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PENETRATION RESPONSE OF SOIL REINFORCED WITH FLEX CELL

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ABSTRACT: Soil reinforcement using geocell is found to be an effective method to reduce foundation settlements. This thesis presents the effect of flex cell and inclusion on the penetration response on a sand bed. Laboratory penetration test were performed on unreinforced and reinforced sand. A series of test conditions, including unreinforced cases, were conducted by varying parameters such as number of cell layers, vertical spacing and depth to top most layer of cell. The magnitude of penetration response increase and settlement reduction depends greatly on the cell distribution. The magnitude of increase of penetration response and settlement reduction was quantified by using factors such as maximum load and penetration ratio.

KEYWORDS: Flex cell, maximum load, penetration ratio.

I. INTRODUCTION

Development of infrastructure is the important need in present time. To fulfil 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 constraints many times construction takes place on poor soil. 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. Soil reinforcement is one of the most popular ground improvement techniques. 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. Hence flex cell can provide better lateral confinement to in fill soils. The reinforced composite formed by the flex cell 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. Here we collect Sandy soil for the test and evaluation of the soil penetration that the reinforcement materials to be used. Here the Flex Cells are the reinforcement materials to be added. Flex Cells are plastic and they are insoluble in soil. By using these materials we perform test by making the materials into cells and applied in this sand soil and observing the value by load test. Compare the values and observe that whether the soil get strength or not.

II. RELATED WORK

Husna Humayoon and Binil Gopinath, (2016) carried out a study on the improvement of CBR using waste plastic material as geo cell in natural soil from kuttanadu in Alappuzha district (specific gravity 2.22). In this study, usage of locally available waste plastic bottle is used to improve the strength of sub grade soil. Waste plastic bottle is used to make mats which are induced in the sample to increase the strength. Mats of 3.5 cm dia and of varied thickness are used. They are placed at 2 cm, 4 cm, 6 cm and 8 cm depth. CBR tests are performed individually for each. For further results CBR tests are performed by using sand which is filled in the mat. Tests are made for optimum conditions of depth, ie,4 cm. Test result, shows that the CBR value is increasing upto a particular limit of thickness and depth.

Krishna and Biswas, (2015) studied geocell reinforced foundations. Geocell-reinforcement in ground improvement is being used very extensively in present days. It is a three dimensional honeycombed confinement system, made of geosynthetics, which significantly improves the bearing capacity of soft soils, specially, in foundations, and pavements applications. Apart from improving the soil strength, it has also been extensively used in various slope stabilization, embankment construction and railway track applications. Various parameters are needed to be considered and designed for the application of geocellsystems, like: geometrical parameters of geocell, its location and infill soil characteristics This paper briefly discussed about geocell reinforced foundation systems and various parameters influencing the performance of the same. The developments and parametric studies on geocell foundation performances are discussed giving the optimum values of various parameters.

G. MadhaviLatha and Amit Somwanshi, (2009) studied on bearing capacity of square footing on geosynthetic reinforced sand. Load test is conducted on 150x150x25 mm footing with different geogrids. The size of testing tank is 900x900x600 mm. They concluded that a) effective depth of the zone of reinforcement below a square footing was twice the width of the footing b) within the effective reinforcement zone, the optimum spacing of reinforcing layers was about 0.4 times the width of the footing and c) the optimum width of reinforcement is about 4 times the width of the square footing.

III. METHODOLOGY

The materials used in carrying out this study were sand and Flex Cell. The properties of sand used are shown in Table 1.Experimental penetration test would be conducted in a cylindrical tank of size 32cmheight and 28cm diameter. The sand bed would be prepared in 6 layers of 50 mm thickness. Each layer was compacted to achieve the desired relative density of 1.5 g/cc. Load is applied with strain rate of 6 mm/min. Flex cells are placed in required depth and spacing. Table 2 shows the test configuration.

Table 1: Properties of sand

Fineness modulus	5.25
Effective size,D_{10}	0.35
Uniformity coefficient,Cu	1
Coefficient of curvature Cc	4
Specific Gravity	2.89

Table 2: Test configuration

NO OF LAYERS	DEPTH OF FIRST LAYER	SPACING OF LAYERS
N=1	1D,2D,3D	_
N=2	1D	1D,2D,3D
	2D	1D,2D,3D
	3D	1D,2D,3D

Fig 1: Preparation of test bed

Fig 2: Marking of reinforcement location

Fig 3: Placing of flex cell

IV. EXPERIMENTAL RESULTS

1 Penetration test on unreinforced sand:

Load test is conducted on unreinforced sand. The load-settlement curve is shown in figure 5.1.

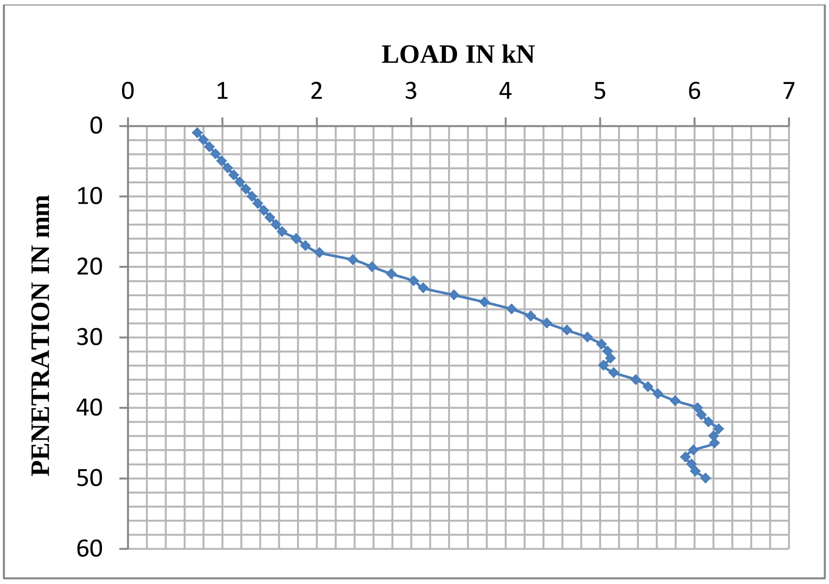

Fig 4: Load-penetration curve for unreinforced sand

The maximum load carrying capacity of sand is 6.26 kN.

2 Penetration test on Reinforced sand:

Reinforcements are placed at required depth with varying number of layers and spacing.

2.1 Single Layer:

A series of load test is conducted on sand reinforced with a single layer of reinforcement at different depth. Figure 5 shows the settlement response of sand reinforced at 1D, 2D and 3D depth using Flex cell.

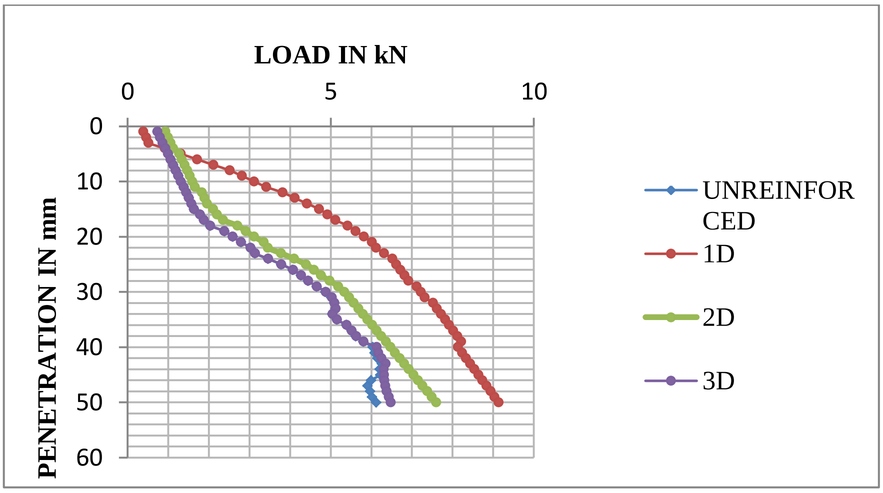

Fig 5: Load-Penetration curve for single layer of Flex cell.

Table 3: Maximum load carrying capacity of sand reinforced with single layer

DEPTH	MAXIMUM LOAD IN(kN)
1D	9.135
2D	7.602
3D	6.48

2.2 Double Layer:

Penetration tests were conducted on sand reinforced with double layer of flex cell. The depth and spacing were varied and the reinforcing effect is studied. Figure 6, 7 and 8 show the Penetration VS Load curves for double layer of reinforcement at different depths. Table 4 shows the load capacity values of sand reinforced with double layer of flex cell.

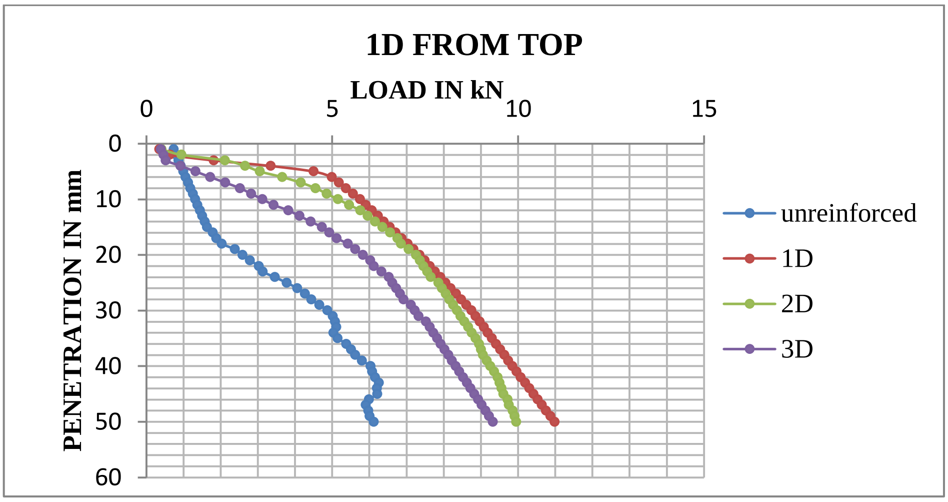

Fig. 6: Penetration- Load Curve for sand reinforced with double layer at 1D depth from top and different spacing.

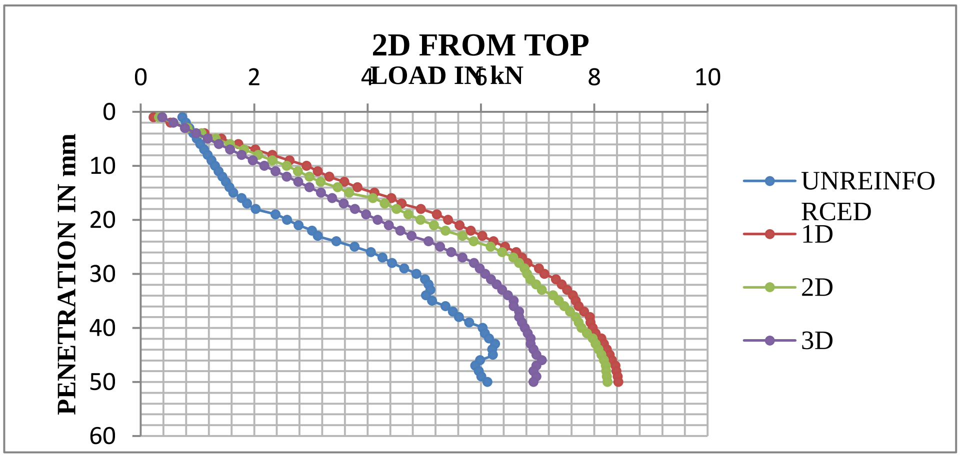

Fig. 7: Penetration- Load Curve for sand reinforced with double layer of at 2D depth from top and different spacing

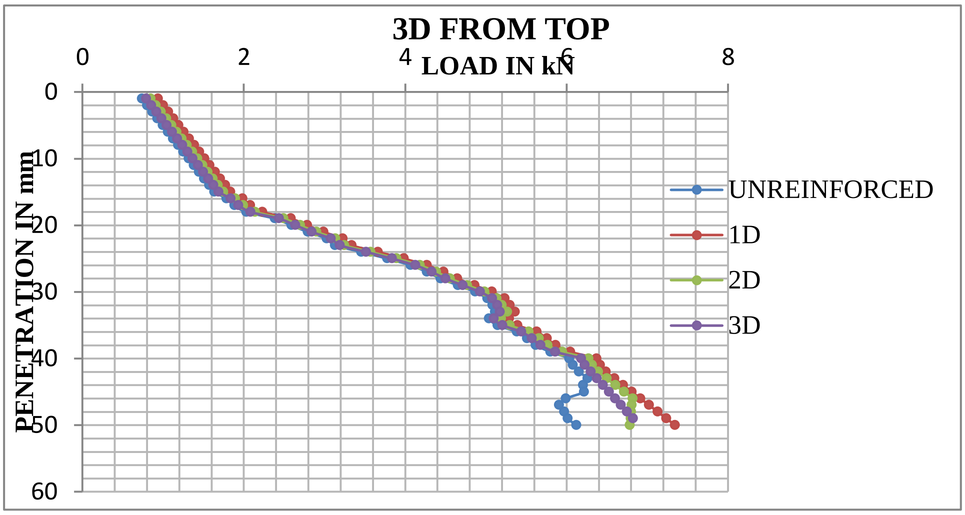

Fig. 8 Penetration- Load Curve for sand reinforced with double layer of at 3D depth from top and different spacing.

Table 4: Maximum load for 50 mm penetration of sand reinforced with double layer of Flex cell

DEPTH	SPACING	MAXIMUM LOAD IN k N
1D	1D	10.98
	2D	9.96
	3D	9.32
2D	1D	8.43
	2D	8.24
	3D	7.08
3D	1D	7.3446
	2D	6.8181
	3D	6.8997

3 Penetration ratio (PR):

Penetration ratio (PR) is the ratio of load of reinforced soil to that of the unreinforced soil the same settlement.

$$PR=\frac{Load\ of\ reinforced\ soil\ at\ 25\ mm\ settlement}{load\ of\ un\ reinforced\ soil\ at\ 25mm\ settlement}X100$$

3.1 Effect of depth of placement:

A series of Penetration tests were conducted to study the effect of depth of single reinforcement. Flex cells were placed at 1D, 2D and 3D depth. The Penetration ratio (PR) for single layer is shown in Table 5. The variation of PR is shown in figure 9.

Table 5: Penetration ratio (PR) for single layer

DEPTH	PR %
1D	175.18
2D	116.21
3D	100.23

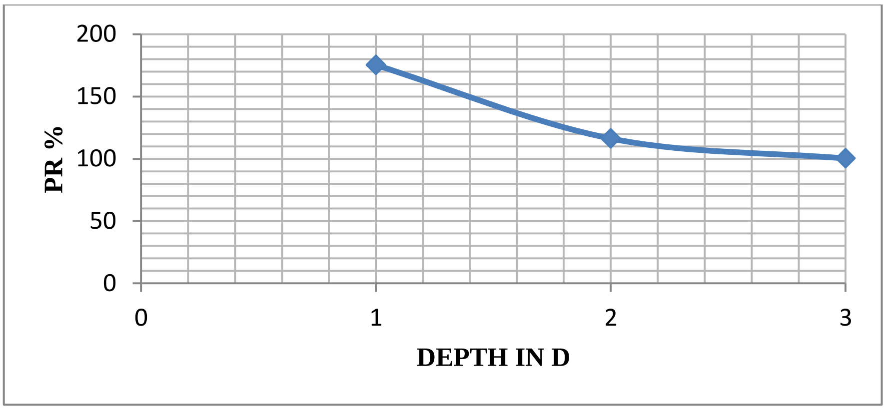

Fig 9: Variation of PR with depth for single layer

The magnitude of improvement in bearing capacity depends on the depth of placement. The peak improvement is at 1D depth and the improvement is 1.5 times that of unreinforced sand.

3.2 Effect of spacing of layers:

A series of Penetration tests were conducted on sand reinforced with flex cell at constant depth and different spacing. Effect of spacing is studied on sand reinforced with two layers. It is observed that the magnitude of load varies with spacing. For each depth the peak bearing capacity is observed for 1D spacing. It is also observed that the settlement varies with spacing. Fig 10 shows the effect of spacing on PR for two layers of flex cell. Table 6 shows the PR and maximum load variations of two layers with spacing respectively.

Table 6: PR values for double layer with spacing

DEPTH	SPACING	PR%
1D	1D	213.126
	2D	208.01
	3D	175.37
2D	1D	170.51
	2D	163.61
	3D	139.89
3D	1D	105.42
	2D	103.06
	3D	101.56

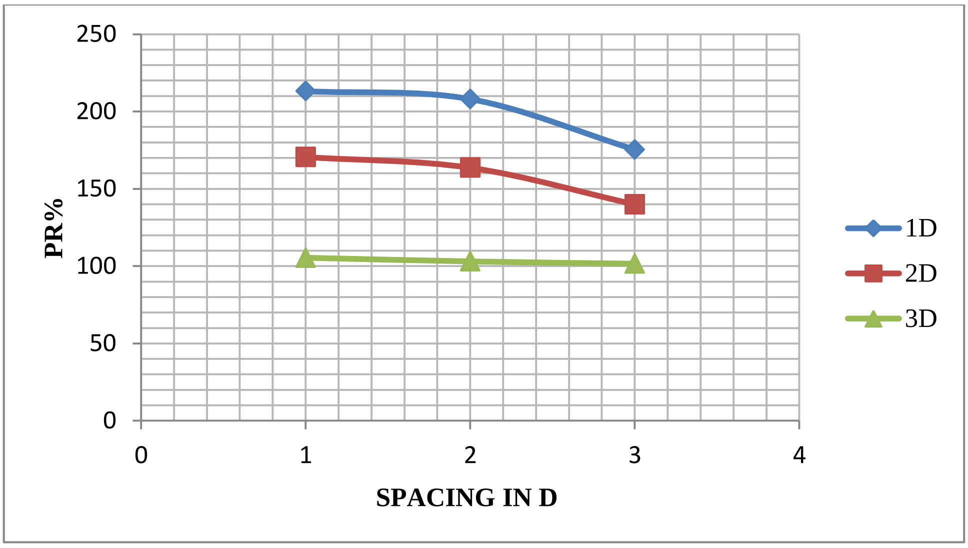

Fig 10: Variation of PR with spacing for double layer

In above two layer condition the maximum load carrying is the top layer placed 1D from top and spacing between the layers is 1D and the maximum load carrying is 1.8 times of unreinforced condition.

V. CONCLUSION

A series of laboratory Penetration tests were conducted on flex cell reinforced sand foundation to investigate the effect of using reinforcement. The inclusion of flex cell significantly increases the penetration ratio and reduces the settlement.

Based on the results obtained from the present investigation, the following conclusions can be made.

1) The magnitude of improvement in bearing capacity depends on the depth of placement of flex cell and spacing of layers.

2) For single layer reinforcement the peak improvement is observed at 1D depth, and the improvement is 1.5 times that of unreinforced sand.

3) For double layer reinforcement the peak improvement is observed at 1D depth with 1D spacing, and the improvement is 1.8 times that of unreinforced sand.

5) The maximum penetration ratio is at double layer.

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