
Effective Means of Silt Fence Installation



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Effective Means of Silt Fence Installation

Abstract

Surface water pollution can be greatly reduced through the installation of effective silt fence. Silt fence is placed around construction sites in which the top soil is exposed. Silt fence is typically ineffective due to poor design and installation. The objective of this project was to design and build a machine capable of installing silt fence properly. Enviro-Mech is a design team formed by four senior students in the Biosystems and Agricultural Engineering Department at Oklahoma State University. Enviro-Mech is to create a machine which installs silt fence to standards established by the Failure Avoidance and Effective Silt Fence Technology (FAESF) group using a vibratory plow manufactured by Charles Machine Works, Inc. Results of this project reflect the extent to which Enviro-Mech has accomplished the design criteria. The FAESF group required that the new equipment be compatible with their new fence design and that it does not promote installation-related erosion. More specifically, the design criteria provided by the FAESF group require that the new installation equipment be capable of installing fence in a trench eight to ten inches deep, with soil backfilled and compacted. Charles Machine Works, Inc. also provided design criteria which required that the final design be compatible with current Ditch Witch vibratory plows and that the final prototype be economically feasible and marketable. Through the production of a prototype and extensive testing, these criteria have been measured. Results meet or exceed the sponsors' requirements.

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Introduction

Silt fence is a temporary sediment barrier consisting of filter fabric entrenched in the soil and attached to supporting posts (fig. 1) (Salix, 2000). 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 restriction traps the eroded soils, preventing offsite pollution of surface waters surrounding construction sites.



Figure 1. Properly Installed Silt Fence (Salix, 2000)

Problem Definition



Figure 2. Failure due to Concentrated Parallel Flow (Barfield et al., 2000)

Current methods of installation are the primary causes of fence failure (Salix, 2000). Proper 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 that may increase erosion (fig. 2). An edge or toe of the fabric is installed in a shallow trench that is rarely compacted adequately, thereby allowing undercutting to occur.

Placement of the fabric 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 of runoff is too great, the fence will stretch and eventually be overtopped allowing soil particulates to leave the site (fig. 3). In addition, supporting posts are typically undersized and unable to support the forces imposed during times of high runoff flow.



Figure 3. Failure resulting from Excessive Stretching and Overtopping (Barfield et al., 2000)

Dr. Billy Barfield of the Biosystems and Agricultural Engineering (BAE) department at Oklahoma State University and a research team are developing improved methods of controlling sediment and storm water (Barfield et al., 2000). They have been working for three years with sponsorship from the Environmental Protection Agency to design a replacement for the current silt fence. The research team will implement the proposed standards developed by the new filter fence project, “Failure Avoidance and Effective Silt Fence Technology” (FAESF). Standards for the project are:

1. Control undercutting and overtopping due to cross-contour installations,
2. Control lateral flow along the silt fence,
3. Improve the trapping of fine silts and clays through the use of polyacrilamides incorporated into the fabric,
4. Provide posts and fence with adequate strength to prevent excessive stretching and overturning, and
5. Provide post footings with adequate bearing capacity.

Charles Machine Works of Perry, Oklahoma has joined this team’s effort by providing resources to develop machinery and equipment to install the new filter fence. The use of a machine will mechanize the process and improve the consistency of installation. Charles Machine Works is the parent company of Ditch Witch™, a world-wide manufacturer of digging and trenching equipment.

Statement of Work

The Enviro-Mech design group is composed of four BAE students in BAE 4012 Senior Design. Enviro-Mech's efforts focused on reducing failures due to improper installation procedures while Dr. Barfield's team continued 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 the current proposed standard for the fence design (fig. 4).

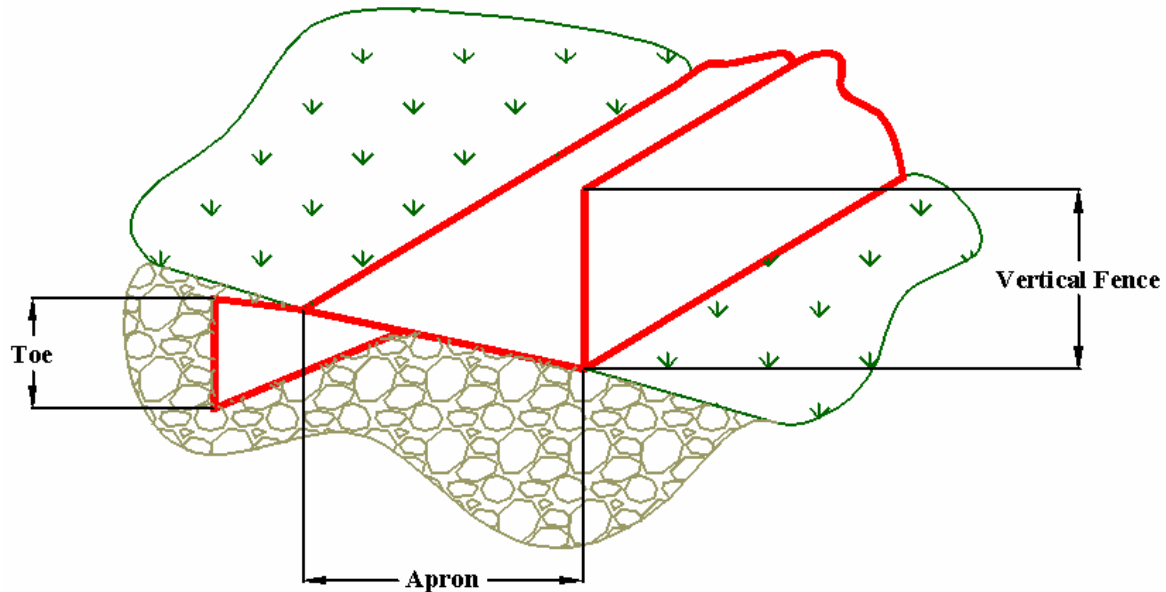


Figure 4. New Fence Configuration from the FAESF (Barfield et al., 2000)

A machine was designed, built, and tested to install the fence. It was capable of handling a large roll of the filter fence material. Filter fence material was placed in a trench and soil was re-compacted around the fabric. Final dimensions and shape of the trench was determined through testing. Filter fence material has a section that lies on the ground as an apron helping reduce the possibility of undercutting. This apron was stretched along the ground surface and then attached to vertical supports. Methods for handling the material and installing the fabric properly were investigated by the design team. Installation was divided into two steps. In phase two, a second machine will be developed to install vertical supports and attach the fabric. This portion of the project was not addressed by the Enviro-Mech design team.

Investigation

Currently Recommended Silt Fence Practices

National Resource Conservation Service (NRCS) recommended practices specify that the fence shall be installed parallel to the contour, with a maximum runoff area and slope for each fence section (NRCS, 2003). NRCS also has a recommended fence configuration (fig. 5). There must be 14 to 28 inches of vertical fence, measured from ground level. There are also specific requirements for either steel or wood support post dimensions. Joints must be securely fastened. A trench should be dug along the path of the silt fence that is 4 inches wide and a minimum of 8 inches deep. 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 and compact the trench. The fence must then be inspected after each runoff event and maintenance performed.

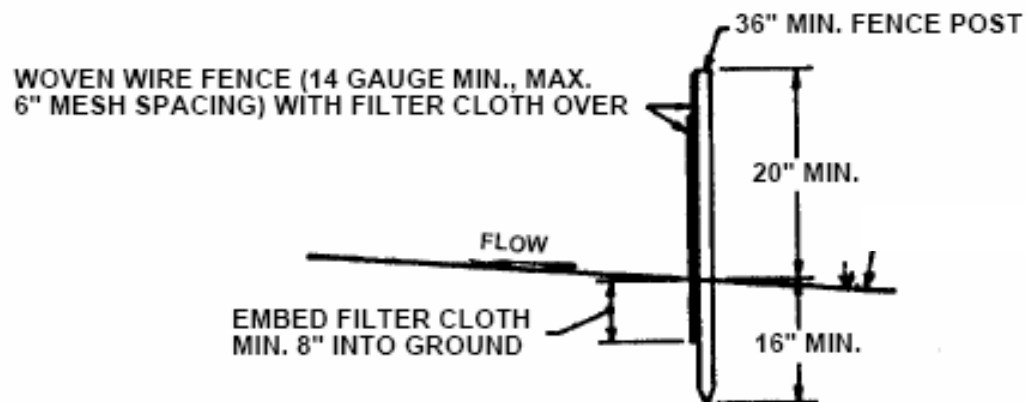


Figure 5. Current NRCS Recommended Practices (NRSC, 2003)

When a fence is installed attempting these procedures, performance is usually unsatisfactory. The problem is that these are only recommended practices, not required practices. The majority of silt fence placed in the field does not meet these specifications because installation technique is inadequate. The primary difference, affecting installation, between the design by the FAESF research group and the current fence is the addition of the ground surface apron.

Current Equipment Patented and in Production

There are five machines patented to install silt fence (appendix A). Of the patented concepts, only Carpenter and Vreeland are being manufactured by Carpenter Erosion Control of Ankeny, Iowa and Erosion Runner LTD of Cincinnati, Ohio, respectively. Two other companies; McCormick Equipment of Pleasantville, Iowa and ImpleMax of Bozeman, Montana also manufacture silt fence installation machines. However, neither has a registered patent.

The Tommy Silt Fence Machine, from Carpenter Erosion Control, slices through soil and inserts the silt fence without displacing soil (Carpenter, 2003). The apparatus is comprised of a ground-driven vertical wheel positioned between two narrow panels that run along the sides of the blade (fig. 6). Silt fence is pulled off of a roll by the wheel, funneled into the machine, and inserted into the soil held open by the panels. As the machine progresses, soil collapses onto the fabric securing the fence in the desired position. Soil disturbance is minimized by using static slicing. Therefore, the soil is not re-compacted after installation.



Figure 6. Tommy Silt Fence Machine (Tommy, 2003)

McCormick Equipment has designed a three-point mounted model that uses static slicing similar to the Tommy design and does not re-compact the soil (McCormick, 2003). However, there is no wheel to feed the fabric down into the slot (fig. 7). McCormick claims that a feeding wheel can cause the fabric to bunch and clog, contradicting claims of the Tommy machine.



Figure 7. McCormick Silt Fence and Waterway Fabric Installation Plow (McCormick, 2003)

The Erosion Runner design incorporates a plow blade with curved surfaces on both the front and rear edges creating a trapezoid-like shape (Erosion Runner, 2003). A guide follows directly behind the plow blade and feeds fabric into the slot created. After installation, the ground is compacted by the tractor wheel while posts are driven into the ground using a hydraulically actuated impact cylinder.

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 (fig. 8) (ImpleMax, 2003). The fence has a shaped edge that passes through a formed channel on the back edge of the plow blade. This feature ensures that the fence is fed to the base of the slit. Patents are pending on this technology.



**Figure 8. ImpleMax SF12c Silt Fence Installer
(ImpleMax, 2003)**

Similar Vibratory Plow Applications

Charles Machine Works currently produces vibratory plows to install communication cables (Ditch Witch, 2001). 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 has a separate channel to feed cable attached to the back of the blade through a four-bar linkage (fig. 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 located at the back edge of the blade creating a groove to feed the cable (fig. 10). A guide plate extends along the length of the groove and lies into the groove to hold the cable in place.

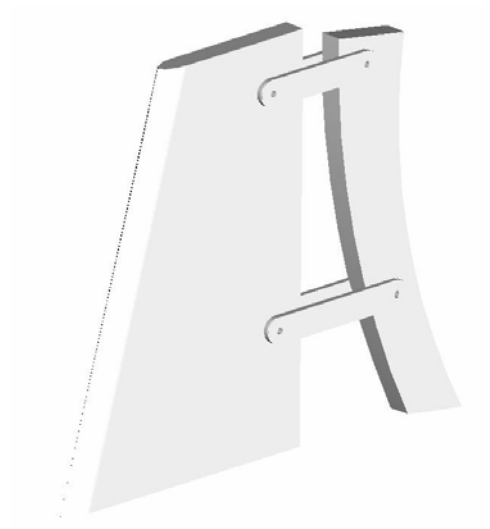


Figure 9. Four-Bar Linkage for Cable Applications

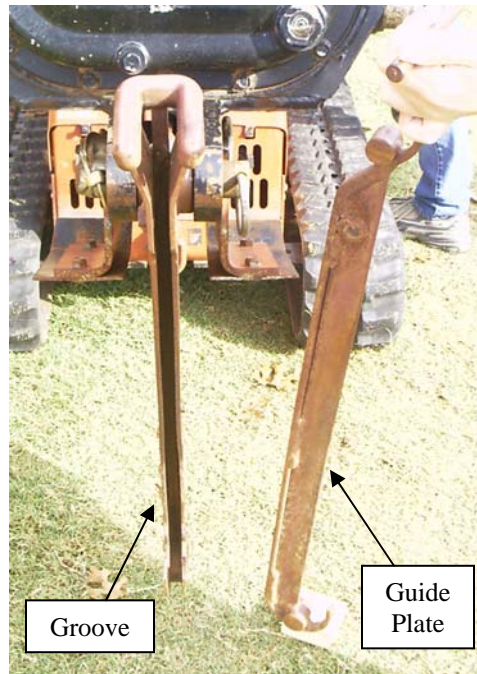


Figure 10. Cable Installation Blade

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 increase the risk of soil erosion. Approximate dimensions of the final fence design have been provided by the FAESF research group (fig. 11). The overall filter fence design consists of a secured toe, an apron, and the vertical fence portion supported by posts. The FAESF standards require that the toe of the fence be secured in a fashion that will prevent

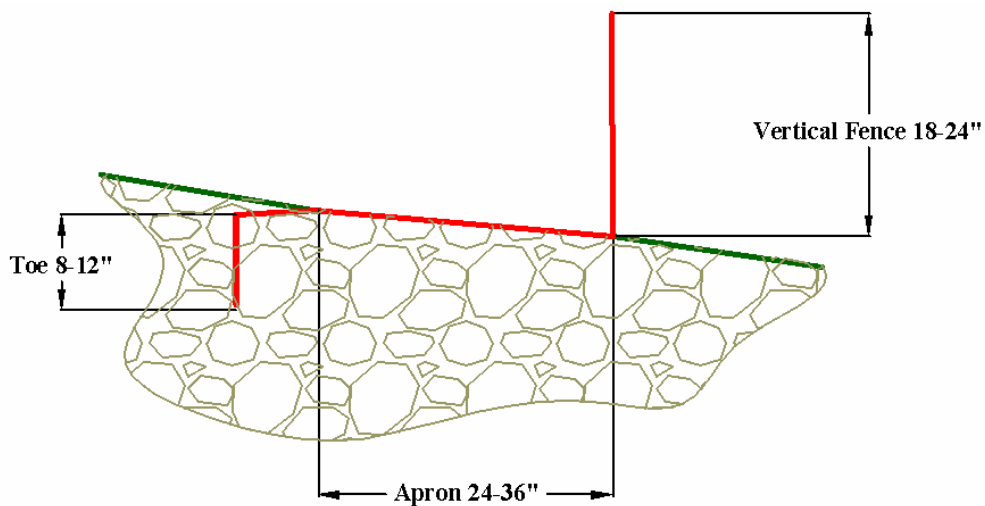


Figure 11. Design Specifications from the FAESF Research Group

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.

Charles Machine Works has requested that the design be compatible with a current production vibratory plow. The final design should be economically feasible, and the design should be marketable. Depending on the required power, the SK500, 255SX, and the 410SS vibratory plows have been recommended (fig. 12). Operator safety was also taken into consideration when making design decisions.



Figure 12. Ditch Witch SK500 with Vibratory Plow Attachment

The SK500 is unique due to a design that allows for quick-change attachments. 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 limitation would increase the overall price of a silt fence installation machines, because they could not be used for other applications when not installing silt fence. The final design objectives are:

1. Capable of handling current and new filter fabric rolls,
2. Compatible with a current vibratory plow model,
3. Installs to the depth required to secure the fabric,
4. Compacts soil after installation to prevent undercutting, and
5. Operates in many soil types and conditions.

Concept Development

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

Potential Solutions

Proposal A – Two-Disk Method

The first design concept utilized two narrow disks to feed the fabric into a slot (fig. 13). The roll of fabric was oriented vertically, and the fabric was fed into the disks that follow the plow and rotate 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. This apparatus is followed by packing wheels to ensure the soil is re-compacted into the slot to resist. This concept is similar to the operation of a row crop planter.

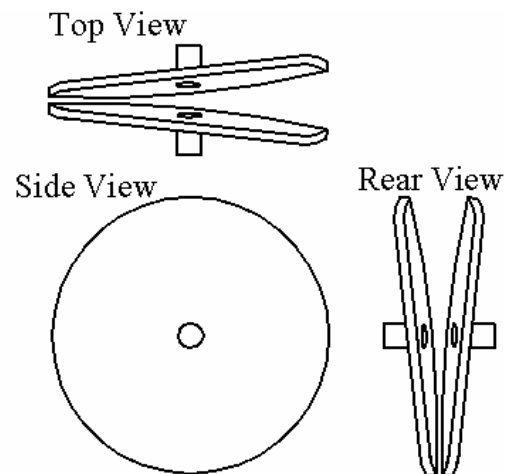


Figure 13. Two-Disk Method Diagram

Proposal B – Feed Channel Method

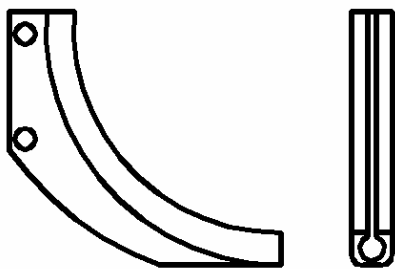


Figure 14. Feed Channel Method

A channel was attached to the rear of the vibratory plow blade similar to the current cable feeding (fig. 14). The fence required added bulk along one edge to secure it in the slot and allow it to be fed. For application, the end of the fabric could have a cord or a T-shaped edge. During installation, the fence edge was slid through the channel and placed at the bottom of the slot made by the plow. The fence was guided into the slot by press wheels following behind the process.

Proposal C – Tension Rod Method

A spring loaded rod was used to direct the fence material into the slot (fig. 15). The roll of fabric was parallel with the ground and perpendicular to the direction of travel. Fabric would fold around the rod when it made contact. The rod slid along the bottom of the slot, pinching the fabric at the bottom. The rod acted as a pressure point at the bottom of the slot, pulling more fabric around the rod and down into the slot as the machine traveled forward. The rod moved over the small flap of fabric at the bottom of the slot, leaving it stationed in the slot as the machine moves forward. A packing wheel followed, securing the fence in place.

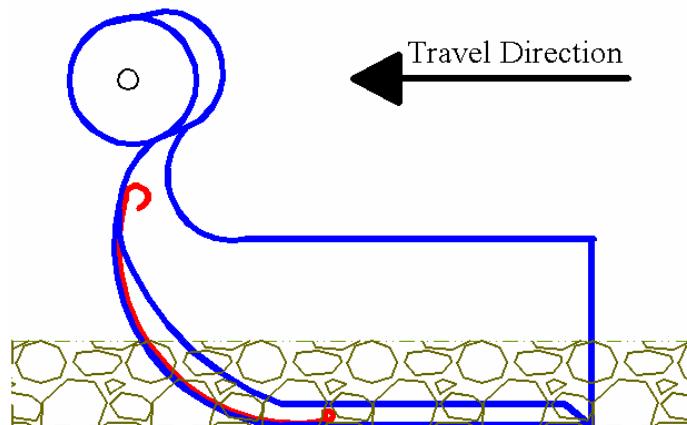


Figure 15. Tension Rod Method

Testing and Analysis

Testing was performed to determine the most effective and financially feasible method of installation. The testing was divided into three areas: methods, concept, and final design. Testing occurred as part of the concept refinement phases. Initial testing determined if the various methods of installation were effective. Methods deemed adequate were incorporated into a complete machine design. Those machine designs were analyzed to determine overall complexity and manufacturing costs. This information was then used to select the final design that achieves all of the objectives for properly installing silt fence.

Methods Testing

Methods testing was kept simple to allow quick execution. Fence was manually inserted into slots created using a vibratory plow (fig. 16 and fig. 17). The slot was much narrower and collapsed more easily than expected.



Figure 16. SK500 Creating Slot



Figure 17. Silt Fence Hand-Inserted into Slot

The two-disc method was quickly eliminated, due to the size of the disc required to achieve the proper installation depth and the potential for tearing the fence material. The feed channel method was ruled out after evaluating the turning capability of the design.



Figure 18. Tension Rod in Slot

The fabric needed to be in a protective shield while being pulled into the ground. With this method, the shield would be attached directly to the back of the blade. The length of the rigid section in the ground would limit the turning radius of the machine.

From methods testing performed January 21, 2004, the tension rod method was selected as the preferred form of fence insertion because of the simplicity of the design and the possible multiple configurations (fig. 18). After finalizing the decision to implement the tension rod method, concept testing began to determine the prototype design.

Concept Testing

An evaluation plan was created involving a sequence of tests to determine the final configuration. To ensure the safety of the operators throughout testing, lift capacity of the machine was determined. The SK500 was capable of lifting 1275 lbs from the attachment bar, in addition to the vibratory plow, before becoming unstable on the tracks.

Ideas of how to attach the installation equipment to the SK500 were evaluated. In order to allow quick changes for design verification, short extensions were added to the SK500 attachment bar, and a square frame was built around the vibratory plow. The frame was fabricated using 2" X 2" X 3/16" square steel tubing. Multiple attachments were added to, and removed from, this tube frame as the project progressed (fig. 19). Fabrication was completed by the Biosystems and Agricultural Engineering Laboratory at Oklahoma

State University. The laboratory prefers to work with English units, therefore the remainder of this report is in English units.

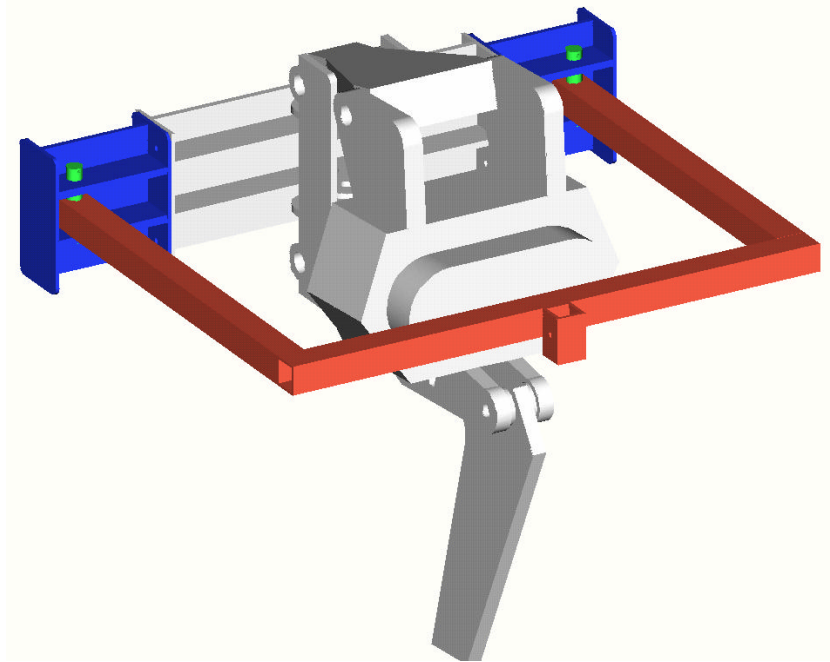


Figure 19. Vibratory Plow with Extensions and Square Testing Frame

During methods testing, the group discovered that a shield would be needed to protect the fabric as it was inserted in the base of the slot. This shield will impose the primary source of frictional forces during fabric installation. An experimental shield was designed and fabricated (fig. 20). A tension rod of 1/2-inch diameter steel was required to maintain strength, yet allow flexing. The shield was designed with a 3/4-inch gap to allow room for the rod and for fabric feed. The shield was constructed from 1/8-inch steel plate, with a wide funnel-shaped mouth.

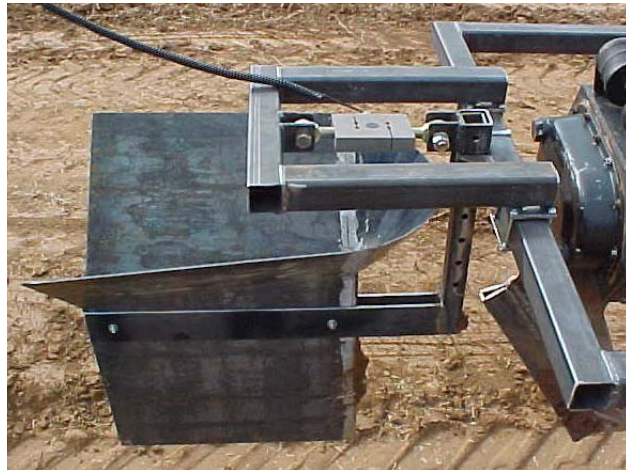


Figure 20. Experimental Shield and Load Cell

Brackets for a load cell were built to enable measurement of the forces generated by entering the soil and being pulled through the ground. Forces collected during testing were read at the center of the shield (fig. 21). Each pass saw similar entry forces with a plateau at approximately 75 lbs. One pass exhibited higher forces, but this peak occurred when the shield deviated from the path created by the vibratory plow. The front edge of the shield broke its own path through the soil. The design group determined that the shield must follow the path of the blade, even when following contours.

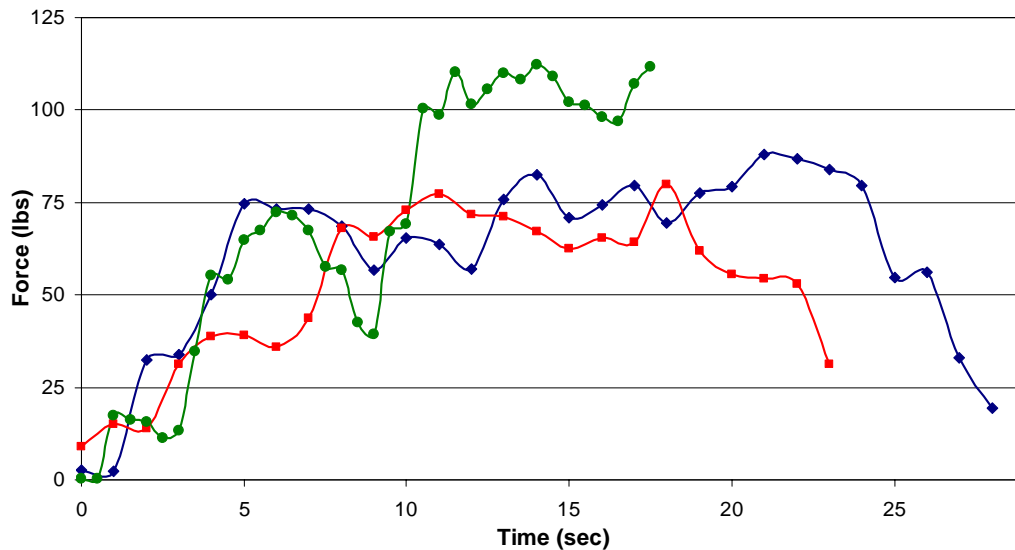


Figure 21. Load Data for Three Passes

During the February 18, 2004 field test, the group observed that the back portion of the shield appeared to be coming out of the slot (fig. 22). A toe was added to the front of the shield in an effort to pull it down into the soil, reducing entry forces and preventing the back portion of the shield from lifting out of the soil (fig. 23). Adding a toe did not solve the problem. Forces entering and moving through the soil were unchanged. Deflection in the load cell connections supporting the shield had caused the shield to lift out of the ground.



Figure 22. Shield Pulling Out of Ground during Testing



Figure 23. Shield with Toe Added

The initial concept for the frame consisted of two parallel frame rails connected to the extensions used with the square tube testing frame. Components following the vibratory blade were mounted between the two long rails. Two important concepts the group wanted to target were the ability of the shield to trail closely behind the blade and for the shield to pivot in order to follow the blade through a curved path. During load testing, the team observed that a very complex network of pivot points would be required in this parallel frame to follow the blade through the ground. This meant that the main frame must move with the vibratory plow and have a pivot point behind the plow for shield attachment, ruling out the use of extensions on the attachment bar.

Difficulty in designing a frame that could attach to components behind the vibratory blade, yet not interfere with the vibratory motor, forced the team to develop two new concepts (fig. 24 and fig. 25). The first frame, designed to use a bent plate that was boxed in to add rigidity, arched over the top of the vibratory plow. Due to increased bending moments created by the components mounted at the pivot point, this design was not pursued. Design concept two used rectangular tubing in an octagonal pattern to wrap around the vibratory plow.

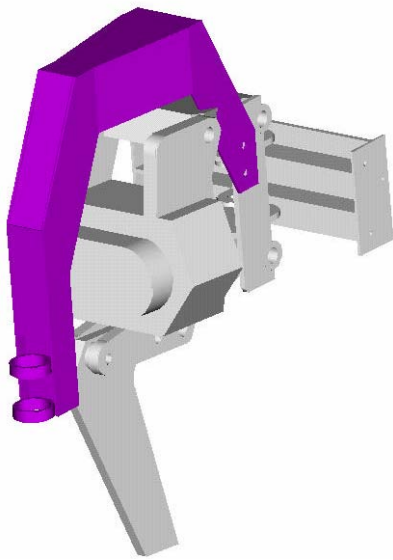


Figure 24. Over-the-Top Frame Concept

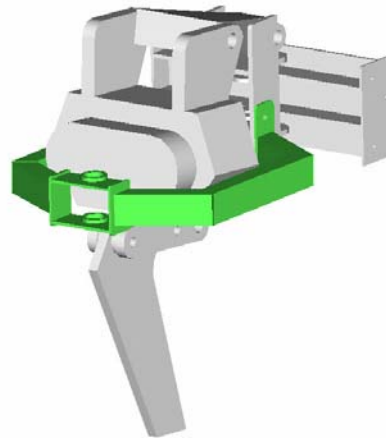


Figure 25. Wrap-Around Frame Concept

A tension rod was fabricated with a radius of 18 inches similar to the rod used during methods testing. A pivot plate was attached at one end of the arc. Two support members were added to maintain the rigidity of the upper portion of the rod. The mounting bracket for the shield and tension rod was constructed from square tubing and attached to a pivot on the rear of the square testing frame (fig. 26). The shield was positioned between two square tubes to maintain the inside gap.



Figure 26. Testing New Pivot Design and Tension Rod Mounting

With the tension rod and shield in place, approaches to attaching a roll of fabric were tested. Testing began with manual manipulation of the fabric. It was pulled off a roll and through the shield at a variety of angles. Adjustable brackets were bolted to the testing frame to support the fabric roll (fig. 27). From this testing, the most efficient placement of the fabric roll relative to the tension rod was determined.

Packing wheels were needed to recompact the soil and secure the fabric in the soil slot (fig. 28). Initially, spring loaded wheels were proposed, but the complexity of the design forced the group to re-evaluate. We concluded that the maximum force applied to the packing wheels was controlled by the hydraulic lift cylinder and the weight of the machine. The packing wheels could be used as a depth gauge to assist the operator in maintaining a consistent depth.



Figure 27. Adjustable Frame to Find Proper Fabric Roll Location and Orientation



Figure 28. Packing Wheel

Final Design Testing

Final design testing was used to evaluate the prototype and to determine if design criteria had been met. The final design had to meet the requirements and expectations of the design team and sponsors. Testing was also used as an opportunity for fine-tuning the installation process.

Final testing revealed that improper operation during initial entry into the ground caused soil to enter the bottom of the shield. Soil was collecting and compacting around the bottom edge of the tension rod. This build-up restricted free movement of the fabric along the rod. Welding a steel plate to the bottom surface of the shield corrected this problem.

The team also observed that the wind was unrolling the fabric faster than it could be installed (fig. 29). In order to control the unrolling of the fabric, the group added a contact plate with curvature equal to a full roll of fabric to provided braking.



Figure 29. Fabric Unrolling due to Wind

Using a spring scale, tests were conducted to determine the force needed to remove the silt fence from the trench (fig. 30). The FAESF group had requested this information for use in conjunction with their new fence design. Testing was performed in both packed and unpacked trenches to determine if changes in soil type or texture affected performance. Force was recorded when the fence began to slide out of the slot. Averages for each soil condition were recorded (table 1).



Figure 30. Spring Scale Testing to Determine the Force Required to remove Fabric from the Soil

Table 1. Spring Test Results

Soil Condition	Force (lb)
Bare, Unpacked	15
Bare, Packed	50
Grass, Unpacked	40
Grass, Packed	> 50

Final design testing was performed under several different conditions, including cleared and grassed surfaces. Testing was performed along straight and highly curved paths (fig. 31). A variety of testing conditions were considered in order to simulate actual field use. Testing was also performed at the NRCS Agricultural Research Station Hydraulics Laboratory located west of Stillwater, Oklahoma. Testing at this site allowed us to simulate rainfall conditions and evaluate the performance of the fence when compared to hand installed fence following the current practices at the same location (fig. 32). This testing confirmed that the machine provides superior results when compared to hand installation.



Figure 31. Curved Installation Path



Figure 32. Rainfall Simulation at NRCS-ARS Hydraulics Lab

Final Design

The OSU Silt Fence Installer final design consists of a main frame, sub frame, shield, tension rod, fabric tension arm, and packing wheels. During the design of these parts, consideration was given to the cost and safety of each component.

Frame

The OSU Silt Fence Installer is connected to the SK500 by two 1/4-inch steel plates bolted to the SK500 frame with four 1/2-inch bolts, two inches in length. The main frame is made of 2" X 3" X 1/4" rectangular steel tubing in an octagonal configuration that encompasses the vibratory motor (fig. 33).



Figure 33. Main Frame on SK500

At the rear of the main frame, a pivot point allows the shield to follow the path of the blade (fig. 34). The sub-frame has a three-inch tall, 2.5-inch outer diameter bushing that is retained between two similar bushings on the main frame. This assembly is held in position by a two-inch pin. The main pin has a 3/4-inch hole through the center to accommodate a fastening pin. This fastening pin secures two plates that hold the main pin into location without transferring any of the sub-frame loading to the fastening pin. A grease zerk was added to the center collar for lubrication to reduce friction and wear on the pivot parts.

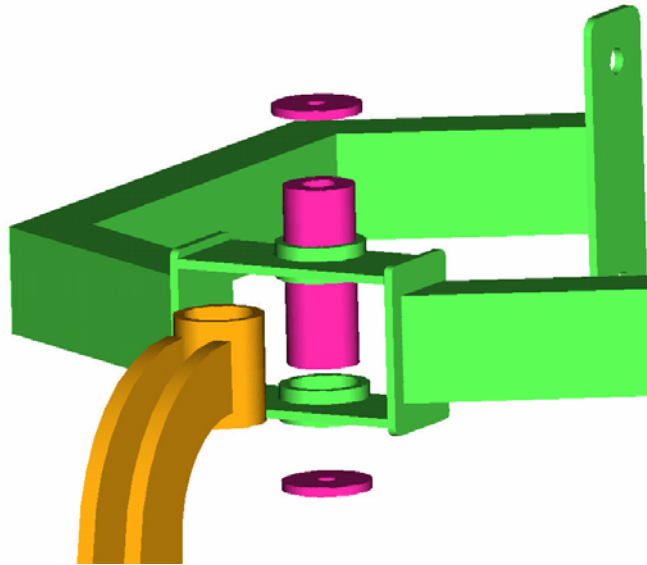


Figure 34. Exploded View of Main Pivot

The sub-frame begins with two 1/2-inch steel plates that connect to the pivot point (fig. 35). The shield is nestled between these arms and is welded in location. Mounting locations for the fabric roll, tension rod, and packing wheels are also incorporated in the sub-frame.

A fabric roll support arm, made of 2" X 2" X 3/16" square steel tubing, is welded to the sub frame. Welded to the support arm at 30 degrees from horizontal, a one-inch outside diameter rod works much like a paper-towel dispenser. Rolls of fabric are placed on the fabric rod and allowed to rotate as material is fed around the tension rod and into the shield. An adjustable, ten-inch diameter, 1/8-inch steel plate is added to the support arm. This round plate gives the roll of fabric a flat surface on which to rest for stability and provides adjustment for fabric position.

To provide proper placement of the tension rod, a 1.5" X 1.5" X 3/16" tube was welded to the fabric support arm. A series of 1/4-inch parallel plates with 1/2-inch holes were used for a bracket that pins the tension rod in place. The packing wheel mount is a series of 3/8-inch plates with a 1-inch hole for a pivot pin connection.

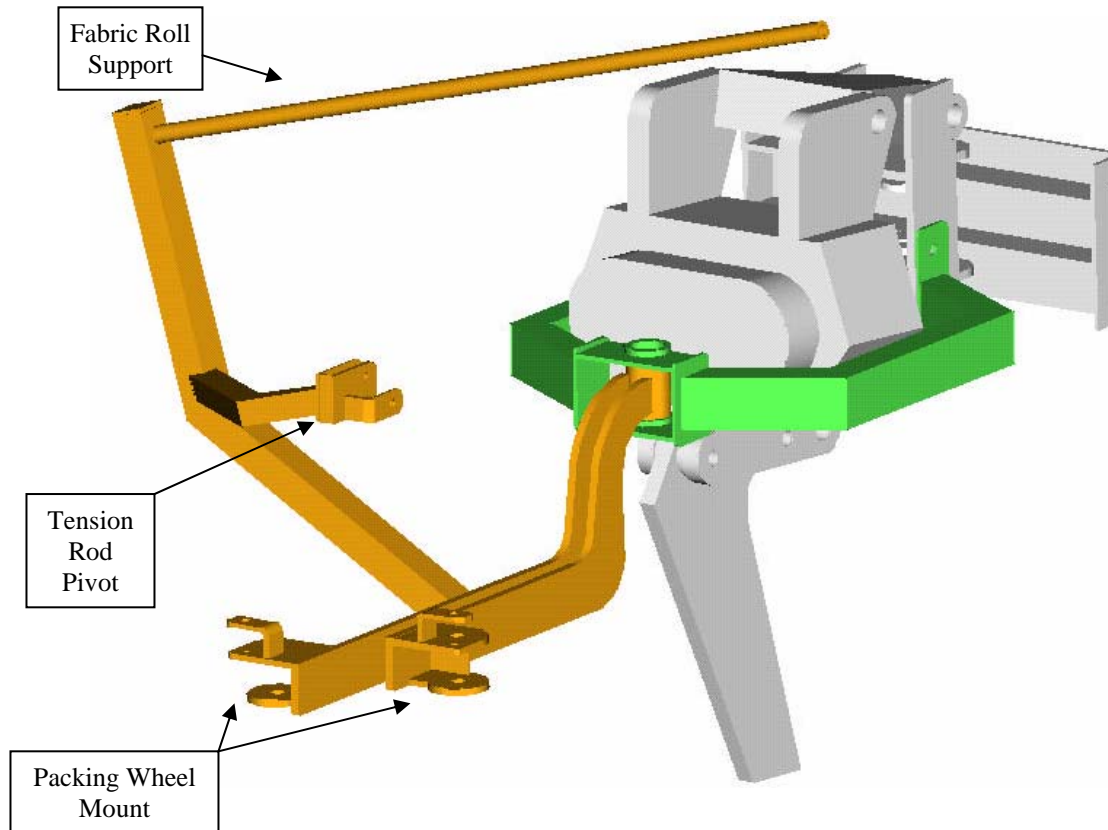


Figure 35. Sub-Frame mounted to Main Frame and SK500

Components

Due to complexity and manufacturing cost, the original conically-shaped front of the shield was revised (fig. 36). The front section of the shield was changed to a simple V-shape knife edge. A cap at the bottom of the shield was also designed to prevent soil from entering and packing against the tension rod, as encountered during final testing. The body of the shield is made from two pieces of 1/8-inch steel sheet metal, separated by 3/4-inch. The shield keeps the soil slot open as the tension rod directs the fence material into the trench.

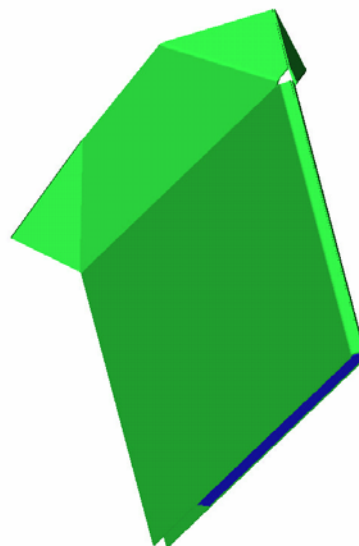


Figure 36. Revised Shield

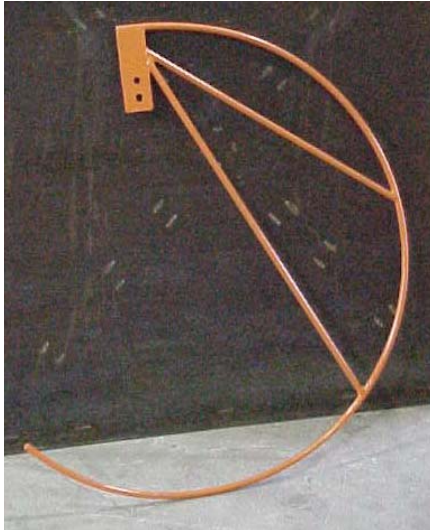


Figure 37. Tension Rod

The tension rod was made from a curved 1/2-inch steel rod that forms two-thirds of a circle with a three-foot diameter (fig. 37). Proper placement and curvature of the rod was critical for proper installation of fabric. Two cross pieces were welded to the inside upper portion of the circular rod in order to ensure rigidity. The rod was attached to the shield frame using a two-pin method. One of the pins acts as a pivot and the other spring-loaded pin holds the rod in place. This system allows the rod to pivot in-and-out of the shield. Moving the tension rod out of the shield enables convenient loading of the fabric during the start of fence installation. Once the fabric has been properly loaded, the tension rod can be pinned into operating position inside the shield.

A fabric tension arm was constructed from a curved piece of 3/16-inch plate welded to a 1.5" X 1.5" X 3/16" tube (fig. 38). The plate matches the contour of a full roll of fabric. Carried on a spring-loaded arm, the plate presses on the fabric roll. Contact friction prevents the wind from unrolling the fabric.



Figure 38. Fabric Tension Arm

As stated in the design criteria, loose soil must be compacted in order to prevent undercutting. Two ten-inch diameter wheels were added, one on each side of the shield, in a staggered, toed-out position. Working together, the wheels provide the force needed for proper soil compaction. Down-pressure is created by the SK500. The position of the packing wheels effectively collects loose soil and compacts it near the installed fence. A

three-position selection bracket allows the wheels to operate at depth settings of six, eight, and ten inches to gauge the installation depth of the fabric (fig. 39). The wheels also pivot outward to allow easy loading of the fabric roll on the tension rod (fig. 40).

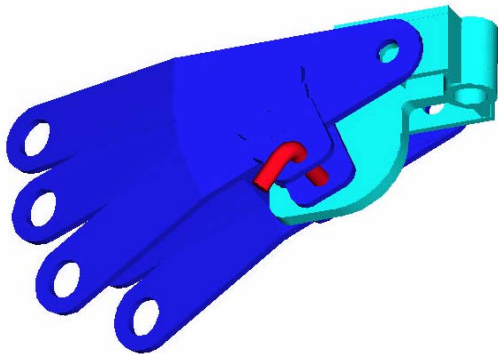


Figure 39. Depth Selector Positions

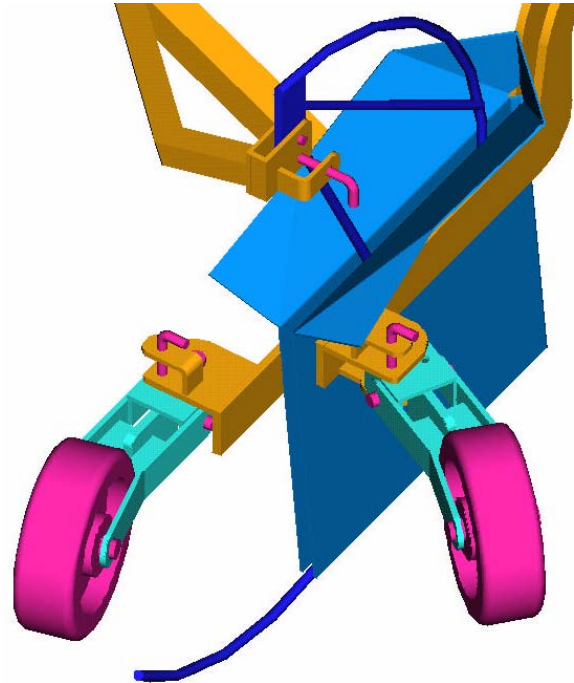


Figure 40. Packing Wheels

Operator's Manual

After the final prototype was completed, an operator's manual was created. The initial portion covered safety concerns. Sections regarding initial machine assembly, safe operating procedures, and troubleshooting were also included. The complete manual is included in Appendix B.

The design of the SK500 locates the operator of the machine at the end opposite the moving components during operation. The controls also do not permit the operator to leave them without automatically disengaging the machine. The gap located between the moving vibratory plow casing and the main frame was design to be a full-inch wide to minimize the potential for pinched fingers. The second pinch point is the main pivot that allows the sub frame to swing behind the machine. These areas are clearly labeled with precautionary stickers. The final area of concern is the tension rod pivot point (fig. 41). To minimize risk a spring pin is used that clicks itself into place, allowing the operator to keep hands clear when rotating the tension rod.



Figure 41. Tension Rod Pivot Point

Project Schedule

Project scheduling was divided into two major sections, by semester. In each semester, the schedule contained tasks and subtasks. During the fall semester, the main tasks included Project Definition, Concept Development, Investigation and Testing, and Documentation. The spring semester continued those tasks, with the addition of Final Design and Drafting. The fall schedule was completed as planned, with the exception of methods testing, which occurred at the beginning of the spring semester. Concept testing was completed concurrently with the feasibility study and Pro-Engineer modeling. Once conceptual developments were complete, component procurement and final drafting began. Prototype fabrication followed. Final testing of the prototype was completed and a final drawing review performed. A detailed Gantt chart showing the entire fall and spring semesters can be found in Appendix C.

Cost Analysis

Prototype Budget

The budget was broken down into the four components of the machine (table 2). Material cost and manufacturing times for each component were estimated, based on industry experience. Fabrication cost was based solely on the equipment use fee charged when components are fabricated in the Biosystems and Agricultural Engineering Laboratory. It did not include the machinists' labor because that is covered by a different division of Oklahoma State University. A 20 percent contingency was added to both the material and fabrication charges to cover the cost of any concept components that may need to be constructed in addition to the final prototype.

Table 2. Silt Fence Installer Proposed Budget

	Material Cost	Fabrication Time	Fabrication Cost	Total Cost
Plow Blade	\$30.00	10 hr	\$24.00	\$54.00
Frame Work	\$210.00	25 hr	\$60.00	\$270.00
Feeding Mechanism	\$120.00	25 hr	\$60.00	\$180.00
Packing Wheel	\$180.00	25 hr	\$60.00	\$240.00
Total Cost	\$540.00	85 hr	\$204.00	\$744.00

Prototype Fabrication Cost

The fabrication costs for the completed machine included costs for the various intermediate concept testing components. After finishing fabrication of the final prototype, the total cost for each of the areas was determined (table 3). Fabrication time for the frame work was underestimated. This was due to the multiple experimental variations built to finalize the pivot locations and the overall component layout and complexity of the welded assemblies. However, the cost of the packing wheels was

overestimated, because suitable wheels were donated from a previous research project. Overall, budget estimation was relatively close, with the final prototype fabrication costs being \$55.28 less than the budget.

Table 3. OSU Silt Fence Installer Prototype Fabrication Costs

	Material Cost	Fabrication Time	Fabrication Cost	Total Cost
Plow Blade	\$9.40	8 hr	\$60.00	\$69.40
Frame Work	\$212.37	52 hr	\$146.25	\$358.37
Feeding Mechanism	\$112.98	23 hr	\$52.50	\$165.48
Packing Wheel	\$50.22	18 hr	\$45.00	\$95.22
Total Cost	\$384.97	101 hr	\$303.75	\$688.72

Estimated Manufacturing Cost

Manufacturing cost of the OSU Silt Fence Installer assumes a production rate of 100 units per year (table 4). The raw material prices used were current wholesale prices available in the Stillwater area. Charles Machine Works has created a formula to estimate their cost of manufacturing from previous products. Labor and overhead costs were estimated using this relationship. The total cost to manufacture the OSU Silt Fence Installer is \$460. The complete parts manual for the final prototype is included in Appendix D.

Table 4. Estimated Manufacturing Cost for OSU Silt Fence Installer

	Direct Raw Material Cost	Labor and Overhead Cost	Total Cost
Frame Work	\$62	\$175	\$237
Feeding Mechanism	\$21	\$100	\$121
Packing Wheel	\$27	\$75	\$102
Total Cost	\$110	\$350	\$460

Competitive Comparison

The retail price for the OSU Silt Fence Installer allowed for a 60% profit margin, including both the factory and dealer markup. This brought the total retail price for the silt fence installer attachment to \$1150. The prices of the current machines on the market were researched (table 5). These all connected to either a tractor three point or skid steer quick connects to supply power to the machines. For this reason, the price of the SK500 was not included, but the vibratory plow attachment was.

Table 5. Price Comparison with Products Currently Available

Product	Retail Price
Tommy Silt Fence Machine	\$7177
McCormick Silt Fence Installer	\$4925
ImpleMax SF12c	\$11794
OSU Silt Fence Installer and Vibratory Plow Attachment	\$6400

Conclusion

Results of this project reflect the extent to which Enviro-Mech has accomplished the design criteria. The FAESF group required that the new equipment be compatible with their new fence design and that it does not promote installation related erosion. More specifically, the design criteria provided by the FAESF group require that the new installation equipment be capable of installing fence in a trench eight to ten inches deep, with soil backfilled and compacted. Charles Machine Works, Inc. also provided design criteria which required that the final design be compatible with current Ditch Witch vibratory plows and that the final prototype be economically feasible and marketable. Through the production of a prototype and extensive testing, these criteria have been measured. Results meet or exceed the sponsors' requirements.

Considering the criteria set forth by the FAESF group, Enviro-Mech's design performed well. Through final design testing we showed that the installation equipment provided an average fence installation depth of eight inches. Soil compaction was another criterion met. With the silt fence installed, backfilled, and the soil compacted, testing was performed to determine the force required to remove the fence from the trench. Test results confirmed secure placement, requiring an average force of 45 pounds to pull the fence from the ground (fig. 42). All of the results illustrated compliance with the criteria set by the FAESF research group.



Figure 42. Installed Fence

Charles Machine Works required that the final prototype be compatible with their current vibratory plows. A design was developed to attach to the SK500 vibratory plow. The SK500 was used throughout testing and proved to be capable of handling the weight and providing the power needed to operate the new installation attachment.

Second, Charles Machine Works asked that the new design be economically feasible. As an attachment, the final prototype met that criterion. Every effort was made to keep the cost of the new design profitable. For example, the original conically-shaped shield was changed to a V-shape to minimizing fabrication time.



Figure 43. Final Prototype with Design Team

Finally, Charles Machine Works asked that the final design be marketable. It should be competitive in the equipment market, based on efficiency, operator safety, and cost. Through extensive field testing, the final design has proven to be efficient. It has met all the installation requirements stated in the design criteria and operates at a speed desired by the operator. Operator safety was emphasized. All moving parts were clearly labeled. Additional safety considerations have been addressed in the Operator's Manual. Finally, the relative

production cost of the prototype makes it marketable. With low production costs, the selling price is competitive with similar products currently being used.

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ENVIRO-MECH

MISSION STATEMENT

Enviro-Mech is a group of highly motivated individuals with diverse backgrounds coming together to create efficient, reliable equipment to improve the quality of life along with the preservation and conservation of the world's natural resources.

Silt Fence Installation

Kody R. Featherston

Candice L. Johnson

J. Kent Evatt

Monica L. Johnston

BAE 4022 – Spring 2004



WHAT IS SILT FENCE?

- A silt fence is a temporary sediment barrier consisting of filter fabric entrenched into the soil and attached to supporting posts.





PROBLEM DEFINITION

- Common failures are caused by:
 - Improper Installation
 - Incorrect Location
 - Inadequate Strength





FAESF

- Failure Avoidance and Effective Silt Fence Technology
 - control undercutting and overtopping
 - control lateral flow along the silt fence
 - improve the trapping of fine silts and clays
 - provide adequate strength posts and fence
 - provide for adequate bearing capacity of post footings



STATEMENT OF WORK

- Enviro-Mech will focus on reducing failure due to improper installation.
- Dr. Barfield's team will continue developing a new filter fence material configuration and support mechanism.
- Enviro-Mech will design and build a machine which will create a trench, lay the fence, and backfill the trench.



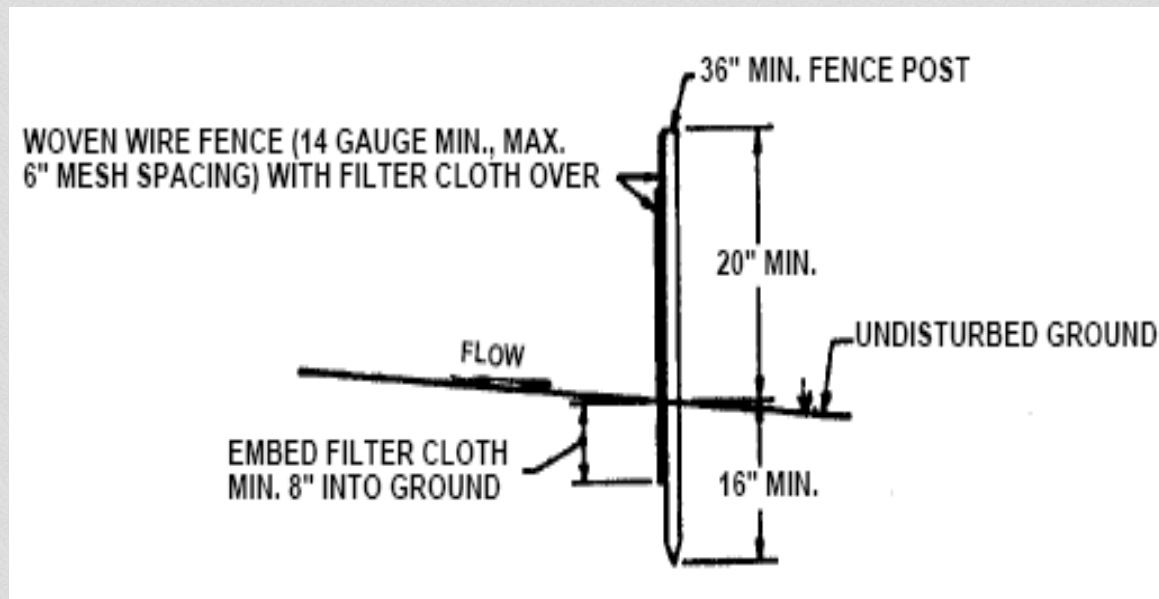
INVESTIGATION

- Recommended Silt Fence Practices
- Current Equipment Patented
and in Production
- Similar Vibratory Plow Applications



RECOMMENDED PRACTICES

- Information Concerns
 - Trench Dimensions
 - Fence Location
 - Post Height
 - Fence Size





CURRENT EQUIPMENT

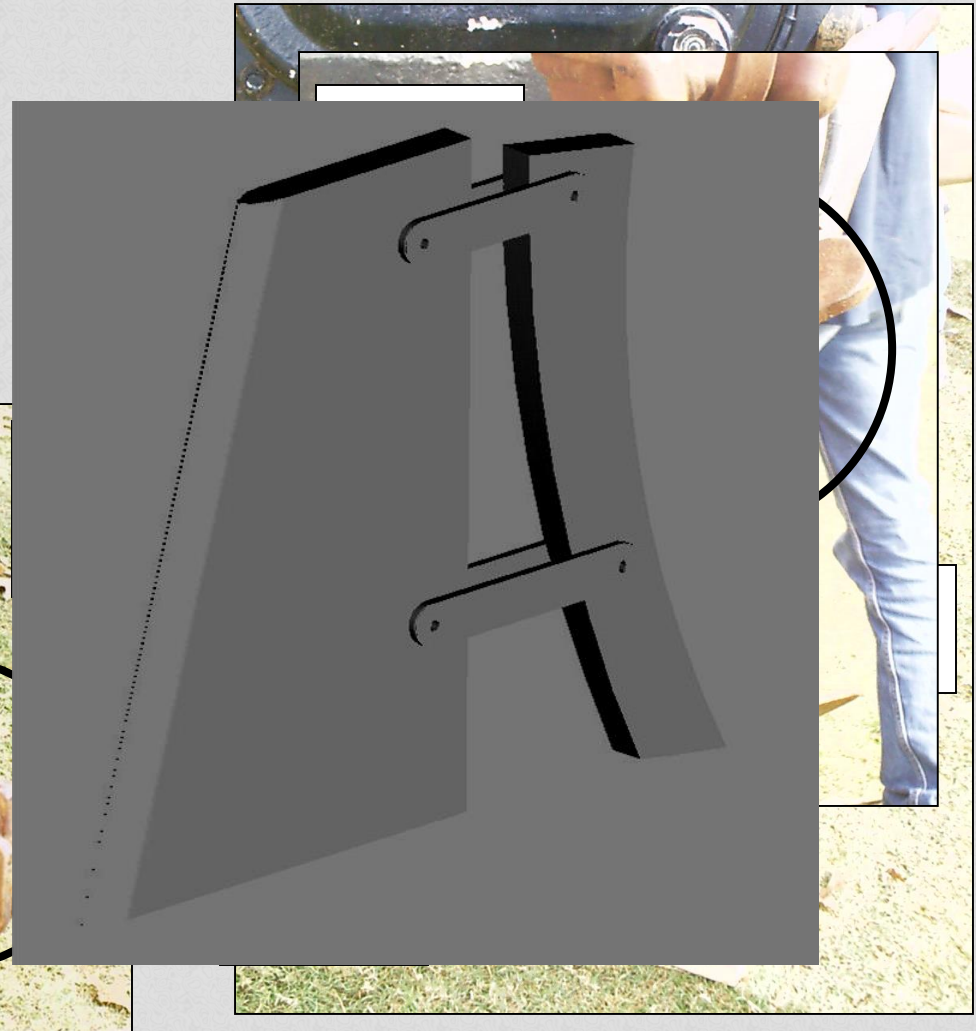
- Tommy Silt Fence Machine
- Erosion Runner
- ImpleMax SF12c
- McCormick Equipment





VIBRATORY PLOW

- Cable Installation Blades
 - Integrated Slot
 - Four Bar Linkage





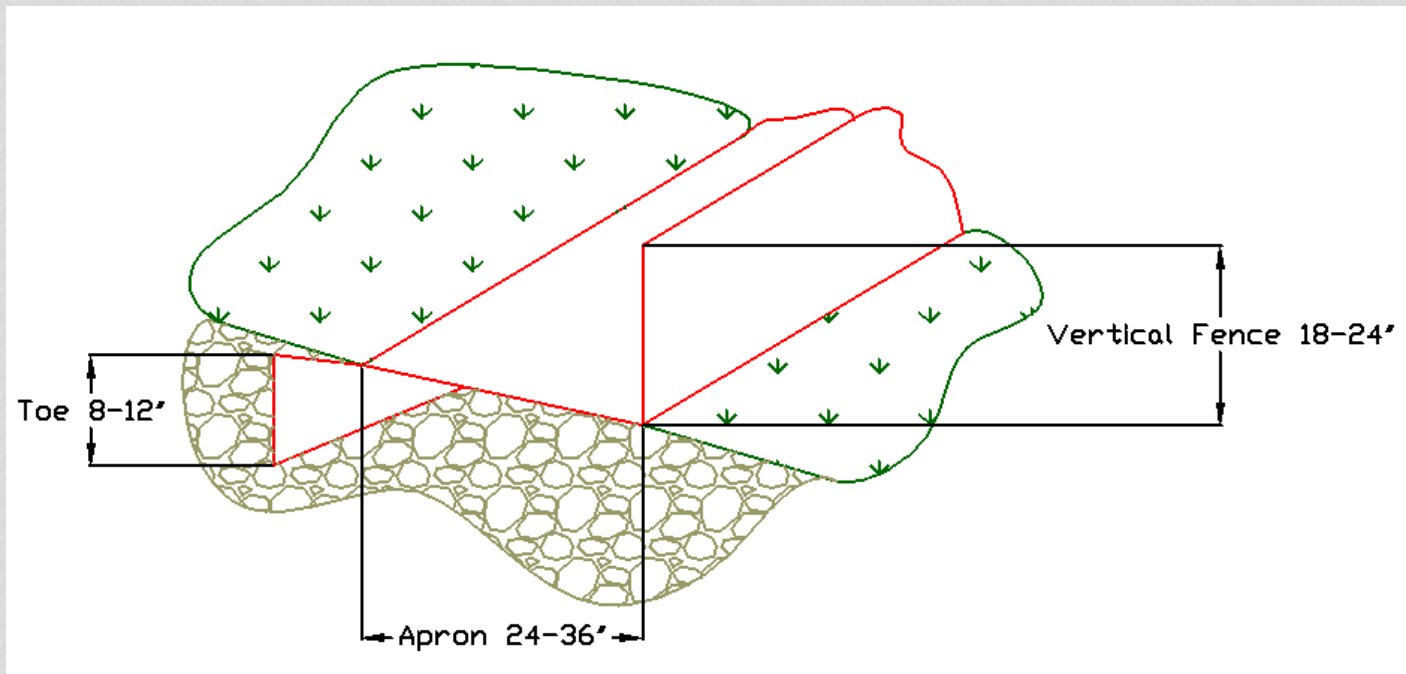
CONCEPT DEVELOPMENT

- Design Criteria
 - FAESF Research Group
 - Charles Machine Works
- Potential Solutions
 - Proposal A - Two-Disk Method
 - Proposal B - Feed Channel Method
 - Proposal C - Tension Rod Method



DESIGN CRITERIA

- FAESF Proposed Design





DESIGN CRITERIA

- Design compatible with current power source provided by Charles Machine Works
- Economical
- Marketable
- Safe





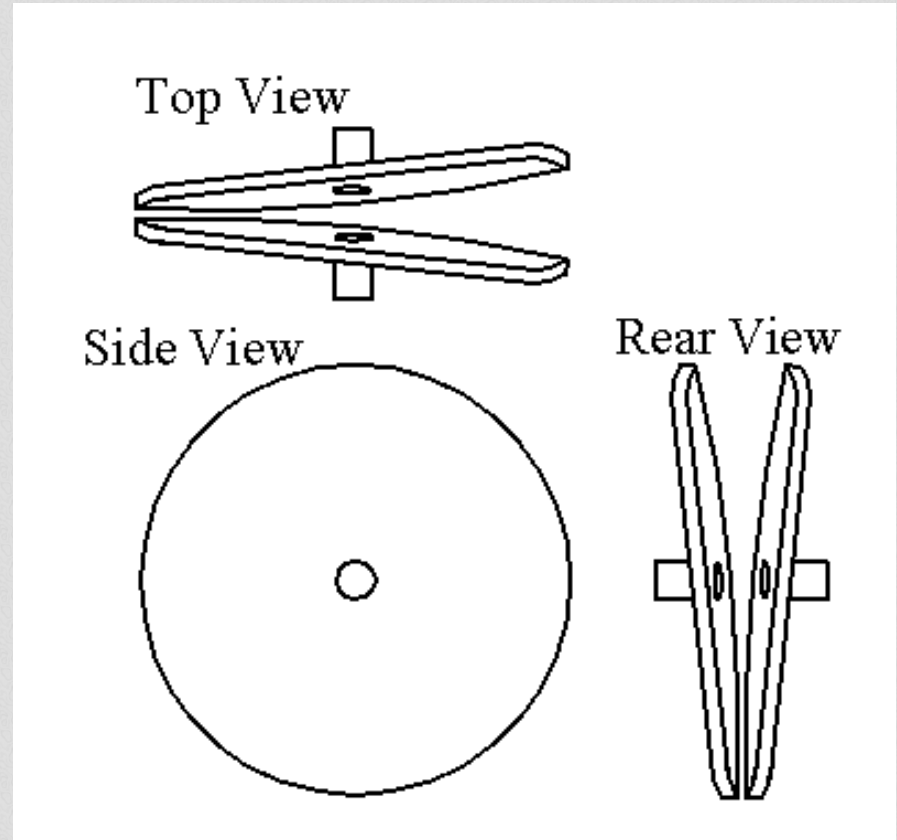
INSTALLATION METHODS

- Proposal A - Two-Disk Method
- Proposal B - Feed Channel Method
- Proposal C - Tension Rod Method



PROPOSAL A TWO-DISK METHOD

- Two narrow disks pinch the fabric.
- The disks feed the fabric into the slot.
- Fabric is released at the bottom of the slot.

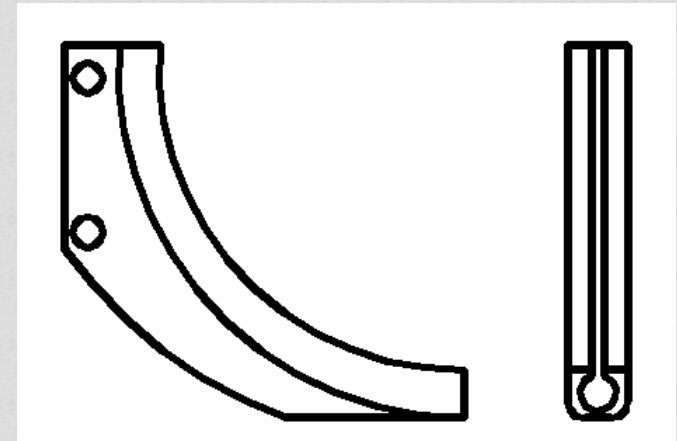




PROPOSAL B

FEED CHANNEL METHOD

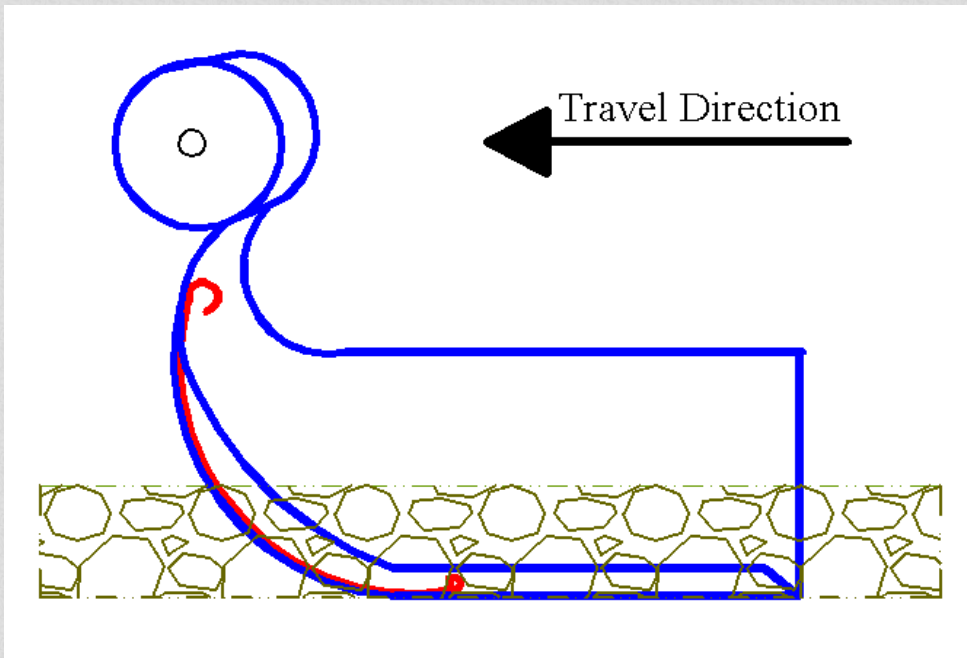
- Channel will be attached similar to four-bar linkage currently used.
- The fence will require added bulk to bottom edge.





PROPOSAL C

TENSION ROD METHOD



- Spring loaded rod will guide material through slot.
- The end of the rod acts as a pressure point.



TEST AND ANALYSIS

- Testing was required to determine the most effective and financially feasible solution.
 - Methods Testing
 - Concept Testing
 - Final Design Testing



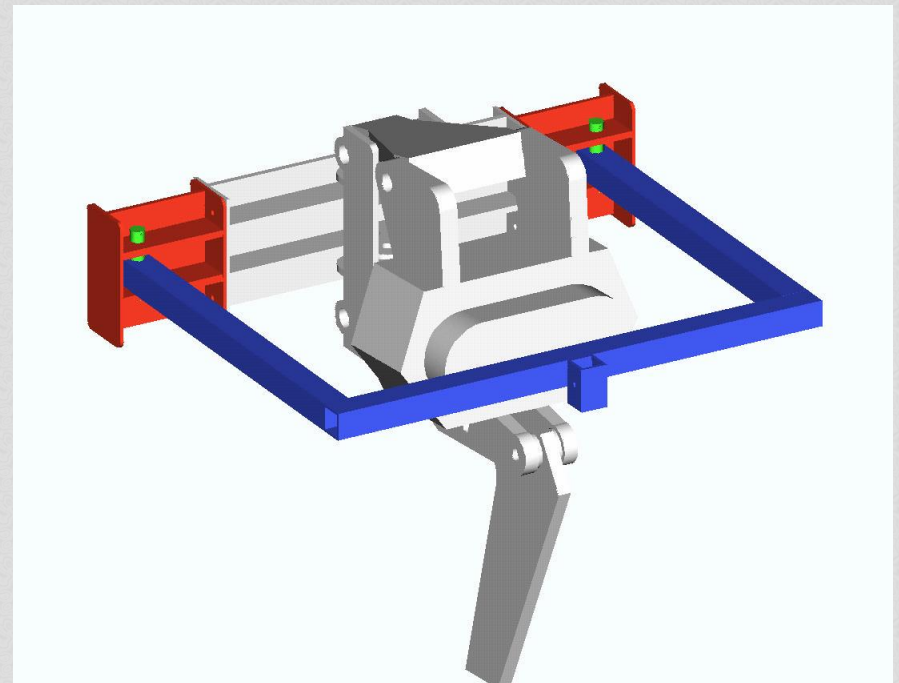
METHODS TESTING





CONCEPT TESTING

- Max lift capacity of machine
- Extensions and Tubular Frame to attach test components





COLLECTING LOAD DATA



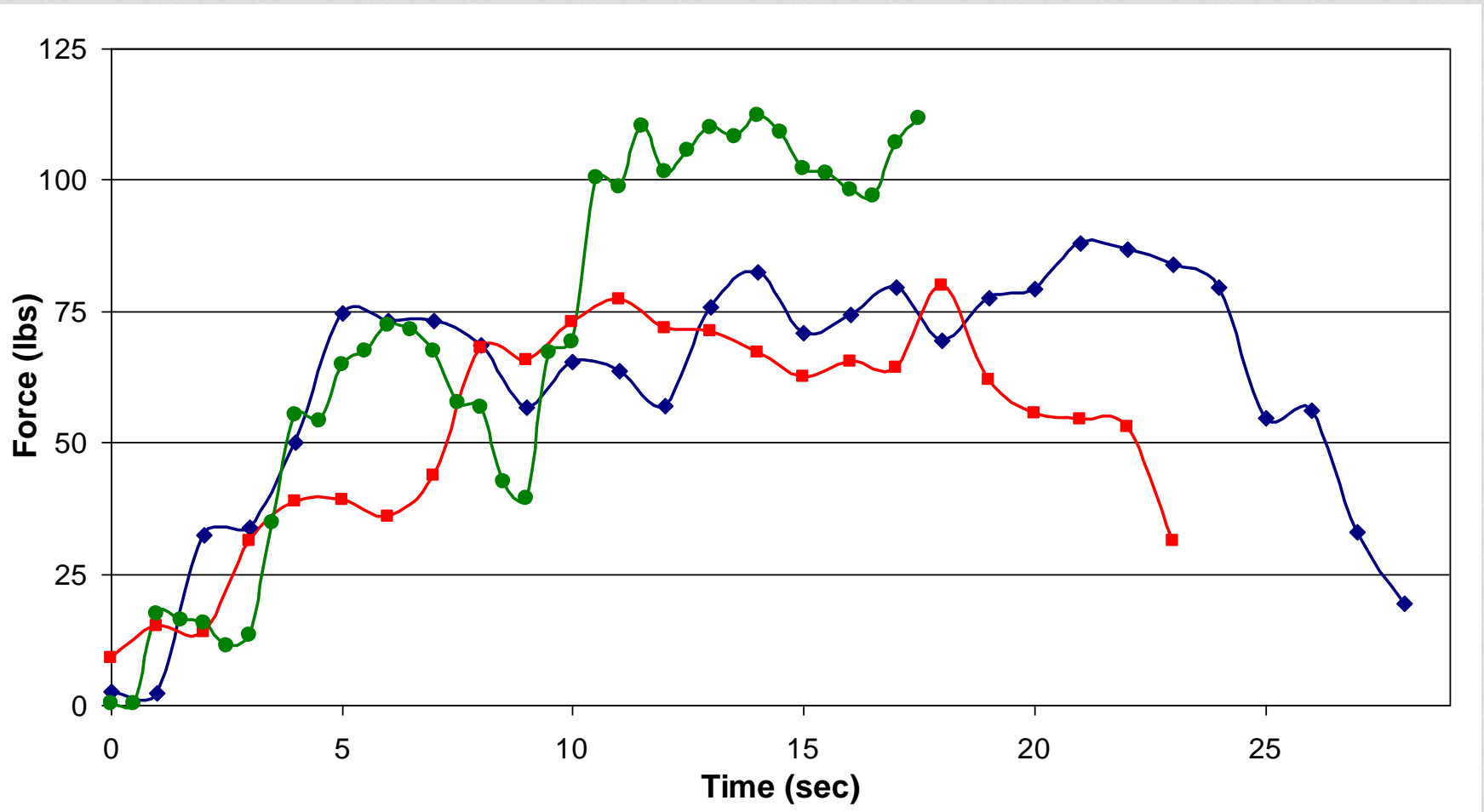


SHEILD DESIGN





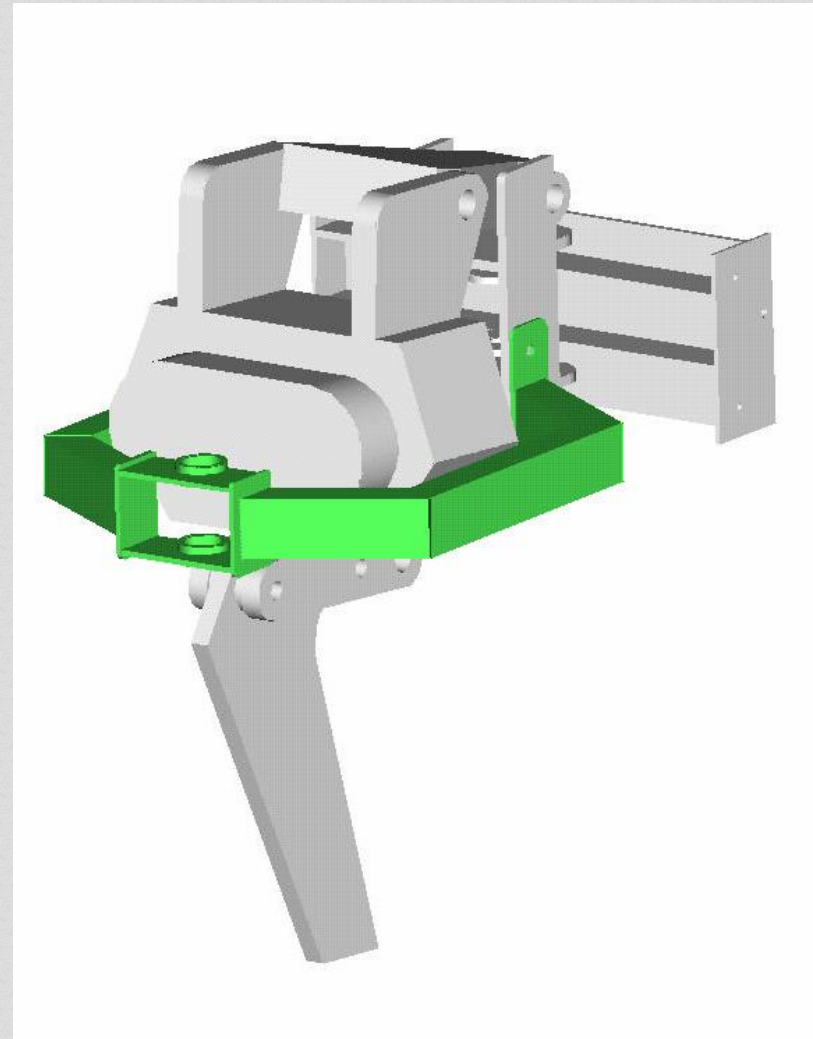
LOAD DATA





FRAME DESIGN

- Parallel Frame Rails
- Over the Top
- Wrap Around





FABRIC ROLL LOCATION





PACKING WHEEL DESIGN





FINAL DESIGN TESTING

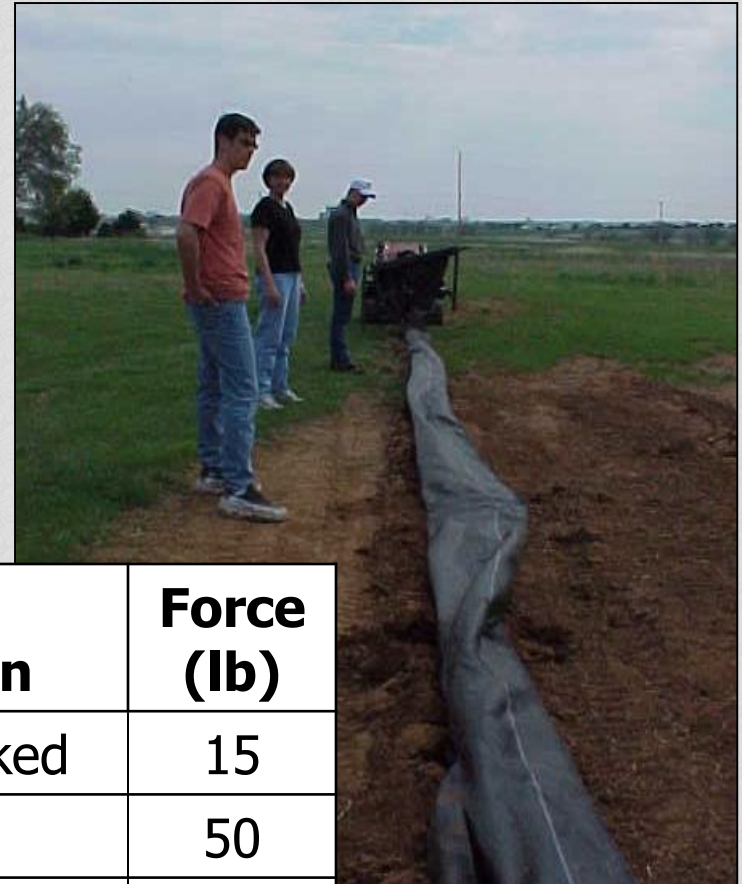
- Issues Discovered
 - Soil Packing Against Tension Rod Inside Shield
 - Wind Unrolling Fabric Faster than Installed





FINAL DESIGN TESTING

- Forces for removal measured



Soil Condition	Force (lb)
Bare, Unpacked	15
Bare, Packed	50
Grass, Unpacked	40
Grass, Packed	> 50



FINAL DESIGN TESTING



- Surfaces
 - Grass
 - Bare Soil
- Paths
 - Straight
 - Curved





FINAL DESIGN TESTING





FINAL DESIGN

- Frame
 - Main Frame
 - Sub Frame
- Components
 - Shield
 - Tension Rod
 - Fabric Tension Arm
 - Packing Wheels

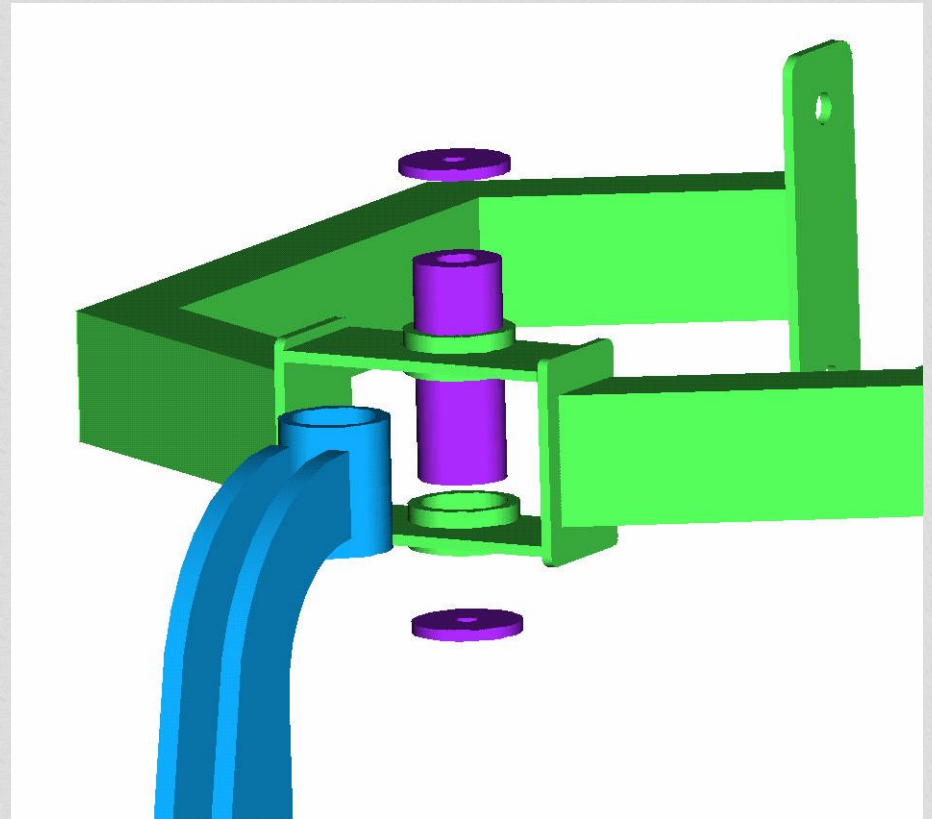


MAIN FRAME



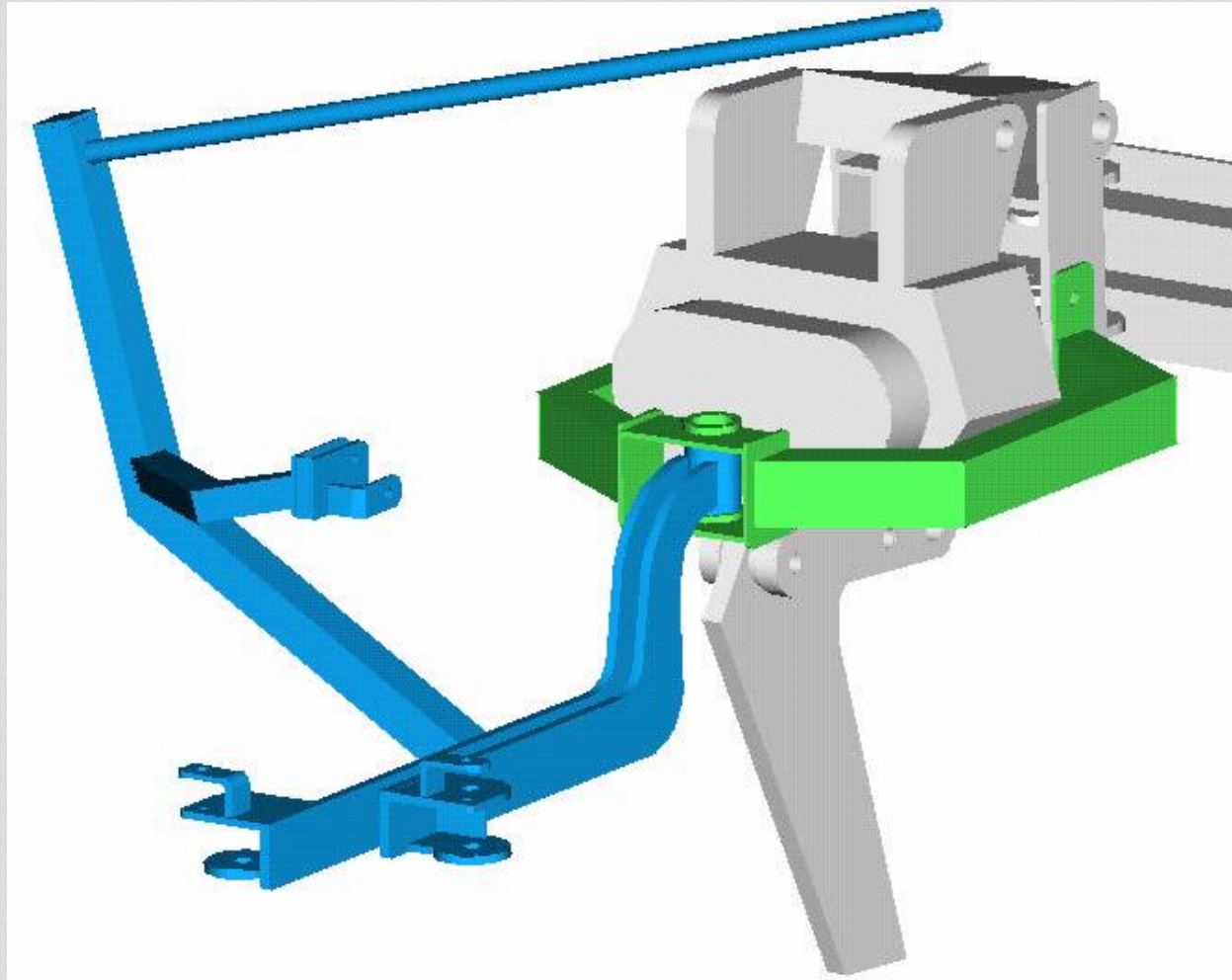


PIVOT





SUB FRAME



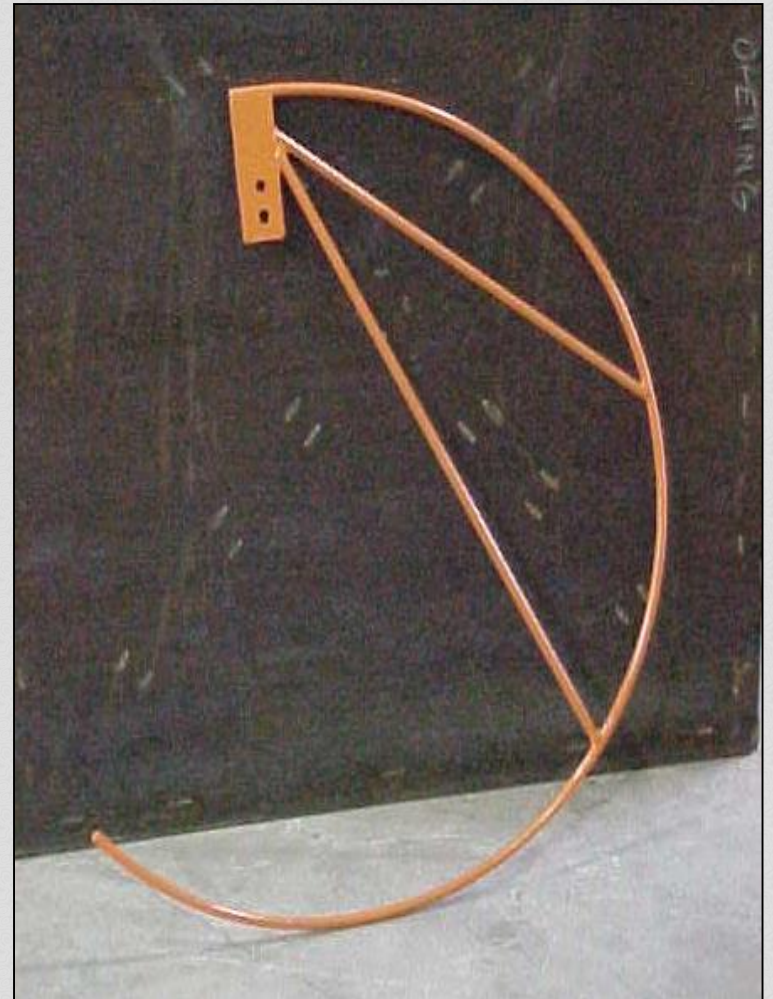


SHIELD





TENSION ROD



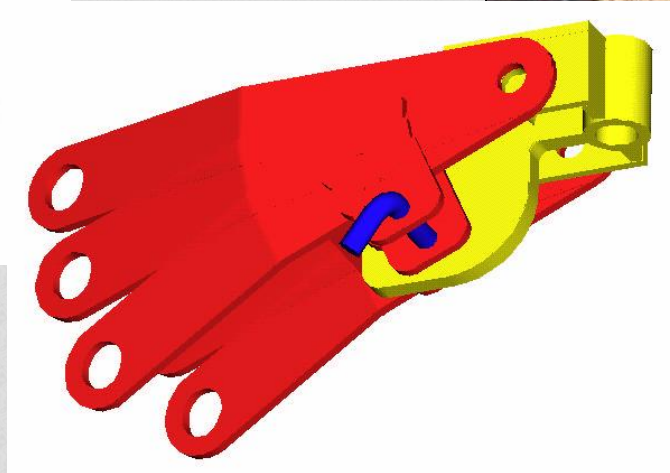
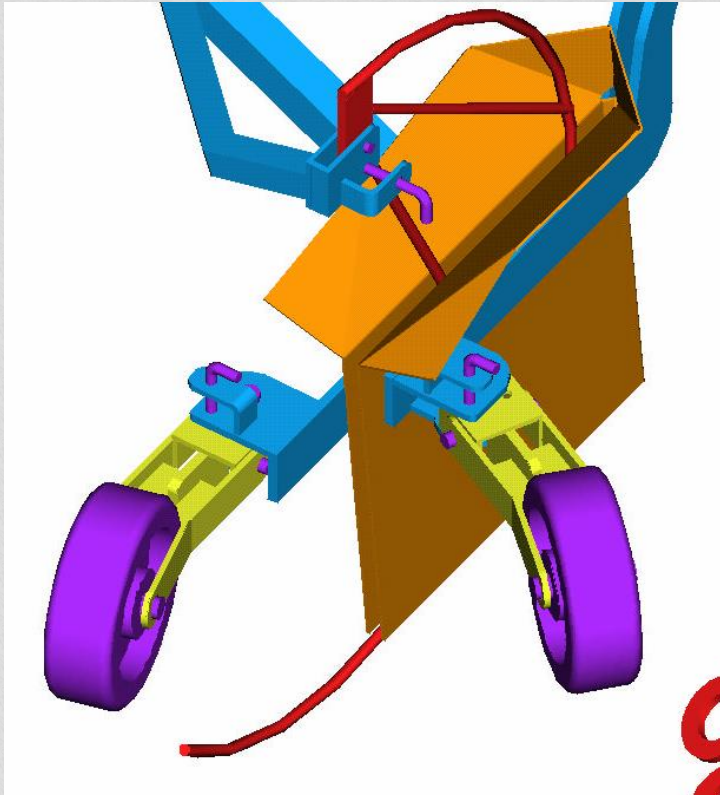


FABRIC TENSION ARM





PACKING WHEELS





SAFETY

- Rounded Corners
- Clearly Labeled Pinch Points
- Spring Pins





MANUALS

- Operators Manual
- Parts Manual

OSU Silt Fence Installer

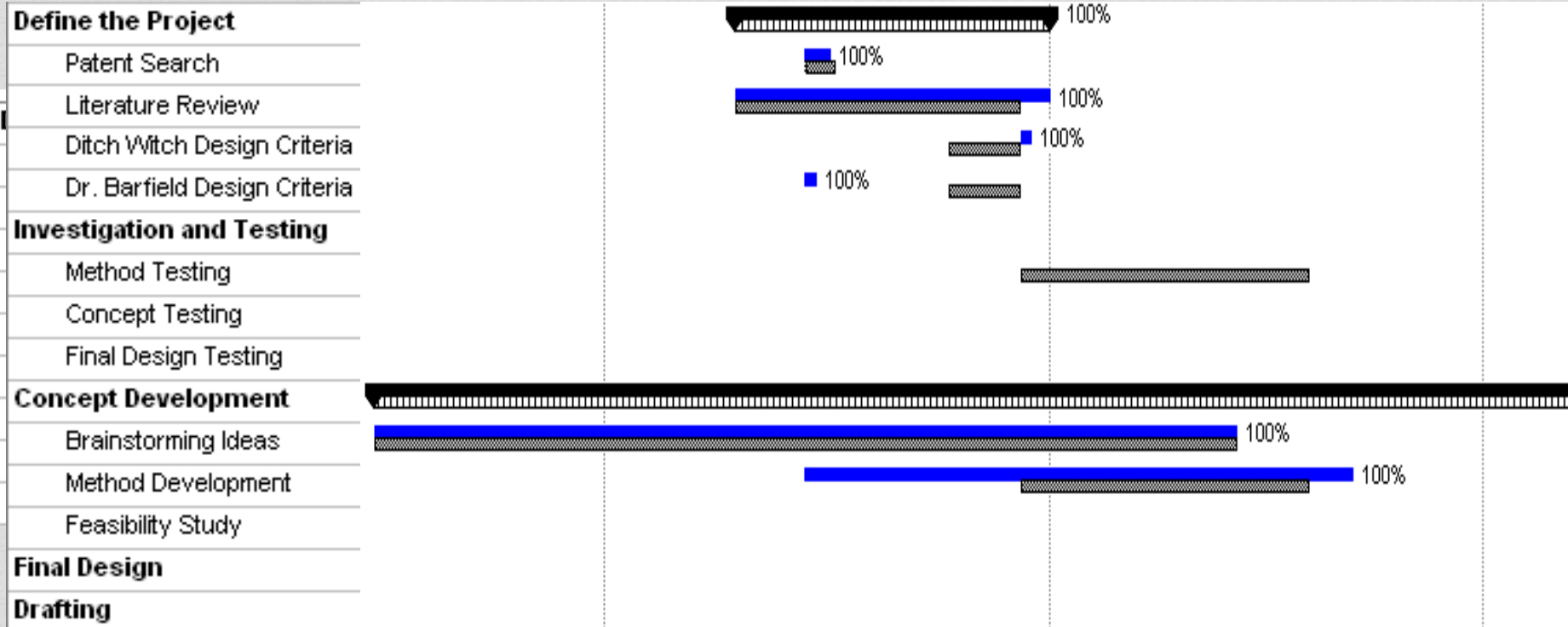
Sub Frame

Part Number	Part Description	Quantity
SF104	Sub Frame	1
SF001	Center Bushing	1
SF002	RH Curved Plate	1
SF003	LH Curved Plate	1
SF101	Packing Wheel Mount	2
SF004	Top Plate	1
SF005	Bottom Plate	1
SF006	Brace	1
SF102	Support Section	
SF007	Lower Tube	1
SF008	Upper Tube	1
SF009	Fabric Rod	1
SF010	Tube Cap	1
SF103	Rear Section	1
SF011	Side Tube	1
SF012	Rear Tube	1
SF013	Pivot Tab	2
SF014	Bent Spring Tab	1
SF015	Pivot Plate	2
SF016	Spacer	1
SF017	Spring Pin Plate	1



PROJECT SCHEDULE

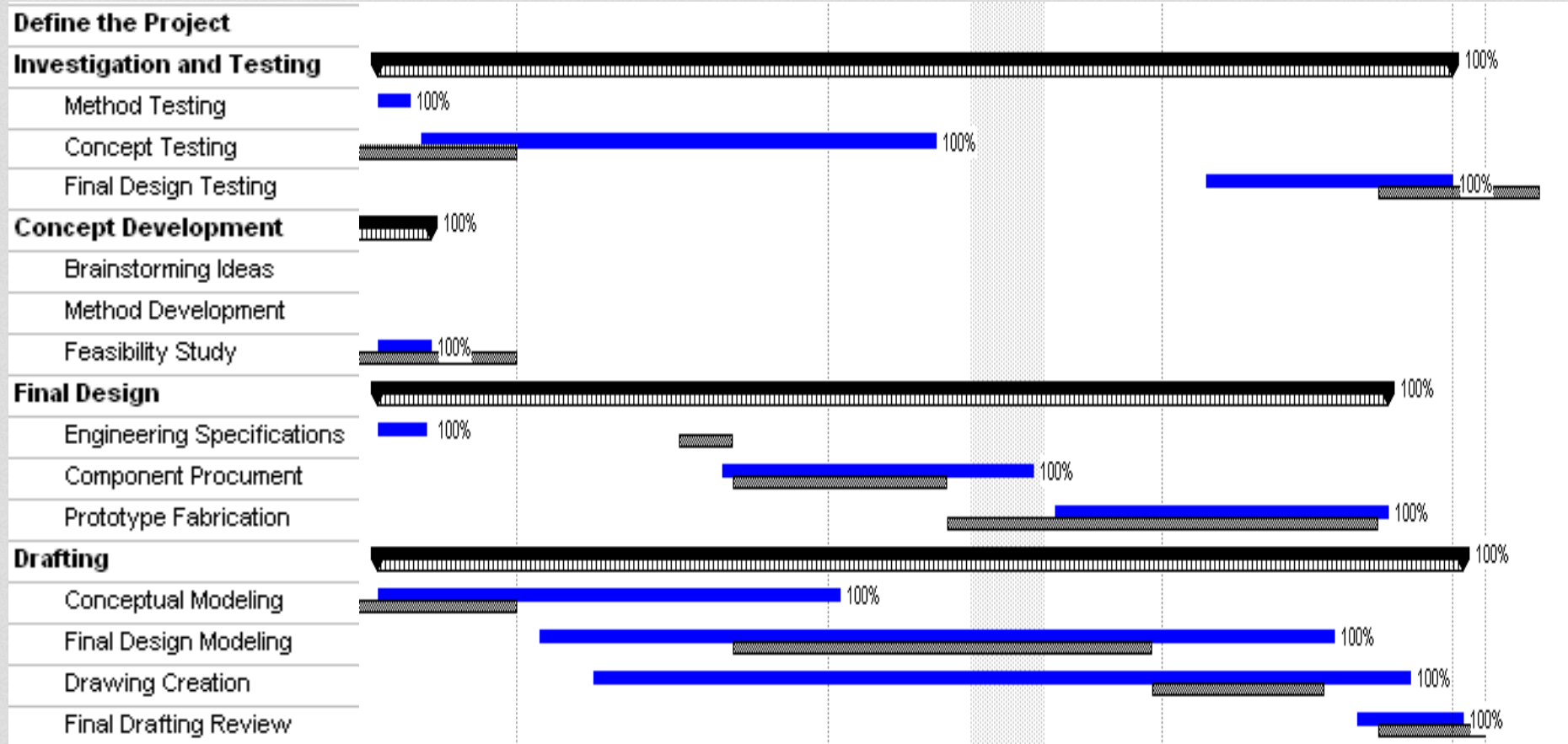
Fall Semester Accomplishments





PROJECT SCHEDULE

Spring Semester Accomplishments





PROTOTYPE EXPENSES

	Material Cost	Fabrication Cost	Total Cost
Projected Budget	\$540	\$204	\$744
Actual Cost	\$385	\$304	\$689

\$55 Under Budget



ESTIMATED MANUFACTURING COST

	Direct Material	Labor and Overhead	Total
OSU Silt Fence Installer	\$110	\$350	\$460



COMPETITIVE COMPARISON

Retail Price

Tommy Silt Fence Machine
McCormick Silt Fence Installer
ImpleMax SF12c
**OSU Silt Fence Installer
and Vibratory Plow**

\$7177
\$4925
\$11795
\$6400

Estimated Retail of \$1150



CONCLUSION





THANK YOU

Enviro-Mech would like to thank those who have contributed to our Senior Design Project.



- Richard Sharp - Project Engineer
- Kelvin Self - Manager R & D



- Dr. Billy Barfield - FAESF Research Group
- Dr. Ellen Stevens - FAESF Research Group
- Wayne Kiner - BAE Laboratory Manager
- Dr. Paul Weckler - Senior Design Instructor
- Dr. Ron Elliot - BAE Department Head



ENVIRO-MECH

MISSION STATEMENT

Enviro-Mech is a group of highly motivated individuals with diverse backgrounds coming together to create efficient, reliable equipment to improve the quality of life along with the preservation and conservation of the world's natural resources.

Questions

Silt Fence Installation



Kody R. Featherston

Candice L. Johnson

J. Kent Evatt

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BAE 4012 - Senior Design

December 6th, 2003

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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



Figure 1. Properly Installed Silt Fence¹

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.¹

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 flow²

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 overtopping²

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.²

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.

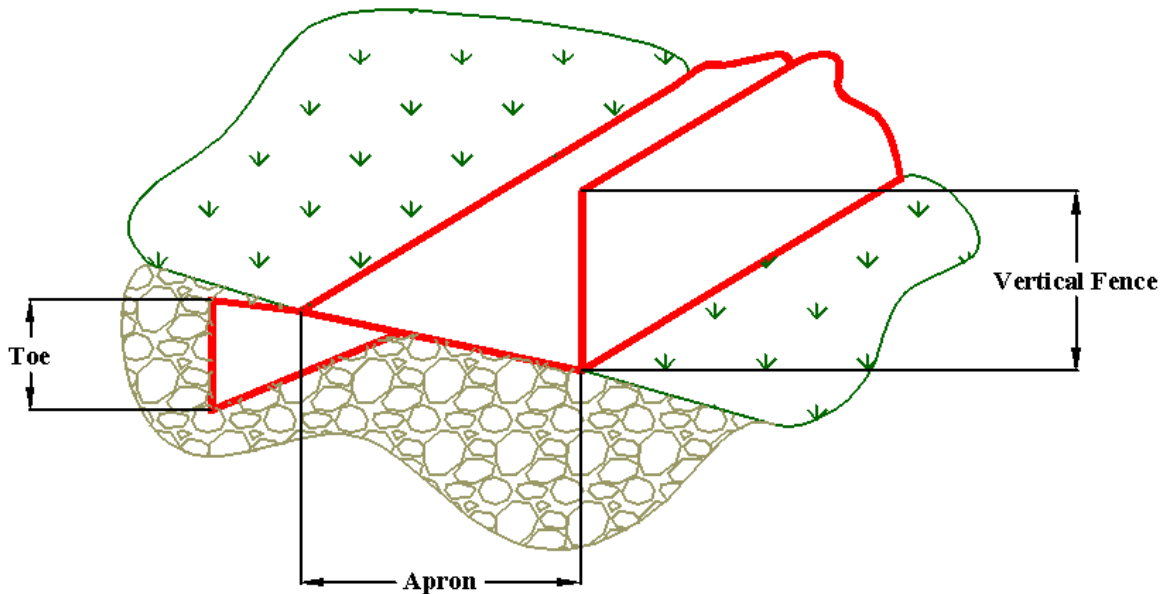


Figure 4. Current Fence Configuration from the FAESF

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.³

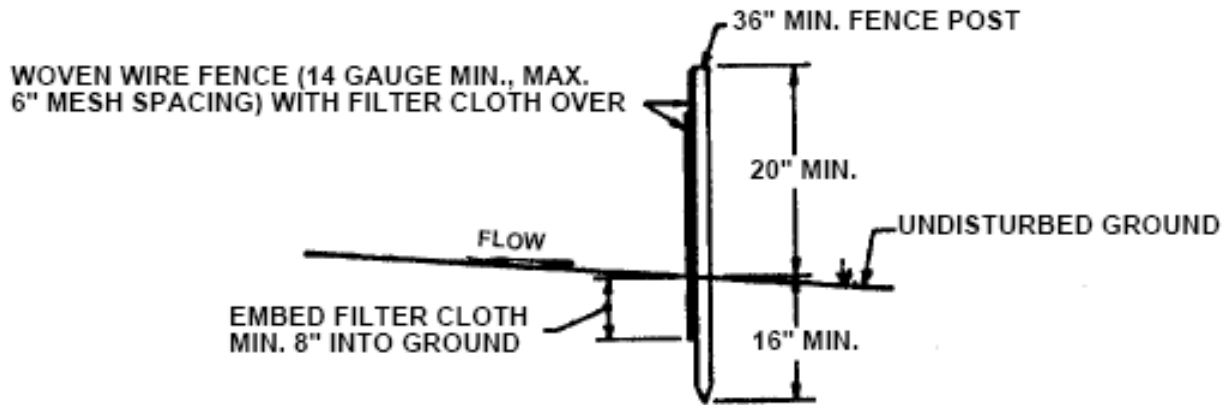


Figure 5. NRCS Recommended Practices³

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



Figure 6. Tommy Silt Fence Machine⁴

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.⁴

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.⁵

McCormick Equipment has designed a three point mounted model that uses static slicing similar to the Tommy design and



Figure 7. McCormick Silt Fence and Waterway Fabric Installation Plow⁶

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.⁶



Figure 8. ImpleMax SF12c Silt Fence Installer⁷

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.⁷

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

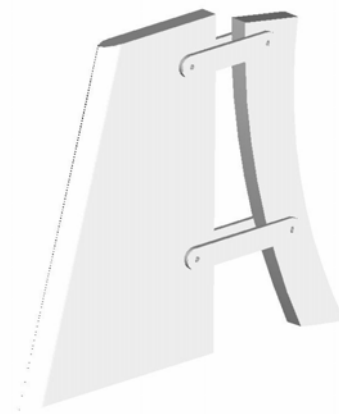


Figure 9. Four Bar Linkage for Cable Applications

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

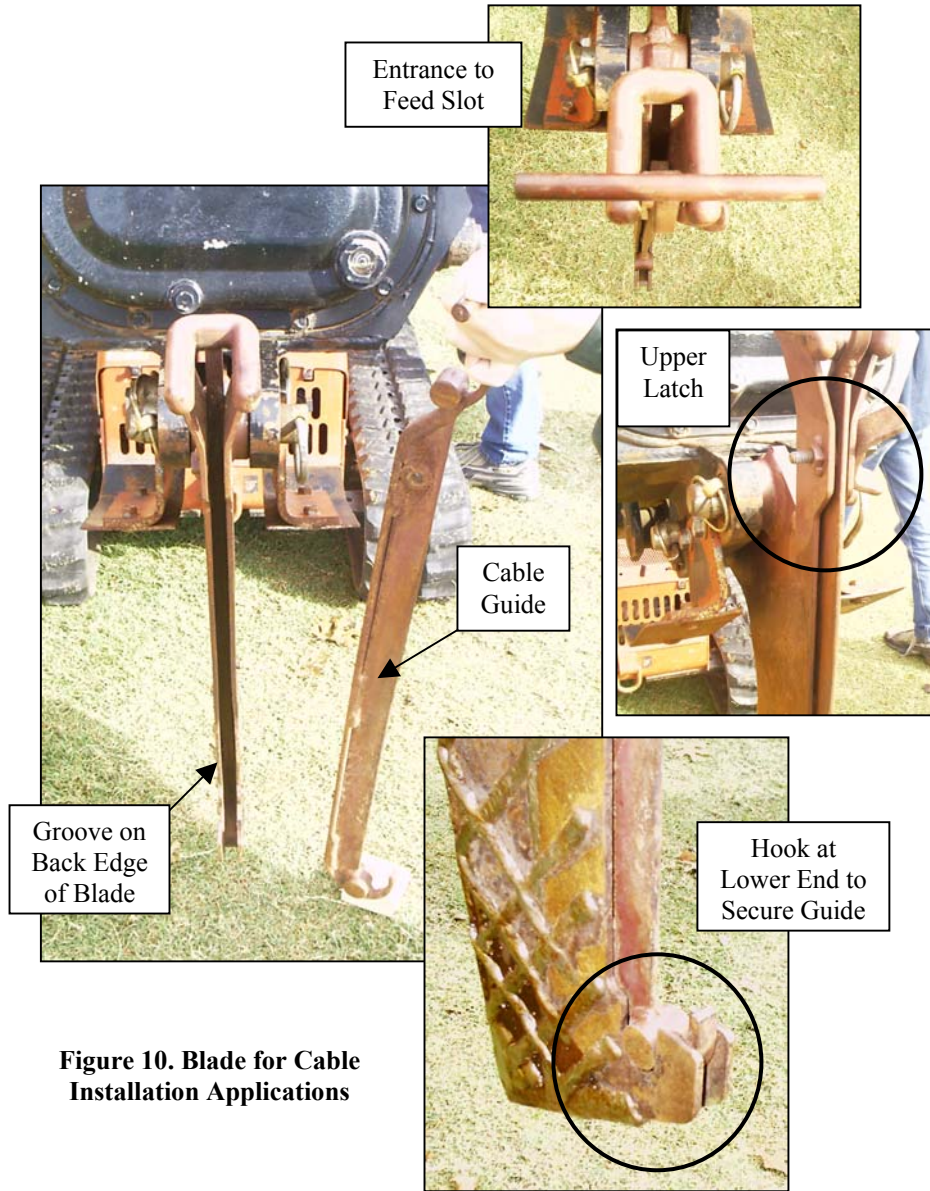


Figure 10. Blade for Cable Installation Applications

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.

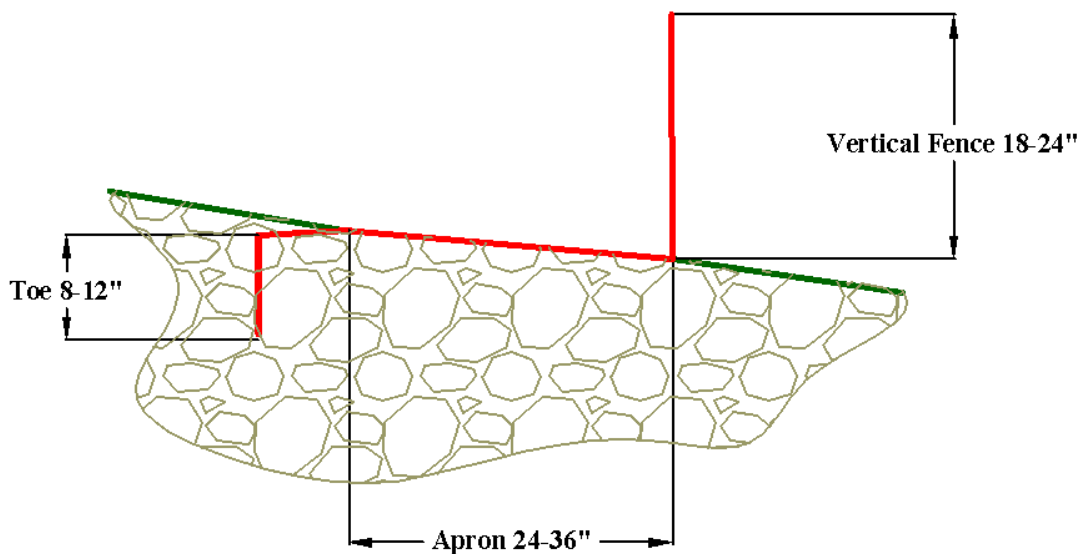


Figure 11. Design Specifications from the FAESF research group

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



Figure 12. Ditch Witch SK500

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 has 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 methods 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 feed 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

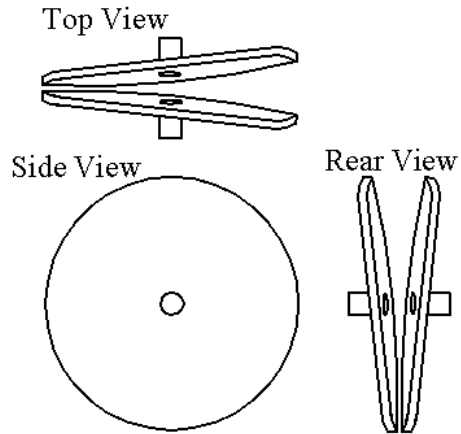


Figure 13. Two-Disk Method Diagram

the slot where the fabric is released. It is followed by packing wheels to ensure the soil is recompacted and will resist erosion at the disturbance. This concept is similar to the operation of a row crop planter.

Proposal B – Feed Channel Method

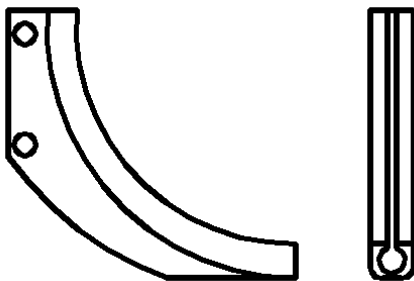


Figure 14. Feed Channel Method

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

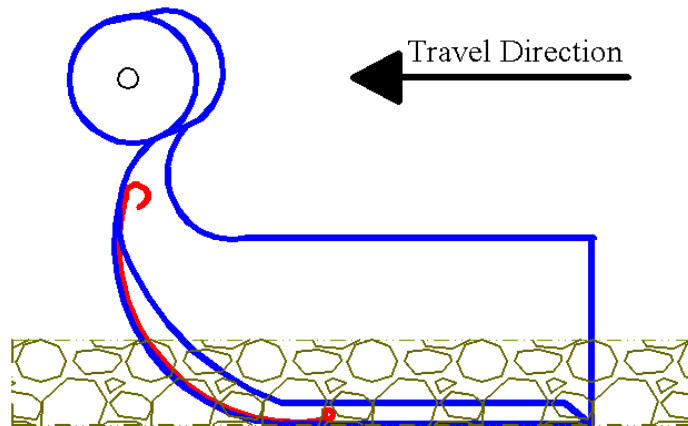


Figure 15. Tension Rod Method

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.

	Material Cost	Fabrication Time	Fabrication Cost	Total Cost
Roll Handler	\$30.00	10 hr	\$24.00	\$54.00
Plow Blade	\$210.00	25 hr	\$60.00	\$270.00
Feeding Mechanism	\$120.00	25 hr	\$60.00	\$180.00
Packing Wheel	\$180.00	25 hr	\$60.00	\$240.00
Total Cost	\$540.00	85 hr	\$204.00	\$744.00

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.

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Appendices

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ENVIRO-MECH

MISSION STATEMENT

Enviro-Mech is a group of highly motivated individuals with diverse backgrounds coming together to create efficient, reliable equipment to improve the quality of life along with the preservation and conservation of the world's natural resources.

Silt Fence Installation

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BAE 4012 – Fall 2003



WHAT IS SILT FENCE?

- A silt fence is a temporary sediment barrier consisting of filter fabric entrenched into the soil and attached to supporting posts.





PROBLEM DEFINITION

- Common failures are caused by:
 - Improper Installation
 - Incorrect Location
 - Inadequate Strength





FAESF

- Failure Avoidance and Effective Silt Fence Technology
 - control undercutting and overtopping
 - control lateral flow along the silt fence
 - improve the trapping of fine silts and clays
 - provide adequate strength posts and fence
 - provide for adequate bearing capacity of post footings



STATEMENT OF WORK

- Enviro-Mech will focus on reducing failure due to improper installation.
- Dr. Barfield's team will continue developing a new filter fence material configuration and support mechanism.
- Enviro-Mech will design and build a machine which will create a trench, lay the fence, and backfill the trench.



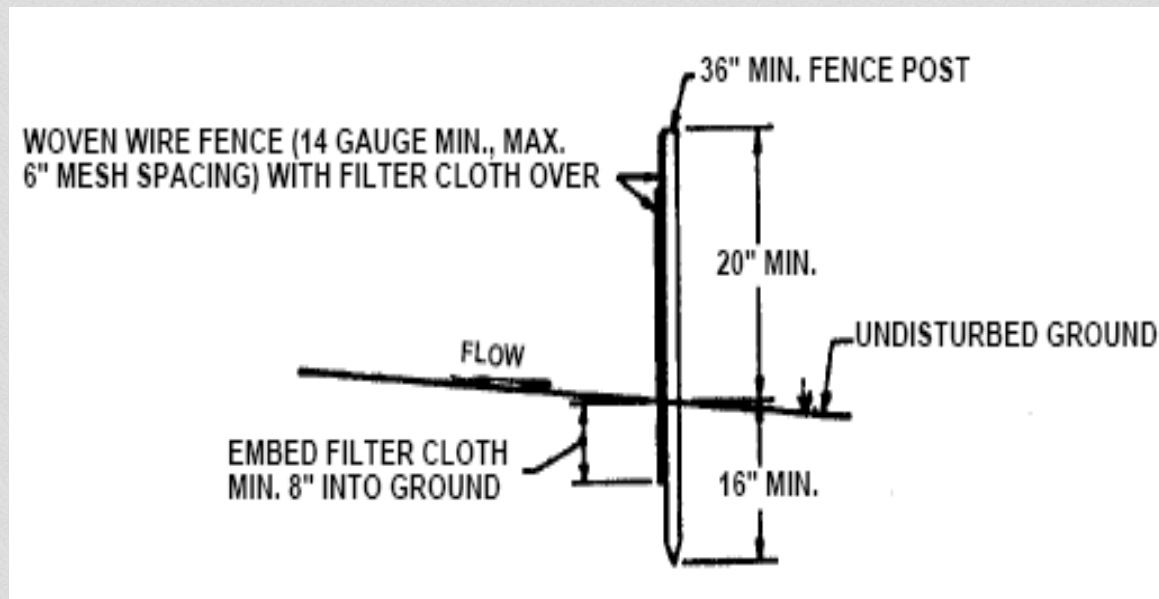
INVESTIGATION

- Recommended Silt Fence Practices
- Current Equipment Patented
and in Production
- Similar Vibratory Plow Applications



RECOMMENDED PRACTICES

- Information Concerns
 - Trench Dimensions
 - Fence Location
 - Post Height
 - Fence Size





CURRENT EQUIPMENT

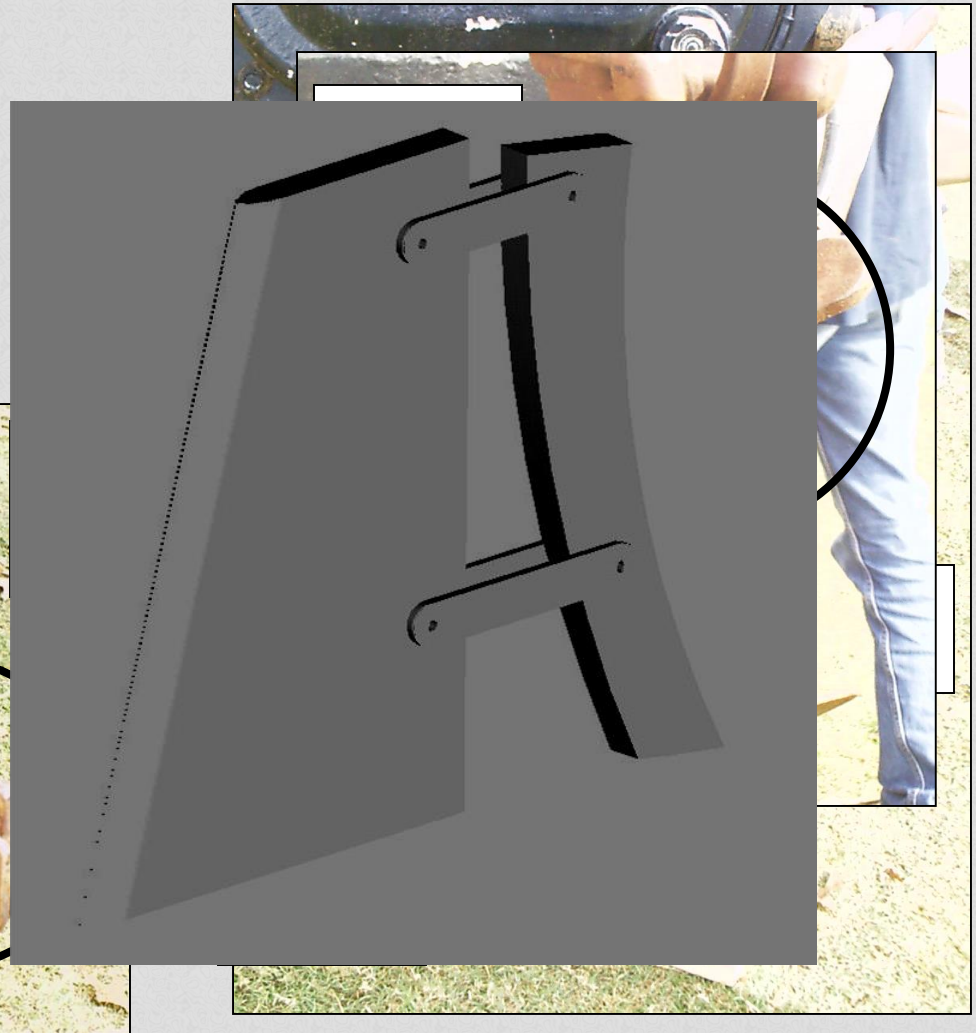
- Tommy Silt Fence Machine
- Erosion Runner
- ImpleMax SF12c
- McCormick Equipment





VIBRATORY PLOW

- Cable Installation Blades
 - Integrated Slot
 - Four Bar Linkage





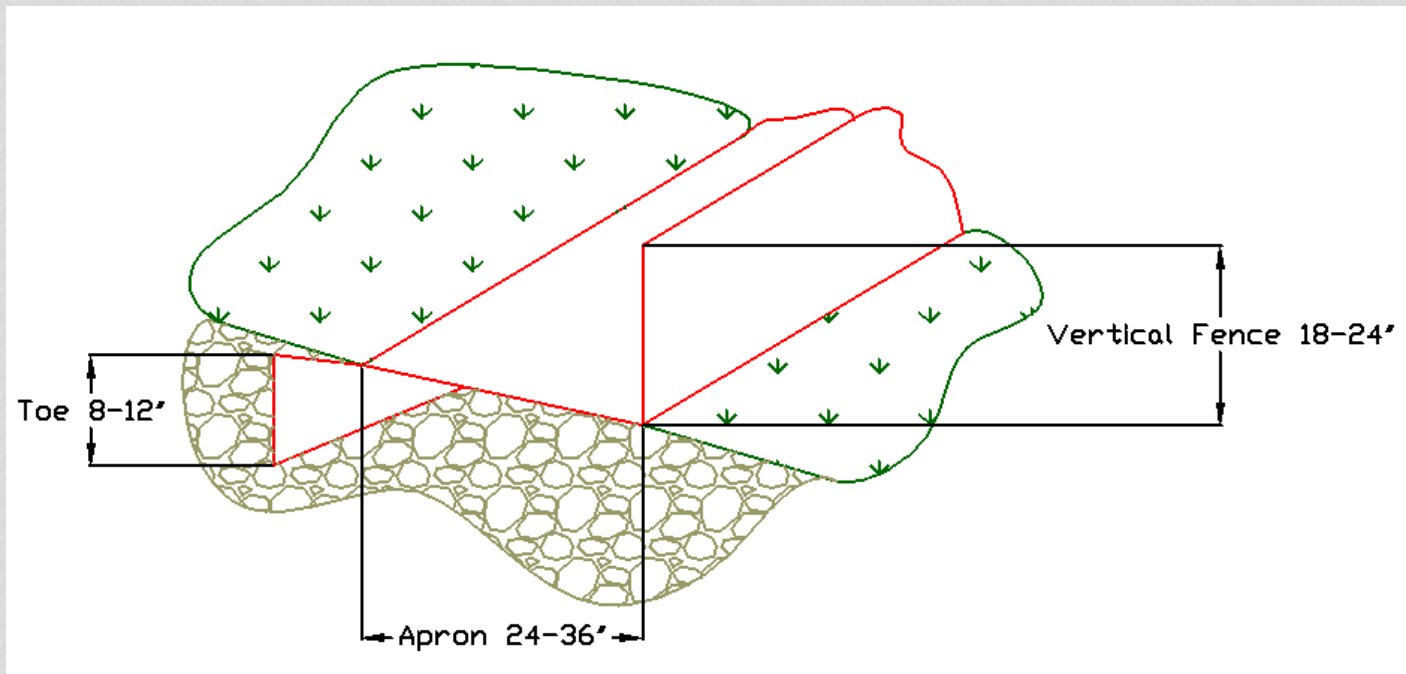
CONCEPT DEVELOPMENT

- Design Criteria
 - FAESF Research Group
 - Charles Machine Works
- Potential Solutions
 - Proposal A - Two-Disk Method
 - Proposal B - Feed Channel Method
 - Proposal C - Tension Rod Method



DESIGN CRITERIA

- FAESF Proposed Design





DESIGN CRITERIA

- Design compatible with current power source provided by Charles Machine Works
- Economical
- Marketable





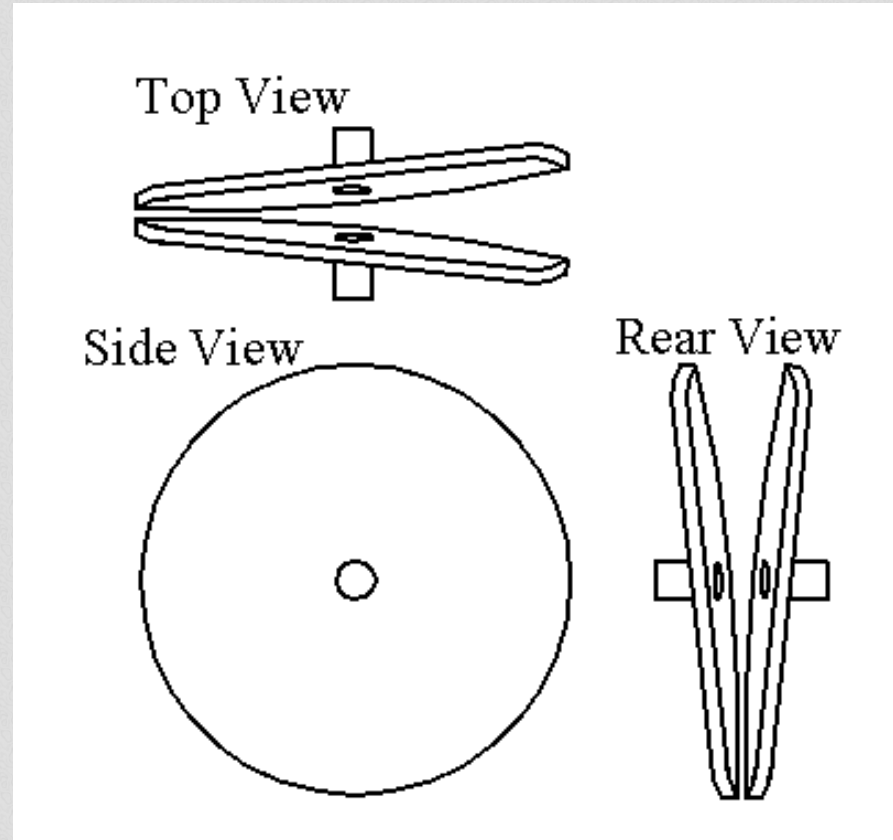
INSTALLATION METHODS

- Proposal A - Two-Disk Method
- Proposal B - Feed Channel Method
- Proposal C - Tension Rod Method



PROPOSAL A TWO-DISK METHOD

- Two narrow disks pinch the fabric.
- The disks feed the fabric into the slot.
- Fabric is released at the bottom of the slot.

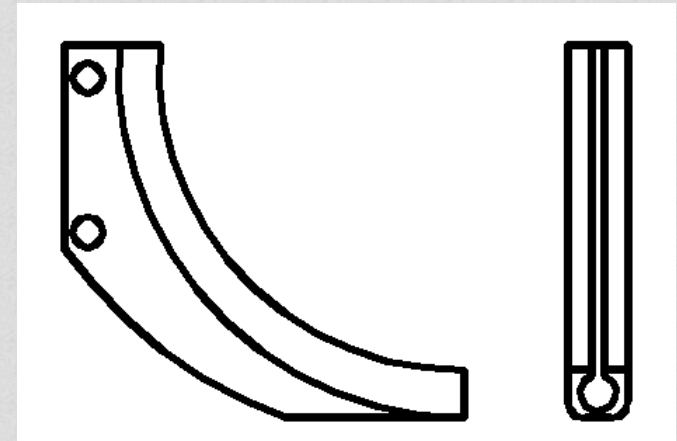




PROPOSAL B

FEED CHANNEL METHOD

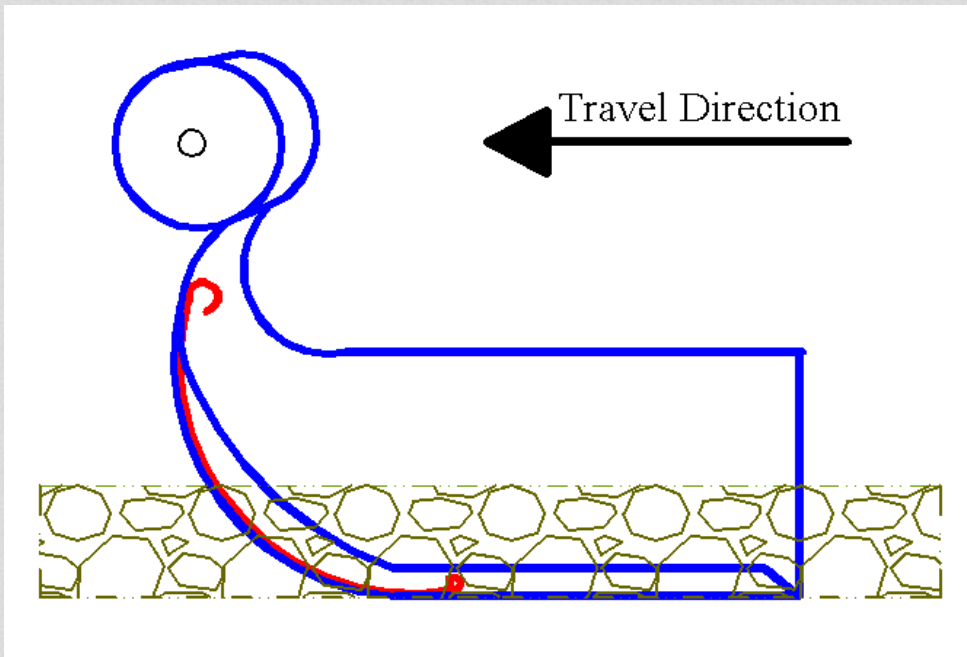
- Channel will be attached similar to four-bar linkage currently used.
- The fence will require added bulk to bottom edge.





PROPOSAL C

TENSION ROD METHOD



- Spring loaded rod will guide material through slot.
- The end of the rod acts as a pressure point.



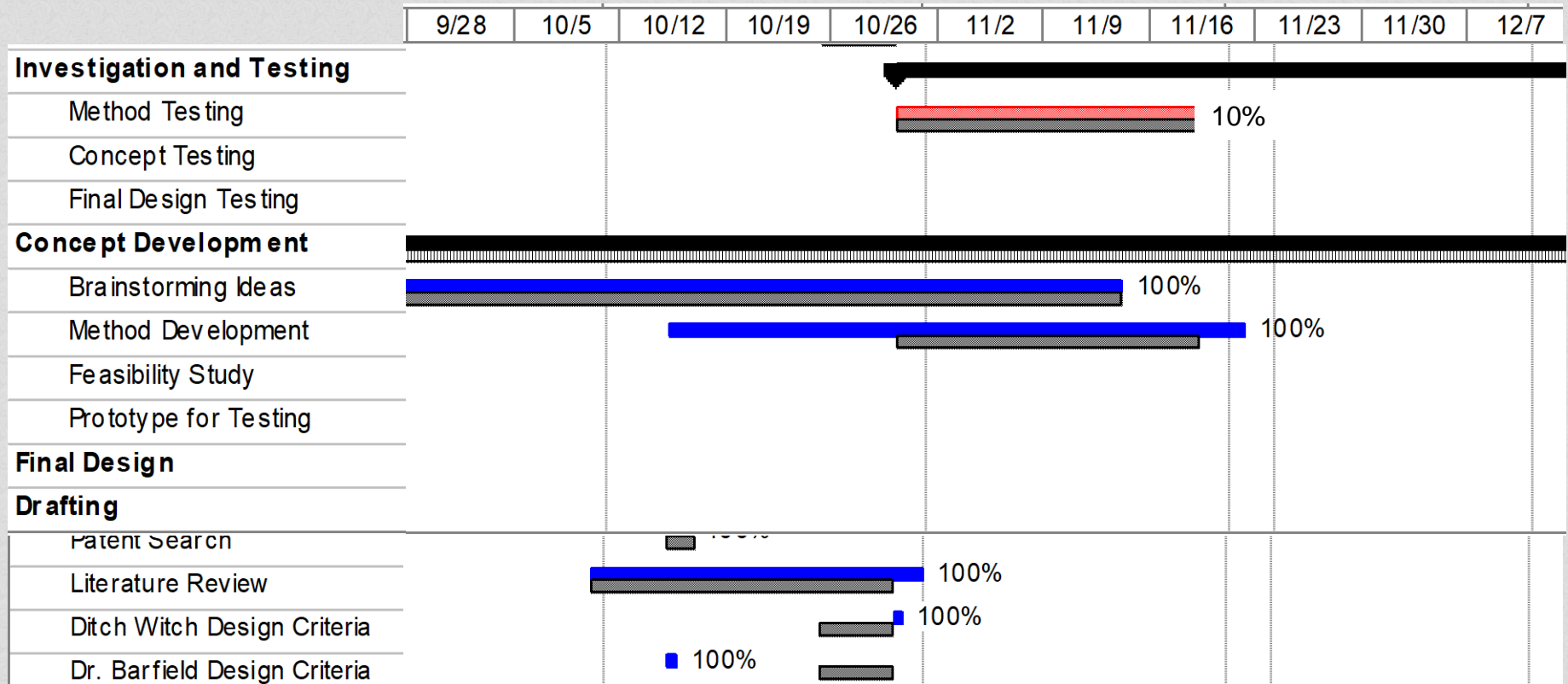
TEST AND ANALYSIS

- Testing is required to determine the most effective and financially feasible solution.
 - Methods Testing
 - Concept Testing
 - Final Design Testing



PROJECT SCHEDULE

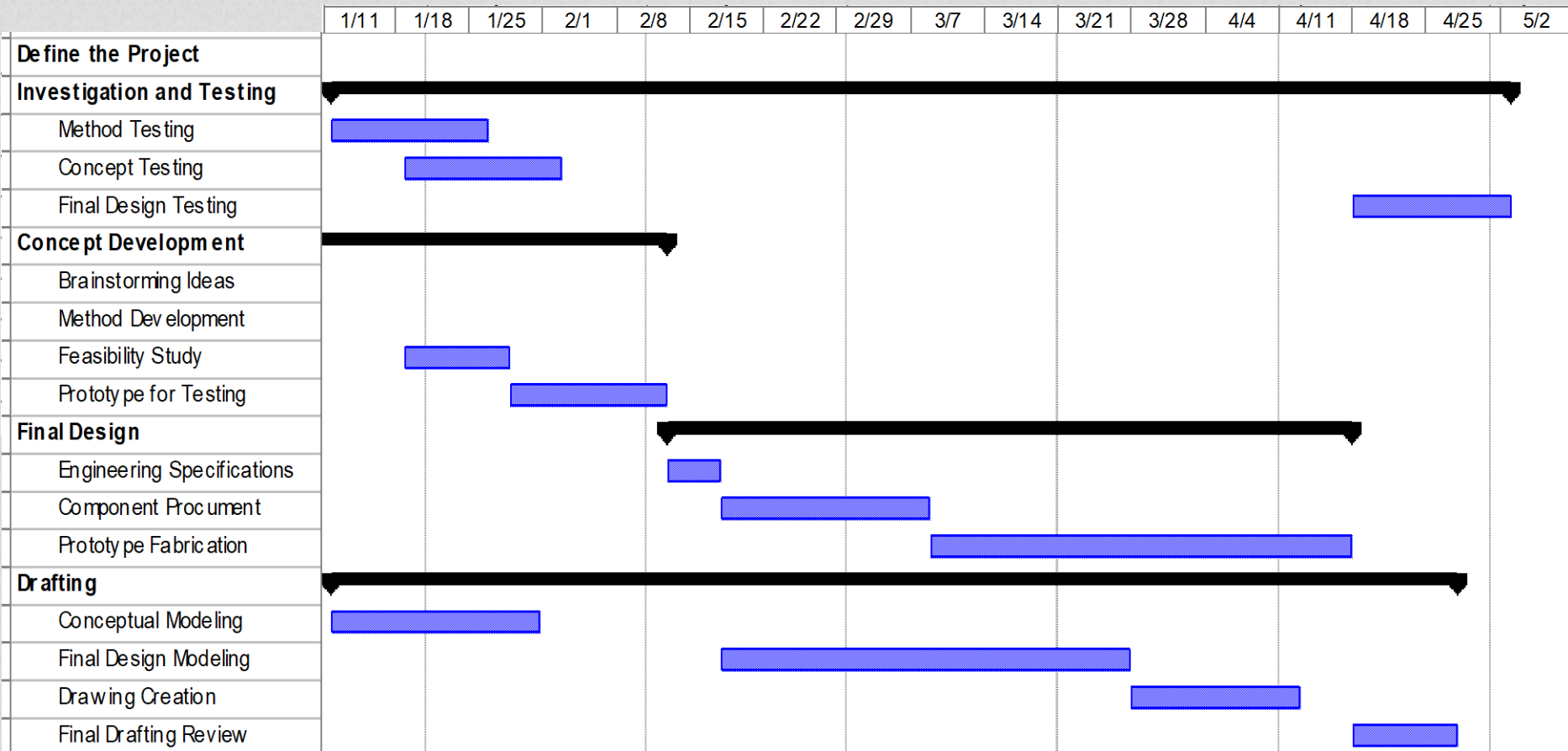
Fall Semester Accomplishments





PROJECT SCHEDULE

Spring Semester Plans





PROJECT BUDGET

	Material Cost	Fabrication Time	Fabrication Cost	Total Cost
Web Handling	\$30.00	10 hr	\$24.00	\$54.00
Feeding Mechanism	\$330.00	50 hr	\$120.00	\$450.00
Packing Wheel	\$180.00	25 hr	\$60.00	\$240.00
Total Cost	\$540.00	85 hr	\$204.00	\$744.00



THANK YOU

Enviro-Mech would like to thank those who have contributed to our Senior Design Project.



- Richard Sharp - Project Engineer
- Kelvin Self - Manager R & D



- Dr. Billy Barfield - FAESF Research Group
- Dr. Ellen Stevens - FAESF Research Group
- Dr. Paul Weckler - Senior Design Instructor
- Dr. Glenn Brown - Senior Seminar Instructor
- Dr. Ron Elliot - BAE Department Head



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Questions