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# Evaluation of the Base/Subgrade Soil under Repeated Loading: Phase II–In-Box and ALF Cyclic Plate Load Tests

## 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 layers in flexible pavements. It presents the findings from large-scale cyclic plate load tests on Accelerated Load Facility (ALF) sections and sections built inside a test box. Another report presented the findings from laboratory triaxial tests and finite element analyses.

## OBJECTIVE

The objectives of this research study were to (1) develop an indoor cyclic load testing facility; (2) conduct large-scale, in-box experimental testing to investigate the influence of subgrade strength and the reinforcement type and stiffness on the base reinforcement benefits; and (3) validate the results of the cyclic load actuator by comparing the pavement response under cyclic plate loading with that of rolling wheel loading on full-scale ALF test sections.

## SCOPE

The stated objectives of this study were achieved through conducting both experimental testing and numerical modeling programs. The experimental testing program included conducting large-scale in-box cyclic plate load testing on geogrid base reinforced pavement sections, full-scale cyclic plate load testing on several ALF test sections, and small-scale laboratory triaxial testing on geogrid reinforced base aggregate specimens. The numerical modeling program included developing finite element models to evaluate the effect of geogrid location, thickness of the base course layer, tensile modulus of geogrid reinforcement, and strength of the subgrade material on the benefits of geogrid reinforced flexible pavements.

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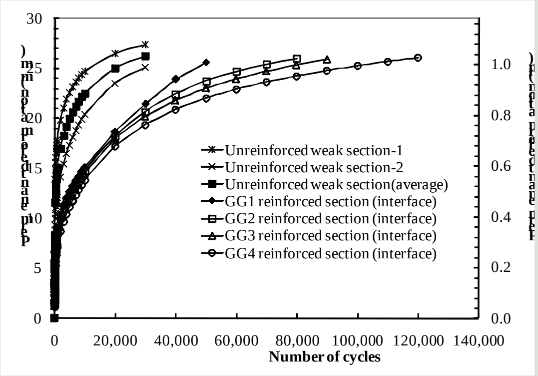
## METHODOLOGY

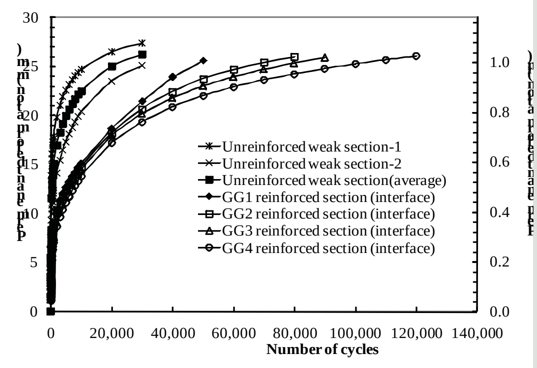
An indoor cyclic plate load testing facility was developed for the purpose of evaluating the performance of base and subgrade soil in flexible pavement sections under repeated loading test conditions. The testing facility was used to conduct an in-box, large-scale testing program to investigate the potential benefits of using geogrid stabilization and base reinforcement in flexible pavement. The geogrid benefit in terms of increasing the service life of a pavement structure was evaluated using the traffic benefit ratio (TBR).

The parameters studied included the tensile modulus of the geogrid, the aperture shape (geometry) of the geogrid, and the location of the geogrid. The experimental study also included the investigation of the stress distribution and permanent vertical strain in the subgrade, the pore water pressure development in the subgrade, and the strain distribution along the geogrid.

The cyclic plate load testing facility was also used to test full-scale test lane sections built at the Pavement Research Facility (PRF) site to evaluate the performance of pavement sections with different base/subbase materials. The pavement response from cyclic plate load tests was compared with the results of rolling wheel accelerated load testing.



*(a) Effect of geogrid types*



*(b) Effect of geogrid location*

*Figure 1. Development of surface permanent deformation*

## CONCLUSIONS

- The TBR can be increased up to 15 at a rut depth of 0.75 in. with the inclusion of the geogrid for pavement constructed using a 12-in. thick base course layer on top of weak subgrade soil with CBR ≤ 1%.
- Of the four geogrids tested in this study, the GG1 geogrid, with triangle aperture and the highest tensile modulus, performed consistently better than the other three geogrids. GG2 and GG3 geogrids, which have different geometry but similar tensile modulus, provided closer improvement with triangle geogrid GG3 and performed slightly better. Of the two geogrids with triangle aperture, the GG4 geogrid with higher tensile modulus performed better than the GG3 geogrid. Of the two geogrids with rectangle aperture, the GG2 geogrid with higher tensile modulus performed better than GG1 geogrid.
- Based on laboratory compaction techniques, better performance was observed when the geogrid layer was placed at the upper one third of the base aggregate layer than that when the geogrid was placed at the base-subgrade interface or at the middle of base layer.
- Better interlocking can be achieved by placing geogrid on top of a loose aggregate layer, sandwiching it by another layer of loose aggregate, and then compacting both layers together. A better geogrid-base interaction can also be achieved by applying a prime coat to the surface of the support soil layer before placing geogrid, which promotes bonding to the subsequent confined layer.
- The strength of the subgrade is very important in the performance of all pavement sections.

## RECOMMENDATIONS

- Consider reinforcing the base aggregate layer with geogrids for pavements built over weak subgrades with $M_r$ < 2000 psi, especially wherever it is difficult to stabilize/treat the soft subgrade soil with lime or cement and to create working platforms for constructing pavements and embankments.
- Use geogrids with an elastic tensile strength at 2% strain, $T_{2\%} \geq 250$ lb/ft, in flexible pavement design.
- For flexible pavements built on top of soft subgrades (or to create a working platform), place one layer of geogrid at the base-subgrade interface (stabilization layer) immediately above the non-woven geotextile (when required based on design) for a base course thickness of less than 18 in. For base thicknesses equal or greater than 18 in., two geogrid layers are recommended, one layer to be placed at base-subgrade interface and another at the geogrid layer within the upper one third of the base course layer.