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Improvement of Strength of Clayey Soil Using Ceramic Dust

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Abstract:

The ceramic industry, which comprises with walltiles, bricks and roof tiles, floor tiles, sanitary accessories, refractory materials and ceramic materials for domestic and other uses, is generating a huge amount of ceramic wastes. Therefore, their problem of disposal is also a great concern. This research delineates the effects of waste ceramic dust on strength characteristics of clayey soil. Soil samples were prepared with the inclusion of various proportion of ceramic dust with clayey soil. The test results indicate that Atterberg limits showed significant variation with inclusion of different percentages of ceramic dust with the studied clayey soil. On the other hand, unconfined compressive strength value increase with the increase of inclusion of ceramic dust up to 20%. It is recommended that ceramic dust up to 20% may be used for improving the geotechnical properties of clayey soil.

Keywords —**Clayey soil, Ceramic dust, Stabilization, Unconfined Compressive Strength.**

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I. INTRODUCTION

Clayey soil, also known as problematic or expansive soil has peculiar cyclic swell-shrink behaviour and for this reason construction on expansive soil always creates many problems for Civil engineers. When moisture content increases, the soil shows its swelling behaviour, but when the moisture decreases it shows shrinkage behaviour. During the volume change behaviour expansive soils cause large uplift pressures and upheaval of structures built on them. to this movement, lightly loaded structures such as foundations, pavement, canal beds and linings, and residential structures established on them are severely damaged. The enormous volume change is due to the presence of montmorillonite group of minerals. They are characterized by high cation exchange capacity, small particle size and large specific area. Such soils should be stabilized to improve their properties for safe, reliable and well-balanced construction on them. The requirements to improve the soil properties for construction works result in the use of a variety of stabilizers. One of them is the stabilization using dust/powder like waste materials with and without a binder like lime, cement etc. There has been a radical variation in the volume and properties of the solid waste owing to increase in population, urbanization, industrialization and change in lifestyle. As a result, solid wastes become more harmful to surroundings, and needs cautious disposal practices. It has been evaluated that about 30% of daily manufacturing in the ceramic industry goes as waste. The ejection of that creates soil, water and air pollution. Ceramic dust is a cohesion less element, which can improve the characteristics of soil.

II. LITERATURE REVIEW

Koyuncu(2004) added ceramic tile dust wastes up to 40% to find out its impact on swelling pressure and swelling potential of Na-bentonite, and observed that swelling pressure and swelling potential reduced by 86% and 57% respectively at 40% addition of ceramic tile dust waste. According to the results of these experiments, a remarkable decrease of zinc (Zn) was noted in the content of CMW from ceramic refinery plant and it was reused as a construction material.

Rajamannan(2013) investigated the effect of addition of ceramic waste to clay materials, and concluded from chemical, mineralogical and morphological analyses, that ceramic waste can be added to the clay material with no detrimental effect on the properties of the sintered fire-clay products. The test results also indicate that the ceramic waste may be used as filler in ceramic bricks, thus enhancing the possibility of its reuse in a safe and sustainable way.

Babitasingh (2014) investigated in this paper brings out the results of experimental program carried out in the laboratory to evaluate the effectiveness of using foundry sand and fly ash with tile waste for soil stabilization by studying the compaction and strength characteristics for use as a sub-grade material. The California bearing ratio value of clayey soil improved significantly i.e. from 2.43% to 7.35% with addition of foundry sand, fly ash and tile waste in appropriate proportion.

Hiranandani (2014) carried out study on the Dune-Sand has nil cohesion and thus has a very low compressive strength. A linear increment was observed in CBR values in both unsoaked and soaked conditions. The investigation reported herein presents a study of stabilization of Dune-Sand with Ceramic Tiles Wastage as admixture. All the California Bearing Ratio tests were conducted at maximum dry density and optimum moisture content as arrived from Standard Proctor Test. Direct shear tests were also performed.

Shivanarayana (2014) concluded for any pavement, the subgrade layer is very important and it has to be strong to support the entire wheel load. The liquid limit, plastic limit and the shrinkage limits was found to be 65.56%, 32.026% and 12.40% respectively. Addition of tile waste up to 30% decreases the values of liquid limit, plastic limit and optimum moisture content. And increases the values of shrinkage limit, maximum dry density, unconfined compressive strength and California bearing ratio (CBR).

III. MATERIALS

A. Soil

The soil used in the present study is kaolinite clay of low plasticity. It has been collected from Thonnakkal. On visual examination it was found to be white in colour. The soil obtained from the site is processed and powdered for testing purposes. The properties of the soil are studied using standard procedures and the results are tabulated in table.

TABLE 1
Properties of kaolinite clay

Properties	Result
Specific Gravity	2.63
Liquid limit(%)	32
Plastic limit (%)	20
Shrinkage limit(%)	17.25
Plasticity index (%)	12
Natural moisture content(%)	26
Optimum moisture content(%)	23.5
Maximum dry Density (g/cm3)	1.5
Percentage of clay	68
Percentage of silts	21.93
Percentage of sand	10.07
UCC strength(kPa)	50.32
Classification of soil	CL

B. Ceramic dust

A ceramic tile is an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. Ceramic materials may have crystalline or partly crystalline structure, or may be amorphous. The tile waste mainly consisting of Cao and Silica. Tiles waste was collected from a local industry Euro-Tech Pvt.Changaramkulam, Malappuram district, Kerala. Ceramic tile waste are cheap and non-reusable material, it is shown in all construction area and easy to collect. By the using of ceramic tile waste to reduce the waste materials in earth and economical.

IV. METHODOLOGY

The index properties of soil were determined as per the respective IS Codes. Basic geotechnical laboratory testing was performed to establish the initial properties of the untreated clay used for the study. Basic geotechnical properties testing such as Atterberg limits, specific gravity, grain size distribution, unconfined compressive strength and compaction test were conducted to assess the behaviour of the soil used in this study.

The effect of ceramic dust powder on the geotechnical properties of clay, the soil is mixed with ceramic dust powder by percentages 5%, 10%,15%,20% and 25% of dry weight and various tests are done.

The study focuses on studying the effect of ceramic dust on the soil strength improvement and further applications of ceramic dust stabilized clay.

V. RESULTS AND DISCUSSION

A .Liquid limit

From the test results, it has been found out that when 5% ceramic dust was added the liquid limit decreased to 31%,when 10% was added liquid limit decreased to 29%.When 15% ceramic dust was added liquid limit showed a greater decrement in liquid limit of 26.5%.Further when 20% ceramic dust was added then liquid limit obtained was 25%.Finally when 25% ceramic dust was added liquid limit decreased to 23%.So it was concluded that liquid limit of soil goes on reducing from 32.0% to 23% when ceramic dust is added from 0 to 25%. This happens because the surface area of the mixture of ceramic dust with soil decreases due to the coarser particles of ceramic dust. However, it demands less water content to attain its liquid limit.

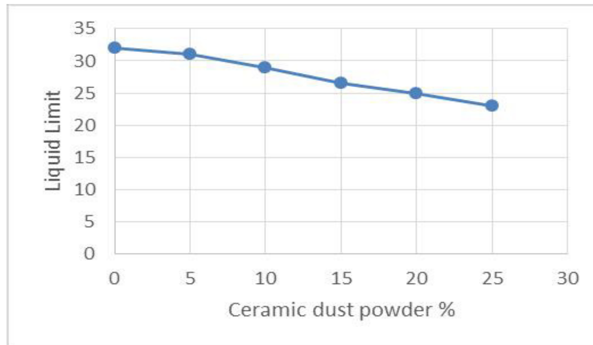

Fig. 1 Variation of liquid limit due to differentpercentage of ceramic dust.

B. Plastic limit

Plastic limit is the moisture content at which it can no longer be moulded without cracking. It is found that when 5% ceramic dust was added plastic limit decreased to 19.23%,when 10% ceramic dust was added plastic limit decreased to 17.90%. It is obvious from Figure 2 that the plastic limit of soil reduces from 20% to 14.10% for the inclusion of ceramic dust up to 25%.The change in plastic limit beyond 20% is not much significant with increase in the further percentage of the ceramic dust powder.

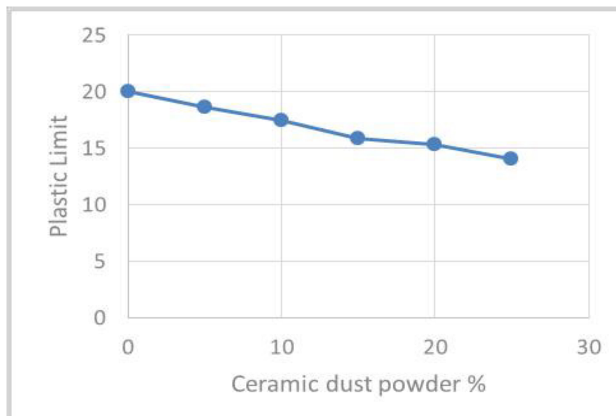

Fig. 2 Variation of plastic limit due to differentpercentage of ceramic dust.

C. Plasticity Index

It is prominent that the plasticity index goes on decreasing with addition of ceramic dust. The plasticity index decreases from 12 % to 8.9% when ceramic dust is increased from 0 to 25%. As ceramic dust is cohesion less, it was expected that it would reduce the plasticity index of soil and the result satisfies the expectation. Publication had also similar findings. A reduction in liquid limit, plastic limit and plasticity index with increase in ceramic dust content was observed. In the present study as well, a similar trend is seen in the soil characteristics with the addition of ceramic dust.

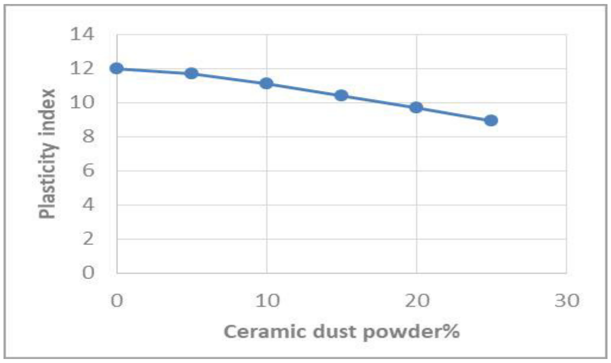

Fig. 3 Variation of plasticity index due to different percentage of ceramic dust

D. Unconfined Compressive Strength

It is obvious that when ceramic dust is added from 0 to 20%, the unconfined compressive strength value rises from 50.32 kN/m2 to 70.56 kN/m2.The unconfined compressive strength value increases due to both the coarser particles and lime present in the ceramic dust, which acts as a cementitious material. The pozzolanic reaction of lime present in ceramic dust with the amorphous Silica and Alumina present in soil is responsible for the rise in unconfined compressive strength value. With the addition of ceramic dust beyond 20%, extra lime reacts with inadequate amorphous Silica and Alumina present in soil and results in carbonation reaction and strength decreases.

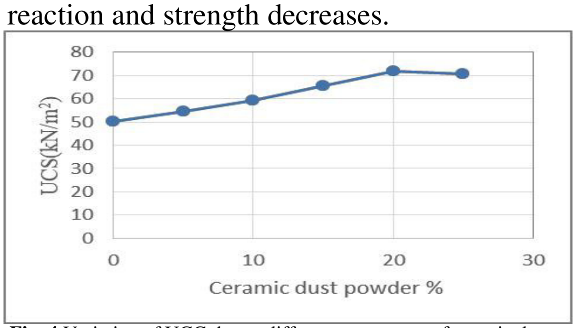

Fig. 4 Variation of UCC due to different percentage ofceramic dust.

VI. CONCLUSION

From the test results it was noted that:

- The Atterberg limits go on decreasing with the percentages of addition of ceramic dust.
- The liquid limit, plastic limit and plasticity index decreases with increase in the percentage of ceramic dust.
- The unconfined compressive strength goes on increasing with increase in percentage of ceramic dust.
- From the obtained results preferable addition of ceramic dust is 25% having maximum stabilization and economic considerations for soil.

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