

Effect of Aegle Marmelos (Bael fruit) Powder on Strength Parameters of Black Cotton Soil

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Abstract—Black cotton soil has the tendency to increase in volume when comes in contact with water and decreases in volume as water losses. Similarly, black cotton soil has low strength and CBR value. To improve black cotton soil, soil admixtures like chemical grout, fly ash, cement, epoxy, acrylamide, polyurethane, etc. are used. However, they exhibited certain negative impact on environment. The natural material for treatment of soil was required to overcome ill-effects of conventional ground improvement techniques. Hence, the use of Aegle Marmelos (Bael fruit) having gum enveloping the seeds was made during the present study. The performance of black cotton soil at different percentage of Aegle Marmelos (Bael fruit) powder was studied by conducting various experiments with adopted procedure. Here the laboratory tests were conducted on black cotton soil at different percentage of Aegle Marmelos (Bael fruit) powder with different curing periods. The study shows that the addition of 2.0% Aegle Marmelos (Bael fruit) powder improves the unconfined strength and CBR value of black cotton soil.

Keywords— Aegle Marmelos (Bael fruit), Black cotton soil, UCS, MDD, OMC, CBR

I. INTRODUCTION

The black cotton soil covers about 20 % of the total area of India. Low strength and deformation is the main problem possess by black cotton soil. The deformation of soil causes extensive damage to structures resting on them. To overcome these issues, the soil admixtures like chemical grout, fly ash, cement, epoxy, acrylamide, polyurethane, etc. are used for soil improvement. However, they exhibited certain negative impact on environment. Hence, the natural material for treatment of soil is need of the hour. The present worked focused to overcome the issue.

The Aegle Marmelos (Bael fruit) consists of gum enveloping the seeds. It was commonly used as household glue and was employed as an adhesive by jewellers. It was mixed with lime plaster for waterproofing wells and was added to cement when building walls. The performance of black cotton soil at 1 and 2 % of Aegle Marmelos (Bael fruit) powder was studied by conducting various experiments with adopted procedure [1].

The powder of Aegle Marmelos (Bael fruit) is depicted in Fig. 1.



Fig. 1: Aegle Marmelos (Bael fruit) powder

II. LITERATURE REVIEW

Due to physical and chemical characteristic of black cotton it is subjected to change in volume therefore this soil is more expansive. The black cotton soil treated with ferric chloride showed excellent results [2]. The treatment of Sabarmati soil had been done using different percent of agar biopolymer (0.5, 1, 2, and 3%) at different curing time (4hrs, 8hrs, 1, 3, and 7 days). The shear strength was decreased due to moisture absorption under water soaking condition. The decrease in shear strength of treated soil was 10% for 3 and 2% agar, and 20% for 0.5 and 1% agar [3]. The fly ash was also used for the treatment of black cotton soil. The UCS of treated black cotton soil was maximum at 30 % mix [4].

Improvement in CBR value of black cotton soil was observed with addition of lime. Decrease in the swelling pressure was observed in black cotton soil treated with lime [5]. The effect of wetting and drying cycles on the UCS and CBR of compacted and cured samples of stabilized Berea sands was investigated. Different sample mix were prepared with different percent of lime fly ash and tested after 4, 8 and 12 cycles of wetting and drying. The results showed the reduction in UCS and CBR with increase in the number of wetting and drying cycles that is dependent on the amount of lime and fly ash and the ratio of lime to fly ash [6]. The gum of Aegle Marmelos (Bael fruit) powder was used in various fields as binding agent.

It was also mixed with lime plaster for water proofing wells and was added to cement when building walls [7].

The literature shows that black cotton soil was stabilized by various techniques. However, further study on Aegle Marmelos (Bael fruit) powder was carried out in order to finding the suitability of the natural binding material for soil improvement.

III. METHODOLOGY

To find out the effects of Aegle Marmelos (Bael fruit) powder on various geotechnical properties black cotton soil the experimental work was carried out with different % of powder and mixing mechanism.

The specific gravity of black cotton soil was observed to be 2.53 and the result of sieve analysis of BC soil showed that more than 50 % of soil was finer than 75 μ . Soil was classified as ‘MH’ as per IS classification system.

The various geotechnical tests such as liquid limit, plastic limit, standard Proctor test, UCS, CBR, swelling pressure were determined as per IS 2720 (part). The adopted procedure for preparation of soil sample for liquid limit test, plastic limit test, standard Proctor test and UCS test was used as per earlier study [1].

For determination of California bearing ratio, the Aegle Marmelos (Bael fruit) powder and black cotton soil passed from 4.75 mm sieve were mixed together in wet condition in required proportion. Compaction of soil samples was done as per IS: 2720 (Part VII) and the compacted moulds were kept in water tank for 96 hours soaking. Then the CBR values of various samples were determined as per IS 2720 (Part 16). Same procedure was adopted for preparation of unsoaked samples but these samples were cured for 7 days for determination of CBR values. The unsoaked CBR samples for 7 days curing are shown in Fig. 2.



Fig. 2: 7days Curing of Unsoaked CBR Samples

For determination of swelling pressure, compaction of soil samples was done as per IS: 2720 (Part VII) and the swelling pressure test was carried out.

IV. RESULTS AND DISCUSSION

The liquid limit and plastic limit results of untreated and treated BC soil with Aegle Marmelos (Bael fruit) powder at different % was determine and is presented in Table 1 [1]. The increase in the liquid limit, plastic limit and plasticity index was observed with the increase of % of Aegle Marmelos (Bael fruit) powder.

**TABLE 1:
LIQUID LIMIT AND PLASTIC LIMIT**

Tests	Untreated soil	Soil treated with Aeglemarmelos (Bael fruit) powder (%)		
		1 %	2 %	3 %
LL	56.77	68.3	76	81.05
PL	23.15	23.61	27.92	30
Ip	33.62	44.69	48.08	51.05

Black cotton soil was treated with different % of Aegle Marmelos and standard Proctor test was conducted on treated and untreated soil. Table 2 shows the results of satandard Proctor test in terms of maximum dry density and optimum moisture content [1]. It was observed that as the % of Aegle Marmelos increases the MDD and OMC of treated soil decreases.

**TABLE 2:
MDD AND OMC OF SOIL**

Content	Untreated soil	Aegle Marmelos (Bael fruit) powder		
		1 %	2 %	3 %
MDD (kN/m ³)	15.52	15.47	14.75	15.2
OMC (%)	26.97	25.23	25.1	23.1

The UCS samples of treated BC soil with different % of Aegle Marmelos (Bael fruit) powder were cured for 1, 7 and 28 days and tested in the laboratory. Fig. 3, Fig.4, and Fig.5 shows the effect of Aegle Marmelos (Bael fruit) powder and curing periods on UCS of treated soil.

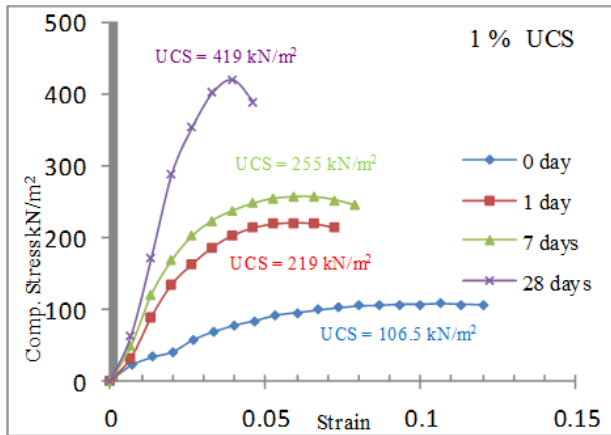


Fig.3: UCS of 1% Aegle Marmelos (Bael Fruit) Powder

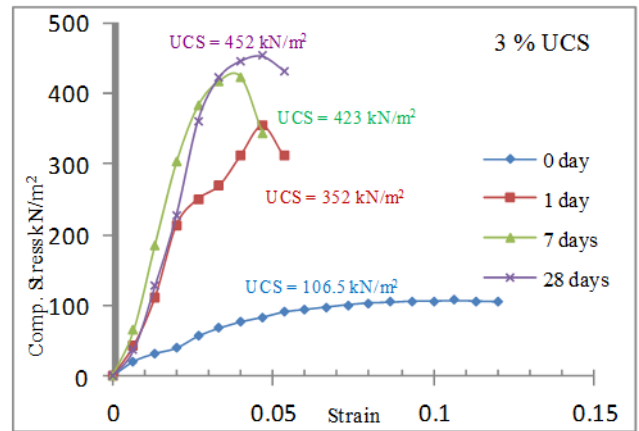


Fig.5: UCS of 3% Aegle Marmelos (Bael Fruit) Powder

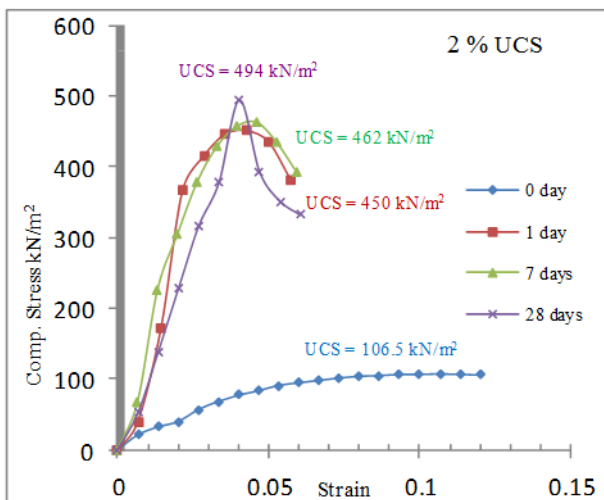


Fig.4: UCS of 2% Aegle Marmelos (Bael Fruit) Powder

Two samples were used for determination of unconfined compressive strength of treated BC soil and average strength of each case is shown in Table 3 [1]. And percentage improvement in UCS is presented in Table 4.

**TABLE 3:
UNCONFINED COMPRESSIVE STRENGTH OF SOIL**

Days	Untreated soil (kN/m ²)	Aegle Marmelos (Bael fruit) powder (kN/m ²)		
		1 %	2 %	3 %
0	128.15	--	--	--
1	--	217.5	417.33	351
7	--	244.5	436.25	402
28	--	379.5	462.5	424.5

**TABLE 4:
PERCENTAGE IMPROVEMENT IN UCS**

Days	Aegle Marmelos (Bael fruit) powder (%)			
	0 %	1 %	2 %	3 %
1	-	69.72	225.66	173.9
7	-	90.79	240.42	213.7
28	-	196.14	260.91	231.252

It was observed that UCS of treated soil increases up to addition of 2 % of Aegle Marmelos (Bael fruit) powder for all curing period. The UCS also increases with the curing period.

CBR test was carried out on BC soil mixed with different % of Aegle Marmelos (Bael fruit) powder for determining CBR values of soaked and unsoaked samples. The maximum soaked CBR values and unsoaked CBR values for BC soil mixed with Aegle Marmelos (Bael fruit) powder were observed to be at 2% Aegle Marmelos (Bael fruit) powder. The CBR values for soaked and unsoaked samples of treated and untreated BC soil are presented in Table 5 and Table 6. The effect of Aegle Marmelos (Bael fruit) powder on CBR is shown in Fig. 6 and Fig.7.

**TABLE 5:
CBR IN SOAKED CONDITION**

Description	Untreated soil	Aegle Marmelos (Bael fruit) powder		
		1%	2%	3%
CBR	1.26	2.12	2.77	2.04

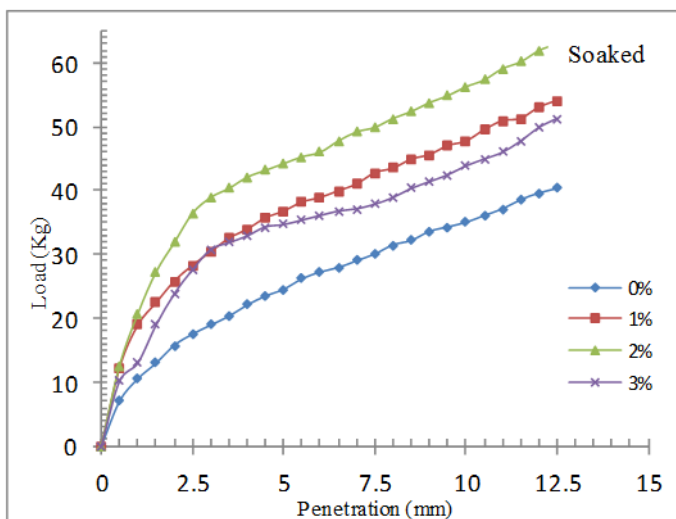


Fig.6: Effect of Aegle Marmelos (Bael Fruit) Powder on Soaked CBR Samples

**TABLE 6:
CBR IN UN-SOAKED CONDITION WITH 7 DAYS CURING**

Description	Untreated soil	Aegle Marmelos (Bael fruit) powder		
		1%	2%	3%
CBR	4.89	6.13	11.02	7.66

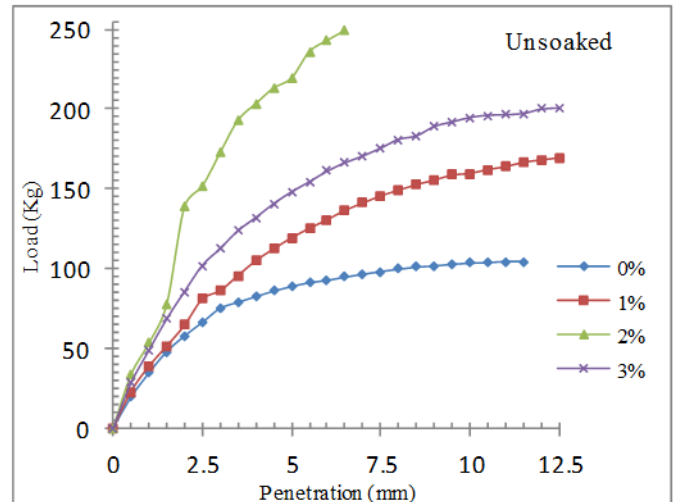


Fig.7: Effect of Aegle Marmelos (Bael Fruit) Powder on Unsoaked CBR Samples

The percentage improvement in CBR in soaked and unsoaked condition is presented in Table 7.

**TABLE 7:
PERCENTAGE IMPROVEMENT IN CBR**

CBR	Aegle Marmelos (Bael fruit) powder (%)			
	0 %	1 %	2 %	3 %
Soaked	-	68.25	119.84	61.9
Unsoaked	-	25.36	125.36	56.65

The swelling pressure of untreated and treated BC soil with 2 % of Aegle Marmelos (Bael fruit) powder was found to be 0.545 and 0.349 kg/cm² respectively. The swelling pressure of black cotton soil decreases with 2 % of Aegle Marmelos (Bael fruit) powder.

V. CONCLUSIONS

1. The liquid limit and plastic limit of treated black cotton soil increases as the percentage of Aegle Marmelos (Bael fruit) powder increases.
2. Plasticity index of black cotton soil increases with increase % of Aeglemarmelos (Bael fruit) powder.
3. The maximum dry density and optimum moisture content decreases as the percentage of Aegle Marmelos (Bael fruit) powder increases.
4. The unconfined compressive strength of treated black cotton soil increases as the curing period increases.
5. The unconfined compressive strength was found to be maximum at optimum percentage of Aegle Marmelos (Bael fruit) powder 2%.

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6. The soaked and unsoaked CBR are maximum at optimum percentage of Aegle Marmelos (Bael fruit) powder 2%.
7. The swelling pressure decreases with addition of Aegle Marmelos (Bael fruit) powder.

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