

# **Effect of Alkali Resistant Glass Fibre and Vitrified Polish Waste on Strength Properties of Black Cotton Soil**

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**ABSTRACT:** A laboratory experimental study is conducted to find the effect of Vitrified Polish Waste (VPW), ARGF on mechanical properties of Black Cotton Soil. The first phase of project work includes the effect of VPW on compaction characteristics of black cotton soil. The next phase focuses on the Unconfined Compressive Strength values of mixture of Black Cotton Soil with optimum dosage of VPW randomly reinforced with varying percentage of ARGF. The work also focuses on change in Unconfined Compressive Strength with the curing period. The results indicated that with addition of VPW to Black Cotton Soil, the Maximum Dry Density is increased and Optimum Moisture Content is decreased. The Unconfined Compressive Strength values are increased with addition of ARGF to mixture of BC soil and optimum dosage of VPW. The unconfined compressive strength values are increased with curing period. Finally the UCS values for different combinations like BC soil alone, BC soil and randomly distributed fibers ARGF. The maximum UCS result is obtained for the mixture of Black Cotton Soil and optimum dosage of VPW with 0.75% of ARGF.

**KEYWORDS:** Black Cotton soil, Vitrified Polish Waste, Alkali Resistant Glass Fibre, Unconfined Compressive Strength, Optimum Moisture Content.

## **I. INTRODUCTION**

In Today's world, due to quick improvement in urbanization and modernization less measure of territory is available for advancement. The extending estimation of territory and the limited availability of land for advancement lead to improvement of distinctive structures. The stability of any structure relies on the properties of soil on which it is to be built. In case, if the earth is having poor bearing capacity at shallow underneath the ground surface, then major foundation problems exist. This problem can overcome by using stacks, wells and caissons. Significant foundations are exorbitant and financially impractical and uneconomical. Expansive soil are the fundamental cause of damages to several civil engineering structures like highways, airport runways, spread footings, buildings and earth dams constructed over expansive soil. Black Cotton soil is one of the soil which is having high compressibility. Black Cotton soil has many problems like less stability, low shear strength and large expansion and shrinkage in volume with respect to weather. Black Cotton soil occupies nearly 23% of the area in India. BC soil contains mainly Montmorillonite clay which absorbs the water, hence dramatic changes in the volume of the soil which leads to damages to the structure. Hence to overcome this problem it is needed to improve the properties of the Black cotton soil by possible economical methods. So use of Industrial Waste is one among that to improve the properties of BC soil. Many experiments have been carried out to improve the soil properties by using various admixtures like GGBS, Lime, Copper Slag, Fly ash...etc. In the present study Vitrified Polish Waste is used to improve the properties of soil.

Extending urbanization and rising lifestyles due to mechanical headways have added to manufacture the measure of a combination of solid wastes like Fly Ash, Blast Furnace Slag, Recycled Aggregates, Red Mud, Kraft Pulp creation development, Waste Tea, etc. The exchange of these wastes has transformed into a critical regular issue in a making country like India and in this way the probability of reusing the solid wastes for use being developed materials is of

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extending noteworthiness. A noteworthy number of these wastes are suspended particulate matters which are most perilous to human wellbeing. These misuses furthermore cause water infecting by suffusion of dissolvable matters that finally spoils ground water resources. In this manner, these current wastes should be treated and used to avoid the diverse outcomes for individuals, further, to make the soil strata more suitable and more grounded for improvement purposes. Beside the above recorded mechanical misuses, Vitrified Polish Waste (VPW) is created from the Vitrified tile manufacturing industry which is used in the present study.

## II. RELATED WORK

**Arun Patidar and Dr H.K. Mahiyar (2014):** Carried out an experimental study on Index Properties and Engineering Properties of Black Cotton soil using High Density Poly Ethylene fiber waste, lime and stone dust. They used various percentages of HDPE fibers like 0.5, 1, 1.5 and stone dust by (5%, 10%, and 15%) and lime by (3%, 6%, and 9%) to study the engineering behaviour of BC soil. With the increasing percentage of lime, the liquid limit and plastic limit of Black Cotton soil was decreased on the other hand with the increase in % of stone dust and % of fiber, the liquid limit and plastic limit of BC soil was increased. The CBR value of BC soil was increased with the combination of 1% fiber, 10% stone dust and 6% lime and also the Unconfined Compressive Strength of BC soil was increased with varying percentage of stone dust, lime and fiber. **Dr. D. Koteswara Rao, M Anusha et al., (2013):** Investigated the effect of Vitrified Polish Waste on improving the properties of marine clay. This study dealt with the strengthening of marine clay by VPW. In this experimental work, addition of VPW in different proportions by 5%, 10%, 15%...30% by replacing black cotton soil. It was observed that improvement in liquid limit by 35.66%, Plasticity index was improved by 38.65%, Maximum dry density of Marine Clay was improved by 16.99% with the addition of 15% Vitrified Polish Waste. It was also observed that the CBR value of the marine clay has increased by 187.3% on addition of 15% of VPW. **K Uppaiah, G.V.R Prasada Raju et al., (2013):** Carried out an experimental study on Relative Performance of Vitrified Polish Waste and Ground Granulated Blast Furnace Slag in improving Expansive Soil Subgrades. In this study it was found that the Vitrified Polish Waste was more (27%) effective than the Ground Granulated Blast Slag in reducing the Differential Free Swell Index of Expansive soil. Vitrified Polish Waste was more effective than the Ground Granulated Blast Furnace Slag in reducing the liquid limit and the plastic limit. The improvement in CBR value of black cotton soil by stabilizing with VPW. The Compaction Parameters and CBR showed considerable improvement when BC soil was blended with VPW where as it has shown the marginal improvement when blended with GGBS. The experimental observation were carried out on addition of VPW with different proportion of 5%, 10% by replacing black cotton soil. From the result it was concluded that addition of 10% VPW increases the maximum dry density by 13.61% and CBR value is increased by 7.07%.

## III. MATERIALS

### 1. BLACK COTTON SOIL

The black cotton soil is obtained from Hosadurga Region, Chitragurga District. The sample was collected from a profundity of around 1.5m underneath the ground level by open digging. The acquired soil is air dried and pounded physically. The soil clearing through 425 $\mu$  IS sieve is utilized for the study. All the tests are directed according to IS-2720 principles. The properties of black cotton soil are displayed in table 1.

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Table 1 Geotechnical properties of BC soil

Sl. No	Properties	Values
1	Specific gravity	2.51
2	Liquid limit (%)	54
3	Plastic limit (%)	22.75
4	Plasticity index (%)	31.25
5	Shrinkage limit (%)	12.37
6	Silt and Clay content (%)	76
7	Sand (%)	24
8	Maximum Dry Density(kN/m <sup>3</sup> )	13.09
9	Optimum Moisture Content (%)	22

## 2. VITRIFIED POLISH WASTE

Vitrified polish waste is an industrial waste by product which is used as a filling material in vitrified tile industry is collected from the “Suntel Ceramic Industries” Jambudiya Gujrat.



Fig.1 VPW used in present study

### Physical properties of the VPW

The physical properties of the VPW are presented in Table 2. After the test it was found to be medium sand as 1.43 %, fine sand 97.5 % and Silt and clay percentage was found to be 1.07 %. After the compaction test on VPW the MDD of VPW was found to be 15.499 and OMC was 20 %

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Table 2 Physical properties of the VPW

Properties	Values
Coarse sand (%)	0.00
Medium sand (%)	1.43
Fine sand (%)	97.5
Silt & clay (%)	1.07
Compaction Properties	
MDD (KN/m <sup>3</sup> )	15.499
OMC (%)	20
Atterberg limits	NP

### 3. ALKALI RESISTANT GLASS FIBER (SYNTHETIC FIBER):

Alkali resistant glass fibre contains high percentage of Zirconia (ZrO<sub>2</sub>). The Zirconia percentage decides the alkali resistance of glass fibre. The physical and Chemical Properties of ARGF are presented in table. It is obtained from Chemzest Enterprises, Perambur, Chennai.



Fig. 2 Alkali Resistant Glass Fiber

#### Physical properties of Alkali Resistnat Glass Fiber

This article deals with the results of an experimental investigation on strength properties of Black Cotton Soil with Alkali Resistant Glass Fibres. Alkali-resistant glass fibres are used in this investigation fibres are having density of 24.53 kN/ m<sup>3</sup>, Diameter of 12.8 micron and length are cut into 12 mm.

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Table 3 Physical properties of Alkali Resistant Glass fibers

Physical Properties	Unit	Results obtained
Density	kN/m <sup>3</sup>	24.53
Specific gravity	-	2.68
Diameter	micron	12.8
Length	mm	12
Colour	-	White or colourless
Tensile strength	N/mm <sup>2</sup>	1710
Water absorption	%	< 0.1

## IV.METHODOLOGY

Initially Basic test on black cotton soil is carried out like Specific Gravity, Sieve Analysis and Atterberg limits then to find the Moisture- Density relationship of Black Cotton Soil the Compaction test is carried out. Then again test is further extended to obtain the MDD & OMC of Black Cotton Soil mixed with varying percentages (5%, 10%, 15% and 20%) of VPW. Finally, the Unconfined compressive strength specimens are prepared according to the maximum dry density obtained from the compaction of BC soil and VPW. For the mixture of BC soil and opt VPW, ARGF fibres are added in different percentage (0.25%, 0.5%, 0.75% and 1%) then the Unconfined Compressive Strength test is carried out.

## V. RESULTS

The tests were carried out on compaction of black cotton soil with varying percentage of VPW to obtain the optimum dosage of VPW, which can be used for the further experimental study

### a. Compaction characteristics of black cotton soil mixed with vitrified polish waste

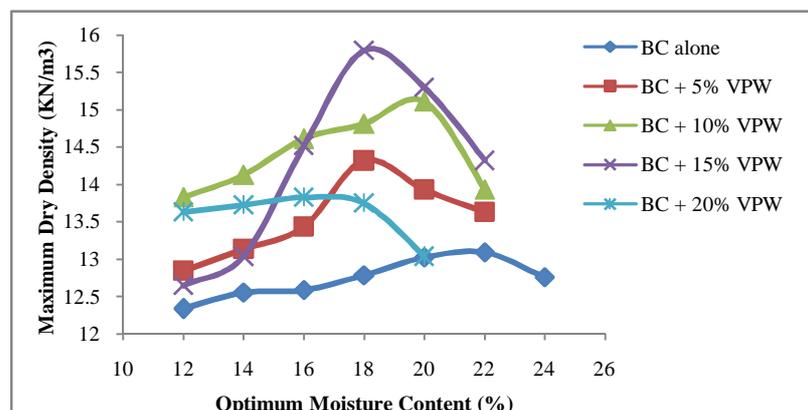


Fig.3 Compaction characteristics of BC soil with varying percentages of VPW

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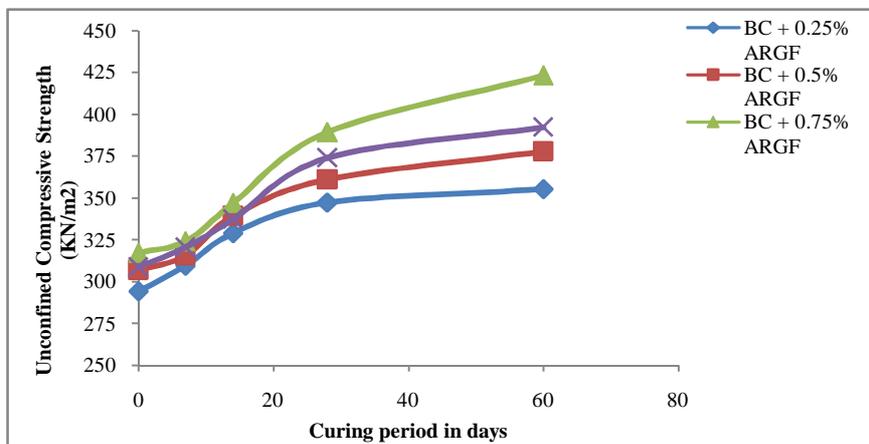
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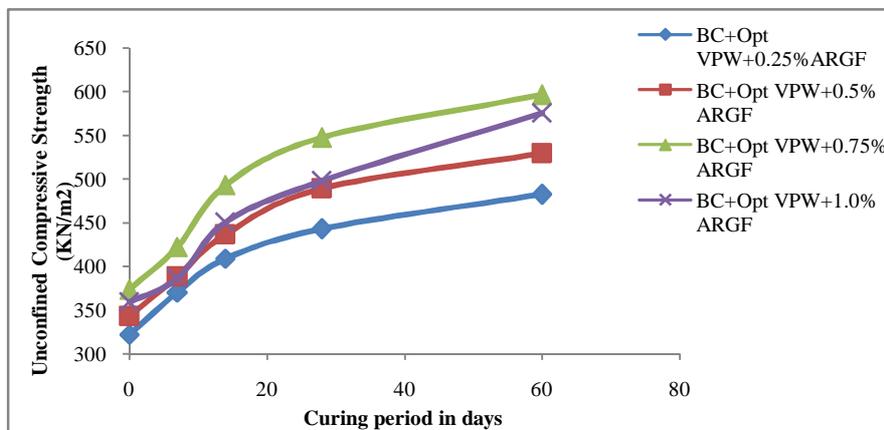
From Fig. 3 It can be noticed that with addition of VPW to BC soil, the MDD and OMC value are changing, As the addition of VPW increases from 5%, 10% & 15% to BC soil the MDD has increased significantly and the OMC has decreased. After that with the addition of 20% there was no further increase in MDD and the OMC. From Fig 3 it can be observed that the MDD & OMC are obtained with the addition of 15% of VPW are maximum. The max value of MDD is 15.79 and OMC is 18% are achieved on the addition of 15% VPW to the BC soil.

### b. Unconfined compressive strength test results



**Fig. 4** Variation of UCS for BC soil with various percentage of ARGE fibres

The Fig. 4 shows the effect of ARGF on UCS of BC soil. From fig, it is clearly observed that UCS of soil is increased upon curing. The specimen having 0.75% fibres gives the best UCS for all curing days. As the fibres are synthetic no biodegradation has occurred due to this, UCS has not decreased upon curing.



**Fig. 5** Variation of UCS for BC soil blended with 15% VPW for various percentages of ARGF

From Fig 5. it can be observed that with the increase in content of ARGF the Unified Compressive Strength also got increased. For all different curing days, the maximum Compressive Strength is obtained for the mixture of 0.75% fiber. From the above figure it is observed that the compressive Strength increases up to fiber content of 0.75% beyond

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which starts decreasing for all different curing days. The specimen containing 0.75% ARGF gives maximum compressive Strength values for different curing days.

### c. Comparison of UCS results

#### i. Comparison of UCS of BC Soil Alone and BC Soil + 15% VPW.

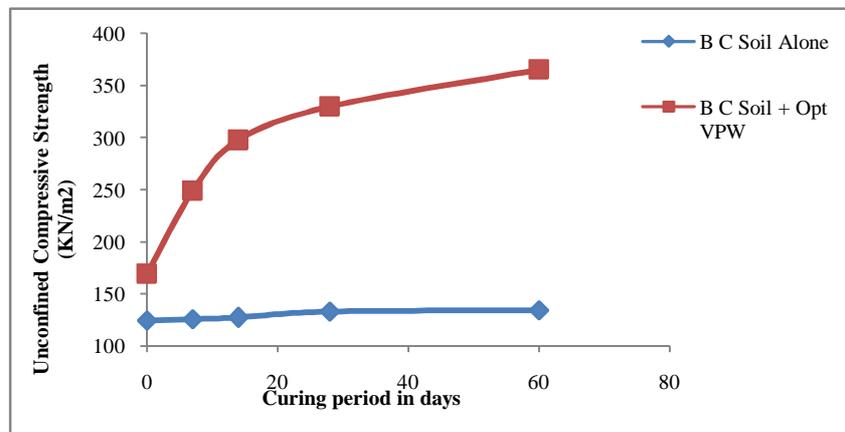


Fig. 6 Comparison of UCS of BC Soil Alone and BC Soil + 15% VPW

From Fig. 6 it can be observed that the UCS of BC soil alone increased slightly upon curing. For the sample treated with optimum VPW, it can be observed the UCS strength rapidly increased up to 14 days curing after which increase in strength was gradual due to cementitious properties of VPW

#### ii. Comparison of UCS of BC Soil Alone, BC +15% VPW, BC+ 0.75% ARGF and BC Soil + 15% VPW+ 0.75% ARGF.

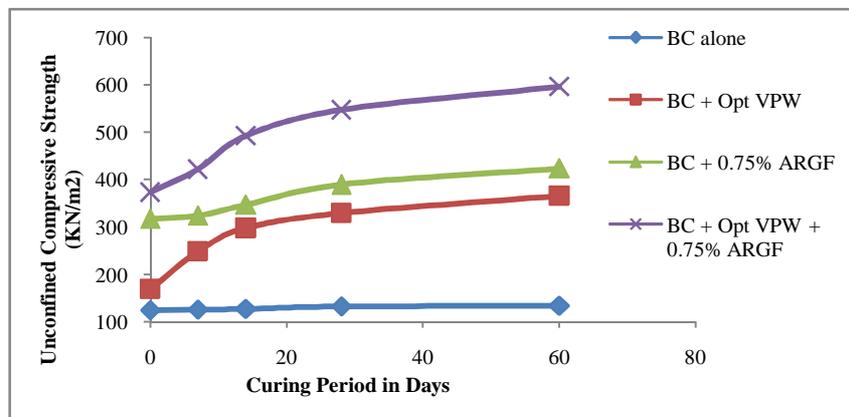


Fig. 7 Comparison of UCS of BC Soil Alone, BC +15% VPW, BC+ 0.75% ARGF and BC Soil +15% VPW+ 0.75% ARGF.

From the fig 7, it represents that the UCS of Black Cotton Soil alone increases slightly with curing. It was observed that the UCS value for BC soil with 0.75% ARGF and BC soil reinforced with 0.75% ARGF with optimum dosage of VPW shows similar variations in the strength up to a period of 28days. With addition of opt VPW the

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strength goes on increasing due to the presence of cementitious material, henceforth the presence of optimum VPW and 0.75% of ARGF shows the maximum strength for the Black Cotton Soil for a curing period up to 60 days.

## VI. CONCLUSION

1. VPW is a by-product of Vitrified tile manufacturing industry which is proved to be economical, good stabilizing material and rich in silica.
2. The density of BC soil increased from  $13.09 \text{ KN/m}^3$  to  $15.79 \text{ KN/m}^3$  by addition of VPW. High value Maximum Dry Density is found to be  $15.79 \text{ KN/m}^3$  with Optimum Moisture Content of 18%.
3. From moisture density relationship the optimum VPW content is discovered to be 15%, as Dry Unit Weight is maximum corresponding to 15% of VPW when compared to other percentage of VPW.
4. Addition of 0.75% ARGF with BC soil blended with 15% VPW, the UCS increased from  $134.15 \text{ KN/m}^2$  to  $596.381 \text{ KN/m}^2$  for 60 days curing.
5. The UCS of specimens containing 15% VPW and 0.75% ARGF has increased with curing, which increased from  $373.261 \text{ KN/m}^2$  to  $596.381 \text{ KN/m}^2$  for 60 days curing.
6. From the current study, it is clear that Vitrified Polish Waste is an effective fill material and can be an emerging waste disposal solution for the fast-developing ceramic tile industry. However, with the addition of Cement, the Vitrified Polish Waste is even more effective.
7. This leads to a two-fold advantage of utilizing the potentially emerging industrial waste with adequate geotechnical properties as fill material and also solving the problem of waste disposal.

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