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PARAMETRIC STUDY ON GEOGRID – REINFORCED FLEXIBLE PAVEMENT

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ABSTRACT

Due to the rapid increase in the growth of traffic, there is frequent occurrence of various damages in the pavement. To rectify the damage in the pavement many improvement methods are adopted using chemicals, admixtures, industrial waste, etc. Even though it cannot fulfil the strength requirement of the pavement for traffic flow. In view of this for the past four decades, the attempts were made to use geosynthetics in the pavement. In this line, the attempt is made to investigate the effect of reinforcement in the flexible pavements. The models are made with and without reinforcement and their performances are perceived by analysis made using finite element programme PLAXIS 8.2. The analysis of pavements involves the parametric study of displacement, effective stress and effective strain. Results of unreinforced and reinforced pavement obtained and are compared. From the comparisons, it is observed that the strength of the geosynthetic reinforced pavement is prominently higher than the unreinforced pavement (nearly 11 times). This technique helps to analyze the pavement on weaker soil with geosynthetics.

Keywords: Flexible pavement, Stabilization, Geogrids, Finite element program.

I.INTRODUCTION

Due to rapid increase in population and urbanization, the need of automobiles is increased which includes the heavy vehicles. Due to several reasons, the pavement laid on too weak soil and thus it does not support the development. To sustain the growth, it is mandatory to have a high performing pavement. Even though there are various efforts taken to improve the soil using various techniques and admixtures it did not meet the growth of automobile industry demand. Hence for the past four decades researchers are using geosynthetics as a reinforcement material in the pavement construction. The tensile force acting on the pavement due to the vehicle can be handled using geosynthetics reinforcement.

Many scientific enquiries have been carried out using geosynthetics as a reinforcement material. Binqueet and Lee (1975) has modelled a tank and ate-mpted geosynthetics reinforcement and Das (1994) has also performed geosynthetics reinforced soil to improve the bearing capacity ratio of the soil. Many analytical studies were also carried out on geosynthetics reinforced soil in various finite element programme. Sadok Benmebarek et al., (2013) studied the bearing capacity improvement of an unpaved road with geogrid as reinforcement. Hence in this study the objective is formulated and analyzed to study the characteristics of material used in the pavement configurations, analyze the behaviour of reinforcement over the pavement under various loading conditions and also to study the effect of location of geosynthetics in reinforced pavement with the material test results obtained from the laboratory.

II. MATERIALS AND PROPERTIES

The materials used for the study is collected, tested and their physical properties were determined. The subgrade material used in the study is lateritic soil and collected from available soil near SRM University. The sub base material used is collected from the quarry available near Chennai and the size of the sub base material is less than 40 mm. The base course selected for the study is water bound macadam course with the size less than 20 mm.

Various tests were carried out to determine the properties of soil and aggregates. The tests done for the subgrade material are free swell, standard Proc-tor compaction test, CBR, Atterberg limits and specific gravity as per IS 2720. To study the aggregate properties different tests are carried out in the laboratory and the results obtained are 32.05 (aggregate impact test), 18.78 (aggregate crushing test) and 11 (aggregate abrasion test). The test results of the subgrade, sub base and base course material are shown in Table 1.

Table I: Laboratory Test results of subgrade material

Soil properties	Values
Bulk density	20 kN / m^3
Void ratio	0.497
Porosity	0.988
Max dry density	1.79 g / cc
Max wet density	2.542 g / cc
Clay content	53%
Sand content	47%
Specific gravity	2.68
Liquid limit	64.5%
Plastic limit	24.89%
Plasticity index	39.61%
Optimum moisture content	12%
CBR Value	2.66%

III.EXPERIMENTAL INVESTIGATION

The pavement is modelled with size 1.8 m width and 1.2 m depth in the PLAXIS 8.2. The four different layers of pavement materials are fly-ash of depth 210 mm and the subgrade material is filled for about 500 mm. The sub base course of 240 mm and the base course of 250 mm. The thickness of each layer is formulated based on the CBR value obtained as per IRC. A steel plate of 300 mm diameter, EA of 38399 kN/m^2 is used for the transfer of load. The model pavement used for the analysis is shown in the Figure 1. The proper-ties of the materials used in the study are given in the Table 2.

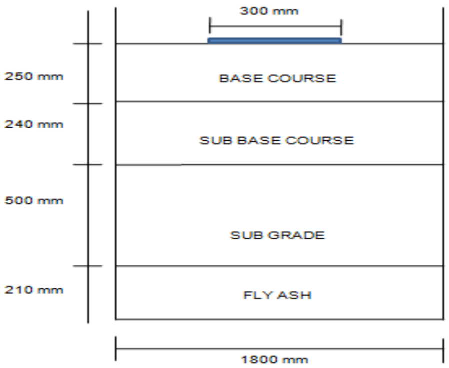


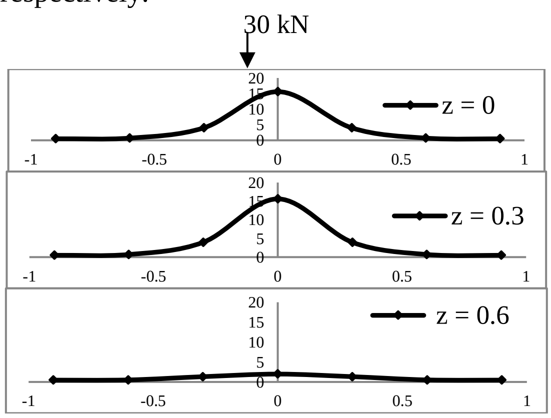
Fig.1. Pavement configuration

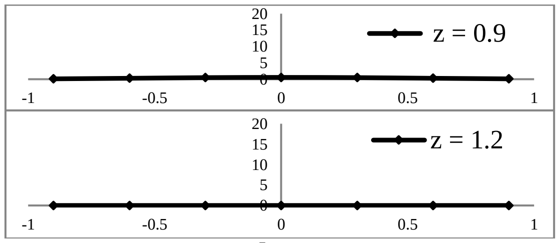
Table II: Properties of Material

Parameters	Flyash	Subgrade	Base course
γ_{dry}, kN/m^3	15.27	17.9	20
γ_{sat}, kN/m^3	16.04	21.05	21
E, kN/m^2	1747	2000	42500
ν	0.33	0.3	0.2
C, kN/m^2	32	100	1
φ, Degree	31.62	34	43
Ψ, Degree	1.62	2.65	13

IV. RESULTS AND DISCUSSIONS

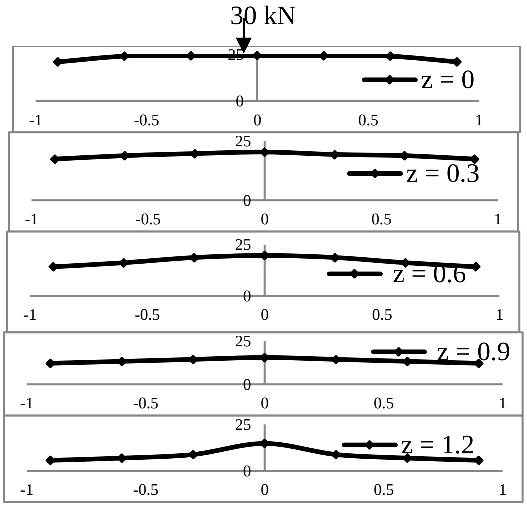
For the unreinforced pavement model, the load of 30 kN is applied as a maximum capacity to the analysis, beyond which the soil started to fail. The displacement, stress and strain of the pavement are analyzed and calculated for every 0.3 m in both horizontal and vertical directions. The total displa-cement of the pavement observed is shown in figure 2. The effective vertical stress and strain of the unreinforced pavement is shown in figure 3 and 4 respectively.





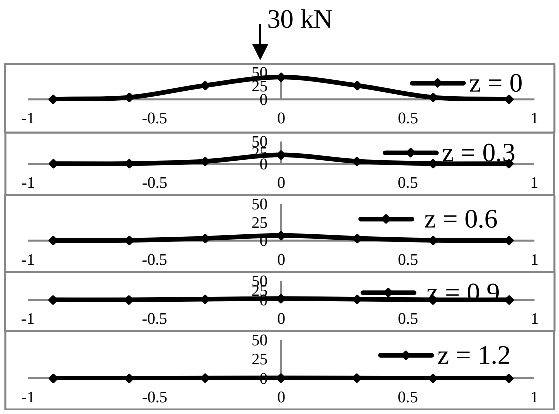
Y dir -Displacement x 10^{-5} (m), X dir–Distance (m)

Fig.2. Variation of Displacement on unreinforced pavement model under the load of 30 kN.



Y- dir – stress (kN/m^2), X dir – Distance (m)

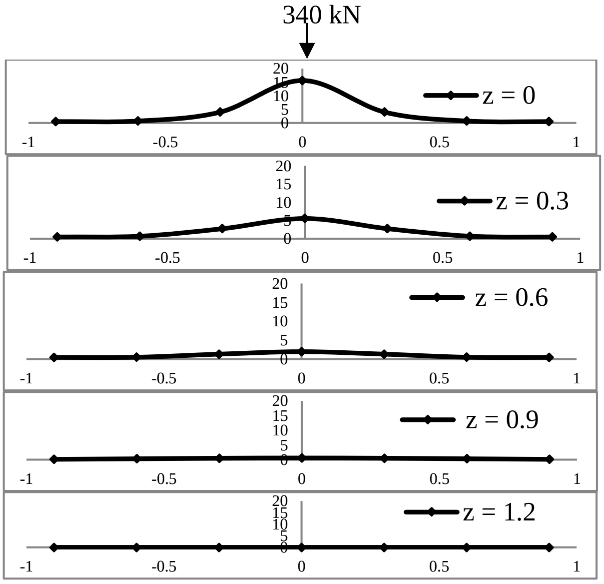
Fig. 3: Variation of effective stress on unreinforced pavement model under the load of 30 kN.



Y- dir – Strain x 10^{-3}, X -dir – Distance (m)

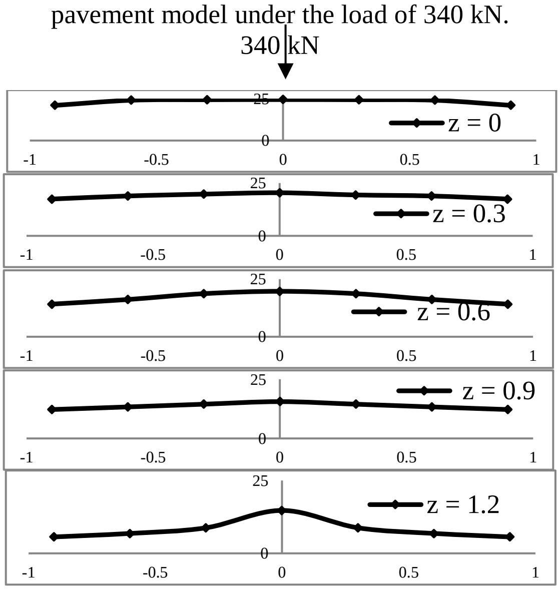
Fig.4. Variation of effective strain on unreinforced pavement model under the load of 30 kN.

Similarly, the analysis is carried out on the pave-ment reinforced with geogrid at the interface of the subgrade and sub base course. In this model, the load is increased until it reaches the displace-ment obtained in the unreinforced pavement condition and it is 340 kN. For this load the displacement, stress and strain are observed and are shown in figure 5, 6 and 7 respectively.



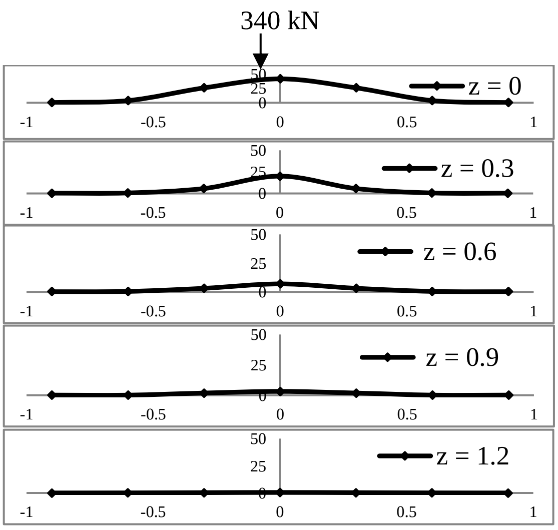
Y-dir - Displacement x 10^{-5} m, X dir - Distance (m)

Fig.5. Variation of displacement on unreinforced pavement model under the load of 340 kN.



Y- dir – stress kN/m^2, X dir – Distance m

Fig.6. Variation of effective stress on unreinforced pavement model under the load of 340 kN.



Y- dir – Strain, X dir – Distance (m)

Fig.7. Variation of effective strain on unreinforced pavement model under the load of 340 kN.

V.COMPARISON ON PARAMETRIC STUDY RESULTS

The displacement, stress and strain values of unreinforced pavement model at 30 kN and reinforced pavement model at 340 kN are found to be same and it is depicted in table 3. From the comparisons of unreinforced and reinforced pavement, it is observed that the improvement in strength characteristics of reinforced pavement is nearly 11 times more than the unreinforced pavement.

Table III: Comparison on parameters of unreinforced and reinforced pavement

Parameters	Unreinforced pavement (30 kN)	Reinforced pavement (340 kN)
Displacement	15.61 x 10^{-5} m	15.29 x 10^{-5} m
Max. effective vertical stress	43.79 kN/ m^2	43.36 kN/ m^2
Max. effective vertical strain	86.87 x 10^{-3}	86.63 x 10^{-3}

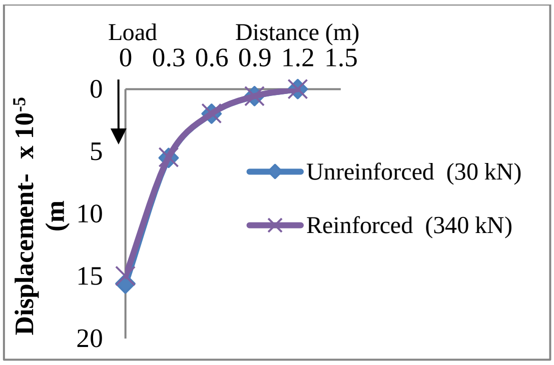


Fig.8. Variation of displacement on unreinforced and reinforced pavement

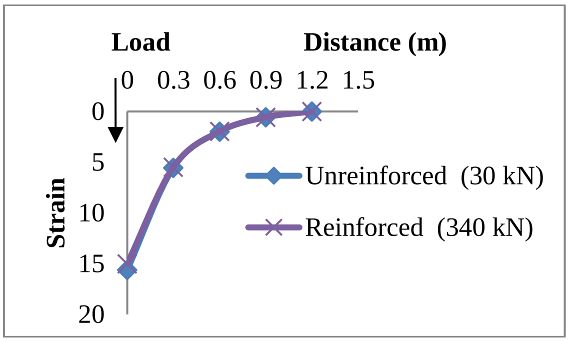


Fig.9. Variation of effective stress on unreinforced and reinforced pavement

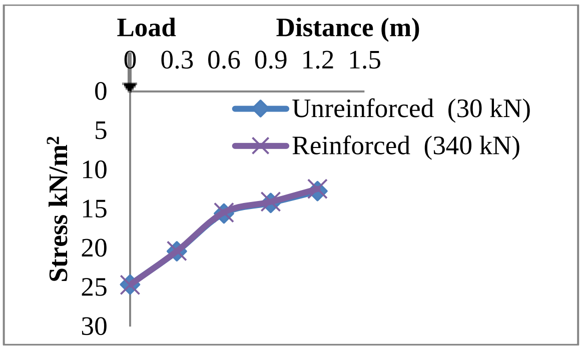


Fig.10. Variation of effective strain on unreinforced and reinforced pavement

VI. CONCLUSION

Based on the analysis on unreinforced and reinforced pavement model study, the following conclusions are drawn.

1. The load bearing capacity of geogrid reinforced pavement is increased upto nearly 11 times when compared to the unreinforced pavement.
2. The displacement of the reinforced pavement for the maximum bearable load of unreinforced pavement is nearly zero which is negligible.
3. When geogrid is used as the geosynthetics material the strength of the pavement is increased due to its better interlocking capacity.

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