NUMERICAL MODELLING OF GEOGRID REINFORCED UNPAVED FLEXIBLE PAVEMENT

by
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Dedicated

To

Maa Bhadrakali

CERTIFICATE

This is to certify that the thesis entitled "NUMERICAL MODELLING OF GEOGRID REINFORCED UNPAVED FLEXIBLE PAVEMENT" being submitted by Mr, Praveen Aggarwal to the Indian Institute of Technology, Delhi is a record of bonafide research work carried out by him under my supervision and guidance. The thesis work, in our opinion, has reached the standard, fulfilling the requirements for DOCTOR OF PHILOSOPHY degree. The research report and the results presented in this thesis have not been submitted, in part or full, to any other University or Institute, for the award of any degree or diploma.

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(Praveen Aggarwal)

ABSTRACT

Unpaved roads with low volume of traffic are often constructed for construction and access roads; contractors haul roads and forest roads etc. Over a period of time geosynthetics have come out as common construction material. Now geosynthetics are used in the construction of embankments, foundations, retaining walls and pavements. It is observed that geosynthetics in the pavement layer oiler resistance to pavement deformation and improves the load spreading quality of pavement layer in addition to its application such as drainage, filtration and separation etc.

In India water bound macadam is being used as subbase/base course in roads and sometimes also as wearing course because of costly bituminous material and stage construction strategy.

Numerical modelling is a well established technique to study the behaviour of any system. It reduces the efforts and money to study the behaviour of any system as compared to full scale experimental studies, Very limited studies have been made to study the pavement behaviour by numerical modelling.

In the present study, a comprehensive testing program has been devised to study the stress-strain-volume change behaviour of various constituting materials of geogrid reinforced unpaved flexible pavement. Constituting materials Yamuna sand (subgrade) and WBM (base/wearing course) were tested under triaxial testing at three confining pressures of 50 kPa, 100 kPa and 200 kPa. From the triaxial test results material parameters required *as* per HISS constitutive model are calculated. Triaxial tests were also performed on unreinforced composite material (100 mm diameter by 100 mm long

Yamuna sand specimen overlain by 100 mm diameter by 100 mm long WBM specimen) and geogrid reinforced composite material (100 mm diameter by 100 mm long Yamuna sand specimen overlain by 100 mm diameter by 100 mm long WBM specimen with a layer of 100 mm diameter of geogrid at the center level in Yamuna sand) at three confining pressures of 50 kPa, 100 kPa and 200 kPa to verify the constitutive model used for Yamuna sand and WBM. In reinforced composite material reinforcing material geogrid was placed at the center level in the subgrade because mode of failure in unreinforced composite • material was by bulging in Yamuna sand portion (visual observations). All the triaxial tests were performed on saturated, 100 mm diameter by 200 mm long specimens.

Wide width tensile strength tests in machine direction and cross machine direction were performed to calculate the material parameters of reinforcing material as per von-Mises yield criterion.

Pullout tests were also performed on geogrid embedded in Yamuna sand at three normal pressures of 25 kPa, 50 kPa and 100 kPa to calculate the material parameters of interface elements as per HISS constitutive model.

Once the material parameters of Yamuna sand, WBM, geogrid and interface element is obtained, models used were verified by comparing the predicted stress-strain volume change behaviour of unreinforced and reinforced composite materials with the experimentally obtained results using finite element technique. Both the predicted and experimentally obtained results are close to each other, hence verify the models used.

Pavement model tests were performed on 700 mm wide x 700 mm long x 600 mm deep model pavement. A loading plate of 100 mm diameter was used for application of under monotonic and cyclic loading. Pavement model consist of 500 mm thick subgrade (Yamuna sand) and 100 mm compacted thickness of WBM. In geogrid reinforced pavement model, a 700 mm x 700 mm layer of the geogrid was placed horizontally at 50 mm below the top surface of the subgrade and at 150 mm below the finished surface of the model pavement.

From monotonic test results load-deformation behaviour was obtained and 60% of the peak load i.e. 2000 N of load was used for cyclic loading tests in both unreinforced and reinforced pavement model tests.

From the cyclic loading tests, variations of total and permanent deformation with number of cycles (up to 10000 cycles) were obtained,

Experimentally obtained behaviour of unreinforced and geogrid reinforced model pavement under monotonic loading were compared with the predicted behaviour (obtained by using the material parameters of constituting materials) using FEM technique. Predicted results mutches closely in the initial portion in both unreinforced and reinforced pavement models, but after about 2000 N of plate load predicted results start deviating from the observed results, The reason understood *is* the strain softening stale developed in some of the elements in model pavements at this high load, and as the constituting materials are modelled up to strain hardening state only, deviation in observed and predicted behaviour start taking place,

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