

# Penetration Response of Soil Reinforced with Pet Bottle Cell

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**ABSTRACT:** In this project we have studied the penetration response of soil reinforced with PET bottle cell. PET bottle cells are made in the form of a geo cell. These are introduced into the soil and the penetration response of the soil is found by conducting penetration tests in a cylinder. First of all we test the soil having a density by load test and the results are recorded. PET bottle cell having a dimension are made and then tests are conducted in soil with PET bottle cells placed in a single layer and then in double layer at different depths with different spacing.

**KEYWORDS:** PET cell, maximum load, penetration ratio.

## I. INTRODUCTION

Footings are an important component of any structure and primarily serve to safely and economically transfer concentrated loads produced by a structure to the underlying footing material. The footings on horizontal soil are usually designed by primarily taking into account two factors, the bearing capacity of the soil and the settlement of the footing. Both the loading and settlement of the footing must be within the allowable limits for a safe footing design. Many approaches and theories are available to determine the bearing capacity in situ and in laboratory studies by considering these two factors. Weak sand deposits have led to a low bearing capacity of deposit in many regions. As a result of this, in situ stabilization of these soil deposits has risen markedly. Soil reinforcement is an effective and reliable technique for improving the strength and stability of soil. The reinforced soil or mechanically stabilized earth is a compacted soil fill, strengthened by the inclusion of tensile elements like geo grids, geo textiles, geo mat and strips. It is now well established in heavy construction industry for the construction of structures like retaining walls, embankments over soft soil, steep slopes, foundations etc.

## 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 diameter 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 up to a particular limit of thickness and depth.

Krishna and Biswas, (2015) studied geo cell reinforced foundations. Geo cell-reinforcement in ground improvement is being used very extensively in present days. It is a three dimensional honeycombed confinement system, made of geo synthetics, 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 geo cell systems, like: geometrical parameters of geo cell, its location and infill soil characteristics This paper briefly discussed about geo cell reinforced foundation systems and various parameters influencing the performance of the same. The developments and parametric studies on geo cell 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 geo synthetic reinforced sand. Load test is conducted on 150x150x25 mm footing with different geo grids. 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 PET cell. The properties of sand are shown in Table 1. Experimental penetration test was conducted in a cylindrical tank of size 32cm height 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 1.5g/cc. Load is applied with strain rate of 6mm/min. PET 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 co-efficient, $C_u$	1
Coefficient of curvature $C_c$	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 PET bottle 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 4.

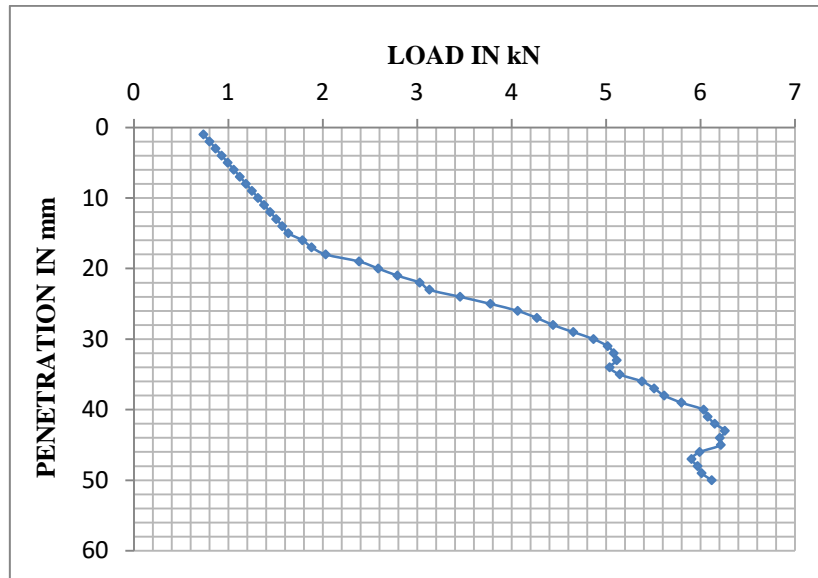


Fig 4: Load-penetration curve for unreinforced sand

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 PET bottle cell

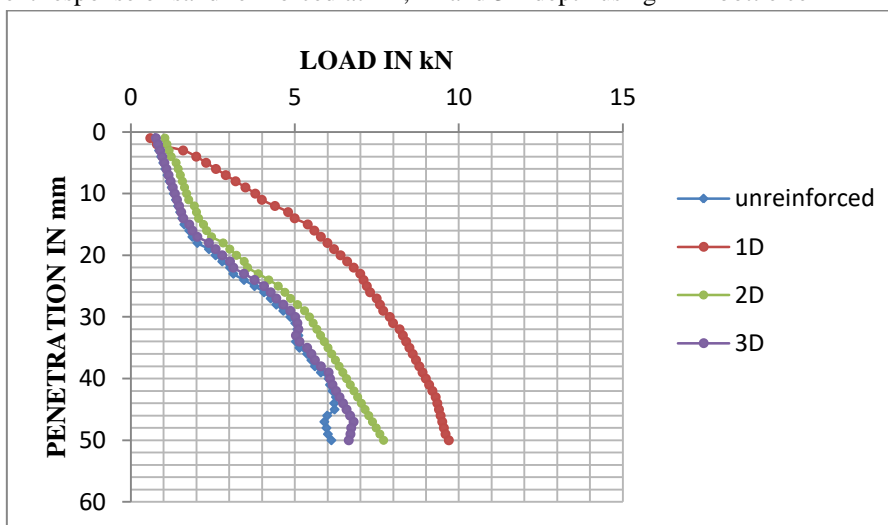


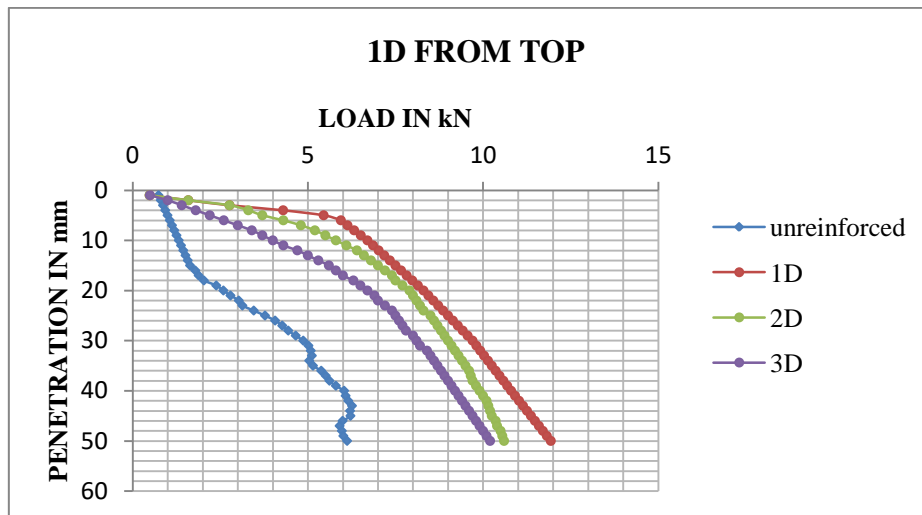
Fig 5: Load-Penetration curve for single layer of PET Bottle cell.

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

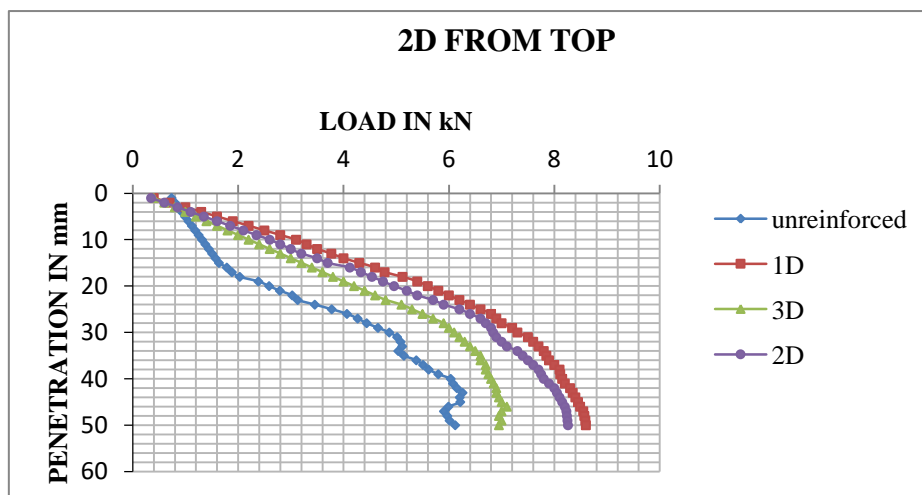
DEPTH	MAXIMUM LOAD IN(kN)
1D	9.7
2D	7.712
3D	6.7975

**2.2 Double Layer:**

Penetration tests were conducted on sand reinforced with double layer of PET bottle. The depth and spacing was varied and the reinforcing effect is studied. Figure 6, 7 and 8 the Penetration VS Load curve for double layer of reinforcement. Table 4 shows the load capacity values of sand reinforced with double layer of PET bottle.



**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**

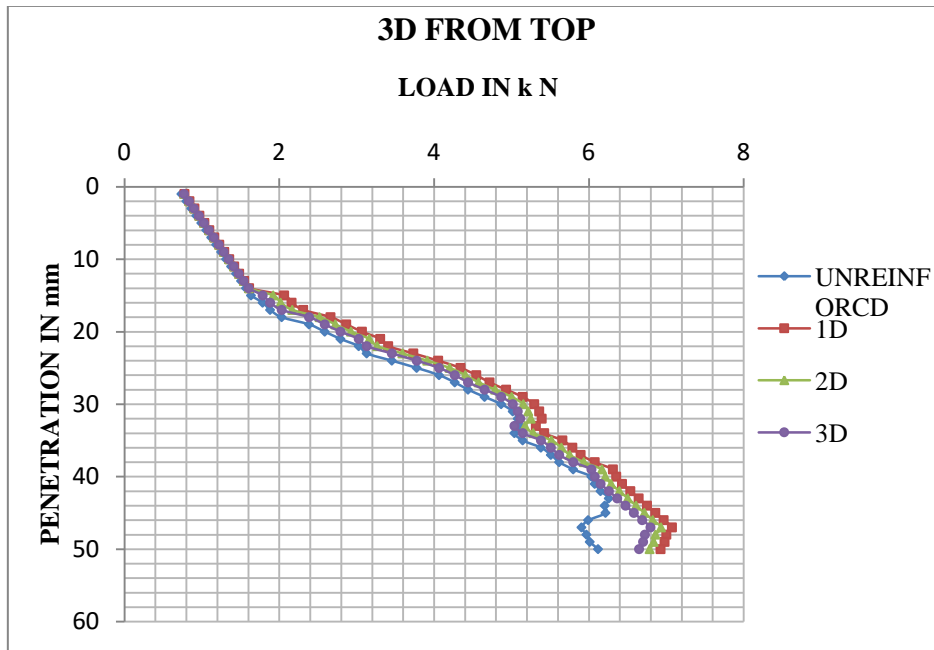


Fig. 8 Penetration- Load Curve for sand reinforced with double layer of at 3D depth from top and different spacing.

Table 4: Maximum load for 50 mm penetration of sand reinforced with double layer of PET bottle

DEPTH	SPACING	MAXIMUM LOAD IN k N
1D	1D	11.934
	2D	10.6
	3D	10.2
2D	1D	8.6
	2D	8.26
	3D	7.1
3D	1D	7.0755
	2D	6.9345
	3D	6.7985

**3 Penetration ratio (PR):**

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

$$PR = \frac{\text{Load of reinforced soil at 25 mm settlement}}{\text{load of un reinforced soil at 25mm settlement}} \times 100$$

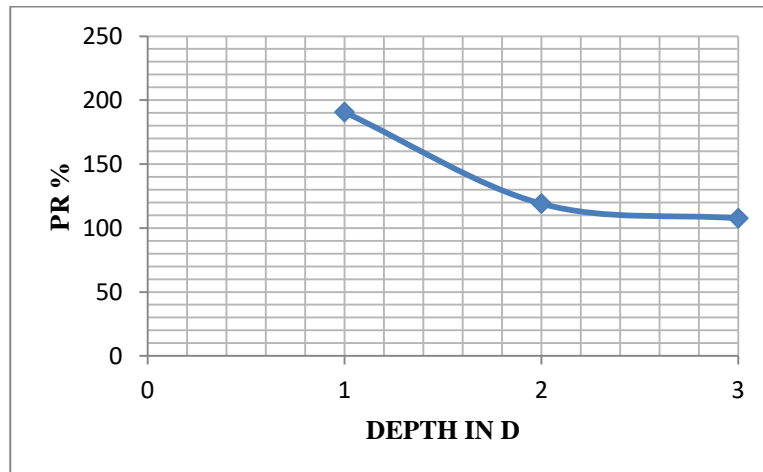


3.1 Effect of depth of placement:

A series of Penetration test were conducted to study the effect of depth of single reinforcement. PET bottle cell were placed at 1D, 2D, 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	190.62
2D	119.13
3D	107.64



**Fig 9: Variation of PR in PET cell for single layer.**

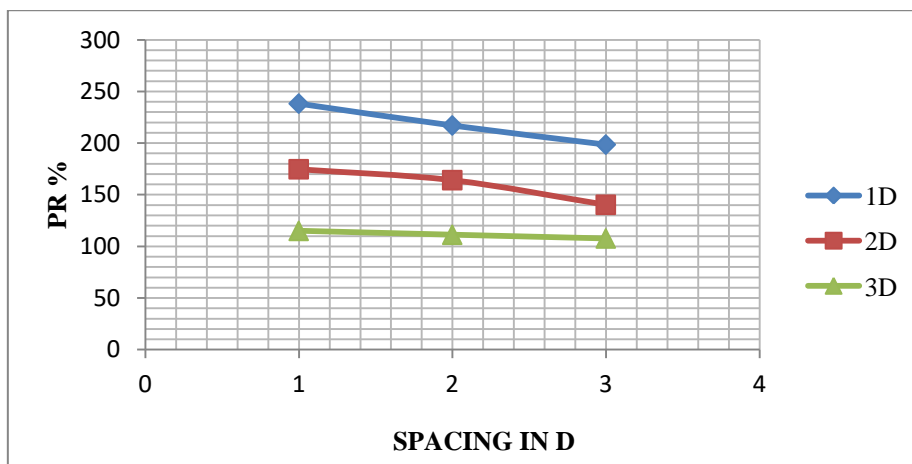
It is observed that there is significant improvement in bearing capacity due to PET cell reinforcement. For PET all the peak improvement is observed for sand reinforced at 1D depth, and the improvement is 1.6 times that of unreinforced sand.

3.2 Effect of spacing of layers:

A series of Penetration tests were conducted on sand reinforced with PET 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 double layer of PET cells. Table 6 shows the PR and maximum load variations of double layer with spacing respectively.

**Table 6: PR values for two layer with spacing**

DEPTH	SPACING	PR%
1D	1D	238.27
	2D	217.09
	3D	198.56
2D	1D	174.7
	2D	164.14
	3D	140.31
3D	1D	115
	2D	111.27
	3D	107.67



**Fig 10: Variation of PR in PET cell for double layer with spacing**

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 it is 2 times that of unreinforced condition.

### V. CONCLUSION

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

Based on 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 PET cell and spacing of layers.
- 2) For single layer PET cell reinforcement the peak improvement is observed at 1D depth and the improvement is 1.6 times that of unreinforced sand.
- 3) For double layer PET cell reinforcement the peak improvement is observed at 1D depth with 1D spacing and the improvement is 2 times that of unreinforced sand.
- 5) The penetration ratio is maximum at double layer.



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