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Stabilization of Black Cotton Soil using Medical Waste

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***Abstract*:- Black cotton soil is not well suitable for construction because of its high shrinkage and swelling properties, so it becomes challenge to the civil engineers. By using economical stabilizing materials we can improve this soil strength. Medical waste such as syringes, medicine scrappers are first sterilized and powdered then mixed with soil at certain proportion. In this project medical wastes are mixed with black cotton soil at proportion of 3%, 5%, 7% and 9%. Basic soil sample tests and strength determining test like standard proctor test, CBR test, unconfined compression test are conducted. It was found that engineering properties of black cotton soil improved by addition of medical waste powder, but at certain point the strength attains maximum peak value. After that addition of medical waste does not impact any change in the strength.**

Keywords:- Black cotton soil, sterilize, CBR test, unconfined compression test, standard proctor test, medical waste

I. INTRODUCTION

This project is about stabilization of black cotton soil using harmless medical waste like syringes without needles, medicine scrappers. Medical waste are difficult to dispose and it requires certain methodology which is cost high. Therefore i decided to use this medical waste as stabilizing material , with proper sterilizing methods this medical waste becomes safer to use in construction. We can also obtain sterilized medical wastes from bio medical waste plant. To ensure safety about human beings and environment this project is specifically conducted for highway projects on black cotton soil region only. The total quantity of medical waste generated in India per day is 550 tonnes per day, so there is a need to reuse this waste. In this project the strength parameters of the black cotton soil is examined when it mixed with medical waste powder at different proportion of mixing. Basic soil sample test are conducted to find the engineering properties of the soil, CBR test, SPT and UCC test are conducted for the soil sample first and then conducted for the soil mixed with medical waste powder at different proportion. The most important of this tests are to determine the correct proportion of mixing which gives optimum strength to the soil and it will be takes as standard mix and can be used for highway project.

II. MATERIALS USED

Black cotton soil is taken as the basic soil sample because stabilization on this type of soil shows strength variation which is easy for to analyse and examine. Medical waste like syringes without needles and medicine drops scrappers are taken as stabilizing materials, which is further sterilized and powdered.

A. Black cotton soil

Black cotton soil contains high amount of montmorillonite clay mineral, which is responsible for its high shrinkage and swelling properties. Around 22% of total area of India contains black cotton soil. States like Gujarat, Maharashtra, Karnataka, Madhya Pradesh and some parts of Tamilnadu. Mostly it occurs on the deccan plateau. Due to covid pandemic I could not collect the soil sample, so I purchased black cotton soil (Fig. 1) from Maharashtra by courier service. I have ordered around 8kg of soil.

Fig. 1 black cotton soil sample

B. Medical wastes

Medical wastes are classified into liquid wastes, solid waste, radio active waste and further classified into hazardous and non hazardous. From this I have taken only the non hazardous solid waste like syringes without needles because needles contains blood tissues which tends to risk life, therefore blood tissues contented waste should not be used. Other waste like IV tubes, glucose bag, medicine wrappers and tonic bottles can also be used. But whatever the medical waste we have taken it should be treated/sterilized first in order to remove the bacteria and medical chemical composition matters from the waste. Due to the pandemic time I could not get the medical waste from the bio medical waste plant, so I have advised to use the newly brought syringes. I have ordered 200- 5mm syringes,100 – 3mm syringes in local medical shop, I collected various medical waste in my own house like eye drops bottles, sanitizers bottles which is exhausted (Fig. 2).

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Fig. 2 Medical wastes

1) Sterilize

The term sterilize means treating the waste to remove or destroying the pathogenic bacteria. Some of the sterilizing methods are chemical disinfection, microwave method, UV rays method and steam boiling method. I have sterilized the medical waste by boiling at 93.3 degree Celsius.

2) Grinding

Grinding is known as conversion of materials into finer particles. The medical wastes after sterilized it will be grinded to make it into powder form, then only the mixing will be gentle. Grinding process is achieved by company called Kandan grinding company shown in Fig. 3, they cost for the process based on weight of the waste like 50 rupees per kilogram. The medical waste after grinding, as show in Fig. 4.

Fig. 3 Kandan grinding

Fig. 4 Medical waste powder

3) Mixing

Mixing with soil is done by manually and mixing will be four different proportion 3%, 5%, 7% and 9%. CBR test, unconfined compression test and standard proctor test is conducted for each proportion and the overall results will be discussed.

TABLE 1
MIXING PROPORTION

Mix designation	***Mix***
03:97	3% of medical waste powder + 97% of black cotton soil
05:95	5% of medical waste powder + 95% of black cotton soil
07:93	7% of medical waste powder + 93% of black cotton soil
09:91	9% of medical waste powder + 91% of black cotton soil

III. TEST AND RESULTS

A. Geotechnical properties

TABLE 2
PROPERTIES OF BLACK COTTON SOIL

Properties	***values***
Dry density	*1300 to 1800 kg/m3*
Liquid limit %	*40 to 60 %*
Plastic limit %	*20 to 60 %*
Soil classification	*CH or MH*
Free swell index	*40 to 180 %*

B. Water content

TABLE 3
WATER CONTENT TABLULATION

Samples	w_1	w_2	w_3	w
1	*20.8*	*39.5*	*35.6*	*26.35*
2	*18.9*	*37.6*	*34.2*	*22.22*
3	*20.8*	*38.7*	*34.9*	*27*

The average Water content of black cotton soil is found out to be 25.19 %.

C. Particle size distribution

This classification test determines the range of sizes of particles in the soil and the percentage of particles in each of these size ranges.

1) Sieve analysis

TABLE 4
SIEVE ANALYSIS TEST

Sieve (mm)	***Retained wt(g)***	***Cumulative Retained (g)***	***Cumulative retained%***	***%Finer***
4.75	0	0	0	0
2.36	34.32	34.72	5.72	94.28
1.18	10.32	44.64	7.44	92.56
0.6	83.76	128.4	21.4	78.6
0.425	25.68	154.08	25.68	74.32
0.3	24.08	178.56	29.76	70.24
0.15	22.08	200.64	33.44	66.56
0.075	21.06	222	37	63

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2) Hydrometer analysis

Hydrometer analysis is done on the percentage of soil passing through 75 micron sieve and the particle size distribution curve as show in Fig. 5.

TABLE 5
HYDROMETER TEST

Sieve size (mm)	*%Finer*
0.065	60.8
0.0574	54.67
0.0423	44.26
0.0313	31.69
0.0118	24.97
0.0089	22.64
0.0063	18.61
0.0053	15.28
0.00221	8.69

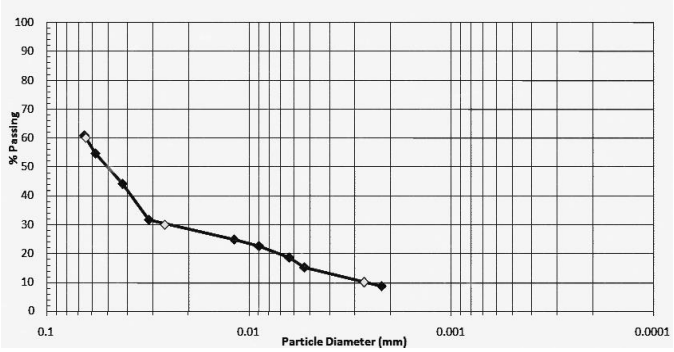

Fig. 5 Particle size distribution curve

D_{60} = 0.064 C_U = 0.064 / 0.0027 = 23.704
D_{30} = 0.026
D_{10} = 0.0027 C_C = (0.026)2 / (0.064*0.0027) = 3.912

D. Atterberg Limits

1) Liquid limit

The liquid limit of black soil is found to be 47.6 % Inference Since the liquid limit comes out to be < 50%, therefore the soil is medium to high plastic.

2) Plastic Limit

The average plastic limit of black soil was found to be 24.68%.

3) Plastic Index

Plastic Index (PI) = Liquid Limit(W_{LL}) –Plastic Limit (W_{PL}) = 48-25=23% and the nature of the soil is determined from the Fig. 6.

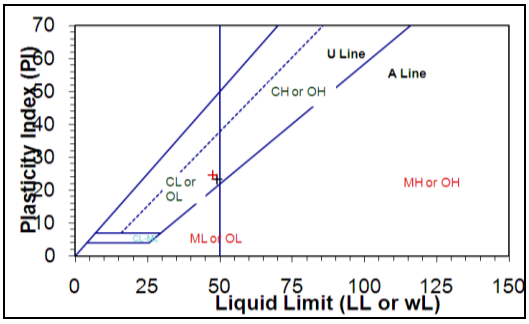

Fig. 6 plastic index VS Liquid limit

Since plasticity index of black cotton soil is 23%, therefore the soil is medium to high plastic.

E. Shrinkage Limit

TABLE 6
SHRINKAGE LIMIT

Shrinkage dish	**1**	**2**	**3**
Initial water content of wet soil pat W_1(g)	47.10	47.69	46.80
Mass of oven dry soil pat in gm Ws (g)	27.36	25.50	26.90
Volume of wet soil pat in cc (V_1)	23.24	23.40	22.85
Volume of dry soil in cc (V_2)	12.78	13.61	12.30
Shrinkage limit WSL (%)	8.87	9.30	7.88

The average shrinkage limit of black cotton soil was found to be 8.68%.

F. Specific gravity test

TABLE 7
SPECIFIC GRAVITY TEST

Sample	**1**	**2**
W_1 = Weight of Empty Density bottle	30	28.6
W_2 = Weight of Density bottle + oven dry soil	38	36.5
W_3 = Weight of Density bottle + oven dry soil + water	84.2	84.5
W_4 = Weight of Density bottle + water full	79.4	79.7
Specific gravity	2.64	2.75

Specific gravity of soil sample was found to be 2.69 and hence the soil is clayey as per IS : 2720(Part 4)-1985.

G. Standard proctor compaction test

The standard proctor test is conducted for basic soil sample first and then conducted for each proportional mix. Dia of mould – 10cm, height of mould - 12.6 cm, Volume =989.6 cm3.

The optimum moisture content and maximum dry density with respect to Biomedical waste powder mix are given in the table above. The optimum moisture content with respect to biomedical waste mix are plotted in (Fig. 7) and maximum dry density with respect to Biomedical mix are plotted in (Fig. 8).

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TABLE 8
COMPARISON OF SPT RESULTS

Bmw mix %	Optimum moisture content	maximim dry density g/cc
0	17.8	2.03
5	16.8	2.04
7	15.8	2.05
9	15.05	2.05

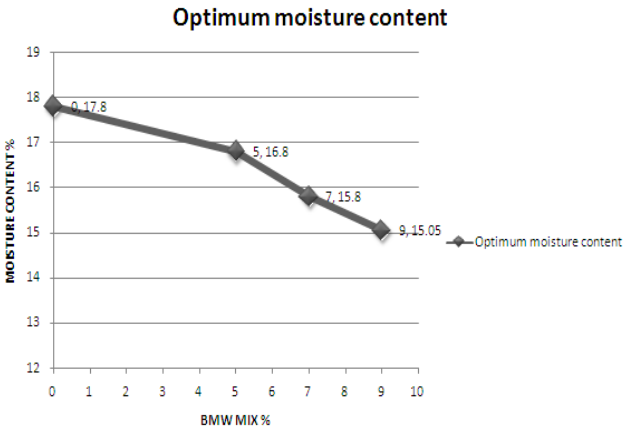

Fig. 7 Optimum moisture content VS BMW mix %

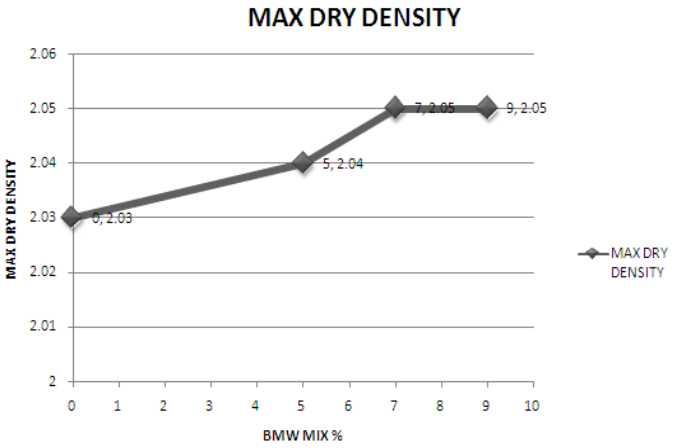

Fig. 8 Maximum dry density VS BMW mix %

The Maximum dry density increases with increase in BMW mix. But at 9% mix there is no increase in max dry density.

H. Unconfined compression test

The unconfined compression test conducted for soil sample and for different mix proportions. Each test values are determined and plotted in (Fig. 9) for comparative purpose. The maximum unconfined compressive strength of each test helps to identify the strength variation, as shown in Fig. 10

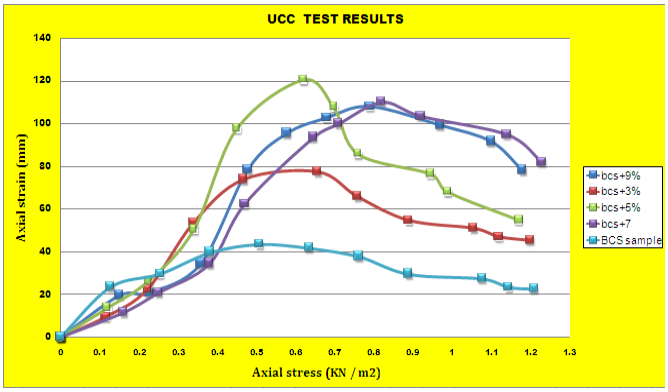

Fig. 9 UCC comparison graph

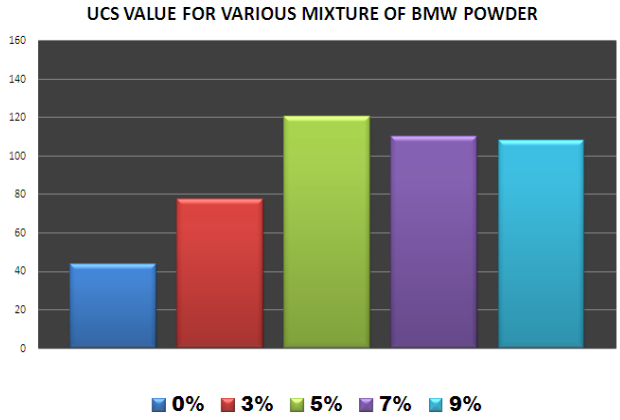

Fig. 10 Unconfined compressive strength

I. CBR Test

CBR test are conducted for each sample as like ucc test, as shown Fig. 11. The California bearing ratio test for each samples are listed below. The comparison graph for 2.5 mm and 5mm penetration also plotted, as shown in Fig. 12.

TABLE 9
CBR TEST RESULTS

BMW mix percentage %	CBR value %	
	2.5 mm	5 mm
0	2.1	1.95
3	2.01	1.84
5	3.54	2.8
7	3.85	3.03
9	1.75	1.5

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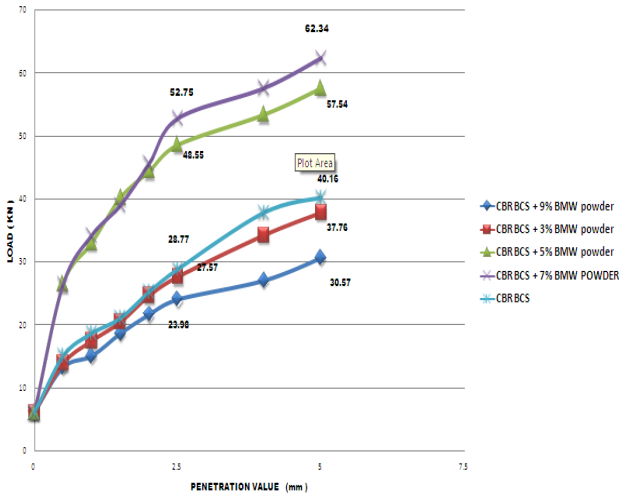

Fig. 11 CBR Tests results

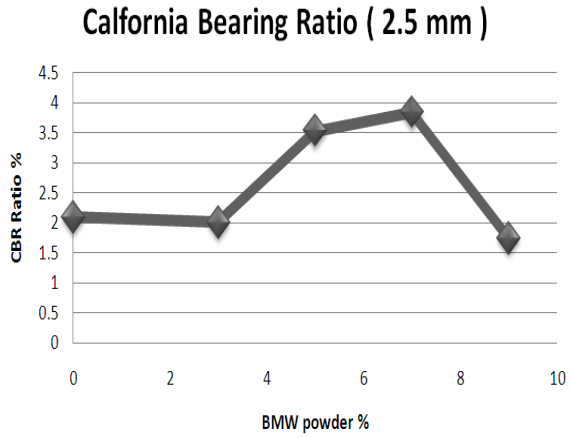

Fig 12 CBR comparison chart (2.5mm)

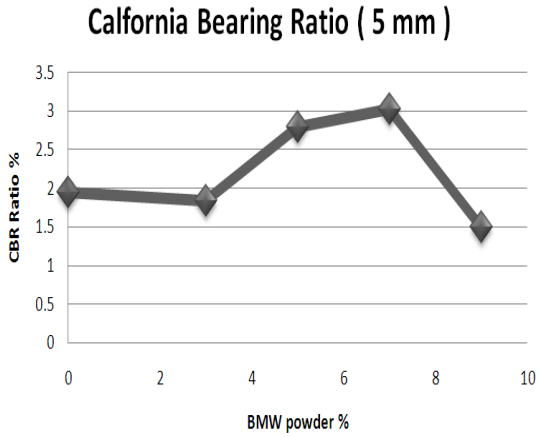

Fig. 13 CBR Comparison chart (5mm)

The CBR value start decreasing after 7% Bio medical waste mix.

IV. CONCLUSION

The Maximum dry density increases with increase in BMW mix. But at 9% mix there is no increase in max dry density. The Ucc strength maximum at 5% BMW mix, after 5% it starts to decrease, the CBR value start decreasing after 7% BMW mix. As the result obtained from different soil test I have concluded that the medical waste powder increasing the properties of black cotton soil. The maximum strength in properties obtained when the mix proportion is between 5% to 7%. The peak strength achieved in between this proportion. I will do further research on this project in future by implementing geo synthetic materials as soil cover in order to provide extra safety to the ground water from effect of BMW mixed within the soil. This project is suitable for highway projects. Using Non-hazardous Medical waste as filling and stabilizing material in safety methods helps to discompose the medical waste and also economic. Medical waste in mixed condition and used under the ground surface to certain depth as like Bio medical waste plant landfill so there is no threats for human.

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