iJRASET
International Journal For Research in Applied Science and Engineering Technology



INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 10 **Issue:** V **Month of publication:** May 2022

DOI: https://doi.org/10.22214/ijraset.2022.43372

www.ijraset.com

Call: 08813907089 | E-mail ID: ijraset@gmail.com

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

Behaviour of Sulfate Infected BC Soil with the Addition of Lime Stone Powder and Different Fibres

Kashinath[1], Dr. S. Krishnaiah[2], Dr. K. B. Prakash[3]
[1]*Ph.D. Scholar, Civil Engineering Department, Government Engineering College, Haveri, Karnataka, India-581110*
[2]*Professor, Civil Engineering Department, JNTU, Anantapuram,Andrapradesh India-515002*
[3]*Professor and Head, Department of Civil Engineering, SGBIT, Belagavi, Karnataka, India-590010*

Abstract: ***The stress resistant properties of soils can be improved in a variety of ways. For example, sheets, strips or rods of metal or polymeric materials can be placed in the soil to create a composite material. Researchers believe that there is a great potential of combined usage of monofibres and hybrid fibers as a stabilization materials in sulphate infected black cotton soil mix, making it stronger and durable. But not much progress has been made in this regard. The main objective of this research work is to investigate the index properties and stress resistant properties by adding stabilization materials like, lime stone powder along with monofibres and hybrid fibres. The research is proposed to address the following problems. 1. Effect of replacement of sulphate infected BC soil by stabilization material such as lime stone powder (LSP) in different percentages like 0%, 5%, 10%, 15%, 20%, 25%, 30%, 35% and 40% and thereby determining the optimum dosage of stabilization materials. 2. Effect of addition of different monofibres such as Jute fibre (JF), Poly propylene fibre (PPF), Waste plastic fibre (WPF) and High density polyethelene fibre (HDPEF) on the properties of sulphate infected BC soils. 3. Effect of addition of different hybrid fibres such as (JF+WPF), (PPF+WPF) and (PPF+HDPEF) on the properties of sulphate infected BC soils. It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material has shown improved index properties at 15% replacement level. Unsoaked CBR value, soaked CBR value, cohesion value from direct shear test and UCC test cohesion value, all show an increasing trend upto 15% replacement of black cotton soil by lime stone powder. After 15% replacement level, all the above values go on decreasing. It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material along with monofibres has shown improved stress resistance properties when monofibres are added at 1.5% by volume fraction. From the results obtained, it may also be concluded that, the performance of HDPE fibres is better than polypropylene fibres, waste plastic fibres and jute fibres in enhancing the stress resistance properties of sulphate infected black cotton soil using lime stone powder as stabilization material.***

Keywords: Lime stone powder, Polypropylene fibres, Sulfate infected BC soil, Stabilization, Stress resistant.

I. INTRODUCTION

Good quality soil is always essential for the construction of any civil engineering infrastructures. This is even true for roads and highways. Good quality sub-grade soils are necessary for durable roads. Sometimes such soils may not be available and the construction engineer or highway engineer is likely to face problem in the design and constructions. The sulphate infected black cotton soil exhibits low load bearing capacity. and high swelling property and this may pose many problems on site. Volume changes of some soils resulting from changes in their water content may cause unappreciable movement of structure that are founded on such soils, resulting in heaving, shear failure, accessible settlement, cracking and breaking up. Among the problems of soils, the soil infected with sulphates pose peculiar problems on site. Unless the problems of sulphate bearing soils are not addressed properly, the durability of the structure will be in question. The sulphate attack on soil is usually accompanied by strength loss and large volume changes resulting in substantial heave in stabilized earth works. Many researchers have reported examples of detrimental effect of sulphate either naturally present in the ground or artificially added. Among the most commonly encountered naturally occurring sulphates in the earth's crust are calcium sulphate which occurs as gypsum (or selenite (CaSO4.2H2O)) [Veith 20]. Sulphate may be present within the soil already or may be produced from the oxidation of sulphide minerals. Sometimes industrial activities are responsible for the presence of sulphates in soils. As the concentration of sulphate in soils increase, its detrimental effects also increase. Many researchers have reported examples of detrimental effects of sulphates, either naturally present in the ground or artificially added when soils are modified or stabilized with lime and/or cement [Mitchell 17 and Hunter 11] in USA. The expansion in lime-stabilized clay in the presence of sulfates is believed to be partly caused by the growth of ettringite crystals formed on the clay particle surfaces [Mitchell 17].

©IJRASET: All Rights are Reserved

There is a deliberate bias and focus towards the more 'troublesome'sulfate-bearing soils, Lower Oxford Clay (LOC). In addition, there is an interest in the utilization of wastepaper sludge ash (WSA) as a soil stabilizer. WSA is an industrial by-product of wastepaper recycling and re-processing, that is increasingly becoming abundant in UK as paper recycling rates increase [Kinuthia et al. 14]. So far, the progress in this regard has been minimal. But now with the implementation of government schemes like "Pradhan Mantri Gram Sadak Yojana (PMGSY)", NHDP Project, Golden Quadrilateral Project, North South East Corridor Project, the road constructions scenario has taken a big leap forward. However, fund constraints, lacks of good quality construction materials in the vicinity of the project considerably hamper the progress. One of the major costs involved in road construction is the transportation of materials. To minimize this cost, the locally available materials should be used, particularly the soil. But if the soil available locally is not of good quality, it causes a major problem for this soil has to be stabilized suitably.

II. LITERATURE REVIEW

During the last few decades, many researchers have studied the behaviour of sulphate infected black cotton soil. Stabilization of soils with hydraulic binders is essential to improve their engineering properties. Therefore, they can be used, in situ, in geotechnical applications such as sub-base layer with the required performances. Sulphates and sulfides are naturally present in the soils, mainly as gypsum CaSO4 · 2H2O or pyrite FeS2. Sulphates are widely recognised in altering soil stabilization, inducing considerable swellings. Le Borgne [10] describes the effects of 0.62 and 6.20 g of SO_2^{-4} · kg^{-1} (as gypsum) in silt treated with 1.5% of quicklime and 6% of cement CEMII.

The effects are evaluated with various physical and mechanical tests. Xing et al. (2009) study the UCS of NaCl-rich soils (chloride concentrations from 1.54 to 16.00 $g.kg^{-1}$), treated with 21% of cement CEMI 32.5: 8.00 g of chloride · kg^{-1} decrease the UCS values about 20% compared with a soil with 1.54 of chloride · kg^{-1}. Parker [15] reported that sulfate attack of the lime stabilized capping layer of the new carriageways on the 7.5 km A10 Wadesmill bypass U.K. resulted in heave that left up to 25% of the carriageways buckled, cracked and ridged. Similarly, Wild et al. [21], researching on industrial kaolinite clay stabilized with various lime and gypsum contents, agreed with Mehta [16] that osmotic swelling would take place within the colloidal layer in regions of high sulfate concentration in close proximity to the developing ettringite rods at the clay particle surfaces. Research work by Kinuthia et al. [13] and Bai et al. [6] has established the principal crystalline components in WSA as typically calcium oxide (about 5 wt.% of which is free quicklime with traces of calcium hydroxide). The ash is highly alkaline (pH 11–12) probably as a result of the residual free CaO. Basu et al. [3] studied about the usage of jute-synthetic blended woven geotextile in construction of unpaved rural roads. Laboratory test results shows that, this woven geotextile can be suitable for use as a separation layer as well as a reinforcing material for construction of medium traffic-volume unpaved roads. The use of jute (z85%) in cross direction resulted in notable increase in modulus, breaking strength, CBR puncture resistance of the geotextiles as compared to 100% HDPEF geotextile. Bent and Broms [4] studied about the usage of geofabric in stabilizing very soft clay. The method has been used in Malaysia and Singapore to stabilize very soft clay in setting ponds with a shear strength of approximately 3kPa so that the area can be used for construction. They have observed that, Geo-fabric can be used to increase the bearing capacity of very soft clay so that the fill required for the preloading of the clay can be placed. Wild et al. [22] studied the lime stabilized sulphate bearing clay soils stabilized with ground granulated blast furnace slag (GGBFS) and have concluded that, partial substitution of lime with GGBFS gives improved 7 days and 28 days strengths for both kaolinite and Kimmeridge Clay, the maximum level of lime substitution is different for the two clay types. Bidula Bose [5] studied the geo-engineering properties of the virgin soil and fly ash treated soil and it was found that there was 55% increment in the CBR value when compared with the virgin soil. Anil and Sivapullaiah (2011) studied the effectiveness of fly ash with ground granulated blast furnace slag in the soil and it was found that the UCS of flyash-GGBFS mixture increases with the increase in the GGBFS content. And also it was observed that the strength increases with the curing period. Sahu [19] observed that, stabilized fly ash with optimum lime content shows maximum economy. Three combinations were tried, stabilized fly ash with 50% sand, optimum lime content and activators (optimum lime content+20% sand). The saving was 6.0, 25.3 and 20.3% respectively. It was seen that the rate of increase of CBR value of fly ash stabilized with lime is more than with sand.

From the above literature review, it appears that chlorides and sulphates have an influence on the properties of treated soils. However, no specific threshold concentrations could be defined to predict the stabilization disturbances in treated soils containing anions such as chlorides and/or sulfates. Hence, it is clear that only a few limited research works have been carried out on ground granulated blast furnace slag and waste paper ash (WSA) behaviour study on sulphate infected black cotton soil with fibres.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

III. EXPERIMENTAL INVESTIGATION

Main objective of this experimental programme is to study the behavior of sulfate infected black cotton soil which is stabilized using lime stone powder and different fiberes.

A. Preperation of Potassium Sulphate Solution and Soil Sample

Potassium sulphate (K2SO4) powder was used to raise the sulphate level in the soil. Potassium sulphate powder was mixed with the calculated amount of water and the solutions were prepared. In the study, potassium sulphate concentration 20000 ppm was used. A series of tests were first performed on compacted soil specimens without any admixture followed by additional tests.



Figure 1 Blending of artificial laboratory soil samples prior to compaction.

B. Maximum Dry Density and Optimum Moisture Content Test

This test was conducted to know the MDD and OMC of the freshly prepared soil sample for soil mix and for different combinations as per IS: 2720-1974, Part-6. Each soil sample was prepared by initial dry mixing of raw soil about 3kg. Then water was added about 3% of weight of soil sample and mixed again until the water spreads all over the soil. The dry and wet mixing of soil-water was carried out in a non-porous metal tray in order to avoid water loss. The soil samples were subjected to this test and respective optimum moisture content and maximum dry densities of all combinations were determined. Determination of water content was carried out by the oven drying method.

C. California Bearing Ratio Test

This test was conducted to know the CBR of the freshly prepared soil sample for soil mix and for different combinations as per IS : 2720-1987, Part-XVI. The test is performed by measuring the pressure required to penetrate a soil sample with a plunger of standard area. The measured pressure is then divided by the pressure required to achieve an equal penetration on a standard material. It is the ratio of force per unit area required to penetrate a soil mass with standard circular piston at the rate of 1.25mm/min. to that required for the corresponding penetration of a standard material. During immersion, water will flow into the sample due to capillary action. If after the first 3 days in the tank there is still little or no water at the top of the specimen, then water is added to the top of the specimen for the remainder of the soaking period prior to testing for strength.

D. Direct Shear Test

This test was conducted to know the shear strength parameter of the soil for the soil mix and for different combinations as per IS : 2720-1986, Part-13. For each test three specimen samples were extracted after compacting the soil specimen in the standard proctor mould. The specimen samples were tested with different normal stresses i.e., 100 kpa, 200 kpa and 300 kpa in undrained conditions. The proving ring readings were noted at fixed interval of horizontal dial gauge readings to study the stress-displacement behaviour of soil specimen. The stress-horizontal displacement curves were plotted to study the stress-displacement behaviour of soil specimen. The shear strength parameters were also studied.

E. Unconfined Compression Shear Test

This test was conducted to know the shear strength parameter of the soil for the soil mix and for different combinations as per IS : 2720-1973, Part-10. The shearing strength is commonly investigated by means of compression tests in which an axial load is applied to the specimen and increased until failure occurs. The unconfined compressive strength is the load per unit area at which unconfined cylindrical specimen of soil will fail in a simple compression test. If the unit axial compression force per unit area has not reached a maximum value up to 2 percent axial strain, unconfined compressive strength shall be considered the value obtained at 2 percent axial strength.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 10 Issue V May 2022- Available at www.ijraset.com

IV. EXPERIMENTAL RESULTS OF SULPHATE INFECTED BLACK COTTON SOIL USING LIME STONE POWDER AS STABILIZATION MATERIAL

A. Index properties of sulphate infected black cotton soil using lime stone powder as stabilization material.

Table 1. gives the index properties of black cotton soil using lime stone powder as stabilization material in it. The variation of specific gravity, liquid limit, plastic limit, plasticity index, shrinkage limit and pH value of lime stone powder based stabilization material are shown in figure 2 to figure 6.

Table 1- Index properties of sulphate infected B C soil using lime stone powder as stabilization material

Percentage replacement of B C soil by lime stone powder	Specific gravity	Average specific gravity	Liquid limit (%)	Average liquid limit (%)	Plastic limit (%)	Average plastic limit (%)	Plasticity index	Average plasticity index	Shrinkage limit (%)	Average shrinkage limit (%)
0	2.42	2.45	59.04	59.00	26.81	26.40	32.23	32.60	20.6	20.91
	2.46		59.12		26.45		32.67		21.28	
	2.48		58.85		25.94		32.91		20.84	
5	2.45	2.47	55.18	55.12	27.45	27.35	27.73	27.77	19.67	19.56
	2.49		55.14		27.39		27.75		19.48	
	2.47		55.04		27.21		27.83		19.53	
10	2.5	2.50	50.65	50.55	28.04	27.84	22.61	22.71	17.65	17.85
	2.51		50.62		27.67		22.95		17.98	
	2.49		50.39		27.81		22.58		17.91	
15	2.51	2.52	46.24	46.18	30.24	30.12	16	16.06	14.87	14.85
	2.53		46.11		30.04		16.07		14.76	
	2.52		46.18		30.08		16.1		14.92	
20	2.53	2.53	46.71	46.68	29.82	29.67	16.89	17.01	15.23	15.13
	2.52		46.55		29.69		16.86		15.05	
	2.54		46.78		29.51		17.27		15.11	
25	2.57	2.56	47.12	47.24	28.61	28.76	18.51	18.48	16.45	16.41
	2.55		47.42		28.98		18.44		16.44	
	2.56		47.18		28.69		18.49		16.35	
30	2.58	2.59	48.79	48.75	28.29	28.34	20.5	20.41	17.21	17.16
	2.59		48.64		28.31		20.33		17.14	
	2.59		48.82		28.43		20.39		17.12	
35	2.62	2.61	50.87	50.85	27.42	27.31	23.45	23.54	18.34	18.29
	2.6		50.72		27.38		23.34		18.31	
	2.62		50.96		27.14		23.82		18.22	
40	2.68	2.66	51.91	51.72	26.92	26.85	24.99	24.87	19.12	19.04
	2.65		51.69		26.78		24.91		19.07	
	2.64		51.55		26.84		24.71		18.92	

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

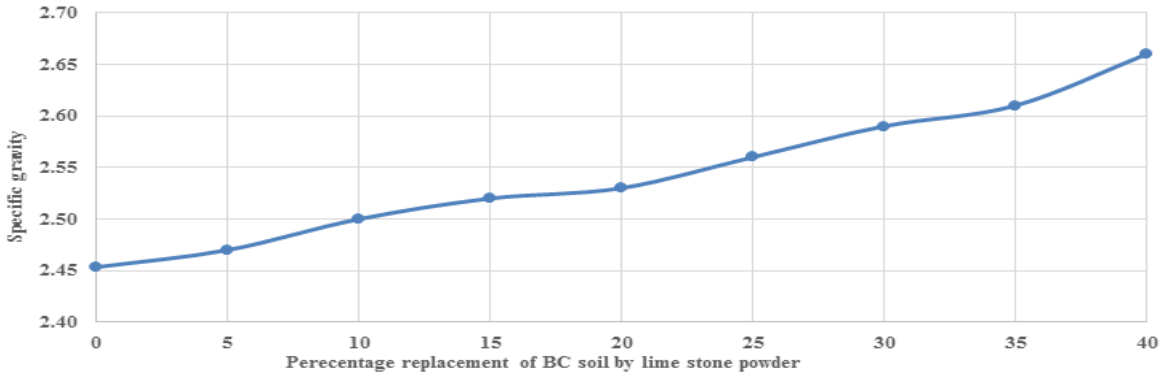


Figure 2 Variation of specific gravity for different percentage replacement of BC soil by lime stone powder.

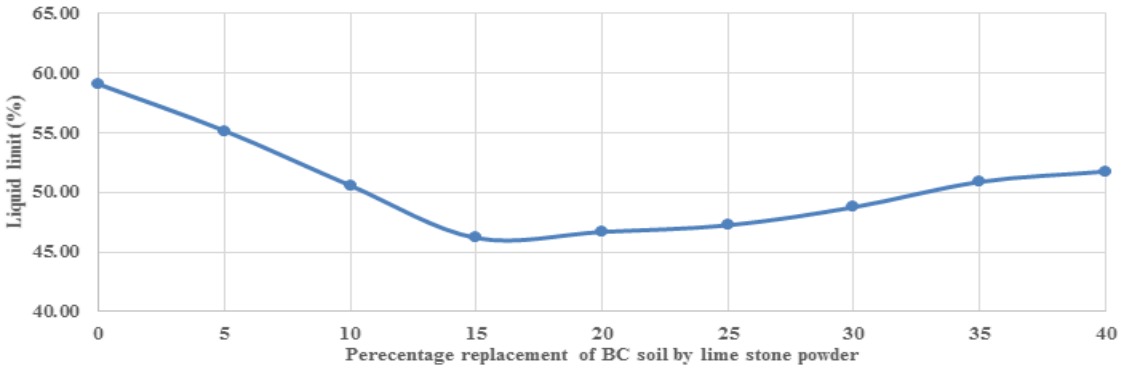


Figure 3 Variation of liqquid limit for different percentage replacement of BC soil by lime stone powder.

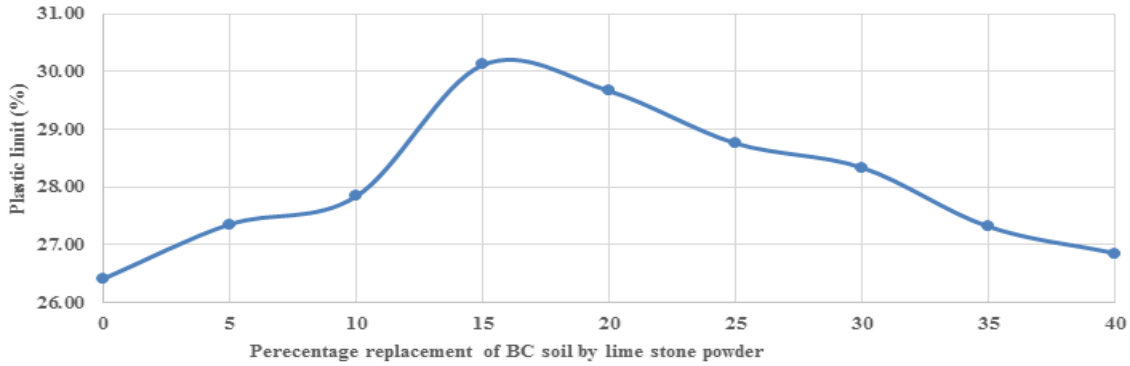


Figure 4 Variation of plastic limit for different percentage replacement of BC soil by lime stone powder.

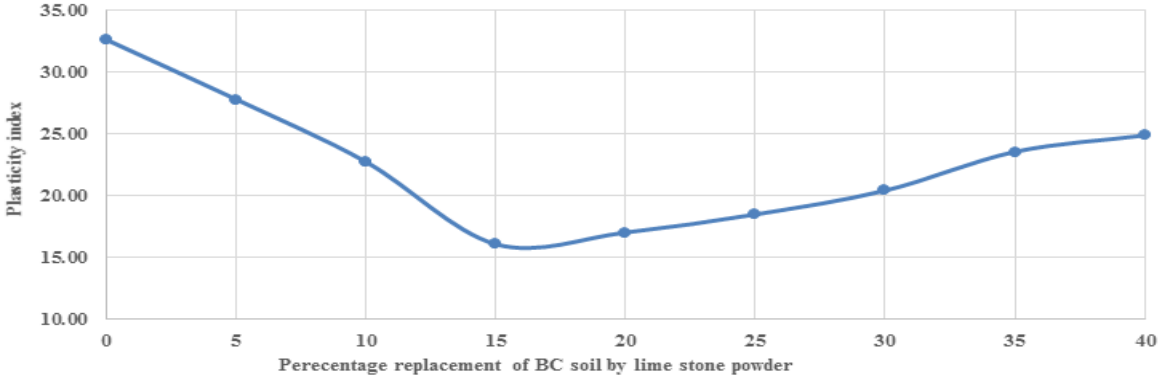


Figure 5 Variation of plasticity index for different percentage replacement of BC soil by lime stone powder

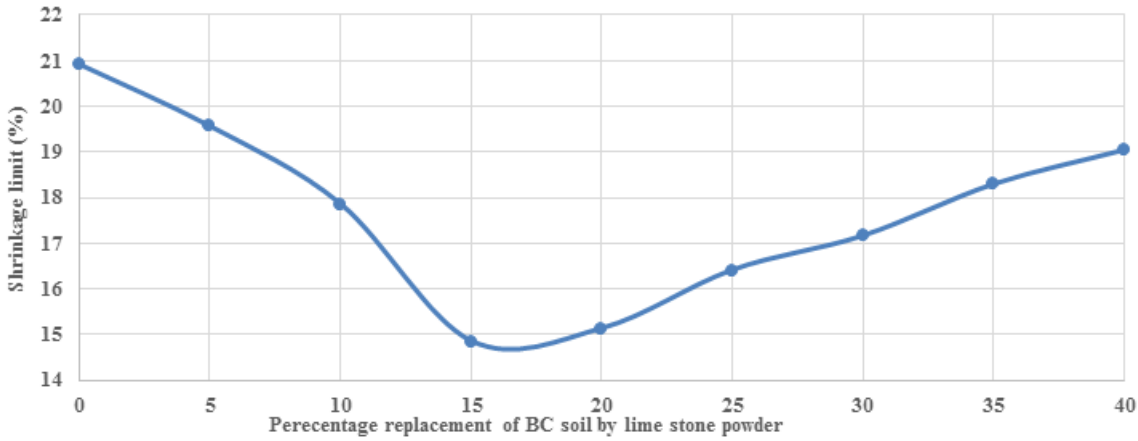


Figure 6 Variation of shrinkage limit for different percentage replacement of BC soil by lime stone powder.

It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material has shown improved index properties at 15% replacement level. Table 1 and related graphs show the improvement in index properties for sulphate infected black cotton soil when treated with lime stone powder as stabilization material with 15% replacement level.

Liquid limit and shrinkage limit values show a decreasing trend upto 15% replacement of black cotton soil by lime stone powder. After 15% replacement level, liquid limit and shrinkage limit values go on increasing. The percentage decrease in liquid limit and shrinkage limit at 15% replacement level are found to be 21.73% and 28.99% respectively with respect to reference mix. Plastic limit shows an increasing trend upto 15% replacement of black cotton soil by lime stone powder. After 15% replacement level, plastic limit goes on decreasing. The percentage increase in plastic limit at 15% replacement level is found to be 12.35% with respect to reference mix. Plasticity index which is an effective parameter for controlling the swell potential of soil, is also less at 15% replacement level. The percentage decrease in plasticity index at 15% replacement level is found to be 50.74% with respect to reference mix. Higher the plasticity index, higher is the swell.

This may be attributed to the fact that at 15% replacement of black cotton soil by lime stone powder, an appropriate development of a cementitious matrix, resulting from the pozzolonic reactions forming calcium silicate hydrates (CSH), calcium aluminosilicate hydrates (CASH) and calcium aluminate hydrates (CAH) under the localized alkaline conditions within the soil matrix.

Thus, it may be concluded that the sulphate infected black cotton soil using lime stone powder as stabilizing material shows improved index properties at 15% replacement level.

B. Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material.

Table 2 to Table 3 gives the stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material. The variation in MDD, OMC, unsoaked CBR, soaked CBR, cohesion, angle of shearing resistance (ϕ), UCC cohesion and UCC (α) are shown in figure 7 to figure 14.

Table 2 - Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material.

Percentage replacement of B C soil by lime stone powder	MDD (gm/cc)	Average MDD (gm/cc)	OMC (%)	Average OMC (%)	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)
0	1.64	1.62	22.86	22.92	3.22	3.29	2.54	2.57
	1.61		22.98		3.34		2.56	
	1.6		22.93		3.32		2.61	
5	1.64	1.65	23.69	23.79	3.95	3.96	3.14	3.12
	1.66		23.86		4.05		3.08	
	1.65		23.81		3.89		3.15	
10	1.75	1.75	24.62	24.65	4.68	4.45	3.94	3.92
	1.74		24.59		4.35		4.01	

	1.77		24.75		4.31		3.81	
15	1.83	1.84	26.68	26.66	5.96	5.86	4.36	4.35
	1.82		26.79		5.82		4.41	
	1.86		26.51		5.79		4.28	
20	1.82	1.81	27.15	27.10	5.72	5.75	4.28	4.26
	1.83		27.03		5.68		4.33	
	1.79		27.11		5.84		4.18	
25	1.78	1.79	28.23	28.16	5.14	5.24	4.05	4.12
	1.77		28.18		5.28		4.13	
	1.81		28.07		5.31		4.18	
30	1.77	1.77	27.93	28.01	4.91	4.92	3.89	3.96
	1.76		28.04		4.88		3.92	
	1.78		28.06		4.96		4.06	
35	1.72	1.73	29.25	29.24	4.71	4.68	3.72	3.65
	1.74		29.35		4.59		3.57	
	1.72		29.12		4.75		3.66	
40	1.71	1.71	29.71	29.62	4.31	4.25	3.64	3.42
	1.72		29.62		4.23		3.27	
	1.69		29.54		4.22		3.36	

Table 3 - Some more stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material.

Percentage replacement of B C soil by lime stone powder	Cohesion from direct shear test (kg/cm2)	Average cohesion (kg/cm2)	Angle of shearing resistance from direct shear test (ϕ) (degree)	Average angle of shearing resistance (ϕ) (degree)	UCC cohesion (kg/cm2)	Average UCC cohesion (kg/cm2)	UCC (α)	Average UCC (α)
0	8.92	9.10	18.12	18.36	8.86	8.90	16.74	16.75
	9.28		18.65		9.08		16.58	
	9.11		18.31		8.76		16.92	
5	10.13	10.24	17.62	17.50	10.81	10.87	16.35	16.38
	10.27		17.49		10.88		16.41	
	10.32		17.38		10.92		16.38	
10	11.63	11.53	16.42	16.45	11.86	11.95	15.75	15.82
	11.45		16.38		11.93		15.91	
	11.52		16.54		12.06		15.79	
15	13.34	13.56	15.48	15.56	12.99	12.95	15.45	15.55
	13.62		15.62		12.92		15.61	
	13.71		15.58		12.93		15.59	
20	13.01	13.04	15.72	15.68	12.75	12.65	15.84	15.74
	13.12		15.69		12.58		15.72	
	12.98		15.62		12.61		15.65	
25	12.88	12.85	15.79	15.75	12.17	12.14	15.71	15.77
	12.92		15.77		12.08		15.81	
	12.74		15.69		12.18		15.78	
30	12.11	12.04	15.95	15.88	11.26	11.23	15.95	15.98
	12.05		15.78		11.14		15.92	
	11.96		15.91		11.29		16.06	
35	11.58	11.52	16.21	16.23	10.82	10.91	16.11	16.05
	11.61		16.15		10.98		16.01	
	11.37		16.34		10.92		16.02	
40	10.94	10.85	16.92	16.82	10.7	10.59	16.22	16.12
	10.78		16.75		10.64		15.98	
	10.82		16.79		10.42		16.17	

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

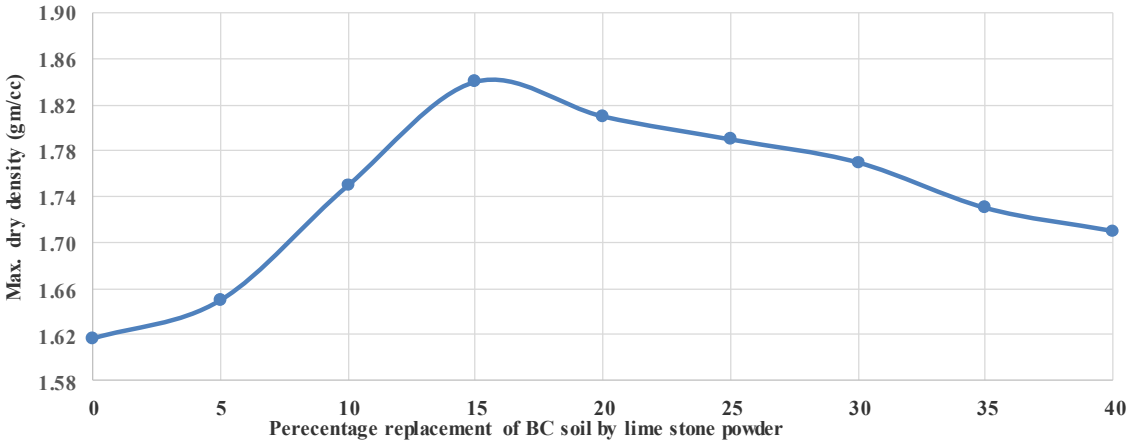


Figure 7. Variation of max. dry density for different percentage replacement of BC soil by lime stone powder.

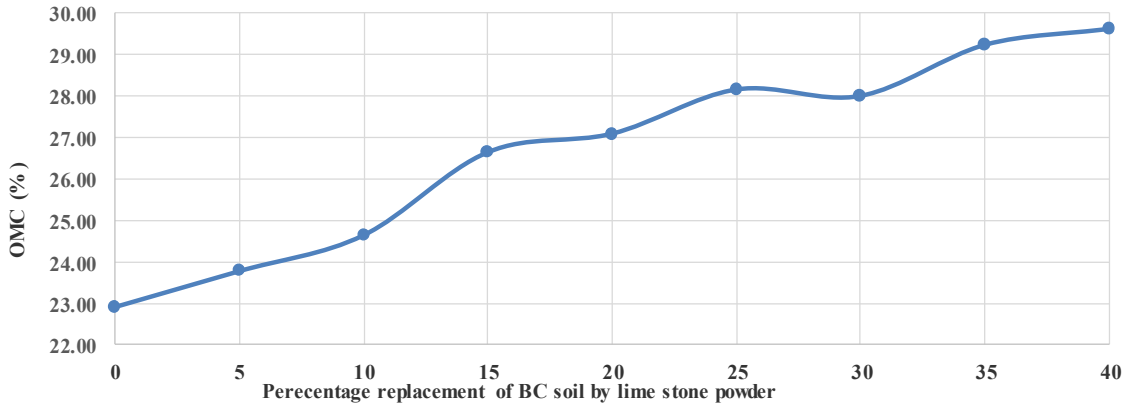


Figure 8. Variation of optimum moisture content for different percentage replacement of BC soil by lime stone powder.

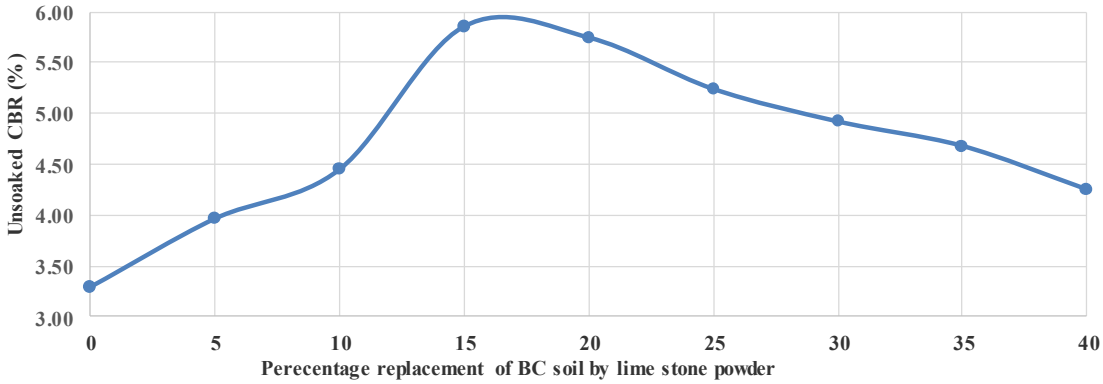


Figure 9. Variation of unsoaked CBR for different percentage replacement of BC soil by lime stone powder.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

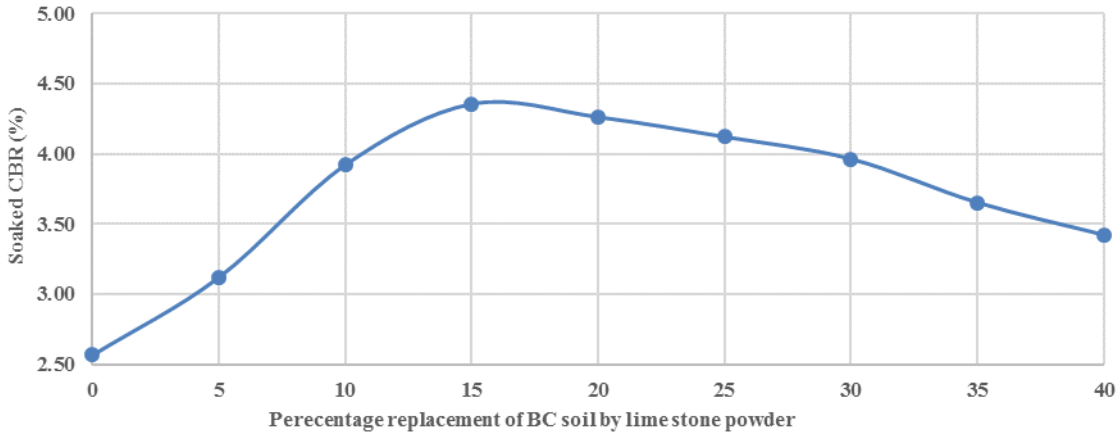


Figure 10. Variation of soaked CBR for different percentage replacement of BC soil by lime stone powder.

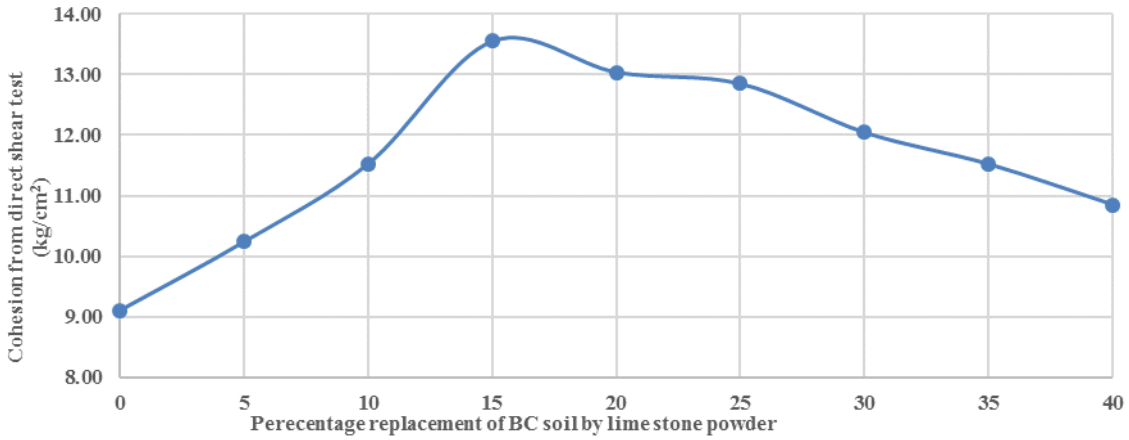


Figure 11. Variation of cohesion of direct shear test for different percentage replacement of BC soil by lime stone powder.

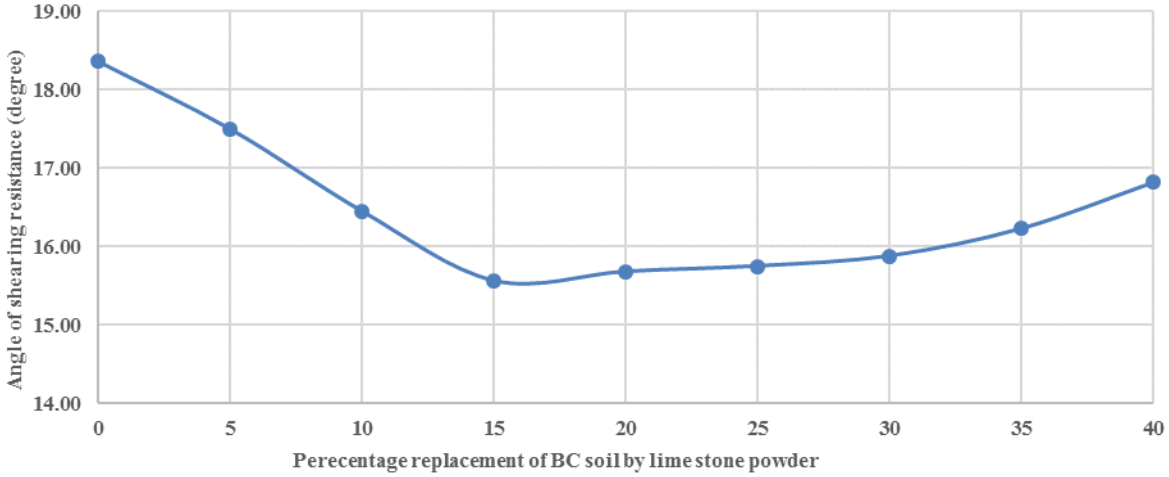


Figure 12. Variation of angle of shearing resistance of direct shear test for different percentage replacement of BC soil by lime stone powder

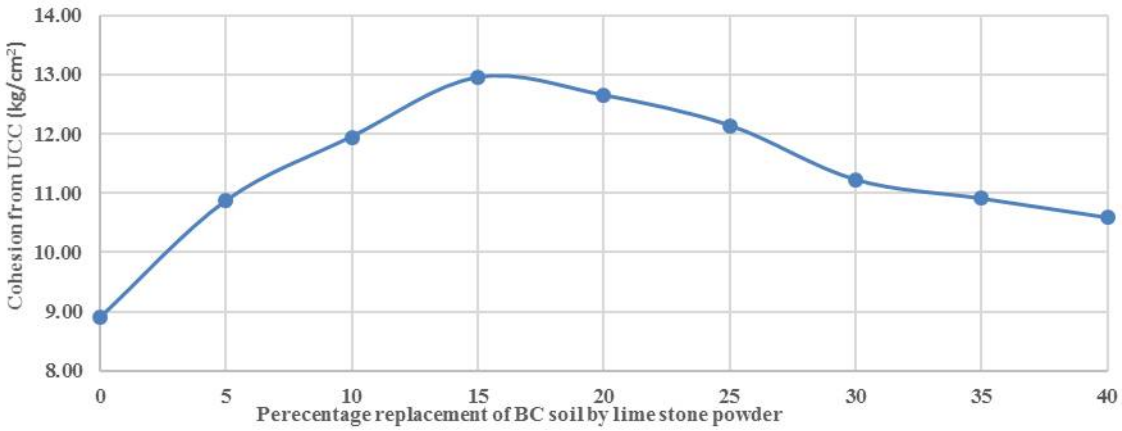


Figure 13. Variation of Cohesion of UCC test for different percentage replacement of BC soil by lime stone powder.

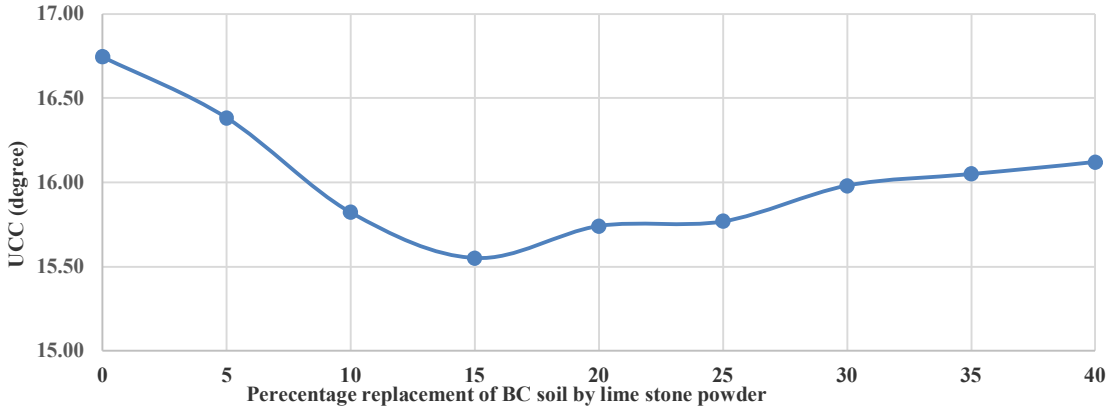


Figure 14. Variation of α of UCC test for different percentage replacement of BC soil by lime stone powder.

It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material has shown improved stress resistance properties at 15% replacement level. Table 2 and table 3 and related graphs show the improvement in stress resistance properties for sulphate infected black cotton soil when treated with lime stone powder as stabilization material with 15% replacement level.

Unsoaked CBR value, soaked CBR value, cohesion value from direct shear test and UCC test cohesion value, all show an increasing trend upto 15% replacement of black cotton soil by lime stone powder. After 15% replacement level, all the above values go on decreasing.

The percentage increase in unsoaked CBR value, soaked CBR value, cohesion value from direct shear test and UCC test cohesion value at 15% replacement level are found to be 43.88%, 41.04%, 32.85% and 31.27% respectively with respect to reference mix.

Angle of shearing resistance Φ obtained by direct shear test and α value obtained by UCC test shows a decreasing trend upto 15% replacement of black cotton soil by lime stone powder. The percentage decrease in angle of shearing resistance Φ obtained by direct shear test and α value obtained by UCC test at 15% replacement level are found to be 15.25% and 7.15% respectively with respect to reference mix.

This may be due to the fact that at 15% replacement of black cotton soil by lime stone powder, an appropriate colloidal product may be formed which consists of a complex calcium-sulpho-aluminate-silicate hydrate (C-A-S- S-H) on the surface of the clay plates. From this colloidal surface product, a crystalline compound commonly known as ettringite (C_3A-3C S-H32) nucleates. Ettringite is known to impart significant strength enhancement, due to its needle like crystal crystalline morphology.

Thus, it may be concluded that the sulphate infected black cotton soil using lime stone powder as stabilizing material show improved stress resistance properties at 15% replacement level.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

C. Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with monofibres.

Table 4 and table 5 gives the stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material at 15% replacement level along with monofibres like HDPE, Polypropylene, waste plastic and jute fibres. The variation in unsoaked CBR value and soaked CBR value for different monofibres are shown in figure 15 to figure 22.

Table 4 - Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with monofibers like HDPE fibres and PPF fibres

Perecentage of fibres added by volume fraction	HDPE fibres				Polypropylene fibres			
	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)
0.0	5.96	5.86	4.36	4.35	5.96	5.86	4.36	4.35
	5.82		4.41		5.82		4.41	
	5.79		4.28		5.79		4.28	
0.5	7.95	7.92	5.66	5.84	7.31	7.24	5.23	5.15
	7.89		5.88		7.26		5.12	
	7.93		5.98		7.15		5.11	
1.0	9.18	9.11	7.18	7.12	8.59	8.65	6.38	6.28
	9.11		7.06		8.74		6.18	
	9.03		7.13		8.61		6.29	
1.5	12.45	12.36	8.18	8.23	9.62	9.56	7.45	7.35
	12.38		8.32		9.38		7.38	
	12.25		8.19		9.68		7.23	
2.0	9.42	9.35	7.62	7.51	8.68	8.72	6.52	6.42
	9.38		7.51		8.65		6.45	
	9.26		7.39		8.82		6.28	

Table 5 - Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with monofibers like WPF fibres and Jute fibres

Perecentage of fibres added by volume fraction	Waste plastic fibres				Jute fibres			
	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)
0.0	5.96	5.86	4.36	4.35	5.96	5.86	4.36	4.35
	5.82		4.41		5.82		4.41	
	5.79		4.28		5.79		4.28	
0.5	7.16	7.12	5.12	4.94	6.75	6.68	4.62	4.75
	7.12		4.96		6.81		4.82	
	7.08		4.75		6.49		4.81	
1.0	8.48	8.45	5.72	5.56	7.15	7.14	5.02	5.20
	8.36		5.45		7.21		5.34	
	8.51		5.51		7.05		5.23	
1.5	9.23	9.24	6.92	6.82	7.96	7.86	6.17	6.12
	9.17		6.83		7.84		6.16	
	9.31		6.71		7.79		6.04	
2.0	8.11	8.05	6.11	6.12	6.88	6.81	5.72	5.64
	8.06		6.07		6.74		5.68	
	7.98		6.18		6.82		5.52	

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

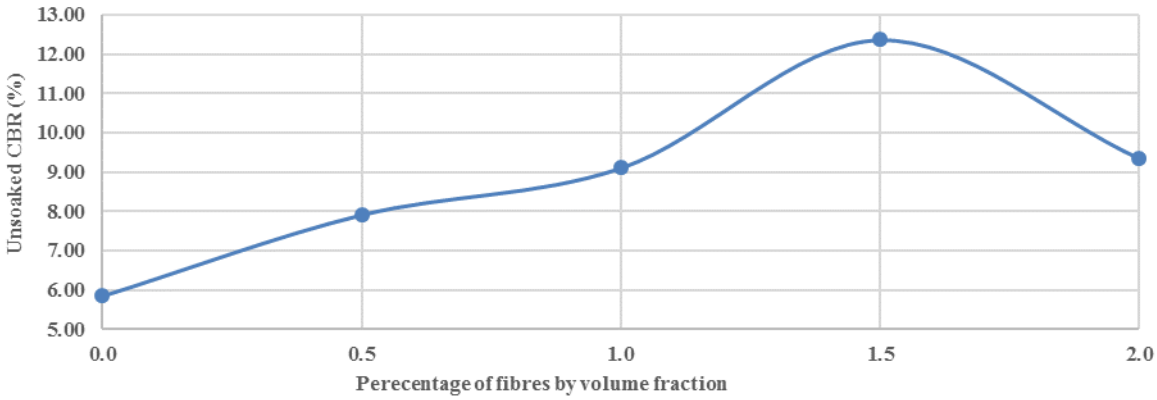


Figure 15. Variation of unsoaked CBR for different percentage of HDPE fibres when BC soil is replaced by lime stone powder.

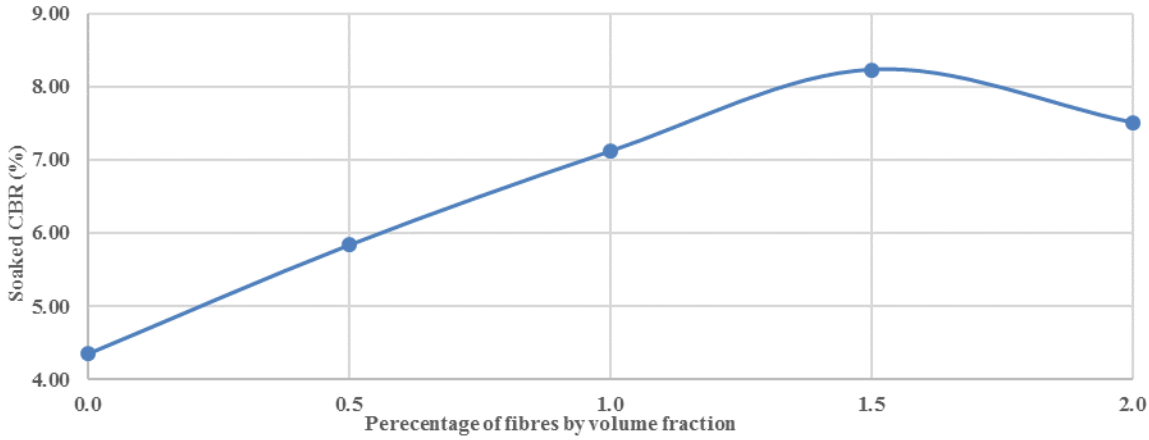


Figure 16. Variation of soaked CBR for different percentage of HDPE fibres when BC soil is replaced by lime stone powder.

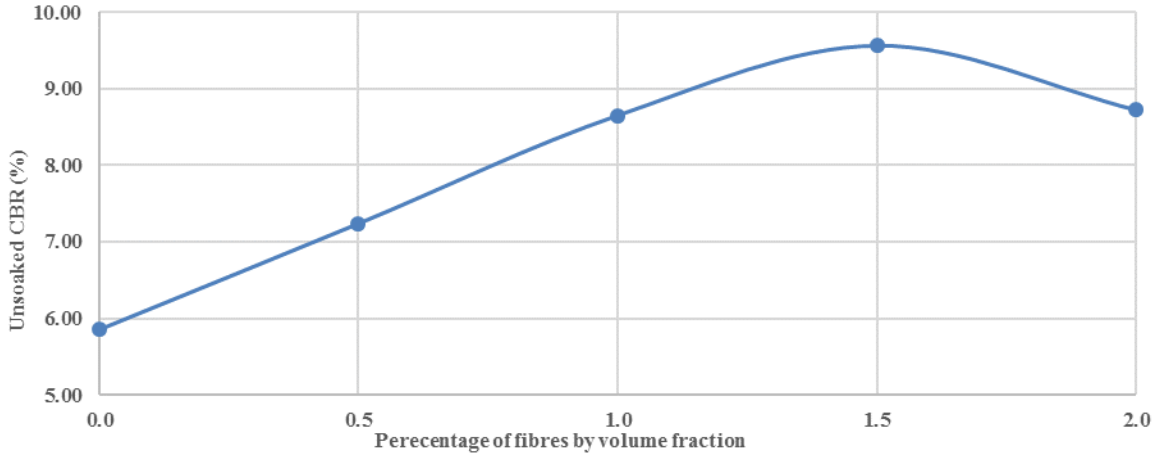


Figure 17. Variation of unsoaked CBR for different percentage of polypropylene fibres when BC soil is replaced by lime stone powder

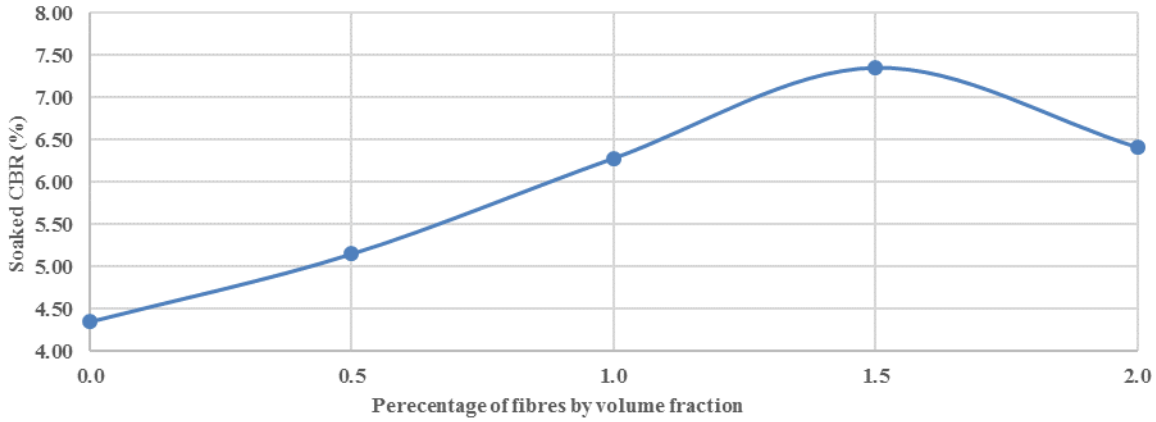


Figure 18. Variation of soaked CBR for different percentage of polypropylene fibres when BC soil is replaced by lime stone powder.

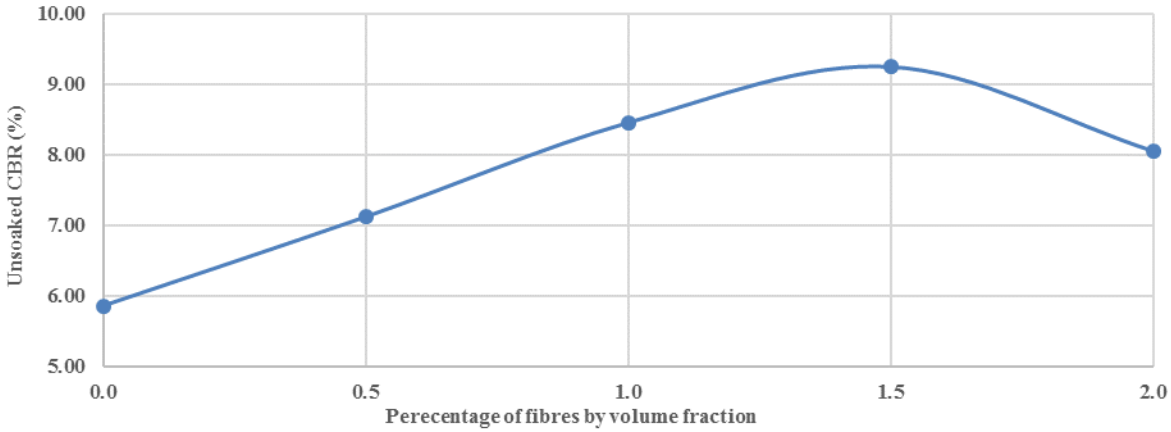


Figure 19. Variation of unsoaked CBR for different percentage of waste plastic fibres when BC soil is replaced by lime stone powder

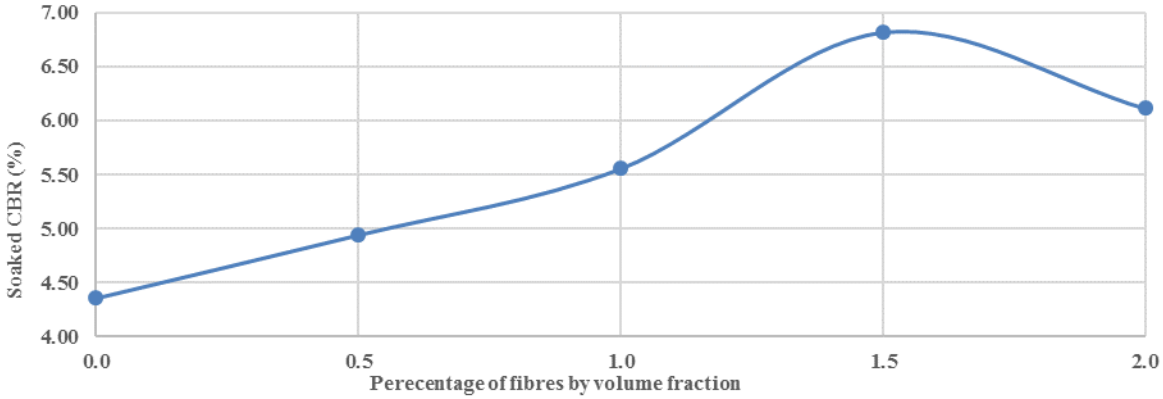


Figure 20. Variation of soaked CBR for different percentage of waste plastic fibres when BC soil is replaced by lime stone powder.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

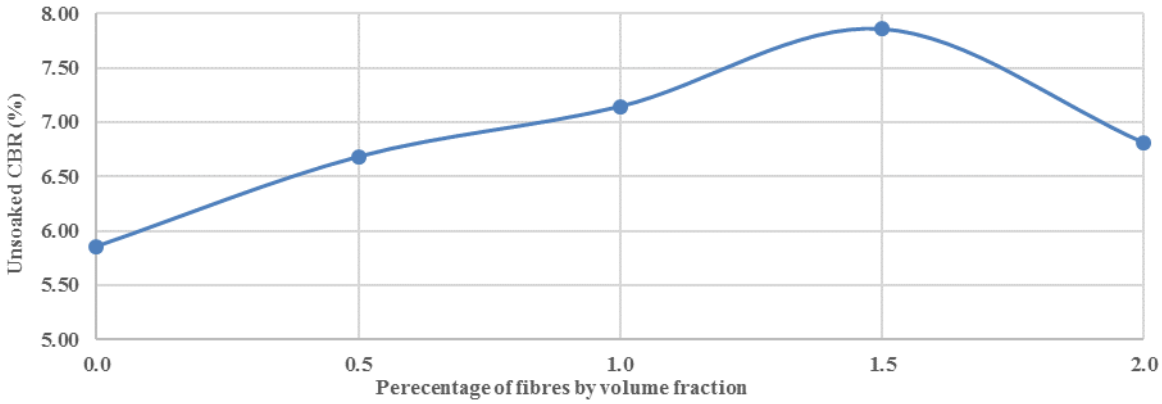


Figure 21. Variation of unsoaked CBR for different percentage of jute fibres when BC soil is replaced by lime stone powder.

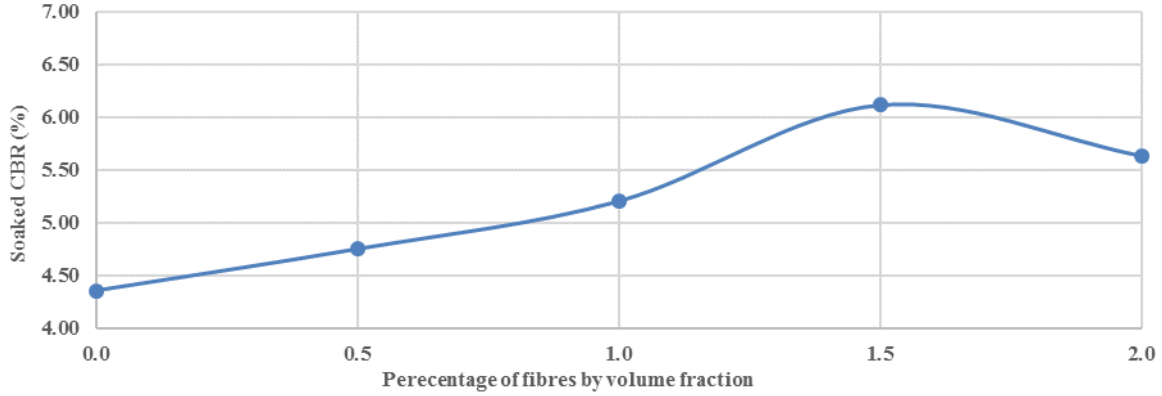


Figure 22. Variation of soaked CBR for different percentage of jute fibres when BC soil is replaced by lime stone powder.

It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material along with monofibres has shown improved stress resistance properties when monofibres are added at 1.5% by volume fraction. Table 4 and Table 5 and related graphs show the improvement in stress resistance properties for sulphate infected black cotton soil when 15% block cotton soil is replaced by lime stone powder and different monofibres are used. Various monofibres such as HDPE fibres, Polypropylene fibres, waste plastic fibres and jute fibres all have shown good results at 1.5% dosage level. Unsoaked CBR value and soaked CBR value have shown an increasing trend upto 1.5% addition of fibres. The percentage increase in unsoaked CBR value for various monofibres such as HDPE fibres, polypropylene fibres, waste plastic fibres and jute fibres, at 1.5% dosage are found to be 52.63%, 38.74%, 36.64% and 25.49% respectively with respect to reference mix. The percentage increase in soaked CBR value for various monofibres such as HDPE fibres, polypropylene fibres, waste plastic fibres and jute fibres, at 1.5% dosage are found to be 47.13%, 40.80%, 36.20% and 28.87% respectively with respect to reference mix. Thus, it is clearly seen that addition of monofibres have dramatically increased the stress resistance properties of sulphate infected black cotton soil treated with lime stone powder. This may be attributed to the fact that the additions of fibres to the soil increase the interfacial bond, thereby increasing the friction between soil and fibres. This renders it difficult for soil particles that surround fibres to change in position from one point to another and thereby improving the bond force between soil particles. When local cracks appears in the soil, fibres across the crack will take on the tension in the soil, which effectively impedes further development of cracks and improves the resistance of the soil to the force applied. Thus, the crack can be prevented by bridging effect of fibres. Further, the cementitious matrix produced from the pozzolonic reaction by the stabilizing material, may cover around the fibre surface may improve the interfacial bond and may increase the friction co-efficient between soil and fibres. Thus, it may be concluded that the addition of monofibres such as HDPE fibres, polypropylene fibres, waste plastic fibres and jute fibres to sulphate infected black cotton soil using lime stone powder as stabilizing material significantly enhance the stress resistance properties.

From the results obtained, it may also be concluded that, the performance of HDPE fibres is better than polypropylene fibres, waste plastic fibres and jute fibres in enhancing the stress resistance properties of sulphate infected black cotton soil using lime stone powder as stabilization material.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

D. Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with hybrid fibres.

Table 6 and table 7 gives the stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material at 15% replacement level along with hybrid fibres like (PPF+HDPEF), (PPF+WPF) and (JF+WPF). The variation in unsoaked CBR value and soaked CBR value for different hybrid fibre combinations are shown in figure 23 to figure 28.

Table 6- Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with hybrid fibers like (PPF+HDPEF) & (PPF+WPF)

Perecentage of hybrid fibres added by volume fraction	**(PPF + HDPEF)**				**(PPF + WPF)**			
	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked) (%)
(0%+0%)	5.96	5.86	4.36	4.35	5.96	5.86	4.36	4.35
	5.82		4.41		5.82		4.41	
	5.79		4.28		5.79		4.28	
(0.25%+0.25%)	9.26	9.24	6.35	6.32	7.56	7.65	5.75	5.52
	9.12		6.29		7.68		5.45	
	9.34		6.31		7.72		5.37	
(0.5%+0.5%)	11.12	11.28	7.92	7.83	9.88	9.86	6.59	6.65
	11.36		7.85		9.91		6.81	
	11.37		7.71		9.78		6.55	
(0.75%+0.75%)	12.95	12.88	8.85	8.95	10.82	10.65	8.12	8.24
	12.83		9.02		10.62		8.32	
	12.85		8.99		10.51		8.27	
(1%+1%)	11.92	11.85	8.11	8.16	9.95	9.82	7.58	7.68
	11.89		8.24		9.84		7.64	
	11.75		8.12		9.68		7.82	

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

Table 7- Stress resistance properties of sulphate infected B C soil using lime stone powder as stabilization material along with hybrid fibers like (JF+WPF)

Perecentage of hybrid fibres added by volume fraction	(JF + WPF)			
	CBR (Unsoaked) (%)	Average CBR (Unsoaked) (%)	CBR (Soaked) (%)	Average CBR (Soaked (%)
(0%+0%)	5.96	5.86	4.36	4.35
	5.82		4.41	
	5.79		4.28	
(0.25%+0.25%)	6.95	6.95	5.18	5.12
	7.02		5.04	
	6.89		5.15	
(0.5%+0.5%)	8.16	8.12	6.28	6.45
	8.11		6.48	
	8.09		6.59	
(0.75%+0.75%)	9.28	9.24	7.21	7.15
	9.26		7.05	
	9.18		7.18	
(1%+1%)	8.13	8.25	6.27	6.27
	8.34		6.33	
	8.27		6.21	

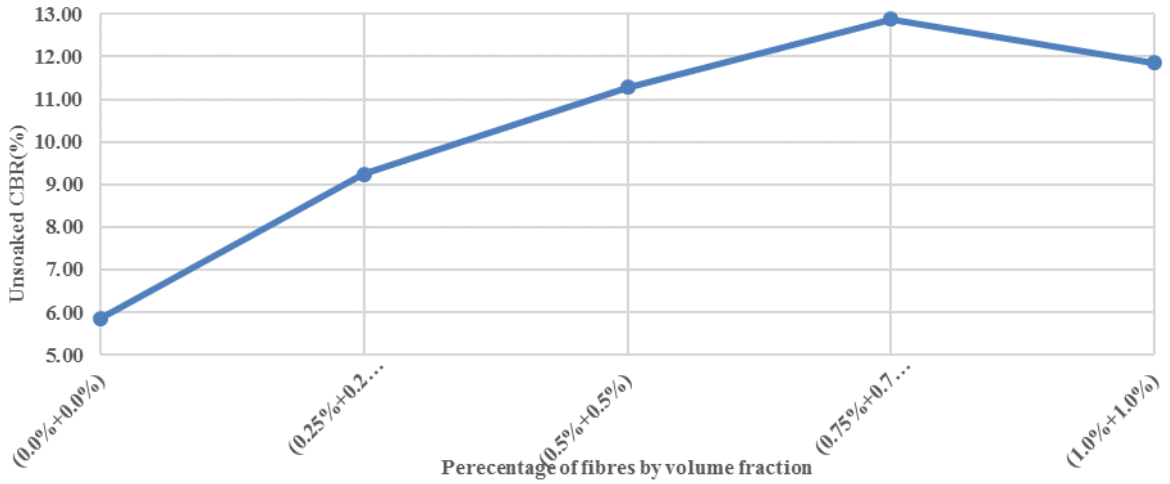


Figure 23 Variation of unsoaked CBR for different percentage of (PPF + HDPEF) when BC soil is replaced by lime stone powder.

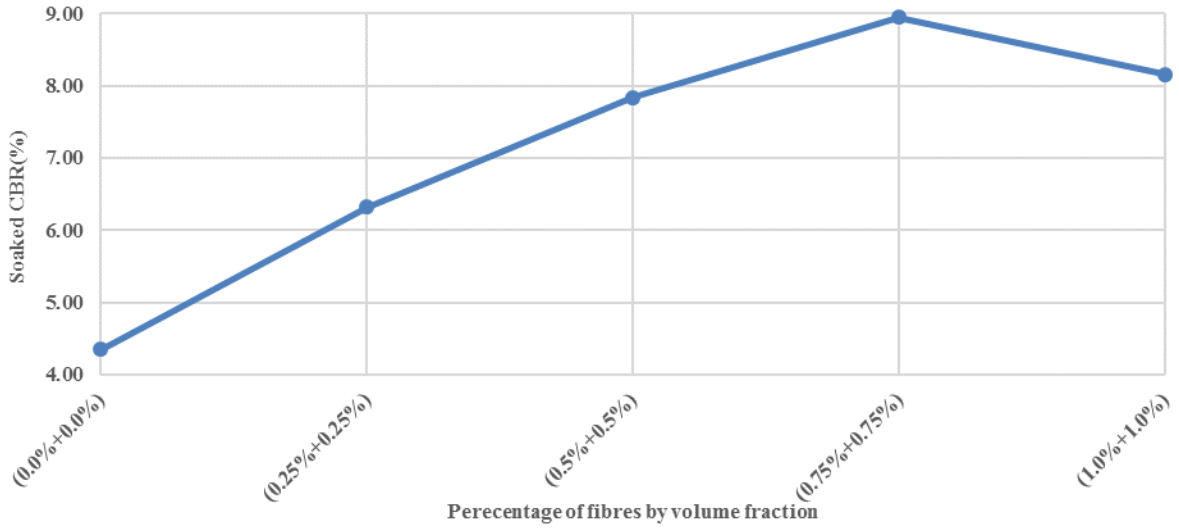


Figure 24 Variation of soaked CBR for different percentage of (PPF + HDPEF) when BC soil is replaced by lime stone powder.

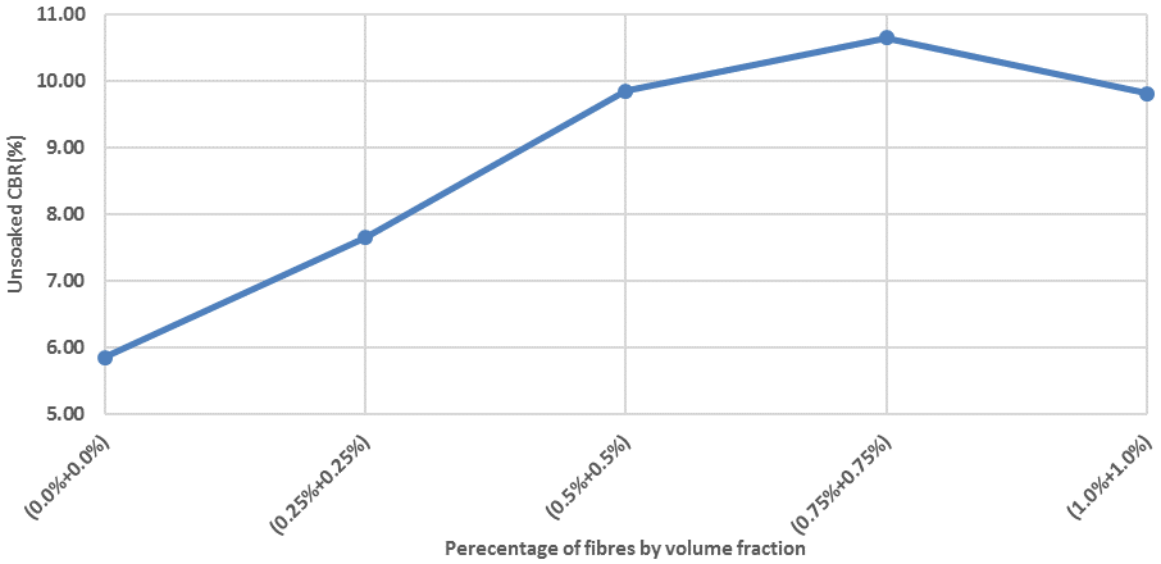
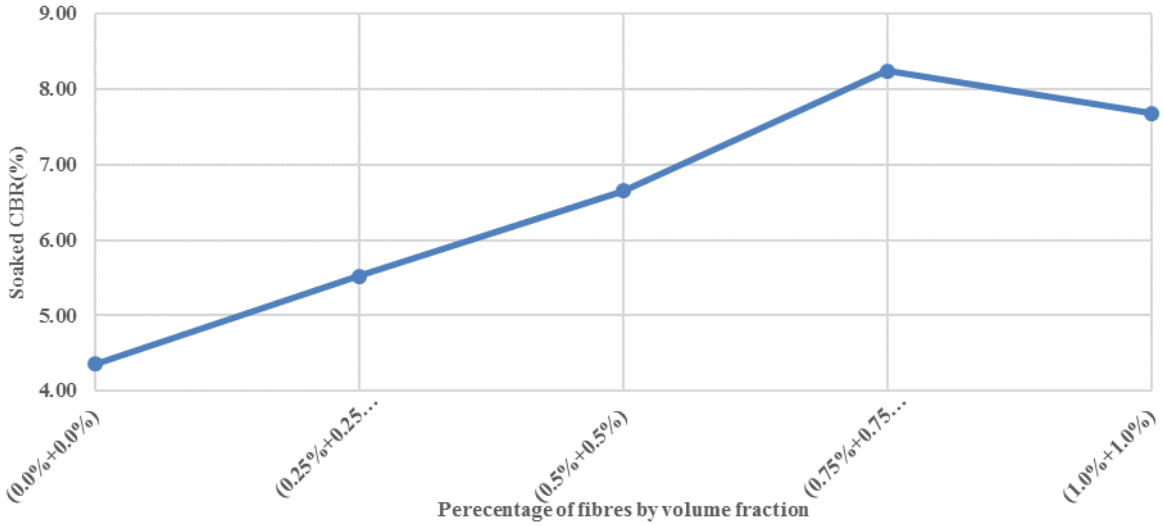


Figure 25 Variation of unsoaked CBR for different percentage of (PPF + WPF) when BC soil is replaced by lime stone powder.



©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

Figure 26 Variation of soaked CBR for different percentage of (PPF + WPF) when BC soil is replaced by lime stone powder.

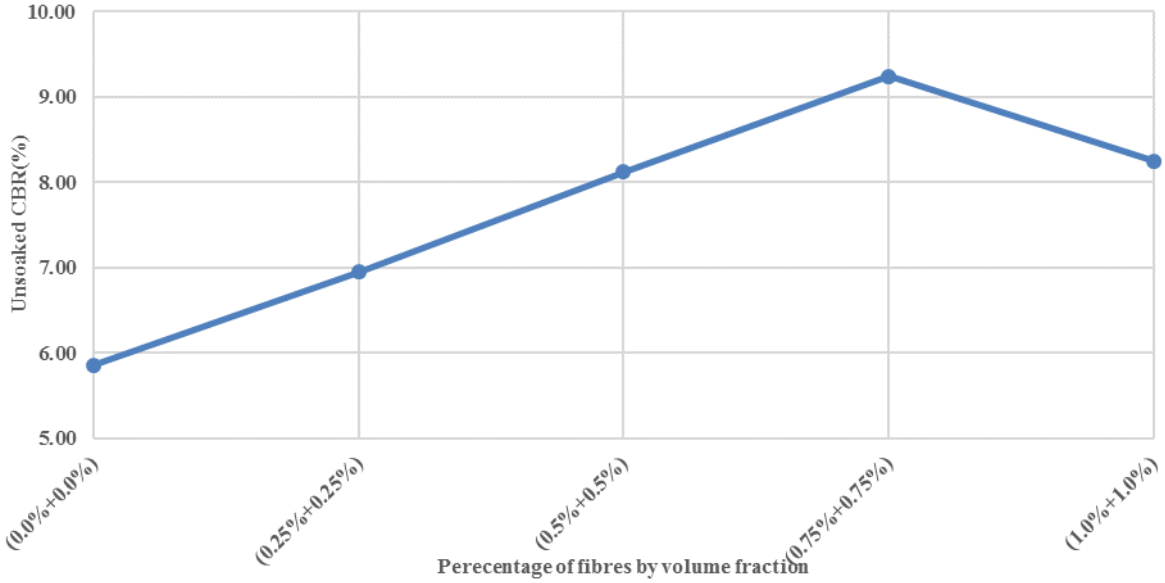


Figure 27 Variation of unsoaked CBR for different percentage of (JF + WPF) when BC soil is replaced by lime stone powder.

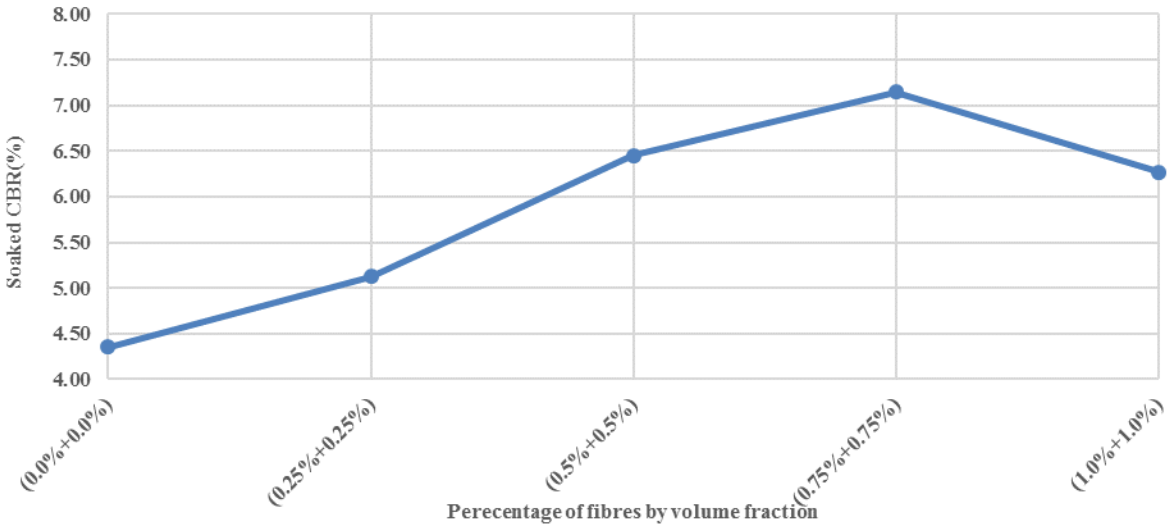


Figure 28 Variation of soaked CBR for different percentage of (JF + WPF) when BC soil is replaced by lime stone powder.

It is observed that the sulphate infected black cotton soil using lime stone powder as stabilization material along with hybrid fibres has shown improved stress resistance properties when hybrid fibres are added at (0.75%+0.75%) by volume fraction. Table 6 and table 7 and related graphs show the improvement in stress resistance properties for sulphate infected black cotton soil when 15% block cotton soil is replaced by lime stone powder and different combination of hybrid fibres are used. Various hybrid fibre combination such as (PPF+HDPEF), (PPF+WPF), and (JF+WPF) all have shown good results at (0.75%+0.75%) dosage level. Unsoaked CBR value and soaked CBR value have shown an increasing trend upto (0.75%+0.75%) addition of fibres. The percentage increase in unsoaked CBR value for various combination of hybrid fibres such as (PPF+HDPEF), (PPF+WPF), and (JF+WPF) at (0.75%+0.75%) dosage are found to be 54.53%, 45.01% and 36.62% respectively with respect to reference mix. The percentage increase in soaked CBR value for various combination of hybrid fibres such as (PPF+HDPEF), (PPF+WPF), and (JF+WPF) at (0.75%+0.75%) dosage are found to be 51.34%, 47.15% and 39.09% respectively with respect to reference mix.
Thus, it is clearly seen that addition of hybrid fibres have significantly increased the stress resistance properties of sulphate infected black cotton soil treated with lime stone powder.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |

This may be attributed to the fact that the additions of hybrid fibres to the soil increase the interfacial bond, thereby increasing the friction between soil and fibres. This renders it difficult for soil particles that surround fibres to change in position from one point to another and thereby improving the bond force between soil particles. When local cracks appears in the soil, fibres across the crack will take on the tension in the soil, which effectively impedes further development of cracks and improves the resistance of the soil to the force applied. Thus, the crack can be prevented by bridging effect of fibres. Further, the cementitious matrix produced from the pozzolonic reaction by the stabilizing material, may cover around the fibre surface may improve the interfacial bond and may increase the friction co-efficient between soil and fibres. Further more, the hybrid fibres will act synergistically and play their role in bridging the small cracks and large cracks.

Thus, it may be concluded that the addition of hybrid fibres such as (PPF+HDPEF), (PPF+WPF), and (JF+WPF) to sulphate infected black cotton soil using lime stone powder significantly enhance the stress resistance properties.

From the results obtained, it may also be concluded that, the performance hybrid fibre combination (PPF+HDPEF) is better than (PPF+WPF) and (JF+WPF) in enhancing the stress resistance properties of sulphate infected black cotton soil using lime stone powder as stabilization material.

V. CONCLUSIONS

Following conclusions may be drawn from the study.

1) The sulphate infected black cotton soil using lime stone powder as stabilizing material shows improved index properties at 15% replacement level.

2) The sulphate infected black cotton soil using lime stone powder as stabilizing material show improved stress resistance properties at 15% replacement level.

3) The addition of monofibres such as HDPE fibres, polypropylene fibres, waste plastic fibres and jute fibres to sulphate infected black cotton soil using lime stone powder as stabilizing material significantly enhance the stress resistance properties.

4) The performance of HDPE fibres is better than polypropylene fibres, waste plastic fibres and jute fibres in enhancing the stress resistance properties of sulphate infected black cotton soil using lime stone powder as stabilization material.

5) The addition of hybrid fibres such as (PPF+HDPEF), (PPF+WPF), and (JF+WPF) to sulphate infected black cotton soil using lime stone powder significantly enhance the stress resistance properties.

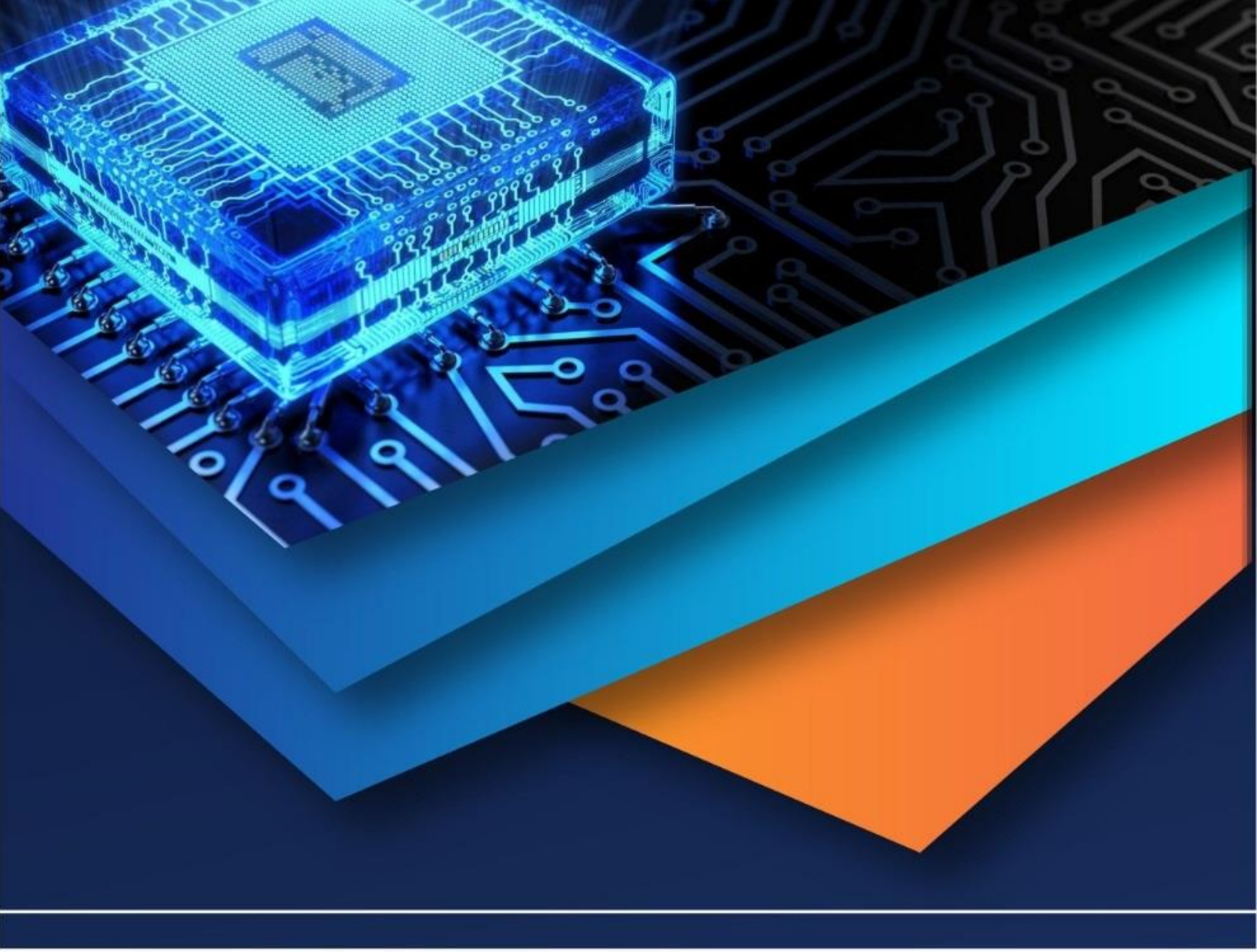
6) The performance of hybrid fibre combination (PPF+HDPEF) is better than (PPF+WPF) and (JF+WPF) in enhancing the stress resistance properties of sulphate infected black cotton soil using lime stone powder as stabilization material.

REFERENCES

[1] Anil Kumar Sharma, Sivapullaiah, P.V. “Soil stabilization with waste materials based binder”, Proceeding of Indian Geotechnical Conference, 2011.
[2] Austroads, “Pavement design, a guide to structural design of road pavements”, AP-G17/04, Austroads Inc., Sydney, 2004.
[3] Basu, G., Ray, A. N., Bhattacharyya, S.K. and Ghosh, S.K., “ Construction of unpaved rural road using jute-synthetic blended woven geotextile-A case study”, Journal of Geotextiles and Geomembranes, 27(6), 506-513, 2009.
[4] Bent, B. and Broms,” Stabilization very soft clay using geofabric”,Journal of Geotextiles and Geomembranes, 5(1), 17-28, 1987.
[5] Bidula Bose, “Geo-Engineering properties of expansive soil stabilized with fly ash”, Electronic Journal of Geotechnical Engineering, 12, 1339-1353, 2012
[6] Bai, J., Chaipanich, A., Kinuthia, J.M., O'Farrell, M., Sabir, B.B., Wild, S, “Compressive strength and hydration of wastepaper sludge ash-ground granulated blastfurnace slag blended pastes”, Cement and Concrete Research 33, 1189–1202, 2003.
[7] I.S. 2720 (Part 16) (1979), “Indian standard for determination of CBR”, Bureau of Indian Standards Publications, New Delhi.
[8] I.S.2720 (Part 8) (1974), “Indian standard for plasticity test”,Bureau of Indian Standards Publications, New Delhi.
[9] Erdal Cockca, “Use of class C fly ashes for the stabilization of an expansive soil”, Journal of Geotechnical and Geoenvironmental Engineering, 568–573, 2001.
[10] Guichard, C, “ Eléments perturbateurs de la prise dans les sols traités aux liants hydrauliques”, Définition, détection, seuils et remèdes, Master, Institute National des Sciences Appliquées de Strasbourg, 2006.
[11] Hunter, D, “Lime-induced heave in sulphate bearing clay soils”, ASCE. Journal of Geotechnical Engineering 114, 150–167, 1988.
[12] Harris, J. P., Sebesta, S., & Scullion, T, “Hydrated lime stabilization of sulphate-bearing vertisols in Texas”, Transportation Research Record, 1868, 31–39 (2004).
[13] Kinuthia, J.M., O'Farrell, M., Sabir, B.B. and Wild, S, “ A preliminary study of the cementitious properties of wastepaper sludge ash (WSA) — ground granulated blast-furnace slag (GGBS) blends”, Proceedings of the International Symposium on recovery and recycling of paper, Dundee, 19th March 2001, Edit. Ravindra K Dhir, Mukesh C Limbachiya & Moray D Newlands, pp. 93–104, Thomas Telford ISBN: 07277 2993 (2001).
[14] Kinuthia, J.M., O'Farrell, M., Sabir, B.B. and Wild, S, “ A preliminary study of the cementitious properties of wastepaper sludge ash (WSA) — ground granulated blast-furnace slag (GGBS) blends.”, Proceedings of the International Symposium on recovery and recycling of paper, Dundee, 19th March 2001, Edit. Ravindra K Dhir,Mukesh C Limbachiya & Moray D Newlands, pp. 93–104, Thomas Telford ISBN: 07277 2993 (2001).
[15] Le Borgne, T, “Effects of potential deleterious chemical compounds on soil stabilisa tion (PhD thesis)”, Nancy-University, 2010.
[16] Mehta, P.K, “Mechanism of sulphate attack on portland cement”, Cement and Concrete Research 13, 401–406, 1983.
[17] Mitchell, J.K, “Delayed failure of lime-stabilized pavement bases”, Journal of Geotech nical Engineering, 112 (3), 274–279, 1986.

[18] Parker, D, "25% of A10 hit by sulphide attack", New Civil Engineer, 25 March, 2004.
[19] Sahu C.S, "Ground improvement techniques, Training manual, training program for engineers involved in PMGSY, Chap V ", State Technical Agency, U.C.E. Burla, Orissa, 2004.
[20] Veith, G, "Engineering properties of sulphate-bearing clay soils with limeactivated ground granulated blastfurnace slag (GGBS)", Ph.D Thesis, University of Glamorgan, Pontypridd, U.K., 2000.
[21] Wild, S., Arabi, M.R., Leng-Ward, G, "Sulphate expansion of lime stabilized kaolinite II: reaction products and expansion", Clay Minerals 28, 569–583, 1993.
[22] Wild, S., Kinuthia, J.M., Jones, G.I. and Higgins, D.D, " Effect of partial substitution of lime with ground granulated blast furnace slag (GGBFS) on the strength properties of lime-stabilized sulphate-bearing clay soils", Engineering Geology, 51(1), 37-53, 1998.
[23] Wild, S., Kinuthia, J.M., Jones, G.I. and Higgins, D.D, "Suppression of swelling associated with ettringite formation in lime stabilized sulphate bearing clay soils by partial substitution of lime with ground granulated blast furnace slag", Journal of. Engineering Geology, 51(4), 257-277, 1999.

©IJRASET: All Rights are Reserved | SJ Impact Factor 7.538 | ISRA Journal Impact Factor 7.894 |



10.22214/IJRASET

45.98

IMPACT FACTOR: 7.129

IMPACT FACTOR: 7.429

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Call : 08813907089 (24*7 Support on Whatsapp)