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A LABORATORY STUDY ON USE OF BITUMEN EMULSION IN GRAVEL ROAD

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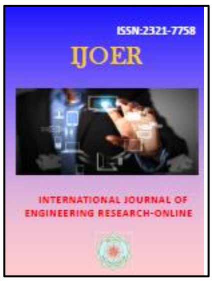

ABSTRACT
Starting from the base, soil is one of nature's most abundant construction materials. Almost all type of construction is built with or upon the soil. The most important part of a road pavement is subgrade soil and its strength. If strength of soil is poor, then stabilization is normally needed. Subgrade is sometimes stabilized or replaced with stronger soil material so as to improve the strength. Such stabilization is also suitable when the available subgrade is made up of weak soil. Increase in sub grade strength may lead to economy in the structural thicknesses of a pavement. Cement, fly ash, lime, fibers etc. are very commonly used for 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 emulsion for improving the strength of gravel soil expressed in terms of CBR values which may prove to be economical. In this study, the whole laboratory work revolves around the basic properties of soil and its strength in terms of CBR. A little cement added to provide better soil strength. It is observed that excellent soil strength results by using cationic bitumen emulsion (CMS) with little quantity of cement used as filler. The appropriate mixing conditions for gravelly soil with CMS Bitumen emulsion have been first attempted. This is followed by deciding four particular material conditions to show the variation in dry density and CBR value to achieve the best possible strength properties of gravel soil.

1. INTRODUCTION

Beginning from the base, soil is a champion among the most bottomless development materials of nature. Pretty much all sort of development is based with or upon the dirt. Long haul execution of asphalt structures is inside and out influenced by the quality and strength of the sub-review soils. In-situ sub-reviews as often as possible don't give the bolster required to accomplish adequate execution under the activity stacking with expanding natural requests. In spite of the way that adjustment is an outstanding alternative for enhancing soil building properties yet the properties decided from adjustment move comprehensively as a result of heterogeneity in soil creation, differentiates in small scale and full scale structure among soils, heterogeneity of geologic stores, and due to compound differences in invention collaborations between the dirt and used stabilizers. These properties require the possibility of site-particular treatment choices which must be acknowledged through testing of soil-stabilizer blends.

Regardless of whether the asphalt is adaptable or unbending, it lays on a dirt establishment on a dike or cutting, regularly that is known as sub-review. It might be characterized as a compacted layer, by and large happening nearby soil just underneath the asphalt covering, giving a reasonable establishment to the asphalt. The dirt in sub-review is typically worried to certain base level of worries because of the activity loads. Sub-level soil ought to be of good quality and fittingly compacted in order to use its full quality to withstand the worries because of activity burdens for a specific asphalt. This leads the monetary condition for general asphalt thickness. Then again the sub-level soil is described for its quality with the end goal of plan of any asphalt.

2. MATERIALS USED

I. **Bitumen emulsion**
II. **Soil**

2.1 Bitumen Emulsion

Emulsified Bitumen usually consists of bitumen droplets suspended in water. Most emulsions are used for surface treatments. Because of low viscosity of the Emulsion as compared to hot applied Bitumen, The Emulsion has a good penetration and spreading capacity. The type of emulsifying agent used in the bituminous emulsion determines whether the emulsion will be anionic or cationic. In case of cationic emulsions there are bituminous droplets which carry a positive charge and Anionic emulsions have negatively charged bituminous droplets.

Based on their setting rate or setting time, which indicates how quickly the water separates from the emulsion or settle down, both anionic and cationic emulsions are further classified into three different types. Those are rapid setting (RS), medium setting (MS), and slow setting (SS). Among them rapid setting emulsion is very risky to work with as there is very little time remains before setting. The setting time of MS emulsion is nearly 6 hours. So, work with medium setting emulsion is very easy and there is sufficient time to place the material in proper place before setting. The setting rate is basically controlled by the type and amount of the emulsifying agent. The principal difference between anionic and cationic emulsions is that the cationic emulsion gives up water faster than the anionic emulsion

2.2.soil

The proportion between the mass of any substance of an unmistakable volume partitioned by mass of equivalent volume of water is characterized as Specific Gravity. For soils, it is the quantity of times the dirt solids are heavier in the evaluation to the equivalent volume of water present. So it is essentially the quantity of times that dirt is heavier than water. Particular gravities for various kind of soils are not same. In the season of trial it ought to be thought about the temperature rectification and water ought to be sans gas refined water. This particular gravity of soil is signified by 'G'. Particular gravity is exceptionally a critical physical property used to figure other soil designing properties like void proportion, thickness, porosity and immersion condition.

As it is examined, the proportion between the heaviness of the dirt solids and weight of an equivalent volume of water is named as Specific Gravity. The estimation is done in a volumetric carafe in a test setup where the volume of the dirt is discovered and its weight is then further isolated by the heaviness of equivalent volume of water

$$G = \frac{(M2-M1)}{(M2-M1)-(M3-M4)}$$

Specific gravities for different soil are not same generally, the general range for specific gravity of soil can be categorized are:

Table 1: Standard Specific Gravity

Type of soil	Specific gravity
Sand	2.63 to 2.67
Silt	2.65 to 2.7
Clay and Silty soil	2.67 to 2.9
Organic soil	1+ to 2.6

2.2.1Particle Size Distribution

The organization of soil particles are of an assortment of sizes and shapes. The scope of molecule size present in a similar soil test is from a couple of microns to a couple of centimeters. Numerous physical properties of the dirt, for example, its quality, penetrability, thickness and so forth are relied on upon various size and state of particles present in the dirt specimen.

Strainer investigation which is accomplished for coarse grained soils just and the other technique is sedimentation examination utilized for fine grained soil test, are the two strategies for discovering Particle measure dispersion. Both are trailed by plotting the outcomes on a semi-log chart where ordinate is the rate better and the abscissa is the molecule distance across i.e. sifter sizes on a logarithmic scale. The sifter examination for coarse grained soil has been directed.

Very much reviewed or ineffectively evaluated are principally the sorts of soil found. Very much evaluated soils have diverse particles of various size and shape in a decent sum. Then again, if soil has particles of a few sizes in overabundance and lack of particles of different sizes then it is said to be inadequately or consistently reviewed.

The outcomes from sifter examination of the dirt when plotted on a semi-log chart with molecule distance across or the strainer measure in millimeter as the X-pivot with logarithmic hub and the rate better as the Y-hub. This semi-log diagram gives a reasonable thought regarding the molecule estimate conveyance. From the assistance of this bend, D10 and D60 are steadfast. This D10 is the breadth of the dirt beneath which 10% of the dirt particles lie. The proportion of, D10 and D60 gives the consistency coefficient (Cu) which thus is a measure of the molecule estimate run in the dirt example.

2.2.2 Liquid limit and Plastic Limit Test

The fluid furthest reaches of a dirt is the clamminess substance or the current dampness, imparted in rate of the mass of the oven dried soil at the breaking point composed between the fluid and plastic states. The moistness content at this point of confinement condition is self-decisively characterized as far as possible and is the clamminess content at a consistency as controlled by strategy for the standard fluid utmost mechanical gathering.

As far as possible is the dampness content relating to the limit between fluid state and plastic conditions of soil mass. At fluid cutoff the dirt has such a low shear quality (17.6g/cc) which streams to standard measurement for a length of 12mm of a furrow when shook 25 times utilizing the standard fluid utmost gadget or contraption. Casagrande mechanical assembly is one of the contraption utilized for deciding the fluid furthest reaches of a dirt material. The water content at which 25 drops of the container to make the depression excessively close, is called as far as possible.

As far as possible (PL) is the dampness content at which the dirt stays in plastic state. It is the water content at which the dirt just starts to disintegrate when moved into a string of 3mm width.

Plasticity Index (IP) = Liquid Limit (WL) - Plastic Limit (WP)

2.2.3 Compaction Test (Modified Proctor Test)

Delegate Test is basically for assurance of the relationship between the dampness substance and dry thickness of soils compacted in a shape of a given size with a 2.5 kg rammer dropped from a stature of 30 cm. It is an exploration focus test framework for tentatively choosing the ideal dampness content (OMC) at which a given soil sorts will get most thick and fulfill its greatest dry thickness (Yd). The name Proctor is given out of thankfulness for R. R. Delegate for showing that the dry thickness of soil for a compactive effort depends on upon the measure of water the dirt holds all through soil compaction in 1933. His one of a kind test is most by and large suggested as the standard Proctor compaction test, which as of late was updated to make the new compaction test. That is Modified Proctor Test.

In the event of adjusted delegate every one of the techniques stay same with just a couple of little changes. In particular here the compaction load is higher. Here rammer measure 4.5 kg and that dropped from tallness of 18 inches. By and large these lab tests are comprises of compacting soil at perceived dampness content into a round and hollow shape of standard estimations.

The dirt that is ordinarily compacted into the shape to a specific measure of identical layers, every one getting a number blows from a standard weighted sledge at a standard stature. This system is then repeated for particular characteristics of clamminess substance and the dry densities are resolved for every one case. For this situation materials are filled in five comparable layers with 25 blows in every one layer. The mallet and the shape for altered delegate test are demonstrated as follows.

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Fig 1.Modified Proctor test apparatus

Normal wet density = (weight of wet soil in mould gms) **/** (volume of mould cc)

$$\text{Dry density } \gamma_d \text{ (gm/cc)} = \frac{\text{wet density}}{1+\frac{\text{moisture content}}{100}}$$

Moisture content (%) = ((weight of water gms) **/** (weight of dry soil gms)) 100 %

2.2.4 California Bearing Ratio Test

CBR is the proportion of force for every unit region needed to enter a soil mass with standard load at the rate of 1.25 mm/min to that needed for the ensuing penetration of a standard material. The accompanying table gives the standard loads utilized for diverse penetrations for the standard material with a CBR quality of 100%.This standard load is taking limestone as a standard material and its CBR value at 2.5 mm, 5 mm, 7.5mm & 10 mm penetration are fixed as standard load for CBR value determination.

CBR value is calculated by this formula:

C.B.R. = (Test load /Standard load) 100 %

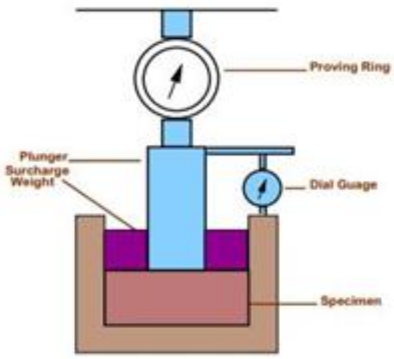

Fig. 2. California Bearing Ratio Testing Machine

Standard load is for particular depth of penetration of plunger is given bellow.

Table 2: Standard load in different penetration

Penetration of plunger (mm)	Standard load (kg)
2.5	1370
5	2055
7.5	2630
10	3180

The CBR test is done on a compacted soil (by 30 blows) in a barrel shaped CBR form of 150 mm distance across and 175 mm tallness gave divisible neckline of 50 mm and a distinct punctured base plate of hard metal. A displacer plate, 50 mm significant inside the shape all through the illustration availability by which case of 125 mm significant is obtained as real profundity. The dry thickness and water substance be remained same as would be kept up all through field compaction. All around, CBR characteristics of both splashed and in un-doused examples are resolved. Every one extra charge opened weight; 147 mm in estimation with a central whole 53 mm in separation crosswise over and weighing 2.5 kg is considered plus or minus equivalent to 6.5 cm of development. At least two extra charge weights are issued which are determined to the illustration. Load is associated so that the infiltration is about 1.25 mm/min. The heap readings are recorded at particular entrances, 0, 0.5, 1, 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 8, 9, 10, 11, 12, and 12.5 mm. The most extraordinary load and entrance is recorded if it occurs for an infiltration of shy of 13 mm.

The bend is for the most part raised upwards despite the fact that the underlying bit of the bend might be sunken upwards because of surface anomalies. A redress is then connected by attracting a digression to the bend at the purpose of most noteworthy incline. The redressed source will be the point where the digression meets the abscissa. The CBR qualities are typically figured for entrances of 2.5 mm and 5mm. Generally the CBR values at 2.5mm entrance will be more superb than 5mm infiltration and in such a case the past is taken as the CBR regard for configuration motivations behind a black-top structure and that is the reason CBR is a basic assurance of black-top thickness. If the CBR worth contrasting with an infiltration of 5mm outperforms that for 2.5mm, the test is reiterated. In case undefined outcomes take after, the bearing proportion identifying with 5mm entrance is taken for plan.

3. RESULTS AND DISCUSSION

3.1 SPECIFIC GRAVITY TEST

Specific gravity of soil is very important property to understand the soil condition. As previously discussed here

M1 = weight of empty pycnometer

M2 = weight of pycnometer + soil

M3 = weight of pycnometer + soil +water

M4 = weight of pycnometer + water

Table 3: Specific gravity test result

Sample No	M1 (gm)	M2 (gm)	M3 (gm)	M4 (gm)	Sp. Gravity
1	115	165	384	351.9	2.73
2	114	164	384	352.9	2.71
3	115	165	386	353.9	2.74

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 have been done in room temperature nearly 25*C.

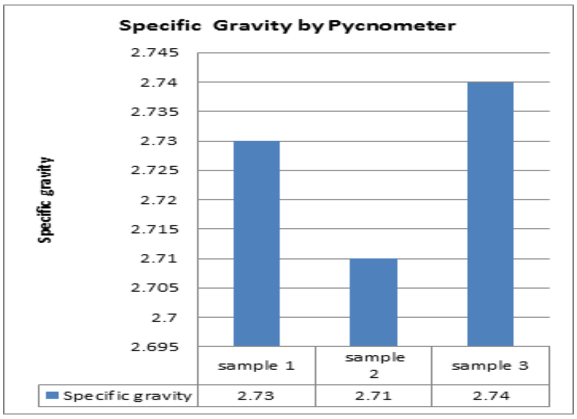

Figure 3.1(a) Specific gravity of soil samples

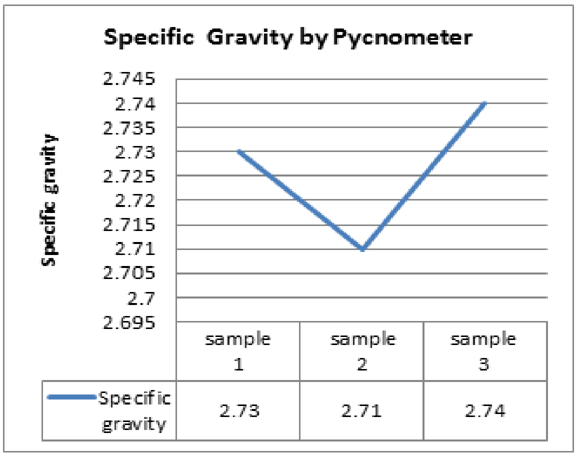

Figure 4.1(b) Specific gravity of soil samples

3.2 Particle size distribution (Dry sieve analysis)

Various physical and engineering properties with the help of which soil can be properly identified are called index properties. Soil grain property depends to individual solid grain and remains unaffected by the state in which a particular soil exists in nature. Here 2000 gm of sample soil was 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 4: Particle size distribution

Sieve No.	Sieve size	Mass of soil retained in each sieve (gm)	Percent retained (%)	Cumulative retained (%)	Percent finer (%)
1	4.75 mm	0	11.7	11.7	88.3
2	2 mm	99.1	31.3	43	57
3	1.18 mm	318.8	14.6	57.6	42.4
4	1 mm	397.5	4.3	61.9	38.1
5	600 micron	510.2	12.9	74.8	25.1
6	300 micron	255.1	18.6	93.4	6.6
7	150 micron	166.2	3.7	97.1	2.9
8	75 micron	132.1	2.1	99.2	0.8
9	Pan	0.008	0.8	100	0

3.3 Liquid limit Test

Soil sample taken = 300grms

The soil sample is sieved through 425μ sieve

Table 5: Liquid limit test results

S.No	Observations	8%	10 %	12 %	14%	16 %
1	No.of drops	55	50	40	25	22
2	Container No	1	2	3	4	5
3	Weight of the container + wet soil (grms)	88.5	92.6	91.8	101.2	106
4	Weight of the container + dry soil (grms)	81	84	82	87	90

5	Weight of water(grms) (3-4)	7.5	8.5 5	9.8	14.1 7	15. 6
6	Weight of empty container (grms)	46	46	46	45	45
7	Weight of oven dry soil(grms) (4-6)	35	38	36	42	45
8	Water content (%) (5/7)	21.4 2	22. 5	27. 2	33.7 5	34. 8

3.4 Plastic limit Test

Soil sample taken = 120grms

The soil sample is sieved through 425µ sieve.

Table 6: Plastic limit test results

S.No	Observations		
1	Container No	1	2
2	Weight of the container + wet soil (grms)	80	86
3	Weight of the container + dry soil (grms)	74	79
4	Weight of water(grms) (3-4)	6	7
5	Weight of empty container (grms)	47	45
6	Weight of oven dry soil(grms) (4-6)	27	34
8	Water content (%) (5/7)	22	20

The plastic limit of soil = $\frac{22.22+20.4}{2}$ = **21.56 %**

Plasticity Index (I_P) = LL –PL = 33.75 – 21.56 = **12.19 %**

3.4 Compaction Test

Commonly utilized changed delegate test has been executed for 3000 gm soil test taken for every trial. Altered delegate test was taken after as indicated by IS standard. From this test, most extreme dry thickness of the example was observed to be 2.026gm./cc and OMC of 10.52%.

Yuehaun et al. had been done an exploratory review on frothed bitumen adjustment for Western Australian asphalts. What's more, correspondingly a work was produced on froth bitumen adjustment by Martin in Queensland in 2011. The regular matter on both works is to give the ideal incentive on bitumen content rate 3% to 4%. In the wake of testing in various rate 3%, 5% and 7% it is seen that most extreme dry thickness of this dirt is not all that mucheffectively changed. As it is utilized as a settling operator to being relevant it ought to be conservative. Along these lines, 3% emulsion is taken in this specific review.

As I already said not very many works had done on bitumen soil adjustment. Just bitumen sand adjustment IS code is accessible. Along these lines, how to blend the rock soil with emulsion is the primary issue. In this way four specific conditions for testing are utilized here to check the variety of most extreme dry thickness of this rock soil blending with emulsion.

Case A: Normal accessible tried soil is utilized for testing

Case B : Normal accessible soil tried with 3% SS, MS and RS emulsion included

Case C: Normal accessible soil tried with 3% SS, MS and RS emulsion and 2% bond included

Case D : Normal accessible soils tried blending with 3% of SS, MS and RS emulsion and 2% of bond included and hold up 5 hour before testing.

In this four particular condition 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 this four particular conditions tested modified proctor graph listed below. Those graphs strictly indicate that Case D gives the optimum value.

Case (A) : Normal available tested soil is used for testing

Weight of soil taken =5 kg

Passing through 4.75mm IS sieve

Table 7 Proctor compaction test results for **Case A**

S.No	Observations	10 %	12%	14 %	16 %	18 %	20 %
A.	Density						
1	Mass of Mould + Compacted soil (grms)	226 6	2345 .4	245 5	258 5	238 5	217 6
2	Mass of Mould (grms)	540	540	540	540	540	540

3	Mass of Compacted soil (grms)	1726	1805.4	1915	2045	1845	1636
4	Bulk density (g/cm^3)	1.73	1.81	1.92	2.05	1.85	1.64
5	Dry density (g/cm^3)	1.59	1.65	1.72	1.82	1.62	1.43
B.	Water content						
6	Container No	1	2	3	4	5	6
7	Mass of container + wet soil (grms)	77	77	91	92	91	100
8	Mass of container + dry soil (grms)	73	75	86	88	86	93
9	Mass of water (grms)	4	2	5	4	5	6
10	Mass of container (grms)	43	43	43	43	43	43
11	Mass of dry soil (grms)	30	32	48	49	48	57

Table 8: Proctor compaction test results for Case A

S.No	Observations	10 %	12%	14 %	16 %	18%	20%
A.	Density						
1	Mass of Mould + Compacted soil (grms)	2315	2429	2602	2718	2535	2515
2	Mass of Mould (grms)	540	540	540	540	540	540
3	Mass of Compacted soil (grms)	1775	1889	2062	2178	1995	1975
4	Bulk density (g/cm^3)	1.78	1.894	2.07	2.18	2	1.979
5	Dry density (g/cm^3)	1.65	1.75	1.91	2	1.767	1.758
B.	Water content						
6	Container No	1	2	3	4	5	6
7	Mass of container + wet soil (grms)	110	121.1	94.5	101	102	95.7
8	Mass of container + dry soil (grms)	105	115.1	90.5	96	95	89.7
9	Mass of water (grms)	5	6	4	5	7	6
10	Mass of container (grms)	42	42	42	42	42	42
11	Mass of dry soil (grms)	63.4	73.13	48.5	54	53	47.7
12	Water content (%)	7.89	8.204	8.25	9.26	13.21	12.58

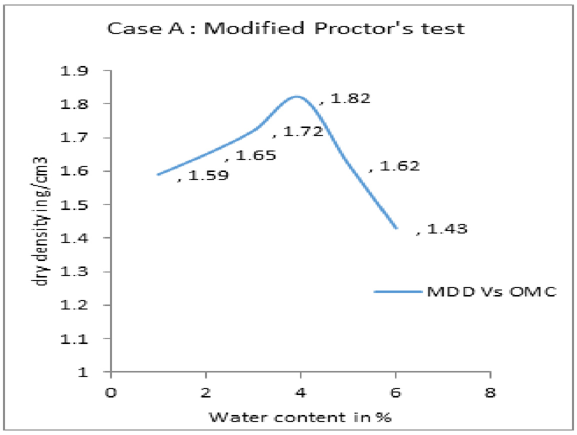

Figure 4.5 Proctor compaction test results for **Case A**

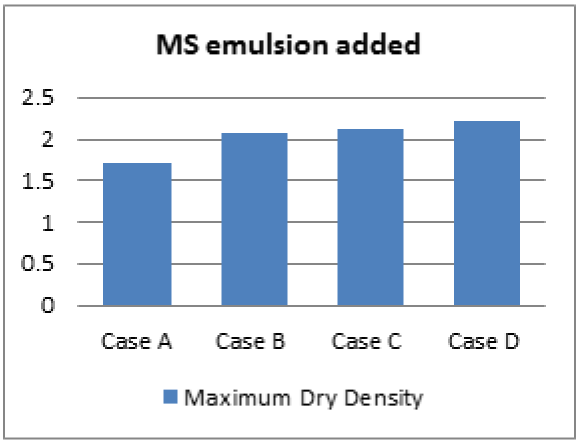

Figure 4.6 Variation of MDD for MS emulsion added

This result gives us a clear idea about used 3% bitumen content added to soil will give optimum results following mixing procedure D .

3.6 CBR TEST : 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 prepare graph 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. Standard load of different penetration is discussed before.

Here testing is done on three different testing condition on previously four cases. So total twelve number of CBR value is measured by moulding twelve different specimens, three different type of specimen 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 study it is shown that how bitumen content and mixing procedure effect on CBR value of a particular soil. CBR value and the CBR graph is case wise shown below.

Case (A) : Normal available tested soil is used for testing

Volume of Mould used 2250cc

Maximum dry density from Proctor's test = 1.72 g/cc

Optimum moisture content = 11.62%

Table 9: CBR test results for Case A

S.No	Penetration dial gauge reading	Penetration	Guage readings	
			Dial guage reading	Proving readings
1	0	0	0	0
2	50	0.5	1.21	33
3	100	1	2.12	57.81
4	150	1.5	2.15	85.09
5	200	2	3.15	114
6	250	2.5	4.18	140.18
7	300	3	7.44	203.72
8	350	3.5	10.23	279.9
9	400	4	12.87	351
10	450	4.5	17.54	478.36
11	500	5	21.7	591.87
12	600	6	26.14	712.91
13	700	7	28.45	755.91
14	1000	10	35.14	958.37
15	1250	12.5	47.58	1279.6

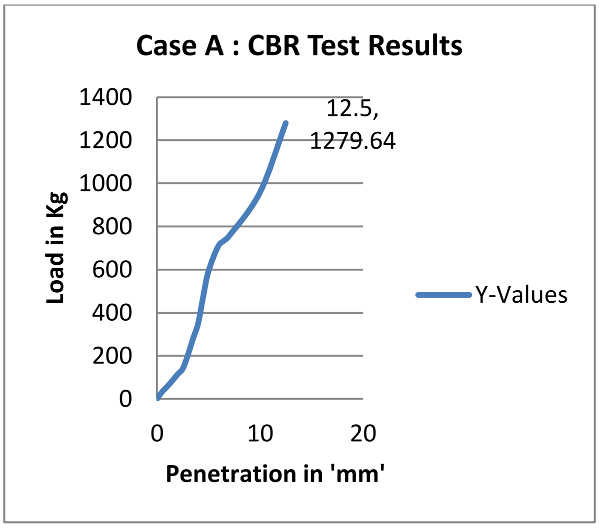

Figure 4.9 CBR test results for **Case A**

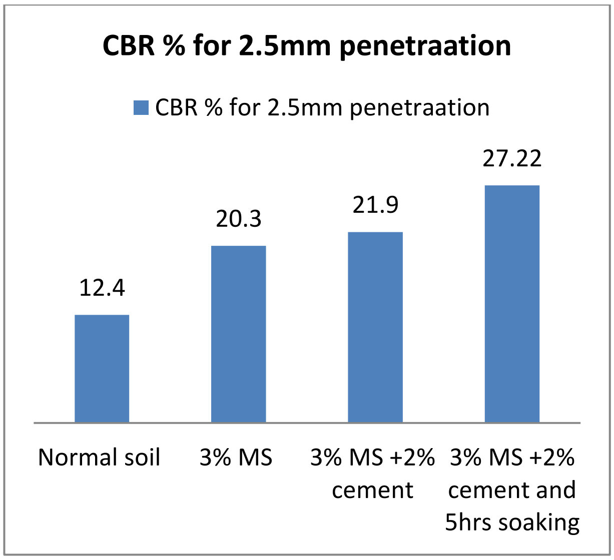

Figure 4.13 (b) Variation of CBR value for 2.5mm penetration results for **MS emulsion** added to soil from **Case A to Case D**

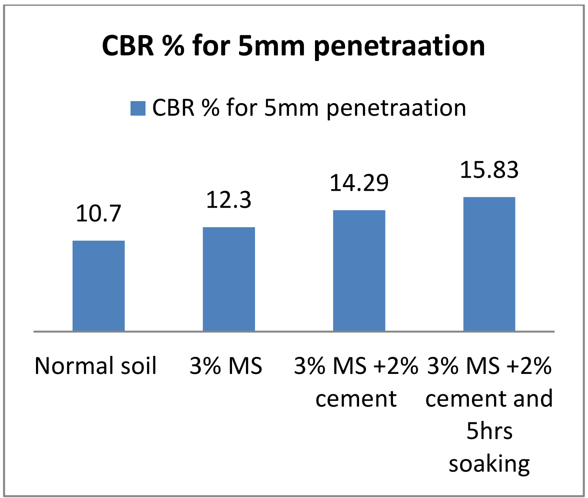

Figure 4.13 (c) Variation of CBR value for 5mm penetration results for **MS emulsion** added to soil from **Case A to Case D**

This result gives us a clear idea about used 3% MS emulsion bitumen content added to soil will give optimum results following mixing procedure D .

4. CONCLUSION

- From this study it is clear that there is a considerable improvement in California Bearing Ratio (CBR) of sub-grade due to use of MS bitumen emulsion if proper mixing is done.
- It is seen that it best results are obtained if the soil emulsion mix is left for about five and half hours after mixing.
- In each state of condition it was found that CBR value has increased consecutively from Case A to Case D.
- In this particular experimental study CBR value has increased up to fifty percent of the unmodified soil CBR.
- Observing its economic cost and quality of stabilization improvement, it is clear that this type of stabilization may be applicable in gravel soil road or in shoulder portion of highways.

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