



To Enhance the Properties of Black Cotton Soil for Road Construction

Momin Nooh, Momin Altamash, Khan Taha, Shaikh Umar, Mr. Vikas Gore, Mr. Prathamesh Patil, Ms. Vaishnavi Naik*

ARMJET, Shahapur, Thane, Mumbai University

Corresponding Author Email id: noohzeeo.khushal10@gmail.com

ABSTRACT

Black cotton soil has poor shear strength and significant swelling and shrinking, which means that modifying either of the soil's physical or engineering attributes can change how it behaves when stresses are applied to it. By adding admixtures like manufactured sand, cement, and fly ash, changes in swelling and shrinkage ratio that result from changing climatic conditions can be reduced in BC soil. The current study evaluates the physical and engineering characteristics of BC soil that has been combined with admixtures in varied amounts, and the results are tabulated by comparing them to industry standards.

The experimental study also showed that when conducting standard proctor tests and CBR tests, there is a gradual increase in the CBR values with increasing percentages of admixtures like cement, M-sand, and fly ash in the soil mix. However, there is a significant reduction in the optimum moisture content for the given soil with increasing percentages of M-sand with cement and fly ash.

Keywords: Black cotton, shear strength, shrinking, climate change, fly ash.

1. Introduction

1.1 General

The majority of the land in India is covered by expansive soil, sometimes referred to as clayey soil. The main cause of the shrinkage and swelling of these soils is seasonal fluctuations. To make soil acceptable for construction purposes, its qualities must be enhanced. Chemical stabilisation is one of the various methods that may be used to improve the soil's qualities. Terrasil enhanced the strength qualities of expanding soils. Terrasil & zyenbond are two of the most well-known chemical admixtures used in soil adjustment. The crucial characteristics, for instance, list characteristics, unrestricted compressive quality criteria, and California bearing proportion values. The cost of the materials used to build roads rises as stone resources are depleted. Modification of soil can be accomplished by inserting chemicals like lime, cement fly ash, etc. for stabilisation. to improve the soil's performance, strength, and durability. In the construction of rural roads, it can be used to create sub-base or base. To produce the desired impact in the chemical stabilisation process, soil stabilisation mostly rely on chemical reactions between stabiliser & soil minerals. Black cotton dirt covers a major portion of India. Basalt residual deposits give rise to black cotton soils. They have a hue that ranges from grey to black and are quite clayey. Increasing the depth of the foundation, compacting the soil, replacing the soil beneath the foundation, and stabilising the soil are some methods used to increase the strength of the soil.

Since the last two decades, infrastructure development in India has increased significantly. Pavement construction is progressing quickly as a result of it. Many times during the process, it is necessary to lay pavement on soft, unfavourable ground. Because such subgrade soils have a very low California Bearing Ratio (CBR) value, the thickness of the pavement layers increases. Large amounts of natural resources are consequently needed, which causes the depletion of priceless natural resources. Therefore, increasing the CBR value of the subgrade results in sustainable development, which is highly desired in a nation like ours. Construction on such areas might occasionally cause problems.

1.2 Principle of Black Cotton soil

Modification of soil can be accomplished by inserting chemicals like lime, cement fly ash, etc. for stabilisation. to improve the soil's performance, strength, and durability. In the construction of rural roads, it can be used to create sub-base or base. To produce the desired impact in the chemical stabilisation process, soil stabilisation mostly rely on chemical reactions between stabiliser & soil minerals

1.3 Advantages of Black cotton soil

1. Easily available in konkan region
2. Have good aesthetic.

- 3.Lower material uses .
- 4.It is good for government uses.
- 5.It helps aquatic life

1.4 Disadvantages of Black cotton soil

- 1.Have much lower strength than regular soil
- 2.Require special treatment to get usable

1.5 Comparison between Regular and Black Cotton Soil

- 1.Black cotton soil are good for road.
- 2.Good aesthetical appearance than regular soil
- 3.Strength is practically lower than regular soil

1.6 Problem Statement

Nanocastic substances The Zydex industries introduced Terrasil and Zycobond, two nanotechnology-based products that can address moisture and bonding problems. Terrasil is a water proofing agent, and Zycobond is a bonding substance. When nanoparticles are added to soil, the soil is altered at the atomic or molecular level, which affects the soil's strength, permeability indices, and resistance qualities. Another application for cement is as a stabiliser. In this study, soil stabilisation using various chemical dosages was examined, and the strength of the stabilised soil was assessed following a curing period.

1.7 Objective of the study

To enhance the black cotton soil's technical qualities so that the road constructed on it can effectively sustain moving loads. Using less expensive materials, such as mixing black cotton soil with industrial waste and chemical admixtures, to boost strength, durability, and performance. To prevent paving-surface fractures and road collapse. The addition of lime increases the black cotton soil's bearing ability. Changes in soil strength as a function of water content. Lime's impact on the soil's CBR value. To increase the black cotton soil's shear strength. To manage the soil's ability to shrink and swell. To enhance the soil's qualities and make it more advantageous for next construction projects

1.8 Scope of the Project

Expansive The nature of black cotton soil causes numerous issues with the construction of pavement. In the world of civil engineering, building a road in a black cotton soil is a difficult challenge. Heavy heaves brought on by expansive soil swelling can be very difficult on light civil engineering constructions. The volume of the B.C. Soil significantly varies when it is in contact with moisture. Numerous issues with maintenance and the economic life of the road are related to this type of phenomenon. The effectiveness and lifespan of the pavement are significantly impacted. Therefore, it is crucial to improve the characteristics of black cotton soil because seasonal moisture variations in expanding soil deposits surrounding and beneath the structure cause their subsequent poor performance and short lifespan.

1.9 Application

Clayey black cotton soil is utilised extensively for agricultural purposes. Due to its depth and natural impermeability, it has a high water retention capacity. The presence of humus, iron, and aluminium compounds gives black soil its dark hue. For maximum productivity, black soil is used to grow crops including cotton, pulses, millets, linseed, tobacco, sugarcane, vegetables, and citrus fruits.

Alluvial soil can range in kind from sandy loam to clay. Alluvial soil's colour can range from light grey to ash grey based on the local climate in a given area. Due to the presence of iron oxide, the colour of the laterite soils is reddish brown. When wet, laterite soil is soft; when dry, it is hard.

2. Review of Literature

2.1 General

The utilization of black cotton soil has wide use. The work has been finished by different specialists on utilization of fractional support of optical filaments in BC soil. For our review we alluded the accompanying writing audit.

2.2 Review of literature

In her 2014 study, Aparna Roy examined high plasticity soil stabilised with varying amounts of rice husk ash and a negligible amount of cement. For changes in the soil's qualities such as MDD, OMC, CBR, and UCS, observations are made. According to the data, an increase in RHA content raises OMC while lowering MDD. Additionally, the CBR value and UCS of the soil are greatly enhanced by the RHA content. based on the maximal strength improvement that was seen. By examining the enormous improvement in the CBR Value of soil testing, we recommend using an optimal amount of 10% RHA content with 6% cement.

In order to get the California Bearing Ratio (CBR) value,

Norazian Khallid et al. (2014) tested the effectiveness of employing combinations of lime with palm oil fly ash (Lime POFA) in soft soil stabilisation. The Palm Oil Fly Ash (POFA) additives used are a fine waste material produced during the burning of palm oil fibre. According to ASTM C618 standards, the POFA utilised is designated as Class-F fly ash and is described as a siliceous and aluminous substance with little to no cementitious value. the ideal level of 6% hydration Time included their research as a functional ingredient to the different POFA mixtures for the pazzolanic reaction. The results demonstrated that the highest yield was obtained by combining 6% lime with 3% POFA.

2.3 Summary

In view of the review completed on every one of the alluded specialized papers, holes were recognized so unbiased of our venture could be finished. Framework of undertaking was drafted and plans to make it a result-based project were settled.

3. Methodology

3.1 Material specification

The most recent wave of nanotechnology is used in Zycobond, an acrylic co-polymer additive. Its application is advised for topical irrigation of sealing the surface layer as a rolling and dust treatment, as well as soil stabilisation.

Table 3.1 Properties of zycobond

Parameter	Value
Colour	Milky White
Odour	No
Flash Point	100 JC
Exploration Hazard	No
Ignition Temperature	Above 200 JC
Solubility in water	Dispersible
pH Value	5-6

3.2 Test performed on BC Soil

Planning and monitoring for nutrient management include routine soil nutrient collection and analysis. A check on the effectiveness of fertiliser use can be made by sampling the soil in order to determine the proper rate of nutrients for the best development and production. Obtaining a reliable sample and translating it into a helpful fertility recommendation need a number of steps..

3.3 Summary

In this chapter, all the material requirements, design requirements as well as the methodology incorporated to carryout tests on black cotton soil are briefly discussed.

4. Result and Discussions

4.1 General:

In this part, conversation in view of same outcomes is interpreted in plain structure also the outcomes are shown in graphical structure for legitimate comprehension and to read up the variety design for various cases

4.2 Results for Specific Gravity Result

The major test carried out on BC Soil is for specific gravity. The results are interpreted in below format

Sr No.	Samples	1	2	3
1	Wt. of empty Pycnometer (W1) gm.	617.8	618.2	610.6
2	Wt. of Pycnometer + Soil (W2) gm.	816.1	814.8	808.0
3	Wt. of Pycnometer + Soil+ Water (W3) gm.	1561.3	1570.6	1542.2
4	Wt. of Pycnometer + Water (W4) gm.	1446	1445.3	1415.5
5	$G_s = [(W2-W1) / (W4-W1) - (W3-W2)]$	2.38	2.75	2.8

Table 4.1 Result of Specific Gravity Result

So we determine the findings using the specific gravity test.

Average Sp. Gravity = 2.64

4.3 Plastic Limit Test :

At the moisture content, the soil transitions from a friable condition to a plastic one. It is clear that the interaction with the earth occurred, and a plastic limit is visible as a result. Finding the soil sample's plastic limit is the goal.

4.4 What Is the Purpose of a Plastic limit Test?

The plastic limit is one of the measured parameters of the Atterberg limits test (ASTM, 2010), which is used for differentiating consistency states of finer particles in soil material. If there are coarser particles (coarse sand, gravel, or cobbles), the finer particles operate as a matrix and may control how the soil mass behaves. Water content affects the consistency states; when the water content rises, the states become solid, semisolid, plastic, and liquid.

The water content at which a soil-water paste transforms into a plastic consistency when rolled into a 3.175-mm (1/8-inch) diameter thread is known as the "plastic limit."

4.5 Plastic limit Application

The water concentration at the transition from a plastic to a semi-solid state is known as the plastic limit (PL). A soil sample is continuously rolled into a thread for this test until it begins to disintegrate.

4.6 Discussion:

The plastic limit is the lowest water content at which soil cannot crumble when rolled into a thread of 3 mm in diameter. In other words, earth may deform plastically at a certain moisture level.

4.7 Result on plastic limit test:

Sr No.	Particulars	Sample 1	Sample 2	Sample 3
1	Container No.	1	2	3
2	Weight of container	14.10	16.79	16.78
3	Weight of container + Wet soil in gm	32.49	24.06	24.04
4	Weight of container + Dry soil in gm	27.69	22.63	22.60
5	Weight of dry soil (4-2)	13.59	5.84	5.80
6	Weight of water (3-4)	4.80	1.43	1.44
7	Water Content % (6/5)	35.32	24.48	24.74

Table 4.7 Result of Plastic Limit Test

4.8 Properties of Black Cotton Soil:

Plasticity: The high clay concentration in black cotton soil contributes to its great plasticity.

Shrink-swell behaviour: The soil cracks and becomes unstable as it expands when it is wet and contracts when it is dry.

The earth is quite compressible, which makes it simple to settle.

Low permeability of black cotton soil makes it challenging for water to seep into and drain through the soil.

Low shear strength of the soil makes it vulnerable to instability and slope failure.

Bearing capacity: Because of the soil's limited bearing capacity, shallow foundations cannot be built on it.

5. Conclusion

5.1 General

The black cotton soil creates various issues and damages structures when it comes into contact with water. The various geotechnical qualities were also improved by the inclusion of hazardous debris, such as marble dust, fly ash, cement, and terrasil stabilised black cotton soil. The expansive soil's liquid and plastic limits are further reduced by the addition of various percentages of terrasil and zycobond. The final optimum composite results in an increase in the standard proctor test, or the maximum dry density of black cotton soil, from 2.07 g/cm³, but a drop in the ideal water content of black cotton soil from 12%. The cbr test's findings demonstrate that terrasil causes an increase in the black cotton soil's drenched and unsoaked values.

5.2 Scope for further study

If soil is exposed to moisture before improving its characteristics, it undergoes significant volumetric changes. The characteristics of black cotton soil must be improved for a road to operate well and last a long time. We can determine the ideal ratio for every black cotton soil with a specific clay % by understanding the impact of various combinations on the soil's clay percentage. Effect of Terrasil on the soil at various dosages and for various stabilising times

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