

# Effect of P<sup>H</sup> on Shear Strength Behaviour of Expansive Soil

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**Abstract:** The spatial extent of black cotton soil in India is more with low bearing capacity and high settlements. These soils have to be stabilized to improve bearing capacity and to reduce settlements of the structures to be constructed on them. Huge amount of research is carried in stabilizing black cotton soils with various stabilizers (lime, cement, phosphogypsum, rice husk ash, groundnut shell ash, waste saw dust ash and other materials) showed improvement in the properties of the soil. Recently Bio-Enzymes also used as stabilizers. This paper is an attempt to study the effect of Sulphuric acid and Sodium Hydroxide on black cotton soils when mixed at pH levels of H<sub>2</sub>SO<sub>4</sub>: 1, 3, 5 and NaOH: 9, 11, and 13 with the help of EDAX and SEM tests.

## I. INTRODUCTION

In India, expansive soils are called as black cotton soil. The name black cotton soil as an agriculture origin. The greater part of this dirt are dark in shading and are useful for agribusiness developing cotton and happening in Maharashtra, Karnataka, Gujarat parts of Andhra Pradesh and tamilnadu. These are costly in nature .by virtue of high swelling in shrinkage potential these are distinctive soils to manage in an establishment plan. All these black soil are not expensive soils and all expensive soils are not in black in colored. These soil passed high strength in summer and decrease rapidly in winter. The soil has a swelling property due to presence of montmorantite mineral. Black soil which are high expensive characteristics. These soils are low shrinkage limit and with high optimum moisture content. It is high sensitive to a moisture charges. Black cotton soils are generally found in sedimentary plain as a result thousands of eroding the clay content from the surroundings and also on level land on plateaus as well as in depressions. Smaller areas of expensive soils are found on hill slopes and piedmont plains. These dirt gangs low quality and experience costs volume changes making the utilization in the development in an unexpected way. The properties pf dark cotton soil might be modified in any ways i.e., mechanical, warm, substance and so forth. Alterations of dark cotton soil by admixtures is a typical adjustment strategy for such soils. The swelling soils of India have been origin in subaqueous solution of basally rock r weathering or insult . Form this information

infrastructures may be prevented from damages causing expensive soils, Black soils are highly argillaceous and are relatively rich in CaCO<sub>3</sub>. soil differ from one part of the world to another, even one part of a background to another. They differ because of a how they are formed. Five major factors interact to create different types of soils

### Parent material:

This alludes to the mineral material, or natural material from which the dirt is shaped. Soils will convey the qualities of its parent material, for example, shading, surface, structure, mineral arrangement, etc. For instance, if soils are shaped from a zone with substantial rocks (parent rocks) of red sandstone, the dirt will likewise be red in shading and have a similar vibe as its parent material.

### Climate:

This is likely the most imperative factor that can shape the development of soils. Two vital climatic parts, temperature and precipitation are vital. They decide how rapidly enduring will be, and what sort of natural materials might be accessible on and within the dirt. Dampness decides the substance and organic responses that will happen as the dirt are framed. Hotter atmosphere with more precipitation implies progressively vegetative spread and increasingly creature activity. It additionally implies more spillover, more permeation and more water disintegration. They all assistance to decide the sort of soils in a area.

**Organisms:**

The source and wealth of natural issue is down to the living things (plants and creatures) that live on and in the dirt. Plants specifically, give bunches of vegetative buildup that are added to soils. Their underlying foundations likewise hold the dirt and shield them from wind and water disintegration. They cover the dirt from the sun and other natural conditions, helping the dirt to hold the required dampness for concoction and organic responses. Growths, microorganisms, bugs, night crawlers, and tunneling creatures help with soil air circulation. Worms help breakdown natural issue and help disintegration. Creature droppings, dead creepy crawlies and creatures result in all the more rotting natural issue. Microorganisms also help with mineral and nutrient cycling and chemical reactions.

**Time:**

Soils can take many years to form. Younger soils have a few attributes from their parent material, yet as they age, the expansion of natural issue, introduction to dampness and other ecological variables may change its highlights. With time, they settle and are covered further beneath the surface, setting aside some effort to change. In the end they may change starting with one soil type then onto the next.

**Relief:**

This refers to the scene position and the slants it has. Steep, long inclines mean water will rundown quicker and conceivably disintegrate the surfaces of slants. The impact will be poor soils on the inclines, and more extravagant stores at the foot of the slants. Likewise, slants might be presented to more straightforward daylight, which may dry out soil dampness and render it less rich.

**II. LITERATURE SURVEY**

An extensive literature review of conducted on one main parameters of this project Black cotton soil and mixes with chemicals. A very few literature is reported are available regarding above motioned areas .The literature review was conducted to a specifically answer the following questions.

1. Experimental methods to increase in strength of Black Cotton soil.
2. Test parameters followed by various researchers.
3. What are the important conclusion and recommendations for each paper.

A brief review of the literature available on the stabilization

is discussed here.

One of the major mechanical soil toxins are antacids and acids. Substance hurling of clayey soils happens when they are wetted by watery arrangements of antacids and acids. Establishment issues are by and large progressively perceived basically because of spillage of acids into soil. Extraordinary hurling because of the invasion of acids into the bed soils can cause perilous disfigurements of the establishments and super structures. Studies has demonstrated that physico-synthetic response occurring between clayey minerals and corrosive effectively deteriorate earth minerals bringing about expanded volume and diminishing in quality. The idea of soil contamination cooperations relies upon the mineralogy of soil and type and centralization of the toxin [1]. The affectability of soil to condition depends on the neighborhood condition as well as impacted by mineral structure, for example, molecule measure, holding attributes between particles, particle trade limit, and so forth [2]. Acids are one of the significant waste effluents from ventures. Corrosive arrangements are discharged into the dirt condition from different ventures, for example, copper purifying enterprises, creation of composts, refining of oil, oil-copying businesses, and lead-corrosive stockpiling battery and so forth. In 2004, 180 million tons sulphuric corrosive was delivered on the planet out of which Asia establishes 35%. Sulphuric acids are broadly utilized in businesses, for example, petrochemicals, paper, Iron and Steel. Phosphoric Acid is another corrosive which is utilized widely in manure and calfskin industry and its impacts on soils holds significance in setting to India as it is an agrarian country. Prolonged connection of soil with the contaminants can prompt gathering of contaminants in top soils. It might influence the structures, dams, roadways which cause avalanches, settlements, soil disintegration and underground auxiliary unsteadiness. Aftereffects of certain investigations demonstrate that the adverse impact of leakage of acids into subsoils can cause serious establishment disappointments [3]. The defiled soil, contingent upon nature of pore liquid, demonstrates noteworthy changes in swell potential qualities [4]. Examinations did on Khvalynian muds demonstrated that even an immaterial substance of sulfuric corrosive in water prompts a significant increment of swelling [5]. In view of writing audited obviously there is a huge impact of H<sub>2</sub>SO<sub>4</sub> on the establishment soil prompting irregular conduct. Despite the

fact that the component for such conduct was clarified, the mineral change and smaller scale basic varieties have not been engaged. A geotechnical engineer, in light of traditional geotechnical standards, couldn't totally clarify the conduct of corrosive defiled soil without considering the huge mineralogical and microstructural changes that may happen. Thus in this paper, an endeavor was made to demonstrate the impact of various centralizations of sulphuric corrosive on the mineralogical and microstructural changes that may impact the building properties of soil. Prof. R.P. Lohtia: One of the major modern soil toxins are antacids and acids. Substance hurling of clayey soils happens when they are wetted by watery arrangements of salts and acids. Establishment issues are in effect progressively perceived fundamentally because of spillage of acids into soil. Exceptional hurling because of the penetration of acids into the bed soils can cause unsafe distortions of the establishments and super structures. Studies has shown that physico-concoction response occurring between clayey minerals and corrosive effectively break down dirt minerals bringing about expanded volume and diminishing in quality. The idea of soil poison associations relies upon the mineralogy of soil and type and convergence of the contamination [1]. The affectability of soil to condition depends on the neighborhood condition as well as impacted by mineral structure, for example, molecule estimate, holding qualities between particles, particle trade limit, and so forth [2]. Acids are one of the real waste effluents from businesses. Corrosive arrangements are discharged into the dirt condition from different ventures, for example, copper purifying enterprises, generation of manures, refining of oil, oil-copying businesses, and lead-corrosive stockpiling battery and so forth. In 2004, 180 million tons sulphuric corrosive was created on the planet out of which Asia establishes 35%. Sulphuric acids are generally utilized in enterprises, for example, petrochemicals, paper, Iron and Steel. Phosphoric Acid is another corrosive which is utilized widely in manure and cowhide industry and its consequences for soils holds significance in setting to India as it is an agrarian country. Prolonged cooperation of soil with the contaminants can prompt collection of contaminants in top soils. It might influence the structures, dams, parkways which cause avalanches, settlements, soil disintegration and underground auxiliary unsteadiness. Aftereffects of certain investigations

show that the impeding impact of leakage of acids into subsoils can cause serious establishment disappointments [3]. The polluted soil, contingent upon nature of pore liquid, demonstrates huge changes in swell potential qualities [4]. Examinations completed on Khvalynian muds demonstrated that even an inconsequential substance of sulfuric corrosive in water prompts a significant increment of swelling [5]. In light of writing surveyed plainly there is a huge impact of H<sub>2</sub>SO<sub>4</sub> on the establishment soil prompting strange conduct. In spite of the fact that the instrument for such conduct was clarified, the mineral change and miniaturized scale auxiliary varieties have not been engaged. A geotechnical engineer, in view of ordinary geotechnical standards, couldn't totally clarify the conduct of corrosive debased soil without considering the critical mineralogical and microstructural changes that may happen. Thus in this paper, an endeavor was made to demonstrate the impact of various groupings of sulphuric corrosive on the mineralogical and microstructural changes that may impact the designing properties of soil. Prof. T S Umesha: An extensive exploratory examination has been done to comprehend the impacts of acids tainting on geotechnical properties of dark cotton soil. The ends dependent on the investigation are Liquid cutoff diminishes with increment in any corrosive focus for all the three acids. Plastic limit increments up to 5 percent of corrosive fixation in the pore liquid and after that it diminishes up to 15 percent convergences of any corrosive. Versatility file diminishes up to 15 percent convergences of any corrosive. Ideal dampness content show expanding pattern up to 5 percent corrosive fixation and after that show diminishing pattern up to 15 percent corrosive focus contrasted with soil with water. The most extreme dry unit weight show diminishing pattern with increment in corrosive focus contrasted with soil with water. There is decrease in unconfined compressive quality for corrosive debased soil. The quality decrease is more for soils with higher corrosive focus because of decrease in union. The scopes of ideal water substance are diverse for soil with various corrosive focuses and at the particular ideal dampness content all dirt will give crest quality. Water holding limit assume a job in quality decrease. Prof. P V Sivapullaiah: Black cotton soil loses its pliancy properties because of corrosive sullyng. There is likewise proof that corrosive defiled soil demonstrates lower dry unit weight for the equivalent compactive exertion. Along these lines there might be a conceivable decrease in

quality with expanded corrosive focus in the pore liquid. Henceforth a progression of unconfined pressure quality tests were performed on tests arranged with debased pore liquid containing distinctive corrosive fixations at the separate Proctor conditions. The pressure strain bends for Black cotton soil acquired from unconfined compressive quality test for different focuses (1.25 to 15 percent) of corrosive in the pore liquid alongside water as pore liquid are appeared in Figs 13 to 15 for hydrochloric, phosphoric and sulphuric acids separately. The pressure strain bends are direct nearly up to crest pressure and flop in break mode. The strain comparing to top pressure also, the greatness of pinnacle pressure diminishes with increment in the centralization of corrosive. It is additionally seen that at lower centralizations of contaminants (1.25 and 2.5 percent) the firmness incredibly decreases and thus the modulus of versatility and such soils will have a propensity for extensive settlements. The comparison of the unconfined compressive quality test results for the three acids at corrosive groupings of 1.25, 2.5, 5, 10 and 15 percent separately is appeared in Figs. 6.25 to 6.29. The quality of soil is nearly the equivalent under indistinguishable states of corrosive fixation. The expansion in strain is in the request of hydrochloric, phosphoric and sulphuric acids for various corrosive focuses.

### III. MATERIALS AND METHODOLOGY

In this chapter, characterization of materials used in study, details of the experimental investigations such as selection of chemicals like  $H_2SO_4$  and  $NaOH$  for proportioning of stabilizers, equipment used for sample preparation. Strength increment obtained by conducting various tests are presented in this study. The experiments were conducted on black cotton soil to know their physical and engineering properties are specific gravity, Atterberg Limits, Compaction Test, Unconfined compression Test, Free swell index Test. In the present investigation the following materials are used:

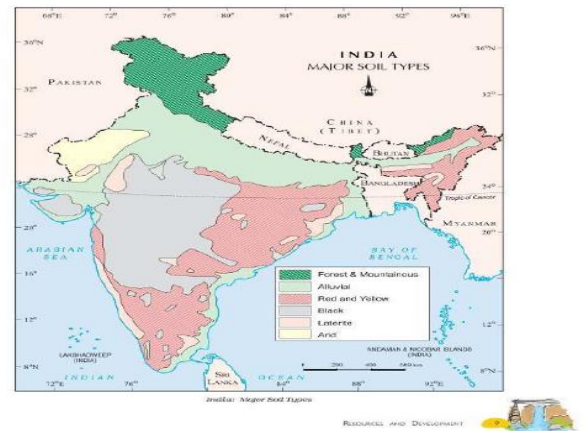
1. Expansive soil
2. Chemicals
  - a. Sulphuric Acid
  - b. Sodium Hydroxide.

### EXPANSIVE SOILS IN INDIA:

In India expansive soils are termed as black cotton soil, used for growing cotton as chief crop found mainly in the states of Andhra Pradesh, Gujarat, Maharashtra, Madhya Pradesh, some parts of Tamil Nadu and Uttar Pradesh. They cover an area of 21% of the total area of the country.

Clays are characterized as follows:

1. Having particles size less than 2 microns.
2. High specific area.
3. High Cat ion Exchange Capacity.

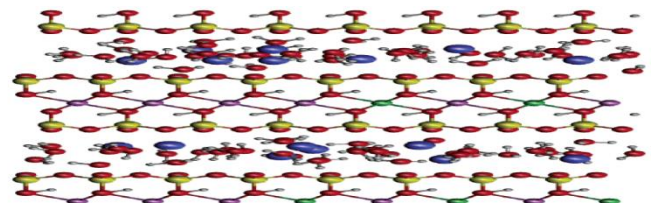


### DISTRIBUTION OF BLACK COTTON SOILS IN ANDHRA PRADESH:

In the state of Andhra Pradesh 40% of the land is covered by black cotton soils having poor drainage, also called as Regurs. pH ranges from 8 and 9, with clay content of 40 to 60%. The black color to the soil is due to the presence of compounds of Magnesium mineral derived from Basalt.

### Behavior of Expansive Soils:

Black soils are having inherent property of shrinking when dried and swelling when they come in contact to water. Negatively charged Alumino-Silicate layers present in clays kept together by cat-ions. The most important property is the ability to adsorb water between the layers which results in strong repulsive forces and clay expansion.



Damages To The Constructions Built On The Expansive Soils Are As Follows:

Damages to the constructions built on the expansive soils are as follows:

1. Severe structural damage by differential settlements
2. Cracks in basement floors, drive ways etc.
3. Disruption of sewer lines and pipe lines
4. Heaving of roads.

Foundations on regurs may move in the vertical direction leading to differential settlements, show sign of unacceptable cracks as the position of ground water changes with season.

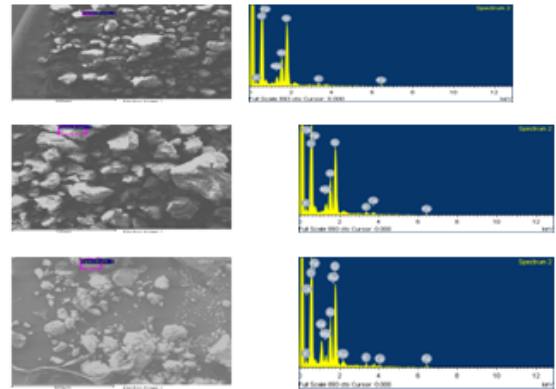
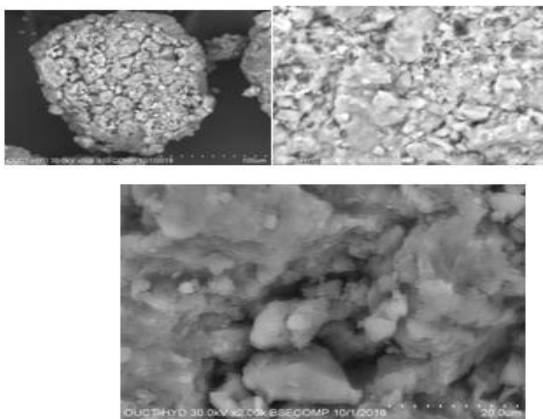


Fig: Edax analysis of untreated and treated BC soil with H<sub>2</sub>SO<sub>4</sub> of p<sup>H</sup> 1,3 and 5.

EDAX ANALYSIS (Wt.%) OF UNTREATED AND TREATED BC SOIL WITH NaOH

Element	BC Soil	NaOH of p <sup>H</sup> =9	NaOH of p <sup>H</sup> =11	NaOH of p <sup>H</sup> =13
O	49.59	48.36	44.80	42.64
Mg	2.42	2.68	1.35	1.10
Al	8.5	9.14	8.21	7.78
Si	23.92	23.25	16.27	14.32
K	1.33	2.24	2.8	3.5
Ca	1.48	2.14	2.94	5.79
Fe	14.24	10.64	5.61	3.84



**EDAX RESULTS:**

EDAX ANALYSIS (Wt.%) OF UNTREATED AND TREATED BC SOIL WITH H<sub>2</sub>SO<sub>4</sub>.

Element	BC Soil	H <sub>2</sub> SO <sub>4</sub> of p <sup>H</sup> =1	H <sub>2</sub> SO <sub>4</sub> of p <sup>H</sup> =3	H <sub>2</sub> SO <sub>4</sub> of p <sup>H</sup> =5
O	49.59	50.75	48.86	54.55
Mg	2.42	2.10	1.66	1.84
Al	8.5	8.69	8.68	7.83
Si	23.92	20.50	19.08	19.52
K	1.33	1.36	1.20	1.35
Ca	1.48	1.66	1.44	4.34
Fe	14.24	14.94	9.78	6.00

**IV. RESULTS&DISCUSSIONS**

In this chapter, the test results of black cotton soil such as liquid limit and plastic limit, OMC&MDD, Cohesion and shear of soil when mixed with different pH of sulphuric acid and sodium hydroxide discussed, analyze and presented .Then the comparison of different pH of Black Cotton soil analyzed and discussed in the study. In the study we conduct test with different pH values of 1, 3, 5, 9, 11, 13.

**PLANNING FOR LABORATORY TEST:**

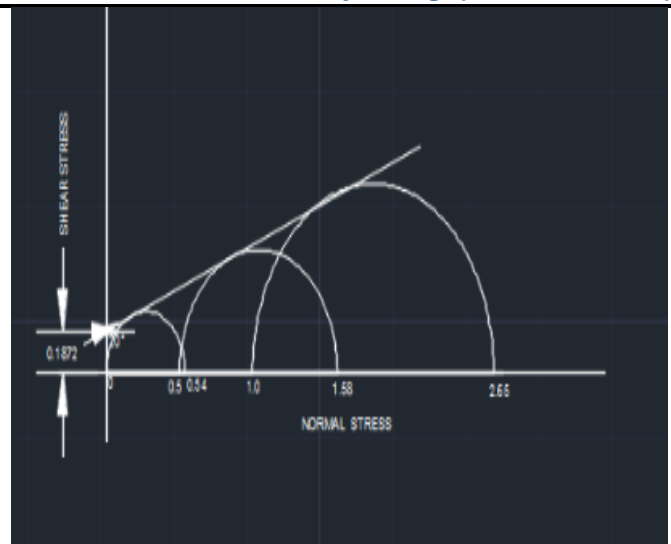
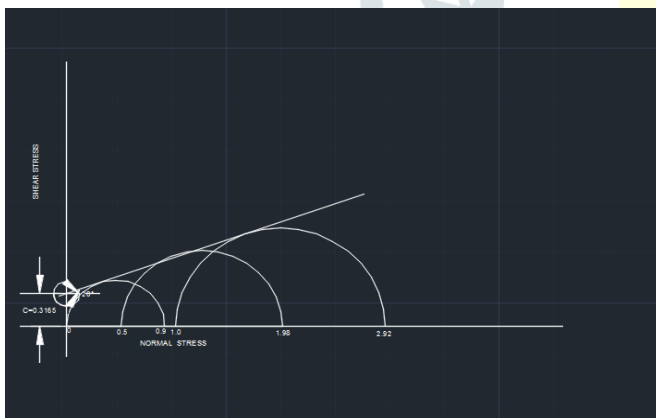
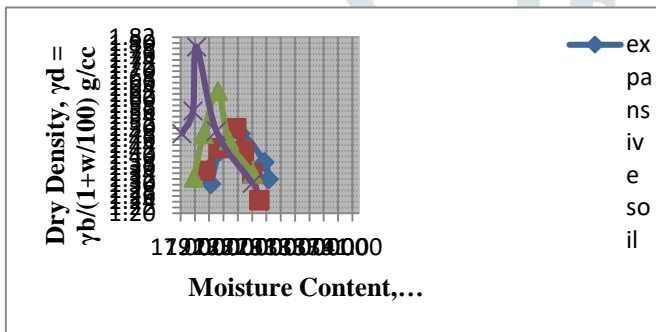
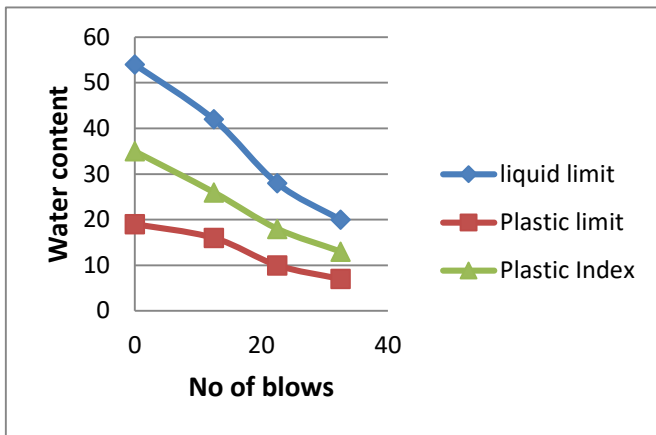
H<sub>2</sub>SO<sub>4</sub> was added the soil with increase in the negative logarithmic hydrogen ion concentration of 1, 3&5 at constant normality. NaOH was added at pH values of 9, 11 &13. Plastic limit, liquid limit, light compaction, unconfined compressive strength test and tri-axial tests were performed. To find the chemical changes in the soil EDX and SEM tests were performed in the Osmania University Campus Hyderabad.

Black cotton soil was proposed to use embankment was modified by mixing sulphuric acid and sodium hydroxide in different proportions, The mix of BC soil .

**Index properties of soil mixed with sulphuric acid and sodium hydroxide**

**a) Black cotton soil**

The Liquid limit, Plastic limit and Plasticity index of BC soil are analysed with different pH values of 1, 3, 5, 9, 11, 13. The test values are shown in table .



**V.CONCLUSION**

Significant and desirable results have been found by adding the chemicals i.e, sulphuric acid and sodium hydroxide in the concentration of chemicals of constant normality increases, it is added to water it is changed to different pH levels i.e to pH= 1,3,5,9,11,13. The usage of pH as shown considerable affection the enhancement of soil properties. The enhancement of soil properties with the addition of H<sub>2</sub>SO<sub>4</sub> and NaOH is mainly because of bonding between the chemicals soil properties. The following conclusion are drawn from the experimental results obtained. Compaction strength and swelling characteristics of expansive soils are dependent on type of chemicals that is sulphuric acid is added to the water it is pH=1,3,5,9,11,13 the maximum dry density is increases and optimum moisture content is decreases to increases. The normality of chemical is sulphuric acid. Tri axial test: addition of H<sub>2</sub>SO<sub>4</sub> increases pH=1,3,5 shear strength of the soil also increases. Tri axial test: addition of NaOH increases pH=9,11,13 shear strength of the soil also increases

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