Effective Stormwater and Sediment Control During Pipeline Construction Using a New Filter Fence Concept

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Title: Effective Stormwater and Sediment Control During Pipeline Construction Using a New Filter Fence Concept
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EPA Project Officer: Bala Krishnan
Project Period: 9-10-03 to 9-9-04
Project Amount: $159,734
Research Category: Pollution Prevention

Description:

Objective(s) of the Research Project Specified for Current Project Period:

1) Develop an analysis of the regulatory criteria for implementing the improved silt fence
2) Prepare and present a workshop at the IPEC meeting (*Task completed for Year 1 and reported in 01/10/04 report*)
3) Develop threshold design criteria for sediment control, effluent guidelines under Phase II SWP based on a regional impact analysis
4) Prove the new silt fence design and implementation under laboratory and field conditions where the current silt fence fails due to:
   a) Flow concentrations that result from current installation technology
   b) Failure to trap clays and fines

Objective(s) Proposed for Year 2 Project Period to be Addressed in Current Project Period:

5) Investigate use of polyacrylimide (PAM) applied upslope of the fence or fused onto the apron to enhance settling
6) Develop design requirements for machine systems to install fences

Progress Summary/ Accomplishments (since 03/09/04):

Objectives 1 and 3: Regulatory agencies within the region were contacted concerning their current and anticipated requirements, and most reported that they are in a transition period of finalizing and then implementing their regulations. Therefore, there is nothing definite in place on which to base an analysis or recommendations. We will continue to follow up with the agencies to obtain their policies and regulations as soon as they are distributed. In the meantime, we concluded that it was better to wait for good information than to base the assessment on speculation.

Objective 4: A pilot-scale field installation consisting of one panel of fence between two lateral flow barriers was constructed to make preliminary assessment of the increased detention and sediment trapping due to the lateral flow barriers and to assess the proposed collection trough. We tested the system by first pouring two 5-gallon buckets of water and sediment onto the apron and observing the detention, deposition, and quality of the effluent as it flowed out through the fence. We then diverted runoff from our rainfall simulator into the fence. This runoff was excess that was relatively concentrated flow over bare soil at the edge of the test plot. At the conclusion of this exercise, the trapped sediment was at least 1 inch deep. Also, we observed the flow going down the side of the trough, and it looked relatively clear. Much of the flow in the collection trough came from water bypassing the fence segment, so the water in the trough is not an indicator of the performance of the fence.

Figure 1 Pouring water into pilot-scale fence and flow barriers.

Figure 2 Water flowing through fence and down the side of the trough is relatively

Based on those observations, some modifications were made to the fence and collection system, and a full-size fence with sampling system was erected. The purpose of this installation was to observe the functioning of the components under the simulated rainfall. In general, we were very pleased with the results. The collection system at the fence functioned as intended, and there was significant impoundment in the lateral flow barriers. The water coming through the fence was obviously cleaner than the runoff flowing toward the fence over the sheet metal. While this run was not intended for data collection, we did take grab samples at the edge of the source area and at the fence. The concentration of sediment in the grab samples at the fence was about 1/3 the concentration at the source area.

Figure 3 Sediment accumulation between flow barriers

Based on our observations, additional modifications to the collection system at the fence were implemented. These modifications will allow collection of the flow that is lost through seepage under the apron. In addition, the lateral flow barriers were originally attached with velcro and then sealed with silicone caulking material. The silicone did not develop a firm bond and we observed water and sediment leaking under the barriers at several locations (in addition to what passed through the fabric). A system for attaching the barriers using aluminum channels and push rivets was developed. This creates a better seal between the barriers and the fence, also the angle between the barrier

and fence can be set during installation. Ideally, the barriers will be oriented perpendicular to the contour.

There were significant rain delays throughout June and early July, but the new system is now complete. A simulation for data collection will be completed in the near future.

Figure 5 Water passing through fence is relatively clear

Objective 5: To address the objective of trapping fines, an investigation is currently underway to identify various formulations of polyacrilimide (PAM) that have the best potential to enhance the flocculation of clay particles under the anticipated field conditions. The previous report covered a series of exploratory experiments conducted to narrow down the ranges of options and to allow the graduate student conducting the research to become proficient in operating the new equipment. The series of formal tests is now underway and involves three stages: Prescreening tests, screening tests, and confirmative tests. Two soils with a high clay content are being tested, one known as Red Clay and the other known as Nasty Clay (so named for its undesirable properties with respect to walking on, grading, etc). The other two soils, known as Loam and Teller, have lower clay contents. Red Clay, Nasty Clay, and Loam are the soils which are being used in the field testing at the USDA lab. One run of prescreening tests has been completed for each soil. Three charge densities of 15Mg/mol PAM were tested – 10, 20, and 30 – designated PAM10, PAM20, and PAM30, respectively. Samples with sediment concentrations of 25,000 ppm were treated with 20 mg/l of PAM, mixed in the jar test apparatus, and allowed to settle for 5 minutes. Turbidity was measured before treatment and after settling. Using flocculation efficiency as the standard, the first series of tests suggests that PAM10 is the most effective. Flocculation efficiency (E) is computed as:

Figure 4 Collection system for samples at the fence

Figure 6 Water and sediment impounded between the flow barriers

$$E = \left(\frac{1 - T}{T_0} \right) \times 100$$

where T is the turbidity of the supernatant after treatment and T_0 is the initial turbidity.

Objective 6: An OSU Biosystems and Agricultural Engineering senior design team, in cooperation with the industry partner Charles Machine Works, created an attachment for an existing Ditch Witch vibratory plow and successfully installed silt fence. A field test was conducted at the USDA Hydraulics Lab wherein the fence was installed with the machine and

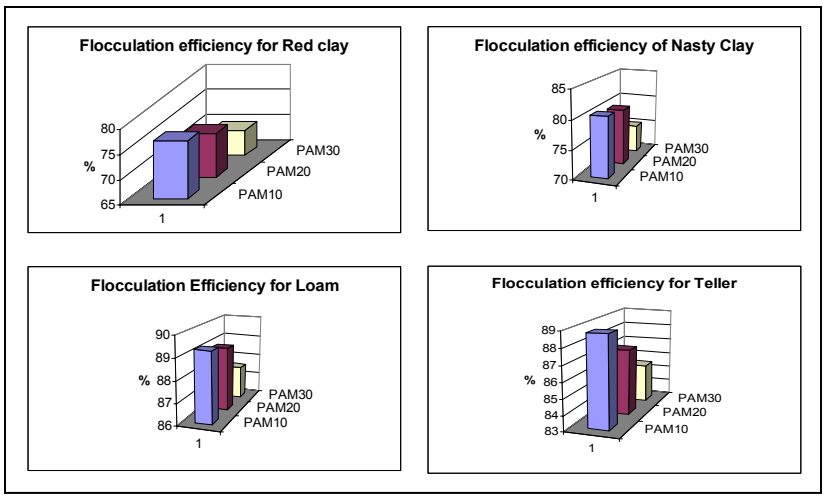

Figure 7 Results of prescreening tests for flocculation efficiency

then water was directed along the toe of the fence. The flow came from a 2-inch hose and was much greater than what would be seen in any field installation. The installation was successful in that there was no failure at the toe of the fence due to scour or undercutting. The industrial partner has expressed a strong interest in developing the attachment into a commercially available product.

Publications/ Presentations: The following included a paper published in a proceedings and an oral presentation given at the meeting:

Figure 8 Installing silt fence with vibratory plow

Stevens, E.W., K.A. Gasem , B.J. Barfield , and M.D. Matlock. 2004. Better Sediment Control Using Engineered Silt Fence. *IN*: Proceedings, 6th International Conference On Hydroscience And Engineering; Brisbane, Australia.

Stevens, E.W., B.J. Barfield, K.A. Gasem, and M.D. Matlock. 2004. On and off site sediment control using silt fence. *IN*: Proceedings, World Water and Environmental Resources Congress 2004; Salt lake City, UT, June 27 – July 1.

E.W. Stevens, Christianson, R.D, Barfield, B.J. 2004. Hydraulics of flow through and along silt fences. American Society of Agricultural Engineers Meeting Paper No. 04-2234. Joint ASAE and CSAE/SCGR Annual International Meeting, Ottawa, Ontario, Canada. (To be published/presented August 2004)

In addition to the above publications, Dr. Stevens presented information from the project at a continuing education session given at the annual meeting of the Oklahoma Section of the American Society of Civil Engineers, May 20, 2004.

Figure 9 Silt fence attached to posts

Future activities: The principal efforts for the next quarterly reporting period will be continuation of field testing, laboratory analysis of samples

Figure 10 Running water along toe of fence

obtained in the field testing, completion of the mathematical model up to the calibration/verification stage, and completing laboratory analysis of selected PAM formulations. The first series of field tests will focus on determining the best fence configuration (i.e., length of apron, spacing of flow barriers, method of attachment, etc.) to optimize the hydraulics of the fence given varying slopes and soil types. An additional series of field tests will then be conducted to optimize the performance of the PAM, including methods of emplacement, additives needed, etc.

Supplemental Keywords: Soil, sediments, pollution prevention, sustainable development, engineering, hydrology, south central, Oklahoma, EPA Region 6, petroleum industry, construction industry.

Figure 11 No undercutting of toe of fence – water did pass through fence