Title: MSE Wall & Reinforcement Testing at MUS-16 Bridge Site

State Job Number: 14735
PID Number: 76063
Research Agency: University of Akron
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Sponsor(s): Tony Vogel
Study Start Date: 4/3/2000
Study Completion Date: 10/29/2004
Study Duration: 55 months
Study Cost: $348,871.00
Study Funding Type: 80 Federal / 20 State

STATEMENT OF NEED:
MSE walls have become a desirable alternative to the conventional retaining walls due to the ease of construction, cost benefits, and readily available industrial support. Currently, there is no universally agreed approach to MSE walls analysis and design.

RESEARCH OBJECTIVES:
To confirm the design by proof testing the reinforcing elements, provide documentation, and develop correlations between the reinforcing effects and the movements of the soil. Monitor for an additional one year to gather time dependent variations of the wall behavior under service conditions.

RESEARCH TASKS:
- Develop and carry out an instrumentation plan and a monitoring plan for MSE walls at MUS-16-7.16 to assure the safety of the project and to provide the guidance for long-term maintenance.
- Carry out in-situ pullout tests to gain better understanding of the effects of boundary conditions on pullout behavior and the load transfer mechanism between the soil and the reinforcement.
- Monitor the behavior of the reinforced soil, the abutment pile foundation, and the load distribution between the pile and the reinforced soil.
- Monitor and gather time-dependent variations of the wall behavior under service conditions for an additional year.
- Develop a better understanding of the relationship between the MSE wall elements and the influencing factors (i.e., reinforcement tensile force, soil movement, and earth pressures) in terms of the internal and external failure mechanisms.
- Document the information and findings as a database for further studies on the MSE wall system.
- Interpret the collected data to evaluate the adequacy of the current design and analysis methods.
- Provide recommendations for future MSE wall design in order to improve the efficiency of the current design methods and to reduce the cost of MSE walls.

RESEARCH DELIVERABLES:
The Final Report containing a detailed summary of the collected data and the important findings from the instrumentation. It will also contain the comparison between current MSE wall design and the suggested design based on the results form the instrumentation. An Excel spreadsheet to calculate the reinforcement length by using the virtual soil wedge method is going to be a product of this research also.
RESEARCH RECOMMENDATIONS:
- Use the conventional segmental concrete facing elements due to higher stiffness and a more uniform vertical earth pressure distribution.
- Continue to require the use of driven piles behind MSE walls to support bridge abutments.
- FHWA design method yields conservative results for simple geometry walls, and yields erroneous results for more complex geometry walls such as sloping fill. An extra factor of safety is recommended.
- Pull out resistance of reinforcement straps are highly dependent on location; it is therefore recommended to use in-situ pull out tests to be conducted at various elevations of the MSE walls.
- More research is needed to investigate the interaction between a variety of MSE wall shapes and types with the reinforced soils.
- Further research is needed to better understand the Virtual Soil Wedge method recommended by Dr. Liang.

PROJECT PANEL COMMENTS:
Jawdat Siddiqi:
ODOT utilizes complex wall geometries frequently. It is important to realize that FHWA recommendations and AASHTO Standard Specification provide factors of safety for complex wall geometries less than what would be considered adequate in the transportation industry. The pullout testing implementation provided in the research recommendations can serve multiple purposes i.e. it can provide means of determining the pullout resistance as well as provide corrosion rate data that can be utilized in determining the expected life of the structure by testing the soil reinforcement after the pullout test has been conducted.

Omar Abu-Hajjar:
It is reassuring to know that the FHWA method yields conservative results for simple geometry walls, but engineers need to be extra careful using it in complex geometry walls. The Excel spreadsheet using the virtual soil wedge is a reliable and quick way to compare design results with the FHWA method.

IMPLEMENTATION STEPS & TIME FRAME:
- The report has already been distributed to the Vice Chair of AASHTO SCOBS Technical Committee T-15 for review and possible modification to the AASHTO Standard Specifications that deal with the design of MSE Walls. This will have a direct impact on ODOT designed projects as ODOT follows the AASHTO Standard Specification for the design of the MSE Walls. This action step is on idle until AASHTO approves and implements the revisions in the design specifications.
- Pullout testing would be implemented by ODOT as per the research recommendations and to gather data on corrosion losses. There is a need for ODOT to determine how fast reinforcing straps are corroding. MSE walls are currently designed for 100 years, any rehabilitation and maintenance work to be done on the MSE walls after initial construction will be very costly. Chemical make up of soils, winter salting, rainfall amounts, and traffic patterns may affect the durability and the interaction of soils with the reinforcing straps. A second research phase is necessary for this project. Phase II will focus the research on the environmental factors affecting the durability of the straps and the geotechnical sampling of the reinforced mass. The additional research will directly measure the pull out force; therefore, confirming design assumptions. ODOT will be selecting between 10 to 15 sites to cover a wide range of different MSE wall samples. This phase is to start within six months from the completion of original project, and it will last for five to six year of collecting data.
- ODOT will continue to utilize spread footing abutments directly supported on MSE Wall embankments and the driven pile supported abutments on MSE Walls, as appropriate.
The Virtual Soil Wedge Method will serve as a backup design verification method. This action step will be implemented once a spreadsheet is received from the researcher.

**EXPECTED BENEFITS:**
- AASHTO implementation of the research recommendations will result in safer MSE Wall structures.
- ODOT will have better understanding of the reinforcing straps durability by performing pullout testing.

**EXPECTED RISKS, OBSTACLES, & STRATEGIES TO OVERCOME THEM:**
- ODOT will pursue the modifications to the Standard Specification with the Technical Committee T-15. This process might take some time until AASHTO approves and implements the changes.
- The OSE is currently looking for funds to implement the pullout testing and with proper accounting techniques the funds can be allocated to perform such testing for every MSE wall project.

**OTHER ODOT OFFICES AFFECTED BY THE CHANGE:**
None

**PROGRESS REPORTING & TIME FRAME:**
- AASHTO committee will be slow to change the design specifications, so progress reporting will be on yearly basis.
- All other implementation steps will be monitored on quarterly basis.

**TECHNOLOGY TRANSFER METHODS TO BE USED:**
The method for technology transfer to be used is project deliverables such as a final report and an Excel spreadsheet.

**IMPLEMENTATION COST & SOURCE OF FUNDING:**
The process to implement the steps will be part of the office overhead. The new research phase will cost about $250,000.

Approved By: (attached additional sheets if necessary)

Office Administrator(s):
Signature: 
Office: OSE 
Date: 11/3/04

Signature: 
Office: 
Date: 

Division Deputy Director(s):
Signature: Tony J. 
Division: Hwy Ops 
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