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Mechanically reinforced granular shoulders on soft subgrade: Laboratory and full scale studies

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A B S T R A C T

A recently completed field study in Iowa showed that many granular shoulders overlie clayey subgrade layer with California Bearing Ratio (CBR) value of 10 or less. When subjected to repeated traffic loads, some of these sections develop considerable rutting. Due to costly recurring maintenance and safety concerns, the authors evaluated the use of biaxial geogrids in stabilizing a severely rutted 310 m tests section supported on soft subgrade soils. Monitoring the test section for about one year, demonstrated the application of geogrid as a relatively simple method for improving the shoulder performance. The field test was supplemented with a laboratory testing program, where cyclic loading was used to study the performance of nine granular shoulder models. Each laboratory model simulated a granular shoulder supported on soft subgrade with geogrid reinforcement at the interface between both layers. Based on the research findings, a design chart correlating rut depth and number of load cycles to subgrade CBR was developed. The chart was verified by field and laboratory measurements and used to optimize the granular shoulder design parameters and better predict the performance of granular shoulders.

1. Introduction

Shoulder rutting performance problems are common in areas where the granular shoulder material is supported by weak subgrade. With repeated traffic loads, bearing capacity failure in the subgrade occurs leading to progressive rutting. In addition to being hazardous to drivers, severely rutted shoulders are expensive to maintain. Ruts are commonly maintained by shoulder blading and as necessary adding granular material. These maintenance practices, however, are considered temporary solutions as they neither address the problem nor prevent it from reoccurring.

The performance of 25 granular shoulder sections in Iowa was recently evaluated using various in situ tests with the objective improving shoulder performance while keeping ownership costs low (Mekkawy et al., 2010). At about 40% of the inspected sections, the subgrade layer had a California Bearing Ratio (CBR) of 10 or less. As a result, bearing capacity failure of the subgrade as well as lateral displacement of the granular and subgrade materials with repeated traffic loads were frequently observed. Based on the findings of the field study and on a pilot study basis, a granular shoulder test section overlying a soft subgrade was constructed and monitored. The test section involved three sections with different geogrids at the interface between the subgrade and the granular layer. Monitoring the test section for a period of about one year demonstrated the success of geogrid stabilization in eliminating rutting. To supplement the field study, a laboratory box model was designed to evaluate several stabilized models, which were subjected to cyclic loading with three incremental loading stages. The soil properties and displacement before and after each test were recorded and compared. The laboratory box model comprised of a loading frame, reaction beam, hydraulic actuator, and a steel box to contain the soil. The overall scope of the field and laboratory experimentations, which is the focus of this paper, was:

- Evaluate the use of geogrid reinforcement to eliminate rutting.
- Compare and contrast, through laboratory testing, selected geogrid stabilizers.
- Develop simple designs tools, which will result in more stable shoulder sections and better prediction of performance in terms of rut depth and number of loading cycles.

To help design stable granular shoulders, a design chart was developed from the semi-empirical method proposed by Giroud

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