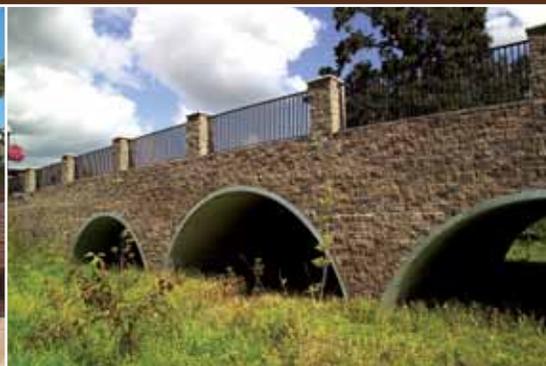
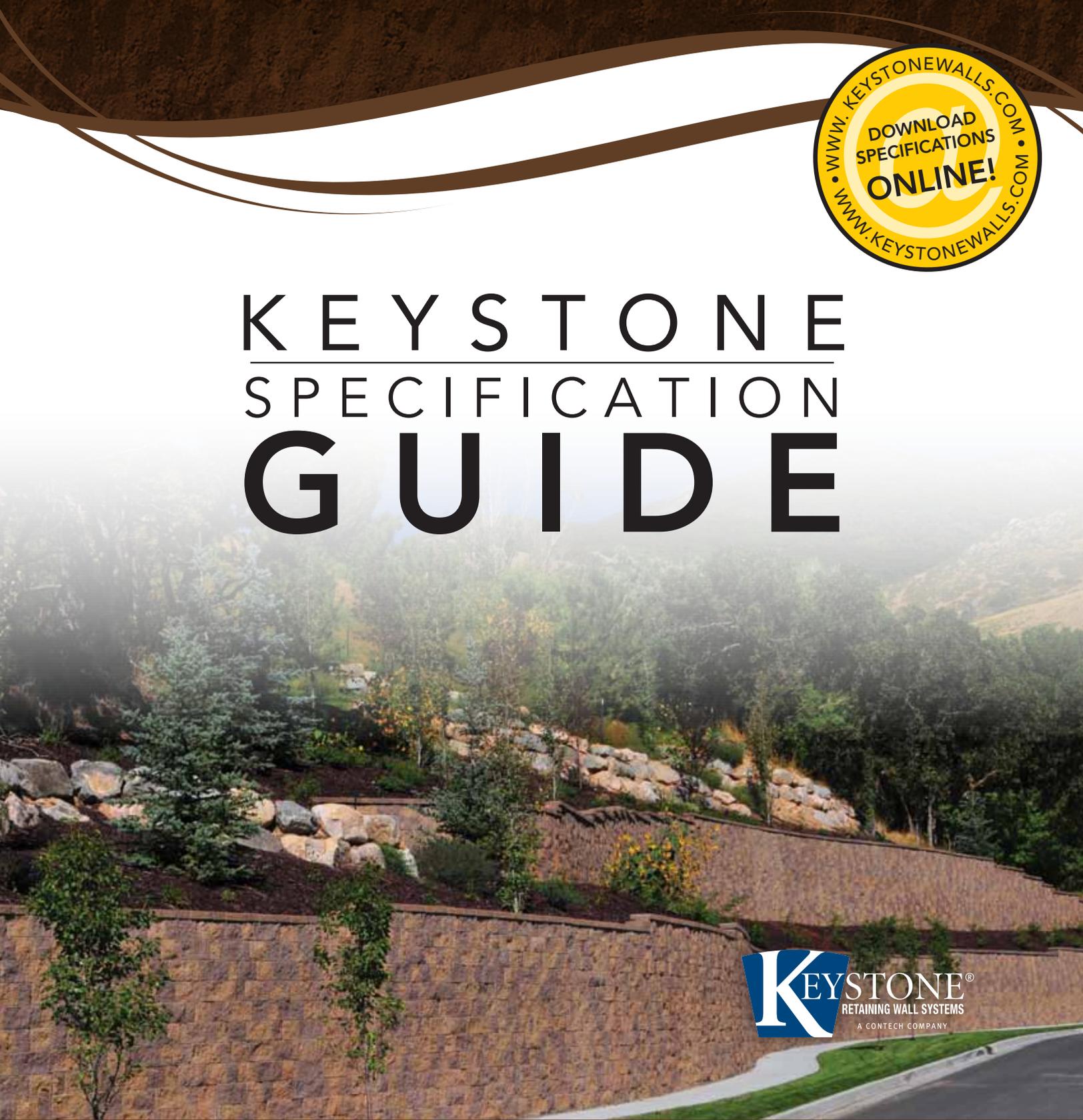




# KEYSTONE SPECIFICATION GUIDE

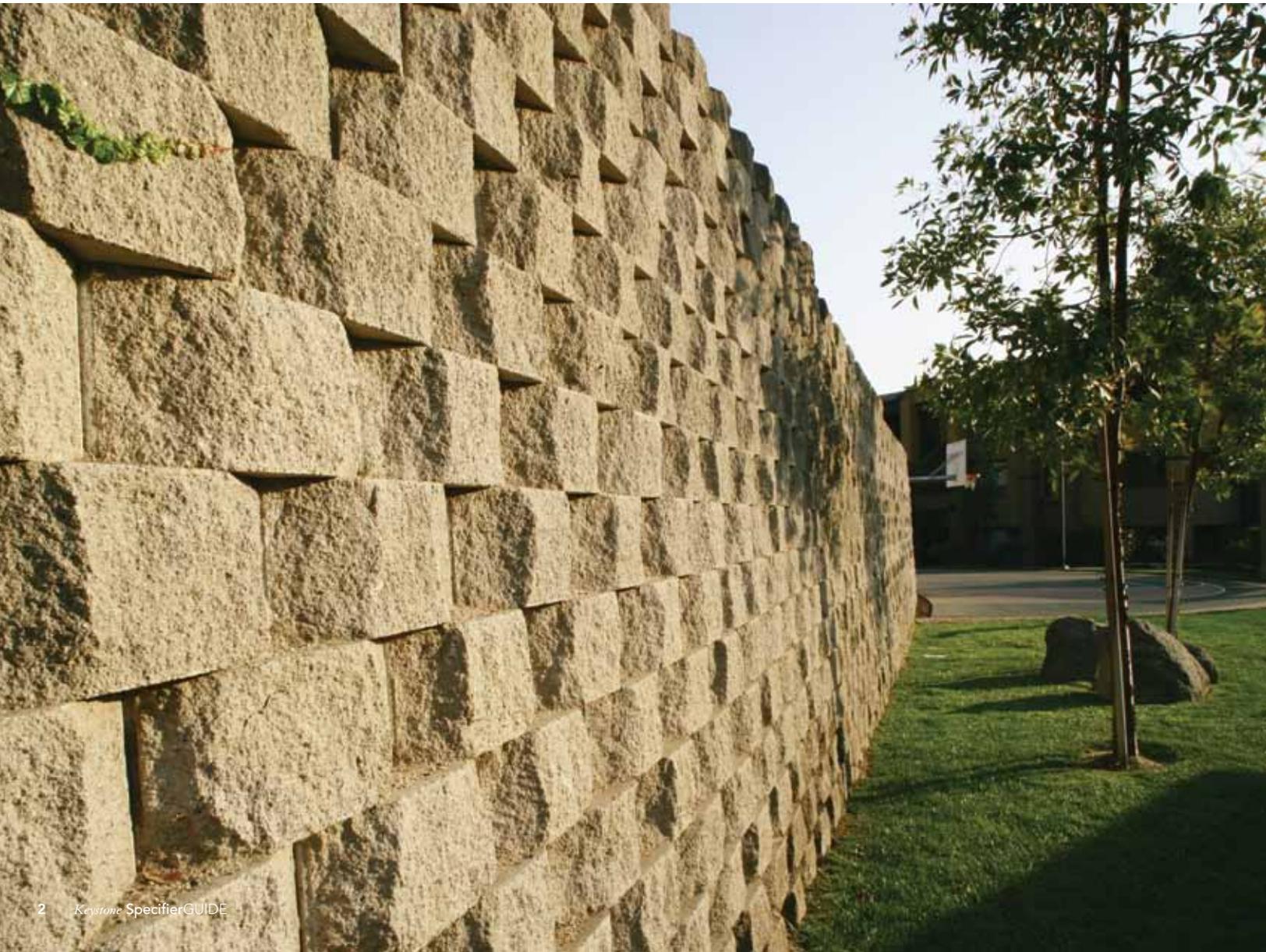


## THE RIGHT SOLUTION

With 25 years at the forefront of the industry, Keystone Retaining Wall Systems, Inc. continues to set the worldwide standard in soil retention, erosion control and landscape systems. Keystone is the product of the energy, passion, and focus of the people that promote it. Keystone works with the best network of manufacturers, product developers, engineers, and sales professionals in the business. They ensure that Keystone products and services offer the best site solutions for residential, commercial, recreational, industrial, and governmental applications.

Offering a broad family of products, Keystone has the right solution to meet the most challenging structural and landscape sites. Keystone also leads the marketplace in segmental retaining wall performance and aesthetics.

The Keystone difference lies in its outer beauty and inner strength. Keystone's patented, interlocking, fiberglass pin system ensures a positive connection from wall unit to wall unit and also between the wall units and soil reinforcement. In addition, Keystone's patented pins aid in horizontal alignment, as well as providing for the ability to vary wall set-back.





# KEYSTONE® STANDARD

The Keystone Standard is an American original and remains the industry leader. Its height-to-depth ratio delivers a structurally sound, engineered wall system with superior construction stability, durability, and strength. This product is the preferred choice for tall walls and critical structures.



8" 90° Corner unit  
Face Area • 1 sq. ft.  
8" h x 18" w x 9" d  
(203 x 457 x 228 mm)  
100 lbs. (45 kg)



2 Connection Pins  
required per unit



Standard I - Straight Split



Standard II - Tri-Plane



Standard I - Tri-Plane



Standard II - Straight Split

Face Area • 1 sq. ft. per unit  
8" h x 18" w x 18" to 21" d  
(203 x 457 x 457-533 mm)  
105 lbs (48 kg)

# KEYSTONE® COMPAC

The Keystone Compac is the perfect choice when the deep embedment length of the Keystone Standard unit is not required. An installer's favorite, its lighter weight and shorter tail design make it easy to handle.



Compac I - Tri-Plane



Compac II - Tri-Plane



Compac III - Tri-Plane

Alternative face options available:



Straight Split



Hewnstone



Victorian

Face Area • 1 sq. ft. per unit  
8" h x 18" w x 12" d (203 x 457 x 304 mm)  
85 lbs (39 kg)



8" 90° Corner unit  
Face Area • 1 sq. ft.  
8" h x 18" w x 9" d  
(203 x 457 x 228 mm)  
100 lbs. (45 kg)



2 Connection Pins  
required per unit

\* Note: Unit colors, dimensions, weight, and availability may vary by manufacturer.



# 133<sup>KEYSTONE</sup>ELITE®

The Keystone 133Elite® is perfect for large wall applications. Its 8" x 24" (200 x 600 mm) face dimension creates a larger-scale look, aesthetically matching the larger wall look and feel, while reducing the number of units required to complete the job. The Keystone 133Elite® can satisfy a wide array of design requirements from corners to sweeping curves. The Keystone 133Elite® is simply the best combination of strength, beauty, and efficiency on the market.



Hewnstone



Random Score

\*Note: Units shown have chamfer on three sides.

Face Area • 1.33 sq. ft. per unit  
8"h x 24"w x 11½"d (203 x 609 x 292 mm)  
Approx. • 95 lbs (43 kg)



133Elite® 90° Hewnstone Corner

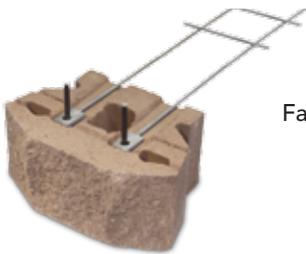
8"h x 18"w x 6"d  
(203 x 457 x 152 mm)  
Approx. • 55 lbs (25 kg)



2 Shouldered Pins required per unit

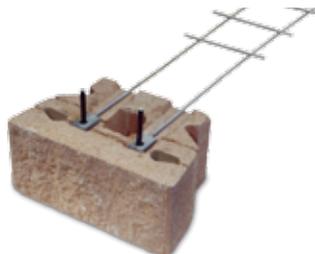
## SOFT KEYSTEEL PANEL SYSTEM CONTECH

The KeySteel™ system is specifically designed for use in the highway and heavy construction industries using patented Keystone modular concrete units and inextensible steel soil reinforcement to develop a durable, aesthetically appealing, and cost effective reinforced soil retaining wall structure.



Tri-Plane

Face Area • 1 sq. ft. per unit  
8"h x 18"w x 12"d  
(203 x 457 x 304 mm)  
90-95 lbs (40-43 kg)



Straight Split



2 Connection/Steel Pins required per unit



Tri-Plane



Straight Split

Face Area • 1 sq. ft. per unit  
8"h x 18"w x 12"d  
(203 x 457 x 304 mm)  
85 lbs (38 kg)

## KEYSTONE KEYGRID SYSTEM

The Keystone KeyGrid system is an economical solution when a geosynthetic reinforced retaining wall system is required. Patented Keystone modular concrete units and geosynthetic reinforcement are combined to develop a durable, beautiful long lasting wall structure.



2 Connection Pins required per unit

\* Note: Unit colors, dimensions, weight, and availability may vary by manufacturer.



## KEYSTONE CENTURY WALL®

Designed specifically for medium to large wall and loading conditions, Keystone Century Wall™ blends the distinctive look and character of natural stone with the structural integrity that lets you build with confidence.



**Large unit**  
Face Area • 1 sq. ft.  
8" h x 18" w x 12" d  
(203 x 457 x 304mm)  
93 lbs. (42 kg)



**Medium unit**  
Face Area • .62 sq. ft.  
8" h x 11" w x 12" d  
(203 x 279 x 304mm)  
58 lbs. (26 kg)



**Small unit**  
Face Area • .38 sq. ft.  
8" h x 7" w x 12" d  
(203 x 177 x 304mm)  
37 lbs. (17 kg)



**8" 90° Corner unit**  
Face Area • 1 sq. ft.  
8" h x 18" w x 9" d  
(203 x 457 x 228 mm)  
100 lbs. (45 kg)



1-2 Shouldered Pins  
required per unit

## KEYSTONE HALF-CENTURY™

The three different-sized units make Keystone Half Century Wall™ fast and almost effortless to create visually stunning, yet structurally sound, taller wall structures. Keystone Half Century Wall can be combined with Keystone Century Wall or used on its own for almost any application.



**Large unit**  
Face Area • .5 sq. ft.  
4" h x 18" w x 12" d  
(101 x 457 x 304mm)  
47 lbs. (21 kg)



**Medium unit**  
Face Area • .31 sq. ft.  
4" h x 11" w x 12" d  
(101 x 279 x 304mm)  
29 lbs. (13 kg)



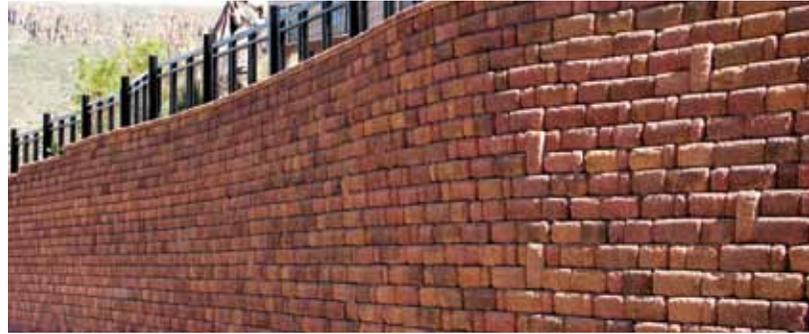
**Small unit**  
Face Area • .19 sq. ft.  
4" h x 7" w x 12" d  
(101 x 177 x 304mm)  
19 lbs. (8 kg)



1-2 Shouldered Pins  
required per unit

KEYSTONE®  
*Country Manor*®

Keystone Country Manor® offers the appearance of rustic, hand-laid stone walls with the strength and ease of installation provided by the latest in dry-stacked, modular, pin-connected technology. With three finished sides on each unit, Country Manor offers endless building possibilities.



3 - piece Country Manor Unit Sizes



Unit 16/14

Lg. Face Area • .66 sq. ft.  
6" h x 10" d x 16" / 14" w  
(152 x 254 x 406/355mm)  
65 lbs. (29 kg)



Unit 12/10

Lg. Face Area • .50 sq. ft.  
6" h x 10" d x 12" / 10" w  
(152 x 254 x 304/254mm)  
45 lbs. (20 kg)



Unit 6/4

Lg. Face Area • .25 sq. ft.  
6" h x 10" d x 6" / 4" w  
(152 x 254 x 152/101mm)  
25 lbs. (11 kg)



Keystone Country Manor Cap Unit

\*3" h x 12" d x 14" / 8" w  
(76 x 304 x 355/203mm)  
30 lbs. (13 kg)

Optional Country Manor Unit Sizes



Unit 6/8

Lg. Face Area • .33 sq. ft.  
6" h x 10" d x 8" / 6" w  
(152 x 254 x 203/152mm)  
35 lbs. (15 kg)



Unit 10/8

Lg. Face Area • .42 sq. ft.  
6" h x 10" d x 10" / 8" w  
(152 x 254 x 254/203mm)  
45 lbs. (20 kg)



Unit 12/12

Lg. Face Area • .50 sq. ft.  
6" h x 10" d x 12" / 12" w  
(152 x 254 x 304/304mm)  
45 lbs. (20 kg)  
(90° ends for vertical stacking capability)



1-2 Shouldered Pins required per unit

\* Notes: (1) Unit colors, dimensions, weight, and availability may vary by manufacturer. (2) The number of units in the Keystone Country Manor system vary by manufacturer. Contact your local representative for further details.



KEYSTONE  
*Stonegate*®  
COUNTRY MANOR®

Featuring the look of smooth, weathered stone of quaint European origins, Stonegate® Country Manor® has all the unique features of the original Keystone Country Manor®, but with a smooth face resembling cut stone for a more refined look.

Stonegate Country Manor Unit Sizes



Unit 16/14

Lg. Face Area • .66 sq. ft.  
6" h x 10" d x 16" / 14" w  
(152 x 254 x 406/355mm)  
65 lbs. (29 kg)



Unit 12/10

Lg. Face Area • .50 sq. ft.  
6" h x 10" d x 12" / 10" w  
(152 x 254 x 304/254mm)  
45 lbs. (20 kg)



Unit 6/4

Lg. Face Area • .25 sq. ft.  
6" h x 10" d x 6" / 4" w  
(152 x 254 x 152/101mm)  
25 lbs. (11 kg)



1-2 Shouldered Pins required per unit

## Gravity Walls

One of the most basic types of retaining walls, the gravity wall, relies on its mass and depth to resist the earth pressure that is attempting to move the structure in a lateral direction. Keystone units are able to resist lateral pressure with their weight and embedment depth. The mortarless, yet structurally interconnected, Keystone units also permit water drainage to prevent hydrostatic loads. For low, non-critical applications, Keystone products make highly cost-effective gravity wall structures.

Maximum wall height for non-critical walls is dependent on wall batter, soil loads affecting the walls, and site conditions including drainage considerations.

- 133Elite — 2.5' (.7 m)
- Standard units — 6' (1.8 m)
- Compac units — 3' (1 m)
- Century Wall — 3' (1 m)
- Country Manor — 2' (0.6 m)



## Reinforced Soil Walls

For taller or more critical walls, Keystone units are combined with soil reinforcement options (such as geogrids, earth anchors or galvanized steel grid reinforcing) to create larger composite structures. With a properly designed combination, the reinforced soil mass can support greater earth pressure and surcharge loads. These composite structures have permitted the construction of retaining wall structures over 65' (20 m) high and support roads and buildings. Call your local Keystone Representative to see which option will work best for your project.



## Geogrid

Since the early 1980's, geogrid has proven successful in providing durable soil reinforcement for the retaining wall industry. Proper design methodology today incorporates the laboratory tested connection strength of all Keystone concrete units and specific geogrid types in all reinforced retaining wall systems. Geogrids are made from high-density polyethylene or high tenacity polyester yarns.

### Key properties of geogrid include:

- High tensile strength
- Long-term creep resistance
- Open geometry for interlock
- Non-degradable
- "Off-the-shelf" availability



### The advantages of geogrid-reinforced structures include:

- Economical construction by utilizing a wider range of site soils for the reinforced fill zone, minimizing the need to import select fill
- Construct walls faster without waiting for shop drawings, forming, steel placement and curing time of site cast concrete; the wall structure and backfill are constructed at the same time.
- Eliminates the need for deep structural footing and excavation due to flexible vs. rigid structure system
- Provides durability; long term performance resists effects of water, micro-organisms, alkali or acidic soils

## Soil Properties

The very purpose of a retaining wall system is to safely hold soil in place to make a grade or elevation change in the shortest possible horizontal distance. The soil's shear strength (angle of internal friction and moist soil weight) determines the design characteristics of the soil for use within the wall structure. The design properties of the reinforced zone, the soil above and behind the wall structure, and of the foundation material under the structure, must be determined. A qualified geotechnical engineer should be consulted to establish site-specific soil properties. Taller walls or difficult site conditions will typically require a more extensive geotechnical investigation including laboratory testing of soil.

*Note: the better the soil (more granular higher friction angle and better drainage capability), the more efficient and cost effective the wall design and soil reinforcement solution will become. Better quality soils are more easily placed and compacted resulting in superior structure performance.*



## Engineering Properties

A retaining wall is a structural system which, when properly designed, retains a soil mass and safely supports any surcharge loadings applied to the structure. The engineering properties of the system components are determined by laboratory testing and provide the technical data necessary to complete the design in accordance with accepted design standards. Typical engineering data requirements are:

- Unit dimensions, shape/weight
- Unit to unit shear strength
- Unit to geogrid connection strength
- Geogrid long-term design strength
- Geogrid soil interaction
- Soil Design Properties

\*Keystone test data is available for all material requirements.

\* Note: Unit colors, dimensions, weight, and availability may vary by manufacturer.

**Section 02834 (32 32 23)  
KEYSTONE CONCRETE RETAINING WALL**

**PART 1: GENERAL**

**1.01 Description**

- A. Work shall consist of designing, furnishing and construction of a KEYSTONE® Retaining Wall System in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the plans. No alternate wall systems will be considered.
- B. Work includes preparing foundation soil, furnishing and installing leveling pad, unit drainage fill and backfill to the lines and grades shown on the construction drawings.
- C. Work includes furnishing and installing geogrid soil reinforcement of the type, size, location, and lengths designated on the construction drawings.

**1.02 Related Sections**

- A. Section 02300 (31 00 00) - Earthwork

**1.03 Reference Documents**

- A. American Society for Testing and Materials (ASTM)
  - 1. ASTM C140 Sampling and Testing Concrete Masonry Units
  - 2. ASTM C1372 Specification for Dry-Cast Segmental Retaining Wall Units
  - 3. ASTM D422 Particle-Size Analysis of Soils
  - 4. ASTM D698 Laboratory Compaction Characteristics of Soil -Standard Effort
  - 5. ASTM D1557 Laboratory Compaction Characteristics of Soil -Modified Effort
  - 6. ASTM D3034 Polyvinyl Chloride Pipe (PVC)
  - 7. ASTM D4318 Liquid Limit, Plastic Limit and Plasticity Index of Soils
  - 8. ASTM D4475 Horizontal Shear Strength of Pultruded Reinforced Plastic Rods
  - 9. ASTM D4476 Flexural Properties of Fiber Reinforced Pultruded Plastic Rods
  - 10. ASTM D4595 Tensile Properties of Geotextiles - Wide Width Strip
  - 11. ASTM D5262 Unconfined Tension Creep Behavior of Geosynthetics
  - 12. ASTM D5818 Evaluate Installation Damage of Geosynthetics
  - 13. ASTM D6637 Tensile Properties of Geogrids – Single or Multi-Rib
  - 14. ASTM D6638 Connection Strength - Reinforcement/Segmental Units
  - 15. ASTM D6706 Geosynthetic Pullout Resistance in Soil
  - 16. ASTM D6916 Shear Strength Between Segmental Concrete Units
- B. American Association of State Highway and Transportation Officials (AASHTO)
  - 1. AASHTO M 252 Corrugated Polyethylene Drainage Pipe
- C. Geosynthetic Research Institute (GRI)
  - 1. GRI-GG4 Determination of Long Term Design Strength of Geogrids
  - 2. GRI-GG5 Determination of Geogrid (soil) Pullout
- D. National Concrete Masonry Association (NCMA)
  - 1. NCMA SRWU-1 Test Method for Determining Connection Strength of SRW
  - 2. NCMA SRWU-2 Test Method for Determining Shear Strength of SRW

**1.04 Submittals/Certification**

- A. Contractor shall submit a Manufacturer's certification, prior to start of work, that the retaining wall system components meet the requirements of this specification and the structure design.

- B. Contractor shall submit construction drawings and design calculations for the retaining wall system prepared and stamped by a Professional Engineer registered in the state of the project. The engineering designs, techniques, and material evaluations shall be in accordance with the Keystone Design Manual.

**1.05 Quality Assurance**

- A. Contractor shall submit a list of five (5) previously constructed projects of similar size and magnitude by the wall installer where the specific retaining wall system has been constructed successfully. Contact names and telephone numbers shall be listed for each project.
- B. Contractor shall provide evidence that the design engineer has a minimum of five years of documented experience in the design for reinforced soil structures. The design engineer shall provide proof of current professional liability insurance with an aggregate coverage limit of not less than \$2,000,000.
- C. Owner shall/may provide soil testing and quality assurance inspection during earthwork and wall construction operations. Contractor shall provide any quality control testing or inspection not provided by the Owner. Owner's quality assurance program does not relieve the contractor of responsibility for quality control and wall performance.

**1.06 Delivery, Storage and Handling**

- A. Contractor shall check all materials upon delivery to assure that the proper type, grade, color, and certification have been received.
- B. Contractor shall protect all materials from damage due to job site conditions and in accordance with manufacturer's recommendations. Damaged materials shall not be incorporated into the work.

**PART 2: PRODUCTS**

**2.01 Definitions**

- A. Keystone Unit: a concrete retaining wall element machine made from Portland cement, water, and aggregates.
- B. 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 function primarily as reinforcement.
- C. Unit Drainage Fill: drainage aggregate that is placed within and immediately behind the Keystone concrete units.
- D. Reinforced Backfill: compacted soil that is placed within the reinforced soil volume as outlined on the plans.

**2.02 Keystone Concrete Retaining Wall Units**

- A. Keystone concrete units shall conform to the following architectural requirements:
  - 1. Face color: concrete gray, unless otherwise specified. The Owner may specify standard manufacturers' color.
  - 2. Face finish: sculptured rock face in angular tri-plane or straight-face configuration. Other face finishes will not be allowed without written approval of Owner.
  - 3. Bond configuration: running with bonds nominally located at midpoint of vertically adjacent units, in both straight and curved alignments.
  - 4. Exposed surfaces of units shall be free of chips, cracks or other imperfections when viewed from a distance of 10 feet (3 m) under diffused lighting.
- B. Keystone concrete materials shall conform to the requirements of ASTM C1372 - Standard Specifications for Segmental Retaining Wall Units.

C. Keystone concrete units shall conform to the following structural and geometric requirements measured in accordance with ASTM C140 Sampling and Testing Concrete Masonry Units, ASTM D6916 Determining the Shear Strength Between Segmental Concrete Units and ASTM D6638 Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units:

1. Compressive strength:  $\geq 3000$  psi (21 MPa)
2. Absorption:  $\leq 8\%$  (6% in northern states) for standard weight aggregates. *(Note to Specifier: Select appropriate unit(s) below and delete others)*
3. Keystone Standard Units:
  - a. Width: 18" (457 mm), plus/minus 1/8" (3 mm).
  - b. Depth: 18" (508 mm) minimum, plus/minus 1/8" (3 mm), not including rough split face.
  - c. Height: 8" (203 mm), plus/minus 1/16" (1.5 mm) 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: 900 pounds per linear foot (13000 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
4. Keystone Compac Units:
  - a. Width: 18" (457 mm), plus/minus 1/8" (3 mm).
  - b. Depth: 12" (305 mm) minimum, plus/minus 1/8" (3 mm), not including rough split face.
  - c. Height: 8" (203 mm), plus/minus 1/16" (1.5 mm) measured to top and bottom planes.
  - d. Weight: 75 pounds (35 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.
5. Keystone Century Wall Units:
  - a. Width: Varies – 7 to 18" (178-457 mm), plus/minus 1/8" (3 mm).
  - b. Depth: 12" (305 mm) minimum, plus/minus 1/8" (3 mm), not including rough split face.
  - c. Height: 8" (203 mm) and 4" (101 mm), plus/minus 1/16" (1.5 mm) 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: 1000 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
  - f. Geogrid/Unit Peak Connection Strength: 700 pounds per linear foot (7250 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
6. Keystone Country Manor Units:
  - a. Width: 4" - 16" (102 - 406 mm), plus/minus 1/8" (3 mm).
  - b. Depth: 10" (254 mm) minimum, plus/minus 1/8" (3 mm), not including rough split face.
  - c. Height: 6" (152 mm), plus/minus 1/16" (1.5 mm) 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: 800 pounds per linear foot (8700 N/m), minimum, at 2 pounds per square inch (13 kPa) normal pressure.
  - f. Geogrid/Unit Peak Connection Strength: 400 pounds per linear foot (4300 N/m), minimum, at 2 pounds per square inch (13 kPa) normal force.
7. Keystone 133 Elite Units:
  - a. Width: 24" (610 mm), plus/minus 1/8" (3 mm).
  - b. Depth: 11" (279 mm), plus/minus 1/8" (3 mm).
  - c. Height: 8" (203 mm), plus/minus 1/16" (1.5 mm) measured to top and bottom planes.
  - d. Weight: 95 pounds (43 kg) per unit minimum using standard weight aggregates.

- e. Inter unit shear strength: 1200 pounds per linear foot (17,000 N/m) minimum at 2 pounds per square inch (13 kPa) normal pressure;
- f. Geogrid/unit peak connection strength: 700-plf (10,000 N/m) minimum at 2 pounds per square inch (13 kPa) normal force.

8. 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.

E. Keystone concrete units shall conform to the following construction requirements:

1. Vertical setback: 1/8" (3 mm)  $\pm$  per course (near vertical) or 1" (25 mm) + per course per the design;
2. Alignment and grid positioning mechanism fiberglass pins, two per unit minimum;
3. Maximum horizontal gap between erected units shall be  $\leq 1/2$ " (13 mm).

**2.03 Shear Connectors**

- A. Shear connectors shall be 1/2" (12 mm) diameter thermoset isophthalic polyester resin pultruded fiberglass reinforcement rods to provide connection between vertically and horizontally adjacent units with the following requirements:
  1. Flexural Strength in accordance with ASTM D4476: 128,000 psi (882 MPa) minimum;
  2. Short Beam Shear in accordance with ASTM D4475: 6,400 psi (44 MPa) minimum.
- B. Shear connectors shall be capable of holding the geogrid in the proper design position during grid pre tensioning and backfilling.

**2.04 Base Leveling Pad Material**

- A. Material shall consist of a compacted crushed stone base or non reinforced concrete as shown on the construction drawings.

**2.05 Unit Drainage Fill**

- A. Unit drainage fill shall consist of clean 1" (25 mm) minus crushed stone or crushed gravel meeting the following gradation tested in accordance with ASTM D-422:

Sieve Size	Percent Passing
1" (25 mm)	100
3/4" (19 mm)	75-100
No. 4 (4.75mm)	0-10
No. 50 (300um)	0-5

- B. Drainage fill shall be placed within the cores of, between, and behind the units as indicated on the design drawings. Not less than one cubic foot (0.028 m<sup>3</sup>), of drainage fill shall be used for each square foot (0.093 m<sup>2</sup>) of wall face unless otherwise specified.

**2.06 Reinforced Backfill**

- A. Reinforced backfill shall be free of debris and meet the following gradation tested in accordance with ASTM D-422:

Sieve Size	Percent Passing
2" (50 mm)	100
3/4" (19 mm)	100-75
No. 40 (425um)	0-60
No. 200 (75um)	0-35

Plasticity Index (PI) <15 and Liquid Limit (LL) <40 per ASTM D-4318.

- B. The maximum aggregate size shall be limited to 3/4" (19 mm) unless field tests have been performed to evaluate potential strength reductions to the geogrid design due to damage during construction.
- C. Material can be site-excavated soils where the above requirements can be met. Unsuitable soils for backfill (high plastic clays or organic soils) shall not be used in the backfill or in the reinforced soil mass.
- D. Contractor 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.

## 2.07 Geogrid Soil Reinforcement

- A. Geosynthetic reinforcement shall consist of geogrids manufactured specifically for soil reinforcement applications and shall be manufactured from high tenacity polyester yarn or high density polyethylene. Polyester geogrid shall be knitted from high tenacity polyester filament yarn with a molecular weight exceeding 25,000 g/m and a carboxyl end group values less than 30. Polyester geogrid shall be coated with an impregnated PVC coating that resists peeling, cracking, and stripping.
- B.  $T_a$ , Long Term Allowable Tensile Design Load, of the geogrid material shall be determined as follows:
  - $T_a = T_{ult} / (R_{FCr} * R_{Fd} * R_{Fid} * F_S)$
  - $T_a$  shall be evaluated based on a 75-year design life.
- 1.  $T_{ult}$ , Short Term Ultimate Tensile Strength shall be determined in accordance with ASTM D4595 or ASTM D6637.  
 $T_{ult}$  is based on the minimum average roll values (MARV).
- 2.  $R_{FCr}$ , Reduction Factor for Long Term Tension Creep  
 $R_{FCr}$  shall be determined from 10,000-hour creep testing performed in accordance with ASTM D5262. Reduction value = 1.45 minimum.
- 3.  $R_{Fd}$ , Reduction Factor for Durability  
 $R_{Fd}$  shall be determined from polymer specific durability testing covering the range of expected soil environments.  $R_{Fd} = 1.10$  minimum.
- 4.  $R_{Fid}$ , Reduction Factor for Installation Damage  
 $R_{Fid}$  shall be determined from product specific construction damage testing performed in accordance with ASTM D5818 (GRI GG4). Test results shall be provided for each product to be used with project specific or more severe soil type.  $R_{Fid} = 1.05$  minimum.
- 5.  $F_S$ , Overall Design Factor of Safety  
 $F_S$  shall be 1.5 unless otherwise noted for the maximum allowable working stress calculation.
- C. The maximum design tensile load of the geogrid shall not exceed the laboratory tested ultimate strength of the geogrid/facing unit connection divided by a factor of safety of 1.5. The connection strength testing and computation procedures shall be in accordance with ASTM D6638 Connection Strength between Geosynthetic Reinforcement and Segmental Concrete Units (NCMA SRWU-1).
- D. Soil Interaction Coefficient,  $C_i$   
 $C_i$  values shall be determined per ASTM D6706 (GRI:GG5) at a maximum 3/4" (19 mm) displacement.
- E. Manufacturing Quality Control  
The geogrid manufacturer shall have a manufacturing quality control program that includes QC testing by an independent laboratory.  
The QC testing shall include:
  - Tensile Strength Testing
  - Melt Flow Index (HDPE)
  - Molecular Weight (Polyester)

## 2.08 Drainage Pipe

- A. If required, the drainage pipe shall be perforated or slotted PVC pipe manufactured in accordance with ASTM D-3034 or corrugated HDPE pipe manufactured in accordance with AASHTO M252.

## 2.09 Geotextile Filter Fabric

- A. When required, Geotextile filter fabric shall be 4.0 oz/sy, polypropylene, needle-punched nonwoven fabric.

## PART 3: EXECUTION

### 3.01 Excavation

- A. Contractor shall excavate to the lines and grades shown on the construction drawings. Owner's representative shall inspect the excavation and approve 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 and replacement of unsuitable foundation soils and replacement with approved compacted fill will be compensated as agreed upon with the Owner.

### 3.02 Base Leveling Pad

- A. Leveling pad material shall be placed to the lines and grades shown on the construction drawings, to a minimum thickness of 6" (150 mm) and extend laterally a minimum of 6" (150 mm) in front and behind the Keystone wall unit.
- B. Soil leveling pad materials shall be compacted to a minimum of 95% Standard Proctor density per ASTM D-698 or 92% Modified Proctor Density per ASTM D1557.
- C. Leveling pad shall be prepared to insure full contact to the base surface of the concrete units.

### 3.03 Keystone Unit Installation

- A. First course of units shall be placed on the leveling pad at the appropriate line and grade. Alignment and level shall be checked in all directions and insure that all units are in full contact with the base and properly seated.
- B. Place the front of units side-by-side. Do not leave gaps between adjacent units. Layout of corners and curves shall be in accordance with manufacturer's recommendations.
- C. Install shear/connecting devices per manufacturer's recommendations.
- D. Place and compact drainage fill within and behind wall units. Place and compact backfill soil behind drainage fill. Follow wall erection and drainage fill closely with structure backfill.
- E. Maximum stacked vertical height of wall units, prior to unit drainage fill and backfill placement and compaction, shall not exceed two courses.

### 3.04 Structural Geogrid Installation

- A. Geogrid shall be oriented with the highest strength axis perpendicular to the wall alignment.
- B. Geogrid reinforcement shall be placed at the strengths, lengths, and elevations shown on the construction design drawings or as directed by the Engineer.
- C. The geogrid shall be laid horizontally on compacted backfill and attached to the Keystone wall units. Place the next course of Keystone concrete units over the geogrid. The geogrid shall be pulled taut, and anchored prior to backfill placement on the geogrid.

- D. Geogrid reinforcements shall be continuous throughout their embedment lengths and placed side-by-side to provide 100% coverage at each level. Spliced connections between shorter pieces of geogrid or gaps between adjacent pieces of geogrid are not permitted.

**3.05 Reinforced Backfill Placement**

- A. Reinforced backfill shall be placed, spread, and compacted in such a manner that minimizes the development of slack in the geogrid and installation damage.
- B. Reinforced backfill shall be placed and compacted in lifts not to exceed 6" (150 mm) where hand compaction is used, or 8 - 10" (200 to 250 mm) where heavy compaction equipment is used. Lift thickness shall be decreased to achieve the required density.
- C. Reinforced backfill shall be compacted to a minimum of 95% Standard Proctor density per ASTM D-698 or 92% Modified Proctor Density per ASTM D1557. The moisture content of the backfill material prior to and during compaction shall be uniformly distributed throughout each layer and shall be dry of optimum, + 0%, - 3%.
- D. Only lightweight hand operated equipment shall be allowed within 3 feet (1 m) from the tail of the Keystone concrete unit.
- E. Tracked construction equipment shall not be operated directly upon the geogrid reinforcement. A minimum fill thickness of 6" (150 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 MPH (15 KPH). Sudden braking and sharp turning shall be avoided.
- G. At the end of each day's operation, the Contractor shall slope the last lift of reinforced backfill away from the wall units to direct runoff away from wall face. The Contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

**3.06 Cap Installation**

- A. Cap units shall be glued to underlying units with an all-weather adhesive recommended by the manufacturer such as Keystone Kapseal.

**3.07 As-built Construction Tolerances**

- A. Vertical alignment: ± 1.5" (40 mm) over any 10' (3 m) distance.
- B. Wall Batter: within 2 degrees of design batter.
- C. Horizontal alignment: ± 1.5" (40 mm) over any 10' (3 m) distance. Corners, bends & curves: ± 1 foot (300 mm) to theoretical location.
- D. Maximum horizontal gap between erected units shall be ≤ 1/2" (13 mm).

**3.08 Field Quality Control**

- A. Quality Assurance - The Owner shall/may 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 quality control testing.
- B. Quality Assurance should include foundation soil inspection. Verification of geotechnical design parameters, and verification that the contractor's quality control testing is adequate as a minimum. Quality assurance shall also include observation of construction for general compliance with design drawings and project specifications. (Quality Assurance is usually best performed by the site geotechnical engineer.)
- C. Quality Control – The Contractor shall engage inspection and testing services to perform the minimum quality control testing described in the retaining wall design plans and specifications. Only qualified and experienced technicians and engineers shall perform testing and inspection services.
- D. Quality Control testing shall include soil and backfill testing to verify soil types and compaction and verification that the retaining wall is being constructed in accordance with the design plans and project specifications.

**PART 4: MEASUREMENT AND PAYMENT**

*Since introducing its first concrete segmental retaining wall products to the marketplace, Keystone has been a leader in providing site solutions in erosion control and soil retention methods. Our focus is to provide customers with solutions to successfully complete their project with our products. We not only offer superior products, but outstanding support services as well.*

*The Keystone website, [www.keystonewalls.com](http://www.keystonewalls.com), is an interactive resource offering all of Keystone's product information and marketing support tools. The website also offers information about our unique design software for retaining wall layout and design.*

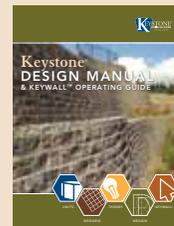
*Here are some of the many excellent resource materials to help you get the job done:*

**Literature**

- *Keystone Product Portfolio*
- *Construction and Design Manuals*
  - *Wall Design Details*
  - *Construction Steps*
  - *Preliminary Design Charts*

**Software**

- *KeyEstimator™*
- *KeyWall™ Engineering Software & Manual*
  - *Specifications (three versions specific to performance based)*
  - *CAD details (AUTOCAD)*

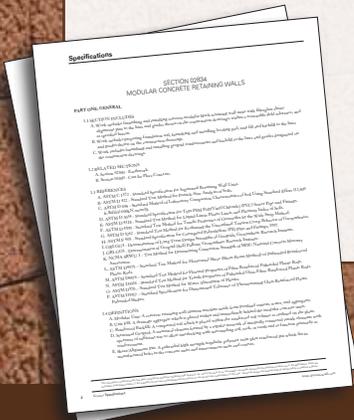


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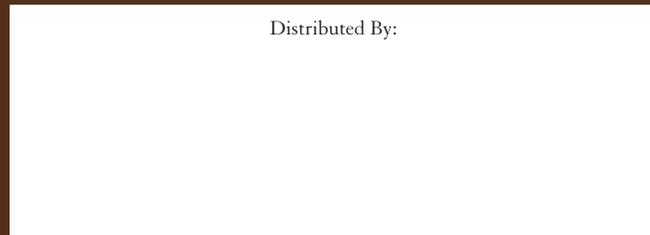
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