EFFECT OF AXIAL STIFFNESS OF GEOGRID IN THE FLEXIBLE PAVEMENT DEFORMATION THROUGH FINITE ELEMENT ANALYSIS WITH PLAXIS 2D

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Abstract : The technique of using geosynthetics is widely used in the pavement construction. Many laboratory tests have been conducted to study the behaviour of soil reinforced with different types of geosynthetics and while constructing roads on a weak subgrade geogrids can be used as a reinforcement which will improve the performance of these roads by reducing permanent deformation. This study illustrates the functioning of geogrids having different axial stiffness values in flexible pavement through finite element analysis with PLAXIS 2D software. Geogrid is widely used material as a reinforcement in various flexible as well as rigid pavements.The flexible pavement is one of the major area, where the improvement in performance of pavement service life is very much needed. Material models such as Mohr-coulomb and linear elastic are employed in the analysis to describe the behavior of the materials. The triangular element of 15-noded is used for layers of pavements. The vehicle loading and thickness of each layer was used as per IRC 37-2012. In the present study, axissymmetric model is used in the PLAXIS 2D for investigating the effect of axial stiffness of geogrids in the reduction of vertical deformation when placed at the interface if sub base and base course. Dicrease in vertical deformation observed with increase in axial stiffness of the geogrid. The results showed maximum reduction in vertical surface deformation in geogrid reinforced pavement when the stiffness of geogrid is 800kN/m.

Key Words: Finite element analysis;, Stiffness; Geogrid;Deformation.

1. INTRODUCTION

Depending on the composition, pavement is classified as either flexible or rigid or composite. Flexible pavement consists of layers of different granular materials. Majority of roads in India are constructed of flexible pavements. It is a load bearing structure which transfers the load stresses from a grain to grain contact and make a smooth riding surface without causing discomfort for the passengers. In this paper attempt has been made to study the effect of geogrids when used below the surfeace course. In the available literature [2] it is reported that geogrids are good as reinforcement for improving engineering performance. The life of flexible pavement is depending on the various parameters such as layers thickness, quality of pavement materials used, repetition of wheel loads considered in the design, camber provided, and environment conditions. Many researchers studied the effect of geogrid reinforcemnt in improving the structural perfomrance of the flexible pavements. Anand.B.Tapse, M.S. Ranadive [1] studied the performance evaluation of flexible pavements using finite element method and analyzed the main parameters of geogrids at different depths. Role of geogrid in reducing the rut depth was studied [3]. Strain behaviour of geosynthetic reinforced flexible pavement was studied using finite element model [4]. A finite element response model has been developed and stress strain response parameters for geosynthetic reinforced flexible pavement explained using it [5]. Bakarsdale et.al [6] studied geosynthetic reinforced flexible pavement with finite element analysis and highlighted the benefits of geosynthetics, authors evaluated the potential structural and economic advantages of gesynthetic reinforcement within a granular base of a surfaced flexible pavements and beneficial effects of aggregate base reinforcements are investigated in this study using FEM model. Abdhesh K. Sinha, Satish Chandra, Praveen Kumar [7] have done finite element analysis using ANSYS software using different sub base materials. M.D.Nazzal, et.al [8] analysed the effect of geogrid stiffness and base course thickness in improving the pavement section. T.Shahu, Patel, S. Patel and A.Senapati [9] studied engineering properties of copper slag-fly ash-dolime mix using finite element simulation method and compared the effectiveness of the above materials in water bound macadam layer. Effect of geogrid stiffness and interface friction on the deformation and stress was studied using ABAQUS [10]. Finite element analysis was done for granular materials at low stress level using Mohr-Coulomb material model [11].E.M Ibrahim et al. Studied the effect of geogrid reinforcement on flexible pavements and cocnluded that geogrids are effective in reducing tensile stresses in flexible pavements and it was also found that the geogrid reinforcement should be placed directly underneath AC layer to reduce tensile strains [14]. Geogrids are very good in improving shear strength properties when used as a reinforcement with construction and demolition materials [15]. Moayedi et al studied the effect of geosynthetic reinforcement in reducing vertical displacement when placed at the bottom of the AC layer [17]. Mccartney JS et al studied the response of geogrid reinforced flexible pavements to static surface loading [16]. Authors concluded that Poisson's ratio of the base course layer was found to be a useful parameter to account for he effect of geosynthetic reinforcement on the base lateral confinement [16].

2. APPLICATIONS OF GEOSYNTHETICS

The major benefit of using geogrid in the flexible pavement is less rutting and minimal lateral displacement of the granular material. Geogrid will make the layer more stiffer and reduces the deflection due to repeated wheel loads. Geosynthetics are classified into geotextiles, Geogrids, Geonets, Geostrips, Geomembranes etc. geosynthetics are one of the widely used materials in flexible pavement now a days as a reinforcement due to un availability of good quality materials. Geosynthetics are composed of polymers and are designed to solve many geotechnical and pavement related problems. Geosynthetic reinforcement are very effective to carry the shear stresses developed due to vehicular loads. Geogrids will resist the aggregate movement in the pavement under repeated wheel load and it will also distribute the load effectively. Due to the additional adhesive shear resistance load carrying capacity will is more in geogrid reinforced pavements [12] The geogrids quickly react to applied wheel loads with an increase in the elastic modulus. Addition of geogrids will increase the strength by improving the CBR of soil [2]. Reflective cracking in the pavements can be prevented by using geosynthetic materials and lateral drainage will also be improved [13] A figure representing a geogrid is shown below

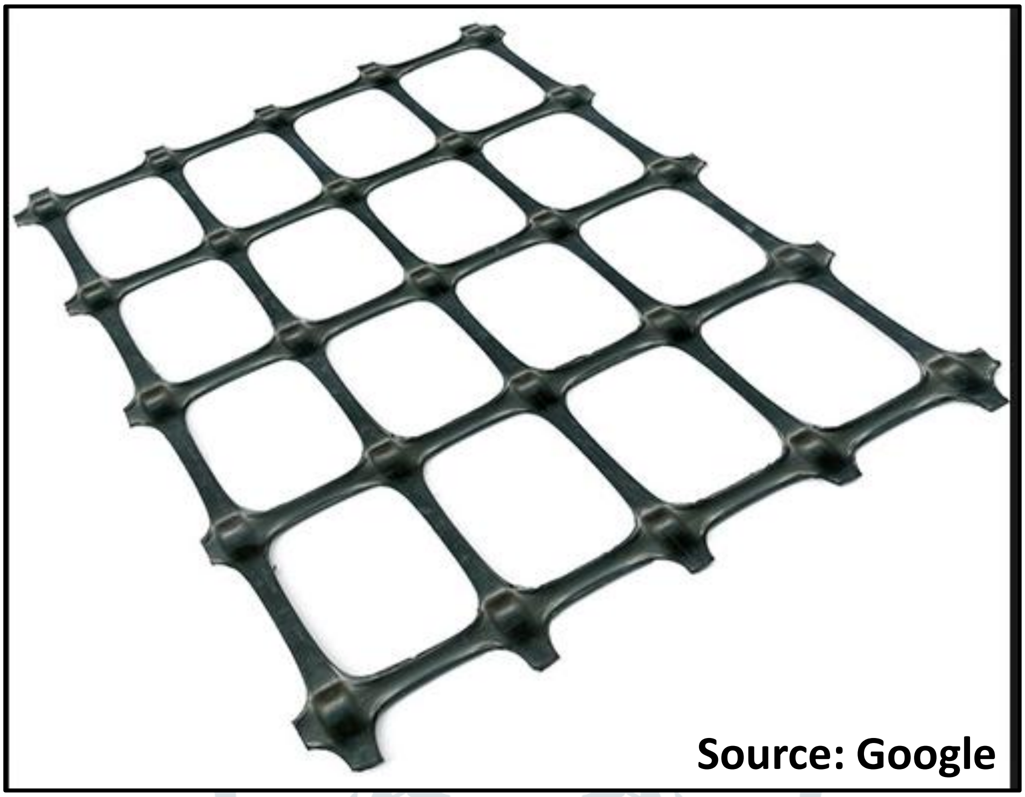

Figure 1. Geogrid

3. MATERIALS AND METHODS

Flexible pavement section containing 4 layers, surface layer (asphalt concrete), base layer, sub base layer (sand), subgrade (clay) used in the two dimensional finite element analysis. The pavement section has been subjected to static loading as per IRC:37-2012. The thickness of the pavement layers is selected according to current practice and as per provisions given in IRC:37-2012. PLAXIS 2D finite element software is used to analyze the effect of different axial stiffness of the geogrid on vertical diformation. The total thickness of the pavement used for modelling is 1150mm, which contains 500mm subgrade, 300mm subbase, 250mm base, and 100mm surface layer. Geogrid layer is placed at the interface of sub base and base course. A 575kPa loading was applied on the single lane carriage way. In this study 15 noded triangular element is used to model the pavement section. To minimize the influence of the stress distribution, boundary conditions were chosen. Dual wheel load of 575kPa was applied on the carriage way. Analysis was done with and without geogrid. Geogrids of different stiffness values are used in the analysis to study their effect on the pavement section. Pavement material priperties and types of models used in the analysis are given in the Table 1.

Table 1. Pavement Material Properties

Material	Surface Course (Asphalt Concrete)	Base Course (Crushed Aggregates)	Subbase	Subgrade
Type of model	Linear Elastic	Mohr-Coulomb	Mohr-Coulomb	Mohr-Coulomb
Thickness (mm)	100	250	300	500
Dry unit weight (kN/m3)	23	22	15	14
Saturated unit weight (kN/m3)	-	24	16	16.2
Cohesion (kN/m2)	-	1	1	1200
Angle of internal friction	-	42	40	5
Elastic modulus (MPa)	1000	20	43	10
Poisson's ratio	0.35	0.35	0.35	0.35

Table 2. Mechanical Properties of Geogrid

Type of material	Material model	Axial stiffness
Geogrid	Linear Elastic	200-800 kN/m

4. DISCUSSIONS ON OUTPUT FROM PLAXIS AND CONCLUSIONS

In the present study, finite element analysis has been done to study the effect of axial stiffness of the geogrid in reducing vertical deformation. Analysis using PLAXIS 2D showed increase in axial stiffness of the geogrid will reduce the vertical deformation, as shown in the figures below.

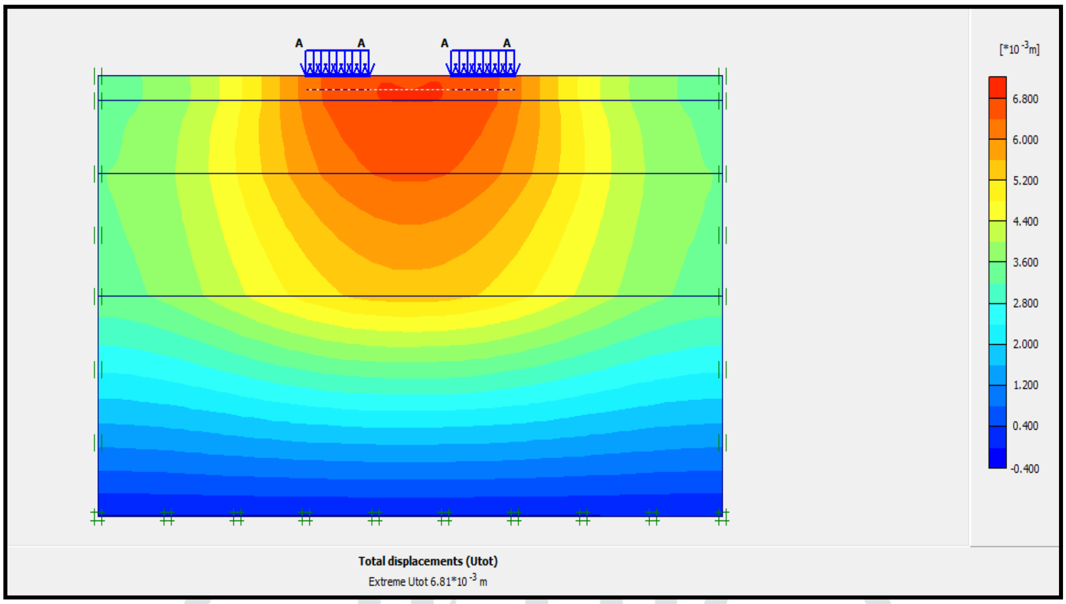

Figure 2. Total displacements for unreinforced pavement

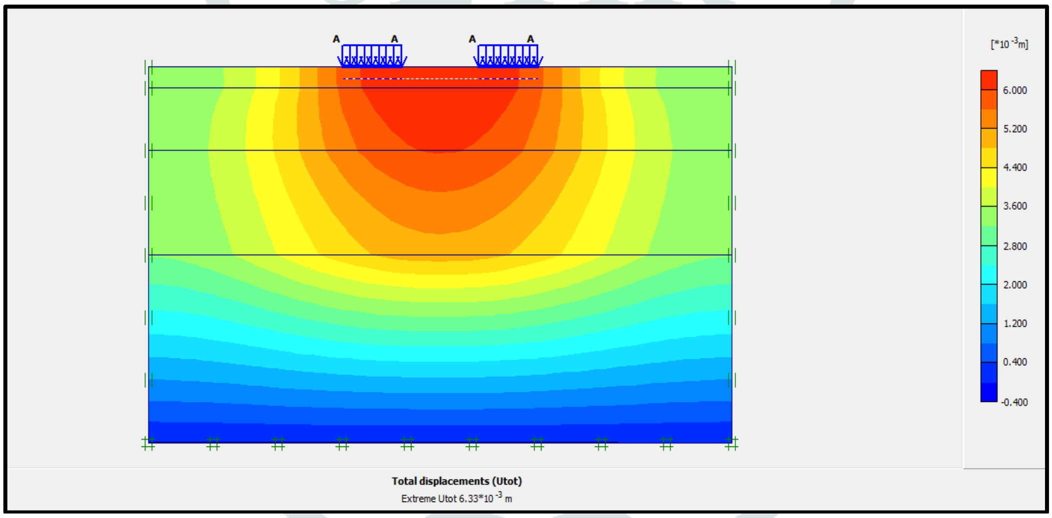

Figure 3. Geogrid reinforced pavement with axial stiff ness of 200 kN/m

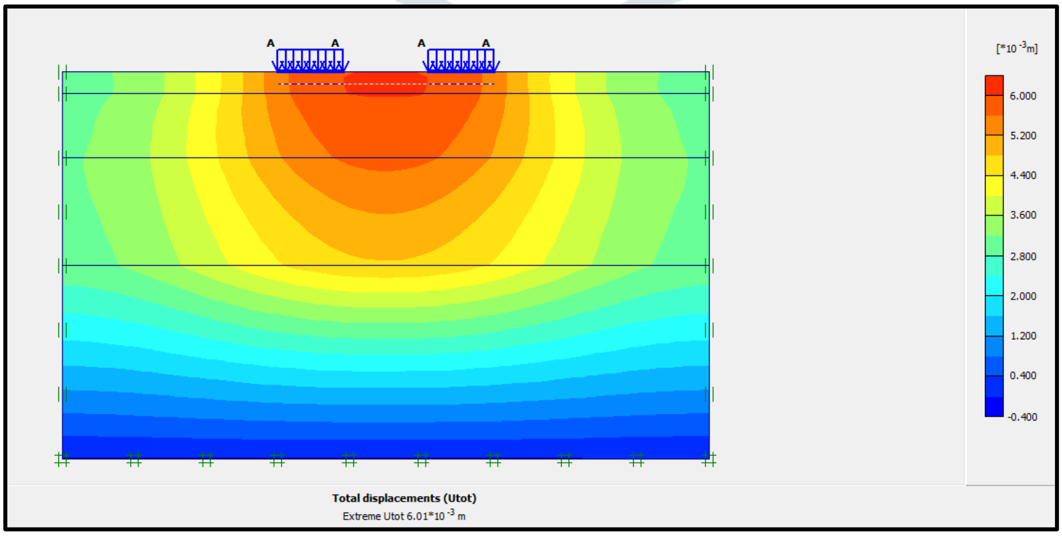

Figure 4. Geogrid reinforced pavement with axial stiffness of 500 kN/m

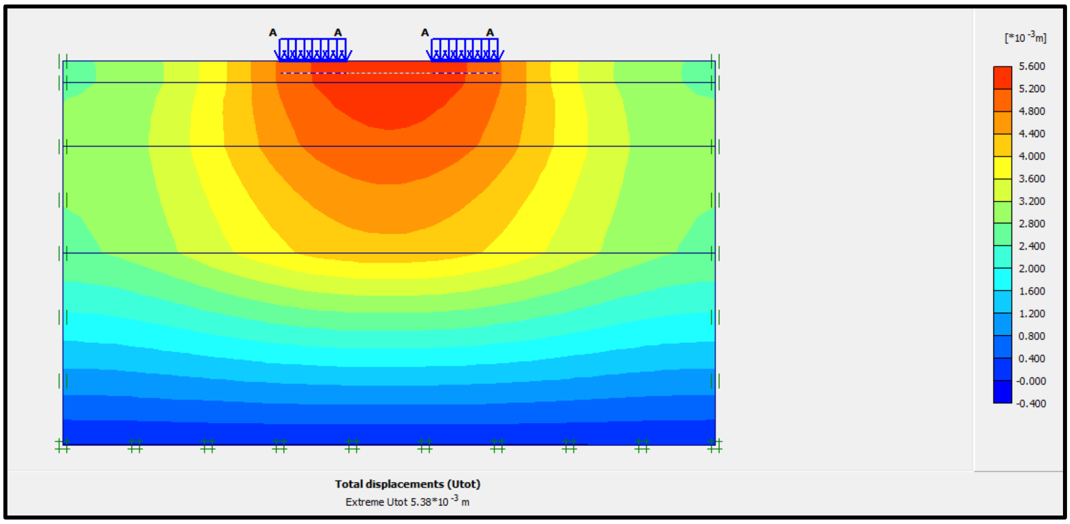

Figure 5. Geogrid reinforced pavement with axial stiff ness of 800 kN/m

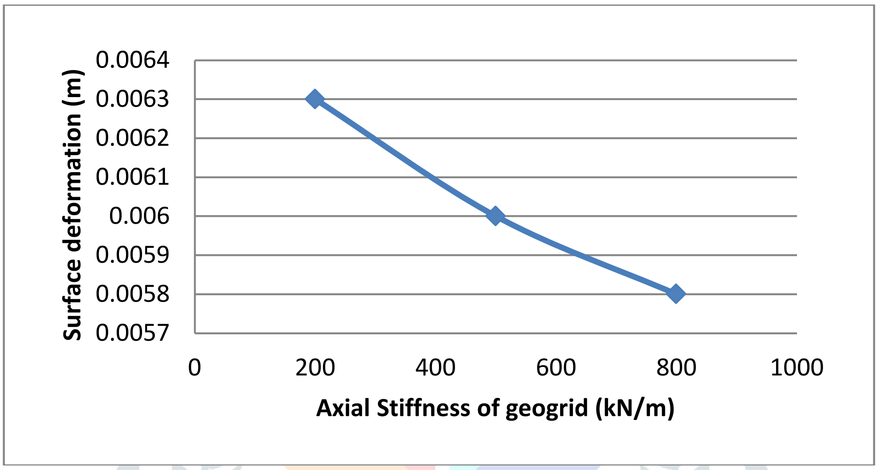

Figure 6. Variation in surface deformation with respect to axial stiffness og geogrid

Finite element analysis results showed that for the same loading conditions, geogrids are very beneficial when used between wearing course and base course . Surface deformations in the pavement section with respect to different axial stiffness is shown in the figure 5. Axial stiffness of the geogrid is varried between 200 kN/m to 800 kN/m. Following conclusions can be drawn from the analysis done using PLAXIS 2D.

1. Reduction in the vertical deformation is observed with increase in stiffness of geogrid from 200 kN/m to 800 kN/m.
2. Vertical deformation of geogrid reinforced pavement under dual wheel load is less compared to unreinforced pavement.
3. Maximum reduction in vertical deformation of 0.00143m is observed when th stiffness value of geogrid is 800 kN/m henece geogrid with this value found effective when used as a reinforcement in pavements.

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