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STABILIZATION OF EXPANSIVE SOIL USING MARBLE DUST AND CALCIUM CHLORIDE

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Abstract: Our research involves the application of calcium chloride and marble dust to expansive soil to improve its engineering properties. Expansive soils swell greatly when [1] wet and shrink when wet. Lightly loaded civil engineering structures such as residential buildings, pavements, and canal linings are badly harmed as a result of this alternative swelling and shrinking. As a result, it is vital to reduce these problems caused by [2] expansive soils and prevent structural cracking. As a remedy to the problem of expanding soils, many novel foundation approaches have been revised. The stabilisation of expanding clays with various additives has also been quite successful. Chemical stabilisation [3] is a typical technique used for improving the expansive characteristics of soil. In this study, marble dust was used as an admixture and calcium chloride (CaCl2) as an addition to determine the pre- and post-treatment geotechnical parameters of expansive soil, including OMC and MDD, Atterberg limits, DFS (differential free swell), and strength characteristics.

1. Introduction

Among the problematic soils, expansive soil is one that is most likely to contract or expand as a result of variations in moisture content. Almost every continent has expansive soils. Many nations have remarked on the terrible consequences of this type of soil. The main issue with expansive soils is that they can't be predicted by conventional elastic or plastic theory since their deformations are much larger than elastic deformations. The structures that sustain them frequently [10] suffer severe damage from the movements, which are frequently irregular. If swelling soils are found during the project, the appropriate corrective actions must be implemented to enhance the soil or lessen its negative consequences. When planning and designing a project vs. after construction, different corrective actions could be required. When problematic soils [5] are removed and replaced or soil qualities are altered, a variety of stabilisation techniques are useful for enhancing expansive soils. These strategies can be used independently or in combination with certain design considerations. The properties of the expanding soil can also be altered by the addition of substances such as lime, cement, $CaCl_2$ [13], rice husk [7, 9], fly ash [8], and so on. Permeability, soil compaction, and structural durability are all important considerations for designers. The impact of additives and the ideal dosage of chemicals employed are strongly influenced by the soil's mineralogical makeup. When exposed to moisture, expansive soils inflate greatly and shrink when the moisture evaporates. Residential buildings, pavements, and canal linings are only a few examples of the light-weight civil engineering projects that are severely harmed by this alternate swelling and shrinkage. As a result, reducing the obstacles posed by expanding soils [15] and preventing structural cracking is critical. As a result of the problem of expanding soils, many new foundation solutions have been revised. Stabilisation of expanding clays with various additions has also been very successful. Chemical stabilisation [14] is a technique often employed to improve expansive soil qualities. In this project, the geotechnical parameters [4] of expansive soil, such as Optimum Moisture Content and Maximum Dry Density, Atterberg limits, DFS (Differential Free Swell), and strength characteristics, were investigated [6] prior to and following treatment with marble dust and $CaCl_2$.

2. Experimental Investigation

Materials utilized for this project were listed below:

- Expansive Soil
- Marble dust
- Calcium Chloride

2.1 Expansive Soil

A 1.2 meter-deep sample of soil was taken from the land at Puritipadu, Gudlavalleru Mandal, Krishna Dt., and Andhra Pradesh. The dirt is then air-dried and sieved through a 4.75 mm sieve. The soil thus recovered is stored in polythene bags for further examination.

2.2 Marble dust

Marble dust, which is a solid pollutant from the marble industry in Vijayawada, can be effectively used as an admixture in this study. Marble dust can be well added to soil as an admixture [12, 14] to increase strength. It is incorporated into the soil at various rates of 3, 6, 9, 12, and 15%.

2.3 Calcium Chloride

In this study, laboratory grade calcium chloride (flakes and granules) containing 98% $CaCl_2$ was employed as an addition. Calcium chloride [13] is added to the expansive soil, which has already been optimised with marble dust, at varied percentages of 0.5, 1.0, 1.5, 2.0, and 2.5%.

3. Methodology and Tests

Three different series of tests were carried out on the soil in order to complete the project's goals.
Below is a list of these examinations.

3.1 First Series of Tests: "Expansive Soil"

- Tests performed on expansive soil include Atterberg limits, Differential Free Swell, Heavy Compaction, UCC, and Tri-Axial.

3.2 Second Series of Tests: "Expansive Soil treated with % variation in marble dust"

- Heavy Compaction, UCC, and tri-axial tests were performed on expanding soil that had been treated with marble dust.

3.3 Third Series of Tests: "Expansive Soil optimized with %, of marble dust and mixed with %, of $CaCl_2$"

- UCC, Tri-axial, and compaction were carried out for expansive soil that had been optimized with marble dust and was mixed with $CaCl_2$.

4. Results and Discussions

- The liquid limit of the soil sample is 86%, and the plastic limit is 38%. The plasticity index is 48. As a result, the soil sample is labelled as highly compressible clay (CH). The differential free swell of the soil sample is quite high because the DFS is larger than 50%, i.e., 145%.
- The maximum dry density of the expanding soil is 1.379 g/cc determined at a water content of 28.882%. The soil's dry density has then gradually decreased as the water content percentage had been increased. The best maximum dry density is 1.469 g/cc with a water content of 23.355% when the soil is mixed with 9% marble dust, 1.57 g/cc with a water content of 21.649% when it is optimised with 9% marble dust and treated with 2.0% $CaCl_2$.

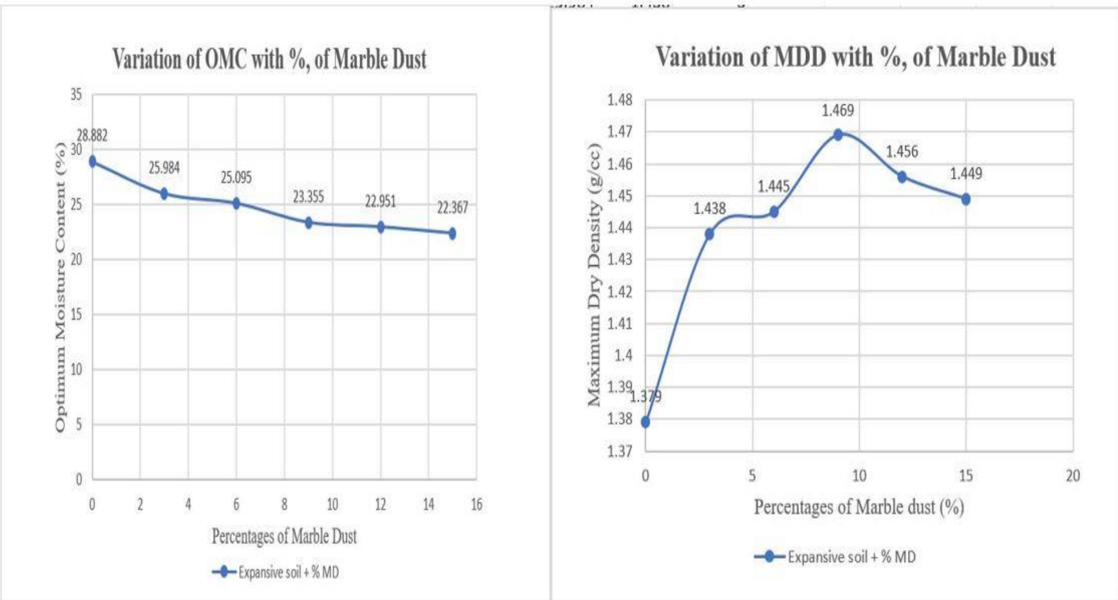

Fig 1. Disparity of OMC & MDD with %, of marble dust

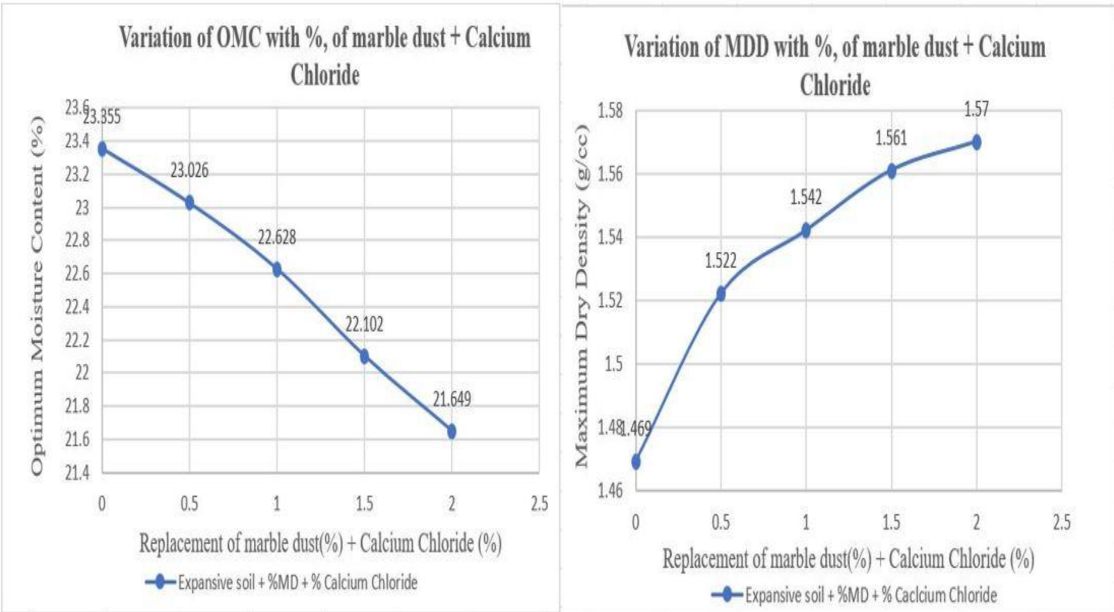

Fig 2. Compaction curves of marble dust treated Soil with % variation of $CaCl_2$

- The expanding soil has a compressive strength of 1.80 kg/cm^2. Strength is increased when expansive soil was treated with 3% marble dust, i.e. 3.62 kg/cm^2. It is calculated that soil with 6% marble dust added to it has a strength of 3.72 kg/cm^2. When soil is treated with 9% marble dust, its strength is determined to be 4.12 kg/cm^2. When the soil is combined with 12% marble dust, the strength is found to be 3.93 kg/cm^2. The soil strength mixed with 15% marble dust is found to be 2.87 kg/cm^2.

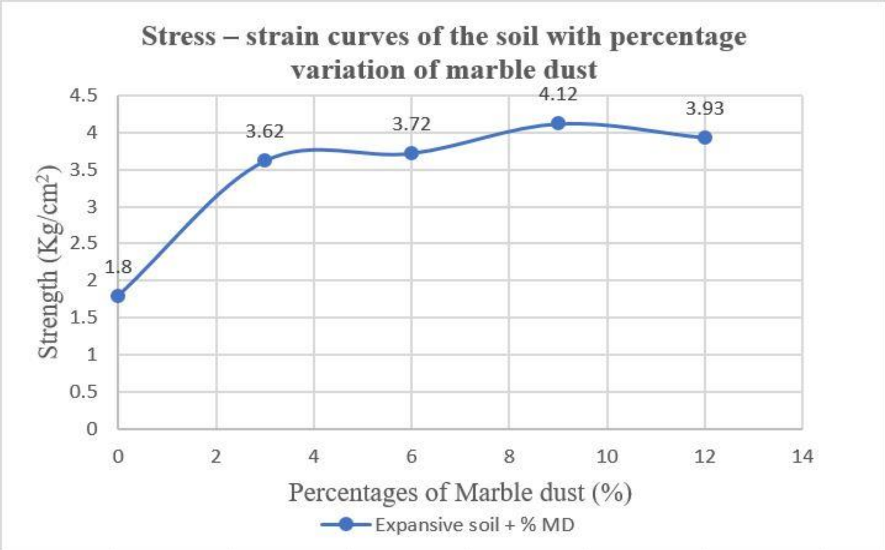

Fig 3. Stress & Strain graph of soil with % difference in marble dust

- The maximum strength is 6.04 Kg/cm^2 found at 2.0% of $CaCl_2$ which is mixed to the expansive soil optimized with 9% of marble dust. The strength obtained at 0.5% of $CaCl_2$ which is treated with soil optimized with 9% of marble dust is 4.25 Kg/cm^2. The strength found at 1.0% of $CaCl_2$ which is treated with soil optimized with 9% of marble dust is 5.11 Kg/cm^2 which was increased. The strength determined at 1.5% of $CaCl_2$ which is mixed with expansive soil optimized with 9% of marble dust is 5.68 Kg/cm^2. The strength obtained at 2.5% of $CaCl_2$ which is treated with soil optimized with 9% of marble dust is 5.63 Kg/cm^2.

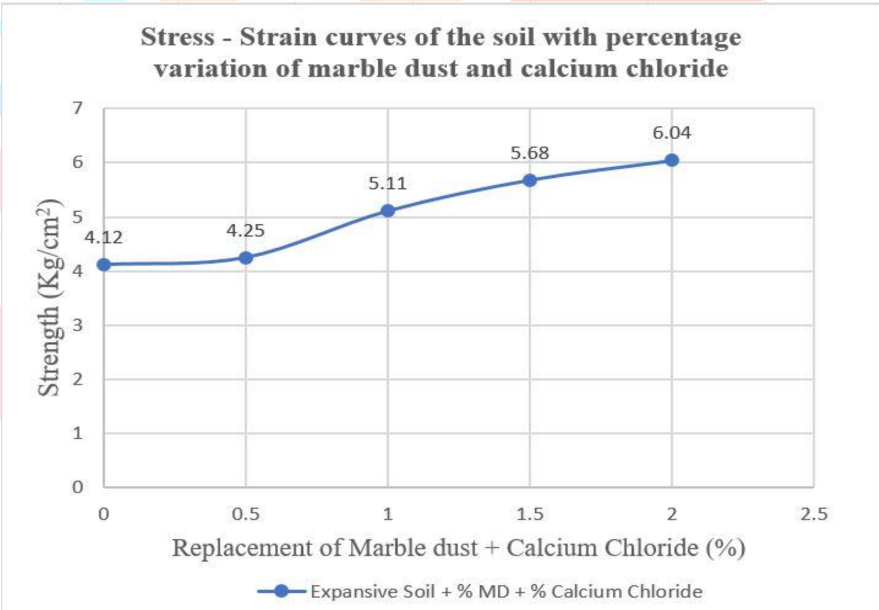

Fig 4. Stress & Strain graphs of marble dust mixed soil with alternate percentages of $CaCl_2$

- Using tri-axial testing equipment, the Mohr's circle constructed using the major and minor principal stresses was used to determine the shear strength characteristics of the soil. The cohesion value was 1 kg/cm^2 and the internal friction angle was 0^0.
- On addition of 9% marble dust, it became 1.8 kg/cm^2, at an angle of internal friction of 19^0 results in the cohesiveness being at its highest.

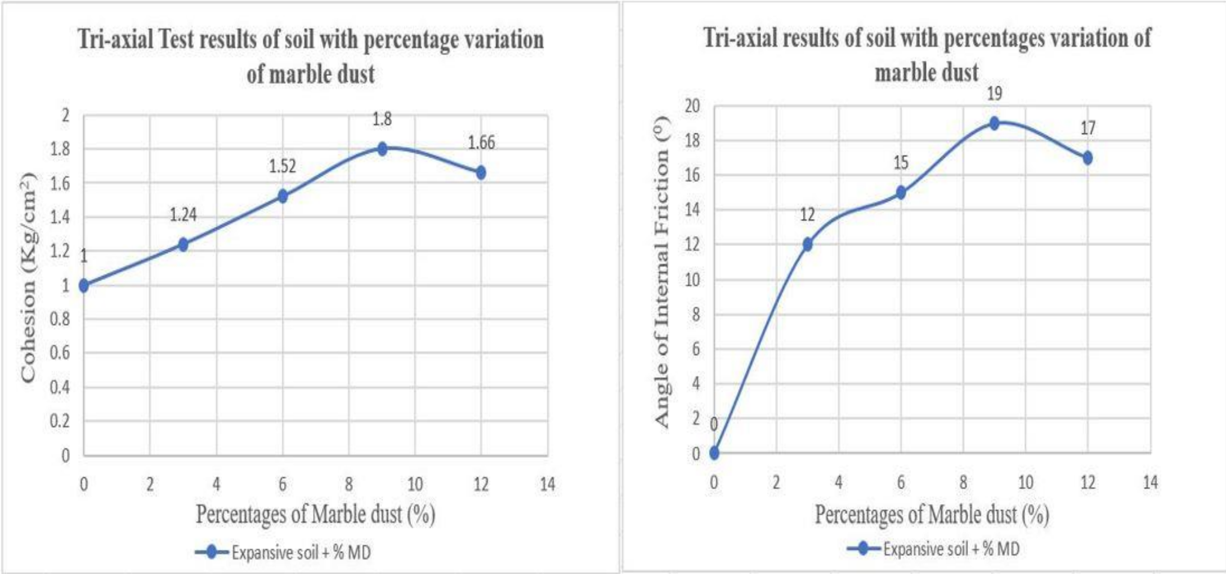

Fig 5. Variation of Cohesion and Angle of Internal Friction with %, of marble dust

- The shear strength parameters were increased on the addition of 2% of $CaCl_2$ to the soil which is optimized with 9% marble dust i.e., cohesion has increased to 2.65 kg/cm^2 and the angle of internal friction is found to be decreased to 15^0.

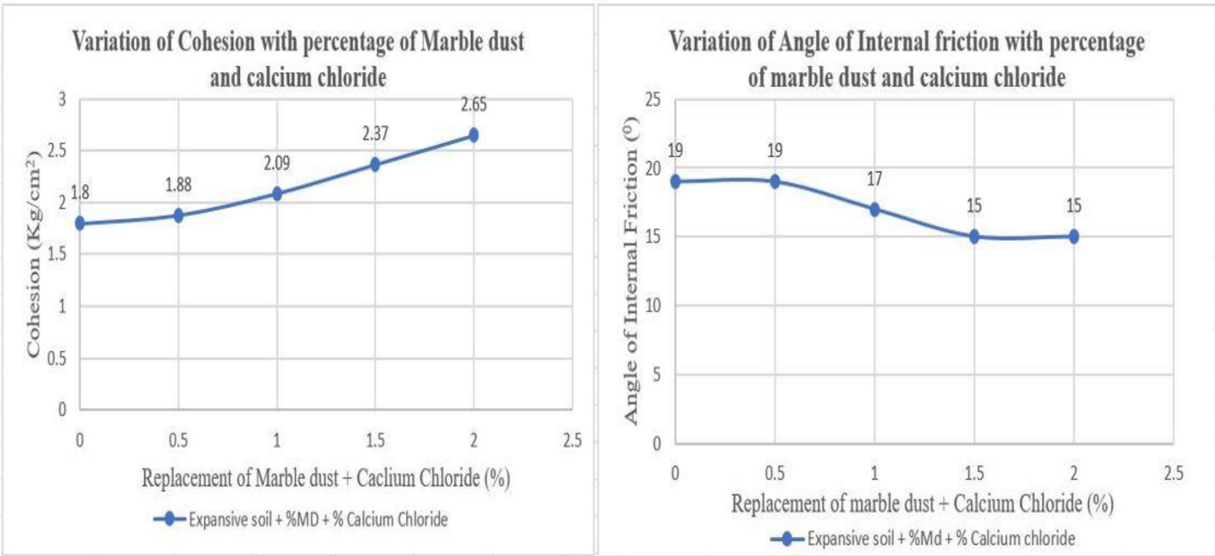

Fig 6. Discrepancy of Cohesion & Angle of Internal Friction with soil optimized with 9% of marble dust and treated with %, of $CaCl_2$

5. Conclusions

All test results are examined to determine the soil's strength characteristics. The following conclusions are drawn in light of the experiment's results:

- The liquid limit of the soil sample is 86%, and the plastic limit is 38%. The plasticity index is 48. As a result, the soil sample is labelled as highly compressible clay (CH). The differential free swell of the soil sample is quite high because the DFS is larger than 50%, i.e., 145%.
- With the addition of marble dust and Calcium Chloride ($CaCl_2$), the soil's MDD steadily increased. The maximum dry density of the soil is observed with a water content of 28.882%, i.e., 1.379g/cc. The maximum dry density of the soil is found at an optimum of 9% of marble dust i.e., 1.469g/cc. The highest dry density was obtained when 2% $CaCl_2$ is added to the optimized soil, i.e., 1.57 g/cc at an optimum of 21.649%.
- The unconfined compressive strength for the soil sample is 1.8Kpa. On the addition of marble dust, at 9%, it has increased to 4.12Kpa i.e., it has increased by 128.8%. On the addition of $CaCl_2$ to the optimized soil, at 2%, it has increased to 6.04Kpa i.e., it has increased by 235.5% for soil sample. And for soil optimized with 9% marble dust, it has increased by 46.6%.
- Additionally, the soil's shear strength characteristics steadily increased. When internal friction was measured at an angle of 0^0, cohesion was found to be 1 kg/cm^2. The cohesiveness has increased by 80% to 1.8 kg/cm^2

at 19^0 with the addition of marble dust at a rate of 9%. When $CaCl_2$ was added to the improved soil, it grew once again to 2.65 kg/cm^2, increasing by 165% for the soil sample and decreasing the internal friction at an angle of 15^0. And it has increased by 47.22% for the soil that has been improved with 9% marble dust. These allow us to draw the conclusion that the addition of calcium chloride ($CaCl_2$) and marble dust has boosted the strength of the expanding soil.

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