

# The Impact of Bagasse Ash on the Index and Black cotton soil's strength characteristics stabilized with Xanthan Gum and Lime

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**Abstract** - The expansive soils are covered over most among the parts of India especially known by name Black Cotton Soil. This soil found to be major problem for construction. It has low shear strength, high shrinkage, swelling and compressibility characteristics. From the outcomes, it is evident that liquid limit increases with the increase in xanthan gum content. The formation of hydrogen bonding and cation bridging by XG contributes to the reduction in compressibility of the soil-XG mixture. On the other hand, the addition of QL results in a substantial decrease in swell pressure, compression index, and coefficient of consolidation. The compressibility characteristics of BC soil effect improved by the addition of XG, BA, QL and their combination, offering potential for soil stabilization applications.

**Key Words:** Xanthan Gum, Bagasse ash, Quick lime

## Introduction

Soil is an essential element of nature. Without soil, it is nearly impossible to imagine life on Earth. The word "soil" comes from the Latin word "solium," which, according to Webster's Dictionary, refers to the upper layer of the earth that can be dug or plowed. In soil engineering, soil is defined as an unconsolidated material made up of solid particles that result from the disintegration of rocks. A land-based structure's strength relies heavily on its base. For this cause, soil plays a crucial role in the accomplishment of any building innovative. Soil can either way be A component of the foundation or serve as a component used in the construction process. Knowing the soil's engineering characteristics is essential for achieving power and financial durability in building. The process of stabilizing soil involves enhancing the soil's appropriateness for a specific for building purposes. The phrase "modification" refers to a slight modification to the characteristics of the soil, whereas "stabilization" indicates a more significant alteration of the engineering characteristics

allowing for construction to take place effectively. In nearly every road construction project, one or both of these stabilization techniques are utilized. The most common method of mechanical soil stabilization is soil compaction, while the addition of materials such as cement, lime, bitumen, or other agents constitutes a soil stabilization technique that uses chemicals or additives. Two are present

primary Chemical and mechanical additives are the two types of additives utilized in chemical soil stabilization. Additives that are mechanical, like soil cement, enhance the soil by adding a material that improves the current soil's ability to support weight. In contrast, additions of chemicals like chemically, lime modify the actual soil, resulting in improved capacity for bearing loads.

## II METHODOLOGY

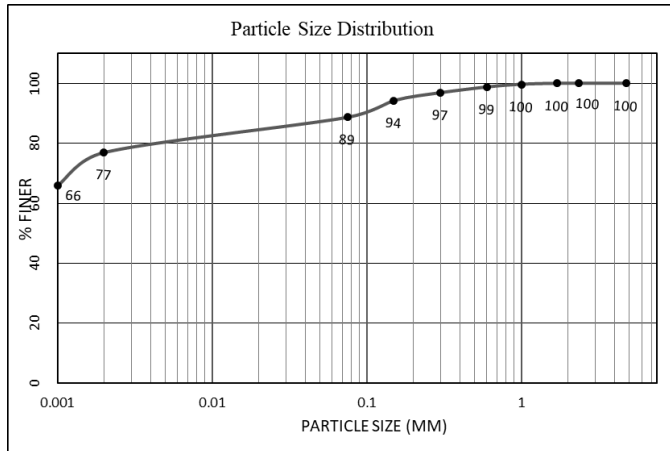
### Black Cotton Soil

A sample of soil was taken from the Kalburgi district in Karnataka. The index characteristics of the soil are summarized in Table 1.

Table 1: characteristics of Black Cotton Soil Index

characteristics	consideration
Colour	Greyish
Atterberg Limits	0
Liquid Limit (%)	83
Plastic boundaries (%)	39
Shrinkage boundaries (%)	7
Particular Gravity	2.59
Mini Compaction Test	0
The highest dry density (g/cc)	1.46
Ideal moisture level (%)	27
Evaluation of Grain size	0
The dirt (%)	0
Rough Sand (%)	0
Mediocre Sand (%)	0
lovely Sand (%)	8
Silt (%)	15
Clay (%)	77
Free Swell Index (%)	110
FSR	2.1

**Figure 1** Distribution of Black cotton soil particle sizes



**Xanthan Gum (XG):**

In this investigation, xanthan gum was sourced from Loba Chemie Pvt. Ltd. in Peenya 2nd Stage, Bangalore Urban District, Karnataka State. Quicklime, also referred to as burnt lime or calcium oxide, is a chemical substance that is utilized extensively. At room temperature, it is a crystalline, white, caustic, alkaline solid. Xanthan gum, which has the chemical formula C<sub>35</sub>H<sub>49</sub>O<sub>29</sub> for its monomer, is an anionic polymer that is naturally formed when the bacteria \*Xanthomonas campestris\* ferments carbohydrates. In the 1950s, this chemical was initially found at the US Department of Agriculture.

Table 2: Chemical Composition of Xanthan Gum Utilized in the Research Study.

Tests	Specifications	Results
Appearance	White or yellowish white free-flowing powder	Yellowish free following powder
Loss on drying	Max 15%	7.90%
Odor	Feeble no desabreable	Feeble no desabreable
Particle size	100 - 200 mesh	Passes test
Ash content	6.5 - 16%	11.66%
pH (1% solution in water)	6 to 8	6.24
Nitrogen content (as N)	Max 1.5%	0.54%
Pyruvic acid	2.40%	3.50%
Heavy metal (as Pb)	maximum 0.001%	0.00%
maximum 10 parts per million	maximum 0.0005%	0.00%
Arsenic (As)	maximum 0.0002 percent	3

**Compaction Parameters:**

A drop weight and a guiding frame make up the hammer assembly. The top, middle, and bottom are the three detachable parts of the guiding frame. The dropped weight is designed to float between the top and bottom sections. The lower part of the guiding rod, which serves as an energy-transferring foot, is 8 cm long and 3.65 cm in diameter. The guiding rod's upper section is 3 cm long and also has a diameter of 3.65 cm. This top portion is used to secure the assembly in place before the hammer is released. The guiding frame's centre section is 19.5 cm long and has a diameter of 1.8 cm. It features a vertical rod that acts as a bore guide for the hammer. This middle portion can be detached from the top and bottom sections, allowing for an easy change of the drop weight used for the test of Proctor and modified Proctor. For the regular Proctor test, the drop weight is 1 kilogram, while for the modified Proctor exam, it is 2.5 kg.

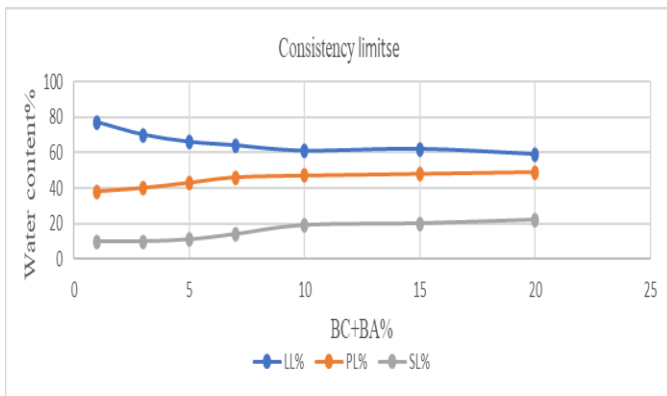
**III. RESULTS AND DISCUSSION**

Consistency limits xanthan gum of expanding soil mixtures:

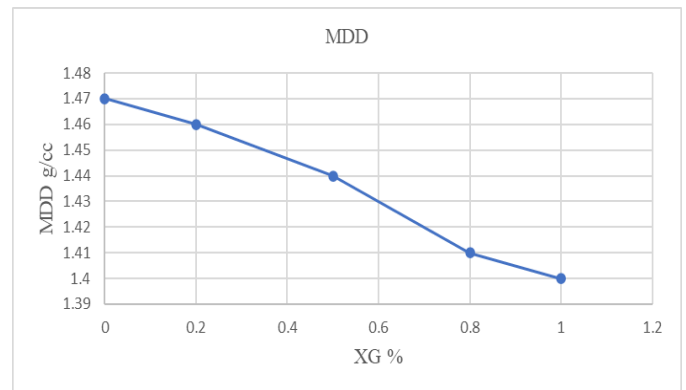
As per the experimental programme, the expanding soil is mixed with xanthan gum and consistency limits were determined immediately after addition. The effect of adding xanthan gum on the consistency limits of expanding soil is discussed below. The outcomes indicate that the fluid limit increases with higher xanthan gum content. When water is added to biopolymer-treated soils, a cross-linking network of monomers is initiated, consuming a notably greater amount of moisture and raising the liquid limit. Additionally, adding xanthan gum increases the pore fluid's viscosity, which promotes more aggregation within the soil matrix.

However, the shrinkage limit does not vary considerably as xanthan gum content increases. Because the pore fluid has less viscosity at lower xanthan gum concentrations, there is less opportunity for hydrogen bonding and cation bridging to build an interconnected network. Consequently, this leads to reduced susceptibility to volume changes upon drying. Moreover, The more xanthan gum there is in the soil, the higher the plasticity index of the treated soil. Once more, when water is added to soils treated with biopolymers, the formation of the monomer cross-linking network requires abnormally high moisture levels.

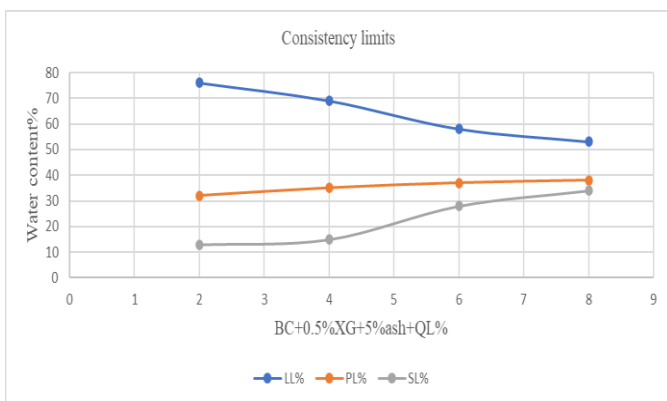
**Fig 1** Variations in the BC soil's shrinkage limits when combined with bagasse ash.



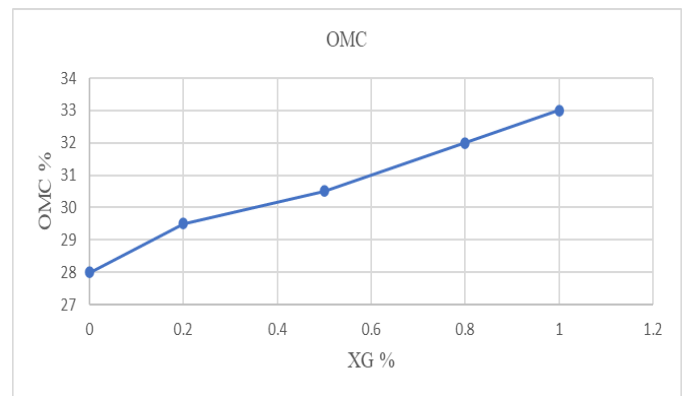
**Fig 2** Variations of the boundaries of BC soil shrinkage with quick lime-treated (BC soil + 0.5% XG + 5% BA + 8% QL) mixtures.



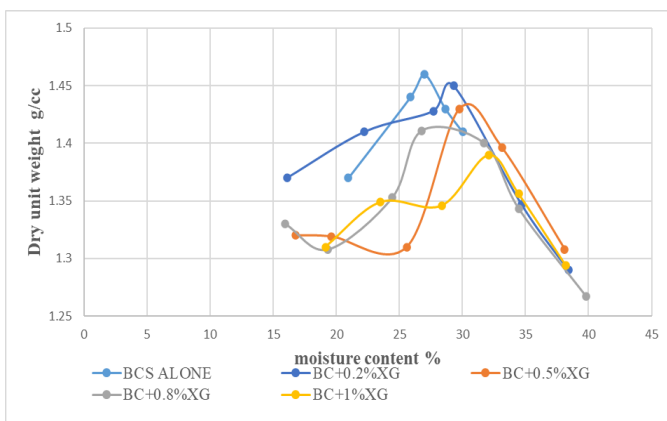
**Fig 5** Change in the Ideal Moisture Content with the Concentration of Xanthan Gum.



**Fig 3** Relationships between the soil's moisture content and dry unit weight-XG mixtures.



**Fig 6.** Unconfined Compressive Strength of Mixtures of Expansive Soil and Xanthan Gum



**Fig 4** Change in Maximum Dry Density with the Content of Xanthan Gum.

Unconfined compressive strength tests were performed on combinations of expansive soil and xanthan gum that had been compacted to maximum dry density and optimal moisture content (OMC). Both immediately after the healing period and seven days later, these tests were carried out. Strength increased slightly for the immediate tests up to 0.5% xanthan gum, after which it decreased. The strength evaluated after curing was higher than that of the specimens tested immediately, and tests conducted after a 7-day curing interval displayed a similar pattern. Further tests were conducted with 14 and 28 day curing times once it was determined that 0.5% was the optimal xanthan gum level.

Overall, the soil strength significantly increased as a result of the extended curing period. Cure phases are 14 and 28 days. Overall, it was observed that the longer the cure period, the greater the increase in soil strength. Expansive soil-xanthan gum combinations' unconfined compressive strength variations were examined for both the initial testing and the seven-day curing period. For both immediate testing and the seven-day curing phase, the stress-strain correlations for BC Soil alone and BC Soil treated with xanthan gum were displayed. This evaluation emphasized the variations in unconfined compressive strength between the ideal 0.5%

xanthan gum mixes and expansive soil with respect to the curing time.

Brittle behavior was demonstrated by the soil, which failed at lower strains due to its peak strength. The resilience of the soil matrix to load was greatly increased by the addition of xanthan gum, and the failure strain progressively increased as the xanthan gum content increased. The soil's stress-strain behavior was also impacted by increased xanthan gum viscosity, which led to a progressive increase in stress until failure. A distinct peak was seen at every tested xanthan gum %, suggesting that xanthan gum has a propensity to agglomerate within the soil matrix. Strength gradually decreased as the amount of xanthan gum was reduced. In all measured xanthan gum percentages, the production of hydrogen bonds and cross-linking components stiffened the soil matrix, increasing its unconfined compressive strength and load resistance.

The differences in unconfined compressive strength of expansive soil-xanthan gum mixes are highlighted in this presentation, taking into account both immediate testing and the seven-day curing time.

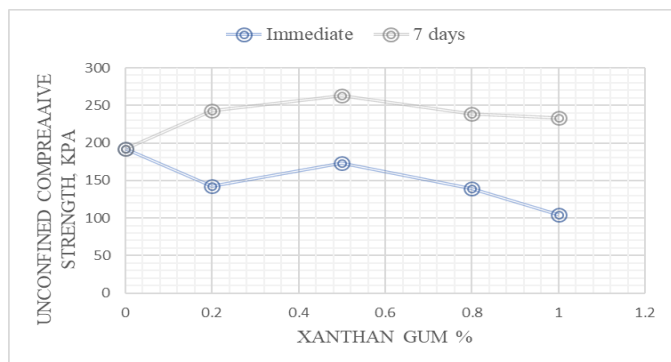
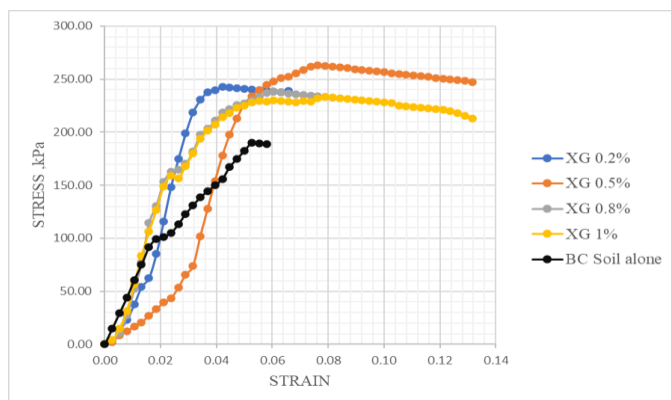


Fig 7. Stress-strain relationships of BC Soil and BC Soil treated with Xanthan Gum for immediate testing.

Fig 8. Stress-strain relationships of BC Soil and BC Soil treated with Xanthan Gum after a 7-day curing period.



When 0.5% xanthan gum (XG) was added, a notable increase in soil strength was noted. and extended aging time. The

results showed that at this dosage, soil strength improved significantly, rising from 172.63 kPa to 391.75 kPa by the 28th day of curing. Xanthan gum possesses a high specific surface area, which facilitates excellent interlocking between soil particles, increasing the soil's strength and stiffness. The strength increases shown for all xanthan gum percentages throughout various curing times show that the biopolymer does not break down but rather keeps strengthening the soil matrix by aggregating, forming hydrogen bonds, and forming cross-linking components. It has been observed that as the soil matrix pores cure, more gel is formed, which promotes improved soil particle aggregation, the creation of a network of interconnected cross-links via cation bridging, and the creation of hydrogen bonds.

### Compressive Strength of Unconfined Expansive Soil and Bagasse Ash Mixtures

Several combinations of expansive soil and bagasse ash, compacted to reach maximum dry density and optimal moisture content (OMC), were subjected to unconfined compressive strength testing. Both immediately and after a seven-day curing period, these tests were conducted. The mixtures' strength rose nonlinearly for the immediate testing. On the other hand, adding bagasse ash to the soil resulted in a constant improvement in strength following a 7-day curing period. Compared to the specimens examined right away, the strength seen after seven days of curing was greater. In particular, adding bagasse ash raised the strength from 140.31 kPa to 193.56 kPa. Cation exchange is one of the factors responsible for this strength rise. Aggregation and flocculation. An increase in the curing duration was associated with a notable improvement in soil strength. Up to 5% Bagasse ash, the strength increase percentage increased; after that, it started to decline, suggesting that 5% Bagasse ash is the ideal amount for stability. Furthermore, for both the immediate testing and the seven-day curing phase, the stress-strain relationships of BC Soil alone and BC Soil treated with Bagasse ash were shown. This shows how expansive soil's unconfined compressive strength varies and how the ideal 5% Bagasse ash blends relate to the curing time.

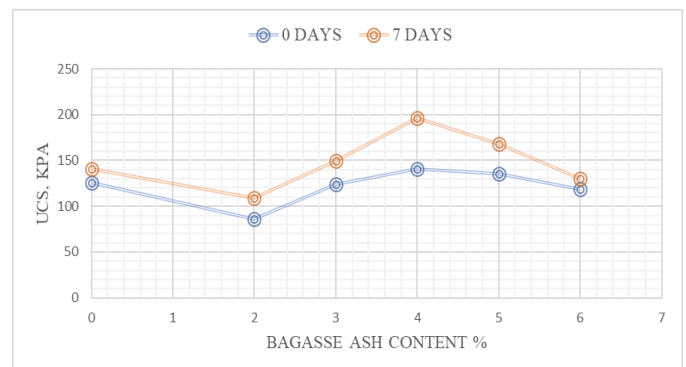
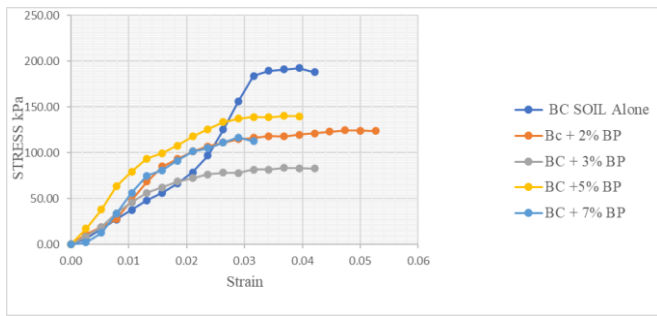
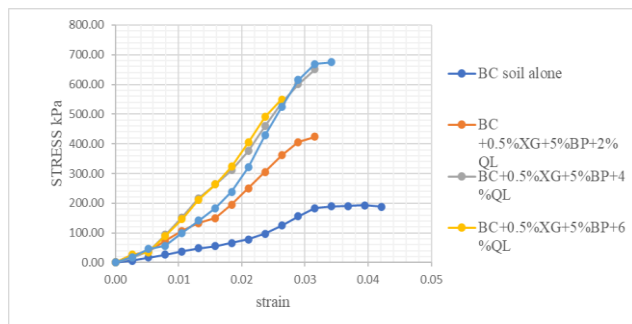


Fig 11. Stress-strain relationships of BC soil alone and BC soil treated with bagasse ash for immediate testing.

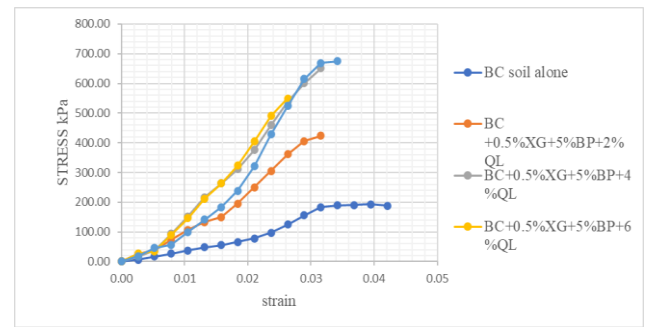


**Fig 12.** Unconfined Compressive Strength of expansive soil (0.5% XG) treated with bagasse ash and quick lime.

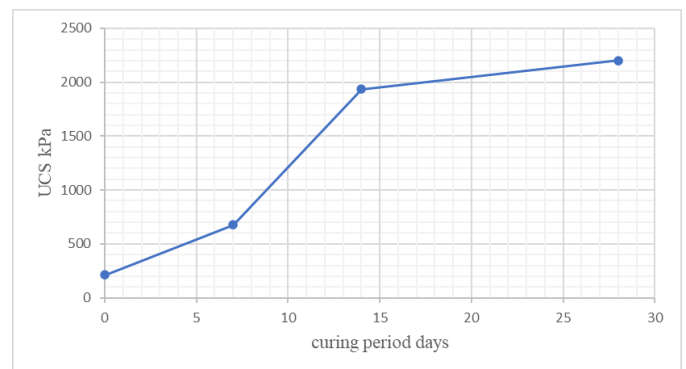
The outcomes showed the strength increased with the quick lime content up to 8%, after which it began to decrease. Therefore, 8% quick lime was determined to be the optimum amount for stabilization. Upon curing for 28 days, the strength was 1923.68 kPa. Furthermore, the differences in unconfined compressive strength between the immediate and seven-day curing periods for the expansive soil treated with fast lime mixes were examined. During immediate testing, the stress-strain correlations were shown for BC soil by itself as well as for BC soil mixed with 0.5% XG treated with quick lime. Impact of the curing time on the unconfined compressive strength of expansive soil treated with quick lime and bagasse ash and containing 0.5% XG. The soil specimen tested immediately after the preparation of the sample with 8% content was found to have a strength of 212.38 kPa. However, this strength increased with the curing period. After curing for 7 days, the formation of hydrogels resulted in an increased strength of 675.05 kPa. As the hydrate gels continue to harden over time, the soil's strength further improved, with compressive strengths recorded at 1568.64 kPa and 1923.68 kPa after curing for 14 days and 28 days, respectively.



**Fig 13.** connections between stress and strain in BC soil treated with bagasse ash, xanthan gum, and quick lime for a seven-day curing period vs BC soil left alone.



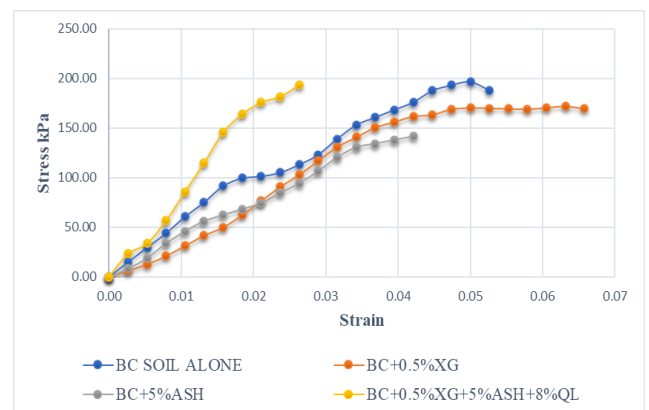
**Fig 14** Variation in the Unconfined Compressive Strength (UCS) of a mixture consisting of 0.5% xanthan gum (XG), 5% bone ash (BA), and 8% quercetin (QL).



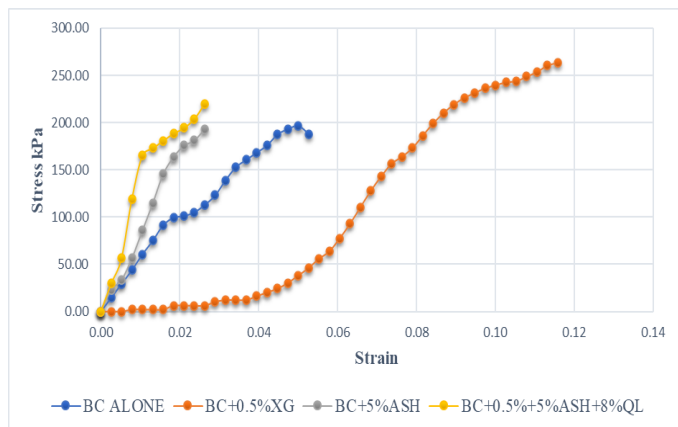
**Fig 15.** Strength properties of BC soil that has been treated with the ideal proportion of xanthan gum and quick lime.

The soil becomes more viscous and resistant to load when xanthan gum is added. Higher xanthan gum (XG) concentration causes ductile failure, which indicates the development of a vast network of interconnected biopolymer soil matrices that are better able to withstand loads at higher strains. In contrast, brittle failures were observed in both the biopolymer (BC) soil treated with bio-ash (BA) and quicklime, as well as in samples containing 0.5% XG combined with BA and lime.

**Fig 16.** The stress-strain relationships for optimal percentages of additives should be tested immediately.



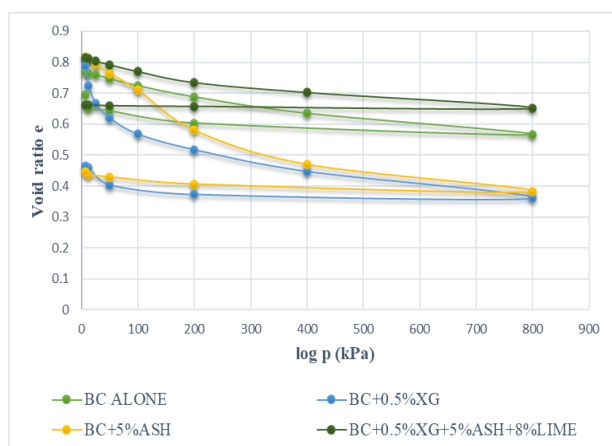
**Fig 17.** The stress-strain relationships corresponding to the optimal percentages of additives for a curing period of seven days.



Combination	Swell Potential %	Swell Pressure kPa	Compression Index (Cc)
BCS Alone	6.5	300	0.275
BC +0.5% XG	1	120	0.036
BC+ 5%ASH	4.8	225	0.048
BC +0.5% XG+ 5%ASH+8% QL	0	22	0.017

Table 1: Compressibility properties of soil treated with black cotton an optimal combination of XG and bagasse ash.

**Fig 19** e vs log p curves for BC soil treated with XG, BA, and QL and BC soil alone



**IV. FINALLIES**

The research indicates that the combination of Xanthan Gum (XG), Bagasse Ash (BA), and Quick Lime (QL) can successfully enhance Black Cotton (BC) soil's engineering qualities and strength. XG, a biopolymer, enhances soil strength by forming cross-links and hydrogen bonds, while

QL contributes causes pozzolanic reactions and cementitious compound production, which lead to increased strength over time. The curing period is crucial for the soil mixes' stress-strain behavior. The unconfined compressive strength (UCS) values generally increase with time, though variations are observed depending on the type and content of the additives. However, shrinkage limit remains constant across various percentages of xanthan gum change attributed to lower specific gravity xanthan gum compared to the soil, which affects its structure. Conversely, the addition of QL alters the soil structure to a flocculated state, which increases the void ratio and results XG enhances the soil's strength through cross-linking and hydrogen bonding, resulting in higher rises up to 0.5% XG but then decreases for both 0-day and 7-day curing periods. Therefore, a concentration of 0.5% XG is identified as optimal for stabilization. The UCS values continue to rise with the addition of QL, although the percentage increase in strength varies with the QL content. reactions with QL contributes to this strength increase. The optimal stabilization percentages are 8% QL and a combination of 0.5% XG, 5% BA, and 8% QL, based on strength criteria.

Meanwhile, adding QL results in a substantial decrease in swell pressure, compression index, and coefficient of consolidation, further reducing the soil's compressibility.

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