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An Experimental Study of Soil Stabilization using Marble Dust

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ABSTRACT: The main objective of this study is to investigate the use of waste marble dust in stabilizing soil and to evaluate the effects of marble dust on CBR values of unsaturated soil by carrying out standard proctor tests and CBR tests on different soil samples. The results obtained are compared for the three different percentage of marble dust and inferences are drawn towards the bearing strength of soil with different combination of marble dust.

In this study, waste limestone dust and waste dolomitic marble dust, by-products of marble industry, were used for stabilization of clayey soils. The marble dust addition ratios which have been studied were 10%, 15 % and 20% by weight. Marble dust had a noticeable role in the hydration process because of high calcium content. Obtained results showed that marble dust addition to the clay samples will reduce the cost of constructing structures on problematic soils, and finding new utilization areas for waste marble dust will decrease environmental pollution. Utilizing waste marble dust materials in problematic soils will have great contribution to the economy and conservation of resources.

I. INTRODUCTION

Soil Stabilization is the alteration of soils to enhance their physical properties. Stabilization can increase the shear strength of a soil and/or control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations[1]. The Engineering Properties of soil are depended on the many points like minerals, water table, soil water behavior etc. which vary as per area to area. Due to which we can't get desire properties suitable to our needs of construction. To resolve this problem we have technique called stabilization which means to stable or to modify or to improve the soil properties in positive manner. So we can have a construction works which fulfill our needs and objective.

"Soil stabilization can be explained as the increasing or maintaining the soil properties by physical and chemical alteration of soil to enhance their engineering properties."

Stabilization allows for the establishment of design criteria as well as the determination of the proper chemical additive and admixture rate to be utilized in order to achieve the desired engineering properties. Benefits of the stabilization process can include higher resistance values, reduction in plasticity, lower permeability, reduction of pavement thickness, elimination of excavation material hauling or handling.

Soil properties vary a great deal and construction of structures depends a lot on the bearing capacity of the soil, hence, we need to stabilize the soil which makes it easier to predict the load bearing capacity of the soil and even improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids. Thus, it is better to mix different types of soils together to improve the soil strength properties. It is very expensive to replace the inferior soil entirely soil and hence, soil stabilization is the thing to look for in these cases.

II. LITERATURE REVIEW

Adarsh Minhas (2016) [1] has studied about stabilization of alluvial soil using marble dust and found that the addition of marble powder in the soil sample the OMC increased. This shows some variation in OMC due to the addition of marble powder. All in three cases (5, 10, and 15%) of marble dust to the alluvial soil shows same variation in OMC. And prominent improvement seen in CBR values when natural soil is replaced by the addition of marble dust.

Tarkeshwar Pramanik, S. Kishor Kumar and J.P. Singh (2016) [2] has studied about the behaviour of Soil for Sub Grade by using Marble Dust and Ground Granulated Blast Furnace Slag and found that The characteristics of soils vary significantly with Marble dust-GGBS content. The Optimum Moisture Content (OMC) increases and Maximum Dry Density (MDD) decreases with increase in percentage of Marble dust-GGBS and With increases 20%-20% of Marble dust and GGBS percentage compressive strength of soil increases.. CBR value for soaked and unsoaked condition increases with increases in percentage of Marble dust and GGBS.

Altug (2015) [3] the main objective of this research was to investigate the possibility of utilizing waste marble dust in stabilizing problematic soils (especially swelling clays). The marble dust addition ratios which have been studied were 0 %, 5 %, 10 %, 20 % and 30 % by weight. Physical, mechanical and chemical properties of soil and marble dust samples were investigated.

Stoltz *et al.* (2014) [4] probed the effect of weathering of lime treated clayey soils by alternate cycles of wetting and drying on the hydro- mechanical properties of the stabilized soil. The results of the study showed a progressive increase in swelling and loss of strength of the stabilized soil with increase in number of wetting and drying cycles.

Sachin N. Bhavsar and Ankit J. Patel (2014) [5] has studied about Effect of waste material on swelling and shrinkage properties of clayey soil and they concluded From that their results clearly identified that for the replacement of soil by stabilizer the linear shrinkage is reducing for the both stabilizing agents.

Sabat and Nanda (2011) [6] had studied the effects of marble dust on strength and durability of rice husk ash stabilized expansive soil and found that addition of marble dust increased the strength, decreased the swelling pressure and made the soil-rice husk ash mixes durable. The optimum proportion of soil: rice husk ash: marble dust was found to be 70:10:20

III. MATERIALS AND METHOD

The soil used for this study was collected from a small pond near Ottu village in Sirsa district. Various tests - like liquid limit, plastic limit, proctor compaction test and CBR test are performed. After performing these all tests I found that the liquid limit and plastic limit of soil is very high and CBR value of this soil is very low. These type of soils are not suitable for road construction because of high swelling and shrinkage properties. Thus to increase various properties of such soil it should be needed to stabilize.

The stabilizer material used for the study was marble dust. The marble dust was collected from a marble cutting and polishing industry (The Makrana marble industry) in Makrana village of Nagaur district.

A. Experimental Metrix

Liquid limit test, plastic limit test, Standard Proctor Test, California bearing ratio(CBR) test were carried out for both natural soils and with the addition of marble dust with three different percentages (10%, 15%, 20%).

IV. RESULTS AND DISCUSSION

The Various tests are conducted on black- cotton soil mixed with marble dust in different proportion as per IS code of practice.

Test results variation of LL, PL, PC and CBR are shown in Table1 to 9.

Table I shows that liquid limit increases as the percentage of marble dust increases. In table 2 plastic limit test shows that plasticity indexed also increases upto 15% replacement and then slightly decreases at 20%. As the results shows that the Optimum Moisture Content (OMC) increases and Maximum Dry Density (MDD) decreases with increase in percentage of Marble dust. As compared to untreated soil, the percentage increase in OMC at 15% addition of Marble dust is 22.39% due to change in plasticity index and liquid limit. The increasing percentage of marble dust with soil increases the plasticity index and reduces the swelling properties of soil. This is very helpful to control volume changes in soil due to clayey particles. The CBR value of the soil is increased with increasing order of marble dust percentage. The optimum results were found when soil was stabilized with 15% marble dust. The CBR value is increased from 2.40 % to 14.6. %.

Index Properties

Liquid limit of soil with different marble content:

Table 1: liquid limit.

Marble dust (%)	Liquid limit (at 25 no of blows)
0	38.15
10	42.921
15	41.08
20	42.15

Comparison of liquid limit with different marble dust percentage
Plastic Limit

Table 2: Plasticity index of soil.

Marble dust (%)	Plasticity index (%)
0	15.0
10	20.041
15	20.19
20	19.64

PROCTOR COMPACTION TEST

Table 3: OMC and MDD of soil when Marble dust: 0%.

Sample No	1	2	3
Weight of mould (kg)	4.732	4.732	4.732
Volume of mould cc	1000	1000	1000
Number of blows	25	25	25
Weight of wet soil + mould (kg)	6.794	6.704	6.744
Bulk density (kg/m3)	2.02	1.972	2.01
Weight of soil sample taken for oven dry (gms)	39.36	47.01	26.4
Weight of soil sample after oven dried (gms)	32.14	37.83	21.82
Weight of water (gms)	7.22	9.18	4.58
Water content (%)	22.46	24.26	20.98
Dry density (kg/m3)	1.674	1.642	1.655

Table 4: OMC and MDD of soil when Marble dust: 10%.

Sample No	1	2	3
Weight of mould (kg)	4.732	4.732	4.732
Volume of mould cc	1000	1000	1000
Number of blows	25	25	25
Weight of wet soil + mould (kg)	6.798	6.766	6.67
Bulk density (kg/m3)	2.066	2.034	1.938
Weight of soil sample taken for oven dry (gms)	130	110.04	150
Weight of soil sample after oven dried (gms)	114.24	95.92	134.05
Weight of water (gms)	15.76	14.72	15.95
Water content (%)	18.32	21.17	15.72
Dry density (kg/m3)	1.7461	1.6786	1.6747

Table 5: OMC and MDD of soil when Marble dust: 15%.

Sample No	1	2	3
Weight of mould (kg)	4.732	4.732	4.732
Volume of mould cc	1000	1000	1000
Number of blows	25	25	25
Weight of wet soil + mould (kg)	6.746	6.778	6.788
Bulk density (kg/m3)	2.014	2.046	2.056
Weight of soil sample taken for oven dry (gms)	107.04	78.8	96.84
Weight of soil sample after oven dried (gms)	92.36	65	81.97
Weight of water (gms)	14.68	13.8	14.87
Water content (%) dust	15.89	21.24	18.14
Dry density (kg/m^3)	1.7378	1.6875	1.7403

Table 6: OMC and MDD of soil when Marble dust: 20%.

Sample No	1	2	3
Weight of mould (kg)	4.732	4.732	4.732
Volume of mould cc	1000	1000	1000
Number of blows	25	25	25
Weight of wet soil + mould (kg)	6.68	6.734	6.788
Bulk density (kg/m3)	1.956	2.002	2.056
Weight of soil sample taken for oven dry (gms)	101	68.77	90.56
Weight of soil sample after oven dried (gms)	88.47	59.33	76.4
Weight of water (gms)	12.53	9.44	14.16
Water content (%)	22.4	15.91	18.54
Dry density (kg/m^3)	1.598	1.725	1.734

CBR TEST RESULTS

Table 7: CBR test of soil when Marble dust 0%.

Dial Gauge Reading	**Proving Ring Reading**	**Penetration**	**Load (kg)**
0	0	0	0
50	1	0.5	1.299378186
100	4	1	5.197512742
150	8	1.5	10.39502548
200	12	2	15.59253823
250	17	2.5	22.08942915
300	21	3	27.2869419
350	25	3.5	32.48445464
400	30	4	38.98134557
450	35	4.5	45.47823649
500	38	5	49.37637105
550	42	5.5	54.57388379
600	46	6	59.77139653
650	50	6.5	64.96890928
700	54	7	70.16642202
750	59	7.5	76.66331295
800	64	8	83.16020387
850	67	8.5	87.05833843
900	70	9	90.95647299
950	73	9.5	94.85460754
1000	76	10	98.7527421
1050	79	10.5	102.6508767
1100	82	11	106.5490112
1150	85	11.5	110.4471458
1200	88	12	114.3452803
1250	90	12.5	116.9440367
	Penetration (mm)	CBR	
	2.5	1.612367092	
	5	**2.4027431**	

Table 8: CBR test of soil when Marble dust: 10%.

Dial Gauge Reading	Proving Ring Reading	Penetration	Load (kg)
0	0	0	0
50	11	0.5	14.29316004
100	30	1	38.98134557
150	48	1.5	62.37015291
200	70	2	90.95647299
250	**87**	2.5	113.0459021
300	107	3	139.0334659
350	130	3.5	168.9191641
400	143	4	185.8110805
450	156	4.5	202.7029969
500	**171**	5	222.1936697
550	184	5.5	239.0855861
600	198	6	257.2768807
650	211	6.5	274.1687971
700	223	7	289.7613354
750	234	7.5	304.0544954
800	245	8	318.3476555
850	256	8.5	332.6408155
900	267	9	346.9339755
950	278	9.5	361.2271356
1000	289	10	375.5202956
1050	290	10.5	376.8196738
1100	300	11	389.8134557
1150	310	11.5	402.8072375
1200	320	12	415.8010194
1250	328	12.5	426.1960449
	Penetration (mm)	CBR	
	2.5	8.251525704	
	5	**10.812344**	

Table 9: CBR test of soil when Marble dust: 15%.

Dial Gauge Reading	Proving Ring Reading	Penetration	Load (kg)
0	0	0	0
50	13	0.5	16.8919164
100	31	1	40.2807238
150	57	1.5	74.0645566
200	84	2	109.147768
250	118	2.5	153.326626
300	142	3	184.511702
350	166	3.5	215.696779
400	190	4	246.881855
450	212	4.5	275.468175
500	231	5	300.156361
550	254	5.5	330.042059
600	277	6	359.927757
650	300	6.5	389.813456
700	320	7	415.801019
750	339	7.5	440.489205
800	357	8	463.878012
850	375	8.5	487.26682
900	392	9	509.356249
950	408	9.5	530.1463
1000	424	10	550.936351
1050	439	10.5	570.427023
1100	452	11	587.31894
1150	464	11.5	602.911478
1200	476	12	618.504016
1250	487	12.5	632.797176
	Penetration (mm)	CBR	
	2.5	11.19172452	
	5	**14.6061489**	

Table 10: CBR test of soil when Marble dust: 20%.

Dial Gauge Reading	Proving Ring Reading	Penetration	Load (kg)
0	0	0	0
50	14	0.5	18.1912946
100	38	1	49.376371
150	60	1.5	77.9626911
200	85	2	110.447146
250	**110**	2.5	142.9316
300	130	3	168.919164
350	150	3.5	194.906728
400	169	4	219.594913
450	190	4.5	246.881855
500	**209**	5	271.570041
550	230	5.5	298.856983
600	249	6	323.545168
650	268	6.5	348.233354
700	287	7	372.921539
750	305	7.5	396.310347
800	323	8	419.699154
850	340	8.5	441.788583
900	355	9	461.279256
950	370	9.5	480.769929
1000	386	10	501.55998
1050	400	10.5	519.751274
1100	415	11	539.241947
1150	429	11.5	557.433242
1200	442	12	574.325158
1250	455	12.5	591.217074
	Penetration (mm)	CBR	
	2.5	10.43296353	
	5	**13.2150871**	

V. CONCLUSION

The addition of the marble dust to the soil reduces the clay contents and thus increases in the percentage of coarser particles. Overall it can be concluded that soil stabilized with marble dust can be considered to be good ground improvement technique, especially in engineering projects on weak soils where it can act as a substitute to deep/raft foundations, reducing the cost as well as energy.

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