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Stabilization of Gravel Soil Using Bitumen Emulsion

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Abstract—*Soil is one of nature's most abundant construction materials. Almost all types of construction are built with or upon the soil. In this case, the transportation engineering before constructing a road, the sub-grade soil is considered and if the strength is poor then it is deliberated about its stabilization. Cement, fly ash, lime and many types of available fiber are very commonly used for soil stabilization. The Bitumen Emulsion is very rarely applied practically in soil stabilization. The main objective of this experimental study is to improve the properties of the gravel soil by adding bitumen emulsion. An attempt has been made to use the emulsion for improving the strength and California Bearing Ratio (CBR) values of gravel soil are also proved the environment friendly and economical. This may be varied as useful for rural pavement. Thus, this experimental investigation is improved the soil strength and controlled the pollution. The soil with higher stability has more strong foundation and thus having very strong and durable structure. The variation of strength of sub-grade soil using bitumen emulsion with little quantity of cement is used as filler. Here, this research paper is explored the properties and its stability of gravel soil using bitumen emulsion as chemical stabilizing agent. Here, four particular conditions are shown the variation in dry density and CBR values are improved the properties of gravel soil.*

Keywords: *Gravel soil, CBR, Bitumen Stabilization, Bitumen emulsion.*

1. INTRODUCTION

Starting from the base, soil is a standout amongst the most abundant construction materials of nature. Just about all kinds of construction are based with or upon the soil. Long term performance of pavement structures is altogether affected by the stability and durability of the sub-grade soils [1]. In situ sub-grades frequently don't provide the support required to achieve acceptable performance under the traffic loading and the environmental demands [2]. Despite the fact that stabilization is a well-known option for improving soil engineering properties, the properties determined from stabilization shift broadly because of heterogeneity in soil creation, contrasts in micro and macro structure among soils, heterogeneity of geologic stores, and because of chemical contrasts in concoction interactions between the soil and utilized stabilizers [3]. These varieties require the thought of site-specific treatment alternatives which must be accepted through testing of soil-stabilizer mixtures. Whether the pavement is flexible or rigid, it rests on a soil foundation of an embankment or cutting, normally that is known as sub-grade [4]. Sub-grade soil may be defined as a compacted layer, generally occurring local soil just beneath the pavement crust, providing a suitable foundation for the pavement [5].

In this paper, red coloured laterite type gravel soil is taken as experimenting material. Medium settling emulsion (MS) is used as stabilizing agent in this particular work. Bitumen makes soil stronger and resistant to water and frost. Actually bitumen is a very effective agent for sand stabilization but for soil stabilization it is being very costly. There is no any particularly following process or method for soil bitumen stabilization and most importantly there is no any code for bitumen soil stabilization in Indian Standard.

2. OUTLINES OF THE EXPERIMENTAL WORK

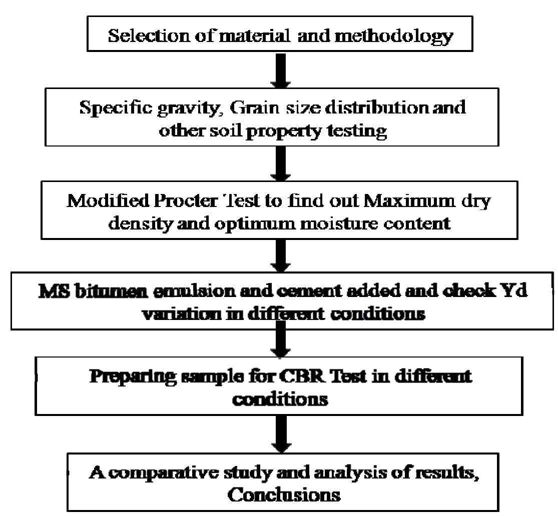

Fig. 1: Methodology Flow Chart

This experimental investigation deals with some specific tests like Modified Compaction Test, CBR Test and the main objective is to optimize this stability of soil or improve the dry density property. An attempt has been made to maximize optimizing stability changing the mixing process with bitumen emulsion. Here, bitumen stabilization is used in rural gravel road and shoulder of highway pavement.

3. EXPERIMENTAL INVESTIGATION

3.1 Specific gravity Test

Here, soil material is tested three times and the average specific gravity value comes 2.726. But, here no temperature correction is done. This test has been done in room temperature nearly 25°C.

3.2 Liquid limit and Plastic Limit Test

The gravel soil used in this experimental work was course grained soil, which is obtained from local road routes in Rourkela NIT campus. The soil was tested for specific gravity, liquid limit, plastic limit and grain size distribution as to be well known about physical properties of this particular soil material. From these experimental results, a proper idea has been appeared about the type of soil.

Liquid Limit (WL):	28.91%
Plastic Limit (WP):	21.67%
Plasticity Index (IP):	7.24%

3.3 Particle Size Distribution

Various physical and engineering properties with the help of which soil can be properly identified are called index properties. Soil grain property depends on individual solid grain and remains unaffected by the state in which a particular soil exists in nature.

Here 2000 gm of sample soil has been taken and dried in oven for 12 hours. Mostly used test for grain size distribution analysis is sieve analysis. Eleven sieves were used. And the results from sieve analysis of the soil are plotted on a semi-log graph with particle diameter or the sieve size in X axis and percentage finer in Y axis.

Table 1: Sieve analysis result

Sieve No. #	Sieve size	Mass of soil retained in each sieve (gm)	Percent retained (%)	Cumulative retained (%)	Percent finer (%)
1/2 Inch	12.5mm	0	-----	0	100
3/8 Inch	9.5 mm	99.1	4.95	4.95	95.05
1/4 Inch	6.3 mm	318.8	15.94	20.84	79.16
#4	4.7 mm	397.5	19.88	40.77	59.33
#8	2.36mm	510.2	25.51	66.28	33.72
#16	1.2 mm	255.1	12.71	79.03	20.97
#30	600 μm	166.2	8.31	87.34	12.66
#50	300 μm	132.1	6.61	93.95	6.05
#80	150 μm	48.7	2.44	96.39	3.61
Pan	-----	72.3	3.6	100	0

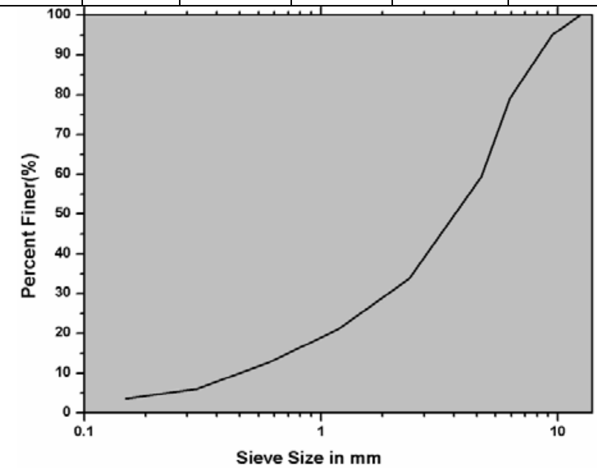

Fig. 2: Grain size distribution graph

3.4 Compaction Test

Very commonly used modified proctor test had been done. Taking 3000 gm soil sample is taken in each time. From the sieve analysis, soil is the gravel type of soil. Modified proctor tests were followed according to IS standard. The maximum dry density of the taken specimen is 2.026 gm/cc and the optimum moisture content of that taken specimen value is found 10.52%.

***Case A*:**	Normal available tested soil is used for testing
***Case B* :**	Normal available soil tested with 3% MS emulsion added
***Case C*:**	Normal available soil tested with 3% MS emulsion and 2% cement added
***Case D* :**	Normal available soils tested mixing with 3% of emulsion and 2% of cement added and wait 5 hour before testing

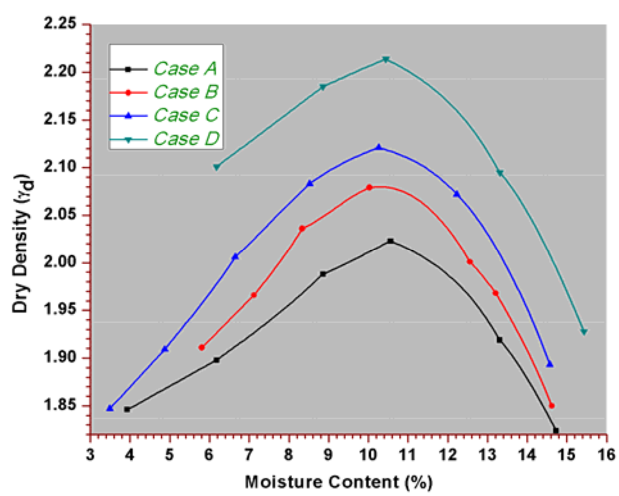

Fig. 3: Modified proctor test comparison graph

In these four particular conditions, modified proctor test is performed and plotted with moisture content percentage in X axis and corresponding dry density value in Y axis. From carves of graphs plotted, there is a crown point where the value of dry density is maximum. Here corresponding moisture content is optimum moisture content. In these four particular conditions, the modified proctor graph is listed below. This graph strictly indicates that Case D gives the optimum value.

3.5 CBR Test

The CBR is the measure of resistance of a material to penetration of a standard plunger under controlled density and moisture conditions. This is an extremely normal test to comprehend the sub-grade stability before construction of roadways. The test has been broadly researched for the field connection of flexible pavement thickness necessity. Fundamentally testing is carried out taking after IS: 2720 (Part 16). The test comprises of bringing on a round and cylindrical plunger of 50mm diameter to penetrate a pavement part material at 1.25mm/minute. The loads, for 0.5mm, 1mm, 1.5mm, 2mm, 2.5mm, 5mm, 5.5mm, 6mm….., up to 12mm to 13 mm are recorded in every 0.5mm of gaping. Penetration in mm are plotted in X axis and load expressed in kg with corresponding points are plotted in Y axis and prepared the graphs for different specimen. The CBR values at 2.5mm and 5.0mm penetrations are calculated for each specimen from the corresponding graphs which is shown below. Generally the CBR value at 2.5mm penetration is higher and this value is adopted. CBR is defined as the ratio of the test load to the standard load, expressed as percentage for a given penetration of the plunger. This value is expressed in percentage.

Here testing is done on three different testing conditions on previously four cases. So, total twelve numbers of CBR values are measured by moulding twelve different specimens. Three different types of specimens are used for each case. The corresponding CBR value for each type of specimen is written on left above corner of each graph. In this comparative experimental work it is shown that how bitumen content and mixing procedure effect on CBR value of a particular soil. CBR value and the CBR graph have been shown each case wise below.

Case A

Mould size: standard volume 2250 cc
Case A: Normal available tested soil is used for testing in this case
Used proctor test result of Case A.
Maximum Dry Density value: 2.026 gm./cc
Optimum Moisture Content: 10.52%
CBR test is done in three conditions. First one is in unsoaked condition, secondly in two days of soaking condition and lastly in four days of soaking condition. CBR value at 2.5mm penetration and 5mm penetration is calculated.

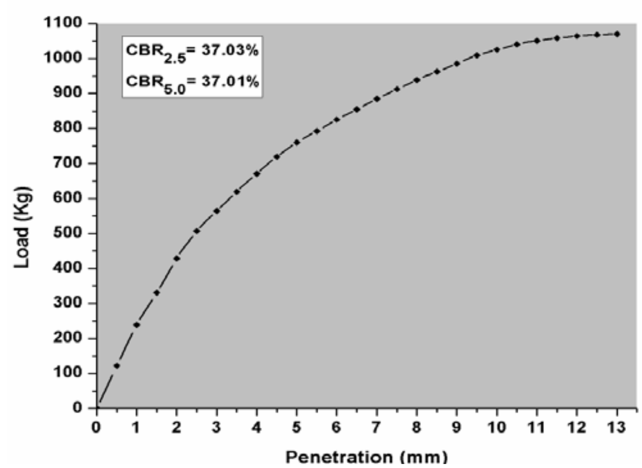

Fig. 4: CBR Test Result, Case A (Unsoaked)

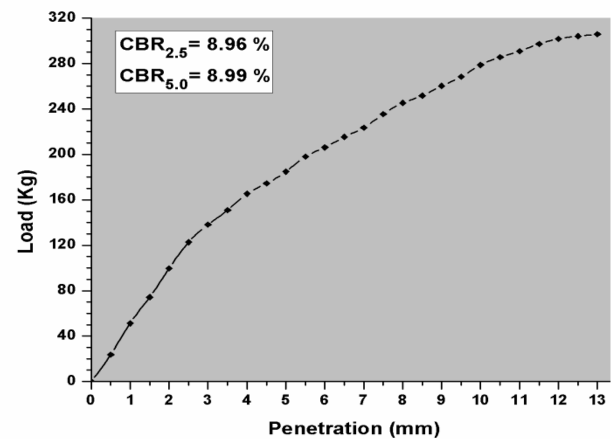

Fig. 5: CBR Test Result, Case A (2 days of soaking

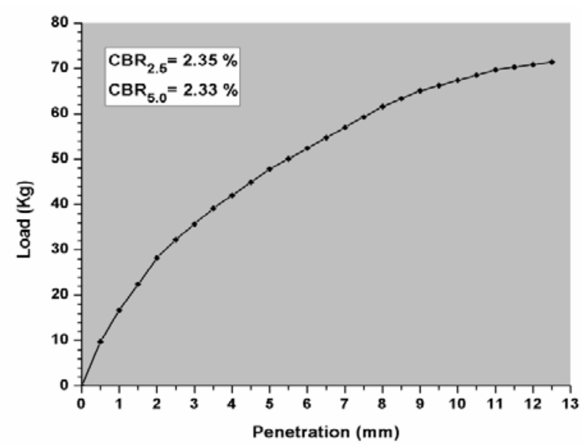

Fig. 6: CBR Test Result, Case A (4 days of soaking)

Case B:

Maximum Dry Density value: 2.083 gm./cc
Optimum Moisture Content: 10.45%

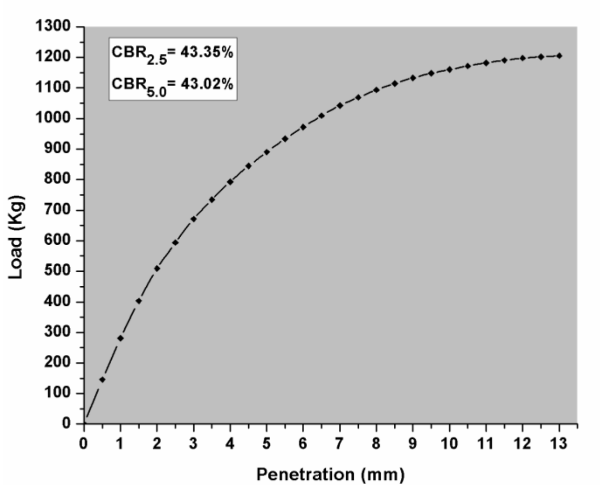

Fig. 7: CBR Test Result, Case B (Unsoaked)

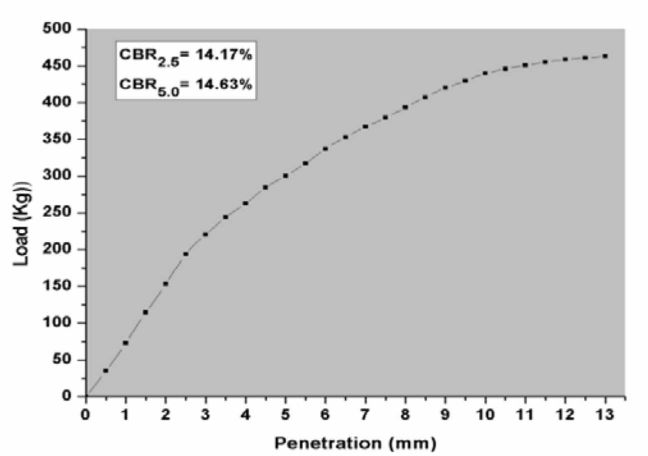

Fig. 8: CBR Test Result, Case B (2 days of soaking)

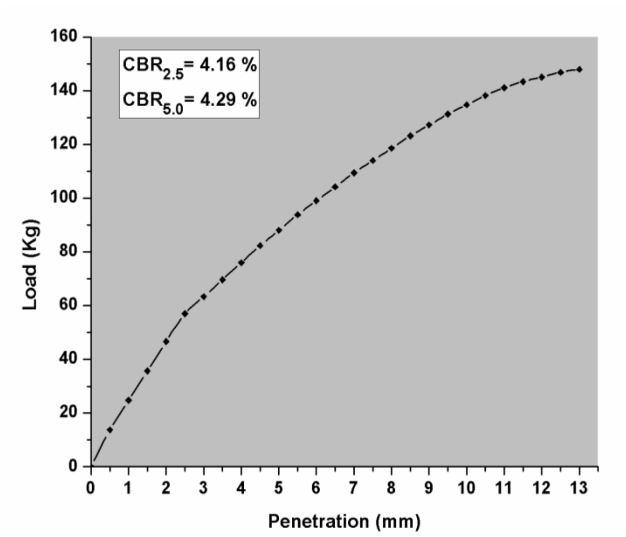

Fig. 9: CBR Test Result, Case B (4 days of soaking)

Case C:

Maximum Dry Density value: 2.123 gm/cc
Optimum Moisture Content: 10.25%

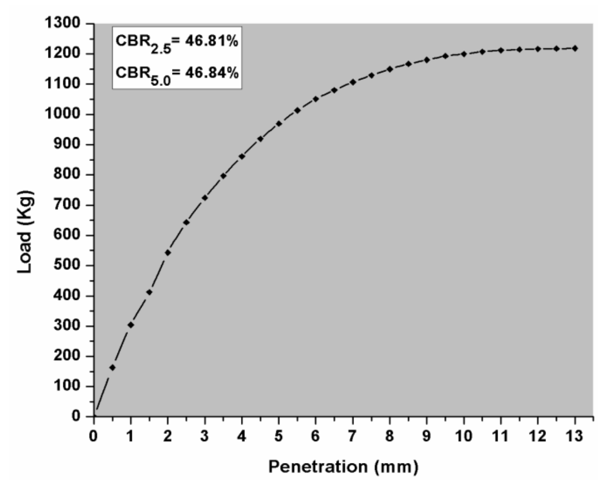

Fig. 10: CBR Test Result, Case C (Unsoaked)

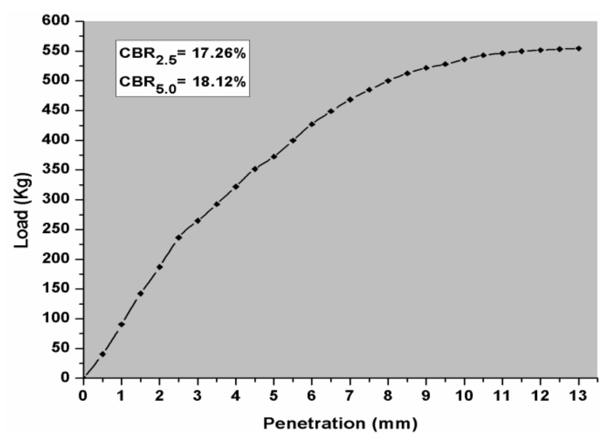

Fig. 11: CBR Test Result, Case C (2 days of soaking)

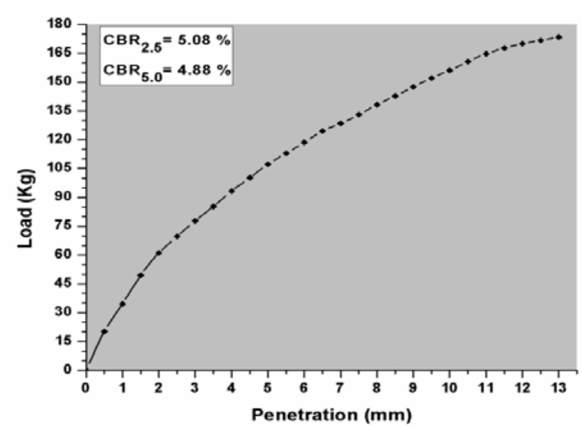

Fig. 12: CBR Test Result, Case C (4 days of soaking)

Case D:

Maximum Dry Density value: 2.212 gm/cc
Optimum Moisture Content: 10.58%

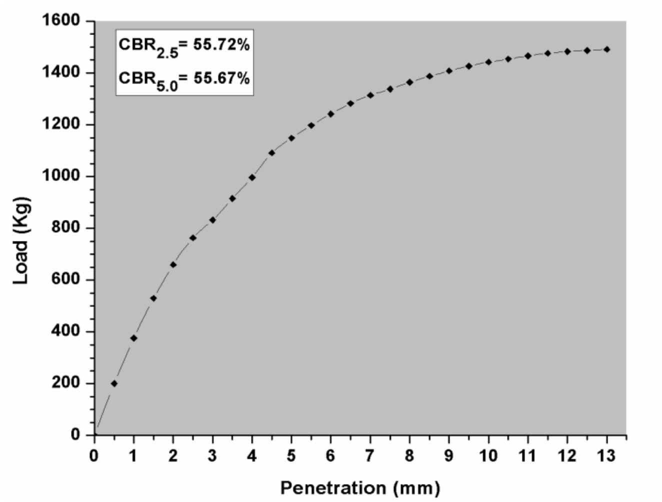

Fig. 13: CBR Test Result, Case D (Unsoaked)

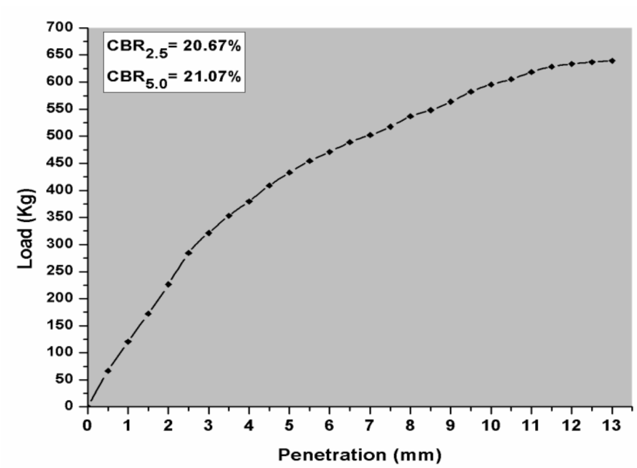

Fig. 14: CBR Test Result, Case D (2 days of soaking)

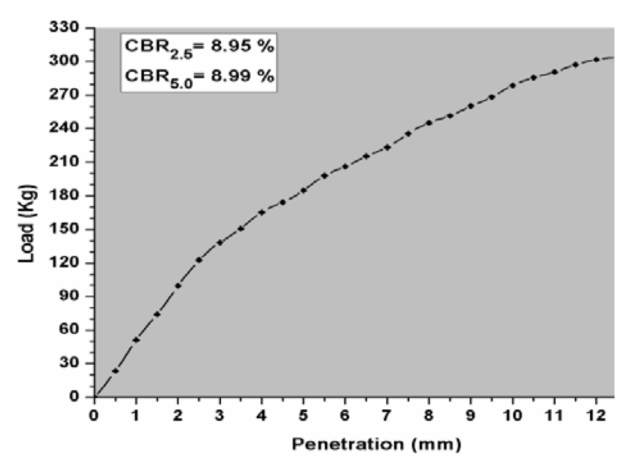

Fig. 15: CBR Test Result, Case D (4 days of soaking)

4.6 Discussion & Conclusion

Sub-grade may be defined as a compacted soil layer, generally of naturally occurring local soil, assumed to be 300 mm in thickness, just below of the pavement crust. It provides a suitable foundation for the pavement. So it is very important to improve stability of sub-grade soil, it may be replaced by good soil or by stabilization of existing soil. To check the sub-grade soil stability, CBR test is very commonly used test. The all CBR results are plotted in a bar to check whether the improvement of CBR is done or not and if done then what would be that condition where CBR value become maximum. Bar, given below, give about a clear idea on this.

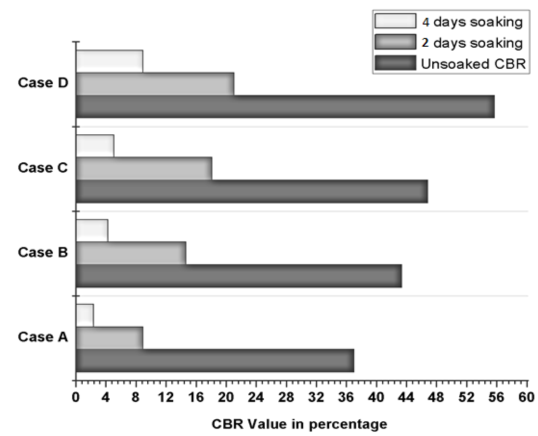

Fig. 16: CBR value comparison bar chart

From the experimental investigation, it is clear that there is considerable improvement in California Bearing Ratio (CBR) of sub-grade soil due to use of MS bitumen emulsion in proper mixing way. It is seen that it is better to work with after five to five and half hour of mixing. In each three state of conditions, CBR value increases consecutively from Case A to Case D. In this particular experimental work, it is shown that CBR value may be increased up to fifty percent of the available soil CBR. Seeing its economic cost and quality of stabilization improvement, this type of stabilization may be applicable in gravel soil road or in shoulder of highways.

REFERENCES

[1] IRC-SP-2007, "Guidelines for the Design of Flexible Pavements for Low Volume Rural Roads" IRC, New Delhi.

[2] Alayaki F.M. and Bajomo O.S., "Effect of Moisture Variation on the Strength Characteristics of Laterite Soil", in *Proceedings of the Environmental Management Conference*, Federal University of Agriculture, Abeokuta, Nigeria, 2011.

[3] Marandi S.M. and Safapour P., "Base Course Modification through Stabilization using Cement and Bitumen", *American Journal of Applied Sciences*, 6, 1, 2009, pp. 30-42.

[4] Jones D., Rahim S., Saadeh S., and Harvey J.T., "Guide lines for the Stabilization of Sub-grade Soils in California", Guideline:UCPRC-GL-2010-01,2012.

[5] Tom V. Mathew, "Pavement materials: Soil Lecture notes in Transportation Systems Engineering", 2009.