Curlex® Blocs – Natural Filters for Challenging Conditions

August 2013

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STUDY SITE
All activities conducted for this study were completed at ErosionLab®
(www.erosionlab.com), which is a large-scale erosion and sediment control research laboratory located near Rice Lake, WI, USA. More specifically, the Channel Erosion Research Facility (CERF) was utilized. The facility contains 13 test channels that are up to 24.38 m (80 ft) long and can be shaped to match specific test requirements. CERF can produce flows up to 2.27 m^3/s (80 ft^3/s). Water is pumped from an onsite pond, which provides a constant flow of water to the test channels.

METHODS
Simulate channelized flow based on typical conditions present in the field. Quantify flow rate and water quality before and after filter station constructed with patent pending Curlex® Blocs.

Erosion Channel Preparation
The earthen channel for this study was prepared by hand-raking to a uniform surface to form a parabolic shape (Figure 1). A vibratory plate compactor was then used to compact the channel to ≈90% of standard Proctor density to remain consistent with preparation techniques called out in large-scale ASTM channel erosion test standards. Curlex® Enforcer® was installed in the channel following compaction. Lastly, the Curlex Bloc filtering station was installed over the Curlex Enforcer 18.29 m (60 ft) from the inlet to simulate proper spacing between Curlex Bloc filter stations with an approximate installed height of 0.9 m (3 ft) within a channel containing a grade of 5%; however, due to the height of the stacked Curlex Blocs, the channel length, and channel gradient only one Curlex Bloc filtering station could be evaluated during the simulation as compared to a series of filtering stations that would be present in field applications. Table 1 contains information on the test soil used at ErosionLab. Coarser soils would be removed more effectively by the Curlex Bloc filter stations due to their larger size so they were not used during the simulation. Figure 2 shows a photo of the soil used during this simulation.

Table 1. Soil Used ErosionLab.

Location	Generic Soil Name	% sand	% silt	% clay
ErosionLab	clay	31	42	27

Figure 1. Prepared earthern channel before installation of Curlex Enforcer and Curlex Blocs.

Figure 2. Premeasured bucket of soil ready to be mixed in tank.

BEST MANAGEMENT PRACTICES (BMPs) EVALUATED

Curlex Enforcer and Curlex Blocs, as manufactured by American Excelsior Company®, were used during the simulation. Curlex Enforcer contains 0.68 kg/m^2 (1.25 lb/yd^2) of naturally seed free Great Lakes Aspen excelsior fibers that are dyed green for aesthetics and bound by two layers of extra heavy-duty black UV stabilized netting. Curlex Blocs contain Great Lakes Aspen excelsior fibers densely packed into a rectangular shape with dimensions of 45.7 cm x 40.6 cm (18 in x 16 in). The excelsior fibers inside Curlex Blocs are encased by a biodegradable cotton containment material.

BMP Installation

Curlex Enforcer was installed parallel to flow within the entire 24.38 m (80 ft) long parabolic channel that contained an approximate top width of 4.88 m (16 ft). Eleven gauge, U-shaped steel wire staples 15.2 cm x 2.5 cm x 15.2 cm (6” x 1” x 6”) were used to anchor the Curlex Enforcer (Figure 3). A “5 on a dice” pattern was followed at an approximate density of 2.3 staples/m^2 (1.9 staples/yd^2). Two adjacent rows of 45.7 cm x 40.6 cm (18 in x 16 in) Curlex Blocs were installed on top of the Curlex Enforcer in the channel perpendicular to flow with the 45.7 cm (18 in) side up (Figure 4). Curlex Blocs in lengths of 1.2 m and 2.4 m (4.0 ft and 8.0 ft) were used in the simulation to help offset seams between rows of Curlex Blocs in the channel. A third row of Curlex Blocs was placed on top of and in the middle of the two adjacent bottom rows to form a pyramid-shaped filtering station. The top row was also installed with the 45.7 cm (18 in) side up, which resulted in a total installed height of approximately 0.9 m (3 ft). Oak stakes with nominal dimensions of 2.9 cm x 2.9 cm x 121.9 cm (1.125 in x 1.125 in x 48 in) were installed approximately every 0.6 m (2 ft) across the length of both sides of the Curlex Blocs except for in seam locations where the stake density was every 0.3 m (1 ft) (Figure 5). A common row of stakes was used between the bottom two adjacent rows of Curlex Blocs. Rope was used to anchor the Curlex Blocs. It was woven from the bottom front Curlex Bloc over the top Curlex Bloc to the bottom back Curlex Bloc (Figure 6).

Figure 3. Installing Curlex Enforcer.

Figure 4. Installing second bottom row of Curlex Bloc filter station.

Figure 5. Pounding stakes for Curlex Bloc filter station.

Figure 6. Wrapping rope to secure Curlex Bloc filter station.

Channelized Flow Simulation

Increasing volumes of flow were added to the channel over time. The total constant flow time was four hours. Table 2 provides the flow conditions over the course of the simulation.

Table 2. Flow conditions during simulation at ErosionLab.

	Average Flow Volume	
Time (hours into simulation)	m^3/s	ft^3/s
0 – 2.0	0.0208	0.0684
2.0 – 3.5	0.0743	0.2437
3.5 – 4.0	0.0771	0.2530

After flow began, velocity measurements were periodically taken 6.1 m (20 ft) downstream from the inlet and 1.5 m (5 ft) downstream of the Curlex Bloc filter station. These velocity measurements were used to help determine when steady state flow conditions were present in the channel. During the first 2.0 hours a pre-calibrated sediment-laden slurry was pumped into the simulation channel (Figures 7 and 8). Soil was added to the tanks and recirculating pumps were used to help keep the sediment in suspension. Evacuation pumps were used to transfer the sediment-laden slurry from the tanks to the earthen channel. Water quality grab samples were taken from the outlet of the evacuation pump hose from each tank to quantify the total suspended solids (TSS) entering the channel. Two tanks were used so flow was continuous throughout the simulation. During the second two hours of the simulation sediment free water was pumped directly into the channel with a force to generate TSS within the channel (hoses pointed at soil). This was done to increase the volume of water in the channel.

Figure 7. Tanks, pumps, and hoses before flow began.

Figure 8. Mixing of sediment-laden slurry in tank before being pumped into channel.

Laboratory Analyses

Grab samples obtained during testing were analyzed for TSS. All samples settled for ≥96 hours then a portion of the clear water was decanted from the bottles before they were placed into the forced air laboratory oven. Bottles were removed from the oven after all moisture had evaporated from the bottles.

RESULTS

Steady state flow was established one hour into the continuous flow. Periodic velocity and TSS grab samples were taken before and after the Curlex Bloc filter station after steady state conditions began (Figure 9). Figures 10 through 16 provide visuals of the conditions of the simulation during and after the four hour consecutive flow. Table 3 contains flow volume, TSS level, and flow velocity results over the course of the simulation.

Table 3. Summary of flow conditions and TSS levels during Curlex Bloc filter station simulation.

Time into Simulation (minutes)	Average Flow Volume		Average TSS of Water Entering Channel (ppm)	Average TSS of Water 1.5 m (5 ft) Downstream of Curlex Bloc Filter Station (ppm)**	Average Velocity 12.2 m (40 ft) Upstream of Curlex Bloc Filter Station		Average Velocity 1.5 m (5 ft) Downstream of Curlex Bloc Filter Station	
	m^3/s	ft^3/s			m/s	ft/s	m/s	ft/s
23	0.0208	0.0684	557.93	n/a	0.36	1.19	0.21	0.69
33	0.0208	0.0684	430.10	n/a	0.45	1.47	0.20	0.64
46	0.0208	0.0684	354.56	n/a	0.57	1.87	0.34	1.10
60*	0.0208	0.0684	415.42	n/a	0.69	2.25	0.40	1.30
90	0.0208	0.0684	474.29	236.51	0.68	2.22	0.45	1.48
120	0.0208	0.0684	698.20	350.00	0.71	2.32	0.51	1.68
150	0.0743	0.2437	492.98	193.44	0.68	2.23	0.54	1.78
180	0.0743	0.2437	n/a	n/a	0.70	2.31	0.56	1.85
210	0.0743	0.2437	n/a	n/a	0.67	2.20	0.44	1.44

*Steady state conditions started

**Samples were not taken directly from the clear water exiting the Curlex Blocs

Figure 9. Checking flow velocity shortly after simulation began.

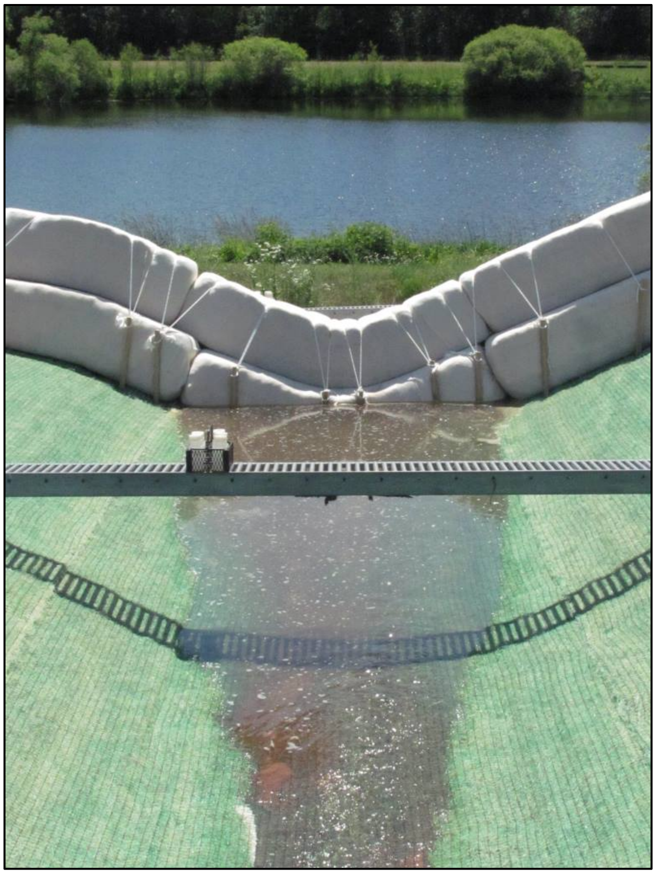

Figure 10. Flow conditions in front of Curlex Bloc filter station near end of four hour simulation.

Figure 11. Typical water quality exiting Curlex Bloc filtering station during simulation.

Figure 12. Appearance of front bottom Curlex Bloc after simulation.

Figure 13. Containment material removed from front bottom Curlex Bloc after simulation.

Figure 14. View of the underside of the front bottom Curlex Bloc after containment material was removed following simulation.

Figure 15. Cross section view of the front bottom Curlex Bloc after containment material was removed following simulation.

Figure 16. Containment material removed from back bottom Curlex Bloc after simulation.

OBSERVATIONS

- Some sediment settled into the Curlex Enforcer matrix before reaching the Curlex Bloc filter station.
- Sediment-laden slurry flowed into the Curlex Bloc filter station and exited as clear, relatively sediment free water.
- After four hours of constant flow simulation the effectiveness of the system showed no signs of decreasing.
- Pooling height increased in front of the Curlex Bloc filter station as the volume of water added increased; however, the flow out of the Curlex Bloc filter station remained relatively constant. This leads us to believe the true flow rate capacity of the Curlex Bloc filter station was not determined by the activities in this simulation.
- The true capacity of the Curlex Enforcer and Curlex Bloc filter station was not determined during the simulation based on TSS results and post simulation photos showing additional sediment storage capacity.

- The system of Curlex Enforcer and Curlex Blocs effectively reduced total suspended solids from the concentrated sediment-laden flows from soil containing 31% sand, 42% silt, and 27% clay. TSS reductions were the highest seen by any natural system at ErosionLab that did not require the use of flocculant materials.

- Grab samples from behind the Curlex Bloc filter station should have been taken directly in back of the Blocs instead of 1.5 m (5 ft) behind them. It was observed that sediment had settled on top of the Curlex Enforcer behind the Curlex Bloc filter station. When the dip cup was placed into the channel for sampling, some of the sediment would become entrained in the flow again and falsely get measured as TSS behind the Curlex Bloc filter station. Dip cups should have been placed directly in back of the Curlex Blocs to collect the flow coming out of them rather than the flow downstream of them.

- Only one Curlex Bloc filter station was evaluated during this simulation due to channel length restrictions. In the field, a series of Curlex Bloc filter stations would be installed so the TSS would continue to decrease as the flow came in contact with additional Curlex Bloc filter stations.

- Prior independent research has quantified Curlex fiber's unique capability to remove polynuclear aromatic hydrocarbons (PAHs), which are typical components of asphalts, fuels, oils, and greases. Thus, the filtering capability of the system goes far beyond the efficient removal of fine sediments, which makes Curlex Bloc one of the most diverse and beneficial natural filters available.