Performance Evaluation of Sandy Soil by Using Waste Plastic Cups As Reinforcement

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Abstract— Engineers from the past have endeavoured to find solution to many soil-related distresses such as settlement, slope failures, slides, and soil erosion. Reinforcement of soils can be done with different type of fibres, e.g. with natural material like Jute, Sisal, coir, palm etc. and synthetic material like as polypropylene, glass, nylon etc. Development of Geosynthetics over the years helped technologists in manufacturing various types of textiles to tackle from such kind of problems. This paper focused on use of waste plastic cup as reinforcement between the layers of a soil mass to increase bearing capacity of the soil. It had been used to improve engineering behaviour of soil mass and their results been reviewed. The main objective of soil reinforcement is to increase bearing capacity, improve stability, decrease settlement and lateral deformation under a square footing. The laboratory plate load test is performed and comparison is done of unreinforced sand and reinforced sand by the help of waste plastic cups. This study involves the investigation of the effect of waste plastic cups on sand for which a series laboratory plate load test have been performed with varying depth of placement, and varying the number of layers of waste plastic to increase the bearing capacity of sand and calculating the viii improvement factor of the sand. The laboratory test tank sand bed is prepared by soil rainfall technique and the size of test tank is taken as five times the width of the mild steel plate of size 200mm*200mm*20mm The size of test tank is 1000mm *1000mm *1000mm. It has been found that the ultimate bearing capacity of sand is increased upto depth 5 cm after that it decreases is increment in bearing capacity of sand reinforced with waste plastic cups twice in comparison to the unreinforced sand.

Keywords: Sandy Soil, Waste Plastic Cups, Reinforcement

I. INTRODUCTION

At present due to the rapid development of infrastructures in the metro cities the soil reinforcement become a prime issue of concern to strengthen the soil properties to bear the load which is transferred by the infrastructure e.g. roadways, building, bridges, embankments etc. Some technique of ground improvement is soil removal and replacement, soil compaction, precompression and consolidation, grouting and injection, chemical stabilization, geotextile and geomembrane. The purpose of these techniques is to increase the strength of soil and reduce the settlement to a considerable extent. Soil reinforcement can also be done by the use of waste plastic cups as it provide the confinement to the soil due to which the bearing capacity of sand is improved, and hence provide the strength and reinforcement to the soil. As the plastic products have become a basic need in our day to day life hence it is produced at large rate worldwide and globally in a year the waste plastic production crosses 150 million tonnes. Per year Central Pollution Control Board (CPCB), India (Times of India, April 30 2015) has conducted survey in 60 cities of India, the amount of plastic waste generated is estimated to be 15,342.6 tonnes per day (TPD) which is approximately 5.6 million tonnes per annum(TPA) while more the 6000 tonnes remains uncollected and littered The use of waste plastic cups, polyethylene bags etc is increasing at an alarming rate and almost every plastic is non-biodegradable and unfit for incineration because they emit harmful gases .In 2005 Mumbai city flood was basically due to choking of drains by plastic waste material that is thrown by the people. This is the best example that how the waste plastic garbage creates problems in our lives. So, there is a need to use these waste plastic properly. Plastic cups that is also used in marriages parties, daily life is thrown after used but these can be reuse to strengthen the soil and increase the bearing capacity of sand as it will provide confinement to the soil and improves strength And also this is one of the way to recycle the waste in meaningful, efficient, cost effective Also waste plastic can be used as an alternative to other expensive material such as cement, lime etc. If the design maximum load a soil is not able to bear then the properties of soil can be enhanced by soil reinforcement.

Soil reinforcement can also be achieved by using waste plastic cups for improving subgrade and stability of earth embankments. This technique can be effectively used to meet the challenges of society and to reduce the quantity of waste plastic that lead to ecofriendly safe environment. Generally the waste that plastic include Poly- ethylene Terephthalate (PET), High Density Polyethylene (HDPE), Low Density Polyethylene (LDPE), Poly Vinyl Chloride (PVC), Poly Propylene (PP) and Polystyrene (PS). In this study, PET plastic bottle strips are used to improve the engineering Properties of soil. The results obtained from the testing programme suggested that addition of waste plastic cups in sand provides an increase in bearing capacity of soil and decrease in settlement. The bearing capacity improvement factors is identified by plotting the graph between stress and settlement and bearing capacity is determined for unreinforced sand and for reinforced sand by waste plastic cups. The effect of depth of placement of waste plastic cups, and number of layer of waste plastic cups on bearing capacity of sand used is been calculated.

In this paper waste plastic cup is used for the laboratory plate load test to provide improved bearing capacity of sand. There are various parameters which determine the bearing capacity and settlement of a unreinforced and sand reinforced by waste plastic cups Laboratory plate load test on a test plate of size 200mm x 200mm x 20mm in size. Plate Load Test was conducted in the Laboratory on prepared test bed of sand. The tests were conducted on unreinforced sand beds and the plastic cup reinforced sand beds.

A. Need of Study

Due to rapid development and scarcity of land has made it necessary to provide strength in situations where loose soils are found and also the waste plastic been generated in a large scale. Their use as reinforcement for weak soils to improve its strength is a way of recycling these materials in a meaningful, efficient and cost effective manner. Also, waste plastic can be used in soil improvement as a replacement for other expensive admixtures like cement, lime etc. as plastic is a cheaper alternative. As per the study by Modak et al. (2012), if locally available soil is inadequate to support design maximum loads, the properties can be improved by soil reinforcement techniques. So, the use of waste plastic cups can be a good idea for reinforcement of soil.

B. Objectives of the Study

The following broad objectives are set:

1) To study the effect of depth of placement of waste plastic cups on bearing capacity of sand.
2) To study the effect of number of layers of waste plastic cups on bearing capacity of sand.
3) To obtain the optimum depth of waste plastic cups to get the maximum bearing capacity.
4) To obtain the optimum number of layers of waste plastic cups to get the maximum bearing capacity.

II. LITERATURE REVIEW

Soil reinforcement is a technique used to improve the stiffness and strength of soil. Availability of different material and techniques for reinforcement is one of the major reasons for the continuous increase in the application of the reinforcement of soil. Use of reinforcement by using different forms of Geosynthetic is a traditional way of soil reinforcement. Ease in the construction, overall economy, less time consuming etc. are the advantages because of which soil reinforcement is popular worldwide (Dash et al. 2003). Planar reinforcement has been used in different construction like; foundation, roads, and in walls from the past few decades (Binquet and lee 1975, Guido et al. 1986, Khing et al. 1993, Htamai et al. 2001, Leonard et al. 2002). T.G Sitharam et.al (2014*)* studied the use of Bamboo in Soft-Ground Engineering and its Performance comparison with Geosynthetic, for that laboratory plate load test isperformed. Reinforcing the soil with 3D reinforcement system such as geocell and bamboo cells yields maximum benefit than the planar reinforcements such as geogrid and bamboo grids. The tensile strength of bamboo is approximately nine times higher than that of the commercial geocell material. *G. Madhavi Latha et al (2009)* studied the effect of reinforcement form on bearing capacity of square footings on sand. The conclusion drawn is relative performance of reinforcement (i.e. geocell, planar layers and randomly distributed mesh elements) in improving bearing capacity and reducing deformation of square footing resting on sand bed is studied, through numerical and experimental studies. u-depth of placement, d-diameter of geocell, h-height of geocell layer. The optimum placement criteria- u/B=0.05, h/B=0.6, b/B=5.93, d/B=0.55. The reinforcement provided in the form of randomly distributed mesh is inferior to planar or geocell because of the reduction in the overall Confinement effect due to small size opening. *Sujit Kumar Dash(2018)* studied the geocell reinforcement for performance improvement of vertical plate anchors in sand. The conclusion drawn from it is the optimum length of the geocell reinforcement is about 5 times the anchor height and the increase in performance improvement with an increase in width of the geocell mattress is significant only up to bgc/ha = 3(width of geocell-bgc, the height of anchor-ha). With an increase in height of geocell(hgc) strain in geocell is reduced. *Arghadeep Biswas & A. Murali Krishna(2017)* They review the geocell-reinforced foundation systems. The design and behavior of geocell-reinforced systems are depended on subgrade strength. The initial selection of geocell-geometry (height, width, pocket-size etc.) has to be as per type and/or quantity of improvement required and available subgrade strength. *Abbas (2018)*

He examined the effect of inclined load on strip footing on reinforced sandy soil utilizing exploratory model. A total number of 48 plate load test were conducted, eight tests were without reinforcement and remaining with the reinforcement of geogrid. The effect of the load inclination angle (α), number of geogrid layers (N) and the relative density (RD) on the bearing capacity, settlement and horizontal displacement were examined. From experimental result there is significant increase in bearing capacity using geogrid reinforcement, bearing capacity increased with increasing no. of layers attaining an optimum value of N=4-5 along with decrease in horizontal displacement of footing.

III. METHODOLOGY

To achieve the above objectives, experimental studies are carried out in laboratory. Plateload test will be conducted in an existing test tank cum loading apparatus. The dimensions of test tank: length, 1000 mm; width 1000 mm; and height, 1000 mm and a square-shaped mild steel plate of size length, 200 mm; width, 200 mm; and height, 20 mm in size is used as the model footing. The base of the footing is made rough by coating it with a thin layer of sand using epoxy glue. The size of test tank is selected as five times the width of the test plate based on IS: 1888-1982 to reduce the scaling effects. Sand bed is prepared through rainfall technique (pluviation). Above the sand bed, the reinforcements were placed to the full width of the tank. The waste plastic cups were filled with clean sand using pluviation technique to maintain the uniform density. Upon filling the waste plastic cups with the sand, the fill surface was leveled and footing was placed in a predetermined alignment in such a way that the load from the jack would act at the center on the footing.

Footing was loaded with a hand-operated hydraulic jack supported against the selfreacting frame. The load transferred to the footing was measured through pre-calibrated proving ring (1 small division =0.0397 kN). Loads were applied in steps with equal load increments in each step. Settlement was recorded with the help of dial gauges. The size of waste plastic cups used in the experiment is 10cm in height and 5 cm in diameter. The load settlement behaviour being observed for different depth of waste plastic cups and number of layers of waste plastic cups.

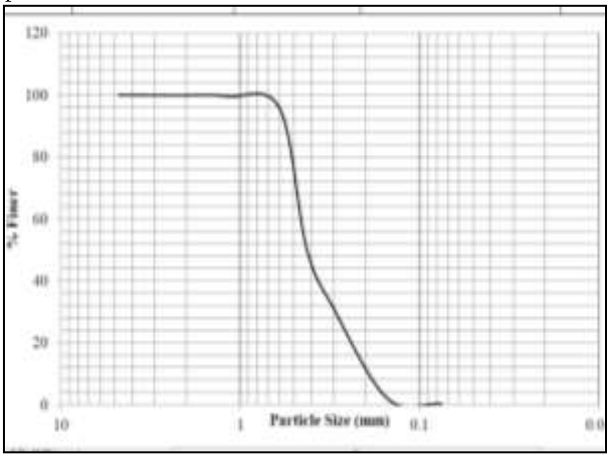

Fig. 3.1: Grain size distribution curve

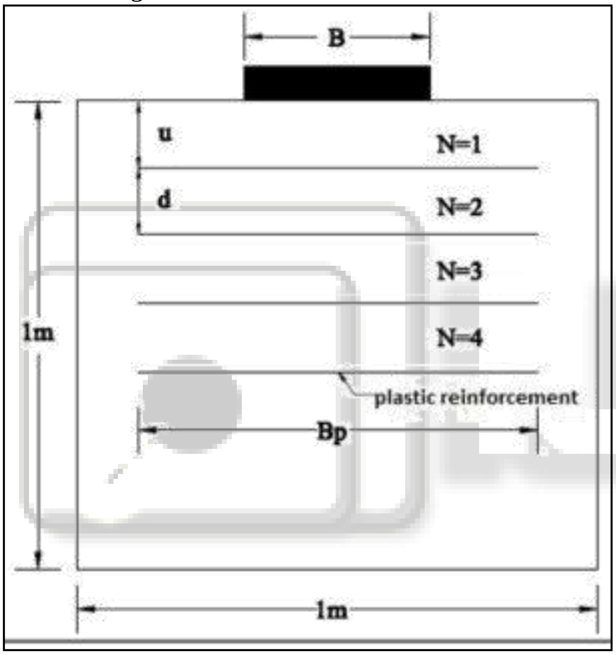

Fig. 3.2: Plastic reinforcement at different depth and number of layer

Fig. 3.3: Testing Setup of laboratory plate load test

IV. RESULTS

From the experiments the stress versus settlement curves has been plotted. Ultimate bearing capacity for each case have been determined from the plotted graphs and a combined graph for reinforced sand by waste plastic cups to the unreinforced sand have been plotted. To find out the bearing capacity of sand tangent method is used because there is not sudden failure of soil at particular load intensity.

A. Test result of unreinforced sand bed

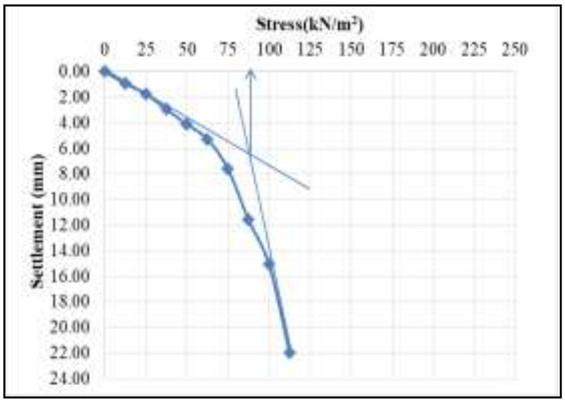

Fig. 4.1: Effect of load intensity on settlement without using waste plastic cups from the 200 mm square plate footing

B. Test result of reinforced sand bed at a depth of 5 cm

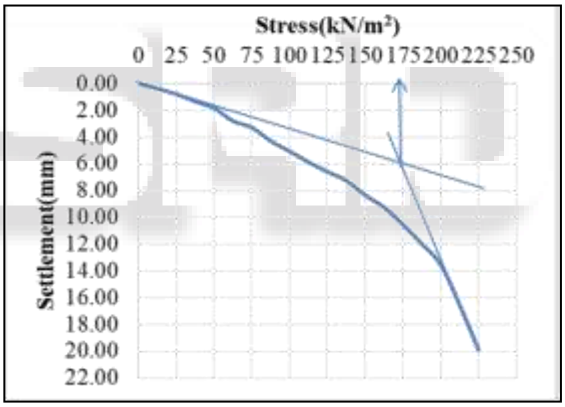

Fig. 4.2: Effect of load intensity on settlement using waste plastic cups at 5 cm depth from the 200 mm square plate footing

C. Test result of reinforced sand bed at a depth of 10 cm

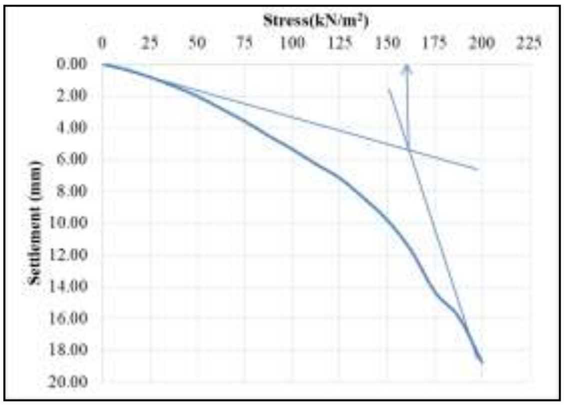

Figure 4.3: Effect of load intensity on settlement using waste plastic cups at 10 cm depth from the 200 mm square plate footing

D. Test result of reinforced sand bed at a depth of 15 cm

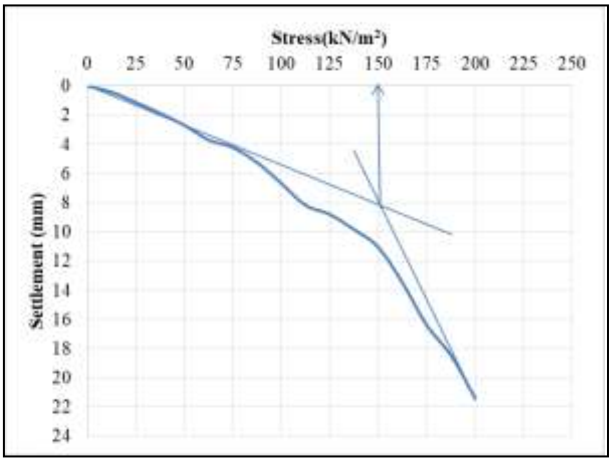

Fig. 4.4: Effect of load intensity on settlement using waste plastic cups at 15 cm depth from the 200 mm square plate footing

E. Test result of reinforced sand bed at a depth of 20 cm

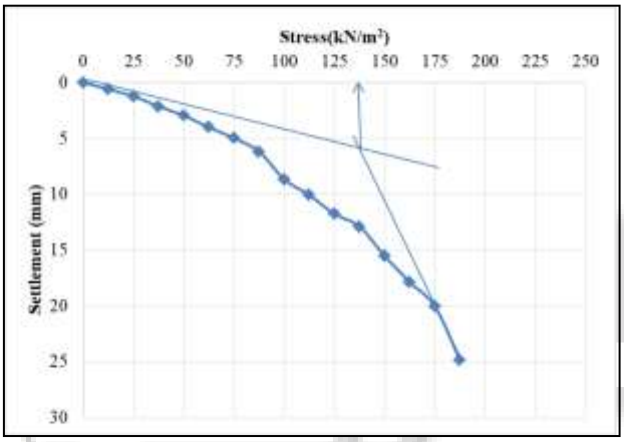

Fig. 4.5: Effect of load intensity on settlement using waste plastic cups at 20 cm depth from the 200 mm square plate footing

V. CONCLUSION

1) It has been found that the ultimate bearing capacity of sand is increased upto depth 5 cm after that it decreases.
2) For constant u/B, the optimum s/B% is 7.5%
3) For constant s/B, the optimum u/B ratio is 0.25.
4) Hence from above results it can be concluded that for maximum improvement factor, the optimum depth is 5 cm.
5) With introduction to the layer of waste plastic cups the bearing capacity is maximum for two number of layer of waste plastic cups and minimum for one layer of waste plastic cups.
6) Based on the results of this study, it is concluded that bearing capacity of unreinforced sand can be improved by reinforcing it with the help of waste plastic cups.

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