Section 2431. Segmental Retaining Wall

2431.01 DESCRIPTION.

Furnish and install segmental retaining wall (SRW) units, wall fill, and granular backfill material to the lines and grades shown in the contract documents. Segmental retaining walls are defined as systems which usually require mesh or strips in the backfill material behind the wall facing to limit backfill material stresses by reinforcing the soil structure.

2431.02 DESIGN.

A. Design

1. Wall Design Engineer.
The Wall Design Engineer is required to be Professional Engineer licensed in the State of Iowa.

2. Minimum Design Requirements.
The SRW is required to be designed according to ASTM C 90 and recommendations of the National Concrete Masonry Association (NCMA) Design Manual for Segmental Retaining Walls. The following table summarizes the minimum design criteria and is based upon the structure being critical:

External Stability	Minimum Factor of Safety
Sliding, Fs_{sl}	1.5
Overturning, Fs_{ot}	2.0
Bearing Capacity, Fs_{bc}	2.0

Internal Stability	Minimum Factor of Safety
Tensile Overstress, Fs_{to}	1.2
Pullout, Fs_{po}	1.5

Local Stability	Minimum Factor of Safety
Fs_{sl} (Maximum Unreinforced Height)	1.5
Fs_{ot} (Maximum Unreinforced Height)	2.0
Shear Facing Units, Fs_{sc}	1.5
Facing Connection Strength, Fs_{cs}	1.5
Global Stability	1.5

3. Submittals.
Prior to beginning SRW construction, submit the following for review according to Article 1105.03:

- Detailed design calculations (including soil bearing pressure), construction drawings, and shop drawings, all prepared and sealed by the Wall Design Engineer.
- A detailed explanation of the design properties for the geogrid reinforcement with the design.
- The quality control test limits for the geogrid meeting those design requirements.

B. Materials.
Furnish a wall manufactured by a company on the approved manufacturer's list in Materials I.M. 445.04. Ensure both the supplier of all substantial material components and the Wall Design Engineer have demonstrated experience in reinforced soil-reinforced SRWs for previous projects.

1. Concrete Units.

a. Ensure the following:

- Concrete segmental units and cap blocks comply with the requirements of ASTM C 1372, except with a minimum 28 day compressive strength of 5500 psi (40 MPa) for any one individual unit, and 6000 psi (41 MPa) for the average of three units.
- The 24 hour water absorption rate does not exceed 5%.
- The top surface of cap blocks are sloped 10:1 from front to back or from a crown at the center.

b. Ensure block sampling and testing comply with ASTM C 140, except replace Section 6.2.4 with:

The specimens shall be coupons cut from a face shell of each unit and sawn to remove any face shell projections. The coupon size shall have a height to thickness ratio of 2 to 1 before capping and a length to thickness ratio of 4 to 1. The coupon shall be cut from the unit such that the coupon height dimension is in the same direction as the unit height dimension. Compressive testing of full size units shall not be permitted. The compressive strength of the coupon shall be assumed to represent the net area compressive strength of the whole unit.

c. Freeze-thaw durability testing will be required as described in ASTM C 1372 Sections 4.2, 4.2.1, and 7.3. Ensure testing is done according to ASTM C 1262.

d. Ensure specimens meet weight (mass) loss limits for testing in water as required in ASTM C 1372 Section 4.2.1.

e. Ensure specimens are also tested in a 3% saline solution and comply with either of the following:

- The weight (mass) loss of each of five test specimens at the conclusion of 40 cycles does not exceed 1% of its initial weight (mass); or
- The weight (mass) loss of four out of five specimens at the conclusion of 50 cycles does not exceed 1.5% of its initial weight (mass).

f. Ensure testing is continued until one of the following occurs:

- The weight (mass) loss each of five test specimens exceeds 2% of its initial weight (mass), or
- The weight (mass) loss of one of the five test specimens exceeds 2.5% of its initial weight (mass), or
- The specimens have been tested for at least 100 cycles.

g. Submit complete durability test reports for water and saline conditions, including the cycle number at which failure occurred, to the Engineer.

h. Ensure all units are 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 construction.

i. Ensure SRW units dimensions do not differ by more than ±1/16 inch (±1.5 mm).

2. Leveling Pad.

Use supplier/manufacturer recommended leveling pad materials. If granular material is recommended for the leveling pad, use backfill material meeting the requirements of Section 4132. If unreinforced concrete is recommended for the leveling pad, use Class C concrete meeting the requirements of the Materials I.M. 529 and Section 2403.

3. Unit Fill.

If fill is required by the construction drawings for in-place concrete segmental units, place porous backfill material meeting the requirements of Section 4131.

4. Subdrains.

a. Ensure the subdrains are a minimum of 4 inches (100 mm) in diameter and meet the requirements of Article 4143.01, B.

b. Provide Standard Road Plan RF-19F Type A outlets and fit with Standard Road Plan RF-19E rodent guards.

5. Backfill Material.

Use granular backfill meeting the requirements of Section 4133 for fill soil material in the entire reinforced earth zone.

6. Geogrid Reinforcement.

Comply with the following:

- Type, strength, and placement location determined by the Wall Design Engineer.
- Design properties of the reinforcement determined according to the procedures outlined in NCMA Section 3.5.
- Detailed test data (including strength, creep, site damage, and pullout testing) submitted to the Engineer for approval at least 30 days prior to construction.
- Of a type recommended by the block supplier to be compatible with the facing units, with a minimum long term design strength of 1500 pounds per foot (1000 kg/m).
- Regular grid structure having an aperture geometry and rib and junction cross-sections sufficient to permit significant mechanical interlock with the granular backfill material.

- High continuity of tensile strength through all ribs and junctions of the grid structure.
- High resistance to deformation under sustained long term design load while in service, and resistant to: 1) ultraviolet degradation; 2) damage under normal construction practices; and 3) all forms of biological or chemical degradation normally encountered in the granular backfill material.

7. Certifications.

a. Submit a notarized manufacturer's certification to the Engineer at least 14 days prior to the preconstruction conference, stating that the SRW units meet the requirements of this specification.

b. Submit a notarized manufacturer's certification signed and sealed by an officer of the manufacturer, prior to start of work, stating that the geogrid reinforcement meets the requirements of the SRW unit manufacturer and this specification.

2431.03 CONSTRUCTION.

A. Construction Supervision.

1. SRW units and geogrid reinforcement material suppliers shall provide, at no additional cost to the Contracting Authority, a qualified and experienced representative on site at the beginning of wall construction for up to 3 working days.

2. The Contractor is to provide an experienced and qualified field construction supervisor to direct all work at the site.

B. Excavation.

Excavate to the lines and grades shown on the construction drawings as being the reinforced earth zone. Take precautions to minimize over excavation. If required, design a system for excavation support at no additional cost to the Contracting Authority.

C. Foundation Soil Preparation.

1. Excavate foundation soil as required for base course leveling pad dimensions and limits of reinforced earth zone as shown in the contract documents.

2. The Engineer will examine foundation soil to assure that the actual foundation soil strength meets or exceeds the assumed design bearing strength. Remove soils not meeting the required strength and replace with soil meeting the design criteria.

3. Ensure the earth foundation has a density equal to or greater than 90% Standard Proctor Density. Step the earth foundation at the required intervals to keep it a minimum 2 feet (600 mm) below the finished grade.

D. Leveling Pad.

1. Place the leveling pad a minimum of 6 inches (150 mm) in thickness.

2. Construct the leveling pad to ensure complete contact of the retaining wall unit with the leveling pad. Ensure no gaps exist between the retaining wall unit and the leveling pad.

E. Unit Installation.

Install materials at the proper elevation and orientation shown in the contract documents. Install the concrete segmental units and geogrid reinforcement according to the approved submittals in Article 2431.02, A, 2. The plans govern in all conflicts between the two requirements.

F. Subdrains.

1. Install subdrains as shown in the contract documents to maintain gravity flow of water to outside of the reinforced earth zone. Outlet subdrains into a storm sewer access or along a slope at an elevation lower than the lowest point of the pipe within the SRW reinforced earth zone.

2. Place porous backfill material meeting the requirements of Article 2431.02, B, 3, around the subdrain to a minimum cover of 3 inches (75 mm).

G. Backfill Material Placement.

1. Compact the granular backfill material according to Article 2107.03, H. Place the granular backfill material as shown in the contract documents in maximum 8 inch (200 mm) lifts, compacted to a minimum 95% of standard Proctor density (ASTM D 698). Ensure moisture limits are between 3% under optimum moisture to no more than the optimum moisture content. Place the backfill material, spread, and compact in such a manner that eliminates the development of wrinkles and/or movement of the geogrid reinforcement.

2. Only hand-operated compaction equipment will be allowed within 3 feet (1 m) of the front of the wall face.

3. Do not operate tracked construction equipment directly on the geogrid reinforcement. A minimum backfill material thickness of 6 inches (150 mm) is required prior to operation of tracked vehicles over the geogrid reinforcement. Minimize turning of tracked vehicles to prevent tracks from displacing the fill and damaging the geogrid reinforcement.

4. Rubber-tired equipment may pass over the geogrid reinforcement, if done according to the manufacturer's recommendations. Avoid sudden braking and sharp turning.

H. Geogrid Installation.

1. Overlapping the geogrid in the design strength direction will not be permitted. The design strength direction is that length of geogrid reinforcement perpendicular to the wall face. Use one continuous piece of material. Butt adjacent sections of geogrid in a manner to ensure 100% coverage after placement.

2. Install the geogrid reinforcement under tension. Apply a nominal tension to the reinforcement and maintain it by staples, stakes, or hand tensioning. The tension applied may be released after the geogrid reinforcement has been covered and held in place with soil fill.

2431.04 METHOD OF MEASUREMENT.

Measurement will be as follows:

A. Segmental Retaining Wall.
Square feet (square meters) from measurements of the front face of the wall in place. The height will be measured from the top of the leveling pad to the top of the wall, including coping or cap block.

B. Granular Backfill Material.
Tons (megagrams) or cubic yards (cubic meters) as stipulated in the contract documents.

C. Excavation.
Classed and measured according to Section 2102.

2431.05 BASIS OF PAYMENT.

Payment will be the contract unit price as follows:

A. Segmental Retaining Wall.

1. Per square foot (square meter).

2. Payment is full compensation for furnishing all materials, tools, and labor for the performance of all work necessary to construct the wall, according to the contract documents, including the design, foundation preparation, leveling pad, geogrid fabric, porous backfill material, and subdrains.

B. Granular Backfill Material.
Per ton (megagram) or cubic yard (cubic meter) as stipulated in contract documents for material furnished, hauled, placed, and compacted.

C. Excavation.
Article 2102.05, A, 1, applies for each class of excavation for preparing the reinforced earth zone for construction of the wall. This will normally be included for payment with other excavation required by the contract documents.