

ICC-ES Evaluation Report

ESR-4674

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DIVISION: 32 00 00— EXTERIOR IMPROVEMENTS Section: 32 32 00— Retaining Walls Section: 32 32 23— Segmental Retaining Walls	REPORT HOLDER: CORNERSTONE WALL SOLUTIONS INC.	EVALUATION SUBJECT: CORNERSTONE 100 STRAIGHT FACE	
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1.0 EVALUATION SCOPE

Compliance with the following codes:

- 2021 and 2018 [International Building Code® \(IBC\)](#)

Properties evaluated:

- Physical properties

2.0 USES

The CornerStone 100 Straight Face system segmental retaining wall (SRW) system consists of modular concrete units for the construction of conventional gravity retaining walls and geogrid-reinforced-soil retaining walls with a mass of reinforced soils, stabilized by horizontal layers of geosynthetic reinforcement materials or a reinforced masonry retaining wall system.

3.0 DESCRIPTION

3.1 CornerStone 100 Straight Face Units:

The CornerStone 100 Straight Face concrete units are available in the configuration shown in [Figure 1](#). The dimensions and weights are also shown in [Figure 1](#). Cap blocks can be used with the CornerStone 100 Straight Face concrete units as shown in [Figures 2](#) and [3](#).

All units are made with normal-weight aggregates, and comply with ASTM C1372, 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 C1372 must be submitted to the code official for approval prior to construction.

3.2 Geogrid:

The geogrid materials listed in [Table 1](#) are proprietary materials used to increase the height of the CornerStone 100 Straight Face Systems above the height at which the wall is stable under its self-weight as a gravity system.

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 depend on the weight and geometry of the concrete units and soil to resist lateral earth

pressures and other lateral forces. For masonry retaining wall systems, refer to Section 4.1.5 of this report. 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, as applicable.

External stability analysis must be similar to that required for conventional retaining walls, and must consider base (lateral) sliding, overturning, bearing capacity (and excessive settlement), and overall (deep-seated) slope stability. Internal stability analysis of CornerStone 100 Straight Face SRWs without geogrid-reinforced soil must consider movement between courses. Internal stability analysis of the SRWs with geogrid-reinforced soil must consider the maximum allowable reinforcement tension, pull-out resistance of reinforcement behind the active failure zone (excessive movement of geosynthetic material through the reinforced soil zone), and the connection strength of geosynthetic reinforcement material to the SRW concrete units or blocks, and movement between courses.

Minimum safety factors used in design (for external stability check) for SRWs, with and without a geogrid-reinforced soil mass, must be 1.5 for deep-seated (global) stability and 2.0 for bearing capacity. The minimum safety factors must be 1.5 for lateral sliding and 2.0 for overturning for SRWs with a geogrid-reinforced soil mass. The minimum safety factors against lateral sliding and overturning must be 1.5 (IBC Section 1807.2.3, as applicable), for SRWs without a reinforced soil mass. Minimum safety factors used in design (for internal stability) must be 1.5 for peak connection strength between the geosynthetic material and SRW units, and for peak shear strength between SRW units with or without geosynthetic material. Seismic safety factors for all limit states related to SRW design may be 75 percent of the corresponding minimum allowable static safety factors.

A site-specific soils investigation report in accordance with IBC Section 1803, is required. The soils investigation report shall specify the ultimate tensile strength, long-term design strength and allowable tensile strength of the geosynthetic reinforcement material, and the soil-reinforcement and interaction coefficients, including the coefficient of interaction for pullout and coefficient of direct sliding. The soils investigation report shall also specify safety factors for tensile rupture and pullout of the geosynthetic reinforcement. Where the wall is assigned to Seismic Design Category (SDC) C, D, E or F, the site-specific soils report must include the information as required by IBC Section 1803.5.11. Where the wall is assigned to Seismic Design Category (SDC) D, E or F, the site-specific soils report must include the information as required by IBC Section 1803.5.12.

The design of the CornerStone 100 Block wall is based on accepted geotechnical principles for gravity and soil-reinforced structures. Specifics of design recommended by the manufacturer are found in the CornerStone 100 by CornerStone Installation Guide; and the National Concrete Masonry Association report, "Design Manual for Segmental Retaining Walls", NCMA Report No. TR 127A/ISBN 1-881384-07-1, dated 2009.

4.1.2 Conventional Gravity Retaining Walls: The gravity wall system depends on its weight and geometry to counteract the lateral earth pressures and other lateral forces. Gravity wall design shall be based on standard engineering principles. The maximum practical height above the wall base is approximately 4 feet (1.2 m). A gravity wall detail is shown in [Figure 3](#) of this report.

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 CornerStone 100 Block 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 CornerStone 100 Block unit selected, soil reinforcement strength and soil interaction, soil strength properties, and structure geometry. Inter-unit shear capacity equations are provided in [Table 2](#). Grid-to-block pullout resistance values/equations are provided in [Table 3](#). The maximum practical height above the wall base is approximately 50 feet (15 m). A geogrid wall detail is shown in [Figure 2](#) of this report.

4.1.3.2 Structural Analysis: Structural analysis must be based on accepted engineering principles, and the IBC. The analysis must include all items noted in Sections 4.1.1, 4.1.3.2.1 and 4.1.3.2.2 of this report. 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 CornerStone 100 Block 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-CornerStone 100 Block connection (see [Table 3](#)). 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.

4.1.4 Backfill and Drainage: Backfill material placed behind the CornerStone 100 Block concrete units as a reinforced soil mass must consist of approved suitable fine grain or coarse grain materials as specified by the soils registered design professional. Provisions for drainage shall also be determined by the soils registered design professional.

4.1.5 Reinforced Masonry Retaining Walls: The design of reinforced masonry retaining wall systems must comply with Section 1807.2 and Chapter 21 of the IBC.

4.2 Installation General:

- a) When required hire a licensed professional engineer to design and analyze the retaining wall project. Review local county codes and follow all regulations.
- b) Excavate the appropriate reinforcement zone removing any organic materials that are not competent back fill materials such as topsoil. Dig a base trench minimum 24 inches to 36 inches (610 mm to 915 mm) wide and a minimum of 6 inches (152 mm) deep. Remove all vegetation and unsuitable organic soils. (Do not use these for structural backfill.) Compact soil base properly.
- c) Base stabilization fabrics may be used on the base leveling pad trench.
- d) Prepare base leveling pad trench with 6 inches (152 mm) of well graded gravel and compact firmly with vibrating compaction equipment.
- e) Level the base levelling pad gravel from front to back and side to side. This procedure will ensure a straight and stable wall.
- f) Remove the SecureLug from the first base course. Lay your first course use a string line to align the first row of units. Place each unit front edge to edge, lining up the back of the units. Ensure each block is level front to back and side to side.
- g) Sweep the top of each course units to clear debris. Lay the following courses in a running bond pattern so each unit is centered on two units below. Pull each unit forward to lock connecting securelugs in place to the blocks below.
- h) Place perforated drainage pipe behind the base of the wall. Day light the drainpipe when required. Drainpipe may be sock wrapped.
- i) Add 12 inches (305 mm) of free draining gravel behind the wall. Fill the hollow core of the CornerStone wall units with the same materials.

- j) Place the approved backfill materials in layers of no more than 8 inches (203 mm) deep. Compact each layer well, making sure to keep the compaction equipment 12 inches (305 mm) away from the back of the wall.
- k) Place the approved geogrids on top and as close to the front of the units as possible. Lock the next course of units into place over the geogrid pinching between the securelugs and units below. Gently tension the geosynthetics toward the back of the compacted backfill. Repeat the backfilling steps. Always work from the back of the block toward the end of the reinforced zone.
- l) Repeat the steps of backfill, courses and geogrid layers per the approved design.
- m) Sweep off the top course of units. Secure caps to the top of the wall using an approved concrete adhesive.
- n) Place soil separation fabric on top of the backfill and drainage materials as well as the back side of the wall caps. Cover with topsoil.
- o) CornerStone retaining wall system may also be installed using inside and outside 90 degree corners when applicable.
- p) CornerStone retaining wall system may also be installed using inside and outside curves with a minimum radius of 4 feet (1219 mm).

4.3 Special Inspections: Special inspection must be provided in accordance with IBC Sections 1705.1.1, 1705.4 and 1705.6. The inspector's responsibilities include verifying the following:

1. The modular concrete unit type and dimensions.
2. CornerStone 100 Block unit identification compliance with ASTM C1372, including compressive strength and water absorption, as described in Section 3.1 of this report.
3. Product identification, including evaluation report number (ESR-4674).
4. Foundation preparation.
5. CornerStone 100 Block unit placement, including proper alignment and inclination.
6. Geosynthetic reinforcement type (manufacturer and model number), location and placement.
7. Backfill placement and compaction.
8. Drainage provisions and water management.

5.0 CONDITIONS OF USE:

The CornerStone 100 Block Retaining Wall System 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 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 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.
- 5.3** A site-specific soils investigation in accordance with IBC Section 1803, as noted in Section 4.1.1 of this report, must be provided for each project site.
- 5.4** In areas where repeated freezing and thawing under saturated conditions occur, evidence of compliance with freeze-thaw durability requirements of ASTM C1372 must be furnished to the code official for approval prior to construction.
- 5.5** 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.
- 5.6** 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.

- 5.7 Under the 2021 and 2018 IBC, project specifications for soil and water conditions that include sulfate concentrations identified in ACI 318-19 and ACI-318-14 Table 19.3.1.1, respectively, as severe (S2) or very severe (S3), must include mix designs for the concrete, masonry and grout that comply with the intent of ACI 318-19 and ACI 318-14 Table 19.3.1.1, respectively.
- 5.8 As to the geogrid reinforcement material, 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 January 2021).

7.0 IDENTIFICATION

- 7.1 Each pallet of concrete units is identified with the manufacturer's name and address, the name of the product, the unit type, and the evaluation report number (ESR-4674).
- 7.2 The report holder's contact information is the following:

CORNERSTONE WALL SOLUTIONS INC.
370, 5222 – 130TH AVENUE SE
SUITE 349
CALGARY, ALBERTA T2Z 0G4
CANADA
(800) 939-9193
info@cornerstonewallsolutions.com
www.cornerstonewallsolutions.com

- 7.3 The Additional Listee's contact information is the following:

YORK BUILDING PRODUCTS
4126 BUCKEYSTOWN PIKE
FREDERICK, MARYLAND 21704

TABLE 1—CORNERSTONE 100 BLOCK RETAINING WALL SYSTEM

Wall Systems	Geogrid Types	Nominal Weight (lbs)
CornerStone 100 Block	Mirafi 3XT	81.7 lbs (37.1 kg)
	Mirafi 8XT	
	Synteen SF 35	
	Synteen SF 80	
	Stratagrid SGU 60	
	Stratagrid SGU 120	

TABLE 2—INTER-UNIT SHEAR RESISTANCE EQUATIONS¹

Wall Systems		Serviceability Shear Strength ² (lbs/ft)		Peak Shear Strength (lbs/ft)	
		Equation	Maximum	Equation	Maximum
WITHOUT GEOGRID					
CornerStone 100 Block		$F = 891 + N \cdot \tan 31.0^\circ$	1966	$F = 921 + N \cdot \tan 47.7^\circ$	2887
WITH GEOGRID					
CornerStone 100 Block	Mirafi 3XT	$F = 437 + N \cdot \tan 38.7^\circ$	1870	$F = 1188 + N \cdot \tan 31.0^\circ$	2263
	Mirafi 8XT	$F = 346 + N \cdot \tan 35.0^\circ$	1847	$F = 722 + N \cdot \tan 42.0^\circ$	2652
	Synteen SF 35	$F = 375 + N \cdot \tan 31.0^\circ$	1522	$F = 1058 + N \cdot \tan 38.7^\circ$	2587
	Synteen SF 80	$F = 156 + N \cdot \tan 35.0^\circ$	1661	$F = 773 + N \cdot \tan 38.7^\circ$	2495
	Stratagrid SGU 60	$F = 368 + N \cdot \tan 35.0^\circ$	1623	$F = 978 + N \cdot \tan 38.7^\circ$	2414
	Stratagrid SGU 120	$F = 551 + N \cdot \tan 21.8^\circ$	1415	$F = 1601 + N \cdot \tan 21.8^\circ$	2465

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

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

²The serviceability shear strength is based on prescribed deformation criterion, which is either $\frac{3}{4}$ inch (19 mm) or a value equal to 2 percent of the unit height, whichever is less.

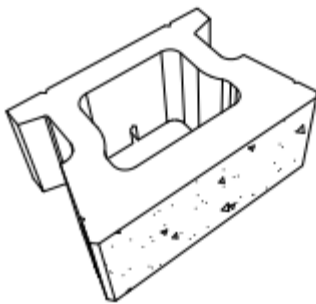
TABLE 3—GEOGRID-TO-BLOCK PULLOUT RESISTANCE EQUATIONS¹

Wall Systems		Serviceability Connection Strength ² (lbs/ft)		Peak Connection Strength (lbs/ft)	
		Equation	Maximum	Equation	Maximum
WITH GEOGRID					
CornerStone 100 Block	Mirafi 3XT	$F = 690 + N \cdot \tan 5.7^\circ$	869	$F = 1076 + N \cdot \tan 11.3^\circ$	1434
	Mirafi 8XT	$F = 947 + N \cdot \tan 5.7^\circ$	1158	$F = 1289 + N \cdot \tan 16.7^\circ$	1924
	Synteen SF 35	$F = 463 + N \cdot \tan 5.7^\circ$	638	$F = 836 + N \cdot \tan 11.3^\circ$	1186
	Synteen SF 80	$F = 809 + N \cdot \tan 5.7^\circ$	1022	$F = 1021 + N \cdot \tan 11.3^\circ$	1448
	Stratagrid SGU 60	$F = 771 + N \cdot \tan 11.3^\circ$	1127	$F = 1002 + N \cdot \tan 16.7^\circ$	1637
	Stratagrid SGU 120	$F = 1096 + N \cdot \tan 5.7^\circ$	1310	$F = 1448 + N \cdot \tan 21.8^\circ$	2305

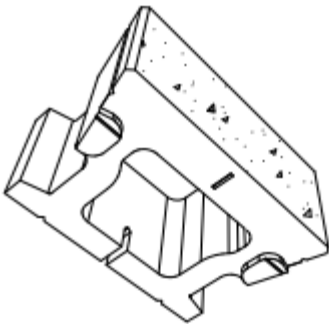
For SI: 1 lb/linear foot = 14.6N/m.

¹Where N = superimposed normal (applied) load (lb/linear foot of geogrid measured along the wall length direction).

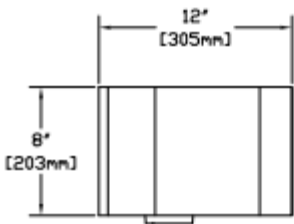
²The serviceability connection strength is based on a maximum $\frac{3}{4}$ inch (19 mm) of geogrid displacement.



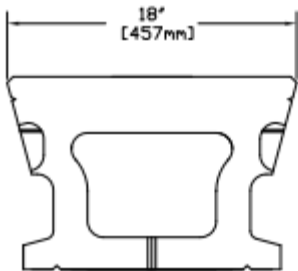
Isometric Top View



Isometric Bottom View



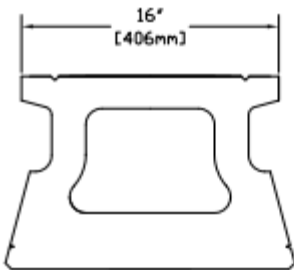
Side View



Bottom View

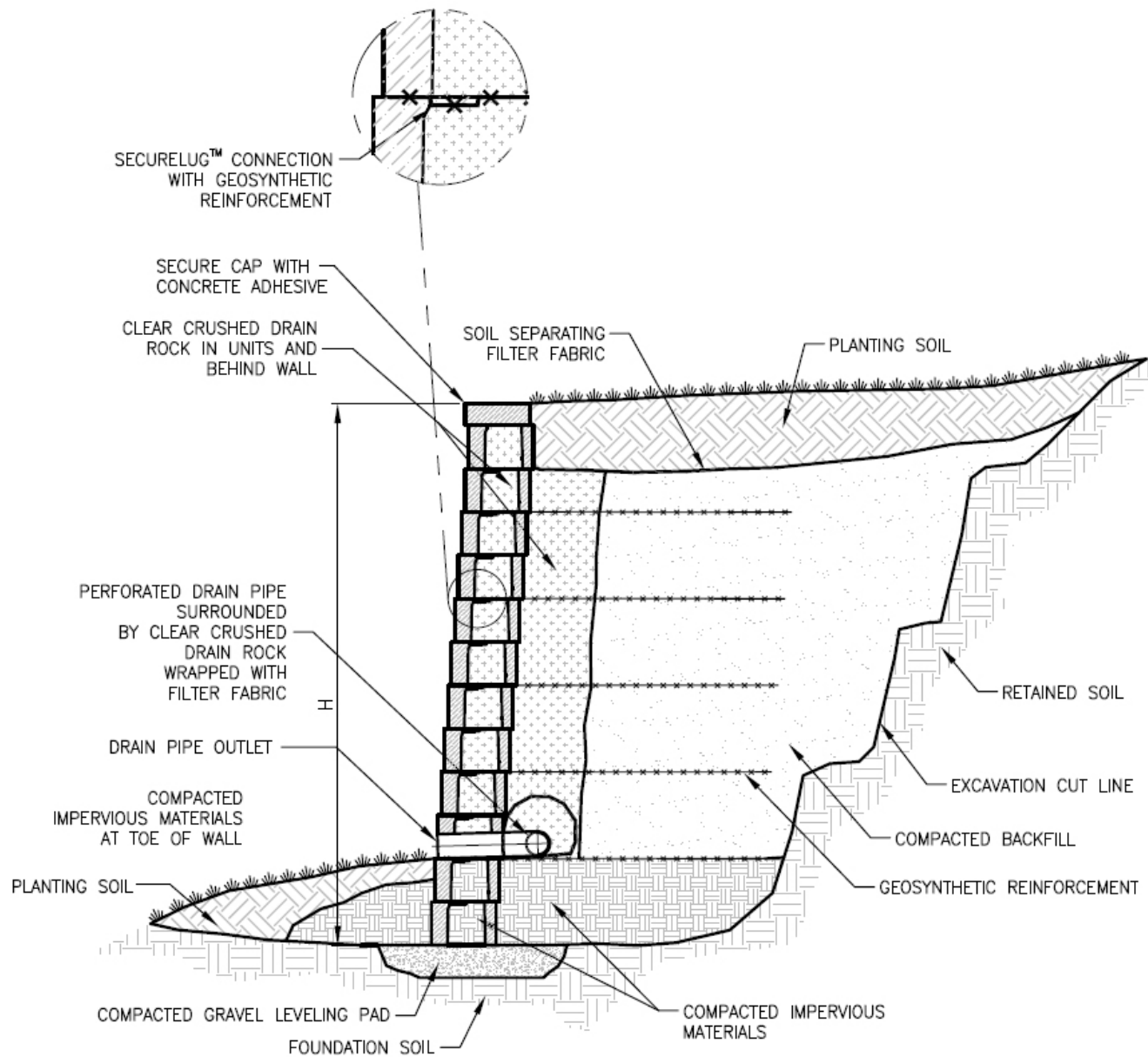
Dimensions

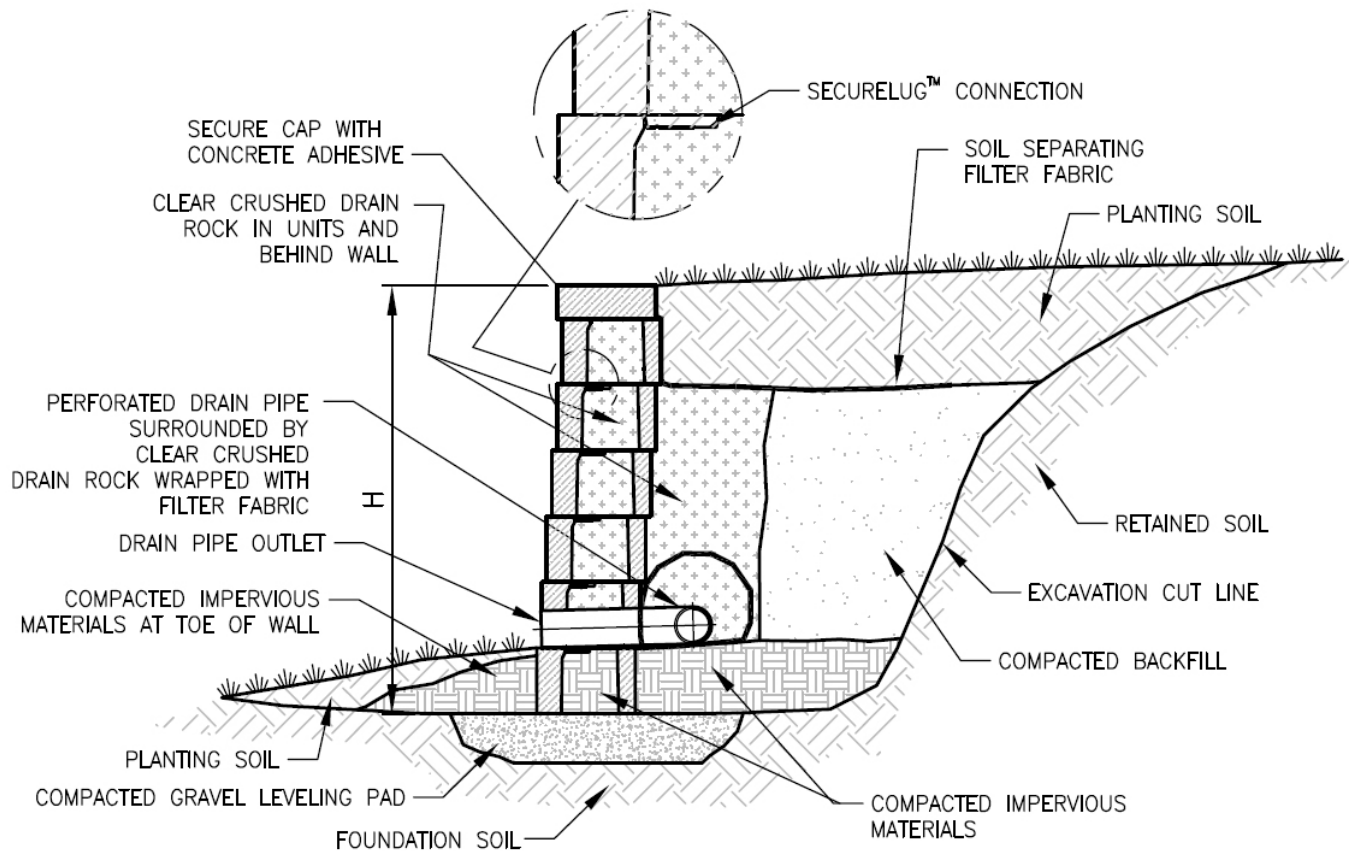
Face Width	18"	457mm
Back Width	16"	406mm
Depth	12"	305mm
Height	8"	203mm
Face Area	1 ft	
Setback	4.5°	$\frac{5}{8}$ " / Unit
Weight	75lbs	34Kg



Top View

FIGURE 1— CORNERSTONE 100 STRAIGHT FACE BLOCK DETAILS

**FIGURE 2— GEOGRID RETAINING WALL**

**FIGURE 3— GRAVITY RETAINING WALL**