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MODULAR BLOCK RETAINING WALLS (MINOR CONCRETE STRUCTURES) (OAKDALE 2411)

PART 1 GENERAL

1.01 SUMMARY

- A. Section Includes:
 - 1. Construction of modular block retaining walls.
 - 2. Furnishing and installing modular block units to the lines and grades designated on the construction drawings or as directed by the Engineer.
 - 3. Furnishing and installing appurtenant materials required for construction of the retaining walls as shown on the construction drawings.
- B. Method of Measurement:
 - 1. Measure by the square feet of frontal face area, including area installed below finished grade.
- C. Basis of Payment:
 - 1. Payment shall cover supply and installation of modular block units along with backfill, geogrid and other appurtenant and incidental materials required for construction of the retaining walls as shown on the construction drawings. It shall include all compensation for labor, materials, supplies, and equipment associated with constructing the modular block retaining walls, including but not limited to:
 - a. Excavation
 - b. Modular blocks
 - c. Select granular fills
 - d. Drain tile
 - e. Aggregate leveling pad
 - f. Drainage aggregate
 - g. Geotextile
 - h. Geogrid
 - i. Common Borrow
 - 2. Compensation for excavation and backfill necessary for modular block retaining wall construction will be included in the bid price of the modular block retaining wall.
 - 3. Payment for modular block retaining wall will be based on the bid price listed on the Bid Form and according to the following schedule. All associated work items shall be considered incidental.

1.01 REFERENCES

- A. MnDOT 2105 – Excavation and Embankment
- B. MnDOT 3149 – Granular Material

- C. MnDOT 3138 – Aggregate for Surface and Base Courses
- D. MnDOT 3278 – Corrugated Polyethylene Drainage Tubing
- E. MnDOT 3733 – Geotextile
- F. ASTM C 33 – Specification for Concrete Aggregates
- G. ASTM C 90 – Specification for Load-Bearing Concrete Masonry Units
- H. ASTM C 140 – Methods of Sampling and Testing Concrete Masonry Units
- I. ASTM C 150 – Specification for Portland Cement
- J. ASTM C 331 – Specification for Lightweight Aggregates for Concrete Masonry Units
- K. ASTM C 595 – Specification for Blended Hydraulic Cements
- L. ASTM C 618 – Specifications for Fly Ash and Raw or Calcined Natural Pozzolan for Use as a Mineral Admixture in Portland Cement Concrete
- M. ASTM C 920 – Specification for Elastomeric Joint Sealants
- N. ASTM C 989 – Specification for Ground Iron Blast-Furnace Slag for Use in Concrete and Mortars.
- O. ASTM C 1262 – Standard Test Method for Evaluating the Freeze-Thaw Durability of Manufactured Concrete Masonry Units and Related Concrete Units
- P. ASTM D 698 – Laboratory Compaction Characteristics of Soil Using Standard Effort
- Q. ASTM D 2487 – Classification of Soils for Engineering Purposes
- R. ASTM D 4354 – Standard Practice for Sampling of Geosynthetics for Testing
- S. ASTM D 4439 – Standard Terminology for Geosynthetics
- T. ASTM D 5262 – Tensile Properties of Geotextiles by the Wide Strip Method
- U. ASTM D 5262 – Standard Test Method for Evaluating the Unconfined Tension Creep Behavior of Geosynthetics
- V. Geosynthetic Research Institute (GRI): 215-895-2000
 - 1. GG1: Geogrid Rib Tensile Strength
 - 2. GG2: Geogrid Junction Strength
 - 3. GG4(a): Determination of the Long-Term Design Strength of Stiff Geogrids
 - 4. GG4(b): Determination of the Long-Term Design Strength of Flexible Geogrids
 - 5. GG5: Standard Method of Test for Geogrid Pullout Behavior
- W. National Concrete Masonry Association (NCMA) – Design Manual for Segmental Retaining Walls, First Edition, 1993

1.02 DEFINITIONS

- A. Allowable Strength (T_{allow}):
 - 1. The allowable tensile strength after reducing the ultimate tensile strength (T_{ult}) to account for creep reduction and other partial factors of safety. Determine by GG4 (a) or (b), whichever method is applicable.
- B. Ultimate Strength (T_{ult}):
 - 1. The ultimate tensile strength of a geogrid determined by the wide width tensile strength test method (ASTM D 4595).
- C. Geosynthetic:
 - 1. A planar product manufactured from polymeric material used with a soil, rock, earth, or other geotechnical engineering related materials as an integral part of a constructed project, structure, or system (ASTM D 4439).
- D. Geogrid:
 - 1. Any synthetic planar structure formed by a regular network of tensile elements with apertures of sufficient size to allow interlocking with surrounding soil, rock, earth, or any other geotechnical material to perform the functions of reinforcement and/or separation (GRI GG1).
- E. Cross-Machine Direction:
 - 1. The direction in the plane of the fabric perpendicular to the direction of manufacture (ASTM D 4439).
- F. Machine Direction:
 - 1. The direction of the plane of the fabric parallel to the direction of the manufacture (ASTM D 4439), also referred to as main direction.
- G. MARV:
 - 1. Minimum Average Roll Value.
- H. Ultraviolet (UV) Resistance:
 - 1. The deterioration in tensile strength from exposure to ultraviolet light generally expressed as percent strength retained for a certain length of exposure.

1.03 SUBMITTALS

- A. The Contractor shall submit one sample of each proposed type of modular block unit a minimum of ten days prior to construction for approval. The sample shall be typical of the size, texture, color and finish.
- B. Manufacturer's Data:
 - 1. The Contractor shall submit descriptive technical data on the modular block.
- C. Certificate of Compliance stating that the materials provided meet the requirements specified, including modular block, geotextile, geogrid and grain size and compaction tests on the select granular fill according to ASTM D 422 and ASTM D 698.

- D. Field Density Test Reports shall be submitted immediately for review and acceptance or direction on corrective action required.
- E. Contractor shall submit three block units for each type of block and three cap block units to an independent laboratory for strength tests in accordance with ASTM C 140 and ASTM C 90. Three strength tests shall be completed on each type of block. Results shall be submitted to the Engineer prior to the start of wall construction.
- F. Submit freeze-thaw test results from within the last three months for same type of block units manufactured at the same plant, (ASTM C 1262). Test results shall be submitted to the Engineer prior to construction of the wall.
- G. Geogrid Submittals:
 - 1. Submit a complete package of laboratory test data that documents the geogrid design properties and associated index property testing as specified herein. The submittal should contain a calculation of the Allowable Strength (T_{allow}). This information should be supported by the laboratory test data for each critical parameter, including partial factors of safety, in the determination of key design properties if other than the default values prescribed in Paragraph 2.01 J. The information should be submitted a minimum of two weeks prior to the delivery of materials to the site.
 - 2. Provide the minimum index, property test values, prescribed on Table 1.
 - 3. In case of a dispute over the validity of design properties or testing, the Engineer can require the Contractor to supply design property test data from a qualified/approved third party laboratory to verify the value/test data submitted at no additional expense to the Owner.
 - 4. The Engineer will notify the Contractor in writing of acceptance of the submitted geogrid reinforcement(s).
 - 5. The manufacturer will supply with each geogrid shipment a material certification, executed by a duly qualified officer of the company/corporation, which identifies the minimum average roll value (MARV), for each of the quality assurance tests, specified in Table 1. Geogrid materials shipped to the project site with MARV below the minimums established in Table 1 shall be returned to the manufacturer and replaced at no additional cost to the Owner.
 - 6. Submit a labeled sample indicating machine/main and cross-machine direction.

1.04 QUALITY ASSURANCE

- A. The Contractor shall check the materials upon delivery to assure that proper material has been received.
- B. The Contractor shall prevent excessive mud, wet cement, epoxy and like materials from affixing themselves to the materials until the completed wall is accepted.
- C. The Contractor must receive written acceptance of geogrid reinforcements from the Engineer prior to accepting delivery on the project site. Check the geogrid upon delivery to ensure that the proper geogrid was received from the manufacturer.

PART 2 PRODUCTS

2.01 MATERIALS

- A. Cementitious Materials. Materials shall conform to ASTM C 150.
 - 1. Limestone: Calcium carbonate, with a minimum 85 percent (CaCO₃) content, may be added to the cement, while still meet the requirements of ASTM C 150 as follows:
 - a. Limitation on Insoluble Residue – 1.5 percent.
 - b. Limitation on Air Content of Mortar – Volume percent, 22 max.
 - c. Limitation on Loss of Ignition – 7 percent.
 - 2. Blended Cements – ASTM C 595.
 - 3. Pozzolans – ASTM C 618.
 - 4. Blast Furnace Slag Cement – ASTM C 989.
- B. Aggregates shall conform to the following specifications, except that grading requirements shall not necessarily apply:
 - 1. Normal Weight Aggregates – ASTM C 33.
 - 2. Lightweight Aggregates – ASTM C 331.
- C. Other constituents:
 - 1. Air entraining agents, coloring pigments, integral water repellents, finely ground silica and other constituents shall conform to applicable ASTM Standards and/or shall be shown by certified testing that the constituent is not detrimental to the durability of the concrete segmental retaining wall units or any material customarily used in masonry construction.
- D. Foundation Drain:
 - 1. Drainpipe shall consist of perforated polyethylene (PE) pipe wrapped in a geotextile sock or non-perforated where required. Pipe shall meet the requirements of MnDOT 3278. Pipe diameter shall be as shown on the construction drawings. Fittings shall conform to manufacturer's recommendations.
- E. Construction Adhesive:
 - 1. The type of adhesive utilized to bond modular block units to each other and to the wall caps, as shown shall be in accordance with ASTM C 920.
- F. Base Material:
 - 1. Material footing shall conform to MnDOT 3138 aggregate base course Class 5. A minimum of six inches of compacted base is required.
- G. Backfill:
 - 1. Select granular borrow for wall backfill shall meet the requirements of MnDOT Section 3149.2B2 modified to less than five percent passing the No. 200 sieve.
- H. Surface Sealer:
 - 1. Penetrating water repellent recommended by the modular block unit manufacturer and is silane or ethyl siloxane with at least 40 percent active content by weight.
- I. Geotextile:
 - 1. Geotextile shall meet the requirements of MnDOT Section 3722.
- J. Geogrid:
 - 1. Method of Manufacture:
 - a. A geogrid shall consist of polymer tensile elements manufactured into a regular network, so as to create apertures of sufficient size to efficiently reinforce soil, rock

and other geotechnical materials that meets that definition and provides a product with the design properties listed in Table 1.

2. Design, Property, Requirements:

- a. The geogrid shall be dimensionally stable and possess high resistance to damage during construction, ultraviolet light degradation, and all forms of chemical and biological degradation encountered in the soil at the project site. The geogrid manufacturer/supplier must clearly indicate the primary strength direction on each roll supplied to the project. The geogrid shall possess the Minimum Design and Minimum Index Properties itemized in Table 1.
- b. The Allowable Strength (T_{allow}) shall be determined based on the procedures defined in Section 1.03.A. using the following default factors of safety or factors of safety supported by actual test data.

FS_{id} = Factor of Safety, construction and installation damage – Use 1.4 or submit test methods and results to support value used.

FS_{cd} = Factor of Safety, chemical degradation – Use 1.4 or submit test methods and results to support value used.

FS_{bd} = Factor of Safety, biological degradation – Use 1.3 or submit test methods and results to support value used.

FS_{cr} = Factor of Safety, creep deformation – Use 3.0 or submit test methods and results to support value used.

TABLE 1
Geogrid Reinforcement Minimum Requirements

Property	Test Method	Geogrid
(T_{allow}) Allowable Strength Main Direction (b/ft) ¹	---	600
C_i , Coefficient of Interaction	---	0.7
Facing Connection ²	NCMA	See Note 3

1) Allowable strength as defined in section 1.03A and based upon minimum average roll values.
2) The minimum connection strength shall be defined by the following envelope:
Peak ($a_{cs} = 550$ lb/ft. $\theta_{cs} = 14^\circ$, sc (Max) = 600 lb/ft)
Service State ($a_{cs} = 350$ lb/ft. $\theta_{cs} = 14^\circ$, sc (Max) = 390 lb/ft)

2.02 PHYSICAL REQUIREMENTS

- A. Modular Block Units shall have a minimum 28-day compressive strength of 5,500 psi and an average of 5,800 psi for 3 units in accordance with ASTM C 90, and the concrete masonry shall have adequate freeze-thaw protection with maximum 24-hour moisture absorption of 5.0 percent. Exterior dimensions of the block may vary; however, the units are required to have a minimum of 0.5 square feet of face area, a 6 inch height, and depth as shown on the drawings. The block shall have a minimum unit weight of 45 pounds per square foot of wall face area. The units shall be split to present a stone texture. The block color shall consist of a shade subject to approval by the Owner matching the color of existing block walls in the project area. The units shall be positively interlocked by means of clips, pins or lip extensions from the block.

B. Wall Caps:

1. Precast concrete units shall be placed as caps on top of all modular block retaining walls. The units shall have a minimum of a 4 inch height, a 10 inch depth and a color and texture on exposed faces to match that of the modular block units. The cap units shall meet the physical requirements for the modular block units.
- C. Salvaged block units from removal of the existing wall can be incorporated into the new wall provided they meet all the requirements of Paragraph 2.04 and match color and style of new blocks. Blocks must also be of same manufacturer to ensure block-to-block connection.

2.03 PERMISSIBLE VARIATIONS IN DIMENSIONS

- A. Overall dimension (width, height, length) as defined by the manufacturer shall not vary more than +0.1-inch in the depth or length of the units and not more than 0.05-inch in height from the specified dimension.

2.04 FINISH AND APPEARANCE

- A. All units shall be sound and free of cracks and other defects that would interfere with the proper placing of the units or significantly impair the strength or performance of the construction. Minor cracks incidental to the usual method of manufacture, or minor chipping resulting from shipment and delivery, are not grounds for rejection. Units showing cracks larger than 0.05 inches when measured along their length shall not be used within the wall.
- B. The faces of units that are to be exposed shall be free of chips, cracks or other imperfections when viewed from a distance of 30 feet. 5 percent of a shipment may contain slight cracks or small chips not larger than 1 inch.

2.05 SAMPLING AND TESTING

- A. The purchaser and authorized representative shall be accorded proper facilities to inspect and sample units from lots ready for delivery. The Contractor shall notify the authorized representative in writing a minimum of 5 calendar days prior to shipment of materials.
- B. Sample and test units for compressive strength and absorption in accordance with ASTM C 140 and ASTM C 90, except that:
 1. Compressive testing specimens shall be coupon size and testing of full size units will not be permitted. The coupon shall be cut from the unit face and sawn to remove any face shell projections. The coupon shall have a height to thickness ratio of 2:1 and a length to thickness ratio of 4:1 and cut such that the coupon height dimension is in the same direction as the unit height dimension.
- C. Except as specified in Paragraph 2.03, the expense of inspection and testing shall be borne by the Contractor.
- D. Freeze-Thaw Testing:
 1. Testing shall be in accordance with ASTM C 1262. Specimens shall be tested in a 3 percent saline solution and shall conform with either of the following:
 - a. The loss of each of 5 test specimens at the conclusion of 90 cycles shall not exceed 1 percent of its initial mass

- b. The loss of each of 4 of the 5 test specimens at the conclusion of 100 cycles shall not exceed 1.5 percent of its initial mass. The maximum allowable loss for the fifth specimen shall not exceed 10 percent.
2. Test reports, including the cycle number at which failure occurred, shall be submitted to the Engineer.
3. Recent test reports, within the last 3 months on cap units and block units of same manufacture are sufficient. Provide results along with manufacturer certification.

PART 3 EXECUTION

3.01 EXCAVATION

- A. The Contractor shall excavate only within limits necessary for construction of the modular block retaining wall

3.02 FOUNDATION SOIL PREPARATION

- A. Foundation soil shall be excavated as required for base leveling pad dimensions as shown or as directed by the Engineer. Unsatisfactory material encountered below the grades shown shall be removed as directed and replaced with suitable common excavation material.
- B. Where the foundation becomes unstable due to the Contractor's lack of control of groundwater or surface water, the unstable material shall be removed as directed and replaced with satisfactory material at no additional expense to the Owner. Over excavation will not be paid for and replacement with same and/or wall system components to the indicated excavation grade as selected by the Engineer will be required at the Contractor's expense. Backfill shall be placed in 8-inch lifts and compacted. Required density is 98 percent of maximum density, ASTM D 698.
- C. The ground surface shall be broken up to a minimum depth of 12 inches beneath the leveling pad, pulverized and compacted to the specified density. The subgrade soil shall be tested to ensure that the density meets or exceeds 98 percent of Standard Proctor Density.

3.03 AGGREGATE BASE AND FOUNDATION DRAIN

- A. Aggregate base materials shall be installed upon subgrade as shown. The aggregate base shall be placed in one lift and compacted to 98 percent of maximum density. Aggregate base shall be to depths and widths as shown, and shall be of consistent gradation and materials throughout the length of the wall.

3.04 MODULAR BLOCK UNIT INSTALLATION

- A. Modular Block Units:
 1. First course of concrete wall units shall be placed on the prepared base. The units shall be checked for level and alignment. The first course is the most important to insure accurate and acceptable results.
 2. Ensure that modular block units are in full contact with the prepared base.
 3. Modular block units shall be placed end-to-end at constant elevations for full-length wall alignment where possible. Alignment shall be done by using a string line or offset from a base line.

4. Construction for modular block wall shall begin at lowest base elevation and progress towards the highest base elevation.
5. Lay up each course insuring a positive connection between adjacent courses is achieved following the manufacturer's instruction. Modular block units shall have no gap between units at the facing of the wall.
6. Place geogrid and pull taut and secure with pins or other approved method. Backfill in accordance with 3.04 C. Lay up additional courses of block, geogrid, geotextile and backfill as shown on the drawings.
7. Sweep all excess material from the top of the modular block units and install next course. Insure all voids are filled.
8. Alignment Tolerances:
 - a. Horizontal: 1-inch from the alignment shown on the plans.
 - b. Vertical: The top of footing elevations shall be within 1-inch from elevations shown on the Plans.
 - c. Plumbness:
 1. Batter: Shall fall within the maximum and minimum shown in the plans.
 2. Level: Blocks shall be placed level within 0.1-inch in 50 feet perpendicular and parallel to the wall alignment.
9. Apply surface sealer to the entire front face and top of the wall. Apply in accordance with manufacturer's recommendations.

B. Geogrid Placement:

1. The type(s) of geogrid reinforcement defined in Section 2.01 J shall be installed at the locations indicated on the drawings in accordance with these specifications.
2. The Contractor is responsible for determining the correct location, elevation, direction of geogrid reinforcement placement, and geogrid type. The proper roll direction orientation must clearly be indicated in the geogrid manufacturer/supplier's submittal, Section 104.
3. Paint the edges of the geogrid rolls to differentiate between different types of geogrid in the field.
4. The geogrid reinforcement shall be placed in continuous longitudinal strips in the main direction perpendicular to the structure face. Connections in the main direction are not allowed.
5. All geogrid reinforcement shall be placed to lay flat and pulled taught prior to backfilling with soil. The geogrid shall be held in place by suitable means (pins, stakes, etc.) during fill placement to prevent the development of wrinkles during placement of backfill.
6. Only that amount of geogrid reinforcement required for immediately pending work can be placed, so as to prevent undue damage and exposure. Only the geogrid reinforcement, which can be covered with compacted soil in the same day, should be installed.
7. Placement Tolerance: Except as noted on the drawings, the surface for geogrid and backfill placement shall be kept approximately horizontal fill surface. The geogrid reinforcement should be placed within the following tolerances:
 - a. Elevation: 1-inch.
 - b. Horizontal: Continuous horizontally, within +1-foot on ends of layers.
 - c. Length: Equal to or greater than minimum length shown on Drawings.
 - d. Variation from these tolerances only by written permission of the Engineer.

2. The maximum loose lift thickness for fill placement shall be eight inches for self-propelled heavy construction equipment and six inches for lightly loaded hand compaction equipment.
3. Backfill shall be placed, spread and compacted in such a manner to minimize the development of wrinkles and/or movement of geogrid reinforcement from its original installed position.
4. Fill shall be compacted to 95 percent Standard Proctor Density.
5. At the completion of each day's work, the backfill shall be graded and sealed with proof rolling, to prevent ponding of water on the partially completed surface of the reinforced soil mass.
6. Rubber-tired equipment may pass over the geogrid reinforcement at slow speeds, less than 3 mph. Avoid sudden braking and sharp turning.
7. Under no circumstance can track-type construction equipment be operated on the geogrid without a minimum 8 inches thick compacted soil cover being in place.

D. Waterproof Sealer:

1. A clear, penetrating, breathable, chlorine resistant water repellent sealer meeting the requirements on the file in the MnDOT Concrete Unit (651-779-5572) shall be applied to the top, the exposed front face, and the back side of the upper three courses of each retaining wall.
2. Due to the hazardous ingredients contained in sealer formulations, extreme care must be exercised in their handling and use, and the manufacturer's recommendations shall be closely followed.
3. The Contractor shall comply with the manufacturers written instructions for preparing, handling, and applying the surface sealer. The surface to be treated shall receive a light water blast to the extent that the surface is clean and free of oils. Before the surface sealer is applied, the surface to be sealed shall be dry and free of all dust debris and frost. Surface sealers shall be applied at the heaviest application rate specified by the manufacturer.

E. Utilities:

1. Utilities should be located outside the construction limits of the retaining wall. Wall and utility construction shall be coordinated so that any underground utilities within the construction limits of the modular block retaining wall shall be installed as the wall is being constructed. Once the geotextile layers are being installed, neither the geotextile nor the utility shall be disturbed at any time. Any additional work on utilities will require dismantling and reconstructing the wall.
2. All materials and work performed as specified above will be incidental to construction of the wall.

3.05 QUALITY CONTROL

- A. The Contractor shall establish and maintain quality control for the work under this section to assure compliance with contract requirements and maintain records of its quality control for all construction operations including, but not limited to, the following:
 1. Foundation Preparation and Back Fill Density tests a minimum of one per day or two for every 2-foot lift, whichever is greater.
 2. Alignment Tolerances:
 - a. Horizontal.
 - b. Vertical.
 - c. Plumbness.

3. Furnish a copy of the records of inspection and tests, as well as the records of corrective action taken to the Engineer.

END OF SECTION