EarthStabilizer™ Design-Based Solution for Stabilizing Slopes with the Gripple Terra-Lock System and American Excelsior Turf Reinforcement Mats

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Gripple – Company Introduction

Gripple is the market-leading manufacturer of wire joiners and tensioners for the agriculture and viticulture market, and cable suspension solutions for the construction market.

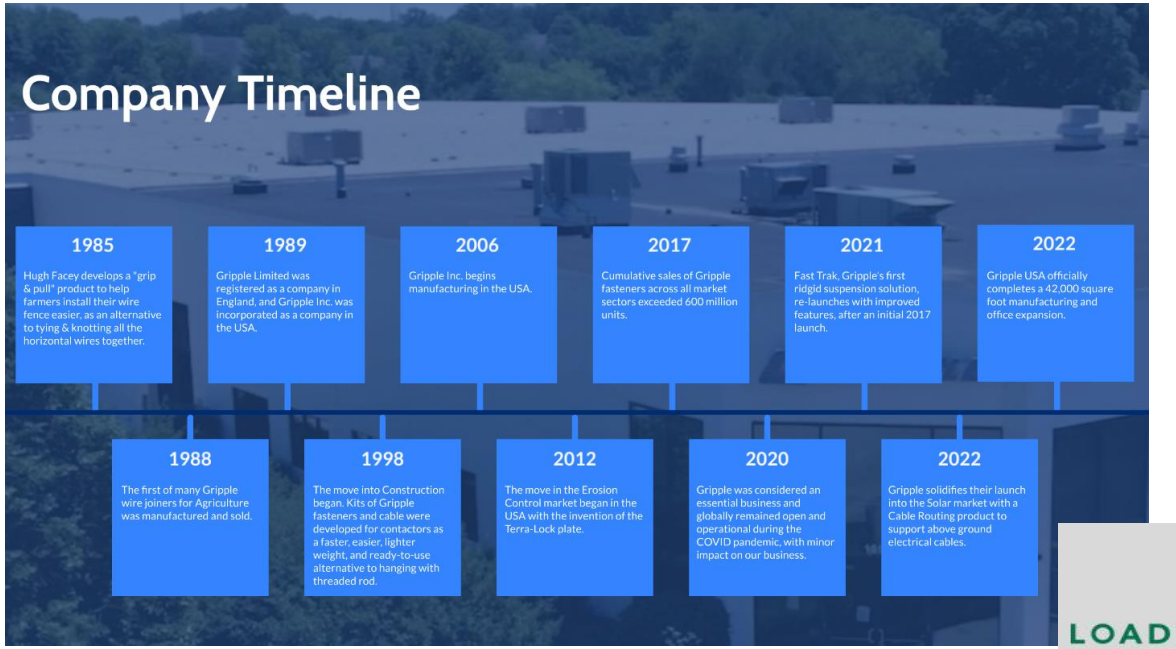
Gripple began as one man's ingenuity to solve a problem. Today, it's a global brand, servicing five key market sectors and employing over 700 people across 14 global locations. Characterized by our commitment to people and a desire to challenge convention, the business has experienced consistent growth and evolution since its foundation in 1989.

Gripple is a 100% employee-owned company, meaning all our people own shares in the business. This has been the case since 1994 and was formalized in 2011 with the establishment of GLIDE, an organization representing all employee shareholders who work in the member companies.

GLIDE is an acronym for
Growth Led Innovation
Driven Employee
Company.

GRIPPLE®

Gripple – Company Introduction



History 1985-2024

Tooling, Die Casting, Transit Packaging and Machine Design

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Find us in MasterSpec®
a product of The American Institute of Architects

- IECA – International Erosion Control Association
- ECTC – Erosion Control Technology Council – Directing Member
- SE IECA & Iberoamerican Chapter – Lincoln Del Pino from Gripple
- MASTERSPEC
  - MasterSpec is a master guide building and construction specification system used within the United States by architects, engineers, landscape architects, and interior designers
- Buy American Act Compliant

GRIPPLE®

American Excelsior Continuous Innovation

1888
Curlex® packaging fibers

1960s
AEC Invents ECBs
"Curlex® I"

1980s
Curlex® II – 1st DN ECB
Curlex® III – 1st HD ECB

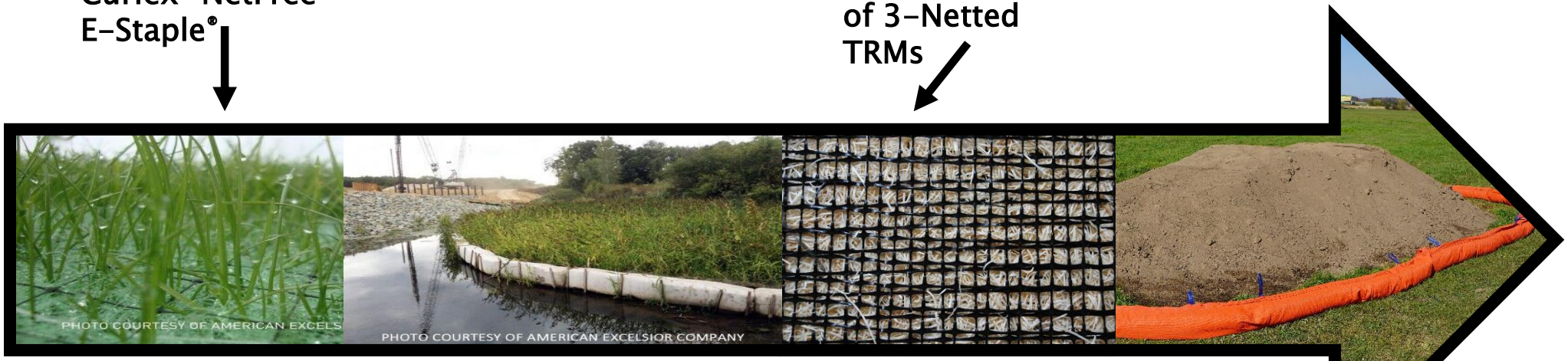
1990s
ErosionWorks®
Sediment Log®
QuickGRASS®
ErosionLab®

American Excelsior Company®

American Excelsior Continuous Innovation

2000s
Recyclex® TRM
Curlex® NetFree™
E-Staple®

2018
TriNet® Family
of 3-Netted
TRMs

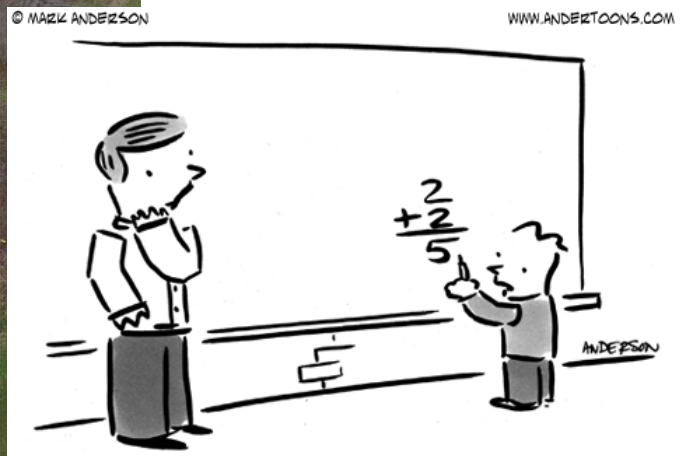


2012
Curlex® Bloc

2020
Curlex® Hi-Vis
Logs™

American Excelsior Company®

The ErosionLab®



"I prefer to think of it as added value."

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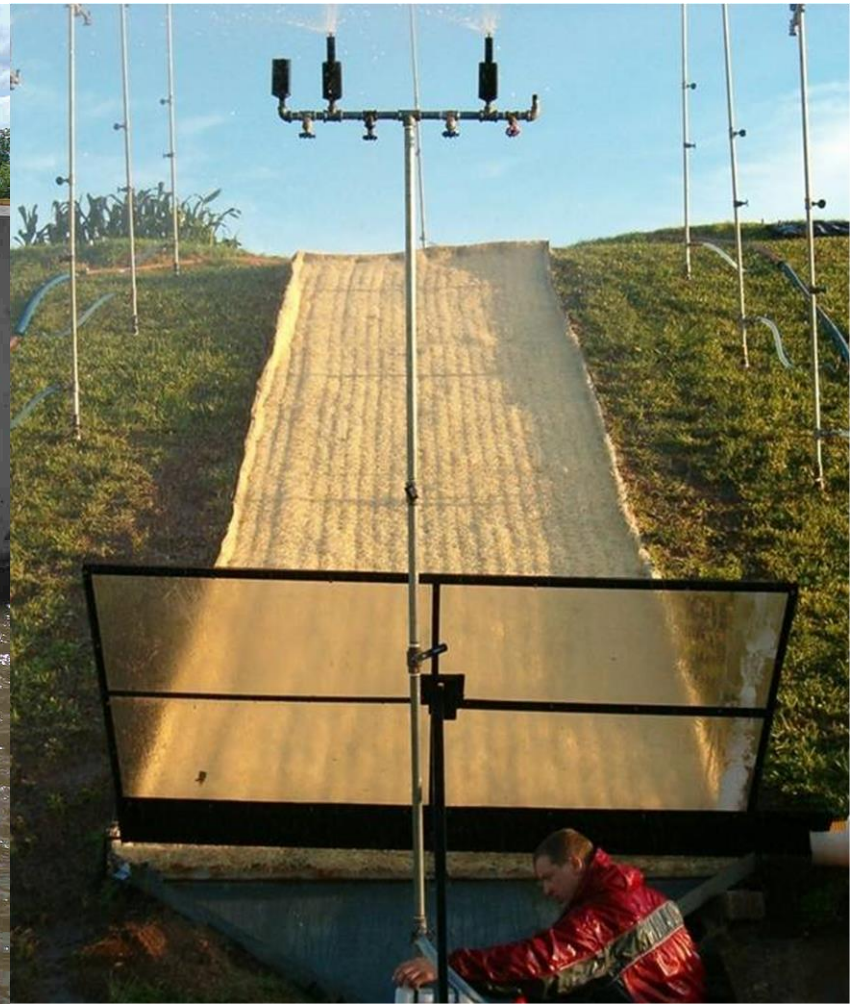
ASTM Large-Scale Testing



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The Problem EarthStabilizer™ Solves

Shallow Plane Failures and Transitional Slides

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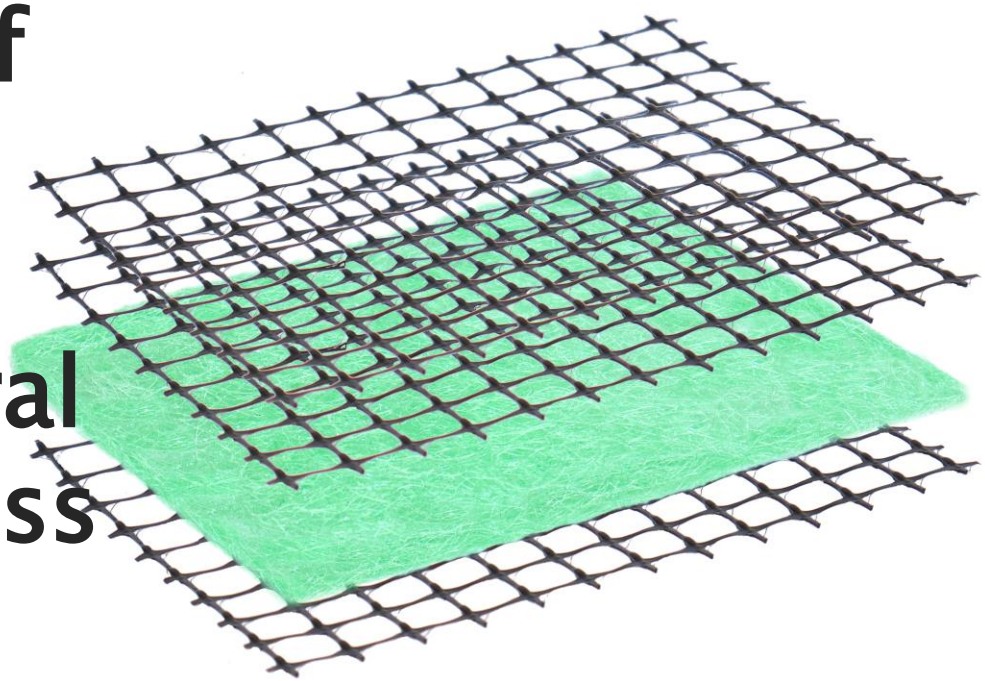
What are TRMs?

Common Characteristics:

- Two or three layers of netting
- Fiber layer
  - Synthetic or Natural
- Long-term shear stress protection
- Long-term vegetation support



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When are TRMs Used?

In channels when:

1. Vegetation cannot withstand design hydraulic force on its own.

2. “Peace of Mind” long-term vegetation reinforcement is desired.

3. Shear Stress is greater ≈3.5lbs per ft^2.

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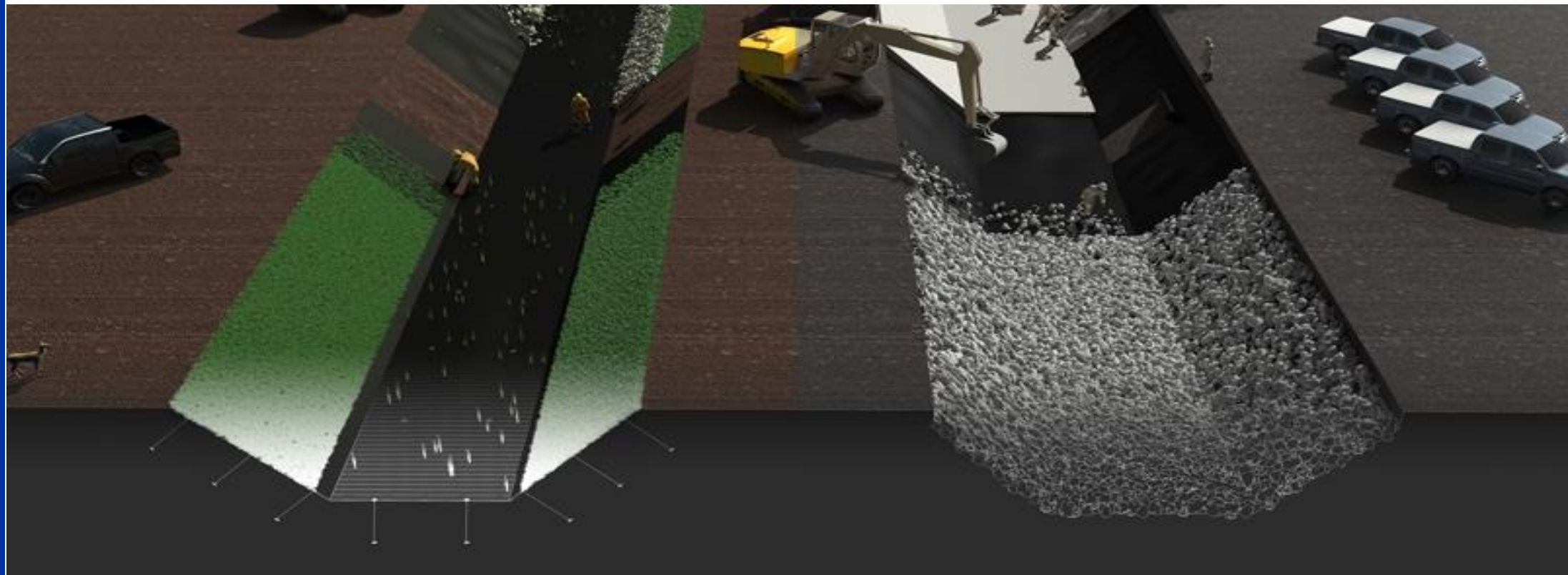
Environmental Benefits of a Vegetated Swale

Reducing Flow Velocity, Increasing Sedimentation and Filtration

(TSS Median Removal = 81%)

Pollutant	Median % Removal
Oxygen-Demanding Substances	67
Nitrate	38
Total Phosphorus	9
Hydrocarbons	62

Pollutant	Median % Removal
Cadmium	42
Copper	51
Lead	67
Zinc	71



When are TRMs Used?

On slopes when:

1. Long-term vegetation reinforcement is needed.

2. Steepness is >1H:1V.

3. Shear Stress is greater 3.5lbs per ft^2.

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Terra-Lock & TriNet Recyclex TRM Comparison to Rip Rap

EarthStabilizer System

- Designed systems provide both erosion control and shallow-plane stabilization without over-excavation and environmental disturbance.
- Lower labor and transportation costs to deliver to and install an area of equal size.
- Increased stormwater filtration and infiltration.
- Cleaner, cooler water discharges.
- Safer/softer than Rip Rap.
- Can be used as a transition from hard armor.

Rip Rap

- High shear and impact resistance that TRMs may not be able to withstand.
- Long design life but needs constant maintenance and inspection to function at full capacity.
- High transportation cost.
- Does little to enhance surrounding habitat.
- Not aesthetically pleasing.
- Direct exposure to sunlight heats the rocks which warms the waterways.

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TriNet® Family of TRMs

- TriNet Recyclex
  - 14 lb/ft² of vegetated shear stres
- TriNet Curlex
  - 13 lb/ft² of vegetated shear stres
- TriNet Coconut
  - 12 lb/ft² of vegetated shear stres
- TriNet Straw Coconut
  - 10 lb/ft² of vegetated shear stres

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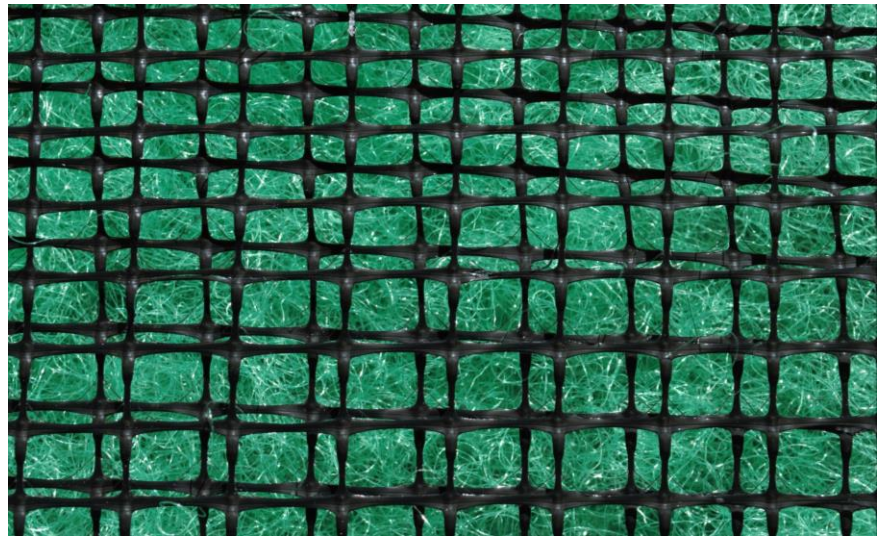
Recyclex® Family of TRMs

- Crimped, curled fibers similar to Curlex®
  - 80% or more ≥5” long
- Specific gravity = 1.28
  - Product will not float
- 95% Fiber memory
  - Maintains form after loadin
- 18 bottles diverted from landfills for every pound of Recyclex fibers
  - 358,628 bottles diverted in one TL of Recyclex



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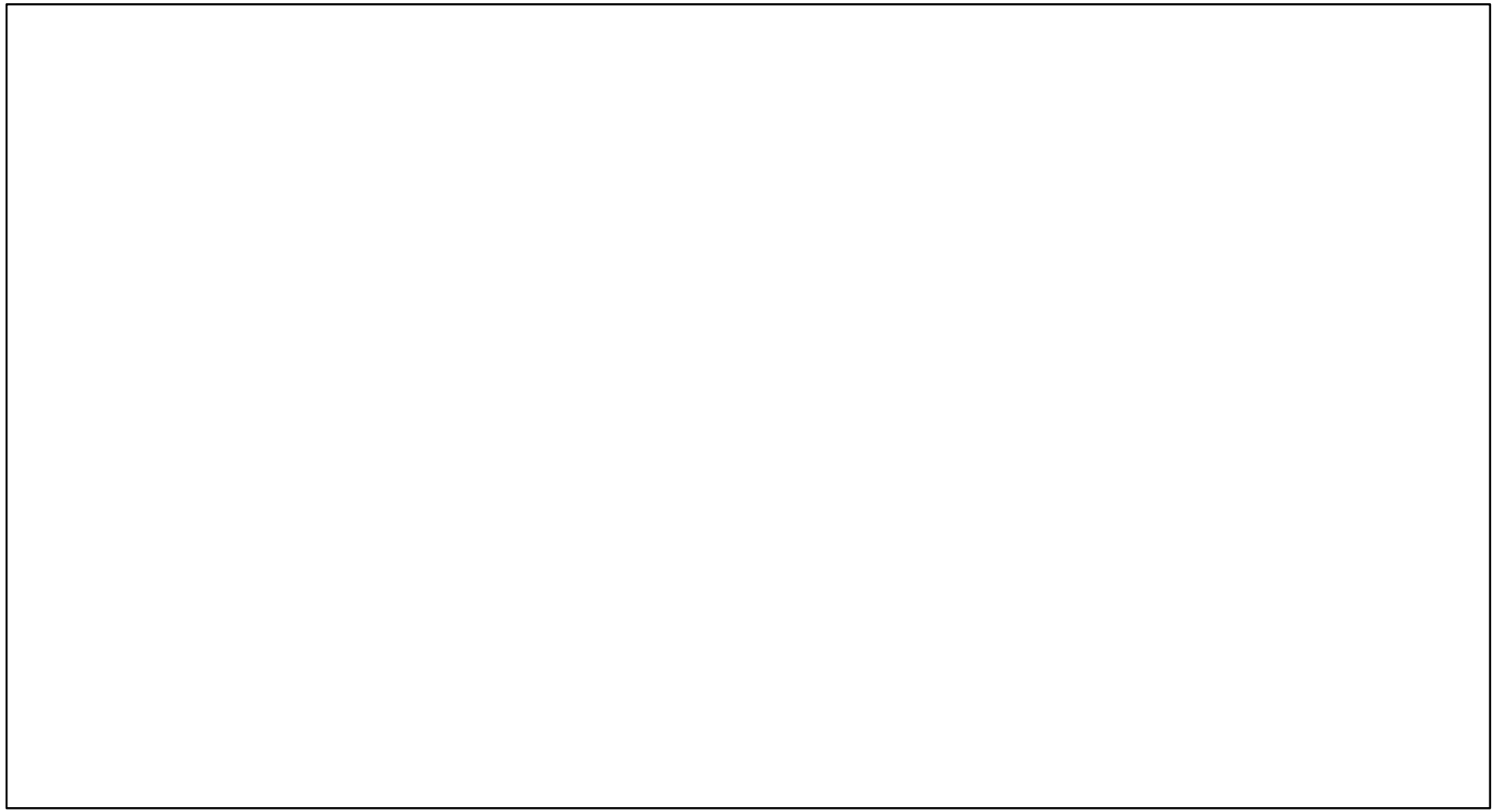
Fibers Type Impacts TRM Performance



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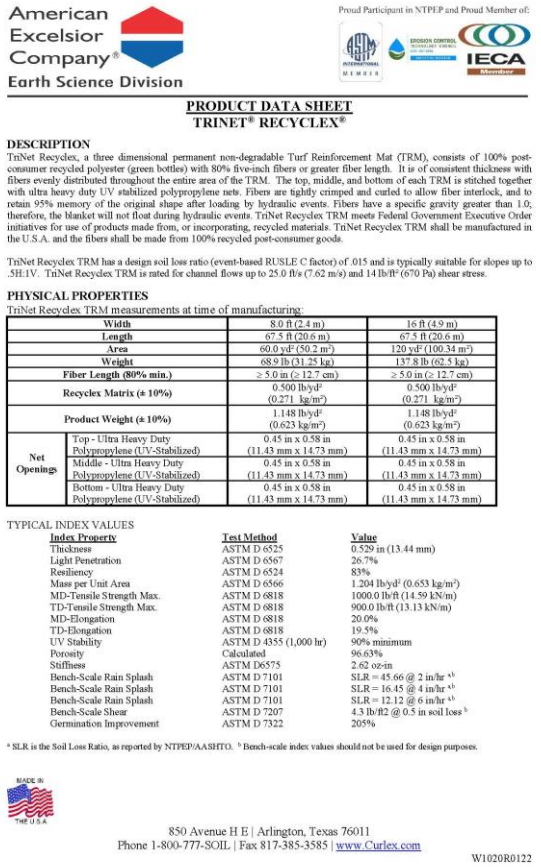
TriNet® Recyclex® TRM

- Non-degradable Turf Reinforcement Mat (TRM)
- Three ultra heavy-duty UV stabilized polypropylene nets
- Suitable for slopes up to .5H:1V.
- Rated for channel flows up to 25.0 ft/s (7.62 m/s) and 14 lb/ft² (670 Pa) shear stress.



American Excelsior Company®
Earth Science Division

Proud Participant in NTPEP and Proud Member of:

PRODUCT DATA SHEET
TRINET® RECYCLEX®

DESCRIPTION

TriNet Recyclex, a three dimensional permanent non-degradable Turf Reinforcement Mat (TRM), consists of 100% post-consumer recycled polyester (green bottles) with 80% five-inch fibers or greater fiber length. It is of consistent thickness with fibers evenly distributed throughout the entire area of the TRM. The top, middle, and bottom of each TRM is stitched together with ultra heavy duty UV stabilized polypropylene nets. Fibers are tightly crimped and curled to allow fiber interlock, and to retain 95% memory of the original shape after loading by hydraulic events. Fibers have a specific gravity greater than 1.0; therefore, the blanket will not float during hydraulic events. TriNet Recyclex TRM meets Federal Government Executive Order initiatives for use of products made from, or incorporating, recycled materials. TriNet Recyclex TRM shall be manufactured in the U.S.A. and the fibers shall be made from 100% recycled post-consumer goods.

TriNet Recyclex TRM has a design soil loss ratio (event-based RUSLE C factor) of .015 and is typically suitable for slopes up to .5H:1V. TriNet Recyclex TRM is rated for channel flows up to 25.0 ft/s (7.62 m/s) and 14 lb/ft² (670 Pa) shear stress.

PHYSICAL PROPERTIES

TriNet Recyclex TRM measurements at time of manufacturing:

Width		8.0 ft (2.4 m)	16 ft (4.9 m)
Length		67.5 ft (20.6 m)	67.5 ft (20.6 m)
Area		60.0 yd² (50.2 m²)	120 yd² (100.34 m²)
Weight		68.9 lb (31.25 kg)	137.8 lb (62.5 kg)
Fiber Length (80% min.)		≥ 5.0 in (≥ 12.7 cm)	≥ 5.0 in (≥ 12.7 cm)
Recyclex Matrix (± 10%)		0.500 lb/yd² (0.271 kg/m²)	0.500 lb/yd² (0.271 kg/m²)
Product Weight (± 10%)		1.148 lb/yd² (0.623 kg/m²)	1.148 lb/yd² (0.623 kg/m²)
Net Openings	Top - Ultra Heavy Duty Polypropylene (UV-Stabilized)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)
	Middle - Ultra Heavy Duty Polypropylene (UV-Stabilized)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)
	Bottom - Ultra Heavy Duty Polypropylene (UV-Stabilized)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)	0.45 in x 0.58 in (11.43 mm x 14.73 mm)

TYPICAL INDEX VALUES

Index Property	Test Method	Value
Thickness	ASTM D 6525	0.529 in (13.44 mm)
Light Penetration	ASTM D 6567	26.7%
Resiliency	ASTM D 6524	83%
Mass per Unit Area	ASTM D 6566	1.204 lb/yd² (0.653 kg/m²)
MD-Tensile Strength Max.	ASTM D 6818	1000.0 lb/ft (14.59 kN/m)
TD-Tensile Strength Max.	ASTM D 6818	900.0 lb/ft (13.13 kN/m)
MD-Elongation	ASTM D 6818	20.0%
TD-Elongation	ASTM D 6818	19.5%
UV Stability	ASTM D 4355 (1,000 hr)	90% minimum
Porosity	Calculated	96.63%
Stiffness	ASTM D6575	2.62 oz-in
Bench-Scale Rain Splash	ASTM D 7101	SLR = 45.66 @ 2 in/hr [a,b]
Bench-Scale Rain Splash	ASTM D 7101	SLR = 16.45 @ 4 in/hr [a,b]
Bench-Scale Rain Splash	ASTM D 7101	SLR = 12.12 @ 6 in/hr [a,b]
Bench-Scale Shear	ASTM D 7207	4.3 lb/ft2 @ 0.5 in soil loss [b]
Germination Improvement	ASTM D 7322	205%

[a] SLR is the Soil Loss Ratio, as reported by NTPEP/AASHTO. [b] Bench-scale index values should not be used for design purposes.

MADE IN THE U.S.A.

850 Avenue H E | Arlington, Texas 76011
Phone 1-800-777-SOIL | Fax 817-385-3585 | www.Curlex.com

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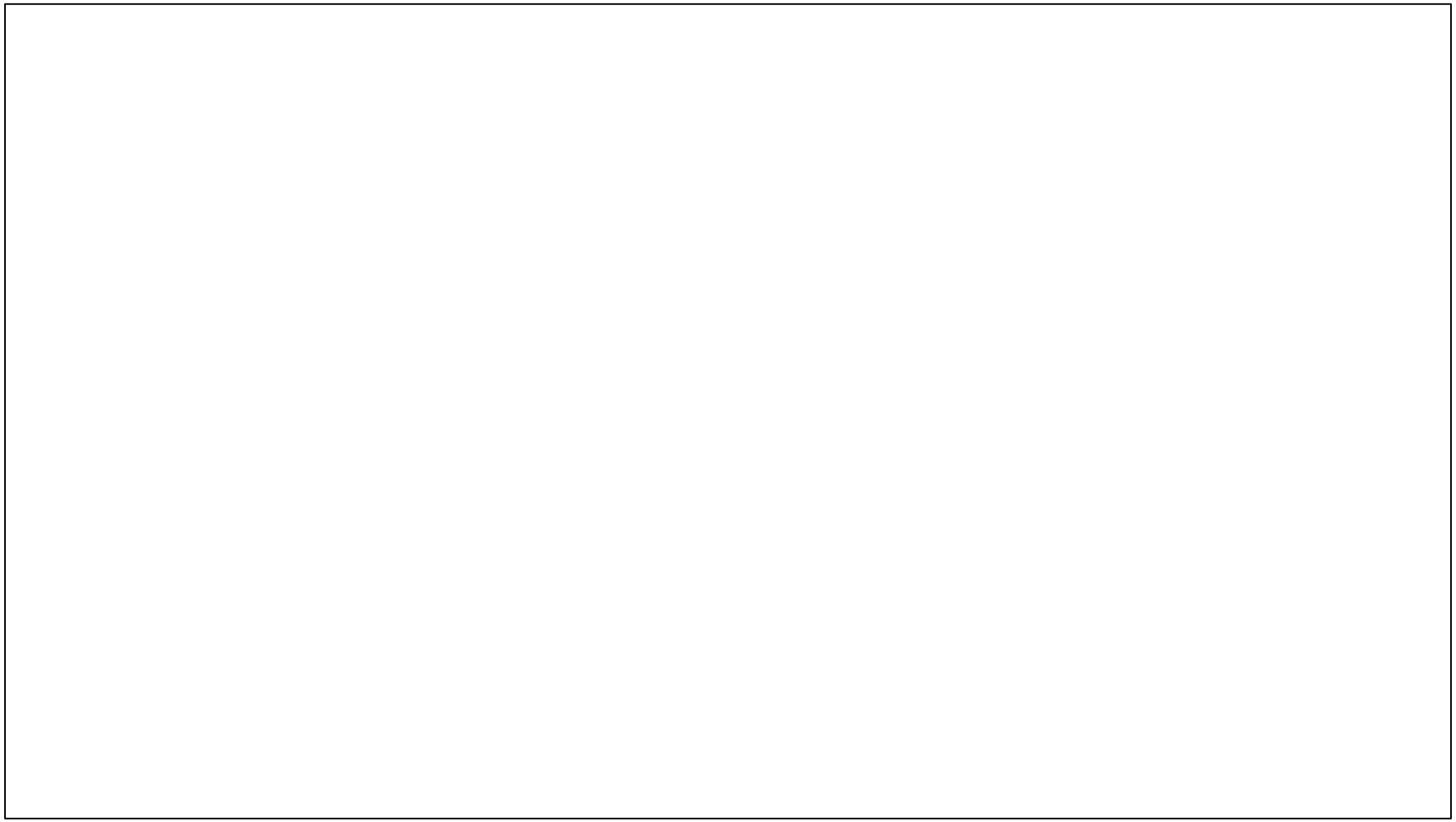
Importance of Synthetic Fiber Types



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TriNet Recyclex During Construction

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TriNet Recyclex
One Year Post Construction

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Terra-Lock® - Twist Anchors (TL-TA)

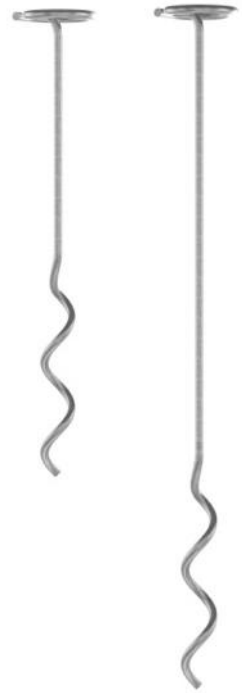
TL-TA1
Moderate Soils

8 IN 12 IN

- Easy installation up to 10x faster with standard electric drill and custom chuck
- Superior pullout performance compared to traditional pins and stakes
- Ensures close contact between the matting and soil
- Made in USA & meets Buy American Act! Now ISO 9001 compliant

TL-TA2
Tough Soils

8 IN 12 IN



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Terra-Lock® - Twist Anchors (TL-TA)

-TESTING-

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Anchor Pull Out Resistance (lb. of force)

									
	TL-TA1 (8”)	TL-TA1 (12”)	TL-TA2 (8”)	J-Hook (18”)	Washer Pin (18”)	Washer Pin (12”)	Sod Staple (6”)	Sod Staple (8”)	Wood Stake (8”)
SOIL TYPE									
Clay	189	233	216	45	40	45	24	30	232
Loam	163	198	132	34	14	22	20	48	153
Sand	50	106	59	22	9	10	8	9	34

Gripple – Twist Anchors Recommendations

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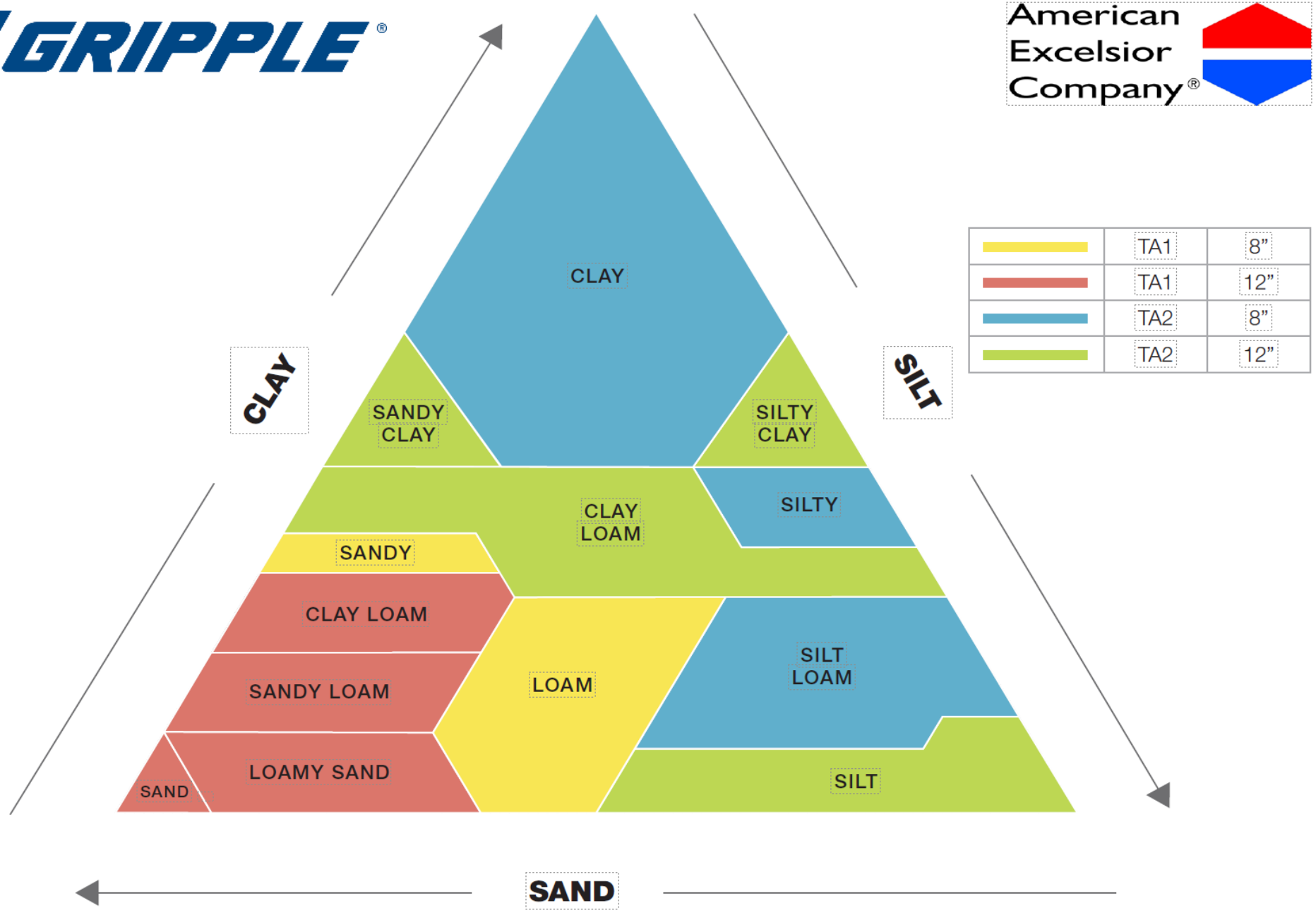
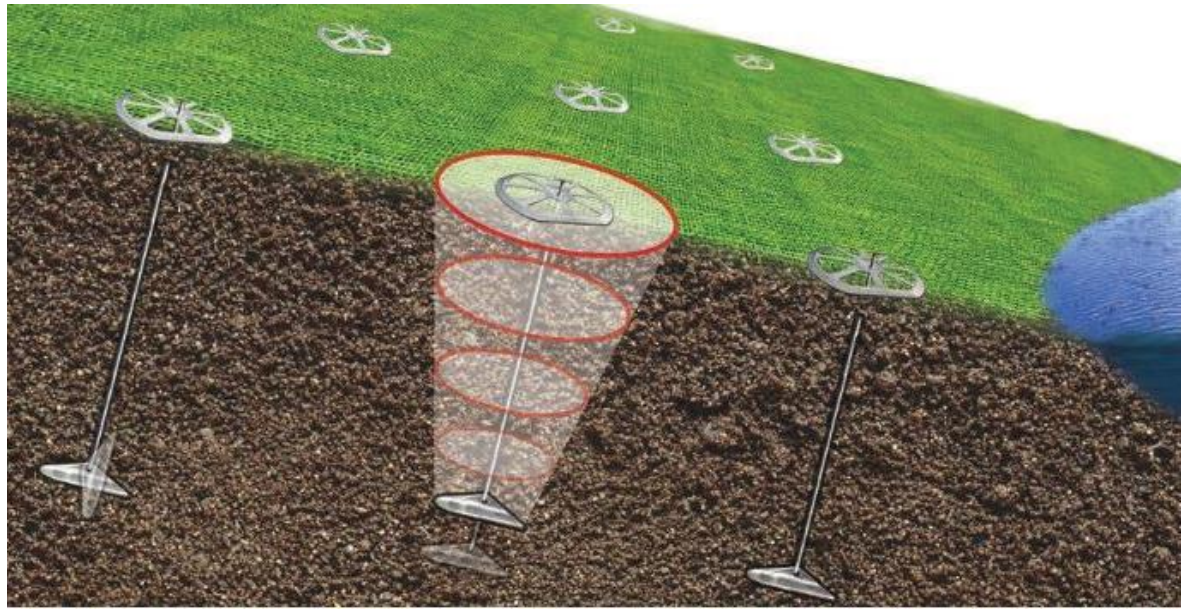


Terra-Lock™ Earth Percussion Anchors

Secures TRM in erosion control and soil stabilization applications.

- Open face promotes vegetation regrowth
- Pre-assembled kit ensures time and labor savings
- Tendon can be cut below grade



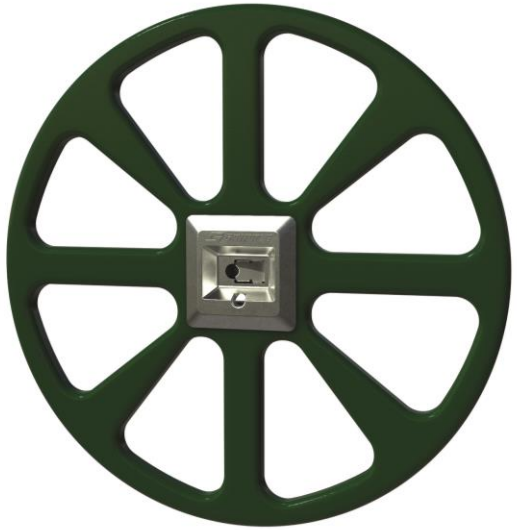
Terra-Lock® Earth Percussion Anchor Kits Available From AEC

Terra-Lock (TL) Top Bearing Plate Options

TL-100

TL-304

TL-406



TL-800 TOP

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Terra-Lock® Earth Percussion Anchor Kits Available From AEC

Terra-Lock Anchors (TLA)

TL A2

TL A3

TL A4

TL-A5

Tendons:

Diameter: 3mm to 8mm / Material: Zinc Aluminum or Stainless Steel

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EarthStabilizer™ Solution Installation TriNet® Recyclex ® and Gripple Terra-

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Anchor Behavior in Free Draining Soils

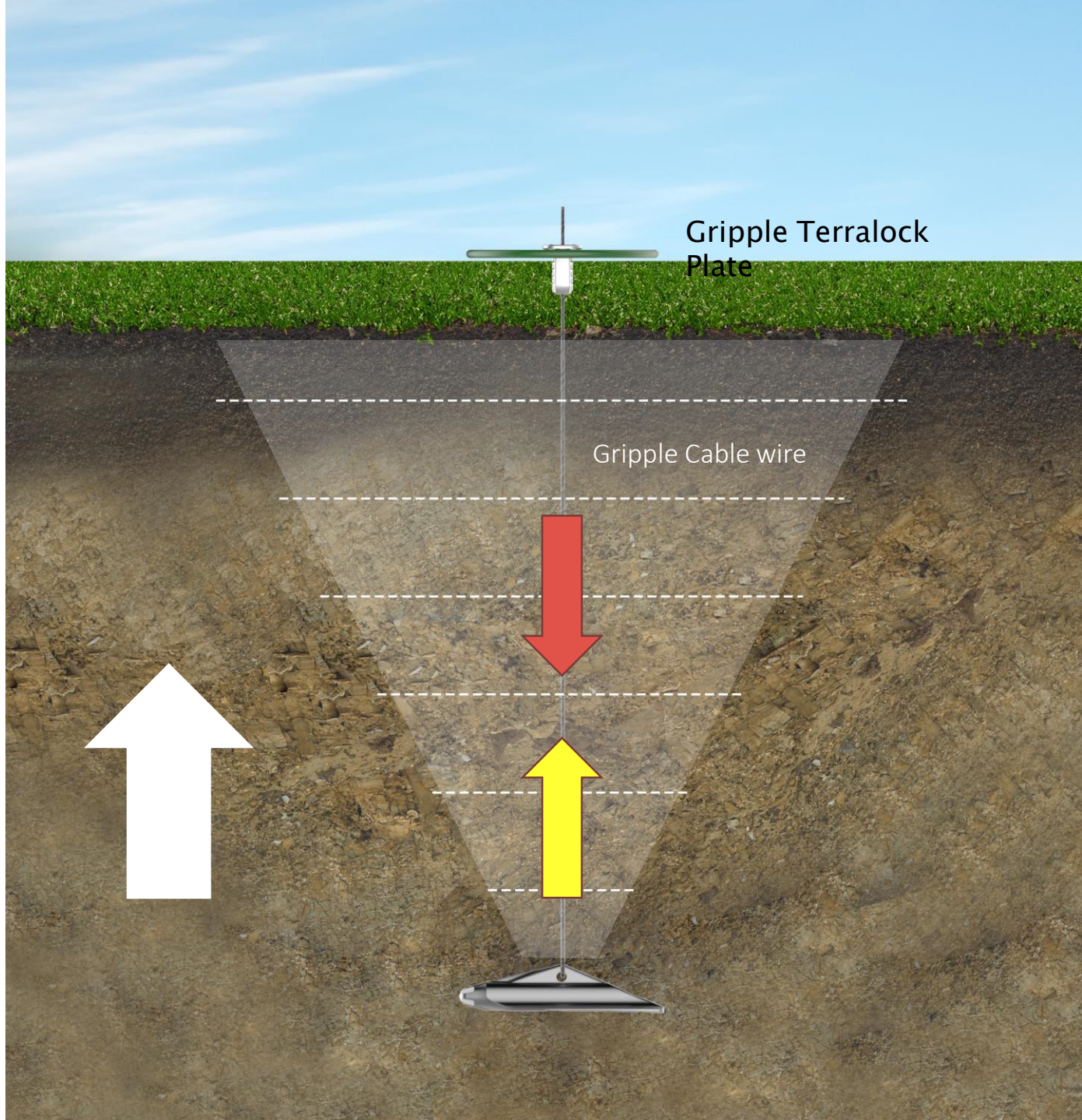
As earth pressures increase, penetrating earth anchors, which are always under tension, effectively transfer these pressures from the surface to the anchor, ensuring their stability.

In free draining soils the friction angles of the soils enhances the pullout capabilities of the anchors and allows for the expansion of the frustrum cone that is formed.

FREE DRAINING

FRICTIONAL RESPONSE

FORMATION OF CONE TO RESIST MOVEMENT



Anchor Behavior in Cohesive Soils

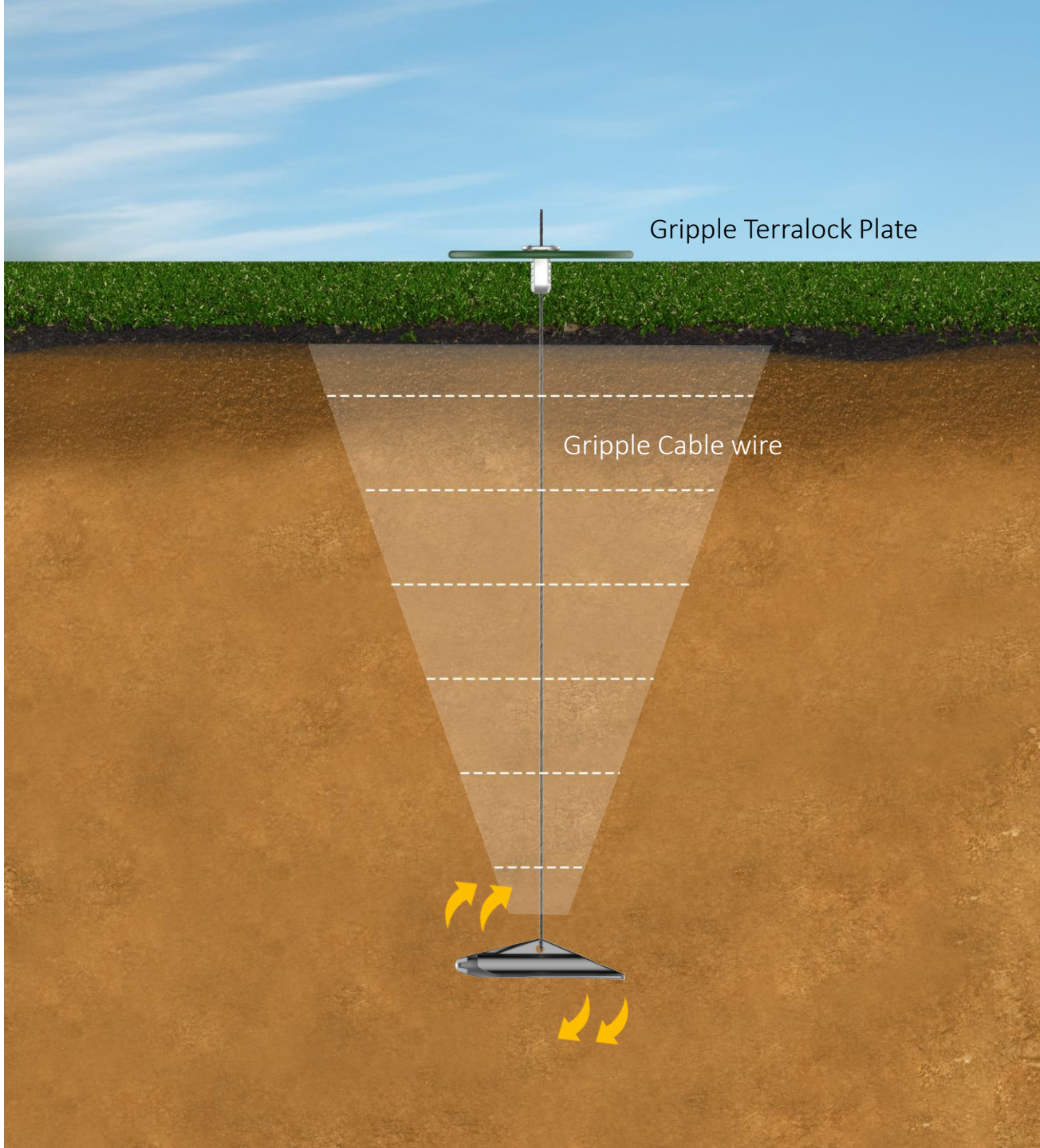
As earth pressures increase, penetrating earth anchors, which are always under tension, effectively transfer these pressures from the surface to the anchor, ensuring their stability.

However, in Cohesive Soils depths will typically be deeper to compensate for the narrowing of the frustrum cone. It is also commonplace to upsize to the next larger anchor allowing for a larger surface area.

COHESIVE

COHESIVE RESPONSE

MOTION OF SOIL AROUND ANCHOR RESISTS MOVEMENT



ANCHOR SYSTEM – ANCHOR

SYSTEM FOUNDATION

DRIVEN DEEP INTO THE GROUND AND TAPS INTO THE ENGINEERING PROPERTIES OF THE SOIL.

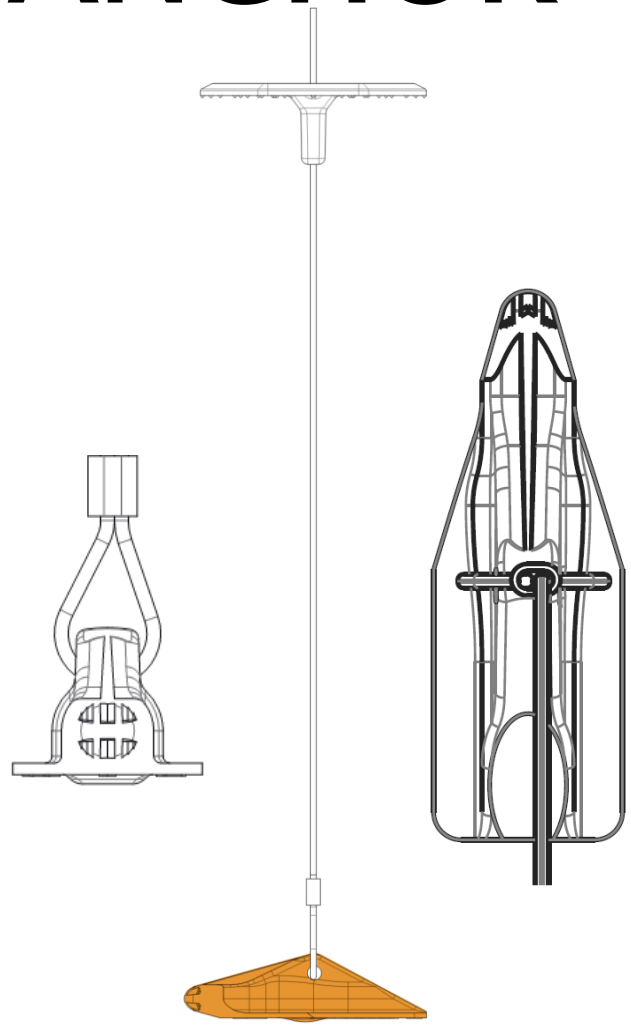
SPECIFICALLY DESIGNED

FRONTAL PROFILE = EASE OF INSTALL

TOP PROFILE = HIGH LOADS

SMALL WITH HIGH LOAD CAPACITY

FOUR SIZES CAN BE PROPERLY SPECIFIED FOR THE ENGINEERING PROBLEM.



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ANCHOR SYSTEM – TENDON

LOAD TRANSMISSION

TRANSMITS THE LOADS FROM THE MOVING OBJECT, DEEP INTO THE FOUNDATIONS OF THE SYSTEM.

CORROSION RESISTANT

ZINC-ALUMINIUM ALLOY OR STAINLESS STEEL.

HIGH LOAD CAPACITY

FLEXIBLE MEMBER THAT CARRIES HIGH LOADS WITH A LIGHT WEIGHT

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ANCHOR SYSTEM – TOP TERMINATION

SECURES THE SYSTEM

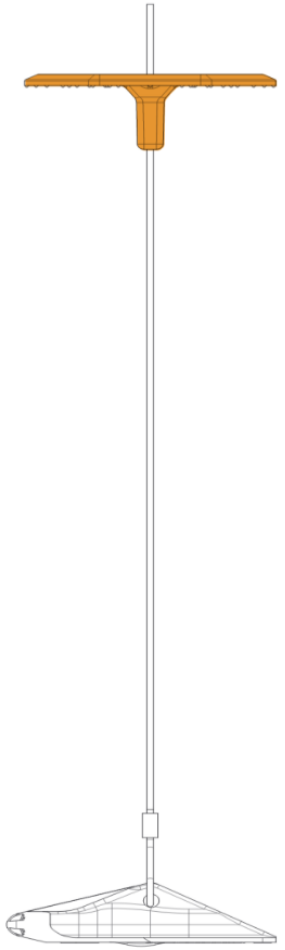
INTERACTS WITH MOVING OBJECTS / OTHER PARTS OF THE SYSTEM

MAINTAINS TENSION

LOCKING SYSTEM SELF TIGHTENS SO ALL OF THE FORCE IS QUICKLY TRANSFERRED INTO THE GROUND

SELF LOCKING

CONNECTS WITH THE TENDON ALLOWING FORCES TO BE TRANSFERRED



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How the System Works
TriNet Recyclex

- American Excelsior's TriNet Recyclex TRM provides the erosion control portion of the design and provides protection against sheet flow, rain drop impact, and pre-determined shear velocities both in its unvegetated and vegetated stages.

- The TRM is the "face" of the design, protecting against impacts while providing an aesthetically pleasing finished installation that will promote and reinforce the chosen vegetatior

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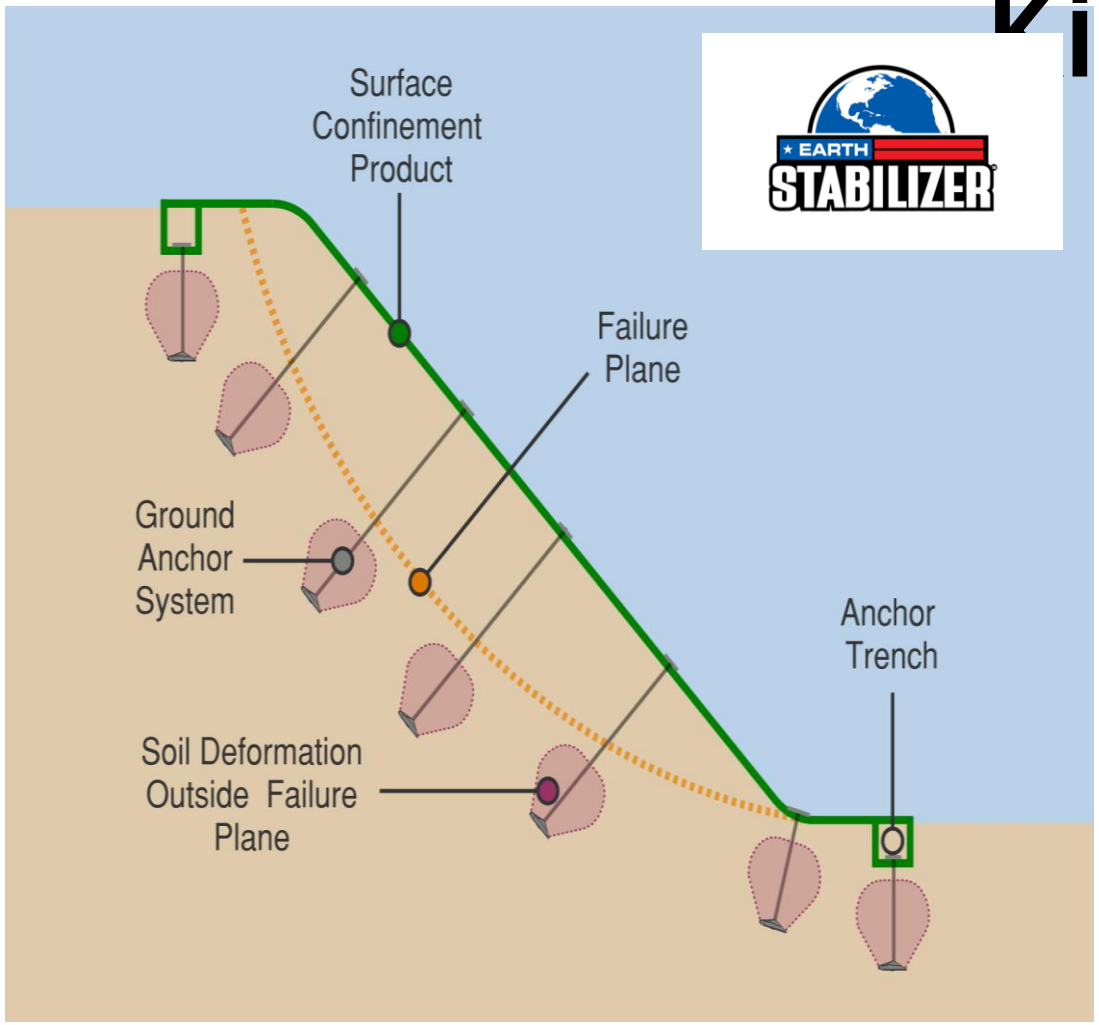
How it Works
Terra-Lock® Earth Percussion Anchor Kits



Once the anchors reach past the failure zone, the developed frustum cone applies subsurface tension to achieve a dynamic load and compress the soils to achieve the bearing capacities needed to stabilize the slope.

- Twist Pins are used to provide the intimate contact needed between the TRM and surface of the slope or channel. TRMs provide the erosion control portion of the design.

KEY BENEFITS

- Environmentally friendly – No grouts, reduced carbon emissions.
- Fast, easy installation with limited earth disturbance.
- Economically friendly compared to other stabilization methods.

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Slope Stability Solutions Examples

The data on the following slides was compiled through utilization of 2D software to determine factor of safety.

- The system integrates two established techniques to effectively manage surficial erosion, safeguarding the slope against sheet flow and raindrop impacts. Additionally, it offers a shallow-plane reinforcement to enhance slope stability.

- The integration of penetrating earth anchors and turf reinforcement mats offers a rapid installation process and delivers instant measurable outcomes in addressing the persistent issue of transitional and shallow-plane failures that affect the engineering community nationwide.

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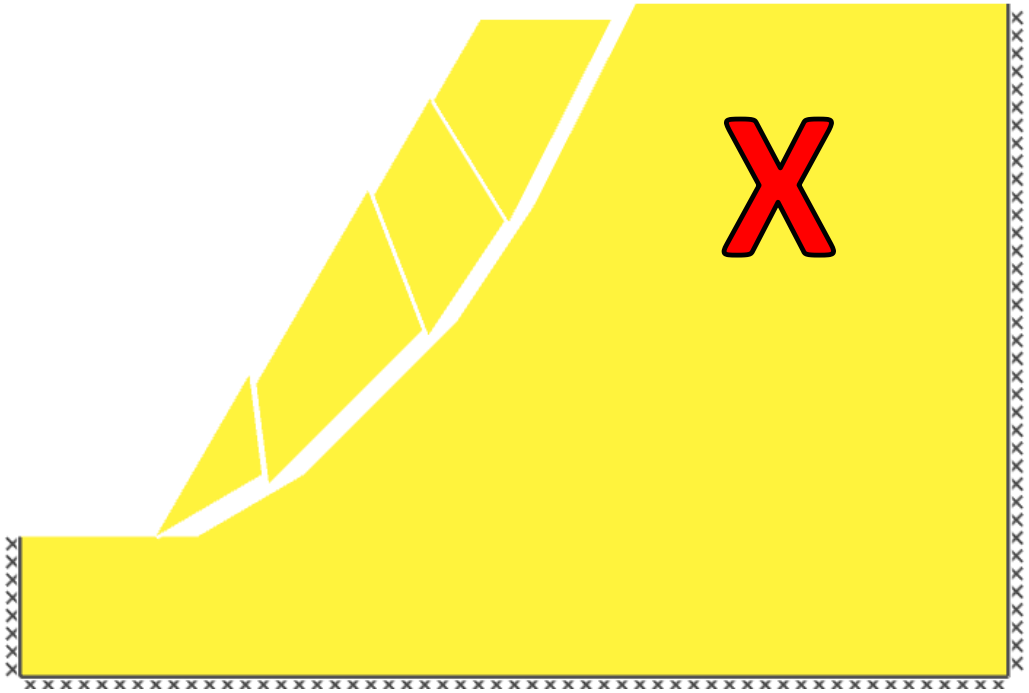
Slope Stability
No System

Input Parameters:

- Slope Height = 30m or 98.5’
- Cohesion, c = 30 kPa
- Angle of Internal Friction, ϕ = 30°
- Slope Angle = 60°

Safety Factor	0.973

Unmitigated Slope



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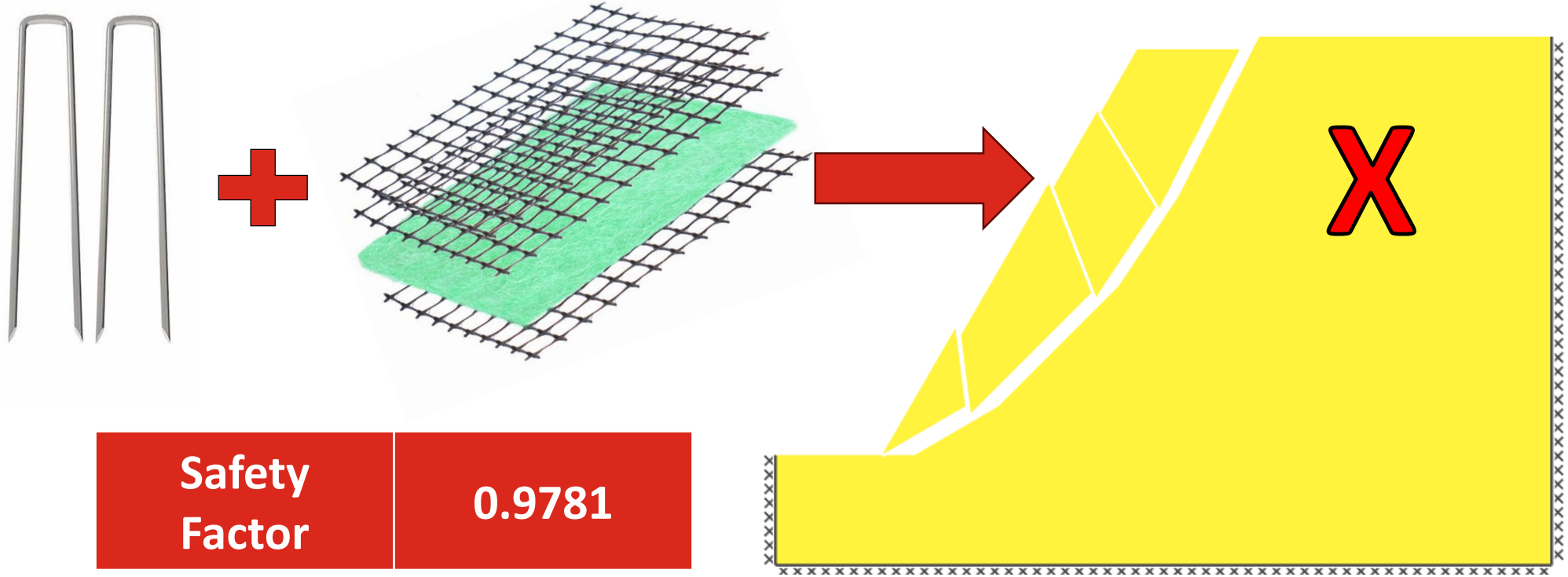
Slope Stability
Using TRMs and Pins



Safety Factor	0.9781

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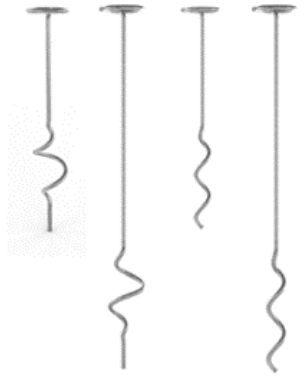
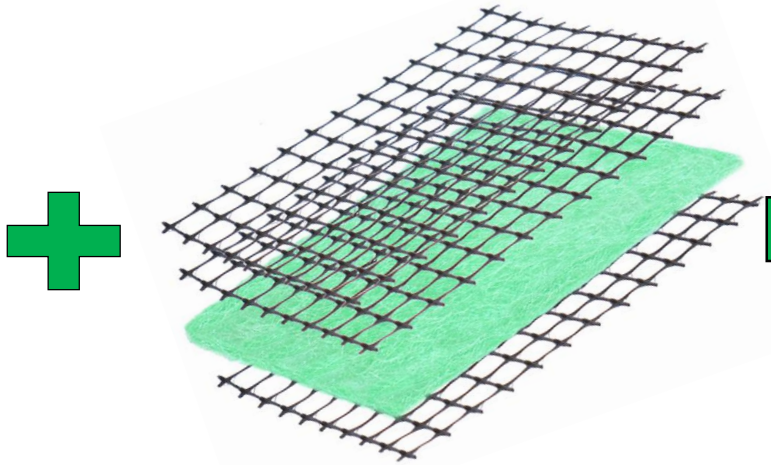
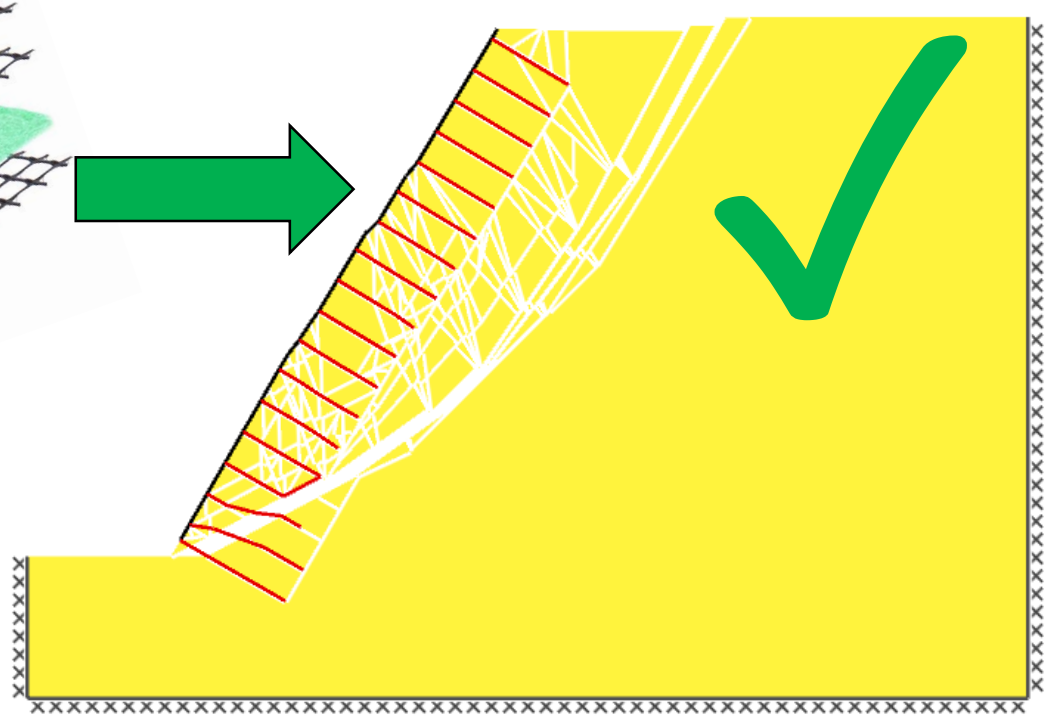
EarthStabilizer™ Solutions Using Terra-Lock PEAs, Twist Pins, and TRMs







Safety Factor	1.52

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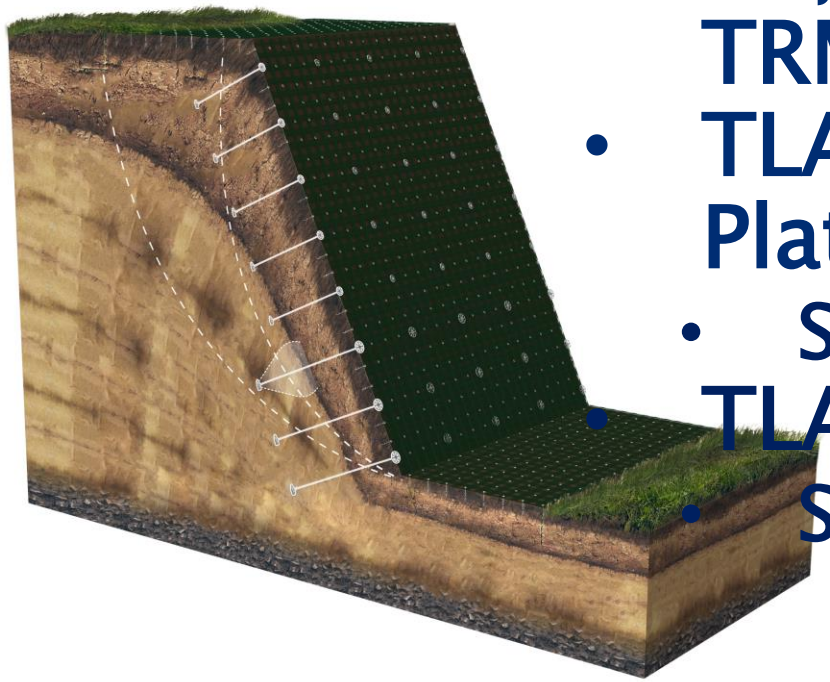
Products Used to Stabilize Example Slope



- 20,000SY of TriNet Recyclex TRM
- TLA5 Anchors & TL808 Bearing Plates
  - Spacing Pattern = 1.5SY
- TLA2 – 12” Twist Pins
  - Spacing Pattern = 1SY

Installation depths ranged from 6’ to 9’ which provided 4.5 kips of pullout resistance per anchor.

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How Do We Solve the Problem with EarthStabilizer™?

Two-Part Analysis Based on Anchor Selection and Slope Stability – Part 1

1. **Anchor Selection:** Helps determine the appropriate anchors to support the TRM or other BMP used for erosion control.
   - **a. Geotechnical Report**
     - i. Soil classification
     - ii. Soil density, friction angle, cohesion, Atterberg limits, etc.
     - iii. SPT boring logs including depths, soil descriptions, and blow counts or N value.
   - **b. General Slope information**
     - i. Slope gradient, 1:1, 2:1, etc.
   - **c. Loading information**
     - i. Hydraulic shear max in lb/ft2 or kN/m2 are perfect to determine maximum loading.
     - ii. Any other loading that may be applied to the slopes. This will vary depending on the situation.
   - **d. Surface protection used**
     - i. TRMs and/or other BMPs

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How Do We Solve the Problem with EarthStabilizer™?

Two-Part Analysis Based on Anchor Selection and Slope Stability – Part 2

2. Slope Stability: This focuses on determining the global stability of the slope to prevent large failures, beyond erosion control.
   a. **Slope Cross Sections (Critical Sections)**
      i. The most efficient format is a simple 1:1 line drawing of the critical slope(s). A .dwg AutoCAD drawing is preferred but can redrawn from a PDF if needed.
      ii. Water table information. This is typically included in the Geotech, but it can influence the stability of the slope.
      iii. Acceptable Factor of Safety. This is dependent on client comfort, risk of failure, and other factors. US Army Corp of Engineers typically require 1.3 – 1.5 for designs however this is dependent on the client.

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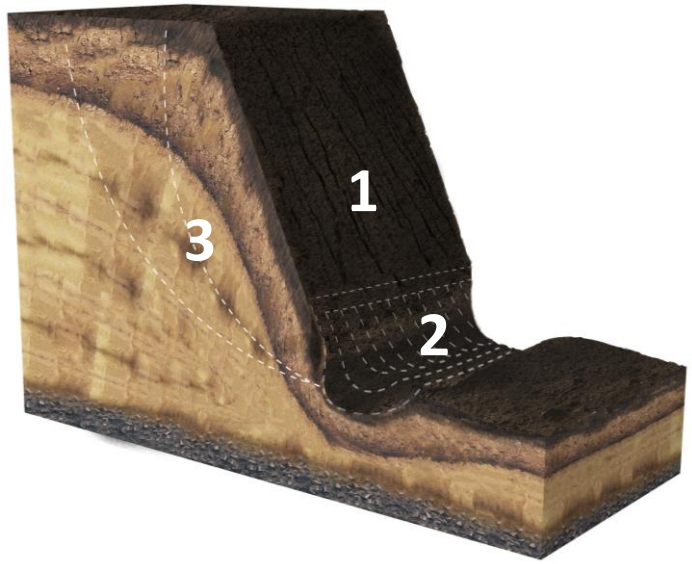

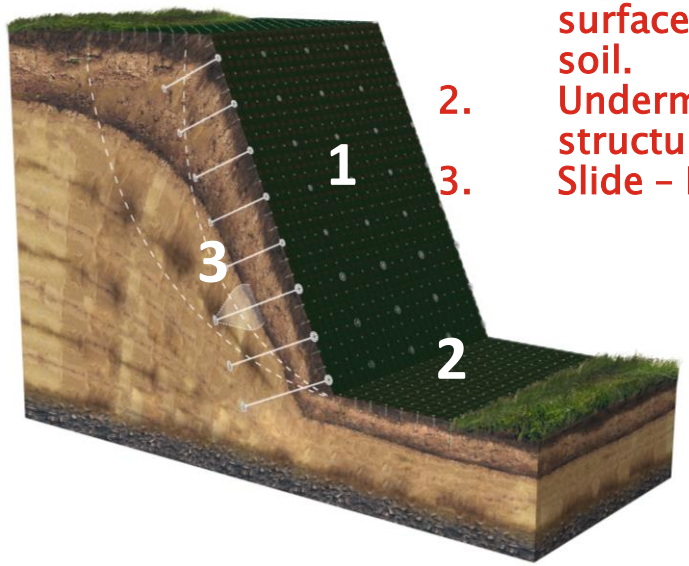

1. Slip – Transitional slip surface, shallow mass of soil.
2. Undermining of the structure.
3. Slide – Rotational sliding.

1. The facing material (TRM) stabilizes and traps surface materials, water and nutrients into the cut; its open 3D structure aids the rapid development of vegetation, the roots of which form a complex matrix with the TRMs reinforcing nature. This structure, combined with anchors, allows the loads caused by failures to be spread across the whole system delivering high performance.
2. Fixing the facing material with Terra-Lock pins prevents uplift to ensure development of a natural cohesive matrix with the TRM. The pins also work with the anchors to stop shallow masses of soil from sliding down the slope.
3. Anchoring the upper sections of the slope prevent surface sliding mechanisms and help to reinforce against erosion. The anchors around the toe of the slope penetrate beyond calculated failure planes to increase stability.

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Benefits Summary

FAILURE PREVENTION	• ACTIVELY HOLDS SURFACE LOCKING ANY MOVEMENT DEEP INTO THE STRUCTURE. • CATCHES AND RETAINS SURFACE FAILURES.
INCREASED FACTOR OF SAFETY	• INSTALLATION DEPTH AND FREQUENCY OF ANCHORS IS DESIGNED TO INCREASE THE SLOPE FACTOR OF SAFETY. • MEANING DURABLE LONG-LASTING STRUCTURES.
STEEPENED SLOPES	• ALLOWS SLOPES AND EMBANKMENTS TO BE MADE STEEPER. • REDUCES GROUNDWORKS AND MAXIMIZES THE USE OF SPACE.
LIGHTWEIGHT	• ADDS NO OVERBURDEN TO THE SLOPE REDUCING THE RISK OF SLIPPAGE OR SUBSIDANCE.

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Benefits Summary Continued

EROSION PROTECTION	• OFTEN AN UNDERLYING CAUSE OF SLOPE OR STRUCTURE FAILURE. FACING MATERIALS PREVENT THESE FAILURES BUILDING UP INTO CATASTROPHIC FAILURE.
INCREASE PERFORMANCE	• FOR SOME GEOSYTHETICS IT CAN INCREASE THE SHEAR PERFORMANCE OF THE MATERIALS BY OVERCOMING SHEAR STRESSES.
SELF TIGHTENING	• THE FASTER THE HYDRAULIC FLOWS THE MORE THE ANCHOR SYSTEM IS FORCED INTO THE FACING MATERIAL HOLDING IT IN PLACE.
MINIMIZES EXCAVATION	• ANCHORS CAN REDUCE AND REPLACE TRENCHING AND ALSO TAKES UP NO SPACE.

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Thank You
Questions?

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