Silt Fence Installation

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**Introduction**

Silt fence is a temporary sediment barrier consisting of filter fabric entrenched into the soil and attached to supporting posts shown in Figure 1. A silt fence is solely intended to control sediment. Current designs consist of a vertical geotextile fabric with a toe section compacted into the soil and vertical stakes holding it in place. The geotextile is designed to retain sediment-laden water allowing the soil particles to fall out of suspension and separate from the runoff. This traps the eroded soils preventing offsite pollution of surface waters surrounding construction sites.

![Figure 1. Properly Installed Silt Fence](image)

**Problem Definition**

Current methods of installation are the primary causes of fence failure. The design of the fence requires that it be installed along the contour of the slope, preventing runoff from traveling along the length of the fence. If the fence is installed along the slope it can create concentrated flow increasing erosion as shown in Figure 2. An edge or toe of the fabric is installed in a shallow trench that is rarely compacted.

![Figure 2. Failure due to concentrated parallel flow](image)
adequately, thereby allowing undercutting to occur. Placement is also critical when
determining the volume of water that can be retained behind the fence and the area of
runoff being captured by each section of fence. If the area is too great, the fence will
stretch and eventually be overtopped, allowing soil particulates to leave the site as shown
in Figure 3. In addition, posts are typically undersized and are unable to support the
forces imposed on the fence during times of high runoff flow. Fences are relatively
ineffective overall as they are currently used due improper installation.\(^1\)

![Figure 3. Failure resulting from excessive stretching and overtopping\(^2\)](image)

Dr. Billy Barfield of the Biosystems and Agricultural Engineering (BAE)
department at Oklahoma State University and his research team are developing improved
methods of controlling sediment and storm water. They have been working for three
years with sponsorship from the Environmental Protection Agency to design a
replacement for the current silt fence. Charles Machine Works of Perry, Oklahoma has
joined the effort providing resources to develop a piece of equipment to install the new filter fence. A machine will add repeatability to the process and improve the consistency of installation procedures. Charles Machine Works is of course the parent company of Ditch Witch, a world-wide manufacturer of digging and trenching equipment. The new filter fence project is named FAESF or Failure Avoidance and Effective Silt Fence Technology. The goals of the project are:

- control undercutting and overtopping due to cross-contour installations,
- control lateral flow along the silt fence,
- improve the trapping of fine silts and clays through the use of polyacrilamides incorporated into the fabric,
- provide adequate strength posts and fence to prevent excessive stretching and overturning, and
- provide for adequate bearing capacity of post footings.

**Statement of Work**

The Enviro-Mech design group is composed of four BAE students in BAE 4012 Senior Design. Enviro-Mech’s efforts will focus on reducing failures due to improper installation procedures while Dr. Barfield’s team will continue to develop the new filter fence material configuration and the fence support mechanism. Because the filter fence design is still being finalized, the installation equipment will be designed to handle current estimates for the final fence design shown in Figure 4.

A machine will be designed and built to install the fence. It will be capable of handling a large roll of the filter fence material. Filter fence material will be placed in a trench and have soil recompacted around the fabric. Final dimensions and shape of the trench will be determined through research. Filter fence material will also have a section that lies on the ground as an apron helping reduce the possibility of undercutting. This
apron will be stretched along the ground surface and then attached to vertical supports. Methods for handling the material and installing it properly will be investigated by the design team.

![Figure 4. Current Fence Configuration from the FAESF](image)

### Investigation

**Current Recommended Silt Fence Practices**

The National Resource Conservation Service (NRCS) recommended practices specify the fence shall be installed parallel to the contour with a maximum runoff area and slope for each fence section. Figure 5 shows the recommended configuration. There must be 14 to 28 inches of vertical fence when measured from ground level. There are also specific requirements for either steel or wood support dimensions. Joints must be securely fashioned. A trench should be dug along the path of the silt fence that is 4 inches wide and a minimum of 8 inches deep. The posts are driven at least 16 inches into the ground with a minimum of 20 inches remaining above the surface. The fence is then
stretched tight with the geotextile covering a wire mesh backing which is then connected to the posts. The final step is to backfill the trench and compact it. The fence must then be inspected after each runoff event and maintenance performed. 

![Diagram of NRCS Recommended Practices](image)

**Figure 5. NRCS Recommended Practices**

If fence is installed using these procedures as it is during laboratory testing, the silt fence is usually effective. The problem is that these are only recommended practices, not required, and the majority of silt fence installed in the field does not meet these specifications.

**Current Equipment Patented and in Production**

There are five machines patented to install the current silt fence. These patents are included in Appendix A. Of the patented concepts, only Carpenter and Vreeland are currently manufacturing machines under the brand names of Carpenter Erosion Control and Erosion Runner LTD, respectively. Two other companies, McCormick Equipment and ImpleMax, also manufacture silt fence installation machines; however, neither has a registered patent for their designs.

The Tommy Silt Fence Machine, from Carpenter Erosion Control, slices through soil and inserts the silt fence without displacing soil. The apparatus is comprised of a
ground-driven vertical wheel that is positioned between two narrow panels that run along the sides of the blade. Silt fence is pulled off of a roll by the wheel, funneled into the machine, and inserted into the soil being held open by the panels as shown in Figure 6. As the machine progresses, soil collapses onto the fabric, securing the fence in the desired position. The soil disturbance is minimized by using static slicing, so the soil is not recompacted after it is disturbed.  

The Erosion Runner design incorporates a plow blade with curved surfaces on both the front and rear edges creating a trapezoid like shape. A guide follows directly behind the plow blade and feeds fabric into the slot formed by the plow blade. After installation, the ground is later compacted by the tractor wheel while posts are driven into the ground using a hydraulically actuated cylinder device. 

McCormick Equipment has designed a three point mounted model that uses static slicing similar to the Tommy design and
does not recompact the soil either, however, there is no wheel to feed the fabric down into the slot, shown in Figure 7. McCormick claims that a feeding wheel can cause the fabric to bunch and clog.  

The ImpleMax SF12c Silt Fence Installer uses a vibratory plow to create a slit and is designed to attach to front end loaders and skid steers with standard quick connections as shown in Figure 8. The fence has a shaped edge that passes through a formed channel on the back edge of the plow blade. There are patents pending for this technology that ensures that the fence is feed to the base of the slit.

**Similar Vibratory Plow Applications**

Ditch Witch currently produces vibratory plows to install cables. A vibratory plow utilizes engine power to vibrate the blade up and down. This motion decreases the total power required to pull the blade through the soil. There are two designs for this application. The first method has a separate channel for the cable to feed through attached to the back of the blade through a four bar linkage as seen in Figure 9. This design allows the
cable to float in the bottom of the slot without moving up and down with the plow. The second design is comprised of two flanges off the back edge of the blade creating a groove for the cable to feed down, shown in Figure 10. A guide plate lies in the back of the channel and holds the cable into the groove.\(^8\)

Figure 10. Blade for Cable Installation Applications
Design Criteria

The new machine for installing the filter fence must be compatible with the overall purpose of filter fence. It must not promote concentrated flows that could potentially increase the risk of soil erosion.

Approximated dimensions of the final fence design have been provided by the FAESF research group and are shown in Figure 11. The overall filter fence design consists of a secured toe, an apron, and the vertical fence portion supported by posts. The FAESF goals require that the toe of the fence be secured in a fashion that will prevent undercutting and allow the water to move up onto the apron portion unobstructed. In order to ensure that the water flow does not divert along the toe, the installation must protect the toe with compacted soil and avoid creating depressions that could act as channels. Once the runoff reaches the apron portion, the filter fence can begin the process of impounding the runoff and allowing sediment to settle without erosion or undercutting.

Figure 11. Design Specifications from the FAESF research group
Charles Machine Works has requested that the design be compatible with a current production power source. The final design should be economically feasible and the design should be marketable. Depending on the required power, the SK500, 255SX, and the 410SS have been recommended.

The SK500 is unique due to a design that allows for quick change attachments, shown in Figure 12. The filter fence installation machine could potentially be an attachment for this product. The latter two models are dedicated machines with specific fixed attachments. This would increase the overall price of a silt fence installation machine because they could not be used for other applications when not installing silt fence.

**Concept Development**

Enviro-Mech team members brainstormed ideas independently. The group then met and evaluated the designs. Suggestions and modifications were made to each of the designs. Action items were assigned to each member at the end of each of these meetings in order to continue the investigation and research of the project. Methods of installation, trench dimensions, web handling techniques, and recompaction were all developed separately. By developing concepts individually the ideas for each component can create
many different combinations to create the most effective machine. After comparing the various designs, the overall best methods were selected to begin the first stages of testing.

**Test and Analysis**

Testing will be required to determine the most effective and financially feasible method of installation. The testing as been divided into three areas, methods, concept, and final design, that will occur during corresponding concept development phases. Initial testing procedures will determine if the various method of installation are effective. Methods deemed adequate will then be incorporated into a complete machine design. Those machine designs will be analyzed to determine overall complexity and manufacturing costs. This information will then be used to determine the final design that achieves all of the objectives for properly installing silt fence.

Method testing will be very simple to allow quick execution. Inserting the fence into slots created using a vibratory plow will be done by hand for the different concepts. After installation methods have been manually tested, design alternatives for the selected methods will be evaluated for feasibility.

Concept testing will be the second phase of testing where the components of the machine will be combined to determine the final configuration of the web handling, insertion system, and the packing wheels. After these phases of testing are complete the final design will be constructed. Final design testing will evaluate if goals were met and if any fine tuning is required. The final design must be a device that meets the requirements and expectations of our team and sponsors.
Potential Solutions

Proposal A – Two-Disk Method

The first design option utilizes two narrow disks to feed the fabric into the slot. The disk configuration is shown in Figure 13. The roll of fabric is oriented vertically and the fabric is fed into the disks that are following the plow and rotating at the speed of travel. The disks pinch the fabric above ground and ensure that it is pulled down into the base of the slot where the fabric is released. It is followed by packing wheels to ensure the soil is recomppacted and will resist erosion at the disturbance. This concept is similar to the operation of a row crop planter.

Proposal B – Feed Channel Method

A channel will be attached to the rear of the vibratory plow blade similar to the current cable feeding system shown in Figure 14. The fence will require added bulk along one edge to secure it into the slot and allow it to be fed. The end of the fabric may have a cord or some type of T-shaped edge. During installation, the fence edge would slide through the channel and be placed at the bottom of the slot made by the plow. The fence will be fixed into the slot by press wheels following behind the process.
**Proposal C – Tension Rod Method**

A spring loaded rod will be used to direct the fence material into the slot shown in Figure 15. The roll of fabric would be parallel with the ground and perpendicular with the direction of travel. Fabric would fold with contact from the rod. The rod slides on the bottom of the slot pinching the fabric at the bottom. It acts as a pressure point at the bottom of the slot pulling more fabric around the rod and down into the slot as the machine travels forward. As the machine moves forward the rod moves over the small flap of fabric at the bottom of the slot leaving it stationed in the slot. Packing wheel will follow fixing the fence into place.

**Project Schedule**

Project scheduling has been split into two major sections that represents the two semesters. In each semester the schedule contains tasks and subtasks. During the fall semester the main tasks included Project Definition, Concept Development, Investigation and Testing, and Documentation. The spring semester has the same tasks with Final Design, and Drafting added. The fall schedule has been completed as planned with the exception of methods testing, which will begin first thing in the spring semester. Concept testing will be completed concurrently with a feasibility study and conceptual modeling. Once conceptual developments are complete, component procurement and final drafting with begin. This will be followed by prototype fabrication. Once the prototype is
complete, the final testing will be performed and a final drawing review performed. A
detailed Gantt chart showing the entire fall and spring semesters can be found in
Appendix B.

**Proposed Budget**

The budget was broken down into the four components of the machine. Material
cost and manufacturing times for each component was estimated based on experience.
The fabrication cost was based solely on the equipment use fee charged when
components are fabricated in the BAE laboratory. It does not include the machinists’
labor. A 20 percent contingency was added to both the material and fabrications cost to
cover the cost of any concept testing components that may need to be constructed in
addition to the final prototype. The estimated budget is shown in Table 16.

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<th>Fabrication Cost</th>
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Table 16. Proposed Budget

**Conclusion**

The project definition has been completed and concept development is proceeding
on schedule. Spring semester allows for further testing and analysis and prototype
fabrication. Budget considerations have been made and the project is ready to move
forward. On approval the project will progress as stated in this proposal.
Bibliography


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