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Optimization of Clay Soil Stabilization using Waste Plastic Powder

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Abstract*: *Usage of plastic products, including polythene sacks, cans, containers and packages, etc., is growing every day. It further raises the quantity of plastic material waste. This contributes to numerous issues with the environment and climate. For several decades much of the waste generated today will linger in the atmosphere, posing a number of environmental problems. herefore, excess will be utilized successfully in any sector of technological advancement. Many by-products are being produced using the plastic wastes. By adding plastic wastes to the clay soil, we have to know about the changes in the strengths like California bearing ratio, free swell index, and Unconfined Compression test. The soil collected for the investigation is from the southern district of Tamilnadu, India. The different percentage of plastic powder was replaced to improve the soil property.

Keywords* : *Plastic wastes, Environmental concern, Clay soil, Stabilization

I. INTRODUCTION

Clay soils have wide found in Bombay, the western part of Madhya Pradesh, part of Gujarat, and in some parts of Tamil Nadu. Here, a large area is occupied by soils derived from the Deccan trap. Clay soil take in water heavily, swell, become soft and lose strength. These soils are capable of readily compressible when wet and propensity to hoist during wet conditions [1-3]. Clay soil shrinks in volume and develops fracture during summer. They are represent by utmost hardness and cracks during dry. These properties make them poor foundation soils and earth construction material. Subgrade and embankment have a major impact on the quality and efficiency of the pavements, as they act as foundation for the pavements. The essence of the soils is well known to establish a strong and long-lasting road network in clay soil regions. Adequate construction techniques and dynamic construction approaches will be implemented on these soils. [4].

Primary soil factions in Indian soils are inorganic clays of average to high compressibility. Clay soil contains large quantity of montmorillonite mineral in the whole clay soil structure and appears blackish-grey in color. Due to its large swelling and shrinkage property is problem to geotechnical and highway engineers [5,6]. The earth is quite rigid when it is dry, but lacks stability when it is wet. The moisture and dried cycle leads to vertical displacement of the ground mass and leads to a settlement, extreme depression, cracking and uniformity failure of a pavement. This often shapes clods which are not readily pulverized for road construction use. This presents severe difficulties with the road construction. In the upper layers of the plot the weakened subgrade tends to increase, particularly when there are several vacuums in the foundation. The incremental infiltration of the soil with damp clay often contributes to a path collapse. Some of the factors which influence the behavior of these expansive soils are initial moisture content, initial dry density, amount and type of clay, Atterberg limits of the soil, California bearing ratio and swell potential [7-9].

Fig 1 shrinkage in summer and swelling in rainy

Stabilization of soil is the method of changing some soil characteristics by various techniques such as mechanically or chemically to enhance the soil particles that has all the coveted engineering properties. Soils are commonly stabilized to improve their stability and durability or to stop disintegration and dust accumulation in soils. Soil property is different from one place to another place and also different for the same place [10-12]. Different technique are used to stabilize soil and until deployment on the earth, the process should be tested in the laboratory with the dirt.. The principles of stabilizations are

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- Analysis of land characteristics in the region under research.
- Determine the soil property that requires adjustment in order to obtain the design benefit and choose the appropriate and inexpensive stabilization process.
- Tester of the sample for consistency and longevity of the stabilized soil mix in the laboratory.

It is superior to fuse distinct variety of soil to increase the strength of the soil. It is high costly to change the secondary soil with whole soil. The different soil characteristics such as bearing capacity, shear strength, drainage, etc. can be increased by mixing with plastic powder wastes.

- For construction in the field of clay soil of a strong and safe road network.
- Plastic bags are hard and expensive to recycle and most are contained in places where photodegradation takes over 300 years.
- All these incidents have contributed to studies to assess adolescents' awareness and role on environmental risks from plastic waste mismanagement [13-16].

II. SOIL PROPERTIES

A. Atterberg Limits

- **Shrinkage Limit:** This limit is determinate when the volume of soil does not reduced during the loss of water. It also briefed as the lowest moisture content at which the soil can still be fully saturated. It is denoted by W_S [17].
- **Plastic Limit:** This limit available betwixt the plastic and semi-solid state of the soil. It is found by rolling the soil a thread of 3 mm without break of the soil on a flat surface.. The plastic limit is denoted by W_P [18].
- **Liquid Limit:** Moisture contents of the soil betwixt the liquid state and the plastic state of the soil. It is as the lowest moisture content at which the soil have minimum shear strength . It is measured by the Casagrand's apparatus and is denoted by W_L.

B. Particle Size Distribution

Soil at any place consist of different size of the particle from fine size to large size particle of all size distributed in a single located sample. The dissemination of particles of various sizes estimates many physical characteristic of the soil such as its strength, permeability, density, etc. Particle size distribution is determined using two techniques, first is sieve analysis is used to for coarse-grained soils only and the second technique is done for fine-grained soil. Above twain are pursue by drafting the values on a semi-log graph. The percentage finer N as the ordinate and the particle diameter i.e. sieve size as the abscissa on a logarithmic scale. The resulting curve offers us an overview into the form and soil grade. If the curve is on the left side and higher up, indicate that he soil contains more fine particle; if the curve it is bends to the right side , we can deduce that the soil contain higher coarse particles. In the field soil is primarily two kinds- uniformly graded and well graded Well graded soils contain the soil particle of all size in most even distribution. In the uniformly graded soil the particle size of soil is more common and some size is may left in the soil. Rare case the curve looks flat indicate that some particular size of the particle is absent in the soil is called as gap graded or skip graded [19].

C. Specific Gravity

Specific gravity of the soil is the density of the soil is higher than the number of folds with density of the standard liquid. It is also defined as the ratio of the mass of any substance of a definite volume to the mass of an equal volume of water [19].

D. Unconfined compression test (UCC test)

Unconfined compressive strength is estimated using the tri-axial test. In the tri-axial test confining stress is zero and subjected to vertical force only. The cylindrical specimen is loaded still the shear failure occur [20,21].

III. MATERIALS AND METHOD

A. Clay soil

Clay soil is collected from Kilakarai to Sayalkudi, Tamilnadu, India which is used for our present study.

B. Plastic waste powder

Fig 2 Waste Plastic Powder

Plastic waste powder (PP) used was obtained as crushing waste powder from RK enterprises, Tirunelveli district, Tamilnadu, India. The quantities and properties of Plastic powder produced bet on large processing aspects and characteristics of the taking in to the manufacturing process. Since the concentrations of the relative constituent in plastic powder will differ considerably, Plastic powder consists of some physical properties that are comparatively consistent [22-24].

C. Experimental investigation

The experimental work consists of the following steps:

- Specific gravity of soil
- Determination of soil index properties (Atterberg Limits)
  - Liquid limit (LL) by Casagrande's apparatus
  - Plastic limit (PL)
- Particle size distribution by sieve analysis
- Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test
- Determination of the shear strength by:
  - Unconfined compression test (UCC)
  - California Bearing Ratio (CBR)
- Free Swell Index (FSI) [25-30]

IV. RESULT AND DISCUSSION

Specific gravity

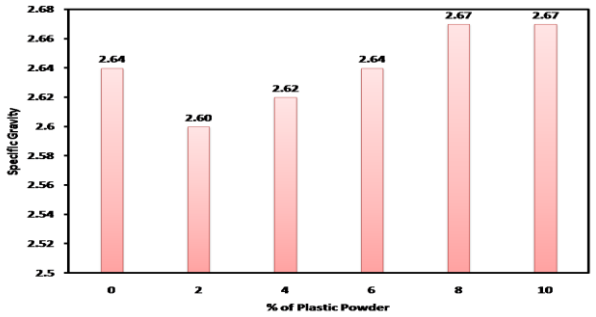


Fig 3 Specific Gravity of PP

Average specific gravity G=2.67. Figure 3 shows, by adding the plastic powder from 2 to 10 % the specific gravity of the soil is an increase from 2.60 to 2.67. The increase of addition of plastic powder the specific gravity of the soil is identified with the mild change of specific gravity. The increase of specific gravity is due to the density of the plastic powder is slightly more than the water.

Particle size distribution (sieve analysis)

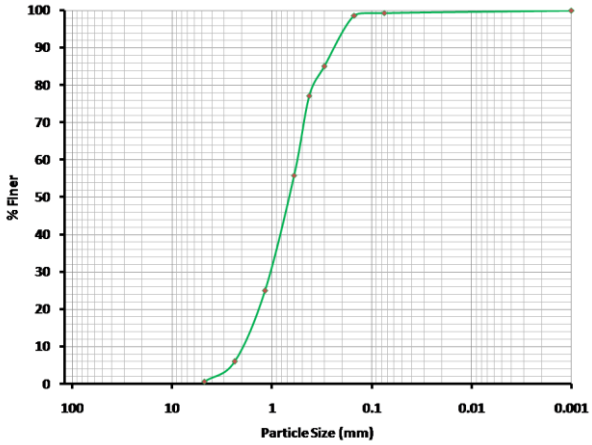


Fig 3 Particle Distribution Curve of PP

From Figure 4, we get the Uniformity coefficient (C_u) = 2.36 (C_u must be greater than 4 for gravel and 6 for sand). Coefficient of curvature (C_c) = 0.816 (C_c = 1-3 for well-graded soil). So it is poorly graded clay soil.

Index properties

Liquid limit (LL)

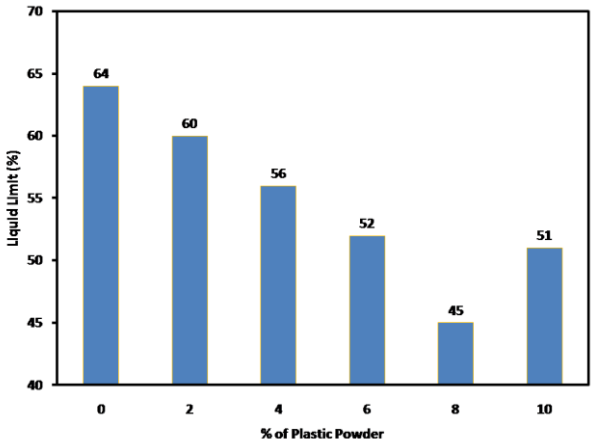


Fig 4 Liquid limit of PP

The value of LL in clay soil mixed with various percentages of plastic powder waste shown in Figure 4. The clay has the property to absorb plenty amount of water towards it and then swell. By adding the 2 to 10 % of plastic powder waste the LL drastically fall. From the graph, it is clear that higher the percentage of plastic powder will lead to decreasing the LL of soil.

Plastic limit (PL)

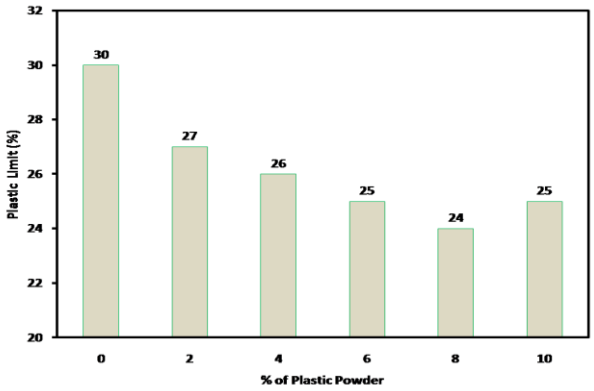


Fig 5 Plastic limit of PP

The values of PL in clay soil reinforced with various percentages of plastic powder are shown in the graph. From Figure 5 it shows that with higher the percentage of plastic powder brings the PL of soil fall down. The plastic limit of the soil increases from 30 to 24% with an increase in plastic powder up to 8%.

Plasticity index (PI)

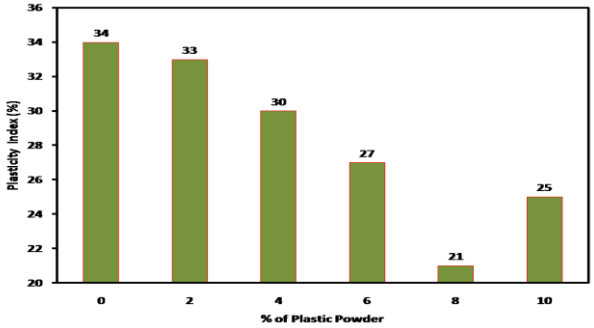
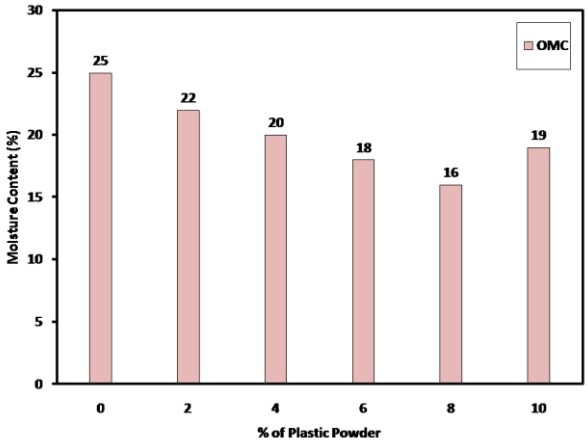


Fig 6 Plasticity index of PP

The readings of PI of clay soil mixed with distinct percentages of Plastic powder are shown in the graph. Figure 6 tells that higher the percentage of PP the PI of soil goes on decreasing from 34 to 21% with an increase in plastic powder up to 8%. PI is depending on the LL and PL so the plasticity index so similar behavior with an increase in the plastic powder waste.

Standard Proctor Compaction Test



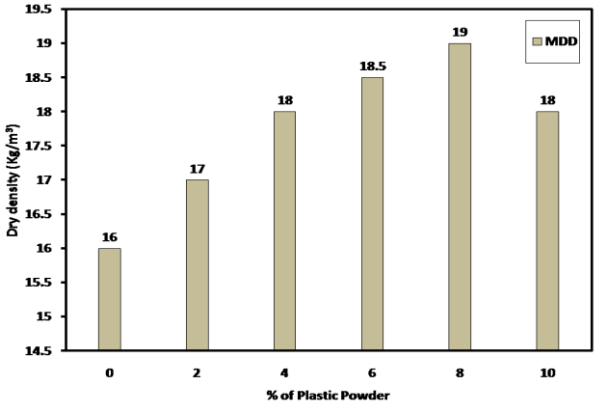


Fig 7 Moisture Content and dry density of PP

Higher the percentage of PP reduces the OMC of soil. The OMC reduces from 25 to 16% when the plastic powder is increased from 0 to 8%. The results of MDD tests on clay soil treated with different percentages of PP are view from the graph. The MDD will inversely relate with the OMC so the dry density increase with low to high PP values (16 to 19 KN/m^3).

Unconfined compression strength

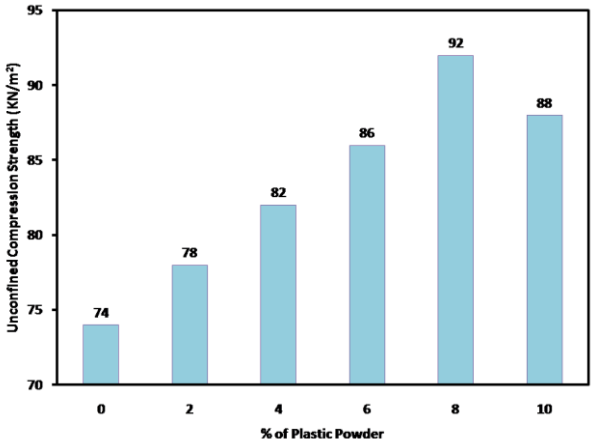


Fig 8 Unconfined compression strength of PP

As in the fig 8 it was clear that with an upturn in the percentage of PP, the UCC of soil fall down. The increasing of the UCC of the soil is due to occupying the void in the soil by the plastic powder. The UCC rose from 74 to 92 kN/m2 when the plastic powder is raised from 0 to 8%. After the particular percentage of plastic powder, UCC starts to decrease due to plastic is less rigid and due to its plastic property, its UCC value falls.

California bearing ratio (unsoaked and soaked test)

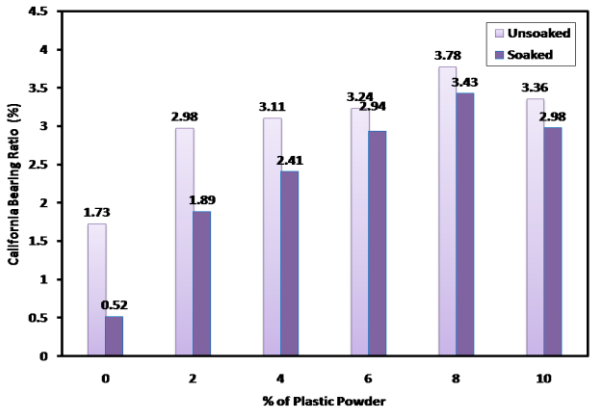


Fig 9 California bearing ratio of PP

The unsoaked CBR increases from 1.73 to 3.78% when the plastic powder is increased up to 8% shown in figure 9. Adding of plastic powder escalates the bonds between clay particle and plastic powder that direct to the property of clay plastic mixture to sustain hike loads correlated with unstabilized clay [20]. The soaked CBR value is a little bit fewer than unsoaked CBR value is due to the soaked soil sample takes less load compared to the unsoaked sample and reaches penetration value quickly.

Free swell index

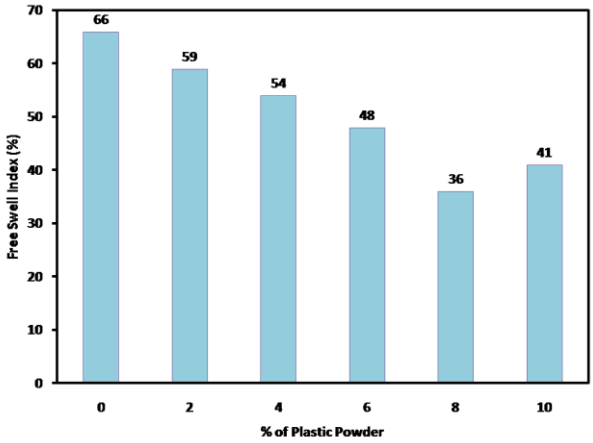


Fig 10 Free swell index of PP

The FSI decreases from 66.25 to 35.58% when the plastic powder is increased from 0 to 8% shown in figure 10. As we know that plastic is inert as well as nonreactive to the water. The water plays the main role in the swelling index so the swelling of the soil sample is get reduced due to the addition of plastic powder.

V. CONCLUSION

A continuous laboratory investigation were operated to find the effects of waste plastic powder on the LL, PL, PI, MDD, OMC, UCC, soaked CBR, shear strength parameters and swelling pressure of clay soil. On the basis of result from the test able to conclude the following thing

- The LL gradually decreases (64 to 45%) with an increasing percentage of PP, 0 to 8% respectively.
- PL and PI is decline the percentage from 34 to 21% on the addition of PP.
- The MDD goes on increasing (1.6 to1.8g/cc) and OMC goes on decreasing (25 to 16%) with an increase in the percentage of addition of PP from 0% to 8%.
- The UCC goes on increasing with the increase in percentage (74 to 92KN/m^2) of the addition of PP.
- The unsoaked CBR goes on increasing (1.73 to 2.92%) with an increase in the percentage of the addition of PP.
- The free swell index of the soil decreases from 31.88 to 18.18% with an increase in PP.
- Economical point of view, it is shows that waste PP up to 8% can be used to strengthening the sub-grade of flexible pavement.

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