SPECIFICATION FOR SEGMENTAL RETAINING WALL SYSTEMS

PART 1: GENERAL

1.01 Description

A. Work shall consist of furnishing materials, labor, equipment and supervision to install a segmental retaining wall system in accordance with plans and specifications and in reasonably close conformity with the lines, grades, design and dimensions shown on plans or established by Owner or Owner's Engineer.

1.02 Reference Standards

A. Segmental Retaining Wall Units

1. **ASTM C 140** – Standard Test Methods for Sampling and Testing Concrete Masonry Units and Related Units
2. **ASTM C 1372** – Standard Specification for Dry-Cast Segmental Retaining Wall Units

B. Geosynthetic Reinforcement

1. **ASTM D 4595** – Standard Test Method for Tensile Properties of Geotextiles by the Wide-Width Strip Method
2. **ASTM D 5262** – Standard Test Method for Evaluating the Unconfined Tension Creep and Creep Rupture Behavior of Geosynthetics
3. **ASTM D 5321** – Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear
4. **ASTM D 5818** – Standard Practice for Exposure and Retrieval of Samples to Evaluate Installation Damage of Geosynthetics
5. **ASTM D 6706 –** Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil

C. Soils

1. **ASTM D 698** – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort
2. **ASTM D 2487** – Standard Practice for Classification of Soils for Engineering Purposes (Unified Soil Classification System)
3. **ASTM D 422** – Standard Test Method for Particle-Size Analysis of Soils
4. **ASTM D 4318** – Standard Test Methods for Liquid Limit, Plastic Limit and Plasticity Index of Soils
5. **ASTM G 51** – Standard Test Method for Measuring pH of Soil for Use in Corrosion Testing

D. Drainage Pipe

1. **ASTM F 758** – Standard Specification for Smooth-Wall Polyvinyl Chloride (PVC) Plastic Underdrain Systems for Highway, Airport and Similar Drainage
2. **ASTM F 405** – Standard Specification for Corrugated Polyethylene (PE) Pipe and Fittings

E. Engineering Design

1. "NCMA Design Manual for Segmental Retaining Walls," 3rd Edition, 2009.

F. Where specifications and reference documents conflict, the Wall Design Engineer shall make the final determination of applicable document.

1.03 Submittals

A. Materials Submittals: The Contractor shall submit manufacturers' certifications two weeks prior to start of work stating that the SRW units and geosynthetic reinforcement meet the requirements of Section 2 of this specification.

B. Design Submittal: The Contractor shall submit two sets of detailed design calculations and final retaining wall plans for approval at least two weeks prior to the beginning of wall construction. All calculations and drawings shall be prepared and sealed by a professional Civil Engineer (P.E.) – (Wall Design Engineer) experienced in SRW design and licensed in the state where the wall is to be built.

1.04 Delivery, Storage and Handling

A. Contractor shall check materials upon delivery to ensure that the specified type and grade of materials have been received and proper color and texture of SRW units have been received.

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

C. Contractor shall prevent excessive mud, wet concrete, epoxies and similar materials that may affix themselves from coming in contact with materials.

D. Contractor shall protect materials from damage; no damaged material shall be incorporated into the segmental wall.

E. Geosynthetic shall be protected from UV exposure and the protective covering on geosynthetic shall remain until immediately before installation and shall be stored at temperatures above -10 degrees F.

PART 2: MATERIALS

2.01 Segmental Retaining Wall Units

A. SRW units shall be machine-formed, Portland cement concrete blocks specifically designed for retaining wall applications. SRW units currently approved for this project are:

VERSA-LOK Accent® Retaining Wall Units as manufactured by _____.

B. Color of SRW units shall be _____.

C. Finish of SRW units shall be split-face.

D. SRW unit faces shall be of straight geometry.

E. SRW unit height shall be 4 inches.

F. SRW units shall provide a minimum weight of 115 psf wall face area.

G. SRW units shall be solid through the full depth of the unit.

H. SRW units shall have a depth (front face to rear) to height ratio of 2:1, minimum.

I. SRW units shall be capable of being erected with the horizontal gap between adjacent units not exceeding 1/8 inch.

J. SRW units shall be interlocked with connection pins that provide ¾-inch setback or ¼-inch setback from unit below (yielding a 10.6-degree or 3.6-degree cant from vertical).

K. SRW units shall be sound and free of cracks or other defects that would interfere with the proper placing of the unit or significantly impair the strength or permanence of the structure. Any cracks or chips observed during construction shall fall within the guidelines outlined in ASTM C 1372.

L. Concrete SRW units shall conform to the requirements of ASTM C 1372 and have a minimum net average 28 days compressive strength of 3000 psi. Compressive strength test specimens shall conform to the saw-cut coupon provisions of ASTM C 140.

M. SRW units' molded dimensions shall not differ more than $\pm$ 1/8 inch from that specified, as measured in accordance with ASTM C 140. This tolerance does not apply to architectural surfaces, such as split-faces.

2.02 Segmental Retaining Wall Unit Connection Pins

A. SRW units shall be interlocked with VERSA-TUFF® connection pins. The pins shall consist of glass-reinforced nylon made for the expressed use with the SRW units supplied.

2.03 Geosynthetic Reinforcement

A. Geosynthetic reinforcement shall consist of high-tenacity PET geogrids, HDPE geogrids, or geotextiles manufactured for soil reinforcement applications. The type, strength and placement of the geosynthetic reinforcement shall be determined by procedures outlined in this specification and the "NCMA Design Manual for Segmental Retaining Walls," (3rd Edition, 2009), and materials shall be specified by Wall Design Engineer in their final wall plans and specifications. The manufacturers/suppliers of the geosynthetic reinforcement shall have demonstrated construction of similar size and types of segmental retaining walls on previous projects.

   The geosynthetic type must be approved one week prior to bid opening. Geosynthetic types currently approved for this project are:

   VERSA-Grid® Geogrids

B. The type, strength and placement of the reinforcing geosynthetic shall be as determined by the Wall Design Engineer, as shown on the final, P.E.-sealed retaining wall plans.

2.04 Leveling Pad

A. Material for leveling pad shall consist of compacted sand, gravel, or combination thereof (USCS soil types GP, GW, SP and SW) and shall be a minimum of 6 inches in depth. Lean concrete with a strength of 200-300 psi and 3 inches thick maximum may also be used as a leveling pad material. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.

2.05 Drainage Aggregate

A. Drainage aggregate shall be angular, clean stone or granular fill meeting the following gradation as determined in accordance with ASTM D 422:

Sieve Size	Percent Passing
1 inch	100
3/4 inch	75-100
No. 4	0-60
No. 40	0-50
No. 200	0-5

2.06 Drainage Pipe

A. The drainage collection pipe shall be a perforated or slotted PVC, or corrugated HDPE pipe. The drainage pipe may be wrapped with a geotextile to function as a filter.

B. Drainage pipe shall be manufactured in accordance with ASTM F 405 or ASTM F 758.

2.07 Reinforced Backfill Soil

A. The reinforced soil material shall be free of debris. Unless otherwise noted on the final, P.E.-sealed, retaining wall plans prepared by the Wall Design Engineer, the reinforced material shall consist of the inorganic USCS soil types GP, GW, SW, SP and SM, meeting the following gradation, as determined in accordance with ASTM D 422:

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

B. The maximum particle size of poorly-graded gravels (GP) (no fines) should not exceed 3/4 inch unless expressly approved by the Wall Design Engineer and the long-term design strength (LTDS) of the geosynthetic is reduced to account for additional installation damage from particles larger than this maximum.

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

D. The pH of the backfill material shall be between 3 and 9 when tested in accordance with ASTM G 51.

2.08 Geotextile Filter

A. Drainage geotextile shall consist of geosynthetic specifically manufactured for use as a preamble soil filter that retains soil while still allowing water to pass throughout the life of the structure. The type and placement of the geotextile filter material shall be as required by the Wall Design Engineer in their final wall plans and specifications.

PART 3: DESIGN PARAMETERS

3.01 Soil

A. The following soil parameters, as determined by the Owner's Geotechnical Engineer, shall be used for the preparation of the final design:

	Unit Weight (γ) (pcf)	Internal Friction Angle (ϕ) (degrees)	Cohesion (c) (psf)
Reinforced Fill	_____	_____	0
Retained Soil	_____	_____	0

Foundation Soil _____ _____ _____

(If internal friction angles are not available for the above section, the specifier can provide the USCS soil type classification for the reinforced, retained, and foundation soils and/or attach the geotechnical investigation report for this project.)

B. Should the actual soil conditions observed during construction differ from those assumed for the design, design shall be reviewed by the Wall Design Engineer at the Owner's Geotechnical Engineer's direction.

3.02 Design

A. The design analysis for the final, P.E.-sealed retaining wall plans prepared by the Wall Design Engineer shall consider the external stability against sliding and overturning, internal stability and facial stability of the reinforced soil mass, and shall be in accordance with acceptable engineering practice and these specifications. The internal and external stability analysis shall be performed in accordance with the "NCMA Design Manual for Segmental Retaining Walls," (3rd Edition, 2009), using the recommended minimum factors of safety in this manual.

B. External stability analysis for bearing capacity, global stability, and total and differential settlement shall be the responsibility of the Owner and the Owner's Geotechnical Engineer. The Geotechnical Engineer shall perform bearing capacity, settlement estimates, and global stability analysis based on the final wall design provided by the Wall Design Engineer and coordinate any required changes with the Wall Design Engineer.

C. While vertical spacing between geogrid layers may vary, it shall not exceed 2.0 feet maximum in the wall design.

D. The geosynthetic placement in the wall design shall have 100% continuous coverage parallel to the wall face. Gapping between horizontally adjacent layers of geosynthetic (partial coverage) will not be allowed.

PART 4: CONSTRUCTION

4.01 Inspection

A. The Owner or Owner's Engineer is responsible for verifying that the materials supplied by the Contractor meet all the requirements of the specification. This includes all submittals for materials and design, qualifications and proper installation of wall system.

B. Contractor's field construction supervisor shall have demonstrated experience and be qualified to direct all work at the site.

4.02 Excavation

A. Contractor shall excavate to the lines and grades shown on the project grading plans. Contractor shall take precautions to minimize over-excavation. Over-excavation shall be filled with compacted infill material, or as directed by the Wall Design Engineer, at the Contractor's expense.

B. Contractor shall verify location of existing structures and utilities prior to excavation. Contractor shall ensure all surrounding structures are protected from the effects of wall excavation. Excavation support, if required, is the responsibility of the Contractor.

4.03 Foundation Preparation

A. Following the excavation, the foundation soil shall be examined by the Owner's Engineer to assure actual foundation soil strength meets or exceeds the assumed design bearing strength. Soils not meeting the required strength shall be removed and replaced with infill soils, as directed by the Owner's Geotechnical Engineer.

B. Foundation soil shall be proof-rolled and compacted to 95% standard Proctor density and inspected by the Owner's Geotechnical Engineer prior to placement of leveling pad materials.

4.04 Leveling Pad Construction

A. Leveling pad shall be placed as shown on the final, P.E.-sealed retaining wall plans with a minimum thickness of 6 inches. The leveling pad should extend laterally at least a distance of 6 inches from the toe and heel of the lowermost SRW unit.

B. Granular leveling pad material shall be compacted to provide a firm, level bearing surface on which to place the first course of units. Well-graded sand can be used to smooth the top 1/4 inch to 1/2 inch of the leveling pad. Compaction will be with mechanical plate compactors to achieve 95% of maximum standard Proctor density (ASTM D 698).

4.05 SRW Unit Installation

A. All SRW units shall be installed at the proper elevation and orientation as shown on the final, P.E.-sealed wall plans and details or as directed by the Wall Design Engineer. The SRW units shall be installed in general accordance with the manufacturer's recommendations. The specifications and drawings shall govern in any conflict between the two requirements.

B. First course of SRW units shall be placed on the leveling pad. The units shall be leveled side-to-side, front-to-rear and with adjacent units, and aligned to ensure intimate contact with the leveling pad. The first course is the most important to ensure accurate and acceptable results. No gaps shall be left between the front of adjacent units. Alignment may be done by means of a string line or offset from base line to the back of the units.

C. All excess debris shall be cleaned from top of units and the next course of units installed on top of the units below.

D. Two VERSA-TUFF connection pins shall be inserted through the pin holes of each upper-course unit into receiving slots in lower-course units. Pins shall be fully seated in the pin slot below. Units shall be pushed forward to remove any looseness in the unit-to-unit connection.

E. Prior to placement of next course, the level and alignment of the units shall be checked and corrected where needed.

F. Layout of curves and corners shall be installed in accordance with the wall plan details or in general accordance with SRW manufacturer's installation guidelines. Walls meeting at corners shall be interlocked by overlapping successive courses.

G. Procedures C. through F. shall be repeated until reaching top of wall units, just below the height of the cap units. Geosynthetic reinforcement, drainage materials, and reinforced backfill shall be placed in sequence with unit installation as described in Section 4.06, 4.07 and 4.08.

4.06 Geosynthetic Reinforcement Placement

A. All geosynthetic reinforcement shall be installed at the proper elevation and orientation as shown on the final P.E.-sealed retaining wall plan profiles and details, or as directed by the Wall Design Engineer.

B. At the elevations shown on the final plans, (after the units, drainage material and backfill have been placed to this elevation) the geosynthetic reinforcement shall be laid horizontally on compacted infill and on top of the concrete SRW units, to within 1 inch of the front face of the unit below. Embedment of the geosynthetic in the SRW units shall be consistent with SRW manufacturer's recommendations. Correct orientation of the geosynthetic reinforcement shall be verified by the Contractor to be in accordance with the geosynthetic manufacturer's recommendations. The highest-strength direction of the geosynthetic must be perpendicular to the wall face.

C. Geosynthetic reinforcement layers shall be one continuous piece for their entire embedment length. Splicing of the geosynthetic in the design-strength direction (perpendicular to the wall face) shall not be permitted. Along the length of the wall, horizontally adjacent sections of geosynthetic reinforcement shall be butted in a manner to assure 100% coverage parallel to the wall face.

D. Tracked construction equipment shall not be operated directly on the geosynthetic reinforcement. A minimum of 6 inches of backfill is required prior to operation of tracked vehicles over the geosynthetic. Turning should be kept to a minimum. Rubber-tired equipment may pass over the geosynthetic reinforcement at slow speeds (less than 5 mph).

E. The geosynthetic reinforcement shall be free of wrinkles prior to placement of soil fill. The nominal tension shall be applied to the reinforcement and secured in place with staples, stakes or by hand tensioning until reinforcement is covered by 6 inches of fill.

4.07 Drainage Aggregate and Drainage Material Placement

A. Drainage aggregate shall be installed to the line, grades and sections shown on the final P.E.-sealed retaining wall plans. Drainage aggregate shall be placed to the minimum thickness shown on the construction plans between and behind units (a minimum of 1 cubic foot for each exposed square foot of wall face unless otherwise noted on the final wall plans).

B. Drainage collection pipes shall be installed to maintain gravity flow of water outside the reinforced-soil zone. The drainage collection pipe shall be installed at the locations shown on the final construction drawings. The drainage collection pipe shall daylight into a storm sewer or along a slope, at an elevation below the lowest point of the pipe within the aggregate drain. Drainage laterals shall be spaced at a maximum 50-foot spacing along the wall face.

4.08 Backfill Placement

A. The reinforced backfill shall be placed as shown in the final wall plans in the maximum compacted lift thickness of 8 inches and shall be compacted to a minimum of 95% of standard Proctor density (ASTM D 698) at a moisture content within -1% point to +3% points of optimum. The backfill shall be placed and spread in such a manner as to eliminate wrinkles or movement of the geosynthetic reinforcement and the SRW units.

B. Only hand-operated compaction equipment shall be allowed within 3 feet of the back of the wall units. Compaction within the 3 feet behind the wall units shall be achieved by at least three passes of a lightweight mechanical tamper, plate or roller.

C. At the end of each day's operation, the Contractor shall slope the last level of backfill away from the wall facing and reinforced backfill to direct water runoff away from the wall face.

D. At completion of wall construction, backfill shall be placed level with final top of wall elevation. If final grading, paving, landscaping and/or storm drainage installation adjacent to the wall is not placed immediately after wall completion, temporary grading and drainage shall be provided to ensure water runoff is not directed at the wall nor allowed to collect or pond behind the wall until final construction adjacent to the wall is completed.

4.09 SRW Caps

A. SRW caps shall be properly aligned and glued to underlying units with VERSA-LOK adhesive, a flexible, high-strength concrete adhesive. Rigid adhesive or mortar are not

acceptable.

B. Caps shall overhang the top course of units by 3/4 inch to 1 inch. Slight variation in overhang is allowed to correct alignment at the top of the wall.

4.10 Construction Adjacent to Completed Wall

A. The Owner or Owner's Representative is responsible for ensuring that construction by others adjacent to the wall does not disturb the wall or place temporary construction loads on the wall that exceed design loads, including loads such as water pressure, temporary grades, or equipment loading. Heavy paving or grading equipment shall be kept a minimum of 3 feet behind the back of the wall face. Equipment with wheel loads in excess of 150 psf live load shall not be operated within 10 feet of the face of the retaining wall during construction adjacent to the wall. Care should be taken by the General Contractor to ensure water runoff is directed away from the wall structure until final grading and surface drainage collection systems are completed.

END OF SECTION