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Effect Of Stabilization Of Black Cotton Soil Using Different Ternary Blends On Atterberg Limits.

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ABSTRACT- Through the use of mechanical and chemical methods, soil characteristics are improved in the process of soil stabilisation. Binders like cement and lime increase soil stabilisation by enhancing their technical qualities and resulting in a better building material. Increasing a soil's shear strength and general bearing capacity is what stabilises it. Once stabilised, a solid monolith is created that limits permeability, reducing the potential for shrinkage and expansion as well as the negative consequences of freeze-thaw cycles. The extent by which a soil's volume can alter in response to its moisture content is known as its shrink/swell potential. Here in this study the combinations of different stabilizers obtained as waste is mixed in different proportions and blended to form the ternary blends and used for the stabilization of BC soil. In this paper the effect of ternary blends on Atterberg limits of BC soil is discussed and found to improve their Atterberg Limits.

Key words: BC soil, Stabilization, Ternary Blends, Atterberg limits.

1.INTRODUCTION

Some expansive soils have an expansion capacity of 10%. This abrupt shift in volume can easily generate enough force to seriously harm a house, structure, or road. In-situ, or natural condition, soils can be improved via soil stabilisation, which eliminates the need for expensive remove-and-replace operations. Soils used as the foundation for roadways, construction pads, or parking lots are frequently chemically treated to manage a soil's engineering characteristics, such as its moisture content. Lime, products derived from lime, or other compounds, such as Portland cement, are used to stabilise soil. The permanent connections between soil particles are created by these substances through pozzolanic processes. To ensure that there is sufficient material available to stabilise the soil permanently, pre-project testing is crucial. Due to the expense of disposal and the risk of contaminating groundwater and land if heavy metals are present in them, they also have a negative effect on sustainability and the environment.

2. METHOD AND MATERIALS

2.1. Materials

2.1.1 Black cotton soil

The soil used in the study is obtained from Belagavi in the state of Karnataka. It is smooth in texture. For the purpose of tests, the soil is collected at a depth of 1m below the ground level. It is pulverized, dried, sieved through different sieves for the required tests and stored in polythene bags in the laboratory. The chemical compositions of BC soil are as shown in table: 1

Fig: 1 BC soil used in research work.

Table: 1 Chemical composition of BC soil.

Chemical present	Available percentage.
Ca O	1.05
SiO_2	79.47
Al_2O_3	10.59
Fe_2O_3	5.07
MgO	2.11
Na	0.6
K	1.11

2.1.2 Ordinary Portland cement (OPC-53 grade)

OPC is procured commercially and is used for research work. The chemical compositions of cement is shown in table: 2

Fig: 2 Cement used in research work.

Table: 2 Chemical composition of cement.

Chemical present	Available percentage.
Ca O	63
SiO_2	21.9
Al_2O_3	6.9
Fe_2O_3	3
MgO	2.5
SO_3	1.7

2.1.3 Fly ash

Fly ash is obtained from Raichur thermal power plant in Karnataka state. It is a non-self-cementing material. Here the sample passing 425 microns is used for different tests. The chemical compositions of fly ash are shown in table: 3

Fig:3 Fly ash used in research work.

Table: 3 Chemical composition of fly ash.

Chemical present	Available percentage.
Ca O	3.08
SiO_2	59.94
Al_2O_3	22.87
Fe_2O_3	4.67
MgO	1.55
SO_3	0.35

2.1.4 Ground granulated blast furnace slag

GGBFS is very fine off-white coloured powder which is commercially procured for the research work. The chemical compositions of GGBFS is shown in table: 4

Fig: 4 Ground granulated blast furnace slag used in research work.

Table: 4 Chemical composition of GGBFS

Chemical present	Available percentage.
Ca O	43.2
SiO_2	33.8
Al_2O_3	13.68
Fe_2O_3	0.4
MgO	0.46
SO_3	-----

2.1.5 Silica fume

It is also known as micro silica, is an amorphous, ultrafine powder. Silica fume used in the present work is commercially procured. The chemical compositions of silica fume are shown in table: 5

Fig: 5 Silica fume used in research work.

Table: 5 Chemical composition of silica fume.

Chemical present	Available percentage.
Ca O	0.67
SiO_2	93.38
Al_2O_3	0.69
Fe_2O_3	1.25
MgO	1.73
SO_3	------

2.1.6 Metakaolin

Metakaolin is fine powder which is little pinkish white in colour. It is also commercially procured for the present work. The chemical compositions of metakaolin is shown in table: 6

Fig: 6 Metakaolin used in research work.

Table: 6 Chemical composition of metakaolin.

Chemical present	Available percentage.
Ca O	0.39
SiO_2	54.3
Al_2O_3	38.3
Fe_2O_3	4.28
MgO	0.08
SO_3	0.03

2.1.7 Rice husk ash

The rise husk ash is collected from Vishalakshi Rice Mill at Belagavi. The rise husk ash is ground and sieved through 0.075mm aperture before use. The chemical compositions of rice husk ash is shown in table: 7

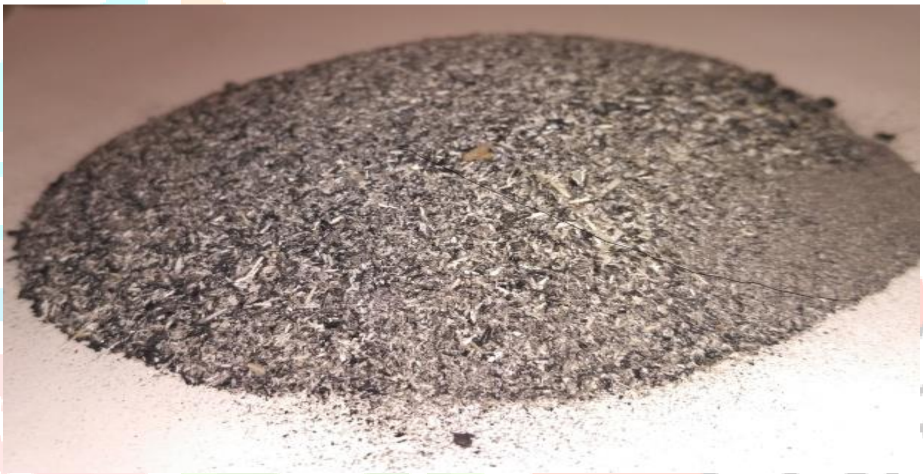

Fig: 7 Rice husk ash used in research work.

Table: 7 Chemical composition of rice husk ash

Chemical present	Available percentage.
Ca O	3.82
SiO_2	80.0
Al_2O_3	3.93
Fe_2O_3	0.41
MgO	0.25
SO_3	0.78

2.2 Methodology

2.2.1 Mix Design

The mix design is decided keeping the best value of cement percentage as common and varying the percentages of remaining stabilizers in the ternary blend combination. In the study cement is kept as the common stabilizer and the remaining two stabilizers are changed to form the different types of ternary blends. The mix design samples are prepared as shown in table: 8

Table 8 Mix design details

Mix Proportion of Ternary Blends

No of samples	Ternary Blend	Component	Percentage variation of stabilizer			
			10%	20%	30%	40%
			Proportion in Blend	Proportion in Blend	Proportion in Blend	Proportion in Blend
1	(C+FA+GGBFS)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Fly ash(F)	3.5%	8.5%	13.5%	18.5%
		GGBFS(G)	3.5%	8.5%	13.5%	18.5%
2	(C+FA+SF)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Fly ash(F)	3.5%	8.5%	13.5%	18.5%
		Silica fume(S)	3.5%	8.5%	13.5%	18.5%
3	(C+FA+MK)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Fly ash(F)	3.5%	8.5%	13.5%	18.5%
		Metakaolin (M)	3.5%	8.5%	13.5%	18.5%
4	(C+FA+RHA)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Fly ash(F)	3.5%	8.5%	13.5%	18.5%
		Rice husk ash(R)	3.5%	8.5%	13.5%	18.5%
5	(C+GGBFS+SF)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		GGBFS(G)	3.5%	8.5%	13.5%	18.5%

		Silica fume(S)	3.5%	8.5%	13.5%	18.5%
6	(C+GGBFS+MK)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		GGBFS(G)	3.5%	8.5%	13.5%	18.5%
		Metakaolin (M)	3.5%	8.5%	13.5%	18.5%
7	(C+GGBFS+RHA)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		GGBFS(G)	3.5%	8.5%	13.5%	18.5%
		Rice husk ash(R)	3.5%	8.5%	13.5%	18.5%
8	(C+SF+MK)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Silica fume(S)	3.5%	8.5%	13.5%	18.5%
		Metakaolin (M)	3.5%	8.5%	13.5%	18.5%
9	(C+SF+RHA)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Silica fume(S)	3.5%	8.5%	13.5%	18.5%
		Rice husk ash(R)	3.5%	8.5%	13.5%	18.5%
10	(C+MK+RHA)	BC soil (S)	90%	80%	70%	60%
		Cement (C)	3.0%	3.0%	3.0%	3.0%
		Metakaolin (M)	3.5%	8.5%	13.5%	18.5%
		Rice husk ash(R)	3.5%	8.5%	13.5%	18.5%

2.3 Experimental Investigation.

2.4 Experimental results of Atterberg limits on B.C soil stabilized with ternary blends

2.4.1 Test on liquid limit properties of black cotton soil stabilized with different ternary blends

Table: 9 gives the results of liquid limit properties of BC soil when different ternary blends are used as stabilizing material in different percentages. The variation of liquid limit is shown in figure 8.

Table: 9 Liquid limit test results on BC soil stabilized with ternary blends

Percentage replacement of BC soil by ternary blends	(C+FA+ GGBFS)	(C+FA+ SF)	(C+FA+ MK)	(C+FA+ RHA)	(C+GGBFS+ SF)	(C+GGBFS+ MK)	(C+GGBFS+ RHA)	(C+SF+ MK)	(C+SF+ RHA)	(C+MK+ RHA)
0% ternary blend (Ref Mix)	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00	65.00
10%ternary blend (3%+3.5%+3.5%)	58.50	59.80	60.15	60.20	58.10	57.40	58.32	58.85	59.20	60.10
20%ternary blend (3%+8.5%+8.5%)	55.20	56.25	56.60	56.75	54.25	52.10	54.40	55.70	55.80	56.54
30%ternary blend (3%+13.5%+13.5%)	48.85	50.50	50.72	50.83	47.00	46.00	47.23	50.05	50.25	50.65
40%ternary blend (3%+18.5%+18.5%)	44.30	44.80	45.06	45.10	43.70	42.70	44.00	44.55	44.64	44.90

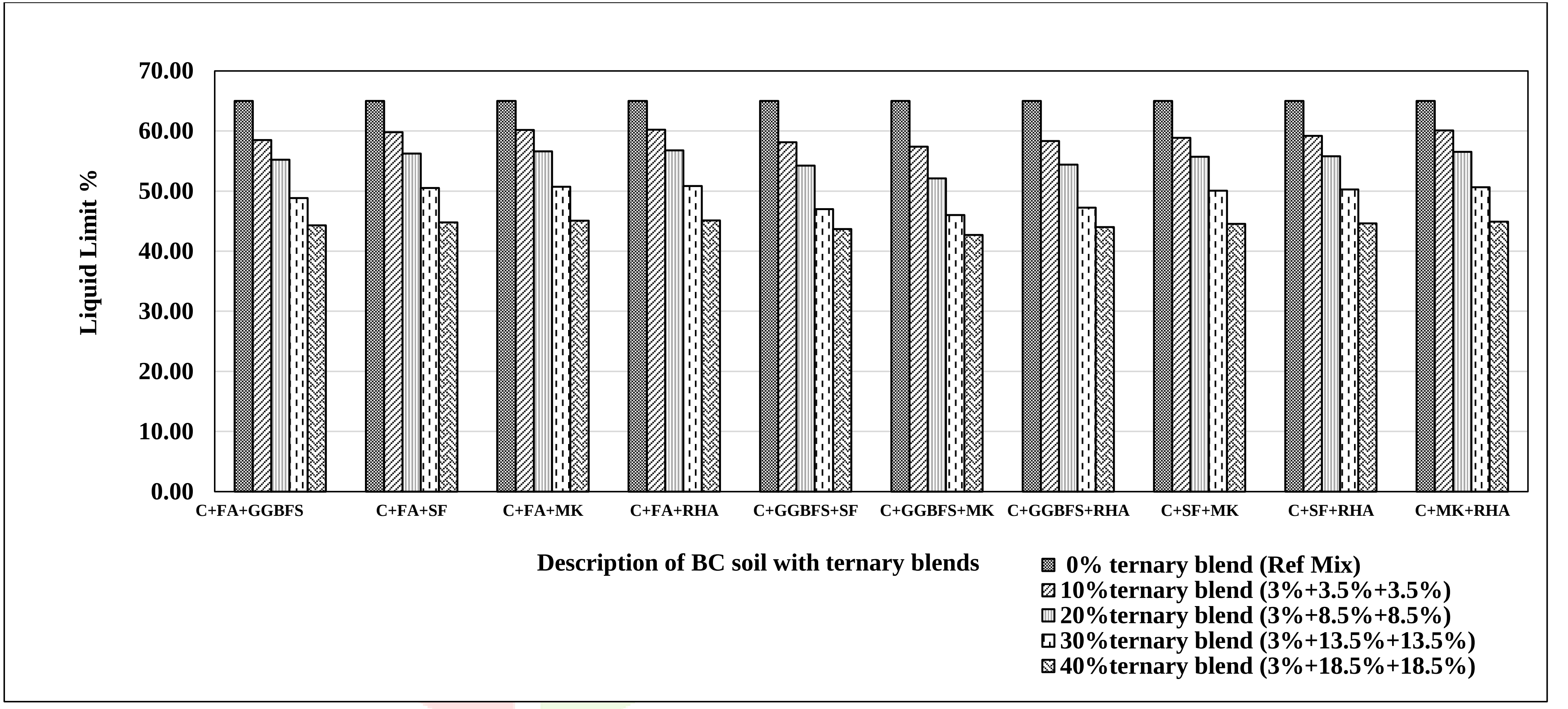

Fig: 8 Variation of liquid limit for different percentage replacement of BC soil by ternary blends.

2.4.2 Test on plastic limit properties of black cotton soil stabilized with ternary blends

Table: 10 gives the results of plastic limit properties of BC soil when different ternary blends are used as stabilizing material in different percentages. The variation of plastic limit is shown in figure 9.

Table: 10 Plastic limit test results on BC soil stabilized with ternary blends

Percentage replacement of BC soil by ternary blends	C+FA+ GGBFS	C+FA+ SF	C+FA+ MK	C+FA+ RHA	C+GGBFS+ SF	C+GGBFS+ MK	C+GGBFS+ RHA	C+SF+ MK	C+SF+ RHA	C+MK+ RHA
0% ternary blend (Ref Mix)	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00	27.00
10%ternary blend (3%+3.5%+3.5%)	25.58	25.72	25.78	25.82	25.51	24.20	25.56	25.61	25.66	25.76
20%ternary blend (3%+8.5%+8.5%)	24.97	25.15	25.27	25.33	24.88	23.60	24.92	25.05	25.12	25.23
30%ternary blend (3%+13.5%+13.5%)	23.77	23.93	23.98	24.08	23.58	22.65	23.73	23.83	23.88	23.95
40%ternary blend (3%+18.5%+18.5%)	Non-Plastic									

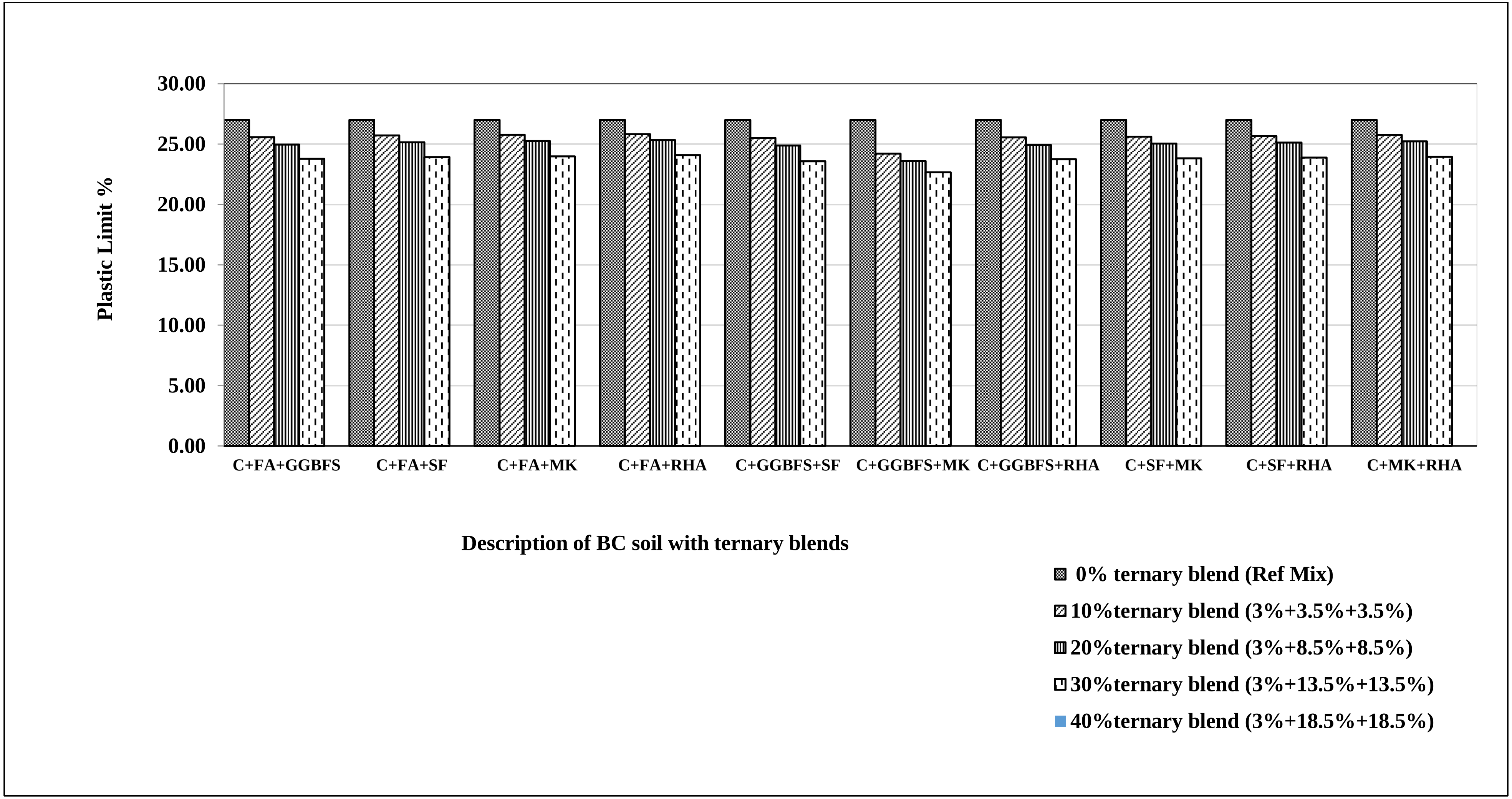

Fig: 9 Variation of plastic limit for different percentage replacement of BC soil by ternary blends.

2.4 .3 Test on plasticity index properties of black cotton soil stabilized with ternary blends

Table: 11 gives the results of plasticity index properties of BC soil when different ternary blends are used as stabilizing material in different percentages. The variation of plasticity index is shown in figure 10.

Table: 11 Plasticity index test results on BC soil stabilized with ternary blends

Percentage replacement of BC soil by ternary blends	C+FA+ GGBFS	C+FA+ SF	C+FA+ MK	C+FA+ RHA	C+GGBFS+ SF	C+GGBFS+ MK	C+GGBFS+ RHA	C+SF+ MK	C+SF+ RHA	C+MK+ RHA
0% ternary blend (Ref Mix)	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00	38.00
10%ternary blend (3%+3.5%+3.5%)	32.92	34.08	34.37	34.38	32.59	33.20	32.76	33.24	33.54	34.34
20%ternary blend (3%+8.5%+8.5%)	30.23	31.10	31.33	31.42	29.37	28.50	29.48	30.65	30.68	31.31
30%ternary blend (3%+13.5%+13.5%)	25.08	26.57	26.74	26.75	23.42	23.35	23.50	26.22	26.37	26.70
40%ternary blend (3%+18.5%+18.5%)	Non-Plastic									

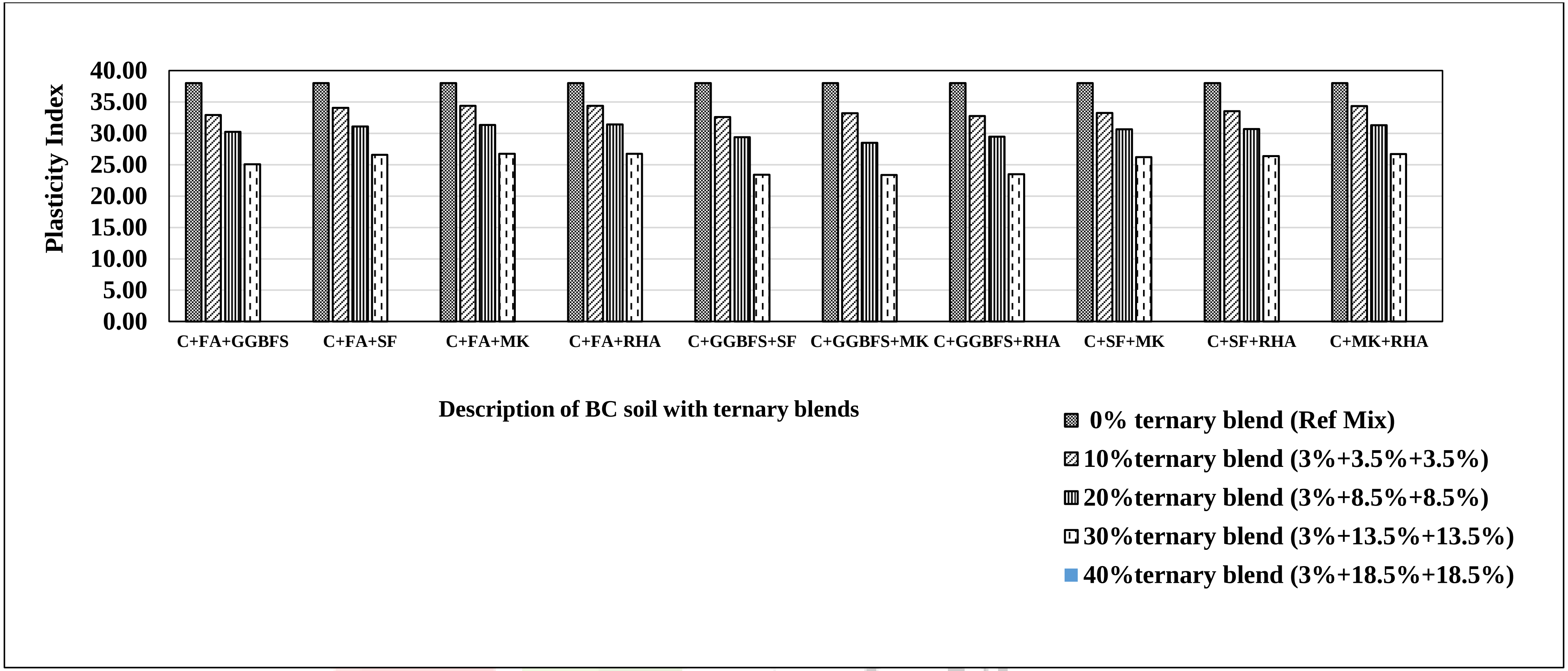

Fig: 10 Variation of plasticity index for different percentage replacement of BC soil by ternary blends.

2.5 Observation and discussions

a) Liquid limit

Table: 9 show results of liquid limit of BC soil stabilized with different percentages of ternary blends. Figure: 8 show the variation of liquid limit of BC soil stabilized with different percentages of ternary blends. The liquid limit values show decreasing trend from 0% to 40% for all ternary blend combinations. The lowest liquid limit values obtained for (C+FA+GGBFS), (C+FA+SF), (C+FA+MK), (C+FA+RHA), (C+GGBFS+SF), (C+GGBFS+MK), (C+GGBFS+RHA), (C+SF+MK) (C+S+RHA) and (C+MK+RHA) are respectively 44.30%, 44.80%, 45.06%,45.10%,43.70%,42.70%,44.00%,44.55%,44.64% and 44.90%.

The aggregation of clayey particles is the cause of the reduction in liquid limit. The thickness of the diffused double layer and the shearing resistance at the particle level determine the BC soil's liquid limit. The thickness of the diffused double layer decreases with the addition of the ternary blend, lowering the liquid limit. Thus, it can be concluded that the liquid limit of BC soil stabilized with various ternary blend combinations reach their least value at 40% replacement. Among all the ternary blend combinations the least value of liquid limit is obtained for (C+GGBFS+MK)

b) Plastic limit

The test results from table: 10 show results of plastic limit of BC soil stabilized with different percentage of ternary blends. Figure: 9 shows the variation of plastic limit of BC soil stabilized with different ternary blends. It shows decreasing trend with increase in percentage up to 30% and later it behaves as non-plastic for all ternary blend combinations. The lowest plastic limit values obtained for (C+FA+GGBFS),(C+FA+SF), (C+FA+MK), (C+FA+RHA), (C+GGBFS+SF),(C+GGBFS+MK), (C+GGBFS+RHA), (C+SF+MK) (C+SF+RHA) and (C+MK+RHA) are respectively 23.77%,23.93%,23.98%,24.08%,23.58%,22.65%,23.73%,23.83% 23.88% and 23.95%.The lowest plastic limit is obtained for (C+GGBFS+MK). The less soil that needs to be flocculated and the less compressible soil are the causes of this. Thus, it can be concluded that the plastic limit of BC soil stabilized with various ternary blend combinations reach their least value at 30% replacement. Among all the ternary blend combinations the least value of plastic limit is obtained for (C+GGBFS+MK).

c) Plasticity Index

The test results from table: 11 show results of plasticity index of BC soil stabilized with different percentage of ternary blends. Figure: 10 shows the variation of plasticity index of BC soil stabilized with different ternary blends. It shows decreasing trend with increase in percentage up to 30% and later it behaves as non-plastic for all ternary blend combinations. The lowest plasticity index values obtained for (C+FA+GGBFS),(C+FA+SF), (C+FA+MK), (C+FA+RHA), (C+GGBFS+SF),(C+GGBFS+MK), (C+GGBFS+RHA), (C+SF+MK) (C+SF+RHA) and (C+MK+RHA) are respectively 25.08, 26.57, 26.74,26.75, 23.42, 23.35, 23.50, 26.22, 26.37, 26.70.

The amount of water stored in the pores, diminishes and hence plastic limit reduces, which in turn causes the plastic limit to fall and the plasticity to decrease. This decrease in PI makes the soil-binder mixture more workable and increases the soil's tolerance to pressures brought on by swelling and shrinkage. Thus, it can be concluded that the plasticity index of BC soil stabilized with various ternary blend combinations reach their least value at 30% replacement. Among all the ternary blend combinations the least value of plasticity index is obtained for (C+GGBFS+MK).

2.6 Conclusions on BC soil stabilized with different ternary blend

From the above observations the following conclusions may be drawn.

- Liquid limit, shows least values at 40%
- Plastic limit shows least value at 30% replacement level for all ternary blend combinations and at 40% they become non-plastic.
- plasticity index shows least value at 30% replacement level for all ternary blend combinations and at 40% they become non-plastic.

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