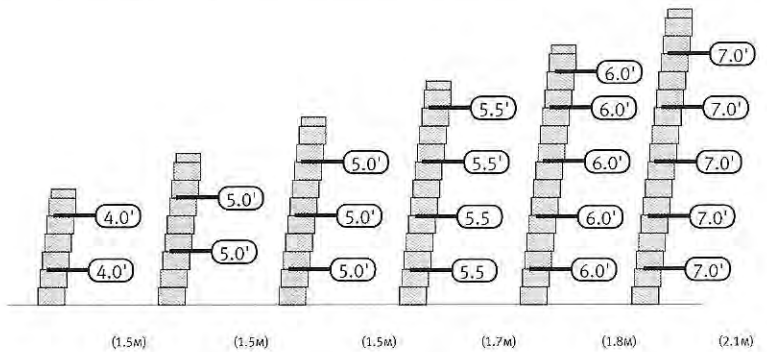


CASE 1

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

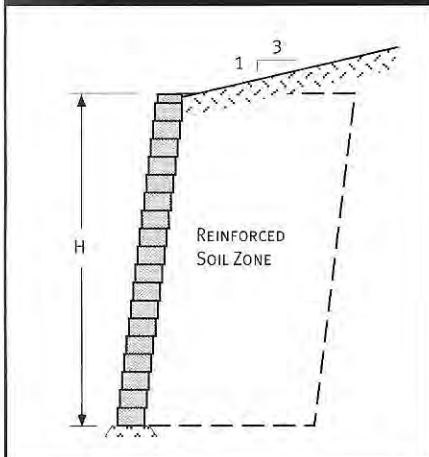


► Geogrid Placement

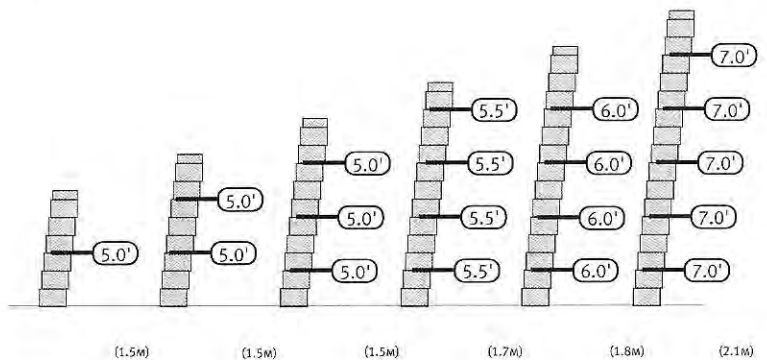


CASE 2

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



► Geogrid Placement



CASE 3

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

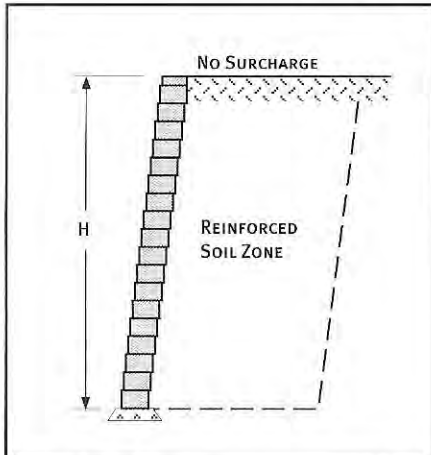
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

DESIGN CHARTS

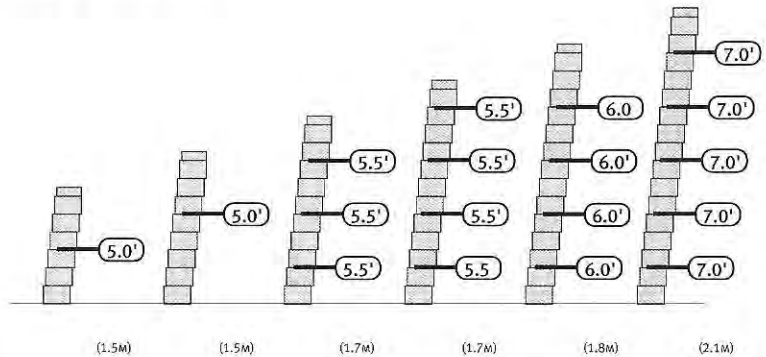
REINFORCED WALL CHARTS

► COMPAC UNITS - 1-1/4" (25mm) SET BACK

► SILTY SAND: $\phi=30^\circ$, $\gamma=120$ pcf (19kN/m³)

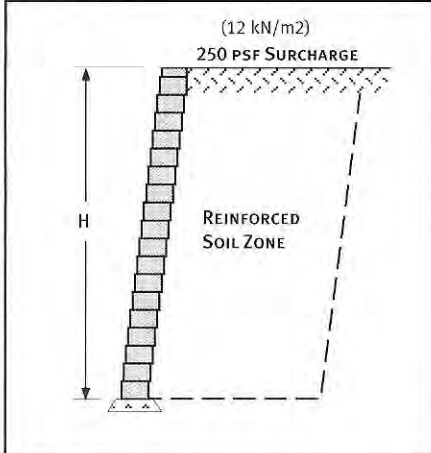


► Geogrid Placement

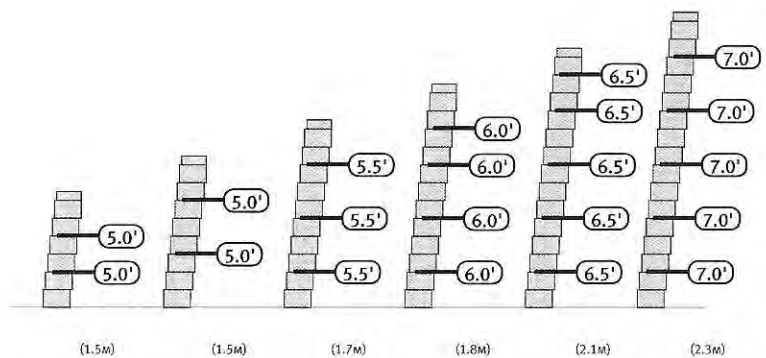


CASE 1

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

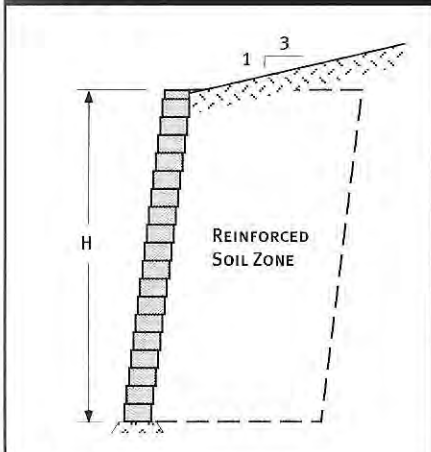


► Geogrid Placement

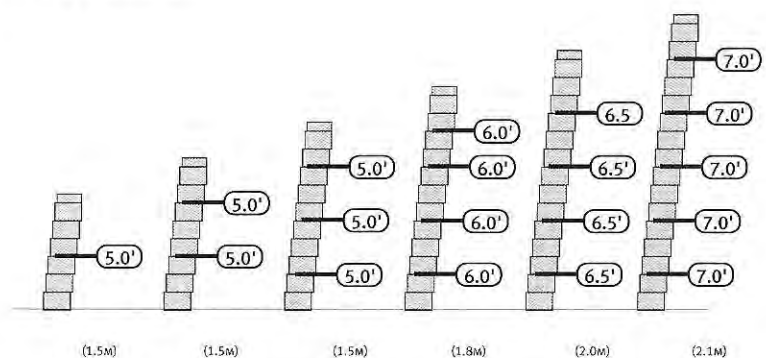


CASE 2

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



► Geogrid Placement



CASE 3

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

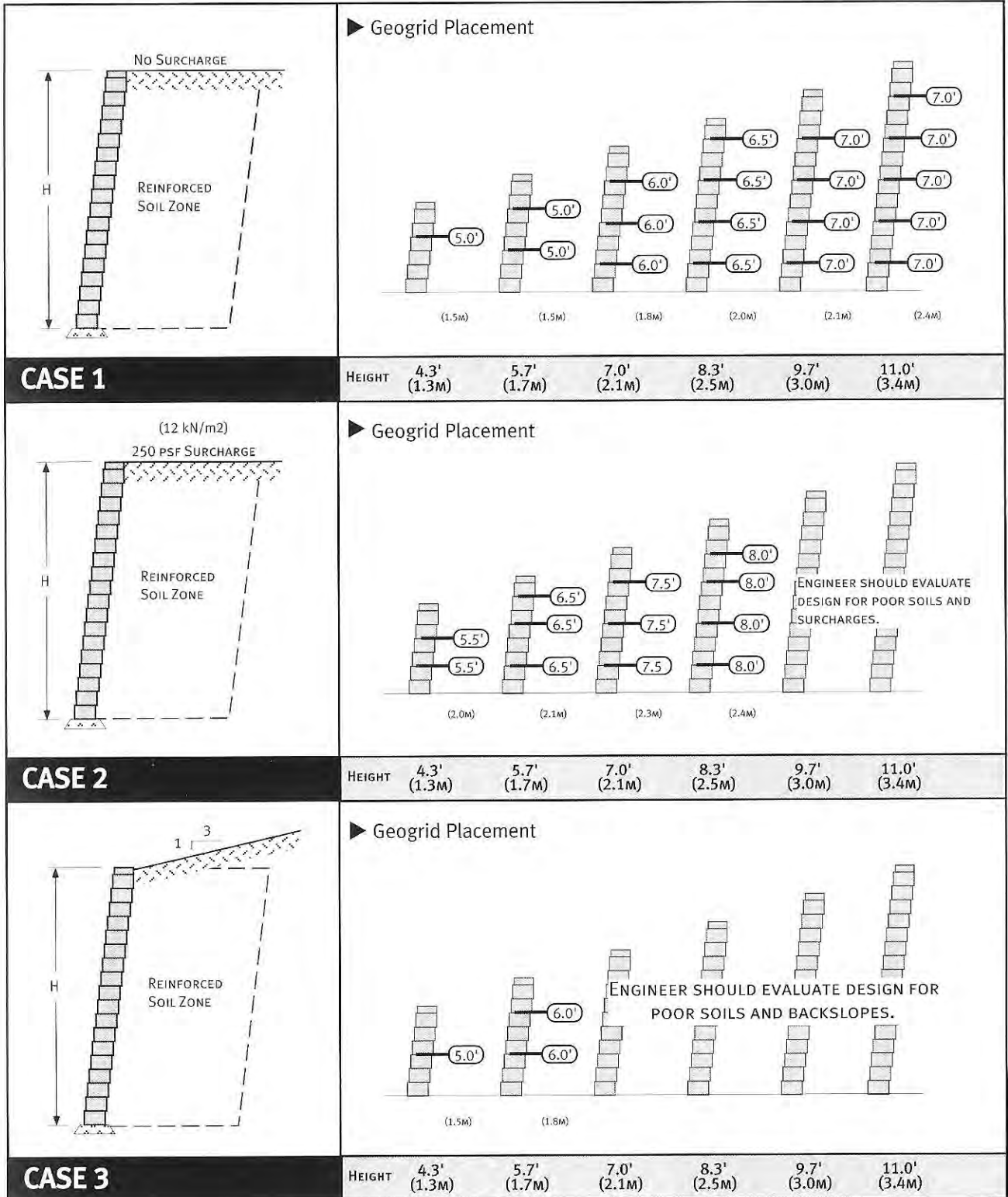
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

► **REINFORCED WALL CHARTS**

► **COMPAC UNITS - 1-1/4" (25MM) SET BACK**

► **SILT/LEAN CLAY: $\phi=26^\circ$, $\gamma=120$ pcf (19kN/m³)**

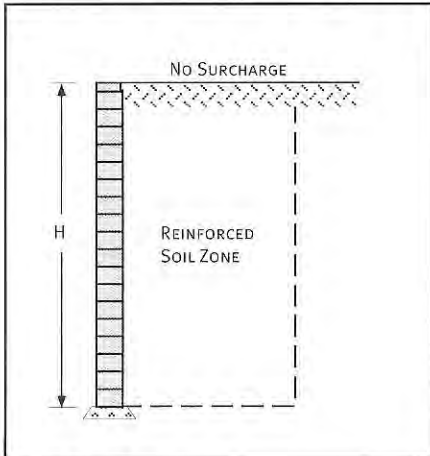


D E S I G N C H A R T S

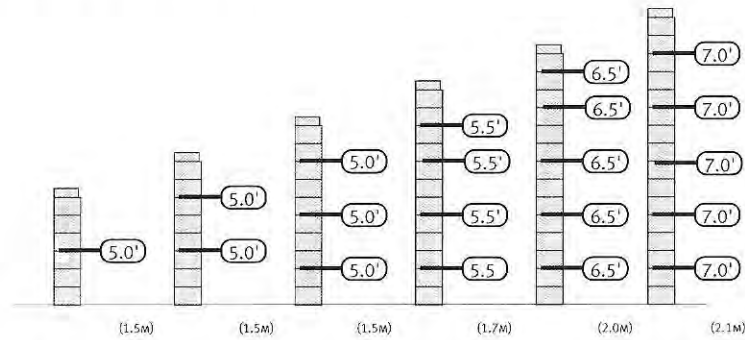
REINFORCED WALL CHARTS

► **COMPAC UNITS - NEAR VERTICAL**

► **SAND/GRAVEL: $\phi=34^\circ$, $\gamma=120$ pcf (19kN/m³)**

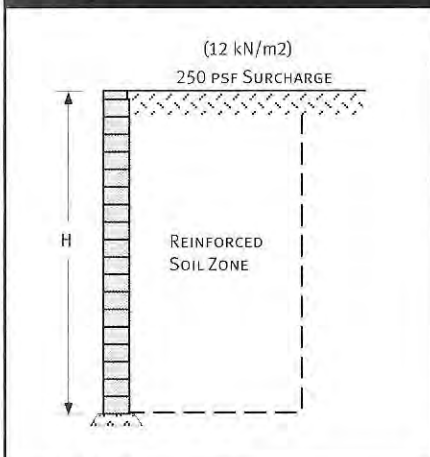


► Geogrid Placement

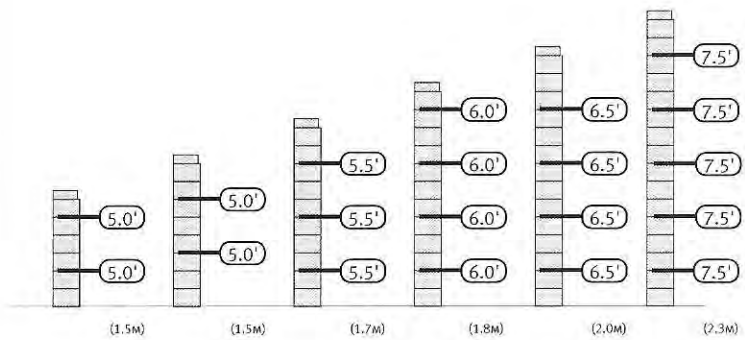


CASE 1

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)

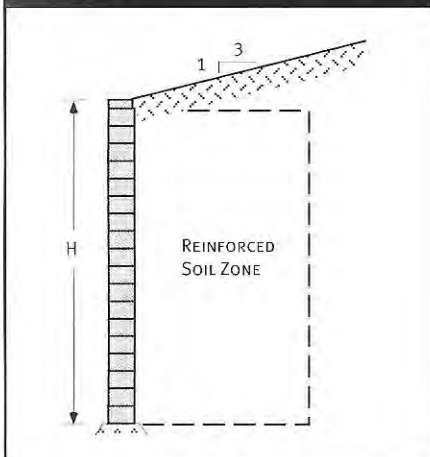


► Geogrid Placement

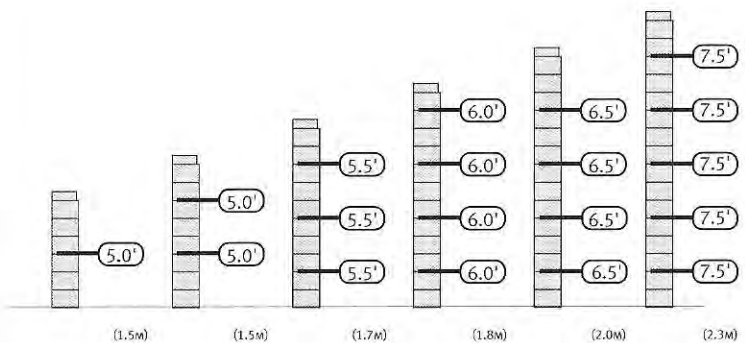


CASE 2

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



► Geogrid Placement



CASE 3

HEIGHT 4.3' (1.3M) 5.7' (1.7M) 7.0' (2.1M) 8.3' (2.5M) 9.7' (3.0M) 11.0' (3.4M)



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

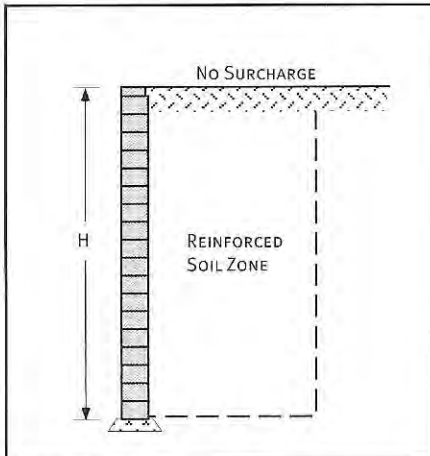
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

D E S I G N C H A R T S

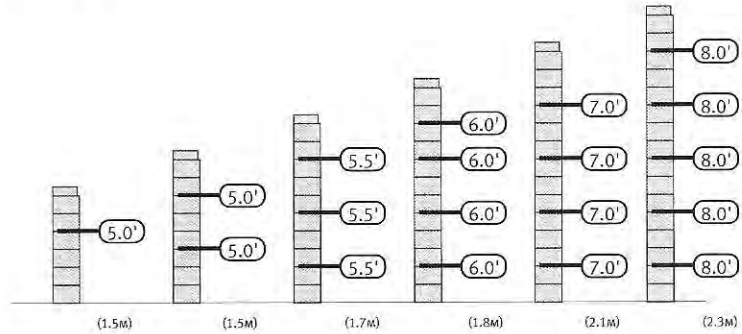
► REINFORCED WALL CHARTS

► COMPAC UNITS - NEAR VERTICAL

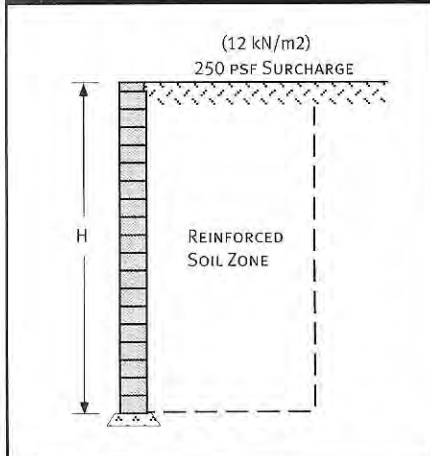
► SILTY SAND: $\phi=30^\circ$, $\gamma=120$ pcf (19kN/m³)



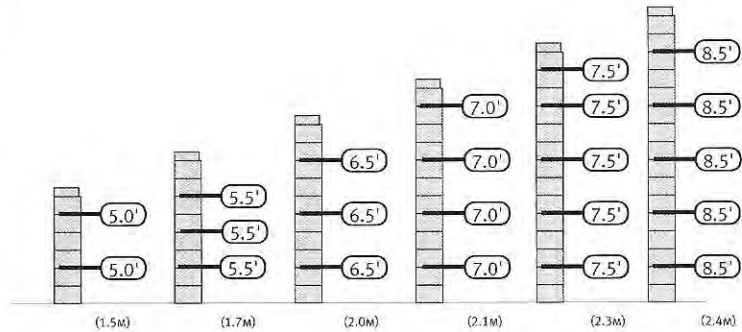
► Geogrid Placement



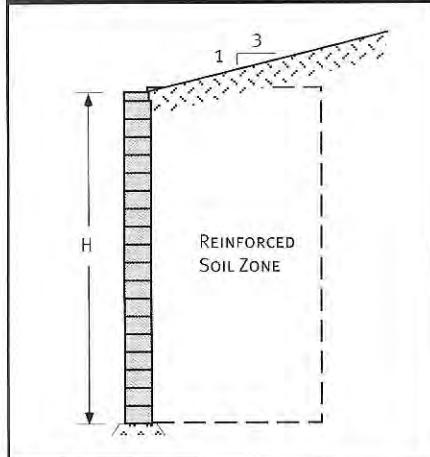
CASE 1



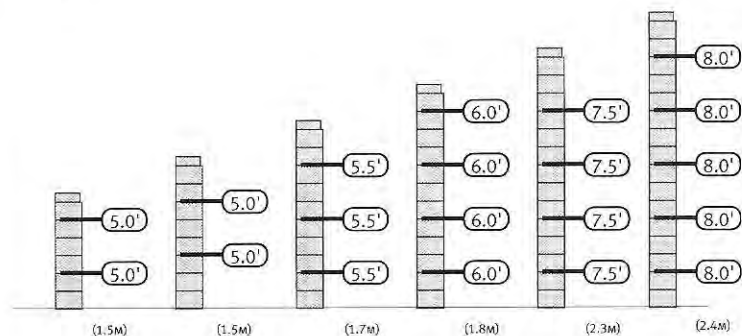
► Geogrid Placement



CASE 2



► Geogrid Placement



CASE 3



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

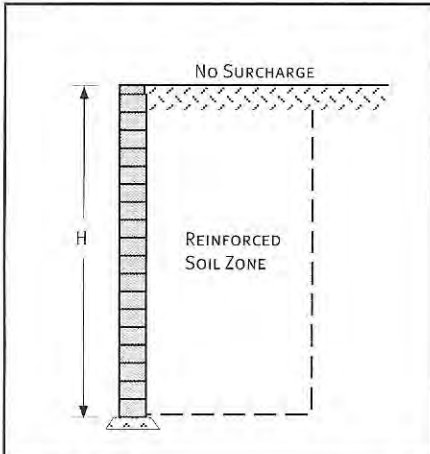
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.

DESIGN CHARTS

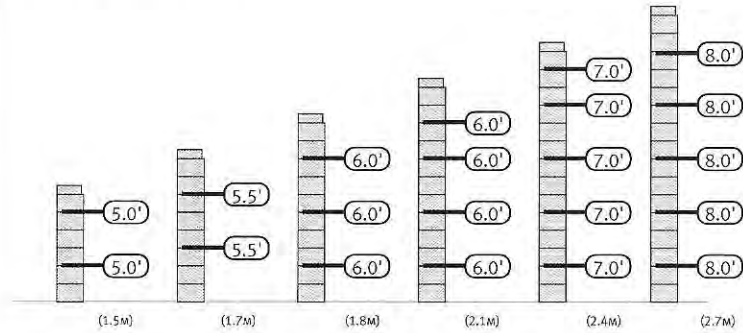
REINFORCED WALL CHARTS

► COMPAC UNITS - NEAR VERTICAL

► SILT/LEAN CLAY: $\phi=26^\circ$, $\gamma=120$ pcf (19kN/m³)

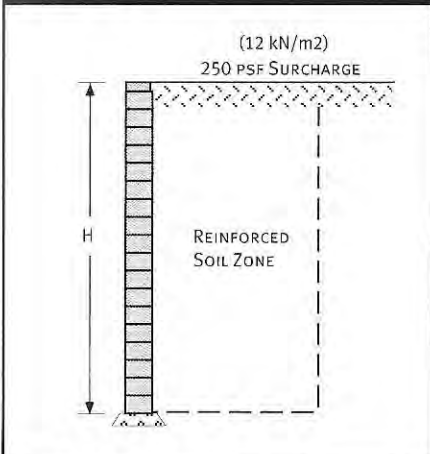


► Geogrid Placement

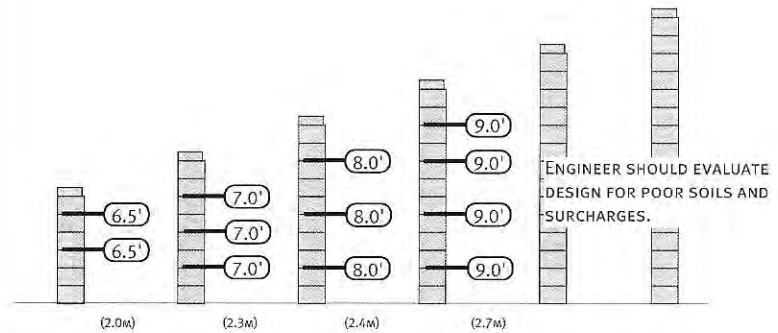


CASE 1

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------

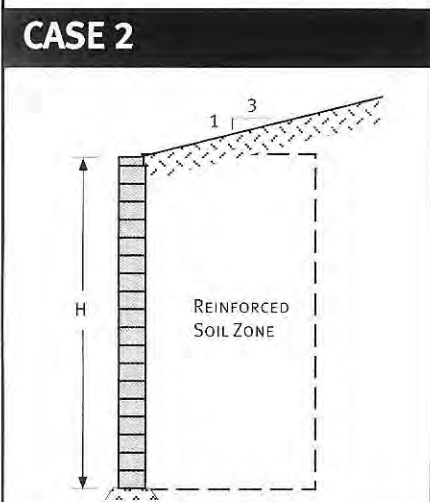


► Geogrid Placement

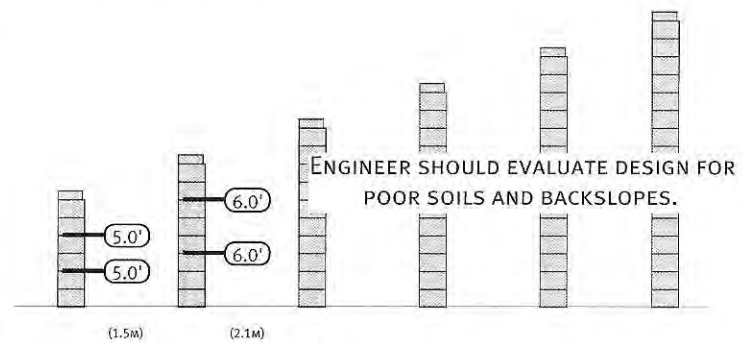


CASE 2

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



► Geogrid Placement



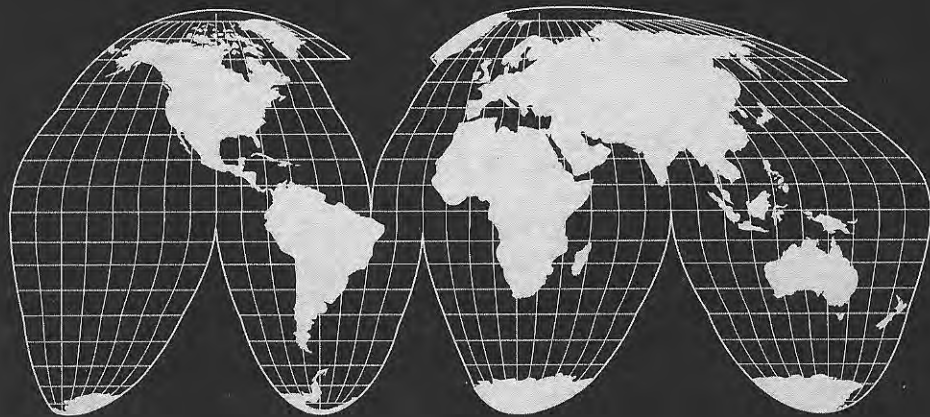
CASE 3

HEIGHT	4.3' (1.3M)	5.7' (1.7M)	7.0' (2.1M)	8.3' (2.5M)	9.7' (3.0M)	11.0' (3.4M)
--------	----------------	----------------	----------------	----------------	----------------	-----------------



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC.
Minneapolis, Minnesota
(952) 897-1040
(952) 897-3858-fax
www.keystonewalls.com

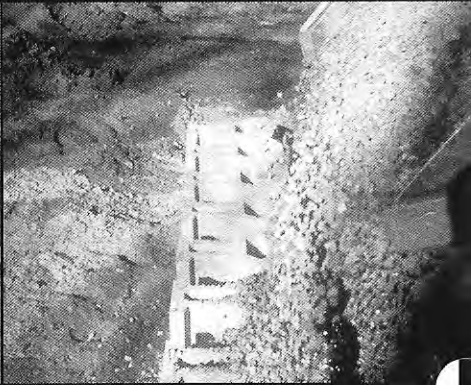
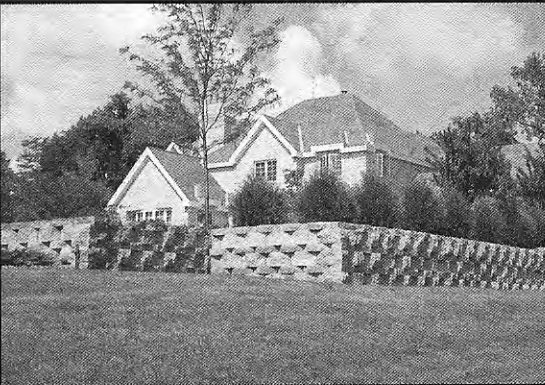
The information contained herein has been compiled by Keystone® Retaining Wall Systems, Inc. and to the best of our knowledge, accurately represents the Keystone product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user. Structural design and analysis shall be performed by a qualified engineer.



We reserve the right to improve our products and make changes in the specifications and design without notice. The information contained herein has been compiled by KEYSTONE and to the best of our knowledge, accurately represents the KEYSTONE product use in the applications which are illustrated. Final determination of the suitability for the use contemplated and its manner of use are the sole responsibility of the user.



Retaining Excellence™



© 2006 KEYSTONE RETAINING WALL SYSTEMS, INC. • A Contech Company • 4444 West 78th Street • Minneapolis, MN 55435 U.S.A.
(952) 897-1040 • (952) 897-3858 fax • www.keystonewalls.com • TE-DC03