40 Years of Slope Surface Stabilization Evolution

Turf Reinforcement Mats (TRMs) with fibers from 100% recycled post-consumer goods were invented in the early 2000s. Photo courtesy of American Excelsior Company.

The year 1974 was historic for many reasons. How could anyone forget events such as President Nixon resigning or Hammering Hank Aaron surpassing Babe Ruth's all-time home runs record? The year will also be remembered by many as the year Land and Water Magazine was born. The next 40 years would see a plethora of advancements in slope surface stabilization. This article will discuss some of the regulation, products, organizations, manufacturers, and Department of Transportations related to slope stabilization and how they have evolved since 1974. For clarity, slope surface stabilization involves surface erosion processes only and does not consider slope subsurface stabilization activities, which involve different physics. In addition, not every best management practice (BMP) is discussed herein because there are so many tools in the tool box that

an article exclusively on products could be written. No products or solutions were intentionally omitted from this article, but please keep in mind the author was asked to focus on mulch and rolled erosion control products (RECPs) related to slope surface stabilization and how this segment of the industry evolved over the past 40 years.

Litigation

Sediment is only one of the many pollutants that can be carried by storm runoff. The United States Environmental Protection Agency (EPA) reports that sediment is the largest pollutant of our nation's water bodies on a volume basis. Disturbed slopes can be a major source of sediment, if not addressed properly. The need for sediment control practices can be reduced greatly by implementing sound slope surface stabilization techniques that keep the soil on the slope and prevent it from ever becoming entrained in runoff as sediment.

Unfortunately, back in 1974 slope surface stabilization techniques were not followed just because people "thought it was a good idea." Most were not going to spend time and money on slope surface stabilization if they did not have to. In addition, the detrimental effects of soil erosion were not as universally known as they are today. The EPA was four years old in 1974. The Clean Water Act was only two years old in 1974 so litigation had begun, but the administration of the new program was still gaining steam.

In 1972, the National Pollution Discharge Elimination System (NPDES) was created in Section 402 of the Clean Water Act. Under the new NPDES, discharges of pollutants from any point source into the nation's waters were prohibited unless the discharge was covered by a NPDES permit. One of the main keys that would begin to advance slope surface stabilization awareness was that the program gave EPA authority to regulate discharges into the Nation's waters. EPA began regulating discharges by setting limits on the effluent introduced into a body of water from an operating and permitted facility (EPA, 2014).

In 1977, Congress amended the Clean Water Act to enhance the NPDES program. The amendment made the program more in-depth with a focus from conventional pollutants to toxic discharges. Congress passed the Water Quality Act (WQA)

Curlex®, the first ever Erosion Control Blanket (ECB). Photo courtesy of American Excelsior Company.

in 1987, which required increased monitoring and assessing of water bodies. The goal of the changes was to take the NPDES water quality standards from paper to measurable improvements in the nation's waters. Additional amendments to the Clear Water Act in 1987 required EPA to address stormwater runoff in two phases. Phase I of the NPDES Storm Water Program began in 1990 and applied to large and medium Municipal Separate Storm Sewer Systems (MS4) and 11 industrial categories including construction sites disturbing five acres of land or more. Phase II of the NPDES Storm Water Program was to apply to additional MS4s and construction sites disturbing less than five acres to one acre of land.

Litigation that "forced" maturity and evolution of the slope surface stabilization industry the most was perhaps the implementation of NPDES Phase II in March 2003. Phase II required NPDES permits for disturbed sites as small as one acre. NPDES permits for construction sites now required the owners and operators to implement BMPs to control polluted stormwater runoff or risk potential fines for noncompliance. This was a great shot in the arm for the slope surface stabilization and advocates of clean water industry because it was well documented by this time that unprotected slopes were a major source of sediment-laden (polluted) runoff.

Today, slope protection after disturbance is "part of everyday life" and our Nation's waters are benefiting. EPA litigations over the past 40 years have greatly helped the slope surface stabilization evolve to this level.

Tools in the Toolbox

In the past 40 years we have gained a wide variety of great products for slope surface stabilization; however, not all BMPs perform at the same level. For example, lower end solutions such as base hydraulic mulch may work well on flatter slopes. An additional level of protection in the form of an Erosion Control Blanket (ECB) may be needed for more severe slope applications. Lastly, if long-term reinforced vegetation is needed on the slope a permanent Rolled Erosion Control Product (RECP) or, Turf Reinforcement Mat (TRM), could be the answer. Synergistic BMP combinations can also be powerful solutions to even the most challenging requirements. Conceivably the most important thing to remember about all these tools that are in

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our BMP toolbox is that they all work best when they are properly installed in the appropriate applications.

Choosing the right solution is the key. Keep in mind that all technologies and products have their limitations and advantages. Many items need to be considered when deciding which technology to use. So how do we put this all together and match the right product to the right application and get the job done successfully the first time? Answers to the following six basic questions for slope applications can help get the selection process started:

1. How steep is the slope?
2. What is the length of the slope?
3. What is the soil type?
4. Will the slope receive overland flow from above?
5. How long do I need/want the product to last?
6. Is there a local water source (if considering hydraulically applied products)?

<u>RECPs – Open Weave Textiles (OWTs)</u>

Open weave textiles (OWTs) have been imported from Asia for decades. Like every product or BMP out there, OWTs have their benefits and limitations. OWTs contain large open spaces and are commonly comprised of jute or coir (fibers from the

husks of coconuts) fibers. OWTs can also be derived from non-degradable fibers. The Erosion Control Technology Council (ECTC) defines an OWTs as "A temporary degradable rolled erosion control product composed of processed natural or polymer yarns woven into a matrix, used to provide erosion control and facilitate vegetation establishment."

RECPs – Erosion Control Blankets (ECBs)

An Erosion Control Blanket (ECB) is defined by ECTC as "A temporary degradable rolled erosion control product composed of processed natural or polymer fibers mechanically, structurally or chemically bound together to form a continuous matrix to provide erosion control and facilitate vegetation establishment." ECBs were invented by American Excelsior Company® (AEC) in the 1960s as Curlex®. The first ECBs contained one layer of netting glued to the top of an excelsior (shaved wood fiber) fiber matrix. Curled and barbed excelsior fibers were engineered to provide optimum erosion control and vegetation establishment capabilities. The fiber matrix expands when wetted and contracts as it dries and releases the moisture to the seed bed. This repeated expanding and contracting creates an intimate, Velcro-like connection with the subgrade. The single netted excelsior blanket was the only ECB in 1974. Thus, for several years excelsior blankets "were the slope surface stabilization industry" as far as ECBs went. To this day, excelsior ECBs remain the only ECBs with engineered fibers designed specifically for erosion control and revegetation performance.

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It was not until 1984 that single net straw ECBs were first manufactured. The entire straw blanket process is cheaper than excelsior, but again not all products react or perform the same way. Flat, hollow straw fibers lay on top of the subgrade, thus they tend to work well as mulch blankets assisting germination on flatter slope applications.

Dyed Green Excelsior ECBs offer a "finished look" to slope surface stabilization ECB applications. Photo courtesy of American Excelsior Company.

Around the same time single net straw ECBs were introduced to the toolbox, AEC released the first double netted ECB. Double netted ECBs provided more tensile strength and opened up the door for additional slope surface stabilization applications.

The invention of the green-dyed ECB, QuickGRASS®, by AEC in the mid 1990's, did not increase the performance of the ECB, but it did expand the applications to more urban slope surface stabilizations because of the instant "finished" look after installation customers wanted instead of the mainly brown or tan options.

The company further advanced ECBs in 2001 with the development of Curlex® NetFree™, which still remains the only biodegradable ECB that does not contain netting. The netless product consists of biodegradable curled and barbed excelsior fibers stitched together with biodegradable thread. The innovation helped expand the industry into more environmentally sensitive and urban areas.

Innovation of netless products made plugging on slopes very easy. Photo courtesy of American Excelsior Company.

After 40 years of innovations, a wide variety of ECBs exist today. The most common ECBs now are the time-tested and proven curled and barbed excelsior fiber matrix, basic straw mulch blankets, straw/coconut blends, and coconut fiber ECBs. Today's wider and longer rolls have lowered installation costs and reduced the number of seams between products. Companies constantly have something new in the hopper so, stay tuned to see what's coming next to the world of ECBs.

RECPs – Turf Reinforcement Mats (TRMs)

ECBs work well at temporarily controlling erosion on slopes where the final vegetation provides sufficient permanent erosion control protection. However, as the industry progressed, some slope conditions existed where permanent vegetation alone did not provide sufficient erosion control protection. Thus, Turf Reinforcement Mats (TRMs) were developed. TRMs are defined by ECTC as "A rolled erosion control product composed of non-degradable synthetic fibers, filaments, nets, wire mesh and/or other elements, processed into a permanent, three-dimensional matrix of sufficient thickness. TRMs, which may be supplemented with degradable components, are designed to impart immediate erosion protection, enhance vegetation establishment and provide long-term functionality by permanently reinforcing vegetation during and after maturation. Note: TRMs are typically used in hydraulic applications, such as high flow ditches and channels, steep slopes, stream banks, and shorelines, where erosive forces may exceed the limits of natural, unreinforced vegetation or in areas where limited vegetation establishment is anticipated."

TRMs were just starting to get their feet wet in 1974. Enkamat® was the first TRM on the market, and it was released by Colbond in 1973 (Colbond, 2014). The permanent RECP vastly expanded the slope surface stabilization challenges that could be solved. Numerous unique TRMs would be invented over the next several decades. In 1999 the U.S. EPA published, "A Storm Water Technology Fact Sheet: Turf Reinforcement Mats," which recognized the importance of TRMs as Stormwater BMPs.

AEC developed Recyclex® TRM in 2001, and its fibers are made from recycled

Representative hydroseeder used 40 years ago. Photo courtesy of Finn® Equipment as supplied by Profile® Products LLC.

green soda bottles. Slope surface stabilization applications, such as landfills, relish the environmentally-friendly idea of using the bottles to reinforce the vegetation on the surface of the landfill instead of burying the bottles as garbage within the landfill.

High Performance TRMs (HP TRMs) contain extremely high tensile strength (typically ≥3,000 lb/ft according to ASTM D6818). HP TRMs are commonly used in applications beyond slope surface stabilization, such as levees, where they are installed with earth percussion anchors.

Today, TRMs come in all shapes, sizes, and colors. There are several quality TRMs to choose from, but please remember the importance of matching the right product to the right application. No BMP is a "one size fits all" solution.

Base Mulches – Dry and Hydraulic

Straw mulch has been used to varying effectiveness levels since the early days of slope surface stabilization. Over the years, advancements in tackifiers and application methods (various crimping techniques) have improved the performance capability of blown straw on flatter applications;

Hydraulically Applied Erosion Control Product (HECP) Application. Photo courtesy of American Excelsior Company.

however, large-scale performance testing conducted as part of an EPA grant quantified the relatively low performance capability of blown straw on slope surface stabilization applications as compared to a myriad of alternative options that now exist (Lipscomb et. al., 2006). In addition to ECBs, several mulch-based options provide a higher level of performance than blown straw. Several of these mulch options are Hydraulically Applied Erosion Control Products (HECPs). ECTC defines HECP as, "A manufactured, temporary degradable, pre-packaged fibrous material that is mixed with water and hydraulically applied as a slurry designed to reduce soil erosion and assist in the establishment and growth of vegetation."

Basic HECPs were being used 40 years ago and prior. Common hydraulic mulch products are wood fiber, paper, or wood and paper blends. Hydraulic mulches typically also contain a stabilizing emulsion.

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HECPs – Bonded Fiber Matrix (BFM)

A breakthrough in HECP technology occurred in 1993 when Weyerhaeuser introduced Soil Guard® as the industry's first Bonded Fiber Matrix (BFM) (Soil Guard is a registered trademark of Mat, Inc. today). The invention of the BFM introduced cross-linking chemistry of the polysaccharide tackifiers for the first time. The cross linking technology, after properly drying and curing, increases bond strength, makes them water resistant allowing the product to be hydrated repeatedly, and increases the overall longevity of the matrix as compared to base mulches.

HECPs – Fiber Reinforced Matrix (FRM)

Fiber Reinforced Matrix (FRM) is generally a hydraulically-applied matrix typically containing organic defibrated fibers, cross-linked insoluble hydro-colloidal tackifiers, and reinforcing natural and/or man-

made fibers for the purpose of vegetation establishment and erosion control. Several products available today could match the loose guidelines of FRM presented above. These products are typically wood fiber or coconut fiber based (with additional chemical and/or fiber components).

HECPs – Flexible Growth Medium™ (FGM™)

Flexible Growth Medium (FGM) is similar to a FRM, but there are some key differences. FGM technology was invented and patented by Kevin Spittle in the mid-1990s, so it pre-dates FRM technology. FGM technology was first released to the industry by Profile Products. FGMs were developed to provide an additional level of performance above BFM technology providing enhanced and immediate erosion control upon application as opposed to BFMs that may require a curing/drying period of 24-48 hours depending upon weather and antecedent soil moisture conditions. FGMs contain specific levels of components such as ≥77% thermally refined wood fibers, ≥9% Cross-Linked Biopolymers and Water Absorbents, ≥4% crimped biodegradable man-made fibers, and ≥4% micro-pore granules. The additional advanced chemistry and crimped reinforcing fibers result in higher performance capabilities as compared to most other HECPs.

Industry Organizations

ECTC

Slope surface stabilization products and practices were used during the 70s and 80s, but in the 1990s industry activity skyrocketed. With the increased use of the products and practices came the need for standardization means. Several progressive RECP manufacturers recognized that standardized testing protocol, design specifications, and installation methods were essential to the continued advancement of the expanding industry. In July of 1992, the Erosion Control Technology Council (ECTC) was formed to "self-regulate" its activities and improve the overall use of RECPs.

A lot of advancements have occurred within ECTC since its inception. Today the membership includes manufacturers of erosion control products, fabricators of erosion control products, distributors of erosion control products, consulting engineers, universities and testing laboratories.

This BFM shoot was done as a dormant seeding project, late in the fall of 2012. Dormant seeding is done late in the year, when soil temperatures are too low for germination. The after picture was taken in the Spring of 2014. Location, Prairie Lake in Northern Minnesota.

ECTC is a non-profit organization that is funded through membership dues.

ECTC's original mission was "to be the recognized industry authority in the development of standards, testing, and installation techniques for rolled erosion control technologies." The organization's mission was expanded in 2008 to include Sediment Retention Fiber Rolls (SRFRs) and Hydraulically Applied Erosion Control Products (HECPs). ECTC has provided the industry with many tools and will continue to be an integral arm contributing to the advancement of the slope surface stabilization industry into the future.

ASTM International

ASTM International (known as the American Society for Testing and Materials until 2001) has been another instrumental organization contributing to the evolution and advancement of the slope surface stabilization industry. As previously mentioned, the ECTC formed in 1992 and began working on various test methods related to RECPs initially; however, ASTM has been and continues to be the "gold stamp" of test standards. Recognizing this, several members of ECTC along with testing laboratories, consulting engineers, and others contacted ASTM. In 1996, ASTM D18.25 Subcommittee on Erosion and

Sediment Control Technology was formed under the Main Committee D18 on Soil and Rock.

Through the years framework for several test methods was started at ECTC then brought to ASTM International for review and eventual publication. This relationship has worked well to help advance a quickly growing industry. ASTM D18.25 has been a very active Subcommittee since day one. The Subcommittee currently has 21 active standards on the ASTM books.

In addition, Subcommittee D35.05 on Geosynthetic Erosion Control was formed at ASTM in 1998. D35.05 is under the Main Committee D35 on Geosynthetics. Standards regarding TRM material properties are typically overseen by D35.05. Subcommittee D35.05 has seven active standards on the ASTM books.

Excelsior ECBs on Utility Slope Surface Stabilization Project in 1997. Photo courtesy of American Excelsior Company.

IECA

The International Erosion Control Association (IECA) was only two years old in 1974. Mr. George Harrison, a hydroseeding and tree service contractor from Washington, was the first president of the group. Mr. Harrison helped coordinate the first erosion control conference that totaled around 35 attendees in 1972. The need for an association of erosion control specialists was recognized at the conference, and later that year the non-profit educational organization was formed as the National Erosion Control Association in 1972.

In 1973, the association adopted the name of the International Erosion Control Association to reflect the global emphasis of the group. The year 1976 brought the creation of the organization's first newsletter. The REPORT would be an educational voice of the industry for decades. State representatives began developing IECA Chapters in 1988, which further expanded the educational footprint of the organization in the United States. The next year the first two International IECA meetings were held. In 2007, IECA published Environmental Connection, which was its first member's only magazine to help advance the industry.

Today, IECA remains the largest industry organization focused on erosion and sediment control. Their annual Environmental Connection Conference brings together around 2,000 attendees to network with the top professionals, attend educational and certification courses, visit with vendors to see what's new in the industry, and to have fun.

Manufacturers

Manufacturers have provided a multitude of product innovations over the past 40 years. They have also advanced the slope surface stabilization industry in many other ways. For example, finding material specifications for a product 40 years ago was not the easiest task in the world. Over time, manufacturers created libraries of specifications and other useful design documents. Today, support documentation is accessible at the click of a mouse. Forty years ago hand calculations were the norm. Today, several manufacturers provide free, easy-to-use slope surface stabilization design software programs. Many of the design programs are also available on the Internet like the support documents.

Whether it be for a field day at their large-scale laboratory or a call asking about site-specific questions, manufacturers are a great educational resource. Manufacturers have been an important component of the industry's evolution over the past 40 years, and they still remain eager to help out today.

Years of constant innovation require a dedication to research and development programs by manufacturers. There are several quality public and private hydraulic laboratories available today where manufacturers can push their innovations to the next level to further advance slope surface stability applications. In addition, one manufacturer has even invested into the largest privately owned research and development laboratory of its kind.

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Department of Transportations (DOTs)

Detailed specifications and Qualified Product Lists (QPLs) for slope surface stabilization products by state department of transportations (DOTs) were few and far between 40 years ago. With the Clean Water Act in its infancy, states did not fuly know exactly what was expected or required of them yet. In addition, specification requirements at the time were fairly straight forward because there were only a few slope surface stabilization BMPs to choose from. Simply stating "erosion control" on slopes was sufficient for several years. As more technologies evolved over time states began writing more diverse specifications, which eventually led to the birth of QPLs.

Today all 50 state DOTs have specifications in place for slope surface stabilization products, which is a huge improvement from 40 years ago. In addition, 39 of the state DOTs have some form of a QPL for slope surface stabilization materials. Some states have very detailed specifications to help ensure they are getting the right product for the right application. The evolution of index and performance tests

through organizations such as the ECTC and ASTM International has made this possible. On the other hand, some states still have "generalized" specifications that inadvertently allow very different products into the same applications. In these cases, the low price leader typically prevails, which unfortunately is not always the right product for the right application. Due to this, although state DOTs have made great strides toward performance-based specifications over the past 40 years, the industry still has more work to complete together to bring everyone up to the same level, which will improve the frequency of the right products ending up in the right applications.

Conclusion

It was an honor to write this article on 40 Years of Slope Surface Stabilization Evolution. So much has improved and we are definitely heading in the right direction, but there is still room to get better. This industry has been blessed with so many passionate and talented individuals over the past 40 years who are ultimately the drivers to success. The entire Land and Water staff from day one through today is a prime example of the special people in this industry. Please join me in congratulating them on their 40th anniversary. Thank you for your dedication and contribution to the industry!

I am already thinking of content for the article on the next 40 years of this exciting industry, if I should be so lucky to have that opportunity in the future. What do you think the next 40 years will bring?

Contributions

Thank you to Patti Karpik with Mat, Inc., Kevin Spittle and Marc Theisen with Profile Products LLC, Laurie Honningford with ECTC, Jill DiCicco with ASTM International, and Russ Adsit with IECA for contributing content to this article. **L&W**

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Works Cited

Colbond. 2014. About Us, History. Website: www.colbond-geosynthetics.com.

Lipscomb, C. M., T. Johnson, R. Nelsen, and T. Lancaster. 2006, July/August. "Comparison of Erosion Control Technologies: Blown Straw vs Erosion Control Blankets." Land and Water.

United States Environmental Protection Agency. 2014. National Pollutant Discharge Elimination System Permit Program. Website: www.epa.gov/npdes/.