RESEARCH
PROJECT CAPSULE
October 2020
[20-3GT]
TECHNOLOGY TRANSFER PROGRAM

Development of a Design Methodology for Geosynthetic Reinforced Pavement using Finite Element Numerical Modeling

PROBLEM

Pavement structures are built to support loads induced by traffic vehicular loading and to distribute them safely to the underlying subgrade soil. A conventional flexible pavement structure consists of a surface asphalt layer (AC) and a base course layer of granular materials built on top of a subgrade layer. One of the common types of pavement failures (or distress) is the excessive surface rutting, especially when pavements built over weak and wet subgrade soils do not have enough strength to support construction/traffic loads. Due to the soft nature of Louisiana soils, in many cases, pavements must be built over soft subgrade soil, which is often associated with many design and construction difficulties. The design and construction of flexible pavements over weak and wet subgrades has always been a challenge for pavement engineers. The common practice in Louisiana is to stabilize/treat the upper part (~12 in.) of weak subgrade soil with cement or lime, depending on subgrade soil type, to create a working platform through improving the engineering strength/stiffness properties of the subgrade. This will help eliminate the problem and reduce the risks of excessive permanent deformations (rutting) by spreading tire pressure into a wider influence area and thus reducing the vertical pressure acting on top of the untreated subgrade layer. However, the difficulty of stabilizing/treating very weak subgrade soils with cement or lime in certain conditions and for highway widening and highway exit/entrance applications calls for an alternative solution. Geosynthetics can offer an environmentally friendly and potentially cost-effective alternative solution to this problem by reinforcing/stabilizing bases/subgrades of roads built over weak subgrade soil, especially in cases where it is difficult to use cement or lime. In this application, geosynthetics placed either on top of the subgrade or within the base course layer work with the soil and granular material to create a reinforced section through separation, confinement, stabilization and/or reinforcement functions.

OBJECTIVE

There are five main objectives of this research project. The first is to develop finite element models to simulate the performance of geosynthetic reinforced pavements of different traffic sections, built over subgrade soils of different strength conditions, with acceptable accuracy. The second objective is to calibrate and validate the finite element (FE) models using the results of the in-box laboratory cyclic plate load tests and the results of full-scale accelerated load tests on geosynthetic-reinforced test lane sections built at the ALF site. To achieve the third objective, the team will conduct an FE parametric study to evaluate and quantify the effect of different variables and parameters contributing to the benefits and improved performance of geosynthetic reinforced pavements for different traffic sections. A sensitivity analysis will also be conducted to examine the effect of reinforced properties for a range of pavement cross sections and varying traffic loads in Louisiana. The final objective will be to develop a design methodology for geosynthetic-reinforced pavements that in general falls within the context of mechanistic-empirical pavement design guideline (MEPDG) and is compatible with procedures developed under the NCHRP 1-37A Design Guide.

JUST THE FACTS:

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Duration:
36 months

End Date:
April 30, 2023

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POINTS OF INTEREST:

Problem Addressed / Objective of Research / Methodology Used / Implementation Potential

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METHODOLOGY

To achieve the objectives of this study, the following tasks will be completed. A thorough literature review will be conducted using published articles and reports related to the experimental, analytical, and numerical modeling of geosynthetic-reinforced pavements and methodologies. Next, finite element numerical models for geosynthetic-reinforced pavement sections will be developed. These models will then be verified and calibrated using the results of in-box laboratory cyclic plate load tests, and the results of accelerated load tests conducted on geosynthetic-reinforced sections built at the ALF site. Upon completion of this task, a finite element parametric study will be conducted followed by development of advanced regression models. These regression models will be used to quantify the geosynthetic reinforcement benefits as a function of design parameters. A design procedure for geosynthetic-reinforced pavements will then be developed, followed by development of design charts and tables for these pavements. A life-cycle cost benefit analysis will be conducted as well. Lastly, a final report will be prepared.

IMPLEMENTATION POTENTIAL

Recommended design methodology and procedure for geosynthetic reinforced/stabilized flexible pavements will be provided to DOTD, which will include guidance on how to incorporate the benefits of geosynthetic reinforcement in the design of flexible pavements within the context of the Mechanistic-Empirical Pavement Design Guide (MEPDG). In addition, design tables/charts will be provided for evaluating the equivalent resilient modulus for base layers (M_r), the extended service life of pavement in terms of traffic benefit ratio (TBR), the reduction in base course layer thickness in terms of base course reduction (BCR) factor, and modification of pavement rut models.