TECH Report

Clifton Block Retaining Wall System

DIVISION: 32 00 00 - EXTERIOR IMPROVEMENTS
SECTION: 32 32 23 - SEGMENTAL RETAINING WALLS

REPORT HOLDER:

MIDWEST MANUFACTURING

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TECH Report

Clifton Block Retaining Wall System

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Division 32 00 00 – Exterior Improvements
Section 32 32 23 – Segmental Retaining Walls

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Evaluation Subject:
Clifton Block –Retaining Wall System

1.0 EVALUATION SCOPE

Compliance with the following codes:
2015, 2012, 2009 and 2006 International Building Codes (IBC)

Properties evaluated:
Physical Properties

2.0 USES

The Clifton Block Retaining Wall System consists of modular concrete units for the construction of conventional gravity or geogrid-reinforced-soil retaining walls.

3.0 DESCRIPTION

3.1 Clifton Wall Units:

The Clifton block units have either a straight or beveled face profile. Cap Block is available in two sizes (3-1/2" x 16" x 12-1/2") and (3-1/2" x 18-1/4" x 13") and Corner Blocks with a straight profile.

The Clifton block units have a rear-lip system. See figure 1 for configuration, dimensions and nominal weights. The nominal unit weights, noted in table 1 are used in design.

All units are made with normal-weight aggregates and comply with ASTM C1372, including having a minimum 28-day compressive strength of 3500 psi on the net area.

Concrete adhesive is used to permanently secure the cap unit to the top course of the SRW. The adhesive must provide sufficient strength and remain flexible for the expected life of the SRW.

3.2 Leveling Base Material:

The leveling base material shall be a non-frost susceptible, well-graded, compacted angular gravel-sand mixture. (GW as per ASTM D2487)

3.3 Unit Core and Drainage Fill:

Unit core and Drainage fill must be ¾" to 1" crushed stone (angular stone) with no fines (clean aggregate), placed inside the unit cores and between and behind the units. The unit core fill provides additional weight to the completed wall section, for stability, as well as local drainage at the face of the structure and a filter zone to keep the backfill soils from filtering out through the space between units.

3.4 Geogrid:

The geogrid material listed in Vendor Data File are used to increase the height of the Clifton Retaining 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. Many geogrid materials are to be placed unidirectional.

3.5 Drainage Pipe:

Drainage pipe shall be a perforated corrugated polyethylene or perforated PVC pipe, with a minimum diameter of 4 inches, protected by a geotextile filter to prevent the migration of soil particles into the drainage pipe. Geotextile filter is a non-woven needle-punched geotextile that will have an apparent opening size ranging between U.S. sieve sizes #100 to #70 and a minimum unit weight of 5.0 oz. per square yard. The coefficient of permeability will typically range between 0.04 and 0.12 in/second.

3.6 Backfill Materials:

Backfill (reinforced and retained zones) shall be free of excess moisture, roots, muck, sod, snow, frozen lumps,

organic matter or other deleterious materials. All rock particles and hard earth clods shall be removed.

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. The SRW design shall be in accordance with the design manual for segmental retaining walls, National Concrete Masonry Association (NCMA), current edition which will be regarded to as the "NCMA Design Manual". The following is a summary of the minimum factors of safety for the various modes of failure evaluated in the proposed design:

MODE OF FAILURE	MINIMUM VALUE
External	
Base Sliding	1.5
Overturning	2.0
Bearing Capacity	2.0
Internal	
Tensile Overstress	1.5
Pullout	1.5
Internal Sliding	1.5
Local	
Facing Shear	1.5
Connection	1.5
Unreinforced overturning	1.5

The Seismic safety factor may be 75 percent of the minimum allowable static safety factor.
A site-specific soils investigation report in accordance with 2015, 2012, 2009 and 2006 International Building Codes (IBC) Section 1802, as applicable, may be 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 of the geogrid. The soils investigation report must also specify safety factors for tensile rupture and pullout of the geogrid from the soil. The design of the Clifton Retaining Wall must be based on accepted geotechnical principles for gravity and soil reinforced structures.

4.1.2 Gravity Retaining Walls:

The gravity wall system relies on the weight and geometry of the Clifton Block Units to resist lateral earth pressures. Gravity wall design is based on standard engineering principles for modular concrete retaining walls. Inter-unit shear capacity equations are provided in the vendor data file.

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 Clifton Block units and the reinforced soil mass to act as a coherent gravity mass to resist lateral earth pressures. The design of the reinforced soil structure is specific to the Clifton Block unit selected, soil reinforcement strength and soil interaction, soil strength properties, and structure geometry. Figure 2 shows typical component details.

4.1.3.2 Structural Analysis:

Structural analysis must be based on accepted engineering principles and the IBC. The analysis must include all items notes in sections 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 form 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 with 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.

4.1.3.2.2 Internal Stability Analysis:

1. Geogrid must be based on local stability of the Clifton Block unit during construction. Vertical spacing is typically limited to two 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 tension must not exceed the allowable geogrid strength.

3. Connection capacity must be checked for each connection of geogrid to the Clifton Block unit (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 the 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 the applicable geogrid interaction and sliding coefficient adjustment factors are applied.

4.2 Installation:

The wall system units are assembled in a running bond pattern. The wall system units are assembled without mortar or grout, and are stacked and aligned at the designed setback using the vertical lip at the lower rear edge. The system may include horizontal layers of structural geogrid reinforcement in the backfill soil mass. Requirements for installation of the Clifton Block Retaining Wall system are as follows:

1. Excavate for leveling pad and reinforcing 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 minimum 6-inch-thick leveling pad of crushed stone, compacted to at least a 90 percent of the maximum dry density as determined by ASTM D1557 (95 percent per ASTM D698). (An unreinforced concrete pad in accordance with 2015, 2012, 2009 IBC Section 1809.8 or 2006 IBC Section 1805.4.2.3, as applicable, may be utilized in place of the crushed stone pad.)

4. Install the first course of Clifton Block units, with the sides touching and the textured face outward, ensuring units are level from side to side and front to back. Stack the SRW units in a running bond (vertical joints offset one block every block course).

5. Units with cores must be filled with unit core drainage fill described in Section 3.2 of this report. The unit core drainage fill is required for all installations and must extend back a minimum of 12" from the back of the unit. (See Figure 2)

6. Clean the top surface of the units to remove loose aggregate.

7. Geogrids shall be installed at the lengths, elevations and locations shown on the drawings. Install geogrid reinforcing to within 1 inch of the outer face of the wall. Check to ensure that the proper orientation of the geogrid reinforcement is used so the rolls are placed side by side; no overlap is required. Geogrids are pulled taut to remove slack from the geogrid before backfill is placed and shall be anchored by pinning or placing soil on the geogrid at the back of the reinforced zone. The entire length is pulled taut to remove any folds or wrinkles.

8. Place and compact backfill over the geogrid reinforcement layer in appropriate lift thickness to ensure compaction. Backfill used in the reinforced fill mass must consist of suitable fine-grained or course-grained soils placed in lifts compacted to at least 90 percent of the maximum dry density as determined by ASTM D1557 (95 percent per ASTM D698). 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. The

reinforced backfill must be placed and compacted no lower than the top unit-elevation to which geogrid placement is required.

4.3 Special Inspections:

Special inspection must be provided in accordance with 2015 and 2012 IBC Section 1705.4, or 2009 IBC Section 1704.5, as applicable. The inspector's responsibilities include verifying the following;

1. The modular concrete unit dimensions
2. Clifton Block Unit identification of compliance with ASTM C1372, including compressive strength and water absorption, as defined in Section 3.1 of this report.
3. Foundation preparation
4. Clifton Block unit placement, including alignment and inclination.
5. Geosynthetic reinforcement type and placement
6. Backfill placement and compaction.
7. Drainage Provisions.

5.0 CONDITIONS OF USE:

The Clifton Block Retaining Wall System described in this report comply with, or are suitable alternatives to what is specified in, the codes indicated 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 2015, 2012, 2009 IBC Section 1803 or 2006 IBC Section 1802, as applicable, as noted in Section 4.1.1 of this report, must be provided for each project.

5.4 In areas where repeated freezing and thawing under saturated conditions occur, evidence of compliance with 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 the 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 appropriate sections of the NCMA Design Manual for segmental Retaining Walls, and must be approved by the code official.

5.7 Project specifications or soil and water conditions that have sulfate concentrations identified in ACI 318, as severe or very severe, shall include mix designs for the concrete masonry and grout that comply with the content of ACI 318.

5.8 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 TEST DOCUMENTS

Design data in this report is based on test results performed by Bathurst, Clarabut Geotechnical testing Inc. in accordance with NCMA Segmental Retaining Wall Design Manual and ASTM 6916-03.

VENDOR DATA FILE

UNIT INFORMATION		
Cap Height	3.50	inches
Unit Height	8	inches
Unit Width	Beveled: 17 Straight: 18	inches
Unit Depth	12	inches
Setback	0.79	inches
Batter/Unit	5.64	degrees
Weight (unfilled)	Beveled: 70 Straight: 77	lbs
Approximate Unit Weight (Infilled)	Beveled: 100 Straight: 104.4	lbs
Fill per Block	.289	Cu Ft
Center of Gravity	Beveled: 5.42 Straight: 5.10	inches

GEOSYNTHETIC INFORMATION

PRODUCT	Tult (lbs/ft)	RFcr	RFd	RFid	LTDS(lbs/ft)	Ci	Cds
SYNTEEN SF35	3600	1.51	1.10	1.05	2064	0.8	0.8

UNIT TO UNIT INTERFACE PROPERTIES

Minimum Shear Capacity	700	lbs/ft
Friction Angle	32	degrees
Maximum Shear Capacity	2913	lbs/ft

Geosynthetic to Unit Interface Properties

Product	Min. Conn. Capacity (lbs/ft)	Normal Load (IP-1) (lbs/ft)	Conn. Capacity (IP-1) (lbs/ft)	Normal Load (IP-2) (lbs/ft)	Max Conn. Capacity (IP-2) (lbs/ft)	Min. Shear Capacity (lbs/ft)	Friction Angle (degrees)	Max Shear Capacity (lbs/ft)
SYNTEEN SF35	805	1517	1753	2636	1930	676	34	2193

Table 1

RETAINING BLOCK UNIT NOMINAL WEIGHT	
Product	Nominal Weight (lbs)
Clifton	Beveled: 70 Straight: 77

Figure 1 (Unit Dimensions HxWxD)

Clifton (Beveled) 8”x17”x12”

Clifton (Straight) 8”x18”x12”

Figure 2 (Typical Wall Section)