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Improvement in Engineering Properties of Locally Available Expansive Soil using Construction & Demolition Waste and Marble Waste Powder

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Abstract: ***The objective of the paper is to explore the possibility of the utilization of construction & demolition waste(CDW) and marble waste (WM) powder for improving the engineering properties of expansive soil (black cotton soil). The effects of both construction-demolition waste(CDW) and waste marble powder at varying percentage(10%-50%) on the soil were examined individualy by conducting a series of experiments . This paper offers the comparative analysis of the effects of demolition waste and marble waste powder on the index and geotechnical properties of the soil. Tests in this experimental program include Liquid limit, Plastic limit, Free swell index, Proctor field density and California bearing ratio (CBR) test. Experimental results show remarkable improvement in the engineering properties of the black cotton soil when mixing with construction-demolition waste(CDW) and waste marble(WM) powder individually.***
Keywords : Expansive soil, Construction & demolition waste, Waste marble powder, Engineering properties.

I. INTRODUCTION

The construction on the black cotton soil is always problematic because of its behavior of swelling and shrinking. When black cotton soil comes in contact with water it swells and volume of the soil increases and when water content decreases considerable shrinkage occurs in the soil. This behavior of the black cotton soil is mainly due to the presence of montmorillonite mineral in it. This alternate swelling and shrinkage causes large amount of change in the volume of the soil and results in damaging the structure. Alternate swelling and shrinkage also causes differential settlement, which is very dangerous to the structures constructed on it. It has been estimated that the damage to civil structures on this account is in terms of billion dollars worldwide. Black cotton soil is one of the major soil deposit in India and occupies more than 10% land area of the country. Black cotton soil covers mainly the plateaus of Maharashtra, Saurashtra , Malwa, Madhya Pradesh, Chhattisgarh. These soils cover an extensive area of 300,000 km^2, but in Madhya Pradesh it occupies 47% of the land area.The uncertainty in the engineering properties of the black cotton soil may be reduced by replacing it with another good quality soil or by other stabilizing materials. Cement, lime, bitumen, chemicals and salts have shown encouraging results in the stabilization of the expansive soils but these are costly. Researchers have experimented several materials for the stabilization of the expansive soils. Research concerning the use of by-products and waste materials to improve the properties of soil has been going on for many years. In recent years the efforts have been made to use waste products such as fly ash , ground granulated blast furnace slag , fly ash etc. in the stabilization of the poor soil and other civil applications. By using these materials major attention may be focused on the protection of the environment and effectively concerning the natural resources and recycling of waste materials. Apart from environmental benefits utilization of waste materials or industrial by-products is cost effective also.Demolition waste is one of such waste which can be utilized for improving the engineering properties of soils , as it contains cement and sand in it. Sand is cohesion less in nature and thus reduce the water absorption tendency of the clay rich soil and makes the soil denser. Demolition waste is one of the major constituents of the solid waste and its production is growing rapidly as the population and urbanization is increasing. Demolition waste has almost no scrap value and is generally thrown out at landfill site. By making use of demolition waste in the stabilization of soil solid waste management can be improved simultaneously. It is cost effective also. Similarly marble waste is another waste material which is the by-product of marble cutting industries. It has very fine particle size. Marble waste is non plastic, less reactive in nature. Leaving it in environment is problematic.

II. OBJECTIVES OF THE EXPERIMENTAL STUDY

A. Effective utilization of locally available soil i.e. black cotton soil.

B. Utilization of construction & demolition waste to reduce the municipal solid waste
C. Waste Management of marble waste powder by using it as soil stabilization material.
D. Cost effective stabilization of the locally available soil by using locally available waste products.
E. Determination of optimum proportion of demolition waste and marble waste for improving the index properties , dry density and C.B.R. value of the soil.

III.EXPERIMENTAL WORK

A. Material Used

1) Soil : Locally available Black cotton soil is employed in this experimental work. It has tendency to swell and shrink because of presence of montmorillonite clay mineral. It possess lesser bearing capacity and dry density, while higher liquidity, plasticity and swelling. Following is the list of various characteristics of the black cotton soildetermined in laboratory used in this investigational analysis.

Table -1: Properties of natural black cotton soil

Serial .	**Property**	**Value**
1	Liquid Limit (L.L.)	44.4%
2	Plastic Limit(P.L.)	25.26%
3	Plasticity Index(P.I.)	19.15%
4	Soil Classification	CI
5	Free Swell Index	54.54%
6	Specific Gravity(S.G.)	2.61
7	Natural Water Content	5.15%
8	Max. Dry Density(M.D.D.)	1.686
9	C.B.R (soaked)	2.44%
10	Fineness Modulus(FM)	2.19

2) Demolition Waste : Crushed and tested concrete cubes obtained from concrete laboratory of the institute are used in this experimental program for the stabilization of the black cotton soil. It is assumed that it possess almost similar characteristics as concrete demolition waste generated at construction site. Cubes waste was crushed and then Crushed material was then sieved using the IS sieve 4.75 mm. to get useful fraction.

Table -2 Properties of the sieved fraction of Demolition waste

Serial No.	Properties	Value
1.	Specific Gravity (S.G.)	2.89
2.	Fineness (FM)	19%

3) Marble Powder **:** Marble powder is the waste generated from the marble cutting industries. Which is very fine in nature. Physical properties of marble waste powder used in this experimental study are tabulated below.

Table -3 Properties of Marble Powder used in the study

Serial No.	Properties	Value
1.	Specific Gravity (S.G.)	2.85
2.	Fineness (FM)	3.4%
3.	Color	White
4.	Form	Powder

B. Preparation of the Specimens and Methodology

The black cotton soil was collected from the Badagaon (Gwalior) Madhya Pradesh.(LAT- 26.2258◦ , LONG-78.2597◦). After the collection of the black cotton soil it was stored carefully in a closed space to avoid any kind of water/moisture to maintain the natural properties of the soil throughout the experimental program. First of all identification/classification of the soil was done by

sieve analysis. After the identification of the black cotton soil, the engineering properties like specific gravity, water content , liquid limit, plastic limit, swell index, bearing capacity of the black cotton soil by C.B.R were determined using standard IS code methods. For the determination of water content oven dry test was performed in which the soil sample is kept at the temperature of (105°c-110°c) for 24hours. For the determination of the specific gravity Pycnometer method was performed. Liquid limit was calculated by using Casagrande apparatus, and Plastic limit was calculated by forming the threads of the soil of 3cm dia. and checking the appearance of the cracks on the specimen. Proctor light weight compaction test was performed for obtaining the Max dry density (M.D.D) and optimum moisture content (O.M.C.) .Bearing capacity of the soil was determined by California bearing ratio test.. Swell index was examined as per IS 2720 : Part 40 (1997) "Free swell index of soils", Bureau of Indian Standards, New Delhi. After determination of the engineering properties of the black cotton soil construction & demolition waste and marble waste powder were blended with the soil at varying percentage individually and same tests were performed again on different samples to observe the improvement in the engineering properties of the soil.

C. Preparation of Demolition Waste

Construction & demolition waste is available almost everywhere. In this experimental study fine part of crushed concrete cubes (left out portion after removal of coarse aggregates) from universal testing machine was used which possess almost similar quality as of construction & demolition waste. Crushed concrete cubes were broken into smaller pieces and sieved from IS sieve 4.75mm. Portion passed from 4.75 mm sieve were used and retained portion on the sieve was discarded.

D. Preparation of Marble Powder

There are several Marble cutting industries in Gwalior and its vicinity. Marble powder used in this experimental study was obtained from the local market only, which is easily available at cheap cost.

IV. RESULTS AND DISCUSSION

After the detailed investigation and analysis the following results has been obtained.
Effects on Properties of the Soil after mixing Marble Waste and Construction & demolition waste individually

A. Liquid Limit

The liquid limit test of a soil is the moisture content, expressed in percentage of the weight of the oven dried soil, at the boundary between the liquid and the plastic states of consistency. The moisture content at this boundary is defined as the water content at which 2 halves of a soil cake will flow together , for a distance of half inch(12.7mm) along the bottom of the groove of standard dimensions separating the 2 halves , when the cup of a standard liquid limit apparatus is dropped 25 times from a height of 1cm at the rate of 2 drops/ second. The results of liquid limit at different
proportions of CDW & MW with black cotton soil are shown. It was observed that with the increment of the both stabilizers (CDW & MW) liquid limit of the specimen decreased.

Table -4 Liquid Limit of Different Samples

Serial No.	Sample Name	Average Liquid Limit of the sample on Semi log Graph
1	Natural Black cotton soil	44.40%
2	Soil+10%C.D.W	41.80%
3	Soil+20%C.D.W	37.90%
4	Soil+30%C.D.W	35.70%
5	Soil+40%C.D.W	32.25%
6	Soil+50%C.D.W	31.50%
7	Soil+10% M.W	38.40%
8	Soil+20% M.W	37.00%
9	Soil+30% M.W	35.10%
10	Soil+40% M.W	32.00%
11	Soil+50% M.W	29.20%

(Results are the average value of 3 specimens)

Graphical Representation of Variation of Liquid Limit for Various Percentage of C&D and MW

FIG-1 (a) Liquid Limit at Different Proportion of CDW

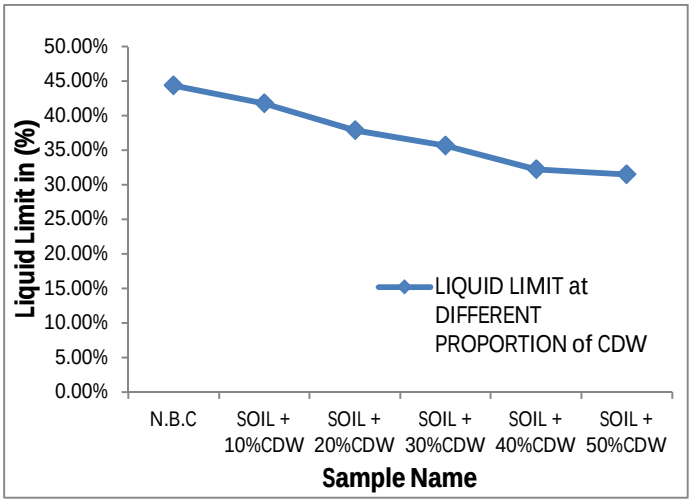
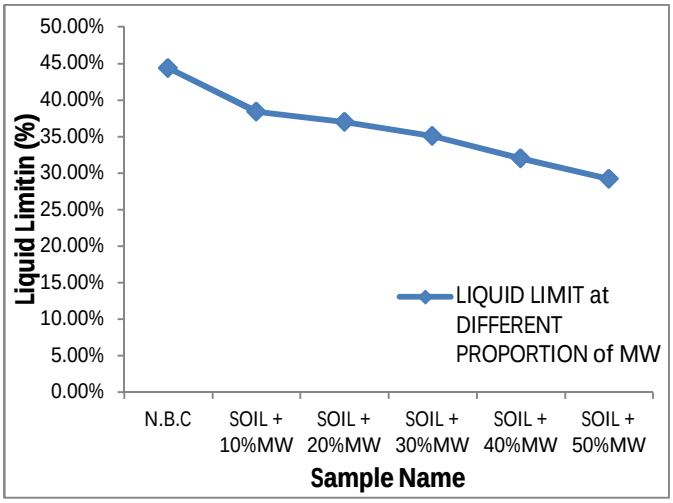


FIG-1 (b) Liquid Limit at Different Proportion of MW



B. Plastic Limit

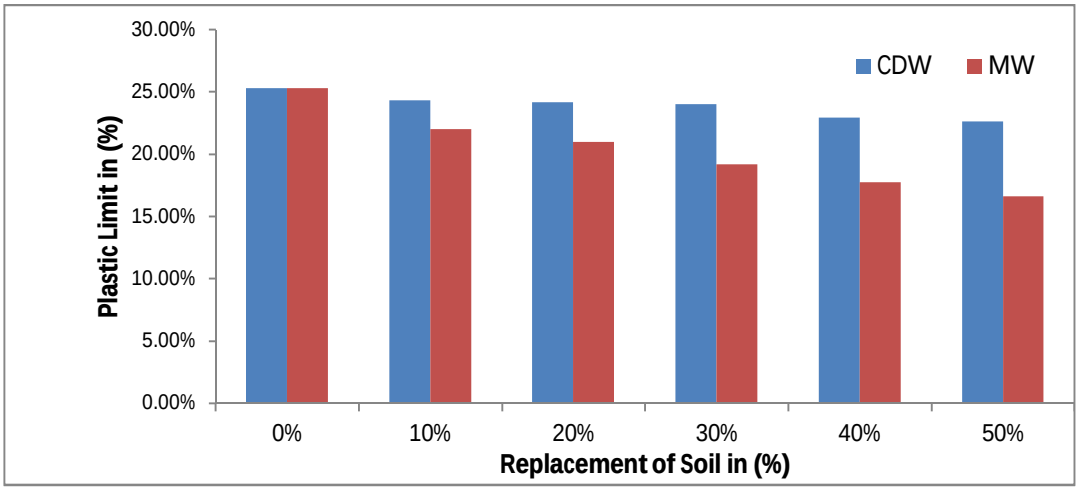
It is defined as the water content at which a soil would just start to crumble when rolled into a thread of 3mm diameter. (As per IS:2720 part 5). Results are shown in table no. 5

Table -5 Plastic Limit at different proportion of CDW and MW :

Serial No.	Sample Name	Average Plastic Limit of the sample
1	Natural Black cotton soil	25.26%
2	Soil+10%C.D.W	24.30%
3	Soil+20%C.D.W	24.13%
4	Soil+30%C.D.W	23.98%
5	Soil+40%C.D.W	22.93%
6	Soil+50%C.D.W	22.60%
7	Soil+10% M.W	21.98%
8	Soil+20% M.W	20.96%
9	Soil+30% M.W	18.85%
10	Soil+40% M.W	17.75%
11	Soil+50% M.W	16.59%

(Results are the average value of 3 specimens)

Figure -2 Graphical Representation of Variation of Plastic Limit at different proportions of CDW & MW

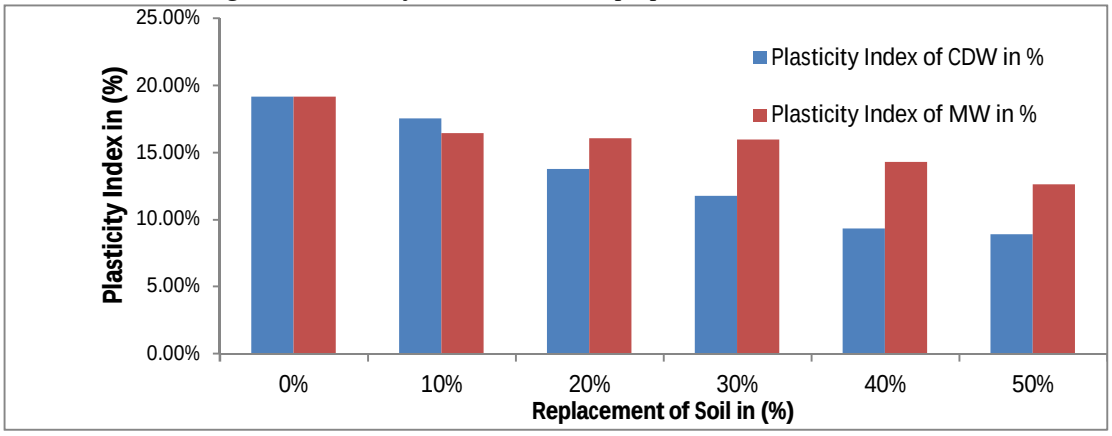


C. Plasticity Index

It is the numerical difference between liquid limit and plastic limit.

Plasticity Index = liquid limit - plasic limit.

Figure -3: Plasticity Index at different proportion of CDW & MW

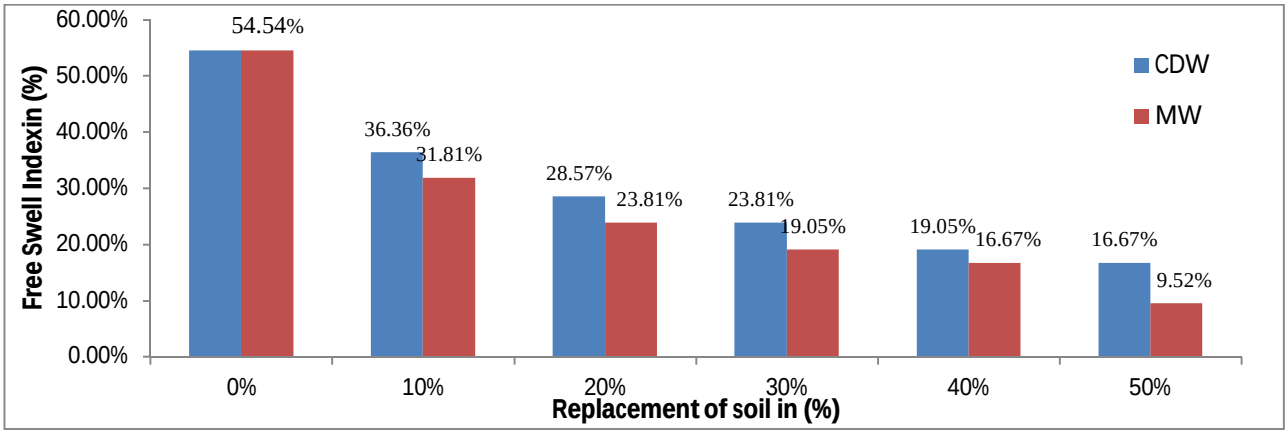


D. Free Swell Index Test

Free Swell Index is refer as the increase in volume of soil without any external strained when the soil is subjected to submergence in water. Free swell index test was performed as per IS :2720 (Part XL)- 1977.

Free Swell Index = $\frac{Vd-VK}{Vk}$ (where V_d = volume of soil specimen in distilled water cylinder after 24 hours and V_k = volume of soil specimen in kerosene cylinder after 24 hours)

FIG - 4 Free Swell Index at different proportion of CDW and MW :



E. Proctor Field Density Test

It is a laboratory method used for determining the optimum water content at which a the soil will achieve its maximum dry density. This test was performed for determining the maximum dry density (M.D.D.) and the optimum moisture content (O.M.C) of the soil using light compaction as per IS :2720 (Part 7) -1980.

Table -6 Optimum moisture content(O.P.C.) & Maximum dry density(M.D.D) of different samples :

Sample	O.M.C.(%)	gm/cm^3
N.B.C.	19.50%	1.686
Soil +10% CDW	19.23%	1.707
Soil +20% CDW	19.19%	1.721
Soil +30% CDW	17.25%	1.774
Soil +40% CDW	16.67%	1.804
Soil +50% CDW	15.93%	1.820
Soil + 10% MW	18.76%	1.714
Soil +20% MW	16.64%	1.788
Soil +30% MW	16.38%	1.822
Soil +40% MW	16.29%	1.840
Soil +50% MW	14.69%	1.848

Graphical representation of Variation of OMC & MDD at different proportions of CDW & MW

FIG -5(a) Variation in OMC & MDD in CDW

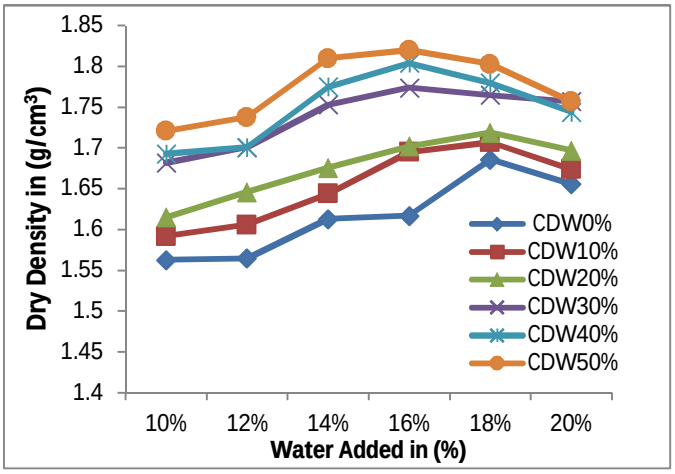
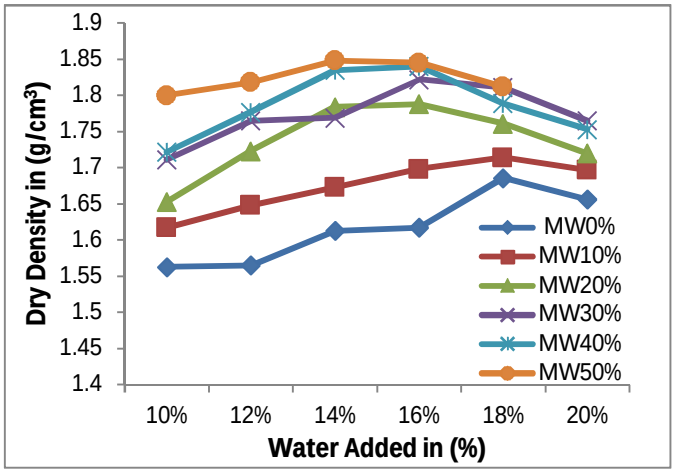


FIG -5(b) Variation in OMC & MDD in MW



F. California Bearing Ratio (Soaked)

C.B.R. is the ratio of force / unit area required to penetrate in to a soil mass with a circular plunger of 5 cm diameter at the rate of .125cm/min. California bearing ratio tests were performed on the various soil samples containing different proportions of demolition waste & marble waste individually as well as combinedly as per Bureau of Indian Standard Specifications (IS: 2720-part: 16, 1979), in soaked condition.

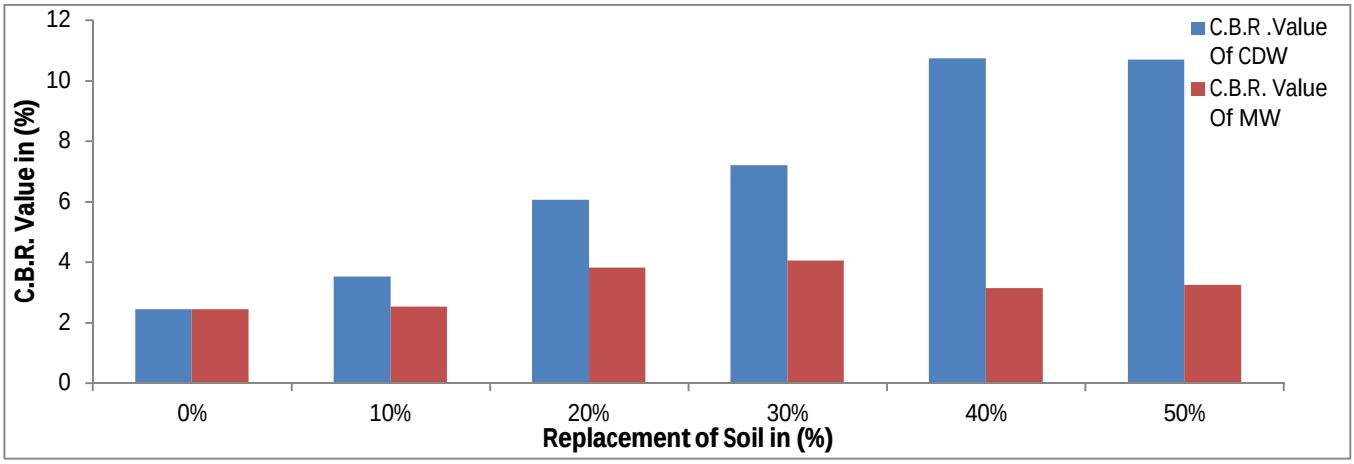
It has been proved that if a subgrade having a CBR value less than 10% , the sub base material will tend to deflect under traffic loadings cause pavement disintegration (Amadi, 2014). It is therefore essential for highway construction to provide a subgrade with a CBR value of not less than10%.

Table -7 C.B.R. Results of Demolition Waste and Marble Powder Individually :

S. No.	SAMPLE NAME	C.B.R. Value In (%)
1	N.B.C.	2.44
2	Soil +10% CDW	3.52

3	Soil +20% CDW	6.05
4	Soil +30% CDW	7.213
5	Soil +40% CDW	10.74
6	Soil +50% CDW	10.69
7	Soil + 10% MW	2.53
8	Soil +20% MW	3.81
9	Soil +30% MW	4.05
10	Soil +40% MW	3.13
11	Soil +50% MW	3.25

FIG -6 Graphical representation of C.B.R. values at different proportions of CDW & MW



V. CONCLUSION (RESULTS & DISCUSSION)

A. Liquid limit of the samples containing demolition waste varying (0% to 50 %) reduced constantly from 44.4% to 31.5% while samples containing marble powder varying (0% to 50 %) reduced constantly from 44.4% to 29.2%.

B. Plastic limit of the samples containing demolition waste varying (0% to 50 %) reduced constantly from 25.26% to 22.60% while samples containing marble powder varying (0% to 50 %) reduced constantly from 25.26% to16.59%.

C. Swelling index of the samples containing demolition waste varying (0% to 50 %) reduced constantly from 54.54% to 16.67% while samples containing marble powder varying (0% to 50%) reduced constantly from 54.54% to 9.52%.

D. Dry density of the soil sample containing demolition waste varying (0% to 50 %) increased constantly from 1.686 to 1.820 while samples containing marble powder varying (0% to 50 %) increased constantly from 1.686 to 1.848

E. C.B.R. value of the samples containing demolition waste varying (0% to 50 %) increased till 40% replacement of the soil, after that showed negative impact. While samples containing marble powder varying (0% to 50 %) showed the increment till 30% replacement of the soil, after that showed negative impact.

VI. FUTURE SCOPE OF WORK

From the above study it is shown that the C&D waste is more effective in improving geotechnical properties like CBR value of the soil while marble dust is more effective than C&D waste in the improvement of index properties (liquid limit, plastic limit, free swell index of the black cotton soil). It seems that these two wastes compliments each other to improve most of the properties of the soil. Hence future work can be carried out to use both wastes simultaneously in appropriate amount to improve all required engineering properties of the black cotton soil . Detail experimental work is required to try various percentage combinations of CDW and MW to get desired engineering properties

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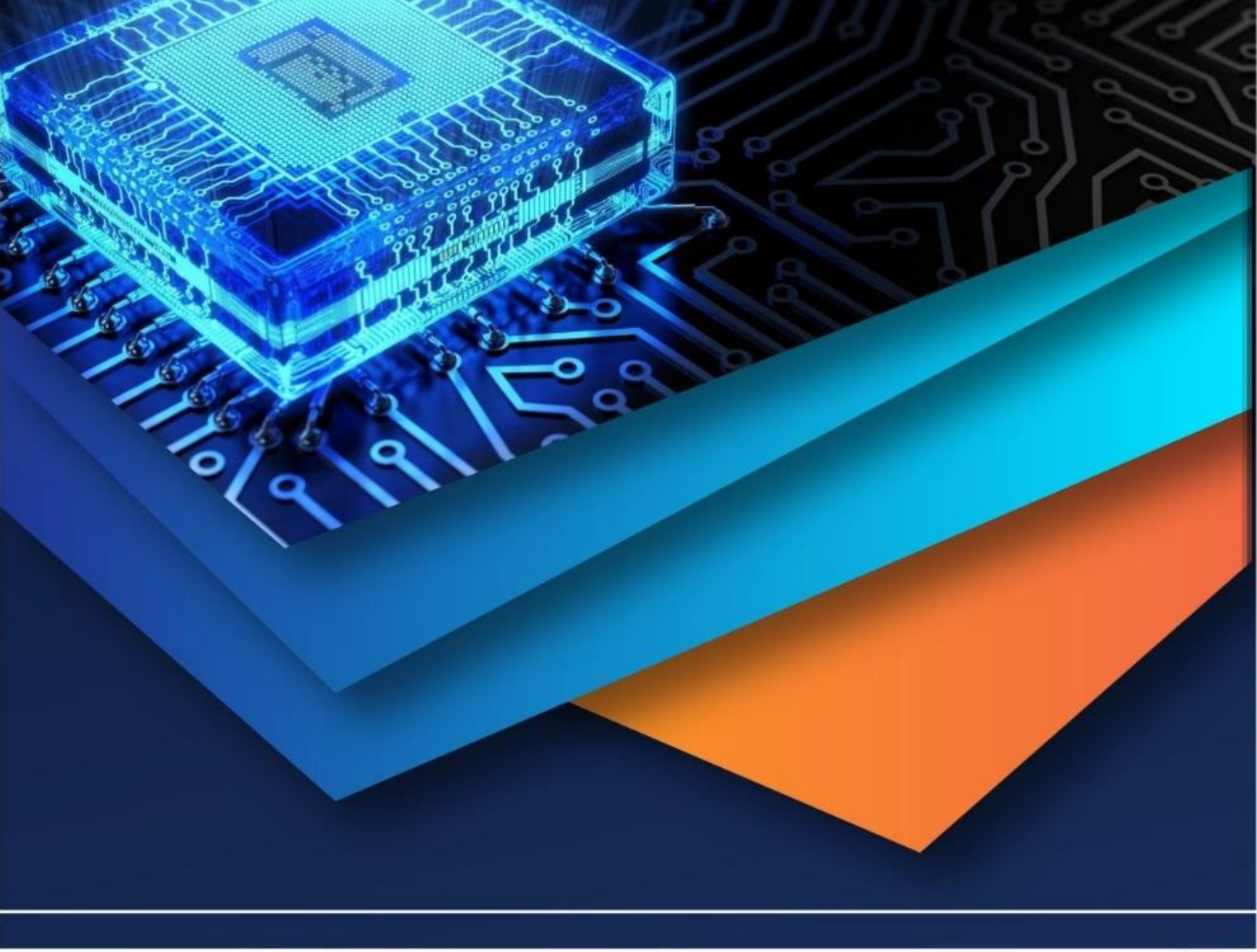

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