Improvement of swelling and shrinkage properties of Black Cotton Soil by mixing with concrete waste

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***Abstract*- the black cotton soil is a type of problematic expansive soil which causes many problems in the construction of structures founded on them. It is having a swelling and impervious nature with poor geotechnical subgrade characteristics. In this research an approach is made towards the way of improvement in the various geotechnical properties of black cotton soil such as index properties, swelling characteristics, consolidation characteristics and strength characteristics by blending it with concrete waste. Hence, from these approaches, the impacting effect of concrete waste on the environment reduced due to optimum utilization of this concrete waste in the improvement in various properties of black cotton soil.**

Index Terms- Problem Associated with B. C. Soil, Plastic Limit Test, Liquid Limit Test, Specific Gravity, Standard Proctor Test, Shrinkage Limit Test, Free Swell Index

I. INTRODUCTION

To design foundation on black cotton soil (expansive soil) has always be a difficult task for engineer as the structure resting on black cotton soil cracks without any warning.

In India Black Cotton soil in extensive. They have variable thickness and are underlain by sticky material. In terms of geotechnical Engineering, Black Cotton soil is one which when associated with as engineering structure and in presence of water will show a tendency to swell or shrink causing the structure to experience moments which are largely unrelated to the direct effect of loading by the structure. Black Cotton soil is not suitable for the construction work on account of its volumetric changes.

It swells and shrinks excessively with change of water content. Such tendency of soil is due to the presence of fine clay particles which swell, when they come in contact with water, resulting in alternate swelling and shrinking of soil due to which differential settlement of structure take place, so the stabilization is being done for the stabilization of black cotton soil has been done in this project work by using concrete waste an admixture.

In this project, we are going to analysis the optimum % of concrete waste to reduce swelling and shrinkage properties of black cotton soil.

The black cotton soil is found to contain montmorillonite clay mineral which has high expensive characteristics. Black cotton soil is excessive variation in volume and stability and considerable shrinkage on drying and high swelling pressure.

This present study concentrated on minimizing the swelling and shrinkage properties of black cotton soil with adding concrete waste at various percentages.

Problem Associated with Black Cotton Soil

Black cotton soil are problematic for engineers everywhere in the world, and more so in tropical countries like India because of temperature variations and because of distinct dry and seasons, leading to wide variation in moisture content of soils. The following problems generally occur in black cotton soil-

High Compressibility

Black cotton soil is highly plastic and compressible, when they are saturated. Footing, resting on such soil undergoes consolidation settlements of high magnitude.

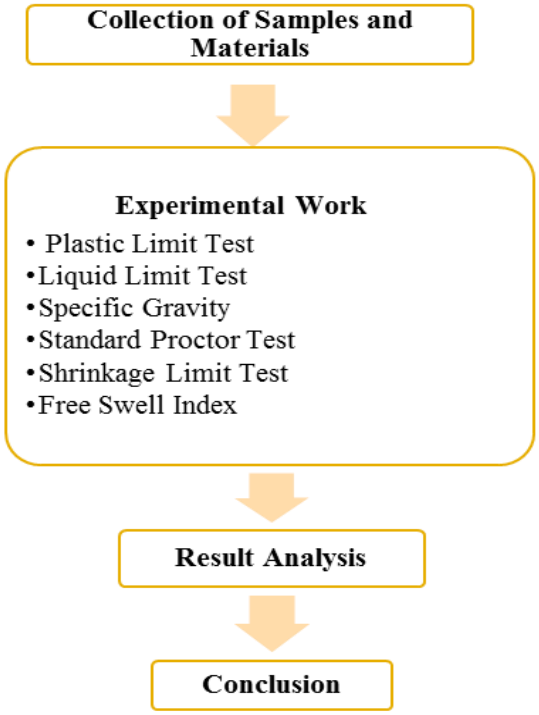
Swelling

A structure built in a dry season when the natural water content is low shows differential movements as a result of soils during subsequent wet season. This causes structure supported by such swelling soils to lift up and crack. Restriction on having developed swelling pressure making the structure suitable.

Shrinkage

A structure built at the end of the wet season when the natural water content is high, show settlement and shrinkage cracks during subsequent dry season.

II. METHODOLOGY



III. EXPERIMENTAL INVESTIGATIONS

Materials

Soil (Black Cotton Soil)

Natural black cotton soil was obtained from A/P-Gadmudshingi, Tal. –Karvir Dist.-Kolhapur in Maharashtra State The soil was excavated from a depth of 2.0 m from the natural ground level. The soil is dark brown to black in color. The obtained soil was air dried, pulverized manually and soil passing through 600µ IS sieved was used. This soil has a property of high moisture retentively and develops cracks in summer. This soil predominantly consists of expansive on it as the principal clay mineral. The physical properties of the soil used in this investigation are given in Table Sieve analysis, and Atterberg's limits were performed to classify the soil the index properties, Compaction characteristics and unconfined compressive strength test were carried out for both fine and coarse soil mixtures. The soils were classified in accordance with Indian Standard classification of soil for engineering purpose.

Table I: Physical properties of soil

Specific Gravity	Grain size distribution			Atterberg's Limit	
	Gravel	Sand	Silt & Clay	Liquid Limit	Plastic Limit
2.52	0%	10.06%	89.94 %	56.51	23.04

Table II: Minimum Compaction & Compressive Strength of Black Cotton Soil

Maximum Dry Density	Optimum Moisture Content
1.42	28.96

Concrete waste

Ready mix concrete is a type of concrete that is manufactured in a factory or batching plant, according to set recipe, and then delivered to work site, by truck mounted transit mixers. Then at the end of each working day , it is common practice for the ready mix concrete industry to thoroughly clean the inside of a concrete trucks drum and it produces large amounts of waste wash water that leads to problem of environmental impact.

It has been calculated that a 9 cub. m RMC truck contains, at the end of each working day, approximately 200 to 400 kg of returned plastic concrete. This material can be left overnight in the truck with the addition of hydration control admixtures or washed out.

When washed out, with addition of about 700L to 1300L of water, the material can be mechanically separated out into aggregates ready for reuse and water containing amounts of suspended fine particles. After evaporating the water from this slurry it converts into a fine powder form and seems like a concrete. And that powder form of waste, we called as a concrete waste.

Figure 1 Concrete waste

Effect of concrete waste to the environment –
Another problem regarding water in concrete industry is wash water from washing mixers, trucks. Because of environmental requirements , wash water cannot be run out of ready- mixed concrete plant as effluent without adequate treatment. The treatment process in this case is relatively expensive process for ready-mixed concrete producer.
Production of large amounts of waste wash water coming from ready- mixed concrete plants leads to problems of environmental impact. National laws usually prohibited the disposal of such type of water, due to their extremely high pH value and suspended matter amount, and require the water to be treated prior to discharge.

Basic tests
The basic tests performed for this project are liquid limit test & plastic limit [IS: 2720(Part5)-1985], Standard proctor test [2720 (Part 8)-l 983], determination of free swell index of soils [IS: 2720 (part 40) 1977], specific gravity [III/Set 1) – 1980], shrinkage limit [IS: 2720 (Part VI) – 1972]

IV. EXPERIMENTS

Liquid Limit Test
The tests to find liquid limit of black cotton soil and BC with Concrete waste. The results are tabulated as below.

Collective Results for Liquid limit
Table I: Variation of Liquid Limit with concrete waste percentage

Sr.No.	Soil Type	Liquid Limit
1.	Only BC	56
2.	BC + 5% concrete waste	33
3.	BC + 10% concrete waste	40
4.	BC + 15% concrete waste	43

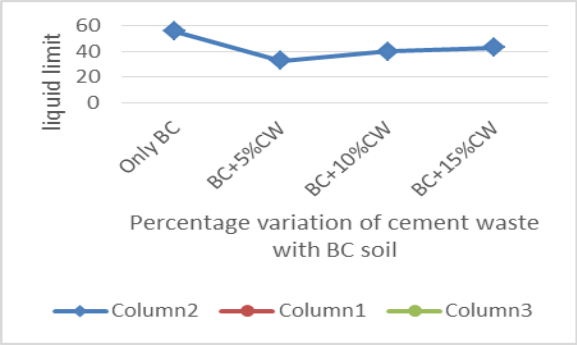


Figure 2 Variation of Liquid Limit with concrete waste percentage

Plastic Limit
The tests to find plastic limit of black cotton soil with concrete waste are carried out. The results are tabulated as below
Table IV: Variation of Plastic Limit test of Black cotton soil with concrete waste percentage

Sr.No.	Soil Type	Plastic Limit
1	Only BC	24.03%
2	BC + 5% concrete waste	31.66%
3	BC + 10% concrete waste	40.83%
4	BC + 15% concrete waste	32.04%

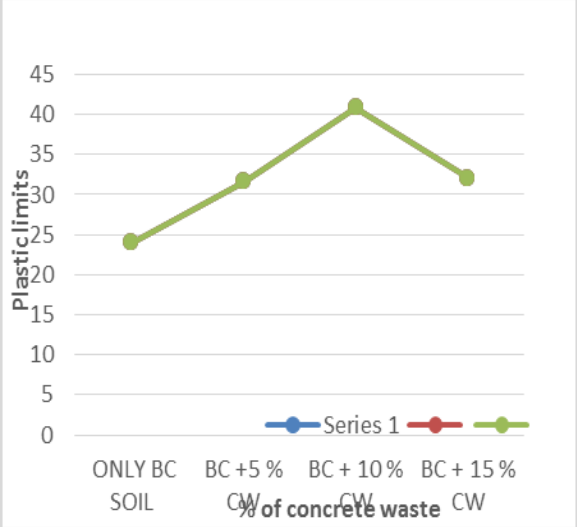


Figure 3 Variation of Plastic Limit Test of Black cotton soil with concrete waste percentage

Plasticity index
The plasticity index of soil is defined as the numerical difference between its liquid limit and plastic limit.

- Plasticity index =liquid limit –plastic limit.

Table V: Result of Plasticity Index

Content	Plasticity index (%)
Only BC soil	31.97 7
BC soil+ 5% concrete waste	1.34
BC soil+10% concrete waste	0.83
BC soil+15% concrete waste	10.96

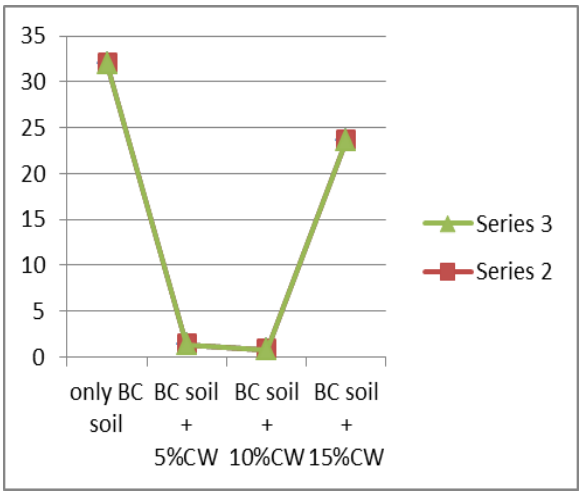


Figure 2 variation of Plasticity Index of soil with concrete waste percentage

Sr. No.	Content	Specific gravity
1	Soil	2.52
2	Soil+5%concrete waste	3.06
3	Soil+10%concrete waste	3.22
4	Soil+15%concrete waste	3.30

Table VI: Variation of specific gravity with concrete waste percentage

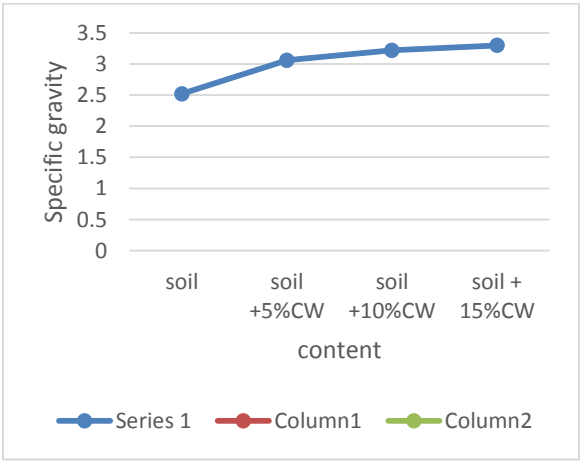


Figure 5 Variation of specific gravity test of Black cotton soil with concrete waste percentage

Standard Proctor Compaction Test

The tests to find standard proctor compaction of black cotton soil are carried out. The results are tabulated as below

Table VI: Variation of Maximum Dry Density and Optimum Moisture content of Black cotton soil with concrete waste %

Sr. No.	Soil Type	MDD (g/cc)	OMC (%)
1.	Black cotton Soil (BC)	1.4	28.96
2	BC + 5%concrete waste	1.43	19.64
3	BC + 10%concrete waste	1.37	22.5
4	BC + 15%concrete waste	1.41	26.13

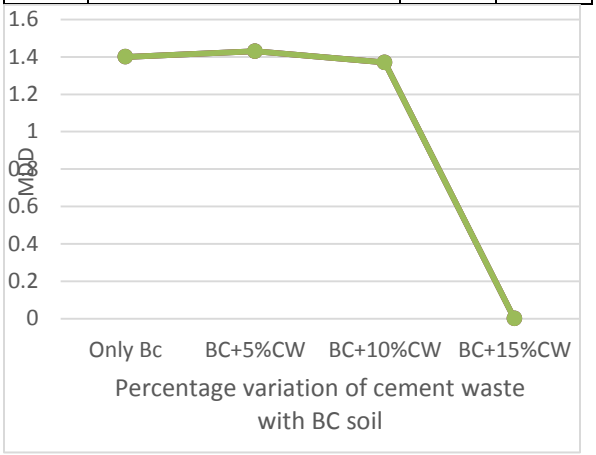


Figure 6 Variation of MDD of Black cotton soil with concrete waste percentage

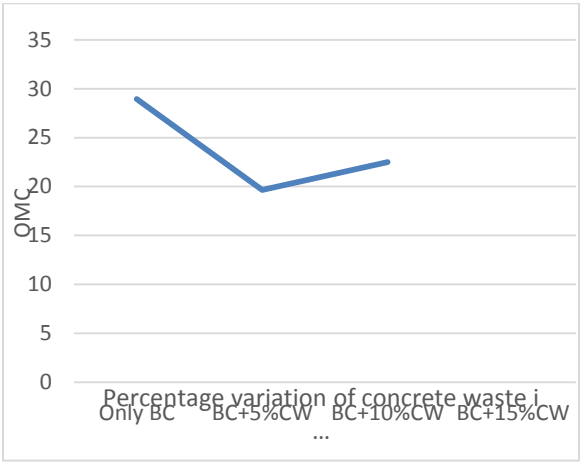


Figure 7 Variation of OMC of Black cotton soil with concrete waste percentage

Shrinkage limit test

Shrinkage limit test is performed on sample and results are tabulated in table VII

Table VII: Variation of shrinkage limit of BC soil with CW percentage

Sr.No.	Soil Type	Shrinkage limit (%)
1	Only BC	12.5
2	BC+5% CW	9
3	BC+10% CW	5
4	BC+15% CW	3.63

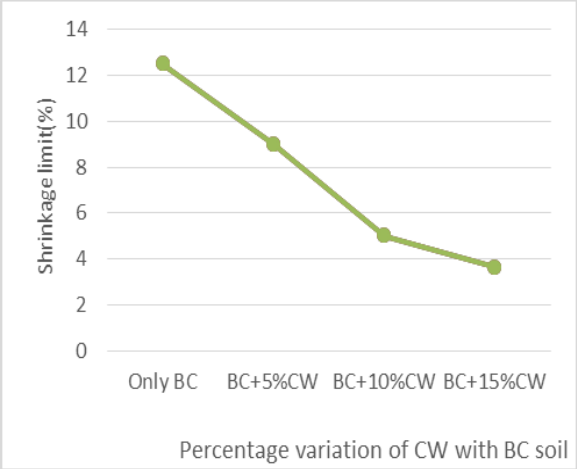


Figure 8 Variation of shrinkage limit of black cotton soil with CW percentage

Free Swell Index

Free Swell Index is the increase in volume of a soil, without any external constraints, on submergence in water.

Free Swell Index, (%) = [(Vd- Vk)/ Vk] x 100

Table VIII: Result of Free Swell Index of Black cotton soil with Concrete Waste percentage

Sr. No.	Description	Reading after 24 hours		Free swell Index %
		Kerosene (Vk)	Water (Vd)	
1.	Black cotton Soil	6	10	66.67
2.	BC soil + 5% concrete waste	7.5	11	46.67
3.	BC soil + 10% concrete waste	9	12.5	38
4.	BC soil + 15% concrete waste	11	14	27.27

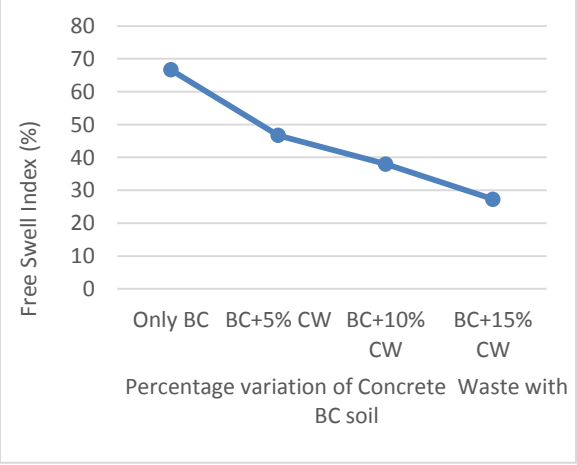


Figure 9 Free Swell Index of Black cotton soil with concrete waste percentage

VI. CONCLUSION

From the result of investigation following conclusion can be drawn,

- The liquid limit and plastic limit of soil is increases with addition of concrete
- Up to 10% and decreases at 15% concrete waste.
- Plasticity index of soil is decreases from 29.01% to 24.67% with increases in concrete waste content up to 15%
- The maximum dry density of BC soil is increases with adding 5% of concrete waste and decreases its optimum water content.
- As the concrete waste percentage in soil increases, it exhibits low swelling pressure and value of free swell index is decreases. Also the shrinkage limit of soil is decreases by addition of concrete waste.
- Concrete waste is a hazardous material which can be effectively used for ground stabilization purpose.
- It reduces the shrinkage and swelling characteristic of soil, hence concrete waste improves the most of engineering properties of BC soil as expansive soil tends to non-expansive nature.

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