ICC-ES Evaluation Report

ESR-2113

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DIVISION: 32 00 00—EXTERIOR IMPROVEMENTS
Section: 32 32 23—Segmental Retaining Walls

REPORT HOLDER:

KEYSTONE RETAINING WALL SYSTEMS, INC.
4444 WEST 78TH STREET
MINNEAPOLIS, MINNESOTA 55435
www.keystonewalls.com

EVALUATION SUBJECT:

KEYSTONE RETAINING WALL SYSTEMS

ADDITIONAL LISTEE:

RCP BLOCK AND BRICK, INC.
8240 BROADWAY
LEMON GROVE, CALIFORNIA 91945

1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2009 and 2006 *International Building Code*® (IBC)
- 2009 and 2006 *International Residential Code*® (IRC)
- 1997 *Uniform Building Code*™ (UBC)

Properties evaluated:

Physical properties

2.0 USES

The Keystone Retaining Wall Systems consist of modular concrete units for the construction of conventional gravity or geogrid-reinforced-soil retaining walls.

3.0 DESCRIPTION

3.1 Keystone Units:

Keystone concrete units are available in four configurations: Standard, Compac, Compac II, Country Manor. See Figure 1 for dimensions and nominal weights. Standard, Compac, Compac II units and corresponding cap units have either a straight or three-plane split face. Country Manor units have a straight face. Cap units are half-height units without pin holes in the top surface. The nominal unit weights, noted in Figure 1, are to be used in design.

Standard, Compac and Compac II units have four holes each for installation of two fiberglass connection pins. Country Manor units have six holes for installation of two fiberglass connection pins. The Small Country Manor Unit has three holes, for installation of one fiberglass connection pin. The underside of each unit has a slot to receive the connection pin. See Figure 1 for typical unit configurations.

All units are made with normal-weight aggregates, and comply with ASTM C 1372, including having a minimum 28-day compressive strength of 3,000 psi (21 MPa) on the net area. In areas where repeated freezing and thawing under saturated conditions occur, evidence of compliance with freeze-thaw durability requirements of ASTM C 1372 must be submitted to the code official for approval prior to construction.

3.2 Fiberglass Pins:

Pultruded fiberglass pins provide alignment of the units during placement, positive placement of the geogrid reinforcement, and inter-unit shear strength. The connection pins are 0.5 inch (12.7 mm) in diameter and 5.25 inches (133 mm) long, and have a minimum short beam shear strength of 6,400 psi (44 MPa).

3.3 Unit Core Drainage Fill:

Unit core drainage fill must be $^1/_2$ inch to $^3/_4$ inch (13 mm to 19 mm) clean, crushed-stone material that is placed between and behind the units. The unit core fill provides additional weight to the completed wall section for stability, local drainage at the face of the structure, and a filter zone to keep the backfill soils from filtering out through the space face between units.

3.4 Geogrid:

The geogrid materials listed in Table 2 are proprietary materials used to increase the height of the Keystone Wall System above the height at which the wall is stable under its self-weight as a gravity system. Geogrids are synthetic materials specifically designed for use as soil reinforcement.

4.0 DESIGN AND INSTALLATION

4.1 Design:

4.1.1 General: Structural calculations must be submitted to the code official for each wall system installation. The system must be designed as a gravity or reinforced-soil retaining wall that depends on the weight and geometry of the concrete units and soil to resist lateral earth pressures and other lateral forces. Lateral earth pressures are determined using either Coulomb or Rankine earth pressure theory. The design must include evaluation of both external and internal stability of the structure and include consideration of external loads such as surcharges and seismic forces. Minimum safety factors are 1.5 for

base sliding and 2.0 for overturning (1.5 for overturning on gravity walls), and 2.0 for bearing capacity. Seismic safety factors may be 75 percent of the minimum allowable static safety factors.

A site-specific soils investigation report in accordance with 2009 IBC Section 1803, 2006 IBC Section 1802 or UBC Section 1804, as applicable, is required. The soils investigation report must specify the soil-reinforcement and interaction coefficients, including the coefficient of interaction for pullout and coefficient of direct sliding; and the applicable safety factors for the determination of the ultimate tensile strength, long-term design strength and allowable tensile strength of the geogrid. The soils investigation report must also specify safety factors for tensile rupture and pullout of the geogrid. The design of the Keystone wall is based on accepted geotechnical principles for gravity and soil-reinforced structures. Specifics of design recommended by the manufacturer are found in the Keystone Design Manual dated February 2011.

4.1.2 Gravity Retaining Walls: The gravity wall system relies on the weight and geometry of the Keystone units to resist lateral earth pressures. Gravity wall design is based on standard engineering principles for modular concrete retaining walls. The maximum height of retaining walls constructed using Keystone Standard, Compac, Compac II and Country Manor units is shown in Figure 2 for different soil and back slope combinations. Typical design heights are 2.5 to 3 times the depth of the unit being used. Inter-unit shear capacity equations are provided in Table 1.

4.1.3 Geogrid-reinforced Retaining Walls:

4.1.3.1 General: The geogrid reinforced soil system relies on the weight and geometry of the Keystone units and the reinforced soil mass to act as a coherent gravity mass to resist lateral earth pressures. The design of a reinforced soil structure is specific to the Keystone unit selected, soil reinforcement strength and soil interaction, soil strength properties, and structure geometry. The maximum practical height above the wall base is approximately 50 feet (15 m). Figure 3 shows typical component details.

4.1.3.2 Structural Analysis: Structural analysis must be based on accepted engineering principles, the Keystone Design Manual dated February 2011, and the IBC or UBC, as applicable. The analysis must include all items noted in Sections 4.1.3.2.1 and 4.1.3.2.2 of this report, and must follow the design methodology of the Keystone Design Manual dated February 2011. All contact surfaces of the units must be maintained in compression.

4.1.3.2.1 External Stability Analysis:

1. The minimum length of the reinforced mass is 0.6 times the height of the wall (as measured from the top of the leveling pad to the top of the wall) or as required to satisfy a safety factor of 1.5 on sliding at the base, whichever is greater.
2. The minimum safety factor for overturning the reinforced mass is 2.0, considering the mass as a rigid body rotating about the toe of the wall.
3. Global stability analysis must be provided for walls with slopes below the toe of the wall, walls on soft foundations, walls that will be designed for submerged conditions, or tiered walls.
4. After completion of the internal stability analysis and geogrid layout, sliding along each respective geogrid layer must be checked, including shearing through the connection at the wall face.

4.1.3.2.2 Internal Stability Analysis:

1. Geogrid spacing must be based on local stability of the Keystone units during construction. Vertical spacing is typically limited to 2 times the depth of the unit.
2. Tension calculations for each respective layer of reinforcing must be provided. Tension is based on the earth pressure and surcharge load calculated from halfway to the layer below to halfway to the layer above. Calculated tensions must not exceed the allowable geogrid strength.
3. Connection capacity must be checked for each geogrid-to-Keystone connection (see Table 2). The calculated connection capacity must be equal to or greater than the calculated tension for each layer.
4. A calculation check must be made on pullout of the upper layers of geogrid from the soil zone beyond the theoretical Coulomb or Rankine failure plane. The pullout capacity must be equal to or greater than the calculated tension after applying the applicable geogrid interaction and sliding coefficient adjustment factors.

4.2 Installation:

The wall system units are assembled in a running bond pattern, except for the Country Manor units, which are assembled in a random bond pattern. The wall system units are assembled without mortar or grout, utilizing high-strength fiberglass pins for shear connections, mechanical connections of reinforcing geogrid, and unit alignment. The system may include horizontal layers of structural geogrid reinforcement in the backfill soil mass. Requirements for installation of the Keystone Retaining Wall System are as follows:

1. Excavate for leveling pad and reinforced fill zone.
2. Inspect excavations for adequate bearing capacity of foundation soils and observation of groundwater conditions by a qualified geotechnical engineer.
3. Install a 6-inch-thick (152 mm) leveling pad of crushed stone, compacted to 75 percent relative density as determined by ASTM D 4564. (An unreinforced concrete pad in accordance with 2009 IBC Section 1809.8, 2006 IBC Section 1805.4.2.3 or UBC Section 1922, as applicable, may be utilized in place of the crushed stone pad.)
4. Install the first course of Keystone units, ensuring units are level from side to side and front to back. Adjacent Keystone units are placed so pin holes are approximately 12 inches (305 mm) on center.
5. Install the fiberglass pins in the units to establish the angle of wall inclination (batter). The pin placement and resulting batter for given units are as follows:

    - Standard, Compac and Compac II Units: Placing the pin in the rear pin holes in every course provides a minimum wall inclination of 7.1 degrees from vertical toward the backfill [1 inch (25.4 mm) minimum setback per course]. Pin placement alternating between the front and rear pin holes on vertically adjacent rows provides a wall inclination of approximately 3.6 degrees from vertical toward the backfill [$^1/_2$ inch (13 mm) minimum setback per course]. The pin placement during assembly in the front pin hole provides a wall inclination of approximately 0.5 degree from vertical toward the backfill [$^1/_8$ inch (3 mm) minimum setback per course].

- Country Manor Units: Placing the pin in the rear pin holes in every course provides a wall inclination of approximately 9.5 degrees from vertical toward the backfill [1 inch (25.4 mm) setback per course]. Placing the pin in the middle pin hole provides a wall inclination of approximately 0.5 degree from vertical toward the backfill [$^1/_8$ inch (3 mm) minimum setback per course].

6. Fill the unit cores with unit core drainage fill described in Section 3.3 of this report. The unit core drainage fill is required for all installations and must extend back a minimum of 2 feet (610 mm) from the outside or front face of the wall. See Figure 3.
7. Clean the top surface of the units to remove loose aggregate.
8. At designated elevation per the design, install geogrid reinforcing. All geogrid reinforcement is installed by placing it over the fiberglass pin. Check to ensure the proper orientation of the geogrid reinforcement is used so the strong direction is perpendicular to the face. Adjacent rolls are placed side by side; no overlap is required.
9. Pull taut to remove slack from the geogrids before placing backfill. Pull the entire length taut to remove any folds or wrinkles.
10. Place and compact backfill over the geogrid reinforcing layer in appropriate lift thickness to ensure compaction.
11. Repeat placement of units, core fill, backfill, and geogrids, as shown on plans, to finished grade.
12. Backfill used in the reinforced fill mass must consist of suitable fine-grained or coarse-grained soil placed in lifts compacted to at least 90 percent of the maximum dry density as determined by ASTM D 1557 (95 percent per ASTM D 698). The backfill soil properties, lift thickness, and degree of compaction must be determined by the soils engineer based on site-specific conditions. In cut-wall applications, if the reinforced soil has poor drainage properties, a granular drainage layer of synthetic drainage composite should be installed to prevent buildup of hydrostatic pressures behind the reinforced soil mass. Provisions for adequate subsurface drainage must be determined by the soils engineer.
13. Stack and align units using the structural pin connection between vertically adjacent units at the design setback batter. The completed wall is built with alignment tolerances of 1.5 inches (40 mm) in 10 feet (3048 mm) in both the horizontal and vertical directions.
14. When required by the design, geogrid reinforcement is placed at the elevations specified in the design. The reinforced backfill must be placed and compacted no lower than the top unit-elevation to which geogrid placement is required.

4.3 Special Inspection:

Special inspection must be provided in accordance with IBC Section 1704.5 (IBC and IRC) or UBC Section 1701.5.7.1, as applicable. The inspector's responsibilities include verifying the following:

1. The modular concrete unit dimensions.
2. Keystone unit identification compliance with ASTM C 1372 and UBC Standard 21-4, as applicable, including compressive strength and water absorption, as described in Section 3.1 of this report.
3. Foundation preparation.
4. Keystone unit placement, including alignment and inclination.
5. Geosynthetic reinforcement type (manufacturer and model number) and placement.
6. Backfill placement and compaction.
7. Drainage provisions.

5.0 CONDITIONS OF USE

The Keystone Retaining Wall Systems described in this report comply with, or are suitable alternatives to what is specified in, those codes listed in Section 1.0 of this report, subject to the following conditions:

5.1 The systems are designed and installed in accordance with this report; the Keystone Design Manual, dated February 2011; the manufacturer's published installation instructions; and accepted engineering principles. If there is a conflict between this report and the manufacturer's published installation instructions, this report governs.

5.2 The Keystone Design Manual, dated February 2011, is submitted to the code official upon request.

5.3 The wall design calculations are submitted to, and approved by, the code official. The calculations must be prepared by a registered design professional where required by the statutes of the jurisdiction in which the project is to be constructed.

5.4 A site-specific soils investigation in accordance with 2009 IBC Section 1803, 2006 IBC Section 1802 or UBC Section 1804, as applicable, as noted in Section 4.1.1 of this report, must be provided for each project site.

5.5 In areas where repeated freezing and thawing under saturated conditions occur, evidence of compliance with freeze-thaw durability requirements of ASTM C 1372 must be furnished to the code official for approval prior to construction.

5.6 Special inspection must be provided for backfill placement and compaction, geogrid placement (when applicable), and block installation, in accordance with Section 4.3 of this report.

5.7 Details in this report are limited to areas outside of groundwater. For applications where free-flowing groundwater is encountered, or where wall systems are submerged, the installation and design of systems must comply with the recommendations of the soils engineer and the appropriate sections of the NCMA Design Manual for Segmental Retaining Walls, and must be approved by the code official.

5.8 Under the 2009 IBC, project specifications or soil and water conditions that have sulfate concentrations identified in ACI 318-08 Table 4.2.1 as severe (S2) or very severe (S3), shall include mix designs for concrete and masonry and grout that comply with the intent of ACI 318-08 Table 4.3.1. See 2009 IBC Section 1904.5.

5.9 Under the 2006 IBC, project specifications or soil and water conditions that have sulfate concentrations identified in ACI 318-05 Table 4.3.1 as severe or very severe, shall include mix designs for concrete and masonry and grout that comply with the intent of ACI 318-05 Table 4.3.1. See 2006 IBC Section 1904.3.

5.10 This report evaluates only the connection strength of the geogrid material when attached to the concrete units. Physical properties of the geogrid material or its interaction with the soil have not been evaluated.

6.0 EVIDENCE SUBMITTED

Data in accordance with the ICC-ES Acceptance Criteria for Segmental Retaining Walls (AC276), dated October 2004 (editorially revised May 2011).

7.0 IDENTIFICATION

Each pallet of concrete units is identified with the manufacturer's name (RCP Block and Brick) and address, the name of the product, the unit type, and the evaluation report number (ESR-2113). Fiberglass pins are provided with each shipment of blocks, with a letter of certification by Keystone.

TABLE 1—INTER-UNIT SERVICE-STATE SHEAR RESISTANCE[1]

UNIT	SHEAR STRENGTH
Standard	F = 1548 + 0.31 N
Compac	F = 769 + 0.51 N
Compac II	F = 1263 + 0.12 N
Country Manor	F = 92 + 0.81 N

For **SI:** 1 lb/linear foot = 14.6 N/m.

[1]The inter-unit service-state shear resistance, F [lb/linear foot (N/m)], of the Keystone units at any depth is a function of the pin strength and superimposed normal (applied) load, N [lb/linear foot (N/m)].

TABLE 2—GEOGRID-TO-BLOCK PULLOUT RESISTANCE EQUATIONS[1]

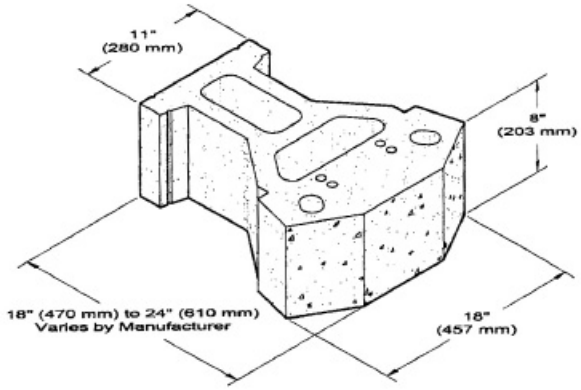
GEOGRID	PEAK CONNECTION STRENGTH (pounds/linear foot)		SERVICEABILITY CONNECTION STRENGTH (pounds/linear foot)	
	Equation	Maximum	Equation	Maximum
KEYSTONE STANDARD UNIT				
Strata Systems				
Stratagrid SG 200	P = 835 + 0.73 N	1566	P = 795 + 0.23 N	1013
Stratagrid SG 300	P = 650 + 0.45 N	2000	P = 500 + 0.27 N	1100
Stratagrid SG 500	P = 1591 + 0.62 N	2759	P = 994 + 0.21 N	1702
Stratagrid SG 600	P = 1417 + 0.62 N	3409	P = 878 + 0.18 N	1791
TC Mirafi Geogrid				
Miragrid 3XT	P = 1595 + 0.00 N	1595	P = 822 + 0.14 N	1302
Miragrid 5XT	P = 600 + 0.29 N	1644	P = 484 + 0.14 N	915
Miragrid 7XT	P = 1137 + 0.36 N	2284	P = 781 + 0.27 N	1720
Miragrid 8XT	P = 958 + 0.47 N	1897	P = 334 + 0.51 N	1398
Miragrid 10XT	P = 1226 + 0.53 N	2896	P = 1000 + 0.21 N	1766
Huesker Geogrid				
Fortrac 20/13-20	P = 500 + 0.75 N	750	P = 400 + 0.60 N	700
Fortrac 35/20-20	P = 700 + 0.75 N	1050	P = 500 + 0.60 N	900
Fortrac 55/30-20	P = 950 + 0.87 N	2300	P = 650 + 0.72 N	2000
Fortrac 80/30-20	P = 1200 + 1.0 N	2800	P = 900 + 0.72 N	2100
Fortrac 110/30-20	P = 2000 + 0.78 N	4145	P = 1342 + 0.42 N	2846
Tensar Geogrid				
UX1400SB	P = 700 + 0.89 N	2500	P = 400 + 0.70 N	2100
UX1500SB	P = 1000 + 0.89 N	4400	P = 700 + 0.89 N	2750
UX1600SB	P = 1100 + 0.89 N	4500	P = 800 + 0.60 N	3000
KEYSTONE COMPAC UNIT				
Strata Systems				
Stratagrid SG 150	P = 444 + 0.60 N	1259	P = 358 + 0.38 N	878
Stratagrid SG 200	P = 889 + 0.31 N	1624	P = 519 + 0.14 N	767
Stratagrid SG 300	P = 550 + 0.25 N	2000	P = 400 + 0.16 N	1100
Stratagrid SG 500	P = 802 + 0.51 N	2174	P = 446 + 0.29 N	1000
Stratagrid SG 600	P = 850 + 0.25 N	2800	P = 500 + 0.16 N	1800

TABLE 2—GEOGRID-TO-BLOCK PULLOUT RESISTANCE EQUATIONS[1] (Continued)

GEOGRID	PEAK CONNECTION STRENGTH (pounds/linear foot)		SERVICEABILITY CONNECTION STRENGTH (pounds/linear foot)	
	Equation	Maximum	Equation	Maximum
KEYSTONE COMPAC UNIT (Continued)				
TC Mirafi				
Miragrid 2XT	P = 213 + 0.55 N	1314	P = 302 + 0.23 N	680
Miragrid 3XT	P = 695 + 0.21 N	1128	P = 469 + 0.19 N	882
Miragrid 5XT	P = 763 + 0.23 N	1459	P = 564 + 0.27 N	1293
Miragrid 7XT	P = 443 + 0.67 N	1571	P = 289 + 0.55 N	1182
Miragrid 8XT	P = 635 + 0.38 N	1780	P = 444 + 0.34 N	1465
Miragrid 10XT	P = 752 + 0.65 N	1988	P = 518 + 0.62 N	1760
Huesker				
Fortrac 20/13-20	P = 372 + 0.23 N	716	P = 338 + 0.16 N	684
Fortrac 35/20-20	P = 809 + 0.31 N	1557	P = 809 + 0.12 N	1115
Fortrac 55/30-20	P = 983 + 0.51 N	2453	P = 919 + 0.32 N	1957
Fortrac 80/30-20	P = 1000 + 0.47 N	2979	P = 1000 + 0.36 N	2525
Tensar				
UX1400SB	P = 600 + 0.80 N	2600	P = 400 + 0.70 N	2100
UX1500SB	P = 800 + 1.10 N	3800	P = 700 + 0.89 N	2750
KEYSTONE COMPAC II UNIT				
Strata Systems				
Stratagrid SG 150	P = 798 + 0.34 N	1576	P = 593 + 0.27 N	1184
Stratagrid SG 200	P = 707 + 0.93 N	1754	P = 928 + 0.10 N	1250
Stratagrid SG 300	P = 980 + 0.62 N	1913	P = 980 + 0.19 N	1490
Stratagrid SG 500	P = 626 + 1.15 N	2000	P = 770 + 0.42 N	1705
TC Mirafi				
Miragrid 2XT	P = 800 + 0.29 N	1452	P = 800 + 0.29 N	1452
Miragrid 3XT	P = 811 + 0.36 N	1617	P = 571 + 0.45 N	1593
Miragrid 5XT	P = 1200 + 0.38 N	2050	P = 691 + 0.55 N	1941
Miragrid 7XT	P = 1173 + 0.40 N	2222	P = 622 + 0.47 N	1948
Miragrid 8XT	P = 960 + 0.84 N	2490	P = 691 + 0.73 N	2280
Huesker				
Fortrac 35/20-20	P = 916 + 0.57 N	1576	P = 743 + 0.16 N	1040
Fortrac 55/30-20	P = 1166 + 0.70 N	2518	P = 1096 + 0.23 N	1808
Fortrac 80/30-20	P = 819 + 0.31 N	2663	P = 1032 + 0.31 N	1957
KEYSTONE COUNTRY MANOR UNIT				
Strata Systems				
Stratagrid SG 150	P = 377 + 0.47 N	950	P = 327 + 0.48 N	932
Stratagrid SG 200	P = 550 + 0.43 N	1238	P = 311 + 0.38 N	903
Huesker				
Fortrac 20/13-20	P = 427 + 0.18 N	702	P = 310 + 0.23 N	675
Tensar				
BX1200	P = 474 + 0.42 N	1142	P = 494 + 0.36 N	1045

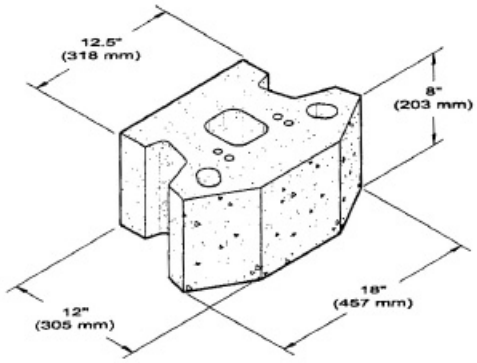
For **SI:** 1 lb/linear ft. = 14.6 N/m.

[1]Where N = superimposed normal (applied) load (lb/linear foot).



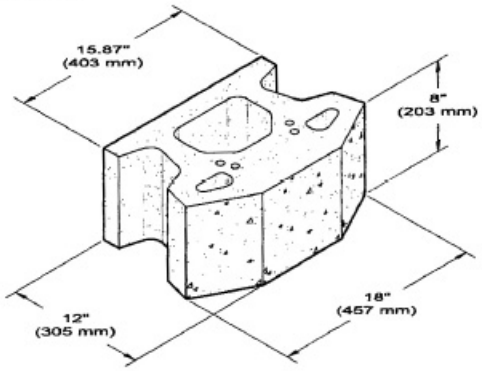
Standard Unit

110 lb. (50 kg)



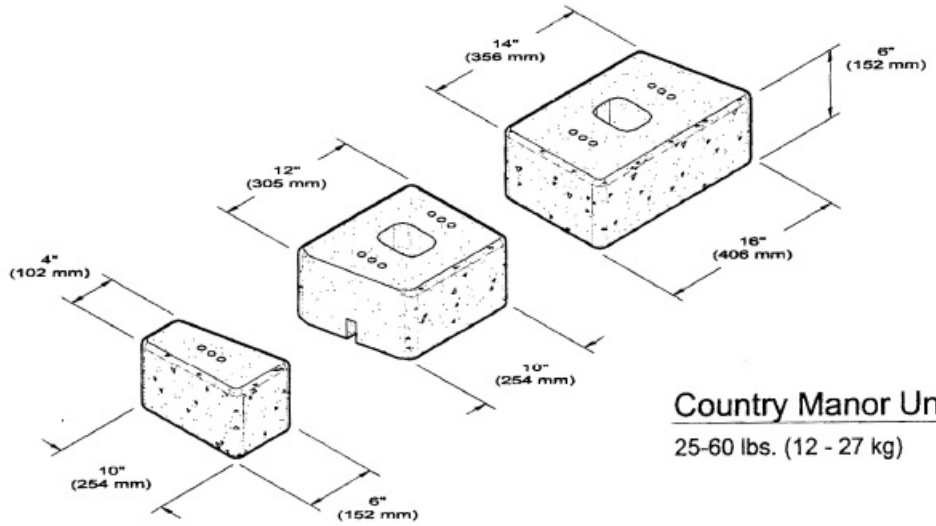
Compac Unit

85 lb. (40 kg)



Compac II Unit

82 lb. (37 kg)



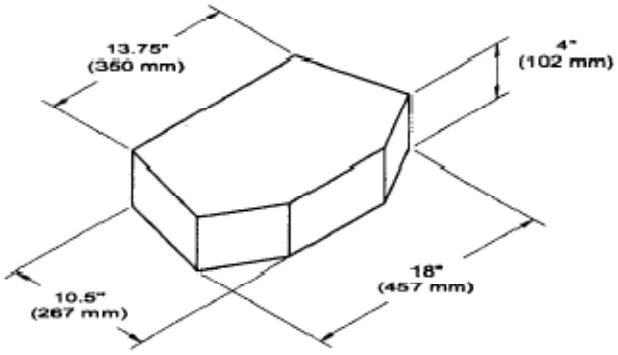
Country Manor Unit

25-60 lbs. (12 - 27 kg)

FIGURE 1—KEYSTONE WALL UNITS

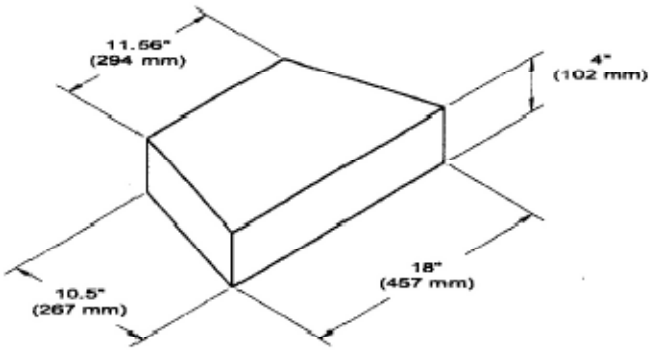
Cap Unit

45 lb. (20 kg)



Universal Cap Unit

51 lb. (23 kg)



Country Manor Cap Unit

24 lbs. (11 kg)

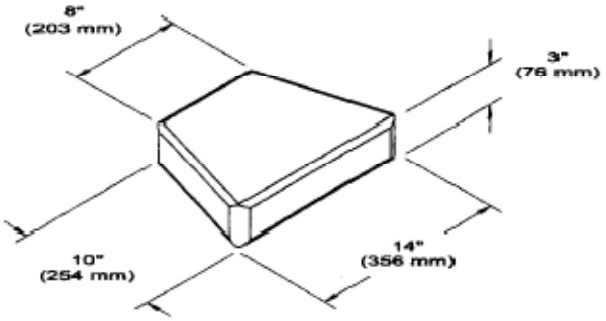
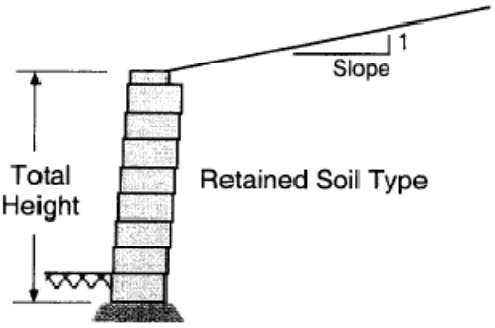
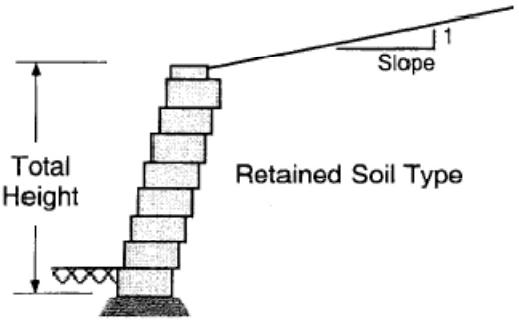


FIGURE 1—KEYSTONE WALL UNITS (Continued)



NEAR VERTICAL WALL
(Minimum setback per unit)



ONE INCH SETBACK WALL
(1" min. setback per unit)

STANDARD UNITS

MAX. HGT.	Backslope			
Soil Type	Level	4H:1V	3H:1V	2H:1V
Sand/Gravel	5.2'	4.7'	4.6'	4.1'
Silty Sand	4.7'	4.3'	4.1'	3.6'
Silt/Lean Clay	4.4'	3.9'	3.7'	2.9'

STANDARD UNITS

MAX. HGT.	Backslope			
Soil Type	Level	4H:1V	3H:1V	2H:1V
Sand/Gravel	6.8'	6.2'	5.9'	5.3'
Silty Sand	6.1'	5.5'	5.2'	4.4'
Silt/Lean Clay	5.3'	4.5'	4.1'	3.2'

COMPAC/COMPAC II UNITS

MAX. HGT.	Backslope			
Soil Type	Level	4H:1V	3H:1V	2H:1V
Sand/Gravel	2.9'	2.6'	2.5'	2.3'
Silty Sand	2.6'	2.4'	2.3'	2.0'
Silt/Lean Clay	2.4'	2.1'	2.0'	1.7'

COMPAC/COMPAC II UNITS

MAX. HGT.	Backslope			
Soil Type	Level	4H:1V	3H:1V	2H:1V
Sand/Gravel	3.8'	3.4'	3.3'	2.9'
Silty Sand	3.4'	3.0'	2.9'	2.4'
Silt/Lean Clay	3.0'	2.7'	2.5'	2.1'

COUNTRY MANOR UNITS

MAX. HGT.	Backslope	
Soil Type	Level	3H:1V
Sand/Gravel	2.0'	1.5'
Silty Sand	1.5'	1.5'
Silt/Lean Clay	1.5'	1.0'

COUNTRY MANOR UNITS

MAX. HGT.	Backslope	
Soil Type	Level	3H:1V
Sand/Gravel	3.0'	2.5'
Silty Sand	2.5'	2.0'
Silt/Lean Clay	2.0'	1.5'

Notes: Calculations assume a moist unit weight of 120 lbs/cf 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" crushed stone levelling pad as compacted foundation material.

For **SI:** 1 inch = 25.4 mm.

FIGURE 2—GRAVITY WALL CHARTS

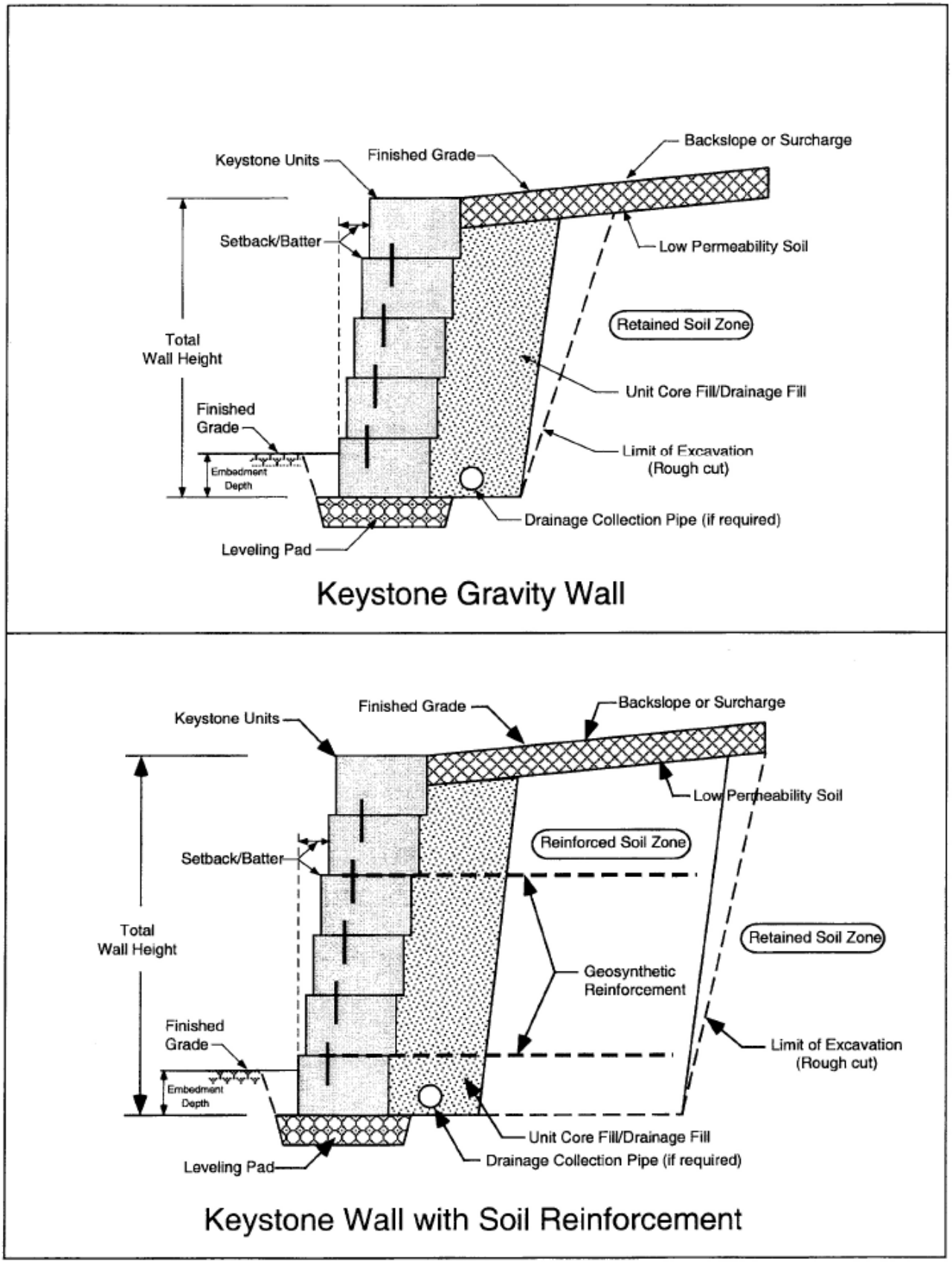


FIGURE 3—TYPICAL WALL SECTIONS