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Improvement the Geotechnical Properties of Clayey Soil by Mixing Plastic Waste

Bhagwant Yadav[1], Durgesh Nandan Verma[2], Prakash Singh[3]
[1]Student,[2]Assistant Professor,[3]Assistant Professor.
[1]Student Department of Civil Engineering, Dr K.N. Modi University, Newai, Rajasthan
[2]Assistant Professor, Department of Civil Engineering, Dr K.N. Modi University, Newai, Rajasthan
[3]Assistant Professor, Department of Civil Engineering, Dr K.N. Modi University, Newai, Rajasthan

Abstract: Clayey soil gathered locally and two types of adjusted soil (clayey soil with 10% sand and clayey soil with 10% sand) Separately, 20 percent sand). These soils have been fortified with PET bottles that have been mixed at random. Strips with varying aspect ratios (length/width) of 1, 2, and 3 with a constant width of 5 mm. The strips were combined with 0.5 percent, 1 percent, 1.5 percent, and 2 percent by weight of each aspect ratio soil. The soil's shear strength measurements and consolidation qualities are being improved. The effects of adding PET bottle strips to the mix have been tested in the lab. The classification by conducting normal laboratory tests on soil fortified with PET bottle strips Atterberg's limits, grain size distribution, Proctor's standard test, and unconfined UU triaxial test and compressive strength test According to the findings of this investigation, the ideal In the case of soil compacted with energy, the percentage of PET bottle strip reinforcement is 1%. according to Proctor compaction standard As a result, the compressibility properties of In the laboratory, three different types of soil were combined with 1% PET bottle strips. In order to investigate the impact of increasing the bearing capacity of soil-based footings, Small scale model footing tests were carried out with small scale model footings reinforced with PET bottle strips. 5 cm and 10 cm square footings are available. The experiments were carried out using the original clayey. In the lab, with and without PET bottle strips, soil and two types of modified soils were tested. In the instance of PET bottle strip reinforcements, 1% PET bottle strips were used for various aspects of the tests.

1. INTRODUCTION

Despite some Indian states' bans, the use of plastic products such as polythene bags, bottles, containers, and packaging strips is skyrocketing. As a result, open garbage landfills are filling up with this rich resource on a regular basis. Waste plastic is collected in many regions for recycling and repurposing. The bottled water industry is the world's fastest expanding beverage industry. Recycling plastic garbage generated by the use of water bottles has become a global concern. Because recycling of plastic bottles has not kept up with the rise in sales of virgin resin polyethylene terephthalate (PET), reuse has become important to preserve ecological balance. After shredding with suitable aspect ratio (length to width ratio) and strip content, the best solution to deal with the increasing strain of waste plastic on open landfills is to use it for ground development, particularly for reclaimed land. Furthermore, waste plastic materials can be used to improve soil properties and tackle difficulties linked to waste plastic disposal, which is an environmental concern. The strategies used to increase soil attributes such as strength and other relevant features can be classified into the following groups.
Soil stabilisation with a binding agent is the process of improving the engineering properties of soil by combining a binding agent with the soil particles, such as lime and cement, to bind them together.
Soil stabilisation with continuous planer members/sheets as reinforcement: Under compression, soils are strong, but in tension, they are weak. The introduction of reinforcing materials in the direction of tensile stress improves this soil's weak property. Galvanized or stainless steel strips, bars, grids, or fabrics of specified material, as well as wood polymer and plastic, are commonly used as reinforcement material. The reinforcement is inserted or layered in certain directions and positions, similar to how steel is placed in concrete.
Soil stabilisation using ply soil (randomly mixed fibres/discrete members): Soil stabilisation using ply soil (randomly

mixed fibres/discrete members): Randomly distributed fibres in soil (RDFS) are a new approach that involves adding fibres of a specific type and quantity to the soil, mixing them together, and then laying them down. 'Ply soil' is the name given to the composite substance. As a result, the approach of RDFS preparation is similar to traditional stabilisation techniques. Many investigations have been conducted in this area by many investigators.

Naeini and Sadjadi (2008), Gosavi et al. (2004), Consoli et al. (2005), Dutta and Venkatapparao (2007), Babu and Chouksey (2010) all looked at how fibre reinforcements could improve soil. They discovered that increasing strength parameters led to an increase in residual strength, ductility, and energy absorption capacity in the soil. On the basis of experimental and numerical studies, Chandrasekhar et al. (1998), Basudhar et al. (2007), Sharma et al. (2009), Madhavilatha and Somwanshi (2009), Al-Saidi (2009), Kumar and Kaur (2012) discovered that the use of reinforcements increases the bearing capacity of footings placed on reinforced soil compared to unreinforced soil.

2. LITERATURE REVIEW

Vinod et al. (2009) investigated the influence of braided coir rope reinforcement on load settlement behaviour of square model footings built on loose sand using laboratory model testing. According to the findings of the study, adding braided coir rope reinforcing layer(s) significantly enhanced the load carrying capacity of the model footing at all levels of normalised settlement. The best place for the reinforcement was about 0.4B below the model footing's width B base. When the length of braided coir rope was raised to a length ratio of 3, the strength improvement ratio increased noticeably. When the vertical spacing of reinforcement was reduced, the strength improvement ratio improved practically proportionally. Single and multiple layers of reinforcement could result in a strength enhancement ratio of around 3.4 and 6.6, respectively.The findings of laboratory model tests on the behaviour of a model foundation lying on loose sand reinforced by geogrids under inclined stress were presented by Al-Saidi (2009). Using the geogrid, several parameters were investigated in order to determine the general behaviour of improvement in the soil. The depth of the reinforcement layer, the vertical spacing of reinforcement layers, and the degree of inclination of the load are among these characteristics. The results revealed that the best reinforcement ratio for the first layer is 0.5. Increases in the ratio of vertical spacing layer to footing width greater than one have little effect on soil improvement.Choudhary et al. (2010) conducted a series of CBR experiments on randomly reinforced soil using varied percentages of HDPE of various lengths and proportions. From their research, they came to the following conclusions. The CBR value was enhanced by adding HDPE strips to local sands. When the strip content was 4% and the aspect ratio was 3, the highest improvement in CBR was attained. With more waste plastic strip content and length, the reinforcing benefit increased.Maheshwari et al. (2012) used a series of laboratory model footing experiments to explore the effect of randomly distributed fibres on highly compressible clayey soil. The 0.25 percent, 0.50 percent, and 1.00 percent of polyester fibres with a diameter of 12 mm were used. The findings of load settlement curves on unreinforced soil and soil reinforced with varied amounts and depths of fibre reinforced soil were reported. The findings show that using randomly distributed fibres to strengthen highly compressible clayey soil increased ultimate bearing capacity and decreased ultimate load settlement.

Fiber reinforced soil can be considered as a function of fibre weight fraction, aspect ratio, and surface friction, soil properties (i.e. angle of internal friction), density, and confining stress on shear strength of reinforced soils, according to Rao et al. (2012). Kumar and Kaur (2012) used a total of 93 small scale model footing load experiments to examine the potential benefits of fibre reinforced soil foundations over unreinforced sands subjected to inclined loads. This study looked at the impacts of soil reinforcement (% of fibres), reinforced layer thickness, soil density, and load inclination on certain key parameters such ultimate bearing capacity, vertical settlement, and horizontal deformation. The use of fibre reinforced sand improved the ultimate bearing capacity, vertical settlement, and horizontal deformation of the foundation, according to test results. The dependent variable was anticipated settlement, and the dependent variable was a statistical model based on experimental data for predicting the settlement (Sp) of square footing on reinforced sand at any weight applied (Sp).Ahmadi and Bonab (2012) investigated small-scale physical model tests using both experimental and analytical methods. A series of experiments were carried out with and without reinforcement on the top of the backfill for this purpose. The specimens differed in terms of the number of geotextile layers, the vertical distance between layers, and the distance between the strip footing and the wall. Particle image velocimetry methods were used to investigate soil failure in the bearing capacity step and the backfill shear zones. Analytical methodologies were used to investigate the strip footings' bearing capacity. The findings suggested that reinforcing the top zone of flexible retaining structures would be preferable to leaving it unreinforced. By increasing the number of reinforcement layers, the final bearing capacity and wall deflection might be greatly increased. There was an ideal vertical spacing of the layers when three layers of reinforcement were utilised, at which the bearing capacity was the highest. The results of the experimental models and the analytical solution were found to be in good agreement.

On reinforced stone dust, Mahali and Sinha (2015) conducted a series of California bearing ratio (CBR) experiments. PET strips of three different diameters were employed in this study. The influence of strip content (0.25 percent to 2%), as well as length, on the CBR value of reinforced stone dust was studied. The highest CBR value of a reinforced system was found to be roughly 2.79 times that of an unreinforced system. Kala (2017) investigated the use of waste plastic as a geotechnical material to solve both geotechnical and environmental problems in an experimental setting. It was discovered that adding 4 percent PET bottle plastic waste to the soil sample increased bearing capacity by up to 39.9 kN/m2. In addition, Chandrasekhar et al. (1998), Basudhar et al. (2007), Sharma et al. (2009), Madhavilatha and Somwanshi (2009), Al-Saidi (2009), Kumar and Kaur (2012) discovered that the use of reinforcements increases the bearing capacity of footings placed on reinforced soil compared to unreinforced soil. As a result, it appears that there is need for research into the behaviour of clay combined with randomly distributed plastic fibre obtained from waste PET bottles in order to lessen environmental hazards. In order to improve the strength and stability of soil, waste plastic strips can be mixed with it. In this regard, the current study was conducted to examine the behaviour of clayey soil mixed with waste PET bottle strips. Apart from that, there is still the possibility of determining the bearing capacity of footings using soil that has been enhanced with PET bottle strips. With this in mind, the current study was conducted, with the objectives and scope of work outlined in Chapter 1, to investigate the improvement of soil with PET bottle strips, as well as the effect on footing bearing capacity.

3. MATERIALS AND METHOD

The current investigation looked at the effect of ground improvement through the utilisation of PET bottle strips, and it used three different types of soil to do so. In order to create two additional varieties of soil, in addition to the mostly clayey dirt that was harvested, the soil was also mixed with sand in proportions of 10 percent and 20 percent respectively. The three distinct types of soil each required their own unique formulation, which was accomplished by generating fresh mixtures using PET bottle strips in varied percentages and aspect ratios. This research included three distinct kinds of materials: soil, sand, and strips cut from PET bottles. Their characteristics and properties are discussed in greater depth in the next sections, which are located after this one.

3.1.1 Sand

In this study, all experimental works have been undertaken with one type of locally collected sand. The sand is medium grained unifor2m quarry sand having sub-angular particles of weathered quartzite.

3.1.2 Soil Types Used

For the current investigation collected clayey soil and two types of amended soil (with sand) have been used in this present study. The three types of soil namely S1, S2 and S3 have been identified as follows:

1) Clayey soil (S1).

2) Soil with 90% clayey soil and 10% sand by weight of dry soil (S2).

3) Soil with 80% clayey soil and 20% sand by weight of dry soil (S3).

3.1.3 PET Bottle Strips as Reinforcement

For the present study, plastic strips have been obtained from PET bottles, procured for this purpose. Strips of required sizes of 5 mm × 5 mm, 5 mm × 10 mm and 5 mm × 15 mm with aspect ratios of 1, 2 and 3 have been prepared by cutting the PET bottles. These strips have been used as reinforcement. The content of PET bottle strips has been varied with 0.5%, 29 1.0%, 1.5% and 2.0% to study the effect of the variation of content with different proportion of the soil-reinforcement mixes. Typical waste PET bottle strips are shown in Fig. 3.1.

Fig. 3.1: PET bottle strips

Fig. 3.2: Samples after failure at different confining pressures

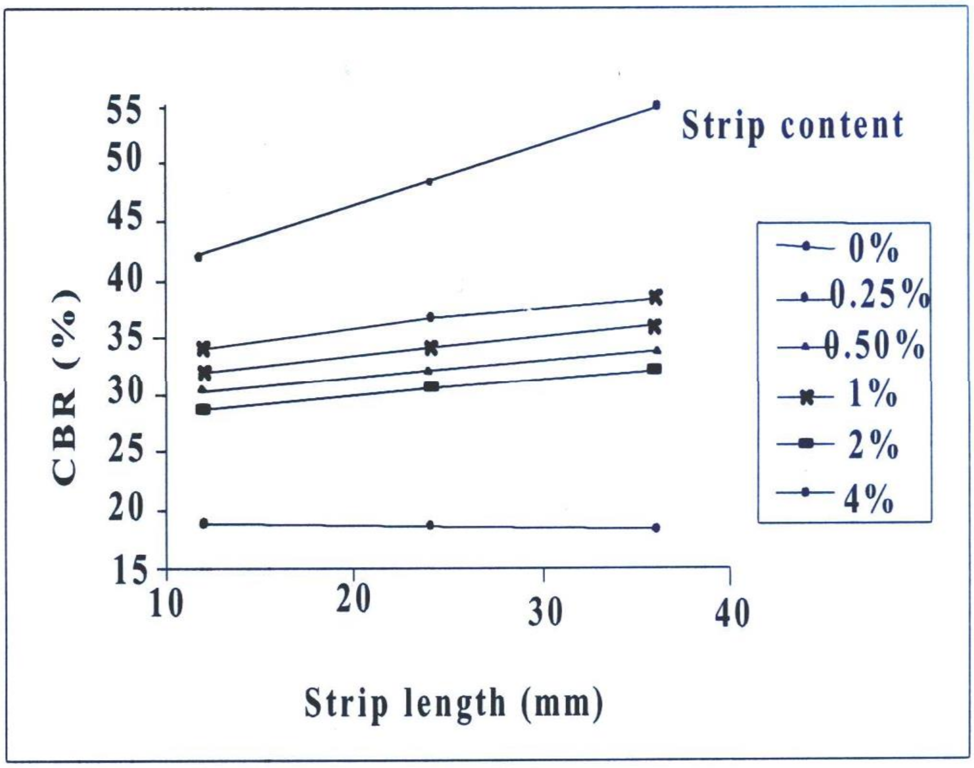

Fig 3.3 CBR versus. strip length (2.7) (Choudhary et al., 2010)

4. RESULTS AND DISCUSSION

This section attempts to investigate the impact of PET bottle strip reinforcements on the ultimate bearing capacity of footings based on the findings from experimental inquiry and numerical analysis. As a result of experiments and the output of the PLAXIS 3D programme, load-settlement curves for footings with dimensions of 5 cm x 5 cm and 10 cm x 10 cm have been provided earlier in Chapter. Since it can be seen that curves derived by experimentation and mathematics exhibit a constantly curved tendency, the ultimate loads have been deduced from these curves using the double tangent approach. From the curves, it can be shown that the ultimate load borne by soil reinforced with PET bottle strips is highest for strip content of 1% and aspect ratio 2 compared to that of all other mixes, both for experimental and numerical examples, for both sizes of the footings. The experimental and numerical values of the ultimate bearing capacities for square footings with dimensions of 5 cm and 10 cm are shown in Table 6.1. For 5 cm and 10 cm square footings, the values were 442 kg and 1740 kg, respectively, as determined by trials with 1% strip content and aspect ratio 2. On the other hand, 395 kg and 1605 kg, respectively, were the results of a numerical analysis for square footings of 5 cm and 10 cm. Despite the fact that the equivalent values for aspect ratios 1 and 3 were lower than those for aspect ratio 2, they were greater than the corresponding values for the comparable unreinforced soil types. The early nature of load-settlement curves derived from experimental and numerical data coincide within a tolerable range of fluctuation, as can also be observed. Additionally, it is obvious that the experimental results exceed the relevant numerical value. For 5 cm and 10 cm footing sizes, respectively, they differ on average by 12.72% and 9.29%. As the amount of fibre in the soil increased, it was discovered that the bearing capacity of the soil increased initially in both cases, for square footing widths of 5 cm and 10 cm. The tests were carried out for fibre contents of 0.5%, 1%, 1.5%, and 2%, with the best result obtained for 1% fibre concentration. Following, it was discovered that the bearing capabilities decreased for fibre concentration larger than 1%. The S1, S2, and S3 soil types all showed the same variance. The ultimate bearing capacities for soil types S1, S2, and S3 were determined to be 16.064 kg/cm2, 18.263 kg/cm2, and 22.242 kg/cm2 for widths corresponding to 5 cm and 16.194 kg/cm2, 18.134 kg/cm2, and 22.261 kg/cm2 for widths corresponding to 10 cm, respectively, for aspect ratio of 2 and fibre content of 1%.

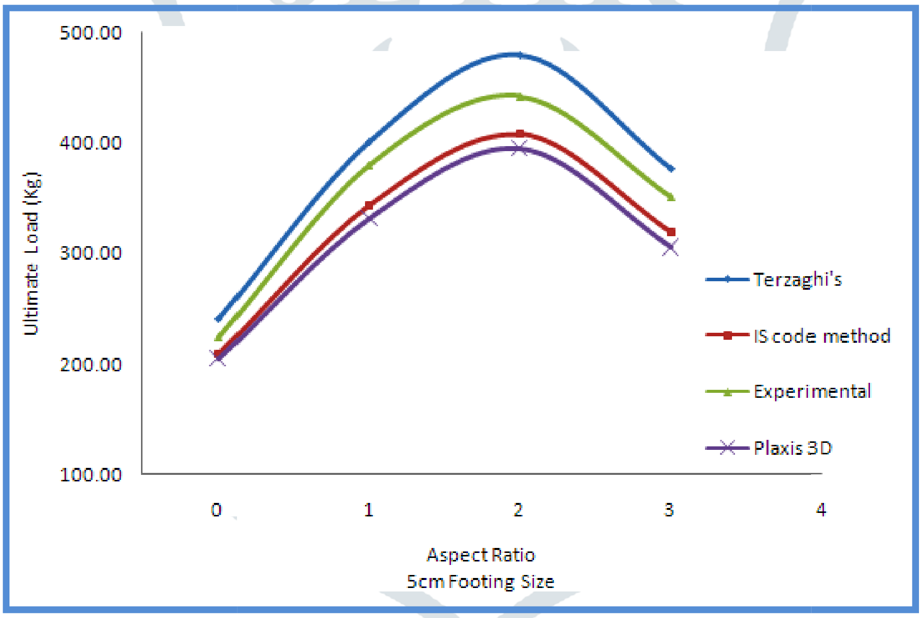

Fig.4: Variation of Ultimate loads with aspect ratio for various analyses

5. CONCLUSION

With the advancement of civilization and industrialization, there is an increasing lack of land with a significant bearing capacity for the construction of structures. In addition, there are a lot of waste products that have been dumped globally as a result of human activity. PET bottles are one type of garbage that people use and discard. Recycling this could lessen environmental risks and facilitate building on unstable ground. It also seems that there is room for research into how clay behaves when mixed with randomly arranged plastic fibre from used PET bottles, which can be recycled to lessen environmental hazards. Soil can therefore be mixed with waste plastic strips to strengthen and stabilise the soil.

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