Evaluation of Geogrid as Reinforcement in Soil Layers using Light Weight Deflectometer and Field CBR Test

Sunil Dighe & Lekhaz Devulapalli *
The Bombay Textile Research Association, L B S Marg, Ghatkopar (W), Mumbai 400086

Abstract
The inclusion of the geosynthetics as reinforcement in the pavement layer improves theperformance of pavement during its service life. In the present investigation, geogrid is addedas reinforcement in compacted layer of soil. Thelong-term performance of the pavement majorly depends on proper compaction of the pavementlayers and reinforced material used in it. In this paper modulus and strength of the geogrid reinforced and unreinforced soil layers is investigated by using Light Weight Deflectometer (LWD)device and field California Bearing Ratio (CBR)test apparatus respectively. The LWD is the non-destructive, portable testing deviceused to evaluate the modulus and deflection. While the field CBR test is conducted to evaluate the strength of the geogrid reinforced and unreinforced soil material in the test tank. The layer of geogrid (750 x 450 mm) is placed on first compacted soil layer as reinforcement. Over that 100 mm thick soil material is placed and compacted to required density.The LWD and field CBR tests are conducted on top surface of compacted soilmaterial in unreinforcedas well as reinforced test tank. Based on the test resultsit is concluded that geogrid had improved the modulus and strength of the compacted soil materials by 31.70 % and 29.84% respectively in comparison to unreinforced soil material.

Key words:
Light weight deflectometer; Field CBR; Geosynthetic; Geogrid

Citation
Sunil Dighe & Lekhaz Devulapalli - "Evaluation of Geogrid as Reinforcement in Soil Layers using Light Weight Deflectometer and Field CBR Test", *BTRA Scan* - Vol. LI No. 4 Oct. 2022, Page no. 9 to 13

1.0 Introduction:

In civil engineering practice over the recent decades the use of geosynthetic as reinforcement during pavement construction becomes very popular due to its potential benefits. The use of geosynthetics as pavement reinforcement improves bearing capacity substantially. The bearing capacity of the pavement is a major concern at weak subgrade region and also quantity of the soil fill available during construction is limited in most part of the country. The use of geosynthetics as pavement reinforcement solves this problem by increasing soil bearing capacity and increases material confinement in pavement layers (resulting in a reduction in pavement design thickness). In the present investigation geogrid is used as reinforcement in compacted layer of soil. The use of geogrid as reinforcement in the pavement layer, increases interlocking between soil particles, restricts lateral movement, and reduces vertical subgrade deformations. These geogrid reinforcement properties in the compacted layer soil are measured by using LWD [1]. Geogrid reinforcement improves the load bearing capacity of the pavement with a single layer of reinforcement. This increase in pavement bearing capacity is checked by determining the modulus and deflection of the pavement using LWD [2], [3].The CBR value of the pavement layers determines the pavement's long-term performance. The use of geogrid in pavement layers improves the CBR value significantly when compared to unreinforced sections, and it is measured using a field CBR test that is widely accepted in the construction field [6], [7]. In this paper, soil material is compacted in layers in the test tank to required density. During the compaction of the soil material, single layer of geogrid are placed at particular

*Corresponding author,
E-mail: soillab@btraindia.com

heights in the test tank.The LWD and field CBR tests are then conducted as per planned sequence in reinforced and unreinforced test tank. Based on results the strength and modulus values are used to evaluate the performance of the reinforced soilmaterial in comparison to the unreinforced soil is discussed.

2.0 Materials

The soil and geogrids used in the investigation are depicted in Fig.1-2. The engineering properties of these materials are determined in the laboratory by conducting various tests according to IS codes. The results of soil and geogrid are tested in laboratory and listed in table1 and table 2 below.

Table 1: Engineering properties of soil material

Sr.no	Type of Material	Test Parameter	Value	Reference Code
1	 *Fig. 1 soil material*	Water content	15.25 %	IS:2720 (part-2) [8]
		Specific gravity	2.31	IS: 2720 (part-3/ sec2) [9]
		Soil gradation	Well graded sand with little fines (SW)	IS: 2720 (part-4) [10]
		Plasticity index	Non plastic	IS: 2720 (part-5) [11]
		Dry density	1.78 g/cc	IS: 2720 (part-7) [12]
		CBR unsoaked	4.10 %	IS: 2720 (part-16) [13]
		CBR soaked	3.24 %	

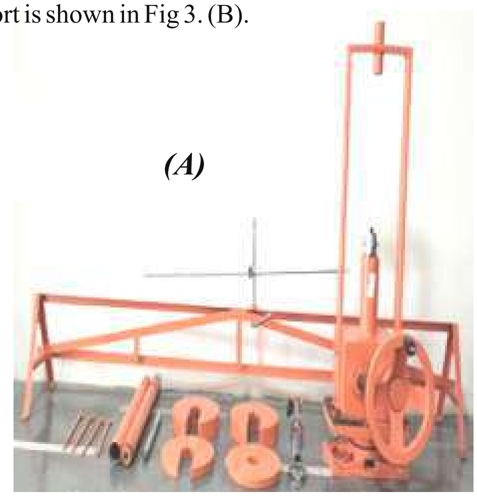
Table 2: Engineering properties of geogrid material

Sr. No	Type of material	Test Parameter	Value	Reference code
1	Geo grid  *Fig. 2 Geogrid material*	Nominal Tensile Strength	60 kN/m	ASTM: D6637 [15]

3.0 Test Apparatus Description and Testing Procedure

3.1. Field California Bearing Ratio

Field CBR test apparatus is used in this paper to determine the California Bearing Ratio (CBR) of the soil, and a typical image of the test apparatus is shown in Fig.3 (A).The entire field CBR test apparatus is assembled, and the entire assembly is secured to the fix support is shown in Fig 3. (B).



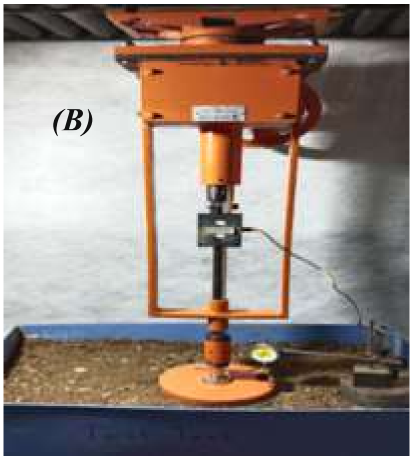


Fig.3. (A) Typical Field CBR apparatus(B)Field setup of field CBR test apparatus

The Field CBR test procedure consists following steps. The test surface area is cleaned and levelled. The equipment is secured to fixed support to provide load reaction. The surcharge annular weight of 5 kg is kept in position on the surface to be tested. The piston is lowered through hole of annular weight to establish full contact between test surface and piston by applying smallest load (not exceeding a total load of 40 N). While the seating load is on the piston, a 3 to 6 mm layer of clean sand is spread over the surface to be covered by the surcharge annular weight so that load distribution is uniform. The proving ring and dial gauge reading is set to zero before application of load on piston. Then the load is applied on piston through wheel arrangement of the equipment. The penetration rate of the piston is kept approximately 1.25 mm/min. The applied load is recorded at the penetration value equal to 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 4.0, 5.0, 7.5, 10.0 and 12.5 mm. The maximum load and corresponding penetration value are also noted if it occurs before the penetration value is less than 12.5 mm [14].

3.2 Light weight deflectometer

In this paper, Dynatest LWD is used to estimate the modulus of compacted soil layers, and it consists of the elements shown in Fig.4. The LWD procedure consists of the following steps. Initially, the test site is levelled, and ribbed rubber is placed on the levelled surface. The LWD is then kept over ribbed rubber, along with the loading plate. To ensure good contact between the loading plate and the soil, the three initial drops are released from a predetermined height. Then next three drops are used to measure deflection and modulus. The LWD estimate the modulus value from measured a deflection (generated after the impact) based on the force needed to generate a given deflection for that soil type [16], [17].

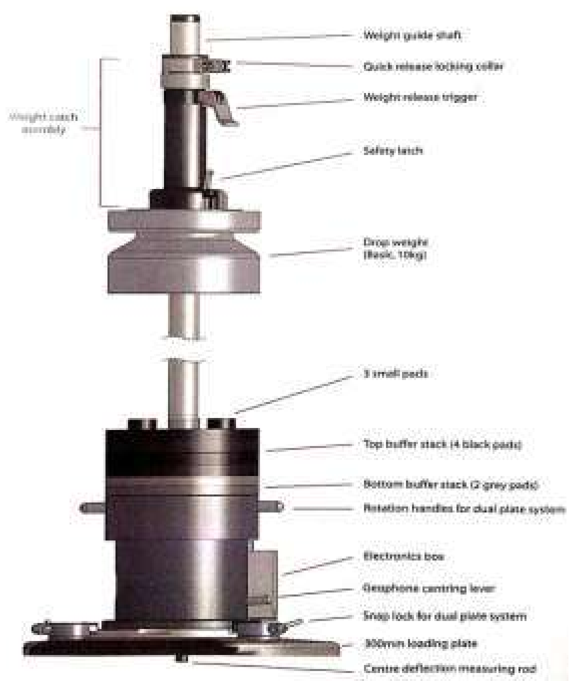


Fig.4 Typical Image of LWD [17]

4.0 Test Sequence

The schematic cross-section of the reinforced test tank is depicted in Fig. 5.

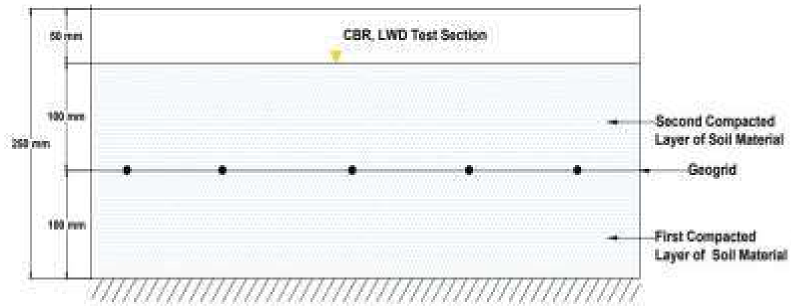


Fig 5schematic cross-section of the reinforced test tank

The test tank 800 mm x 500 mm x 250 mm (i.e., Length, Width and depth respectively) is kept on the test location as depicted in (Fig. 6).To initiate the testing, the first layer of soil material (100 mm) is placed in tank and compacted to required density. On top of the first layer, second layer 100 mm thick soil is compactedto required density in case of unreinforced test. While in case of reinforced test the geogrid 750 x 450 mm is placed on the first compacted layer of soil in the tank and over that 100 mm soil material is compacted to required density. The field density of compacted soil material is checked using pave tracker depicted in Fig 9.The LWD and CBR test are conducted on top surface unreinforced as well as reinforced test tank. The performance values are noted. The sequential images of the test conducted are depicted in Fig. 7-10.

Fig6. Test tank– 800 x 500 x 250 mm

Fig7. Compaction of the 100 mm soil material

Fig 8. Placing of geogrids above 100 mm compactedsoil material

Fig 9. Placing and compaction of 100 mm over geogrid and checking density by pave tracker

Fig10. Conducting LWD and Field CBR test on the reinforced test section

5.0 Results and Discussion

The performance of LWD and field CBR test on unreinforced and reinforced soil material is depictsin Fig 11-12. The test results are shown in table 3.The test results LWD and field CBR shows that modulus as well as strength values ofreinforced soil increased in comparison to unreinforced soil material by 31.70 %and 29.84% respectively.

Table. 3 CBR test results of the reinforced and unreinforced test section at different layers

Test Name	Test Parameter	Unreinforced soil material	Reinforced soil material
LWD	Modulus (MPa)	20.5	27
Field CBR	CBR (%)	2.58	3.35

Fig 11. LWD test results of unreinforced and reinforced soil material

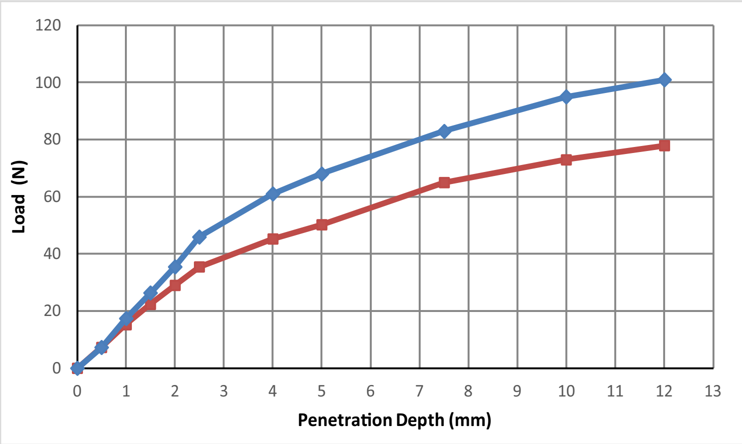


Fig: 12Field CBR test results of reinforced (Blue line) and unreinforcedsoil material (dark red line)

The results show that the strength and modulus values of geogrid reinforced sections are increased than that of unreinforced sections. The use of geogrid as reinforcement in soil improved the bearing capacity of compacted layers by interlocking soil materials and provided material confinement within layers. The soil-bearing capacity increases with the addition of one layer of reinforcement. The reinforcement also provides additional support in response to the applied load, by the deformation of reinforcement in the upward direction below the region of applied load [6]. This mechanism was latter introduced by Giroud and Norway (1981) as membrane tension support. The soil material is weak in tension and geogrid is strong in tension. So as the soil is reinforced with geogrid the tensile load is taken by the geogrid. The part of the applied load is transmitted laterally to the adjacent soil at the soil geogrids interface which increases the bearing capacity of reinforced soil [4]. This increase in the bearing capacity of soil can correlate to an increase in the strength and modulus value.

6.0 Conclusions

The CBR values and modulus on unreinforced and reinforced soil material is determined by performing field CBR test and LWD in the test tank. Based on the results the following broad conclusions are drawn.

1. The performance of compacted soil material is greatly enhanced due to the inclusion of geogrid as reinforcement
2. The field CBR values of reinforced soil material increased by 29.84 % for unreinforced soil material
3. The modulus values of reinforced soil material are increased by 31.70 % with respect to unreinforced soil material

Note:The present investigation is conducted on a single source of soil and geogrid. It is needed to perform the tests on different types of soil material and geosynthetics to achieve consistency..

Future scope

In the present investigation, the LWD and Field CBR test are conducted on particular soil material. The geosynthetics material as reinforcement in soil material is complex phenomenon; hence there is a scope for further research. The research may be conducted on following aspect.

I. Evaluation of geogrid as reinforcement with different type of soil material
II. Evaluation of different type of geosynthetic as reinforcement with different type of soil material

References

1. Elhakim, A.F., Elbaz, K. and Amer, M.I., 2014. The use of light weight deflectometer for in situ evaluation of sand degree of compaction. HBRC Journal, 10(3).
2. Jitareekul, P., Sawangsuriya, A. and Singhatiraj, P., 2017. Integration of pavement layer evaluation using LWD for road safety control. Procedia engineering, 189, pp.111-117.
3. Dwivedi, S. and Suman, S.K., 2019. Quality assessment of road shoulders using light weight deflectometer and geogauge. Int J Recent Techn Eng.
4. Giroud, J.P. and Han, J., 2004. Design method for geogrid-reinforced unpaved roads. I. Development of design method. Journal of Geotechnical and Geoenvironmental Engineering, 130(8), pp.775-786.
5. Bandyopadhyay, K. and Bhattacharjee, S., 2010, December. Comparative study between laboratory and field CBR by DCP and IS method. In Indian Geotechnical Conference, Kolkata, Indian, December.
6. Carlos, D.M., Pinho-Lopes, M. and Lopes, M.L., 2016. Effect of geosynthetic reinforcement inclusion on the strength parameters and bearing ratio of a fine soil. Procedia Engineering, 143, pp.34-41.
7. Balamaheswari, M., Anitha, B., Kanimozhi, B. and Prabhu, N., 2022. Improvement of California Bearing Ratio value in weak subgrade soil with the developed anchored geogrid. Materials Today: Proceedings, 49, pp.1537-1542.
8. IS: 2720 (Part 2):1973, Methods of Test for Soils- part 2: Laboratory water content determination.
9. IS: 2720 (Part 3/sec 2):1980, Methods of Test for Soils- part 3/sec2: Laboratory specific gravity of soil.
10. IS: 2720 (Part 4):1985, Methods of Test for Soils- part 4: Laboratory Grain size analysis of soil.
11. IS: 2720 (Part 5):1985, Methods of Test for Soils- part 5 : Laboratory determination of liquid limit and plasticlimit
12. IS: 2720 (Part 7):1980, Methods of Test for Soils- part 7: Laboratory determination of dry density and optimum moisture content.
13. IS: 2720 (Part16):1987, Methods of Test for Soils –Part (16): Laboratory Determination of CBR.
14. IS: 2720(Part 31):1990, Methods of Test for Soils –Part (31): Field Determination of California Bearing Ratio.
15. ASTM: D6637, Standard Test Method for Determining Tensile Properties of geogrids by the Single or Multi-Rib Tensile Method.
16. ASTM E2835, 2020 Standard test method for measuring deflections using a portable impulse load device.
17. Dynatest 3031 LWD test system owner's manual. https://dynatest.com/equipment/light-weight-deflectometer/, Accessed 12th oct 2022.inetics of the curing process by FTIR spectroscopy," Polym. Networks Blends, vol. 7, no. 1, pp. 1–11, 1997, Accessed: Oct. 14, 2022.