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Research Article

A Comparative Analysis of Increasing the UCS Strength of Expansive Soil under Curing Conditions with Calcite, Tile Bond, and Plaster of Paris

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Abstract-Expansive clay soils are found all over the world and can seriously harm structures and infrastructure. Expanding soils have been stabilized using a variety of techniques and stabilizers to make them more useful for building. It's A comparison study describes an experimental study that aims to improve the mechanical qualities of expanding soil by stabilizing it using three different stabilizers, such as calcite, plaster of Paris (POP) and tile bond. The unconfined compressive strength (UCS) test is carried out at room temperature and 14 days after close curing. The strength of UCS in expansive soil has increased. Plaster of Paris shows a significant strength rise, increasing from 270kPa to 485kPa 80% with 3% addition and by 64% at 5%. At 7% addition, calcite shows an increase of 412 kPa, resulting in a 52% strengthgain. While applying 5% tile bond, the 415kPa strength decreases and then increases by 53%.

Key words: Expansive Soil, Plaster Of Paris, Unconfined Compressive Strength.

I. INTRODUCTION

Research on improving the properties of expansive soil has investigated a variety of inputs, including cement, lime, and industrial wastes. According to a study by A. Sharo et al. (2019), adding cement and lime considerably decreased flexibility and swelling potential while boosting UCS, D. Goutham & A. Krishnaiah (2020) reviewed multiple stabilizers, including lime and fly ash, highlighting their effectiveness in improving geotechnical properties. When
H. Putra et al. (2016) examined the function of magnesium chloride in enzyme-mediated calcite precipitation, they obtained a UCS of 0.6 MPa, showing a significant increase in strength through carbonate precipitation. Furthermore, after 28 days of curing, K. Divya Krishnan & P. Ravichandran (2020) discovered that phosphor gypsum, an industrial waste, improved UCS by 50% at 6% addition, demonstrating its potential as a sustainable soil stabilizer. These investigations together highlight how different additions might improve the stability and strength of expanding soils. This overview looks at several ways to enhance expansive soils' properties. Chemical admixtures such as calcium chloride and ultra-fine slag can increase strength while decreasing swelling, hydraulic conductivity, and plasticity

(Suresh & Murugaiyan, 2021).Using tile waste improves maximum dry density and California bearing ratio while lowering swelling pressure, liquid limit, and plastic limit (Rani et al., 2024).Microbial Induced Calcite Precipitation (MICP) has the potential to improve unconfined compression strength while decreasing swelling and plasticity (Chittoori & Neupane, 2018).The use of Marble Waste Powder (MWP) dramatically increases unconfined compression strength while significantly decreasing soil plasticity and free swell index (Zumrawi & Abdalla, 2018). By using different stabilization techniques and curing conditions, expansive soils can have their UCS increased. Higher lime concentration and longer curing times often result in better strength expansion. Lime treatment has been demonstrated to enhance UCS.

This study compares three distinct additives to increase the expansive soil bearing capacity under 14 days curing conditions when pozzolanic reactions occur. Through cementing action, these chemicals improve the soil's mechanical properties and decrease its expansivity. The benefits of experiments to enhance the properties of expansive soil treated with various additions are discussed in this article.

II. MATERIALS AND METHODS

A. Materials

The expansive soil used in this study was collected from Rasoolpur, which is near Jampur City, in the District of Rajanpur, Punjab, Pakistan. The soil sample was collected up 2.5ft below the earth, it is guaranteed to reflect undisturbed subsurface conditions. As a visual indicator of its mineral composition and depositional environment, the soil has a pale- yellow shade.
The soil's index qualities provide important information about how it behaves and if it is suitable for engineering uses shown in Table 1. At 48%, the soil obtains the liquid limit, or the moisture level at which it changes from a plastic to a liquid condition.

Table 1 Index properties of Soil

Properties of soil	Value
Liquid limit (%)	48
Plastic limit (%)	21
Plasticity Index	27
Specific gravity(g/cm^3)	2.59
Classification USCS	CL
Maximum dry density MDD	1.59
Optimum water content (%)	20
UCS (kPa)	270

This comparatively high result suggests that the soil can store water at a moderate to high capacity and is susceptible to large volume fluctuations in response to changes in moisture content. The soil's moisture level at which it changes from a semi-solid to a plastic condition is known as the plastic limit, and it is 21%. This results in a plasticity index of 27. The maximum dry density of 1.61 g/cm^3 and an ideal moisture content of 20% determine the compaction characteristics of the soil.

B. Methodology

Plaster of Paris (POP), tile bond, and calcite are the three additions that will be used in this study to improve the mechanical qualities of expansive soils. A gypsum hydrate called plaster of Paris is used as a cementing agent to strengthen bonds and lessen the expansivity of the soil. By improving the strength of the soil, tile bond combination of cement, sand, and filler material contributes to mechanical stability. Because of its inherent cementing qualities, calcite ($CaCO_3$), often known as chalk, is utilized to lessen expansion.

To evaluate their effects, the additives are added to the soil in different weight percentages (1%, 3%, 5%, 7%, and 9%). Following their preparation with these chemicals, the soil samples are subjected to a controlled 14-day curing procedure. To preserve moisture and establish a stable environment for the chemical interactions between the soil and the additives, the samples are covered in polythene sheets and allowed to cure at room temperature.

The treated soil samples are subjected to an unconfined compressive strength (UCS) test following a 14-day curing period. This test measures how much the soil's mechanical qualities have improved, especially its strength. The analysis's objectives are to determine each additive's efficacy in stabilizing expansive soils and to pinpoint the ideal percentage for optimum outcomes. This method demonstrates how these materials used to reduce soil expansivity and enhance its appropriateness for use in civil engineering applications.

III. RESULTS AND CONCLUSION

The UCS values of expansive soil treated with varying percentages of POP following 14 days of curing are displayed in this graph. Plaster of Paris percentages (1%, 3%, 5%, 7%, and 9% by weight) are shown on the x-axis, while UCS values in kilopascals (kPa) are shown on the y-axis.

Untreated Soil (0% POP): Compared to the treated samples, the untreated expansive soil's UCS is substantially lower at 270 kPa. This demonstrates how expansive soil's poor mechanical qualities in its natural condition render it unsuitable for structural uses. Significantly raises the UCS. The UCS increases to 441 kPa at 1% POP and reaches its maximum at 485 kPa at 3% POP shown in Figure 1. This suggests that POP increases bonding within the soil matrix and decreases expansivity to effectively increase the soil's compressive strength.

At 3%, the UCS starts to fall. At 5 percent, the UCS falls to 458 kPa, then to 455 kPa at 7 percent and 444 kPa at 9 percent. This implies that while low POP concentrations improve the qualities of the soil, high POP concentrations may result in decreasing returns or even poorer bonding.

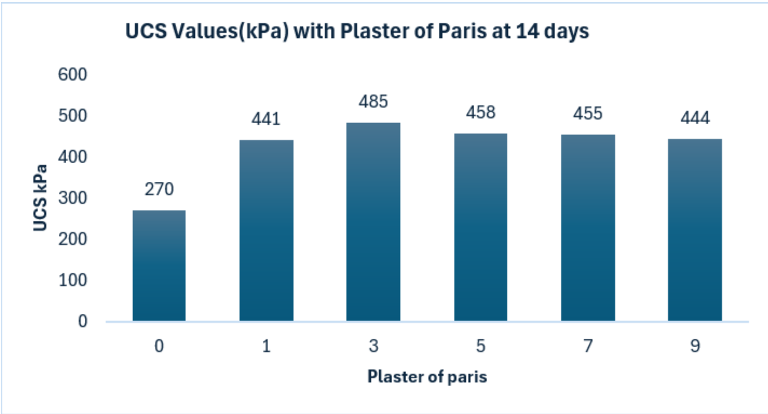

Figure 1 Plaster of Paris

The UCS gradually rises with the addition of calcite. The UCS increases to 293 kPa at 1% calcite, indicating an 8.5% improvement shown in Figure 2. With 3% calcite producing a UCS of 341 kPa and 5% calcite raising it even higher to 373 kPa, this pattern persists. Because calcium carbonate crystals grow inside the soil matrix, filling holes and sticking particles together, calcite's cementing activity is responsible for the strength gain. With 7% calcite, the UCS peaks at 412 kPa, showing a 52.6% improvement over untreated soil. This is the ideal dosage of calcite to increase the strength of the soil. But at this point, the UCS starts to drop; 9% calcite produces a marginally lower value of 394 kPa.

The pozzolanic reaction to completely develop and produce stable cementitious chemicals that increase the soil's compressive strength, the 14-day curing time is essential. This enhancement is essential for geotechnical applications since it solves the untreated soil's high expansivity and poor strength. The results therefore show that calcite is an excellent stabilizing addition, with the greatest advantages coming from a 7% dose and a 14-day curing duration.

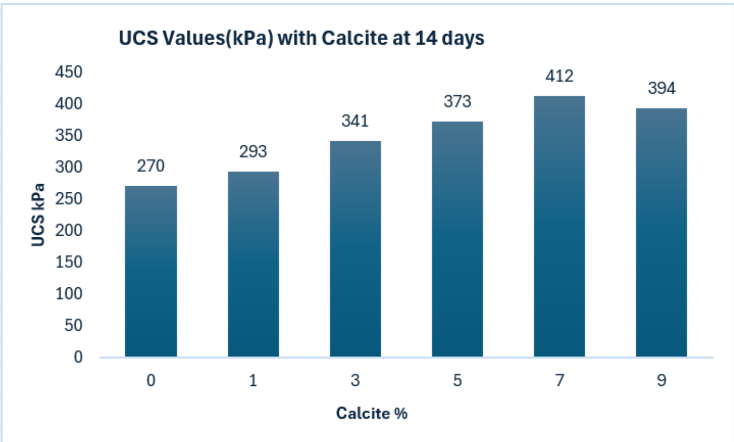

Figure 2 Calcite CaCO

The UCS increases significantly to 374 kPa at 1% tile bond, showing a 38.5% improvement. The UCS rises to 414 kPa at 3% tile bond, continuing this progression shown in Figure 3. The UCS slightly rises to 415 kPa at 5%, suggesting that this dosage marks the maximum strength enhancement. The pozzolanic processes made possible by the tile bond components a blend of cement, sand, and filler materials are what cause the increase in UCS. Calcium silicate hydrate (C-S-H) and calcium aluminate hydrate (C-A-H) are created when calcium hydroxide from the cement combines with the silicates and aluminates in the soil during the 14-day curing period. By its attachment soil particles together, these secondary compounds reduce porosity and fill gaps, increasing the soil's resilience and compressive strength.

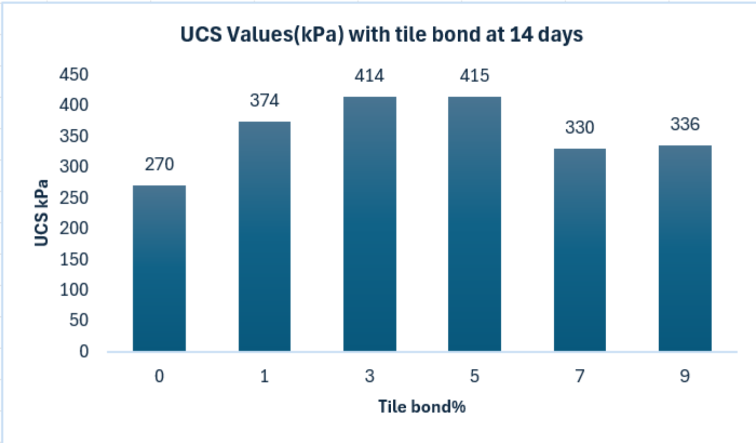

Figure 3 Tile Bond

IV. CONCLUSION

This study demonstrates how well three chemical additives calcite ($CaCO_3$), tile bond (a cementitious combination), and plaster of Paris (gypsum hydrate) stabilize expansive soil through pozzolanic reactions throughout a 14-day curing period. The greatest UCS was found in plaster of Paris (485 kPa at 3%), followed by calcite (412 kPa at 7%), and tile bond (415 kPa at 3–5%) shown in Figure 4. While tile bond and calcite require larger doses (3–7%) for best results, plaster of Paris works best at small quantities (3%). Plaster of Paris is recommended for uses when quick strength gains at low doses are needed.

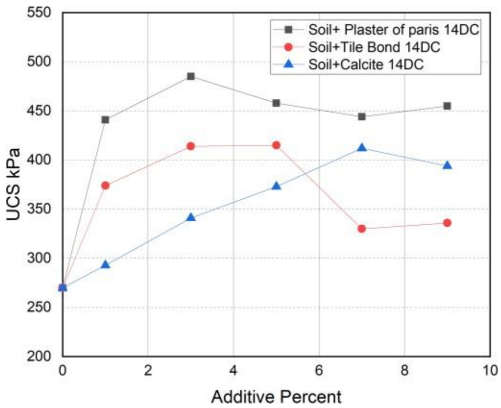

Figure 4 Compression

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