Effect of Waste Marble Powder on Index Properties of Expansive Soil

Harsh K. Gokani[1], Khetesh D. Akoliya[2] Deepak N. Davera[3], Parv J. Vaghela [4],Vaishali R. Patel[5]
[1]Department of Civil Engineering
A.D Patel Institute of Technology
New V.V Nagar – 388120

Abstract

The expansive type of soil known as black cotton soil in India, which shows swelling & shrinkage when it comes in contact with water. So the property the strength and other index properties of this soil are very poor. Soil stabilization with different soil stabilizer shows improvement in engineering & index properties of expansive soil. In this research paper, waste marble powder (by-product of marble industry) used as stabilizer. Marble powder mainly contains high amount of calcium, silica, alumina which aids in the stabilization of the soil. This work shows the determination of the swelling potential of virgin soil as well as when mixed with varying proportion of marble dust (from 10 to 30%).The results obtained in laboratory provide satisfactory reason for using the marble powder as a stabilizer for improving index properties of black cotton soil.

Keywords: *Expansive soil, Waste marble powder, Soil stabilization, Index properties.*

INTRODUCTION

Expansive soil which creates always a problem in construction of civil engineering structures. When this soil comes in contact with the water swelling occurs in the soil and shrinks when water content decreases in the soil because of which structures are damaged. In India, the predominant states for this type of soil are Tamilnadu, Karnataka, Gujarat, Andhra Pradesh, Madhya Pradesh and Maharashtra [1].

When any buildings or structures are associated with black cotton soil, it experiences settlement. Design and construction of structure on expansive soils is prove to be challenging task for geotechnical engineers[2].The behavior of expansive soil depends largely upon the amount of different clay minerals illite, kaolinite and montmorillinite present in the soil. Among three, montmorillinite has the maximum ability to swell. These clay minerals impart cohesion and plasticity. The study of clay mineral is essential for understanding the behavior of expansive soils [3].So for improving the behavior of this soil, soil stabilization with appropriate stabilizer is necessary. Addition of marble dust decreases liquid limit, plastic limit & plasticity index. Also experimental results shows that the swelling of black cotton soil decreases with increasing percentage of marble powder waste in expansive soil for curing period of 7 and 28 days [4].

The black cotton soil contains high percentage of montomonillonite which renders high degree of expansiveness. This property of expansive soil results cracks in various components of building without any warning. The behavior of expansive soil is changed when it comes in contact with water. The strength properties of these soils change according to the amount of water contained in the soil. We observed many problems with the industrial development. One of them is the proper disposal of waste generated by various industries. This waste causes many serious environment problems like environmental pollution. So utilization of industrial waste in construction industry is the best solution of this problem. Using industrial waste in construction industry have many advantages such as disposal of waste, saving biodiversities, increasing soil properties like strength &other index properties of expansive soil[5].

Marble is a metamorphic rock which is made by the metamorphism of the limestone under extreme thermal and pressure. The states contain marble stone are Rajasthan, Haryana, Gujarat, Jammu & Kashmir, Madhya Pradesh, Uttar Pradesh, Maharashtra etc. This research paper contains the study of the effect of marble powder on expansive soil. It contains determination of index properties of virgin soil as well as when it mixed with varying proportion of marble powder (from 10 to 30%). Addition of marble dust improves liquid limit, plastic limit& plasticity index. The engineering behaviour of clayey soils depends on its Atterberg's limits like iquid limit (WL) and plastic limit (WP) &plasticity index (PI), which is the main index parameter of the classification of fine-grained soils.

PROBLEMS WITH EXPANSIVE TYPE OF SOIL

1. Black cotton soil in India, covering an area of about 3.0 lacks sq.km. These soils are considered as problematic soils because of their swelling & shrinkage properties. When they come in contact with water during monsoon, they expand in summer, they shrink. Because of this alternate swelling and shrinkage, structures founded on them are severally damaged.
2. In rainy season these soil becomes very soft by filling up of water in the cracks & fissures reducing the bearing capacity of soil.
3. In saturated conditions these soils have high consolidation settlements & are very compressible.
4. Infrastructures like roads, buildings, bridges within found on black cotton soil normally undergo foundation problems. The solutions of this problem contains either removal of the existing soil and replaces the same with a non-expansive type of soil or go for soil stabilization which improves the index & engineering properties of the existing soil. Replacing the existing soil sometimes not a solution. Therefore, the best available approach is soil stabilization with suitable stabilizers. Various types of soil stabilizers (i.e. fly ash, cement kiln dust, lime, chemicals, different geo materials like Geosynthetics, Geogrid.) are available which used for stabilizing soil. However, the selection of soil stabilizer depends upon the type of soil and availability of stabilizers.

MATERIALS

Black cotton soil which is used for the research work is brought from a construction site of commercial building at Bhavnagar Gujarat. The properties of virgin soil are shown in Table 1.Grain size distribution of virgin soil is carried out by sieve analysis & particle size distribution curve is shown in Fig. 1. Table 2 shows percentage of soil retained on each sieve on the basis of total mass of soil sample.

Table 1: *Virgin soil sample properties*

Material	
(1) Black cotton Soil	
Coarse sand (%)	0.25
Medium sand (%)	3.05
Fine sand (%)	25.21
Silt & clay (%)	71.49
Liquid limit (WL %)	41.5
Plastic limit (WP %)	17.32
Plasticity index (PI %)	24.18
Maximum dry density	1.73
Free swell index	55.45
California bearing ratio (CBR)%	8.248
Soil classification	CI

Table 2: *Particle Size Distribution of Virgin Soil*

IS sieve (mm)	Mass of soil Retained(g)	% mass retained	Cum% retained	% Finer
4.75	-	-	-	100
2.00	-	-	-	100
1.00		-	-	100
.600	0.67	-	-	100
.425	4.23	0.134	0.134	99.86
.300	56.4	0.142	0.276	99.72
.212	48.10	0.454	0.73	99.27
.150	57.34	0.534	1.264	98.74
.075	50.12	4.84	6.104	93.89
Pan		93.89	100	0

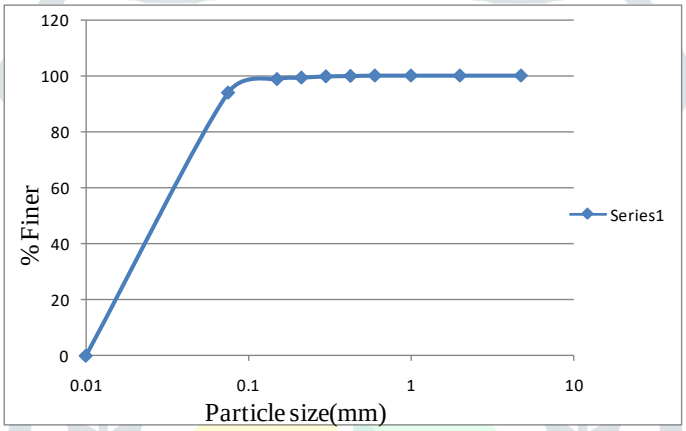

Fig. 1:*Particle Size Distribution curve for virgin soil*

(2) Marble Powder

Marble is known as metamorphic rock. The marble dust was generated from marble industries. The major constituent of marble powder is calcium carbonate which aids in the stabilization of the soil. The soil stabilized by using marble dust can be utilized in the construction of pavement structures and foundations. This work aims to reduce the properties of expansive soils by using marble powder and study of the changes found in index properties of soil samples with increasing percentage of marble powder.

Table 3: *Chemical Composition of marble powder*

ound	Mass (%)
Calcium oxide (CaO)	50-56
Silica	0.33-1.20
Alumina	0.42-0.86
Iron oxide	0.10-0.28
Magnesium oxide	0.8-1.8

EXPERIMENTAL SETUP

To investigate index properties of virgin soil and the same with marble powder the Liquid Limit (LL) test [7], Plastic Limit (PL) test[7], Standard Proctor test [8]and free swell index test[9] are performed as per IS standards.

Liquid Limit Test, Plastic Limit test:

The virgin soil sample & same with varying proportion with marble powder tested for determining Atterberg's limits like liquid limit & plastic limit. The water content of the soil pat when the groove cut in it closer over 12mm at 25 drops is known as the liquid limit of the soil. The experimental set up for this test is shown in Fig.2

Fig. 2: *Casagrande Apparatus*

Standard Proctor Test:

This test was performed by compacting a wet soil sample in a mould in three equal layers by giving 25 nos. of blow. After the finial layer is compacted the bulk density of the soil & its moisture content is determined. The tests are repeated on soil samples with increasing moisture content. A graph of dry density versus moisture content is plotted and the maximum dry density & optimum moisture content value are obtained from graph. The experimental set up for this test is shown in Fig.3

Fig. 3: *Standard Proctor Test Apparatus*

Free Swell Index Test:

This test is provided to reflect the potential of soil to swell under different simulated conditions. For

the soil sample free swell index is calculated as percentage increase in volume of soil after submerging the soil in water for 24 hours.

RESULTS AND DISCUSSION

1. Atterberg's Limits:

Table 4: *Atterbg's Limit Values For Mix Proportions Of soil & Marble Powder*

Sr. No	Particulars of Tests	MP 0%	MP 10%	MP 20%	MP 30%
1.	Soil Classification	CI	CL	CL	CL
2.	Liquid Limit (WL %)	41.5	31.4	26.6	24.61
3.	Plastic Limit (WP %)	17.32	16.56	14.1	12.94
4.	Plasticity index (PI %)	24.18	14.84	12.2	11.67

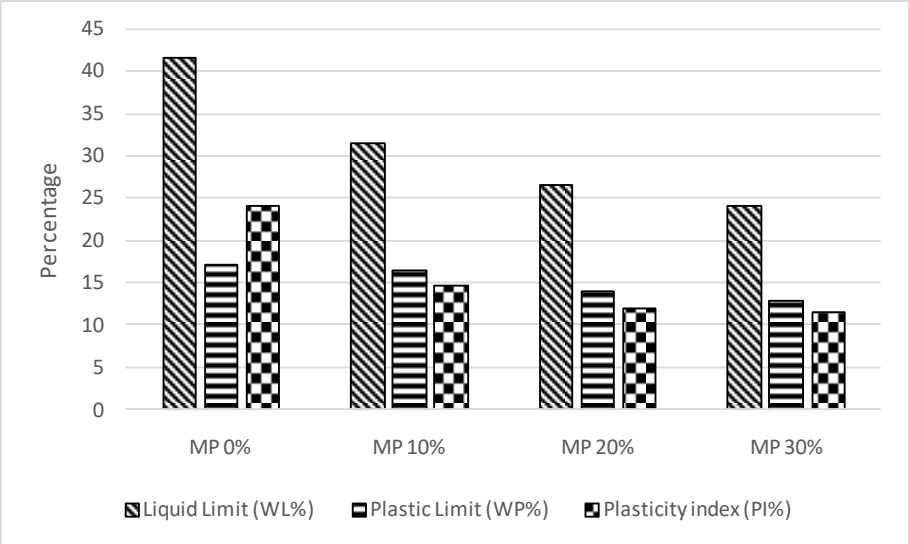

Fig.2: *Effect of MP on Liquid limit, Plastic limit & Plasticity Index*

Replacement of black cotton soil by the waste marble powder it is identified that the values of liquid limits are decreasing with increasing the amount of marble powder. The liquid limit values for 10% replacement of marble powder are 31.4 % which shows 24% less than the black cotton soil. In the same manner at 20% replacement of marble powder liquid limits value decrease by 35% & at 30% replacement liquid limit value decrease by 40%.As the same reduction is found in plastic limit value for 10%,20%,30% marble powder are 4%,18%,25%. It is found that for plasticity index for 10%, 20%, 30 % marble powder are respectively 27%, 49%, & 50 %.

2. Standard Proctor Test:

Table 5: *Standard Proctor test Values For Mix Proportions Of soil & Marble Powder.*

Content	MP 0%	MP10%	MP 20%	MP 30%
MDD (g/cc)	1.73	1.78	1.82	1.88
OMC (%)	18.2	17.1	16.9	14.2

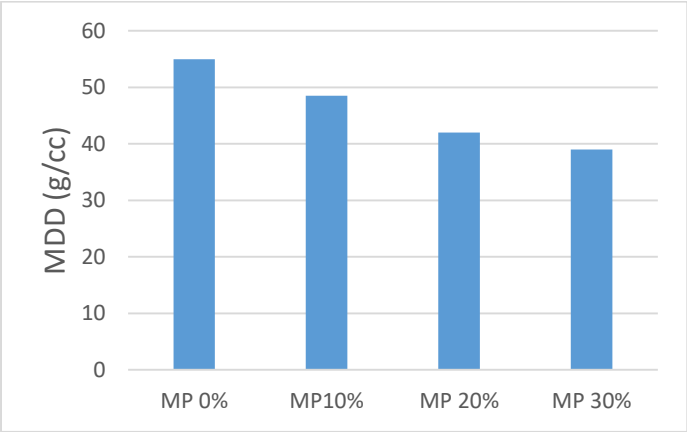

Fig.3: *Effect of MP on Maximum dry density.*

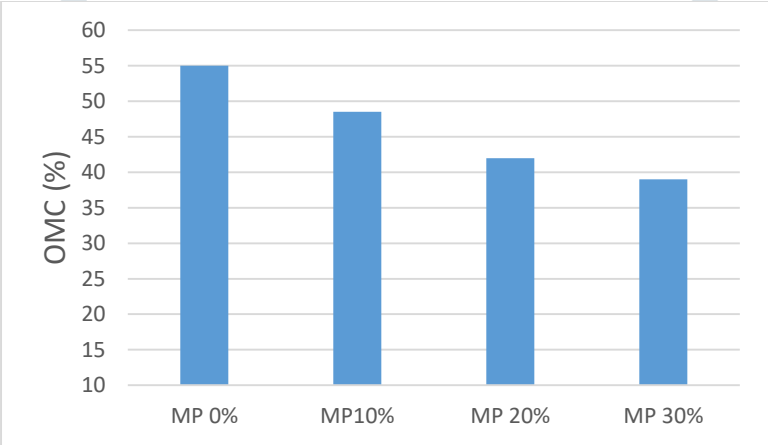

Fig.4: *Effect of MP on Optimum Moisture Content*

The above values show the impact of marble powder on maximum dry density and optimum moisture content. So we can conclude that with the increasing amount of marble powder dry density is increasing and optimum moisture decreases.

3. Free Swell Index Test:

Table 6: *Free Swell Index test Values For Mix Proportions Of soil & Marble Powder.*

Content	MP 0%	MP10%	MP 20%	MP 30%
The initial volume(ml)	10	10	10	10
The finial value (ml)	15.5	14.85	14.2	13.9
Free swellindex (%)	55	48.5	42	39

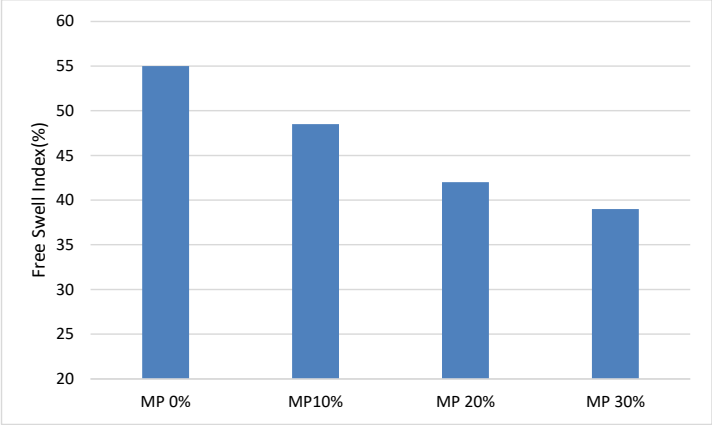

Fig.5: *Effect of MP Free Swell Index Test*

With replacement of black cotton soil by marble powder content the swelling index is decreasing from 55% to 39%.

CONCLUSION

Based on laboratory tests conducted on black-cotton soil mixed with marble powder from 0% to 30% by weight of dry soil. The following conclusions can be drawn:

1. Marble powder addition showed improvement in performance of expansive soils with the help of cation exchange reaction. The presence of excess Ca2+ ions are responsible for the improved performance
2. The liquid Limit of soil sample is 41.5%.Soil sample is classified as inorganic clay of medium plasticity.With addition of marble powder soil change from medium plasticity to low plasticity
3. The liquid Limit of soil sample are decreasing with increasing amount of marble powder from 10% to 30%. It is decreasing from 41.5% to 24.61%.
4. There is significant reduction in plasticity index from 24.18% to 11.67%.
5. Theresults of swell index indicate that the degree of expansiveness reduced from medium to low.

From the above test results obtained it can be concluded that the impact of marble powder on expansive soil is improving the index properties of the soil. So use of marble powder is preferable for stabilization because it gives positive results as stabilizer.

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