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Geopolymer Soil Stabilization Using Acacia Ash for Strength Improvement

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Abstract:

This paper presents the stabilization of black cotton soil (BC soil) using Acacia ash. The ash is collected from acacia plant and alkali activators like sodium hydroxide and sodium silicate were used. This study mainly concentrates on the effectiveness of acacia ash and alkali activators in stabilization for enhancing the strength properties of BC soil and to obtain optimum proportion of acacia ash. In this study the molar concentration of sodium hydroxide was 8M and the addition of acacia ash was 15% and 18%. The samples were prepared with and without mix of alkali activators. The unconfined compressive strength (UCS) test was conducted on soil specimens to characterize the strength. The test was performed before and after stabilization. The results revealed that 8M of NaOH with 15% acacia ash gave maximum UCS value. The moisture changes in BC soils, compressibility, plasticity and strength properties can be greatly improved with the addition of Acacia ash. From the results the strength properties of BC soil were improved is clearly visualized. Finally, the study showed that the acacia ash with alkaline activators used could improve the strength properties of BC soil.

Keywords: *Geopolymer, Acacia ash, Black cotton soil, UCS test.*

I. INTRODUCTION

Soil Stabilization is a technique to improve the engineering and geotechnical properties of soil. The black cotton soils (BC soil) are highly clayey soils, they have less strength to withstand the loads from the structure. The strength of this soil has to be increased before any construction. Usually the soil stabilization is performed with materials like lime, cement, fly ash, GGBS, polymers, fibers, chemical reagents, waste materials. However, these stabilization materials have their own deficiencies such as environmental impacts in terms of CO_2 emission, energy consumption, cost and cause problematic expansion in the presence of sulfate. In this study the chemical stabilization is performed. The ash is collected from Acacia tree. The Acacia is an invasive tree, which has long roots and spreads quickly. It is threat to ecosystem, so mass cutting of trees is done and its parts are used for various purposes. The stabilization is performed by geopolymerization process. The geopolymers are inorganic, covalently bonded amorphous networks. The applications of geopolymers are still in development.

II. Materials

The materials used in the study are:

2.1 Soil- The soil was collected from Semmedu region in Coimbatore. The top soil is removed up to 1m depth and then the soil collected. The soil collected is black cotton soil.

2.2 Acacia Ash- The acacia ash is collected from acacia wood. The collected ash was sieved through 75micron sieve. The specific gravity of ash is 2.47.

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The micro structural studies were conducted to know the composition of minerals present in ash.

2.3 Alkali Activators- The alkali activators used in the study are sodium hydroxide and sodium silicate. These are cheaper compared to other activators and maintain higher capacity to detach the silicate and aluminate monomers. The sodium hydroxide was collected in pellets form and dissolved in water. The sodium silicate is used as deflocculating agent.

III. Methodology

The collected soil is black cotton soil (BC soil). The tests were conducted to know the properties of the soil. The strength properties of the soil were also tested, the strength of this soil is low. To improve the strength properties of soil, in this study the stabilization of soil is done using geopolymerization process.The test specimens were firstprepared by mixing soil and Acacia ash of 15% and 18% by using maximum optimum moisture content of soil. The other test specimens were prepared by mixing soil, acacia ash(15%& 18%) and alkali activators. The alkali activators for unconfined compressive strength kept 20% (10% sodium hydroxide & 10% sodium silicate) and 10% of water by weight. The prepared test samples were kept for curing. The UCS test was conducted for every 1, 7, 14, 21, 28 days of curing. The test was conducted for both stabilized and unstabilized soil specimens. The strength of stabilized soil increased within 7 days curing.

Table 1

The properties of black cotton soil.

Specific gravity	2.56
Percentage of clay	65%
Percentage of sand	35%
Liquid limit	55%
Plastic limit	30%
Unconfined Compressive Strength	60 kPa
Differentialfree swell index	40%

Fig 1 Sodium hydroxide and sodium silicate

Fig 2 Acacia ash and Black cotton soil

Fig 3 Soil specimens for UCS test

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(a) **(b)**

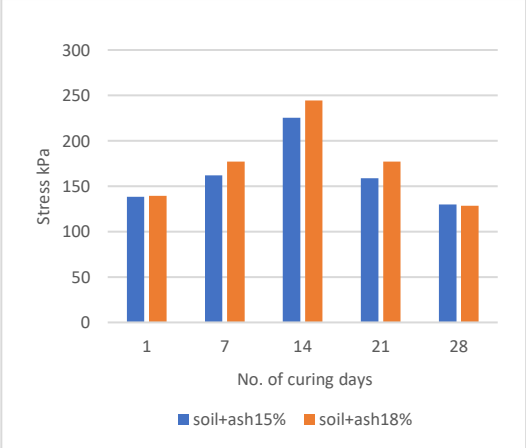
Fig 4 The soil samples are kept for curing

IV. Results

The prepared testsamples were kept for curing. The curing was kept for 1, 7, 14, 21 and 28 days to study the variation in the strength. The variation in the strength is observed by UCS values.

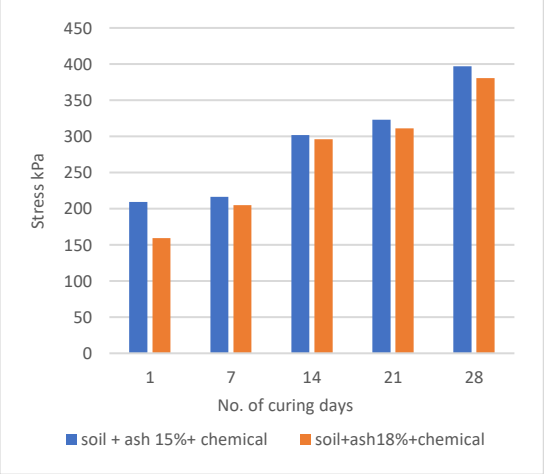
Unconfined compressive strength

1) The UCS test results of soil specimens prepared with additionof ash content(15% & 18%) is shown below. It was observed that the UCS value first increased and then decreased with increase in number of days for curing.



Graph:1UCS test results with ash content 15% and 18%

2) The UCS test results of soil specimens prepared with the molar concentration of NaOH at 8Mwith addition of 15% and 18% of acacia ash is shown below. It is observed that the UCS value increased with increase in no. of days of curing.



Graph:2 UCS test results with ash content 15% and 18% with 8M of NaOH.

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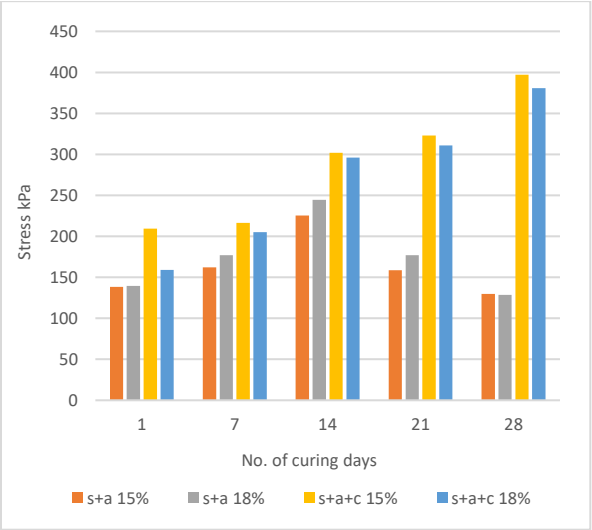
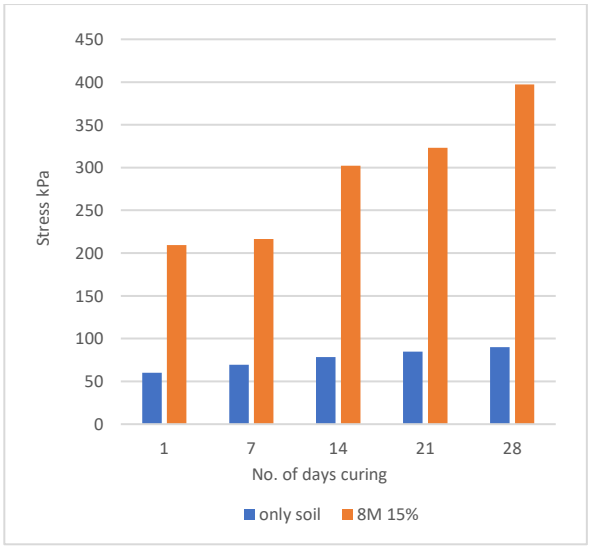
3) The below graph showsthe variation of strength of all the samples with increase in curing days.



Graph:3 UCS test results of samples with 15% and 18% ash content and ash content of 15% and 18% with 8M of NaOH.

It is observed that the maximum strength is obtained for sample prepared by 15% ash with 8M of NaOH.

4) The below graph shows the UCS test results for unstabilized soil and stabilized soil.



Graph:4 Comparison of strength of unstabilized soil and stabilized soil(15% ash with 8M of NaOH) from UCS test result.

It is observed that the BC soil strength increased predominantly with increase in curing days.

V. Conclusion

Based on the result, the following conclusions can be drawn:

- Fromunconfined compressive strength test result, it is concluded that the optimum proportion of ash is 15% and the optimum molar concentration of NaOH is 8M.
- It is observed that the stabilization of black cotton soil with acacia ash &alkali activators is effective in strength improvement. The UCS strength increased with increase in the number of days of curing.
- From the test it is concluded that the stabilized soil gives maximum UCS value of 397 kPa at molar concentration of NaOH of 8M with ash of 15% after 28 days of curing.The unstabilized soil gives maximum UCS value of 90.11 kPa after 28 days of curing.
- In samples having only ash content, the strength first increased and then decreased after 28 days of curing i.e., (225.46 kPa to158.69 kPa). The soil is only effective when it is treated with both ash content &alkali activators.
- From results it is concluded that the soil samples stabilized with both ash and alkali activators gives predominant strength after 28 days of curing i.e., (209.35 kPa to 397.09 kPa).

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