SECTION 31 35 19.16
ENGINEERED BANK STABILIZATION

*This guide specification has been prepared by Solmax to assist design professionals in the preparation of a specification section covering the use of Engineered Bank Stabilization for constructing stream and pond banks. 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 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 an Engineered Bank Stabilization for constructing stream and pond banks.

## 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 linear meter (or linear foot - as indicated in contract documents) of stream or pond bank including seams, overlaps, and wastage.

B. Basis of Payment: By the linear meter (or linear foot - as indicated in contract documents) of stream or pond bank 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 366 – Standard Specification for Commercial Steel (CS) Sheet, Carbon (0.15 Maximum Percent) Cold-Rolled.

2. A 1023 – Standard Specification for Stranded Carbon Steel Wire Ropes for General Purposes.

3. B 85 – Standard Specification for Aluminum-Alloy Die Castings.

4. B 240-10 – Standard Specification for Zinc and Zinc-Aluminum (ZA) Alloys in Ingot Form for Foundry and Die Castings.

5. D 1557 – Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Modified Effort

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

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

8. D 4439 – Standard Terminology for Geosynthetics.

9. D-4491 – Standard Test Methods for Water Permeability of Geotextiles by Permittivity

10. D-4533 – Standard Test Method for Trapezoid Tearing Strength of Geotextiles

11. D-4632 – Standard Test Method for Grab Breaking Load and Elongation of Geotextiles

12. D-4751 – Standard Test Methods for Determining Apparent Opening Size of a Geotextile

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

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

15. D-5199 – Standard Test Method for Measuring the Nominal Thickness of Geosynthetics

16. D-5261 – Standard Test Method for Measuring Mass per Unit Area of Geotextiles

17. D-6241 – Standard Test Method for Static Puncture Strength of Geotextiles and Geotextile-Related Products Using a 50-mm Probe

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

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

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

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

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

23. E8/E8M – Standard Test Methods for Tension Testing of Metallic Materials

24. MIL-STD-810 Method 501.5 – High Temperature

25. MIL-STD-810 Method 502.5 – Low Temperature

26. MIL-STD-810 Method 504.1 – Contamination by Fluids

27. MIL-STD-810 Method 510.5 – Sand and Dust

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 Calibration

## 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 9001:2008 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. *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.

G. *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.

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 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 Bank Stabilization. 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 and geotextile components are 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 and geotextile components are 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 $MJ/m^2$-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 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 test results demonstrating that the Anchor head can resist both the impact strength and impact fatigue required by the specification.

j) Documentation of test results demonstrating that the Anchor load bearing plate can resist both the punching shear and HPTRM pull-through strength required by the specification.

## 1.7 DELIVERY, STORAGE, AND HANDLING

A. Material 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. Material shall be wrapped with a material that will protect the product 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.B.6. The protective wrapping shall be maintained during periods of shipment and storage.

E. During storage, the material 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 product.

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 Bank Stabilization shall be furnished by a single manufacturer as a complete system.

B. Approved Engineered Bank Stabilization Manufacturers:

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

C. Approved Engineered Bank Stabilization Solution:

1. PROPEX Scourlok Engineered Bank Stabilization

D. Alternate Engineered Bank Stabilization 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 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:

d) Overall alternative engineered bank stabilization solution design methodology

e) Input parameters

f) Calculations / Model output

g) Anchor system information including: materials, strength, length, spacing (vertical & horizontal), size, locking mechanism, load bearing plate, and tendon

h) Factor of Safety for Sliding, Overturning, and Bearing Capacity to support the engineered bank stabilization design; with the conditions analyzed and documented for the proposed project

i) Alternative engineered bank stabilization solution 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. ENGINEERED BANK STABILIZATION: A system constructed of rigid cells armored with a High Performance Turf Reinforcement Mat (HPTRM) and internally lined with high durability nonwoven geotextile. The HPTRM is fastened to the rigid cells to provide a flexible exterior, control erosion, and improve system durability and forms pockets that can be filled with mulch or other media to promote and sustain vegetation. The durable geotextile lining allows the rigid cell to be filled with earth, sand, gravel, crushed rock and other granular material. Engineered Earth Anchors can also be utilized with the system to provide additional resistance to lateral earth pressures.

B. HPTRM:

1. A 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 heat-set and woven into uniform configuration of resilient pyramid-like projections to improve interlock and minimize yarn displacement around anchors 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]<br>90 at 6,000 hrs |
| Carbon Footprint [2] | ISO 14064-3 GHG Protocol PAS 2050:2011 | Maximum | Kg $CO_2e$ | 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 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)

10. Functional Longevity: The HPTRM component 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 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 $CO_2e/m^2$ when tested per GHG Protocol, ISO 14064-3:2006, and PAS 2050:2011.

12. 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.

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, needlepunched, 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 | Test Parameters | Units | Property Requirement |
|---|---|---|---|---|
| Mass Per Unit Area | ASTM D-5261 | Minimum | oz/yd² (g/m²) | 6.5 (220) |
| Thickness | ASTM D-5199 | Minimum | mils (mm) | 57 (1.37) |
| Color | Visual | - | - | Tan |
| Grab Tensile Strength | ASTM D-4632 | Minimum | lbs (N) | 210 (934) |
| Grab Tensile Elongation | ASTM D-4632 | Minimum | percent | 80 |
| Trapezoidal Tear | ASTM D-4533 | Minimum | lbs (N) | 80 (356) |
| CBR Puncture | ASTM D-6241 | Minimum | lbs (N) | 550 (2447) |

| | | | | |
|---|---|---|---|---|
| Apparent Opening Size (AOS) | ASTM D-4751 | Maximum | in (mm) | 0.004 - 0.007 (0.11 - 0.18) |
| Permittivity | ASTM D-4491 | Minimum | $sec^{-1}$ | 1.1 |
| UV Resistance | ASTM D-4355 | Minimum | percent | 80 at 1000 hrs |
| Chemical Exposure (Diesel fuel and deicing fluid) | MIL-STD-810 Method 504.1 | Minimum | percent | 90 |
| Acid and Alkali Exposure (Sulfuric Acid) | MIL-STD-810 Method 504.1 | Minimum | percent | 90 |
| Acid and Alkali Exposure (Calcium Hydroxide) | MIL-STD-810 Method 504.1 | Minimum | percent | 80 |
| High Temperature Exposure | MIL-STD-810 Method 501.5 | Minimum | percent | 90 |
| Low Temperature Exposure | MIL-STD-810 Method 502.5 | Minimum | percent | 90 |
| Blowing Sand Abrasion | MIL-STD-810 Method 510.5 | Minimum | percent | 85 |
| Burn Propagation when filled | - | Minimum | - | No Flame Spread |

D. Rigid Cell:

1. The rigid cell should meet the following values:

| **Property** | **Test Method** | **Units** | **Property Requirement** |
|---|---|---|---|
| Ultimate Tensile Strength | ASTM E8/E8M | psi (Mpa) | 99,350 (685) |
| Ultimate Tensile Elongation | ASTM E8/E8M | percent | 7 |
| Weld Shear Strength | ASTM E8/E8M | percent | 70 |
| Rigid Cell Dimensions | - | ft | 4 x 3 x 15 |

| | | | |
|---|---|---|---|
| | | (m) | 1.2 x 0.9 x 4.5 |
| Wire Diameter | - | inches (mm) | 0.157 (4) |

E. Engineered Earth Anchor:

1. Anchors with a minimum drive depth, size, loading, and spacing specified by the engineer of record and/or the manufacturer used to provide surficial slope stabilization and/or erosion protection as depicted in the construction plans, engineering submittals and/or drawings.

2. The engineered earth anchor components shall be constructed of materials suitable to resist corrosion and UV degradation particularly at the soil/air interface.

3. The top load bearing plate shall have openings allowing vegetative growth through the plate. The bearing plate shall include a recessed cavity so that the tendon can be cut flush or below the bearing plate surface.

4. The anchor head shall be constructed of materials suitable to resist the potential stresses seen during installation.

5. The top load bearing plate shall be of sufficient size to resist forces acted upon by the tensioned anchor.

6. For quality control purposes and warranty claims, engineered earth anchors should be delivered to the jobsite fully assembled and ready for installation.

7. Material Properties:

| **Component** | **Material Composition** | **Physical Properties** |
|---|---|---|
| Anchor Head | Aluminum Alloy | 7.4 in. x 2.4 in. x 2.0 in. (188 mm x 61 mm x 51 mm) (L x W x H) Bearing Area: 14.5 in$^2$ (94 cm$^2$) |
| Cable Tendon | Galvanized Steel | Diameter: 0.1875 in. (4.8 mm) |
| Lower Termination | Aluminum Ferrule | Length: 1.0 in. (25 mm) Wall Thickness: 0.1 in. (2 mm) |

| | | |
|---|---|---|
| Load Bearing Plate | Aluminum Alloy | Diameter: 6.3 in. (160 mm)<br>Thickness: 0.40 in. (10 mm)<br>Bearing Area: 20 $in^2$ (130 $cm^2$) |
| Top Termination | Aluminum Alloy | Circumferential Wedge Grip Assembly to Eliminate Cable Pinch Points<br>Grip to Cable Contact Surface Area: 0.6 $in^2$ (3.9 $cm^2$)<br>Grip to Cable Contact Ratio: > 80% of Cable Diameter |

8. Performance

| **Performance Property** | **Value** |
|---|---|
| Ultimate Assembly Strength | 2,800 lbs (12.5 kN) |
| Ultimate Cable Strength | 3,700 lbs (16.5 kN) |
| Typical Working Load Range* | 800 - 2,000 lbs (3.6 - 8.9 kN) |
| Typical Embedment Depth | 6 - 12 ft. (1.8 – 3.7 m) |
| Anchor Head Impact Strength | 34,000 lbs (151 kN) |
| Anchor Head Impact Fatigue | > 12,000 Loading Cycles |
| Load Bearing Plate Punching Shear | 2,800 lbs (12.5 kN) |
| Load Bearing Plate / HPTRM Pull-Through Strength | 2,800 lbs (12.5 kN) |

* 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 SUBGRADE PREPARATION

A. Excavate a shallow, level trench at least 0.9 m (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.

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).

<u>OR</u>

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 MIRAFI  180N 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 unit.

## 3.2 INSTALLATION

A. Install the Engineered Bank Stabilization at elevation and alignment indicated.

B. Starting with the lowest portion of the alignment, lower the first unit onto the foundation layer and expand into place. At each terminus of this lowest section of the alignment, curve the turn the unit into the slope so the ends of this run can be buried.

C. Gradual curves can be created due to the system flexibility. Curving is done during setup and all curved units must be set out and joined before filling. Each of the 4.6 m (15 ft) long units can be curved a maximum of 30 cm (12 in) from the tangent line set by the previous unit. Tighter concave or convex curves can be achieved as shown below.

D. Concave curves are formed by removing a single rear facing panels and creating a triangular unit.

1. Begin the process by removing the spirals on each side of the panel and cut along the geotextile inside the unit, just under the row of staples.
2. Remove the rigid cell panel and reapply the spirals at each corner to secure the internal panels.
3. Overlap the corner spirals and insert the joining pins in order to complete the triangular cell.
4. Zip-tie the excess geotextile liner to the rigid cell panel to keep it out of the way during filling.

E. Convex curves are formed by removing a single front facing panel and creating a triangular unit.

1. Begin the process by cutting the exterior HPTRM down the middle of the cell to expose the rigid cell panel and geotextile lining.
2. Remove the spirals on each side of the panel and cut along the geotextile inside the unit, just under the row of staples.
3. Remove the rigid cell panel and reapply the spirals at each corner to secure the internal panels.
4. Overlap the corner spirals and insert the joining pins in order to complete the triangular cell.
5. Zip-tie the excess geotextile liner to the rigid cell panel to keep it out of the way during filling.
6. Shingle the exterior HPTRM in the direction of flow and trim excess material in order to maintain a 15 cm (6 in) overlap.
7. Using stainless steel hog rings, secure the overlap to the rigid cell, leaving a minimum of 7.5 cm (3 in) beyond the hog rings.

F. If required, Engineered Earth Anchors can be utilized with the system to provide additional resistance to lateral movement.

1. With the unit set in place, expanded, and filled approximately halfway, mark the location of anchors on the slope behind the units. Anchor locations should align with the intermediate dividing walls of the unit.
2. Cut a hole in the geotextile liner near the intermediate dividing wall to thread the anchor head from the inside of the unit toward the marked

location on the slope behind the unit. The hole should be cut approximately 1 ft (0.3 m) from the top of the unit.

3. Place the drive rod into the anchor head and drive anchor near horizontal into rear excavation at the marked locations. Remove anchor drive rod and set anchor.
4. On the inside of the unit, apply light force to ensure the anchor top plate is set against the walls of the unit and the locking mechanism of the anchor is set.

G. Place a 15 cm (6 in) thick fill material approved by the Engineer within the units. Check and adjust the units to ensure a level placement. If joining the units together in series, do not fill the end cell more than 15 cm (6 in) prior to joining units.

H. Install remaining fill in lifts no more than 0.6 m (2 ft). Fill the units and backfill behind the units simultaneously so as to balance the earth pressures. When normal water levels are present, face units should be filled with granular, self-consolidating material. Compact infill and backfill to the specified modified Proctor dry density per the Engineer's recommendation, but never less than 87% of the maximum dry density per ASTM 1557.

I. For vegetation establishment on the face of the units, fill the pocket between the HPTRM and the cell with seed and growth media. This can consist of topsoil, or other organic material, and seed in accordance with Section [32 velocity 19 SEEDING AND SODDING] [_____ - _______]. Place a minimum of 2 cm (1 in) of topsoil/seed mix on the top of the filled unit.

J. Pull the remaining portion of the HPTRM tightly across the top of the filled unit. Fasten the HPTRM top cover to the back of the unit walls as well as the intermediate walls with stainless steel hog rings. Turn down excess HPTRM along the back side of the unit prior to placing fill behind unit.

K. Units can be joined by connecting the spirals from one unit to another.

1. Align the units, overlapping the spirals and insert the joining pin to permanently attached to each other.
2. When joining facing units, the HPTRM is to be spliced together. Shingle the exterior HPTRM in the direction of flow and trim excess material in order to maintain a 15 cm (6 in) overlap. Using stainless steel hog rings, secure the overlap to the rigid cell, leaving a minimum of 7.5 cm (3 in) beyond the hog rings.

L. Repeat Steps A. through K. for each subsequent unit. Incorporate a setback with unit to provide the desired overall slope angle

**END OF SECTION**