



Improvement of Strength of Sub-Grade Soil Using Marble Dust

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Abstract: The demand for utilization of industrial by-products and wastes in road pavement is increasing and becoming more important. Government policies and public awareness are also contributing to the enhancement of both this demand and utilization. Around 4000 marble mines and 1100 marble processing units are spread all over India. Near about 5-6 million tones/year of marble dust is generated and is disposed of on road-sides causing environmental degradation, drainage problem and damaging the agricultural land. The gradation curve of the sieve analysis resulted that the soil is sandy associated with the silt of low compressibility (SM- Silty Sand). The CBR (California Bearing Ratio) value and UCS (Unconfined Compressive Strength) of soil give the clear idea about the quality of sub-grade material to that of the required as per IRC (Indian Road Congress) Code. As per the relative IRC SP 72-2007, the thickness of sub-grade from the computed statics will be 300mm with the modified soil component after the replacement of soil with the 15% of marble dust which is quite economical and there is significant improvement in the CBR and value of the sub-grade i.e. 6.8 and 4.5 at un-soaked and soaked condition. Thus it is concluded that marble dust is potentially useful in stabilizing of soil, however, the stabilizing effect is purely dependent on the percentage or replacement of marble dust and result obtained are encouraging for the improved the village road condition and avoiding the regular periodical patch maintenance by the authority.

Keywords: Marble dust, California Bearing Ratio (CBR), Unconfined Compressive Strength (UCS).

I. Introduction

The economic growth of any country is depended upon the infrastructural development. In every five year plan, the lion share of investment takes place for the infrastructures specifically highways and expressways. India has an extensive road network of 3.3 million km which is the second largest in the world. The eleventh five-year plan also invested more than 3.5 lakh crores in the road sector. With the evolution of the road industry and growing traffic on roads, construction materials have also been evolved and more unconventional ingredients have been incorporated. The demand for utilization of Industrial by-products and wastes in road pavement is increasing and becoming more important. Hence engineers are taking the strenuous effort to design the quality road pavements and it depended on the strength of the sub-grade. Government policies and public awareness is also contributing to the enhancement of both this demand and utilization.

Sandy Clayey soils, which becomes unattainable to avoid them for highway construction and airways. Economic development of any country is controlled to a great extent by highway and airway networks. Therefore, the development and use of methods to decrease the cost of pavements is very necessary. For this work it is essential to know the condition of the sub-grade soil before designing the type and the thickness of pavement, as the sub-grade carries the traffic loads as well as the pavement loads. The major function of pavement is to distribute stresses to the sub-grade (K.Uppaiah et.al.-2013). The process of improving the behaviours of soil is known as Soil Stabilization. It is done by various methods and one of them is mixing the Stabilizing Additives. In this study, it has been planned to mix the Marble dust and GGBS (Ground Granulated Blast furnace Slag) with different proportions in Sandy Clayey soil.

II. Literature review

The abstract of most related and the latest literature are summarized here. Literature from e-journals was accessed through internet whose websites are given in the reference section.

C. Gupta and R. K. Sharma (2014) studied the marble was most preferred stone of India and available mostly in Rajasthan and Madhya Pradesh. The authors investigated the rapid growth of industries of marble produces hazardous waste materials to a large extent. The authors concluded that there was an urgent need for exploring the alternative of disposal of this material.

J Jayapal et al. (2014) investigated the properties of local Clayey soil in Chennai and concluded that can be improved by adding quarry dust, fly ash and lime. P S Singh and R K Yadav (2014) investigated the industrial waste

like marble dust had a potential to modify the engineering behavior of black-cotton soil and to make it suitable for many geotechnical applications. M Singh and A Mittal (2016) concluded that the waste tier can use for the improvement of bearing capacity soil up to optimum rubber content and tier waste can effectively use as soil reinforcement beneath footing, embankment and retaining wall.

T Pramaniket *et al* (2016) concluded that the Marble dust and GGBS is potentially useful in stabilizing of soil. E Ravi *et al.* (2016) investigated the feasibility of utilizing the industrial by-product copper slag as a stabilizer in the expansion soil where swelling characteristics are higher and cause severe damage to the structure and road pavement. The authors studied the adequate percentage of copper slag additive in the strength enhancement of clay soil.

After a thorough review of available literature, it has been identified that marble is one of the most preferred stone of India and is available mostly in Ludhiana, PUNJAB. The Rapid growth of industries of marble produces hazardous waste materials at a large extent which creates a big problem to the humans surrounding them as well as acts as a pollutant so affect the ecological system of the environment. It shows that there is an urgent need for exploring the alternative of disposal of these materials.

Majority of the natural soil in village roads of Punjab is Subgrade is predominantly sandy silt with low compressibility (SM group). Looking into this marble dust which is waste material can be utilized in subgrade soil in Punjab area thus improving its CBR value thus to stabilize the soil sub-grade. So an effort has been made to the replace locally available soil sample with marble dust for the poorly graded sand with fine content to achieve desired strength and thickness.

III. Objectives of the study

The main objective of this study is to solve the problem of the disposal of marble waste by using it in soil stabilization and the land will be used for other purposes.

1. To determine the effect of optimum value, that has been used to get the good results with the marble waste replacement.
2. To identify the optimum proportion of the marble dust.
3. To ascertain the strength of the suitability of road sub-grade as per the provision of IRC codes.
4. To develop the statically charts as a suitable tool to be used by the site staff.

IV. Methodological Approach

1. To collect the sub-grade soil sample.
2. To carry out the field investigation and other laboratory tests.
3. To carry out the CBR test for the sub-grade soil sample.
4. To categorize the Sub-grade soil sample.
5. To carry out the physical test on marble dust.
6. To carry out the engineering test on a varying percentage of marble dust replacement and soil mixes.
7. To find out the CBR of the sub-grade soil sample.
8. To find out the UCS of the sub-grade soil sample.
9. To analyze the final thickness of sub- grade at desired CBR.

V. Experimental Investigation

As per Unified Classification System (UCS) the soil sample belonged to CL-ML group and is grouped as sandy associated with the silt of low compressibility (SM). Table No 1 shows the engineering properties of the soil sample.

Table 1 Engineering Properties of soil sample

Sr. No	Engineering Properties	Value
1.	Liquid Limit(LL)%	27
2.	Plastic Limit(PL)%	20.4
3.	Plastic Index(Ip)	6.6
4.	Specific Gravity(G)	2.3
5.	Optimum Maximum Content(OMC)%	18.1
6.	Maximum Dry Density(MDD)g/cc	1.89

As the design of Flexible Pavement according to Indian Road Congress (IRC) is highly dependent on California Bearing Ratio of Soil and so CBR (California Bearing Ratio) test was performed and the test result shows that CBR of the soil sample is 2, which is very low. Low bearing ratio required high Pavement thickness which becomes very uneconomical so improvement is necessary. In view of this shows that only techno-economical feasible method available is to increase the sub-grade strength of village road. In the present study, the improvement of sub- grade soil with the optimum proportion of marble dust is considered.

- 1) Local sourcing of materials: For the present study, the sample of marble dust is procured from the local market.

- 2) Chemical Composition of marble dust: Marble dust consists of a high percentage of CaO & SiO₂ as shown in Table 2. It consists mainly of 40% amount of CaO and 28% of SiO₂

Table 2 Chemical Composition of Marble Dust

S. No.	Oxide Compound	Mass Percentage
1	CaO	40.45
2	Al ₂ O ₃	0.42
3	SiO ₂	28.35
4	Fe ₂ O ₃	9.70
5	MgO	16.25

Physical properties of marble dust

The Bulk density of marble dust is 986 kg/m³ and specific gravity is 2.73. It was proposed to replace soil sub-grade with marble dust with 5%, 10%, 15% and 20%. The following test was performed and Table No 3 shows the variation of different engineering properties after replacement of soil with marble dust.

Table 3: Engineering Properties of Soil, Soil + Marble Dust (MD) mixes

S. No.	Engineering Properties	Soil+0% Marble Dust (MD)	Soil+5% Marble Dust (MD)	Soil+10% Marble Dust (MD)	Soil+15% Marble Dust (MD)	Soil+20% Marble Dust (MD)
1	Liquid Limit, %	27	26	25.6	25	24.8
2	Plastic Limit, %	20.4	19.5	19.4	18.7	18
3	Plasticity Index, %	6.6	6.5	6.2	6.3	6.8
4	Maximum dry density, g/cc	1.89	1.74	1.72	1.67	1.6
5	Optimum moisture content, %	18.1	16.8	15.8	15.3	14.8
6	CBR(Soaked) ratio	2	3.5	4.2	4.5	4.02
7	CBR(Un-soaked) ratio	2.4	5.36	6.4	6.8	6.2

Experiments showed that thereafter replacement of 5%, 10%, 15%, and 20% of marble dust with soil resulted in minor changes in the behavior of plasticity of the soil, change in the plasticity of the soil is related to the plasticity of the added marble dust.

From the above Table No 3, it was seen that the CBR of soil sample has been increasing as the percentage of marble dust is increased both in soaked and un-soaked condition. Also, it is seen that there is a significant change in the properties of OMC and MDD. The value of OMC and MDD is slightly decreased.

Figure 1 Effect of Marble Dust on OMC

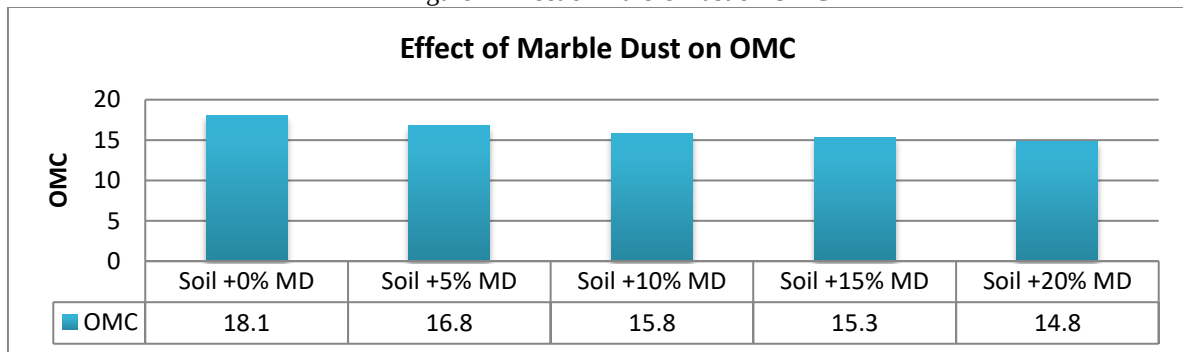


Figure 2 Effect of Marble Dust on MDD

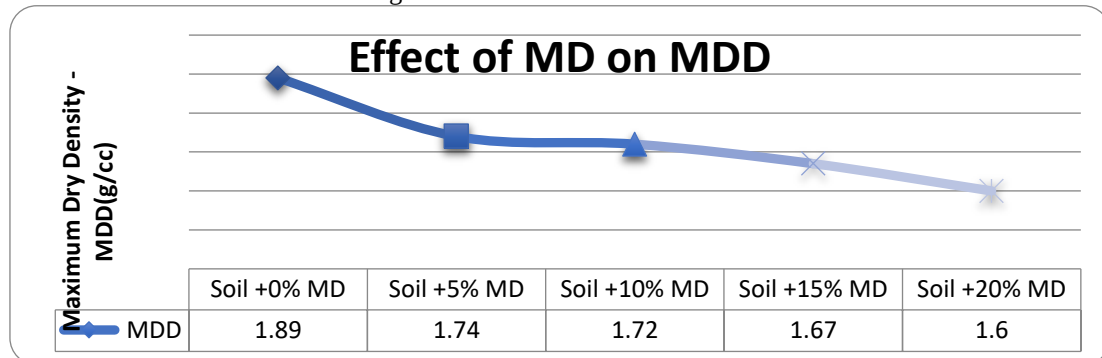
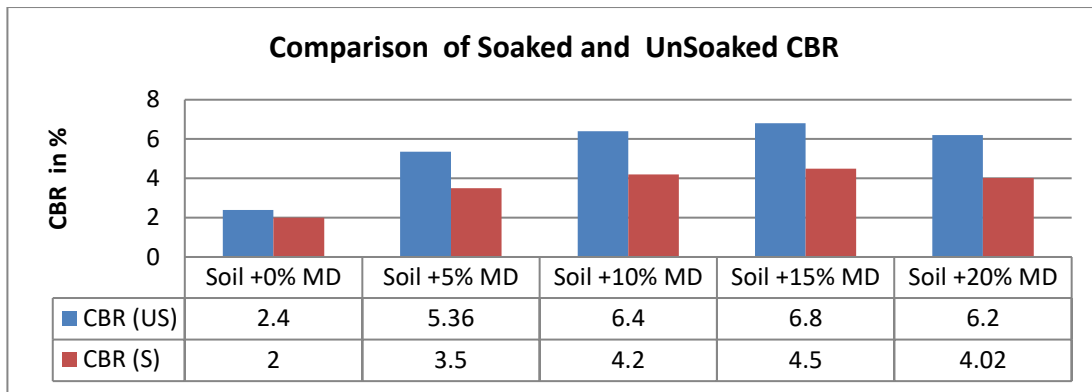
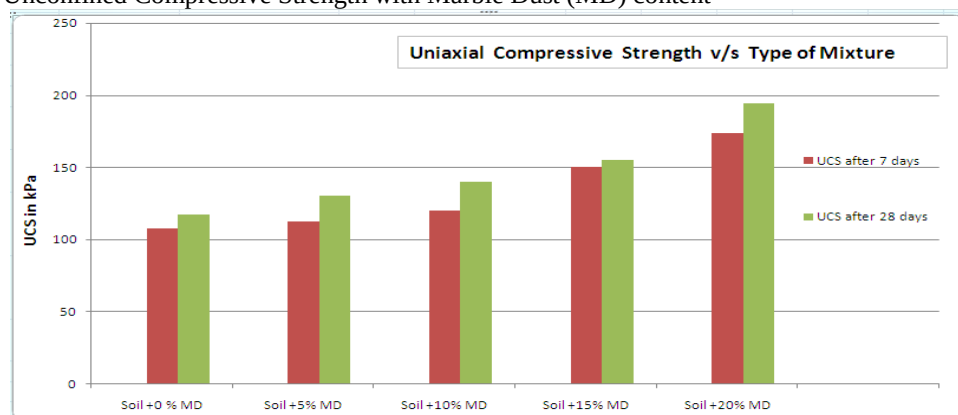


Figure 3 Comparison of Soaked and Un-Soaked CBR



Thus, the above results in Figure 1 show that decrease in the liquid limit, is due to Marble Dust (MD) which has improved the CBR value also and the increase in the soil property has resulted in the stabilization of the soil. After the CBR test, unconfined compressive strength was performed. There were variations of unconfined compressive strength with Marble Dust (MD) content for 7 and 28 days of curing as shown in Figure 4

Figure 4 Unconfined Compressive Strength with Marble Dust (MD) content



It is indicated from the Figure 2 that the strength (Unconfined Compressive Strength) of each Marble Dust (MD) - sandy associated with silt of low compressibility (SM) soil specimen increases with the increase of the curing duration and the percentage of Marble Dust (MD).

VI. Conclusion and Suggestion

This shows that there is a scope of improvement of soil sub-grade possible by replacing the soil sub-grade. OMC, MDD, CBR, and UCS aim to evaluate the percentage replacement of soil.

1. The soil sample was tested on the laboratory for soil classification, MDD, OMC, and CBR, UCS.
2. Now the sub-grade soil is modified by the addition of Marble Dust (MD) with 0, 5, 10, 15, 20 percent and the lab test was carried out.
3. The result shows OMC is 18.1, 16.8, 15.8, 15.3, and 14.8 @ 0, 5, 10, 15, and 20 percent of Marble Dust (MD). The result shows MDD is 1.89, 1.74, 1.72, 1.67, 1.6 @ 0, and 5, 10, 15, 20 percent of Marble Dust (MD) and this shows that OMC, MDD is slightly decreased with the addition of Marble Dust (MD).
4. The CBR value of soil sample at soaked and un-soaked condition was carried and it is seen that there is an increase in the percent of CBR value both in soaked and un-soaked by the increase in the percentage of Marble Dust (MD). Unconfined compressive strength values of specimens indicated that the strength of each Marble Dust (MD) - sandy associated with the silt of low compressibility (SM) soil specimen increases with the increase of the curing duration and the percentage of marble dust.
5. The gradation was thus carried out using sieve analysis and the resulted was tabulated. The CBR value and UCS value of soil give the clear idea about the quality of sub-grade material to that of the required as per IRC Code. IRC recommended the use of the CBR about 2 for village roads which were improved by the partial replacement of soil by replacing Marble Dust (MD). The CBR at the soaked and un-soaked condition and UCS for 7 days and 28 days were carried out with all the other parameters were kept constant.
6. Thus it is concluded that Marble Dust (MD) is potentially useful in stabilizing of soil, however the stabilizing effect is purely dependent on the percentage or replacement of Marble Dust (MD) and result obtained are encouraging for the improved the road condition of village roads and avoiding the regular periodical patch maintenance by the authority.

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