COMMONWEALTH of VIRGINIA

DEPARTMENT OF TRANSPORTATION
1401 EAST BROAD STREET
RICHMOND, VIRGINIA 23219-2000

PHILIP A. SHUCET
COMMISSIONER

December 20, 2004

The Honorable Vincent F. Callahan, Jr.
Chairman, House Appropriations Committee
Virginia House of Delegates
P.O. Box 1173
McLean, Virginia 22101

The Honorable John H. Chichester
Chairman, Senate Finance Committee
Virginia State Senate
P.O. Box 904
Fredericksburg, Virginia 22404-0904

Gentlemen:

An amendment to House Bill 5001, Item 487B, which was passed by the General Assembly in the 2004 Special Session, calls for the Virginia Transportation Research Council to "study the use of soil stabilizers in highway shoulders . . . with the objective of finding a method of substantially reducing the occurrence of pavement/shoulder drop-off at a reasonable cost."

Enclosed is the report by the Virginia Transportation Research Council that examines the installation of soil stabilization products by deeply mixing chemical additives into unpaved shoulders on Route 522 in Powhatan County. Problems arising from the equipment used and an inability to maintain a consistent elevation for both the shoulder and the hard surface pavement compromised the study. Therefore, further work on this promising technique was cancelled until equipment compatible with the study requirements can be acquired. Additional test sections will be installed in the spring of 2005, with a report to be completed in late summer 2005.

An evaluation of the performance of the treatments will provide the basis for additional study leading to recommendations to VDOT's operating divisions regarding improvements to the maintenance practices for unpaved shoulders. If you have questions or need additional information, please let me know.

Sincerely,

Philip A. Shucet

Enclosure

cc: The Honorable Whittington W. Clement

USE OF SOIL STABILIZERS ON HIGHWAY SHOULDERS: INSTALLATION REPORT

A Report in Response to an Amendment to House Bill 5001, Item 487B

Virginia Transportation Research Council
December 1, 2004

PREFACE

The work reported here concludes the first phase of an evaluation of unpaved shoulder stabilization treatments in Virginia. These results will prove valuable for the purpose of supporting improvements to the Virginia Department of Transportation's (VDOT's) practice of maintaining unpaved shoulders.

This study was directed and conducted by the Virginia Transportation Research Council in response to an amendment to House Bill HB5001, Item 487B. The principal investigator for the study was Daniel S. Roosevelt, P.E., Research Scientist, Virginia Transportation Research Council.

The author gratefully acknowledges the valuable assistance provided by the following members of VDOT's Chesterfield Residency staff:

Raymond L Mayo, Transportation Operations Manager II
Earl H. Tyler, Transportation Operations Manager II
Marvin A. Sirry, Assistant Resident Engineer for Maintenance.

Special thanks are extended to those VDOT Area Headquarters employees at Powhatan and Bethia who expertly provided construction support and reliably provided traffic control through safe and secure work zones without incident.

TABLE OF CONTENTS

LIST OF TABLES

EXECUTIVE SUMMARY

Introduction

An amendment to House Bill HB5001, Item 487B, calls for the Virginia Transportation Research Council (VTRC) to "study the use of soil stabilizers in highway shoulders . . . with the objective of finding a method of substantially reducing the occurrence of pavement/shoulder drop-off at a reasonable cost." The complete amendment is provided in the Appendix.

Current research involving soil stabilizers on unpaved roads suggests that these products may be used to stabilize unpaved shoulders and reduce the incidence of low shoulders along the pavement edge. To facilitate an objective performance evaluation, a trial installation was constructed in which representative stabilizer additives were thoroughly mixed into the shoulders of a primary road in Powhatan County, Virginia.

Objective

The purpose of this project is to evaluate the use of soil additives as stabilizers for aggregate and topsoil shoulders. The objectives of the study are to determine (1) the effect soil stabilizers have on the incidence of pavement-shoulder drop-off, and (2) the costs and benefits of using stabilizers versus paving the shoulder or maintaining the shoulder as originally composed.

Methodology

VTRC has an ongoing study of the use of stabilization techniques on unpaved roads. The study is evaluating a number of soil stabilization additives along a single secondary system gravel road using a test and control process. The installation report for the project indicates to be most effective, all the additives tested should be deeply mixed with the aggregate and compacted. This process is known as full-depth reclamation (FDR). Details of the installation may be found in VTRC Report No. 04-R18 entitled *Stabilization Techniques for Unpaved Roads.*

The unpaved road study tested a number of acrylic, soybean/soy lecithin, and chloride salt products. The experimental plan for the current study called for testing one of each type of product based upon preliminary performance data from the unpaved road study. The additives commercially known as Centrophase AD, Soiltac, and magnesium chloride were to be tested.

FDR was to be used in the current study as the basis for the initial testing of the performance of soil additives when used on shoulders. A 0.3-mile-long segment of Route 522 in Powhatan County was chosen as the study site. The Centophase AD and Soiltac test sections were constructed on September 14, 2004. The FDR process could not be satisfactorily completed because the equipment was too large to work effectively in the shoulder area. In addition, achieving the same elevation of the shoulder and the hard surface pavement was difficult. When the process could not be modified without compromising the stabilizer mix design, the installation of the magnesium chloride was cancelled.

Performance Evaluation

After two test sections were installed, the problems of equipment size and weight and the need to comply with requirements regarding mixing and necessary elevation could not be resolved. Rather than continue with the construction of test sections that could not comply with the study specifications, the work was stopped and the placement of the additional test sections was cancelled.

Ongoing Work

Although the work to date has not verified the ability of soil stabilizers to work effectively on unpaved shoulders, it has established that alternate methods for applying stabilizers need to be investigated. The shoulder stabilization process requires equipment that can work in areas from 1 to 6 feet wide yet can scarify and mix the material to a 4- to 6-inch depth. Equipment will be sought that complies with these requirements, and additional test sections will be installed in the spring of 2005. The results, conclusions, and recommendations of this additional study will be reported in late summer 2005.

INTRODUCTION

In House Bill 5001, Item 487B, the Virginia General Assembly directed that "[t]he Department of Transportation, through the Virginia Transportation Research Council, shall allocate such amounts as may be required to study the use of soil stabilizers in highway shoulders at one or more selected locations. In conducting its evaluation, the Council shall include a cost/benefit analysis, with the objective of finding a method of substantially reducing the occurrence of pavement/shoulder drop-off at a reasonable cost. Findings of the evaluation shall be reported to the Chairmen of the House Appropriations and Senate Finance Committees no later than January 1, 2005." The time period between passage of HB5001 and the reporting date specified in the bill did not allow for a full evaluation. This report documents the results of the investigation through November 1, 2004. A final report will be issued in the summer of 2005. The full text of HB5001, Item 487, may be found in the Appendix.

Low shoulders can occur for a number of reasons, but the three most common are (1) traffic action, (2) erosion caused by concentrated flow of water, and (3) resurfacing that increases the elevation of the pavement. The first two are considered maintenance-related, in that the low shoulder condition usually develops over time. The third is construction-related, as the condition occurs because of a planned activity. In the first two cases, the ability of the shoulder to resist deterioration that results in pavement/shoulder drop-off is affected by its durability and load-carrying capacity (strength). The third situation is a scheduling issue and is not the concern of this study.

The Virginia Transportation Research Council (VTRC) has studied stabilization techniques on unpaved roads (see VTRC Report No. 04-R18 entitled *Stabilization Techniques for Unpaved Roads).* The study evaluated a number of soil stabilization additives along a single secondary system gravel road using a test and control process. The findings indicated to be most effective, all the additives tested should be deeply mixed with the aggregate and compacted. This process is known as full-depth reclamation (FDR). Assessment of the individual stabilizers used is ongoing. However, preliminary results on product performance have been obtained, and these were used to select the products for evaluation in this study.

PURPOSE AND SCOPE

Current research on the use of soil stabilizers on unpaved roads suggests that these products may be used to stabilize unpaved shoulders and reduce the incidence of low shoulders along the pavement edge. The purpose of this project is to evaluate the use of soil additives as stabilizers for aggregate and topsoil shoulders. The objectives of the study are to determine (1) the effect soil stabilizers have on the incidence of shoulder drop-off, and (2) the costs and benefits of using stabilizers versus paving the shoulder or maintaining the shoulder as originally composed.

METHODOLOGY

The approach taken to develop the framework to evaluate promising stabilization treatments was based on (1) development of an objective experimental design, (2) selection of a suitable in-service unpaved shoulder site for the trial, (3) selection of representative soil stabilization products, and (4) construction of a trial installation using deep mechanical manipulation to introduce stabilization products into the unpaved shoulder in accordance with vendor recommendations.

Experimental Design

This study uses test and control sections to evaluate the stabilization products and process. The test sections are 500 feet in length and run along one side of the road within a test site. A control section, consisting of similar material but without the stabilizers, is included as a nearby section. For comparison purposes, a paved section will be chosen that closely matches the test section attributes of shoulder width and pavement width, traffic, and percentage of trucks.

Site Selection

The sites for the test and control sections were required to have a history of low shoulders. In 2003, the Virginia Department of Transportation's (VDOT's) Asset Management Division evaluated more than 9,000 unpaved shoulder sites as part of a random condition assessment (RCA). Each sample site was 0.1 mile in length. The RCA rated the condition of the assets at each site. Many studies have shown that the effect of a pavement edge drop-off varies by traffic speed. The higher the speed, the greater the negative effect of the drop-off. Based on one of these studies, *Pavement Edge Drop* by P. L. Olsen in 1986, which was prepared in response to a mandate by the U.S. Congress, many state highway agencies now have a 1.5- to 2-inch edge height criterion for maintenance and allowable edge drops in construction zones. The RCA uses a 1.5-inch criterion for determining low shoulders.

The shoulder was more than or equal to 1.5 inches lower than the pavement in 22.6 percent of the unpaved shoulder samples. Although numerous RCA sample sites met this criterion, a site was chosen in VDOT's Richmond District to take advantage of an existing VDOT hired equipment contract for the Wirtgen Road Reclaimer. This equipment can meter liquids into in-place earth and road base materials as it scarifies and mixes the materials. More information on the machine and the procedure is provided under "Construction of Test and Control Sections."

The location chosen for study was on Route 522 near the intersection with Route 651 in Powhatan County. The roadway was recently reconstructed to create a left-turn lane at Route 651. The through traffic lanes are 10 feet wide, and the shoulders are a minimum of 6 feet wide. The type and volume of traffic at the site are provided in Table 1.

Table 1. Location and Traffic Information for the Study Site

From	To	Length	Average Annual Daily Traffic	4 Tires	Bus	Trucks			
						2 axle	3 axle	1 trailer	2 trailers
0.19 MS Rt. 651	0.01 MN Rt. 651	0.20 mile	6,000	94% of traffic	1% of traffic	1% of traffic	2% of traffic	3% of traffic	0% of traffic

Product Selection

The products used in the previously cited VTRC project to study stabilization techniques fell into three groups: acrylics, soybean/soy lecithin, and chloride salts. Acrylic and lecithin soil stabilizers are emulsions that bond with the soil or aggregate to make a barrier that is naturally biodegradable. The salts draw water from the air at higher humidity levels and keep the soil or aggregate at optimum moisture. To allow consideration of all three methods of stabilization for this project, a product from each group was chosen.

Preliminary data collected since the publication of the study report yielded preliminary results concerning the durability and strength of aggregate mixed with various stabilizer products. Visual assessment included subjective judgments regarding potholes, rutting, wash boarding, dust control, and loss of fines. These results were compared with data collected using the VDOT inertial road profiler and GeoGauge™ data, which measure structural layer stiffness. Based on the preliminary results, Soiltac, Centrophase AD, and magnesium chloride were chosen to represent the acrylic, lecithin, and salt groups in the current study. Because of problems arising during the installation of the test sections, described later, magnesium chloride was not used.

Construction of Test and Control Sections

Sequence of Work

Before the FDR process was conducted and the soil stabilizers were placed, shoulder preparation was required. The existing shoulders were grass covered. The stabilization process would have mixed the grass in with the soil and would not have allowed adequate compaction of the material. The grass was removed 10 to 14 days prior to the start of the reclaiming operation. The grass removal left the shoulders approximately 4 inches low at the pavement edge. The shoulders were brought back up to the elevation of the pavement using No. 26 stone and rolled. After this operation, the shoulders were firm adjacent to the edge of the pavement but softer nearer the ditch line. From that point, the general sequence of activities for stabilization was as follows:

1. At the designated staging area, the liquid stabilization product was diluted with water in accordance with the vendor's recommendations.

2. The stabilization additive was blended into one 3-foot-wide section of shoulder to a depth of 4 inches with the reclaimer. Segment A was stabilized with Soiltac (vinyl acetate copolymer emulsion) on September 14, 2004. The application rate was 0.74 gallon per square yard throughout the 4-inch depth. The Soiltac-to-water dilution ratio for stabilization was 1:1.5. Segment B was stabilized with Centrophase AD (soy/lecithin emulsion) on September 14, 2004. The application rate was 0.5 gallon per square yard throughout the 4-inch depth. The Centrophase-to-water dilution ratio for stabilization was 1:2.75.

3. The stabilized area was re-graded with a motor grader to provide proper drainage and shape to the shoulder.

4. The full width of the shoulder was compacted with a 13-ton vibratory roller compactor.

5. For the Centrophase AD section, an application of the same dilute emulsion was sprayed topically at a rate of 0.1 gallon per square yard in accordance with the vendor's recommendation.

Proposed Stabilization Method

Test sections were to be constructed using the procedure outlined in VTRC Report No. 04-R18. The procedure, used up to this time for roadbed reclaiming, deeply mixes stabilizers into the shoulder material by way of a process known as full-depth reclamation (FDR). FDR is a pavement rehabilitation technique in which the surface material and a predetermined portion of the underlying materials are uniformly crushed, pulverized, or blended as a form of in-place recycling. Additional stabilization of the shoulder material can be achieved by mixing additives into the process. Liquid stabilizers can be blended into the soil/aggregate material through the reclaimer's integrated additive injection system during manipulation. The FDR process was chosen for this project because of its relatively high production rate, the completeness with which the additives are mixed into the shoulder material, and the ability of the reclaimer to monitor the quantity of stabilizer added to the material. With this process, shoulder manipulation is accomplished with a Wirtgen WR 2500 Road Reclaimer and Soil Stabilizer, which incorporates a 690-horsepower, V-12, turbo-charged diesel engine to power a 96-inch-wide by 20-inch-deep cutting rotor.

Modified Stabilization Method Used

The procedure was modified to meet the special conditions of this study. Although the reclaimer normally mixes a 96-inch-wide track, the test sections were set at 3 feet wide. This required that the teeth on the rotor be removed from a 5-foot width, leaving only a 3-foot width for cutting. Normally, the teeth protect the rotor from damage by loosening the roadway material before the rotor comes in contact with the material. To protect the rotor from damage, the depth of cut for the remaining teeth was set at 4 inches. In addition, the direction of travel of the reclaimer was opposite to the direction of travel of the adjacent traffic lane. This allowed the operator to use the edge of the pavement as a guide for the operation and kept the rotor from making contact with the travel lane pavement.

Installation Problems

Although the pre-existing stone shoulders were compacted, the action of the reclaimer on the treated area and the introduction of stabilizer caused the material to flow away from the edge of the pavement. The passing of the work train (i.e., the truck, reclaimer, and roller) caused the reclaimed area to lose shape, requiring additional reworking of the area with the motor grader. Rolling the shoulder with the vibratory roller resulted in a low shoulder at the edge of the pavement. Additional material was pulled back to the edge of the pavement by the motor grader, adding untreated material into the mixture. This compromised the test material by changing the amount of stabilizer per cubic yard of shoulder material in the mixture. In the Centrophase AD section, clay material from the shoulder subgrade was mixed with the No. 26 aggregate, changing the shape of the mixed material.

After two test sections were installed, the problems of equipment size and weight and the needs to comply with strict mixing requirements and a specified elevation could not be resolved. Rather than continue with the construction of test sections that could not comply with the study specifications, the work was stopped and the placement of the additional test sections was cancelled.

Proposed Evaluation Tests

To evaluate the strength and durability of the shoulder material and to estimate the maintenance cycle of the test and control sections, the study plan called for data to be collected semi-monthly for each test section and the control section using the following equipment and methods:

- Dual-Mass Dynamic Cone Penetrometer (DCP);
- GeoGauge™; and
- Visual inspection using RCA rating guidelines.

There are no VDOT specifications or standards regarding this equipment or test methods, but they are easier to employ than standard compaction testing equipment and are comparable to standard compaction testing equipment results.

The DCP is a two-section rod, with the lower section containing an anvil, a replaceable pointed tip, and depth markings every millimeter. The upper section contains a drop hammer with a 575-millimeter drop distance, an end plug for connection to the lower section, and a top grab handle. The test begins with the operator “sealing” the cone tip by dropping the hammer until the widest part of the cone is just below the testing surface. This initial penetration is recorded as Blow 0. The operator then lifts and drops the hammer either one or more times depending on the strength of the soil at the test location. Following each sequence of hammer drops, a penetration reading is taken. This process continues until the desired depth of testing is reached. Data from a DCP test are processed to produce a penetration index (PI), which is simply the distance the cone penetrates with each drop of the hammer. The PI is expressed in terms of millimeters per blow. The PI can be plotted on a layer strength diagram or directly correlated with a number of common pavement design parameters.

The GeoGauge is used in lieu of making nuclear gauge measurements of density and water content. It applies a constant-load vibrating force to the soil's surface and measures the resulting soil displacement. It measures the stiffness or modulus of soil materials. Stiffness is defined as force over deflection of a soil. In this study the GeoGauge is used for comparative purposes only.

The RCA rating procedure is a visual inspection process that uses a pass-fail system. The procedure inspects five conditions for unpaved shoulders:

1. Elevation difference > 1.5 inches (high, low, both) by percentage of length (0, <25, 25-50, >50);

2. Shoulder reverse slope by percentage of length (0, <25, 25-50, >50);

3. Loose aggregate > 2 inches deep by percentage of length (0, <25, 25-50, >50);

4. Pavement corrugation > 1 inch by percentage of length (0, <25, 25-50, >50); and

5. Shoulder wedge, which is not applicable in this case.

DCP and GeoGauge™ data will be collected on approximately 50-foot centers along the length of the test and control sections. In each test section, a set of samples will be taken in the treated material, which is from 0 to 3 feet from the edge of pavement, and along a line approximately 6 feet from the edge of the pavement. In the control section, a set of samples will be taken in the material that is from 0 to 3 feet from the edge of the pavement. DCP, GeoGauge™, and visual inspection data will be collected in the test and control sections every 2 weeks until all the sections have deteriorated at least once. A comparison of the visual record and the GeoGauge™/DCP data is expected to indicate how quickly each section deteriorates.

ONGOING WORK

Although work to date has not determined whether soil stabilizers can work effectively on unpaved shoulders, it has established that alternate methods for applying stabilizers need to be investigated. The shoulder stabilization process requires equipment that can work in areas from 1 to 6 feet wide, yet can scarify and mix the material to a 4- to 6-inch depth. Equipment will be sought that meets these requirements, and additional test sections will be installed in the spring of 2005.

The existing experimental site will be monitored until the questions surrounding the condition of the site and the rigorous nature of the injection process can be resolved. Alternate means of injecting the stabilizer and processing the shoulder material will be investigated. In spring 2005, new test and control sections will be placed using alternate equipment and a modified process will be used as site monitoring and equipment investigation dictate. The results, conclusions, and recommendations of this additional study will be reported in late summer 2005.

APPENDIX

Acts of the General Assembly
2004 Special Session
HB5001/SB5001

Item 487.

Ground Transportation System Planning and Research (60200)	24,115,093	25,036,146
Ground Transportation System Planning (60201)	20,938,670	21,750,945
Ground Transportation System Research (60202)	3,176,423	3,285,201
Fund Sources: Commonwealth Transportation	24,115,093	25,036,146

Authority: Title 33.1, Code of Virginia.

A. Included in the amount for ground transportation system planning and research is $4,000,000 the first year and $4,000,000 the second year from the highway share of the Transportation Trust Fund for the planning and evaluation of options to address transportation needs. Such funds shall be used, but are not limited to, the completion of activities prior to the initiation of an individual project's design or to benefit identification of needs throughout the state or the prioritization of those needs. For federally eligible activities, the activity or item shall be included in the Commonwealth Transportation Board's annual update of the Six-Year Improvement program so that 1) appropriate federal funds may be allocated and reimbursed for the activities and 2) all requirements of the federal Statewide Transportation Improvement Program can be achieved. Such planning and evaluation may be conducted or managed by the Department of Transportation, Department of Rail and Public Transportation, or another qualified entity selected and/or approved by the Commonwealth Transportation Board.

B. Out of the amounts provided for Ground Transportation System Planning and Research, the Department of Transportation, through the Virginia Transportation Research Council, shall allocate such amounts as may be required to study the use of soil stabilizers in highway shoulders at one or more selected locations. In conducting its evaluation, the Council shall include a cost/benefit analysis, with the objective of finding a method of substantially reducing the occurrence of pavement/shoulder drop-off at a reasonable cost. Findings of the evaluation shall be reported to the Chairmen of the House Appropriations and Senate Finance Committees no later than January 1, 2005.

C. Out of the appropriation included for this item, $75,000 in the first year shall be provided to fund the costs of engineering services required to continue efforts to select appropriate traffic calming methods for the Hunter Mill Road area in Fairfax County. VDOT shall transfer such funds to the Northern Virginia Transportation Authority which shall be responsible for ensuring the conduct of the traffic calming study. The Northern Virginia Transportation Authority shall present the findings and recommendations of the engineering review to the Governor and the Chairmen of the Senate Finance and House Appropriations Committees by December 15, 2004.