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Stabilization of Marine Soil using Stone Dust

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Abstract: Certain types of soil expand when they are wetted and shrink when dried. These soils are called Expansive Soils or marine Soils (predominantly available in the coastal regions). They are soft and highly plastic, hence are more problematic for civil engineers in construction facilities. In order to overcome these problems Engineers are working on improvement of the poor Engineering properties of the soil. The aim of this project is to study the properties of marine soil before and after stabilization by using stone dust and find out its use in construction activities in the coastal regions. Certain basic tests like specific gravity, sieve analysis, atterberg's limits a

.nd standard compaction test were carried out on marine soil, stone dust and on their combination added in various proportions. Based on these results, OMC and MDD values were found out. California Bearing Ratio test was conducted to evaluate the subgrade strength of roads and pavement on different combinations of Marine soil and stone dust. The results obtained are analyzed and discussed further in detail.
Keywords: Marine Stabilization, Stone Soil dust.

I. INTRODUCTION

The term soil stabilization means the improvement of stability or bearing power of the soil by the controlled compaction, proportioning and/or the addition of suitable admixture or stabilizers.

Admixtures are the manufactured commercial products that, when added to the soil in the proper quantities, improve some engineering characteristics of the soil such as strength, texture, workability and plasticity. Soil stabilization deals with physio-chemical and chemical methods to make stabilized soil serve its purpose as a construction material. It is the alternation of the soil to enhance their physical properties. Stabilization can increase the shear strength of the soil and/or control the shrink-swell properties of a soil, thus improving the load bearing properties of a soil, thus improving the load bearing capacity of the sub-grade to support the pavements and foundations.

Marine soil properties. They can creep over time under constant load, especially shear stress approaching its shear strength. Making them prone to sliding. These soils experience significant volume change associated with changes in water contents. These volume changes can either be in the form of swell or in the form of shrinkage and this is why they are sometimes known as swell/shrink soils. The clay mineral, Montmorillonite exhibits the highest percentage of swell shrink behavior. Key aspects that need identification when dealing with expansive soils include: soil properties, suction/water conditions, water content variations temporal and spatial. Such soils cannot be used for construction activities and needs to be stabilized in order to develop the various engineering properties.

II. ADVANTAGES OF STABILIZATION

A. To improve certain undesirable properties of soils, such as excessive swelling or shrinkage, high plasticity, difficulty in compacting etc.
B. To strengthen a weak soil and restrict the volume change potential of a highly plastic or compressible soil.
C. To reduce compressibility and thereby settlements.
D. Sometimes, Soil stabilization is also used to prevent Soil Erosion or Formation of Dust, which is very useful especially in Dry and Arid Weather.
E. It is also used to provide more Stability to the soil in slopes or other such places. Stabilization improves the Workability and the Durability of the soil
F. It is also done for soil water proofing. This prevents Water from Entering into the soil and hence helps the soil from losing its Strength.
G. To bring about economy in the cost of construction.
H. To increase the dry density of the soil using stabilizers.

III. MATERIALS AND METHODS

1) *Marine soil:* As discussed earilier , marine soil was collected from karwar region and was transported.
2) *Stone Dust:* Stone dust is collected from our campus which was transported from the quarry which is nearby hence the stone dust was made use. After collecting it was sieved and all the waste particles were removed.
3) *Methodology:* Different basic tests were conducted on the soil and stone dust to know their geotechnical properties in accordance with the IS codes to have an idea about the geotechnical properties of soil and stone dust. The changes in the properties of the soil by replacing the soil with stone dust are discussed in detail in this study. Even the strength characteristics of the stone dust added to the soil is discussed by conducting unconfined compression tests.

IV. RESULTS AND DISCUSSIONS

A. The Tests Conducted On Marine Soil Are

1) Specific Gravity
2) Atterberg's limits (Liquid limit, Plastic Limit)
3) Sieve Analysis
4) Standard Proctor Compaction Test
5) California Bearing Ratio test

a) *Specific Gravity:* Performed in accordance to IS 2720 part 3.

	Pycnometer method			Density bottle method		
	Trail 1	Trail 2	Trail 3	Trail 1	Trail 2	Trail3
W1(g)	638	638	638	64	64	64
W2(g)	1143	1087	1085	127	126	123
W3(g)	1855	1821	1812	202	201	200
W4(g)	1540	1540	1540	162	162	162
G	2.65	2.67	2.55	2.73	2.69	2.80
Avg	2.63			2.74		

Table 1: Results of specific gravity of soil

b) *Atterberg's Limits:* Liquid limit was conducted using Casagrande's apparatus. A graph was plotted between No of blows and water content. Corresponding to 25 blows the liquid limit came to be 38%.The given soil sample was unable to crumble at any moisture content when it was rolled into a thread approximately 3mm in diameter. So, the given soil sample was reported as Non Plastic (NP).It was performed in accordance to IS 2720 part 5.
c) *Sieve Analysis:* It was performed in accordance to IS 2720 part 4.

Sl no	Sieve size	weight retained	%weight retained	Cumulative weight retained	% finer
1	4.75mm	2g	0.2	0.2	99.8
2	2.36mm	2g	0.2	0.4	99.6
3	1.18mm	3g	0.3	0.7	99.3
4	0.600mm	4g	0.4	1.1	98.9
5	0.425mm	712g	71.2	72.3	27.7
6	0.300mm	169g	16.9	89.2	10.8
7	0.150mm	95g	9.5	98.7	1.3
8	0.075mm	12g	1.2	99.9	0.9
9	Pan	1g	0.1	100	0

Table 2: Results of sieve analysis for marine soil

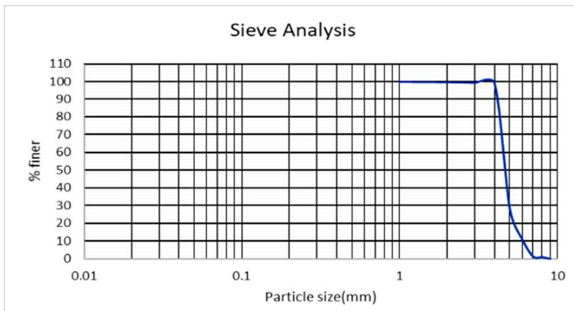

Fig 1: Grain size distribution curve for marine soil

D_{10}=0.58, D_{30}=0.78, D_{60}=0.83

Coefficient of Uniformity,Cu= $\frac{D60}{D10}$ =1.43

Coefficient of Curvature,Cc= $\frac{D30*D30}{D60*D10}$ =1.263

d) Standard Proctor Test: It was performed in accordance to IS 2720 (part 7)

% Water	Weight of mould +soil(g)	Moisture content(%)	Bulk Density (g/cc)	Dry Density (g/cc)
2	10097	1.9	1.470	1.442
4	10121	3.44	1.494	1.444
6	10149	5.26	1.522	1.445
8	10189	7.34	1.562	1.455
10	10231	9.68	1.604	1.463
12	10271	11.69	1.644	1.471
14	10295	13.56	1.688	1.486
16	10347	15.34	1.720	1.487
18	10401	17.53	1.774	1.509
20	10455	19.49	1.828	1.520
22	10393	21.6	1.716	1.411
24	10317	23.45	1.690	1.368
26	10276	25.22	1.649	1.316
28	10224	27.27	1.597	1.255

Table 3: Compaction results for marine soil

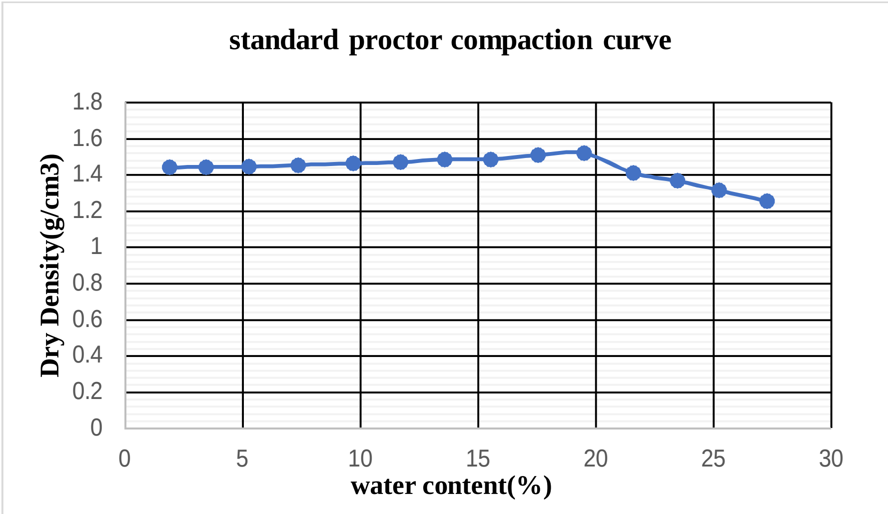

Fig 2: Variation of OMC and MDD for marine soil

e) California Bearing ratio Test: The tests was conducted in accordance with IS:2720-1987(PART 16).

Penetration (mm)	CBR Value
2.50	3.18
5.00	3.20

Table 4: CBR results for marine soil

B. The tests conducted on stone dust are

1) Specific Gravity
2) Sieve Analysis
3) Standard Proctor Compaction Test
4) California Bearing Ratio test

a) Specific Gravity Test On Stone Dust

	Pycnometer method		
	Trial 1	Trail 2	Trail 3
W1(g)	621	622	623
W2(g)	971	951	952
W3(g)	1728	1721	1720
W4(g)	1517	1525	1525
G	2.52	2.47	2.46
Average	2.48		

Table 5: Results of Specific gravity test for stone dust

b) Sieve Analysis

Sl. no.	Sieve size(mm)	Weight retained(g)	%weight retained	Cumulative wt.retained(%)	% finer
1	4.75	24	2.4	2.4	97.6
2	2.36	51	5.1	7.5	92.5
3	1.18	136	13.7	21.2	78.8
4	0.600	702	70.2	91.4	8.6
5	0.425	48	4.8	96.2	3.8
6	0.300	8	0.8	97	3
7	0.150	18	1.8	98.8	1.2
8	0.075	3	0.3	99.1	0.9
9	pan	2	0.2	99.3	0.06

Table 6: Sieve analysis results for Stone dust

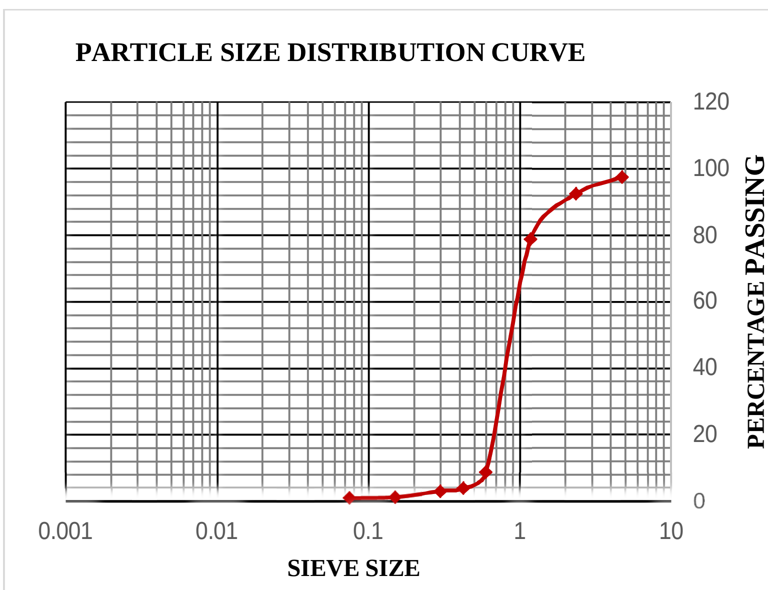

Fig 3: Particle size distribution curve for stone dust

From the graph,
D_{10} = 0.62
D_{30} = 0.78
D_{60} = 0.98
Co- efficient of uniformity(C_u)=$\frac{D30}{D10}$= 1.58
Co-Efficient of curvature(Cc) = $\frac{D30^2}{D60*D10}$ = 1.265
Therefore the stone dust sample taken is well graded.

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c) Standard Proctor Test For Stone Dust

% water	Weight of mould+ soil	Moisture content(%)	Bulk density (g/cc)	Dry density(g/cc)
5	6582g	4.05	2.09	1.99
8	6629g	7.411	2.141	1.982
11	6586g	10.08	2.097	1.889
14	6492g	13.43	2.00	1.755

Table 7: Compaction test results for Stone dust

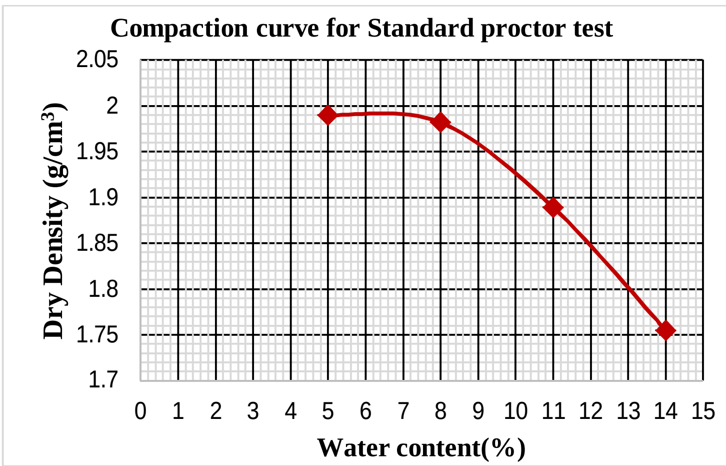

Fig 4: Compaction curve for Stone dust

d) California Bearing Ratio Test: The tests was conducted in accordance with IS:2720-1987(PART 16).

Penetration (mm)	CBR Value
2.50	3.39
5.00	3.18

Table 8: CBR results for stone dust

C. Results Of Tests On The Combination Of Marine Soil And Stone Dust

1) *Standard Proctor Test:* Thistest was performed on the combination of Marine soil (Ms) and Stone dust (Sd).The tabular column and graphs of compaction test for different combinations of Ms and Sd are given below:

Trail 1:90%Ms + 10%Sd

% Water	Wt. of mould+soil(g)	Moisture Content(%)	Bulk Density(g/cc)	Dry Density(g/cc)
8	6079	7.46	1.77	1.64
11	6139	10.42	1.83	1.65
14	6217	12.27	1.91	1.67
17	6301	15.43	1.99	1.70
19	6281	14.51	1.97	1.66

Table 9: Results of compaction test for 90%Ms and 10%Sd

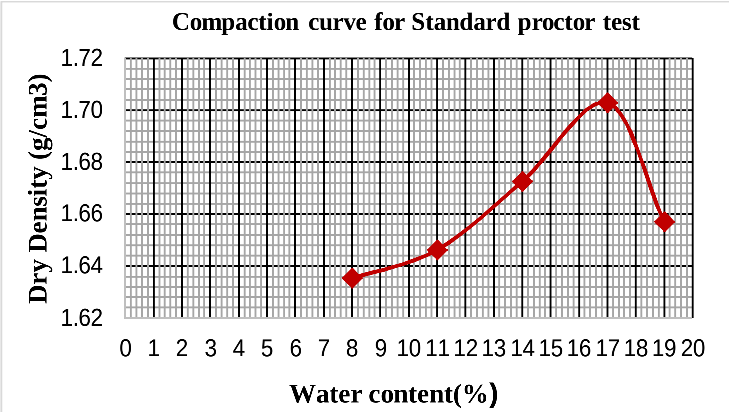

Fig 5: Graph of MDDand MC for 90%Ms and 10% Sd

For this combination the MDD and OMC values are 1.702g/cc and 15.43%.

Trail 2:80%Ms + 20%Sd

% water	Weight of mould+ soil	Moisture content(%)	Bulk density	Dry density(g/cc)
8	6101g	7.35	1.788	1.655
11	6160g	10.79	1.849	1.66
14	6262g	12.69	1.953	1.713
17	6299g	15.23	1.99	1.7
19	6233g	16.74	1.974	1.658

Table 10: Results of compaction test for 80%Ms and 20%Sd

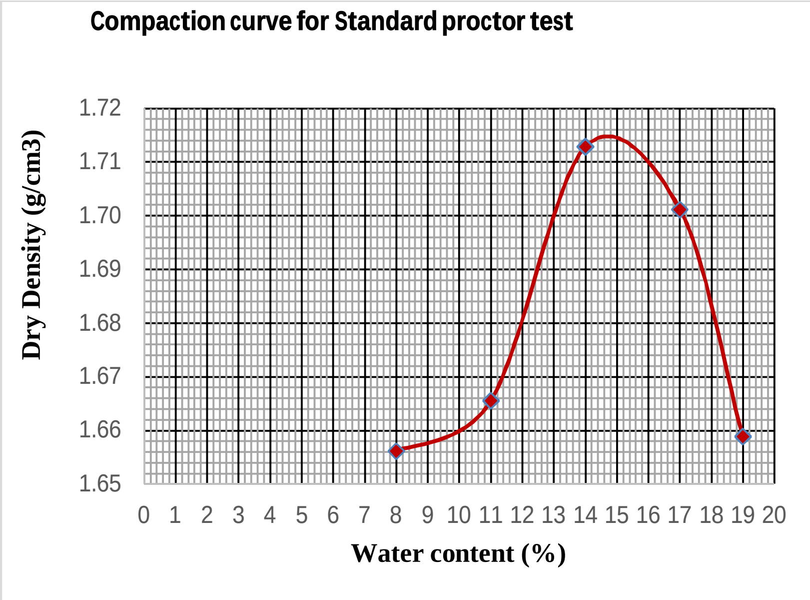

Fig 6: Graph of MDD and OMC for 80%Ms and 20%Sd

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
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Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

For this combination the MDD and OMC values are 1.70g/cc and 15.23%

Trail 3:70%Ms + 30%Sd

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
8	6183g	7.383	1.872	1.733
11	6299g	10.31	1.99	1.793
14	6433g	11.81	2.126	1.865
16	6349g	14.76	2.04	1.758

Table 11: Results of compaction test for 70%Ms and 30%Sd

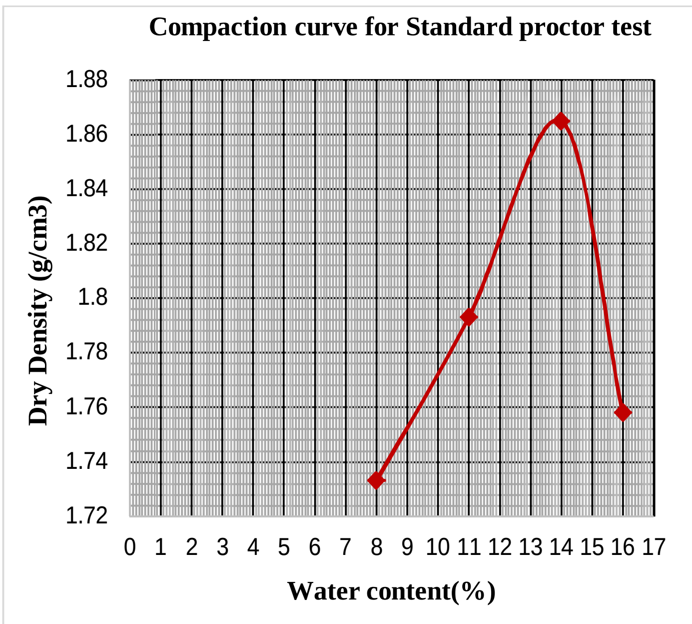

Fig 7: Graph of MDD and OMC for 70% Ms and 30% Sd

For this combination the MDD and OMC values are 1.865g/cc and 9.82%

Trail 4:60%Ms + 40%Sd

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
8	6269g	7.94	1.959	1.814
11	6350g	10.41	2.042	1.839
14	6393g	12.50	2.086	1.796
16	6301g	14.14	1.992	1.717

Table12: Results of compaction test for 60%Ms and 40%Sd

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Volume 7 Issue IV, Apr 2019- Available at www.ijraset.com

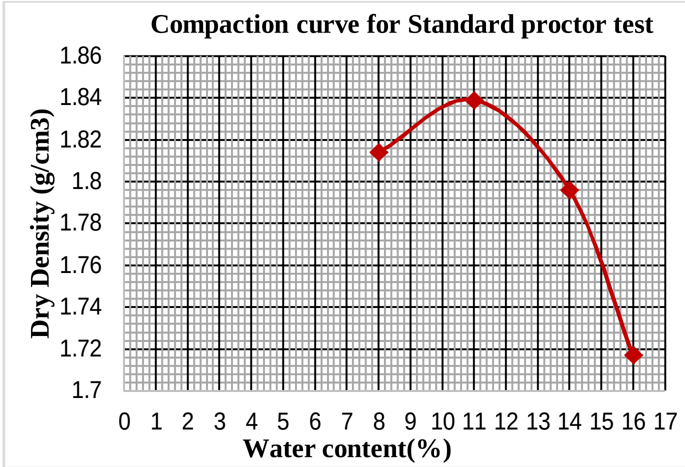

Fig 8: Graph of MDD and OMC for 60%Ms and 40%Sd

For this combination the MDD and OMC values are 1.796g/cc and 12.5%

Trail 5:50%Ms + 50%Sd

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
8	6279g	7.70	1.969	1.823
11	6345g	10.59	2.037	1.835
14	6431g	12.96	2.124	1.863
16	6392g	15.93	1.085	1.797

Table 13: Results of compaction test for 50%Ms and 50%Sd

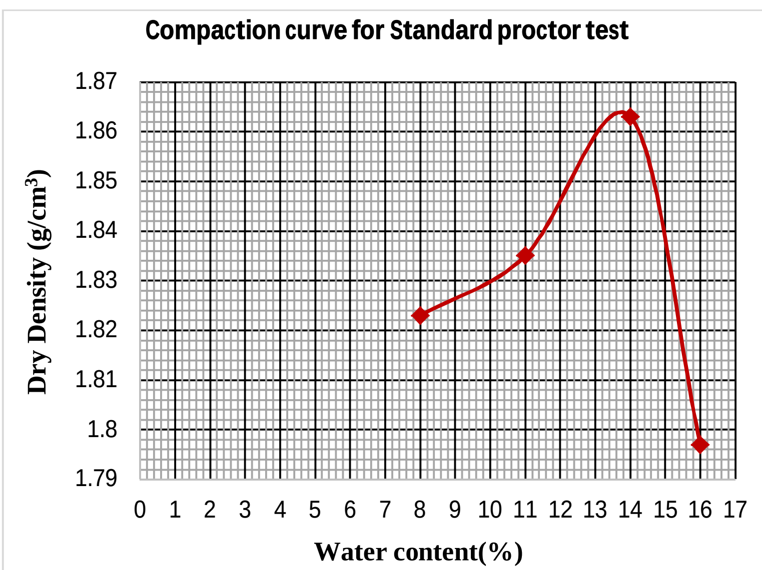

Fig 9: Graph of MDD and OMC for 50%Ms and 50% Sd

For this combination the MDD and OMC values are 1.863g/cc and 12.97%

Trail 6:40%Ms + 60%Sd

% water	Weight of mould+ soil	Moisture content(%)	Bulk density	Dry density(g/cc)
8	10542g	7.93	2.054	1.902
11	10612g	10.79	2.125	1.914
14	10646g	12.12	2.160	1.895
16	10590g	15.15	2.103	1.862

Table 14: Results of compaction test for 40%Ms and 60%Sd

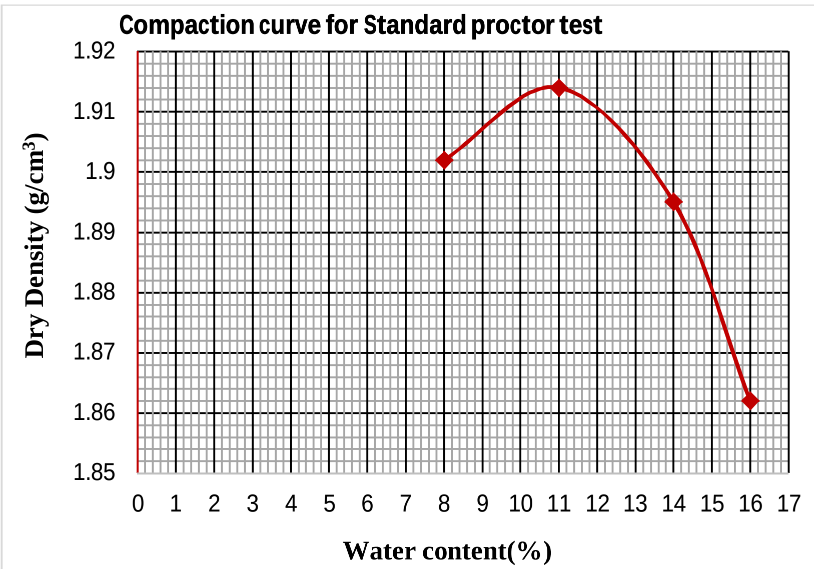

Fig 10: Graph of MDD and OMC for 40%Ms and 60% Sd

For this combination the MDD and OMC values are 1.895g/cc and 12.13%

Trail 7:30%Ms + 70%Sd

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
8	6320g	7.795	2.011	1.862
11	6394g	10.032	2.087	1.880
14	6413g	11.085	2.106	1.847
16	6326g	14.439	2.017	1.739

Table 15: Results of compaction test for 30% Ms and 70%Sd

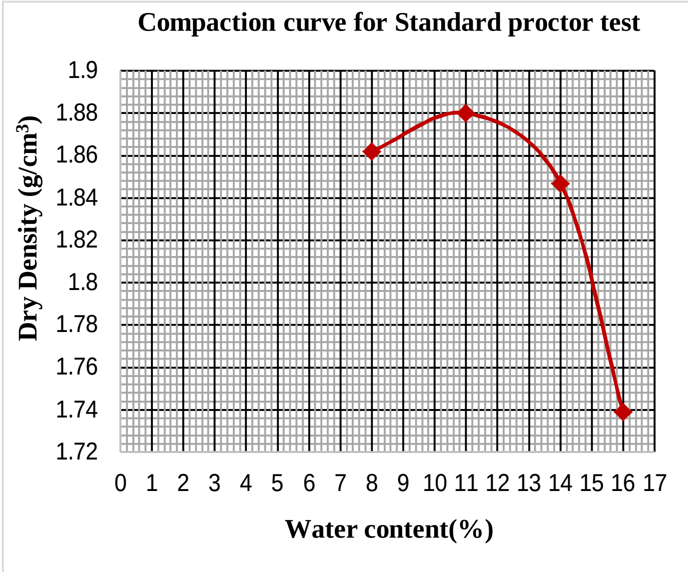

Fig 11: Graph of MDD and OMC for 30%Ms and 70%Sd

For this combination the MDD and OMC values are 1.847g/cc and 11.09%

Trail 8:20%Ms + 80%Sd

% water	Weight of mould+ soil	Moisture content(%)	Bulk density	Dry density(g/cc)
8	10449g	6.23	1.959	1.814
11	10585g	9.29	2.098	1.890
14	10401g	13.58	1.91	1.895

Table 16: Results of compaction test for 20%Ms and 80%Sd

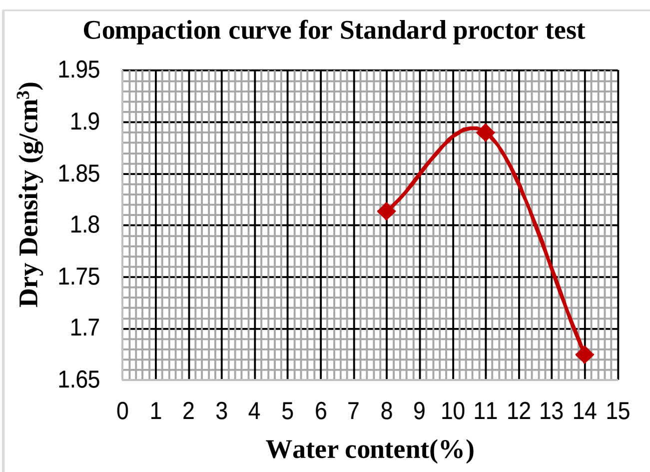

Fig 12: Graph of MDD and OMC for 20%Ms and 80% Sd

For this combination the MDD and OMC values are 1.890g/cc and 9.29%

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Trail 9:10%Ms + 90%Sd

% water	Weight of mould+ soil	Moisture content (%)	Bulk density	Dry density(g/cc)
8	6341g	7.48	2.033	1.882
11	6245g	8.85	1.935	1.743

Table 17: Results of compaction test for 10% Ms and 90%Sd

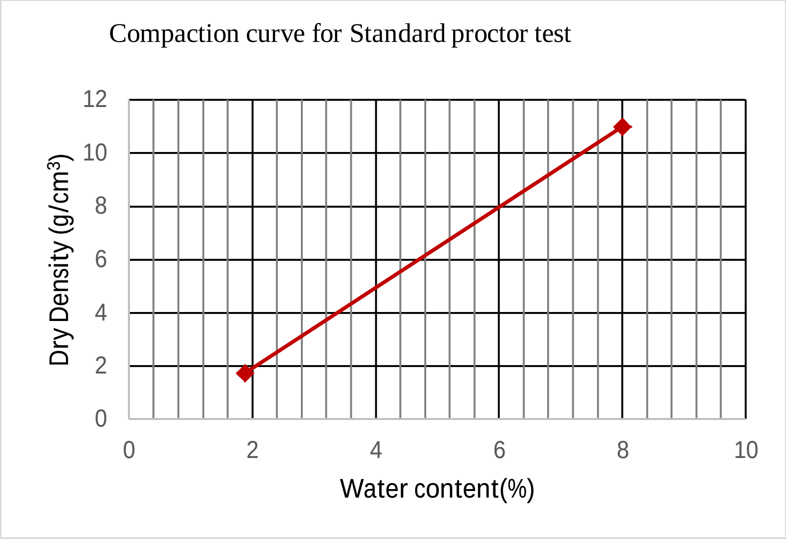

Fig 13: Graph of MDD and OMC for 10%Ms and 90% Sd

For this combination the MDD and OMC values are 1.882g/cc and 7.48%

D. California Bearing Ratio Test

The California Bearing Ratio test is conducted for evaluating the suitability of the subgrade and materials used in sub-base and base course of a flexible pavement. CBR is defined as the ratio of force per unit area required to penetrate a soil mass with a circular plunger of 50mm diameter at the rate of 1.25mm/min to that required for corresponding penetration of a standard material. The specimens are prepared in a cylindrical mould of 150 mm-diameter and 175-mm height and compacted in three layers at its MDD and OMC based on the standard Proctor compaction. The tests were conducted in accordance with IS:2720-1987(PART 16). The mould is kept under CBR testing machine and the load corresponding to the 2.5mm and 5.0mm are taken from load penetration curve to determine the CBR Values. **CBR Value = (Test load/Standard load) × 100** Soaked CBR tests were conducted for the combination of marine soil and stone dust added in various proportions. After compacting the combinations of Ms and Sd in CBR mould, the set-up is kept submerged in water for about 4 days. The specimen is covered with surcharge mass to simulate the effect of overlying material. After 96 hours of submergence, it is taken out and tested to determine the soaked CBR Value.

*Soaked CBR Test :*In soaked CBR test, after preparing the specimens, the specimens are immersed in water and soaked for 4 days to simulate the worst condition of soil. After soaking period is completed, the specimens are tested using CBR testing machine. The soaked CBR condition was selected as it reflected the worst condition to which a pavement soil can be subjected to, as when compared to the unsoaked CBR test conditions. Results of CBR tests for different combinations of Marine soil and stone dust are as presented below:

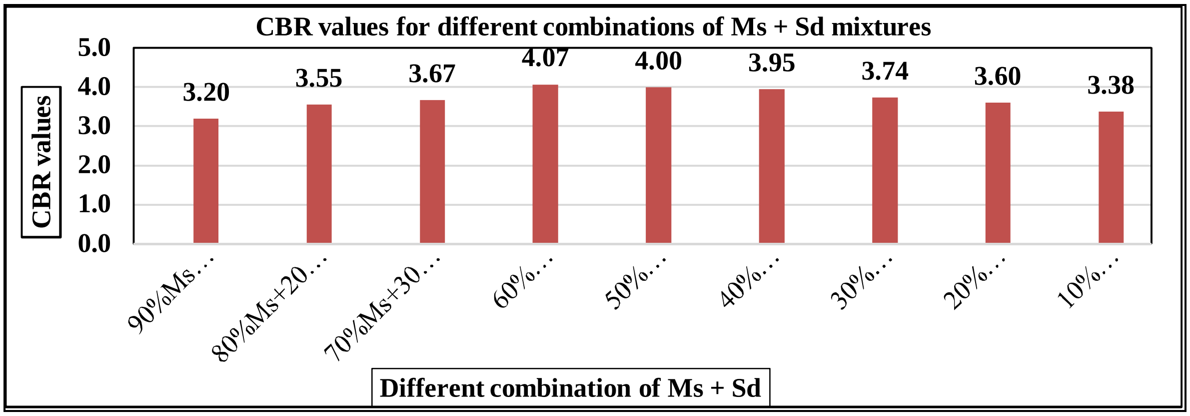

Fig 14. CBR values for different combinations of Marine soil (Ms) & stone dust (Sd) mixtures

	90%Ms +10%Sd	80%Ms+ 20%Sd	70%Ms +30%Sd	60%Ms +40%Sd	50%Ms +50%Sd	40%Ms +60%Sd	30%Ms +70%Sd	20%Ms +80%Sd	10%Ms +90%Sd
Penetration (mm)	CBR Value	CBR Value	CBR Value	CBR Value	CBR Value	CBR Value	CBR Value	CBR Value	CBR Value
2.50	3.20	3.55	3.67	4.07	4.00	3.95	3.74	3.60	3.38
5.00	3.23	3.41	3.54	3.98	3.89	3.82	3.65	3.51	3.16

Table 18: Results of soaked CBR tests conducted for different combinations of Marine soil (Ms) & stone dust (Sd) mixtures

From the Table 16 and Fig 14, it can be observed that, the higher values of CBR is obtained between 60% Ms + 40% Sd combination and 50% Ms + 50% Sd combinations.

V. CONCLUSION

A. With reference to the particle size distribution curve, $C_u$and C_c values for marine soil are 1.43 and 1.263 respectively indicating that the soil sample is well graded whereas in case of stone dust, C_u and $C_c$values are1.58 and 1.265 which resembles that stone dust sample is well graded.

B. From the above results of Standard compaction test, referring to all the OMC and MDD values, the best possible mix obtained is 70%(soil) and 30%(stone dust) whose OMC and MDD values are 1.864g/cm^3 and 14%(from Table no.11 and figure no.7)respectively.

C. After obtaining the results conducted on CBR test in its soaked condition (which reflects the worst case),we observe that the CBR values at 2.5mm penetration are greater than 5mm penetration (refer table No.18) and hence the values corresponding to 2.5mm are considered. The combination of Ms and Sd at which the CBR value is high is observed in between 60% Ms + 40% Sd combination and 50% Ms + 50% Sd combinations (from table no.18 and figure no.14).

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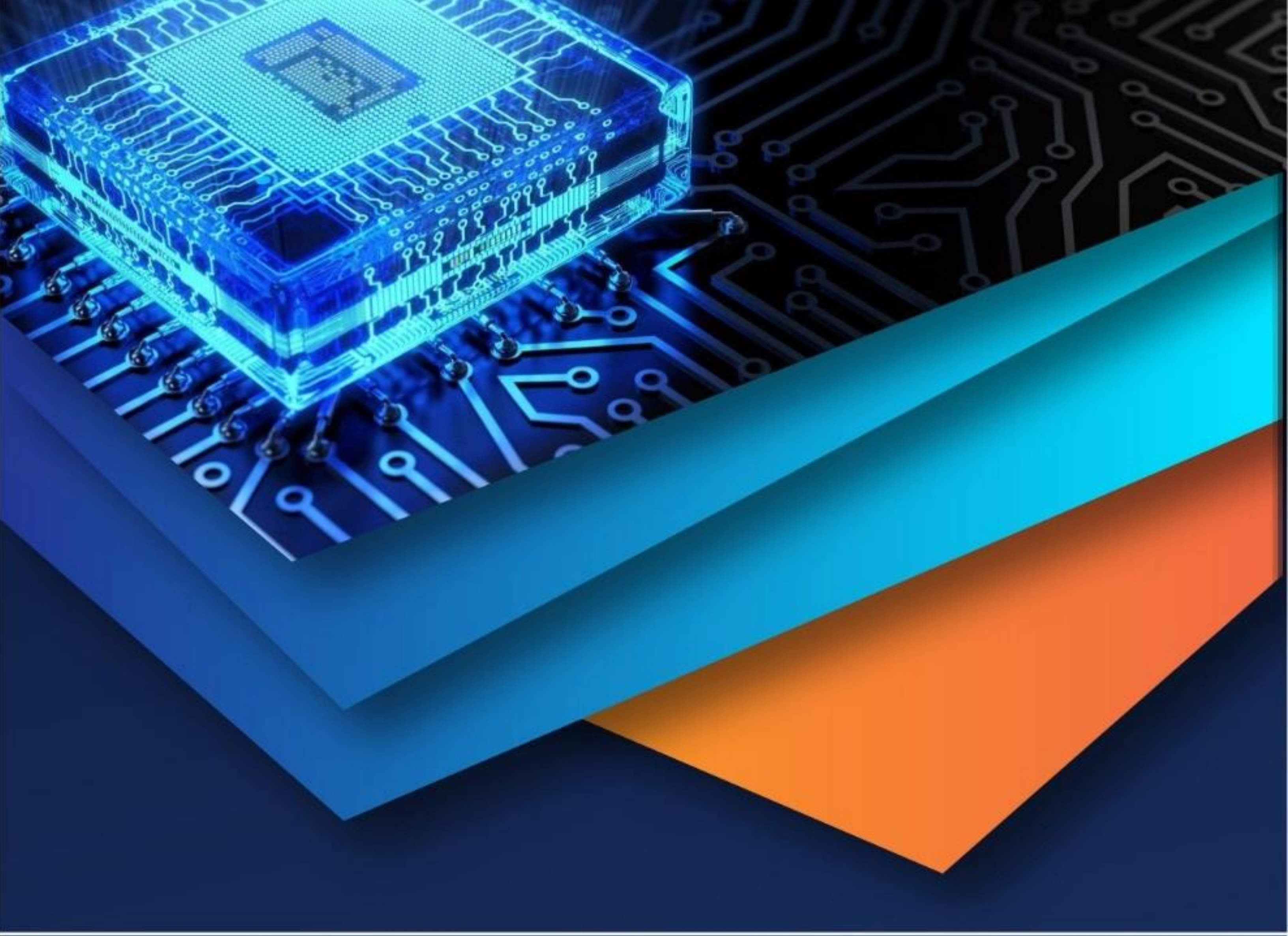

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