Project Title

Use of Geogrid in Pavement Systems to Provide Longer Service Life and Reduced Maintenance

University

University of Utah

Principal Investigators

Evert Lawton
Professor
University of Utah
Phone: (801) 585-3947
Email: lawton@civil.utah.edu
ORCID: 0000-0002-8203-7389

Pedro Romero
Associate Professor
University of Utah
Phone: (801) 587-7725
Email: pedro.romero@utah.edu
ORCID: 0000-0002-9446-4556

Research Needs

The potential benefits of using geogrid to stabilize the base and subbase layers of pavement systems have been studied by numerous researchers (e.g., Al-Qadi et al. 2008, Haas et al. 1988, Huntington and Ksaibati 2000, Kwon and Tutumuler 2009, Qian et al. 2013, Tingle and Jersey 2009, White and Vennapusa 2017, Vennapusa et al. 2018) using both laboratory, large-scale, and field tests. Although the results of most studies have shown improvements in the performance of the pavement systems with the addition of geogrid reinforcement to the base and subbase layers, some research has indicated that increases in the modulus of the pavement system, as measured by the Falling Weight Deflectometer (FWD) test, were not obtained (e.g. Tingle and Jersey 2009, Norwood and Tingle 2014).

In 2010, the 3.0-mile section of roadway on Utah State Route (SR) 30 between Emery Utah and Muddy Creek (MP 13.0 to 15.8) was reconstructed using a geogrid-reinforced pavement system. This project was the first use of geogrid reinforcement to support a pavement system by the Utah Department of Transportation (UDOT) and was intended to demonstrate the effectiveness of geogrid in reducing the base, subbase, and asphalt thicknesses (and thereby reducing the cost), providing longer service life, and reducing the required long-term maintenance of the pavement system. With three coal-fired power plants located nearby, this section of roadway carries between 200 to 300 coal trucks per day in both directions. An 800-ft long test section of this roadway was constructed first consisting of four 200-ft long sections in which a different biaxial

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geogrid was used in each section. The purpose of this test section was to evaluate the effectiveness of each type of geogrid and compare the performance of the four types. While this test section has performed well to date, with no maintenance required, the pavement system for most of the rest of the roadway section has required significant multiple maintenance processes to keep the roadway functional. A recent site visit by the proposer identified 18 sections of the roadway, varying in length from 50 ft. to 150 ft., that had required significant maintenance over the eight years since it was built.

Due to the poor performance of this geogrid-reinforced roadway, UDOT has not used geogrid reinforcement in other state roadway pavement systems to date. Therefore, it is imperative that a forensic investigation of this roadway be performed to determine the cause of the poor performance of the pavement system, and to determine if the use of a geogrid-reinforced pavement system was a viable method in this case that should have resulted in better long-term performance.

Research Objectives

The primary research objectives for this project are as follows:

1. Forensically evaluate this roadway to determine why the test section has performed well but the rest of the section has performed miserably.
2. Evaluate the performance of each of the four geogrids used in the test section.
3. Determine if the geogrid added any benefit to the long-term performance of the pavement system on this roadway.
4. Develop methods to evaluate the use of geogrid-reinforced pavement systems on other projects.
5. Develop construction specifications for geogrid-reinforced pavement systems.

Research Methods

The primary research methods that will be used in this research project are as follows:

1. Perform field tests to determine the engineering properties of the pavement system and the underlying subgrade materials.
2. Obtain samples of materials from all components of the pavement systems at selected locations of the roadway.
3. Perform laboratory tests on the samples obtained from the roadway.
4. Perform large-scale controlled tests in a trench box on geogrid-reinforced pavement systems using four types of geogrid for the reinforcement. The pavement, base course, subbase, and subgrade materials for these tests will be as similar as possible to those used on the actual roadway.
5. Compare results from the field and large-scale tests with existing analysis and design methods to determine their accuracy and validity.
6. Propose improvements to existing analysis and design methods, or develop new ones, as appropriate based on the results of the research.

Expected Outcomes

Results from the large-scale trench box tests will be compared with methods of analysis and design for geogrid-reinforced pavement systems, which will provide important experimental feedback regarding the accuracy and validity of those methods. This feedback may result in either improvements to existing methods or the development of new methods the analysis and design. A design guide will be developed for geogrid-reinforced pavement systems that will be used by UDOT and neighboring state DOTs. In addition, specifications will be written for geogrid-reinforced pavement systems to ensure that these systems are properly constructed to provide longer service lives and reduced long-term maintenance costs.

Relevance to Strategic Goals

USDOT Strategic Goal: State of Good Repair

When properly designed, constructed, and maintained, geogrid-reinforced pavement systems help to improve the performance of roadway infrastructure to ensure that they function as designed within their useful lives at a reduced cost. Successful completion of the proposed research project will result in better methods of design and analysis, along with improved construction specifications, that will allow successful implementation of geogrid-reinforced pavement systems within the State of Utah and surrounding states. The final result will be better maintenance, reliability, and performance of one of the key components of our transportation infrastructure – our roadways.

Educational Benefits

Two graduate students from the Department of Civil & Environmental Engineering at the University of Utah will be funded to work on this project. In addition, it is expected that two undergraduate students will work on this project, with funding provided by the Office of Undergraduate Research Opportunities program at the University of Utah. The results from this project will be incorporated into several graduate level classes in the areas of materials and geotechnical engineering.

Technology Transfer

The results from this research will be presented at the annual UDOT Engineering Conference, the Annual Transportation Research Board Meeting, and a special seminar to be sponsored by UDOT in which UDOT engineers and engineers from other governmental agencies and commercial companies will be invited. Papers will also be published in relevant journals such as Transportation Research Record, Journal of Materials Engineering, and Transportation Geotechnics. Furthermore, a webinar will be arranged through the Mountain Plains Consortium.

Work Plan

A concise list of the major tasks/steps in this research project is as follows:

1. Forensically evaluate the roadway
2. Examine electronic evidence and interview people associated with the project
3. Review construction records and documents
4. Obtain and evaluate available distress data
5. Analyze results of annual Falling Weight Deflectometer tests

6. Perform other types of field tests
7. Obtain samples from the pavement system
8. Conduct appropriate laboratory tests on samples
9. Perform large-scale tests under controlled conditions
10. Evaluate all data and determine the likely reasons for erratic performance of the pavement system
11. Develop a design guide for geogrid-reinforced pavement systems
12. Develop construction specifications for geogrid-reinforced pavement systems
13. Prepare a final written report

Additional details on the major tasks and methods that will be used in this research project to achieve the stated objectives are provided below. The expected month of completion for each task is provided in parentheses at the end of the description.

1. Forensically evaluate the Geogrid Test Section along with the rest of the project limits. (Month 10)

2. Examine photographs and videos of the roadway throughout its life. Interview various people associated with the project (e.g. Construction Manager for the Project, UDOT Manager for the project, and Shed Foreman in charge of maintenance for the roadway) to determine their opinions as to why the test section has performed well while other sections have performed poorly. (Month 4)

3. Review construction records and documents to determine if there were any problems that developed during construction, or if there were any deviations from the construction plans and specifications, that may have contributed to the poor performance of major sections of the roadway. (Month 5)

4. Obtain and evaluate distress data from UDOT Program Development. (Month 6)

5. Take Falling Weight Deflectometer data that has been collected since the roadway was built in 2010, and back calculate the modulus values for each layer as a function of time. (Month 3)

6. Perform other types of field tests (Ground Penetrating Radar, Dynamic Cone Penetrometer, Cone Penetration Test, Plate Bearing Test) to evaluate the engineering properties of the pavement system and the subgrade soils at selected locations, as well as the depths to the groundwater table at these locations. (Month 3)

7. Obtain samples of the wearing surface (asphalt), the supporting soils (UTB, GB, and subgrade soils), and the four types of geogrid by coring, trenching, and boring. (Month 1)

8. Perform various laboratory tests on the samples collected in Task 7 to determine their engineering properties. Types of laboratory tests that will be conducted include soil classification (sieve, hydrometer, and Atterberg limits), wetting-induced volume change (collapse and swell), and resilient modulus. (Month 10)

9. Perform large-scale tests in the University of Utah's Geotechnical Trench Box to compare the performance of the four different geogrids under controlled testing conditions. Materials similar to those used on the actual project (asphalt, untreated base course, granular base, and subgrade soils) will be used for these tests. These tests will be conducted such that comparisons can be made between the geogrid-reinforced pavement system used in the actual project and the design pavement system without the geogrid, thereby allowing determination of the engineering benefit and the cost benefit of using geogrid within the pavement system. (Month 10)

10. Evaluate all the data and determine the likely reasons why some sections have performed well while others have not, which brands of geogrid have performed well enough to warrant use on other projects, and which methods of testing and evaluation are best suited to predict the performance of the geogrid-reinforced pavement systems. (Month 10)

11. Develop a design guide for geogrid-reinforced pavement systems that will be used by UDOT and neighboring state DOTs. (Month 12)

12. Write specifications for geogrid-reinforced pavement systems to ensure that these systems are properly constructed so that they will provide longer service lives and reduced long-term maintenance costs compared to unreinforced systems. (Month 12)

13. Prepare a written report on the research that includes all the data collected, analyses performed, conclusions reached regarding the performance of the different types of geogrid, and the likely reasons why some sections of the roadway have performed well while others have failed. (Month 12)

The anticipated timeline for each of the major tasks is shown in the table below:

Task No.	Months from Starting Date											
	1	2	3	4	5	6	7	8	9	10	11	12
1	■	■	■	■	■	■	■	■	■	■		
2			■	■								
3				■	■							
4					■	■						
5			■									
6	■	■	■									
7	■											
8		■	■	■	■	■	■	■	■	■		
9							■	■	■	■		
10										■		
11											■	■
12											■	■
13											■	■

Project Cost

Total Project Costs: $90,000
MPC Funds Requested: $40,000
Matching Funds: $50,000
Source of Matching Funds: Utah Department of Transportation

References

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