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 high performance turf reinforcement mats (HPTRMs) for erosion control and protection on stable soil slopes. 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 by The Construction Specifications Institute (CSI) including the use of section numbers and titles from the 2018 Edition of Master Format, 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 a High Performance Turf Reinforcement Mat (HPTRM) for erosion control and protection on stable soil slopes.

1.2 RELATED SECTIONS

Edit the following paragraphs to coordinate with other sections of the project's Technical Specifications and bid documents.

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 language 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 yard (or square meter - as indicated in contract documents)

The total square yards (square meter) for measurement shall be based on the area in which the HPTRM will be installed plus percentages to take into account seam overlapping, trenching, curves, waste, etc. The following may be used as guidance in determining the total square yards (square meters) for measurement.

Description	Measurement	Units
1. Installation Area	Shape of area to be installed (i.e. Length X Width)	Square Yard (Square Meter)
2. Overlaps, Trenching, Waste, etc.	10% of Installation Area	Square Yard (Square Meter)
3. Curves, radius (if applicable)	5% of Installation Area	Square Yard (Square Meter)
Total Area	**Installation Area + 10% + 5% (if applicable)**	Square Yard (Square Meter)

The total area for measurement shall include the following components:

1. High Performance Turf Reinforcement Mat (HPTRM), and
2. Securing Pins

B. Basis of Payment: By the square yard (or square meter - as indicated in contract documents) installed.

1.4 REFERENCES

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

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

1. D 4354 – Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing.

2. D 4355 – Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.

3. D 4439 - Standard Terminology for Geosynthetics.

4. D 4759 – Standard Practice for Determining the Specification Conformance of Geosynthetics.

5. D 4873 – Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.

6. D 6524 – Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats (TRMs).

7. D 6525 – Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products.

8. D 6567 – Standard Test Method for Measuring the Light Penetration of a Rolled Erosion Control Product (RECP).

9. D 6575 – Standard Test Method for Determining Stiffness of Geosynthetics Used as Turf Reinforcement Mats (TRMs).

10. D 6818 – Standard Test Method for Ultimate Tensile Properties of Rolled Erosion Control Products.

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

C. Greenhouse Gas (GHG) Protocol

D. International Standards Organization (ISO):

1. 9001:2015 – Quality Management System Certification.
2. 14001:2015 – Environmental Management System Certification
3. 14064-3:2006 – Environmental Management – Life Cycle Assessment
4. 17025:2005 – Laboratory Testing and Calibration

E. Publically Available Specification (PAS) 2050:2011 – Specification for the assessment of the life cycle greenhouse gas emissions

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 9001:2015 certification, and tested in accordance with GAI-LAP procedures.

B. *High Performance Turf Reinforcement Mat (HPTRM):* A long-term, non-degradable RECP composed of ultraviolet (UV) stabilized, non-degradable, synthetic fibers, nettings and/or filaments processed into three-dimensional reinforcement matrices designed for immediate and permanent protection for erosion control applications where design flows exert velocities and shear stresses that exceed the limits of mature natural vegetation. The HPTRM MARV tensile strength per ASTM D-6818 is 3000 lbs/ft in the weakest principle direction.

C. *Manufacturer:* Entity that produces synthetic HPTRM products 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 HPTRM 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 HPTRM 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. *Rolled Erosion Control Product (RECP):* A temporary degradable or long-term non-degradable material manufactured or fabricated into rolls designed to protect the soil surface, reduce soil erosion and if needed assist in the growth, establishment and protection of vegetation.

G. *Securing Pin:* A device designed to secure the HPTRM in place during installation, or until the establishment of vegetation occurs.

H. *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.

I. *Typical Roll Value:* Property value calculated from average or mean obtained from test data.

J. *Vendor:* An entity that provides high performance turf reinforcement mat product(s) to a customer, on behalf of an independent manufacturer. A vendor does not manufacture the actual engineered earth armoring solution 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. Qualifications:

The following documentation shall be submitted to the engineer of record and/or project owner for review and approval prior to installation.

a) A Certificate of Compliance (COC) 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. The COC shall state that the furnished HPTRM meets the requirements of the specification and shall be attested to by a person having legal authority to bind the Manufacturer.

b) The Manufacturer's Manufacturing Quality Control (MQC) Program to assure compliance with the requirements of the specification.

c) A project list demonstrating a documented history of HPTRM installations totaling more than 2,000,000 square yards, with over 500,000 square yards having been installed in the marketplace for more than five (5) years. Past project documentation submitted for evaluation shall include project name, date of installation, and size of the project.

d) A certification demonstrating that the HPTRM is manufactured in a facility that has been ISO 14001 certified for measuring environmental impact and continuously looking for ways to improve it for a minimum of ten (10) years.

e) A certification demonstrating that the HPTRM is manufactured in a facility that has been ISO 9001:2015 certified and tested in a laboratory that has been both GAI-LAP and ISO 17025:2005 certified.

f) Third party / Independent Testing values demonstrating UV resistance testing for two consecutive years including most recent year. Testing and reporting of the results shall follow ASTM D-4355, showing the percent tensile strength retained in both machine and cross-machine direction.

g) Documentation of functional longevity for the HPTRM demonstrating the material's durability in the field. The documentation shall demonstrate a minimum retained tensile strength of 70% per ASTM D-6818 after a minimum of ten (10) years of exposure in an area having a minimum solar radiation of 21.70 MJ/m^2-day. The documentation shall include photos and date of the initial installation and field sampling, and the test results of the field sampling.

h) A certification demonstrating that the HPTRM has been evaluated and certified by an independent third party to have a maximum cradle-to-grave carbon footprint of 2.7 kg CO2e/m2 when tested per GHG Protocol, ISO 14064-3:2006, and PAS 2050:2011.

i) Documentation of full scale flume testing demonstrating the required performance when subjected to at least 0.5 hrs of continuous flow for the unvegetated HPTRM, partially vegetated HPTRM, and fully vegetated HPTRM.

j) Documentation demonstrating that in a vegetated state, the HPTRM can perform 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).

1.7 DELIVERY, STORAGE, AND HANDLING

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

B. Product labels shall clearly depict 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 RECP from damage due to shipment, water, sunlight, and contaminants. Individual roll wrapping will be not be required for HPTRMs exceeding the UV Resistance requirements per ASTM D-4355 in Section 2.2.A.6. The protective wrapping shall be maintained during periods of shipment and storage.

E. 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 UV radiation, precipitation, chemicals that are strong acids or strong bases, flames, sparks, temperatures in excess of 160 degrees F (71 degrees C) and any other environmental condition that might damage the HPTRM.

1.8 QUALITY ASSURANCE SAMPLING, TESTING, AND ACCEPTANCE

A. 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 shall be waived for ISO 9001:2015 Certified Manufacturing Facilities. Documentation of ISO 9001:2015 Certification shall be provided per the requirements of Section 1.6.A.

2 PRODUCTS

2.1 MANUFACTURERS

A. All components of the High Performance Turf Reinforcement Mat solution shall be furnished by a single manufacturer as a complete system.

B. Approved High Performance Turf Reinforcement Mat Manufacturers:

1. Propex Operating Company, LLC
   4019 Industry Drive
   Chattanooga, TN 37416
   (800) 621-1273

C. Approved High Performance Turf Reinforcement Mat:

1. PYRAMAT 75 High Performance Turf Reinforcement Mat (HPTRM)

D. Alternative HPTRM Manufacturers:

1. Alternate manufacturers seeking pre-approval shall be submitted to the engineer of record and/or owner a minimum of ten (10) work days prior to the bid date and must meet the requirements outlined within this document.

2. Alternate manufacturers meeting the material specifications within Section 2 seeking pre-approval shall submit the following for evaluation.

   a) Documentation demonstrating a history of installations designed for non-structural slope protection and/or erosion control meeting the requirements of Section 1.6.A.1.c.

   b) Documentation demonstrating local representation within the state in which the project is being constructed.

   c) Documentation demonstrating the alternative engineering design for slope protection and/or erosion control considered the soil properties, erosion potential, hydrology, hydraulics, and vegetation requirements. The following shall be submitted:

      1) Overall alternative HPTRM design methodology

      2) Input parameters

      3) Calculations / Model output

      4) Factor of Safety to support the erosion control design; with the conditions analyzed and documented for the proposed project

      5) Alternative HPTRM product sample including all components.

3. Alternate manufacturers seeking pre-approval shall have a manufacturer's representative present at the pre-bid meeting.

4. Alternate manufacturers that do not provide documentation meeting or exceeding the requirements of Section 1.6.A will not be approved.

2.2 MATERIALS

A. HPTRM:

1. A three-dimensional, high tensile strength, long term non-degradable lofty woven polypropylene RECP specially designed for erosion control applications that exhibits very high interlock and reinforcement capacity with both soil and vegetative root systems.

2. A homogeneous woven matrix composed of Trilobal monofilament yarns heat-set and woven into uniform configuration of resilient pyramid-like projections to improve interlock and minimize yarn displacement around pins, which also results in greater flexibility for improved conformance to uneven surfaces.

3. A material not comprised of layers, composites, or discontinuous materials, or otherwise loosely held together by stitched or glued netting.

4. Material Properties:

Property	Test Method	Test Parameters	Units	Property Requirement
Thickness [1]	ASTM D-6525	Minimum	in (mm)	0.40 (10.2)
Light Penetration [1] (% Passing)	ASTM D-6567	Maximum	percent	10
Tensile Strength [1]	ASTM D-6818	Minimum	lb/ft (kN/m)	4,000 x 3,000 (58.4 x 43.8)
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	in-lb (mg-cm)	0.534 (615,000)
UV Resistance [2]	ASTM D-4355	Minimum	percent	90 at 3,000 hrs [4] 90 at 6,000 hrs
Carbon Footprint [2]	ISO 14064-3 GHG Protocol PAS 2050:2011	Maximum	Kg CO2e	2.7 per 1 m^2

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.

5. Hydraulic Performance Properties:

a) Flume Testing: The HPTRM must meet the following at a minimum when subjected to at least 0.5 hrs of continuous flow producing the following conditions.

1) Unvegetated HPTRM
Permissible velocity: 9 ft/sec (2.7 m/sec)
Permissible shear stress: 2.8 psf (130 Pa)

2) Partially Vegetated HPTRM
Permissible velocity: 15 ft/sec (4.6 m/sec)
Permissible shear stress: 8 psf (383 Pa)

3) Fully Vegetated HPTRM
Permissible velocity: 25 ft/sec (7.6 m/sec)
Permissible shear stress: 16 psf (766 Pa)

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

1) Each type of HPTRM product shall be subject to a single wave overtopping simulation down the flume on one set of trays (linear and angled sections) at 4.0 cfs/ft for the duration equivalent to 3 test hours (~6 elapsed hours).

2) Passing this wave overtopping test is defined as surviving the three (3) equivalent test hours without visible damage.

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

6. Functional Longevity: The HPTRM shall have a documented installation history demonstrating a minimum retained tensile strength of 70% per ASTM D-6818 after a minimum of ten (10) years of exposure to a minimum solar radiation of 21.70 MJ/m2-day.

7. Environmental Impact: The HPTRM shall be evaluated and certified by an independent third party to have a maximum cradle-to-grave carbon footprint of 2.7 kg CO2e/m^2 when tested per GHG Protocol, ISO 14064-3:2006, and PAS 2050:2011.

8. Manufacturing Impact: The HPTRM shall be manufactured in a facility that is ISO 14001 certified for measuring environmental impact and continuously looking for ways to improve it for a minimum of ten (10) years.

9. 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 yd^2 (m^2)**
Thickness	1/14,700 (1/12,291)
Light Penetration (% Passing)	1/14,700 (1/12,291)
Tensile Strength	1/14,700 (1/12,291)
Tensile Elongation	1/14,700 (1/12,291)
Resiliency	1/14,700 (1/12,291)
Flexibility	1/14,700 (1/12,291)
UV Resistance	Annually

2.3 SECURING DEVICES

A. Securing Pins:

1. Securing pins should be a minimum of 0.20 in. (5 mm) diameter steel with a 1.5 in. (38 mm) steel washer at the head of the pin.

2. Length: 12 to 24 inches (300 to 600 mm) as depicted on the drawings to provide sufficient ground penetration for pullout resistance.

3. Heavier metal securing pins and/or stakes may be required in rocky soils

4. Depending on soil pH and design life of the securing pin, galvanized or stainless steel securing pins may be required.

3 EXECUTION

3.1 PREPARATION

A. The area(s) to be treated with the HPTRM shall be cleared, grubbed, graded and compacted as indicated on the construction plans and technical specifications or as directed by the Engineer of Record.

B. The placement of new fill may require soil placed to be keyed into the existing slope and compacted in horizontal lifts per the Engineer of Record. To ensure compaction at the face of the slope, the slope face may be over-built, compacted in lifts, and then regraded or trimmed to the final grade. All fill shall be placed and compacted per the project's earthwork technical specifications.

C. The subgrade shall be uniform and smooth. Large rocks, soil clods, vegetation, and other sharp objects shall be removed prior to installation of the HPTRM. This will assist in the HPTRM maintaining direct contact with the soil surface.

D. Construct a perimeter trench around the area(s) limits to be treated with the HPTRM as follows:

1. Excavate a Crest of Slope (COS) trench a minimum of 3 ft. (900 mm) horizontal over the crest of the slope when possible. Trench dimensions shall be 12 in. (300 mm) wide by 12 in. (300 mm) deep.
2. Excavate a Toe of Slope (TOS) trench a minimum of 3 ft. (900 mm) horizontal over the crest of the slope when possible. Trench dimensions shall be 12 in. (300 mm) wide by 12 in. (300 mm) deep.
3. Excavate a side trench perpendicular to the contours at each end of the area to be treated (longitudinal limits). Trench dimensions shall be 6 in. (150 mm) minimum wide by 6 in. (150 mm) minimum deep.

E. Refer to Section 3.2 for the appropriate vegetation establishment method.

3.2 VEGETATION ESTABLISHMENT

A. Establish permanent vegetation, where feasible, to assist in the long-term performance of the HPTRM and the control of erosion.

B. A site specific soil test shall be conducted to determine the recommended soil amendments required to establish permanent vegetation.

C. The type and method of vegetation establishment should be unique to the projects geometry, location, climate, season, topography, soils, seed type, etc. and shall be as directed per one of the following:

1. Construction plans
2. Technical Specifications
3. Manufacturer's HPTRM submittal
4. As directed by the Engineer of Record
5. As directed by the project owner.

D. Water and/or irrigate seeded/sodded areas as needed to establish and maintain permanent vegetation until the desired vegetative density has been achieved.

E. Rubber-tired or rubber-tracked vehicles shall be used, and sharp turns avoided. No heavy and/or metal-tracked equipment or sharp turns shall be permitted on the installed HPTRM. Foot traffic and construction equipment shall be avoided over the HPTRM if loose or wet soil conditions exist.

3.3 INSTALLATION

A. Install HPTRM at elevations and alignments indicated.

B. Beginning at the lower elevation end (down gradient) area, place initial end of first roll of HPTRM into the COS trench and secure with securing pins. The securing pins shall be placed at 12 in. (300 mm) intervals.

C. Unroll the HPTRM down the slope.

D. Secure the HPTRM to the slope face with the securing pins driven flush with the HPTRM at the designated frequency based on the slope protection and/or erosion control requirements.

E. Position adjacent up gradient rolls in same manner, overlapping down gradient rolls a minimum of 3 in. (75 mm) until the armoring limits are completed.

F. Secure the overlaps with securing pins placed at 12 in. (300 mm) intervals.

G. Secure the HPTRM end in the TOS and side (longitudinal limits) trenches with securing placed at 12 in. (300 mm) intervals.

H. Backfill and compact the trenches with specified soil or as directed by the earthwork technical specifications or as directed by the Engineer of Record.

I. Alternate installation methods must be approved by the Engineer of Record and manufacturer prior to execution.

J. Refer to Section 3.2 for the appropriate vegetation establishment method.

END OF SECTION