

# TOC



<b>Definitions .....</b>	<b>2</b>
<b>Introduction .....</b>	<b>5</b>
Standard Unit Series .....	8
Compac Unit Series .....	9
<b>Basic Installation .....</b>	<b>11</b>
Wall Sections .....	20
<b>Design Charts .....</b>	<b>23</b>
Gravity Charts .....	25
Reinforced Charts .....	29
<b>Corners &amp; Curves.....</b>	<b>37</b>
90° Outside Corner .....	38
90° Inside Corner .....	44
Acute Corner .....	48
Concave Curves .....	52
Convex Curves .....	58
<b>Wall Finishing.....</b>	<b>65</b>
Caps .....	66
CIP Concrete Coping .....	69
<b>Additional Construction Details.....</b>	<b>71</b>
Retaining Wall Drainage .....	72
Water Applications .....	74
Barriers .....	78
Fencing .....	82
Parapets .....	86
Steps and Stairs .....	88
Terraced and Wall Applications .....	93
Wall Repair .....	94
Planting Guidelines .....	95
Creative Options .....	96

## Definitions

---

**AASHTO** – American Association of State Highway Transportation Officials

**ASTM** – American Society for Testing and Materials

**Backfill** – Soils used to replace a zone of excavated soils.

**Backslope** – The angle of soil for finished grade located behind the top of the wall, usually expressed in a ratio such as 3:1 (3 feet horizontal to 1 foot vertical) or 18.4° (33%).

**Base Course** – First row of Keystone units placed on top of the leveling pad.

**CIP** – Cast in place concrete

**Compaction** – Mechanical effort used in densifying soil to a defined minimum percentage of the maximum compacted weight of the soil. See ASTM D698 and D1557 for reference.

**Core Fill** – See Unit Drainage Fill

**Course** – A horizontal layer or row of Keystone units.

**Drainage Composite** – Three dimensional geosynthetic drainage medium encapsulated in a geotextile filter, used to transport water.

**Drainage Pipe** – A perforated or slotted PVC pipe manufactured in accordance with ASTM D3034 or corrugated HDPE pipe manufactured in accordance with AASHTO M 252 used to transport water away from the drainage zone or reinforced backfill.

**Drainage Zone** – A predetermined depth of clean crushed angular stone located behind a Keystone unit to prevent the development of hydrostatic forces on the Keystone unit. Also see Unit Drainage Fill.

**Efflorescence** – A whitish substance that can naturally occur on all concrete products. It comes from salts within the concrete unit being transported by water or from external chlorides.

**Embedment** – Depth of retaining wall below existing or proposed ground line.

**Exposed Wall Face** – The exposed visible portion of the retaining wall when installed.

**Foundation Soil** – Either in-situ soil or compacted backfill, located beneath wall leveling pad and reinforced fill volume.

**Geogrid** – A structural soil reinforcement 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.

**Geosynthetics** – A range of generally polymeric (plastic) products used to solve civil engineering problems. Generally regarded to encompass eight main categories: geotextiles, geogrids, geonets, geomembranes, geosynthetic clay liners, geofoam, geocells and geocomposites.

**Geotextile Filter Fabric** – Material used for separation and filtration of dissimilar soil types, typically consists in two forms, woven or nonwoven synthetic fibers (polymer based).

**Global Stability** – The general mass movement analysis of a soil reinforced segmental retaining wall structure(s) and adjacent soil masses and slopes.

**HDPE** – High-density polyethylene; a polyethylene thermoplastic made from petroleum.

**Impermeable or Low Permeable Soil** – Clay soil used to prevent water percolation into the drainage zone and reinforced backfill behind the retaining wall.

**Keystone unit** – A concrete retaining wall element, machine made from Portland cement, water, and aggregates.

**Leveling Pad** – Material used to support the Keystone unit, typically compacted crushed stone material or unreinforced CIP concrete.

**Modular Block** – See Keystone unit

**MSE** – Mechanically Stabilized Earth

**NCMA** – National Concrete Masonry Association

**Parapet** – Keystone units or CIP concrete installed above finished grade to create a free standing wall that does not retain soil.

**PPE** – Personal Protective Equipment, i.e.: hard hat, gloves, eye protection, etc.

**PVC** – Polyvinyl Chloride; a thermoplastic polymer.

**Reinforced Soil (Reinforced Backfill)** – Compacted soil that is placed within the reinforced soil volume as outlined on the plans.

**Reinforcement** – See Geogrid.

**Retained Soil** – In-situ soil or compacted backfill located directly behind the reinforced soil volume or gravity wall system.

**Segmental Wall unit** – See Keystone unit

**SRW** – Segmental Retaining Wall; i.e.: multiple Keystone units installed to create a retaining wall

**Surcharge** – Any loading imposed on the soil behind the wall that exerts an additional force on a wall structure. All surcharge loadings are assumed to be uniform live or dead loads. Usually expressed in pounds per square foot (psf) or kilo-newton per meter squared ( $\text{kN}/\text{m}^2$ )

**Surcharge Sloping** – Any additional loading imposed on the wall structure due to backslope conditions behind the wall.

**Swale** – A ditch or depression in the soil at the top of the retaining wall used to divert water to another location away from the wall.

**Toe Slope** – The angle of soil for finished grade located in front of the wall base, usually expressed in a ratio such 3:1 (3 feet horizontal and 1 foot vertical)

**Unit Drainage Fill** – Crushed stone that is placed within and immediately behind the Keystone concrete units, measuring 2 feet in total depth from the proposed wall face. Also see drainage zone.

**Wall Batter** – The setback angle measured in degrees created from the fiberglass pin placement location within the Keystone units. The angle is measured using a plumb line from the toe to the top of the wall along the face of the wall.

The Keystone retaining wall system was created to provide an economical, easy-to-install, aesthetically appealing, and structurally sound system as an alternate to boulder, timber tie, concrete panel, or cast-in-place retaining walls. The Keystone system was initially conceived as a gravity wall system that could be constructed to heights of up to 6.5 feet (2 m). The original Keystone Standard unit was 2 feet (600 mm) from face to tail, providing weight and stability to resist the applied earth pressures. Later, the Keystone Compac unit, a smaller 1-foot (300 mm) deep unit, was introduced. The Keystone units have the stability of a large mass, but are easier to handle, lighter to place, and quicker to install than boulders, crib structures or thin-shelled panel structures. Both units were designed with a structural pin connection and granular interlock, eliminating the need for grouting or mortar. As a result of the structural strength created by the fiberglass pins and unit drainage fill, the interlocked assembly is more stable than most other structures.

Concurrent with the development of the Keystone system, geosynthetic soil reinforcement was gaining approval and acceptance as a viable soil reinforcement material. With the structural pin and crushed stone fill for interlock, the combination of geogrids and Keystone units provide an integrated wall system that can be constructed to heights far exceeding the limits of simple gravity walls. Since 1986, millions of square feet of Keystone retaining walls have been successfully constructed, both as gravity and reinforced systems. Applications vary from residential landscaping walls to structural highway walls, some exceeding 50 feet (15 m) in height.

## KEYSTONE RETAINING WALL UNITS

Keystone retaining wall units are a zero-slump concrete masonry product developed specifically for use in earth retaining wall structures. Keystone has developed a wide variety of shapes and designs to accommodate most architectural and structural requirements. Local producers of the Keystone products have a variety of colors available, complementing most landscaping and structural retaining wall applications.

Keystone structural products currently discussed in this manual include:

- Standard I/Standard II/Standard III
- Compac I/Compac II/Compac III

Other Keystone structural products that utilize Keystone's patented fiberglass pin system:

- Keystone Century Wall®
- 133Elite®
- Keystone® Country Manor®

(Please contact your local Keystone representative for availability.)

The Keystone units listed above are designed for use as structural retaining walls, i.e., those exceeding 6.5 feet (2m) in height and/or supporting structures or highway loading.

In addition to the above units, Keystone has a complete line of landscape products that are marketed and sold through retail distribution and landscape supply outlets. The concepts in this manual apply to all wall construction, but these landscape products are generally not considered for structural applications and are not discussed in further detail in this manual. For more information on these products, contact your local Keystone representative or visit [www.keystonewalls.com](http://www.keystonewalls.com).

# Introduction

## KEYSTONE MATERIALS

Keystone units are typically manufactured of concrete with a minimum compressive strength of 3000 psi (21MPa) at 28 days and a maximum absorption of 8% (6% in northern climates). All dimensions are plus or minus  $\frac{1}{8}$  inch (3mm) except for the unit depth, which varies due to the split rock finish. The manufacturing process is automated, so the mixing, compaction, and curing are performed under controlled conditions and provide consistent quality. The units have various face textures available, depending on your local manufacturer. Some of our most popular textures are molded or split-rock finish in various natural colors. Face shapes can be tri-plane, straight, Victorian, or Sculpterra™ molded face such as Hewnstone.

Standard, Compac, Keystone Century Wall, Keystone Country Manor and 133Elite are vertically interconnected using high-strength pultruded fiberglass pins. The Keystone units have cores that are filled with clean crushed stone to provide additional mechanical interlock and internal drainage. The pins assure a running bond configuration of the units and provide significant lateral connection strength between units. The pins improve the connection between the units and the structural soil reinforcement while assuring proper placement of the reinforcement materials.

The connection pins are available in straight and shouldered designs. Straight pins are  $5\frac{1}{4}$  inches (133mm) long and  $\frac{1}{2}$  inch (12.7mm) in diameter. The Standard and Compac units use straight pins. Shouldered pins are  $3\frac{3}{4}$  inches (95mm) long and  $\frac{1}{2}$  inch (12.7mm) in diameter. The shouldered length portion is  $\frac{7}{8}$  inch (22mm) and the shouldered diameter is  $\frac{3}{4}$  inch (20mm). The Keystone Century Wall, Country Manor and 133Elite units use shouldered pins. The minimum pin strength is 6,400 psi (44MPa) short beam shear strength and 110,000 psi (750MPa) tensile strength. The pins are manufactured of pultruded fiberglass and will not corrode or deteriorate. In addition, the fiberglass pin does not change properties (soften or become brittle) due to the temperature changes typical in retaining wall applications.

## STANDARD UNIT SERIES

The Standard unit varies due to manufacturing considerations from 18 to 21 inches (457 to 534mm) in depth, with a typical face width of 18 inches (457mm) and height of 8 inches (203mm). The geometry yields exactly 1 square foot (0.09 m<sup>2</sup>) of face area per unit. Units weigh from 95 to 125 pounds (43 to 56kg) each, varying with local manufacturing and aggregates. The centroid of the unit is slightly forward of center toward the face, but for design purposes, it is taken at the center. For design purposes, the in-place density of the aggregate filled unit is 120 pcf (18.85 kN/m<sup>3</sup>).



Standard / Standard II / Standard III Units

Standard units are manufactured with a dual pin hole configuration. The front pin setting allows the units to be placed at a minimum setback of approximately  $\frac{1}{8}$  inch (28.6mm) per 8 inch (203mm) unit height (1° batter, for design purposes use 0°). The rear pin setting allows placement of the units at a minimum  $1\frac{1}{8}$  inch (28.6mm) setback per 8 inch (203mm) unit height (8° batter). An alternate placement of front/back pin hole allows a setback of  $\frac{5}{8}$  inch (15.9mm) per 8 inch (203mm) unit height (4° batter).

## COMPAC UNIT SERIES

The Keystone Compac unit is a 12 inch (305mm) deep unit with a typical face width of 18 inches (457mm) by 8 inches (203mm) high. This geometry yields exactly 1 square foot (0.09 m<sup>2</sup>) of face area per unit. Depth may vary from 11.5 to 12.5 inches (280 to 317mm) depending upon local manufacturing and splitting requirements. Units weigh from 70 to 95 pounds (32 to 43kg) each, varying with local manufacturing and aggregates. For design purposes, the in-place density of the aggregate filled unit is 120 pcf (18.85 kN/m<sup>3</sup>).



Compac / Compac II / Compac III Unit

The dual pin hole configuration allows the same 1° (0° for design purposes), 4°, and 8° setback as the Standard unit.

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 CENTURY WALL® UNITS

Keystone Century Wall® is a three piece system that consists of a small, medium, and large unit. The width of the units is the varying dimension that dictates the size. The small unit is 7 inches (178mm) wide, the medium unit is 11 inches (279mm) wide, and the large unit is 18 inches (457mm) wide. The three Century Wall units are 12 inches (305mm) deep and 8 inches (203mm) high. The small unit weighs 37-45 pounds (17-20kg), the medium unit weighs 53-61 pounds (24-28kg), and the large unit weighs 85-93 pounds (39-42kg). Weights may vary with local manufacturing and aggregates.



Century Wall® Units

Similar to the Compac and Standard units, a dual pin hole configuration allows 1° (0° for design purposes), 4°, and 8° setback.

### KEYSTONE COUNTRY MANOR®

Keystone Country Manor® comes in a variety of sizes, most commonly sold as a six piece system, a five piece system, or a three piece system. The units are textured on three sides, allowing for both 1 and 2-sided applications to be built. The width of the units are the varying dimension that dictates the size, each unit has 2 unit width dimensions, because both sides of the unit can be incorporated in the wall face. The various unit widths are 6/4 inches (152/101mm), 8/6 inches (203/152mm), 10/8 inches (254/203mm), 12/12 inches (304/304mm), 12/10 inches (304/254mm), and 16/14 inches (406/355mm). The Country Manor units are 10 inches (254mm) deep and 6 inches (152mm) high. The unit weights from small to large are 25 pounds (11kg), 35 pounds (15kg), 45 pounds (20kg), 45 pounds (20kg), 40 pounds (18kg), and the largest unit weighs 60 pounds (27kg). Weights may vary with local manufacturing and aggregates.



Country Manor® Units

Unique to Country Manor, the three pin hole configurations allow for a near vertical wall, 1 inch setback, or allow random units to protrude from the wall face at a 1 inch increment. (The design batter is 0° or 9.5° for the setback alignment.)

### KEYSTONE 133ELITE® UNIT

133Elite® units are 8 inches (203mm) high and 24 inches (610mm) wide to create a face area of 1.33 square feet (0.124m<sup>2</sup>), hence the name 133Elite®. The depth of the unit is 11.5 inches (292mm). Depending on face treatment, the weight of the 133Elite® unit is approximately 93-100 pounds (42-45kg).



133Elite® Unit

133Elite units are manufactured with one pin position that creates a near vertical setback equal to  $\frac{3}{8}$  inch (9.6mm) per 8 inches (203mm) of unit height (2.5° batter).

**Note:**

*Not all units types, face treatments and colors are available at all manufacturing locations. Please check with your local manufacturer or Keystone supplier for availability.*

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.

## Standard Unit Series



### THE KEYSTONE STANDARD UNIT IS AN AMERICAN ORIGINAL.

The product that started the industry is still the industry leader for tall walls and critical structures.

The height-to-depth ratio of the Keystone Standard unit delivers a structurally sound, engineered wall system with superior construction stability, durability, and strength. Architects, engineers, and contractors rely on the Keystone Standard unit to stand strong when the safety and security of their wall designs matter.

	Standard I	Standard II	Standard III		
<b>Unit Height</b>	8" (200mm)	8" (200mm)	8" (200mm)		
<b>Unit Width</b>	18" (455mm)	18" (455mm)	18" (455mm)		
<b>Unit Depth</b>	18" (455mm)   21" (533mm)	18" (455mm)	18" (455mm)   21" (533mm)		
<b>Face Area per Unit</b>	1SF (.093m <sup>3</sup> )	1SF (.093m <sup>3</sup> )	1SF (.093m <sup>3</sup> )		
<b>Unit Weight</b>	95-125lbs (43-56kg)	93-115lbs (42-53kg)	90-100 lbs (41-45kg)		
<b>Volume of Voids to Tail</b>	0.70 ft <sup>3</sup> /ft <sup>2</sup> (0.21m <sup>3</sup> /m <sup>2</sup> )	0.90 ft <sup>3</sup> /ft <sup>2</sup> (0.27m <sup>3</sup> /m <sup>2</sup> )	0.70 ft <sup>3</sup> /ft <sup>2</sup> (0.21m <sup>3</sup> /m <sup>2</sup> )	0.81 ft <sup>3</sup> /ft <sup>2</sup> (0.025m <sup>3</sup> /m <sup>2</sup> )	1.01 ft <sup>3</sup> /ft <sup>2</sup> (0.031m <sup>3</sup> /m <sup>2</sup> )
<b>Volume of Voids to 24" depth</b>	1.20 ft <sup>3</sup> /ft <sup>2</sup> (0.37m <sup>3</sup> /m <sup>2</sup> )	1.16 ft <sup>3</sup> /ft <sup>2</sup> (0.36m <sup>3</sup> /m <sup>2</sup> )	1.20 ft <sup>3</sup> /ft <sup>2</sup> (0.37m <sup>3</sup> /m <sup>2</sup> )	1.31 ft <sup>3</sup> /ft <sup>2</sup> (0.040m <sup>3</sup> /m <sup>2</sup> )	1.26 ft <sup>3</sup> /ft <sup>2</sup> (0.038m <sup>3</sup> /m <sup>2</sup> )
<b>Fiberglass Pin</b>	Straight Pin				

NOTE: UNIT WEIGHTS, DIMENSIONS AND AVAILABILITY VARY BY MANUFACTURER. PLEASE CONTACT YOUR LOCAL REPRESENTATIVE.



Standard I  
Tri-plane



Standard I  
Straight



Standard II  
Tri-plane



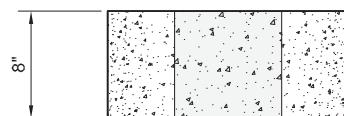
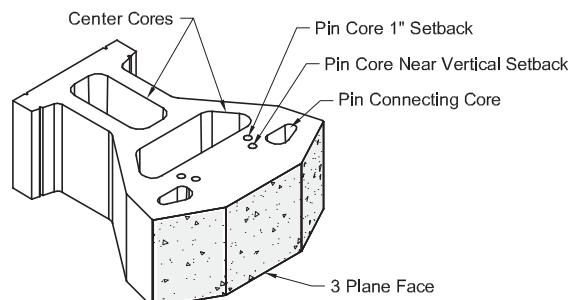
Standard II  
Straight



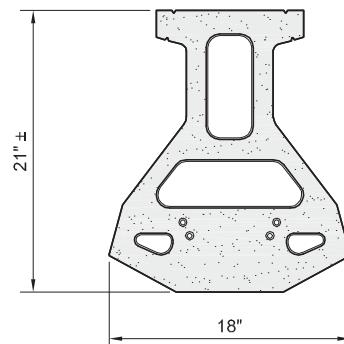
Standard III  
Tri-plane



Standard III  
Straight



3 Plane Standard I Unit Elevation



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 AND BUILD WITH CONFIDENCE.** 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	Compac II	Compac III
<b>Unit Height</b>	8" (200mm)	8" (200mm)	8" (200mm)
<b>Unit Width</b>	18" (455mm)	18" (455mm)	18" (455mm)
<b>Unit Depth</b>	12" (300mm)	12" (300mm)	12" (300mm)
<b>Face Area per Unit</b>	1SF (.093m <sup>2</sup> )	1SF (.093m <sup>2</sup> )	1SF (.093m <sup>2</sup> )
<b>Unit Weight</b>	81-95lbs(37-43kg)	78-91lbs (35-41kg)	69-77lbs (31-35kg)
<b>Volume of Voids to Tail</b>	0.30 ft <sup>3</sup> /ft <sup>2</sup> (0.09m <sup>3</sup> /m <sup>2</sup> )	0.35 ft <sup>3</sup> /ft <sup>2</sup> (0.11m <sup>3</sup> /m <sup>2</sup> )	0.41 ft <sup>3</sup> /ft <sup>2</sup> (0.13m <sup>3</sup> /m <sup>2</sup> )
<b>Volume of Voids to 12" depth</b>	1.30 ft <sup>3</sup> /ft <sup>2</sup> (0.40m <sup>3</sup> /m <sup>2</sup> )	1.35 ft <sup>3</sup> /ft <sup>2</sup> (0.41m <sup>3</sup> /m <sup>2</sup> )	1.41 ft <sup>3</sup> /ft <sup>2</sup> (0.43m <sup>3</sup> /m <sup>2</sup> )
<b>Fiberglass Pin</b>	Straight Pin		

NOTE: UNIT WEIGHTS, DIMENSIONS AND AVAILABILITY VARY BY MANUFACTURER. PLEASE CONTACT YOUR LOCAL REPRESENTATIVE.



Compac I  
Tri-plane



Compac I  
Straight



Compac II  
Tri-plane



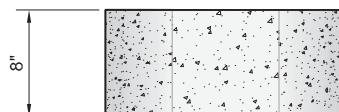
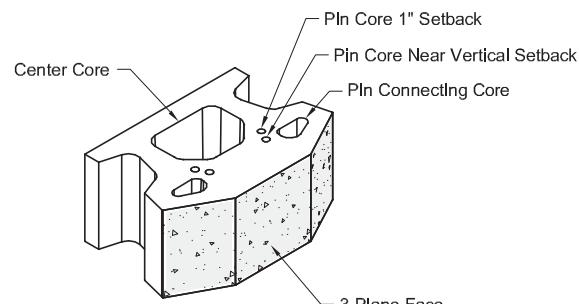
Compac II  
Straight



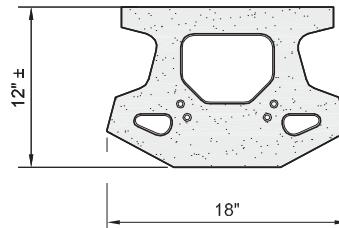
Compac III  
Tri-plane



Compac III  
Straight



3 Plane Compac II Unit Elevation



3 Plane Compac II Unit Plan

#### ALTERNATE FACE TEXTURES

NOTE: PRODUCT VERSIONS VARY BY MANUFACTURER. PLEASE CONTACT YOUR LOCAL REPRESENTATIVE.



Hewnstone



Victorian



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.