

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 Engineered Wrap-Face Vegetated Solutions for constructing reinforced-soil walls and steepened 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 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 Engineered Wrap-Face Vegetated Solution for constructing reinforced-earth walls and steepened slopes.

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 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

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. 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 4759 - Standard Practice for Determining the Specification Conformance of Geosynthetics.
 6. D 4873 - Standard Guide for Identification, Storage, and Handling of Geosynthetic Rolls and Samples.
 7. D 6818 - Standard Test Method for Ultimate Tensile Properties of Rolled Erosion Control Products.
 8. D 6524 - Standard Test Method for Measuring the Resiliency of Turf Reinforcement Mats (TRMs).
 9. D 6525 - Standard Test Method for Measuring Nominal Thickness of Rolled Erosion Control Products.
 10. D 6567 - Standard Test Method for Measuring the Light Penetration of a Rolled Erosion Control Product (RECP).
 11. 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. 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. *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 principle 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. *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.
- G. *Engineered Wrap-Face Vegetated Solution*: A reinforced-earth wall and/or steepened slope system that provides permanent erosion protection and is comprised of consecutive layers of soil-filled wraps using an HPTRM and fiber-composite internal bracing.
- H. *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.
- I. *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.
- J. *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.
- K. *Typical Roll Value*: Property value calculated from average or mean obtained from test data.
- L. *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. 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 manufacturer, product name, style, chemical compositions of filaments or yarns and other pertinent information to fully describe the Engineered Wrap-Face Vegetated Solution. 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 to assure compliance with the requirements of the specification.
- c) A project list demonstrating a documented history of installations of the HPTRM component 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 component 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 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.

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)m 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 armoring solution shall be furnished by a single manufacturer as a complete system.
- B. Approved Engineered Wrap-Face Vegetated Solution Manufacturers:
 - 1. Propex Operating Company, LLC
4019 Industry Drive
Chattanooga, TN 37416
(800) 621-1273
- C. Approved Engineered Wrap-Face Vegetation Solution:
 - 1. PYRAWALL Engineered Vegetated Wall System
- D. Alternate Engineered Wrap-Face Vegetation Solution 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. 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 wrap-face vegetated solution. The following shall be submitted:
 - 1) Overall alternative engineered wrap-face vegetated solution design methodology
 - 2) Input parameters
 - 3) Calculations / Model output
 - 4) Factor of Safety for Sliding, Overturning, and Bearing Capacity to support the wrap-face vegetated solution design; with the conditions analyzed and documented for the proposed project
 - 5) Alternative engineered wrap-face vegetated solution 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. HPTRM:

1. Three-dimensional, high tensile strength, long term non-degradable lofty woven polypropylene HPTRM 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 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:

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 component 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)
6. 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.
7. 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.

8. Manufacturing Impact: The HPTRM component 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 m² (yd²)
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

B. 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 for each lift at a horizontal spacing along the wall not to exceed 68 mm (27 inches). For curved wall applications, this spacing typically ranges from 53 to 61 mm (21 to 24 in).
2. Wood or plastic stakes, or steel pins are used to pin-down the geotextile near the back of the reinforcement zone to hold the geotextile taut while aligning the wall face and placing soil backfill. These are installed as needed along the HPTRM, but at a frequency no less than 1 per 2-3 lineal meters (6.5-10 lineal feet). The stakes or pins shall be 225 to 305 mm long (9 to 12 in) and shall be approved by the Engineer before installation.

3 EXECUTION

3.1 SUBGRADE PREPARATION

- A. Excavate a shallow, level trench at least 1.3 m (4.3 ft.) wide and 15 to 23 cm (6 to 9 in) deep below finished grade using an excavator with smooth bucket to reduce disturbance at the defined subgrade elevation.

- B. The cut-slope excavation width shall not exceed the lines and grades shown on the Plans, and care shall be taken to avoid encroachment near bordering properties. As necessary, to account for grade variations along the wall base line, the trench shall have level sections separated by 30 cm (12 in) steps to allow for grade alignment with the 30 cm (12 in) wrapped lifts.
- C. 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.
- D. If specified by the engineer, a perforated drainage pipe shall be installed at the back of the trench and connected to a prescribed outlet for draining groundwater.
- E. Granular soil is defined as:
 - 1. Classified as GM, GW, SM, SW, GW-GM, SW-SM referencing the USCS (Unified Soil Classification System).
 - 2. Contains maximum particle size of 3.8 cm (1-1/2 in) and less than 12 percent fines passing 0.074 mm (No. 200 sieve).
 - 3. Inert earth material with less than 3 percent organics or other deleterious substances (wood, metal, plastic, waste, etc).

OR

- 4. Meets the untreated base grading requirements for 3.8 cm (1-1/2 in) maximum nominal size crushed aggregate per typical state construction standards.
- A. For clay subgrade soils, line the trench with GEOTEX[®] 801 nonwoven geotextile. Place a 10 cm (4 in) thick loose lift of granular soil on top of the filter fabric and compact it to at least 90 percent of the specified modified Procter dry density per ASTM D 1557. Smooth the surface of the compacted soil to provide a level pad needed for the first layer of HPTRM.

3.2 INSTALLATION

- A. Install the armoring solution at elevation and alignment indicated.
- B. Starting with the lowest portion of the wall alignment, roll out the first layer of the HPTRM along the trench line, with the inboard 1.2 m (4 ft.) of the 2.6 m (8.5 ft.) wide roll laid along the trench footprint. At each terminus of this lowest section of the wall alignment, curve the wall face slightly into the slope so the ends of this run can be buried, leaving no HPTRM edges exposed at the ground surface. Concave curves in the wall are formed by cutting and overlapping the fabric in the 1.2 m (4 ft.) backfill zone; convex curves are formed by spreading the fabric.
- C. Weave the bottom and upright internal bracing components (bars) through the interior pyramidal projections of the HPTRM toward the 1.2 m (4 ft.) fold 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 T-slot at the 4-ft fold line. While holding the face near vertical, connect those 2 bars with the third bar, aligned transverse to the other two using 2 T-slots. Do not allow the vertical face segment to lay down prior to installing this transverse bar, because the vertical bar likely will be damaged and require replacement. Install these braces at a maximum uniform spacing of 68 mm (27 inches) along the wall face; a lesser spacing of 60 mm (24 inches) may be desirable for tighter face liners. Loose fabric at the outboard side is laid out away from the backfill area.

- D. Pull the fabric fairly taut in both directions, then drive stakes or pins 225 to 305 mm long (9 to 12 in) through the HPTRM near the front and rear of the 1.2 m (4 ft.) backfill zone to hold the fabric in place for subsequent soil backfilling at a frequency no less than 1 per 2-3 lineal meters (6.5-10 lineal feet). Exercise extreme caution when driving or operating equipment across this HPTRM, as sudden turns or braking may deform or damage the HPTRM, or pull the wall face out of proper alignment.
- E. Place a 17 to 20 cm (7 to 8 in) thick loose lift of backfill soil approved by the Engineer along the 1.2 m (4 ft.) backfill zone using hand shovels to place soil around the braces first, and then filling the space in-between braces along the face. Compact the soil lift to the specified modified Proctor dry density per the Engineer's recommendation, but never less than 85% of the maximum dry density per ASTM 1557.
 - 1. The internal-braced design of the geosynthetic wrap allows mechanical compaction of the backfill zone immediately adjacent to the face without the use of temporary bracing and without the use of external support at the wall face.
 - 2. Vibratory plate compactors should not be used within 7 cm (3 in) of the face; ramming compactors ("jumping jack" style) should not be used within 30 cm (12 in) of the face.
- F. Place a second lift of backfill soil along the backfill zone and compact it to bring the total height up to 30 cm (12 in) at the face. Cohesive soils may tend to deform laterally more than granular soils and may require additional loose-lift height to achieve the final compacted height. The compacted lift thickness away from the face should be approximately 28 cm (11 in) to allow for a thin soil layer to be placed between the consecutive HPTRM wraps.
- G. Fold the 1.1 m (3.5 ft.) outboard portion of the HPTRM wrap layer back over the backfill zone, stretch it taut to remove wrinkles, and pin it down. Spread approximately 2 cm (1 in) of fine backfill soil with no coarse gravel or larger particles evenly across the fabric in preparation for the next wrapped lift.
- H. To splice onto the end of a HPTRM roll (previous roll), install a brace at 0.45 m (1.5 ft) from the end of the roll. For the new roll to be added, insert a brace close to the roll end, then slide the new roll end into the previous roll end until the new roll end abuts against the final brace of the previous roll. After placing and compacting backfill, fold the top wrap back over the fill and stretch taut to provide an end-to-end overlap of 0.45 m (1.5 ft).
- I. Repeat Steps A. through H. for each subsequent backfill lift. Incorporate a setback with each lift to provide the desired overall slope angle.
- J. To form a curve in the wall alignment, cut the fabric laydown flaps perpendicular to the wall face. Cuts should extend from the back of the flap to not closer than 10 cm (4 in) from the wall face. Spread the fabric at the cuts to form a concave face curve or overlap the fabric at the cuts to form a convex face curve. Add an additional braces within the curve if needed.
- K. For taller walls, the geosynthetic-reinforced zone behind the wrap-face will need to be widened by using supplemental geosynthetic layers sandwiched in-between the upper fabric layer of a given lift and the lower fabric layer of the subsequent lift. Apply a thin layer of soil at fabric interfaces to eliminate complete fabric-to-fabric contact. Alternatively, the supplemental geosynthetic layers can be placed at mid-lift height after the first 15 cm (6 in) lift is compacted.
- L. Where each wrap-face lift ends at the lateral project limits, the wall face should be curved slightly into the slope and buried, leaving no HPTRM loose ends exposed at the ground surface. Overall wall layout and foundation steps are specified in the Construction Plans, but foundation grade elevations may need to be modified to match actual field conditions during construction. Damage to the Engineered Wrap-Face Vegetated Solution resulting from Contractor vehicles, equipment, or operations shall be repaired.

END OF SECTION