MICHIGAN

DEPARTMENT OF TRANSPORTATION

SPECIAL PROVISION

FOR

**GEOSYNTHETIC REINFORCED SOIL ABUTMENT**

GEO:CDJ 1 of 8 APPR:TES:RWS:11-30-22

**a. Description.** The work consists of furnishing and installing a Geosynthetic Reinforced Soil Abutment in accordance with the contract, the *FHWA Design and Construction Guidelines for Geosynthetic Reinforced Soil Abutments and Integrated Bridge Systems, dated June 2018* (Publication No. FHWA-HRT-17-080), the standard specifications, and as directed by the Engineer.

The following definitions apply when used herein and on the plans:

**Beam Seat Setback.** The lateral distance from the back of the geosynthetic reinforced soil (GRS) block units (BU) to the front of the superstructure bearing beam seat area. This distance is a minimum of 8 inches or as shown on the plans.

**Clear Space.** The vertical distance between the top of the GRS abutment wall face and bottom of the superstructure above the wall. This minimum distance is 4 inches and the maximum distance is 8 inches.

**Geosynthetic Reinforced Soil (GRS).** Alternating layers of compacted granular fill reinforced with geotextile reinforcement. Facing elements can be frictionally connected to the reinforcement layers to form an outer GRS wall. Facing elements must consist of solid modular block units (BU).

**Geotextile Reinforcement.** Biaxial geotextile reinforcement having strength and stiffness that are approximately equal in both the machine and the cross machine directions.

**GRS Abutment.** A GRS retaining wall system designed to support the weight of a bridge superstructure. Usually, GRS abutments have three sides: the abutment face wall and two wing or return walls.

**GRS Abutment Face Wall.** The vertical or near vertical wall parallel to the center of superstructure bearing seat and designed to support the bridge superstructure.

**GRS Wing Wall.** A wall attached and adjacent to the GRS abutment face wall. The GRS wing walls are built at the same time as the GRS abutment face wall and at a right or other angle to the GRS abutment face wall.

**Reinforced Soil Foundation (RSF).** A reinforced soil mass located below the GRS. This mass consists of alternating layers of compacted aggregate and geotextile reinforcement.

**Retained Soil.** Backfill located behind the GRS wall mass.

**b. Materials.** The basis of acceptance for all materials not addressed by the standard specifications and specified herein will be a test data certification in accordance with the *MQAP Manual* and as described herein. Furnish all test data certifications by an independent testing laboratory to the Engineer prior to material use.

1. Block Units (BU). Use a solid modular BU from an approved block wall manufacturer listed below or an approved equal product from another manufacturer.

Redi-RockRecon Retaining Wall Systems

05481 US 31 7600 W. 27th Street #229

Charlevoix, MI 49720 St. Louis Park, MN 55426

Ph. (231) 237-9500 Ph. (952) 922-0027

(Modular Block Unit) (Modular Block Unit)

BU from these manufacturers or an equal product from another manufacturer approved by the Engineer must meet the following requirements:

A. Modular Block Unit Requirements. Concrete must meet Grade 3500 or 3500HP requirements. Document by furnishing manufacturer’s test data certification, in accordance with the *MQAP Manual*.

B. Aesthetic Requirements. Meet project aesthetic requirements specified on the plans.

C. Dimensions. Minimum BU dimensions are 16 inches high by 24 inches deep by 22 inches in length. Furnish top block without knobs or tongues. Top block thickness may be reduced to a minimum of 6 inches to meet the project geometry.

D. Fabrication. Do not begin fabrication of the Modular BU more than 1 month prior to the project letting date. Ensure the date of fabrication is marked on each BU. BU’s without the date of fabrication will be rejected.

2. Geotextile Reinforcement. Within the GRS and RSF, use a woven, high density polyethylene, polypropylene or high-tenacity polyester, biaxial geotextile that is resistant to UV oxidation and degradation caused by chemical and temperature exposures normally encountered in the highway environment. The weatherometer test results can be for the product line material type and does not have to be tested directly from the lot of geotextile produced for this site.

Identify the *ASTM* type, class, group, grade, and category of the primary resin used in manufacturing within the test data certification as applicable.

Provide a test data certification showing that the lot of geotextile reinforcement proposed for this site meets the physical property requirements of Table 1.

**Table 1: Woven Geotextile Reinforcement Properties**

|  |  |  |
| --- | --- | --- |
| Property | Test Method | Minimum Value  (Unless Otherwise Noted) |
| Ultimate Tensile Strength  MD(a)  CMD(a) | *ASTM D4595*  Strain Rate of 10% per minute | 4,800 lb/ft  4,800 lb/ft |
| Tensile Strength @ 2% Strain  MD(a)  CMD(a) | *ASTM D4595* | 950 lb/ft  950 lb/ft |
| Apparent Opening Size | *ASTM D4751* | 0.60 mm Maximum |
| Inherent Viscosity (PET (b) only) | *ASTM D4603* | Minimum Number Average Molecular Weight of 25000 |
| Carboxyl End Group (PET (b) only) | *ASTM D7409* | Maximum of Carboxyl End Group Content of 30 |
| UV Resistance | *ASTM D4355/D4355M* | >70% breaking strength after 500 hr |
| a. "MD" and "CMD" represent 'machine' and 'cross-machine' directions, referring to the principle directions of the manufacturing process.  b. PET - Polyester | | |

Acceptance of this material for ultimate tensile strength, tensile strength at 2 percent strain, and apparent opening size will be by test. Samples will be obtained by the Engineer from on-site material. Obtain one sample from the first 1,500 square yards per structure with subsequent samples obtained every 5,000 square yards. Ensure samples are a minimum of 8 feet long by the full roll width, with a 6 square yard minimum. Roll samples, do not fold, and ship in a manner to prevent creases in the fabric. The test data certification will only be used for acceptance of inherent viscosity, carboxyl end group and UV resistance.

3. The use of crushed concrete or material exhibiting cementitious qualities for aggregate in the RSF, GRS Granular Fill, or Reinforced Superstructure Backfill is prohibited.

4. GRS Granular Fill. For granular fill material within the GRS wall mass use one of the following materials, or as shown on the plans:

A. 34G open-graded aggregate, 25A coarse aggregate, or 29A coarse aggregate

The compacted material must have a minimum angle of internal friction of 38 degrees per *AASHTO T236* (large scale direct shear test) or *ASTM D7181* (large scale triaxial compression test, consolidated drained). Provide a test data certification from an independent testing laboratory for the angle of internal friction for the proposed aggregate source. The testing for angle of internal friction must include at least 3 tests on different samples of the proposed source material.

5. Retained Soil. If additional bridge approach embankment fill is required behind the GRS wall mass, provide Structure Backfill, CIP as shown on the plans. Backfill, Structure, CIP will be paid for separately.

6. Reinforced Soil Foundation (RSF). Provide 21AA or 46G aggregate, or as shown on the plans, within the wrapped geotextile reinforcement layers for the RSF volume.

7. Reinforced Superstructure Backfill. Provide 21AA aggregate, or as shown on the plans, within the wrapped geotextile layers for the bridge abutment backfill material situated above the GRS wall mass and below the design pavement section for the bridge approach.

8. Concrete. Use Portland cement concrete meeting the requirements for Grade 3500 or 3500HP concrete in accordance with section 706 of the Standard Specifications for Construction, except as modified herein. Coarse aggregate originating only from geologically natural sources meeting physical requirements of Class 26A may be used.

9. Flashings. Provide grade 304 stainless steel flashings, if shown on the plans. Provide long-life all-weather butyl sealants/adhesives for flashing overlaps.

**c. Submittals.** Furnish an electronic PDF copy of all submittals to the Engineer at least 45 days prior to the start of RSF or GRS abutment construction. The Engineer will approve or reject the submittals within 10 calendar days after receipt of a complete submission. Additional time required due to incomplete or unacceptable submittals will not be justification for time extension or impact or delay claims. All costs associated with incomplete or unacceptable submittals will be borne by the Contractor.

1. Submit test data certifications for the following:

A. Proposed aggregates

B. Geotextile reinforcement

C. Proposed BU

2. Submit detailed GRS installation plan. Within the plan, indicate construction sequence for the GRS elements including width and directional placement of geotextile reinforcement layers throughout the various RSF and GRS zones. The plans present RSF and GRS layout based on generic BU dimensions. The submittal must provide any changes to dimensions, elevations, reinforcement spacing, and quantities in the RSF, GRS and BU due to the selection of a specific BU.

3. Submit a sketch illustrating crane locations, including outrigger pads, in relation to the edge of GRS walls during positioning of the bridge beams. The edge of the crane’s outrigger pad mat must remain a minimum distance of 4 feet from the back of the BU. Crane outrigger pad sizes must result in less than a 4,000 psf bearing pressure being applied to reinforced soil areas near the GRS walls. Calculations must accompany the crane sketches indicating the resulting outrigger and load bearing system (crane, mats, beams, etc.) pressure on the underlying soil.

**d. Construction.** Construction procedures must adhere to the design plans, this special provision and Chapter 7 of the *FHWA Design and Construction Guidelines for Geosynthetic Reinforced Soil Abutments and Integrated Bridge Systems, dated June 2018* (Publication No. FHWA-HRT-17-080). If there is a conflict between these documents, contact the Engineer for clarification.

1. Subgrade Preparation. Excavate to the necessary elevations and dimensions shown on the plans. Provide run-off water controls to prevent excessive flow into the excavation. Provide groundwater control for the excavation. Prior to wall construction, inspect the RSF subgrade and compact, if necessary, in accordance with subsection 205.03.I.1 of the Standard Specifications for Construction, or prepare as required in the contract. Undercut unsuitable material as directed by the Engineer. Undercutting of unsuitable material will be paid for separately as Excavation, Fdn. Unless otherwise directed by the Engineer, replace undercut soils with Backfill, Structure, CIP compacted to 95 percent of the material maximum unit weight in accordance with section 205 of the Standard Specifications for Construction. Structure Backfill, CIP will be paid for separately.

If the base of the excavation is left open, grade the base to one end to facilitate the removal of any water intrusion with a pump. If the excavation is flooded, remove all water along with any unsuitable soils, as directed by the Engineer. Ensure final subgrade is smooth, uniform and free from irregular surface shape or protruding objects that would obstruct placement of geotextile wrapped reinforced aggregate fills for the RSF.

2. Reinforced Soil Foundation (RSF). Construct the RSF in accordance with the plans. For 21AA aggregate, place backfill in lifts measuring not more than 8 inches in thickness. Compact backfill within this zone to 98 percent of its maximum unit weight as determined by the One Point Michigan Cone Test of the *Density Testing and Inspection Manual*. Decrease the maximum lift thickness if necessary to obtain the specified density. For 46G aggregate, compact as described in subsection d.3.E of this special provision.

Encapsulate the entire RSF with geotextile reinforcement. Ensure the wrapped corners of the RSF are tight and without exposed soil. Minimum shingle overlaps of 2 feet are required regardless of structure location. For GRS abutments adjacent to waterways, overlap the RSF geotextile reinforcement a minimum of 3 feet. For proper shingle flow of water over the overlaps, start with the outer layer of the overlap situated on the upstream side of the RSF. Orient overlapped sections of geotextile reinforcement to prevent water from penetrating the layers of reinforcement.

Pull the geotextile reinforcement taut to remove all wrinkles prior to placing and compacting the backfill. Place fill starting at the river side front face and proceeding towards the back to push out folds or wrinkles towards the free end of the reinforcement layer. Ensure the end of the overlap is located at least 3 feet from the RSF edge.

3. Geosynthetic Reinforced Soil (GRS) Abutment. Place courses of BU, and GRS systematically per the contract and the approved installation procedures.

A. Block Unit Placement. Place each course of BU level, even, and within plan tolerance. Place adjacent blocks tightly against each other to prevent backfill from escaping between gaps. For gaps between blocks greater than 1/8 inch, use a compressible backer rod with Geotextile Reinforcement, or Geotextile Liner to cover the gap and prevent backfill loss. Offset subsequent courses of block by half a block width so that vertical joints are not continuous.

Check the vertical alignment of the GRS Abutment Face Wall at least every other block layer. Correct any deviations greater than 0.25 inches. In addition, check every other row of block alignment with a string line referenced off the back of the facing block from wall corner to corner. Correct deficiencies as required.

At right-angle wall corners, stagger face wall and wing wall block courses to form a tight, interlocking, stable corner. For wall corners with angles other than 90 degrees provide custom blocks, sawcut blocks, or provide reinforced concrete so that the corner is tight and stable. If reinforced concrete is used provide concrete texturing to match the BU.

B. GRS Granular Fill. Follow the placement of each course of block closely with granular fill. Carefully place granular fill so as to avoid any damage or disturbance of the wall materials or any misalignment of the BU or soil reinforcement. Remove and replace any wall BU and geotextile reinforcement that become damaged or misaligned during granular fill placement at no cost to the contract. Fill any depressions present behind the BU level to the top of the BU prior to placing the geotextile reinforcement.

For 34G open-graded aggregate, 25A coarse aggregate, or 29A coarse aggregate compact as described in subsection d.3.E of this special provision to achieve a minimum angle of internal friction of 38 degrees.

Perform compaction utilizing only lightweight, hand operated compaction equipment (e.g., a lightweight mechanical tamper, plate, or roller). Adjust granular fill lift heights in order to achieve the compaction requirements. Check the position of the BU after compaction. Any elements that have been displaced should be removed and reset into their proper location and position.

Ensure uniform moisture content throughout each layer of the granular fill prior to and during compaction. Place the granular fill at a moisture content that is within two percentage points of the optimum moisture content percentage, or at a moisture content and density that is uniform and acceptable to the Engineer, throughout the entire lift.

At the end of each day’s operation, slope the last layer of the granular fill away from the wall face and cover with a suitable water-resistant tarp, to rapidly direct runoff away from the wall face. Do not allow surface runoff from adjacent areas to enter the wall construction site.

C. Geotextile Reinforcement. Place geotextile reinforcement in continuous full-length strips from the wall face to the design strip lengths without use of overlap or factory seam splices in the critical load bearing dimensions. Place the roll direction of the geosynthetic perpendicular to the GRS abutment and wing/return wall faces, unless otherwise directed by the Engineer. Extend the geotextile reinforcement so that it is situated between layers of BU to provide a frictional connection. The geotextile reinforcement must extend to within 1 inch of the wall face or shear knobs. Remove all excess geotextile reinforcement extending beyond the wall face by cutting with a razor knife or other means approved by the Engineer.

Uniformly tension geotextile reinforcements to remove any slack in the connections or materials, so that geotextile reinforcements are taut, free of wrinkles, and flat. Where overlaps exist on top of the BU, trim as necessary to prevent varying geotextile reinforcement thickness or excessive gaps between adjacent blocks.

Place granular fill starting at the wall face and moving backwards to remove and prevent the formation of wrinkles in the geotextile reinforcement. Correct any misalignment or distortion of the wall face in excess of the tolerances specified herein at no additional cost to the contract.

Driving equipment directly on the geotextile reinforcement is prohibited. Place a minimum 6 inch layer of granular fill prior to operating any vehicles or equipment over the geotextile reinforcement. Tracked vehicles are not allowed above the geotextile reinforcement.

D. Superstructure Backfill and Approach Integration. Construct reinforced superstructure backfill approach zone per the plans. Wrap the superstructure approach fill with geotextile reinforcement on three sides or as shown on the plans. Multiple sheets are allowed along the width of the approach, as long as all seams are kept perpendicular to the wall face. Wrap geotextile reinforcement on the roadway sides to prevent lateral spreading of the backfills. Place the superstructure backfill geotextile reinforcement so that the roll direction is parallel to the roadway.

For aggregate placed within the superstructure backfill and approach integration zone, compact the soil to 98 percent of its maximum density per the One Point Michigan Cone Test. Do not use sheep’s foot or grid-type rollers for compaction within the reinforced soil mass. Perform compaction within 3 feet of the back face of the BU and abutment backwall utilizing lightweight, hand operated compaction equipment (e.g., a lightweight mechanical tamper, plate, or roller). Adjust granular fill lift heights in order to achieve the compaction requirements.

E. Density Tests. For each layer of granular fill placed behind an GRS abutment, the Engineer will perform at least three field density tests. Do not penetrate the geotextile reinforcement with field density equipment. If the granular fill is such that it cannot be tested accurately with a nuclear gauge, then a procedural specification will be developed by the Engineer at the time of construction. The procedural specification will develop a certain number of passes required based on the Contractor’s compaction equipment and visual movement of the aggregate. The developed specification will address a procedure for smaller hand operated equipment, as necessary.

**e. Measurement and Payment.** The completed work, as described, will be measured and paid for at the contract unit price using the following pay items:

**Pay Item Pay Unit**

Geotextile Reinforcement Square Yard

Geosynthetic Reinf Soil Granular Fill Cubic Yard

Reinf Soil Fdn Aggregate Cubic Yard

Beam Seat Construction (Structure Identification) Lump Sum

Superstructure Backfill Cubic Yard

Block Units Square Foot

1. **Geotextile Reinforcement** will be paid for by the square yard for material placed. Overlaps are included when determining the final as placed quantity. No allowance will be made for material cut off or wasted. Payment for **Geotextile Reinforcement** includes furnishing all material, providing submittals, and all equipment, labor, testing and miscellaneous hardware required for placing all types of geotextile reinforcement used in the GRS Abutments.

2. **Geosynthetic Reinf Soil Granular Fill** will be paid for by the cubic yard for material placed. Payment for **Geosynthetic Reinf Soil Granular Fill** includes furnishing all of the aggregates, conducting angle of friction testing, providing submittals, and equipment, labor and miscellaneous hardware necessary for placing this material at the GRS Abutments.

3. **Reinf Soil Fdn Aggregate** will be paid for by the cubic yard for material placed. Payment for **Reinf Soil Fdn Aggregate** includes furnishing all of the aggregate used in the RSF, testing, providing submittals, and all equipment, labor, and miscellaneous hardware necessary for placing the material. Payment for **Reinf Soil Fdn Aggregate** also includes any dewatering materials equipment and labor necessary to place the RSF for the GRS Abutments.

4. **Beam Seat Construction (Structure Identification)** is paid as a lump sum pay item for each structure and includes furnishing all materials not included in other pay items including but not limited to foam, concrete, stainless steel flashing, sealant, rebar and joint filler, needed to complete the beam seat detailed on the plans. Payment for **Beam Seat Construction (Structure Identification)** also includes providing submittals and all labor and equipment for constructing these items as shown on the plans.

5. **Superstructure Backfill** will be paid for by the cubic yard for material placed. Payment for **Superstructure Backfill** includes furnishing the aggregate used in the reinforced backfills placed immediately behind the ends of the superstructure, and below the typical pavement section. The pay item also includes providing submittals and all equipment, labor, testing, and miscellaneous hardware necessary for placing this material.

6. **Block Units** will be paid for by the square foot of finished wall face area, based on material placed. Payment includes all compensation for furnishing the BU and all equipment, labor, testing, cutting, and miscellaneous hardware necessary for placing the blocks. Payment for **Block Units** also includes any wasted or rejected blocks, providing submittals, and incorporation of aesthetic details (block style and color) required in the contract.

Underdrains, if required on the plans or by the Engineer, will be paid for separately in accordance with the standard specifications.

**Excavation, Fdn** and **Structure Backfill, CIP** required for undercutting unsuitable subgrade soils below the plan RSF elevation will be paid for separately in accordance with the standard specifications. The bottom of the RSF reinforced soil mass shown on the plans will be considered the bottom of footing for measurement purposes.

If the Engineer determines that a sheet pile type **Cofferdam** or use of **Temp Sheeting** is necessary to adequately complete construction of the RSF, and these items are not shown on the construction plans, these items will be paid for separately as extra work and in accordance with the standard specifications. The Contractor should expect that shallow earth berm type cofferdams will be necessary for RSF construction. The costs associated with establishing earth berm type groundwater control and use of submersible pumps and other dewatering equipment for RSF construction will be included in the items covering the general foundation excavation of the GRS abutment volume and in the item **Reinf Soil Fdn Aggregate**.