

# EFFICACY OF OVERLYING COARSE AGGREGATE AND GEOSYNTHETIC SEPARATOR ON CBR VALUE FOR SOFT SUBGRADE OF VARYING PLASTICITY - A LAB STUDY

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## Abstract

Soft subgrade soil poses challenge for construction of pavements. These soft subgrade soils have a tendency to absorb high moisture content and exhibit high compressibility. Under loads. Because of which the life of pavement constructed over these is highly suffered. Among notable properties plasticity index is a reliable property as listed in literature for identifying these soft soil and nature of compressibility. Soil stabilization is one of the techniques listed in literature for improving these soft soils. Often the stabilization suffers due to high cost particularly improving deep deposits of soft soil and time consuming. . Providing stiff layer with gravelly soil can solve the problem to majority extent. These gravelly layer of soils bear the load and distribute through arch action, to, minimize the stresses to soft soil. .However the efficiency of these gravelly layer depends on their relative thickness and prevention from mixing with soft subsoil. This paper discusses the efficacy of overlying aggregate to improve CBR values of soft subgrade in the presence of separator geotextile. The thickness of aggregate is varied and expressed by  $H_r$  (a fraction to soil thickness given as  $H_a/H_s$ ). Laboratory CBR tests are conducted on four subgrade types with varying in plasticity & fines content overlying with gravelly aggregate with  $H_r$  varied from 0, to 0.5 in increments of 0.1. 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 tested without separator is more with  $H_r$ .

**Keywords:** Plasticity index, CBR value, Separator geotextile, Subgrade, CBR

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## 1. INTRODUCTION

Soft soil sub grades are present in several parts of world. Generally the condition and resistance to penetration of subgrade soil influences the overall performance and service life of pavements constructed on soft subgrade.. The thickness of subgrade, moisture content and plasticity properties are important component and have as a substantial impact on base and overall performance. Geogrids are the most feasible and pragmatic choice for reinforcing the clay to improve the CBR value in the circumstances where the effect Plasticity index is severe (7), (9). Recently a new concept of equivalent California Bearing Ratio of the composite systems was introduced and studied (2). A Geosynthetic layer placed as separator will prevent mixing of aggregate to sub soil. The performance of different Geosynthetics in reinforced soil-aggregate systems are depending not only plasticity and also on density (1). The strength of the subgrade is considerably increased by introducing Geogrids reinforcement in the soil. The performance of unpaved roads is better with the inclusion of geotextiles and considerable improvement at larger depth of penetration (5). Apart from planar reinforcement randomly reinforced fiber will influence CBR value (6). The strength of the locally available subgrade soil is improved by addition of

Geotextile and Geogrids(8). Inclusion of coir Geotextile enhances the CBR(3). The strength of the subgrade soil varies with the length and diameter of the jute fiber(4). Inclusion of jute Geotextile decreases the penetration and deformation of the soil and also enhance the CBR value(10).

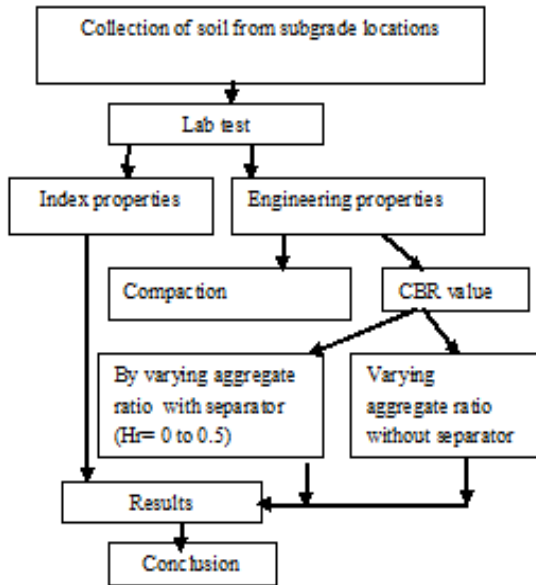
The objective of the present work is to study the efficacy of performance of soil- separator- aggregate system. Studies are carried out by changing plasticity, fines content and thickness of overlying aggregate. The objective, methodology, parameters studied and results are detailed in the subsequent headings.

### 1.1 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 with and without separator geotextile at the interface of soil with aggregate and iii) quantification of the performance improvement.

**Methodology**

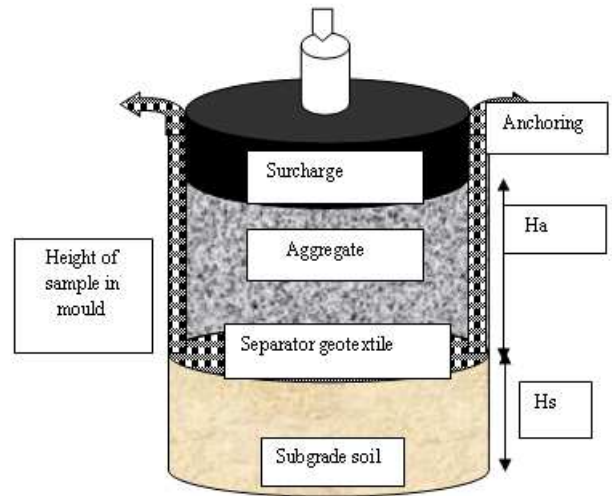
For the objective cited the following is the methodology adopted as shown in figure 1



**Fig-1** Outline of Methodology

**2. EXPERIMENTAL STUDY**

Three types of materials are used in experimental study. The material includes fine grained soil, 20mm size coarse aggregate and geotextile. Four types of fine grained soil with varying plasticity are considered for study. The geotextile used for present study is a woven type and the specifications are presented below. 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, Ha over soil layer of thickness, Hs in CBR mould. The testing is carried out by varying Hr (a ratio of Ha to Hs). The same tests are carried out by placing a separator geotextile at the interface of soil-aggregate. 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 The samples are compacted at maximum dry density condition for performing CBR test and Hr is varied from 0 to 0.5 in the increments of 0.1. Test setup for sample without and with separator geotextile is shown in Figs 2 and 3a &3b.



**Fig-2** Schematic diagram of soil- aggregate- separator geotextile layers for lab CBR test



**Fig.3a** Test setup for CBR value and Aggregate Without separators



**Fig.3b** Test setup for CBR value of soil and aggregate with separator,

**3. PRESENTATION OF RESULTS AND DISCUSSION**

The results are presented in fig. 4 to fig. 12. The properties of soil, aggregate. For quantifying the improvement, the results are expressed in terms of factored CBR ratios  $R_c$  and  $R_c^*$

$$R_c = \frac{\text{layered CBR without separator}}{\text{CBR of natural subgrade}}$$

$$R_c^* = \frac{\text{CBR value for layered soil with separator}}{\text{CBR for natural subgrade.}}$$

**Table -1** Properties of Aggregate

Size of Aggregates (mm)	Density of Aggregate (kN/m <sup>3</sup> )
20	22.95

**Table- 4** Engineering properties of soil subgrade

Sample	OMC, wmax (%)	Maximum dry density(MDD),γ <sub>d</sub> (kN/m <sup>3</sup> )	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

**Table-2** Geo-textile Product Data Sheet (poly propylene Geo-textile TFI 5100)

Properties	Test method	Unit	TFI 5100	TFI 5200
Mass per Unit Area	ASTM D5261	gsm	280	350
Grab Tensile Strength	ASTM D4632	Kn/m	0.30	0.590
Grab Elongation	ASTM D4632	%	15	15
CBR Puncture	ASTM D6241	N	2014	2422
Ultraviolet Resistance	ASTM D4355	—	70% at 500 hr	70% at 500 hr
Apparent opening size	ASTM D4751	mm	0.425	0.425
Permeivity	ASTM D4491	Sec <sup>-1</sup>	0.05	0.05
Flow Rate	ASTM D4491	L / m / s	160	160

**Durability:** All Geotextile has to be covered for two weeks after installation to protect to be durable for a minimum of 25 years in natural soil with 4 < pH < 9 and soil temperature < 22 C

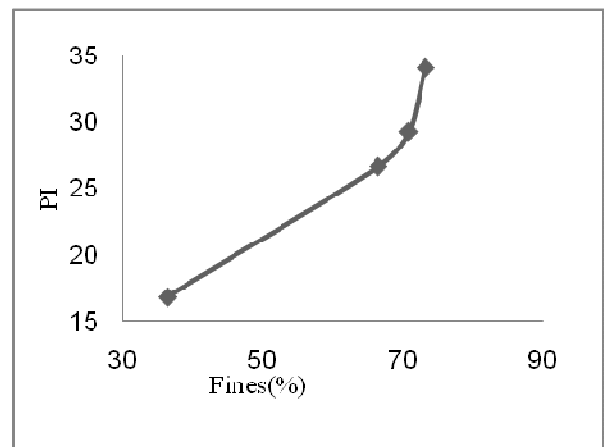
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**Table- 3** Index properties of soil subgrade

Sam ple	L.L (%)	P. L (%)	P.I (%)	Fines (%)	Cc	Cu	I.S classifica tion
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

**3.1 Presentation of Results for PI Variation with Fines (%):**

The variation of plasticity index (PI) with fines (%) is presented in figure4 . It is observed that the value of PI increase with increase in fines (%). Due to lack of interlocking with increase in fines, the soil became more clayey. This resulted in increase in PI



**Fig-4** Variation of P.I with Fines (%)

**3.2 Presentation of Results for OMC and MDD Variation with PI**

It is observed from the figures 5(a) and 5 (b) that the OMC (Optimum Moisture Content) and MDD (Maximum Dry Density) of clay soil with plasticity index of 16.8 and 34.02 respectively. When the plasticity index increases to 34.02, OMC increases by 36.62% and the MDD decreases by 12.12%. It is found that the rate of increase in OMC and decrease in MDD rises when the soil index of plasticity increases. With fines PI increases as seen from curve in fig 4. Hence these fines absorb more moisture due to which OMC has increased. It is seen from fig 5(a) OMC has increased from 15.40 to 21.04 with PI. Also MDD has decreased with fines.

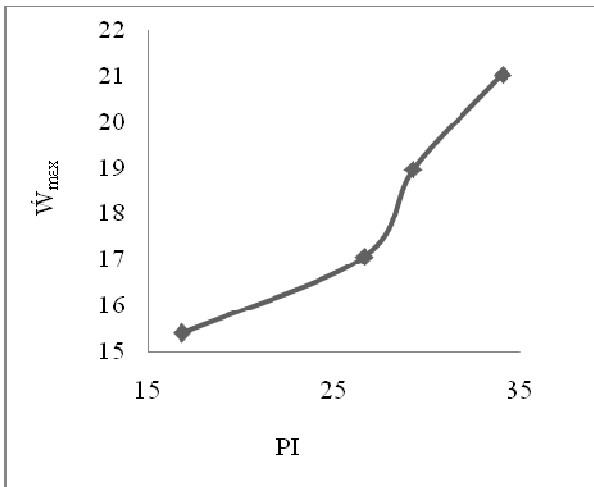


Fig- 5 (a) Variation of OMC with PI

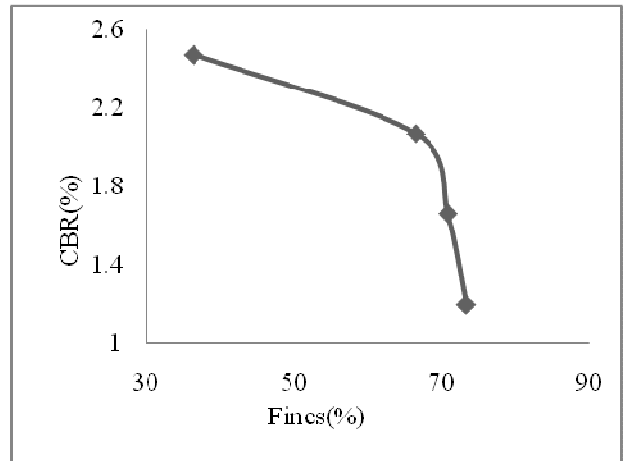


Fig. 6 Variation of % fines and CBR

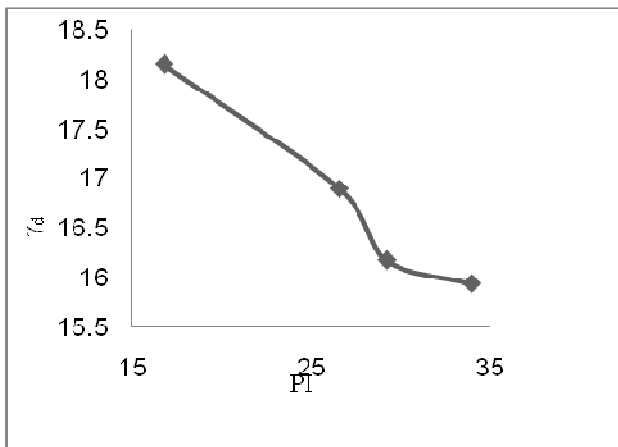


Fig- 5 (b) Variation of MDD with PI

### 3.3 Presentation of Results for CBR Variation with Fines (%):

The variation of CBR with fines (%) is presented in fig. 6. It is observed that the CBR value decreased with increase of fines (%). Due to lack of interlocking with the increase in fines and the water content (O.M.C) the resistance is affected, which in turn decreases the CBR value

### 3.4 Presentation of Results for CBR Variation with PI:

The variation of CBR with P.I is presented in figure 7 it is observed that the CBR value decreased with increase in PI due to increase in OMC and fall in MDD, the resistance is affected, which in turn decreases the CBR value.

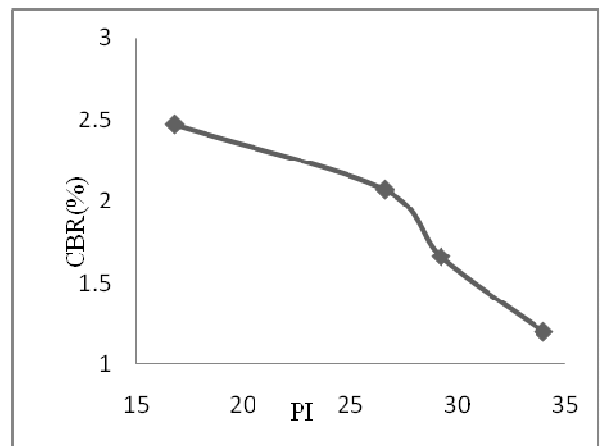


Fig-7 Variation of CBR with P.I

### 3.5 Presentation of CBR values for Hr of the Soil and Aggregate while with and without Separator:

The variation in CBR values with Hr of separator and without separator soil is shown in figure 8. It is observed that the CBR value is increasing with Hr. Using the separator is causing in increase of CBR value. Due to overlaying aggregate, the bearing resistance is increased. With increased Hr due to increased bearing resistance CBR value for all the four soils has increased considerably. With increase in value of Hr from 0 to 0.5 for three different samples, 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 for without separator soil. There is also decrease in CBR value in spite of increasing the Hr value after a certain threshold level. This is due to lack of interlocking with the increase in air voids the resistance is affected. Similarly the CBR value has increased from 2.7 to 4.7; 2.49 to 4.43 and 2.21 to 4.15 for Hr ranging from 0 to 0.5 for separator soil. Here, the penetration of the aggregate is avoided by using separator.

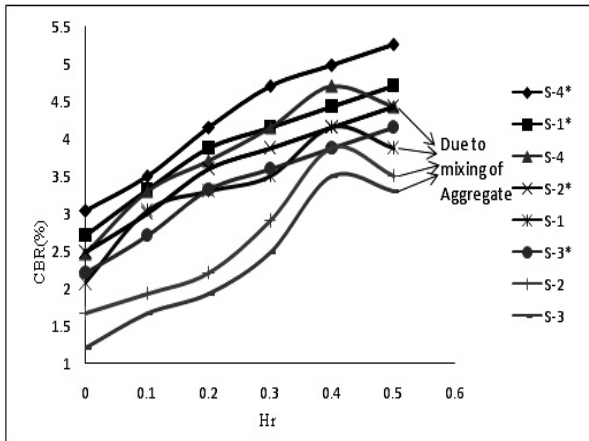


Fig. 8 Variation of CBR with respect to Hr

**3.6 Presentation of CBR values for PI of the Soil and Aggregate with and without Separator for Various:**

The variation in CBR values with PI of soil with and without separator is shown Fig. 9 and 10. It is observed that the CBR value decreased with increase in PI. However using separator is causing increase of CBR value. Due to lack of interlocking with increase in PI and the water content the resistance is decreased which in turn decreases the CBR value for all the four samples having Hr values from 0 to 0.5.

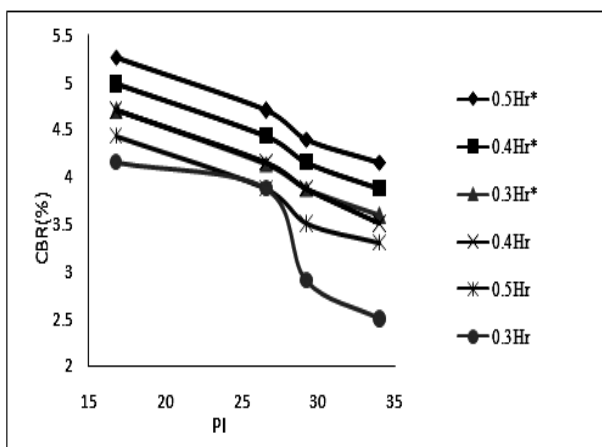


Fig. 9 Variation of CBR with respect to PI

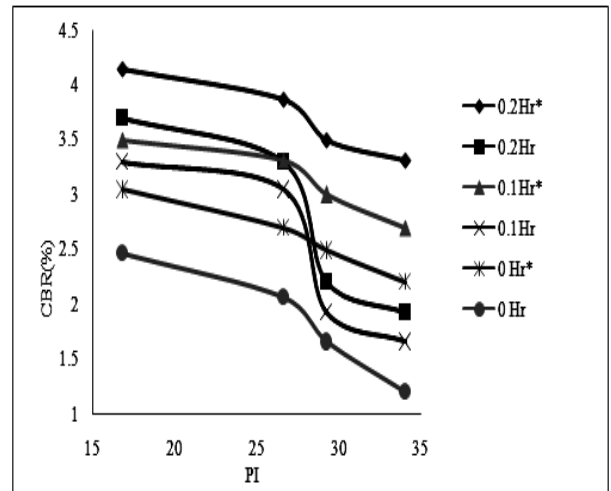


Fig-10 Variation of CBR with respect to P.I

**3.7 Presentation of CBR values for Various Fines (%) of the Soil and Aggregate with and without Separator:**

The variation in CBR values with fines (%) of soil with and without separator is shown in fig 11 and 12. It is observed that the CBR value is decreasing with fines (%). Due to lack of interlocking with the increase in fines and water content the resistance is decreased which in turn decreases the CBR value for all the four samples. However the CBR values increased with the use of separator and also when there is increase in Hr values

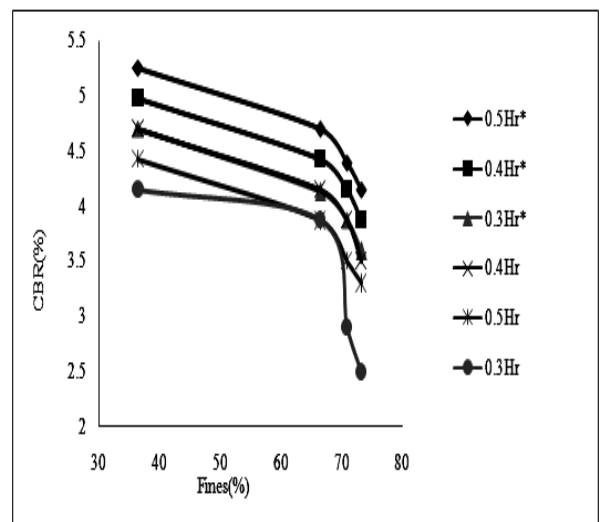


Fig- 11 variation of CBR with Fines (%)

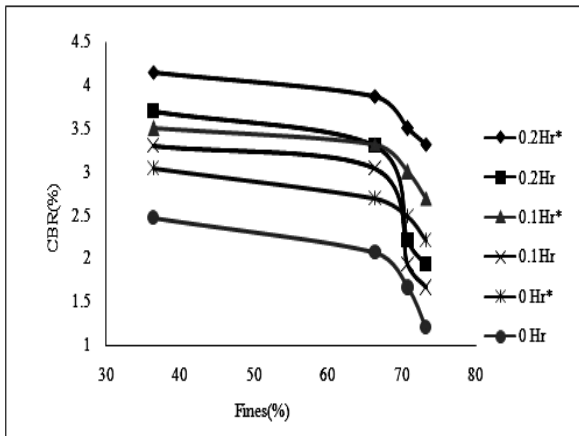


Fig- 12 variation of CBR with Fines (%)

### 3.8 Presentation of Results for Variation of CBR Increase (%) with PI due to Separator:

The variation of CBR increase (%) due to separator with PI is presented in Fig13. It is observed that though CBR has increased with separator, higher improvements are achieved only at low Hr. At low Hr, due to higher significant depth of stress transfer, the tensile strength contribution of separator geotextile comes in to play in sharing part of load. However this contribution is insignificant at higher Hr due to predominant load shared by the aggregate. The improvement percentage is high for Hr 0.2 and low for Hr 0.4.

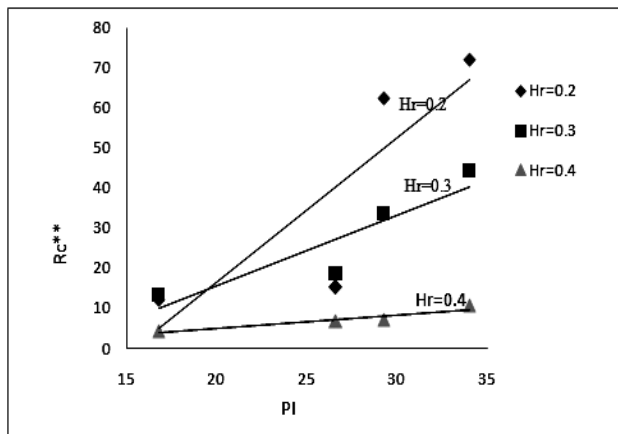


Fig.13 % increase in CBR value and PI

### 3.9 Presentation of Variation of Ratio of Factored CBR, Rc & Rc\* with Hr

The factored CBR values Rc and Rc\* and their variation with Hr is presented in Fig. 14. As expected and it can be seen that a significant contribution is achieved in CBR values due to aggregate and separator geotextile. Hence the problem due to

low CBR of natural subgrades can be overcome by providing either overlying aggregate layer or separator or both. However the combination is to be chosen for best results. As observed from the graph for sample-3 Rc\* has increased from 2.25 to peak value of 3.5 for Hr from 0 to 0.5, but Rc has increased only from 1.2 to a peak value of 2.75 for Hr from 0 to 0.4, and later decreased. The same trend is seen for other soil samples also.

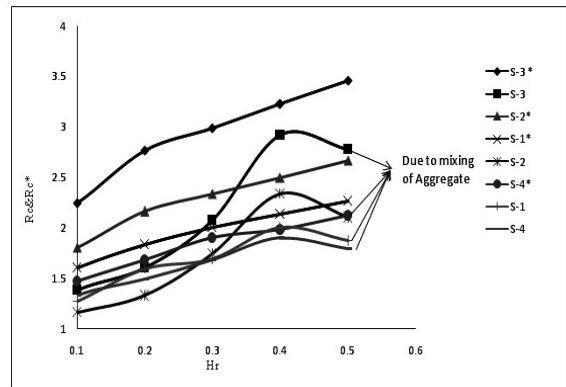


Fig- 14 variation Rc & Rc\* with Hr

### 3.10 Presentation of Variation of Rc & Rc\* with PI:

Sample variation of factored CBR values Rc and Rc\* variation with PI for Hr( 0.3) is presented in Fig. 15. The variation indicated the effect of separator and especially at higher PI. As expected the variation is more significant for samples with separator than for samples without separator. Similar trend is observed for samples tested maintaining other Hras shown in fig. 16 to 18. From the figures an interesting phenomenon is observed. The problem of aggregate mixing with subgrade is aggravated at higher Hr say 0.5, this has resulted in decrease of Rc, however Rc\* showed continuous increase. This demonstrates the need of separator geotextile in order to improve CBR avoiding problems arise due to mixing.

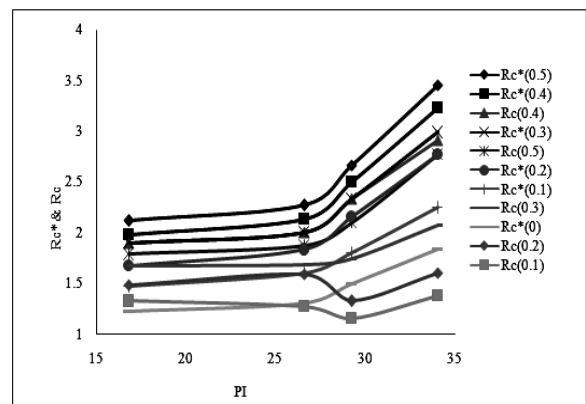


Fig- 15 Variation Rc & Rc\* with PI

## CONCLUSIONS

From the tests conducted on various soil subgrade samples , the following conclusions are drawn ::

1. Fines (%) and PI has an influence on CBR and it is observed that the CBR value decreased by 12% with respect to Fines(%) and by 11.72% with respect to PI.
2. It is observed that the CBR value of composite soil (soil+ aggregate) is 33% more than that of soil alone.
3. CBR of composite soil with separator soil (Hr=0.1 to 0.5) are 23.47% and 50% higher than that of CBR values of the soil without separator.
4. The effect of separator is insignificant at higher Hr value say 0.4 irrespectively of plasticity. The improvement is significant at low Hr of 0.2 over Hr 0.4
5. Given a soil of plasticity index, the factored CBR, has provided a guideline for choosing optimum combination of aggregate and separator geotextile for a desired improvement by avoiding mixing.

## NOTATIONS:

S-1	Sample-1 without separator
S-2	Sample-2 without separator
S-3	Sample-3 without separator
S-4	Sample-4 without separator
S-1*	Sample-1 with separator
S-2*	Sample-2 with separator
S-3*	Sample-3 with separator
S-4*	Sample-4 with separator
L.L	Liquid limit
P.L	Plastic limit
PI	Plasticity Index
Cc	Coefficient of curvature
Cu	Coefficient of uniformity
OMC, $\bar{w}_{max}$	Optimum Moisture Content
MDD, $\gamma_d$	Maximum Dry Density
CBR	California Bearing Ratio
Cs	CBR value of soil-aggregate-separator soil
Cws	CBR value of soil-aggregate soil without separator
Ha	Thickness of aggregate
Hs	Thickness of soil
Hr	Ha/Hs
Hr*	Separator
Rc	Ratio of Cws/Cws@Hr=0
Rc*	Ratio of Cs*/Cws@Hr=0
Rc**	Increased % of CBR Values

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## BIOGRAPHIES



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