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Critical Appraisal on Utilization of Geocell for Improving the Unpaved or Earthen Shoulder

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ABSTRACT

This research paper describes the founding of different research paper published so far worldwide on use of Geocell in road construction. Geocells are three-dimensional, honeycomb-shaped soil-reinforcing geosynthetics composed of polymeric materials and are primarily used for confinement of granular material. Geocells are placed at sub base, in-filled with soil material, and compacted. The cellular structures of the geocells provide lateral and vertical confinement and tensioned membrane effect, thereby increasing the bearing capacity and providing a wider stress distribution. As a result, rutting or permanent deformations under traffic loading can be reduced. India has one of the world's second largest roadway network transporting millions of people every year and also has heavy road traffic condition. Due to heavy traffic condition in India, heavy loading vehicles and other vehicles use pavement shoulder for passing or overtaking operation. Pavement Shoulder is made for some particular uses but heavy loading vehicle in one or two lane road use shoulder for pass away so that rutting of pavement shoulder happened. So it is necessity to improve strength, erosion control, and durability of shoulder for safety of road users for that we use geocell material at sub base or base layer of shoulder for giving better strength and it is also economical.

Keywords: Geocell, Earthen Shoulder, Soft Soil, Soil Reinforcement Technique, Falling Weight Deflectometer, Cellular Confinement System

I. INTRODUCTION

Geocells are three-dimensional honeycombed cellular structures that form a confinement system when in filled with compacted soil. Extruded from polymeric materials into strips welded together ultrasonically in series, the strips are expanded to form the stiff (and typically textured and perforated) walls of a flexible 3D cellular mattress as shown in "Fig. 1". Geocell come under types of Geosynthetics. This type is mainly being used worldwide. Geocell is also known as Cellular Confinement System(CCS) and are widely used in construction for erosion control, soil stabilization on flat ground and steep slopes, channel protection, and structural reinforcement for load support and earth retention. Geocells are placed at sub base or base in-filled with soil material, and compacted. The cellular structures of the geocells provide lateral and vertical confinement and tensioned membrane effect, thereby increasing the bearing capacity and providing a wider stress distribution (Rea and Mitchell 1978). As a result, rutting or permanent deformations under traffic loading can be reduced. India has one of the world's second largest roadway network transporting millions of people every year. And also has heavy road traffic condition. Due to heavy traffic condition in India, heavy loading vehicle and other vehicle used pavement shoulder for passing due to less space on carriageway in one and two lane road mostly. Pavement Shoulder is made for some particular uses like Emergency vehicles may use the shoulder to bypass traffic congestion, pedestrians and cyclists may be allowed to walk or ride on the shoulders. Shoulders help provide extra structural support of the roadway. Etc, but heavy loading vehicle in one or two lane road use shoulder for pass away so that rutting of pavement shoulder happened. So it is necessity to improve strength, erosion control, and durability of shoulder for safety of road users for that we use geocell material at sub base layer of shoulder, with soil stabilization technique for giving better strength and it is also economical.

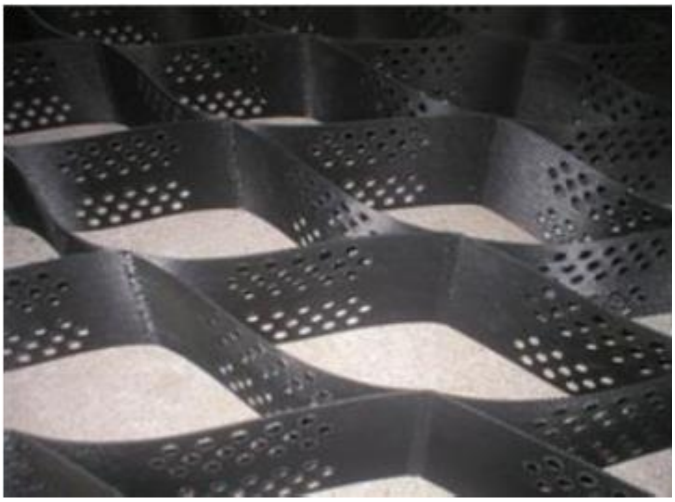

Figure 1 : Close view of geocell pockets

II. LITERATURE REVIEW

S.N. Moghaddas Tafreshi et al.2015 (15) performed a series of cyclic plate load tests on a circular plate with diameter of 300 mm, supported on unreinforced and reinforced beds by one and two layers of geocell. The results show that, as the number of geocell layers increases, the loading surface settlement decreases due, in part, to better load spreading. The optimum depth of the uppermost geocell layer and of the geocell inter-layer spacing both were obtained 0.2 times of plate diameter. Likewise, with increase in the number of geocell layers inside the foundation bed, the pressure transferred to depth, considerably decreases. For instance, at the end cycle of applied pressure of 800 kPa, the vertical stress transferred to a depth of 350 mm beneath the centre of loading surface, is about 462.8, 321.9, 274.3 kPa for unreinforced and reinforced bases with one and two layers of geocell, respectively.

To investigate the performance improvement by layers of geocell, an experimental program was conducted in an outdoor test pit. The test pit, measuring 2000x2000 mm in plan, and 700mm in depth, was excavated in natural ground. The cyclic load using a hydraulic jack was applied on a steel rigid circular plate of 300mm diameter and 25mm in thickness. The schematic cross-section of the test set-up is shown in “Fig. 2”.

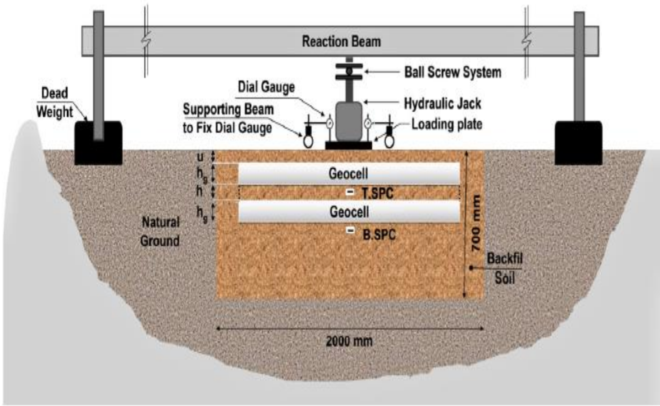

Figure 2 : Schematic cross-section of the test set-up (not to scale), “T.SPC” and “B.SPC” indicate the location of two soil pressure cells.

To measure the settlement of the loading plate, three dial gauges with an accuracy of 0.01% of full range (100mm) were used, the vertical stress inside the foundation bed was measured with two soil pressure cells (abbreviated to SPC:50mm diameter with an accuracy of 0.1% of full range of 1000kPa). The top soil pressure cell (“T. SPC”) and the bottom soil pressure cell (“B. SPC”) are located at 190mm and 350mm beneath centre of the loading plate. In order to compact the layers of foundation bed, a walk-behind vibrating plate compactor,450mm in width, was used. TO achieve the required density of 18.50 kN/ m^3 for the unreinforced layers and of 18 kN/ $m^3$for the geocell reinforced layers, the compactor was used with two and three passes, respectively. These density values were measured in the three cone tests.

S. Davarifard and S.N Moghaddas Tafreshi 2015 (12) have found in their research, the effect of embedment depth on bearing capacity of footing supported by geocell-reinforced bed, using plate load test at a diameter of 300 mm. The embedment depth ratio of the footing was varied from zero to 0.75. The plate load tests were performed in an outdoor test pit dug in natural ground measuring 2000 x 2000 mm in plan and 1000 mm in depth. The geocell used in the tests was non-perforated with pocket size 110 x 110 mm2 and height 100 mm, fabricated from continuous polypropylene filaments as a nonwoven geotextile. The tests were conducted on geocell reinforced bed sand, which was compacted to 85% relative density. The test results demonstrated that the bearing pressure increases with increase in the embedment depth ratio and the number of geocell layers.

The study also compared the embedment depth ratio of one layer geocell reinforcement with two and three layer geocell reinforcement bed with no embedment depth. These comparisons show that the performance of footing on single layer reinforced bed with the embedment depth ratio of 0.25 and 0.75 might be comparable to the performance of footing on geocell-reinforced bed with two and three reinforcement layers.

Ansgar Emersleben1 & Norbert Meyer (1) observed that Geocells consist of a series of interconnected single cells that are manufactured from different types of polymers. The geocells are expanded at the construction site and filled with soil. The cell walls completely encase the infill material and provide all-round confinement to the soil. During vertical loading, hoop stresses within the cell walls and earth resistance in the adjacent cells are mobilized which increases the stiffness and the load-deformation behaviour of the soil. Thus the soil-geocell layers acts as a stiff mat and distribute the vertical traffic loads over a much larger area of the subgrade soil. Large scale static load tests were carried out to evaluate the influence of a geocell layer on the load-deformation behaviour of the soil. The test results show that a geocell layer increases the bearing capacity of the infill materials up to three times compared to an unreinforced soil. The vertical stresses on the soft subgrade, measured by eight earth pressure cells, where also reduced about 30 percent. To verify the results of model tests in-situ field test where carried out within different road constructions. Earth pressure cells where installed on the subgrade to measure the influence of the geocell layers on the stress distribution. After finishing the road construction vehicle crossing tests with a 40-ton truck were carried out while the stresses on the subgrade where measured. Compared to an unreinforced test section the stresses beneath the geocell layer were reduced by about 30 percent. In addition to vertical stress measurements, falling weight deflectometer (FWD) measurements were conducted in reinforced and unreinforced test sections. The results show that the deflections measured in geocell reinforced test section were significantly smaller than in the unreinforced section. Back calculated layer modules were significantly higher in the geocell reinforced section compared to an unreinforced section. Geocells are honeycomb interconnected cells that completely encase the soil and provide all-around confinement, thus preventing the lateral spreading of the infill material. Due to the confinement of the soil the geocells increase the stiffness and the load-deformation behaviour of gravel base layers and thereby reduce the deformation of the soil. The soil-geocell layers act as a stiff mat, thus distributing the vertical traffic loads over a much larger area of the subgrade soil.

Richard J. et al.1993 (11) discovered in this study that the results of a series of large-scale triaxial tests carried out on 200-mm-high isolated geocell-soil composite specimens and unreinforced soil specimens. Two different aggregate soils were used in the test program. The reinforced specimens were tested with a height-to-diameter ratio of unity, which matches the dimensions of these systems in a typical base reinforcement application. The results illustrate the stiffening effect and strength increase imparted to the soil by the enhanced confinement effect. Comparison of reinforced and unreinforced soil specimens showed that the frictional resistance described by the peak friction angle of the soil infill is applicable to the composite structure as well. A simple elastic membrane model can be used to estimate the additional apparent cohesion present in the composite structure.

K. Rajagopal et al.2014 (8) Suggested the improvement in strength and stiffness of sub base layer in a flexible pavement system through use of geosynthetic layer, by doing field plate load tests and a series of laboratory plate load tests. It is seen that both strength and stiffness of pavement system improved by use of geosynthetic. The performance under repeated loads is also better with geo-synthetic reinforcement layers. Modulus improvement factor is high at initial stage and as settlement increase with number of cycles, the modulus value decrease and reached a constant value at end of 20,000 cycles. This could be due to loose packing of GSB layer in lab test. Also we can say modulus improvement factor is high at monotonic loading as compared to cycling load test.

The performance of the geocells as surface confinement layers and as reinforcement layers has been reported by several researchers in the past. Bathurst and Rajagopal et al. have reported the strength and stiffness behaviour of soils confined in single geocell and multiple geocell pockets. Madhavi Latha et al. have reported the benefit of using geocells as basal reinforcement layers for embankments constructed on soft foundation soils. It was reported that the factor of safety of the slopes can be increased significantly because of the interception of the slip surface by the geocell layer. Unni and Chandramouli have reported the construction of geocell-reinforced unpaved road pavements and their performance on different types of subgrade layers.

G. Madhavi Latha,Asha et al.2010 (5) have found in this study that the results of field studies on unpaved low volume roads constructed over weak subgrade using geosynthetic reinforcement. The relative advantages of placing different reinforcing materials like geotextile, biaxial or uniaxial geogrid, geocell layer and tire shreds at the interface of sub grade and base course are studied in terms of increase in load carrying capacity and reduction in rut depth. The rut depths measured in three different test sections when subjected to moving vehicle load simulated by the passage of a scooter on the road at uniform speed for a maximum of 250 passes are compared to understand the relative efficiency of each of these reinforcing materials in reducing the rut formation in unpaved roads. Traffic benefit ratios were also compared for different reinforced test sections.

S.K. Pokharel, J. Han, et al.2009 (13) have reported the behaviour of geocell-reinforced bases under static and repeated loading. Two base course materials, Kansas River sand and quarry waste, were used as infill materials. This study investigated the bearing capacity and stiffness improvement provided by geocell reinforcement and the effect of infill materials. This study also evaluated the permanent deformation and the percentage of elastic deformation of geocell-reinforced Kansas River sand and quarry waste compared with unreinforced bases. The test results show that the single geocell reinforcement can increase the bearing capacity, stiffness, and percent of elastic deformation for each cycle and reduce the permanent deformation.

Gourav dhane et al.2015 (6) to deals with the study of overall mechanism and applications of geocell in the field of civil engineering. In this paper we can conclude that geocell is a soil reinforcement technique which is proved to be a versatile method in terms of its cost effectiveness and it provides all round confinement to the materials hence it prevents the lateral spreading of soil on the application of load. So the use of geocell reinforcement increases the strength and stiffness property of the soft soil.

III. APPLICATION OF GEOCELL

1. Erosion Control using Geocell
2. Ground Stabilization using Geocell
3. Retaining Walls using Geocell
4. Slope & Channel Protection using Geocell
5. Reservoirs & Landfills using Geocell
6. Bearing Capacity Improving

IV. CONCLUSION

From the various studies conducted by many previous researchers, discussed in this paper we can concluded that geocell is a soil reinforcement technique which is proved to be a versatile method in terms of its cost effectiveness and it provides all round confinement to the materials hence it prevents the lateral spreading of soil on the application of load. So the use of geocell reinforcement increases the strength and stiffness property of the soft soil. It is also seen that both the strength and stiffness of the pavement system can be improved by the use of geocell. The performance under repeated loads is also better with geocell reinforcement layers. And also show that a geocell layer increase the bearing capacity of the infill materials up to three times compared to unreinforced soil.

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