MONUMENTAL BLOK
SEGMENTAL RETAINING WALL

PART 1: GENERAL

1.01 Description

A. Work shall consist of designing and constructing a MONUMENTAL BLOK segmental retaining wall (SRW) system, including furnishing of all materials, labor, equipment, testing and inspection, in accordance with these specifications and in reasonably close conformity with the lines, grades, design, and dimensions shown on the project construction drawings.

B. Work includes excavation and foundation soil preparation, furnishing and placement of the leveling pad, drainage fill, drainage system, reinforced (infill) soil, retained (backfill) soil, and geotextile filter to the lines and grades shown on the project construction drawings and in the contractor prepared retaining wall construction drawings.

C. Work includes furnishing and placement of geogrid soil reinforcement of the type (strength), location, and lengths as shown on the contractor prepared retaining wall construction drawings.

D. Work includes identifying, verifying, furnishing, placement, and compaction of reinforced, drainage, and retained fills to the lines and grades shown on the project construction drawings and in the contractor prepared retaining wall construction drawings.

1.02 Related Work

A. Section 02100 - Site Preparation

B. Section 02200 - Earthwork

1.03 Reference Documents

A. Segmental Retaining Wall Design
   1. NCMA Design Manual for Segmental Retaining Walls, Second Edition

B. Segmental Retaining Wall Units
   1. ASTM C140-07a, Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
   2. ASTM C1262-07, Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
   3. ASTM C1372-04e2, Standard Specification for Dry-Cast Segmental Retaining Wall Units
   4. ASTM D6638-07, Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)
   5. ASTM D6916-06c, Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)
   6. NCMA SRWU-1, Determination of Connection Strength between Geosynthetics and Segmental Concrete Units
   7. NCMA SRWU-2, Determination of Shear Strength between Segmental Concrete Units

C. Geosynthetic Reinforcement
   1. ASTM D5262-07, Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
   2. ASTM D6637-01, Standard Test Method for Determining Tensile Properties of Geogrids by the Single or Multi-Rib Tensile Method

3. ASTM D6706-01(2007), Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil

D. Soils
1. ASTM D422-63(2007), Standard Test Method for Particle-Size Analysis of Soils
2. ASTM D698-07e1, Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft^3 (600 kN-m/m^3))
3. ASTM D2487-06, Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
4. ASTM D4318-05, Standard Test Methods for Liquid Limit, Plastic Limit, and Plasticity Index of Soils
5. ASTM D4972-01(2007), Standard Test Method for pH of Soils
6. ASTM D3080, Test Method for Direct Shear Test of Soils under Consolidated Drained Conditions
7. ASTM D4767, Standard Test Methods for Consolidated Undrained Triaxial Compression Test for Cohesive Soils

E. Drainage Pipe
1. ASTM D3034-06, Standard Specification for Type PSM Poly(Vinyl Chloride) (PVC) Sewer Pipe and Fittings
2. ASTM F405-05, Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings

F. Geotextile Filter
1. ASTM D4491-99a(2004)e1, Standard Test Methods for Water Permeability of Geotextiles by Permittivity
2. ASTM D4751-04, Standard Test Method for Determining Apparent Opening Size of a Geotextile
3. ASTM D5261-92(2003), Standard Test Method for Measuring Mass per Unit Area of Geotextiles
4. ASTM D4632, Standard Test Method for Grab Breaking Load and Elongation of Geotextiles.

G. Where specifications and reference documents conflict, the Owner's Representative shall make the final determination of applicable document.

1.04 Submittals

A. The Contractor shall provide a list of successful completed projects of similar scope and size with references, that the company personal assigned to this project have completed in the last 5 years, showing that the installer for the SRW is qualified and has a record of successful performance, at least _____ (30) days before start of SRW construction.

B. The Contractor shall submit _____ (4) sets of design calculations and construction drawings for the Monumental Blok SRW system prepared and sealed by a Professional Engineer licensed in the State or Province of the project. The submittal is to specifically define the reinforced (infill) soil borrow source, providing test results supporting the design parameters utilized, and sufficient control values for construction testing. The Contractor's SRW design shall meet all the requirements established in NCMA's "Design Manual for Segmental Retaining Walls".

C. The Contractor shall submit manufacturer's certifications, with supporting test results, stating the Monumental Blok produced for delivery to this project meets or exceeds the requirements listed in Section 2 of this specification, at least _____ (30) days before start of SRW construction.

D. The Contractor shall submit a list of additional soils testing or global stability analysis required of the Owner in order to complete the SRW design, at least _____ (45) days prior to the start of SRW construction. The Contractor shall also define the any additional special inspection requirements the Contractor will be relying on the Owner to provide during SRW system construction, at least 30 days prior to start of SRW construction.

1.05 Delivery, Storage, and Handling

A. The Contractor shall inspect the materials upon delivery to assure that proper type and grade material has been received.

B. The Contractor shall store and handle all materials in accordance with manufacturer's recommendations and in a manner to prevent deterioration or damage due to moisture, temperature changes, contaminants, breaking, chipping or other causes.

C. The Contractor shall protect the materials from damage. Damaged material shall not be incorporated into the SRW.

PART 2: MATERIALS

2.01 Definitions

A. Monumental Blok: a dry-cast concrete block designed specifically for the task of earth retention and used as the facing system of SRW systems.

B. Segmental Retaining Wall (SRW) system: a system where the basic components are the foundation soil, leveling pad, Monumental Blok units, reinforced soil, retained soil, drainage fill, drains, and geogrid reinforcement (when required).

C. Geogrid reinforcement: a high performance, polymer-coated woven network of polyester yarns or straps used for soil reinforcement.

D. Leveling pad: a level compacted granular soil surface, which distributes the weight of Monumental Blok units over a wider foundation area and provides a working surface for starting SRW construction.

E. Drainage fill: a free-draining aggregate material placed directly behind and between the Monumental Blok units to facilitate compaction of soils and remove groundwater to minimize buildup of hydrostatic pressure behind the wall face.

F. Reinforced (infill) fill: a compacted fill soil placed directly behind the drainage fill which contains horizontal geogrid reinforcement.

G. Retained (backfill) fill: undisturbed native soil or fill soil placed directly behind the reinforced fill.

H. Drainage Collection pipe: a perforated PVC or PE pipe used to collect and convey water to an outlet, preventing buildup of water which infiltrates the soils behind the wall.

I. Geotextile filter: a network of tightly spaced woven or tangled of polypropylene or polyester yarns sufficient to initiate a natural soil filter by allowing some soil particles to pass through the network along with water.

J. Monumental Shear Connector: a specially shaped concrete piece used to connect courses of Monumental Blok together.

K. Monumental Cap unit: a concrete unit used to finish the top of the Monumental Blok wall units.

2.02 Monumental Blok SRW Unit

A. Monumental Blok SRW units shall conform to the color and face finish specified by the Owner. Specialty shapes, colors or textures may require advance ordering to attain in a timely manner.

B. Monumental Blok segmental units shall conform to the minimum requirements of ASTM C1372 for:
   a. Compressive strength: ≥ 3000 psi
   b. Absorption: ≤ 13 lb/ft^3
   c. Freeze-Thaw durability: weight loss ≤ 1 %, after 100 cycles
   d. Permissible variations in dimensions: ± 1/8 inch from the specified standard dimensions for width and length not including split face; for height ± 1/16 inch.

e. Finish and appearance: exposed surfaces of units are not to show cracks or other imperfections when viewed from a distance of not less than 20 ft under diffused lighting.

2.03 Shear Connectors

A. Shear connectors shall be concrete dry-cast keys able to provide structural integrity and to create a batter or a vertical alignment as shown on the plans.

B. Shear connectors used to create a batter, 3 inches of setback, shall be in the form of U-shaped connectors.

C. Shear connectors used to create a vertical alignment shall be in the form of Z-shaped connectors.

2.04 Geosynthetic Reinforcement

A. Geosynthetic reinforcement shall consist of geogrids manufactured for soil reinforcement applications and shall be manufactured from high tenacity polyester multifilament yarns which are woven and coated for protection. These geogrids shall be manufactured with a molecular weight (M_n) [i.e., grams / mole] exceeding 25,000 and a carboxyl end group (CEG) count less than 30.

B. The Long-Term Allowable Tensile Strength of the geogrid shall be determined as follows:

$$Ta = T_{ult}/(RF_{CR}*RF_D*RF_{ID}*FS_{UNC})$$

1. T_{ult}: Ultimate tensile strength conducted per ASTM D6637 and based on minimum average roll value (MARV).
2. RF_{CR}: Creep reduction factor based on a minimum duration of 10,000-hour creep testing according to ASTM D5262 extrapolated to a 75 year service life. RF_{CR} = 1.5 minimum.
3. RF_D: Durability reduction factor shall be determined from specific polymer and expected environment exposure. RF_D = 1.1 minimum.
4. RF_{ID}: Installation damage reduction factor shall be determined from product specific testing using on site soils or more severe soil type source. RF_{ID} = 1.05 minimum.
5. FS_{UNC}: Overall factor of safety to account for uncertainties in the geometry of the structure, fill properties, reinforcement properties, and externally applied loads, minimum 1.5.

2.05 Leveling Pad Material

A. The leveling pad material shall be non-frost susceptible, well-graded sand and gravel with unified soil classification GW; or crushed stone, like Drainage Fill.

B. The leveling pad shall not be less than 8 inches thick.

C. The leveling pad shall extend at least 7 inches from the toe and 12 inches from the heel of the lowermost Monumental Blok unit.

2.06 Drainage Fill

A. The drainage fill material shall be a clean crushed stone or granular fill meeting the following gradation as determined in accordance with ASTM D422:

Sieve Size	Percent Passing
1 inch	100
¾ inch	75-100
No. 4	0-60
No. 40	0-50
No. 200	0-5

2.07 Reinforced Fill

A. The reinforced fill soil shall be free of debris and consist of one of the following inorganic USCS soil types: GP, GW, SW, SP, SM meeting the following gradation as determined in accordance with ASTM D422:

Sieve Size	Percent Passing
4 inch *	100 *
¾ inch	75-100
No. 4	20-100
No. 40	0-60
No. 200	0-35

B. The maximum size shall be limited to ¾ inch for reinforced soil SRW, unless tests* have been performed to evaluate potential strength reduction in the geogrid due to installation damage.

C. The plasticity of the fine fraction of the reinforced soil shall be less than 20.

D. The pH of the backfill material shall be between 3 and 9 when tested in accordance with ASTM D4972.

E. The Wall Designer may utilize finer grain soils with a LL<40 and PI <20 for lower (<15' tall) SRWs utilized for grade separation only (i.e. not supporting buildings or parking), with approval of the Project Geotechnical Engineer, to ensure long-term deformations will remain within tolerable limits.

2.08 Drainage Pipe

A. The drainage collection pipe shall be a perforated or slotted PVC, or corrugated polyethylene pipe with a minimum diameter of 4 inches.

B. The drain pipe shall be placed at the lowest possible elevation within the minimum 12 inches of drainage fill.

C. The drain pipe shall be manufactured in accordance with ASTM D3034 and/or ASTM F405.

2.09 Geotextile Filter

A. The geotextile filter shall be used to protect the drainage material from clogging, by having the following minimum properties:

Property	ASTM	Min. Value - Metric	Min. Value – US units
AOS	D-4751	0.212 mm	70 US sieve size
Grab Tensile	D-4632	0.53 kN	120.0 lbs
Water Flow Rate	D-4491	5500 l/min/sq m	135 gal/min/sq ft
Permittivity	D-4491	Min. 1.7 / sec	Min. 1.7 / sec
Puncture	D-4833	0.3 kN	65.0 lbs

2.10 Concrete Adhesive

A. Concrete specific construction adhesive shall provide sufficient strength and shall be used to permanently secure the Monumental Cap unit on the uppermost course of Monumental Blok unit.

2.11 Performance Criteria

A. This SRW shall be designed by the Contractor's Wall Designer to meet all the design criteria established in NCMA's "Design Manual for Segmental Retaining Walls".

B. The Wall Designer shall identify the borrow source for the Reinforced (infill) soil, providing test results that verify the design properties used, with a sampling interval with index testing required to ensure the soil and/or design parameters have not changed throughout the construction phase.

C. Specific minimum requirements for Contractor quality control testing and observations shall be shown on the drawings.

PART 3: CONSTRUCTION

3.01 Responsibility for Construction

A. The Contractor is solely responsible for performing the work to meet the requirements of this specification.

B. The Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site. The material supplier shall provide sufficient construction assistance to contractors unfamiliar with the Monumental Blok system.

C. The Contractor shall formulate and execute a quality control program to ensure the SRW system is installed according to this specification. The Contractor shall copy the Owner's Representative on all test results and observations made as part of their quality control program.

D. The Owner's Representative may independently verify that the materials supplied and installed by the contractor meet all the requirements of the specification. This includes all submittals and proper installation of the SRW system. The Owner shall share the results of this Quality Assurance testing program with the Contractor.

3.02 Excavation

A. Contractor shall excavate to the lines and grades shown on the construction drawings.

B. Contractor shall take precautions to minimize over-excavation.

C. Contractor shall verify location of existing structures and utilities prior to excavation and shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, shall be designed by the Contractor.

D. All excavation shall be done in full accordance with the prevailing trench and excavation safety laws applicable to the project site.

3.03 Foundation Preparation

A. Following the excavation, the foundation soil shall be examined by the Wall Design Engineer or their designated Special Inspector to assure the actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with soil meeting the design criteria, as directed by the Wall Design Engineer or their designated Special Inspector.

B. Foundation soil shall be proof rolled, inspected, and approved by the Wall Design Engineer or their designated Special Inspector prior to placement of leveling pad materials.

C. Should testing and observations of the foundation soil by the Owner's Representative verify that actual foundation soil strength is deficient, foundation soil correction work will be considered extra and performed under a separate change order to the contract.

3.04 Leveling Pad Preparation

A. Before laying the leveling pad material, a geotextile filter shall be installed over the prepared foundation soil extending towards the back of the excavation, and eventually over the top of the drainage fill to the back of the Monumental Blok units near the top of the wall.

B. A minimum of 8 inch thick layer of compacted base material shall be placed for use as a leveling pad up to the grades and locations as shown on the construction drawings.

C. The granular leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of Monumental Blok units. Compaction shall be performed using three passes of a lightweight compactor, such as a mechanical plate compactor, or sufficient passes to obtain a minimum of 95 percent of the maximum standard Proctor density (ASTM D698).

3.05 Monumental Blok Unit Installation

A. Monumental Blok shall be lifted with a lifting anchor, provided by Techo-Bloc. Use equipment and rigging capable of lifting the Monumental Blok weight (665 lbs for regular unit and 1130 lbs for base unit).

B. The first course of Monumental Blok units shall be placed on the prepared leveling pad at the proper elevation and orientation as shown on the project and/or SRW construction drawings or as directed by the Wall Design Engineer or the designated Special Inspector. Alignment and level shall be checked in all directions and insure that all units are in full contact with the base and properly seated.

C. Place the front of Monumental Blok units side-by-side. No gaps shall be left between the fronts of adjacent units.

D. Place and compact drainage fill in and between adjacent units, and to a minimum depth of 12 inches directly behind the Monumental Blok units. Place and compact reinforced soil behind drainage fill. Drainage fill shall be separated from other soils by the specified geotextile filter.

E. The top of each Monumental Blok unit shall be cleaned and free of foreign material before adding successive courses.

F. Install shear connectors per manufacturer's recommendations.

G. One course of Monumental Blok units shall be the maximum-stacked vertical height prior to drainage fill and backfill placement and compaction.

H. Successive courses shall be installed with the edge of all units aligned with the middle of the unit in the course below.

I. Layout of corners and curves shall be in accordance with the construction plans or in general accordance with manufacturer's recommendations.

3.06 Geogrid Installation

A. Geogrid reinforcement shall be installed in accordance with manufacturer's recommendations.

B. Geogrid reinforcement shall be placed at the strengths, lengths, and elevations shown on the construction drawings or as directed by the Wall Design Engineer or their designated Special Inspector.

C. Geogrid shall be oriented with the highest strength axis perpendicular to the wall face.

D. The top of Monumental Blok units shall be clean and free of debris before installing the geogrid reinforcement.

E. Geogrid shall be laid horizontally on top of the compacted backfill and Monumental Blok units, then into the top groove and out, with the front edge extending 5 inches and 3 inches from the top groove for a wall using Z and U shear connectors respectively.

F. Shear connectors shall be placed on top of the geogrid without decreasing the outside extending edge length mentioned above. Place the next course of Monumental Blok units on top of shear connectors and geogrid.

G. Geogrid shall be placed under tension prior to backfill placement on the geogrid. A nominal tension shall be applied to the reinforcement and maintained by staples, stakes, or pins to ensure that there are no wrinkles or slackness until the reinforcement has been covered by at least 6 inches of backfill.

H. Geogrid reinforcement layers shall be continuous throughout their embedment length and therefore, splicing of the geogrid in the design strength direction (perpendicular to the wall face) shall not be permitted. Adjacent sections of reinforcement shall be butted in a manner to assure 100 percent coverage at each level.

I. Tracked construction equipment shall not be operated directly upon the geogrid reinforcement. A minimum backfill thickness of 6 inches is required prior to operation of vehicles over the geogrid reinforcement.

3.07 Reinforced Backfill placement

A. Backfill shall be placed as shown on the construction drawings and shall be placed directly behind the drainage fill, spread and compacted in such a manner that eliminates the development of wrinkles, movement or installation damage of the geogrid.

B. Backfill shall be placed in maximum lift thickness of 6 inches where hand-operated compaction equipment is used, or 10 inches where heavy compaction equipment is used. Monumental Blok being 16 inches tall requires a minimum of two lifts, the optimum being 8 inches each.

C. Reinforced backfill shall be compacted to a minimum of 95 percent of standard Proctor maximum dry density (ASTM D698) at a moisture content within 2 percent of optimum.

D. Reinforced backfill shall be placed and compacted level with the top of Monumental Blok units and the specified geogrid elevation to ensure that no voids are present under the geogrid reinforcement as it is placed under tension over the reinforced backfill.

E. Only lightweight hand-operated compaction equipment shall be allowed within 2 feet of the back of the Monumental Blok wall units.

F. Rubber tired construction equipment may be driven on reinforcement at slow speeds only (< 10 mph). Sudden stops and sharp turns of tracked or rubber-tired equipment or any other type of vehicle shall be avoided.

G. At the end of each day's operation, the contractor shall slope the last level of reinforced backfill away from the Monumental Blok units to direct runoff away from the wall face. In addition, the contractor shall not allow surface runoff from adjacent areas to enter the wall construction site.

3.08 Drainage Fill and Pipe Placement

A. Drainage fill shall be placed to the minimum finished thickness/width shown on the project/SRW construction drawings or as directed by the Wall Design Engineer.

B. The drainage pipe shall be installed as shown on the project/SRW construction drawings and in accordance with the overall drainage plan for the site.

C. The drainage collection pipe, located just behind the Monumental Blok units, shall be sloped to 2 percent and shall be installed to maintain gravity flow of water outside the reinforced soil zone.

D. The drainage collection pipe shall daylight into a storm sewer system or along a slope at an elevation lower than the lowest point of the pipe within the aggregate drain, every 50 feet maximum.

3.09 Monumental Cap Unit Installation

A. Monumental Cap units shall be properly aligned into the desired position, and secured with a concrete adhesive on top of the cleaned surface of the underlying Monumental Blok.

3.10 Construction Tolerances for Completed Wall

A. The Monumental Blok SRW shall be installed at the plan location shown on the drawings within the following tolerances:

Vertical Plan Location: ± 1.25 ins. max over any 10 ft. distance; 3 ins. maximum
Horizontal Plan Location: ± 1.25 ins. max over any 10 ft. distance; 3ins. maximum

B. The Monumental Blok SRW facing and retaining wall system shall be installed such that the as-built facing alignment is within the following tolerances:

ROTATION: maximum 2.0 degrees, from established plan wall batter.
BULGING: ± 1.00 ins. max over any 10 ft. distance;

PART 4: MEASUREMENT AND PAYMENT

4.01 Measurement

A. The unit of measurement for furnishing and fabricating the Monumental Blok SRW System shall be the vertical square foot of wall surface from the top of the leveling pad to the top of wall or coping block/cap. The quantity to be paid shall be considered full and complete compensation for the; design, supply of materials, installation of materials, excavation to facilitate wall construction, testing for quality control, and all labor, management, tools, equipment, overhead, and insurance to accomplish the work. Excavation of unsuitable materials and replacement with select fill, as directed and approved in writing by the Owner or Owner's Representative, shall be compensated separately.

4.02 Payment

A. The accepted quantities of Monumental Blok SRW system will be paid for per vertical square foot in place as measured from the top of the leveling pad to the top of wall or coping block/cap. The quantities of the Monumental Blok SRW system as approved by the Owner or the Owner's Representative shall be used to determine the area actually supplied. Payment will be made under:

PAY ITEM	PAY UNIT
Monumental Blok SRW	Sq. Ft.