Introduction to the Sediment Control Facility (SCF)

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ABSTRACT

Key Words: Sediment Control, Runoff, Testing, BMPs, P Factor

Project owners and designers in the erosion industry have been searching for performance information on best management practices (BMPs) that are used for slope interruption or placed around the perimeter of construction sites. The function of these products is to break up long slopes and/or retain eroded soil within the project site, which results in reduced sediment concentrations in the exiting runoff. Products that are commonly used in these applications include wood fiber buffer strips, straw wattles, wood fiber logs, wood fiber pads, and silt fence.

Sediment control gained increased importance with Phase II of the National Pollutant Discharge Elimination System (NPDES), which requires sites as small as one acre to follow the erosion and sediment control permitting process. Informal field studies have been conducted on sediment control products, but structured scientific testing is still lacking. Performance information is vital for selecting the proper sediment control product before any soil is disturbed.

This paper explains the Sediment Control Facility (SCF) that was constructed at ErosionLab in Rice Lake, WI, to help fill this void of knowledge. The reasoning behind

the facility, construction, calibration, methods of data analysis, and initial bare soil test results are detailed.

The innovative SCF evaluates the ability of a BMP to reduce rainfall-induced erosion and improve the water quality of the resulting runoff. Bare soil tests, where no product is installed at the toe of the plot, will be used as the control for the facility. Other testing methodologies are currently being developed in the industry that evaluate BMPs subjected to concentrated overland flow. On the other hand, products tested on the SCF will be exposed to runoff that is created from the complex process of rainfall erosion.

The SCF will provide numeric performance values for perimeter control products that are similar to the support practice factors (P factors) used in the Revised Universal Soil Loss Equation (RUSLE). The performance values will provide the missing data for project owners and designers who utilize perimeter control and slope interruption devices.

INTRODUCTION

Silt fence has been used for years in almost every application imaginable. A majority of silt fence failures could be prevented by proper installation. Mechanical slicing equipment has been developed to help address problems associated with silt fence installation; however, not all sites lend themselves to the mechanical equipment. Another problem with silt fence is that vehicular traffic is unable to drive over the product. Lastly, the aesthetics of silt fence are often viewed as a negative property of the product. Many perimeter control and slope interruption products have been developed as alternatives to silt fence to address the concerns associated with silt fence.

The erosion control industry has made enormous strides over the past few years establishing testing protocols to evaluate the effectiveness of rolled erosion control products (RECPs). Performance values for RECPs are obtainable by following the standard testing protocols. ASTM D-6459 (2001), “Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Hillslopes from Rainfall-Induced Erosion” is followed for testing ECBs on slopes and ASTM D-6460 (2001), “Standard Test Method for Determination of Erosion Control Blanket (ECB) Performance in Protecting Earthen Channels from Stormwater-Induced Erosion” is followed for testing ECBs in channels.

Currently, standard test methods are being developed to evaluate the effectiveness of sediment control devices subjected to channelized flow (Sprague, 2004). The existing test method evaluates a product’s ability to filter and retain sediment in a channelized flow scenario, thus the methodology may not represent conditions the products experience when they are installed for perimeter control or slope interruption. Some BMPs are not designed to be installed in locations where channelized flow will occur. The goal of the SCF described herein is to test BMPs that are used for perimeter control and slope interruption. Figure 1 provides an example of a perimeter control product installed in the field. The SCF will test the ability of these BMPs to reduce soil loss and sediment concentrations from runoff created by rainfall-induced erosion up slope of the devices. Many products designed for perimeter control and slope interruption are intended to prevent soil from passing the products. These products are designed to prevent soil that is eroding down a slope at a natural pace not soil that is contained within a mad rush of channelized flow. The two concepts are very different and the SCF will mimic slope erosion unlike the existing test setup that accurately mimics channels.

Figure 1. Excelsior buffer strip used for perimeter erosion control.

Many erosion and sediment control specifications around the country are shifting to performance-based specifications. The Federal Highway Administration (FHWA) has adopted performance requirements for erosion and sediment control products (FHWA, 2004). ECTC, Erosion Control Technology Council, has also created specifications that are based on a product's ability to perform (ECTC, 2004).

Performance values for perimeter control and slope interruption BMPs are lacking. Field studies have been conducted on these products, but values need to be established that quantify the effectiveness of the devices. We need to establish performance levels to better understand and utilize the products. The SCF is the vehicle that will provide the missing performance information needed to avoid costly NPDES fines.

FACILITY DESCRIPTION

The SCF is located within the ErosionLab, which is a large-scale erosion and sediment control research laboratory located near Rice Lake, WI. The facility contains five test plots that are 10.7 m (35.0 ft) long by 2.4 m (8.0 ft) wide. Each test plot was created at an 8H:1V (12.5%) slope and filled with a veneer of loam-textured soil (according to USDA classifications). Each plot is surrounded by 10 rainfall riser holders in which portable rainfall simulator risers are placed. The simulator can produce rainfall events up to 20.3 cm/hr (8.0 in/hr). Water is pumped from an onsite pond, which provides a constant flow of water to the simulator.

SCF IS BORN

Construction of the SCF commenced in May of 2004 and was completed within a few weeks. Figures 2 through 7 illustrate the construction process. First, existing top soil and sod were removed to create a starting point for the plots. Next, the plots were surveyed and graded to an 8H:1V slope. Plot borders were then constructed around the perimeter of the test plots. Next, test material was added and compacted in six inch lifts. A 30.5 cm (12.0 in) veneer of loam test material was constructed within each test plot. Lastly, rainfall riser holders were installed around the plot boundary and an 844.1L (223.0 gal) collection tank was buried at the toe of each plot.

Figure 2. Removal of sod and existing topsoil.

Figure 3. Grade of plots becoming established.

Figure 4. Checking plot depth.

Figure 5. Start of plot filling.

Figure 6. Loam material being added to plot.

Figure 7. Completed plot with collection tank buried at the toe.

CALIBRATION

Calibration of the new facility was completed before any testing was conducted. Twenty raingauges were placed in predetermined quadrants through out the plots (Figure 8). Plots were covered with plastic during calibration runs to prevent infiltration. Various target intensities were calibrated using the Christiansen Uniformity Coefficient (Equation 1).

Equation 1. Christiansen Uniformity Coefficient

$$C_u = 100 \left(1.00 - \frac{\sum |d|}{n \bar{x}} \right)$$

Where:

C_u = Christiansen Uniformity Coefficient (%)
d = $X_i - \bar{x}$
n = number of observations (20 in this case)
$\bar{x}$ = average depth caught (mm)
x_i = depth caught in each rain gauge i (mm)

Calibrations producing a C_u below 80% were deemed unacceptable. Rainfall riser placement and direction of spray were adjusted when a C_u below 80% was achieved. The system was recalibrated until acceptable uniformity coefficients were produced at each of the target intensities. In addition, the operating pressure of the system was adjusted to establish target intensities. All runoff was collected and pumped to larger tanks to monitor the total volume that exited the test plot (Figure 9).

Figure 8. Rainfall hitting plastic during a calibration run.

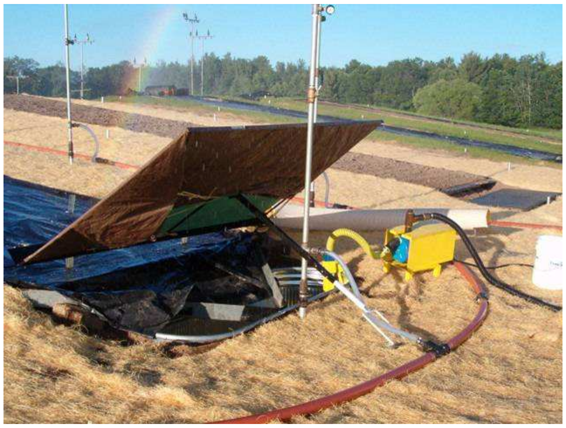

Figure 9. Collection device at toe of slope. Notice buried collection tank and evacuation pump. The collection device will ensure capture of all soil and water that will exit the plots during product testing.

PRODUCTS THAT WILL BE EVALUATED

Performance levels of BMPs that are used for perimeter erosion control or slope interruption will now be able to be quantified. Products currently on the list to test include, but are not limited to: excelsior buffer strips, straw wattles, wood fiber logs, wood fiber pads, and silt fence. Various configurations of each product will be tested including varying densities, diameters, and shapes. In addition, products will be initially installed according to the manufacture's recommendations, but different installation techniques will be tested to determine the methodology that provides the best erosion and sediment control protection. Each product will be replicated a minimum of three times to ensure meaningful statistical data.

DATA ANALYSIS

Data generated from the SCF will be analyzed to determine a product's ability to reduce rainfall erosion and improve water quality as compared to bare soil controls, thus bare soil control testing must be completed before products can be analyzed. The Revised Universal Soil Loss Equation (RUSLE) (Equation 2) structure will be utilized to develop numeric performance values for the products.

Equation 2. RUSLE

$$A=R*K*LS*C*P$$

where

A = estimated soil loss

R = rainfall-runoff erosivity factor

K = soil erodibility factor

LS = slope length and steepness factor

C = cover management factor

P = support factor

RUSLE R factors can be calculated for simulated rainfall events as described by Clopper et al. (2001). K factors can be calculated by back-calculating data from bare soil testing (Clopper et. al, 2001). LS factors can be calculated following equations detailed in Agriculture Handbook 703 (1997). By definition, a C factor equals 1 for bare soil conditions (Renard et al., 1997). The remaining RUSLE factor is the P factor, which is the support practice factor.

According to Agriculture Handbook 703, the P factor in RUSLE is “the ratio of soil loss with a specific support practice to the corresponding loss with upslope and downslope tillage. These practices principally affect erosion by modifying the flow pattern, grade, or direction of surface runoff and by reducing the amount and rate of runoff”.

Numeric performance values for the products tested at the SCF will be generated by calculating P factors for the products following the framework outlined by Clopper et al. (2001), which allows different rainfall intensities to be evaluated. For example, a product having a P factor of 0.5 would reduce soil losses by 50% as compared to bare soil conditions with all other RUSLE factors being equal. It should be noted that RUSLE P factors are time varying over the course of a year and P factors developed through SCF testing will produce event-based values. This important fact will need to be considered when reviewing future SCF results.

The ability of the products to improve water quality will also be quantified. This task will be achieved by comparing sediment concentrations from product tests to sediment concentrations from the bare soil control data set.

INITIAL RESULTS

To date, a bare soil data set consisting of four replications has been established as the control that will be used for future SCF product data. Figure 10 shows a SCF plot during a bare soil control rainfall test. Typical post test plot conditions are shown in Figure 11.

Figure 10. Bare soil plot during rainfall test.

Figure 11. Typical bare soil plot following test series.

The soil erodibility rate (K factor) of the test soil can be determined from the data set following procedures outlined in Clopper et al. (2001). The K factor calculated from the bare soil data set will be used for future analyses of SCF testing involving BMPs. Figure 12 presents Soil Loss vs. RUSLE R factor for the bare soil data set.

An initial K factor of .0512 was calculated from the data. A bare soil test will be completed each time a new product is tested on the SCF, thus the bare soil data set will continue to grow as testing continues.

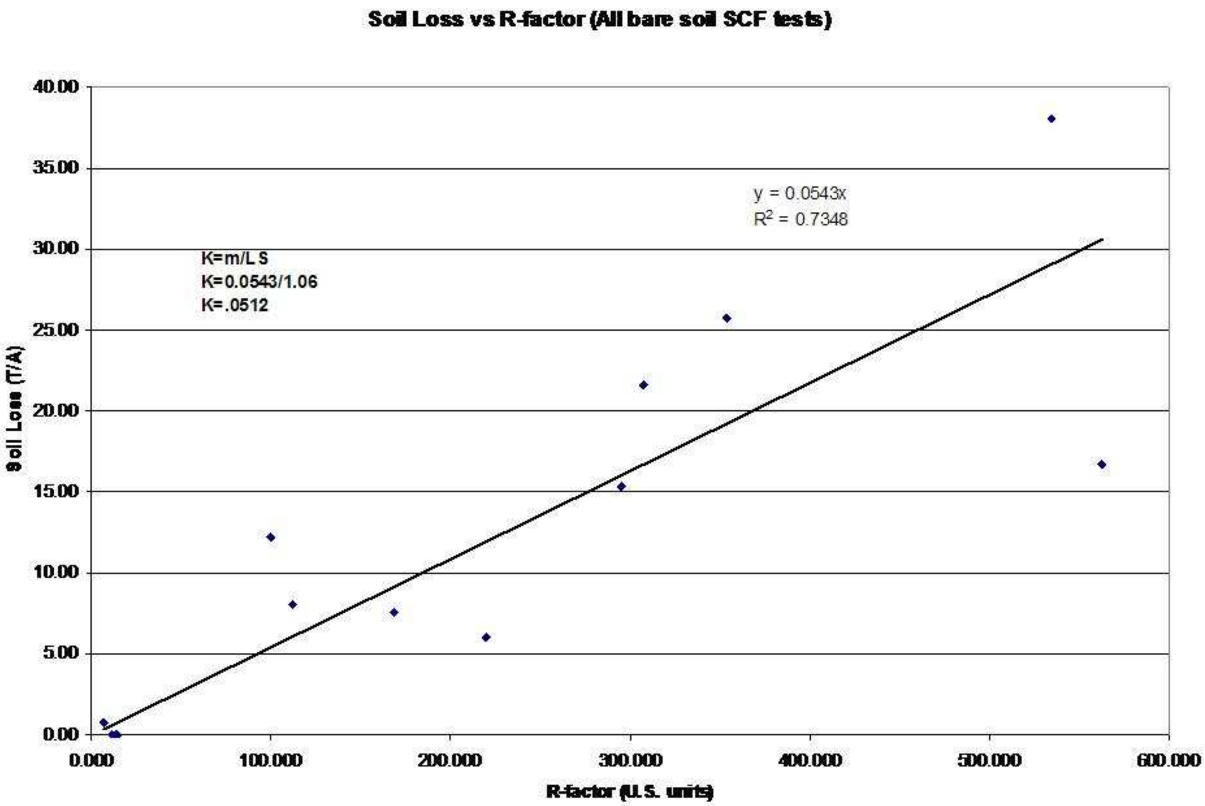

Figure 12. Soil loss vs. R-factor for the four bare soil control test replications.

WHAT'S NEXT?

The next step for the SCF is to test BMPs, analyze the data, and compare the information to the bare soil control data that has been established. As previously mentioned, various product configurations will be tested using different installation techniques. The SCF will provide missing performance values and will help determine ideal installation techniques for perimeter control and slope interruption products.

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