SECTION 323223 - SEGMENTAL RETAINING WALLS

Revise this Section by deleting and inserting text to meet Project-specific requirements.

1. GENERAL
	* + 1. SUMMARY
				1. This Section includes [**single-**] [**and**] [**multiple-**]depth segmental retaining walls [**with**] [**and**] [**without**] soil reinforcement.
				2. Related Requirements:

Retain subparagraph below to cross-reference requirements contractor might expect to find in this section but are specified in other sections.

Section 310000 "Earthwork" for excavation for segmental retaining walls.

Section 312319 “Dewatering”.

* + - 1. REFERENCES
				1. ASTM International

ASTM C1372 - Standard Specification for Dry-Cast Segmental Retaining Wall Units

ASTM D698 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12 400 ft-lbf/ft3)

ASTM D1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort (56,000 ft-lbf/ft3)

ASTM D4632 - Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

ASTM D4751 - Standard Test Methods for Determining Apparent Opening Size of a Geotextile

ASTM D5321 - Standard Test Method for Determining the Shear Strength of Soil-Geosynthetic and Geosynthetic-Geosynthetic Interfaces by Direct Shear

ASTM D6706 - Standard Test Method for Measuring Geosynthetic Pullout Resistance in Soil

ASTM D6638 - Standard Test Method for Determining Connection Strength Between Geosynthetic Reinforcement and Segmental Concrete Units (Modular Concrete Blocks)

ASTM D6916 - Standard Test Method for Determining the Shear Strength Between Segmental Concrete Units (Modular Concrete Blocks)

ASTM D6938 – Standard Test Methods for In-Place Density and Water Content of Soil and Soil-Aggregate by Nuclear Methods (Shallow Depth)

ASTM E329 - Standard Specification for Agencies Engaged in Construction Inspection, Testing, or Special Inspection.

* + - * 1. National Concrete Masonry Association

NCMA - Design Manual for Segmental Retaining Walls 3rd Edition 5th Printing.

* + - 1. SUBMITTALS
				1. Submittals for this section are subject to the re-evaluation fee identified in Article 4 of the General Conditions.
				2. Manufacturer’s installation instructions shall be provided along with product data.
				3. Submittals shall be provided in the order in which they are specified and tabbed (for combined submittals).
				4. Product Date and installation instructions. Foreach type of product.

USE PARAGRAPH BELOW WITH EPD REQUIREMENT WHEN PROJECT ESTIMATE IS $1M OR MORE.

* + - * 1. Submit an Environmental Product Declaration (EPD) from the manufacturer for concrete units within this specification section, if available. A statement of the contractor’s good faith effort to obtain the EPD shall be provided if not available.

Manufacturer-provided EPDs must be Product Specific Type III (Third-Party Reviewed), in adherence with ISO 14025 *Environmental labels and declarations*, ISO 14044 *Environmental management – Life cycle assessment*, and ISO 21930 *Core rules for environmental product declarations of construction products and services.*

Retain the Subparagraph below for small rocks such as Keystone. Remove for large rocks such as Redi-Rock products.

* + - * 1. Samples: For each color and texture of concrete unit specified. Submit [**full-size units**] [**sections of units not less than 3 inches square**].

Retain "Delegated-Design Submittal" Paragraph below if design services have been delegated to contractor or if basis-of-design specification is used and contractor is required to assume responsibility for design if comparable products are proposed.

Delegated-Design Submittal: For segmental retaining walls. Submit detailed design calculations and drawings showing the proposed layout. Delegated design submittals shall be certified by a Professional Engineer registered in the State of New York.

* + - * 1. Qualification Data:

For testing agency.

For installer, submit a list of previous projects totaling a minimum of five (5) projects of similar scope where the specific retaining wall system has been constructed successfully. Include contact names and telephone numbers for each project.

Usually retain "Product Certificates" or "Product Test Reports" Paragraph below. Delete both for minor applications or if specifying specific manufacturers and products. Retain option in either Paragraph if using soil reinforcement.

* + - * 1. Product Certificates: For each type of segmental retaining wall unit [**and soil reinforcement**] from manufacturer.

Retain first subparagraph below if contractor selects retaining wall units.

Include test data for shear strength between segmental retaining wall units according to ASTM D6916.

Retain subparagraph below if contractor selects retaining wall units or soil reinforcement.

Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D6638.

* + - * 1. Product Test Reports: For each type of segmental retaining wall unit[**and soil reinforcement**], for tests performed by a qualified testing agency.

Retain first subparagraph below if specifying freeze-thaw durability and testing is required.

Include test data for freeze-thaw durability of segmental retaining wall units.

Include test data for shear strength between segmental retaining wall units according to ASTM D6916.

Include test data for connection strength between segmental retaining wall units and soil reinforcement according to ASTM D6638.

* + - * 1. Research/Evaluation Reports: For segmental retaining wall units[**and soil reinforcement**], from Uniform Code-ES.

Retain "Preconstruction Test Reports" Paragraph below if retaining "preconstruction testing" article.

* + - * 1. Preconstruction test reports.
				2. Source quality-control reports.

Retain "Field Quality-Control Reports" Paragraph below if contractor is responsible for field quality-control testing and inspecting.

* + - * 1. Field quality-control reports.
			1. QUALITY ASSURANCE

Retain "Testing Agency Qualifications" Paragraph below if contractor selects testing agency or if contractor is required to provide services of a qualified testing agency in "field quality control" article.

* + - * 1. Testing Agency Qualifications: Qualified according to ASTM E329 for testing indicated.
			1. PRECONSTRUCTION TESTING

Retain this article for retaining walls with soil reinforcement if backfill materials or soil reinforcement are selected by contractor. If backfill materials and soil reinforcement are specified by Project's Engineer of record, these tests should have been performed as part of geotechnical site investigation.

* + - * 1. Preconstruction Testing Service: Engage a qualified testing agency to perform the following preconstruction testing:

Test soil reinforcement and backfill materials for pullout resistance according to ASTM D6706.

Test soil reinforcement and backfill materials for coefficient of friction according to ASTM D5321.

* + - 1. DELIVERY, STORAGE, AND HANDLING
				1. Store and handle concrete units and accessories to prevent deterioration or damage due to contaminants, breaking, chipping, or other causes. Damaged material will not be allowed for use.
				2. Store geosynthetics in manufacturer's original packaging with labels intact. Store and handle geosynthetics to prevent deterioration or damage due to sunlight, chemicals, flames, temperatures above 160 deg F or below 32 deg F, and other conditions that might damage them. Verify identification of geosynthetics before use, and examine them for defects as material is placed.
1. PRODUCTS

Manufacturers and products listed in SpecAgent and Masterworks Paragraph builder are neither recommended nor endorsed by the AIA or Deltek. Before inserting names, verify that manufacturers and products listed there comply with requirements retained or revised in descriptions and are both available and suitable for the intended applications.

* + - 1. PERFORMANCE REQUIREMENTS

Delete this article if segmental retaining walls are designed and detailed on drawings and substitutions are not allowed; retain for basis-of-design or performance specification.

Retain "Basis of Design" or "Delegated Design" Paragraph below. Retain "Basis of Design" Paragraph if using basis-of-design specification and contractor is required to assume responsibility for design of comparable products that may be proposed.

* + - * 1. Basis of Design: Design of segmental retaining walls is based on products indicated. If comparable products of another manufacturer are proposed, engage a qualified Professional Engineer, licensed and registered in the jurisdiction of the project’s location*,* to design segmental retaining walls.

Retain "Delegated Design" Paragraph below if contractor is required to assume responsibility for design.

* + - * 1. Delegated Design: Engage a qualified Professional Engineer, licensed and registered in the jurisdiction of the project’s location, to design segmental retaining walls.
				2. Compliance Review: Qualified Professional Engineer responsible for segmental retaining wall design shall review and approve submittals and source and field quality-control reports for compliance of materials and construction with design.

Insert another design standard, such as AASHTO’s "Standard Specification for Highway Bridges," in "Structural Performance" Paragraph below if applicable.

* + - * 1. Structural Performance: Engineering design shall be based on the following loads and be according to [**NCMA's "Design Manual for Segmental Retaining Walls."**]

Gravity loads due to soil pressures resulting from grades [**and sloped backfill**] indicated.

Retain subparagraph below for superimposed loads.

Superimposed loads (surcharge) indicated on Drawings.

NCMA's "Design Manual for Segmental Retaining Walls" establishes a methodology for seismic design specific to segmental retaining walls, but is limited to areas where maximum horizontal ground acceleration is not more than 0.4 g. Verify requirements of authorities having jurisdiction. Horizontal peak ground acceleration (a) is determined by Project's location and site classification. See evaluations.

Horizontal Peak Ground Acceleration (A) for Project: <**Insert value**>.

* + - 1. SEGMENTAL RETAINING WALL UNITS

Limiting maximum water absorption is one way to help ensure that units are resistant to freezing and thawing. Note that freeze-thaw testing is expensive whereas water absorption testing is not.

* + - * 1. Concrete Units: ASTM C1372, Normal Weight, except that[**maximum water absorption shall not exceed 7 percent by weight and**] units shall not differ in height more than plus or minus 1/16 inch from specified dimension.

Edit Paragraph below to suit Project.

[Products:](http://www.specagent.com/Lookup?ulid=7292) Subject to compliance with requirements, provide the following:

[Keystone Retaining Wall Systems, Inc](http://www.specagent.com/Lookup?uid=123457094586).; Keystone Standard 18” Unit – Straight Face; Keystone Standard 18” Unit – Series II; Keystone Standard 18” Unit – Tri-Plane Face.

[Keystone Retaining Wall Systems, Inc](http://www.specagent.com/Lookup?uid=123457094586).; Keystone Compac 12” Unit – Straight Face; Keystone Compac 12” Unit – Series II; Keystone Compac 12” Unit – Tri-Plane Face.

Redi-Rock International; Redi-Rock – [**41 Series Block**][**28 Series Block**][**60 Series Block**].

Approved equivalent.

Retain first subparagraph below for Projects in areas where walls are subject to freezing. Consider deleting option because ASTM C1372 allows freeze-thaw resistance to be demonstrated by "Proven Field Performance" or by testing, unless testing is specified, and freeze-thaw testing is expensive.

Provide units that comply with requirements in ASTM C1372 for freeze-thaw durability.

Edit Paragraph below based on product selection. Retain first option for Redi-Rock (large units) and second option for Keystone (small units).

Provide units that interlock with courses above and below by means of [**integral lugs, lips, or tongues and grooves**] [**pins**].

* + - * 1. Color: Gray.
				2. Shape and Texture: Provide units matching basic shape, dimensions, and face texture of basis-of-design product.

Retain one of last five options in "Batter" Paragraph below with or without first option for units that offset to produce required batter. Delete all if units do not offset and batter is produced by sloping units. First option is a minimum; others are examples based on typical units.

* + - * 1. Batter: Provide units that offset from course below to provide [**at least**] [**1:24**] [**1:16**] [**1:14**] [**1:8**] [**1:5**] batter.
				2. Cap Units: Provide cap units of [**shape indicated**] [**same shape as other units**] with smooth, as-cast top surfaces without holes or lugs.
				3. Special Units: Provide corner units, end units, and other shapes as needed to produce segmental retaining walls of dimensions and profiles indicated and to provide texture on exposed surfaces matching face.
			1. INSTALLATION MATERIALS

Revise "PINS" Paragraph below if metal pins are allowed; delete if exclusively using units with integral lugs or projections.

* + - * 1. Pins: Product supplied by segmental retaining wall unit manufacturer for use with units provided, made from nondegrading polymer reinforced with glass fibers.
				2. Cap Adhesive: Product supplied or recommended by segmental retaining wall unit manufacturer for adhering cap units to units below.

Retain one of three options in "Leveling Base" Paragraphs below to suit height of walls, subgrade soil, availability of material, drainage requirements, and office practice. Consult with Geotechnical Engineer.

* + - * 1. Leveling Base: [**Subbase Course Type 2**][**Item B-12**] as specified in Section 310001 "Earthwork Materials.”

\*\*\*\*\*\* [OR] \*\*\*\*\*\*

* + - * 1. Leveling Base: Un-reinforced concrete footing 6 inches in depth.

Lean concrete leveling course allows the base to be quickly and accurately leveled. Ensure that concrete is weak or thin enough so that differential settlement produces many cracks with slight elevation differences rather than fewer cracks with larger elevation differences.

Leveling Course: Lean concrete with a compressive strength of not more than 500 psi.

* + - * 1. Drainage Fill: Pea gravel as specified in Section 310001 “Earthwork Materials”.

If required, retain “Reinforced-Soil Fill” Paragraph below as recommended by Geotechnical Engineer.

* + - * 1. Reinforced-Soil Fill: Comply with requirements in Section 310001 "Earthwork Materials" for Selected Fill material.
				2. Nonreinforced-Soil Fill: Comply with requirements in Section 310001 "Earthwork Materials" for Suitable Material.
				3. Impervious Fill: Clayey gravel and sand mixture capable of compacting to a dense state.

Retain Paragraph below if drainage geotextile is needed to keep fines in drainage fill from washing out between segmental retaining units.

* + - * 1. Drainage Geotextile: Nonwoven needle-punched geotextile, manufactured for subsurface drainage applications, made from polyolefins or polyesters; with elongation greater than 50 percent.

Apparent Opening Size: No. 70 to 100 sieve, maximum; ASTM D4751.

Minimum Grab Tensile Strength: 110 lb; ASTM D4632.

Minimum Weight: 4 oz./sq. yd.

Retain Paragraph below if using soil reinforcement.

* + - * 1. Soil Reinforcement: Product specifically manufactured for use as soil reinforcement and as specified in Section 310001 “Earthwork Materials”.
			1. SOURCE QUALITY CONTROL

Testing in this article confirms that soil-reinforcement quality does not vary so much among runs that design values, based on testing previous runs of product, are invalid for product used. Delete article if soil reinforcement is not used.

* + - * 1. Factory test and inspect each roll of soil reinforcement for minimum average roll values for geosynthetic index property tests, including the following:

Weight.

Grab or single-rib strength.

Aperture opening.

Rib or yarn size.

1. EXECUTION
	* + 1. EXAMINATION
				1. Examine areas and conditions, with Installer present, for compliance with requirements for excavation tolerances, condition of subgrades, and other conditions affecting performance of the Work.
				2. Proceed with installation only after unsatisfactory conditions have been corrected.
			2. RETAINING WALL INSTALLATION
				1. General: Place units according to NCMA's "Segmental Retaining Wall Installation Guide" and segmental retaining wall unit manufacturer's written instructions.

Lay units in [**running bond**] [**bond pattern indicated**].

Form corners and ends by [**using special units**] [**cutting units with motor-driven saw**] [**or**] [**splitting units with mason's hammer and chisel**].

* + - * 1. Do not use units with chips, cracks, or other defects that are visible at a distance of 20 feet where such defects are exposed in the completed Work.

Retain "Leveling Base" Paragraph below unless a reinforced-concrete footing is required.

* + - * 1. Leveling Base: Place and compact base material to thickness indicated and with not less than 95 percent maximum dry unit weight according to ASTM D698.

Lean concrete leveling course allows the base to be quickly and accurately leveled. Ensure that concrete is weak or thin enough so that differential settlement produces many cracks with slight elevation differences rather than fewer cracks with larger elevation differences.

Leveling Course: [**At Contractor's option, unreinforced lean concrete may be substituted for upper 1 to 2 inches of base**] [**Place unreinforced lean concrete over leveling base 1 to 2 inches thick**]. Compact and screed concrete to a smooth, level surface.

* + - * 1. First Course: Place first course of segmental retaining wall units for full length of wall. Place units in firm contact with each other, properly aligned and level.

Retain subparagraph below if not specifying lean concrete leveling course in "Leveling Course" Subparagraph above. Retain subparagraph below if not specifying lean concrete leveling course in "Leveling Course" subparagraph above.

Tamp units into leveling base as necessary to bring tops of units into a level plane.

* + - * 1. Subsequent Courses: Remove excess fill and debris from tops of units in course below. Place units in firm contact, properly aligned, and directly on course below.

Retain one or more of subparagraphs below depending on requirements retained for concrete units in Part 2.

For units with lugs designed to fit into holes in adjacent units, lay units so lugs are accurately aligned with holes, and bedding surfaces are firmly seated on beds of units below.

\*\*\*\*\*\* [OR] \*\*\*\*\*\*

For units with pins, install pins and align units.

Delete the subparagraph below for large systems such as Redi-Rock wall systems. Edit per manufacturer’s requirements.

* + - * 1. Cap Units: Place cap units and secure with cap adhesive.
			1. FILL PLACEMENT

Consult Geotechnical Engineer or soil report for necessary revisions to this article.

* + - * 1. General: Comply with requirements in Section 310000 "Earthwork" with NCMA's "Segmental Retaining Wall Installation Guide," and with segmental retaining wall unit manufacturer's written instructions.
				2. Fill voids between and within units with drainage fill. Place fill as each course of units is laid.
				3. Place, spread, and compact drainage fill and soil fill in uniform lifts as specified in Section 310000 “Earthwork” for full width and length of embankment as wall is laid. Place and compact fills without disturbing alignment of units. Where both sides of wall are indicated to be filled, place fills on both sides at same time. Begin at wall, and place and spread fills toward embankment.

Revise distance in first subparagraph below as required by soil report or retaining wall design.

Use only hand-operated compaction equipment within 48 inches of wall, or one-half of height above bottom of wall, whichever is greater.

Revise compaction requirements in two subparagraphs below as required by soil report. Information is based on NCMA's "design manual for segmental retaining walls."

Compact reinforced-soil fill to not less than 95 percent maximum dry unit weight according to ASTM D698.

In areas where only hand-operated compaction equipment is allowed, reduce lift thickness to achieve required compaction percentage.

First two subparagraphs below are based on Anchor's recommendations. Delete if inapplicable.

In areas where fill height exceeds 15 feet compact reinforced-soil fill that will be more than 15 feet below finished grade to not less than 98 percent maximum dry unit weight according to ASTM D698.

In areas where fill height exceeds 30 feet compact reinforced-soil fill that will be more than 30 feet below finished grade to not less than 100 percent maximum dry unit weight according to ASTM D698.

Compact nonreinforced-soil fill to comply with Section 310000 "Earthwork."

Retain first Paragraph below if drainage geotextile is needed to keep fines in drainage fill from washing out between segmental retaining units.

* + - * 1. Place drainage geotextile against back of wall, and place layer of drainage fill at least 12 inches wide behind drainage geotextile to within 12 inches of finished grade. Place another layer of drainage geotextile between drainage fill and soil fill.
				2. Place a layer of drainage fill at least 12 inches wide behind wall to within 12 inches of finished grade. Place a layer of drainage geotextile between drainage fill and soil fill.

Retain first Paragraph below if using drainage pipe. Ensure that inverts are indicated on drawings.

* + - * 1. Wrap drainage pipe with filter fabric and place in drainage fill as indicated.
				2. Place surface course specified on the Drawings at top of wall over top edge of drainage fill layer.
				3. Slope grade at top of wall away from wall unless otherwise indicated. Slope grade at wall base away from wall. Provide uniform slopes that prevent ponding.

At the end of each day’s operation, slope the last lift of reinforced backfill away from the wall units to direct runoff away from the constructed portion of the wall.

Retain Paragraph below if using soil reinforcement.

* + - * 1. Place soil reinforcement in horizontal joints of retaining wall where indicated and according to soil-reinforcement manufacturer's written instructions. Embed reinforcement a minimum of 8 inches into retaining wall and stretch tight over compacted backfill. Anchor soil reinforcement before placing fill.

Place additional soil reinforcement at corners and curved walls to provide continuous reinforcement.

Place geosynthetics with seams, if any, oriented perpendicular to segmental retaining walls.

Do not dump fill material directly from trucks onto geosynthetics.

Place at least 6 inches of fill over reinforcement before compacting with tracked vehicles or 4 inches before compacting with rubber-tired vehicles.

Do not turn vehicles on fill until first layer of fill is compacted and second layer is placed over each soil-reinforcement layer.

* + - 1. CONSTRUCTION TOLERANCES

Delete this article if segmental retaining walls are not close to buildings, roads, etc. Revise tolerances to suit Project. Most tolerances cannot be measured precisely due to unit face roughness.

* + - * 1. Variation from Level: For bed-joint lines along walls, do not exceed 1-1/4 inches in 10 feet, 3 inches maximum.
				2. Variation from Indicated Batter: For slope of wall face, do not vary from indicated slope by more than 1-1/4 inches in 10 feet.
				3. Variation from Indicated Wall Line: For walls indicated as straight, do not vary from straight line by more than 1-1/4 inches in 10 feet.
				4. Maximum Gap between Units: 1/8 inch.
			1. FIELD QUALITY CONTROL
				1. Testing Agency: Director’s Representative will engage a qualified testing agency to perform tests and inspections.
				2. Comply with requirements in Section 310000 "Earthwork" for field quality control.

Retain one of two subparagraphs below and revise as required by soil report or engineering design of segmental retaining wall.

In each compacted backfill layer, perform at least one field in-place compaction test in accordance with ASTM D6938 for each [**150 feet**] or less of segmental retaining wall length.

In each compacted backfill layer, perform at least one field in-place compaction test in accordance with ASTM D6938 for each [**24 inches**] of fill depth and each [**50 feet**] or less of segmental retaining wall length.

* + - 1. ADJUSTING
				1. Remove and replace segmental retaining wall construction of the following descriptions:

Broken, chipped, stained, or otherwise damaged units. Units may be repaired if Director’s Representative approves methods and results.

Segmental retaining walls that do not match approved Samples.

Segmental retaining walls that do not comply with other requirements indicated.

* + - * 1. Replace units so segmental retaining wall matches approved Samples, complies with other requirements, and shows no evidence of replacement.

END OF SECTION 323223