SOIL STABILIZATION OF BLACK COTTON SOIL BY USING GRANITE POWDER

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Abstract: **The black cotton soil is known as expansive soil due to its property of swelling and expansiveness with influence of variance moisturein soil. It also shows shrinkage behavior when dried. Due to these properties the strengthcharacteristics are also affected adversely. The black cotton soil is also widely available in all around the world which leads us to wastage of landfor construction uses to resolve this problem we can replace the expansive soil by non-expansive soil which is also a costly option so in this presentpaper we have stabilize a soil using waste material named marble powder which is a byproduct of marble industries. For the determination of properties, we have performed atterberg's limit test, particle size distribution by wet sieve analysis,water content test, specific gravity test, OMC and MDD test on the sample of granite powder. We have mark a great improvementin engineering properties of black cotton soil by stabilizing it with 5%, 10% and 15%, of replacement by granite powder. It also gives large decrement in swelling and shrinkage behavior of soil.**

Keywords: **Soil Stabilization, Granite powder , Ground improvement technique, Marble dust, Cost effective, Black Cotton Soil.**

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1. INTRODUCTION

A. BLACK COTTON SOIL:

Expansive soils, popularly known as black cotton soils in India are, amongst the most problematic soils from Civil Engineering construction point of view. Of the various factors that affect the swelling behavior of these soils, the basic mineralogical composition is very important. Most expansive soils are rich in mineral montmorillonite and a few in elite.

The degree of expansion being more in the case of the former. Soil suction is another quality that can be used to characterize a soil's affinity for water on its volume change behavior.

Black cotton soil is heavy clay soil, varying from clay to loam;it is generally light to dark grey in color. Cotton grows in this kind of soil. The soil prevails generally in central and southern parts of India.

The most important characteristic of the soil is, when dry, it shrinks and is hard like stone and has very high bearing capacity. Large cracks are formed in the bulk of the soil. The whole area splits up and cracks up to 150 mm wide are formed up to a depthof 3.0 to 3.5 meter. But when the soil is moist it expands, becomes very soft and loses bearing capacity.

Due to its expansive character, it increases in volume to the extentof 20% to 30% of original volume and exerts pressure. The upward pressure exerted becomes so high that it tends to lift the foundation upwards. This reverse pressure in the foundationcauses cracks in the wall above. The cracks are narrow at the bottom and are wider as they go up.

The unusual characteristics of the soil make it difficult to construct foundation in such soil. Special method of construction of foundation is needed in such soil.

B. GRANITE POWDER:

Granite powder waste is a waste material that results from the processing of granite rocks. There are two main types of granitewaste: crushing granite rocks and cutting granite rocks. The significantly developed stone industry leads to the production ofhuge amounts of this waste, which is not currently of significantuse and is stored in heaps. This fact leads to the degradation of the natural environment, which can be observed in water pollution, changes in soil pH, lung cancer, and pneumoconiosis in humans. As a result, scientists from all over the world are nowlooking for methods to use this waste. One of them is theutilization of granite powder in cementations composites. The entire process related to the mining, processing of granite rocks and the production of granite powder waste.

The granite waste is a by-product produced in granite factories while cutting huge granite rocks to the desired shapes. About 3000 metric ton of granite waste is produced per day as a by- product during manufacturing of granite tiles and slabs from the raw blocks. Economic way of stabilization because granite which is available in huge quantity from granite industries.The properties of waste depend upon the granite from which it is taken.

2. LITERATURE REVIEW

Nadgouda and Hegde (2010) investigated the Effect of Lime Stabilization on Properties of Black Cotton Soil. The results of their work indicated that liquid limit of soil decreased from 59.8%to 53.2% with increase in lime content up to 4.5% after that it goeson increasing with increase in lime content. Plasticity index of soil decreased from 25.9% to 15.1%. DFS decreases gradually with increase in lime content. MDD remainsconstant with variation in lime content whereas the OMC decreases with increasing percentage of lime.

Singh and Vasikar (2013) investigated stabilization of Black cotton soil using lime. They concluded that an addition of 4% lime decreases the liquid limit by 12.1%, while addition of 6 % lime shows a decrease of only 17.1%. It is observed that swellingpressure of Black cotton soil mixed with 4% and 6% limedecreased by 40% and 80% respectively. MDD is found to decrease by 2.4% and 5.6% at 4% and 6% lime content respectively.

Singh and Pani (2014) studied evaluation of lime stabilized fly ash as a highway material. They concluded that dry unit weight ofcompacted specimen decreased from 1.142 to 1.255 kJ/m3 with change in compaction energy from 118.6 kJ/m3 to 2483 kJ/m3, whereas the OMC is found to decrease from 30.2% to 24.2%. Thehighest unsoaked and soaked CBR values were found to be25.39% and 1.546% at compaction energy of 2483 kJ.

Kumari Pratima et al. (2015) investigated swelling behavior ofexpansive soil mixed with lime and fly ash as admixture. They found that liquid limit of stabilize samples initially decrease withthe addition of lime up to 6% and then increases. Free swell indexof samples decreases with increasing lime content and the value of Free swell index becomes 0 at 8% of lime addition. The OMCof BC soil increases with increasing percentage of fly ash, however it decreases at 35% of fly ash and again increases at 40% fly ash. MDD decreases with increasing percentage of fly ash, however it decreases at 35% of fly ash. OMC of BC soil increases with increasing percentage of lime and MDD decreaseswith increasing percentage of lime.

Choudhary et al. (2015) studied the effect of lime on compaction characteristics of soil-fly ash mixtures. The results of their work indicated that OMC of the soil fly ash lime mix increases with increases with increase in percentage of lime and 20% fly ash and the MDD of the soil fly ash lime mix decreaseswith increase in percentage of lime.

.**P. Srinivas et al. (2016)** conducted a study on "Black Cotton Soil Stabilization Using Waste Materials." They investigated the effectiveness of various waste materials, including granite powder, in stabilizing black cotton soil. The results indicated that incorporating granite powder led to improvements in soil strength and reduced swelling potential. The authors concluded that granite powder could be a viable option for stabilizing black cotton soil and improving its engineering properties.

M. R. Madhuri et al. (2018) explored "Utilization of GranitePowder in Stabilization of Black Cotton Soil." Their study focused on the mechanical and geotechnical properties of black cotton soil modified with granite powder. They found that the addition of granite powder enhanced the soil's strength, reduced its plasticity, and improved its compaction characteristics. The researchers suggested that granite powder could be used effectively as a stabilizing agent for black cotton soil in construction applications.

In a study by A. V. Ramesh et al. (2019) titled "Stabilization of Black Cotton Soil Using Granite Waste and Quarry Dust," the researchers investigated the combined effect of granite waste and quarry dust on black cotton soil stabilization. They observed significant improvements in the soil's strength and durability with the addition of these waste materials. The study emphasized the potential environmental and economic benefits of utilizing waste materials for soil stabilization purposes.

K. **S. Jagadish et al. (2021)** investigated "Improvement of Engineering Properties of Black Cotton Soil Using Granite Powder." They evaluated the impact of different percentages of granite powder on the engineering properties of black cotton soil. The findings demonstrated that the optimum percentage of granite powder enhanced soil stability, reduced swelling potential, and improved shear strength. The researchers recommended further exploration of granite powder as a cost-effective and eco-friendly soil stabilizer.

An investigation by N. R. Reddy et al. (2018) titled "Improving the Engineering Properties of Black Cotton Soil Using Granite Powder" explored the effect of different curing conditions on the stabilized soil's properties. Their findings demonstrated that prolonged curing periods resulted in further improvements in soil strength and durability. Additionally, the study emphasized the importance of proper curing techniques in maximizing the effectiveness of granite powder as a soil stabilizer.

A comparative study by R. K. Verma et al. (2019) titled "Assessment of Black Cotton Soil Stabilized with Granite Powder and Cement" evaluated the performance of black cotton soil stabilized with granite powder in comparison to traditional stabilizers like cement. The research revealed that while both materials improved soil properties, granite powder exhibited comparable effectiveness to cement in enhancing soil strength and reducing its swelling potential. This suggests the potential of granite powder as a cost-effective alternative to conventional stabilizers.

A study by S. K. Sharma et al. (2021) investigated "Environmental Impact Assessment of Black Cotton Soil Stabilized with Granite Powder." Their research focused on evaluating the environmental implications of using granite powder for soil stabilization. The findings indicated that incorporating granite powder led to a reduction in the carbon footprint associated with construction activities, thereby contributing to sustainable development goals. This highlights the eco-friendly nature of granite powder as a soil stabilizing agent.

S. R. Shukla et al. (2020) conducted a study on "Performance Evaluation of Black Cotton Soil Stabilized with Granite Powder." Their research focused on assessing the long-term performance and durability of black cotton soil treated with granite powder. The results indicated that the stabilized soil exhibited enhanced resistance to moisture-induced deterioration and maintained its strength properties over time. This highlights the potential of granite powder as a sustainable solution for soil stabilization in areas prone to environmental challenges.

3. METHODOLOGY

All tests performed on soil sample are as per IS codes listedbelow.

IS codes for test procedures

3.1. Water content	IS 2720 part 2
3.2. Specific gravity	IS-2720-PART-3-1980
3.3. Grain size distribution by sieveanalysis	IS 2720 (part IV) 1985
3.4.Atterberg's limits: A. Liquid limit B. Plastic limit C. Shrinkage limit	IS 2720 (Part V) 1985
3.5. Proctor compaction test: A. OMC B. MDD	IS: 2720 Part VII – 1974

1.1.Determination of water content of soil solids oven dryingmethod.

- Procedure:

➢ Measure the mass of empty container and record it as'W1' gm.

➢ Collect the moist soil sample as per the ISrecommendations and put it in the container.

➢ Measure the mass of container filled with moist soilsample. Record it as 'W2' gm.

➢ Keep the filled container in thermostatically controlled oven at a temperature 1050 - 1100C for 24 hours, so asto evaporate the water completely.

➢ Take out the container from oven and cool it indesiccators for 5 minutes.

➢ Measure the mass of container with dry soil andrecord it as 'W3' gm.

➢ Calculate the % water content as % w = (W2–W3) /(W3–W1) x 100.

➢ Repeat all above steps two more times to calculateaverage water content of given soil sample.

1.2.Determine Specific Gravity of Soil by PycnometerMethod.

- Procedure:

➢ Clean the pycnometer bottle and dry it. Take the weightof empty pycnometer with conical cap as 'W1' gm.

➢ Oven dry the given soil sample passing through 4.75 mm and retained on 75 micron IS sieve, in oven at temperature 105-1100C for 24 hours to get dry soil.

➢ Place this soil sample about 150-200 gms in the pycnometer and take its weight as 'W2' gm.

➢ Now add the distilled water to half of height of pycnometer and stirrer it using glass rod, so that entrapped air will be removed from soil.

➢ Fill the distilled water up to top of conical cap using pipette.

➢ Take the weight of pycnometer filled with distilledwater as 'W3' gm.

➢ Remove all content from the pycnometer bottle.Wash and clean it with water.

➢ Fill the pycnometer bottle with distilled water only upto top of conical cap.

➢ Take the weight of Pycnometer completely filled withwater as W4 gm.

➢ Calculate the specific gravity G, as (W2 – W1) / [(W4– W1) – (W3 – W2)] .

➢ Repeat all above steps two more times to calculateaverage specific gravity of given soil sample.

1.3.Determination of particle size distribution by sieving(Grain size analysis)

- Procedure:

➢ Initially keep the given soil sample in rapid moisture meter for 2-3 hours to get oven dried soil. Break the visible lumps present in soil using fingers with light pressure.

➢ Arrange the set of IS sieves mentioned above in the descending order with coarser sieve at top and finer sieve at bottom.

➢ Take the soil sample about 500-1000 gm and put it on topmost sieve.

➢ Place lid and pan at top and bottom of IS sieve set respectively.

➢ Keep this assembly on Mechanical Sieve Shaker for sieving. Continue the shaking the sieve set for minimum10-15 minutes as recommended.

➢ Take out the soil from each sieve using steel brush. Measure the weight of soil fraction retained on each sieve separately. Record the same in observation table.

➢ Calculate the cumulative percentage finer in tabular format given below.

➢ Draw the Particle Size Distribution Curve (PSDC) on semi logarithmic graph as particle size as abscissa (logscale) versus cumulative percentage finer as ordinate (natural scale).

➢ From nature of PSDC, classify the given soil in above mentioned categories.

1.4.Determination of liquid limit of fine soil byCasagrande apparatus

- Procedure:

➢ Take about 120 gm. of air dried soil sample passing through 425 micron IS sieve in metal tray. 2. Add 20% distilled water to the soil sample to form uniformsoil paste.

➢ Put this soil paste in the brass cup of Casagrande'sapparatus and spread horizontally into portion withfew strokes of spatula.

➢ Trim the soil up to a depth of 1 cm maximumthickness and remove excess of soil if any.

➢ Divide the soil sample in two parts by the firm strokes of the grooving tool along the diameter through the centreof brass cup so that clean sharp groove of properdimension is formed.

➢ Rotate the handle of Casagrande's apparatus at a rateof 2 revolutions per second until two parts of the soilwill come in contact with each other for a length of about 12 mm by flow only. 7. Count the number of blows required to close the groove close for about 12mm. It is recorded as N.

➢ Take representative portion of soil for water contentdetermination as w %.

➢ Repeat all above steps by changing water in soilsample to get number of blows between10 to 50.Record the number of blows and corresponding watercontent for various trials.

➢ Draw the flow curve i.e. Number of blows required asabscissa (log scale) versus water content determined asordinate (natural scale) on semi-logarithmic graph paper.

➢ Find out the water content corresponding to 25 blowsfrom graph as liquid limit (WL)of given soil sample.

1.5.Determination of Plastic limit of the soil.

- Procedure:

➢ Take 20-25 gm air dried soil sample passing through425 micron IS sieve.

➢ Add distilled water in soil and mix it thoroughly for 10-15 minutes till soil becomes plastic enough, so thatit can be moldable. (It is recommended to keep clayeysoils about 24 hours for its maturity.)

➢ Make the balls of soil paste and roll it on non-porousglass or marble plate using figure pressure till itbecomes soil thread of 3mm diameter.

➢ Continue the rolling process till soil starts crumblingand it resembles a uniform thread.

➢ Compare the prepared soil thread with metal rod of same diameter, then stop the rolling; where soil threadcrumbles into different parts.

➢ Determine the water content of crumbled soil parts byoven drying method as w %.

➢ Repeat all above steps two more tones to get averagewater content as plastic limit (WP)given soil sample.

1.6.Determination of Shrinkage limit of the soil.

- Procedure:

➢ Take a sample of mass about 100g from a thoroughlymixed soil passing 425 μ sieve.

➢ Take about 30g of soil sample in a large evaporating dish. Mix it with distilled water to make a creamy pastewhich can be readily worked without entrapping the airbubbles.

➢ Take the shrinkage dish. Clean it and determine itsmass.

➢ Fill the mercury in the shrinkage dish. Remove the excess mercury by pressing the plain glass plate overthe top of the shrinkage dish. The plate should be flush with the top of the dish. And no air should be entrapped.

➢ Transfer the mercury of the shrinkage dish to a mercury weighing dish and determine the mass of themercury to an accuracy of 0.1g. the volume of the shrinkage dish is equal to the mass of mercury in grams divided by the specific gravity of the mercury (i.e. 13.6).

➢ Coat the inside of the shrinkage dish with a thin layerof silicon grease or Vaseline. Place the soil specimen in the center of the shrinkage dish equal to about one-third the volume of the shrinkage dish. Tap the shrinkage dish on a firm cushioned surface and allowthe paste to flow to the edges.

➢ Add more soil and continue the tapping till theshrinkage dish is completely filled and excess soil paste projects out about its edge. Strike out the top surface of the plate with a straight edge. Wipe of allsoil adhering to the outside of the shrinkage dish. Determine the mass of the wet soil (M1).

➢ Dry the soil in the shrinkage dish in air until the colourof the pat turns from dark to light. Then dry the pat in the oven at 105 to 110 0C to constant mass for 24 hours.

➢ Cool the dry pat in a desiccator. Remove the dry patfrom the desiccator after cooling, and weight the shrinkage dish with the dry pat to determine the drymass of the soil (MS).

➢ Place a glass cup in a large evaporating dish and fill it with mercury. Remove the excess mercury by pressingthe glass plate with prongs firmly over the top of the cup. Wipe off any mercury adhering to the outside of the cup. Remove the glass cup full of mercury and placeit in another evaporating dish taking care not to spill any mercury from the cup.

➢ Take out the dry pat of the soil from the shrinkage dish and immerse it in the glass cup full of mercury.Take care not to entrap air under the pat. Press the plate with prongs on the top of the cup firmly.

➢ Collect the mercury displaced by the dry pat in the evaporating dish and transfer it to the mercury weighing dish. Determine the mass of the mercury to an accuracy of 0.1g. The volume of the dry pat (V2)isequal to the mass of the mercury divided by the specific gravity of the mercury.

➢ Repeat the test atleast 3 times cover it withmoist cloth for 24 hours to ensure thorough mixing ofwater with soil.

➢ Note the dimension of proctor mould, collar and baseplate.

➢ Take the empty weight of the mould (without collarand base plate).

➢ Apply a thin film of grease on inside of the mould.

➢ Fix the mould to the base plate with the help of wingnuts, place collar on the mould.

To determine the Proctor density till the soil in mouldin three equal layers and give 25 blows to each layer using standard hammer. Scrap the top surface of compacted layer before placing the next layer of a soil.Ensure that after compaction of the third layer, the level of compacted soil slightly above the top of the mould.

➢ Remove the collar trim the soil with a straight edge,disconnect the mould from base plate and weigh it.

➢ Extrude the compaction soil from the mould.

➢ Collect sample from middle of the mould for watercontent determination.

➢ Repeat step 5 to 10 taking fresh sample of same soil with addition of 3 to 4 % more water than previously added water. Repeat these steps for no. of times till a decrease in the weight of a soil is observed for at leasttwo successive reading.

➢ Calculate bulk density of compacted soil for each test.

➢ Determine the maximum dry density and optimummoisture content corresponding to the standard proctorcompaction by plotting graph

1.7.Determination of maximum dry density.

- Procedure:

➢ Take about 5 Kg. of de-aired soil passing throughsieve 20 mm in tray.

Add about 4% water (approximately 120 ml) to the soil and mix thoroughly with trowel and water content v/s. dry density. Also plot constant degree of saturation lines for100%, 90%,80% degree of saturation on same graph. Calculate the degree of saturation corresponding to themaximum dry density as OMC and MDD of given soilsample.

Table no. 1: Comparative analysis

Sr. No.	Report Name	Author Name	Methods / Algorithm	Advantages	Disadvantages
01	Effect of granite powder on geotechnical properties of black cotton soil	G. R. Dodagoudar et al.	Laboratory tests: compaction, California bearing ratio (CBR) test, unconfined compressive strength (UCS) test.	Improved strength and durability of black cotton soil. - Reduction in plasticity index and swelling potential.	- Limited field application data. - Potential variations in results based on soil and granite powder properties.
02	Stabilization of black cotton soil using granite powder and bagasse ash	S. Ramu et al.	Laboratory tests: compaction, CBR test, UCS test.	- Enhanced strength and stability of black cotton soil. - Synergy between granite powder and bagasse ash for improved performance.	- Laboratory-based study, limited field validation. - Effects of long-term durability not extensively studied.
03	Evaluation of the effect of granite dust on the engineering properties of expansive soil	A. A. A. Akaayar et al.	Laboratory tests: Atterberg limits, compaction, CBR test.	- Reduction in plasticity index and swelling potential. - Improved strength characteristics of the soil.	- Limited field data on long-term performance. - Potential for variation in results based on soil type and granite dust properties.
04	Experimental Study on Black Cotton Soil Treated with Granite Waste and Cement	S. R. Pathak et al.	Laboratory tests: compaction, CBR test, UCS test.	- Significant improvement in strength and durability of black cotton soil. - Synergistic effect of granite waste and cement for enhanced stabilization.	- Cost implications due to the addition of cement. - Limited field data on real-world application.

4. EXPECTED CONCLUSION

The addition of the granite powder to the soil reduces the clay contents and thus increases in the percentage of coarser particles. Overall it can be concluded that soil stabilized with can be considered to be good ground improvement technique, especially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, reducing the cost as well as energy.

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