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EFFECT OF STONE DUST ON GEOTECHNICAL PROPERTIES OF POOR SOIL

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ABSTRACT

California Bearing Ratio (CBR) is a commonly used indirect method to assess the stiffness modulus and shear strength of sub-grade soil in pavement design works, however; if the CBR of available soil is poor, it needs to be improved. Soil stabilizationand mixing of coarse grained soils are some methods of improving CBR of existing soils.Usually fly ash and lime stones are preferred for stabilizing the soil since they possess the pozolanic property but the drawback with these materials are that they don't possess coarser soil particles in them, therefore some of the properties are left to be modified. On the other hand mixing simply the coarser soil in poor soil is also not the proper solution since they do not possess cohesion and pozolanic property. Therefore it was decided to use the material that possess both property so that first hand solution may be given for the strength improvement of the soil.

It was found that the stone dust is the material that possesspozolanic as well coarser contents in it. As well as they are easily available at many locations. Therefore, it was decided to use this material in the present study as stabilizing agent for poor soils. The poor soils like black cotton soil, expansive soil and highly cohesive soil which have CBR less than about 3% can be improved by adding 20-30% sand or stone dust.

With this is view in the present work contains the study of stabilizing behavior of commonly found soil that is black cotton soil. For this purpose their basic properties like percentage finer, LL, PI, particle size distribution, Compaction parameter and soaked CBR were determined from laboratory method. Further stone with relative proportion of 10%, 20%, and 30% by weight of raw soil were mixed to this soil and various properties as mentioned above were determined again. The soaked CBR of this soil (with and without stone dust) were related to percentage finer, LL, PI, Particles size and Compaction properties of soil. From the results of present study and the review of the literature, it may be concluded that the CBR of poor soil can be improved by mixing coarse material like stone dust in it. Further, the material of moderate CBR can also be improved significantly. The other requirement of GSB of grade-Ш like LL, PI and gradation may also be adjusted by manipulating the quantity of stone dust and if required by adding little amount of lime or cement (1 to 2%).

Keywords: Stonedust, Black Cotton Soil, CBR.

1. INTRODUCTION

Californiabearing ratio (CBR) is frequently used as an index test in Civil engineers particularly those in pavement construction to assess the stiffness modulus and shear strength of the sub-grade material. The California bearing ratio test method was originally developed at California division of highways in 1930. It is in essentially a simple penetration test developed to evaluate the strength of road sub-grades.

For soils CBR values falling below 3% is termed as poor soil. The pavement on low CBR valued soils requires more thickness of base course.However increasing the thickness is not the actual solution since there is no substantial increase in the wearing stress (WAPA asphalt pavement guide, 2002).The CBR of poor soil can be improved up to a required level by mixing various additives such as fly ash, sand, soil, fibers, and stone dust etc.

These additive have been used in several sites for the improvement of strength of soil as well as numerous researchers have carried out experiments for improving CBR value of poor soils using different proportions. As discussed above that stone dust is also one of the additive that may be used as stabilizing agent for the improving the strength of soil, therefore the present work is an effort an effort of developing a strategy for improving strength of poor soil by mixing stone dust for road construction.In addition, a statistical model is also developed for estimation of CBR from basic soil properties. Stone dust is the remains of crushed stones thatis widely available at crusher sites where stones are crushed to give it desired shape and sizes for various engineering applications. The residue of these stones may be mixed to the poor cohesive soils and expansive soils to change their behavior for the application of pavement material.

Objectives of the study

- To study the effect of stone dust on liquid limit, plastic limit, plasticity index and free swell index of soil.
- To study the effect of stone dust on compaction characteristics of soil.
- To study the effect of stone dust on CBR value of soil.
- To develop statistical model for determining CBR value of soil.

2. EXPERIMENTAL METHOD

The sample obtained was the black cotton soil which available in Allahabad city at a depth of 0.5 m to 1.5 m below ground level. The stone dust was mixed in poor soil in different proportions so as to study the changes in properties of the soil. The stone dust was collected from the crusher plant situated at Meza Road, Allahabad. The properties of stone dust for example particle size distribution and OMC, MDD and CBR value of stone dust is given in ongoing literatures.

In order to improve the CBR of soils stone dust, it was mixed to them in different percentages. Further, it was attempted from the analysis of results that which percentage of the stone dust is most suitable for enhancing the strength.

3. RESULTS AND DISCUSSION

Results of stone dust

The particle size distribution is given in table 1and shown in figure 1. The compaction graph and CBR graph are shown in figure 2 and 3 respectively.

Table 1: Particle size distribution of stone dust

Sieve size in mm	4.75	2.3	1.2	0.600	0.425	0.300	0.150	0.075
Percentage finer	100	81.23	50.54	23.78	18.87	15.23	12.48	8.25

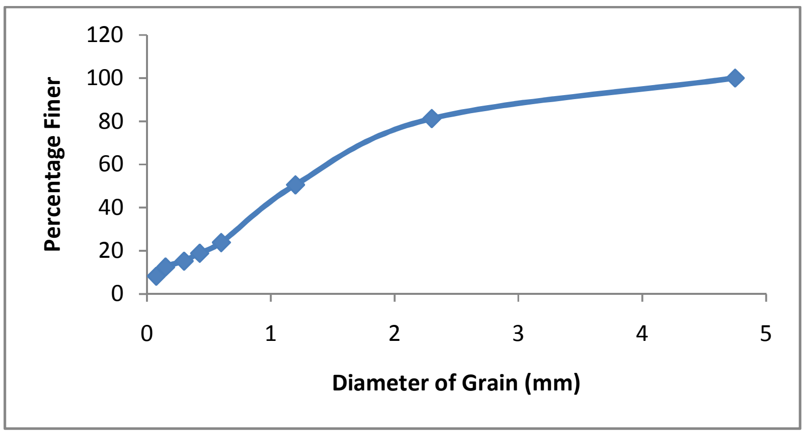

Figure 1: Particle size distribution curve of stone dust

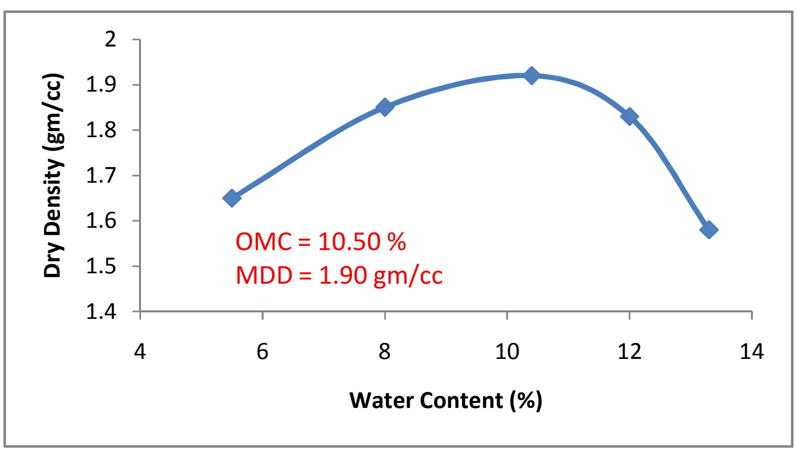

Figure 2: Compaction curve for stone dust

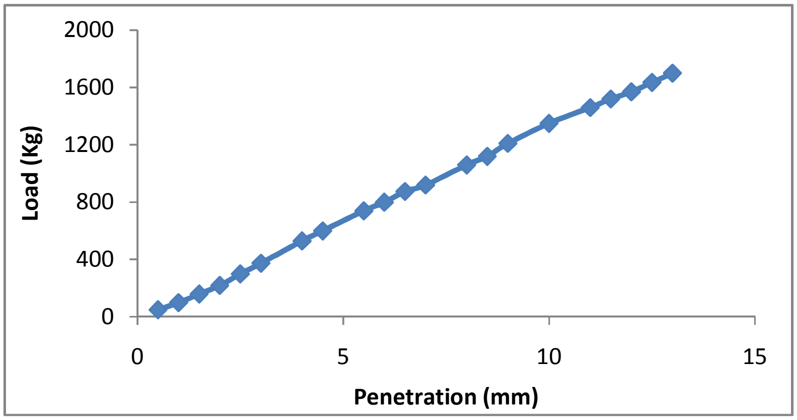

Figure 3: Load penetration curve for stone dust

The summary of test results for stone dust is as follows table 2

Table 2: Test results of stone dust

S.No.	Parameter	Value
1	D_{60}	1.60
2	OMC	10.50%
3	MDD	1.90g/cc
4	CBR Value	59%

Results of black cotton soil

The black cotton soil used in the present study is classified as MH, i.e. silt of high compressibility and plasticity. The compaction curve and CBR graphs of soil sample mixed with stone dust in varying percentages are shown in fig..4 to 7 and fig. 8 to 11 respectively.

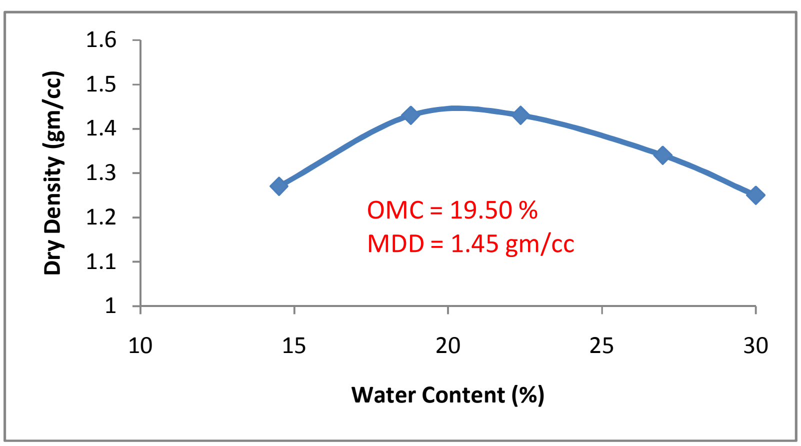

Figure 4: Compaction curve for black cotton soil

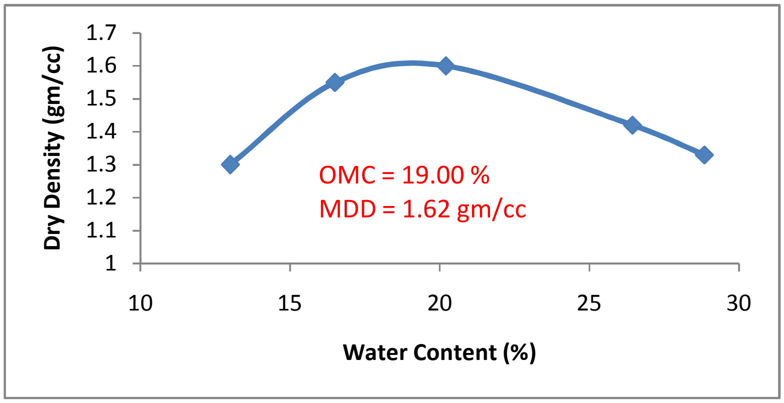

Figure 5: Compaction curves for black cotton soil with 10% stone dust

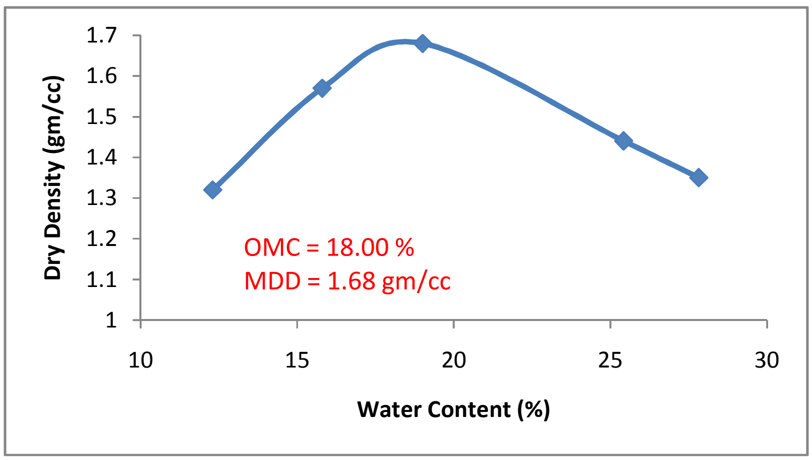

Figure 6: Compaction curve for black cotton soil with 20% stone dust

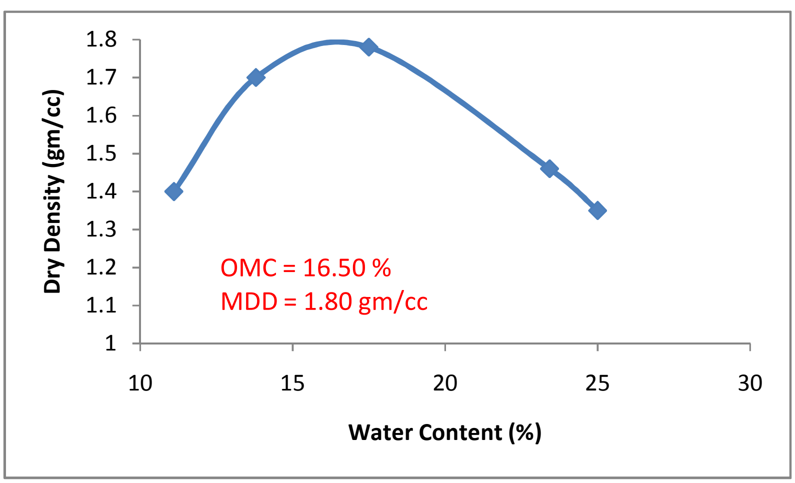

Figure 7: Compaction curve for black cotton soil with 30% stone dust

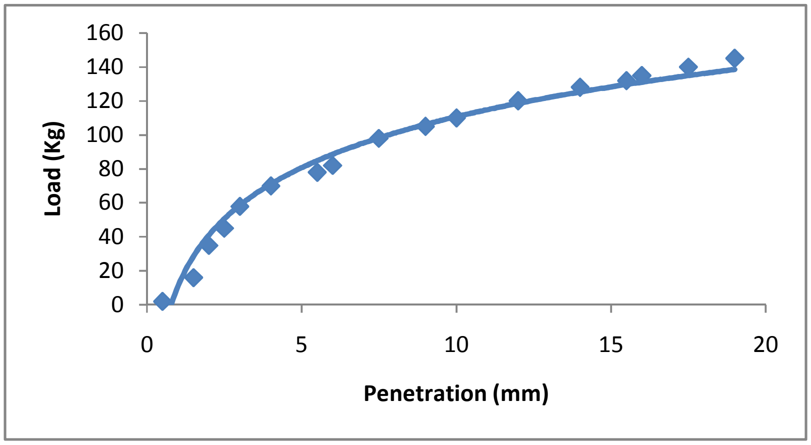

Figure 8: Load penetration curve for black cotton soil

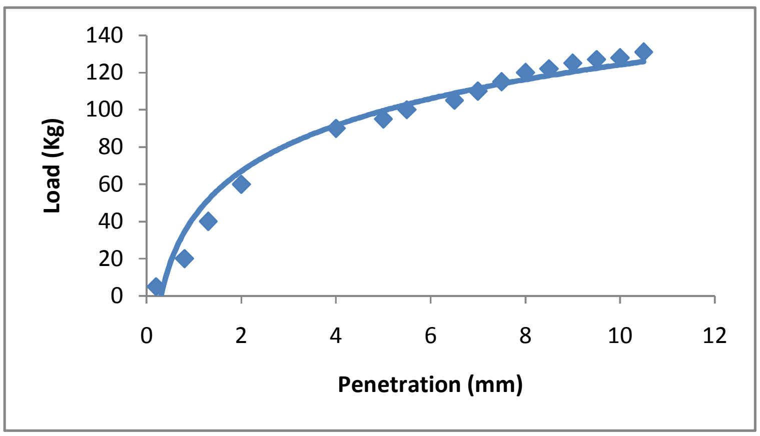

Figure 9: Load penetration curve for black cotton soil with 10% stone dust

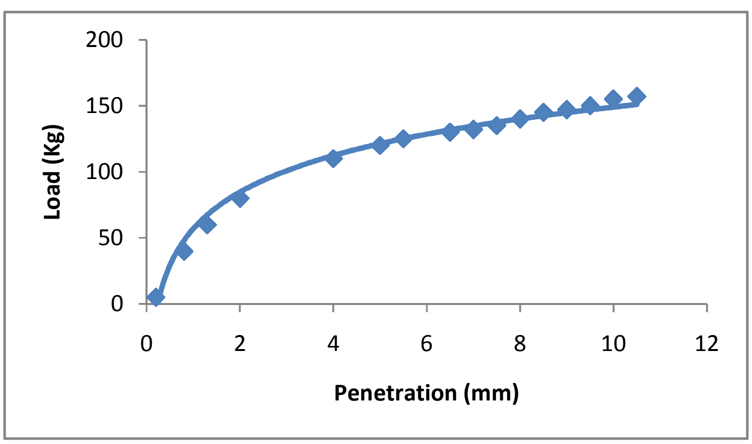

Figure 10: Load penetration curve for black cotton soil with 20% stone dust

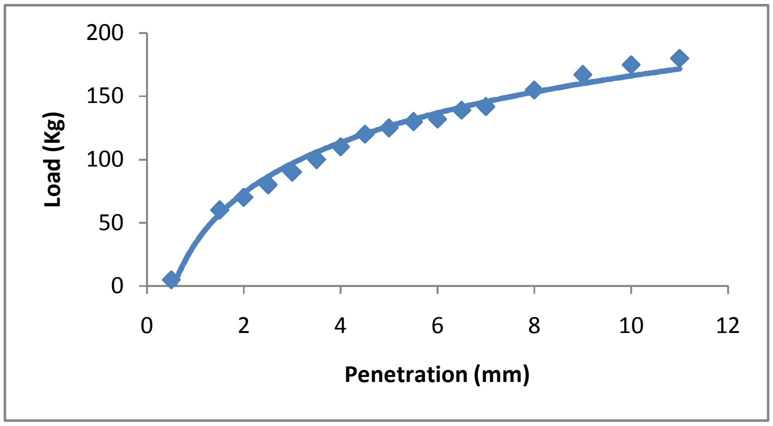

Figure 11: Load penetration curve for black cotton soil with 30% stone dust

Table 3: Summary of test results for stabilized black cotton soil

Parameters	Stone dust mixed by weight of raw soil			
	0%	10%	20%	30%
Percentage finer (75μ)in %	97.38%	86.35	81.57	65.00
Liquid limit, %	56	48	42	30
Plastic limit,%	31	29	25	21
Plasticity index, %	25	19	17	9
Classification group	MH	MI	MI	ML
DFS value,%	52	41	36	27
OMC,%	19.50	19	18	16.50
MDD, g/cc	1.45	1.62	1.68	1.80
Soaked CBR,%	4.00	5.55	6.92	7.87

Effect ofStone Dust on LL, PL and PI of Soils

Variation of liquid limit with stone dust content in black cotton soil, that as the percentage of stone dust increases in the soil, liquid limit is decreased. It is observed and conform from the result that liquid limit is decreased because stone dust has poor liquid limit. It indicates that stone dust has considerably stabilized the soil.

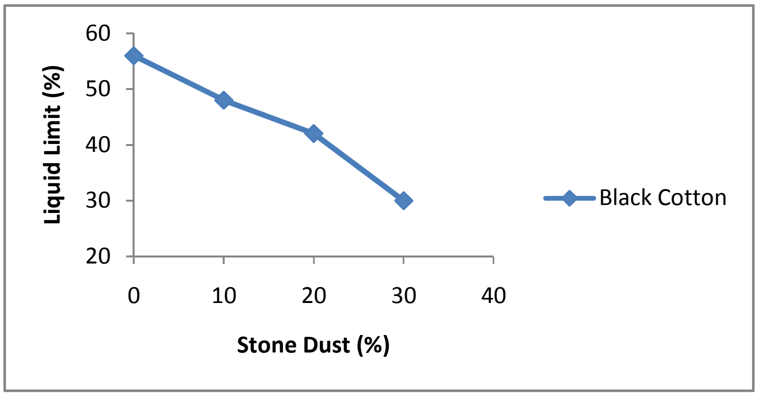

Figure 12: Effect of stone dust on liquid limit

The effect of stone dust mixing on plastic limit is shown in figure 13. Similar to liquid limit the plastic limit also decreases with increasing percentage of stone dust. It indicates that plasticity characteristics enhance according to the requirement of any stabilize soil.

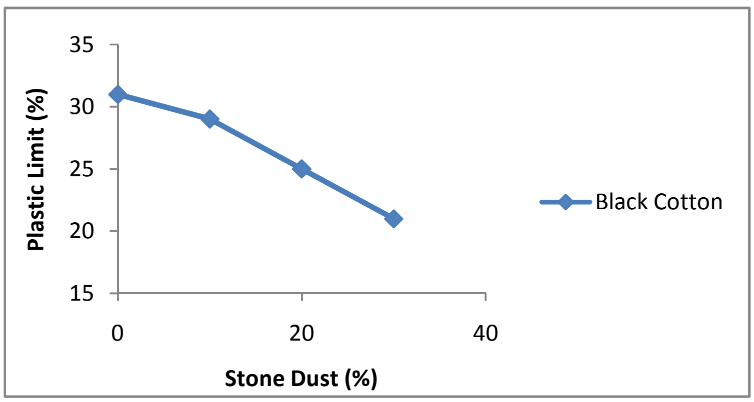

Figure 13: Effect of stone dust on plastic limit

Similar to liquid limit and plastic limit, plasticity index also decreases with the increasing content of stone dust. The effect of stone dust mixing on plasticity index is also shown in figure 14.

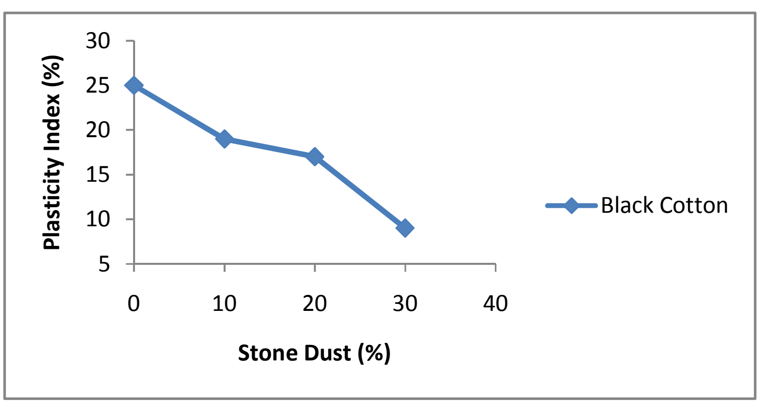

Figure 14: Effect of stone dust on plasticity index

Effect of stone dust on differential free swell

Free swell of soil found to be decreased when mixed with stone dust. It indicates that use of stone dust in stabilization has positive impact on soil swell behavior by decreasing its swelling nature.

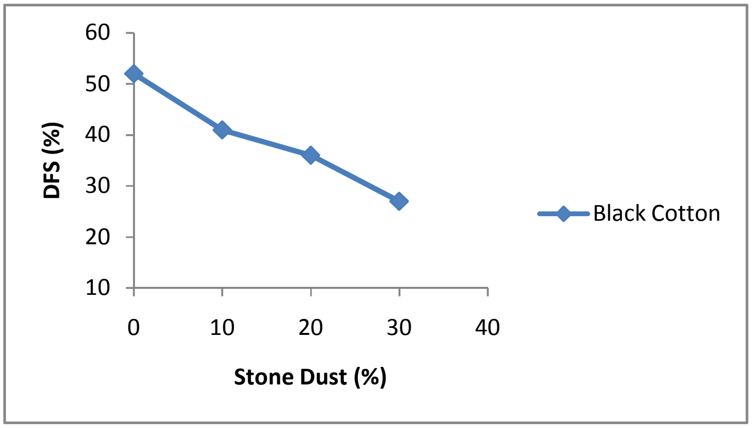

Figure 15: Effect of stone dust on differential free swell

Effect of stone dust on compaction properties

As discussed earlier that optimum moisture content and maximum dry density are the two properties of soil that is counted as compaction behavior of soil. It was observed that optimum moisture content decreased with increasing percentage of stone dust.

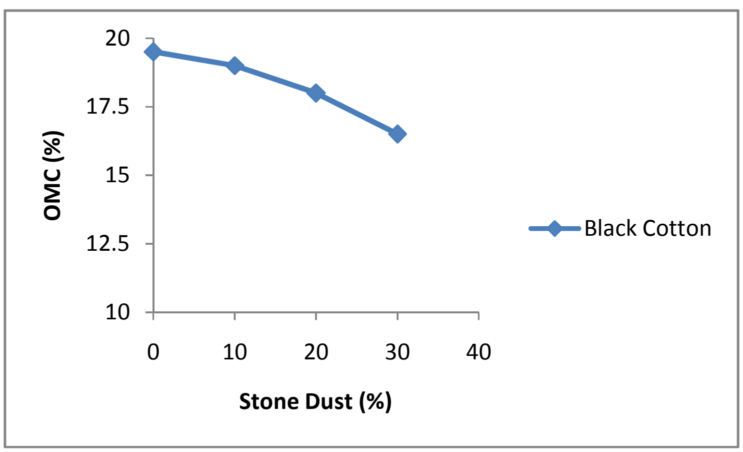

Figure 16: Effect of stone dust on optimum moisture content

The compaction characteristic that is maximum dry density was improved by the effect of stabilization of soil. From figure 17 it is clear that with the increasing percentage of stone dust MDD also increased. The value of MDD of B.C. soil increased from 1.45 g/cc to 1.8 g/cc which is remarkably high.

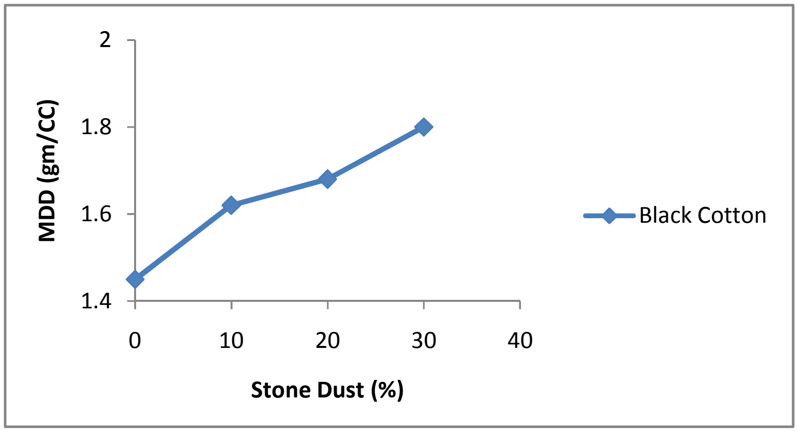

Figure 17: Effect of stone dust on maximum dry density

Effect of stone dust on California bearing ratio (CBR)

As discussed earlier that CBR is the ratio of resistance to penetration of a material to the penetration resistance of a standard crushed stone base material. It meant if CBR increases for any material, (that is soil in this case) then resistance to penetration of a material, (soil) also increases.

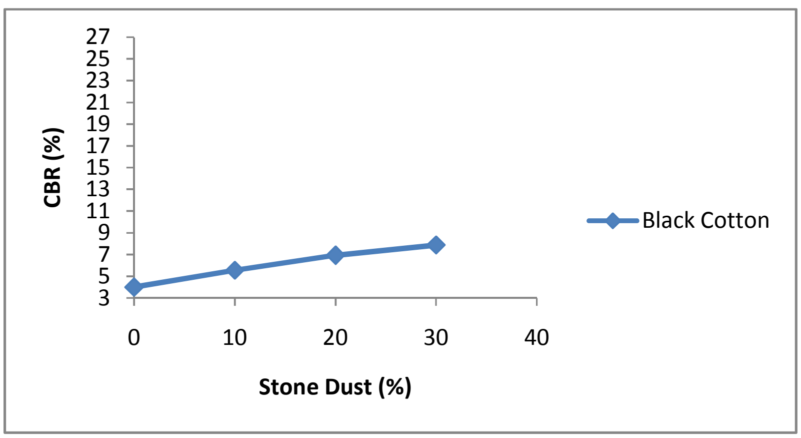

Figure 18: Effect of stone dust on CBR

4. CONCLUSION

The main objectives of this study were todevelop strategy for improving poor soil for road construction and to develop a model for estimating CBR value. A strategy for improving poor soil road construction is developed by mixing stone dust to poor soil in different proportions and observing the improvement in governing properties. The following important conclusion may be drawn from the present study.Liquid limit can be decreased by adding stone dust since stone dust have less liquid limit. Similarly plastic limit may also be decreased for the same reasons. Both liquid limit and plastic limit drops with almost same magnitude.Plasticity index also reduces thereby plasticity characteristics of soil is decreased. This intern's increases the usefulness of soil as highway subgrade material since soils representing higher ranges of plasticity is not considered suitable good for bearing moving loads.

Expansive soil possessing higher differential free swelling index is also not considered good for highway sub grade since expansive soil have the property to absorb and retain moisture for longer period. Therefore they get swelling and shrinking behavior from absorbing and releasing water contents which may create settlement of highways. From the results of differential free swelling tests it was observed that said parameters was decrease with increasing percentage of stone dust.

Optimum moisture content and maximum dry density are the parameters up to which an earthen embankment is compacted. It was observed from the analysis of results that the OMC and MDD may greatly be adjusted by using various percentage of stone dust. Primarily OMC may be reduced by adding stone dust and on this reduced OMC higher values of MDD may be obtained.

CBR values were also increased after stabilizing the soil from stone dust. CBR value, which actually is the resistance of soil against penetration, increased almost twice to its initial value. It was due to mixing of some amount of coarser stone dust into the soil that enhance the strength of soil and finally results in increased CBR.

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