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Improvement in *CBR* Performance of High Plastic Soft Subgrade by Placing Stiffer Aggregate Overlying Layer - A Lab Study

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Abstract

Soft subgrade soil poses problems for supporting loads from pavements due to high compressibility. Plasticity index(PI) is a relative measure of compressibility factor as discussed in literature. Hence high plastic soil aggravates the problem. Soil stabilization, mechanical stabilization is few of the techniques available for modifying the properties of these soft soils. However these techniques often prove costlier and consume lot of time. This paper discusses an alternate option to improve CBR values through provision of stronger layer with coarse aggregate of varying thickness expressed by H_r). CBR tests are conducted on four subgrade types with varying plasticity and fines content with varying H_r (H_a / H_s) from 0, 0.1, 0.2, 0.3, 0.4, and 0.5. Where, H_s and H_a are thickness of soil and that of overlying aggregate in CBR mould respectively It is observed that PI, H_r and fines content effect CBR. The influence is more pronounced with Plasticity and percent fines. Also the increase (%) is marginal for samples with high $H_{r.}$ The problem of mixing of aggregate with soft soil is more with H_r

Key Words: Plasticity index, Fines(%), CBR value, subgrade.

1. Introduction

The service-life and performance of roads depend to a large extent on the strength and stiffness characteristics of subgrade. Subgrade characteristics assist road engineers in the selection of materials for sub-base and base courses of pavements. A new concept of Equivalent California Bearing Ratio of the composite systems was introduced by **(2).** Apart from plasticity, density of soil will also affects the performance of different geosynthetics in reinforced soil-aggregate systems **(1).**PI is the most effective parameter for controlling the strength of the mix as itappears to be independent of fines type**(4).**The effective interlocking effect is more if theGSB(granular sub base) thickness increases**(5)**.

Objective and methodology: The objective of this study is i) to determination of compaction characteristics and lab CBR for, clayey soil subgrade of varying plasticity characteristics, ii) to study the improvement in lab CBR by placing coarse aggregate layer of varying thickness over soft soil subgrade iii) quantification of the performance improvement.

Methodology

For the objective cited the following is the methodology adopted as shown in figure 1

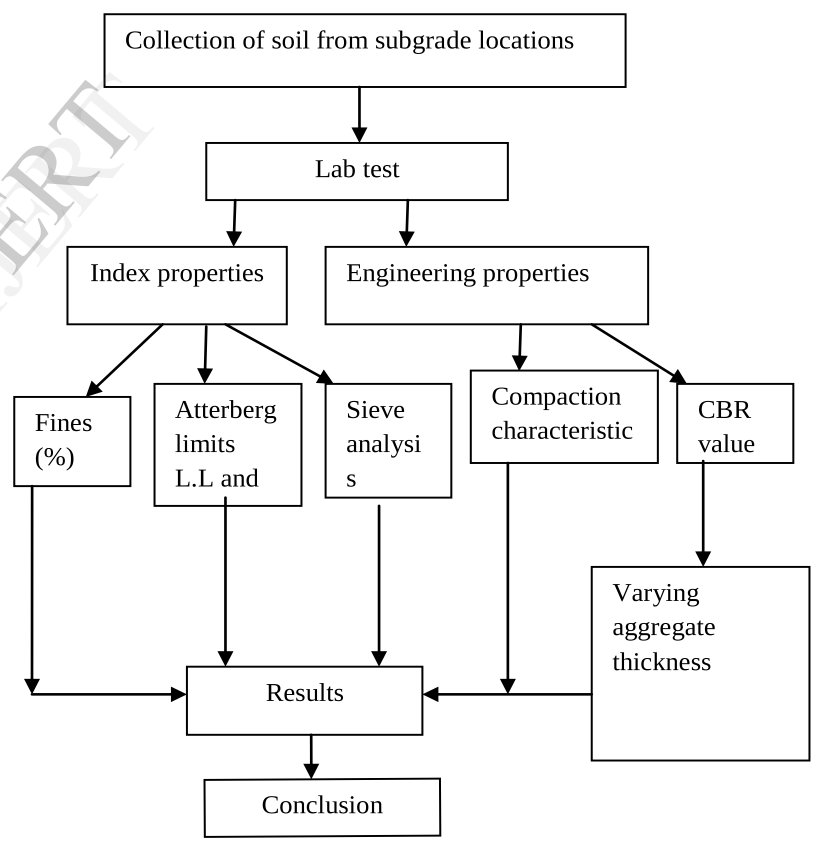

Figure.1 Outline of Methodology

2.Experimental study

Two types of materials are used in experimental study. The material includes fine grained soil, 20mm size coarse aggregate. Four types of fine grained soil with varying plasticity are considered for study. The properties of soil, and aggregate are listed as given below. Lab CBR test is carried out on soil-aggregate composite layer of thickness, H by placing aggregate layer of thickness, H_a over soil layer of thickness, H_s in CBR mould. The testing is carried out by varying H_r (a ratio of H_a to H_s).. The thickness of sample H and the densities of soil and aggregate is maintained throughout all the tests. Spacer disks of thickness 0.5,1cm, 2cm etc. are used for preparing soil specimen with the desired void space (later filled by coarse aggregate) above soil after compaction in CBR mould. A schematic diagram of sample is given in fig.1 For conducting tests optimum conditions in moisture and dry density as obtained through compaction test are maintained. The samples are compacted at maximum dry density condition for performing CBR test and H_r is varied from 0 to 0.5 in the increments of 0.1. Test setup for sample is shown in Figs 1 and 2

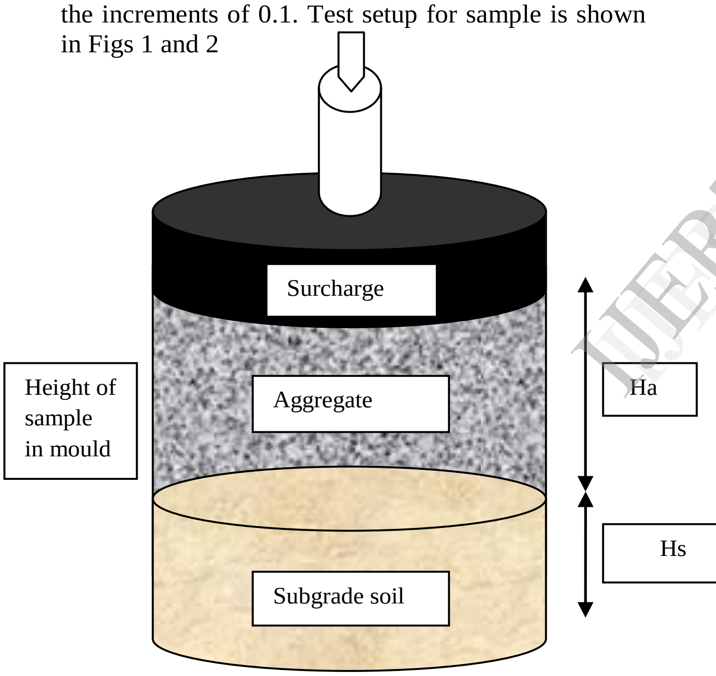

Fig1.0 Schematic diagram of soil- aggregate composite for lab CBR test

Fig.2 Test setup to find CBR value of soil and Aggregate

3. PRESENTATION OF RESULTS AND DISCUSSION

The results of tests are presented in fig. 3 to fig. 7. The properties of soil, aggregate are given in Table 1 to table3For quantifying the improvement, the results are expressed in terms of factored CBR ratios R_c computed as

$$R_C = \frac{CBR\ of\ soil\ subgrade - aggregate\ composite}{CBR\ of\ subgrade}$$

Table:1 Properties Of Aggregate

Size of Aggregates(mm)	Density of Aggregate (kN/m^3)
20	22.95

Table: 2 Index properties of soil subgrade

Sample	L.L (%)	P. L (%)	P.I (%)	Fines (%)	Coefficient of curvature	Coefficient of uniformity	I.S classification
1	49	22.4	26.6	66.4	1.03	5.3	Sandy Clay
2	55	24.76	30.24	70.8	0.9	6	Clayey sand
3	62.5	28.48	34.02	73.2	0.7	7	Clayey sand
4	40	21.2	16.8	36.4	1.2	3.33	Silty sand

Table 3 Engineering properties of Soil subgrade

Sample No.	OMC, W_{max} (%)	Maximum dry density(MDD), γ_d (kN/m^3)	CBR (%)
1	17.07	16.90	2.07
2	18.97	16.18	1.66
3	21.04	15.94	1.20
4	15.40	18.14	2.76

3.1 Presentation of results for variation of CBR: effect of Hr:

The variation in CBR values with Hr of soil and aggregate is shown in figure 3. It is observed that CBR value is increasing with Hr. As the aggregate layer is stronger than subgrade the bearing resiatance to CBR plunger is more, Hence the load for given penetration has increased. Which has a combined effect on improving CBR value. Further as seen from the fig. 3 with increase in Hri.e increasing thickness of overlying aggregate the CBR has increased for all the four soils has increased considerably. As seen for Hr from 0 to 0.5,the corresponding CBR value has increased from 2.09 to 3.59; 1.66 to 3.5, and 1.2 to 3.3 for Hr ranging from 0 to 0.5. At higher Hri.e 0.5, sudden decrease in CBR is noted which is due to mixing of aggregate with underlying soft soil. This is due to lack of interlocking with the increase in air voids the resistance is affected.

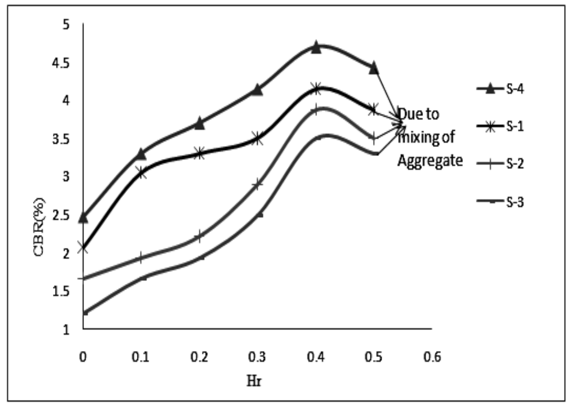

Figure 3 Variation of CBR with respect to Hr

3.2 Presentation of results for variation of CBR: Effect of PI &Hr:

The variation in CBR values with PI of soil is shown Fig. 4a and b. It is observed that the CBR value has decreased with increase in PI. Due to lack of interlocking with increase in PI and the water content the resistance is decreased, which in turn decreases the CBR value. The trend is similar for all the four samples. Further as discussed in article 3.1 and is evident from fig. 4a lower values in CBR (0.5 Hr) than CBR(0.4 Hr) due to mixing.

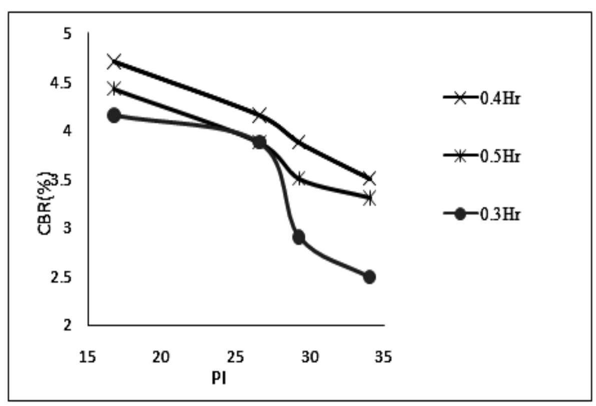

Figure 4a Variation of CBR with respect to PI

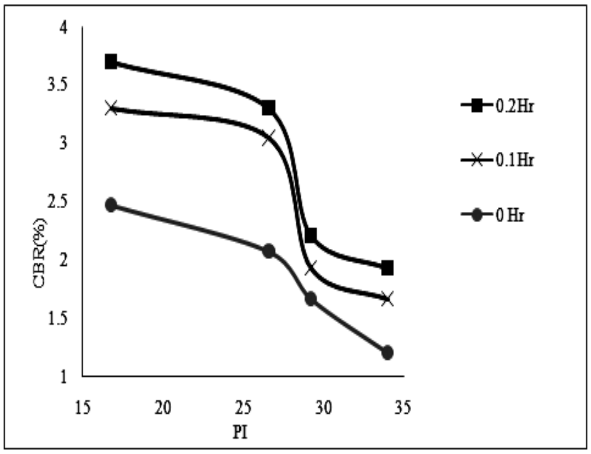

Figure4b Variation of CBR with respect to P.I

3.3 Presentation of results for CBR values: effect of fines (%):

The variation in CBR values with fines (%) of soil is shown in fig 5a and 5b. It is observed that the CBR value is decreasing with fines (%). With the fines the affinity to moisture increases as is evident from O.M.C showed in Table 3. Due to the increased water content and resulting least resistance the CBR value, has suffered. The trend is simi;ar for all samples tested by varying Hr.

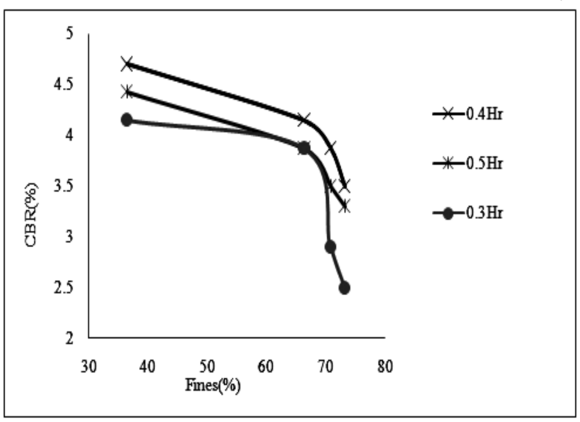

Fig. 5a variation of CBR with Fines (%)

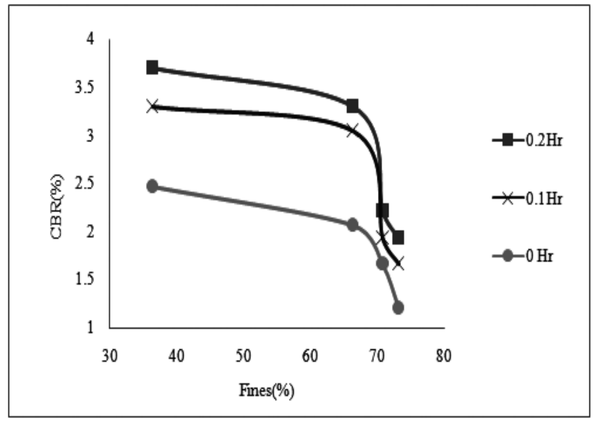

Fig. 5b variation of CBR with Fines (%)

3.4 Presentation of results of variation of factored CBRR$_c$:Effect of Hr:

The variation of R_c with H_r is presented in Fig.6. As expected and it can be seen that a significant contribution is achieved in improving CBR values by placing aggregate. The composite layer consisting soft soil and aggregate exhibited higher resistance.Hence the problem due to low CBR of natural subgrades can be overcome by providing overlying aggregate layer. An improvement of approximately 30 to 40% in CBR is observed and is consistent for all samples. As indicated in Figure 6 and as discussed in article 3.1 mixing of aggregate with soil at higher Hr is observed, Hence the optimum thickness of layer, H_a is to be chosen for the desired improvement Similar trend is is seen for other soil samples also.

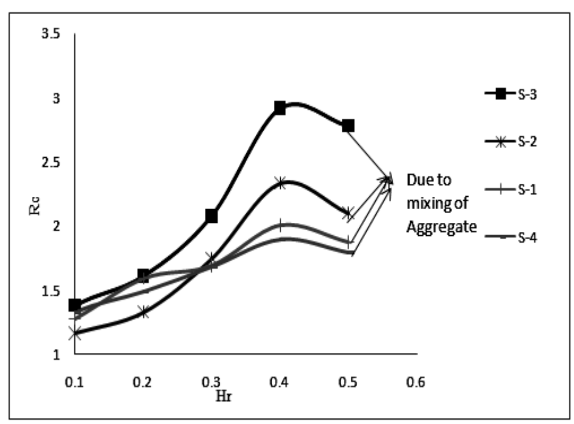

Fig 6 variation Rc with Hr

3.5 Presentation of variation of Rc: effect of PI:

Variation of factored CBR values $R_c$with PIand H_r is presented in Fig. 7. As seen the improvement is low at lower Hr. The improvement is significant from 0.2 H_r to 0.4 Hr.

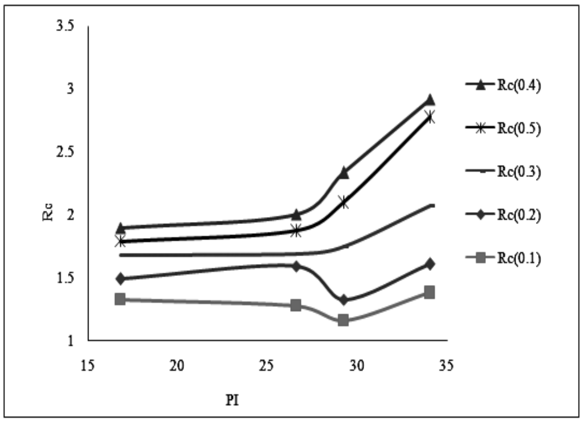

Fig 7 Variation Rc with PI

Conclusions

From the results of tests conducted on various soil subgrade samples and their variation , the following conclusions are drawn :

1. The presence of fines increases the tendency of moisture absorption resulting in higher plasticity, higher optimum water content and lower maximum dry densities.
2. Both Fines (%) and PI has an influence on CBR .It is observed that the CBR value decreased by 12% due to fines(%) and 11.72% with PI.
3. It is concluded that an improvement up to 40% in CBR can be achieved through placing an overlying aggregate.
4. The study helped in determining the optimum Hr so as to have desired improvement particularly for fine grained soils.

Notations:

S-1	**Sample-1**
S-2	**Sample-2**
S-3	**Sample-3**
S-4	**Sample-4**
L.L	**Liquid limit.**
P.L	**Plastic limit**
PI	**Plasticity Index.**
OMC, $\ddot{w}_{max}$	**Optimum Moisture Content**
MDD,γ_d	**Maximum Dry Density**
CBR	**California Bearing Ratio**
Cws	**CBR value of soil-aggregate**
Ha	**Thickness of aggregate**
Hs	**Thickness of soil**
Hr	**Ha/Hs**
Rc	**Ratio of Cws/Cws@Hr=0**

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