TECH FACTS

NORTH AMERICAN GREEN®

Technical Bulletin

Volume 5
Number 2
Feb. 2000

14649 Highway 41 North
Evansville, Indiana 47725

812-867-6632 In Indiana
1-800-772-2040
1-800-448-2040 In Canada
FAX 812-867-0247
www.nagreen.com

# Comparing Composites: North American Green C350™ prevails as the only true TRM

## Introduction

Recently there has been significant professional scrutiny placed on the terminology "or equal" and its legal ramifications of being required in specifications. When designing a project, there are numerous considerations an engineer must address in the selection and use of materials. The actual selection of materials is often determined through either well-substantiated testing or personal experience with a product's past performance. Pending approval by the specifier, the "or equal" clause in a specification allows another product to replace the originally specified material. The submitted "or equal" product often claims the same level of performance or improved performance at significant cost savings to the consumer, but often these claims are unsubstantiated.

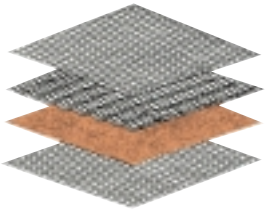
This conundrum is exactly what has been occurring in the rolled erosion control products (RECPs) industry since North American Green introduced the C350™ with its composite turf reinforcement matting (C-TRM) technology. The C350 is a permanent turf reinforcement matting (TRM) that provides superior erosion control and vegetation reinforcement when compared to 100% synthetic TRMs as demonstrated in research conducted at Utah State University (Urroz, 1993). The C350's enhanced laboratory and field performance has lead to the development of "composite" mattings by other manufacturers.

**Figure 1. Schematic of C350 composition**

**Material Composition**

**1. Top Net**
Extra heavyweight UV stabilized polypropylene 8.5 lbs/1000 sq ft (4.2 kg/100 sq m)

**2. Middle Net**
Extra heavyweight UV stabilized polypropylene, crimped 20 lbs/1000 sq ft (9.8 kg/100 sq m) approx wt



**3. Coconut Fiber**
0.5 lbs/sq yd (0.27 kg/sq m)

**4. Bottom Net**
Extra heavyweight UV stabilized polypropylene 8.5 lbs/1000 sq ft (4.2 kg/100 sq m) approx wt

**Thread**
UV stabilized polypropylene

## "Composite" Mattings

A few examples of manufacturers trying to copy the advanced properties of the C350 are Colbond's Enkamat® Composite P/T (a.k.a. Greenfix America CF072RP), Synthetic Industries, Inc./Bon Terra America's CP2, and American Excelsior's Enforcer™ II (see Fig. 2.). Of these three other manufacturer's products, only the Enkamat C has a permanent three dimensional reinforcement structure. However, the Enkamat's permanent structure (without organic matrix) does not meet the Federal Highway Administration (FHWA) specification for minimum TRM thickness (see Table 1). Without the specified thickness there is limited interaction of the vegetation and the matting's permanent structure, potentially resulting in reduced vegetation reinforcement.

## Erosion Control Indices

Tensile strength (both initial and after exposure to UV radiation) and thickness are two physical properties paramount in discerning the turf reinforcement effectiveness of a TRM. Furthermore, these two physical properties are important indices of a matting's durability to survive installation and resist design shear forces both before and after vegetation establishment. The tremendous importance of these physical properties is further corroborated by physical property requirements established in the Federal Highway Administration's FP-96 Standard Specifications for Turf Reinforcement Mats (see Table 1).

The information contained in Table 1 provides data on the physical properties of several commercially available C-TRMs compared to the federally mandated physical properties required for turf reinforcement mats expressed in the FHWA specifications. This data clearly shows that only the C350 exceeds all the physical properties listed in the federal specification, both with and without the coconut fibers present. Only one other "composite" matting, the Enkamat Composite P/T, appears to meet the required properties. However, the thickness of the P/T's permanent structure (without organic component) is significantly deficient of the federal requirement. The two remaining mats fail to meet the required thickness, even with their degradable organic component present.

**Figure 2. Composite mattings with permanent and organic components in tact with thickness directly measured for samples.**

**C350**
**(16.9 mm thick)**

**Enforcer II**
**(8.7 mm thick)**

**CP2**
**(10.7 mm thick)**

**Enkamat Comp P/T**
**(10.2 mm thick)**

**Table 1. Physical properties of composite mats as listed in GFR Specifier's Guide 2000**

| **Material** | **Tensile Strength ASTM D 5035 (MD x TD)** | **Thickness Complete mat/Permanent structure ASTM D 5199** | **UV Resistance ASTM D 4355[1]** |
|---|---|---|---|
| ***FHWA Specification[2]*** | ***1.37 x 0.79 kN/m*** | ***13 mm min.*** | ***No value published in FP-96 80% (FP-92)*** |
| **C350** | **8.74 x 13.11 kN/m** | **16 mm/14.2 mm[3]** | **100%** |
| Enforcer II | 6.6x 8.5 kN/m | 12.7 mm[4] /no value denoted | 90% |
| CP2 | 3.65 x 2.19 kN/m | 6.35 mm/no value denoted | 90% |
| Enkamat Comp P/T | 2.6 x 1.2 kN/m | 13 mm[4]/no value denoted | 80% |

[1] Tensile strength retained after 500 hour exposure in a Xenon-Arc Weatherometer.
[2] FHWA TRM requirements to meet Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects, FP-96 (1996), Section 713.07 Type 5 – TRMs.
[3] Taken from manufacturer supplied literature.
[4] Note value listed by manufacturer and actual sample thickness denoted in Figure 2 of this document.

Why must a C-TRM have a permanent three dimensional structure like the C350? If no significant structure is present after degradation of the organic component, the matting will be limited in the degree of vegetation reinforcement it can provide. Essentially, these other products are more aptly classified as long-term temporary ECBs since all that remains after their organic components degrade are a couple of two dimensional nets with little or no turf reinforcement capabilities (see Fig. 3.).

**Figure 3. Composite matting's permanent structure after organic matrices have been removed. C350's permanent structure is significantly thicker than the other "composite" mattings and the only one able to meet FHWA TRM specification requirement for thickness (see Table 1 above).**

**C350**
**(13.7 mm thick)**

**Enforcer II**
**(2.1 mm thick)**

**CP2**
**(0.25 mm thick)**

**Enkamat Comp P/T**
**(5.8 mm thick)**

## Research - The Key To Success

The C350's advanced and patented design (U.S. Patent #5,849,645) combines a permanent three dimensional netting structure and long-term temporary organic fibers, melding the best performance properties from TRMs and erosion control blankets (ECBs). This combination of synthetic and organic materials has been proven through extensive research to significantly improve erosion control and permanent turf reinforcement capabilities through all phases of a vegetative channel liner's development. On the other hand, many competitor's mattings have been placed on the market with little or no definitive research that we are aware of which substantiates their performance capabilities.

Research data is limited or simply does not exist on the performance of the competitor's emerging products through all the developmental phases of a reinforced vegetated channel liner. One must question their permanent turf reinforcement capabilities since they lack the basic components required to be categorized as TRMs, specifically, a permanent substantially three dimensional reinforcement structure. By omitting this extremely important aspect, other C-TRMs cannot be expected to provide the same level of erosion control and turf reinforcement as the C350.

## Field Performance Research

The C350 has been subjected to extensive third party performance and physical testing to quantify its ability to effectively and permanently control soil erosion and reinforce vegetation. A prime example of research demonstrating the performance of the C350 occurred in outdoor flume testing at the Texas Transportation Institute (TTI). This testing shows the increased erosion control performance provided by the C350 in comparison to some of the other newly released competitor's "composite" mattings that do not contain a permanent three dimensional structure. The C350 significantly out-performed all of the competitive products in preventing soil loss from the vegetated channels (see Table 3.). This further substantiates the claim that a permanent three dimensional netting structure is paramount in providing effective erosion control and turf reinforcement.

**Figure 4. The C350 just after surface application in the test channel.**

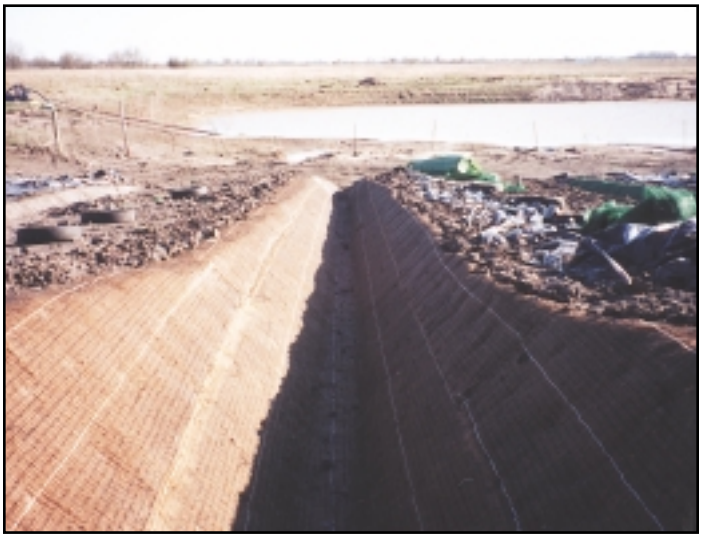
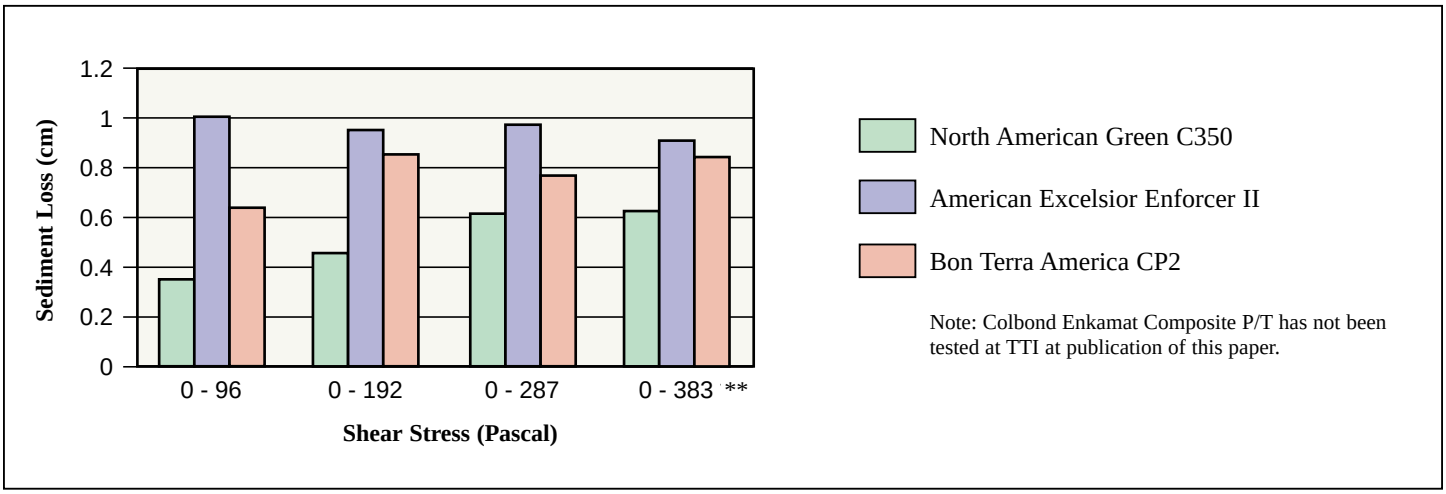


**Figure 5. Flow induced shear force testing being conducted after the 90 day grow in period at the Texas Transportation Institute.**

**Table 3. Channel test results of product performance as published in the February 12, 1999 performance analysis report from the TxDOT/TTI Hydraulics and Erosion Control Laboratory (Northcutt and McFalls).**




** Enforcer II failed (not approved for use on Texas Department of Transportation projects in excess of 0-6 lbs./ft$^2$ flow induced shear stress) at this level of testing due to sediment loss in excess of TTI standards.

While testing conducted at TTI does provide important performance data on various types of mattings, it is not a true indicator of a product's long-term performance properties. Channel testing at TTI is conducted approximately 90 days after matting installation, which leaves much of the organic matrix present in the mattings at the time of testing. Further testing must be provided to substantiate the long-term performance of a C-TRM after significant degradation of the organic matrix has occurred. The C350 has been subjected to this type of testing whereas no such research has been conducted (at time of printing) on the other mattings.

## Unvegetated and Fully Vegetated Testing

Prior to the release of C350 in 1994, North American Green subjected it to rigorous, in-depth performance testing at Utah State University's Water Research Laboratory to define its performance limits. During testing, the unvegetated, partially vegetated, and fully vegetated C350 was exposed to varying intervals and levels of flow induced shear forces and velocities at the Utah State University laboratory (see Figures 6 and 7). Immediately after surface installation, with the coconut fibers present, the C350 was exposed to flow velocities in excess of 9.5 feet per second (fps), exerting 3.2 pounds/square foot (lbs/ft$^2$) of shear stress, before allowing 0.5 inches of soil loss from beneath the matting. Even more noteworthy, in a fully vegetated state with the coconut fibers significantly degraded, the C350 resisted failure by high velocity, 18 fps flow, exerting shear stresses in excess of 8 lbs/ft$^2$, for up to 60 hours (to receive further information on this study contact North American Green)!

**Figures 6. and 7. The C350 was subjected to extensive research, both unvegetated and fully vegetated, at Utah State University's Water Research Laboratory.**

**Unvegetated C350** **Unvegetated P300**

**C350 Reinforced Turf** **Unreinforced Turf**
*(permanent 3-D structure w/o coconut)*
*Note discoloration of outflow due to sediment in unreinforced turf section.*

## Durability and Long-Term Performance

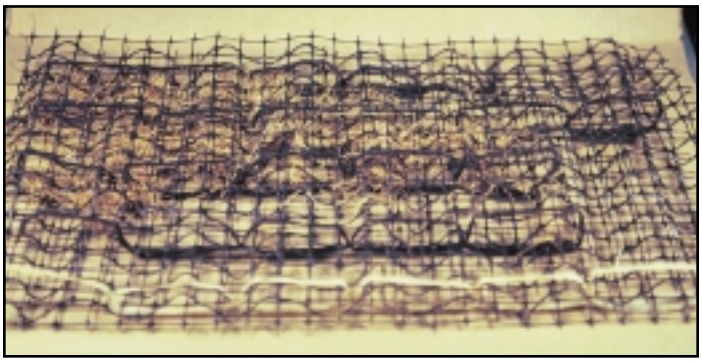
Long-term field testing has also been conducted to further quantify the durability of the C350's permanent three dimensional netting structure. Samples of the C350's permanent net structure were exhumed from a South Carolina channel nearly five years after installation and subjected to physical testing to analyze its durability. After five years of exposure to ultraviolet radiation and field induced weathering, the physical testing results for the field samples demonstrated that the permanent net structure still maintained nearly all of its original physical properties considered important for turf reinforcement, including tensile strength and thickness. More noteworthy is the fact that after being exposed to nearly five years of environmental extremes in a field installation, the C350's permanent netting structure still nearly equaled and in most cases exceeded the original tensile strength and thickness of the other "composite" mattings (see Tables 1 & 4 and Fig. 3).

**Table 4. C350 physical property test results after 5 years of exposure to field conditions.**

| | | |
|---|---|---|
| Exhumed Sample of C350 | Thickness = 14.6 mm (0.57 in) | Machine Direction Tensile Strength 5.9 kN/m (411 lbs/ft) |

**Figure 8. Almost five years after the C350's installation, this close-up view shows the extensive interaction that has occurred between the vegetation's root/stem structures and the C350's permanent three-dimensional netting structure.**


**Figure 9. The C350's permanent net structure still maintains its three-dimensionality (thickness) and strength after nearly five years of weathering and UV exposure in two South Carolina roadside channels.**



## Conclusion

The significantly improved erosion control and turf reinforcement capabilities of North American Green's C350 composite turf reinforcement matting has resulted in an onslaught of other matting manufacturers hustling to get composite products on the market. As a result of their haste, the research needed to substantiate their mattings performance is often compromised or severely limited at best. When reviewing the test data on C-TRMs, or any TRM for that matter, it is paramount that its physical and performance properties be assessed through all three phases of the vegetation's development. If there is little performance test data available to support the manufacturer's claims, the submitted matting should not be accepted as an "or equal," no matter what the cost savings. Other manufacturers may claim their products to be equivalent to the C350, but are they effective in providing the same level of durability and immediate and long-term performance? If your project's channel design is hinged on the improved performance benefits of the C350's C-TRM technology, can you really afford to accept a product that is anything less? Based on the comparison of physical properties, durability, erosion control performance, and turf reinforcement capabilities, C350 prevails as the only true C-TRM in the erosion control industry.