

This guide specification has been prepared by Propex Operating Company, LLC (Propex) to assist design professionals in the preparation of a specification section covering the use of HPTRM's in conjunction with Engineered Earth Anchors for structural slope protection applications. It may be used as the basis for developing either a project specification or an office master specification. Since it has been prepared according to the principles established in the Manual of Practice published by The Construction Specifications Institute (CSI) including the use of section numbers and titles from the 2011 Edition of MasterFormat, this guide specification may be used in conjunction with most commercially available master specifications sections with minor editing.

The following should be noted in using this guide specification:

- *Optional text requiring a selection by the user is enclosed within brackets, e.g.: "Section [01 33 00] [____]."*
- *Items requiring user input are enclosed within brackets, e.g.: "Section [____ - ____]."*
- *Optional paragraphs are separated by an "OR" statement, e.g.:*

***** OR *****

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1 GENERAL

1.1 SUMMARY

- A. The work for this section shall consist of furnishing all materials, equipment, and labor necessary for the installation of an HPTRM and anchors as an Engineered Earth Armoring Solution for structural slope stability and/or slope protection.

1.2 RELATED SECTIONS

Edit the following paragraphs to coordinate with other sections of the Project Manual.

- A. SECTION [01 33 00 SUBMITTAL PROCEDURES] [____ - ____]

- B. SECTION [31 00 00 EARTHWORK] [____ - ____]
- C. SECTION [31 05 19 GEOTEXTILE] [____ - ____]
- D. SECTION [31 25 00 EROSION AND SEDIMENTATION CONTROLS] [____ - ____]
- E. SECTION [32 92 19 SEEDING AND SODDING] [____ - ____]

1.3 UNIT PRICES

Include the following article only for unit price contracts or lump sum contract with unit price adjustments. Delete for lump sum contracts.

- A. Method of Measurement: By the square meter (or square yard - as indicated in contract documents) including seams, overlaps, anchor trenches, and wastage.
- B. Basis of Payment: By the square meter (or square yard - as indicated in contract documents) installed.

1.4 REFERENCES

The following article assumes that the date of each reference standard will be the latest edition as of the date of the project specification. This provision must be defined in Division 1; coordinate with Division 1 statements.

- A. American Society for Testing and Materials (ASTM):
 - 1. A 1023 – Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes
 - 2. B 240-10 – Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloys in Ingot Form for Foundry and Die Castings
 - 3. D 6524 – Standard Test Method for Stiffness of Geosynthetics Used as Turf Reinforcement Mats.
 - 4. D 6525 - Standard Test Method for Measuring Nominal Thickness of Permanent Erosion Control Products.
 - 5. D 6575 – Test Method for Stiffness of Geosynthetics Used as Turf Reinforcements Mats (TRM's)
 - 6. D 4354 - Practice for Sampling of Geosynthetics for Testing.
 - 7. D 4355 - Test Method for Deterioration of Geotextiles from Exposure to Ultraviolet Light and Water (Xenon-Arc Type Apparatus).
 - 8. D 6818 - Test Method for Ultimate Tensile Properties of Turf Reinforcement Mats.
 - 9. D 4759 - Practice for Determining the Specification Conformance of Geosynthetics.
 - 10. D 4873 - Guide for Identification, Storage, and Handling of Geotextiles.

- B. Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP).
- C. International Standards Organization (ISO) 9001:2000 - Quality System Certification.

1.5 DEFINITIONS

- A. *Certificate of Compliance (COC)*: An official document certified by an authorized representative within the manufacturer's company that the manufactured synthetic turf reinforcement mat product(s) meet designated property values as manufactured in a facility having achieved ISO 9001:2000 certification, and tested in accordance with GAI-LAP procedures.
- B. *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.
- C. *Manufacturer*: Entity that produces synthetic turf reinforcement mats through a process directly utilizing obtained raw materials, in a facility owned and operated by said entity, using equipment and assemblies owned and operated by said entity, subject to a certified Manufacturing Quality Control (MQC) Program. Upon completion of production, the manufacturer may sell the turf reinforcement mat product(s) directly to the customer, or through a vendor entity.
- D. *Manufacturing Quality Control (MQC) Program*: A certified and documented program initiated and operated by the manufacturer that outlines the operational techniques and activities which sustain a quality of the synthetic turf reinforcement mat product(s) that will satisfy given needs.
- E. *Minimum Average Roll Value (MARV)*: Property value calculated as typical minus two standard deviations. Statistically, it yields a 97.7 percent degree of confidence that any sample taken during quality assurance testing will exceed value reported.
- F. *Engineered Earth Anchor (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.
- G. *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.
- H. *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 to permanent tie-down of the HPTRM in an armoring solution.
- I. *Trilobal Monofilament Yarn*: A multi-dimensional polymer fiber consisting of a minimum of three points, providing increased surface area and grooves/channels along the fiber to capture additional moisture and sediment to enhance vegetative growth.
- J. *Typical Roll Value*: Property value calculated from average or mean obtained from test data.

- K. *Vendor*: An entity that provides synthetic turf reinforcement mat product(s) to a customer, on behalf of an independent manufacturer. A vendor does not manufacture the actual synthetic turf reinforcement mat product(s), and therefore is not subject to provisions of a certified MQC Program.

1.6 SUBMITTALS

Edit the following to coordinate with Division 1.

- A. Submit under provisions of Section [01 33 00] [____]:
1. Certification:
 - a) The Contractor shall provide the Engineer a certificate of conformance stating the name of the HPTRM manufacturer, product name, style, chemical compositions of filaments or yarns and other pertinent information to fully describe the HPTRM.
 - b) The Manufacturer is responsible for establishing and maintaining a Quality Control Program to assure compliance with the requirements of the specification. Documentation describing the quality control program shall be made available prior to the approval of the armoring solution for use on the project.
 - c) The manufacturer's Certificate of Compliance (COC) shall state that the furnished HPTRM meets MARV requirements of the specification as evaluated under the manufacturer's quality control program. The certificate shall be attested to by a person having legal authority to bind the Manufacturer.
 - d) The Contractor shall establish and maintain a quality control procedure to assure compliance of the armoring solution with the requirements of the specification. Documentation describing the quality control procedure shall be provided to the Engineer.
 2. Manufacturing Quality Control (MQC) test results shall be provided by the manufacturer for the HPTRM component of the armoring solution prior to installation during the duration of the project as material is delivered to the jobsite.
 3. Anchor Testing:
 - a) Prior to installation, the contractor shall perform baseline establishment testing for anchor holding capacity at each discrete area of the armoring solution.
 - b) Baseline establishment testing shall consist of installing one (1) anchor at a location designated by the engineer, setting the anchor at an appropriate embedment depth, and loading the anchor under constant tension.
 - c) The contractor shall measure the depth of initial embedment (after setting the anchor), and commence loading through use of a crane, jack, or similar apparatus. Loading must be recorded using an in-line transducer (load cell) or Dillon scale. Spring / pulley type devices are not acceptable for load measurements.

- d) Loads shall be recorded at tendon displacements of every 25 mm (1 inch), until a load cannot be sustained (indicating impending pull-out), or displacement beyond a minimum embedment as specified by the engineer has been achieved.
- e) The baseline establishment test results shall be forwarded to the engineer by the contractor, and reviewed by the manufacturer. Prior to commencing full installation, the engineer must inform the contractor in writing of sufficient holding capacity demonstrated by the test.
- f) Along with written confirmation of holding capacity, the engineer shall also inform the contractor (in writing) of a frequency of additional quality control load testing to be performed during the installation.
- g) Should any subsequent quality control load testing results fall below a specific tolerance required by the engineer, then the contractor shall cease installation immediately until such time that the engineer has consulted with the manufacturer to develop a corrective action plan.

4. Independent Performance Test Results shall be provided upon request.

1.7 DELIVERY, STORAGE, AND HANDLING

- A. HPTRM 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 HPTRM 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, HPTRM 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 HPTRM.

1.8 QUALITY ASSURANCE SAMPLING, TESTING, AND ACCEPTANCE

- A. HPTRM shall be subject to sampling and testing to verify conformance with this specification. Sampling for testing shall be in accordance with ASTM D 4354.
- B. Acceptance shall be in accordance with ASTM D 4759 based on testing of either conformance samples obtained using Procedure A of ASTM D 4354, or based on manufacturer's certifications and testing of quality control samples obtained using Procedure B of ASTM D 4354.
- C. Quality Assurance Sampling and Testing will be waived for ISO 9001:2000 Certified Manufacturing Facilities. Documentation of ISO 9001:2000 Certification shall be provided upon request.

2 PRODUCTS

2.2 MANUFACTURERS

- A. All components of the Engineered Earth Armoring Solution shall be furnished by a single manufacturer as a complete system.
- B. Approved Engineered Earth Armoring Solution Manufacturers:
1. Propex Operating Company, LLC
4019 Industry Drive
Chattanooga, TN 37416
(800) 621-1273
- C. Alternative Engineered Earth Armoring Solution Manufacturers:
1. For consideration, alternate systems meeting the material specification must also have a documented history of armoring solution installations totaling more than 10,000 square yards and have been in the marketplace for more than five (5) years. Past project documentation will be required for submittal for evaluation to include project name, date of installation, owner's contact information, and a description of the structural mechanisms used to provide engineered slope stability, along with engineering calculations / submittals to support.
 2. Additionally, if an armoring solution manufactured by an entity other than those listed above, the alternative armoring solution manufacturer shall be responsible for providing an engineered solution for slope reinforcement, considering both sliding shallow plane instabilities, as well as global rotational failure potential. The following documentation shall be provided to support the slope reinforcement design for the alternative engineered solution:
 - a) Overall Armoring Solution Design Methodology
 - b) Input Parameters
 - c) Calculations / Model Output
 - d) Anchor Strength
 - e) Anchor Length
 - f) Anchor Spacing (vertical & horizontal spacing)
 - g) Factor of Safety to support the slope reinforcement design; with the conditions analyzed and documented for the proposed project:
 - h) HPTRM and Anchor Sample
 3. For pre-approval of alternative armoring solution manufacturers on this project, all products and documentation described above shall be submitted for review and approval no later than 10 days prior to the bid date.
 4. All product manufacturers seeking approval on this project must have local representation within the state in which the project is bidding. Manufacturers seeking approval must also have a manufacturer's representative present at the prebid meeting.

2.3 MATERIALS

- A. HPTRM:

1. Three-dimensional, lofty woven polypropylene RECP specially designed for erosion control applications on levees, steep slopes, and vegetated waterways.
2. Matrix composed of Trilobal monofilament yarns woven into uniform configuration of resilient pyramid-like projections that minimize watering requirements while enhancing vegetation establishment.
3. Must be a homogeneous matrix, and not comprised of layers, composites, or discontinuous materials, or otherwise loosely held together by stitched or glued netting.
4. The woven matrix of Trilobal yarns must be heat-set to improve interlock and minimize yarn displacement around anchors and pins, which also results in greater flexibility for improved conformance to uneven surfaces.
5. Material is to exhibit very high interlock and reinforcement capacity with both soil and root systems and demonstrate high tensile modulus.
6. The HPTRM should meet the following values:

Property	Test Method	Test Parameters	Units	Property Requirement
Thickness ¹	ASTM D-6525	Minimum	mm (in)	10.2 (0.40)
Light Penetration ¹ (% Passing)	ASTM D-6567	Maximum	percent	10
Tensile Strength ¹	ASTM D-6818	Minimum	kN/m (lb/ft)	58.4 x 43.8 (4,000 x 3,000)
Tensile Elongation ¹	ASTM D-6818	Maximum	percent	40 x 35
Resiliency ¹	ASTM D-6524	Minimum	percent	80
Flexibility ^{2,3}	ASTM D-6575	Maximum	mg-cm (in-lb)	615,000 (0.534)
UV Resistance ²	ASTM D-4355	Minimum	percent	90 at 3,000 hrs ⁴ 90 at 6,000 hrs

Note:

1. Minimum Average Roll Value (MARV).
 2. Typical Value.
 3. A smaller value for flexibility denotes a more flexible material.
 4. Third party / Independent Testing values must be provided showing UV resistance testing for two consecutive years including most recent year.
7. 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 m²) 4 ft² 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).
 - c) Functional Longevity: In addition to the UV resistance per ASTM D-4355 stated above, the HPTRM must have a documented installation showing a minimum retained tensile strength of 70% per ASTM D-6818 after a minimum of 10 years of exposure to a minimum solar radiation of 21.70 MJ/m²-day.
8. 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

2.4 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: 300 to 600 mm (12 to 24 inches); sufficient ground penetration to resist pullout.
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 at the center of the 0.3 m x 0.3 m (1 ft x 1ft) trench spaced 0.3 m (1 ft) apart. Locations of the pins along the vertical overlaps are spaced 0.3 m (1 ft) apart. HPTRM rolls wider than 3.2 m (10.5 ft) must not have a pin spacing greater than 0.45 m (1.5 ft) in any direction to minimize wrinkling of the material common to wide roll width geosynthetics and the loss of intimate contact beneath the HPTRM.
4. Heavier metal stakes may be required in rocky soils
5. Depending on soil pH and design life of the pin, galvanized or stainless steel pins may be required.

B. Engineered Earth Anchor:

1. Anchors with a minimum drive depth specified by the design engineer are used to provide for structural slope stability reinforcement as shown in the drawings.
2. The anchor 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 load bearing plate shall be of sufficient size to resist forces acted upon by the tensioned anchor.
4. Anchors shall meet the following requirements:

Component	Standard(s)	Material Composition	Physical Properties
Anchor Head	Zinc Alloy (ZA 2) ASTM B-240-10	5.0 in. x 1.62 in. x 1.23 in. (L x W x H)	Corrosion resistant pressure die cast zinc alloy.
Lower Termination	Aluminum ferrule MS51844	Length: 17.46mm (11/16") Wall Thickness: 9.53mm(3/8")	N/A
Cable Tendon	Zinc-Aluminum Coated Carbon Steel ASTM A-1023	4mm (5/32") diameter 1x19 strand Zinc-Aluminum Wire Tendon 6FT	Corrosion resistant zinc-aluminum coated cable.

Top Accessory Bearing Plate	Mild Steel Zinc Plated ASTM A366 Plastisol Coating	Diameter: 108mm (6.29in) Thickness: 3.25mm (0.125in)	Corrosion resistant zinc plated steel. Coated with Plastisol.
Top Termination	Zinc Alloy ZA 2 ASTM B-240-10	Diameter: 35mm (1.37x1.37in) Thickness: 2.5mm (0.1in)	Corrosion resistant pressure die cast zinc alloy. Utilizing a multiple point of contact ceramic roller & directional locking device.

5. Performance

Performance Property	Value
Anchor & Cable Assembly Ultimate Strength*	11.57 kN (2.6 Kips)
Anchor Weight	0.182 kg (0.401 lbs)
Anchor Head Bearing Area	3,871 mm ² (6.0 in ²)

* Anchor performance is a function of in situ soil strength and therefore the load range in this specification should be regarded as a guide only. Site specific soil conditions shall be evaluated by a licensed geotechnical engineer to determine the anchor type, depth, and pattern to resist slope instability. Pre-construction pull tests may be recommended.

3 EXECUTION

3.1 PREPARATION

- A. Grade and compact areas to be treated with a armoring solution (compacted as indicated or as directed by Engineer). 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.
- C. Prepare seedbed 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.
- D. Select and apply soil amendments, fertilizer, and seed (if applicable), (in an amount equivalent to 50% of the total mixture required to be installed on the soil surface) in accordance with Section [32 92 19 SEEDING AND SODDING] [____ - ____], to scarified surface prior to installation of armoring solution. Do not mulch areas where mat is to be placed.
- E. Keep areas moist as necessary to establish vegetation. When watering seeded areas, use fine spray to prevent erosion of seeds or soil. If as a result of rain, prepared seedbed becomes crusted or eroded, or if eroded places, ruts, or depressions exist for any reason, rework soil until smooth and reseed such areas.
- F. Excavate a Crest of Slope (COS) trench 300 mm (12 in.) wide by 300 mm (12 in.) deep, a minimum of 900 mm (3 ft.) over the crest of the slope. Excavate a Toe of Slope (TOS) trench 300 mm (12 in.) wide by 300 mm (12 in.) deep, a minimum of 900 mm (3 ft.) past the toe of the slope.

3.2 INSTALLATION

- A. Install HPTRM at elevation and alignment indicated.
- B. Beginning at downstream end of the slope, place initial end of first roll of HPTRM into the COS trench and secure with securing pins at 300 mm (12 in) intervals in between anchors at 1.2 m (4 ft.) intervals.
- C. Unroll the HPTRM down the slope and secure the HPTRM end in the TOS trench with securing pins at 300 mm (12 in) intervals in between anchors at 1.2 m (4 ft.) intervals.
- D. Position adjacent upstream rolls in same manner, overlapping preceding roll minimum 75 mm (3 in) until the armoring limits are completed securing the overlaps with securing pins at 300 mm (12 in) intervals in between anchors at intervals based on the stability requirements of the slope.
- E. Backfill and compact the trenches with specified soil or as directed by Engineer.
- F. Secure HPTRM to the slope with securing pins at a frequency of 2.5 pins per square meter (2 pins per square yard) and anchors at a frequency based on the stability requirements of the slope. Increased anchoring frequency may be required if site conditions are such that the Engineer determines it necessary.
- G. Alternate installation methods must be approved by Engineer prior to execution.
- H. Soil fill and sod/seed the armoring solution:
 - 1. The installed armoring solution shall be seeded (or re-seeded) and soil filled, OR 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. Do not place excessive soil above material.
 - 4. Broadcast additional seed or mulch (if applicable) above soil-filled mat and irrigate as necessary to establish/maintain vegetation

END OF SECTION