Silt Fence Installation Efficacy: Definitive Research Calls for Toughening Specifications and Introducing New Technology

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Introduction: Silt fence is a joke on many construction sites. It is often seen just blowing in the wind, or sagging and broken down. Some specifiers won't utilize silt fence on their sites because it is too often installed improperly, and not maintained. Yet, the need for effective on-site sediment control has never been greater.

Sediment-laden runoff has been shown to result in the loss of in-stream habitats for fish and other aquatic species, an increased difficulty in filtering drinking water, the loss of drinking water storage capacity, and the negative impacts on the navigational capacity of waterways (EPA833-F-00-001, January, 2000 Storm Water Phase II Fact Sheet 1.0). Sediment clogs stormwater conveyance systems and causes expensive maintenance repairs. For these reasons it is unlawful to discharge sediment into our waterways.

Ineffective silt fence is also a waste of valuable environmental protection dollars. Specifications exist to ensure construction monies are properly spent, and to insure that owners' receive their monies worth. When specifications are not followed, or are inadequately written, our financial and environmental resources are wasted.

Still silt fence is often the primary sediment control practice on a site in the early phases of construction for logistical reasons – controls are not practical on the interior until the site work has been completed. When a site is first opened up, silt fence is used on the perimeter, and along waterways, to minimize sediment loss from the site.

Silt fence is also used along streets within a development to prevent sediment from entering the stormwater system. Its somewhat temporary nature promotes its use until more permanent stabilization practices can be utilized.

Problem: Installation Practices

Common trenched installations washed out quickly. *(photo courtesy of Tom Carpenter)*

Numerous improper installation practices associated with trench-based silt fence systems are the cause of many of the problems associated with their use.

- Excavated soil from the trench is intended to embed the silt fence, but is often neither adequately back-filled nor properly compacted.
- The trench may not be completely cleaned out prior to installing the fabric, leaving debris, which can interfere with fabric installation and backfilling.
- Posts are installed in the trench prior to backfilling, preventing compaction equipment from contacting the full width of the trench.
- The silt fence may not be inserted to a uniform depth through the installation, allowing shallow areas to 'washout' more easily.
- And finally, cumbersome trenching equipment may be hard to maneuver in many situations.

Some of these improper installation problems derive from antiquated specifications, that do not provide sufficient detail on such things as:

- What trench depth is effective and what is the relationship between the depth and the backfill;
- What quantity and what type of backfill is appropriate;
- In what manner, at what time, and how much to compact the backfill;
- In what sequence to install the posts.

In addition, common specifications have never been tested for efficacy – we do not have scientific data supporting them.

The introduction of Static Slicing

In the mid 1990's, an effort to overcome many of the deficiencies associated with trench-based silt fence installation culminated in a method called 'static slicing'. The concept originated in Iowa and was field-tested on Iowa DOT projects in 1997. The Iowa DOT recognized the benefits of static slicing through this testing, and approved its use on all DOT projects that same winter.

Nebraska and Minnesota followed suit within a year, and in all 3 states, acceptance of the static slicing method quickly caught on with erosion and sediment control contractors. Since then the machines for mechanical static slicing installation have been commercially successful in many areas of the U.S.

Static slicing is defined as the insertion of a narrow custom-shaped blade at least 10 inches into the ground, and simultaneously pulling silt fence fabric into the opening created, as the blade is pulled through the ground. The blade imparts no vibration or oscillatory motion. The tip of the blade is designed to slightly disrupt the soil upward, preventing horizontal compaction of the soil and simultaneously creating optimum soil condition for future mechanical compaction. Compaction follows (4 passes typically) using a tire on the tractor used to pull the slicing machine. Post-setting and driving, followed with tying the fabric to the post, finalizes the installation.

Evaluating Performance

The designer of the static slicing method recognized the need for independent verification of the benefits of static slicing to facilitate the change of specifications to include the new technology.

The Environmental Evaluation Technology Center (EvTEC), a program of the Civil Engineering Research Foundation (CERF), the research and technology transfer arm of the American Society of Civil Engineers (ASCE), was contacted about their verification process.

EvTEC is operated to assist developers of new environmental technology in bringing their technologies to the marketplace in a timely fashion. EvTEC has a systematic prototype verification process. As part of that process, an industry advisory panel of experts was convened; in this case, state DOTs, civil engineers, and the Environmental Protection Agency. The panel is listed in the appendix to this article.

The panel, an EvTEC representative, and the developer then meet to discuss the new technology, considers the proposed solutions or benefits to be derived, and determine what evaluations and verifications would be significant to specifiers and users of the new technology.

The verification was designed to provide baseline environmental data about both the trenched and static sliced silt fence installation methods by performing actual field tests. The installation protocol outlined in ASTM D6462 Standard Practice for Silt Fence Installation was utilized to provide the basis for comparison. TRI / Environmental, Inc. supervised the research as an independent third-party laboratory, under contract to EvTEC.

The goal was to provide potential users and purchasers with verification information enabling informed decisions about the static slicing method as an alternative to traditional silt fence installation methods. This testing focused on methods rather than equipment so as not to limit the future use of the verification protocol for other installation technologies.

The three objectives determined by the panel were:

1. Determine the relative performance of the static slicing method of silt fence installation as compared to the trenching method.
2. Determine if static slicing is more cost effective to install than trenching.
3. Detail other practical benefits, such as ease of operation and versatility of each method.

Performance was measured in terms of the different installations' water retention capabilities when subjected to runoff. Excessive seepage under the fence (undermining) was expected to adversely effect retention. And this undermining was expected to be related to inadequate compaction of soil within the trench and/or adjacent to the fabric. Therefore, water retention and the degree of compaction achieved were evaluated for each soil type and installation sequence.

Silt fence installations were tested under storm event stresses *(photo courtesy of Tom Carpenter)*

Field Testing Program

This hands-on field research project utilized 52 test segments reflecting different soil types, different installation methods, and different hydraulic conditions. The testing was completed in seven days. All fieldwork involved full-scale equipment and experienced silt fence installers. One primary site, and three other sites were used to provide a variety of installation conditions.

Testing was primarily performed at one site with a predominately silty clay soil type. Several alternative installation schemes were evaluated in order to define the benefits of each installation type (slicing vs. trenching) under a variety of conditions. Various amounts of backfill, degrees of compaction, spacing of posts, volumes of runoff, and types of soil were evaluated. Additionally, installation sequence, such as installing posts before versus after compaction, was evaluated. Performance, as measured by water retention, and efficiency, as measured by installation time, were evaluated.

Thirty tests were performed on a gentle sloping area using 'smile' configurations. These 30 ft. radius smiles created areas to impound or retain runoff. . Six 12 ft. radius 'smiles' were evaluated, and ten straight 100 linear feet segments were constructed to evaluate installation efficiency. An additional six runs were installed to evaluate the methods on steep slopes, in rocky soils, and through wet spoils.

The depth was no less than 10 inches for static slicing nor 6 inches for trenching per the ASTM D6462 specification. The vendor felt the extra depth wasn't critical for slicing (6 in vs. 10 in), but provides a safety factor for the machine operator, reducing the potential for a poor installation. Deeper trenches were not tested because it was beyond the scope of the project to test all trenching alternatives.

For both methods, a 6.5 ft. post spacing was primarily used, as well as a slit film woven textile, 36 inches wide, designated Amoco 2130.

A concentrated flow from a 2-inch diameter hose and 5 H.P. pump created the runoff (the standard was 1000 gallons), which was introduced within 8-10 minutes. The runoff hose was supplied by a tank reservoir that permitted measurement (i.e., volumetric metering) of the outflow.

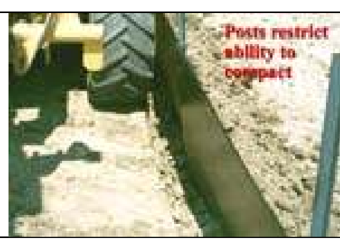
Compaction was measured by a nuclear density gauge, and a cone penetrometer. The panel was hoping to identify alternate, easy to use, economical means for determining compaction effectiveness as an added benefit to this protocol.

The details and sequences of tasks associated with 'traditional' trenching installation methods vary significantly from contractor to contractor. Therefore, 3 general types of trench-based installations were identified based on the likelihood of obtaining a fully-backfilled and densely compacted trench.

1. Minimum Installation (Spec) – Minimum silt fence specifications typically allow for the following practices, and are typically installed in this order: Trenching; Post-setting and Driving; Fabric installation and attachment to the posts; Back-filling (fill to level, if sufficient excavated soil is available); Compaction (required effort not usually defined, detailed, or quantified in the specification).
2. Better' Installation (Spec+) – A better than specified installation of silt fence would include
   1. fabric installation, use of only available backfill, and then compaction before setting and driving posts, or
   2. over-backfilling the trench, or
   3. posting and then mechanically compacting the filled trench.
3. Best' Installation (Spec++) – this would include multiple enhancements, such as, hand-cleaning the trench prior to installing the fabric, mechanical compaction of an over-filled trench, and posting as the final action.

The Minimum 'Spec' installation was included because the vendor felt it was a typical trenching process in the real world. The vendor felt many contractors only backfill with available soil from the upstream side of the trench for two reasons. One, a trencher deposits excavated soil on both sides of the trench, which would require them to hand move soil. Two, contractors normally set the posts and hang the fabric before backfilling, or use pre-fabricated silt fence, which would require them to shovel the excavated soil over the top of the 18-20 inch tall silt fence. These actions are inherently true with all pre-fabricated silt fence materials.

Trenchers left spoil on both sides of the installation.



Posting inhibited the compaction process, and thus the effectiveness of the installation

Static slicing enabled thorough compaction, and thus no washouts

(photos courtesy of Ken Bryce of TRI Environmental, Inc.)

Field Testing Results

In general, the static slicing method was found to provide storm water runoff retention as good as or better than the 'Best' (Spec++) trenched installations, and far superior retention to common (Spec) installations. Additionally, the static slicing method of installation was found to be a much more efficient, and therefore, cost-effective technique for silt fence installation when compared to a range of traditional trenching-based procedures.

However, the 'Best' (Spec++) trenching installation requires nearly triple the effort for similar performance to static slicing. It also requires adequate, trash-free backfill and sufficient soil moisture for compaction, as well as site conditions enabling a trencher to maneuver. This is a demanding trench-based installation – failure to perform any of the tasks completely will likely result in a significant reduction in efficacy.

Static slicing avoids these concerns. Mechanical installation minimizes labor efforts, and potential backfill and compaction problems. Mechanical installation produces a uniform installation and the greatest potential for an effective silt fence, with the least risk for some level of failure.

Retention Performance

Runoff retention tests measured the ability of a 'smile' of installed silt fence to retain runoff. Segments installed using static slicing or the best (spec++) trenching techniques provided superior runoff retention. Those segments installed using minimum effort generally experienced both excessive seepage and washout. Figure 3 'Average results of standard runs' illustrates the performance of these different installations.

It should be noted that in this evaluation, trenches were hand-cleaned prior to fabric placement and backfilling. This procedure was used to optimize trench-based installation performance but is commonly skipped in 'real world' installations. A clean trench allows the fabric to fit snuggly against the ground, minimizing potential piping action that could occur when clods and trash are left in the trench.

Installation Efficiency

It was clear from the fieldwork that the installation time and manual labor associated with any type of trenching installation is substantially greater than the slicing technique. Figure 1 'Silt fence installation productivity' demonstrates this disparity.

One of the clearest advantages to the static slicing method over all trenching-based installations evaluated was greater productivity. This productivity translates into the ability to install silt fence much faster and with a smaller (typically 2 man) crew than trench-based methods.

Compaction Benefits

Performance trends provide a clear indication that a greater level of compaction (i.e. higher density obtained) corresponds to better performance (i.e. greater water retention). System comparisons showed that static slicing provided installations that had both higher densities and greater water retention than all trenching-based installations.

Trenching-based installations were effected by the inability to compact effectively when posts are installed first, when insufficient backfill material is placed in the trench, or when inadequate compaction effort is provided. Still, it should be noted that the installations using static slicing also required reasonable compaction efforts to perform properly.

Compaction density was measured with a nuclear density gauge, and a hand-held cone penetrometer. There was a significant correlation between the cone penetrometer readings and the nuclear density measurements. This may indicate the much easier, and less expensive, hand penetrometer can be effectively used as a field quality assurance tool.

Other Observations

The static slicing method also offers practical advantages over traditional trenching-based methods, including maneuverability, and ease of installation on steep side slopes, through rocky soils, and in saturated soils.

Steep Slopes

A 3:1 slope was available on another site to evaluate the relative ease of installing silt fence by static slicing versus trenching. In both cases, the steepness of the slope tended to encourage the equipment to drift down-slope, although much less for the static slicing method. In comparison to trenching, static slicing provides much straighter, faster installation of silt fence across steep slopes. The spoil from the trenching operation also has a tendency to fall back into the trench and down the slope – both of which would decrease potential efficacy.

Rocky Soils

A third site provided very rocky soil conditions in which to compare static slicing and trenching. While large buried rocks are able to disrupt both installation methods, static slicing appeared to be significantly more resistant to being "kicked" out of the ground. In rocky conditions, the static slicing method provides a better installation than does trenching.

Saturated Soils

A fourth site had wet, organic soils and abundant vegetation making it practically impossible to remove the soils from a trench, install fabric, and then replace and compact clean soil in the trench. Conversely, the static slicing apparatus was able to "insert" the fabric deep into the wet soils without substantially disrupting the area.

Specifications/Recommendations

By analyzing the field-testing performed for this evaluation, there appears to be two possible ways to achieve maximum silt fence performance – static slicing or the very best trench-based installations. Yet, there is no clear, generally accepted specification with explicit installation details to obtain this 'best' trench-based installation.

In all cases, static slicing produced silt fence installations as good as or better than the very best trench-based installations. This finding provides an important argument for toughening trench-based specifications with more specific requirements for backfilling and mechanically compacting the soil.

Still, the combination of maximum performance and maximum productivity can be achieved in one standard installation method – static slicing. The static slicing method is already included in ASTM D 6462 and, therefore, is easily incorporated into project specifications.

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