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Stabilization of Bentonite Soil with Stone Dust

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Abstract: Bentonite soil has the tendency to swell or shrink depending on its water content variations. Due to such expansive characteristics of these soils, the structures constructed over this may develop some cracks in due course of time. It is there for essential to stabilize such soils, prior to any construction work carried out on this to improve its engineering properties. At present waste materials like stone dust from crushers, lime from industry and plastic waste are in abundance at various parts of our country. These wastes not only create health problems but also its disposal is a great problem for our society. This paper deals with a feasibility study carried out to find the suitability of using waste material i.e. stone dust as stabilizing material for improving the engineering properties of bentonite soil. Various tests like CBR, Standard Proctor Test and DFS were performed on the soil samples prepared by using stone dust (5%, 10%, 15% 20% and 25%) mixed with bentonite soil. On the basis of the results obtained from these tests, it may be concluded that the strength of bentonite soil can be substantially improved by mixing with stone dust as stabilized materials.

Keywords: Expansive soil, Bentonite Soil, Stone Dust, Atterberg's limits, DFS, CBR, OMC and MDD.

I. INTRODUCTION

Expansive soils are mostly found in the arid and semi-arid regions and it covers very large area of the world. Expansive soils are found in many parts of the world. Argentina, Australia, Burma, Canada, Cuba, Ethiopia, Ghana, India, Iran, Mexico, Morocco, Rhodesia, South Africa, Spain, Turkey, U.S.A., Venezuela and Israel are reported to have significant area having expansive soil regions Donaldson, (1969). It covers nearly 20% of the landmass in India and includes almost the entire Deccan plateau, Western Madhya Pradesh, parts of Gujarat, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Karnataka, south-eastern Rajasthan and Maharashtra. For swelling to occur, these soils must be initially unsaturated at some water content. If the unsaturated soil gains water content, it swells.

Bentonite is essentially high plastic clay containing not less than 85% of montmorillonite clay mineral. It gets its name from the place where its presence and usages were first discovered – Fort Benton, America. Bentonite is of a great commercial importance possessing inherent bleaching properties like fuller's earth; hence, it is known as bleaching clay. There are two types of bentonites, namely, swelling type or sodium bentonite and non-swelling-type or calcium bentonite. Sodium bentonite is usually referred to as bentonite, whereas calcium bentonite is called Fuller's earth. The commercial importance of bentonite depends more on its physico-chemical properties rather than its chemical composition. Excellent plasticity and lubricity, high dry-bonding strength, high shear and compressive strength, low permeability and low compressibility make bentonite commercially viable. Bentonite is valued in foundry sand binding, drilling mud, iron are palletisation and as a waterproofing and sealing agent in civil engineering works. Processing is a prerequisite for bentonite marketing. Bhavnagar and Kachchh districts of Gujarat and Barmer district of Rajasthan are the major producers of bentonite.

Bentonite soil is a type of clayey soil having montmorillonite clay mineral, which expands when, comes in contact with water and shrinks when the water evaporates**.** This type of soils are generally found in humid environments where expansive problems occur with soils of high Plasticity Index (I_p) or in arid and semi-arid regions of the world where soils of even moderate expansiveness can cause significant damage.

II. LITERATURE REVIEW

Gupta et al. (2002) made a study on the stabilization of black cotton soil using crusher dust a waste product from Bundel khand region, India and optimal percentage of crusher dust was found to be 40%. There was reduction in the swelling potential along with improvement in other engineering properties and the reduction was increased with increasing percentage of stabilizers and days of curing.

Gulsah (2004) investigated the swelling potential of a synthetically prepared expansive soil (kaolinite and bentonite mixture), using aggregate waste (quarry dust) and lime.

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Soosan et al. (2005), the quarry dust/ crusher dust is obtained as solid wastes, during crushing of stones to obtain aggregates. The annual production of quarry dust is roughly around 200 million tons .The disposal of which creates a lot of geo environmental problems. A limited research is available regarding the utilization of this waste for stabilization of expansive soil

Praveen Kumar et.al (2006) conducted California Bearing Ratio (CBR) and static and cyclic tri-axial tests on the four most frequently encountered local materials—fly ash, coarse sand, stone dust, and river bed material (RBM)—for their use in the sub base layer of a flexible pavement. The CBR of stone dust was the maximum value of all, but its behaviour under dynamic load in tri-axial tests was inferior to that of the other materials. Fly ash has low CBR, but better stress-strain behaviour than stone dust.

Ali and Koranne (2011) had studied the combined effects of stone dust (quarry dust) and fly ash (equal proportion of stone dust and fly ash) on swell and strength properties of an expansive soil along with other properties. It was found that there was a maximum improvement in strength properties for the combination of fly ash and stone dust as compared to fly ash or stone dust, added separately.

III.EXPERIMENTAL INVESTIGATIONS

Various tests such as Atterberg's limits (liquid limit and plastic limit) ,DFS, CBR, OMC & MDD, etc., have been performed to find out the engineering properties of bentonite soil as well as the soil mixed with stone dust (5%, 10%, 15% 20% and 25%) as stabilized material.

A. Material Used

Bentonite soil **-** About 100kg of soil sample for the present work was collected from the Jaismer (Rajasthan)

Stone Dust **-** Stone dust for the present work was obtained from stone crusher located at Boranada, Industrial Area Jodhpur.

B. Atterberg's limits

Table 1: Atterbergs Limits of bentonite soil mixed with Stone dust

Stone dust (%)	Virgin Soil (%)	Liquid Limit (%)	Plastic limit (%)	Plasticity Index (%)
-	100	215	36	179
5	95	98	22	76
10	90	55	20	35
15	85	45	17	28
20	80	40	15	25
25	75	39	13	26

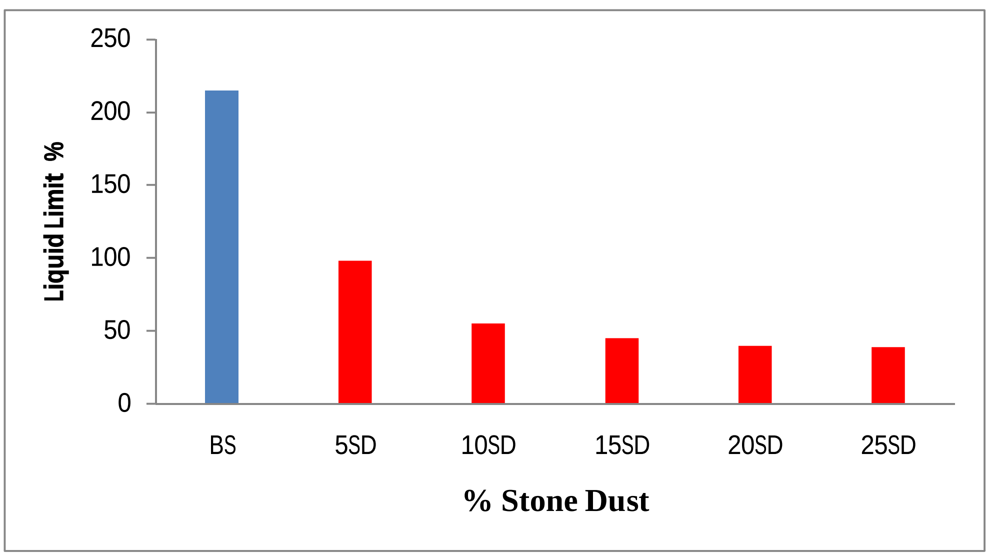

Figure 1: Variation in Liquid Limit with % Stone Dust

C. Standard Proctor Test

Table 2: OMC and MDD of bentonite soil mixed with stone dust

Stone dust (%)	Virgin Soil (%)	Optimum Water Content (%)	Max. Dry Density (g/cm^3)
-	100	32.3	1.58
5	95	30.3	1.64
10	90	29.2	1.66
15	85	28	1.67
20	80	26	1.68
25	75	27	1.62

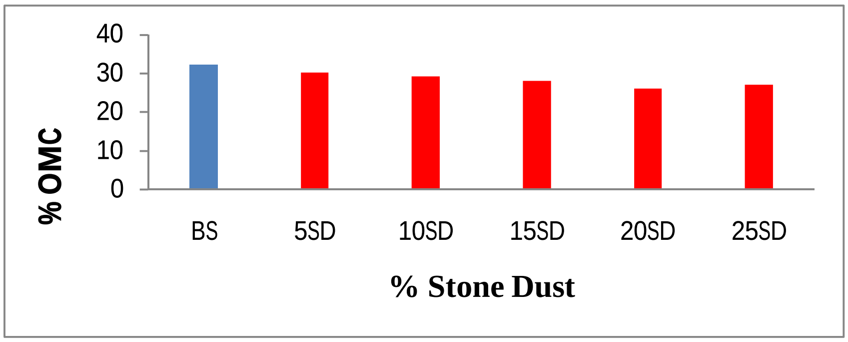

Figure 2: Variation of Optimum Moisture Content with % Stone Dust

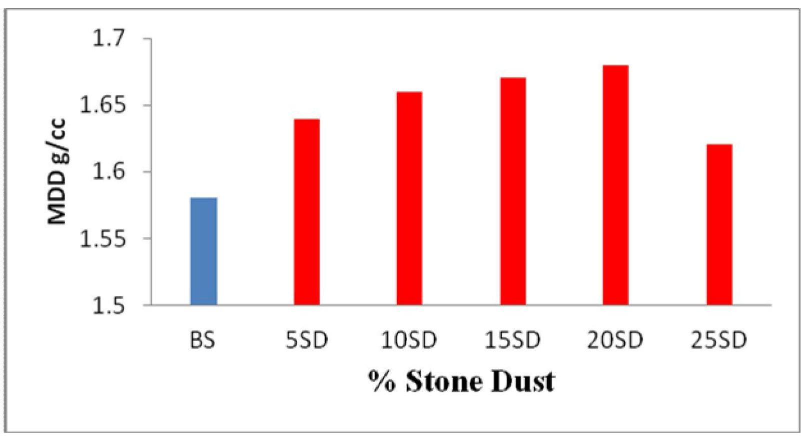

Figure 3: Variation in Maximum dry density with % Stone Dust

D. California Bearing Ratio

Table 3: Un-soaked CBR value for bentonite soil mixed with stone dust

Stone dust (%)	Virgin Soil (%)	Water Content (%)	CBR value at 2.5mm Penetration
-	100	32.3	1.83
5	95	30.3	4.01
10	90	29.2	4.38
15	85	28	5.11
20	80	26	6.57
25	75	27	5.48

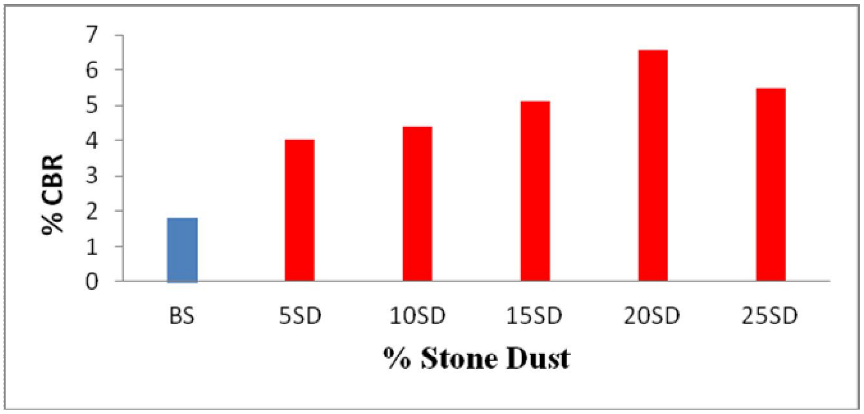

Figure 4: Variation in un-soaked CBR value with % Stone Dust

E. *Differential Free Swelling Index*

Table 4: DFS of bentonite soil with stone dust

Stone Dust (%)	Virgin Soil (%)	DFS (%)
-	100	107.69
5	95	91.67
10	90	84.62
15	85	76.92
20	80	46.15
25	75	61.54

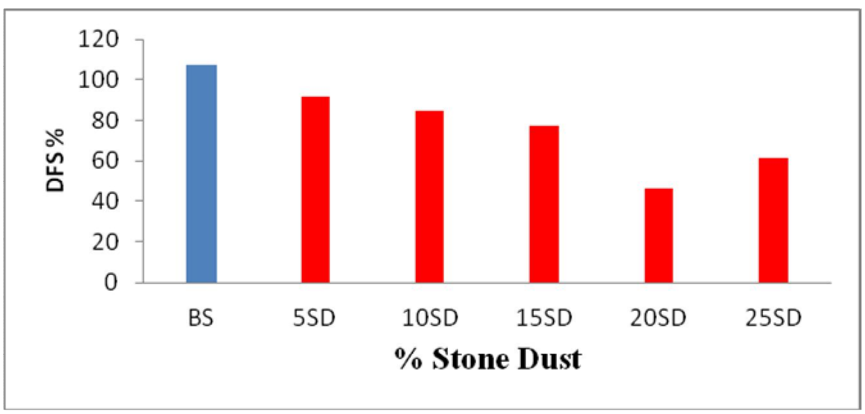

Figure 5: Variation in Differential Free Swelling Index with % Stone Dust

IV. DISCUSSIONS ON THE TEST RESULTS

A. *Discussion on Atterberg's limits Test results*

Liquid limit of bentonite soil was decreases by addition of stone dust at different percentage. The liquid limit of virgin bentonite soil was found to be 215% and the minimum value of liquid limit was found to be 39% at 25% stone dust.

The Plastic limit was decreases with addition of stone dust. Further addition of admixtures plastic limit 36% (for virgin soil) was found to be 13% for bentonite soil with mixed stone dust (25%).

B. *Discussion on the Standard Proctor Test results*

OMC & MDD of the virgin soil was found to be 32.3% and 1.58 g/cm^3 respectively. From the test results, it was found that the Optimum Moisture Content decreases and the maximum dry density increases with the addition of stone dust and maximum value of MDD was found to be 1.68 g/cm^3 with 26% OMC at 20% stone dust and minimum value of MDD was found to be 1.62 g/cm^3 with 27% OMC at 25% stone dust.

C. Discussion on the California bearing ratio results

Un-soaked CBR value of virgin bentonite soil was obtained as 1.83%. In un-soaked California Bearing Ratio (CBR) tests of soil conducted with varying stone dust content, the CBR increased gradually with the increase in stone dust content till its valuation was 20% by weight of the total mixture; it decreased thereafter. The maximum un-soaked CBR value 6.57% was found at addition of 20% stone dust.

D. Discussion on the Differential Free Swelling Index

Differential free swelling index of soil sample decreases with addition of stone dust content and it has been observed that maximum reduction in differential free swelling index was found 57.15% by addition of 20% stone dust.

V. CONCLUSION

On the basis of experimental investigations & results obtained, following conclusion can be drawn –

1) Liquid limit decreases from 215% (for virgin soil) to 39% by addition of 25% stone dust with bentonite soil.
2) Plastic limit was decreases with addition of stone dust. The plastic limit 36% (for virgin soil) was gradually decreased up to 13% for 25 % stone dust.
3) The optimum value of maximum dry density was found 1.68 g/cc at 20% stone dust whereas for virgin soil it was 1.58g/cc.
4) Optimum moisture content 32.3% (for virgin soil) was found gradually decreasing by addition of stone dust and optimum OMC was found 26% at 20% stone dust.
5) The un-soaked CBR value of virgin bentonite soil obtained as 1.83. On the addition of Stone dust, the value of un-soaked CBR increased and the maximum value of un-soaked CBR was found to be 6.57% with 20% stone dust.
6) The maximum reduction in DFS was found to be 57.15% with addition of 20%stone dust in bentonite soil.

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