Joint Transportation Research Program

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Use of Geosynthetics on Subgrade and on Low and Variable Fill Foundations

Introduction

During construction there are significant problems establishing an adequate foundation for fills and/or subgrade for pavements when the natural ground has low-bearing soils. The improvement of the foundation for the fill and subgrade is usually a costly and time-consuming process that may require the replacement of the natural soil and/or the placement of clean granular materials to create a working platform. Geosynthetics such as geogrids, geotextiles, and/or geocells along with granular soils could provide an alternative less costly alternative, in time and money, to establish an adequate foundation for the fill and/or subgrade. Geosynthetics may be used in pavements to reduce pavement thickness or increase the life of the pavement. Geosynthetics may also be used in fill foundations to decrease differential settlements at the top of fills placed on foundations with weak soil areas.

The objective of this study is to advance the knowledge on the use of geosynthetics as reinforcement elements and provide recommendations for their use in embankment foundations and in pavements so that they are properly and effectively used by INDOT.

The objectives have been accomplished through the following tasks: (1) an extensive literature review; (2) a review of best practices by INDOT and neighboring DOTs; and (3) a numerical analyses for the assessment of the potential benefits of geogrid base reinforcement in selected pavement designs and geogrid-reinforcement at the base of an embankment constructed over a localized weak foundation zone.

Findings

- The majority of the DOTs reviewed consider using geosynthetics, such as geotextiles and geogrids, for subgrade separation and stabilization. In general, the geotextile requirements are based on *AASHTO M 288 Specification for Geotextiles* (AASHTO, 2017). Only a few DOTs (3 out of 11) consider using geosynthetics as reinforcement in pavements. The benefits of using geosynthetics as foundation improvement for embankments over soft soils have been identified by many of the DOTs reviewed.
- Geosynthetics, such as geogrids, can provide base reinforcement when they are placed within or at the bottom of unbound aggregate layers in a flexible pavement. Previous studies on base reinforcement have shown that the benefit of geogrid-reinforcement to reduce pavements' permanent deformation is more significant for weaker subgrades (CBR < 3), thinner base course layers (< 200 mm (or 8 in.)), or pavements with higher tensile modulus geogrids. In this study, analyses of pavement designs using Pavement ME—while considering geogrid-enhanced base or subgrade resilient modulus values—showed that geogrid-reinforcement did not produce significant benefits when placed at the interface between subgrade and base, since only a modest increase in pavement life was predicted. Parametric finite element analyses, to investigate the potential benefits of placing a geogrid at the base of a fill over a localized weak foundation zone, showed that (1) the benefits of geogrid-reinforcement decreases when the modulus of the weak zone increases; (2) the use of geogrids is beneficial when the stiffness of the weak zone is at least 5 to 10 times smaller than the foundation soil; (3) the use of geogrids as a deformation-controlling method is justified only when the size of the weak zone is large relative to the embankment foundation width (i.e., weak zone width > 0.3 times embankment base width); (4) the addition of a second geogrid layer decreases differential deformations of

the fill surface by up to a factor of 2; (5) the higher the value of the geogrid tensile modulus, the larger the benefit of the geogrid reinforcement; (6) the decrease in differential settlements at the surface of the fill, because of geogrid-reinforcement, is less than 20%; and (7) it is unlikely that the sole use of geogrids is sufficient to mitigate differential settlements.

- Geocells are three-dimensional geosynthetics that are filled with different types of materials and thus can be used as a strengthening mechanism. Geocell mattresses can be used as base course reinforcement over weak subgrades in unpaved and paved roads and as basal reinforcement for embankments constructed over weak foundations. The inclusion of a geocell-reinforced base could lead to a 50% reduction of the granular layer thickness in unpaved roads and to a 25% reduction in paved roads. There are consistent reports in the technical literature that show that a geocell mattress, when used at the base of an embankment, is effective in reducing differential settlements and in increasing the bearing capacity of the soft foundation.

Implementation

The following recommendations are based on the conclusions obtained from this study. They are divided into two categories: pavement and fill foundation.

Pavement. (1) There is extensive evidence in the literature and in DOTs practices about the suitability of using geotextiles in pavements as separators. The practice is endorsed and should be done following the *AASHTO M 288-17: Standard Specification for Geosynthetic Specification for Highway Applications* (AASHTO, 2017). (2) There is evidence of using geogrids in flexible pavements as a reinforcing mechanism to decrease the thickness of the base layer and/or increase the life of the pavement. The analyses conducted in this report support the previous notion but show that the benefits are marginal. Given the increased cost of placing a geogrid inside the pavement structure, such practice is not recommended. (3) There is no benefit in using geogrids in PCC pavements because of their high stiffness. (4) There is evidence that geogrids can be used to increase the bearing capacity and short-term deformations of the subgrade. However, in Indiana, the common practice is to treat chemically weak subgrades. While geogrids could be used instead of the chemical treatment, this practice is not recommended due to the lack of experience and expertise in Indiana. If geogrids are considered for this purpose, an implementation research project is recommended, which would establish a test site to evaluate short- and long-term performance of the pavement, as well as construction best practices, to decide type of geogrid and installation.

Fill foundation. (1) Geotextiles are recommended as separators between the soil foundation and the fill. (2) Geogrids at the foundation of an embankment over a limited, weak, wet area are recommended only when: (a) the stiffness of the weak foundation soil is about an order of magnitude smaller than the rest of the foundation soil; and (b) the horizontal extent of the weak foundation soil is at least 30% of the base of the embankment foundation. (3) Current procedures for replacing the weak soil under the embankment with a better material or treating the weak soil chemically are endorsed for all situations. Geogrids may always be used in addition to those procedures. (4) Geocell mattresses have the potential to effectively bridge the foundation of the embankment over a weak area. Given the limited experience in Indiana in the use of geocells, an implementation research project is recommended by building a test fill and monitoring it over time to assess performance.

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