SECTION 13200

ANCHOR REINFORCED VEGETATION SYSTEM

PART 1- GENERAL

1.1 SUMMARY

A. The work for this section shall consist of furnishing all equipment and labor necessary for the installation of the Anchor Reinforced Vegetation System as a non-structural erosion control and/or slope protection solution.

1.2 RELATED SECTIONS

A. Earthwork: Section: 02200

B. Solid Sodding: 02934

1.3 REFERENCES

A. American Society for Testing and Materials (ASTM):

1. A 153 - Standard Specification for Zinc Coating (Hot-Dip) on Iron and Steel Hardware
2. A 603-98e1 – Standard Specification for Zinc-Coated Steel Structural Wire Rope
3. A 1023 – Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
4. B 85 – Standard Specification for Aluminum-Alloy Die Castings
5. B 240-10 – Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloys in Ingot Form for Foundry and Die Castings
6. D 570 - Standard Test Methods for Water Absorption of Plastics.
7. D 6475 - Standard test Method for Measuring Mass Per Unit Area or Erosion Control Blankets.
8. D 6524 – Standard Test Method for Stiffness of Geosynthetics Used as Turf Reinforcement Mats.
9. D 6525 - Standard Test Method for Measuring Nominal Thickness of Permanent Erosion Control Products.
10. D 6575 – Test Method for Stiffness of Geosynthetics Used as Turf Reinforcements Mats (TRM's)
11. D 4354 - Practice for Sampling of Geosynthetics for Testing.
12. D 4355 - Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
13. D 4439 - Terminology for Geotextiles.
14. D 6818 - Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats.
15. D 4632 - Test Method for Grab Breaking Load and Elongation of Geotextiles.
16. D 4759 - Practice for Determining the Specification Conformance of Geosynthetics.

17. D 4873 - Guide for Identification, Storage, and Handling of Geotextiles.

18. D 6566 - Test Method for Measuring Mass Per Unit Area of Turf Reinforcement Mats.

B. Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP).

C. International Standards Organization (ISO) 9001:2000 - Quality System Certification.

1.4 DEFINITIONS

A. *Anchor Reinforced Vegetation System (ARVS):* A soil protection system combining a High Performance Turf Reinforcement Mat (HPTRM,), Securing Pins, and Earth Percussion Anchors. The system protects soil surfaces from two failure mechanisms: surface erosion (non-structural applications) and shallow plane instability (structural applications).

B. *Earth Percussion Anchor:* A device designed to permanently stabilize soil via a metal cleat, flexible or rigid tendon, and load bearing plate. The anchor is driven through the HPTRM to the specified depth, and then tensioned appropriately to load-lock for desired pull-out resistance.

C. *High Performance Turf Reinforcement Mat (HPTRM):* A long-term, non-degradable RECP composed of UV-stabilized, non-degradable, synthetic fibers, nettings and/or filaments processed into three-dimensional reinforcement matrices designed for permanent and critical hydraulic applications where design discharges exert velocities and shear stresses that exceed the limits of mature natural vegetation. HPTRMs provide sufficient thickness, strength and void space to permit soil filling and/or retention and the development of vegetation within the matrix. The HPTRM MARV tensile strength per ASTM D-6818 is 3000 lbs/ft in the weakest principle direction.

D. *Rolled Erosion Control Product (RECP):* A temporary degradable or long-term non-degradable material manufactured or fabricated into rolls designed to reduce soil erosion and assist in the growth, establishment and protection of vegetation.

E. *Securing Pin:* A device designed to temporarily hold the HPTRM in place while either vegetation establishes, or the installation of the HPTRM occurs. The securing pin offers no long term value

1.5 DELIVERY, STORAGE, AND HANDLING

A. RECP labeling, shipment and storage shall follow ASTM D 4873.

B. Product labels shall clearly show the manufacturer or supplier name, style name, and roll number.

C. Each shipping document shall include a notation certifying that the material is in accordance with the manufacturer's certificate.

D. Each RECP roll shall be wrapped with a material that will protect the geotextile from damage due to shipment, water, sunlight, and contaminants. (This will be waived for HPTRMs having a 90% retention of strength after 6000 hours of exposure per ASTM D-4355.)

E. The protective wrapping shall be maintained during periods of shipment and storage.

F. During storage, RECP rolls shall be elevated off the ground and adequately covered to protect them from the following: Site construction damage, extended exposure to ultraviolet (UV) radiation, precipitation, chemicals that are strong acids or strong bases, flames, sparks, temperatures in excess of 71 deg C (160 deg F)m and any other environmental condition that might damage the RECP.

PART 2 – PRODUCTS

2.1 MANUFACTURERS

A. All components of the ARVS shall be furnished by a single manufacturer as a complete system.

B. Approved ARVS Manufacturers:

1. Propex Operating Company, LLC – Armormax System

2. Western Excelsior Corporation – Extreme Armor System (XAS)

C. Alternate ARVS Manufacturers:

1. For consideration, alternate systems meeting the material specification must also have a documented history of ARVS installations totaling more than 350,000 square yards and have been in the marketplace for more than three (3) years. Past project documentation will be required for submittal for evaluation to include project name, date of installation, owner's contact information and size of the project.

2. Any alternate products seeking approval must be submitted to the Engineer 10 days prior to the bid date. For acceptance on this project, any alternates seeking approval must meet the requirements outlined in this document. The alternate's product specifications and a product sample must be submitted to the Engineer for approval.

2.2 MATERIALS

A. HPTRM:

1. Three-dimensional, lofty woven polypropylene RECP specially designed for erosion control applications on levees, steep slopes, and vegetated waterways.

2. Must be a homogeneous matrix, and not comprised of layers, composites, or discontinuous materials, or otherwise loosely held together by stitched or glued netting.

3. Material is to exhibit very high interlock and reinforcement capacity with both soil and root systems and demonstrate high tensile modulus.

4. The HPTRM should meet the following values:

Property	Test Method	Measured As	Units	Property Requirement
Thickness	ASTM D6525	Typical	mm (in)	6.4 - 10.2 (0.25 - 0.40)
Light Penetration (% Passing)	ASTM D6567	Typical	percent	10 - 35
Tensile Strength	ASTM D6818	MARV	kN/m (lb/ft)	≥ 58.4 x ≥ 43.8 (≥ 4,000 x ≥ 3,000)
Tensile Elongation	ASTM D6818	Typical	percent	≤ 40 x ≤ 35
Resiliency	ASTM D6524	Typical	percent	≥ 70

UV Resistance	ASTM D4355 or ASTM D7238	Typical	percent	≥ 90 at 6,000 hrs

5. Performance Properties:

   a) Flume Testing: In a vegetated state, the HPTRM must demonstrate acceptable performance (as defined by the Engineer) when subjected to at least 0.5 hrs of continuous flow producing the following conditions.

      1) Permissible velocity: 7.6 m/sec (25 ft/sec)

      2) Permissible tractive force (shear stress): 0.766 kPa (16 psf)

      3) Performance may be demonstrated by:

         i. Flume testing at an independent facility under conditions similar to this project provided that the manufacturer can demonstrate that the material tested is functionally equivalent to the material being supplied. This may be demonstrated by providing index property test results (listed in 2.2.A.4) from a GAI-LAP accredited laboratory for both the tested and supplied materials.

         ii. A documented case history of successful performance (as defined by the Engineer) at an installation similar to this project where (documented) hydraulic forces met or exceeded the requirements listed above provided that the manufacturer can demonstrate that the case history material is functionally equivalent to the material being supplied. This may be demonstrated by providing index property test results (listed in 2.2.A.4) from a GAI-LAP accredited laboratory for both the case history and supplied materials.

   b) Wave Overtopping Testing: In a vegetated state, the HPTRM must demonstrate acceptable performance (as defined by the Engineer) when subjected to wave overtopping simulations, performed by Colorado State University (CSU), and authorized and directed by the U.S. Army Corps of Engineers (USACE).

      1) A single test shall be defined as one wave overtopping simulation down the flume on one set of trays (linear and angled sections) for 3 equivalent test hours at 4.0 cfs/ft. Passing this wave overtopping test is defined as surviving the 3 equivalent test hours without visible damage.

      2) Failure is defined by (0.06 m) 0.2 ft. or more of soil/grass erosion over a (0.37 m^2) 4 ft^2 area.

      3) Each type of HPTRM armoring product shall be subject to 1 wave overtopping test on each tray set at 4.0 cfs/ft for the duration equivalent to 3 test hours (~6 elapsed hours).

6. Manufacturing Quality Control: Testing shall be performed at a laboratory accredited by GAI-LAP for tests required for the HPTRM, at frequency exceeding ASTM D-4354, with following minimum acceptable testing frequency:

Property	Test Frequency m^2 (yd^2)
Thickness	1/10,974 (1/13,125)
Light Penetration (% Passing)	1/10,974 (1/13,125)
Tensile Strength	1/10,974 (1/13,125)
Tensile Elongation	1/10,974 (1/13,125)
Resiliency	1/30,727 (1/36,750)
Flexibility	1/30,727 (1/36,750)
UV Resistance	Annually

2.3 ANCHORING DEVICES

A. Securing Pins:

1. Securing pins should be at least 5 mm (0.20 in.) diameter steel with a 38 mm (1.5 in.) steel washer at the head of the pin. Securing pins should be driven flush to the soil surface.

2. Length: 18 inches.

3. Placement: The pins provide for temporary tie-down of the HPTRM to the slope to aid with vegetation establishment. Locations of the pins along trenches are indicated in the drawings.

B. PDA:

1. PDA with a minimum drive depth of 36 inches are used to provide for permanent tie down of the HPTRM in locations specified in the drawings.

2. The PDA components shall be made of materials suitable to resist corrosion and UV degradation particularly at the soil/air interface, and strategically selected to achieve an expected design life of 50 years.

3. The anchor head shall have smooth edges and shaped in a bullet like configuration with the driving end tapering to a rounded point, minimizing abrasion and installation damage to the HPTRM.

4. The top load bearing plate shall have openings allowing vegetative growth through the plate and protrude only about 0.2 inches above the surface of the mat after installation. The plate shall also include a recessed cavity so that the cable can be cut below the plate surface.

5. The cable tendons shall come with "loops" on the ends to facilitate ease of installation.

6. For quality control purposes and warranty claims, PDAs should be delivered to the jobsite fully assembled and ready for installation, and meet the following requirements:

Component	Standard(s)	Material Composition	Physical Properties
Anchor Head (Bullet Nose)	ASTM B85	Aluminum A383 Alloy	Width: 25mm (1.0in.) Length: 84mm (3.3in.) Bearing Area:16cm^2 (1.5in^2) Weight: 45grams (0.1 lb.).
Cable Tendon	ASTM A1023	Zinc-Aluminum Coated Carbon Steel	Diameter: 3mm (0.12 in.) 1X19 Strand Construction
Load Bearing Plate	ASTM B-240-10	Die Cast Zinc with an Eight (8) Opening Array; Utilizing a Ceramic Roller & Directional Locking Device	Diameter: 108mm (4.25 in.) Thickness: 2.5mm (0.1in.)
Tendon Sleeves	MS51844	Zinc-Aluminum	Length: 15.875mm (5/8") in Wall Thickness: 4.8mm (3/16")

7. Performance

Performance Property	Value
Cable Tendon Working Load Strength	3.56 kN (0.8 Kips)
Cable Tendon Yield Strength	4.89 kN (1.1 Kips)
Composite Anchor Load Strength	2.22 kN (0.5 Kips)
Minimum Anchor Drive Depth	0.91m (3.0ft.)
Maximum Anchor Drive Depth	1.52m (5.0 ft.)

PART 3 – EXECUTION

3.0 PREPARATION

A. Grade and compact areas to be treated with ARVS. Subgrade shall be uniform and smooth.

B. Remove large rocks, soil clods, vegetation, and other sharp objects so that the installed mat will have direct contact with the soil surface. All existing sod and grasses shall be removed and soil shall be exposed prior to the placement of the matting. Placing the ARVS over top of existing sod and grass will not be permitted.

A. Prepare the surface by loosening 50 to 75 mm (2 to 3 in) of soil above final grade. This may be accomplished with a rotary tiller on slopes 3H:1V or flatter.

B. Select and apply soil amendments and fertilizer (in an amount equivalent to 50% of the total mixture required to be installed on the soil surface) in accordance with Section 02934: Solid Sodding, to scarified surface prior to installation of ARVS. Do not mulch areas where mat is to be placed.

C. Keep areas moist as necessary to establish vegetation. If as a result of rain, prepared slope becomes crusted or eroded, or if eroded places, ruts, or depressions exist for any reason, rework soil until smooth and uniform.

D. Excavate an initial anchor trench 300mm (12 in.) wide by 300mm (12 in.) deep, a minimum of 900mm (3 ft.) over the crest of one side of the bank slope.

3.1 INSTALLATION

A. Install RECP at elevation and alignment indicated.

B. The RECP shall be installed longitudinally along the lake slope as shown on the Drawings.

C. Secure RECP with pinning devices and with earth percussion anchors in accordance with the pattern / frequency specified in the project drawings. Increased anchoring frequency may be required if site conditions are such that the Owner determines it necessary.

D. RECP shall terminate at the elevation as shown on the Drawings.

E. Alternate installation methods must be approved by Owner prior to execution.

F. Installation of the RECP and ARVS shall not exceed 1000' at any given time without written pre-approval from the Owner and Engineer.

G. Soil fill and sod the ARVS:

1. Installed ARVS shall be sodded as required by the project documents.
2. Rubber-tired vehicles must be used and sharp turns avoided. No heavy and/or tracked equipment or sharp turns are permitted on the installed HPTRM. Avoid ANY traffic over the HPTRM if loose or wet soil conditions exist.
3. After the HPTRM has been installed, the surface shall be re-checked to ensure that it is uniform and smooth. The surface shall be re-leveled using top soil as necessary prior to sodding to ensure no divots, ruts, or depressions exist.

END OF SECTION