International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 7 Issue 11, November-2018

Improving of Engineering Properties of BC Soils

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***Abstract*—The main objective of this experimental study is to improve the properties of the black cotton soil by adding fine sand problematic soil (Black cotton soil) is too weak and does not have required stability for any kind of construction works. In foundation as well as in pavements, sub grade layer lays below the base course or surface course. To improves the strength of sub grade soil, by improving its engineering properties BC soil,In the present study, stabilization of sub grade soil by using sand and cement (different proportions of cement sand and BC soil) is used to develop the strength of sub grade soil. The aim of this study is to examine the optimum proportion of the stabilizer, which enhance the strength and stability of soil (CBR less than or equal to 2% to more than 7%) which is appropriately suitable for pavements. An experimental study has been made to use fine sand for improving the strength of black cotton soil and 2% of cement is added for providing better soil strength expressed in terms of CBR values which may prove to be economical. Optimal proportion of cement added to provide more soil strength. The appropriate mix for black cotton soil ,fine sand This is followed by deciding particular mix conditions to gives the differences in dry density and CBR value to achieve the great strength properties of BC soil.**

Keywords— Expansive soils, dry density, stabilization, CBR value

I. INTRODUCTION

Black cotton soils are also known as expansive soils. These soils generally occur in arid and semiarid regions of the world. They show very high swell shrink behaviour which makes them unsuitable as foundation soils and earth construction material. These soils are more fertile for agriculture and cotton crop is widely grown in expansive soils, hence expansive soils are popularly known as black cotton soils in INDIA. In other countries this soils are known as expansive soils. These soils are unsuitable for constructions, in order to use this soil as earthwork material for any constructions soil stabilization is needed. The properties of the soil are been determined by conducting different tests, these tests are conducted even to know the bearing capacity of the soil and the stabilization methods that are to be done to increase the bearing capacity of the soil. Expansive soil (Black cotton soil) is very weak and does not have enough stability for any type of construction work. In pavement, sub grade layer is the bottom most layer underlying the base course or surface course. To make the sub grade soil stable, by improving its engineering properties is very essential. In the present work, stabilization of sub grade soil by using sand and cement (varying percentage of sand and constant percentage of cement by weight of soil) is used to enhance the strength of sub grade soil. The purpose of this study is to determine the optimum dose of the stabilizer, which improves the strength of soil (CBR less than or equal to 2% to more than 7%) which is suitable for pavement structure. To evaluate the strength of soil, various tests have been performed such as sieve analysis, liquid limit, Plastic limit, Standard proctor test and CBR test in the laboratory. The result shows that the use of sand and cement in combination increases the California Bearing Ratio values (CBR) i.e. the strength of soil to a great extent. Pavement. Introduction Expansive soil is always problematic for the engineering structures due to its swelling and shrinkage behaviour. It gets shrink when dried in summer and swells when wet in winter season. The structures on these soils experience large-scale damages. The property of expansive soil results cracks in the soil without any warning. These cracks are some time very large and suffer rigorous damage to the structure. Roads running through expansive soil regions are subjected to severe distress resulting in poor performance and increased maintenance cost. Again clayey soil having plasticity index more than 6 are required to be treated and stabilized before going to be used for construction as per the specification of Ministry of Road Transport & Highway, Government of India. To prevent the structure from such damages, stabilization of soil is required with the stabilizing materials like fly ash, lime, sand, bitumen, cement, rice husk ash etc. The engineering properties of Black cotton soil (B.C. soil) can significantly be improved with these stabilizing agents. The technique of stabilizing the soil with sand and cement is being carried from long time. Mixing Portland cement, sand and pulverized black cotton soil with the optimum moisture content and compacting the mix to attain required density. The material obtained by mixing soil, cement and sand is known as cement sand soil. Cement in the range of 2 to 5 percent brings remarkable improvement in the engineering characteristics of B.C. soil. Similarly increasing proportion of sand as stabilizer also improves the properties of soil. Soil–sand-cement is a well prepared mix of soil when water is added to the mix and compacted; the small proportion of cement is not able to bind all the particles to a coherent mass but it interacts with the silt and clay fractions and reduces their affinity to water and reduces the swelling behaviour of mix modifies the properties of the so the strength of soil increase. **Page** behaviour of mix modifies the properties of the so the strength of soil increase.

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Fig 1.0: Wide cracks in expansive soil

EXPERMENTAL INVESTIGATIONS

Hydrometer analysis


Fig 1.3: Sample with hydrometer.

Fig 1.3: Water & Soil mixed sample.

Time in minutes	Hydrometer reading(R_h)	Composite correction	Corrected reading R =(R_h +C_m)	H_e =H+(h-v_h/2a)	D= M(H_e /t)$^{1/2}$	% finer
0.5	26.00	-0.90	26.4	32.3	0.061	58.0
1	25.00	-0.90	25.40	31.3	0.043	54.3
2	24.95	-0.90	25.35	31.25	0.033	50.0
5	22	-0.90	22.4	28.3	0.023	44.1
10	20	-0.90	20.4	26.3	0.016	44.1
15	15.7	-0.90	16.1	22	0.012	32.2
20	15.4	-0.90	15.8	21.7	0.009	26.7
25	10.9	-0.90	11.3	17.2	0.006	21.2
30	10.6	-0.90	11.0	16.9	0.004	19.3
45	9.5	-0.90	9.9	15.8	0.003	14.7
60	5.4	-0.90	5.8	11.7	0.002	6.6
75	5.2	-0.90	5.6	11.5	0.001	3.8
90	5.1	-0.90	5.5	11.4	0.001	2.5
105	0.5	-0.90	0.9	6.8	0.001	2.3
1440	0.5	-0.90	0.9	6.8	0.001	1.8

1.3: Hydrometer analysis.

Corrected reading (R) = (R_h +C_m)

Height (H_e) =H+(h-v_h/2a)   Particle size (D)= M(H_e /t)$^{1/2}$.

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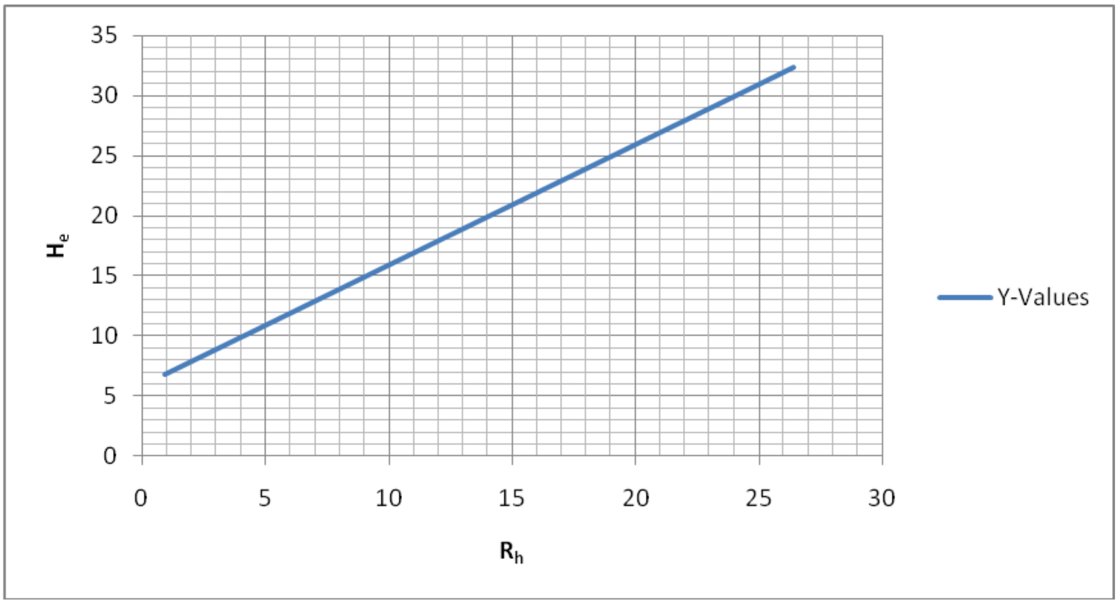
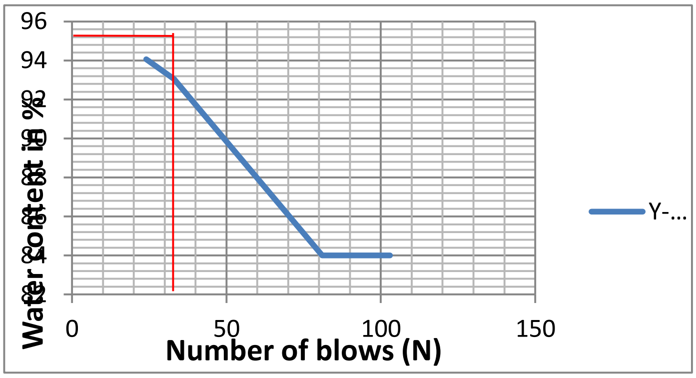


Graph 1.3: Graph plotted between R_h & H_e

Liquid limit test

S.No	Amount of water added(ml)	% of water added	Moisture content	No. of blows
1	105	87.5	78.23	103
2	111	92.5	84	81
3	117	97.5	93.05	33

Graph:-Plot a straight line graph between number of blows and water content.



Graph 1.1: Flow curve for liquid limit test

The flow curve is drawn between logN on x-axis and water content on y-axis

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Plastic limit

Trial no.	Container number	Wt. of container(gm)	Wt. of wet soil + container(gm)	Wt. of dry soil + container(gm)	P.L moisture content(%)
1	1	39.86	60.03	55.19	31.57

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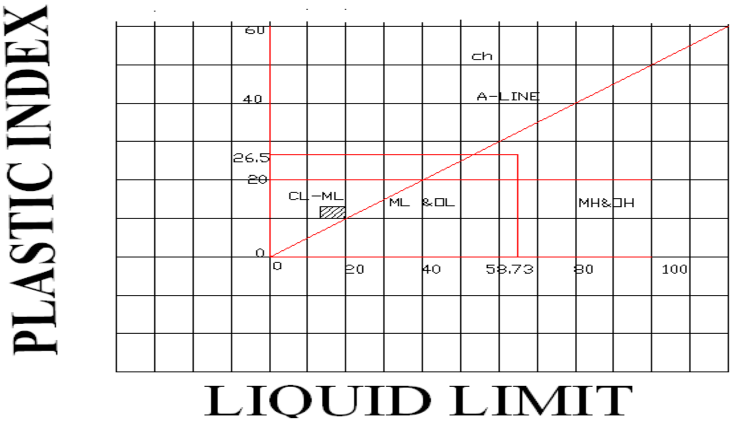


Graph 1.2: Graph plotted between liquid limit & plasticity index

Average plastic limit of the given soil= 38.63%

Plasticity index of the given sample= 32.69 .Shrinkage limit, Ws= ($(M_1-M_s)-(V_1-V_2)* p_w/M_s)$).

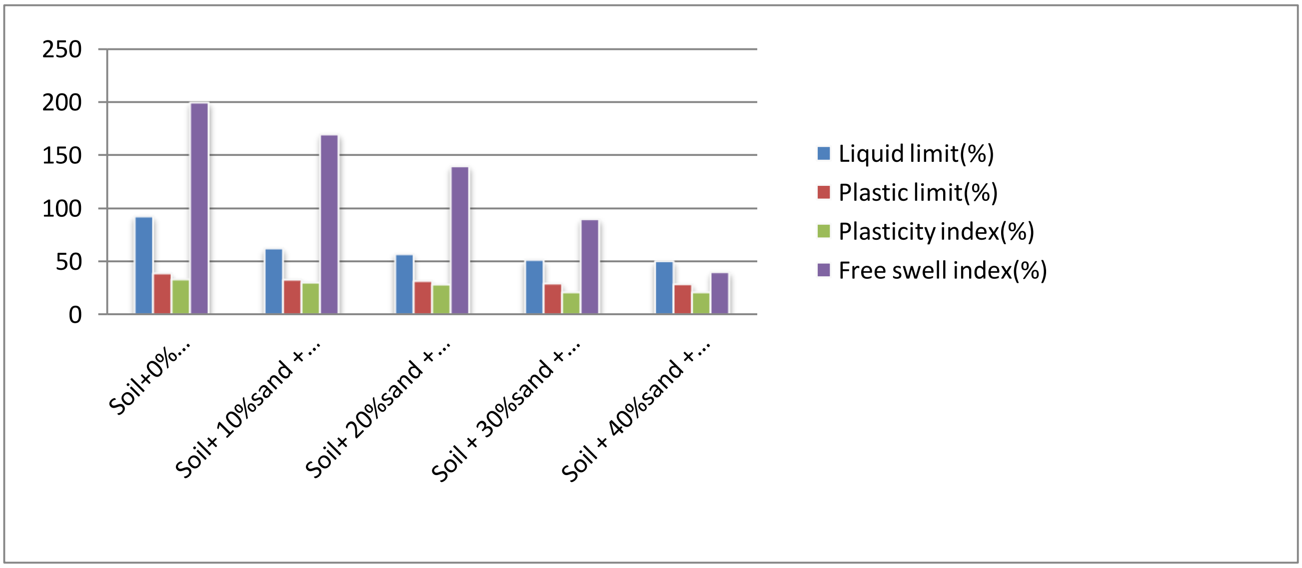
Shrinkage ratio = $M_s/ V_2* p_w$.

Volumetric shrinkage =VS= $((V_1-V_2)/ V2)* 100$

Values of LL,PL PI&SI :-

Soil type	Liquid limit (%)	Plastic limit (%)	Plasticity index (%)	Free swell index (%)
Natural soil	92.5	38.69	32.69	200
Soil + 10%sand + 2%cement	62.1	32.93	29.81	170
Soil + 20%sand + 2%cement	56.8	31.25	27.96	140
Soil + 30%sand + 2%cement	51.1	28.96	20.96	90
Soil + 40%sand + 2%cement	50.0	28.5	20.79	40

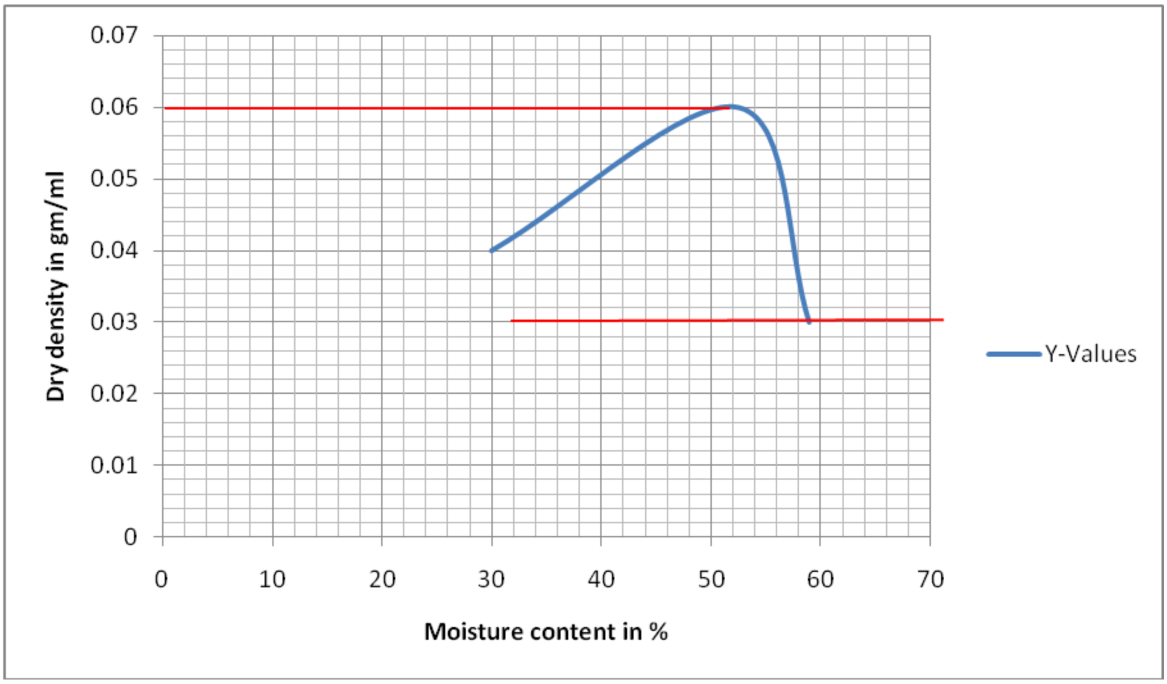
Table 1.2.1: Atterberg limits of soil-sand-cement mixtures



Graph 1.2.2: Comparison of Atterberg limit of different proportion of soil sample.

Table 1.4 : Standard proctor test values.

Sample no	1	2	3
Weight of compacted soil+ mould	6134gms	6120gms	6090gms
Amount of water added	500ml	625ml	750ml
Bulk density(γ)	0.988	0.974	0.94
Moisture content(w)	22%	56.06%	52.54%
Dry density(γ/1+w)	0.04	0.03	0.06



Graph 1.4: A graph is plotted for light compaction curve.

Result

optimum moisture content of soil sample = 52.54%

Maximum dry density of soil sample = 0.06 gm/ml.

1.5.Modified Proctor Test (Heavy Compaction Test)

Sample no	1	2	3
Weight of compacted soil+ mould	10458gms	10544gms	10380gms
Amount of water added	1250ml	1000ml	1500ml
Bulk density(γ)	0.988	0.974	0.94
Moisture content(w)	22%	56.06%	52.54%
Dry density(γ/1+w)	0.04	0.03	0.06

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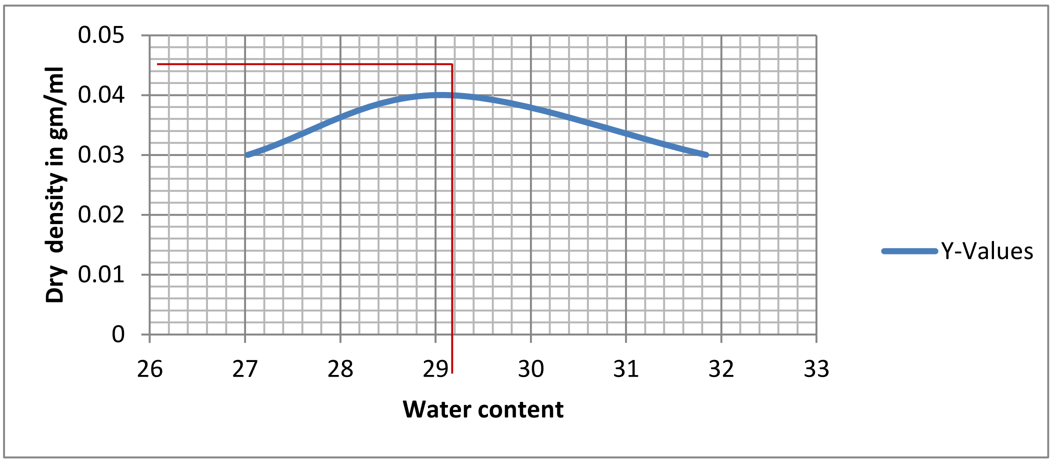


Graph 1.5: Graph plotted for heavy compaction.

Result: Optimum moisture content = 29%.
Max dry density = 0.04 gm/ml.

1.6 CBR test for bc soil stabilized with fine sand&cement

CBR value = Penetrarion load/ Standard load *100.

The mix proportion samples of soil, sand and cement used for stabilization are:

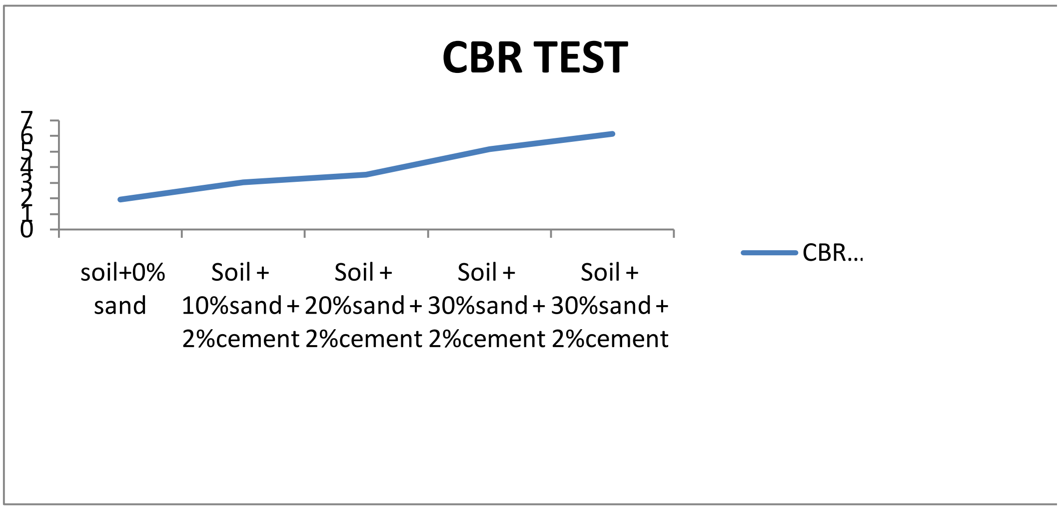
1. BC Natural soil
2. BC Soil + 10%sand + 2%cement
3. BC Soil + 20%sand + 2%cement
4. BC Soil + 30%sand + 2%cement
5. BC Soil + 40%sand + 2%cement

Table 1.6: Tabular column of Standard loads with respect to penetration of plunger

Sl.no	Penetration of plunger in mm	Standard load in kg
1.	2.5	1370
2.	5.0	2055
3.	7.5	2630
4.	10.0	3180
5.	12.5	3600

Sl. No	Soil type	Soaked CBR (%)
1.	Natural soil	1.93
2.	Soil + 10%sand + 2%cement	3.05
3.	Soil + 20%sand + 2%cement	3.53
4.	Soil + 30%sand + 2%cement	5.14
5.	Soil + 40%sand + 2%cement	7.39

Table 1.6: California Bearing Ratio (CBR) test of soil-sand-cement mixtures



Graph 1.6: Comparison of CBR of different proportion of soil samples

CONCLUSIONS

1. Potentially Swelling soils are Prevalent in our Country and must be recognized as a real problem.
2. By conducting grain size analysis and hydrometer tests on the soil specimen, here by we conclude that the soil is been classified as SILTY CLAY.
3. The liquid limit percentage for clay from graph for 25 blows is 92.5% and liquid limit of the given soil samp Clay<75 micron i,e., 0.002mm to 0.0002mm.
4. The average plastic limit of the given soil= 38.63% and the plasticity index of the given sample= 32.69 .
5. The volume of shrinkage of the given clay sample = 15ml after 3 days @ 27^{o}C and the volume of shrinkage= 15ml after 6 days @ 27^{o}C . The Shrinkage limit = 20.5% and Shrinkage ratio = 2.0.
6. The free swell percent of the given clay sample = 200% .

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7. The CBR value of the given clay sample at 2.5mm penetration is CBR(2.5mm)= 1.10 and at 5mm penetration is CBR(5mm)= 1.35.
8. When sand is properly mixed with BC soil the CBR value has raised and the study reveals that the CBR value increases with the increase in sand content and reaches to a desirable CBR value for sub grade of pavement. Normally soaked CBR value is considered for pavement design. Experimentally it is found that the addition of sand content in the soil results in the improvement of soaked CBR value from 1.93% to 7.39%. The maximum CBR is obtained while using 40% sand and 2% cement with the natural soil.
9. Atterberg limits i.e. Liquid limit, plastic limit, plasticity index and free swelling index goes on decreasing with the increase in sand content. Whereas moisture content goes on decreasing and maximum dry density increases with increasing sand content.
10. The black cotton soil after stabilizing with sand and cement for higher MDD & CBR shall be taken for further improvement in CBR value using Geo-textile reinforcement.
11. By conducting standard proctor test on the given clay sample, from graph the optimum moisture content of soil sample = 52.54% and the maximum dry density of soil sample = 0.06 gm/ml .
12. By conducting modified proctor test on the given clay sample , from graph the optimum moisture content of soil sample = 29% and the maximum dry density of soil sample = 0.04 gm/ml .
13. The study reveals that the CBR value increases with the increase in sand content and reaches to a desirable CBR value for sub grade of pavement. Normally soaked CBR value is considered for pavement design. Experimentally it is found that the addition of sand content in the soil results in the improvement of soaked CBR value from 1.93% to 7.39%. The maximum CBR is obtained while using 40% sand and 2% cement with the natural soil.

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