

Section 31 25 13 ENGINEERED MATTRESS SYSTEM

This guide specification has been prepared by Solmax to assist design professionals in the preparation of a specification section covering the use of an Engineered Mattress System for erosion control and protection of channels, slopes, and spillways. It may be used as the basis for developing a project or 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 Master Format, this guide specification may be used in conjunction with most commercially available master specifications sections with minor editing.

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- *Optional text requiring a selection by the user is enclosed within brackets, e.g.: “Section [01 33 00] [____].”*
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****** OR ******

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1 GENERAL

1.1 SUMMARY

- A. This section's work shall consist of furnishing all materials, equipment, and labor necessary for installing an Engineered Mattress System for erosion control and protection of channels, slopes, and spillways.

1.2 RELATED SECTIONS

- 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

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

1.4 REFERENCES

- A. American Society for Testing and Materials (ASTM):
 - 1. D 1557 - Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort
 - 2. D 4354 - Standard Practice for Sampling of Geosynthetics and Rolled Erosion Control Products (RECPs) for Testing.

3. D 4355 - Standard Test Method for Deterioration of Geotextiles by Exposure to Light, Moisture and Heat in a Xenon Arc Type Apparatus.
4. D 4439 - Standard Terminology for Geosynthetics.
5. D 4491 - Test Method for Water Permeability of Geotextiles by Permittivity.
6. D 4533 - Test Method for Index Trapezoid Tearing Strength of Geotextiles.
7. D 4632 - Test Method for Grab Breaking Load and Elongation of Geotextiles.
8. D 4751 - Test Method for Determining Apparent Opening Size of a Geotextile.
9. D 4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
10. D 4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
11. D 6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe.
12. D 6818 - Standard Test Method for Ultimate Tensile Properties of Rolled Erosion Control Products.
13. D 6524 - Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats (TRMs).
14. D 6525 - Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products.
15. D 6567 - Standard Test Method for Measuring the Light Penetration of a Rolled Erosion Control Product (RECP).

- 16. D 6575 – Standard Test Method for Determining Stiffness of Geosynthetics Used as Turf Reinforcement Mats (TRMs).
- B. Geosynthetic Accreditation Institute - Laboratory Accreditation Program (GAI-LAP).
- C. Greenhouse Gas (GHG) Protocol
- D. International Standards Organization (ISO):
 - 1. 9001:2015 - Quality 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. Publicly 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. *Internal Bracing*: Bracing members designed to interlace through the HPTRM and provide internal support during construction and through the project design life.
- 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 principal direction.
- D. *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.

- E. *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.
- F. *Maximum Average Roll Value (MaxARV)*: Property value calculated as typical plus two standard deviations. Statistically, it yields a 97.7 percent degree of confidence that any sample taken during quality assurance testing will be below the value reported.
- G. *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.
- H. *Engineered Mattress System*: An environmentally friendly and corrosion resistant mattress system that provides permanent erosion protection and is comprised of an HPTRM, fiber-composite bracing, synthetic stakes, nonwoven geotextiles, and rock or earth fill.
- I. *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.
- J. *Synthetic Stake*: A device designed to secure the HPTRM in place while either vegetation establishes, or the installation of the Engineered Mattress System occurs.
- K. *Trilobal Monofilament Yarn*: A multi-dimensional polymer fiber with at least three points, providing increased surface area and grooves/channels along the fiber to capture additional moisture and sediment to enhance vegetative growth.
- L. *Typical Roll Value*: Property value calculated from average or mean obtained from test data.
- M. *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 synthetic turf reinforcement mat product(s) and is not subject to a certified MQC Program.

1.6 SUBMITTALS

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 before installation.

- a) A Certificate of Compliance (COC) stating the name of the manufacturer, product name, style, chemical compositions of filaments or yarns and other pertinent information to fully describe the Engineered Mattress System. The COC shall state that the furnished material 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 assures compliance with the specification's requirements.
- c) A project list shows a documented history of installations of the HPTRM component totaling over 2,000,000 square yards, with over 500,000 square yards installed in the marketplace for over five (5) years. Past project documentation submitted for evaluation shall include the project name, date of installation, and size of the project.
- d) A certification showing that the HPTRM component is manufactured in an ISO 14001 certified facility for measuring environmental impact and continuously looking for ways to improve it for at least ten (10) years.
- e) A certification demonstrating that the HPTRM component 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 on the HPTRM component 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 component 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/m²-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 component 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 Engineered Mattress System.

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

1.8 QUALITY ASSURANCE SAMPLING, TESTING, AND ACCEPTANCE

- A. HPTRM component 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 9001:2015 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 Engineered Mattress System shall be furnished by a single manufacturer as a complete system.
- B. Approved Engineered Mattress System Manufacturers:
 - Propex Operating Company, A Solmax Company
 - 4019 Industry Drive
 - Chattanooga, TN 37416
 - (800) 621-1273
- C. Approved Engineered Mattress System:
 - 1. PROPEX Pyramattress Engineered Mattress System
- D. Alternate Engineered Mattress System Manufacturers:
 - 1. Alternate manufacturers seeking pre-approval shall be submitted to the engineer of record and/or owner at least ten workdays before the bid date and must meet the requirements outlined in this document.
 - 2. For consideration, alternate systems meeting the material specification within Section 2 seeking pre-approval shall submit the following for evaluation.
 - a) Documentation demonstrating a history of installations designed for 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 Engineered Mattress System. The following shall be submitted:
 - 1) Overall alternative Engineered Mattress System 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 Engineered Mattress System product sample including all components.
- 3. Manufacturers seeking pre-approval must also 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. Engineered Mattress System: A flexible armoring system composed of a HPTRM, fiber-composite internal bracing, synthetic stakes, and other geosynthetics. The system is constructed in the field, creating internal cells that can be filled with earth, sand, gravel, crushed rock, and other material to provide permanent erosion protection from initial construction. The system can be used on channel bottoms, slopes, and as pipe outlet protection in either a vegetated or unvegetated state. The expected design life of the Engineered Mattress System is up to 75 years because it does not corrode, and it has superior UV resistance, strength, and durability for the most demanding environments.
- B. **HPTRM:**
 - 1. Three-dimensional, high tensile strength, long-term non-degradable lofty woven polypropylene HPTRM specially designed for erosion control applications that exhibit extremely high interlock and reinforcement capacity with both soil and vegetative root systems.
 - 2. A homogeneous woven matrix composed of Trilobal monofilament yarns woven into uniform configuration of resilient pyramid-like projections to

improve interlock and minimize yarn displacement around internal bracing and 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. The HPTRM component 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
Carbon Footprint ²	ISO 14064-3 GHG Protocol PAS 2050:2011	Maximum	Kg CO2e	2.7 per 1 m ²

Note:

5. Minimum Average Roll Value (MARV).
6. Typical Value.
7. A smaller value for flexibility denotes a more flexible material.
8. Third party / Independent Testing values must be provided showing UV resistance testing for two consecutive years including most recent year.
9. Hydraulic Performance Properties:

- a) Flume Testing: The Engineered Mattress System must meet the following at a minimum when subjected to at least 0.5 hrs of continuous flow producing the following conditions.
- 1) Unvegetated Engineered Mattress System
 - Permissible velocity: 10 ft/sec (3.1 m/sec)
 - Permissible shear stress: 4 psf (192 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)
10. Functional Longevity: In addition to the UV resistance per ASTM D-4355 stated above, the HPTRM component 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.
11. Environmental Impact: The HPTRM component shall be 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.
12. Manufacturing Impact: The HPTRM component shall be manufactured in an ISO 14001 facility certified for measuring environmental impact and continuously looking for ways to improve it for at least ten (10) years.
13. 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	1/12,291 (1/14,700)
Light Penetration (% Passing)	1/12,291 (1/14,700)
Tensile Strength	1/12,291 (1/14,700)

Tensile Elongation	1/12,291 (1/14,700)
Resiliency	1/12,291 (1/14,700)
Flexibility	1/12,291 (1/14,700)
UV Resistance	Annually

C. Geotextile Lining

1. The geotextile construction shall be a nonwoven, staple fiber, needle punched, polypropylene geotextile; the fibers are needled together to form a stable network that retains dimensional stability relative to each other.
2. The geotextile should be resistant to UV degradation and biological and chemical environments normally encountered in soils.
3. The geotextile lining should meet the following values:

Property	Test Method	Units	Property Requirement
Grab Tensile Strength	ASTM D 4632	N (lbs)	712 (160)
Elongation	ASTM D 4632	percent	50
CBR Puncture	ASTM D 6241	N (lbs)	1824 (410)
Trapezoidal Tear	ASTM D 4533	N (lbs)	267 (60)
Apparent Opening Size (Maximum Avg. Roll)	ASTM D 4751	mm (US Std)	0.212 (70)
Permittivity	ASTM D 4491	sec ⁻¹	1.5
Water Flow Rate	ASTM D 4491	l/min/m ² (gpm/ft ²)	4482 (110)
UV Resistance (percent retained at 500	ASTM D 4355	percent	70

D. Internal Bracing and Securing:

1. The internal brace assembly comprises 3 nonmetallic polymer bars specially designed, whereby 2 of the bars are threaded through the pyramidal projections of the HPTRM to form a semi-rigid base and upright member, which both are then connected using the third bar as a transverse member. These braces shall be installed within each internal baffle not to exceed 61 mm (24 inches).

2. Synthetic stakes are used to secure the various connections between the HPTRM panels. The synthetic stakes are to be composed of a UV stabilized, nonmetallic polymer and designed to provide a positive connection between the different layers of HPTRM.

3 EXECUTION

3.1 SUBGRADE PREPARATION

- A. Excavate the area to be protected to 30 cm (12 in) deep below finished grade as needed using an excavator with smooth bucket to reduce disturbance at the defined subgrade elevation.
- B. Deleterious material (overly wet soil, uncontrolled loose fill, construction debris, organics, etc.) encountered during this excavation shall be over-excavated, removed, and replaced with compacted granular fill or approved backfill soil. Compact the subgrade as specified by the Engineer.

3.2 INSTALLATION

- A. Install the Engineered Mattress System at elevation and alignment indicated.
- B. Prior to placement of the HPTRM component, install the geotextile liner across the bottom and up the sides of the excavated area.
- C. Beginning at the downstream end of the protected area, begin placement of HPTRM, ensuring enough extra material along edges of installation to cover the side of the excavated area and the top overlap. This amount may vary by project but would be around 450 mm (18 in) for a 300 mm (12 in) deep excavation.
- D. Continue with the placement of additional HPTRM as needed to cover the excavated area, overlapping proceeding layers a minimum of 0.6 m (2 ft) and allowing for enough extra material along the overlap to construct the transition baffle. This amount may vary by project but would be around 450 mm (18 in) for a 300 mm (12 in) deep excavation.
- E. Secure HPTRM overlaps along the bottom layer with synthetic stakes on 0.6 m (2 ft) spacing.
- F. Once the bottom layer of HPTRM is placed, internal baffles are constructed with the HPTRM material facing downstream along each overlap. Additional HPTRM baffles are to be constructed and placed facing downstream to maintain a maximum baffle spacing of 2.4 m (8 ft).
- G. To construct an internal baffle, weave the bottom and upright internal bracing components (bars) through the interior pyramidal projections of the HPTRM

- along the overlap toward the 0.6 m (2 ft) overlap line, being sure to catch 4-8 yarns with the bracing bar at each pyramid. Fold the fabric and stand-up the face, then connect the bars using a bar slot at the overlap line. While holding the face near vertical, connect those two bars with the third bar, aligned transverse to the other two using the bar slots. Install these braces at a maximum uniform spacing of 0.6 m (2 ft) along the baffle.
- H. To construct additional internal baffles, cut a 1.1 m (3.5 ft) wide strip of HPTRM and follow the process shown in Step G. Once constructed and placed, all additional baffles should be secured to the lower HPTRM layer with synthetic stakes on 0.6 m (2 ft) spacing.
 - I. Once the bottom layer of HPTRM and internal baffles are placed, begin infilling the Engineered Mattress System with approved material. Care should be taken when placing fill around the braces and on each side of the internal baffles, to fill on both sides concurrently and avoid damaging the internal baffles.
 - J. A fill should be placed to bring the total infill height up to 30 cm (12 in). If needed, the upper 50-75 mm (2-3 in) of the Engineered Mattress System can be separated with the geotextile liner and filled with topsoil to aid in vegetation establishment.
 - K. Fold the remaining 150 mm (6 in) portion of the HPTRM at each internal baffle over the backfill zone in the upstream direction.
 - L. With the bottom layer of HPTRM and internal baffles installed, and the infill placed, align the upper HPTRM layer and secure with synthetic stakes on each overlap and internal baffle connection on 0.3 m (1 ft) spacing and across the body of the installation on 0.6 m (2 ft) spacing.
 - M. Exercise extreme caution when driving or operating equipment across the HPTRM, as sudden turns or braking may deform or damage the HPTRM or pull the internal baffles out of proper alignment.
 - N. 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.
 - O. Establish permanent vegetation, where feasible, to assist in the long-term performance of the Engineered Mattress System and the control of erosion.

END OF SECTION