

Utilization of Stone Dust to Improve Geo-technical Properties of Soil

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Abstract— The load-bearing capacity of the soil needs to be improving for better strength and performance of the pavement. Stone dust is an easily available material that can be obtained as industrial waste. 10%, 20%, 30%, 40% and 50% stone dust added to the soil for observing the geotechnical properties of soil. A series of test results observed that 40% of stone dust gives a higher strength of the soil. The addition of stone dust is an economical method for enhancement of load-bearing capacity of the soil.

Keywords: Geo-Technical Properties of Soil, OMC & MDD of Soil

I. INTRODUCTION

A worldwide problem that poses several challenges for civil engineers is the presence of Expansive Soils. Expansive Soils are considered a potential natural hazard, which can cause extensive damage to structures if not effectively treated. Such types of soils swell when come in contact with water and shrink when they dry out. One of the most effective and economical methods is the addition of stabilizing agents such as Fly Ash, Lime, Cement, Bitumen and stone dust to Expansive Soil. Purpose of stabilization of soil is improving the strength of the soil and increasing resistance to softening by water through bonding the soil particles together, waterproofing the particles or combination of the two. The simplest stabilization processes are compaction and drainage in which water drains out of wet soil and becomes stronger. The other process is by improving gradation of particle size and further improvement can be achieved by adding binders to the weak soils. Stone wastes contain heavy metals and suspended solids and mainly consist of calcium carbonate (CaCO₃). The stone slurry waste is usually disposed of indiscriminately in open areas and sewage network causing health and environmental problems. The amount of waste accumulating from quarries, stone cutting plants and in open areas is pressing problem facing the stone industry.

II. MATERIAL AND METHODS

A. Materials:

1) Soil:

Soil is collected from Baurari, New-Tehri, Tehri-Garwal, Uttarakhand (India).



Fig. 1: Sample of Soil

2) Stone Dust:

Stone Dust is collected from Ranihaat Naithana Chauras, Pauri Garwal, Uttarakhand (India).



Fig. 2: Sample of Stone Dust

B. Methods:

1) Particle Size Distribution:

The Standard Procedure of test followed as per IS: 2720 (Part IV) – 1985.

2) Atterberg Limit:

Liquid Limit and Plastic Limit of Soil and Stone dust was calculated as per IS: 2720 (Part V) – 1985

3) Shrinkage Limit:

Shrinkage limit of soil and Stone dust was determined in Laboratory as per IS: 2720 (Part – VI) 1972.

4) Specific Gravity:

Specific gravity of soil and Stone dust was observed by the help of density bottle as per IS: 2720 (Part 3) – 1980.

5) Standard Proctor Test:

Maximum Dry Density and Optimum Moisture Content of soil and Stone dust was determined by as per IS:2720 (Part VII) – 1980.

6) California Bearing Ratio Test:

California Bearing Ratio value for soaked and un-soaked condition of soil and stone dust calculated as per IS: 2720 (Part XVI) – 1987 in the laboratory.

III. REVIEW OF LITERATURE

Many researchers have worked on the properties of stone dust to judge its suitability as a construction material in the field of civil engineering. Some of the important findings are briefly reproduced.

Kumar et al. (2014) concluded that the addition of Stone Dust affected all properties of the studied Soil. Addition of Stone Dust resulted in decreases of Liquid Limit from 47.70% to 37.60% and Plastic Limit from 25.65% to 21.83%. Maximum Dry Density increases from 18.04 kN/m³ to 18.84 kN/m³ and decreases Optimum Moisture Content was observed from 15.80 % to 10.00 %. Stone dust increase with soil, California Bearing Ratio value increases from 1.82% to 3.55%. It also noticed that optimum percentage of Stone Dust mixed to the soil improve the CBR value for both soaked and un-soaked condition of sample.

Agarwal et al. (2015) reported that the effect of Stone Dust on stabilized soils. The Soil collected from Pantnagar, U. S. Nagar Uttarakhand and Stone dust purchase from Pal Stone Industry Halduchaud, Uttarakhand. Different percentage of Stone Dust was mixed to the soil for the study of soil geotechnical properties. After conducting a series of test it was found that with increasing proportion for Stone Dust, soil Optimum Moisture Content decreases from 16.50% to 13.25% and Maximum Dry Density increases from 17.27kN/m³ to 18.54 kN/m³. In this paper the behavior of soil with different percentage of Stone Dust was studied for California Bearing Ratio test, also it was observed that 30% of Stone Dust with soil increased the California Bearing Ratio value of soil.

Manjunath et al. (2015) conducted laboratory test for improving strength of Soil. The Soil mixed with different percentage of Stone Dust 5 %, 10 %, 15 %, 20 % and 25% was added to study geotechnical properties of soil. The laboratory experiment shows that plastic limit (33% to 25%) and liquid limit (60% to 47%) decreases with increased proportion of Stone Dust. Optimum Moisture Content decreased from 21 % to 18 % and Maximum Dry Density increased from 16.09kN/m³ to 17.66kN/m³ of Soil with addition of Stone Dust. Unconfined Compressive Strength test conducted for 0 days, 7 days, 14 days and 28 days. The value increases with increasing the percentage of stone dust with increasing the curing period. The maximum value of Unconfined Compressive Strength was found 90kN/m² with 15 % Stone Dust at 28 days curing.

IV. RESULT AND DISCUSSION

A. Geotechnical Properties of Soil:

Geotechnical properties of soil calculated after conducting a series of laboratory test as per IS Code 2720. The laboratory results described as:

S. No.	Parameter	Test Method	Results
1.	Soil Type as Per IS 1498-1970	IS 2720 (Part IV) 1985	Clay
2.	Liquid Limit	IS 2720 (Part V) 1985	28.8 %
3.	Plastic Limit	IS 2720 (Part V) 1985	20.6 %
4.	Shrinkage Limit	IS 2720 (Part VI) 1972	12.8 %
4.	Specific Gravity	IS 2720 (Part III) 1980	2.65
5.	Standard Proctor Test 1) MDD 2) OMC	IS 2720 (Part VII) 1980	17.24 Kn/m ³ 16.10 %
6.	California Bearing Ratio 1) Un-soaked 2) Soaked	IS 2720 (Part XVI) 1987	2.6 % 1.3 %

Table 1: Geotechnical Properties of Soil

S. No.	Parameter	Test Method	Results
1.	Plasticity Index	IS 2720 (Part V) 1985	Non - Plastic
2.	Specific Gravity	IS 2720 (Part III) 1980	3.0

Table 2: Geotechnical Properties of Stone Dust

B. Standard Proctor Test:

Standard proctor test was conducted on 10%, 20%, 30%, 40% and 50% stone dust mixed to the soil. The results obtained after test for each mix of soil and stone dust have been summarized in Table 3 and Figure 3 shows the relation between dry density & water content of soil with different percentage of stone dust. OMC and MDD variation of the soil with stone dust mix shows in Figure 4 & 5.

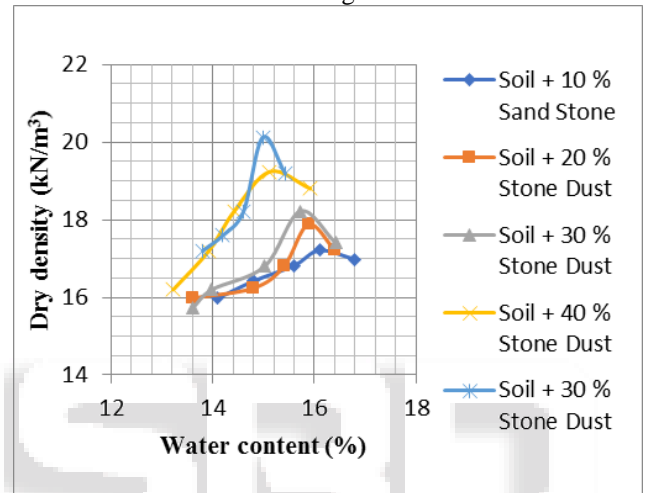


Fig. 3: Dry density & Water content relation of soil with different percentage of stone dust

S. No.	Material	OMC (%)	MDD (KN/m ³)
1.	Soil + 10% Stone Dust	16.40	17.21
2.	Soil + 20% Stone Dust	15.88	16.92
3.	Soil + 30% Stone Dust	15.72	16.42
4.	Soil + 40% Stone Dust	15.12	16.12
5.	Soil + 50% Stone Dust	14.98	14.88

Table 3: OMC & MDD of Soil with Different Percentage of Stone Dust

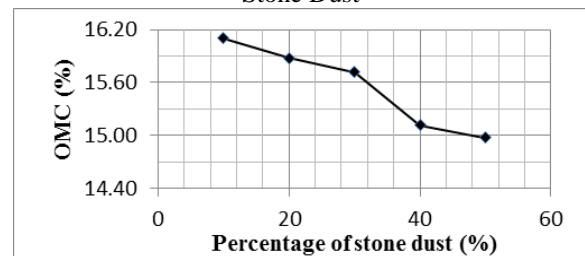


Fig. 4: OMC Variation soil with different % of stone dust

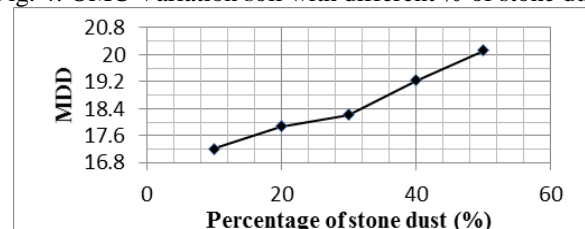


Fig. 5: MDD Variation soil with different % of stone dust

C. Shrinkage Limit:

Shrinkage limit test was conducted on 10%, 20%, 30%, 40% and 50% stone dust mixed to the soil. The results obtained after test for each mix of soil and stone dust have been summarized in Table 4.

S. No.	Material	Shrinkage Limit (%)
1.	Soil + 10% Stone Dust	11.2
2.	Soil + 20% Stone Dust	10.8
3.	Soil + 30% Stone Dust	8.3
4.	Soil + 40% Stone Dust	6.3
5.	Soil + 50% Stone Dust	5.9

Table 4: Shrinkage Limit of Soil with Different Percentage of Stone Dust

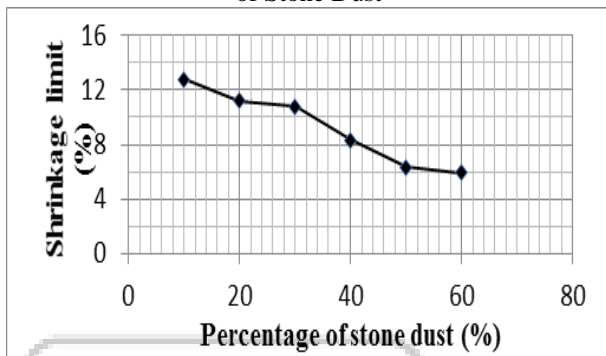


Fig. 6: MDD Variation soil with different % of stone dust

D. California Bearing Ration:

CBR (Un-soaked & Soaked) test were conducted on 10%, 20%, 30%, 40% and 50% stone dust mixed to the soil. The results obtained after test for each mix of soil and stone dust have been summarized in Table 5.

S. No.	Material	CBR	
		Un- Soaked	Soaked
1.	Soil + 10% Stone Dust	6.2	2.6
2.	Soil + 20% Stone Dust	13.4	4.6
3.	Soil + 30% Stone Dust	20.5	7.8
4.	Soil + 40% Stone Dust	22.8	11.2
5.	Soil + 50% Stone Dust	21.2	9.6

Table 5: CBR (Un-Soaked & Soaked) of Soil with Different Percentage of Stone Dust

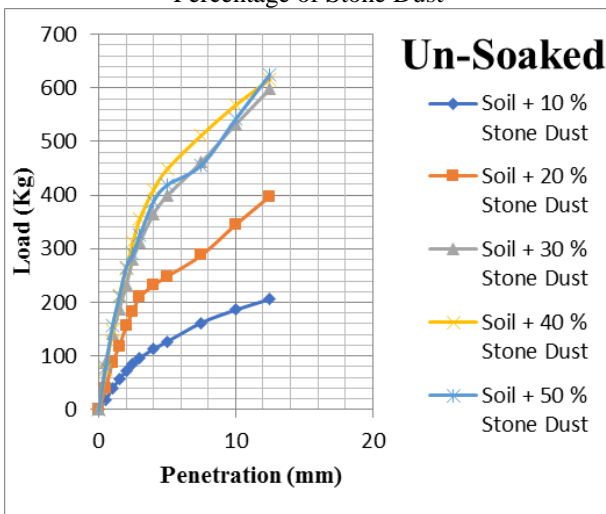


Fig. 7: CBR (Un-soaked) of soil with different percentage of stone dust

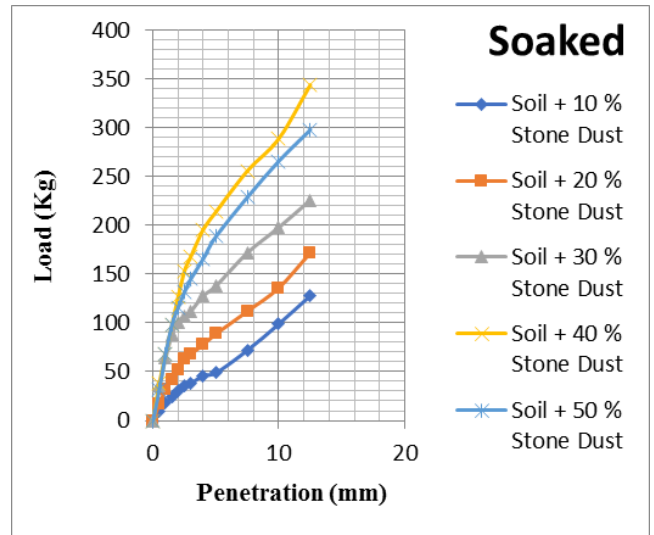


Fig. 8: CBR (Soaked) of soil with different percentage of stone dust

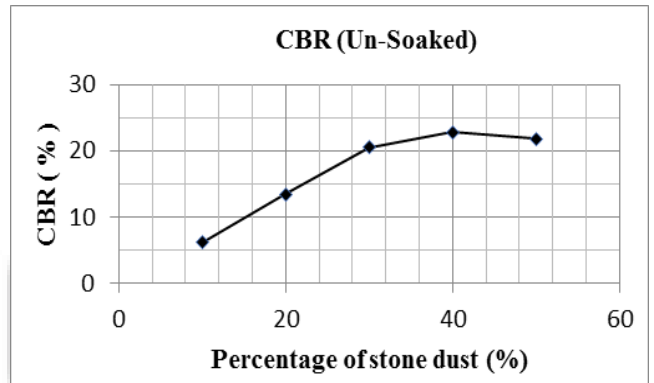


Fig. 9: CBR (Un-soaked) Variation soil with different % of stone dust

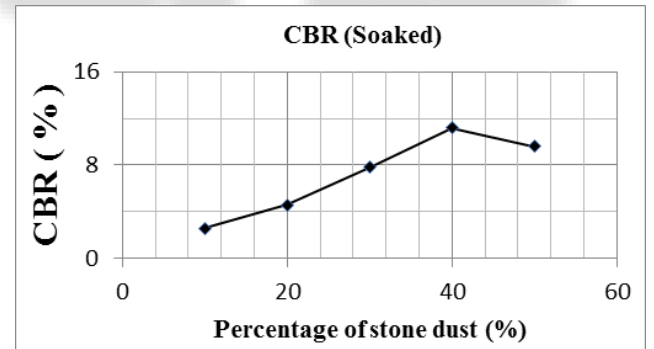


Fig. 10: CBR (Soaked) Variation soil with different % of stone dust

V. CONCLUSION

Experimental work is done on clay soil with 10% to 50% stone dust for obtaining higher strength of the soil. The conclusion of experimental results:

- 1) Shrinkage Limit of Soil decreasing with increasing of stone dust i.e. 5.9% (at 50% Stone dust to the soil).
- 2) OMC & MDD of soil with 40% Stone dust is 19.24kn/m³ and 15.12%.
- 3) CBR value is optimum at 40% of Stone dust added to the soil.
- 4) The strength of the soil is higher at addition of 40 % Stone dust to the soil.

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