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Individual Effect of Lime, Calcium chloride and Fly ash on the Strength Behavior of Expansive Soil

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Abstract: *Stabilization is a method adopted to modify the undesirable properties of expansive soil to utilize the soil in an effective way by improving the strength and subsequently, the stability of the soil occurs. In order to obtain the desired characteristics, in this present investigation, an experimental study has been carried out to assess the beneficial effect of different percentages of lime, calcium chloride and fly ash on the strength characteristics of expansive soil in the area of study in East Godavari District, Andhra Pradesh, India. The quantity of lime, calcium chloride was varied from 0% to 6% with an increment of 2% and fly ash was varied from 0% to 25 % with an increment of 5% by dry weight of soil. The study reveals the influence of different prominent additives on expansive soil by a comparative analysis of their impact on strength characteristics.*

Keywords: *Expansive soil, lime, calcium chloride, fly ash, and unconfined compressive strength*

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I. Introduction

Expansive soil has posed many challenges in the construction domain of the world, just because of its typical swell-shrink behavior and low strength [1]-[4]. Due to the population growth and urbanization, construction activity has increased enormously and sometimes it is necessary to built structures even in the areas of expansive soil. Moreover, these structures, predominantly lightly loaded, founded on such soils exhibit several failures and may cause severe damage due to collapsing [5]-[7].In order to improve the strength of the soil, proper remedial techniques are to be employed to improve the bearing capacity and thus its stability under adverse moisture conditions. The adverse property of expansive soil could be altered by several means including mechanical, thermal, chemical and other [8], [9]. Alteration of expansive soils with different additives also demonstrated considerable success [10]. Various admixtures like lime, fly ash, calcium chloride, cement, gypsum, magnesium oxide, etc are most widely and commonly used additives due to several factors like availability, cost-effectiveness and their efficiency in altering the properties of expansive soils. [11]-[14]. The impact of lime, calcium chloride and fly ash on strength characteristics of various admixtures of soil-lime, soil-calcium chloride, soil-fly ash mixes, and their comparative analysis was evaluated.

II. Experimental Programme

2.1 Materials used

2.1.1 Expansive Soil

The soil that has been used in this study was a typical expansive soil collected from Amalapuram, East Godavari District, Andhra Pradesh. The soil before its use in experimental studies was dried, pulverized and then sieved through 4.75mm size sieve.

2.2.2 Lime, Calcium chloride (CaCl2) and fly ash

Hydrated lime having 85–95% of calcium hydroxide and 7% silica was used in this investigation. The commercial grade calcium chloride used in this investigation consisted of 98% of CaCl2.Fly ash has been collected from Vijayawada thermal power station (VTPS), Krishna District of Andhra Pradesh, India.

2.3 Tests Conducted

The unconfined compressive strength (UCS) tests were conducted for all the untreated expansive soils and soil-lime, soil-CaCl2 and soil-fly ash mix to study the effect of lime, CaCl2, fly ash on the values of UCS as per the I.S. code of practice (I.S. 2720, 1964). All the expansive soils were stabilized at their respective optimum additive contents and the prepared samples tested after 1day. The influence of different additives on Curing period 7, 14 and 28 days was also determined.

III. Results and discussion

Soil-lime, soil- calcium chloride, soil-fly ash mixes were used to perform unconfined compressive strength (UCS) tests, Stress-strain curves, Variation of peak stress and failure strain graphs and the influence of different additives on Curing period were derived and compared in this study.

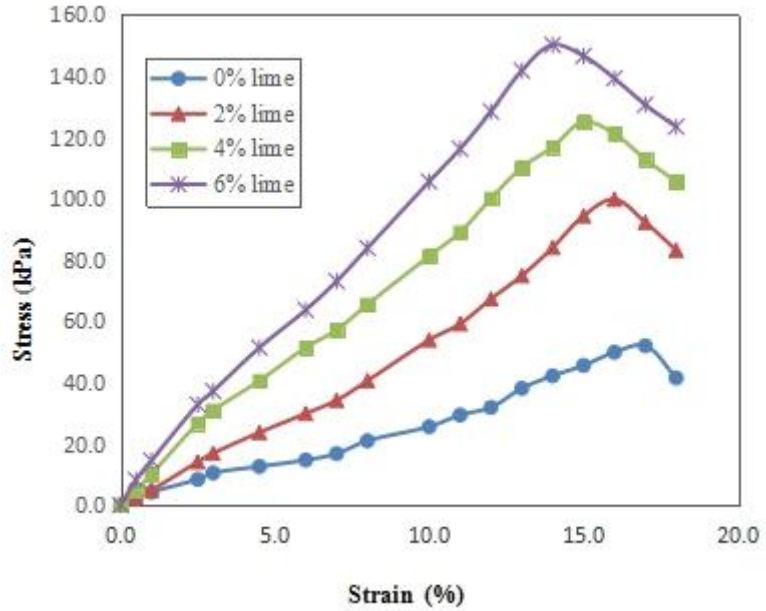

Figure 1.Stress- strain curves (lime)

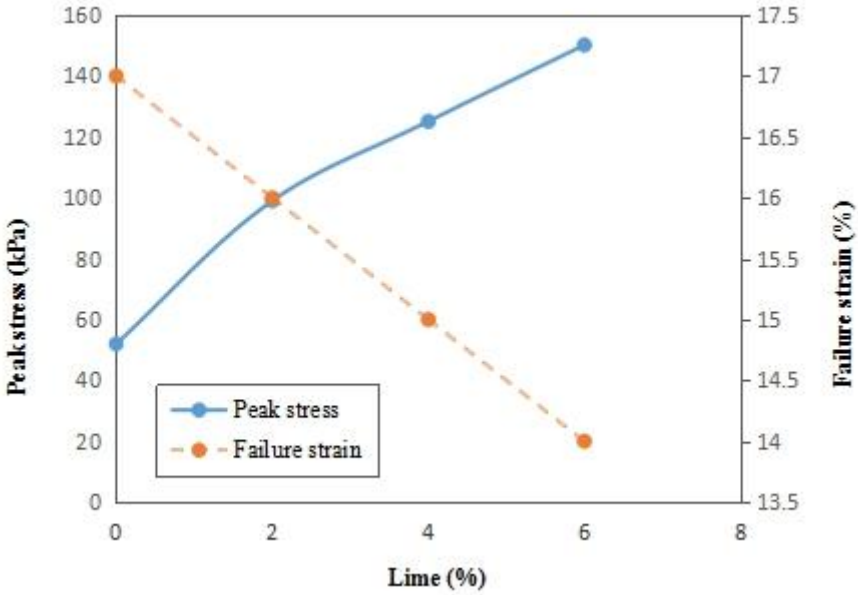

Figure 2. Variation of peak stress and failure strain with lime content

The influence of lime on strength characteristics of parent expansive soil is presented in Figs. 1&2. These stress-strain curves presented in Fig.1 clearly depict that there is an improvement in the UCS and also the corresponding decrease in failure strain. The UCS had improved from 52 kPa for the virgin soil to 150.2 kPa when blended with 6% with an improvement of 188.84% and its corresponding strain had decreased by about 21.4%. The improvement in peak stress and its corresponding failure strains are plotted in Fig.2 which clearly shows that the addition of lime to the virgin expansive soil had shown a promising influence in improving strength characteristics.

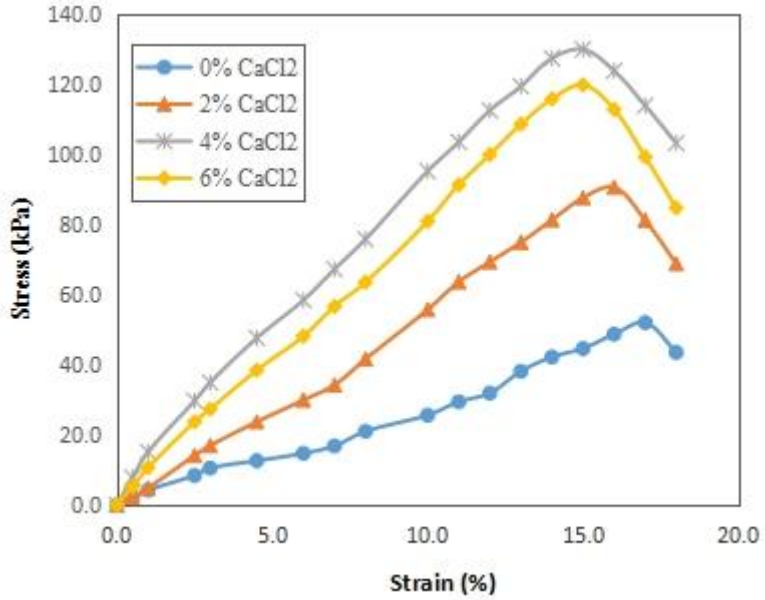

Figure 3. Stress – Strain curves ($CaCl_2$)

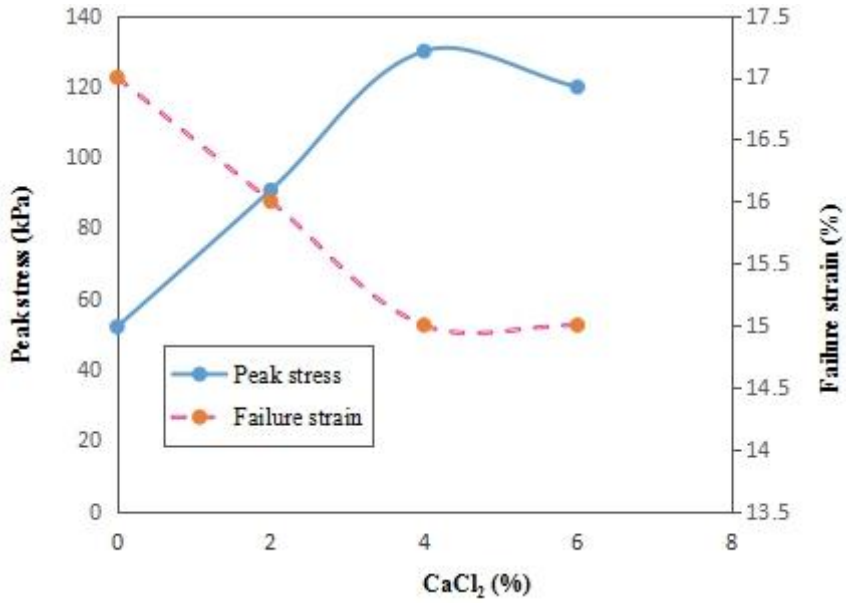

Figure 4. Verification of peak stress and failure strain with $CaCl_2$ content

The influence of $CaCl_2$ on strength characteristics of virgin expansive soil is represented in Fig. 3&4. These stress-strain curves presented in Fig.3 clearly shows that there is an improvement in the UCS and also the corresponding decrease in failure strain. The UCS had improved from 52 kPa for the virgin soil to 129.9 kPa when blended with 4% with an improvement of 140.57% and its corresponding strain had decreased by about 13.3%. The improvement in peak stress and its corresponding failure strains are plotted in Fig.4 which clearly shows that the addition of $CaCl_2$ to the virgin expansive soil had shown a promising influence in improving strength characteristics

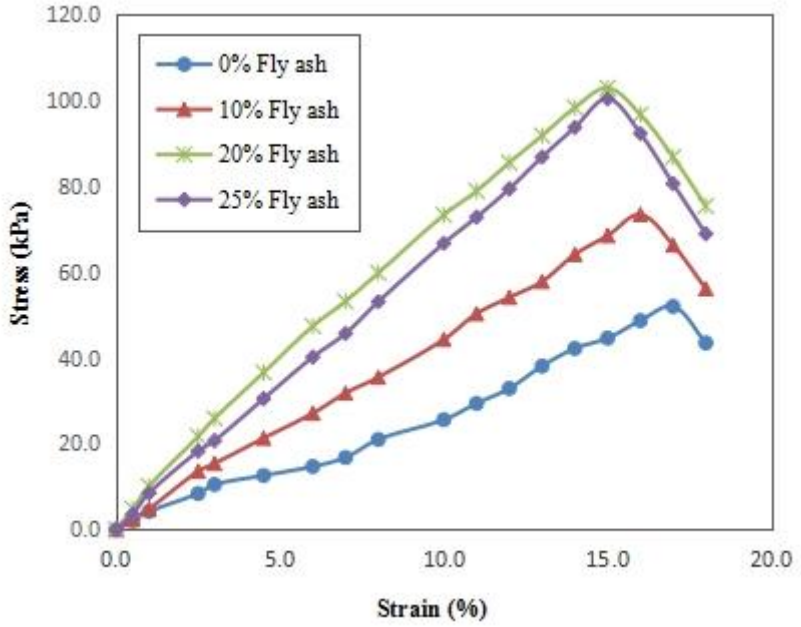

Figure 5. Stress-strain curves (Fly ash)

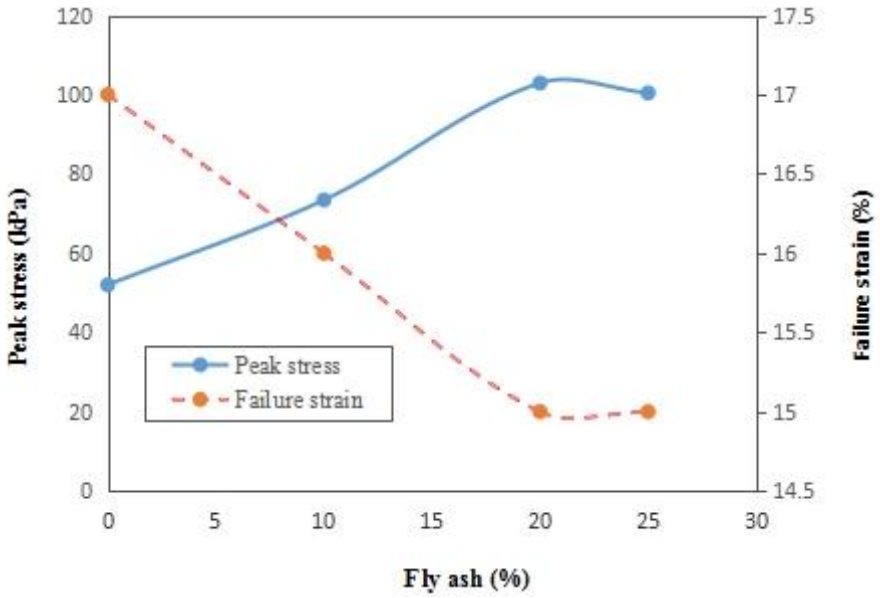

Figure 6. Variation of peak stress and failure strain with fly ash content

The influence of fly ash on strength characteristics of virgin expansive soils presented in Figs. 5&6. These stress-strain curves presented in Fig.5 clearly evident that there is an improvement in the UCS and also the corresponding decrease in failure strain. The UCS had improved from 52 kPa for the virgin soil to 102.9 kPa when blended with 20% with an improvement of 97.88% and its corresponding strain had decreased by about 13.3%. The improvement in peak stress and its corresponding failure strains are plotted in Fig.6 which clearly shows that the addition of fly ash to the virgin expansive soil had shown a promising influence in improving strength characteristics.

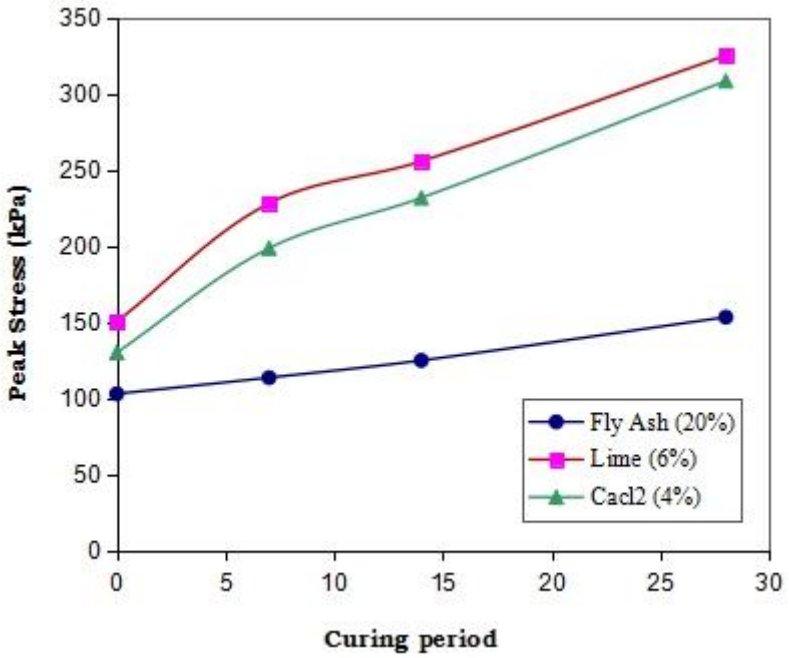

Figure 7. Shows the influence of different additives on Curing period

Impact of curing period on the strength characteristics of soil mixtures with optimum contents of different additives at different curing periods of 0, 7, 14 and 28 days are represented in Fig. 7. The optimum contents of calcium chloride (CaCl2), lime and fly ash are 4%, 6%, and 20% respectively. As a whole, the figure illustrates the unconfined compressive strength in all the three treated expansive soil specimens increased with increasing curing time. Soil mixture containing 4% of CaCl2 attained UCS at an increase of about 52.73% from 0 to 7 days, 16.68% from 7 to 14 days and 33.13% from 14 to 28 days. Soil-fly ash mixture containing 20% of fly ash attained UCS at an increase of 10.3% from 0 to 7 days, 9.95% from 7 to 14 days and 22.7% from 14 to 28 days. Soil-lime mixture containing 6% of lime attained UCS at an increase of about 51.73% from 0 to 7 days, 12.11% from 7 to 14 days and 27.16% from 14 to 28 days. From the Fig.7, overall, it can be observed that the curing period presents a promising increase in UCS with lime-soil mix rather than the other two mixes.

IV. Conclusion

The soil used in this investigation is expansive in nature and classified as CH soil The results of this experimental investigation revealed that the strength (UCS) of expansive soil when blended with 6% of lime had improved about 188.84% and its corresponding strain had decreased about 21.4%. With 4% CaCl2, the improvement in strength is about 140.57% and its corresponding strain had decreased by about 13.3%. In the case of fly ash with 20%, an improvement in strength was by 97.88% and its corresponding strain had decreased by 13.3%.

The effect of curing time on the strength properties of expansive soil stabilized with lime, calcium chloride and fly ash measured in an unconfined compression test. Stress-strain behavior improved with increasing contents of lime, calcium chloride and fly ash. In all the three additives, peak stress (UCS) was found to have increased with increasing curing period for all the additive mixes. The study revealed that a significant increase in strength from 0 to 7 days and there was a minor increase in strength from 7 to 14 days and a marginal increase from 14 to 28 days. The UCS value for fly ash at 28 days is 153.2 kPa, for CaCl2 308.2 kPa, and for lime 324.9 kPa. It is evident that out of three additives lime has given good strength with curing time.

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