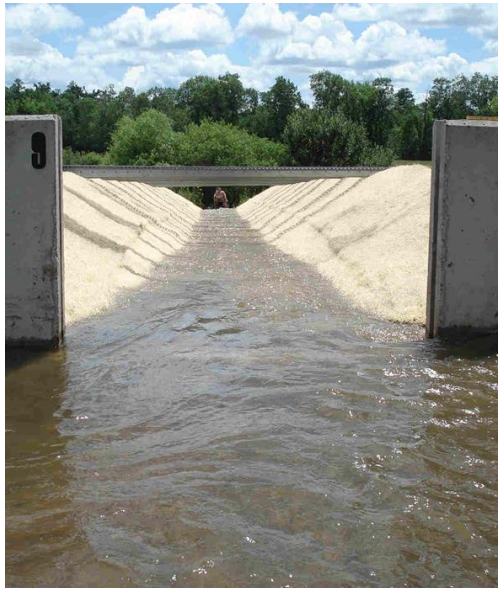


Evaluation of Erosion Control Product Properties, Performance Capabilities, and Failure Mechanisms (Feb. 2022)

Why Do We Do What We Do?

When we break it down into simplistic terms, we are in this industry to protect our soil and water resources. The graphic on the left states it simply as "despite all of our accomplishments we owe our existence to a six-inch layer of topsoil and the fact that it rains." Protecting our precious soil and water resources, as seen on the right, is very important and that is what we are striving for.

Environmental Challenges
What is Our New Normal?

- From the Huffington Post
  - "Climate Change Has 'Loaded The Dice' On The Frequency Of 100-Year Floods" by Chris D'Angelo
  - https://www.huffpost.com/entry/100-year-flood-climate-change_n_59a6eaa3e4b084581a14ea14

- So called 100-year floods are becoming so common that the metric "is pretty much useless now as a baseline for an extreme event."

  - Marshall Shepard, Director of the Atmospheric Sciences Program at the University of Georgia and former President of the American Meteorological Society.

  - "We are in a new normal."

Environmental Challenges
What is Our New Normal?

- From the Insurance Journal
  - https://www.insurancejournal.com/news/southcentral/2018/10/01/503000.htm
  - "Study: Texas to See More Frequent 100-Year Rain Events"

- Decades of additional weather data have led federal officials to reconsider rainfall totals in Texas that define 100-year weather events and caution that extreme rainstorms will strike the state more frequently.

  - The National Oceanic and Atmospheric Administration on September 27 released a study finding that in the Houston area, for instance, 100-year estimates increased from 13" to 18" for a 24-hour period. Rainfall previously classified as 100-year events are now more frequent 25-year events.

Using the Right Product for the Right Application

- **Many BMPs to choose from – this presentation is not about bashing BMPs, but it does point out facts that need to be considered to prevent failures that we are seeing in the field**

- **ECP physical properties (they are mechanically stitched together)**
  - **Bonds**
  - **Composition**

- **Performance capabilities (not always the cheapest option)**

- **Failure mechanisms**

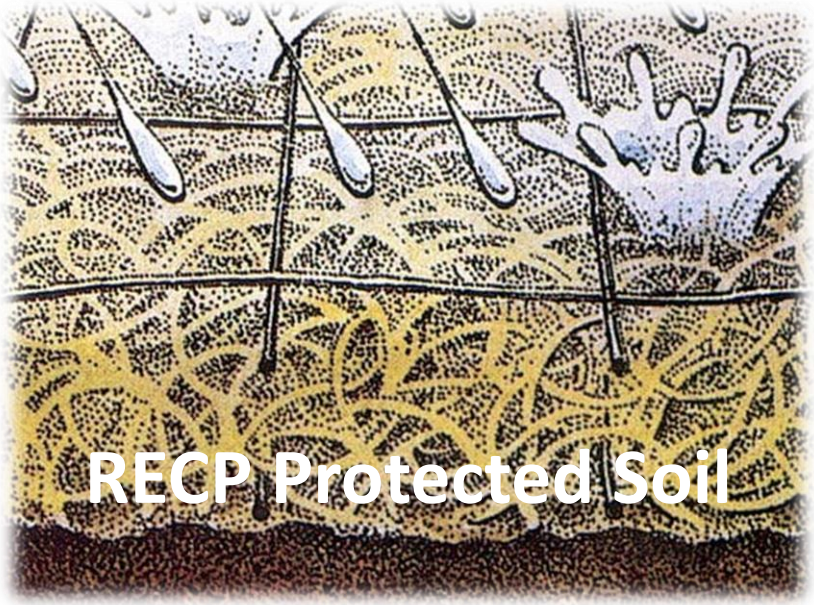
ECPs Can Help Prevent This

Discussion: The soil around this vegetation has eroded and eventually there will be nothing, but eroded soil left. Erosion control products can help prevent this by protecting the soil from erosion and keeping it in place.

What RECPs DO

- Intercept raindrops
- Slow down runoff
- Hold soil in place and prevent it from being washed away, while dewatering the slope
- Provide ideal growing conditions for seeds and plants
- Help prevent fine$
- Saves owner's money

RECP Protection from Rain Splash



Discussion: The photo on the left shows raindrops impacting unprotected bare soil. Rainsplash erosion is shown as well as overland flow in the center of the photo, where the rill is starting. Imagine if there was seed and or soil amendments on the bare soil. They obviously would be washed away. The graphic on the right shows how the matrix of a rolled erosion control product can absorb the raindrop impact and slowly release excess moisture to the soil below, or off the slope depending on the intensity.

RECP Fiber Types

- Coconut
- Straw
- Curlex® Aspen Excelsior (wood)
- Synthetic

Discussion: There are four fiber types commonly used in products for the erosion control industry. AEC manufacturers different RECPs with all four of the fiber types. We have evaluated all of them, so we are able to share the facts about each quantifying why some are better options than others in certain applications.

Coconut Fibers

Discussion: Coconut fibers are imported typically from southern Asian countries such as India, which causes the product to have a poor carbon footprint into North America. Coconut fibers introduce a nonnative matrix into the environment. The dark color of coconut fibers can cause seed burnout before germination occurs in some cases. Coconut fibers inherently contain higher lignin content levels than the other common degradable fiber types, so they degrade a bit slower, which could be desired depending on project requirements.

Straw Fibers

Discussion: Straw fiber are straight, hollow, smooth, and flat, which results in some limitations. Straw fiber is an agricultural by-product that floats in water because of its hollow nature. Because of this, several states do not allow straw in concentrated flow applications such as roadside channels and ditches. Straw products inherently contain seeds some of which could be from noxious weeds. Straw products generally vegetate well in flatter applications that do not see concentrated flows.

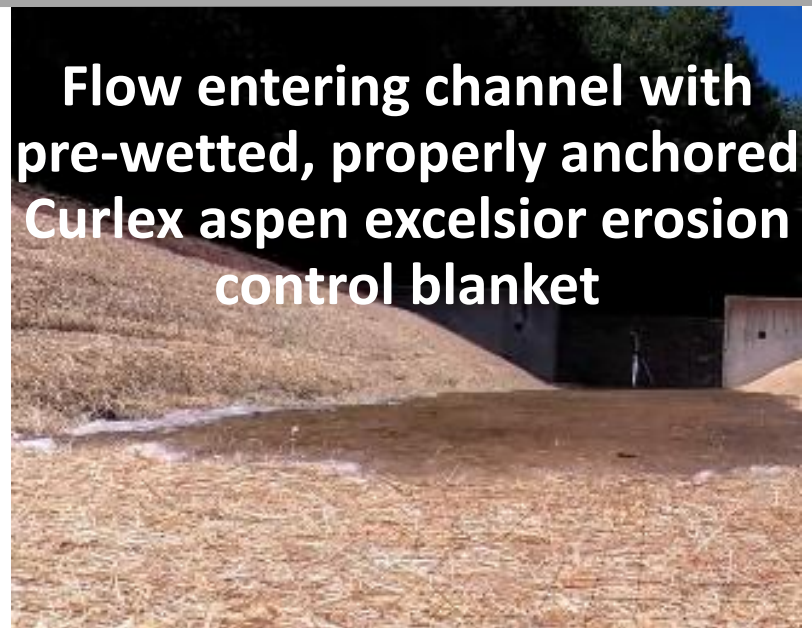
Engineered Curlex® Aspen Excelsior (wood) Fibers

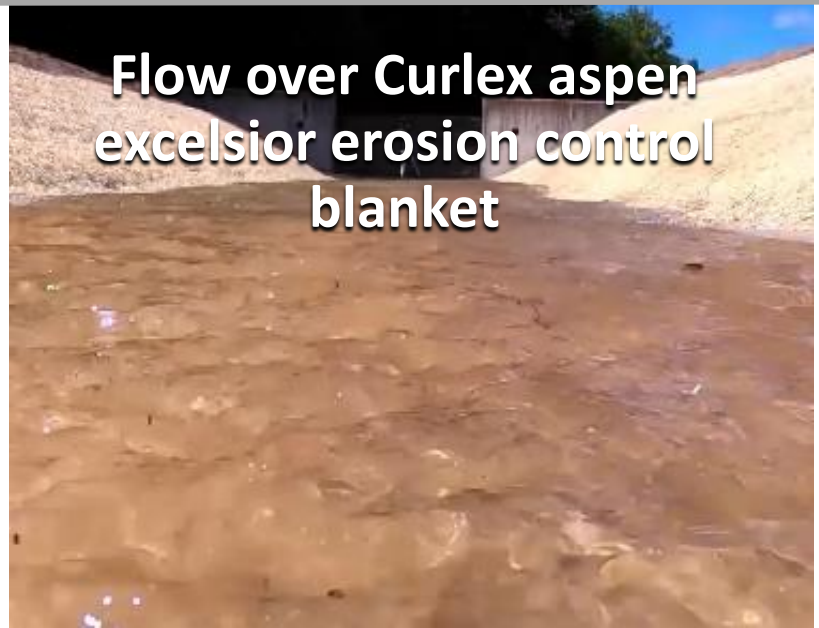
Discussion: Years of ASTM large-scale testing, along with endless field applications, have proven why aspen excelsior's unique properties make it a superior erosion control, sediment control, and revegetation fiber. Engineered Aspen excelsior is free of pitch and other toxins inherent to pine species. The naturally seed free fibers allow for curls and barbs that result in high erosion control capabilities. The fiber matrix provides an ideal "greenhouse-like" effect for seeds to germinate and establish. The unique fiber expands with moisture, which causes it to conform to irregularities in the soil. The rather all-encompassing aspen fiber provides protection from sun burnout, wind, raindrop impact, sheet flow, and concentrated flows.

Fiber Properties & Concentrated Flows

Hollow Straw Fibers

Curlex® Aspen Excelsior Fibers





Results of Fiber Properties During Concentrated Flows

Hollow Straw Fibers

Curlex® Aspen Excelsior Fibers

American Excelsior Company®

Other BMPs Used On Flat Areas & Some Slopes

- **Blown straw**
- **Compost**
- **Hydraulically Applied Erosion Control Products/Hydromulches (some still contain toxic malachite green in their tracer dyes, so be careful not to potentially add unnecessary contaminants to the environment)**

Discussion: BMPs other than RECPs that are used on flat areas and some slopes are blown straw, compost, and hydraulically applied erosion control products to name a few. Netting may be placed over blown straw in rare occurrences. Otherwise, these BMPs primarily rely on crimping or chemical bonds to hold them together and onto the soil.

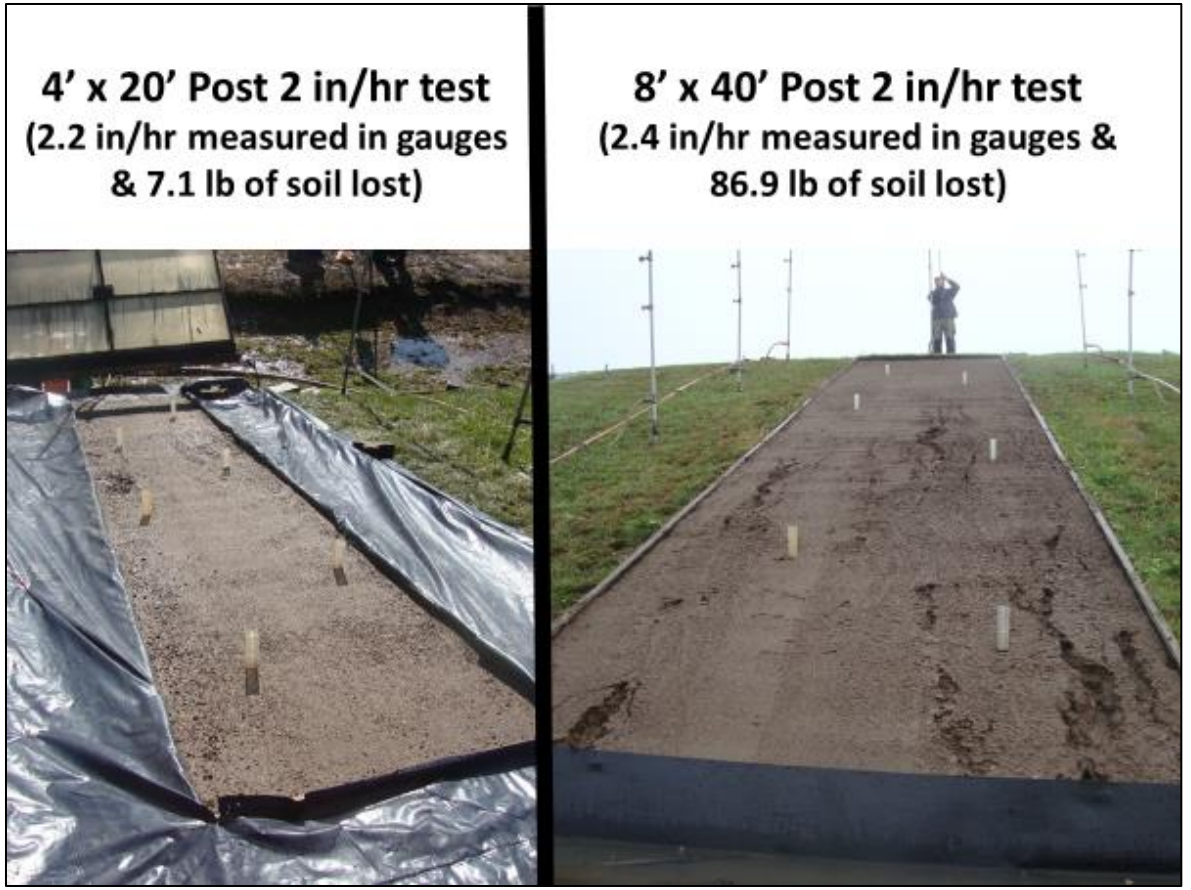
Physical Properties

- Physical vs Chemical bonds
- Excess moisture and weight on slope can be detrimental depending on the event received
- “All or Nothing” failure mechanism
- Biodegradable & Environmentally Friendly options

Discussion: Rolled Erosion Control Products (RECPs) contain physical bonds provided by netting and/or stitching on some products. On the other hand, mulches mainly contain chemical bonds. These differences have their positives and negatives, so understanding them can help ultimately get the right product onto the right project. Some BMPs are basically designed to act as sponges to absorb rainfall during events. This concept can work very well up to a point then mass failure can occur. This is referred to as an “all or nothing” failure mechanism. On the other hand, some products are designed to protect from rainsplash, while also allowing excess runoff to get off the slope while holding the soil in-place. There are biodegradable and environmentally friendly BMP options out there. If you want a biodegradable and environmentally friendly option, make sure to verify any chemicals that may be used because some, such as malachite green, are known to be toxic based on a plethora of published research studies.

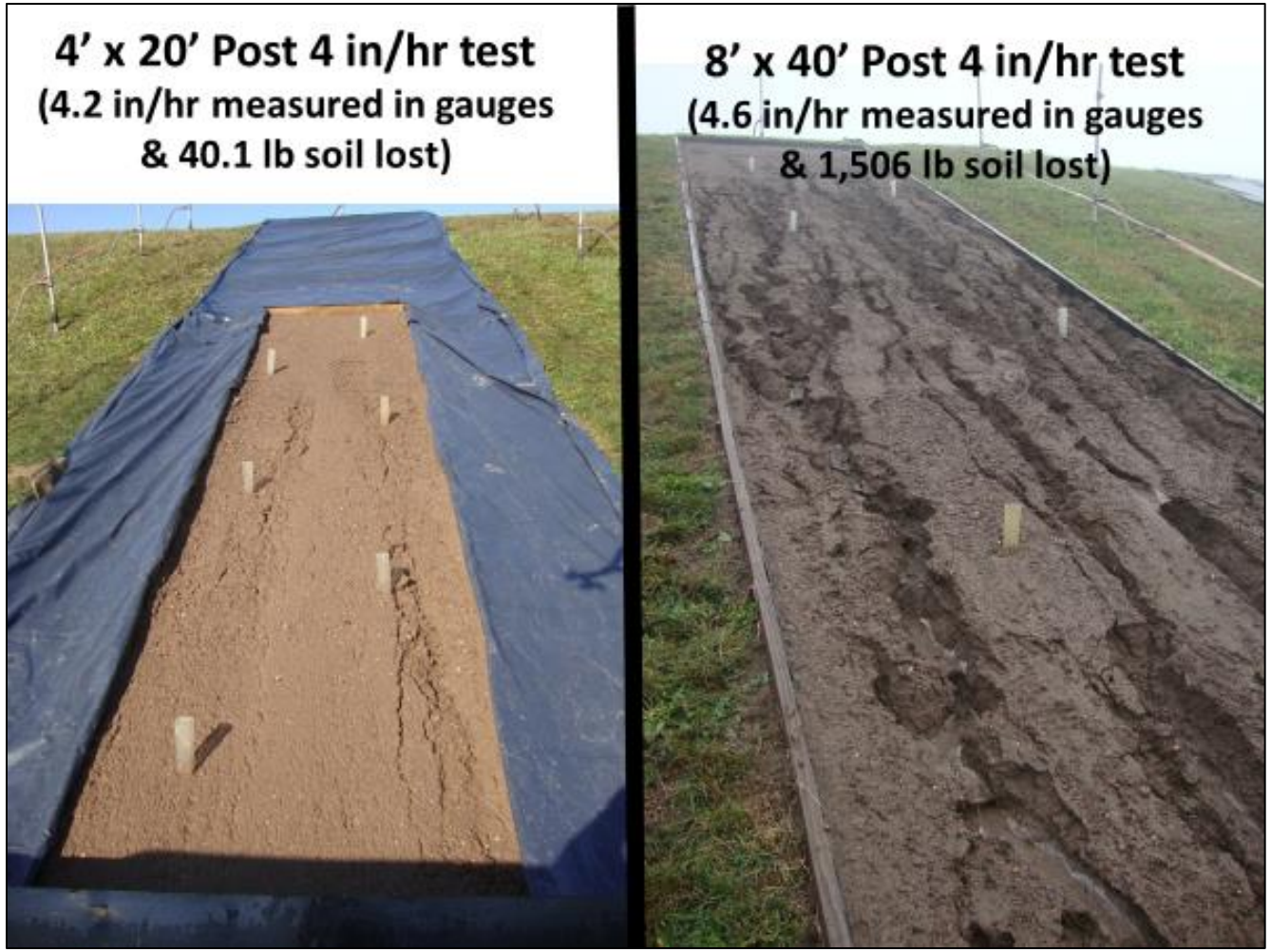
Physical Properties

Discussion: Here's a close up of damage caused by wildlife tracks through an erosion control product that did not have sufficient strength to withstand the force. Once the "crust" of the product was penetrated openings were created for erosion to commence. Over time, this led to rill erosion on the relatively flat site. Would a different BMP with more physical strength have been able to recover better from the large wildlife going across it? Fibers that expand with moisture that are contained by strong physical bonds could have been used because they would have filled in the tracks upon the first rainfall event while maintaining overall system integrity to minimize erosion at the site.



Discussion: Here is a test setup for determining if plot size (length and width) matters to bare soil and ultimately erosion control products on slopes using simulated rainfall.

Conditions were held constant as much as possible with the only variable being plot size. After a target 2 in/hr rainfall event for 20 minutes 7.1 pounds of soil was lost from the 4’x20’ plot and 86.9 pounds of soil were lost on the 8’x40’ plot. Intensities measured on the plots by the rain gauges were 2.2 in/hr on the 4’x20’ plot and 2.4 in/hr on the 8’x40’ plot.



Discussion: Here are the plots following the target 4 in/hr events. Only 40.1 pounds of soil eroded from the 4’x20’ plot as compared to 1,506 pounds from the 8’x40’ plot. Erosion typically starts downslope and crawls its way back up the slope. Thus, it makes complete sense that if you cut half the slope length out of the equation, your erosion potential is greatly reduced. This can be quantified through the RUSLE LS factor as well.

4’x20’ vs 8’x40’ Bare Soil Results

Summary of Results

Plot Size (ft x ft)	Soil Type	Target Rainfall Intensity (in/hr)	Measured Rainfall Intensity (in/hr)	Duration (minutes)	Cumulative Soil Loss (lb)	Cumulative Soil Loss (lb) per Ft^2
4 x 20	ASTM Loam	2	2.2	20	7.1	0.09
8 x 40	ASTM Loam	2	2.4	20	86.9	0.27
4 x 20	ASTM Loam	4	4.2	20	40.1	0.50
8 x 40	ASTM Loam	4	4.6	20	1,506.2	4.7

Discussion: We saw the visual results in the previous slides. Here are the quantified soil loss numbers. Slope length definitely matters regarding soil erosion under simulation rainfall.

Slope Length Matters in the Field

Discussion: Slope length also matters in the field. Imagine in both of these scenarios if the slope length was half of what you see. Do you think the end results would have been different? The BMP used on these sites could not withstand the forces near the end of the longer slopes, so erosion commenced and led to serve soil loss that required the site to be redone. Matching the right product to the right application to start with saves money in the long run.

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Rills – Mother Nature's Way to Dewater Slopes

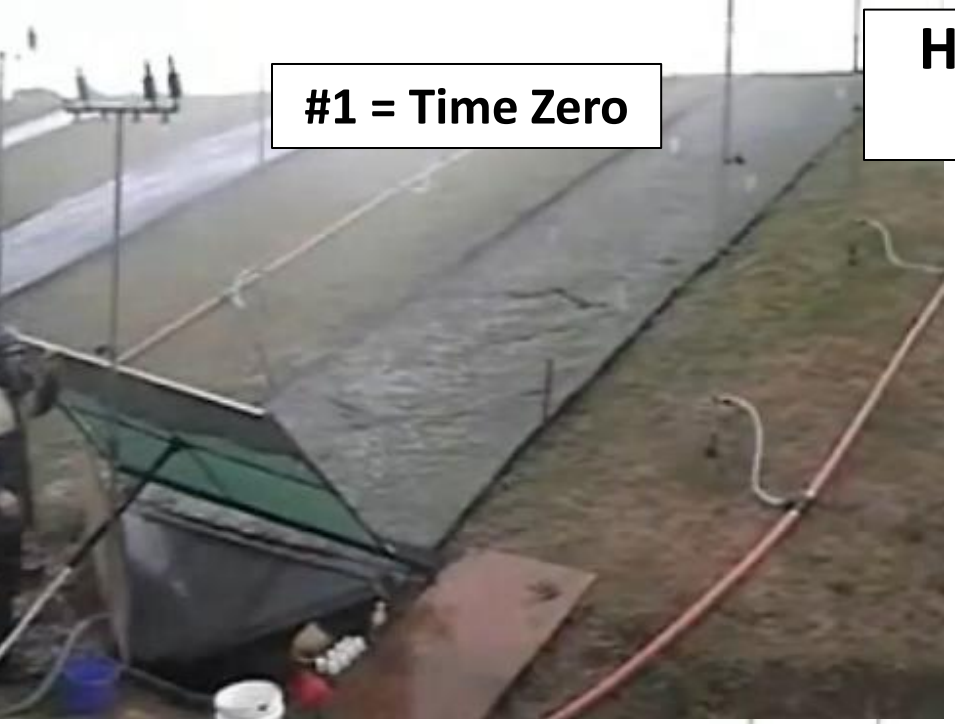
Discussion: These photos show a bare soil plot during simulated rainfall testing. It is a great example of what soil does under rainfall when no cover is present. The rainfall and associated overland flow eventually become concentrated to form rills in the soil. These pathways act as channels for excess water to be caried off the slope. This is commonly seen in nature on exposed slopes as well. In general, soils are rarely designed to, or able to, absorb all the moisture they are exposed to over time.

Failure Mechanism of Products That Rely Mainly on Chemical Bonds

- Designed to absorb a lot of moisture
- Can perform at high levels up until threshold is exceeded
- Excess moisture and weight on slope can be detrimental depending on the event received
- “All or Nothing” failure mechanism

Discussion: Some BMPs rely on moisture absorption as their main form of protection. These products can be successful solutions for certain applications, but overuse outside their capabilities can be dangerous. Adding excess moisture to slopes can be detrimental depending on the soil type and other specific site conditions. BMPs with this failure mechanism can be seen going from almost perfect performance to mass wasting in mere seconds.

HECP Failure Mechanism - Simulated Rainfall



Discussion: This series of photos show what can happen when products without physical stitching and/or netting are exposed to too much rainfall. Keep in mind that many of the mulch-based solutions are designed to have a very high water holding capacity. Some HECPs may be very successful during certain rainfall events, but the "all or nothing" failure mechanism of some products can be destructive as seen here. If the slope is allowed to dry out before the next event, favorable results could be had. These types of material can encourage more moisture onto the slope that the installed system can withstand or the excess moisture to the slope encourages some soils to become supersaturated and liquify. If this happens, we are getting beyond surface erosion and into slope stability challenges. This phenomenon can be seen with several BMPs in labs across the country, if the slope length is sufficient, and the simulator is run long enough to exceed the performance threshold. Remember, one of Mother Nature's ways of helping to prevent this is to have excess precipitation leave slopes.

Industry Opportunity

- **Determine threshold of BMPs by extending test methods?**

- **Match new severe weather patterns to BMP thresholds to match the right product to the right application?**

Discussion: We have an opportunity as an industry to research more to find the water holding capacity slipping point of our BMPs so we can design more successfully as we continue to experience more severe weather patterns. We could quantify how much rainfall BMPs can take before they give out, which would help during risk evaluations. With this in mind, should a test method be established that runs until the breaking point is reached? This is important because our design storms of yesterday may not be sufficient anymore. Thus, it would further help us match the right product to the right application depending on how much rainfall we safely and comfortably want to protect from. We could then check the new normal of severe storms for the project location to help select the right product for the right application. If the slope and rainfall conditions for the site are within a BMP's range, a chemical bonded product may be suitable; however, if the expectant design conditions exceed the capabilities of chemical bonded products, then other options may be more suitable because results can go from almost perfect to catastrophic in 17 seconds as seen in the photos clipped from the original video footage. If the rainfall would have been turned off a few seconds sooner the results would have looked much differently, but we can no longer risk or afford mass wasting on our project sites when Mother Nature's rain doesn't stop "in time".

Limited Physical Bonds Failure Mechanism - Field Results

Discussion: The field results shown here match what has been seen in laboratory conditions when sufficient slope length and rainfall volume, drop size, and duration are applied. Could these have been prevented by determining the slip point of each product that does not contain physical bonds by stitching or netting? Further research and evaluation is needed to determine that.

Blown Product Failure Mechanism - Simulated Rainfall

Discussion: Similarly to the previous series of HECP photos under simulated rainfall, this blown-on product did not contain physical bonding from stitching or netting. This series of photos shows how the product encouraged excess infiltration into the blown material and underlying soil. Up until the point of no return, the BMP was performing well, but little runoff was exiting the plot. In 25 seconds, it went from doing very well to a large area of the plot slipping off.

High Water Holding Capacity Field Results

Discussion: These field results show similar results to the previous slide when the blown product without physical stitching or netting strength took on too much moisture and force from hydraulic events.

Rolled Erosion Control Product with Physical Bonds "Failure Mechanism" and Dewatering of Filtered Runoff

Discussion: The RECP seen here is holding the soil in place while allowing clear runoff to exit the slope. The runoff exiting the slope is key to successful applications. This failure mechanism allows the properly installed system to typically hold up to more severe rainfall events in the field, although we are not suggesting it is an invincible solution that will never have challenges in the field because there are many unique conditions that could come up. However, instead of trying to absorb the majority of the rainfall, the blanket is holding the soil and seedbed in place while allowing the excess precipitation to exit the plot after being filtered by the fiber matrix that is held in place by the physical bonds of the biodegradable stitching in the case shown here. The dewatering of the slope helps reduce soil supersaturation and slip planes. Please note the product shown does not contain netting, but other versions of rolled products could, if increased strength is needed for more severe site conditions. Net strength can be increased with design requirements as needed.

Why Does Longevity Matter?

Discussion: What about longevity? Field experience and project results have shown that most non-physically stitched or netted products may not last long enough for slower-establishing native seeds. Thus, quicker establishing, shallow rooted grasses are commonly used with them. Shallow rooted grasses provide limited erosion control benefits and can get washed away with the BMP when the right product is not matched to the right project conditions like seen in this photo. Shorter-lasting products using quicker establishing, shallow rooted seed mixes certainly have their place, but using a quick degrading product when a slow establishing seed mixture is required for the site should be avoided.

Matching BMP Longevity to Seed & Site Requirements

Discussion: Acres of erosion control blankets (ECBs) with environmentally friendly woven biodegradable jute netting were successfully used on this DOT project after a product providing a lesser functional longevity was originally installed as part of a value engineering spec change proposal. The marketed cost savings of a non-blanket BMP ended up being added cost to this project because blankets had to be brought in to achieve success after the fact because sufficient longevity was not originally provided. Thus, the job had to be done twice, which substantially blew the budget. The proper native seed mix, and resultant deeper root system, were able to be used the second time because the BMP provided sufficient longevity to match the establishment requirements of the seed mix. This is a good example of matching the right product to the right application even though it unfortunately took two attempts on this DOT project.

What Can Happen When Bonds Are Broken?

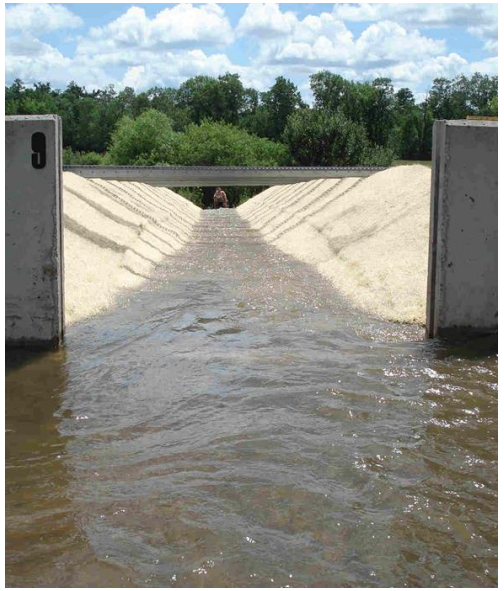
Discussion: This side-by-side comparison done by a contractor was next to a river. Results after the first rainfall event are seen on this slide. The real concern here is that the soil, mulch, fertilizer, and other amendments washed directly into the adjacent water resource. A failure on a back road slope isolated from water resources is much different than a failure next to a water resource. You cannot easily take the pollutants out of the river once they enter it. We need to consider all site conditions and BMP properties and performance capabilities before deploying them to the field. As importantly, we must verify originally specified products are provided to projects and they are properly installed according to manufacturer's recommendations. Could installation have been the issue here with the washed mulch? That's not known, but looking at installation information will help us get a better understanding. When a rolled product is installed, the person unrolling it physically sees what the final product is. You can see its final form and measure its mass per unit area, tensile strength, etc. Proper anchoring patterns are then need to complete the process. Installation of spray on products is much different. It's hard to physically measure the product that gets installed because it's a slurry. Proper installation is dependent upon many factors including, but not limited to, the water to mulch ratio in the tank, mixing time, application direction (or directions depending on the product), and resultant coverage and application rate across the project. How is application rate verified actually verified in the field? One suggestion made is that mulch bags should be required for payment like seed tags are to help ensure the proper amount of mulch was applied to the job. This could be one way to find out the answer before it's too late, because after the installer moves on, it's difficult to know how much of the spray products were installed.

Summary

- **Understanding erosion control products' strengths and weaknesses are important to matching the right product to the right application and managing risk.**
- **Excess moisture retention of some products can be beneficial to a point, but when they "go", it's an "all or nothing" failure mechanism. Designing to proper conditions is key.**
- **Most products available today work well when properly installed in the conditions they physically and chemically can handle.**

Discussion: In summary, some BMPs rely on moisture absorption as a main form of protection. However, adding excess moisture to slopes can be detrimental depending on the soil type and other specific site conditions. BMPs with this failure mechanism can be seen at times going from almost perfect performance to mass wasting in mere seconds. Depending on project conditions, the failure mechanism may or may not matter. Chemical bonds vs physical bond strength provided by netting and/or stitching makes a difference is certain applications. We need to understand product properties, performance capabilities (both in lab and field conditions), and failure mechanisms to better match the right product to the right application so we can continue to progress as an industry. We have a good opportunity in front of us to continue improving as an industry by specifying, providing, and properly installing performance-based solutions that work in the challenging field conditions under today's unpredictable weather patterns.



THANK YOU!

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