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Investigation on Clay Soil Stabilization using Plastic Powder

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Abstract

A huge amount of black cotton soil or clayey soil is available all around the world which leads to a waste of land for construction uses, since it has expansiveness, swelling and shrinkage properties etc. So we have tried to resolve this problem by stabilizing the black cotton soil by waste material marble powder. This study impact with the effect of PP (PP) on expansive soil by conducting the laboratory tests like Atterberg's limit, compaction characteristics, unconfined compressive strength (UCC), California bearing ratio (CBR), and free swell index (FSI) etc. were studied. All the laboratory tests are performed on soil with or without stabilizing material as per IS 2720 code's specification. The test results show that Atterber's limit, optimum moisture content and free swell index value were decreased with every increment of 2% of PP into the soil up to 8%. Also, the maximum dry density, unconfined compressive strength and California bearing ratio values were increased with every increment of 2% of PP into the soil up to 8%. So, this stabilizer (PP) can be used for construction works in an effective manner.

Keywords: *Black cotton soil, clayey soil, plastic powder, stabilizing*

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INTRODUCTION

In Tamil Nadu, about 40–50% of the soil deposited is clay soil, since it is an agricultural area. The major issue in this region is that there is a lot of scarcity of land because of its industrial development. So, we are in urgent need to use these lands for construction work. The major problem in using the expansive soil in construction work is, when water comes into contact, then they cause swelling and when water content decreases shrinkage occurs in the soil [1]. Because of this reason it will not be used in foundation. For many years it was common practice to remove unsuitable soil and replace it with new material. However this is an increasingly costly approach and construction companies are also under increasing pressure to use more sustainable construction methods [2]. Soil stabilization is a well-established technique for use on difficult construction sites. Weak clay soils are stabilized by renovating specially formulated stabilizing materials into the soil [3].

Plastics themselves contribute to approximately 10% of discarded waste in lands, oceans etc. It can release harmful chemicals into the surrounding soil, which can then seep into groundwater or other surrounding water sources and also the ecosystem. Landfill areas contain many different types of plastics; when biodegradable plastics are broken down, methane is released, which is a very powerful greenhouse gas that contributes significantly to global warming. Throughout the world, we are facing the big question on how and where to dump these waste materials. So, a lot of study and research work has been put in, to find resourceful, eco friendly and long lasting ways to use these waste materials in various engineering fields [1]. In geotechnical engineering, soil stabilization or other methods are required when a given site does not have suitable engineering properties to support the structures, roads and foundations in a safe manner. Here, the plastic wastes are made in a powder form and it can be effectively used in the soil stabilization. These processes enable contractors to maximize the use of all site materials and obtain the properties that they need without removing unsuitable material from site and importing aggregates, reducing overall cost, as well as waste, transport movements and carbon emissions, etc.

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MATERIALS AND METHODS

Soil

Soil was collected from Sakkarakottai, Ramanathapuram city. Since, a huge volume of BC soils is present in that area; the cracks are induced in the road because of its variation of seasonal moisture content in the soil. The values of soil properties were determined by IS 2720 code provision, as shown in Table 1 and the grain size distribution of soil is shown in Figure 1. There is need for improvement of this type of soil due to development of infrastructural facility in these areas.

Plastic Powder (PP)

After studying the literatures on soil stabilization using various additives, it has been decided to choose the PP (PP) as best suitable additive with expansive soil for stabilization. The main reasons for choosing these materials are: they are economical, they have disposal problem since they are waste products and also they are locally available materials. The plastic waste was purchased from Shanthi Plastics, Madurai.

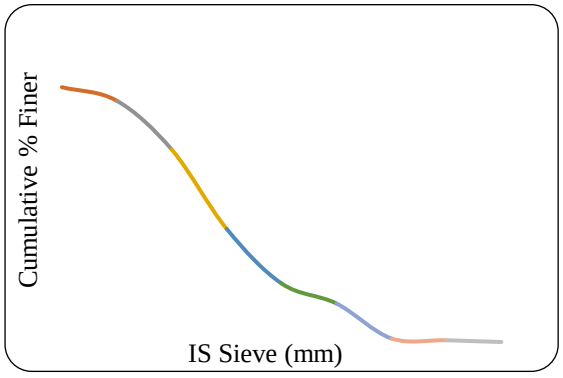
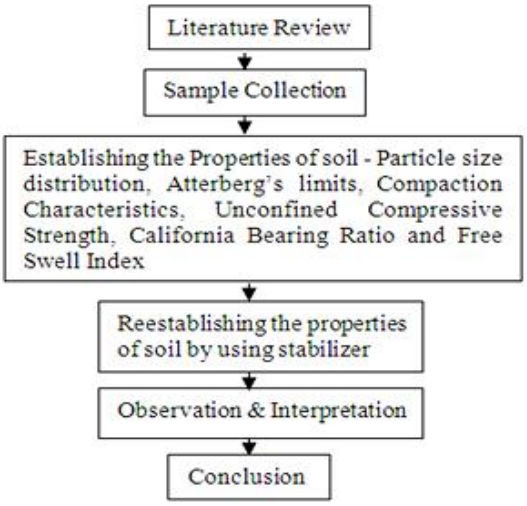


Fig. 1: *Grain Size Distribution Curve for Clay Soil.*

Table 1: *Properties of Expansive Soil.*

Characteristics	Description
Grain size Analysis ○ Sand content (%) ○ Silt content (%) ○ Clay content (%)	 85 14.3 0.7
Specific Gravity	2.55
Atterberg's Limit ○ Liquid Limit (%) ○ Plastic Limit (%) ○ Plasticity Index (%)	 64 30 34
Compaction Characteristics ○ Maximum Dry Density (MDD) in kN/m^3 ○ Optimum Moisture Content (OMC) in %	 16.33 25
Unconfined Compressive Strength (UCS) in kN/m^2	74
California Bearing Ratio (CBR)	1.73
Free Swell Index (%)	66.25
Color	Black

Methodology



Experimental Program

The above soil properties were studied by using various percentages of PP by 0 to 10% at an increment of 2%. All tests are conducted as per IS 2720 code specifications.

RESULTS AND DISCUSSIONS

Atterberg Limits

The results of liquid limit (LL), plastic limit (PL) and plasticity index (PI) on expansive soil treated with different percentage of PP are shown in Figure 2. In this graph, the LL, PL and PI of soil goes on decreasing with every increment of 2% PP up to 8%, after these values are increased. The reduction of plasticity index was an indication of improvement of soil property (i.e., the strength and workability of soil will be high as compared to normal expansive soil) [5].

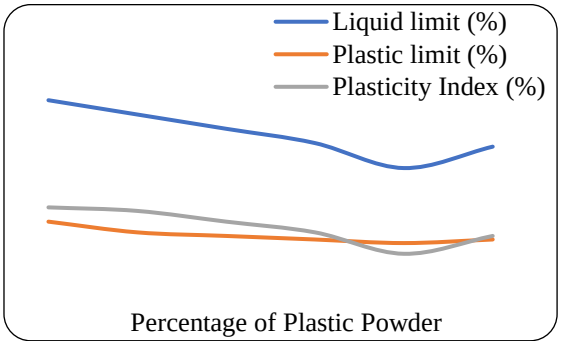


Fig. 2: *Atterberg's Limit of Soil with Different Percentage of PP.*

Compaction Characteristics

The results of modified proctor compaction test results are shown in Figure 3 in terms of maximum dry density and optimum moisture content. The addition of PP in clayey soil increased the maximum dry density of the soil and decreased the corresponding moisture content values up to 8% after that the results are inversed. OMC decreases; may be due to the negligible water absorption capacity of the PP [4, 5].

Unconfined Compressive Strength

From the value of unconfined compressive strength test result, up to 8% addition of PP to the soil caused UCS value to increase and a sudden decrease was observed at 10% addition of PP to the soil. The decrease in the UCS values was attributable to excess PP that occupies spaces within the soil to form weak bonds between the soil and the cementitious compounds formed by reaction [4].

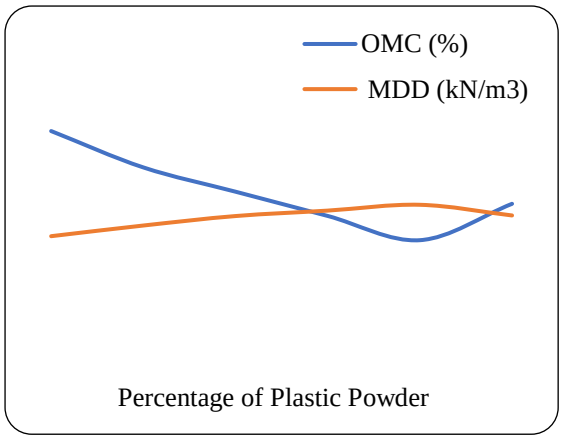


Fig. 3: *Compaction Characteristics of Soil with Different Percentage of PP.*

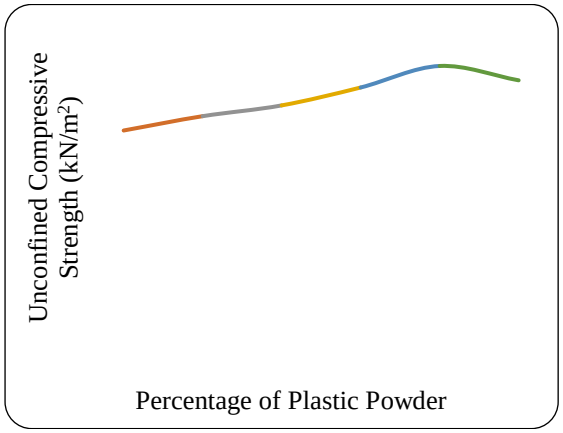


Fig. 4: *Unconfined Compressive Strength of Soil with Different Percentage of PP.*

California Bearing Ratio

The test result shows that, the CBR value of unstabilized soil is 1.73%. This value increases to 2.98, 3.07, 3.24 and 3.78% due to addition of 2, 4, 6 and 8% PP respectively, and after that CBR was decreasing with addition of 10% of PP in soil. This is shown in Figure 5.

Free Swell Index

The Figure 6 shows the free swell index for soil by using different percentages of PP stabilizer. From the figure it is clearly understood that the swelling value is reducing up to 8% and after that it is increasing; from which it can be concluded that PP is a perfect stabilizer to reduce swelling. Higher the FSR; more is the risk of expansion and shrinking of the soil and the addition of PP as a stabilizer in such soils may off-set or reduce this risk [6].

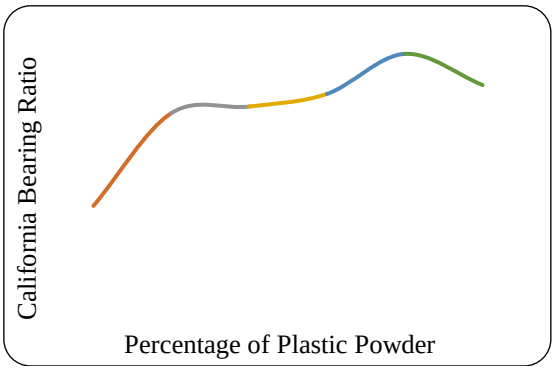


Fig. 5: *California Bearing Ratio for Soil with Different Percentage of PP.*

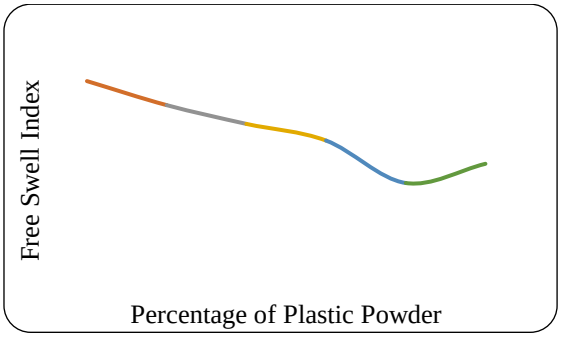


Fig. 6: *Free Swell Index for Soil with Different Percentage of PP.*

CONCLUSION

The following conclusions were made from the experimental study:

1. We can utilize the plastic waste as a useful soil stabilizing material; by using this material we can minimize the waste disposal problem.

2. The optimum usage of plastic powder added to the soil was 8%.
3. This plastic powder is suitable in many geotechnical applications.

Further study is going on for permeability of soil.

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