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Geocell: An Emerging Technique Of Soil Reinforcement In Civil Engineering Field

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Abstract : *In any civil engineering construction work there are two basic criteria's which are to be followed. Firstly the structure should be safe against any type of failure and second is that structure should be economical as far as possible. When the structure is constructed over loose or weak soil then it is very difficult to follow these basic criteria's .Poor soil conditions usually is the reason behind the lack of strength, and associated deformability. Geocell is a Soil reinforcement technique which is proved to be a versatile method in terms of its cost effectiveness for the improvement of the strength of soft soils. It is the latest form of reinforcement which is both economical and durable in long term.. 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. This paper deals with the study of overall mechanism and applications of geocell in the field of civil engineering.*

Keywords – *Confinement, Geocell , Reinforcement technique, Stiffness.*

I. Introduction

Development of the infrastructure is the most important need in present time. To full fill the infrastructural need of population, small multi-story buildings, express highways, high speed rail tracks, new bridges, airports etc. are required to construct. Ultimately loads from such structure come on the ground. Due to space constrains many times construction takes place on poor soil. Construction over poor soil with high loads is a challenge for civil engineers. Replacement of weak soil by some strong soil or improvement of engineering properties of weak soil by different ground improvement techniques are used in such situation. If such soil cannot be removed or uneconomical to remove then we can use ground improvement techniques. Soil reinforcement is one of the most popular ground improvement technique. Ease of construction, overall economy and less time consumption are major advantages of soil reinforcement. Use of metal bars, sheet, and strips were traditional form of reinforcement. Geosynthetics are human-made materials made from various types of polymers used to enhance, augment and make possible cost effective environmental, transportation and geotechnical engineering construction projects. They are used to provide one or more of the following functions; separation, reinforcement, filtration, drainage or liquid barrier.

II. Geocell

Research and development of cellular confinement systems began with the U.S. Army Corps of Engineers in September 1975 to test the feasibility of constructing tactical bridge approach roads over soft ground (Webster, 1979)[1]. Engineers discovered that sand-confinement systems performed better than conventional crushed stone. In terms of the effectiveness of confinement, cellular confinement systems have more attractive features due to its 3D structure than any other planar geosynthetic reinforcement. Hence geocell can provide better lateral confinement to in fill soils. The reinforced composite formed by the geocell and the infill soil has a higher stiffness and shear strength than the unreinforced soil. The term geocell also have two parts first is "geo" which means soil or earth and second is "cell" which means cellular type of shape for infill material such as soil. These cells completely encases weak material such as soil, stones, etc and provide all round confinement due to its three dimensional structure thus preventing the lateral spreading of the material due to which a much stiffer mat like structure is formed and distributes the overcoming load to a much wider area. Geocells were used in the construction of canals, embankments, retaining walls, railways and roads (Dash et al., 2003[2] and Bathurst and Jarrett, 1998[3]). A closer view of geocell packets is presented in Fig 1.

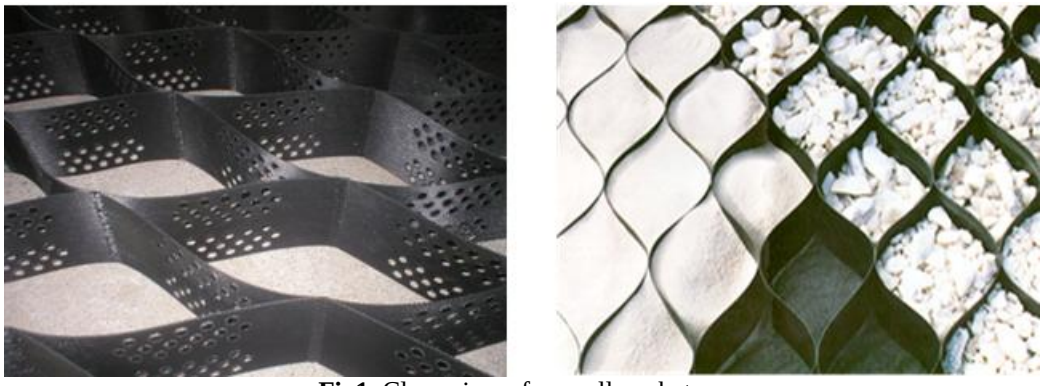


Fig1. Close view of geocell pockets

Nowadays geocells are made up of new type of polymer structure characterized by low temperature flexibility similar to high density polyethylene (HDPE), (Pokharel, 2010[4], Yang, 2010[5]). Geocell come in different shapes and sizes. Fig 2 shows the different type of configuration of geocells.

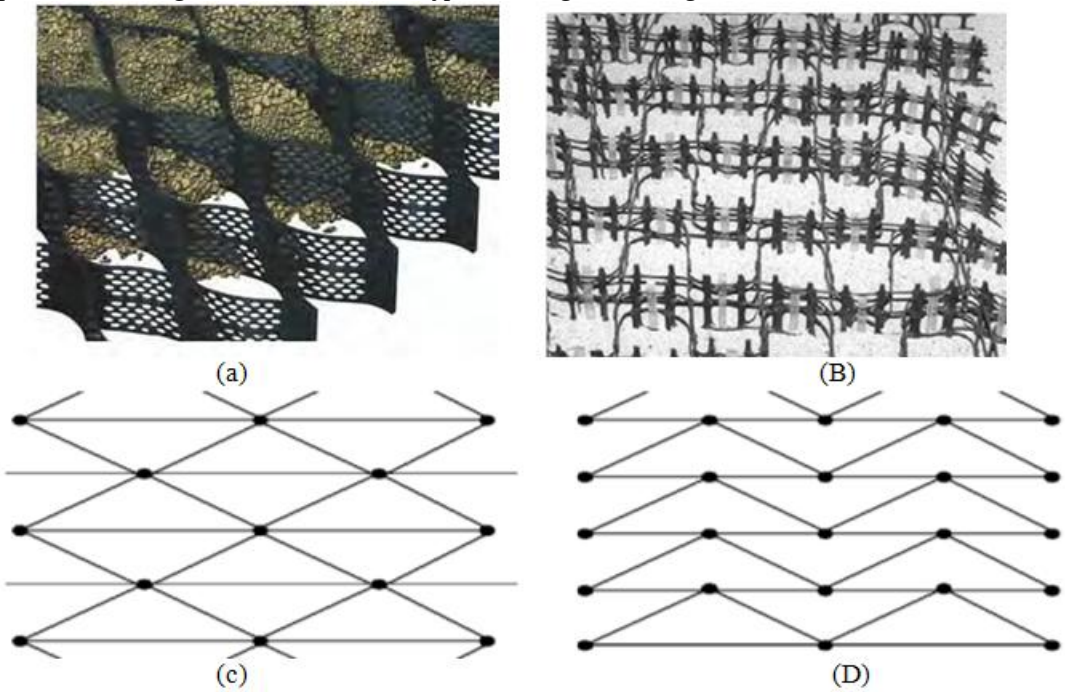


Figure 2: Configurations of geocell reinforcement elements.

a) Perforated geocell (Bathurst and Jarrett, 1998).
b) Handmade geocell (Dash et al., 2003[6]).
c) Handmade geocell diamond pattern (Dash et al., 2003).
d) Handmade geocell chevron pattern (Dash et al., 2003).

III. Mechanish Of Reinforcement

If we compare Geocell reinforced base with unreinforced base then it is experimentally proved that geocell reinforced bases provide more lateral and vertical confinement, Tensioned membrane effect and wider stress distribution. According to Rajagopal et al., (1999)[7] geocell reinforcement imparts apparent cohesive strength even to cohesion less soils and the induced apparent cohesive strength depends on the tensile modulus of the geosynthetic used to form the geocell. Dash et al., (2001a)[8] concluded that Very good improvement in the footing performance can be obtained even with geocell mattress of width equal to the width of the footing, because of the transfer of footing loads to deeper depths through the geocell layer. The surface footing in this

case behaves like a deeply embedded footing thus improving the overall performance also Chevron pattern for the formation of geocells is more beneficial than the geocells in diamond pattern. Boushehrian et al., (2011)[9] studied experimentally and numerically the effect of the depth of the first reinforcement layer (u), spacing between reinforcements (h), and reinforcement stiffness on the bearing capacity of circular and ring foundations of sand. Sitharam et al., (2007)[10] investigated the settlement response of geocell reinforced soil underlying soft clays. They reported a substantial reduction in footing settlement by providing geocell reinforcement in the soft clay bed. Vinod et al., (2011)[11] has reported the results of model tests on the settlement behaviour of strip footing resting on geocell reinforced sand during cyclic loading and concluded that Geocell reinforced foundation exhibit a four-fold increase in ultimate bearing capacity of the footing compared to unreinforced counterparts. Moreover, the laboratory results highlight that cyclic stress ratio and frequency has a significant influence on the settlement behaviour of geocell reinforced foundation. The geometry of the test configuration is shown in Fig 3.

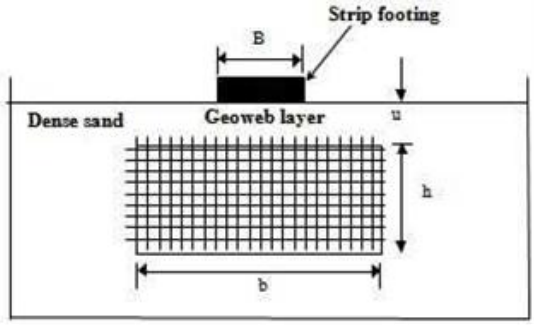
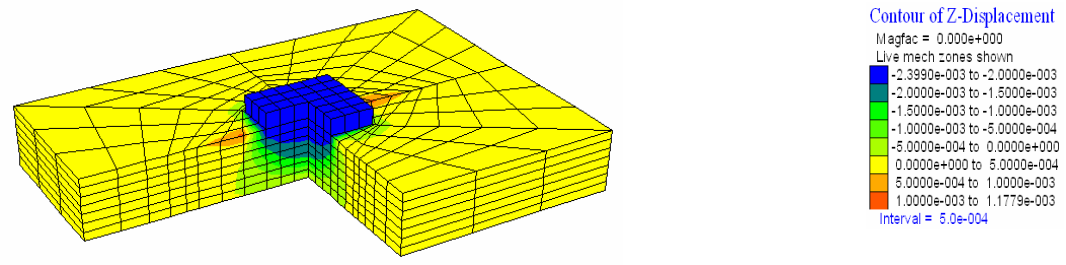
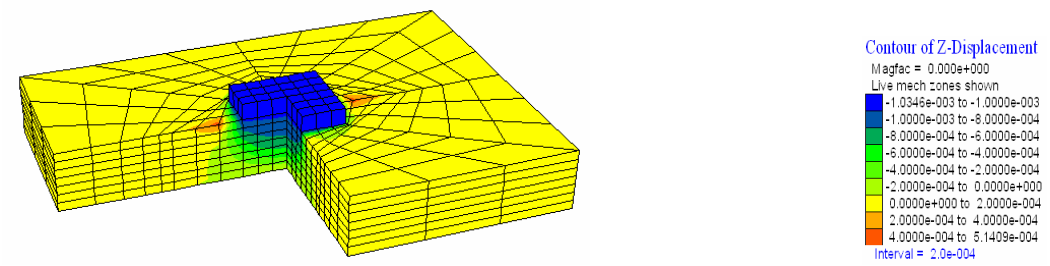


Fig.3. Geometry of the geocell- reinforced foundation bed.

IV. Confinement Of Reinforcement

The confinement effect of geocells improves vastly the shear strength of granular soil**.** To understand the mechanish better Chen et al., (2013)[12] performed test on geocell-reinforced-sand samples of two different sizes. The geocells were made of high-density polyethylene sheets, and the influencing factors examined include the shape (circular, rectangular, and hexagonal cross-sections), size and number of cells. The effects of these variables on the compression strength of samples as well as the stress-strain behaviour were investigated. It has been found that the apparent cohesion of reinforced samples vary with the shape, size and number of cells, of which the cell size is the most significant factor. Among the cells of all shapes, the circular cells induce the highest apparent cohesion. According to Pokharel et al., (2010) due to the three-dimensional structure, the geocell can provide lateral confinement to soil particles within cells. According to Han et al., (2008)[13] geocells have a three-dimensional cellular structure, which can be used to stabilize foundations by increasing bearing capacity and reducing settlements. In the study, a single geocell was filled with sand and subjected to a vertical load to failure. This test process was modelled using the FLAC3D numerical software to investigate the mechanisms of geocell and sand interactions. Experimental and numerical results both demonstrated that the geocell increased the ultimate bearing capacity and the modulus of the sand. patterns of vertical displacements for the unreinforced and reinforced cases. Fig 4 shows the patterns of vertical displacements for the unreinforced and reinforced cases.





(b) Reinforced

Fig.4. Patterns of vertical displacements for the unreinforced and reinforced cases.

As shown in Fig 4, the patterns of vertical displacements for the unreinforced and reinforced cases are very similar, i.e., compression under the load plate but heave away from the load plate. However, the magnitude of the vertical displacement for the unreinforced sand was much larger than that for the reinforced sand under the same vertical load.

V. Application Of Geocell

5.1 In Pavement and Road Construction

Thakur et al., (2012)[14] have studied the effect of geocell-reinforced recycled asphalt pavement (RAP) bases over weak subgrade under cyclic plate loading and found that geocell has improved the performance of RAP bases over weak subgrade as compared with the unreinforced base section and geocell significantly increased the percentage of resilient deformation of the RAP base.The geocell reinforcement reduced the vertical stresses transferred to the subgrade by distributing the load over a wider area. Emersleben et al., (2008)[15] have studied about the bearing capacity improvement of gravel base layers in road constructions using geocell and concluded that geocell layer placed within the gravel base layer of an asphalt paved construction reduced the vertical stresses on subgrade during vehicle crossing about 30 per cent and increased the layer modulus of the gravel base layers compared to an unreinforced layer. As a result the measured deflection s on the asphalt surface were also reduced.

5.2 In Foundation

Sireesh et al., (2009)[16] have performed experiments on circular footing on geocell–sand mattress overlying clay bed with void to study the increase tin the bearing capacity of circular footing. A series of model load tests have been conducted to evaluate the potential benefits of providing geocell reinforced sand mattress over clay bed with a continuous circular void. The test results clearly demonstrate that geocell mattress can substantially increase the bearing capacity and reduce settlement of the clay subgrade with void. Dash et al., (2003)conducted experiments on circular footing supported on geocell reinforced sand underlain by soft clay and concluded that Provision of geocell reinforcement in the overlying sand layer improves the load carrying capacity and reduces the surface heaving of the foundation bed substantially. The performance improvement increases with increase in the width of the geocell layer up to b=D of 5 beyond which it is negligible. Good improvement in the load carrying capacity of the foundation bed can be obtained even with geocell mattress of width almost equal to the diameter of the footing.

5.3 In Railway

Leshchinsky et al., (2012)[17] studied about the numerical modeling of behavior of railway ballasted structure with geocell confinement. In the end of his he concluded that the confinement of the ballast using geocell was quite effective in reducing vertical deformations, especially when low-quality material was used. Higher shear strength of the ballast reduces the need for reinforcement, reducing the need for substructure improvement.

5.4 In Slope Protection

Mehdipour et al., (2013)[18] conducted a Numerical study on stability analysis of geocell reinforced slopes by considering the bending effect and they concluded that geocell reinforcements were found to be advantageous in increasing the factor of safety and reducing the lateral deformations of slopes due to the tensile

strength and bending moment of geocell reinforcement. Also geocell reinforcement acts like a wide slab and it can restrain the failure surface from developing and redistribute the loads over a much wider area.

VI. Conclusion

From the various studies conducted by many previous researchers, discussed 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. Its application in civil engineering field are numerous such as slope protection, earth reinforcement, road or highway load support, channel protection, improving bearing capacity of soft soil to support footing etc. Still there are other applications which are yet to be discovered. In addition, overall behavior of the geocell reinforced soil is of interest for future research.

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