



MagnumStone[®]

RETAINING WALLS

by **CORNERSTONE[®]**

SPECIFICATIONS

**Positive Connection Geogrid
Reinforced Precast
Modular Block Retaining Wall**

Version 3.0 (2023)

DOC.3103-MS-PC

SPECIFICATIONS FOR **MAGNUMSTONE®**

POSITIVE CONNECTION GEOGRID REINFORCED PRECAST MODULAR BLOCK SYSTEM

PART 1 GENERAL

1.01 SCOPE OF WORK

Furnish all labor, materials, equipment, and incidentals required to install a Precast Modular Block (PMB) retaining wall with Positive Connection geogrid reinforcement with MagnumStone® units as specified in the construction drawings or as established by the Owner, Architect or Engineer. With Positive Connection (or mechanical connection) geogrid reinforcement, a single length of geogrid is wrapped through the hollow core of a MagnumStone® unit, providing equal length reinforcement at the bottom and top of the unit.

1.02 REFERENCE STANDARDS

A. Engineering Design

1. AASHTO M288 Geotextile Specification for Highway Applications
2. AASHTO Standard Specifications for Highway Bridges
3. NCMA Design Manual for Segmental Retaining Walls (SRW)
4. ASTM D 6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method
5. ASTM D6638 Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
6. ASTM D 6916 Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units

B. Precast Modular Block (PMB) units

1. ASTM C33/ C33M Specification for Concrete Aggregates
2. ASTM C94/ C94M Standard Specification for Ready-Mixed Concrete
3. ASTM C136 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates
4. ASTM C140/ C140M Sample & Testing Concrete Masonry Units
5. ASTM C150/ C150M Standard Specification for Portland Cement
6. ASTM C260/ C260M Standard Specification for Air-Entraining Admixtures for Concrete
7. ASTM C494/ C494M Standard Specification for Chemical Admixtures for Concrete
8. ASTM C666 / C666M – Standard Test Method for Concrete Resistance to Rapid Freezing and Thawing.
9. ASTM C1776/C1776M-17 (Reapproved 2022) Standard Specification for Wet-Cast Precast Modular Retaining Wall Units
10. NPCA Precast Retaining Wall Systems Best Practices Manual
11. NPCA Quality Control Manual for Precast Concrete Plants

- C. Geosynthetic Reinforcement
 - 1. ASTM D4595 Tensile Properties of Geosynthetics by the Wide Width Strip Method
 - 2. ASTM D5262 Evaluating the Unconfined Creep of Geosynthetics
 - 3. ASTM D6638 Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
 - 4. ASTM D6916 Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)
 - 5. ASTM D 6637 Standard Test Method for Determining Tensile Properties of Geogrids by the Single- or Multi-Rib Tensile Method
 - 6. ASTM D 6706 Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil
- D. Soils
 - 1. ASTM D698 Test Methods for Lab Compaction Characteristics of Soil using Standard Effort
 - 2. ASTM D422 Gradation Analysis of Soil Particles
 - 3. ASTM D4318 Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
 - 4. ASTM D51 Testing Methods for Measuring pH of Soil
 - 5. ASTM D2487 Standard Classification of Soils (Unified Soil Classification System)
- E. Drainage Pipe
 - 1. ASTM D 3034 Specification for Type PSM Polyvinyl Chloride (PVC) pipe
 - 2. ASTM D 1248 Corrugated Plastic Pipe
- F. The Owner or Owner's Representative shall determine the final application if the specifications and reference documents conflict.
- G. When constructing DOT projects, AASHTO and ASTM specifications shall be followed unless otherwise specified by the engineer.

1.03 DESIGN SUBMITTALS

- A. Material installation and description data shall be submitted for each product specified.
- B. PMB designs and drawings shall be submitted and include: bottom and top of wall elevation; drainage details; retaining wall layout with wall lengths, curve radii, and corner angles; typical wall sections; reference distances from fixed points; the type, strength, and location of the geosynthetics; and any other unique application information.
- C. Design Methods and Calculations in accordance with NCMA Design Guidelines and/or AASHTO Standard Specifications for Highways shall be submitted. Global stability analyses shall be calculated and submitted as part of the final design.
- D. Samples of the PMB units, color, and texture shall be submitted, as per design specifications.
- E. Geosynthetic samples shall be furnished as per design.
- F. Test reports in accordance with ASTM C 140/C140M and performed by an independent laboratory shall be submitted.
- G. All submittals shall be provided, reviewed, and approved prior to the start of retaining wall construction.

1.04 RETAINING WALL DESIGN STANDARDS

- A. The wall design engineer and/or geotechnical engineer shall consider the internal stability, local stability, external stability, bearing capacity, and global stability of the soil mass above, behind and below the wall structure.
- B. The MagnumStone® wall system shall be designed in accordance with the NCMA Design Manual for Segmental Retaining Walls, Current Edition or in accordance with AASHTO standards. The minimum factors of safety shall be (or greater if specified by the engineer):
 - 1. **External Stability:** Base Sliding = 1.5; Overturning = 2.0; Bearing Capacity = 2.0; Global Stability = 1.3
 - 2. **Internal Stability:** Tensile Overstress = 1.0; Pullout = 1.5; Internal Sliding = 1.5
 - 3. **Local Stability:** Facing Shear = 1.5; Connection = 1.5
- C. The following soil design parameters shall be used (or specified by the engineer):
 - 1. **Drainage/Unit Fill:** Soil Unit Weight = _____lb/ft³ (kN/m³); Friction Angle = ____degrees; Cohesion = _____lbs/ft² (kPa)
 - 2. **Reinforced Backfill:** Soil Unit Weight = _____lb/ft³ (kN/m³); Friction Angle = ____degrees; Cohesion = _____lbs/ft² (kPa)
 - 3. **Base Leveling Pad:** Soil Unit Weight = _____lb/ft³ (kN/m³); Friction Angle = ____degrees; Cohesion = _____lbs/ft² (kPa)
- D. The site grades and information shall determine the length, height, and overall elevations for the MagnumStone® retaining wall requirements.
- E. The design height (H) shall be measured from the top of the base leveling pad to the top of the wall cap units.
- F. The above and below slopes of the wall details shall be depicted on the site construction drawings.
- G. The minimum embedment depth of the wall shall be no less than 1/2 unit (12"; 0.3 m) or H/10 or as specified by the site construction drawings.
- H. Geosynthetic reinforcement vertical spacing shall not exceed 4 feet (1.2 m), or two units.
- I. Geosynthetic reinforcement shall have 100% horizontal coverage parallel to the length of the wall, unless specified by the engineer.
- J. Geosynthetic minimum length shall not be less than 60% of the height of the wall (H/0.6).

1.05 DELIVERY, STORAGE, AND HANDLING

- A. The Contractor shall inspect all materials delivered to the site to ensure proper type and grade of materials have been received as per the project specifications.
- B. The Contractor shall ensure proper storage, handling, and protection from damage of the materials. Damaged materials shall not be used in the construction of the Precast Modular Block retaining wall.
- C. The Contractor shall prevent excessive mud, wet concrete, or materials that may stain or adhere from coming in contact with the wall materials.
- D. Geosynthetics shall be stored in accordance with the manufactures specifications.
- E. Geosynthetics shall be protected from the weather and any other conditions that could damage the material.

1.06 QUALITY ASSURANCE

- A. Contractor and Site Supervisor shall have proven qualified experience to complete the installation of the Precast Modular Block system.
- B. Retaining wall design engineer shall have proven qualified experience in performing all retaining wall analysis calculations.
- C. The owner is responsible to engage testing and inspection services to provide independent quality construction assurance.
- D. Compaction testing of the reinforcement backfill soils shall be performed every 2 vertical feet (0.6 m) of material installation.
- E. The tests shall be done a minimum of every 50 lineal feet (15 m) along the wall at each level of testing.
- F. Testing shall not be closer than 3 feet (0.9 m) from the back of the wall and done at a variety of locations to cover the entire reinforced soil zone.
- G. Independent inspection professionals shall ensure that all parameters and construction specifications have been followed in accordance to the design drawings and specifications.

1.07 QUALITY CONTROL

- A. The wall project installer is responsible to ensure that all installation and materials meet the quality specified in the construction drawings.
- B. A qualified independent party shall be responsible to verify that installation procedures have been installed in accordance with the specifications and construction drawings.
- C. All site construction tolerances for vertical alignment, horizontal locations for elevations, corner and radius locations, wall batter, and minimum bulging will be within NCMA and/or AASHTO specifications.

1.08 PAYMENT

- D. Payment for the installation of the MagnumStone® wall shall be based on the unit price per square face foot (or square face meter) of wall product installed. The shipping and delivery slips shall be verified by both Contractor and Owner, or Owner's representative, at the time of product delivery to the site; this will be the basis of the final count or product used.
- E. Payment for the placement of the geosynthetics shall be based on the unit price per square yard (or square meter) installed or as per contract agreement.

PART 2 MATERIALS

2.01 PRECAST MODULAR BLOCK (PMB) UNITS

- A. PMB concrete units shall be MagnumStone® units as manufactured by licensed _____ producer in accordance with ASTM and/or AASHTO standards and conform to the NPCA Quality Control Manual for Precast Concrete Plants or per project engineer specifications.
- B. MagnumStone® units shall have a minimum 28 days compressive of equal to 4,000 psi (28 MPa) (or greater if specified) and a maximum absorption of 5 pcf (or less if specified) (ASTM C 140/C140M). (Suggested air content between 5 and 7%)
- C. Color for the MagnumStone® units shall be _____.
- D. ASTM C666 / C666M shall be standard for areas subject to many freeze-thaw cycles.
- E. The maximum water absorption shall be less than 5%. A water-cementitious ratio of 0.45 or less is suggested.
- F. The height shall not vary more than $\pm 3/16^{\text{th}}$ of an inch (5 mm) for every 4 feet (1.2 m); length shall not vary more than $\pm 1/2''$ (13 mm) per unit; and depth shall not vary more than $\pm 1/4''$ (6 mm) per unit. All other specifications must meet ASTM 1776/1776M
- G. The MagnumStone® standard units shall have a face area of 8 sq ft (0.75 m²) and MagnumStone® half high units shall have a face area of 4 sq ft (0.375 m²)
- H. The MagnumStone® Standard unit weight shall be approximately ± 1400 lbs (635 kg) with a gravel infill weight of ± 800 lbs (363 kg).
- I. The MagnumStone® units shall be sound and free of cracks, chips or other defects that may prevent the contractor from properly installing the wall units or reduce the long term strength of the wall structure.
- J. Concrete sampling shall be in accordance with AASHTO T-141. Compression testing shall be in accordance with AASHTO T-23 and AASHTO T-22. Air content testing shall be in accordance with AASHTO T-152 or AASHTO T-196. Slump testing shall be in accordance with AASHTO T-119. 28 day testing shall be in accordance with AASHTO T-23 and AASHTO T-22 or as specified by the project engineer.
- K. Reinforcing mesh (if required) shall be shop-fabricated of cold drawn steel wire conforming to the minimum requirements of ASTM A-82 (AASHTO M-32) and shall be welded into the finished mesh fabric in accordance with ASTM A-185 (AASHTO M-55). Galvanization shall be applied after the mesh is fabricated and conform to the minimum requirements of ASTM A-123 (AASHTO M-111). Connector bars shall be fabricated of cold drawn steel wire conforming to the requirements of ASTM A-82 (AASHTO M-32) and galvanized in accordance with ASTM A-123 (AASHTO M-111).
- L. Electrochemical requirements, if applicable, will follow the AASHTO specifications.

2.02 GEOSYNTHETIC REINFORCEMENTS

- A. Geosynthetic reinforcements shall be high tensile Geogrid or Geotextile specifically manufactured for soil reinforcement applications. Geogrid consists of high-density polyethylene or polypropylene. Geotextiles are woven fabrics.
- B. The construction design and drawings shall show the type, strength, and location of the geosynthetics. Manufacturers specifications shall be used for test data and installation procedures.
- C. Geosynthetics shall be evaluated in accordance with NCMA and/or AASHTO specifications.

2.03 FOUNDATION SOIL

- A. The foundation soils shall be undisturbed native site soils.
- B. The foundation soils shall be inspected and tested by an engineer before installing base leveling gravel.
- C. Disturbed or unsuitable foundation soils shall be properly compacted or replaced with acceptable soils as specified by the engineer.

2.04 BACKFILL SOIL

- A. Backfill soils shall be free of organic materials and other unsuitable materials.
- B. Soils classified as GP, GW, SP, SW, or SM types in accordance with ASTM D 2487 are suitable. All soils shall be approved by the engineer.
- C. The Plasticity Index of the backfill soils shall have a fine fraction of less than 20.

2.05 BASE LEVELING MATERIALS

- A. The base leveling gravel shall be well graded compacted gravel (GW).
- B. Unreinforced concrete base leveling pad can also be used if specified.
- C. AASHTO specifications shall be followed when constructing concrete footing for DOT projects.

2.06 DRAINAGE AND UNIT INFILL AGGREGATE

- A. Drainage Aggregate shall be clean crushed gravel meeting the gradation in accordance with ASTM D 448.
- B. Drainage Aggregates shall be placed in all unit voids and wedge between units with uniform particle size no less than 1" (25 mm) and not more than 5% passing through the No. 200 sieve.

2.07 DRAINAGE PIPE

- A. Drainage pipe shall be perforated PVC or corrugated HDPE pipe with a minimum size of 4" (0.1 m) in diameter.
- B. Geotextile wrap around the drainage pipe may be used as specified by the engineer.
- C. Drainage pipe shall be manufactured in accordance with ASTM D 3034 and/or ASTM D 1248.

2.08 GEOTEXTILE FABRIC

- A. Geotextiles shall be non-woven as specified by the specifications and construction drawings.
- B. Geotextiles when used as a soil separator shall be permeable, allowing water to effectively pass through the fabric openings.

PART 3 EXECUTION**3.01 EXCAVATION**

- A. The Contractor shall excavate to the lines and grades shown on the project grading plans.
- B. Back excavation cuts shall be notched benches of 5 feet (1.5 m) vertical for every 2 feet (0.6 m) horizontal bench, or as per the engineer's specifications.
- C. Over-excavated or filled areas shall be well compacted and inspected by an engineer.
- D. Excavated materials that are used for the backfilling reinforcement zone shall be protected from weather.
- E. Organic or other non-gravel materials shall not be used in the backfilled reinforcement zone.

3.02 FOUNDATION PREPARATION

- A. The foundation trench shall be excavated to the dimensions indicated on the construction drawings.
- B. The reinforced zone and leveling pad foundation soil shall be examined by the on-site engineer to ensure proper bearing strength.
- C. Soils not meeting the required strength shall be removed and replaced with proper materials.
- D. Foundation materials shall be compacted to a minimum of 95% Standard Proctor dry density, or greater, before placing leveling pad (ASTM D 698).

3.03 BASE LEVELING PAD

- A. Granular aggregate materials, minimum 6 inches (0.15 m) thick and width specified on the construction drawings, shall be placed and compacted to a minimum of 95% Standard Proctor dry density, or greater (an unreinforced concrete pad may be used).
- B. The base leveling pad shall be level horizontally and back to front to ensure the first course of units are level.
- C. The top of base leveling pad elevation and installation of granular materials shall be in accordance with the specifications and construction drawings. The toe of the wall burial depth shall be constructed as shown on the construction drawings.
- D. Where concrete reinforced footing is required, they shall be installed below the frost level and constructed in accordance with the specifications and construction drawings.

3.04 UNIT INSTALLATION

- A. The first course of MagnumStone® units shall be carefully placed on a well-graded gravel or concrete leveling pad.
- B. The first row of units shall be level from unit to unit and from back to front.
- C. A string line can be used to align a straight wall. PVC flex pipes can be used to establish smooth convex or concave curved walls.

- D. The smooth back of the units shall be used for alignment and measuring to ensure smooth curves and straight walls.
- E. The second course of units shall have the concrete connecting lugs in the unit voids of the first course below, and pulled forward resting the lugs against the front edge of the two lower unit voids.
- F. All units shall be laid snugly together and parallel to the straight or curved lines.
- G. The MagnumStone® units shall be swept clean of all dirt or rocks before installing the next layer of units or placing the geosynthetics.
- H. After laying each course, perform a visual or string line straightness check.

3.05 GEOSYNTHETIC REINFORCEMENT

- A. Geosynthetic reinforcement shall be cut in 24" (0.6 m) wide strips and twice the length specified in the design plus 2' (0.6 m) for the unit height. One end of the geosynthetic shall be rolled into a tight roll to the point where the design length is still left unrolled. If the design plans show that the first layer of geogrid (50% coverage) is at the bottom of the base course, the geogrid is placed the unrolled portion placed behind the wall from the leveling pad at a right angle to the wall with the rolled portion at the hollow core locations of the first course of MagnumStone® units. The unrolled end of the geogrid shall be tensioned to remove any slack and then secured by staking the end. The first course of MagnumStone® units is then placed over these rolled strips of geogrid and the reinforced zone is backfilled over the unrolled portions. The remaining roll of geosynthetic shall then be unrolled up the inside of the unit and back at a right angle on top of the compacted backfill materials. The units are then filled with drainage aggregate to a height of the next courses connecting lugs.
- B. After the first course of MagnumStone® Units is installed and backfilled, a roll of geogrid shall be placed on the MagnumStone® units, centered on the joint of two units with the correct length of unrolled geosynthetic placed at a right angle to the wall on top of the well compacted backfill.
- C. The second row of MagnumStone® units shall be placed, centered on top of the two units below with the roll of geogrid inside the hollow core. Backfill materials shall then be backfilled and compacted.
- D. The remaining roll of geosynthetic shall then be unrolled up the inside of the unit and back at a right angle on top of the compacted backfill materials. The second end of the geosynthetic reinforcement shall be tensioned to remove any slack and then secured by staking the end.
- E. The next layer of half rolled geosynthetic reinforcement shall then be placed, centered on the joint of the two units below, fitting between the top lengths of the lower layer of geosynthetic reinforcements. The third row of MagnumStone® units shall then be placed on top of the second row of units, centered between the two units below with the roll of geogrid inside the hollow core.
- F. The above steps shall be repeated until the full length of the geosynthetics and wall units have been properly installed.
- G. Ensure that the materials directly behind the wall units are flush or slightly higher than the top of the units so that the geosynthetics will not be sheared on the back of the unit's sharp edge.

- H. Shimming of units shall not be allowed on the geosynthetic layers.
- I. Contractor shall not drive equipment directly on the exposed geosynthetics

3.06 DRAINAGE COMPONENTS

- A. After the second length of the geosynthetic is laid out on top of the compacted backfill materials, the unit voids shall be filled with a free-draining granular material, such as ¾" (19 mm) clear rock (clean gravel).
- B. Drainage pipe and geotextile shall be installed as shown on the construction drawings.
- C. Clean gravel does not require mechanical compaction.

3.07 BACKFILL

- A. The reinforced zone shall be backfilled by placing materials from the back of the wall toward the end of the geosynthetics in order to maintain tension on the reinforcement.
- B. Reinforced backfill materials shall be placed in maximum lifts of 8" (0.2 m) and shall be compacted to a minimum 95% Standard Proctor density or greater, in accordance with ASTM D 698 to the lines and grades shown on the project grading plans.
- C. Only hand-operated compaction equipment shall be used within 2 feet (0.6 m) of the back of the wall.
- D. Soil density testing shall not be taken within this 2 foot (0.6 m) area.
- E. The backfill shall be smooth and level so that the geosynthetic lays flat with no dips or bumps
- F. The toe of the wall shall be filled and compacted as the wall is being constructed.

3.08 CAP INSTALLATION

- A. The MagnumStone® full size cap units shall be placed in the same installation procedures as the regular MagnumStone® units.
- B. Geotextiles should be used as a soil separator between the final layer of drainage materials and the topsoil materials to prevent fines from migrating into the drainage gravel or through the wall face. The fabric shall be placed no less than 4 feet (1.2 m) behind the wall and up the back side of the wall up to the cap unit
- C. A MagnumStone® 6" (0.15 m) high cap can be used to complete the top of the wall. Concrete adhesive shall be used to glue the cap units to the regular units.

-END OF SECTION-