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Effect of Stone Dust on Properties of Soil

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Abstract: Stone dust is a kind of solid waste material that is generated from stone crushing industry which is abundantly available. It is estimated that each crusher unit produce 15%-20% stone dust. Disposal of such wastes poses lots of geo environmental problems such as landfill disposal problems, health and environmental hazards. The best way to eliminate these problems is to make use such waste. Keeping this in view an experimental study was conducted on locally available soil by mixing it with Stone Dust. The effect of randomly distributed Stone Dust on MDD, OMC, and CBR has been discussed in this report. The percentage of stone dust by dry weight of soil was taken as 10%, 20%, 30%, and 50%.The first series of compaction, specific gravity and CBR tests were conducted on the soil and the same tests were conducted in the second series on soil samples mixed with stone dust. Laboratory experiments favorably suggest that mixing stone dust with soil would be effective in improving soil properties. Due to rapid growth of population and industrialization there is tremendous increase in construction activities. The cities and villages are coming closer, there is fast growth of vehicles running on roads. There is shortage of land for construction of buildings, roads, highways and airfields. The land available may not be suitable for construction activities. The soil may be black cotton, clayey, and loamy. The existing site conditions may or may not be sufficiently strong enough to withstand the load coming on it. In order to overcome these problem ground improvement technique such as soil stabilization, soil reinforcement etc. are evolved. The mechanical stabilization of soil proves to be cost effective and reliable. As the property of clayey soil proves to be suitable for mechanical stabilization, the cohesive natured clayey soil were chosen and checked for their geotechnical properties with other general soil characteristics by varying the content of stone dust The modification of soil is carried out by addition of stone dust to original expansive soils in the range of 0 to 50% by the percentage increase of 10%, 20%, 30%, and 50% and the effect of stone dust on liquid limit, plastic limit, plasticity index, dry density, optimum moisture content and CBR values is considered
Keywords: Stone Dust, CBR.

I. INTRODUCTION

The rapid urban and industrial developments pose an increasing demand for the construction of highways embankments and many other civil engineering structures. Hence barren lands and problematic soils, waterlogged areas, landfills, damping yards are to be brought to use for construction activities. The problematic soils such as soft clays, black cotton soils, barren lands, waterlogged lands are to be treated for improving their bearing capacity and settlement behavior. The construction of roads, highways, runways over these soils affect its stability. The embankment laid on these soils will not be stable. Due to shrinkage and swelling nature of sub soil the pavement gets damaged it will cost heavy expenditure for repair. In recent years lot of experimental studies have been carried out on improvement of sub-grade soil, increasing the strength of the pavements and embankments to take heavier loads as well as widening and renewal of roads. The present work is aimed to assess the improvement in gradation. Atterberg's limits, compaction characteristics, specific gravity, CBR values on different samples with varying percentage of stone dust to original soil. The stone dust is added by percentage of weight to the dry soil sample for these properties of soils and properties of stone dust available from nearby stone crushing plant are found out. Due to increase in construction activities the demand of crushed stone for buildings, road, railway ballast and concrete work is increased. For crushing of stones large number of crusher units are installed. The aggregates are produced by blasting and crushing of stones in mechanical crushers, the stone dust is formed in primary and secondary crushing, screening and stock piling. Stone dust is mainly produced during crushing operations. This is a waste product and leads to pollution as well as problem for stock piling it on crusher site to reduce the pollution as well as disposal problem. The present paper deals with the study to be carried out to assess utilization of stone dust in road, highway construction the experimental program consisting of evaluating firstly the properties of original expansive soils collected from different location and the stone dust collected from same locations for modifications of soils. The modification of soil is carried out by addition of stone dust to original expansive soils in the range of 0 to 50 by the percentage increase of 10%, 20%, 30%, and 50% the effect of stone dust on liquid limit, plastic limit, plasticity index, dry density, optimum moisture content and CBR values is considered

II. LITERATURE REVIEW

Soil stabilization is a method of improving soil properties by blending and mixing other materials. Soils are generally stabilized to increase their strength and durability or to prevent erosion and dust formation in soils. The main aim is the creation of a soil material or system that will hold under the design use conditions and for the designed life of the engineering project. The properties of soil vary a great deal at different places or in certain cases even at one place; the success of soil stabilization depends on soil testing. Various methods are employed to stabilize soil and the method should be verified in the lab with the soil material before applying it on the field. The following are the few methods described in literature.

A. *Mechanical method of Stabilization*

In this procedure, soils of different gradations are mixed together to obtain the desired property in the soil. This may be done at the site or at some other place from where it can be transported easily. The final mixture is then compacted by the usual methods to get the required density.

B. *Additive Method Of Stabilization*

It refers to the addition of manufactured products into the soil, which in proper quantities enhances the quality of the soil. Materials such as cement, lime, bitumen, fly ash etc. are used as chemical additives. Sometimes different fibers are also used as reinforcements in the soil. The addition of these fibers takes place by two methods;

1) *Oriented Fiber Reinforcement*

The fibers are arranged in some order and all the fibers are placed in the same orientation. The fibers are laid layer by layer in this type of orientation. Continuous fibers in the form of sheets, strips or bars etc. are used systematically in this type of arrangement.

2) *Random Fiber Reinforcement*

This arrangement has discrete fibers distributed randomly in the soil mass. The mixing is done until the soil and the reinforcement form a more or less homogeneous mixture. Materials used in this type of reinforcements are generally derived from paper, nylon, metals or other materials having varied physical properties. Randomly distributed fibers have some advantages over the systematically distributed fibers. Somehow this way of reinforcement is similar to addition of admixtures such as cement, lime etc. Besides being easy to add and mix, this method also offers strength isotropy, decreases chance of potential weak planes which occur in the other case and provides ductility to the soil.

III. SCOPE AND OBJECTIVE

Due to rapid growth of population and industrialization there is tremendous increase in Construction activities. The cities and villages are coming closer, there is fast growth of vehicles running on roads. There is shortage of land for construction of buildings, roads, highways and Airfields. The land available may not be suitable for construction activities. The soil may be black Cotton, clayey, and loamy. The existing site conditions may or may not be sufficiently strong enough to withstand the load coming on it. In order to overcome these problem ground improvement technique such as soil stabilization, soil reinforcement etc. are evolved. The mechanical stabilization of soil proves to be cost effective and reliable. As the property of clayey soil proves to be suitable for mechanical stabilization, the cohesive natured clayey soil were chosen and checked for their geotechnical properties with other general soil characteristics by varying the content of stone dust. Due to increase in construction activities the demand of crushed stone for buildings, road, railway ballast and concrete work is increased. For crushing of stones large number of crusher units are installed. The aggregates are produced by blasting and crushing of stones in mechanical crushers, the stone dust is formed in primary and secondary crushing, screening and stock piling. Stone dust is mainly produced during crushing operations. This is a waste product and leads to pollution as well as problem for stock piling it on crusher site to reduce the pollution as well as disposal problem.

The modification of soil is carried out by addition of stone dust to original expansive soils in the range of 0 to 50% by the percentage increase of 10%, 20%, 30%, 40%, and 50% the effect of stone dust on liquid limit, plastic limit, plasticity index, dry density, optimum moisture content and CBR values is considered.

A. *Needs and Advantages of Soil Stabilization Using Stone Dust*

Soil properties vary a great deal and construction of structures depends a lot on the bearing Capacity of the soil, hence, we need to stabilize the soil to improve the load bearing capacity. The gradation of the soil is also a very important property to keep in mind while working with Soils. The soils may be well-graded which is desirable as it has less number of voids or uniformly graded which though sounds stable but has more voids.

1) If during the construction phase weak soil strata are encountered, the usual practice Followed is replacing the weak soil with some other good quality soil. With the application of soil stabilization technique, the properties of the locally available soil (soil available at the site) can be enhanced and can be used effectively as the sub-grade material without replacing it.
2) The cost of preparing the sub-grade by replacing the weak soil with a good quality soil is higher than that of preparing the sub-grade by stabilizing the locally available soil using different stabilization techniques.
3) The strength giving parameters of the soil can be effectively increased to a required amount by stabilization
4) It improves the strength of the soil, thus, increasing the soil bearing capacity.
5) It is more economical both in terms of cost and energy to increase the bearing capacity of the soil rather than going for deep foundation or raft foundation.

IV. RESEARCH METHODOLOGY

Various test were performed on the soil sample taken to study the effects of stone dust. The soil sample was taken from the Jammu site at Patoli, (Gurha Bhramna) Akhnoor road near T.V station. The stone dust was obtained from a locally available stone crusher site. The experimental work consists of the following steps:

1) Specific gravity of soil
2) Determination of soil index properties (Atterberg Limits)
   a) Liquid limit by Casagrande's apparatus
   b) Plastic limit
3) Particle size distribution by sieve analysis.
4) Determination of the maximum dry density (MDD) and the corresponding optimum moisture content (OMC) of the soil by Proctor compaction test.
5) Determination of CBR value.

V. ANALYSIS OF DATA

A. *Sieve Analysis*

Sieve analysis of soil collected from Patoli (Jammu) was carried out in order to classify the soil. The following observations were made:

Sample taken passing 4.75mm sieve = 100%

Sample passed through 0.075mm sieve= 57.2%

Table-1 Particle Size distribution of soil sample

Sieve Size	% Finer
20mm	100
10	94.8
4.75	91.4
2.36	89.0
0.425	79.8
0.075	57.2

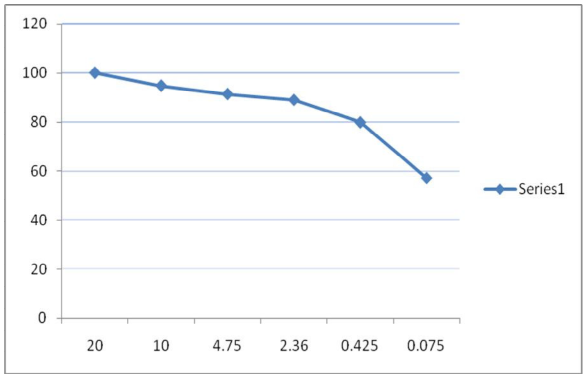

Figure 1: Particle size distribution curve

B. *Liquid Limit Test on soil sample*

Sample Taken [passing through = 425µ] = 150 g

Table-2 Liquid Limit of soil sample

Trial No.	Water content %	Water amount ,ml	No. of Blows
1	50	75	26
2	54.33	81.5	22
3	55	82.5	23
4	60.	90	20

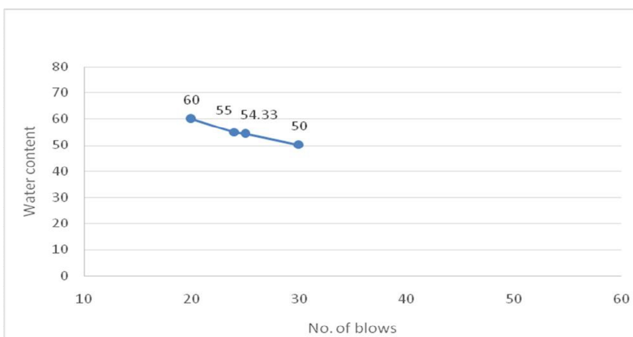

Figure 2: Liquid Limit curve (Casagrande's method)

Liquid limit=54.33

C. *Plastic limit test on soil sample*

Table-3 Plastic Limit test on soil sample

Sample No.	1	2	3
Mass of empty container	12.55	16	11.2
Mass of (can+wet soil) in gms.	21.44	24.2	19.9
Mass of (can + dry soil) in gms.	19.47	22..1 2	18

Mass of soil solids	6.92	6.18	6.78
Mass of pore water	1.97	1.78	1.96
Water content (%)	28.46	28.8	28.9
Average plastic limt	28.72		

Ip = WL – WP = 54.33 –28.72= 25.61
According to UCS Classification of soils, Soil sample-CH Clay, high plasticity.

D. Standard Proctor Compaction Test on soil sample

OMC as obtained from graph = 21.4%
MDD as obtained from graph = 1.378 g/cc

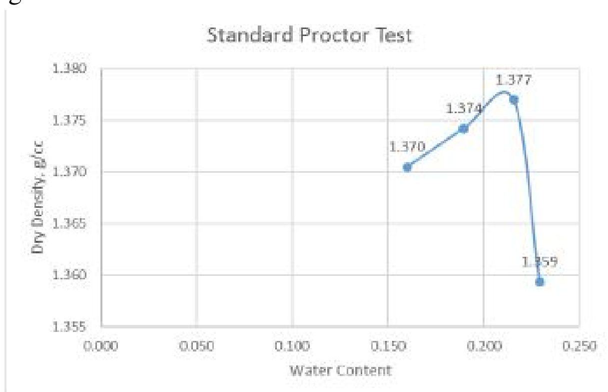

Figure 3: Compaction Curve for soil

E. California Bearing Ratio (CBR) Test on soil sample

The water added was equal to OMC = 21.40%

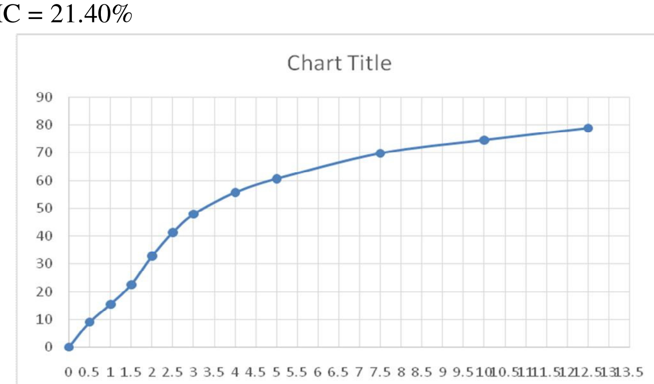

Figure 4: CBR Curve

Load as obtained from graph at 2.5 mm penetration = 41.3 kg
CBR of Specimen = (41.3/1370) *100=3.01%
Load as obtained from graph at 5 mm penetration = 60 kg
CBR of Specimen = (60.63/2055) *100=2.95%

F. Liquid Limit Test on soil added with 10% stone dust

Sample Taken [passing through = 425µ]= 150 g

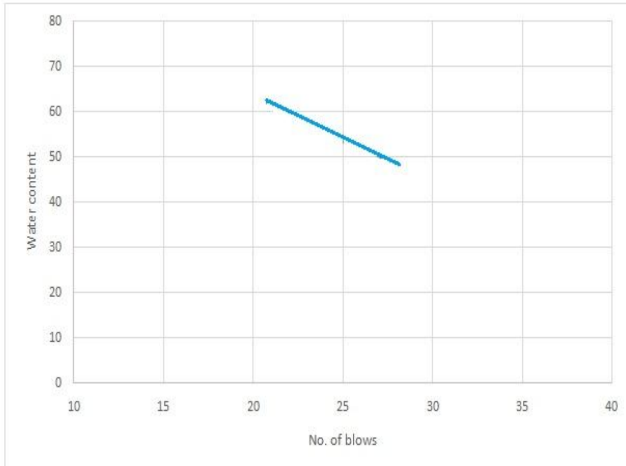

Figure 5 Liquid Limit curve (Casagrande's method)

Liquid limit as obtained from graph = 51%

(Corresponding to 25 blows Log scale)

After modification with 10%, of stone dust, the liquid limit of modified soils are found to be reduced by 6.1%, . The probable reason for reduction of liquid limit of modified soil may be due to mechanical stabilization and addition of non-plastic material.

G. Liquid Limit Test on soil added with 20% stone dust

Sample Taken [passing through = 425µ] = 150 g

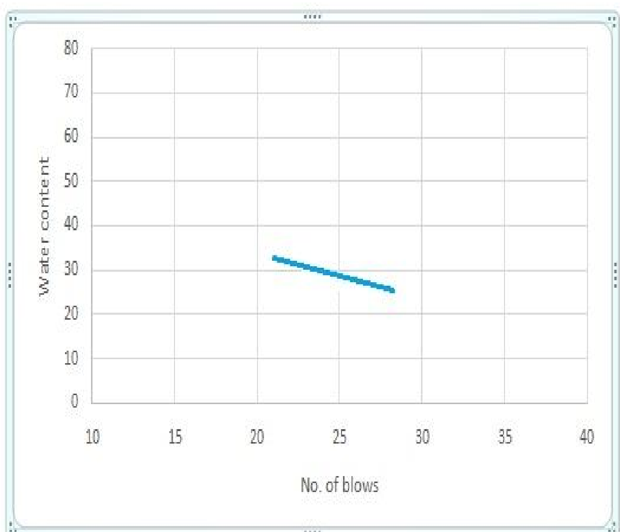

Figure 6: Liquid Limit curve (Casagrande's method) soil added with 20% stone dust.

Liquid limit as obtained from graph = 44%

(Corresponding to 25 blows Log scale)

After modification with 20%, of stone dust, the liquid limit of modified soils are found to be reduced by 19.1%, . The probable reason for reduction of liquid limit of modified soil may be due to mechanical stabilization and addition of non-plastic material.

H. Liquid Limit Test on soil added with 30% stone dust

Sample Taken [passing through = 425µ] = 150 g

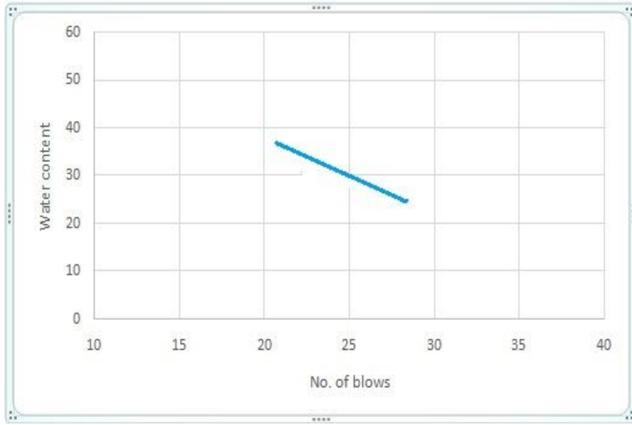

Figure 7 Liquid Limit curve (Casagrande's method)soil added with 30% stone dust.

Liquid limit as obtained from graph = 34%
(Corresponding to 25 blows Log scale)
After modification with 30%, of stone dust, the liquid limit of modified soils are found to be reduced by 37.5%, . The probable reason for reduction of liquid limit of modified soil may be due to mechanical stabilization and addition of non-plastic material.

I. Liquid Limit Test on soil added with 50% stone dust

Sample Taken [passing through = 425µ]= 150 g
Liquid limit as obtained from graph = 28%
(Corresponding to 25 blows)
After modification with 50%, of stone dust, the liquid limit of modified soils are found to be reduced by 48.5 %, . The probable reason for reduction of liquid limit of modified soil may be due to mechanical stabilization and addition of non-plastic material

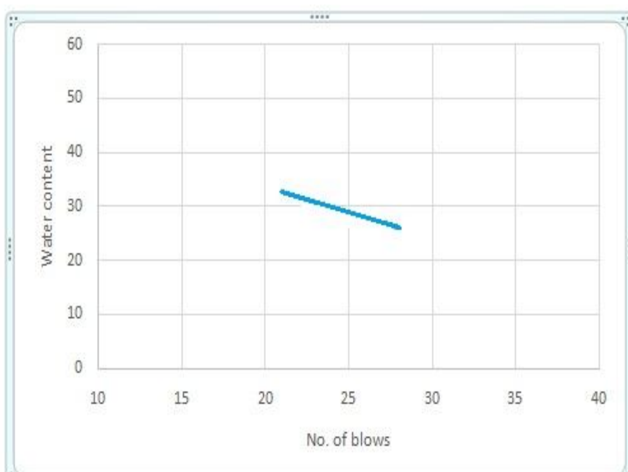

Figure 8: Liquid Limit curve (Casagrande's method) for soil added with 50% stone dust.

Liquid limit as obtained from graph = **28%**
(Corresponding to 25 blows Log scale)
After modification with 50%, of stone dust, the liquid limit of modified soils are found to be reduced by 48.5 %, . The probable reason for reduction of liquid limit of modified soil may be due to mechanical stabilization and addition of non-plastic material

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J. Plastic Limit test on soil added with 10% stone dust

Table 4: Plastic limit test on soil with 10% stone dust

Sample No.	1	2	3
Mass of empty container	10.55	12.33	13.3
Mass of (can+wet soil) in gms.	20.44	22.5	17.9
Mass of (can + dry soil) in gms.	18.47	20.5	16
Mass of soil solids	7.92	6.18	6.78
Mass of pore water	2.13	1.54	1.81
Water content (%)	27	25	26.8
Average plastic limt	**26.26**		

Soil Sample added with 10% stone dust
Ip = WL – WP =51-26.26=24.74.
After modification with 10%, of stone dust, the PI values of modified soils are found to be reduced by small amount of 3.4%.The PI of soil decreases due to decrease in clay content. The clay content determines the amount of surface that is available for water absorption.
Similarly the plasticity index of soil with 20%,30%&50% was found out by the same method which comes to be -19.67, 14.17, 13.08 respectively.

K. Effect of stone dust on maximum dry density and optimum moisture content for soil

Standard Proctor Test on soil added with 10% stone dust:
Sample taken [passing 4.75mm sieve] = 2500 g
Volume of Mold = 1000 cc
OMC as obtained from graph = 21%
MDD as obtained from graph = 1.379 g/cc
Thus as percentage of stone dust is added maximum dry density increases Stone dust is heavier material and its maximum dry density is greater than soil, hence as stone dust percentage goes on increasing maximum dry density increases.

Table-5 Standard Proctor Test on soil added with 10% stone dust.

Test No.	1	2	3	4
Weight of container W0	22.5	29.5	22.5	16
Weight of container + wet soil w1	162.92	172.89	189.71	131.47
Weight of container + dry soil W2	140.5	148	159	107.5
Weight of water (W1-W2)	22.42	24.885	30.71	23.97
Weight of dry soil (W2-W0)	118	118.5	136.5	91.5
Water content W1-W2/W2-W0	.190	.21	.225	.262
Dry density g/cc	1.314	1.379	1.336	1.341

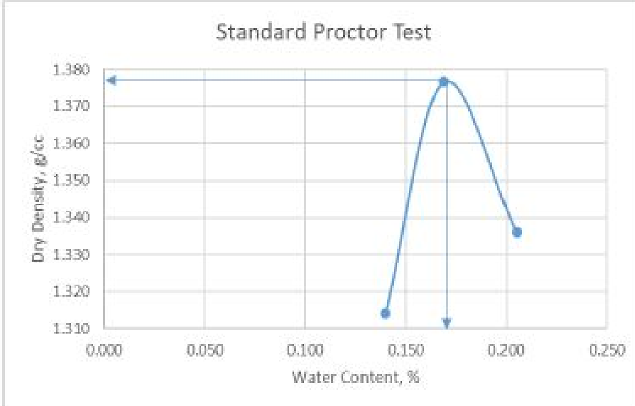

Figure 9: Compaction Curve for soil with 10% stone dust

Similarly proctor test was done on soil added with 20%, 30% & 50% stone dust and the OMC was found to be 20.1%, 19.00%, 17.20% respectively. The MDD was found to be 1.401 g/cc, 1.420 g/cc, 1.565 g/cc.

L. California Bearing Ratio (CBR) on soil with stone dust

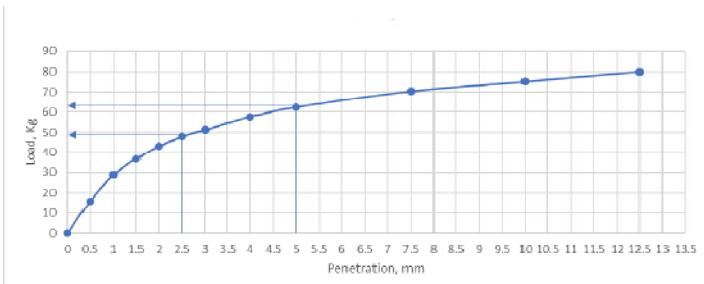

Figure 10: CBR Curve of soil with 10% stone dust

Load as obtained from graph at 2.5 mm penetration = 48 kg
CBR of Specimen = (48/1370) *100=3.49%
Load as obtained from graph at 5 mm penetration = 62.4 kg
CBR of Specimen = (62.4/2055) *100=3.02%
For 20% of stone dust:
Load as obtained from graph at 2.5 mm penetration = 54.4 kg
CBR of Specimen = (54.4/1370) *100=3.96%
Load as obtained from graph at 5 mm penetration = 34 kg
CBR of Specimen = (78.4/2055) *100=3.80%

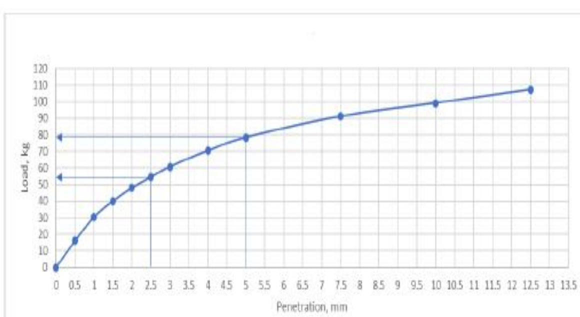

Figure 11: CBR Curve soil with 20% stone dust

For 20% of stone dust:
CBR of Specimen = (54.4/1370) *100=3.96%
Load as obtained from graph at 5 mm penetration = 34 kg
CBR of Specimen = (78.4/2055) *100=3.80%

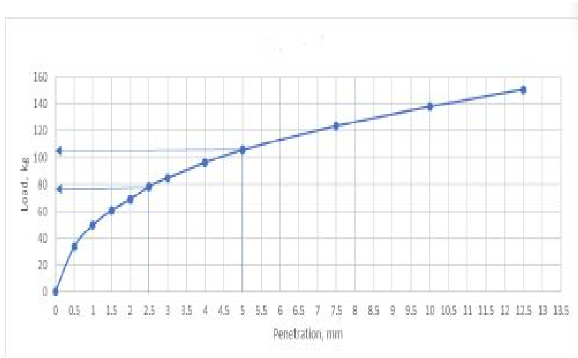

Figure 12: CBR Curve soil with 20% stone dust

For 30% of stone dust:
Load as obtained from graph at 2.5 mm penetration = 78.4 kg
CBR of Specimen = (78.4/1370) *100=5.41%
Load as obtained from graph at 5 mm penetration = 105.6 kg
CBR of Specimen = (105.6/2055) *100=5.12%

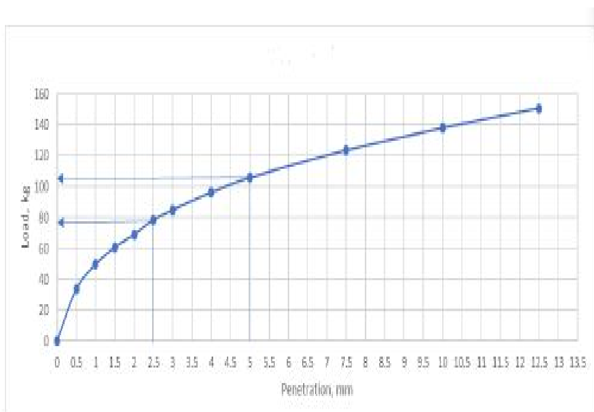

Figure 13: CBR Curve soil with 30% stone dust

For 50% of stone dust:
Load as obtained from graph at 2.5 mm penetration = 78.4 kg
CBR of Specimen = (88.4/1370) *100=6.45%
Load as obtained from graph at 5 mm penetration = 105.6 kg
CBR of Specimen = (125.2/2055) *100=6.1%

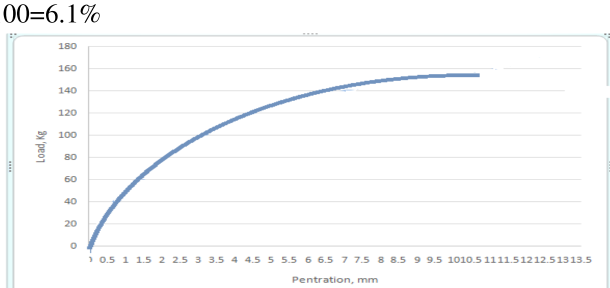

Figure 14: CBR Curve soil with 50% stone dust

M. California Bearing Ratio Value Characteristics

The soil without modification is tested for CBR test and the CBR value is found to be 3.05%. The soil is modified by addition of stone dust in the proportion of 10%, 20%, 30%, and 50%. The increase in percentage of CBR value on addition of 10%, 20%, 30%, and 50% are found to be 14.45%, 29.83%, 77.3%, and 111% respectively.

Table 6: Effect of stone dust on CBR

Sr. No	Property	Soil: stone dust				
	Proportion of soil and stone dust	100:0	90:10	80:20	70:30	50:50
1	CBR%	3.05	3.49	3.96	5.41	6.45

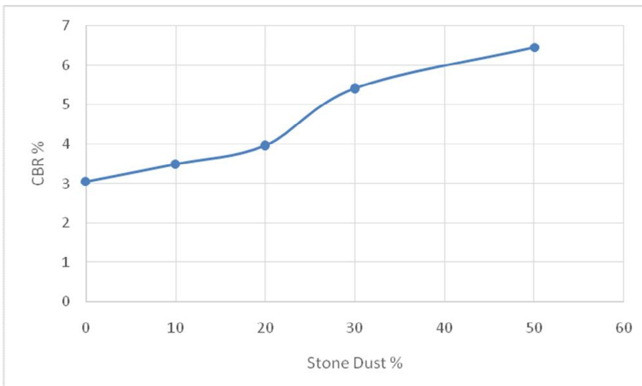

Figure15: Effect of Addition of Stone Dust on C B R for Soil

It is found that as percentage of stone dust increases CBR value increases. From practical consideration the addition of stone dust about 50% of total weight of modified soil mass is feasible and economical. The probable reason for increase in CBR value of soil is by addition of stone dust in comparison with original soil may be due to increase in density of modified soil mass having more strength.

VI. RESULTS AND DISCUSSION

A. Liquid limit

1) The liquid limit of the soil alone was found to be 54.33%
2) The liquid limit of the soil with addition of 10%, 20%, 30% and 50%, stone dust by weight of Soil is found to be 51%, 44%, 28% and 42.3% respectively.

B. Plastic limit

1) The plastic limit of the soil alone was found to be 28.71%
2) The plastic limit of the soil with addition of 10%, 20%, 30% and 50%, stone dust by weight of soil is found to be 26.26%, 24.33.%, 19.83% and 13.08% respectively.

C. *Plasticity Index*

1) The plasticity index of the soil alone was found to be 25.61%
2) The plasticity index of the soil with addition of 10%, 20%, 30% and 50%, bamboo stone dust by weight of soil is found to be 24.74%, 19.67%, 14.17% and 13.08% respectively

D. Standard Proctor Test

1) The optimum moisture content (OMC) and maximum dry density (MDD) of soil alone was found to be 21.4% and 1.378 g/cc respectively.
2) The MDD of the soil with addition of 10%, 20%, 30% and 50%, stone dust by weight of soil is found to be 1.379 g/cc, 1.401 g/cc, 1.42 g/cc and 1.565g/cc respectively and the corresponding OMC is found to be 21%, 20.1%, 19% and 17.20% respectively.

E. California Bearing Ratio (CBR) Test

1) The CBR value of soil alone was found to be 3.05%
2) The CBR value of the soil with addition of 10%, 20%, 30% and 50%, stone dust by weight of soil is found to be 3.49%, 3.96%, 5.41% and 6.45% respectively

VII. CONCLUSION

Based on the studies carried out following are the conclusions drawn:

1) 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.
2) Plasticity index also reduces thereby plasticity characteristics of soil is decreased. This intern's increases the usefulness of soil as highway sub-grade material since soils representing higher ranges of plasticity is not considered suitable good for bearing moving loads.
3) Stone dust a product from crusher unit consists of mainly sand size particles and is having good C.B.R. value.
4) Thus, the stone dust itself can be considered as a good sub base material. Hence it can be used for construction of road embankment
5) From the compaction studies out on stone dust, it is found that the maximum dry density and optimum moisture content relationship is fairly flat at peak values. Hence the variation in water content as compared to optimum moisture content leads to marginal change in maximum dry density.
6) In soil by addition of stone dust showed considerable increase in maximum dry density and considerable reduction in optimum moisture content.
7) The information based on the studies carried out will be useful for the design and construction of sub grade, embankment and structural fills for utilization of stone dust as a stabilizing agent.
8) Stone dust has high specific gravity and the CBR value for standard compaction is more.
9) This indicates that stone dust can be used as an embankment material, backfill material for the lower layer of sub base. Also reuse of this waste material is economically advantages and does not bring any environmental hazards.
10) As the CBR value of stone dust is more, the crust thickness of flexible pavement is less and it is economical in construction of road, highways

REFERENCES

[1] S. A. Naeini and S. M. Sadjadi ,(2008) ," Effect of Waste Polymer Materials on Shear Strength of Unsaturated Clays", EJGE Journal, Vol 13, Bund k,(1-12).
[2] Khanna, S.K. and Justo, C.E.O. "Highway Engineering
[3] A.K. Sabat and S.K. DAs, Effect of Crusher Dust-Lime on Index and Compaction Properties of Murthy, V.N.S. Fourth edition" Soil Mechanics and Foundation Engineering",
[4] Pavement Construction, Proceeding of Indian Geotechnical Conference-2001, Indore (M.P.) 14-16, Dec.
[5] Kaushik N.P., J.K. Sharma, A Bindish and C.A. Prasad, Effect of Flyash and Lime Flyash on the
[6] Characteristics of Expansive Soils, IGC-2003. Geotechnical Engineering for Infrastructural
[7] Geotechnical Properties of Soils in Highway Constructions, Geotechnical Testing Journal, 28 (4), 2005,