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ScienceDirect

Procedia Engineering 189 (2017) 411 – 416

Procedia Engineering

www.elsevier.com/locate/procedia

Transportation Geotechnics and Geoecology, TGG 2017, 17-19 May 2017, Saint Petersburg, Russia

Finite Element Analysis of Flexible Pavement with Geogrids

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Abstract

Geogrids is being increasingly used as a reinforced material in various divisions of civil engineering. The flexible pavement is the one of major area, where the needs of improvement in performance of pavement service life, base course and subgrade. The finite element method is a best suitable tool for solving problems related to nonlinear nature of materials. The objective of this article to access the functioning of geogrids in flexible pavement through finite element analysis with PLAXIS 2D software. The Mohr-coulomb model used for materials in the base layer,sub-base layer and subgrade layer and elastic model interface element used for geogrids to simulate the interaction condition. The triangular element of 15-noded is used for layers of pavements. The traffic intensity and thickness of each layer was use according to codal provisions of Indian road congress (IRC: 37-2012). In the present study, axis-symmetric model is used in the PLAXIS 2D for investigating the effect of axial stiffness of geogrids in the pavement at different thickness of base layer. The finite element analysis results shows the reduction in vertical surface deformation when the geogrids were added between the pavement layers. Results of previously published research shows the improvement in pavement performance when geogrids used as a reinforcement.

Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology

Keywords: Finite element method; geogrids; Pavement; Stiffness; Deformation.

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Peer-review under responsibility of the scientific committee of the International conference on Transportation Geotechnics and Geoecology
doi:10.1016/j.proeng.2017.05.065

1. Introduction

A flexible pavement is a load bearing structure, consisting of layers of different granular materials above the earth. The primary function of flexible pavement is to make a safe riding base without any discomfort for the passenger and vehicles due to excessive deformation of pavement structures. The durability of flexible pavement is depending on the various parameters such as layers thickness, quality of pavement materials and environment conditions. However, it is observed the using of empirical equations and approach in the design methods for estimation of design thickness of pavement does not show to be economical. Modelling of flexible pavement is based on elastic multilayer structure and the computation of stresses and strains at the critical location using a linear layered elastic model. Finite element method is a solution tool for modelling and analyzing of various types of structures. This technique provides a methodology to solve the complex problems related to the pavement structures. The main benefits of the finite element method are its suitability and flexibility for analysis of the different boundary conditions and different materials properties. Many numerical studies have done on the geogrid-reinforced pavement to assess the stresses and deformation. Several researchers have done studies the effect of geogrid-reinforced pavement over the structural performance of roads through laboratory, field, and finite element methods. Barkarsdale et al. [1] studied on the potential benefits of geosynthetics on flexible pavements with finite element analysis. The result shows that the more stiffness of reinforcement improved the bearing capacity ratio of pavement. ABAQUS, a finite element program was used to modelling and validation of the flexible pavement [2]. Elasto plastic Drucker-Prager model suggested for simulating the granular base layer [3].Reduction in rut depth due to reinforcement action of geogrid was achieved with finite element program [4]. The finite element method provides a good prediction of results for three layers materials in pavement section subjected to different loading conditions [5]. A finite element model prepared to identify strain behaviour for flexible pavement reinforced with geosynthetics where reinforcement was used in aggregate layer [6]. Two-dimensional finite element studies under plain strain conditions to analyzing the effect of geogrid stiffness and thickness of asphalt layer in reinforced pavement sections [7]. Mohr-Coulomb material model used for finite element analysis for granular materials at low-stress levels [8].To examine the advantages of geogrid reinforcements in layers of pavement were analyzed by FE model [9]. Geogrid of higher tensile stiffness and having more value of interface friction coefficient provides better performance as a result of a reduction in stress and deformation on the subgrade with the used of ABAQUS [10]. Analyzed the improvement in pavement section using geogrid with consideration of different parameters like axial stiffness of geogrids and base course thickness [11]. Finite element simulation studies for flexible pavement according to Indian road congress (IRC: 37-2012) and compare the cost-effectiveness of copper slag –fly ash- dolime mix to the water-bound macadam layer [12]. Finite element analysis using ANSYS software by applying linear isotropic elastoplastic hardening model and evaluate the performance of different types of sub-base material on the life of pavement [13]. Axisymmetric two-dimensional finite element simulation used for analyzing the main parameters at different thickness of pavement materials [14].Several researchers recommended that geosynthetics using at the interface of base course and sub-base course while other researchers found geosynthetics should be placed between base course and subgrade of the pavement section. In this study, a finite element modeling of pavement section with geogrid is carrying out using PLAXIS 2D software and searching the effect of the interface friction between the geogrid and different material of pavement layers.

2. Materials and methods

2.1 Finite element analysis

A two-dimensional non-linear finite element tool was used to modeling a typical pavement section with assumptions of plain strain conditions. PlAXIS 2D is a finite element tool specially made for stability and deformation analysis for problems of geotechnical structures such as earth retaining structures, foundations, the stability of slopes, pavement structures, and underground structures. A model of pavement section contains surface layer (Asphalt concrete), base layer (copper slag), sub-base layer (sand) and subgrade layer (black cotton soil). The flexible pavement modeled as a multilayer structure subjected to static loading according to IRC: 37-2012[15].The pavement model is using PLAXIS