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A Study on Stabilization of Black cotton soil and Red soil by using Heat Treatment Method

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Abstract - *In general, soil is used as a basic construction material. Expansive soils like clay soil ,these are very expansive in nature if they are attacked by moisture content and they exhibit natural swelling & shrinkage property. This is mainly due to different types of mineral composition (Illite, kaoliite, Montmorillonite) which leads to failure of the structures. For stability of structures, the expansive soils should be stabilized. Most of the soils are stabilized by mechanical/ chemical stabilization with objective to improve strength and permeability of the soil. The black cotton and red soils expels and shrinks when they get contact of moisture content or variation of moisture content. This causes serious problem, When the soil is heated to high temperatures, irreversible changes occur to soil, which make the clayey soils non-plastic and non-expansive. Hence, this study is intended to stabilize the red soil and black cotton soil thermally i.e., heated at different temperatures & the improved index, engineering and swelling properties of the soils with increase in temperature were studied due to fusion of particles.*

Key Words: **Swelling, Shrinkage, Illite, kaoliite, Montmorillonite, Fusion**

1. INTRODUCTION

Soil is defined as unconsolidated material, composed of solid particles, produced by physical and chemical disintegration of rocks. Expansive soil can also be termed as clayey soil that has a high potential for shrinking or swelling due to change in moisture content, which leads to in-stability of the soil. Clayey soil is a fine-grained soil with particle size smaller than 0.002 mm that combines with one or more clay minerals with traces of metal oxides and organic matter. Montmorillonite, a mineral formed due to the chemical weathering of the volcanic ash is the principal constituent. Expansive soils can be found in almost all the continents. In India, large tracts are covered by expansive soils known as black cotton soils. Geographically, Black Cotton Soils covers about 5.46 lakh sq km i.e, 16.6 per cent of the total geographical area of our country. Clay minerals are almost ubiquitous in soil and rock and are among the most reactive silicates. They affect the engineering behavior of soil and rock both as materials of construction and as foundation materials. Destructive results caused by this type of soils had reported in many countries.

1.1 Stabilization Methods of Clay

The process of soil stabilization refers to changing the physical properties of soil in order to improve its strength, durability, or other qualities. Typically, this is important for road construction, and other concerns related to the building and maintenance of infrastructure. Soil that has been stabilized will have a vastly improved bearing capacity, and will also be significantly more resistant to being damaged by water, frost, or inclement conditions. The three basic types of stabilization of clay are as follows:

- Mechanical Stabilization
- Chemical Stabilization
- Thermal Stabilization
- Other Stabilization methods like Removal & replacement, stone columns, grouting and in-situ ground reinforcement.

1.2 Problems of Clay Over Different Constructions

The different types of problems are below for different structures are given below:

- Damage caused to building foundations
  - At the end of rainy season due to swelling
  - At the end of dry season due to shrinkage
- Damage caused to earth structure and dam like piping
- Damage caused to pavements over clay subgrade
  - Longitudinal cracks & frost heaving
  - Shear failure in shoulder region
  - Undulated pavement surface
  - Deterioration of pavement

1.3 Aim and objectives

Aim at assessing black cotton soil and red soil at 100°C, 200°C, 300°C and 400°C temperatures. The work has been planned with the following objectives.

1. Determination of engineering properties black cotton soil and red soil for study.
2. To evaluate swelling of Red soil and black cotton soil.

3. To study the effect of heating on black cotton soil & red soil engineering properties and swell properties.

2. LIITERATURE REVIEW

The presented research is aimed at studying the properties of two different soils by heat treatment method. Variation of some engineering properties of clays with heat treatment[1], describes the index properties of soils which are stabilized by heat treatment method for different temperatures such as 100°C to 1000°C. Effect of Heat Treatment on Strength of Clays[2], describes the unconfined compressive strength of thermally stabilized clay sediment using kaolinite, bentonite, from 110°C to 700°C. Temperature effects on the volume change behavior of Boom clay[3], an experimental study intended to identify the effect of temperature on the preconsolidation pressure of Boom clay and the effect of the over consolidation ratio (OCR) on the thermal volume changes is presented.

3. METODOLOGY

The following flow chart represents the methodology to proceed the research.

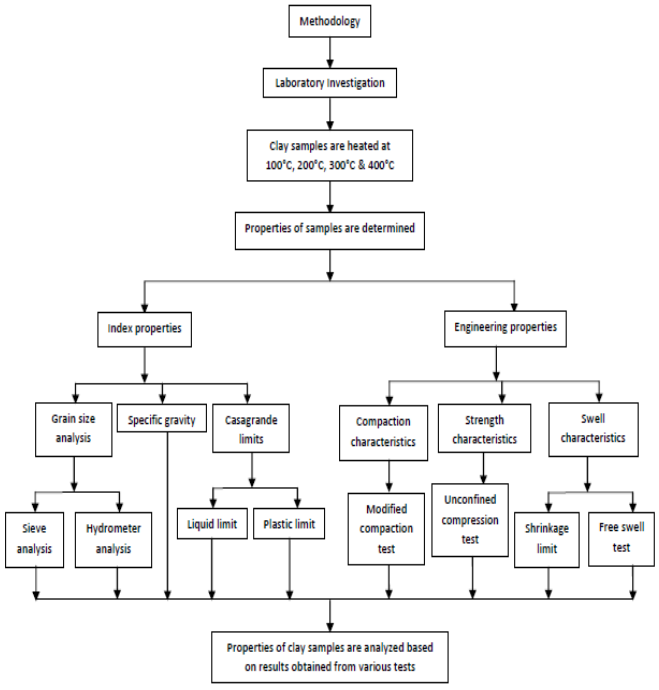

Fig -1: Methodology to be followed

All the tests are conducted according to Indian Standard code IS: 2720. The soil samples were collected from Krishna district, Andhra Pradesh. The soil samples were thermally conducted by using Hot air oven & furnace tube furnace which is used for melting of metals generally. The unconfined compression test is conducted for soil samples with the different curing periods as 3, 7, 14, 21 days.

4. RESULTS

From the initial test results i.e., at 100°C, the black cotton soil is designated as CI (Intermediate Compressible) soil and the red soil is designated as CH (High Compressible) soil according to ISC plasticity chart.

Specific Gravity

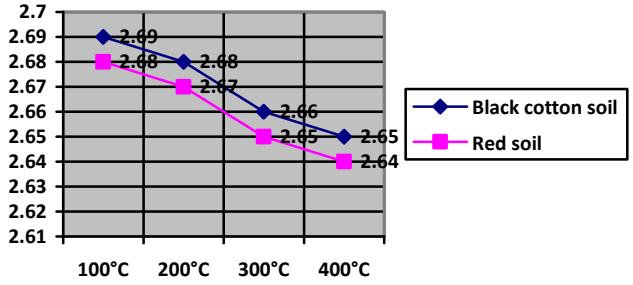

Chart -1: Variation of Specific Gravity

The above chart shows Specific gravity decreased for Black cotton soil from 2.69 to 2.65, for red soil 2.68 to 2.64 due to Volume of the soils increased with the increase in temperature due formation of solid particles by the evaporation of moisture content.

Grain Size Distribution

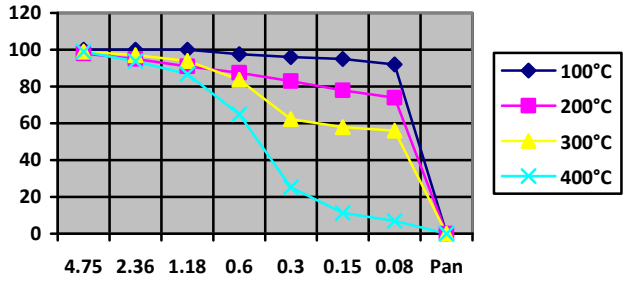

Chart -2: Variation of Grain size distribution for Black Cotton Soil with increase in temperature

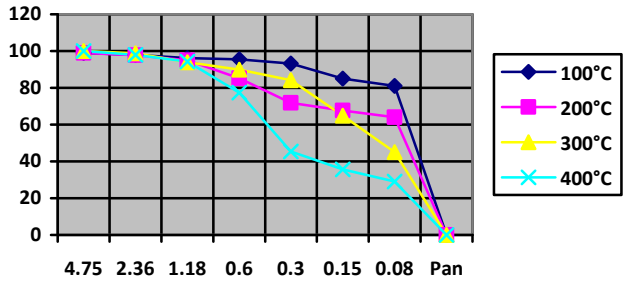

Chart -3: Variation of Grain size distribution for Red Soil with increase in temperature

The above chart shows Grain Size Distribution of Black cotton soil & Red soil for the temperatures 100°C to 400°C. It s clearly observe that if temperature rises, the fines are accumulating each other and formed as coarse grains.

Liquid Limit

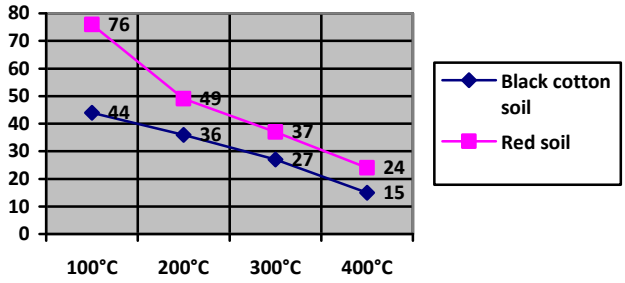

Chart -4: Variation of Liquid limit with increase in temperature

Liquid limit of Black cotton soil is decreased from 44 to 15, for Red soil 76 to 24 with the increase in temperature from100°C to 400°C.

Plastic Limit

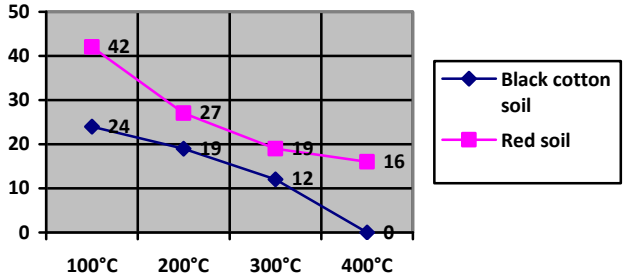

Chart -5: Variation of Plastic limit with increase in temperature

Plastic limit of Black cotton soil is decreased from 24 to Non plastic, for Red soil 42 to 16 with the increase in temperature from100°C to 400°C. Drastic changes observed in black cotton soil from 300°C to 400°C.

Shrinkage Limit

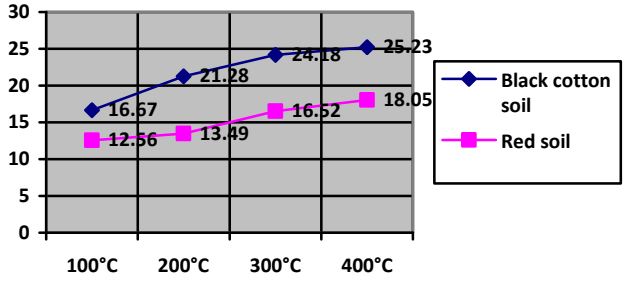

Chart -6: Variation of Shrinkage limit with increase in temperature

Shrinkage limit of Black cotton soil is increased from 16.67 to 25.23, whereas for Red soil is increased from 12.56 to 18.05. The increase in shrinkage limit is attributed to increased particle size.

Differential Free Swell

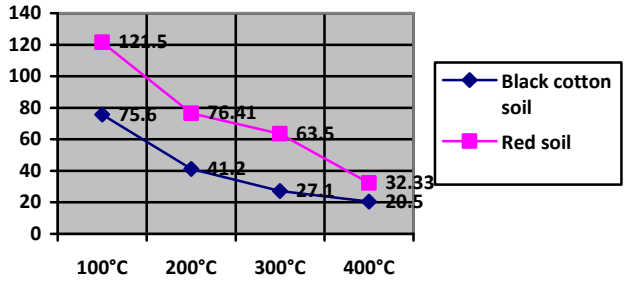

Chart -7: Variation of Differential free swell index with increase in temperature

Free swell of Black cotton soil is decreased 75.6 to 20.5 and for Red soil 121.5 to 32.33. It is clearly observed that the change in clay mineral structure influenced by heating.

Max. Dry Density & OMC

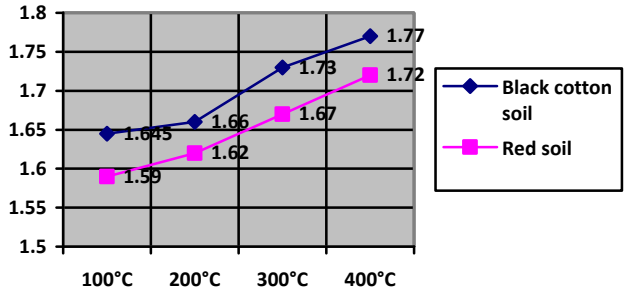

Chart -8: Variation of Max. Dry Density

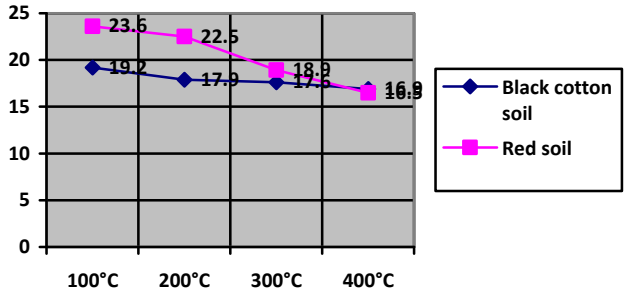

Chart -9: Variation of Optimum Moisture Content

For Black cotton soils at 100°C MDD is 1.645 g/cc at 19.2% OMC, at 400°C MDD is 1.77g/cc at 16.9 OMC. As well as for Red soil 100°C MDD is 1.59g/cc at 23.6% OMC, at 400°C MDD is 1.72g/cc at 16.5%. It is observed that OMC for both

the soils are decreased, MDD is increased with the increase in temperature.

Strength Parameters

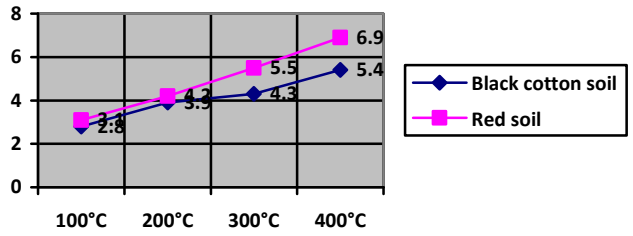

Chart -10: Variation of CBR

The soaked CBR value varies from 2.8 to 5.4 for Black Cotton soil, 3.1 to 6.9 for Red soil. It means the increase in CBR denotes strength development.

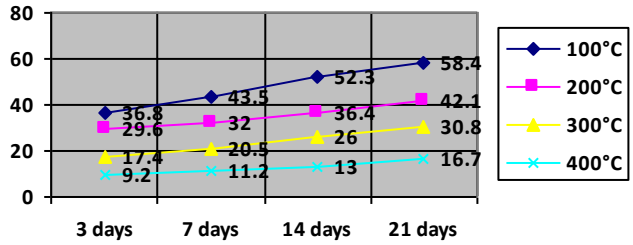

Chart -11: Variation of Cohesive strength at different curing periods for black cotton soil with increase in temperature

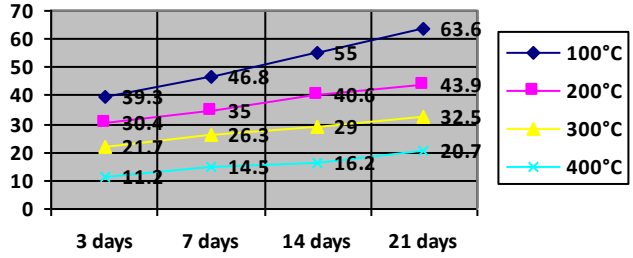

Chart -12: Variation of Cohesive strength at different curing period for red soil with increase in temperature

The above both charts describes that Cohesive strength of both soils is decreased i.e., for black cotton soil 36.8 kN/m^2 to 9.2 kN/m^2, where as for red soil 58.4 kN/m^2 to 16.7 kN/m^2.

5. SUMMARY AND CONCLUSIONS

From the initial test results, it is observed that the collected clay samples are medium & high plasticity clays. When these samples are heated at various temperatures, the index properties like Specific gravity, Liquid limit, Plastic limit & plasticity index are decreased with increase in temperature. The grain size distribution describes that, the fine particles are decreased with increase in temperature due to initiation of fusion of particles. Coming to the soaked condition, the CBR value is increased with increase in temperature. But coming to unconfined compressive strength results, it is clearly observed that compressive strength is decreased with increase in temperature, this means that that clay samples are converting into coarse grained particles, i.e., coarse grained samples may have high bearing capacity and low swelling & shrinkage property.

- Liquid limit decreased at 66% from 100°C to 400°C for black cotton soil, whereas 68% for red soil.
- Black cotton soil is converted into non plastic soil at 400°C and 62% decreased for red soil.
- Soaked CBR values are almost doubled for both black cotton soil and red soil comparing with 100°C to 400°C.
- Unconfined compressive strength is decreased with increase in temperature, since the initial clay sample in converted into coarse grained sample at 400°C.

However, this method is more suitable for soil layers where cold weather conditions, since these plastic soils will swell highly with increase in moisture content. It is best suited for high plastic (CH) soils compared to less plastic (CL) soils. Also it is not economical to use less plastic soils.

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