Mn/DOT Research Proposal FY 2010
RESEARCH PROJECT PROPOSAL

Research Project Title: Subgrade Stabilization ME Properties Evaluation and Implementation

Unsolicited Proposal is in response to a previously submitted problem statement for FY 2009 (Problem Statement A09PS02) for which a research proposal was prepared but not funded

Principal Investigator Information

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Proposal Abstract:

The state and many counties throughout Minnesota are responsible for hundreds of miles of unimproved gravel highways, primarily located in rural regions. Although many of these roads are not subjected to high traffic volume, they may be subjected to substantial truck loads on a seasonal basis due to the agricultural and/or other needs in the area. Such roads often require substantial maintenance at regular intervals. While the costs of maintenance of such unimproved roads may be minimal compared to maintenance of bituminous highways, for example, such costs can still be significant in counties where many miles of such roads exist. This is especially true in counties with limited availability of good quality aggregate and other resources. Various counties have investigated and applied several subgrade stabilization techniques in an effort to increase the performance of these otherwise unimproved highways. This has been done in hopes of decreasing maintenance frequency and cost and extending the life of the road. Although these techniques are becoming more commonly used, minimal information has been obtained relating to the Mechanistic-Empirical properties of these improved materials such that the more cost-effective designs can be implemented. Not knowing the ME properties of the improved subgrade, the designer is forced to use values for the existing subgrade material. While this does lead to extended road life, costs could be greatly reduced by taking advantage of the improved properties of the stabilized subgrade material.

This project with involve working with the state and counties throughout Minnesota to determine which types of subgrade stabilization have been attempted (building on a related study by Gene Skok a few years ago), to evaluate how well each method appears to be working, and to pass this information along to each of the counties and the state for their consideration for future use. A significant portion of the project will be testing field and laboratory samples to quantify the ME properties of the subgrades for implementation by state and county agencies in future road design. For example, Blue Earth County in South Central Minnesota has used an emulsion-stabilization that has been quite successful in decreasing the maintenance of several highways as well as reducing the dust on these roads. As of yet the ME properties have not been determined, although apparent improvements in the life of the roads have been witnessed. Being able to share information on the ME values for various improvement methods and to share this and other successes (as well as failures) would be a great benefit to many of the counties that would like to incorporate such techniques but need confirmation that such a project would meet the needs locally.

Anticipated Duration of Project (in months): 30
Total Budget (direct and indirect costs): $44,369
Budget Details (direct and indirect costs):

Salaries:	
Faculty:	$36,650
Students:	$2,933
Travel:	$1,500
MSU indirect cost recovery:	$3,286

Research Objectives

Counties, Mn/DOT and other entities throughout Minnesota have used various materials and techniques in an attempt to improve subgrade properties for unimproved gravel roads, and in some cases pavements. Materials of note include shredded tires, fly ash, other byproducts, emulsion, lime, and additional items. An earlier study for Mn/DOT by Gene Skok presented various methods of subgrade stabilization in practice at the time. The main objectives of this research are to: 1) determine the various materials that have been used (or are currently being used) by local agencies, using the Skok study as a basis, 2) evaluate the usefulness of such materials in achieving the desired results, 3) determine the appropriate material properties of field and laboratory specimens such that these properties can be implemented for more cost-effective road design, 4) summarize the advantages and disadvantages of each material/technique and provide material properties for desired materials, and 5) provide this information to the state and counties to aid in making informed decisions and designs with respect to future projects. Failed efforts should be addressed to determine (if possible) the reason for the failure and to comment on whether adjustments could be made such that the method could be used successfully in other circumstances. Successful utilizations can certainly be shared such that other groups can benefit from the implementable technologies and ME properties.

Expected Benefits and Users of this Research

The key beneficiaries of this work will be the Minnesota Counties and other entities (including Mn/DOT) that are making an effort in stabilize subgrade materials for both unimproved and improved highways. Although the research will target methods used to improve gravel road subgrades, the methods will be applicable to pavement subgrades, as well. Developing design parameters based on the ME approach will aid in improving pavement and road designs, leading to significant cost savings. These groups would be able to apply the findings of this research by incorporating recommended stabilization techniques, which will decrease maintenance costs and increase the life of the unimproved roads, saving a substantial amount of money on both counts. By providing these stabilization techniques, the costs associated with many projects could be significantly decreased, providing benefits for a wider group within the counties and the department of transportation as well as the general public, whose tax dollars typically fund such projects.

Summary of Research Methodology

This project is intended to be a combination of a review of literature with respect to subgrade stabilization techniques as well as a study to determine the design properties of such improved materials (from both field and laboratory testing) in order to come up with useable design parameters for various stabilization materials and techniques. The literature review will relate to subgrade stabilization, specifically, literature sources that provide information regarding various materials and/or methods that are currently being used to facilitate subgrade stabilization. This will require numerous hours of literature review to provide and compile the appropriate references. Research hours will also be spent contacting Mn/DOT and Minnesota County Engineers and other entities to determine which techniques they may currently be using or may have used in the past, and to survey how effective (or ineffective) such techniques have been. Field samples and testing will be performed at appropriate locations and projects, and laboratory samples will also be tested, in order to determine ME properties of the subgrade materials. The PI would compile the list of materials and methods used, explain how effective such methods have been in serving their intended purpose, provide the material properties to be used in pavement and road design, and prepare the final report detailing such methods to be distributed to the parties interested in such information.

Tasks

Six tasks have been identified to provide the objectives stated above. Each task is explained in greater detail in this section, and the tentative schedule for the project is given in Figure 1.

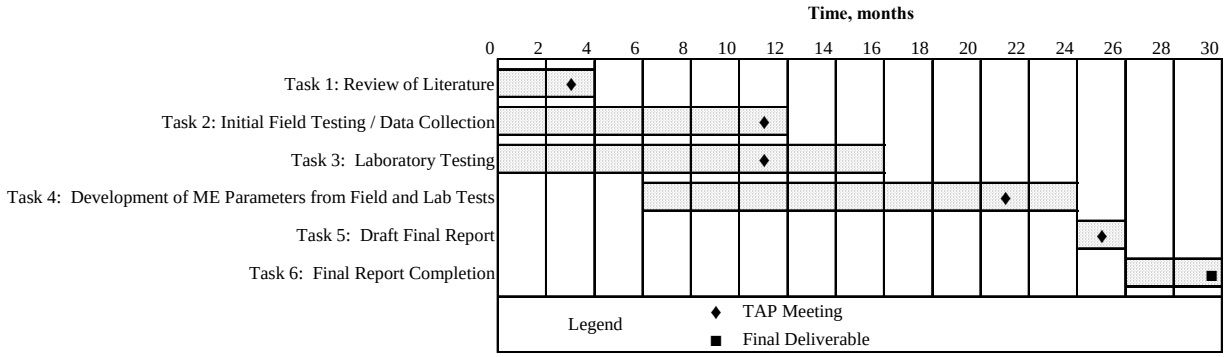

Figure 1. Tentative Project Schedule to Address Unsolicited Subgrade Stabilization Implementation Study

Task 1. Extensive Review of Literature Pertaining to Subgrade Stabilization Techniques
Deliverable: Summary report of a review of literature regarding subgrade stabilization
In this task, several of the objectives of this project will be fulfilled. A previous study by Gene Skok included a survey of various subgrade stabilization methods in use regionally at the time of the study. A thorough literature review will be performed to determine what techniques are being used in an effort to stabilize subgrade materials in road construction and maintenance applications. This will certainly build upon the Skok report, but may not provide a significant amount of additional information beyond that obtained earlier. A listing of the various methods and materials used will be obtained, with descriptions of where such methods have been utilized and how well they performed. The literature review will also be helpful in determining whether an additional survey of Minnesota County Engineers would be useful, or whether the results from Skok provide a sufficient list of materials/techniques for subgrade stabilization.

Task 2. Initial Field Testing and Data Collection
Deliverable: Summary report describing techniques implemented in Minnesota data obtained from each
In this task, field testing will be performed at numerous field sites/projects where subgrade stabilization is being used. Various field tests can be performed to determine the appropriate ME properties for both a) the original subgrade material and b) the stabilized subgrade material, as appropriate. Performing such tests for a variety of stabilization materials and methods and developing design parameters to be implemented at the design stage will be critical to the overall scope of this project.

Task 3. Laboratory Testing
Deliverable: Summary report describing laboratory tests performed and data obtained from each
In this task, laboratory testing will be performed on field samples and lab-prepared samples to determine the stiffness and additional design properties of each. These tests can be used to validate and complement the field testing parameters obtained in Task 2 such that appropriate parameters can be provided in Task 4.

Task 4. Development of ME Parameters from Field and Lab Tests
Deliverable: Summary report providing appropriate design parameters for various stabilization techniques
This task is the basis of the entire study – developing parameters for stabilized subgrades based on lab and field data such that these parameters can be implemented in pavement and road design. Recommendations will be made for design parameters based on the field and laboratory testing. A range of stabilization methods will be investigated in Tasks 2 and 3, and these tests will provide the recommended parameters for Task 4.

Task 5. Draft Final Report
Deliverable: Draft project report, including recommended stabilization techniques and associated ME parameters
This task includes the development and submittal of the draft final report. This report will be submitted first to the project's technical advisory panel for review and approval, and then through the Mn/DOT and/or LRRB publication process for technical and editorial review. The draft final report will follow Mn/DOT's publication guidelines.

Included in the report will be various stabilization methods currently used in Minnesota Counties, recommendations as to the techniques most beneficial for application by county agencies and perhaps Mn/DOT, the design parameters suggested based on the results of this study, and contact information for groups that can provide additional insights into the various methods.

Task 6. Final Report Completion

Deliverable: Final project report

This task includes the development and submittal of the draft final report. The project team will incorporate the technical and editorial review comments from the review process into the report, as appropriate. The report will then be submitted to the Mn/DOT for publication.

Abbreviated Resume

Aaron S. Budge, Ph.D.

EDUCATION

Utah State University	Civil Engineering	B.S., 1998
Utah State University	Civil and Environmental Engineering	M.S., 2000
Utah State University	Civil and Environmental Engineering	Ph.D., 2004

APPOINTMENTS

January 2005 - Present
Assistant Professor, Department of Mechanical and Civil Engineering
Minnesota State University
Mankato, Minnesota

August 2001 – May 2004
Instructor, Department of Civil and Environmental Engineering
Utah State University
Logan, Utah

SELECTED REPORTS AND CONFERENCE PUBLICATIONS

Bay, James A., L.R. Anderson, **A.S. Budge**, and C. Eurfur, *Analytical Modeling of MSE Wall at I-15 and 3600 South*, Research Report No. UT-04.10, Utah Department of Transportation Research and Development Division, Department of Civil and Environmental Engineering, Utah State University, July 2004.

Bay, James A., L.R. Anderson, J.C. Hagen, and **A.S. Budge**, *Factors Affecting Sample Disturbance in Bonneville Clays*, Research Report No. UT-03.14, Utah Department of Transportation Research and Development Division, Department of Civil and Environmental Engineering, Utah State University, May 2003.

Bay, James A., L.R. Anderson, T.M. Colocino, and **A.S. Budge**, *Evaluation of SHANSEP Parameters for Soft Bonneville Clays*, Research Report No. UT-03.13, Utah Department of Transportation Research and Development Division, Department of Civil and Environmental Engineering, Utah State University, May 2003.

Bay, James A., L.R. Anderson, **A.S. Budge**, and M.W. Goodsell, *Instrumentation and Installation Scheme of a Mechanically Stabilized Earth Wall on I-15 with Results of Wall and Foundation Behavior*, Research Report No. UT-03.11, Utah Department of Transportation Research and Development Division, Department of Civil and Environmental Engineering, Utah State University, May 2003.

Budge, Aaron S. and J.A. Bay, *Analysis of Large-span Culverts Subjected to Extreme Live Loads*, Proceedings of the 40th Symposium on Engineering Geology and Geotechnical Engineering, Logan, May 24-26, 2006.

Budge, Aaron S., J.A. Bay, and L.R. Anderson, *Calibrating Vertical Deformations in a Finite Element Model of an MSE Wall*, Proceedings of GeoCongress 2006, Atlanta, February 26 – March 1, 2006.

Budge, Aaron S., J.A. Bay, and L.R. Anderson, *Modeling Drainage Conditions During MSE Wall Construction*, Proceedings of the 54th Annual University of Minnesota Geotechnical Engineering Conference, Minneapolis, February 17, 2006.

Budge, Aaron S. and M.W. Goodsell, *Instrumentation and Behavior of a Mechanically Stabilized Earth Wall on I-15*, Proceedings of the 37th Symposium on Engineering Geology and Geotechnical Engineering, Boise, March 27-29, 2002.

Budge, Aaron S. and J.A. Caliendo, *Lateral Loading of Model Pile Groups*, Proceedings of the 36th Symposium on Engineering Geology and Geotechnical Engineering, Las Vegas, March 28-30, 2001.

Budge, Aaron S., J.E. Apedaile, and K. Jelinek, *Geophysical Measurements to Estimate Degree of Consolidation for Model Lateral Load Tests*, Proceedings of the 34th Symposium on Engineering Geology and Geotechnical Engineering, April 28-30, 1999.

Vandre, Bruce, **A. Budge**, and S. Nussbaum, *DCP – A Useful Tool for Characterizing Soil Properties at Shallow Depths*, Proceedings of the 34th Symposium on Engineering Geology and Geotechnical Engineering, April 28-30, 1999.