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

Period Covered by the Report: 12-10-03 to 3-9-04
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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 (*reported in 01/10/04 quarterly report*)
2) Prepare and present a workshop at the IPEC meeting (*Task completed for Year 1 and reported in 01/10/04 report*)
3) Develop and calibrate a physical process-based model to predict the performance of FAESF and use that model to select alternative designs that would work under a wider variety of conditions than could be tested in this project
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) Prove the new silt fence design and implementation under laboratory and field conditions where the current silt fence fails due to:
   a) Excessive stretching of the filter fabric
   b) Insufficient stability of the support posts
7) Develop design requirements for machine systems to install fences

Progress Summary/ Accomplishments (since 12/09/03):

Further progress has been made in development of the mathematical model. Algorithms have been developed to route flows through and around the flow barriers ("wings") proposed for the new technology. Also, algorithms to define the impoundment geometry have been developed. These algorithms were combined to develop a routing model that will predict detention time and can be used to assess the improvement in trapping efficiency resulting from addition of the flow barriers. In addition, the model will be used to size the apron and barriers for the prototype testing, which is scheduled to begin in June 2004.

A series of laboratory flume tests were conducted to determine if the apron could withstand the stress of moving water without being damaged and also to determine if soil particles would be scoured up through the apron. The flume bed was packed with a highly erodible river sand, and the flows along the apron were gradually increased to 0.183 cfs with a flow depth of about 0.2 feet. This is more discharge and depth than would be expected along the toe of a silt fence in the field. At the conclusion of the test, there was no damage to the silt fence that formed the apron. The water exiting the flume was tested for suspended sediment and compared with water entering the flume, which is lake water. There was no additional sediment in the water that had passed over the apron. The bed was profiled before and after the test, and the moving water did shift the bed material. However, none of it came through the apron. We therefore concluded that the addition of the apron will be effective in preventing undercutting by concentrated flow along the toe of a silt fence. Figure 1 is a photograph of the flume operating.

Figure 1. Laboratory flume to test erosion through apron

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. An extensive literature review was completed to identify formulations of PAM that have proved most successful in soil stabilization and to identify any associated problems, such as harmful residues.

Three promising compounds were identified, and laboratory jar testing is currently underway to determine the best concentration and application rate. The laboratory test also showed that the PAM was more effective in promoting flocculation when the sediment was suspended in tap water than when it was suspended in distilled water. This indicates that the final formulation for field use may need to incorporate calcium or some other compound with a divalent cation. Figures 2 and 3 show the jar test before and after flocculation. The after flocculation photo was taken immediately after the paddles were turned off.

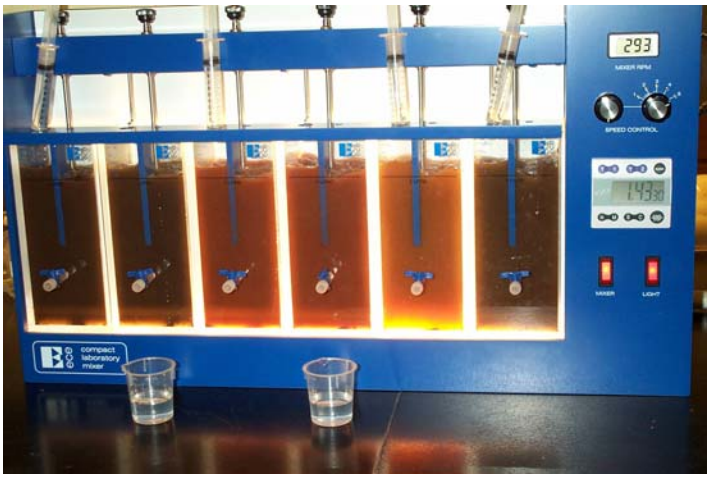

Figure 2. Jar test before flocculation.

A 3-D Pro-E model that simulates the material properties, height of the fence, and post spacing has been developed. The finite finite element analysis module Pro-Mechanica has been set up, and an assessment of the ability of materials with different properties to withstand the loading of impounded and flowing water has been initiated.

As part of the Year 2 objectives, this model will be used to determine an optimum post spacing for each type of material. The relative costs and benefits of using a cheaper, weaker material requiring more post support versus using a stronger, more expensive material and fewer posts can be completed. Figure 4 shows the displacement results from a preliminary analysis of a typical polypropylene fabric with a 3-foot post spacing and loading from approximately 2 inches of impounded water.

Figure 3. Jar test after flocculation

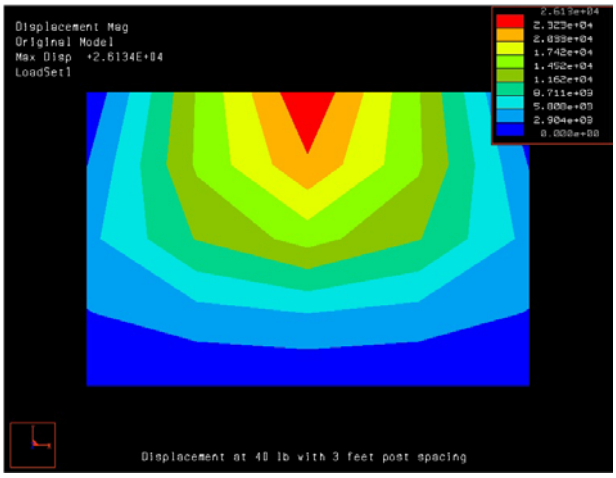

Figure 4. Pro-Mechanica results

An OSU Biosystems and Agricultural Engineering senior design team, in cooperation with the industry partner Charles Machine Works, has modified an existing Ditch Witch tractor and successfully installed silt fence. Figures 5 and 6 show the equipment and installation of silt fence. Their next step is to install fence at the USDA Hydraulics lab and determine if water running along the slot where the toe is placed will seriously undermine the toe.

Figure 5. Tractor laying silt fence

Figure 6. Test of anchoring in slot

Publications/ Presentations: The following will include a paper to be in a published proceedings and an oral presentation to be given at the meeting:

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. (manuscript submitted and accepted, to be published/presented June 2004)

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. (Manuscript submitted, to be published/presented June 2004)

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-xxxx. 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 will present information from the project at a continuing education session to be given at the annual meeting of the Oklahoma Section of the American Society of Civil Engineers in May 2004.

Future activities: The principal efforts for the next quarterly reporting period will be initiation of field testing, completion of the mathematical model up to the calibration/verification stage, and continuing laboratory analysis of selected PAM formulations. Prototype testing is scheduled to begin in June 2004. The students will complete their work on the installation technology, and those results will be assessed and used in completion of Objective 6 (scheduled for Year 2).

Activities for final reporting period in the current project year include completing the field testing of the hydraulic properties of the apron and lateral flow barriers and calibrating/verifying the mathematical model. Year 2 activities to be conducted include continuing the assessment of the strength of the selected fabrics or fabric/backing combinations, and testing various means of emplacing the PAM, including applying it directly to the surface of the fence material, incorporating it into fibrous material, or delivering it in a separate, replaceable container that can be attached to the apron of the fence.

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

Relevant Web Sites: We have obtained the services of a computer specialist who will be creating and maintaining a web site that will display information and photos from project activities. Links to this web site will be provided through the following OSU Biosystems and Agricultural Engineering pages:

http://biosystems.okstate.edu/faculty/barfield_index.htm
http://biosystems.okstate.edu/faculty/stevens_index.htm