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# STUDY OF FOUNDATION STRUCTURE ON LOW BEARING CAPACITY OF SOIL USING GEOSYNTHETIC MATERIAL

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**Abstract**

*A placement of a foundation structure upon soil with inadequate bearing capability might cause structural damage. Because of a range of events like as earthquake, transport loads, & machine vibration for the case for machine foundations, dynamic stress was often imposed on foundation bed. Excessive vibrations from dynamic sources may create structural issues with a foundation soils. Its purpose of this investigation was to assess a performance on machine foundations supported on grovel-reinforced bed. Such experiments were conducted using a finite component software ANSYS. This sewerage treating plant on Tirhut Canal near Muzaffarpur town (Bihar) having a circular foundation of 10 m diameter sitting in clay soil were investigated. This numerical model was first validated using previously published data. In addition, the validated numerical model were utilized to assess a performance for machine foundations. A three situations considered are unreinforced, Geogrid reinforced, &geocell reinforced. A Geogrid were erected at four different depths above a ground: 0.025B, 0.04B, 0.05B, & 0.06B. (Where B are a diameter for the foundation). Depths of a Geocellabove a ground surface were varied as 0.01B, 0.025B, 0.05B, 0.1B, & 0.2B. A comparison of numerous models was carried out in this study. The Geocell depth &Geogrid arrangement have been modified. The optimal positioning of Geocell reinforcing soils resulted to greater bearing capacity and decreased settlement when compared to with an unreinforced foundation base &Geogrid reinforced soil. For the present problem statement over a distance approximately 0.025B, a settling with Geocell reinforced soils are reduced by 53.48 % & soil carrying capacity was raised to 217 %.*

***Keywords:Geo-synthetic material, ANSYS, foundation, soil condition, Low Bearing capacity, Soil-Structure Interaction.***

## 1. Introduction

Foundation structure based on loose soil layers may result in structural problems. These loose earth layers cannot support the structural load of the constructions. Therefore, settling and fractures form on the structures, and the buildings eventually collapse. In these loose soil layers, people use deep foundations to build their structures(Jeremic et al., 2004). However, because of the need of deep foundations, the expenses of building buildings might often be higher. As a result, ground improvements are implemented to prevent the aforementioned issues. The most popular way for improving ground is the application of geo synthetics. These geo synthetics are utilized as reinforcing agents in soil strata, increasing a bearing capacity of soil strata(Al-hussaini, 2020).

Geogrid

Geogrid were geosynthetic material utilized for reinforce soils & other materials. Soil split under stress. Geogrid get a higher tension than soil. This allows them to transmit pressure over a larger area of soils than might be feasible otherwise. An advancement of a process for producing higher modulus polymer materials via tensile drawing with in context of cold working. Such apertures a openings among the neighbouring longitudinal & transverse ribs are big enough so allow allowing soil communications, or strikes over, on one side of a Geogrid to an another(Munawir, 2020).

**Fig.1.1. Geogrid**

(Source: https://5.imimg.com/data5/JU/CR/ZX/SELLER-34984133/biaxial-geogrid-pp-500x500.jpg)

A geosynthetic material composed of parallel pairs of crossing ribs joined by perforations large enough to enable strike-through for surrounding soils, stones, or another geotechnical materials(Alamshahi& Hataf, 2009).

Hence, Geogrid is matrix-like materials having huge open gaps called apertures that were generally 10 - 100 mm apart between ribs known as longitudinal & transverse, correspondingly. Such ribs themselves may be made of a variety of materials, & a rib crossover connecting or junction-bonding processes can vary. Because Geogrid' principal role is obviously reinforcement, parts inside the chapter were organized not on function but per kind of reinforcement applications. Unidirectional, rather than uniaxial, Geogrid were employed in applications wherever a direction of a principal loads is known, such as wall & slope. Bidirectional, also biaxial, Geogrid were utilized in applications whereby a applied stress emanate via random directions, such as pavements & foundations(Ahmad & Mahboubi, 2021).

➢ Physical Properties of Geogrid:

Most physical features of Geogrid, such as construction type, rib dimensions, connection types, apertures size, & thickness, may be determined directly & were quite simple. Other features for relevance including mass by unit areas, which ranges between 200 - 1000 g/m2, & percent open space that ranges as 40 - 95 %. Its latter implies that practically all soils would communicate with, or strike-through, a Geogrid planes(Alamshahi& Hataf, 2009).

<u>Geocell</u>

Geocell are designed for purposes such as protection and stability. They are often utilized to enhance the performance of traditional building materials and erosion-control treatments(Hegde& Sitharam, 2013).

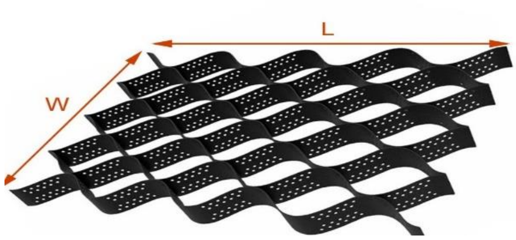


**Fig.1.2. Geocell**

(Source: https://sc04.alicdn.com/kf/Hd1e3374dab8f420dab0ee8dd998dfc05b.jpg)

In recent past studies H. Venkateswarlu (2018) studied "Numerical Analysis of Machine Foundation on Geocell Reinforced Soil Beds." This study employed numerical computations to evaluate machine foundations on geocell-reinforced beds. Studies utilised PLAXIS 2D finite element software. Resonance frequency varies by reinforcing mechanism. Geocells enhanced soil damping by 163%. The study highlights new applications for geocell in machine foundations. A. Hegde (2015) researched Smooth Clay Bed Reinforce by Bamboo Cell &Geocell. The research evaluates the potential of utilising naturally occurring bamboo to increase soft soil carrying capacity. Laboratory plate loads showed that clay beds reinforced with bamboo cells and grid had 1.3 times the ultimate bearing capacity of clay beds reinforced with geocells and geogrid. Analytical model assumptions matched experimental findings well. This research suggests a low-cost alternative to geocell and Geogrid for soft soil. Kolay (2013) studied "Improvement for Shallow Foundation Bearing Capability on Geogrid Reinforced Silty Clay & Sand." A research attempts to increase silty clay soil carrying capacity by adding a thin sand layer and Geogrid at varied depths. Models were used to create the loads against settlement curve for an unreinforced and reinforced soil system with a rectangular foot. The test findings concentrate on silty clay and sand carrying capacity in unreinforced and reinforced non-dimensional soils (BCR). Such study may improve the bearing capacity of shallow foundations and pavements on any soil. A. Hegde did experimental and numerical footing experiments on geocell-reinforced sands and clay (2013). The study presents laboratory test and numerical analysis findings for a square footing on geocell-reinforced sands and clay. Using scale factors, model raft foundation dimensions are calculated. This 3-D geocell piece was computationally reproduced in 2D using the composite model approach (FLAC2D). Experiment and numbers agree. Saeed Alamshahi (2009) studied strip footing on sand slopes using Geogrid and grid-anchor. The study explores the influence of Geogrid inclusions on a rigid strips foundation on a sand slope. Geogrid types, layer count, vertical spacing, and topmost layer depth are used to analyse unreinforced instances. The data were processed to derive qualitative and quantitative bearing capacity and Geogrid parameter correlations. Good agreement between observed and estimated load-settlement results and ideal parameters.

Hussein Ahmad (2020) studied the impact of shear stress on Geogrid-reinforced sand bearing capacity. Analytical studies and experiment testing validate an empirical technique. The study examined the effects of two Geogrid layers, Geogrid embedment depth, layer distance, Geogrid tensile strength, contacting area friction angles, and shear stress distribution at the soil-Geogrid interface. Geogrid length ratios (L/B=5–7) have equal effects on strain value, although short layers have a considerable influence. From the available literature, it is evident that the limited studies have been performed to understand the efficacy of geosynthetics in supporting the foundation. In present study, an attempt has been made to enhance the present knowledge on possible use of geosynthetics in supporting the machine foundation.

## 2. METHODOLOGY

### 2.1. Problem statement

The present study looked at a sewerage treatment plant with a circular base 10 m in diameter resting on reinforced soil mass. Harmonic excitation was employed over the foundation bed to approximate the dynamic force induced by machine vibration. An examination are carried out by the help from a finite elements analysis tools ANSYS. It uses a finite element approach to address starting and boundary value problems. The round machine base was thought to be resting on clayey soil. Geogrid and Geocellgeosynthetic reinforcements were used. To do this, three different scenarios were investigated and compared: unreinforced, Geogrid reinforced, and Geocell reinforced. The three separate situations studied in the study are shown schematically in Fig. To alleviate boundary consequences, soil restrictions of 30 meters in length and 15 meters in depth were proposed. The system was described using a medium mesh, as seen in Figure. There were three different scenarios considered: unreinforced, Geogrid reinforced, &Geocell reinforces. A Geogrid are installed at various depths from the ground surface: 0.025B, 0.04B, 0.05B, and 0.06B (where B is the diameter by a foundation). A depth is a Geocell were altered by the ground surfaces from 0.01B, 0.025B, 0.05B, 0.1B, & 0.2B.

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An aim of project are to study for Foundation Structure on low bearing capacity of soil using geosynthetic material. Main objectives for research work is to design the unreinforced, Geocell and Geogrid reinforcement foundation bed, to evaluate the improvement in a bearing capacity of soils with Geo grid &Geocell material, for determine a load settlement behavior of unreinforced, Geo cell and Geo grid material.

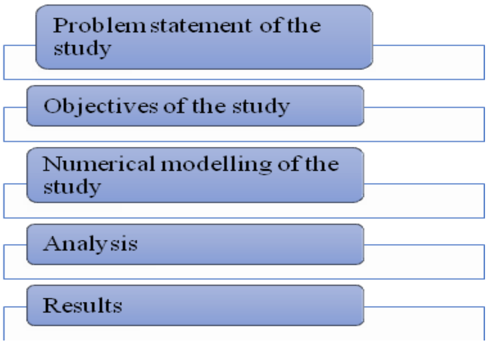


**Fig.2.1. Methodology Process**

**Table.3.1. Details of the numerical analysis**

| Sr. No | Type of reinforced Base | Placement of reinforcement |
|---|---|---|
| 1 | Unreinforced base | - |
| 2 | Geogrid reinforced | 0.025B,0.04B, 0.05B and 0.06B |
| 3 | Geocell reinforced | 0.01B,0.025B, 0.05B,0.1B & 0.2B |

## 2.2. Models

In this study comparison done in between these models

**Unreinforced base**

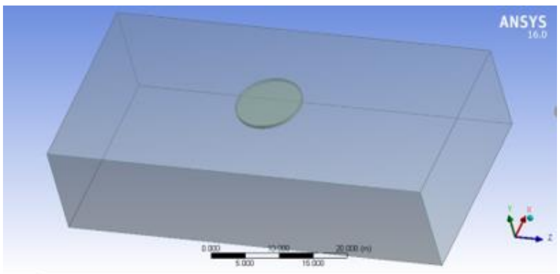


**Fig.2.2. Unreinforced base**

**Geogrid reinforced**

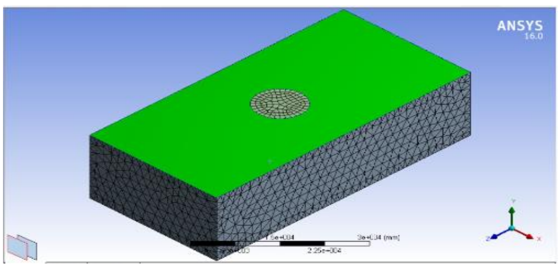


**Fig.2.3. Geogrid reinforced**

**Geocell reinforced**

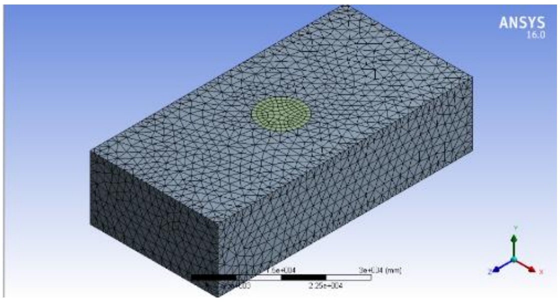


**Fig 2.4: Geocellreinforced**

## 2.3. Material properties

As per the guidelines, the ratio between the weights of the foundation to the weight of the machine was maintained equal to 4.4.

**Table.3.2. Properties of different materials used in numerical modelling**

| Material | Parameter | Value |
|---|---|---|
| Foundationsoil | Unitweight,(kN/m$^3$) | 19 |
| | Young'smodulus,E(kN/m$^2$) | 20,000 |
| | Poisson'sratio,$u$ | 0.3 |
| | Angleofinternal friction,φ ($^0$) | 32 |
| | Cohesion,C(kN/m$^2$) | 0 |
| | Dilatancyangle,ψ ($^0$) | 2 |
| Foundation | Young'smodulusofconcrete,E(kN/m$^2$)<br>Unitweightofconcrete(kN/m$^3$) | 2×10$^7$<br>24 |
| | Poisson's ratio ofconcrete,μ | 0.15 |
| Geocell | Young'smodulus,E(MPa) | 275 |
| | Poisson's ratio,μ | 0.45 |
| | Geocellheight, H(m) | 0.15 |
| | Length ofthegeocell,L(m) | 10 |
| Geogrid | Young'smodulus,E(MPa) | 210 |
| | Poisson's ratio,μ | 0.33 |
| | Length oftheGeogrid, Lg(m) | 10 |
| Infillmaterial(sand) | Unitweight,(kN/m$^3$) | 20 |
| | Elasticmodulus,E(kN/m$^2$) | 50,000 |
| | Poisson'sratio,$u$ | 0.3 |
| | Angleofinternal friction,φ ($^0$) | 36 |
| | Cohesion,C(kN/m$^2$) | 0 |

## 3. ANALYSIS

Under dynamic excitation, severe disruption was seen in unreinforced soil. Heave formation was also seen near the ground surface. The creation of heave was caused by the unreinforced soil's lack of shear strength. Heave was significantly reduced in the case of the Geogrid.

### Unreinforced

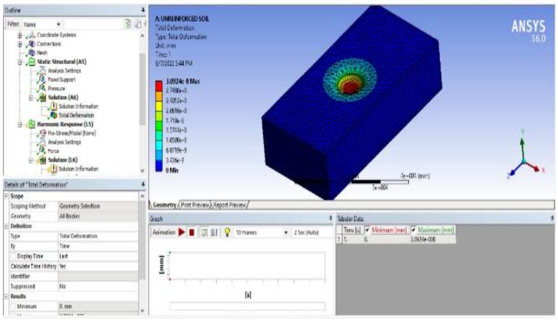


**Fig.3.1. Total deformation**

The settlement findings are shown in the figure above, with settlement increasing mode by mode when pressures are applied. A centre of foundation has a most settling.

### Geogrid

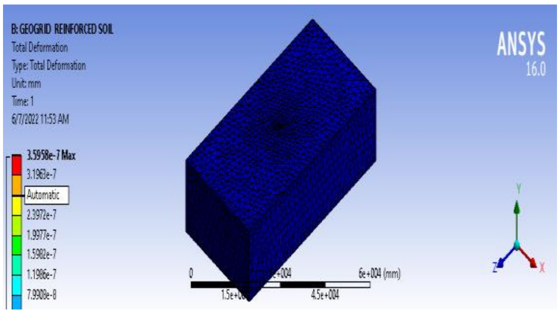


**Fig.3.2. Geogrid reinforced soil with 0.025 B**

The figure above depicts the settlement outcomes in Geogrid reinforced soil with 0.025 B, with settlement increasing mode by mode by applying pressure. Maximum distortion is visible in the final mode.

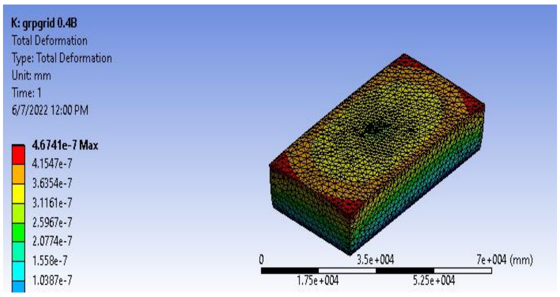

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**Fig.3.3. Geogrid reinforced soil with 0.04 B**

The figure above depicts the settlement results in Geogrid reinforced soil with 0.04B, with settlement increasing mode by mode by applying pressure. Maximum distortion may be noticed in the model's final corner.

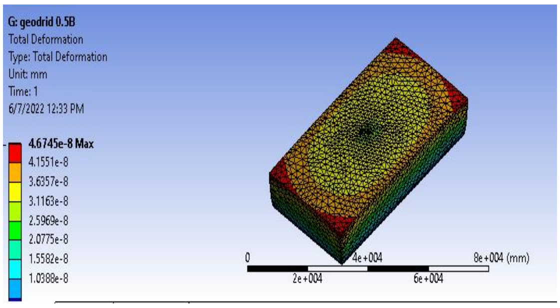


**Fig.3.4. Geogrid reinforced soil with 0.05 B**

Above fig shows the settlement results in Geogrid reinforced soil with 0.05B, in these settlement increases mode by mode applying pressure. Maximum deformation seen at the last corner of the model.

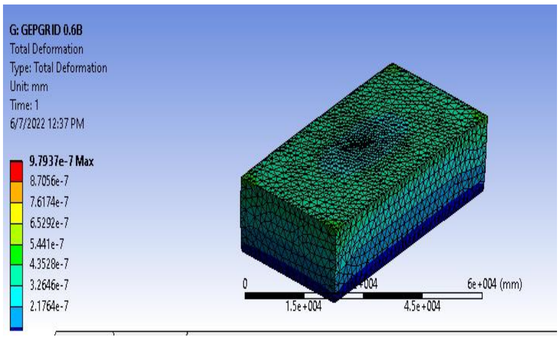


**Fig.3.5. Geogrid reinforced soil with 0.06 B**

The figure above depicts the settlement results in Geogrid reinforced soil with 0.06B, with settlement increasing mode by mode by applying pressure. Maximum distortion may be noticed in the model's final corner.

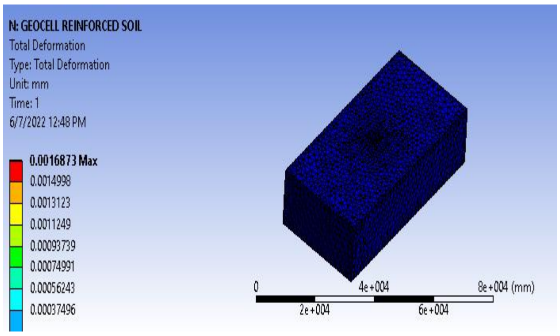


**Fig.3.6. Geocell reinforced soil with 0.01 B**

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Above fig shows the settlement results in Geocell reinforced soil with 0.01B, in these settlement increases mode by mode applying pressure. Maximum deformation seen at the last mode of the model.

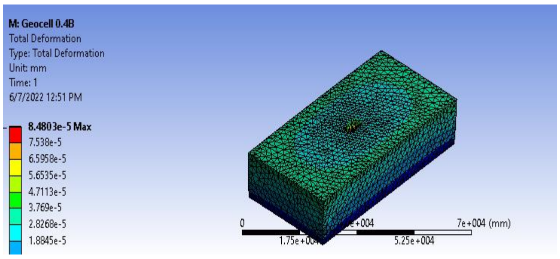


**Fig.3.7. Geocell reinforced soil with 0.025B**

Above fig shows the settlement results in Geocell reinforced soil with 0.025B, in these settlement increases mode by mode applying pressure. Maximum deformation seen at the last corner of the model.

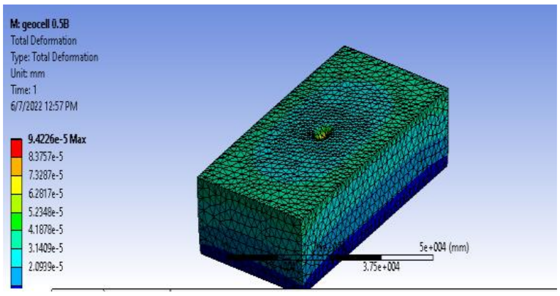


**Fig.3.8. Geocell reinforced soil with 0.05 B**

The figure above depicts the settlement results in Geocell reinforced soil with 0.05B, with settlement increasing mode by mode by applying pressure. Maximum distortion may be noticed in the model's final corner.

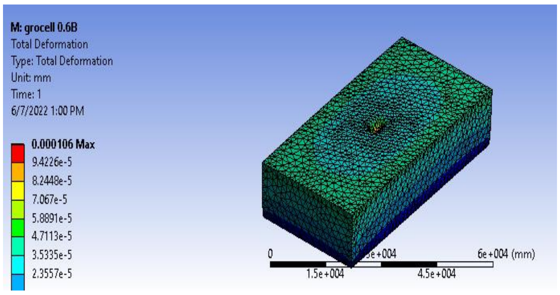


**Fig.3.9. Geocell reinforced soil with 0.1 B**

The figure above depicts the settlement results in Geocell reinforced soil with 0.1B, with settlement increasing mode by mode by applying pressure. Maximum distortion may be noticed in the model's final corner.

## 4. RESULTS

A modest decrease in settlement was discovered in the presence of Geogrid at its optimal position. The presence of Geogrid modifies the tensile strength may explain why the settlement is reduced.

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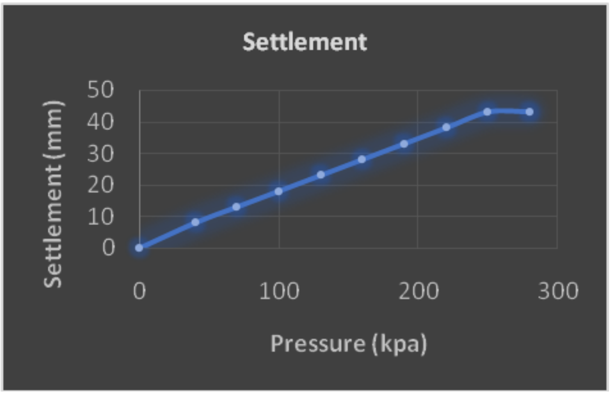
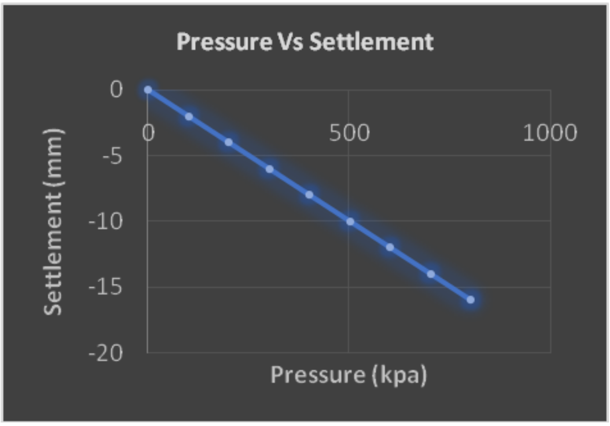


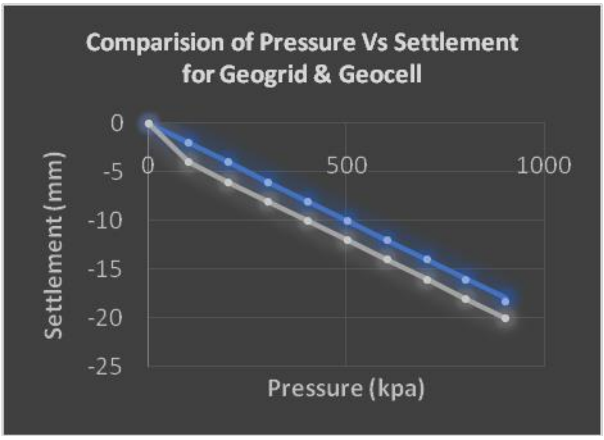

**Graph.4.1. Pressure vs Settlement for Unreinforced**

Above graph shows the results for Unreinforced pressure vs settlement. Maximum settlement shows at pressure 250 kPa to 280 kPa is 43mm.



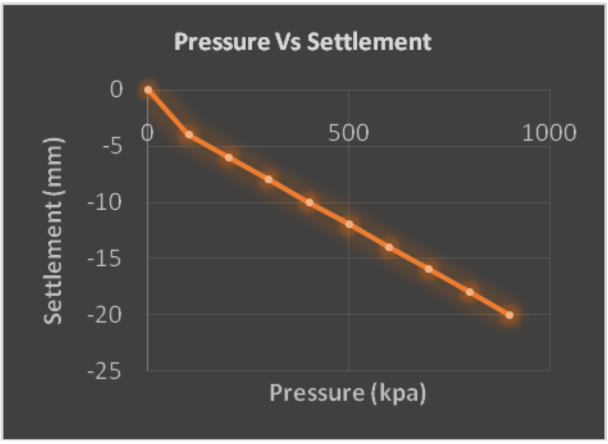

**Graph.4.2. Pressure vs Settlement for Geogrid**

Above graph shows the results for Geogrid pressure vs settlement. Maximum settlement shows at pressure 800 kPa.




**Graph.4.3. Comparison of Pressure Vs Settlement for Geogrid&Geocell**

Above graph shows the results for Comparison of Pressure Vs Settlement for Geogrid&Geocell. Maximum settlement shows in between pressure 800 kPa to 1000 kPa.




**Graph.4.4. Pressure vs Settlement for geocell**

Above graph shows the results for Geocell pressure vs settlement. Maximum settlement shows at pressure 900 kPa.

## 5. CONCLUSION

A primary finding of the study on settlement behaviour for a soft subgrade reinforced by a Geogrid and a geocell are as follows:

The simulated settlement matched the field monitoring data well, showing that the created model and settings were appropriate.

By this investigation, a settling for a geosynthetic reinforced soils mass supporting a machine foundation was numerically examined utilized a finite elements software ANSYS. The geocell outperformed the unreinforced and Geogrid scenarios when subjected to dynamic excitation. The tensile strength & modulus of elasticity to the reinforcement are critical in increasing the soil's bearing capacity up to a particular degree. Increasing the modulus of elasticity of the reinforcing material beyond this point almost never enhances the soil's bearing capacity. The medium Geocell is regarded as the most effective reinforcing material. Reduce the spacing between a reinforcing layers for improve a carrying capacity on the reinforced soils. Inside the effective reinforced zone, the recommended spacing between reinforcing layers is nearly half the width of a footing, i.e. four layers on reinforcing material.

An optimal geocell placement was found to be 0.025B from the ground surface, which is twice as far as the unreinforced condition. Furthermore, the addition of a geocell increased the settling of the foundation soil system, with maximum settlement occurring at higher pressures than the Geogrid. The densification for foundation soil with in a presence of a geocell improved subgrade damping.

The settlement of Geocell is decreased by 53.48% and similar soil bearing capacity is increased by geocell 217 % for current problem statement at a distance of 0.025B

The current study established the use of geocell in supporting machine foundations along these lines. The study only employed one kind of foundation soil. As a result, the given results are only applicable to a limited number of scenarios.

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