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Louisiana Transportation Research Center
4101 Gourrier Ave., Baton Rouge, LA 70808

Evaluating the Benefits of Geogrid Reinforced Bases in Flexible Pavement

Introduction

The inadequacy of many existing roads due to rapid growth in traffic volume provides a motivation for exploring alternatives to existing methods of constructing and rehabilitating roads. The use of geosynthetics to stabilize and reinforce paved and unpaved roadways offers one such alternative. Many studies were conducted to evaluate the improvements associated with geogrid reinforcement of pavements. It is widely believed that geogrid reinforcement of roadways can extend a pavement's service life and/or reduce the pavement's structural thickness.

Several design methods were proposed for flexible pavements with geogrid reinforced base layers. These methods were either based on empirical or analytical approaches. Empirical design methods are usually based on obtaining a performance level from a laboratory model test, which is then extrapolated to the field conditions for design application. The geogrid reinforced design methods based on analytical solution do not address all the variables that affect the performance of these pavements. This report is part of a research study on evaluating the benefits of geogrid reinforcement of base layer in flexible pavements. It presents the findings from laboratory triaxial tests and finite element analyses. Another report of this study will present the findings from large-scale cyclic plate load tests on ALF sections and sections built inside a test box.

Objective

The objectives of this research study are (1) to evaluate the behavior of geogrid reinforced base course aggregate layers and (2) to investigate the effects of different variables and parameters that significantly influence the performance/benefit of the geogrid reinforced base course layer in a flexible pavement's structure.

Scope

The stated objectives of this study were achieved through conducting both experimental testing and numerical modeling programs. The experimental testing program included conducting small-scale laboratory triaxial testing on geogrid reinforced base aggregate specimens. The testing program included monotonic compression triaxial, resilient modulus, and permanent deformation tests. The numerical modeling program included developing finite element models to evaluate the effect of geogrid location, thickness of the base course layer, stiffness of reinforcement material, and strength of the subgrade material on geogrid reinforced flexible pavements.

Methodology

An experimental testing program was conducted to evaluate the effects of different parameters on the performance of geogrid reinforced base course granular materials. Two types of crushed limestone materials (Kentucky limestone and Mexican limestone) and five types of biaxial geogrids (BX-6100, BX-1100, BX-6200, BX-1200, and BX-1500) were used. The parameters studied included the geogrid stiffness, geogrid location, number of geogrid layers, and the effect of stress and moisture content. Two types of triaxial tests were used in this study: static triaxial compression (STC) tests to evaluate the strength/stiffness of the reinforced specimens, and repeated loading triaxial (RLT) tests to evaluate the resilient and permanent deformations of the reinforced specimens.

LTRC Report 450

Principal Investigator:

Murad Abu-Farsakh, Ph.D., P.E.

LTRC Contact:

Zhongjie "Doc" Zhang, Ph.D., P.E.
Phone: (225) 767-9106

Louisiana Transportation Research Center

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4101 Gourrier Avenue
Baton Rouge, LA 70808-4443
www.ltrc.lsu.edu

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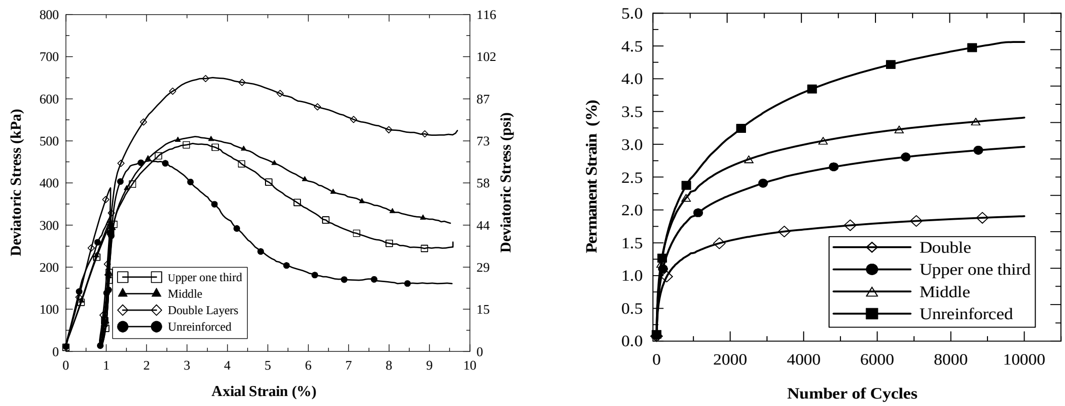

Figure 1
Stress-strain curves and permanent deformation curves for Mexican limestone specimens reinforced with BX-1100 geogrid

Finite element modeling was conducted on geogrid-reinforced base pavement sections to evaluate the effects of subgrade strength, base layer thickness, and the stiffness and location of the geogrid reinforcement layer on the structural performance of reinforced flexible pavement systems. Two types of crushed limestone materials (Kentucky limestone and Mexican limestone) and three types of biaxial geogrids (Type II, Type III, and Type IV) were used. The geogrid benefit in terms of increasing the service life of a pavement structure was evaluated using the traffic benefit ratio (TBR), and the improvement in fatigue life was evaluated using the ratio of the traffic repetitions to reach the specific fatigue for the reinforced section to that of the unreinforced section (N_R/N_U).

Conclusions

- The inclusion of geogrid reinforcement improved the ultimate shear strength and the elastic modulus of base course materials up to 250 percent and 200 percent, respectively.
- The inclusion of geogrid reinforcement significantly reduced the permanent deformation of base course materials down to 35 percent after 10,000 load cycles.
- The geogrid inclusion did not improve the resilient modulus of the geogrid reinforced specimens.
- The inclusion of geogrid reinforcement significantly reduces the vertical strains at the top of the subgrade down to 80%, reducing the lateral strains within the base course and subgrade layers down to 65 percent, and decreasing the shear strains at the top of the subgrade layer down to 70 percent.
- The geogrid benefits were more appreciable in sections with weak subgrades with resilient modulus M_r < 2000 psi as compared to medium and stiff subgrades.
- The geogrid reinforcement had modest to high values of improvement in fatigue life of the pavement structure by up to 180 percent.

Recommendations

- Consider reinforcing the base aggregate layer with geogrids for pavements built over weak subgrades with M_r < 2000 psi, especially where it is difficult to stabilize/treat the soft subgrade soil with lime or cement.
- Use geogrids with elastic tensile modulus at 2 percent strain, $E_{2\%} \geq 250$ lb/ft in flexible pavement design.
- Place the geogrid layer at the base-subgrade interface for pavements with a base thickness < 18 in. and at the middle of the base aggregate layer for base thicknesses ≥ 18 in.