erosion-Control Materials Tested at Texas Field Facility

Sally Godfrey and Joan Tatge

During the late 1980s transportation agencies faced toughened federal regulations for erosion and sediment control. Storm water management was also of growing concern. Addressing these issues was made difficult by the limited quantitative information on the field performance of erosion-control materials, and the fact that hydraulics and erosion research initiated by the Federal Highway Administration had already reached their full potential. Because FHWA was unable to test newer, more advanced products, soil engineers found the task of selecting erosion-control materials difficult.

A variety of laboratory tests described standard-strength properties of erosion-control products, such as tensile strength, shear strength, resistance to abrasion, cutting and tearing characteristics, and heat resistance. Soil-fabric interaction, vegetation establishment and installation methods were also included among the critical factors for determining the field performance of an erosion-control material. These tests were typically conducted at an indoor lab using very small samples, which did not adequately describe field performance.

To address the problems with testing, the Texas Department of Transportation and the Texas Transportation Institute collaborated to develop a field laboratory for evaluating erosion-control materials and technologies for their soil-retention properties and effectiveness in establishing vegetative cover. The primary objective of the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory is to provide manufacturers with an equitable program that TxDOT may use to evaluate their products for erosion control and vegetation establishment. TTI researchers established a vehicle for industry participation to help achieve this

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TxDOT/TTI Hydraulics and Erosion Control Field Laboratory recreates harsh environmental conditions of roadsides.

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TTI researchers Sally Godfrey and Jet McFalls confer at laboratory field site.

TTI

objective. The Industry Advisory Council was formed to encourage representatives of each manufacturer whose products are undergoing testing to participate in the process. In addition to industry representatives, members of the council include a TxDOT representative and one representative from the International Erosion Control Association. The council provides continual guidance on laboratory development and maintenance and input on testing procedures and evaluation criteria.

Unique Evaluation Facility

At the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory, erosion-control and flexible channel lining materials are tested, controlling for soil type, slope ratio, and simulated rainfall or flow rates. The laboratory is the only facility of its kind that recreates the harsh environmental conditions of the roadside.

Located at TTI's proving grounds, the field laboratory is bounded on the north, east, and west by runways, and by an open field to the south. Harsh climatic conditions prevail at the site because it is on a ridge above the Brazos River. The soils there are poor; the heat stored in or reflected from the surrounding pavement influences the facility conditions. Conditions are similar to those of typical highway roadsides.

Earth Embankment

The earth embankment was built from two types of soil found within the 5 hectare (12.5 acre) site. One-half of the embankment was built and capped with a sandy loam soil, the other half with clay soil. The physical properties of these two soils adequately represent the erosive properties frequently encountered in Texas highway rights-of-way.

The L-shaped embankment is 267 meters (876 feet) long at the crest and 6.71 meters (22 feet) high. The cross section of the embankment was finished with a minimum 15.24 centimeter (6 inch) soil cap, with a 2:1 slope on the south and west facing slopes and a 3:1 slope on the north and east facing slopes. The top of the embankment is 7.31 meters (24 feet) wide. It was constructed using TxDOT standards and specifications for construction of highways, streets, and bridges.

The embankment provides a total of 76 subplots, each of them 6.2 meters (20 feet) wide, and allows for repeated product evaluations on the two soil types. A concrete sediment collection box is installed at the base of each plot.

Rainfall Simulators

Rainfall simulators are used to generate the primary data in the sediment retention performance evaluations. Natural rainfall is also recorded, but resulting sediment is not collected. The rainfall simulators are also 6.2 meters wide and are capable of covering the entire plot.

During embankment construction, two reservoirs were created with a natural vertical elevation difference of approximately 1.5 meters (5 feet). The upper reservoir has a surface area of 2.63 hectares (6.5 acres) and has a holding capacity of approximately 43,000 cubic meters (56,000 cubic yards). This reservoir is the primary water supply source for all the experimental work. A 10-horsepower centrifugal pump supplies the rain simulators stationed on the embankment.

The field laboratory also has an on-site suite of weather-recording instruments, including a tipping-bucket rain gauge, hygrothermograph, barograph, recording anemometer and pyronometer. These instruments provide a detailed record of the climatic influences over the study period, and the record is presented with research results.

Channel Facility

During the second phase of laboratory construction in 1992, researchers built 10 at-grade channels—6 at a 7 percent grade and 4 at a 3 percent grade—and a water distribution system which includes a pumping station, corrugated metal piping, and release structures. An earth embankment built between the two reservoirs provided a base for the excavated channels.

Each open channel has a trapezoidal cross section, includes a 0.30-meter (1-foot) bottom, 1:1 side slopes, and a typical 0.91-meter (3-foot) depth beginning 4.5 meters (15 feet) downstream of the channel release. The total length of the test channel section is 26 meters (85 feet).

Maximum test flow capacity was provided by modifying the south reservoir and installing a return pumping station to aid in the reuse of test water. Water supplied by an industrial-grade, high-volume, low-head axial flow pump is capable of producing 136,260 liters per minute (36,000 gallons per minute).

Relevant Research and Evaluation

The TxDOT/TTI Hydraulics and Erosion Control Field Laboratory consistently recreates the harsh environmental conditions encountered in the roadside environment, enabling TxDOT to implement laboratory findings. Researchers have already proven the effectiveness of 18 erosion-control blankets, 8 hydraulics mulches and 9 flexible channel liners for various application areas for TxDOT.

Erosion-Control Blanket Testing

Before an erosion-control blanket may be approved for use within TxDOT, it must be proven at the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory. The only concern of TTI researchers is

field-testing a product's effectiveness in retaining sediment on the slope and promoting vegetative cover in one growing season. Competing manufacturers' products are compared in a single lab evaluation, where salesmanship and independent product testing can have no impact. As a result, manufacturers submit the products they believe can perform well in different soils in the field, will be cost-competitive once approved, and are easy to install.

Many products appear to be similar in composition and theoretically should perform similarly in the field. However, there is often a difference in performance attributable to different installation techniques and how well a blanket bonds with the soil. This may be the reason some manufacturers have chosen to test new products in the controlled environment of the laboratory, including such products as 407GT, which is basically carpet backing; or Soil-Guard, a thick, slurry gel sprayed onto the slope instead of rolled in the traditional manner. Another product, Airtrol Plaster, is a combination of gypsum and mulch, which hardens after it is sprayed onto the slope. These products are less expensive to manufacture and less costly to apply than heavier roll-type blankets.

Continuing Federal Channel Hydraulics Research

To pick up where federal research left off, TTI researchers are using the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory's channel facility to evaluate the effectiveness of flexible channel liners. The facility's water distribution system is used to conduct simulated flow events and to generate shear stress on the liner ranging from zero to thirty-nine kilograms per meter squared.

In 1994 the TTI research team began the channel test flows immediately after the installation of the flexible channel liners. These immediate test flows did not allow the seed enough time to germinate. In 1995 there was a germination period of three months before test flows were initiated. Once this vegetation was established, researchers began to evaluate the effectiveness of various manufacturers' flexible channel liners.

Hydraulic Mulch Study Benefits TxDOT

The ongoing hydraulic mulch study is producing results that may benefit TxDOT operations. If the results continue to be consistent during the next one to two years, TTI researchers may recommend a change in the state's current two-step process for applying

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COMPUTER PROGRAM AIDS IN QUICK EROSION CONTROL

Researchers at the Texas Transportation Institute have devised a software program to assist in the selection of products for erosion and sediment control. The personal-computer-based program quickly generates a Storm Water Pollution Prevention Plan (SW3P) report. It also provides users with an easy-to-use matrix of selection options based on such basic site information as soil data, vegetation information, and application area.

Several erosion-control scenarios may be generated at one time. Users are given the opportunity to analyze plan options to determine which one achieves the required erosion and sediment control at the lowest possible cost.

The program requires that users visualize the site, divide it into the major phases of construction, and conceive a preliminary SW3P. The program may then be used to select appropriate temporary erosion- and sediment-control measures.

Once basic site information (size, location, highway or project number, etc.) is entered, users are given the option of entering soil names. If a soil name is unknown, the program automatically uses the location, by county, as the determinant.

This information is sufficient to generate the appropriate erosion control measures, including structural and nonstructural (vegetation) measures. Standard Texas Department of Transportation (TxDOT) seeding mixtures for permanent and temporary seeding for warm and cool season grasses are included in the program. These are referenced by county so the user is given the correct seeding mixture for the project site.

For structural measures the program determines the appropriate sediment-control measures based upon area, runoff calculations, soil erodibility, and application area.

This new program reduces the time needed to select erosion- and sediment-control measures, which allows designers to spend more time with the SW3P plan. Although the program is tailored for use by TxDOT, it can be customized to fit the needs of transportation agencies across the nation.

—Traci L. Smith

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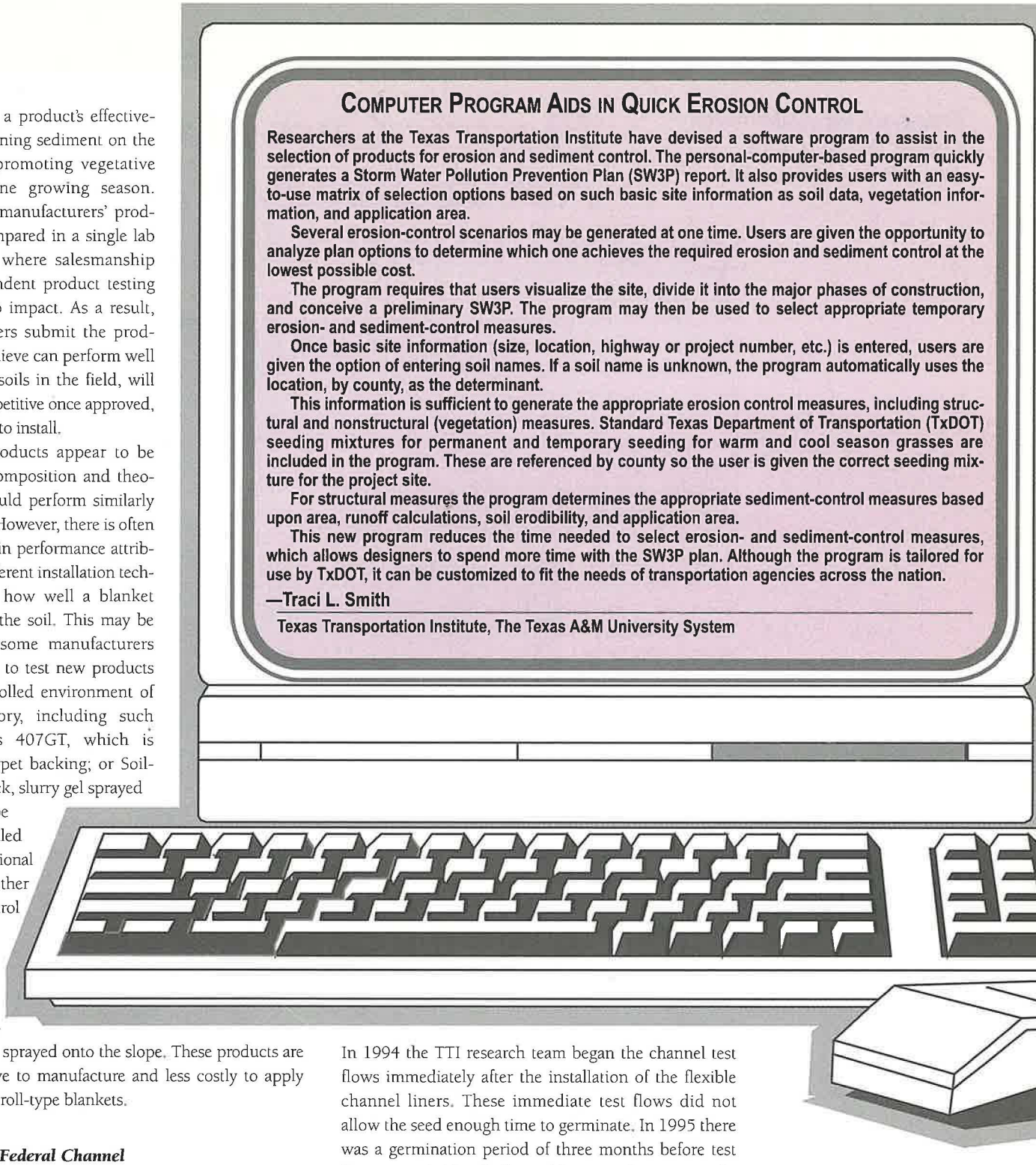

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hydraulic mulch. TxDOT's *Standard Specifications for the Construction of Roadways and Bridges* calls for the seed and fertilizer to be mixed and applied to the slope together. In a separate step the mulch is applied on top of the seed-fertilizer mixture.

TTI's research team did not find sufficient evidence to support TxDOT's assumption that the two-step application process is better for vegetation establishment than a one-step process. At the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory, the adopted two-step application process is being tested in tandem with a one-step process that involves mixing seed, fertilizer, and mulch and applying them all at once. During the two years that TTI has been conducting mulch research there has been no significant difference in the results between the two types of application. If these findings do not change, TxDOT could begin to reduce costs by applying the one-step application process.

Storm Water Management For Construction Sites

Activities that disturb land—such as construction and maintenance operations within highway rights-of-way— are necessary to meet transportation demands. If not treated promptly, erosion-related impacts can include habitat changes, accelerate erosion, and cause sediment losses that increase pollutant loads.

During the past 20 years, a proliferation of erosion- and sediment-control products and methods have been developed, but industry methods have not kept up with the rapid changes in Environmental Protection Agency standards. Education, testing and application vary widely among regions. To meet the stringent environmental requirements placed on agencies today, designers need appropriate guidance on planning, designing and selecting the best management practices for construction sites.

TTI researchers developed a strategy for selecting management practices on the basis of a fundamental understanding of erosion principles. Using data such as erosion production factors, vegetative measurements, and soil erodibility factors generated at the TxDOT/TTI Hydraulics and Erosion Control Field Laboratory, as well as existing literature, a comprehensive PC-based computer program was developed. This program gives users the guidance they need to select the best management practice and generates reports for the storm water pollution prevention system (*please see sidebar on page 13*).

Providing Useful Results to Industry

The research conducted at the TxDOT/TTI Hydraulics and Erosion Control Laboratory is producing information previously unavailable to the erosion industry and the transportation community. Researchers at the laboratory are concerned with finding economical, effective erosion- and sediment-control measures for the range of applications encountered within highway rights-of-way. As transportation agencies face strengthened federal regulations regarding erosion- and sediment-control, and storm water managers search for answers to erosion-related problems, TTI research is playing a key role in providing solutions for both.

***Electric Cars,** continued from page 14*

Some critics admit that the 1998 model electric vehicles will not be attractive from an environmental, performance, or economic perspective. However, the requirement is viewed as a beginning, forcing automobile makers to improve the technology. The impending 1998 requirement means that automobile makers are spending hundreds of millions of dollars on near-term battery technology that is bad for the environment. Instead, resources could be devoted to developing more attractive technologies that will not be available for some years. Research and development should focus on promising technologies that do not require the processing of large quantities of toxic materials. Forcing the sale of lead-acid or other available technology (and the associated recharging infrastructure) does not seem like the best option given the inherent limitations. There are many reasons to force investment in advanced technologies but few, if any, for requiring large numbers of electric vehicles to be sold in model year 1998.

Battery-powered vehicles using near-term technologies do not deliver the promised environmental benefits. It is hoped that environmentally benign and effective technologies such as practical fuel cells will appear soon. In the meantime the 1998 mandates are premature.

For a summary of the study's findings, contact Francis C. McMichael, Carnegie Mellon University, Department of Civil & Environmental Engineering, 5000 Forbes Avenue, Porter Hall 119, Pittsburgh, Pennsylvania 15213-3890.