Enhancing the Stability of Black Cotton Soils by using Geonet

Guruprashanth N[1], Pawan Poudel[2], Tasadduq Hussain Khan[3], Swamy SLN[4], Rizwan J.A[5]
Department of Civil Engineering
Jain Institute of Technology, Davangere
Karnataka, India

Abstract: *Stabilisation of soil involves changing the soil's properties to support its presentation. In many design projects, stabilisation is used, either in its most basic or tightly controlled form. Finally, all plans are based on soil establishment, where increasing soil strength and solidity while lowering improvement costs are the main objectives. Utilizing of byproducts with soil is currently gaining more and more attention daily resulting in the expanding difficulties with waste management. The results of this study, which looked at the effects of Geonet grains on Black Cotton soil at various doses, are reported in this report. Through various measures of the Geonet grain mixture, the soil's behaviour was observed. In order to evaluate the application of Geonet and cement soil, a variety of physical strength execution tests were performed, including the water content test, specific gravity test, grain size analysis test, liquid limit test, standard proctor test, direct shear test, and permeability test. These were designed to assess how the soil's strength qualities had changed over time.*

1. Introduction

In addition to air and water, soil is one of the most vital natural resources since it is essential to life on earth.The term "soil" refers to a natural body made up of layers (or "soil horizons") predominantly made up of minerals. Minerals differ from parent materials in terms of their texture, structure, consistency, colour, chemical make-up, biological make-up, and other physical traits. The final product, soil, is a combination of the climate's effects on temperature and precipitation, relief's effects on slope, organisms' effects on flora and fauna, parent materials' effects on original minerals, and time's effects on parent materials.

Regolith, or loose rock materials, is the term used in engineering for soil. Generally speaking, soil is the regolith depth that impacts and has been impacted by plant roots. Its depth can range from a few centimetres to several metres. A superior soil has a volume that is composed of 45% minerals (sand, silt, and clay), 25% water, 25% air, and 5% both living and dead organic matter.

SOIL STABILIZATION

A. *Factors affecting bearing capacity of soil*

1) Type of soil:

The soil type determines the carrying capacity of soil. Terzaghi equation for bearing capacity makes it clear that different types of soil have different bearing capacities.

2) Soil properties:

The potential of soil to support life is influenced by soil characteristics including shear strength, density, permeability, and others. Because the unit weight of dense sand is more than that of loose sand, it will have a greater bearing capacity.

3) Type of foundation:

The type of foundation used also affects the soils' carrying capacity. The raft or mat foundation secures the structure's load by dispersing it over a broader area, even if the soil has a low bearing capacity.

4) Amount of settlement:

The soil's ability to support a structure depends on how much it has settled. The potential of soil to support life is diminished if the settlement is greater than the potential settlement.

5) Watertable:

In cohesive soil, the permeability is so low that moment of water is low. They do not suffer any reduction in bearing capacity in the inclusion of ground water.

A. Needs for soil stabilization

- The mechanical qualities of the soil are immediately improved through soil stabilization, which also increases the soil's capacity to support loads.
- Optimum moisture content; Prior to stabilisation, soil was damp and muddy, but after stabilisation it is much easier to handle, place, and compact.
- Improved weather condition; When soil is stabilised, its short- and long-term carrying capacity is increased, and it becomes more resistant to water and frost.
- Homogenous mix; A single project site typically receives dirt from many sources. This dirt from diverse sources is blended together through soil stabilisation to form a uniform slurry.
- Soil stabilization is employed to fortify the on-site components for a strong and stable sub foundation.

B. *Methods of Soil Stabilization*

To maximize the strength, durability, or other aspects of soil, it is important to alter some of its physical characteristics. This is frequently essential for building roads and other infrastructure and for other infrastructure-related problems. The carrying capacity of stabilised soil will be greatly increased, and it will also be much less susceptible to damage from water, frost, or adverse weather. The following are the fundamental ways to stabilise clay:

1. Mechanical Stabilization

Volume 11, Issue 05 Published by, www.ijert.org ISSN: 2278-0181

2. Chemical Stabilization
3. Thermal Stabilization
4. In-situ ground reinforcement, stone columns, grouting, and other stabilisation techniques are also available.

2. LITERATURE REVIEW

I. Ms. Rajvinder Kaur, et al., (2019)

This paper entitled that "Tyre Rubber Powder as a Stabilizer". They looked into how well rubber powder stabilised the soil used for black cotton. They used the Atterberg limits, Direct Shear Test, and CBR Test to examine the attributes of altered soils. They investigated the variations in soil characteristics when using different amounts of tyre waste, such as 0%, 5%, 10%, and 15%. Following the Direct shear test, 10% more rubber powder was utilized to boost the shear strength. The value of CBR is increased by 10% rubber powder in the same way. Strength will gradually diminished if the dosage of rubber powder rises above 10%. It is applied to the construction of road shoulders or embankments.

II. J. Jayashree, S.Yaminiroja (2019)

This paper entitled that "Stabilization of expansive soil using rice husk ash and lime." By varying the dosage, they investigated the effect of RHA and lime to stabilise the BC soil. By adding 20% RHA, the soil's OMC rose from 14% to 38%. With 20% RHA, the soil's MDD dropped from 2.03g/cm^3 to 1.632g/cm^3. With 15% RHA, the soil's UCS increased from 49.5 KN/m2 of plain soil to 52.9 KN/m^2. With the increase of RHA and lime, the liquid limit rose from 52% to 70.6% and the shrinkage limit climbed from 11.73% to 48.3%. The soil became non-plastic after the addition of RHA and lime.

III. D. Namrata D Sune, etal.,(2018)

This paper entitled that "Stabilization of black cotton soil by using geotextile material in road construction.'' Improve the earthen buildings' strength attributes by using a well-designed one here in the soil made of black cotton. With increasing percentages of PP strips, the soil sample's MDD increased, with the ideal value occurring at 2% PP. As the percentage of PP increased, the optimal moisture content decreased. At 2% PP, the ideal value was attained. The maximum moisture content attained at 2% PP was roughly twice as high as that of unreinforced soil.

IV. B. Sri Vasavi, et al.,(2016)

This paper entitled that "Stabilization of Expansive Soil using Crumb rubber powder and Cement". The effect of rubber powder in stabilising the clayey soil has been researched. Using the tests CBR Test and Standard Compaction, they looked at the characteristics of modified soils. They experimented with varying concentrations of cement (2%, 4%, 6%), and also crumb rubber powder (2%, 5%, 7%, 9%). They found that the MDD and OMC dropped as the quantity of rubber powder rose. As the amount of rubber powder is increased, the cohesiveness and angle of internal friction both decrease by 7% and 9%, respectively. Wet CBR values are 0, however CBR values before soaking vary from 2.6% to 7.5% in terms of the proportion of crumb rubber powder.

V. Vegulla Raghudeep et al,. (2015)

This paper entitled that "Improvement in CBR value of Black cotton soil by stabilizing it with vitrified polish waste". The effects of waste from vitrified polishing on soil properties. It was their goal to determine whether the rise in thickness of pavement decreased as a result of CBR brought on by the increase of polish waste. In studies on the soil, both on its own and in addition with vitrified polish waste, grain size distribution, Atterbegs limits, compaction, and CBR were all investigated. They discovered that adding 10% vitrified polish waste significantly decreased pavement thickness and boosted CBR value.

The results of a laboratory experiment on expansive soils stabilised with 5% NaOH and treated with CP composed of industrial waste are described in this publication. In order to ascertain whether the characteristics of expansive soil have improved, Coir Pith is added at varying percentages. Tests for liquid limit, modified proctor compaction, and UCS were performed on coir pith- and black cotton-soil mixtures at various admixture amounts, ranging from 2% to 4%. In comparison to BC Soil that had not been treated, the addition of coir pith at 2% and 3% resulted in a lower plasticity index (PI). While the OMC is lower than BC Soil with the increase of 2% and 3% coir pith, the MDD is raised.

VI. Sujitkawade et al., (2014)

This paper entitled that "Stabilization of Black Cotton Soil using Lime and Geogrid". They looked at how soil properties were impacted by lime and geogrid.Their main objectives were to contrast the properties of the soil before and after adding lime and geogrid. Numerous experiments were performed, including those to ascertain the natural moisture content, specific gravity, Atterberg limits, the compaction test, and the compressive strength test. Following lengthy investigation and completion of the aforementioned test, the appropriate lime level was discovered to be 15%, and it was established that the soil's compressive strength had greatly risen.

VII. Ayush Mithal,et al,.(2010)

This paper entitled that "Geotextiles: An Overview". Geotextiles have been used successfully in a number of engineering projects to stabilise soil. The goals are to learn more about geotextile characteristics, including their physical, mechanical, hydraulic, endurance, and durability qualities, as well as their fibre types, both natural and synthetic, uses for geotextiles, applications for them, and environmental impacts. They have concluded that due to geotextiles' functional versatility, it is utilized in a variety of key civil engineering projects. In addition to lowering construction expenses, geotextile use also minimises maintenance expenditures.

VIII. Shabba M and Pavan Kumar Balichakra (2005)

This paper entitled that "Stabilization of Black Cotton Soil with Tyre Waste". They investigated how successfully the soil used to grow black cotton was stabilised by rubber powder. They examined the traits of changed soils using the tests California Bearing Ratio Test and Standard Compaction Test. They investigated how the qualities of the soil were impacted by the amount of tyre trash, which went from 0% to 2%, 4% to 6% to 8% to 10% and 12%. According to the standard compaction curve, the maximum dry density will decrease as the percentage of rubber powder increases. The CBR test showed that the CBR value rises up to 12% with the addition of rubber powder before falling. It is known as Optimum Rubber Content as a result. They have determined that using Rubber Powder in combination with Black Cotton Soil can be used to construct pavement.

3. OBJECTIVES

i. To examine the basic attributes of BC soil by conducting various tests.
ii. To research how adding Geonet alters the BC soil's MDD and OMC.
iii. To investigate the shear strength attributes of BC Soil by adding Geonet.
iv. To evaluate the variation in swelling attributes of BC soil by adding Geonet.
v. To suggest the optimum dosage of Geonet for the present soil.

4. MATERIALS AND METHODOLOGY

I. Materials

a) Black Cotton Soil

b) Geonet

Black Cotton Soil:

When tied to an engineering structure and exposed to water, the naturally expansive black cotton soil will exhibit a tendency to swell or contract, causing the structure to experience moments that have nothing to do with the direct effect of the loading by the structure. A soil sample was taken from the Bilichodu village in the southern Karnataka state of Jaglur Taluk, Davangere District. All of the organic debris and other waste items were removed from the soil's top layer.Expansive soils are soft bedrock or soils that expand or increase in volume when wet and contract when dry. This broad soil is known as "Black Cotton Soil" in India. the hue of this In India, around 30% of the land area is covered by soil that ranges in colour from reddish brown to black, which is helpful for growing cotton. They are also frequently referred to as expansive, bentonite, or black cotton soil. Black Cotton soil, also called as regurs, is widespread in the Deccan Trap region of India. They are sticky material locally called as "Kali Mitta" and vary in thickness. When used in conjunction with an engineering structure, Black Cotton soil exhibits a tendency to swell or contract when there is water present. This result in moments being experienced by the structure those are mostly unrelated to the direct impact of the structure's loading. One of the most frequent reasons for harm to structures and construction is black cotton soil. This can result in a significant economic loss for a country.

Geonet:

Another specialised part of geosynthetics field is geonets, also known as geospacers by some. In order to create them, parallel sets of polymeric ribs are continuously extruded at right angles to one another. Relatively big openings are generated into a netlike pattern when the ribs are expanded. The two most prevalent kinds are either biplanar or triplanar. As an alternative, a wide variety of drainage cores are available. They consist of tiny drainage channels or spacers woven into geotextiles, three-dimensional networks of stiff polymer fibres arranged in different topologies, and polymer sheets with nubbed, dimpled, or cuspated surfaces. Their whole design purpose is contained within the drainage region, which they used to transport any kind of liquid or gas. The in-plane hydraulic flow rate, or transmissivity, is of utmost significance because a geonet's principal purpose is to transport liquid within the plane of its construction. Other characteristics, however, are equally significant since they may affect this value during the course of the geonet's operational life. Consequently, a number of mechanical, endurance, physical, and environmental characteristics will also be covered. Polyethylene resin is used to make every geonet that is currently on the market. Density ranges between 0.94 and 0.96 mg/L, with higher values resulting in more stiff goods. In this respect, the resin is genuine high-density polyethylene (HDPE), as opposed to the HDPE geomembranes, which use a density that is actually medium density. The resin is made up of 0.25 to 0.75% additives that act as processing aids and antioxidants, 2.0 to 2.5% carbon black (often in a concentrated form mixed with a polyethylene carrier resin), and a carrier resin.

Fig 4.1: Geonet

II. Methodology

Preliminary tests were performed on the Black Cotton Soil, Geonet materials in accordance with IS norms and specifications, where the plain black cotton soil was first examined for its engineering properties and then stabilised. Geonet is adjusted in accordance with an ideal proportion mix of (1%, 2%, 3%, 4%, and 5%).

5. RESULT AND DISCUSSION

a) Sampling of soil:

Table 5.1: Sampling of Soil

Soil Particulars	Percentage Variance

Natural BC Soil	0%
Sample 1	BCS + 5% Geonet
Sample 2	BCS + 10% Geonet
Sample 3	BCS + 15% Geonet

b) Water content test:

The amount of water in a soil may be the most important factor that significantly affects numerous soil qualities. Its confidence is crucial. The weight of the dry solids in the soil mass is often expressed as a rate by weight.The water content (w), commonly referred to as the natural water content or the natural moisture content, is the proportion of water to solids in a particular mass of soil. Typically, this ratio is stated as a percentage. The water content of gaps is equal to zero (dry soil) when they are totally filled with air.

Table 5.2: Table Showing Variation of Soil properties from water content

Samples	Water Content (%)
Natural Black Cotton Soil	8.10
5% Geonet + BCS	7.85
10% Geonet + BCS	7.43
15% Geonet + BCS	6.25

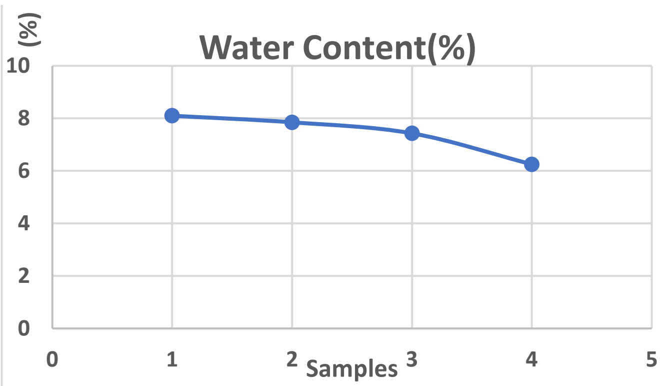

Fig No- 5.1: Water content

c) Specific gravity test by Pycnometer method:

The ratio of the mass/weight of dry soil solids in air to the mass/weight of an equivalent volume of purified water at 270 °C is known as explicit gravity. When calculating void percentage, porosity, degree of immersion, and water content, the specific gravity of the soil is taken into account, provided thickness and water content are known. The specific gravity of the will aids in identifying and organising dirt. According to our experiment, the specific gravity value is 2.28.

d) Liquid limit by Casagrande method:

The liquid limit is the amount of water in a soil that compares to its closest fluid and plastic consistency. The dirt is still in a fluid state at this base water level, but it has only a minimal shearing strength against streaming.Our testing indicates that the liquid limit value is 34.62%.

e) Standard Proctor Test:

The process of densifying soil mass by reducing voids is known as compaction. A dry density is utilized to estimate a soil's level. The amount of compaction is primarily determined by the soil's moisture content, compaction energy, and type. Each soil achieves the highest dry thickness for a given amount of compaction energy at a particular water content, or "optimum moisture content." The compaction test will result in OMC and MDD being up in the air. Every compaction is completed using conventional proctor equipment. For the purpose of verifying the moisture density connection, energy from a 2.6 kg hammer dropping from a height of 31 cm in the shape of a 1000 mm was used. Each layer is compacted in five layers to such an extent that each layer getting 25 blows.

Table 5.3: Table Showing Variation of Soil Properties from Standard proctor test (light compaction test)

Samples	Light Compaction Results	
	OMC (%)	MDD (g/cc)
Natural Black Cotton Soil	13.98	2.05
5% Geonet + BCS	15.86	1.77
10% Geonet + BCS	12.89	0.92
15% Geonet + BCS	9.17	0.88

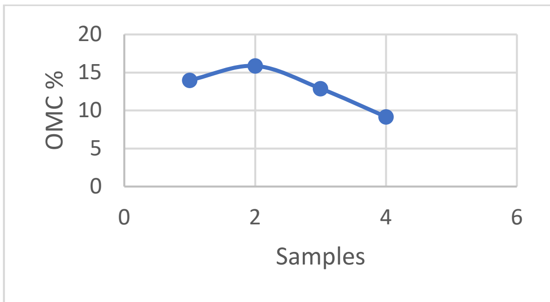

Fig No- 5.2: Showing Graphical Variation of OMC

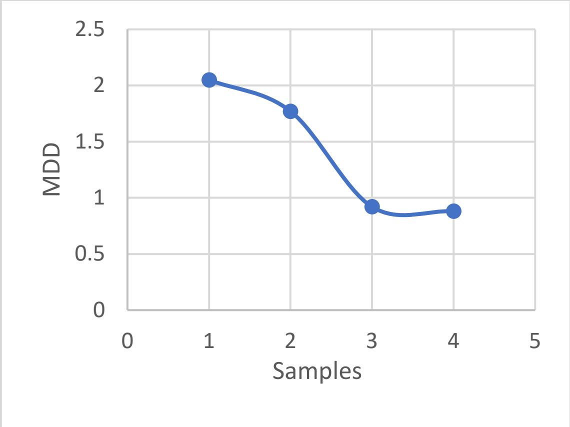

Fig No- 5.3: Showing Graphical Variation of MDD

f) Direct Shear Test:

In order to assess the shear strength of soil materials, geotechnical engineers employ the Direct Shear Test as an experimental technique. A material's shear strength is its highest capacity for resistance under shearing.

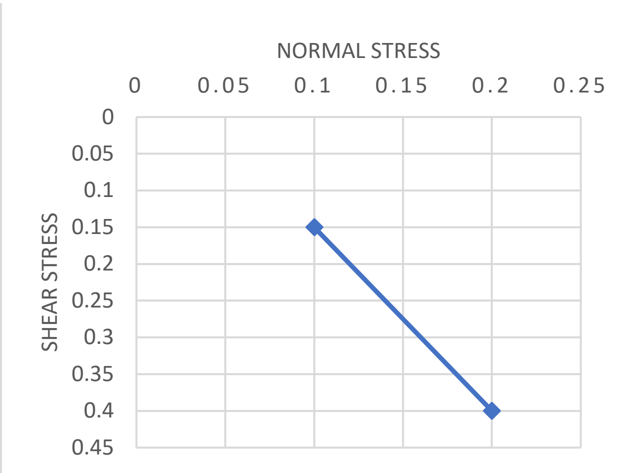

Fig No- 5.4: Showing graphical variation of Direct Shear Test

g) California Bearing Ratio Test:

The California Bearing Ratio (CBR) assesses the durability of the subgrade beneath a street or other cleared area as well as the construction materials employed. The normalised infiltration test was developed by the California Division of Highways for highway design and is used to calculate the proportion because exact tests only evaluate the material's strength and do not accurately reflect the tough modulus.

h) Test Results of Black Cotton Soil:

Table 5.4: Test Results of Index and Engineering Properties of Black Cotton Soil

Sl. No	Properties	Results
1	Initial Moisture Content	8.10%
2	Specific Gravity (G)	2.28
3	Liquid Limit (W_L)	34.62%
4	Plastic Limit Test	24.8%
5	Soil Classification	WG
7	OMC	13.98%
8	MDD	2.05
9	Direct Shear Test	0.15
10	CBR Unsoaked	4.9%

6. CONCLUSION

1) The Well Graded category includes the Soil. Given that the soil is extremely compressible, the liquid limit and plastic limit values are separately 34.62% and 24.8%. As a result, the soil is below the level recommended for nearly geotechnical operations.
2) Geonet and Geo-grids are used to facilitate work on the geotechnical trademark Compressive Strength of BC soils. Geonet has essentially improved the compressive strength of BC soil.
3) It is noticed that, OMC and MDD is decreasing with the addition of 5% Geonet.
4) Overall, we can say, addition of geonet is not suitable for increasing MDD and OMC but it can be used as a patching material.

7. REFERENCES

1) Rajvinder Kaur, Er. Dalvir Singh (2019), *"Tyre rubber powder as a soil stabilizer."* International Journal of Multidisciplinary Research and Development, Volume 6, Issue 8, 2019, Pages 122-125.
2) D.V.S. K Chaitanya, P. Neeharika (2019), *"Soil Stabilization using Geosynthetic Material (Steel Fibres)".* International Journal of Innovative Technology and Exploring Engineering (IJITEE),ISSN: 2278-3075, Volume-8, Issue-6S4,Pages 553-556.
3) Namrata D Sune, S.A Deshmukh (2018), *"Stabilization of black cotton soil by using geotextile*

material in road construction." International Research Journal of Engineering and Technology (IRJET) e-ISSN: 2395-0056 Volume: 05 Issue: 12, Page No: 764-766.

4) B. Sri Vasavi, Dr. D.S.V.Prasad, A.C.S.V. Prasad (2016), *"Stabilization of expansive soil using crumb rubber powder and cement". International JournalOf Innovative Research In Technology (IJIRT),Volume 2 Issue 8 , ISSN: 2349- 6002,Pages 26-31.*

5) J.Jayashree, S.Yaminiroja(2019), *"Stabilization of expansive soil using rice husk ash and lime."* International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-3,Pages 2661-2666.

6) Kesavan M and M Rajalingam (2019*),"Behaviour of Black Cotton Soil Reinforced with Areca-nut fibre".* International Journal of Engineering Science and Computing.Volume9,Issue No.5, Pages 22279-22283.

7) Arthi Priya.D, R.Gopalkrishna,M.Jawahar(2017), *"Stabilization of Black Cotton soil Using Coir Pith"*.IRJET, Volume:04,Issue:02,Pages 1-6.

8) VegullaRaghudeep, M.T.S Lakshmayya, K.S.B Prasad (2015*), "Improvement in CBR value of Black cotton soil by stabilizing it with vitrified polish waste".* International Journal of Innovative Research in Science, Engineering and Technology,Vol. 4, Issue 8, August 2015.Pages 6894-6901.

9) Sujithkawade, MahendraMapari, Shreedhar Sharanappa,(2014)"*Stabilization of Black Cotton Soil using Lime and Geogrid".* International Journal of Innovative Research in Advanced Engineering (IJIRAE),ISSN: 2349- 2163,Volume 1 Issue 5,Pages 87-91.