VEGETATION ESTABLISHMENT AND EROSION CONTROL AS RELATED TO TWO WOOD FIBER MULCHES

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Abstract:

In an effort to better understand the relationship between two wood fiber mulches, vegetation establishment, and rainfall induced erosion events on a sloping soil plot, tests were conducted at the Utah Water Research Laboratory at Utah State University. Two wood fiber mulches were tested and compared to a bare soil control. The test protocol was as follows. Soil plots; prepared by tilling, rolling, and raking; were seeded (perennial rye grass), fertilized, and covered with mulch products at defined rates. Once the plots had dried out sufficiently, the plots were placed on a 4(H):1(V) slope and subjected to a 30-minute, 4 in/hour rainfall event. Following the event, a set of growing lights were placed over the plots and the plants were allowed to grow for 10 days. After 10 days, the lights were removed and the plots were subjected to a 60-minute, 4 in/hour rainfall event at the same slope. Results of this study are presented and discussed with the goal of developing a better understanding of the roll each of the wood fiber mulches play in the processes of erosion control and vegetation establishment.

Key Words:

wood Fiber mulch, vegetation establishment, erosion control, rainfall, slope testing

1 INTRODUCTION

There are four main types of hydraulically-applied erosion control products (HECPs) that are grouped together based on similar performance properties. These categories of HECPs are defined by the Erosion Control Technology Council (ECTC) and are arranged in order of increasing performance as presented below.

- Hydraulic Mulch
- Stabilized Mulch Matrix
- Bonded Fiber Matrix
- Fiber Reinforced Matrix

This paper focuses only on the Hydraulic Mulch (HM) category and more specifically how two wood fiber hydraulic mulches perform under the same erosion control and vegetation establishment testing protocol. A Hydraulic Mulch according to the ECTC is:

> A hydraulically-applied material(s) containing defibrated paper, wood and / or natural fibers that may or may not contain tackifiers used to facilitate vegetation establishment on mild slopes and designed to be functional for up to 3 months.

Application rates of hydraulic mulches vary from 1681 to 2802 kg/hectare (1,500 to 2,500 lb/acre) based on fiber type, slope gradient and slope length. HMs are commonly used to aid in the establishment of vegetation and the temporary stabilization of flat surfaces and mild slopes (≤ 4H:1V). HMs have been evaluated for percent effectiveness at various large scale testing laboratories with values ranging from less than 5 to 75 percent effective. The primary functions of hydraulic mulch products on sloped embankments include protecting an embankment from erosion events prior to plant establishment and facilitating plant establishment. Hydraulic mulch products can aid in seed hydration and germination by increasing the local soil moisture content. Wood fiber mulches can increase the local moisture content by reducing evaporation effects and by supplying supplemental moisture via the water holding capacity of the wood fiber mulch. The ability of wood fiber mulch products to absorb and retain water can vary depending on the manner in which the wood fibers are processed. The development of a healthy stand of plant growth is ultimately the goal for protecting against erosion in the long term. Developing a better understanding of the roll wood fiber base mulches (without tackifiers) play in this process was the goal of this research study.

2 WOOD FIBER MULCH TYPES

There are basically three different types of wood fiber mulches produced; atmospherically refined, hammer-milled and thermally refined. This paper is only focusing on thermally refined and hammer-milled wood fibers. Figure 1 presents a photograph of a 283.5 gram (10 oz) dry sample of both wood fiber types.

• **Figure 1: Photograph of Hammer-Milled Wood Fiber (left) and Thermally Refined Wood Fiber (right) – 283.5 grams of each**

Hammer-milled wood fiber is produced by hammering debarked clean wood shavings or chips through a screen with pre-determined openings designed to cut and grind the chips. A hammer-mill contains a shaft and rotor, the rotor has several shafts that individual hammers are hung on. The rotor is driven by a large motor, spinning the hammers at between 1800 and 3600 revolutions per minute. The Hammers strike the shavings against a screens cutting edge. The screen holes or openings control the length and diameter of the finish product. The fibers are produced to maximize coverage while minimizing the risk of clogging a hydro-seeding machine pump or nozzle tip. Figure 2 presents a stereoscopic image of hammer-milled wood fiber at approximately 20 times magnification.

• **Figure 2: Photograph of Hammer-Milled Wood Fibers at 20 Times Magnification Through a Stereoscope**

A Thermally Refined Pressurized Vessel is the device used to process clean wood chips of approximately 5.1 to 7.6 cm (2 to 3 in) in length and 2.5 to 3.8 cm (1 to 1.5 in) in diameter. The wood chips are conveyed into a plug screw that feeds a vertical digester where the chips are heated under steam pressure for several minutes. While in the vessel the lignin melts. The chips are conveyed via a transport screw into a refiner where the wood is separated into thin long strands. The wood fiber is then conveyed via an airstream into a flash tube dryer to lower the moisture content of the fiber to a value of approximately 12 percent. Figure 3 presents a stereoscopic image of thermally refined wood fiber at approximately 20 times magnification.

• **Figure 3: Photograph of Thermally Refined Wood Fibers at 20 Times Magnification Through a Stereoscope**

3 LABORATORY SETUP AND PROTOCOL

In an effort to replicate conditions that often occur in the field, a testing protocol was setup to mimic typical soil preparation, product application with seed and fertilizer, a rainfall event occurring prior to vegetation establishment, and initial vegetation establishment over a period of time followed by another rainfall event. This scenario is consistent with what can happen to "protected" embankments in the field and was examined in a controlled setting in order to develop a better understanding of the influence of two different types of wood fibers on pre- and post-vegetation rainfall events. In general, the roll of the mulches and other material is to stabilize an embankment until vegetation is established. Pre-vegetation rainfall events not only introduce the risk of soil loss but the seeds can also be washed away. Consequently, the pre- and post- vegetation rainfall events were included in the study.

Two wood fiber hydraulic mulches (hammer-milled and thermally refined) were tested and compared to a bare soil control. Tests were conducted at the Utah Water Research Laboratory (UWRL) and documented in report number 1851 (Tullis, 2008). A summary of the test protocol was as presented in Table 1:

- **Table 1: Test Protocol for Pre- and Post-Plant Establishment Erosion Control Testing**

Test Plots	The test plots measured 1.22 m wide by 5.95 m long by 0.3 m deep (4 ft by 19.5 ft by 1 ft), were filed with a sandy loam soil. The soil plots were tilled, rolled, and raked prior to applying seed and fertilizer. One plot was left as a bare soil control. Wood fiber mulch products were applied at a rate of 2242 kg/hectare (2000 lb/acre) using a hydro-seeder. The test plots were placed on a 4(H):1(V) slope.
Pre-Vegetation Rainfall Event	The test plots were subjected to a 102 mm/hour (4 in/hour) rainfall event for 30 minutes and the run off from each plot collected.
Plant Establishment	A fluorescent light bank was placed over the test plots for a 10-day plant establishment period. No additional water was added to the test plots during the period
Post-Vegetation Rainfall Event	Following the 10-day plant establishment period, the test plots were subjected to another 102 mm/hour (4 in/hour) rainfall event for 30 minutes and the run off from each plot collected.

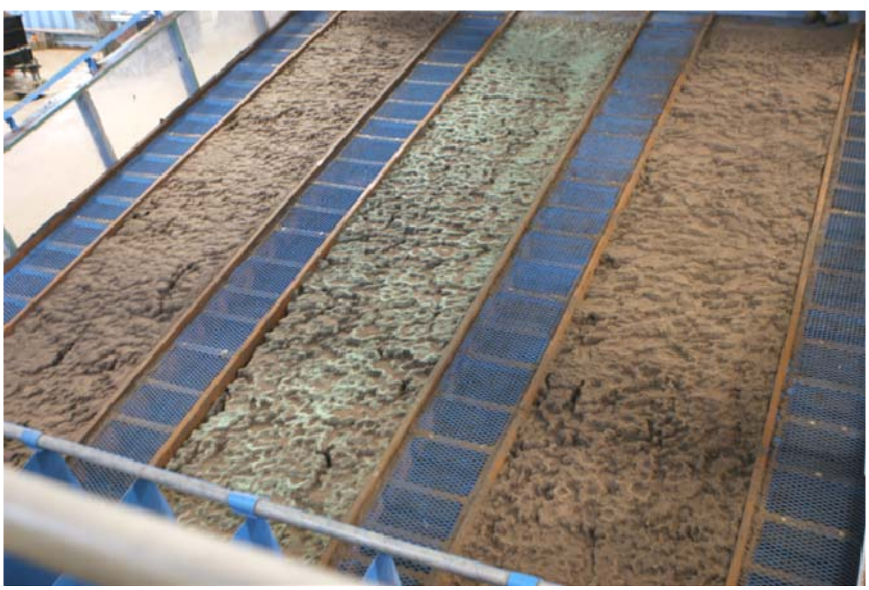
4 TESTING RESULTS

Figure 4 shows the bare soil control and the two wood fiber mulches installed and setup on the specified slope prior to the first rainfall event. Table 2 presents a summary of the testing results for the 30-minute pre-vegetation rainfall event. Figure 5 shows the bare soil control and the two wood fiber mulches immediately after 30-minute pre-vegetation rainfall event.

• **Figure 4: Bare Soil Control (left), Thermally Refined (center) and Hammer-Milled (right) Wood Fiber Mulches Prior to the Pre-Vegetation, 30-Minute Rainfall Event.**

• **Table 2: Summary of Testing Results After First 30-Minute Rainfall Event**

Wood Fiber Type / Condition	Soil Loss (kg)	Soil Loss (lb)	C-Factor	Percent Effective
Hammer-Milled	40.4	89.0	2.11	-111%
Thermally Refined	10.9	24.0	0.57	43%
Bare Soil	19.1	42.1	n/a	n/a



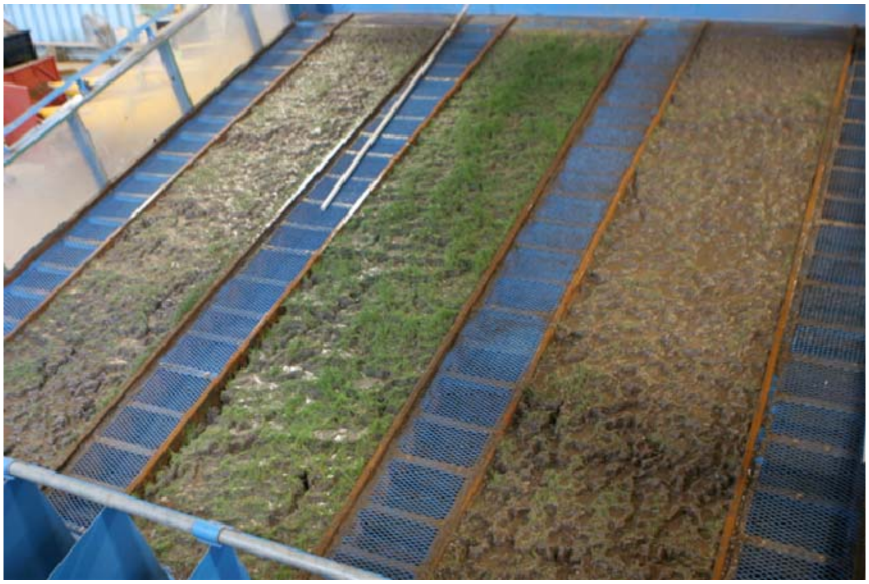
• **Figure 5: Bare Soil Control (left), Thermally Refined (center) and Hammer-Milled (right) Wood Fiber Mulches After the Pre-Vegetation, 30-Minute Rainfall Event.**

Figure 6 shows the bare soil control and the two wood fiber mulches at the 4(H):1(V) slope following the 10-day plant establishment period and just prior to the post-vegetation, 30-minute rainfall event. Table 3 presents a summary of the testing results for the post-vegetation, 30-minute rainfall event. Figure 7 shows the bare soil control and the two wood fiber mulches after the second rainfall event.

• **Figure 6: : Bare Soil Control (left), Thermally Refined (center) and Hammer-Milled (right) Wood Fiber Mulches after the Plant-Establishment Period and Just Prior to the Post-Vegetation, 30-Minute Rainfall Event**

• **Table 3: Summary of Testing Results After Vegetation Period and Second 30-Minute Rainfall Event**

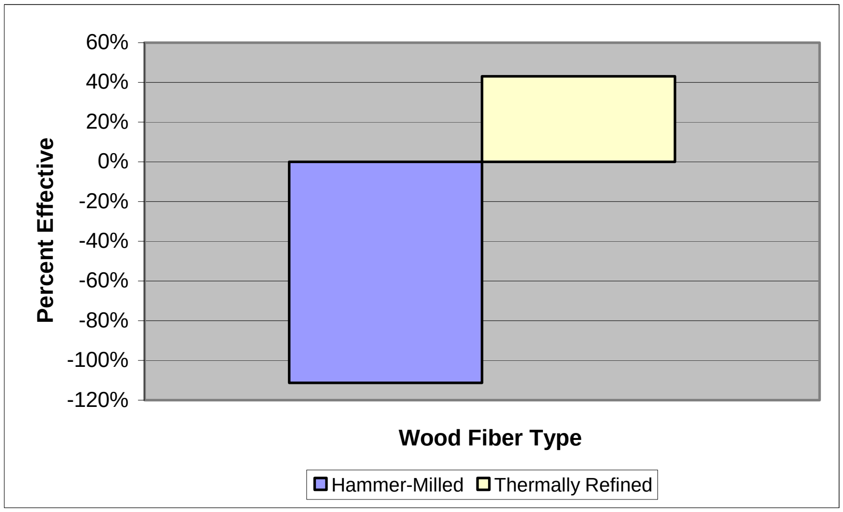
Wood Fiber Type / Condition	Soil Loss (kg)	Soil Loss (lb)	C-Factor	Percent Effective
Hammer-Milled	14.0	30.8	0.58	42%
Thermally Refined	6.3	13.8	0.26	74%
Bare Soil	23.9	52.6	n/a	n/a



• **Figure 7: Bare Soil Control (left), Thermally Refined (center) and Hammer-Milled (right) Wood Fiber Mulches following the Post-Vegetation, 30-minute Rainfall Event.**

5 CONCLUSIONS AND DISCUSSION

Figure 8 shows the percent effectiveness of the two types of wood mulches associated with the pre-vegetation, 30-minute rainfall. Product effectiveness is defined as the percent increase or decrease in soil loss, relative to the bare soil control, with a positive number representing a reduction in soil loss. The test results indicate a wide range of effectiveness between the two different wood fiber products. The thermally refined wood fiber reduced soil loss, relative to the bare soil control by more than 40% (C factor ≈ 0.6). The plot protected with the hammer-milled wood fiber product actually produced more soil loss than the bare soil control plot during the 30-minute test period. The effectiveness was approximately -112%.(C factor ≈ 2.11). There is also a significant variation in the amount of vegetation between the three test plots, as shown in Figure 7. The soil plot protected with the thermally-refined wood fiber mulch produced significantly taller rye grass, compared to the hammer-milled wood fiber plot and the bare soil control. In particular, the thermally refined wood fiber yielded rye grass that was on average 20 percent taller than the hammer-milled results. In addition, the cover density was drastically less with the hammer-milled wood fiber when compared to the thermally refined wood fiber plot. Specifically, the cover density of the thermally refined wood plot was 47 percent and the cover density of the hammer-milled wood plot was 5 percent.



• **Figure 8: Percent Effectiveness of the Two Wood Fiber Mulch Products for the Pre-Vegetation, 30-Minute Rainfall Event.**

Figure 9 shows the percent effectiveness of the two types of wood mulches after the vegetation period and the post-vegetation, 30-minute rainfall event. The vegetated soil plot with the thermally refined wood fiber performed better than vegetated plot with the hammer-milled wood fiber product. Note that both plots with the wood fiber hydraulic mulches produced less soil loss than the bare soil control plot for the post-vegetation rainfall event. The vegetated plot with the thermally refined wood fiber product was approximately 74% effective (C factor $\approx$ 0.26) while the vegetated hammer-milled wood fiber product plot was 42% (C factor $\approx$ 0.58) effective, relative to the bare soil control.

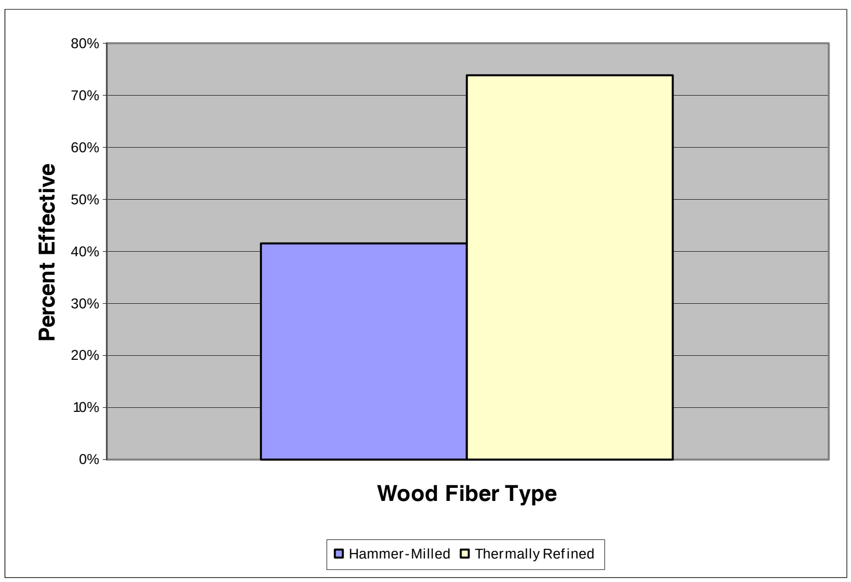


Figure 9: Percent Effectiveness of the Two Wood Fiber Mulch Products for the Post-Vegetation, 30-Minute Rainfall Event.

The significant variation in erosion control effectiveness and plant establishment between the test plots is likely a direct result of the type of wood fiber hydraulic mulch used. The poor performance of the hammer-milled wood fiber in the pre-vegetation test was likely due, in part, to the buoyant nature of the wood fiber. During the rainfall event, the hammer-milled wood fibers would tend to float when sufficient sheet flow was present. The floating wood fibers would congregate together, creating preferential flow paths between the clumps of mulch. These preferential flow paths were the likely cause of the increased soil loss rate, relative to the unprotected, bare soil control plot.

An examination of the water holding capacity for each of these wood fiber mulches was performed according to ASTM D7367. The average water holding capacity for the hammer-milled wood fiber was approximately 470 percent and the average water holding capacity for the thermally refined wood fiber was approximately 1200 percent. The process of hammer-milling the wood fibers likely reduced the fiber porosity and water holding capacity. The variation in the plant establishment shown in Figure 3 was likely influenced, in part, by the amount of seed lost from each plot during the pre-vegetation, 30-minute rainfall event. The thermally-refined wood fiber plot had the least amount of soil (and likely seed) loss and the most rye grass plants. The other factor that influenced the plant establishment rate is the water holding capacity of the wood fiber products. The higher water holding capacity of the thermally-refined wood fiber product increased the amount of water available to that soil plot for seed germination and plant growth.

The superior erosion control protection during the post-vegetation plant establishment test of the thermally-refined wood fiber plot may have been partially influenced by the wood fiber itself. Thermally refined wood fibers have more loft (see Figure 1) and a wider range of fiber sizes (compare Figures 2 & 3). Both of these properties likely contributed to better performance (in erosion control and vegetation establishment) of thermally refined wood fibers when compared to hammer-milled wood fibers. The increased quantity of rye grass plants on the thermally refined wood fiber test plot, relative to the bare soil control and the hammer-milled wood fiber plot, was likely the most significant factor in effectiveness of the thermally-refined wood fiber plot.

6 REFERENCES

Tullis, B.P., 2008. Erosion Control Testing of Two Wood Fiber Mulches and a Bare Soil Control in the Rainfall Simulation Facility. Project Report Number 1851. Utah Water Research Laboratory, Logan, UT.