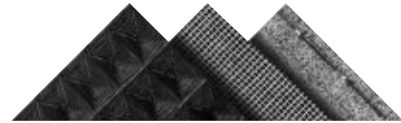




Geosynthetic Products Division
Smart Solutions in Synthetics®

LANDLOK®



Landlok®
Earthstopping Solutions.

Turf Reinforcement Mats

Biotechnical Composites™ in balance with nature.

- ▲ Roadside Ditches
- ▲ Stormwater Channels
- ▲ Detention & Retention Basins
- ▲ Banks & Shorelines
- ▲ Dams, Dikes & Levees
- ▲ Landfill Slopes & Diversion Ditches
- ▲ Steep Slopes
- ▲ Geosynthetic Reinforced Soil Structures
- ▲ Inlet/Outlet Protection



What is Turf Reinforcement?

Turf Reinforcement is a method or system by which the natural ability of plants to protect soil from erosion is enhanced through the use of geosynthetic materials. A flexible three-dimensional matrix retains seeds and soil, stimulates seed germination, accelerates seedling development and most importantly, synergistically meshes with developing plant roots and shoots to permanently anchor this *Biotechnical Composite™* to the soil surface. In laboratory and field analyses, biotechnically-reinforced systems have resisted flow rates in excess of 4.2 m/sec (14 ft/sec) for durations of up to two days, **providing more than twice the erosion protection of unreinforced vegetation**. Proven performance has resulted in the widespread practice of turf reinforcement as a cost-effective alternative to concrete and riprap in the protection of open channels, drainage ditches, detention basins and steepened slopes.

An effective turf reinforcement matrix must endure as an integral part of the *Biotechnical Composite* system. Organic materials are unsuitable for turf reinforcement because they decompose. Degradable materials may temporarily elevate the erosion resistance of vegetation, but once they break down, only unreinforced vegetation remains. Turf reinforcement mattings (TRMs) must be composed of durable synthetic materials stabilized against ultraviolet degradation and inert to chemicals normally encountered in soil.

Synthetic Industries has emerged as the leader in turf reinforcement technology by creating a diverse family of application-specific TRMs. For traditional soil-filled turf reinforcement applications, SI offers higher strength TRMs with sufficient thickness and void space to maximize soil retention and the development of vegetation within or beneath the matrix. These TRMs are typically installed first, then seeded and filled with soil, resulting in superior

performance. For less demanding applications not requiring soil filling, denser, lower profile TRMs have been designed to provide superior aesthetics, long-term ground cover and erosion protection.



Soil-Filled TRM



Non Soil-Filled TRM

Through extensive field and laboratory experience, Synthetic Industries has developed the Landlok® family of TRMs to complement and enhance the physical and biological capability of plants to protect soil from erosion with a proven concept that is **“In Balance With Nature.”**

Designed for “Balanced” Performance

Landlok® turf reinforcement mats are effective from the moment they are installed, providing superior temporary erosion protection, rapid vegetative establishment and outstanding long-term erosion resistance to tractive forces (shear stresses) associated with high flow velocities in steep slopes and channels.

Landlok TRM 1060 consists of a lofty three-dimensional web of **black** polyolefin fibers positioned between two high strength, biaxially oriented nets mechanically bound together by polyolefin stitching to form a dimensionally stable matrix. Landlok TRM 1060 has sufficient thickness (17 mm or 0.7 in) and void space (> 90%), balanced with optimal ground cover ($\approx 75\%$) to allow soil filling and/or retention as well as emergence of plants from beneath or within the matrix. Soil, the “quintessential mulch,” acts as a womb to induce seed germination, nurture seedling development and allow the root system to become entangled with the geosynthetic matrix.

LANDLOK® TRM 1060



Water quality benefits make Landlok® the preferred lining material for stormwater channels.

LANDLOK® TRM 450



Easy to install, lightweight Landlok® erosion mats come in standard widths of 2 and 4 meters (6 1/2 and 13 feet).

Landlok TRM 450 is comprised of a dense, three-dimensional web of **green** polyolefin fibers oriented and mechanically bonded between two nets. This matrix has been designed to be non soil-filled in order to provide maximum erosion protection through increased ground coverage ($\approx 85\%$), while allowing immediate aesthetics and growth of vegetation through the mat. Landlok TRM 450 is generally placed above a seeded surface and relies upon sediment capture rather than soil filling for increased stability. Superior strength, performance and durability separates this TRM from temporary degradable “high velocity” organic blankets.

Research & Development

The bottom line on geosynthetic mattings is proven performance. Through the years, performance characteristics of Landlok® turf reinforcement mats have been extensively monitored through numerous field evaluations, a renowned western US hydraulics laboratory and Texas Transportation Institute's outdoor test facilities. Performance has been quantified using vegetated and non-vegetated mattings versus non-reinforced vegetation or bare soil. The studies developed design windows for TRMs placed over bare soil, filled with soil and fully vegetated. Such information helps provide designers with performance guidelines from time of installation to a mature vegetated condition for the long-term design life of the project.

Results of these studies are presented below in terms of recommended design values of velocity and shear stress for each of the Landlok turf reinforcement mats.

*DOUBLE THE PERFORMANCE OF
UNREINFORCED VEGETATION!*



LANDLOK® TURF REINFORCEMENT MATS MAXIMUM RECOMMENDED DESIGN VALUES

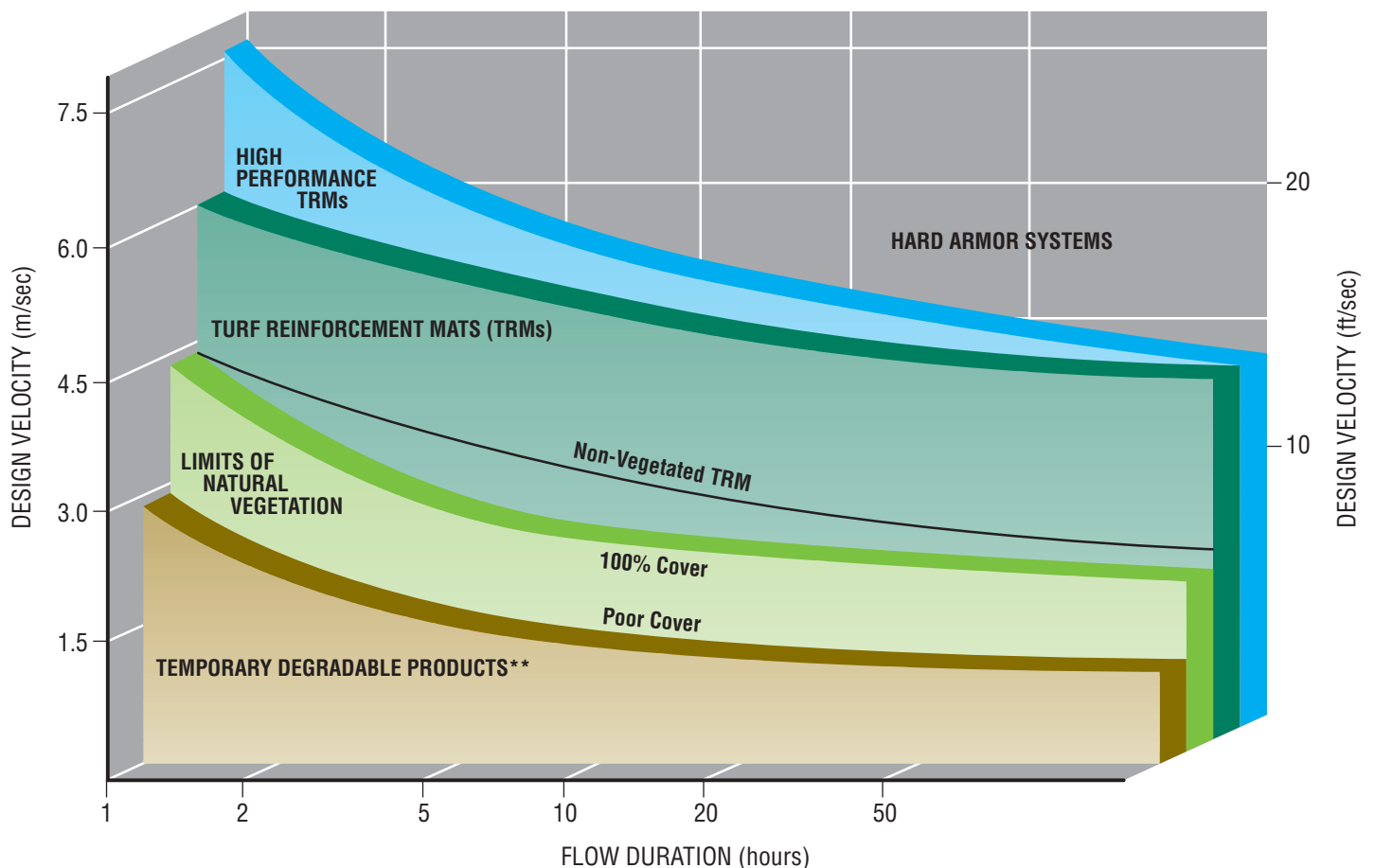
PRODUCT	VELOCITY		SHEAR STRESS	
	SHORT-TERM (1/2 hr)	LONG-TERM (50 hrs)	SHORT-TERM (1/2 hr)	LONG-TERM (50 hrs)
	m/sec (ft/sec)		N/m ² (lb/ft ²)	
LANDLOK® TRM 1060 Non-Vegetated	4.3 (14)	2.4 (8)	285 (6)	95 (2)
Vegetated	6.1 (20)	4.3 (14)	380 (8)	240 (5)
LANDLOK TRM 450 Non-Vegetated	5.5 (18)	2.4 (8)	335 (7)	95 (2)
Vegetated	5.5 (18)	3.0 (10)	335 (7)	190 (4)
NATURAL VEGETATION Class C	1.5 (5)	0.6 (2)	45 (1)	25 (0.5)

Long-Term Performance

The graph below illustrates maximum permissible limiting velocities versus flow duration compiled from existing published evaluations of geosynthetic mattings and classic erosion control studies. Additionally, erosion control materials are grouped into cost-effective performance niches.

Flow values for the various temporary erosion control mulches, blankets, meshes and rovings are footnoted because performance of these materials under extended flow durations has not been reported. From the moment of installation, these materials are vulnerable to short-term, moderate flow velocities. As degradation progresses, long-term performance will be reflected solely in the density of vegetation established, with no reinforcement capabilities. Is temporary erosion protection adequate for your project?

LONG-TERM PERFORMANCE GUIDELINES*



* Based upon long-term (50 hour) flow data.

** Includes erosion control blankets, fiber roving systems, hydraulic/straw mulches, etc.

*PRIOR TO DESIGNING
A PROJECT, DEMAND
LONG-TERM TEST DATA!*

For additional information regarding research and performance data or for design assistance, contact Engineering Services at Synthetic Industries, Geosynthetic Products Division at (800) FIX-SOIL.

Typical Applications

The use of turf reinforcement mats is a well-accepted alternative to hard armor techniques and offers numerous advantages over temporary erosion control measures. When integrated with properly selected vegetation, Landlok® TRMs are ideal for difficult bank protection, slope erosion and flexible channel liner applications. Installation in strict accordance with our published guidelines assures predicted performance on each and every job.

BANK PROTECTION

Clean water lagoons and stormwater detention basins often exhibit fluctuating water levels. As the elevation rises and falls, reinforced vegetation will resist hydraulic forces during drawdown. The use of Landlok turf reinforcement mats provide permanent soil stabilization and root reinforcement to resist erosion and enhance water quality.

SLOPE PROTECTION

When unprotected, even “stable” slopes are subject to erosion from raindrop impact and runoff. The use of Landlok turf reinforcement mats on challenging slopes provide short-term protection and long-term reinforcement of the vegetation. In areas exceeding the performance limits of temporary degradable products (such as open weave geotextiles, fiber rovings or erosion blankets), Landlok is an economical alternative to placement of rock riprap or concrete slope paving.

CHANNEL LINING

In open channels and drainage ditches where high water velocities or shear forces are expected, Landlok turf reinforcement mats and native vegetation create an environmentally superior lining system. These *Biotechnical Composites* allow for more aesthetically pleasing, cost-effective, flexible designs which control erosion, capture sediment, filter contaminants, increase infiltration, recharge groundwater, decrease runoff, possibly reduce pipe sizes and improve wildlife habitat. In highway applications, Landlok “soft armor” designs even benefit traffic safety.



Case Histories

STEEP SLOPE STABILIZATION

The award-winning H-3 Freeway traverses breathtaking tropical mountain scenery on the Hawaiian island of Oahu. Erosion protection of the fragile rainforest slopes presented significant challenges to the Hawaii Department of Transportation (HIDOT). Faced with 100-meter long slopes up to 1H:1V and annual rainfall over 300 cm/year (120 in/year), HIDOT elected to employ reinforced vegetation for slope protection. Due to proven performance, ease of installation and immediate aesthetic appeal, the contractor successfully installed over 100,000 m² (119,600 yd²) of Landlok® TRM 435. Performance of this product was so impressive that a large section of gunite above the Harano tunnels was removed and replaced with this *Biotechnical Composite*.



CANAL BANK PROTECTION

A south Florida water management district administers hundreds of kilometers of navigational canals. Wave action caused by boats, winds and storm activity creates severe bank erosion in many areas. In an effort to eliminate this problem, the district decided to utilize the economical combination of rock riprap for wave energy dissipation and Landlok TRM 1061B for splash zone protection on the C-51 Canal. After the sandy 2H:1V bank slopes were graded, this unique TRM – backed with a lightweight nonwoven geotextile – was unrolled and sodded. Landlok TRM 1061B has been in place for two years with no erosion reported after being subjected to storms as violent as Hurricane Andrew.

Proven Performance

STORMWATER CHANNEL LINING

An exclusive housing development constructed near Aspen, Colorado chose Landlok® TRM 1060 over hard armor systems to line over 5 km (3.1 miles) of stormwater drainage channels. Although soft green landscaping and high water quality were the primary design considerations, spring runoffs from 325 hectares (800 acres) of a snow-covered drainage basin suggested riprap channel protection. After performing an extensive open channel flow analysis, the designers determined velocities and shear stresses were within performance limits of the TRM. Landlok TRM 1060 was installed in May 1992 at 41 percent of the cost of conventional rock lining, saving the client over \$250,000 on this award-winning project. Through extensive monitoring, Landlok TRM 1060 is demonstrating excellent performance, improved water quality and is literally camouflaging this network of stormwater channels. For further information, call SI and request Smart Solutions® SM-203.



SHORELINE PROTECTION

The Port of Houston Authority used Pyramat® to minimize erosion on 2H:1V levee slopes constructed using dredged material from the Houston Ship Channel. Installed in February 1994, this unique high performance turf reinforcement mat was used as a cost-effective alternative to riprap for shoreline protection. Since traditional TRMs are limited to unidirectional flow on inland waterways, Pyramat was chosen because of its superior tensile strength and durability. Pyramat, the next generation in turf reinforcement technology, was installed in intimate contact with the soil but not soil filled and seeded as recommended. Despite these deficiencies and the challenge of 2-meter (6.5-foot) wave attack, the three-dimensional woven geotextile maintained a stable levee and facilitated species abundance. For further information, call SI and request Smart Solutions SM-207 and our Pyramat product brochure.

These case studies only touch on the vast array of project experience we have. SI maintains extensive case history lists and expanded technical papers that can be requested by calling (800) FIX-SOIL.

Product Selection

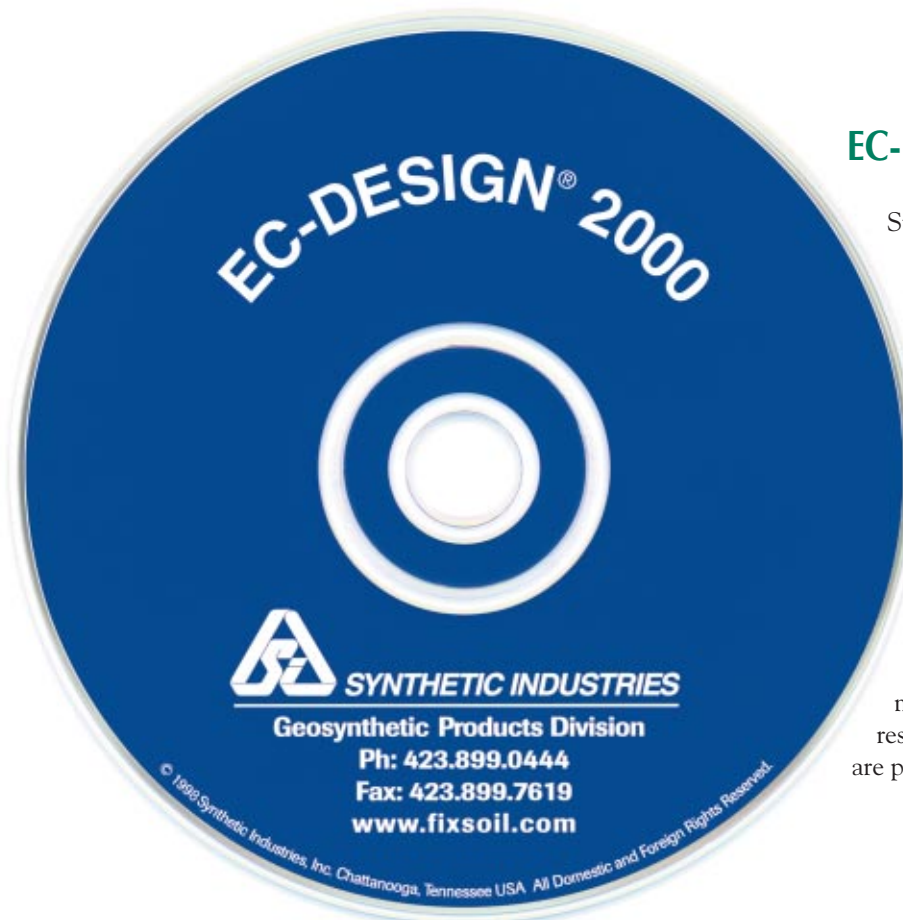
THE RIGHT PRODUCT

Proper selection of erosion control products can be a very complex endeavor. Numerous conditions such as soil type, climate, site geometry, agronomic factors and hydraulic conditions all play a role in this process. Matching the optimum SI erosion control product to the desired application can be estimated using the chart to the right. However, this is only the first step. The most accurate determination of final suitability should be accomplished through design. The maximum permissible design values for each product must be compared to the actual project parameters as the final check for stability and suitability.

PRODUCT	Slope Protection			Channel Lining		Bank / Shoreline	
	1H:1V	2H:1V	3H:1V	Typical Velocities m/sec (ft/sec)	Typical Shear Stress N/m ² (lb/ft ²)	Wave Potential	No Wave Potential
LANDLOK® 407GT / 407GR	–	△	▲	0.6-1.5 (2-5)	23-70 (0.5-1.5)	–	△
LANDLOK FRS 3112 / 3113	△	▲	▲	1.2-2.7 (4-9)	48-96 (1-2)	–	△
LANDLOK TRM 435	▲	▲	△	1.8-4.9 (6-16)	71.8-240.3 (1.5-5.0)	–	△
LANDLOK TRM 450	▲	▲	△	2.4-5.5 (8-18)	96-335 (2-7)	–	△
LANDLOK TRM 1060	▲	△	△	2.4-6.1 (8-20)	96-380 (2-8)	–	△
LANDLOK TRM 1061B	△	△	△	2.4-6.1 (7-20)	96-380 (2-8)	△	▲
PYRAMAT®	▲	–	–	3.0-7.6 (10-25)	144-480 (3-10)	▲	▲
300 mm (12 in) Riprap with GEOTEX® Monofilament Geotextile	–	–	–	–	190 (4)	–	–
Concrete Paving with FIBERMESH® Fibers	–	–	–	> 3 (> 10)	–	–	–

▲ = Primary Application

△ = Secondary Application



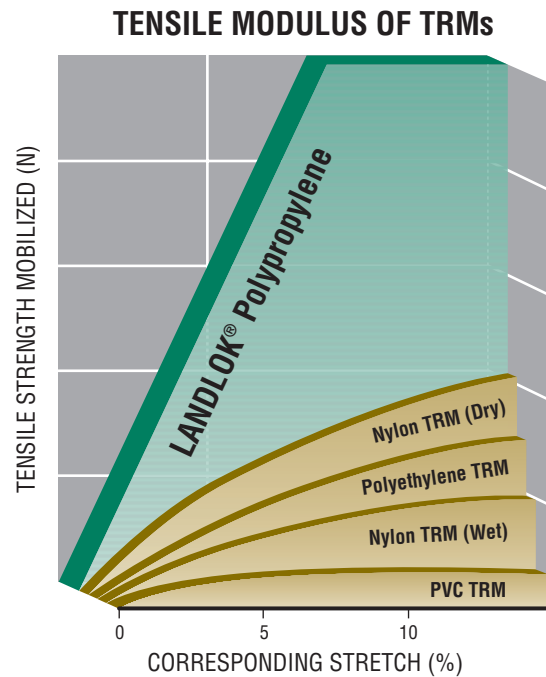
EC-DESIGN® 2000

Synthetic Industries now provides a complete erosion control design computer software program. Using EC-DESIGN® 2000, a user can calculate and select the most appropriate product for a variety of channel and slope erosion control applications. The calculations follow state-of-the-practice Federal Highway Administration (FHWA) procedures including maximum velocity and shear stress analyses, integration of compound channels, soil loss estimations and pull-down window screens. Once the most appropriate product is selected, the results, specifications and CAD drawings are printed or can be saved on a disk.

High Strength Mats

Synthetic Industries manufactures the highest strength TRMs available. How quickly the strength is mobilized (or the mat's tensile modulus) is most important. Excessive elongation (stretching) of a turf reinforcement mat may cause irreparable damage to the *Biotechnical Composite*. At elongations as low as 10 percent, a plant's root system may begin to be ripped away from the matrix and erosion initiated.

At 10 percent elongation, Landlok® turf reinforcement mats provide nearly 3 times the tensile strength of nylon monofilament and fused polyethylene netting geosynthetic mats! As you can see, this benefit increases when the competition gets wet!



SMART SOLUTIONS®

Analyzing and solving civil and environmental problems is our focus. We want to work with you on your next project.

FOR ADDITIONAL INFORMATION, PLEASE CALL:

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Membership Affiliations Include:



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- GEOTEX® woven and nonwoven geotextiles
- GEOTEX® high strength fabrics and geotextile tubes
- PAVE-DRY® asphalt overlay fabrics
- LANDLOK® turf reinforcement mats, erosion control blankets and fiber roving systems
- PYRAMAT® high performance turf reinforcement mat
- GEOFIBERS® 3-dimensional soil reinforcement fibers
- FIBERMESH® synthetic fibers for concrete reinforcement
- NOVOCON® steel fibers for concrete reinforcement

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Pyramat® high performance turf reinforcement mat is covered by U.S. Patents #5,567,087 and 5,616,399. Pyramat is a registered trademark of Synthetic Industries, Inc.

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