An Experimental Study on Use of Bitumen Emulsion in Gravel Road

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Abstract- Soil is one of nature's most abundant building resources, starting at the bottom. Almost all types of construction use the soil or are built upon it. Subgrade soil's strength and importance to a road's pavement are unquestionable. Stabilisation is typically required if the soil's strength is low. In order to increase strength, subgrade is occasionally stabilised or replaced with stronger soil material. When the subgrade is comprised of brittle soil, this stabilisation is also appropriate. A reduction in the structural thickness of a pavement may result from an increase in subgrade strength. For soil stabilisation, materials like cement, fly ash, lime, and fibres are frequently utilised.

The major goal of this experimental investigation is to add bitumen emulsion to the gravel soil to improve its qualities. It has been attempted to utilise emulsion to increase the CBR values of gravel soil in an effort to increase strength, which could prove to be cost-effective. In this study, the basic characteristics of soil and its strength in terms of CBR are the focus of all laboratory work. a small amount of cement was applied to improve soil stability. Excellent soil strength is seen to come from employing cationic bitumen emulsion (CMS) with a small amount of cement utilised as filler. The best circumstances for combining gravelly soil with CMS First attempts were made with bitumen emulsion. Choosing four specific material conditions to display comes next.

Index term: Bitumen Emulsion, Gravel soil, specific gravity, grain size distrubution, plasticlimit liquid limit, standard proctor test, cbr

1 INTRODUCTION

1.1 Introduction

Starting from the base, soil is a standout amongst the most abundant construction materials of nature. Just about all kind of construction is based with or upon the soil. Long term performance of pavement structures is altogether affected by the strength and durability of the subgrade soils. In-situ sub-grades frequently don't provide the support required to achieve acceptable performance under the traffic loading with increasing environmental demands. Despite the fact that stabilization is a well-known option for improving soil engineering properties yet the properties determined
Whether the pavement is flexible or rigid, it rests on a soil foundation on an embankment or. On the other hand the subgrade soil is characterized for its strength for the purpose of design of any pavement.

1.2 Overview of the project

The Indian Road Congress encodes the accurate outline methodologies of the pavement layers based upon the subgrade quality. Subgrade quality is generally communicated as far as CBR. That is the California Bearing Ratio communicated in rate. Consequently, in all, the pavement and the subgrade together must sustain the activity volume.

1.3 Objective and scope of work

- The main objective of this experimental study is to improve the properties of the gravely soil by adding bitumen emulsion as stabilizing agent and little bit cement as filler.
- An attempt has been made to use emulsion for improving the strength and geotechnical properties of gravel soil. Very mostly, use of use of bitumen emulsion is environmentally accepted.
- To achieve the whole project some experimental investigation is needed in laboratory. The experiments which to be conducted are Specific Gravity of the soil sample, Grain size Distribution of soil sample and liquid limit plastic limit test to identify the material and Standard Proctor test to obtain maximum dry density and optimum

moisture content of soil sample, CBR test of soil sample mixing with emulsion and cement.

- So the main objective is to maximize the CBR value by checking some conditions to increase the CBR value of soil subgrade.
- The entire project work can be divided by following cases

Case A: Normal avaílable tested soíl ís used for testíng
Case B : Normal avaílable soíl tested wíth 3% SS, MS & RS emulsíon added
Case C: Normal avaílable soíl tested wíth 3% SS, MS & RS emulsíon and 2% cement added
Case D : Normal avaílable soíls tested míxíng wíth 3% of SS, MS & RS emulsíon and 2% of cement added and waít 5 hour before testíng.

2.LITERATURE REVIEW

Bitumen emulsion is used as chemical stabilizer. Cement is used here as a binder only to improve strength of road. Previously lots of work was done on sand bitumen stabilization and gravel soil bitumen stabilization in different places. This study is being inspired from those researches. Here gravel red coloured soil is used, as it is available in many states of India. Some similar works, done before, is discussed below

2.1 Chinkulkijniwat and Man-Koksung (2010) Ref 1
They directed a test research on compaction aspects of non-gravel and gravelly Soils using a little compaction device. The standard delegate test has been broadly utilized and acknowledged for characterizing soil similarity for field compaction control. Here additionally indicates about the influence of gravel size and gravel content on standard delegate test results. In this study a relationship developed between the summed up optimum water substance of the fine division in the gravelly soil and the gravel content in standard molds using compaction results from the proposed little device.

2.2 Razouki et al. Ref 2
He propose an experimental study on Granular Stabilized Roads. Bitumen was used as a stabilizing agent may act as a binder or as a water-proofing material. Soil-bitumen systems had found the greatest used in road bases and surfaces.

2.3 Michael Ref 3
He had proposed about Bench-Scale Evaluation of Asphalt Emulsion Stabilization of Contaminated Soils. In this study, it was discussed about the application of ambient temperature asphalt emulsion stabilization technology and discussed to the environmental fixation of soils contaminated by organic contaminants.

3.EXPERIMENT PROGRAMME

3. 1 Materials used
1. Bitumen emulsion
2. Soil

3.1.1 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.
From the review of present scenario bitumen emulsion acts as a key tool for mainly for road maintenance and construction. But effectively here emulsion is going to use as a soil stabilizing agent.

The bitumen emulsion used in this study is carried from …………………… and it has following properties.

Colour	Block
Specific gravity	0.97-1.02
Viscosity	

Table 3.1 Physical properties of Bitumen emulsion

3.1.2 Soil :

The soil used for this study is a gravel soil which is collected from the ……..

To find out the physical properties of soil sample collected, the following experiments are carried out.

3.2 Tests conducted on soil

3.2.1 Specific Gravity

3.2.3 Liquid limit and Plastic Limit Test

The liquid limit of a soil is the dampness substance or the existing moisture, communicated in rate of the mass of the broiler dried soil at the limit organized between the liquid and plastic states. The dampness content at this limit condition is self-assertively defined as the liquid limit and is the dampness content at a consistency as determined by method for the standard liquid limit mechanical assembly.

The plastic limit (PL) is the moisture content at which the soil remains in plastic state. It is the water content at which the soil just begins to crumble when rolled into a thread of 3mm diameter.

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

In one sentence the transition state from the liquid limit state to plastic limit is called liquid limit (WL) at this stage all soil posses a certain small shear strength. The transmission from the plastic stated to the semisolid state is termed as plastic limit (WP).

3.2.4 Compaction Test (Modified Proctor Test)

Proctor Test is essentially for determination of the relationship between the moisture substance and dry density of soils compacted in a mould of a given size with a 2.5 kg rammer dropped from a stature of 30 cm. It is a research center test system for experimentally deciding the optimum moisture content (OMC) at which a given soil sorts will get most thick and accomplish its maximum dry density (Yd). The name Proctor is given out of appreciation for R. R. Proctor for demonstrating that the dry density of soil for a compactive exertion relies on upon the measure of water the soil holds throughout soil compaction in 1933. His unique test is most generally alluded to as the standard Proctor compaction test, which recently was overhauled to make the new compaction test. That is Modified Proctor Test.

3.2.5 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.

4.RESULTS AND DISCUSSION

4.1 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 4.1 Specific gravity test result

Sample No	M1 (gm)	M2 (gm)	M3 (gm)	M4 (gm)	Sp. Gravity
1.	114.67	164.67	383.56	351.87	2.73
2.	113.76	163.76	384.41	352.86	2.71
3.	115.34	165.34	385.69	353.94	2.74

4.2 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.

. Table 4.2 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

4.3 Liquid limit Test

Soil sample taken = 300grms

The soil sample is sieved through 425µ sieve.

Table 4.3 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	92.55	91.8	101.17	105.6
4.	Weight of the container + dry soil (grms)	81	84	82	87	90
5.	Weight of water(grms) (3-4)	7.5	8.55	9.8	14.17	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)	21.42	22.5	27.2	33.75	34.8

Figure 4.3 Liquid limit test results

From the graph, The water content for 25 no of blows =33.75%

There fore Liquid limit of soil sample is 33.75%

4.4 Plastic limit Test

Soil sample taken = 120grms

The soil sample is sieved through 425µ sieve.

S.No	Observations		
1.	Container No	1	2
2.	Weight of the container + wet soil (grms)	80	85.5
3.	Weight of the container + dry soil (grms)	74	78.5
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	33.5
8.	Water content (%) (5/7)	22.22	20.4

Table 4.4 Plastic limit test results

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 %

4.5 Compaction Test

Very commonly used modified proctor test has been executed for 3000 gm soil sample taken for each trial. Modified proctor test was followed according to IS standard. From this test, maximum dry density of the specimen was found to be 2.026gm./cc and OMC of 10.52%.

Yuehaun et al. had been done an experimental study on foamed bitumen stabilization for Western Australian pavements. And similarly a work was developed on foam bitumen stabilization by Martin in Queensland in 2011. The common matter on both works is to provide the optimum value on bitumen content percentage 3% to 4%. After testing in different percentage 3%, 5% and 7% it is seen that maximum dry density of this soil is not so much effectively changed. As it is used as a stabilizing agent to being applicable it should be economical. So, 3% emulsion is taken in this particular study.

As I previously said very few works had done on bitumen soil stabilization. Only bitumen sand stabilization IS code is available. So, how to mix the gravel soil with emulsion is the main problem. Therefore four particular conditions for testing are used here to check the variation of maximum dry density of this gravel soil mixing with emulsion.

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

Weight of soil taken =5 kg

Passing through 4.75mm IS sieve

S.No	Observations	10%	12%	14%	16%	18%	20%
	A. Density						
1.	Mass of Mould + Compacted soil (grms)	2265.58	2345.35	2455.1	2584.77	2385.28	2175.81
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1725.58	1805.38	1915.10	2044.77	1845.28	1635.81
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
12.	Water content (%)	8.33	9.25	11.62	12.88	13.62	14.5

Table 4.5 Proctor compaction test results for Case A

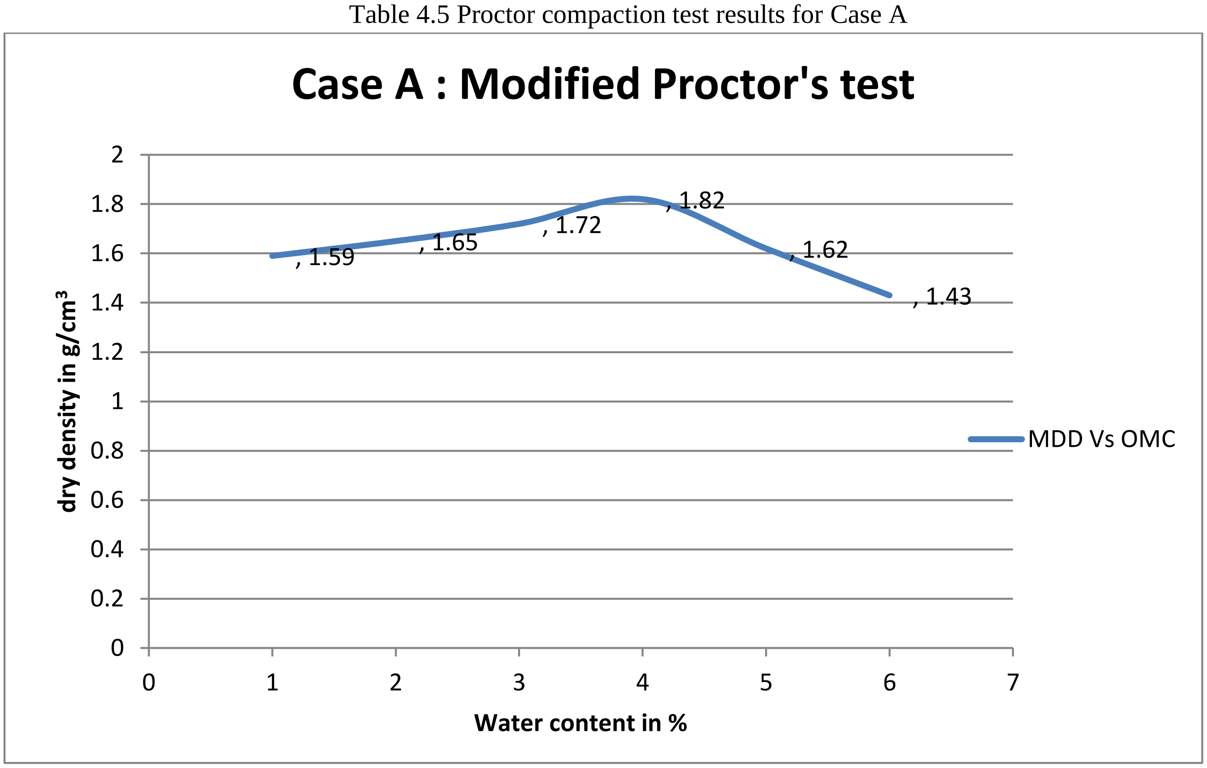

Figure 4.5 Proctor compaction test results for Case A

4.6 Compaction Test Result for Case B

4.6.1 Case (B) : (i) Normal available soil tested with 3% SS emulsion added

Table 4.6.1(i) Proctor compaction test results for Case B Normal available soil tested with 3% SS emulsion added

S. No	Observations	10%	12%	14%	16%	18%	20%
	A. Density						
1.	Mass of Mould + Compacted soil (grms)	2315.30	2429.19	2601.70	2717.85	2535.29	2514.9
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1775.3	1889.19	2061.7	2177.85	1995.29	1974.9
4.	Bulk density (g/cm^3)	1.779	1.894	2.066	2.183	2.000	1.979
5.	Dry density (g/cm^3)	1.649	1.750	1.909	1.998	1.767	1.758
	B. Water Content						
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	110.4	121.13	94.5	101	102	95.7
8.	Masof container + dry soil (grms)	105.4	115.13	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 (%)	7.886	8.204	8.247	9.259	13.207	12.578

4.6.2 Case (B) : (ii) Normal available soil tested with 3% MS emulsion added

S.No	Observations	10%	12%	14%	16%	18%	20%
	A. Density						
1.	Mass of Mould + Compacted soil (grms)	2345.37	2459.09	2608.71	2747.85	2575.29	2534.9
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1808.37	1919.09	2068.71	2207.85	2035.29	1994.9
4.	Bulk density (g/cm^3)	1.813	1.924	2.074	2.2135	2.0405	2.00
5.	Dry density (g/cm^3)	1.72	1.83	1.97	2.10	1.92	1.87
	B. Water content						
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	100.4	111.13	84.5	91	107	93.7
8.	Mass of container + dry soil (grms)	95.4	105.4	80.5	86	100	87.7
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)	53.2	63.3	38.5	44	58	45.7
12.	Water content (%)	9.36	9.47	10.38	11.35	12.05	13.12

Table 4.6.2(ii) Proctor compaction test results for Case B Normal available soil tested with 3% MS emulsion added

4.6.3 Case (B) : (iii) Normal available soil tested with 3% RS emulsion added

S.No	Observations	10%	12%	14%	16%	18%	20%
	A. Density						
1.	Mass of Mould + Compacted soil (grms)	2347.37	2462.09	2618.71	2749.85	2585.29	2544.9
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1807.37	1922.09	2078.71	2209.85	2045.29	2004.9
4.	Bulk density (g/cm^3)	1.811	1.927	2.084	2.215	2.050	2.010
5.	Dry density (g/cm^3)	1.657	1.762	1.886	1.991	1.827	1.778
	B. Water content						
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	100.4	111.13	84.5	91	107	93.7
8.	Mass of container + dry soil (grms)	95.4	105.4	80.5	86	100	87.7
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)	53.4	63.4	38.5	44	58	45.7
12.	Water content (%)	9.26	9.37	10.48	11.25	12.15	13.02

Table 4.6.3(iii) Proctor compaction test results for Case B Normal available soil tested with 3% RS emulsion added

4.7 Compaction Test Result for Case C

4.7.1 Case (C) : (i) Normal available soil tested with 3% SS emulsion and 2% cement added

S.No	Observations	10%	12%	14%	16%	18%	20%
	A. Density						
1.	Mass of Mould + Compacted soil (grms)	2485.07	2598.86	2784.39	2744.46	2604.74	2578.3

2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1945.07	2058.86	2244.39	2204.46	2064.74	2038.3
4.	Bulk density (g/cm^3)	1.949	2.064	2.250	2.209	2.069	2.043
5.	Dry density (g/cm^3)	1.786	1.885	2.043	2.000	1.861	1.819
B. Water content							
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	134.4	111.35	118.37	105.58	91.84	106.91
8.	Mass of container + dry soil (grms)	126.4	105.35	111.37	99.58	86.84	98.91
9.	Mass of water (grms)	8	6	7	6	5	7
10.	Mass of container (grms)	42	42	42	42	42	42
11.	Mass of dry soil (grms)	84.4	63.35	69.37	57.58	44.84	56.91
12.	Water content (%)	9.08	9.47	10.09	10.42	11.15	12.30

Table 4.7.1(i) Proctor compaction test results for Case C Normal available soil tested with 3% SS emulsion and 2% cement added

4.7.2 Case (C) : (ii) Normal available soil tested with 3% MS emulsion and 2% cement added

S.No	Observations	10%	12%	14%	16%	18%	20%
A. Density							
1.	Mass of Mould + Compacted soil (grms)	2465.07	2548.86	2734.39	2704.46	2594.74	2378.3
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	1925.07	2008.86	2194.39	2164.46	2054.74	1838.30
4.	Bulk density (g/cm^3)	1.93	2.014	2.20	2.17	2.06	1.834
5.	Dry density (g/cm^3)	1.84	1.92	2.10	2.07	1.95	1.72
B. Water content							
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	134.4	111.35	118.37	105.58	91.84	106.91
8.	Mass of container + dry soil (grms)	126.4	105.35	111.37	99.58	86.84	98.91
9.	Mass of water (grms)	8	6	7	6	5	7
10.	Mass of container (grms)	42	42	42	42	42	42
11.	Mass of dry soil (grms)	84.4	63.35	69.37	57.58	44.84	56.91
12.	Water content (%)	9.08	9.47	10.09	10.42	11.15	12.30

Table 4.7.2(ii) Proctor compaction test results for Case C Normal available soil tested with 3% MS emulsion and 2% cement added

4.8 Compaction test result for Case D

4.8.1 Case (D) : (i) Normal available soils tested mixing with 3% of SS emulsion and 2% of cement added and wait 5 hour before testing.

S.No	Observations	10%	12%	14%	16%	18%	20%
A. Density							
1.	Mass of Mould + Compacted soil (grms)	2664.51	2844.08	2953.8	2834.1	2724.39	2504.72
2.	Mass of Mould (grms)	540	540	540	540	540	540
3.	Mass of Compacted soil (grms)	2124.51	2304.08	2413.8	2294.1	2184.39	1964.72
4.	Bulk density (g/cm^3)	2.12983459	2.309855	2.41985	2.29985	2.189865	1.969644
5.	Dry density (g/cm^3)	1.9514	2.109	2.190	2.079	1.965	1.744
B. Water content							
6.	Container No	1	2	3	4	5	6
7.	Mass of container + wet soil (grms)	125.58	111.025	126.408	125.47	100.49	103.18
8.	Mass of container + dry soil (grms)	118.58	105.025	118.408	117.47	94.49	96.18

9.	Mass of water (grms)	7	6	8	8	6	7
10.	Mass of container (grms)	42	42	42	42	42	42
11.	Mass of dry soil (grms)	76.58	63.025	76.408	75.47	52.49	54.18
12.	Water content (%)	9.14	9.52	10.47	10.60	11.43	12.92

Table 4.8.1(i) Proctor compaction test results for Case D Normal available soils tested mixing with 3% of SS emulsion and 2% of cement added and wait 5 hour before testin

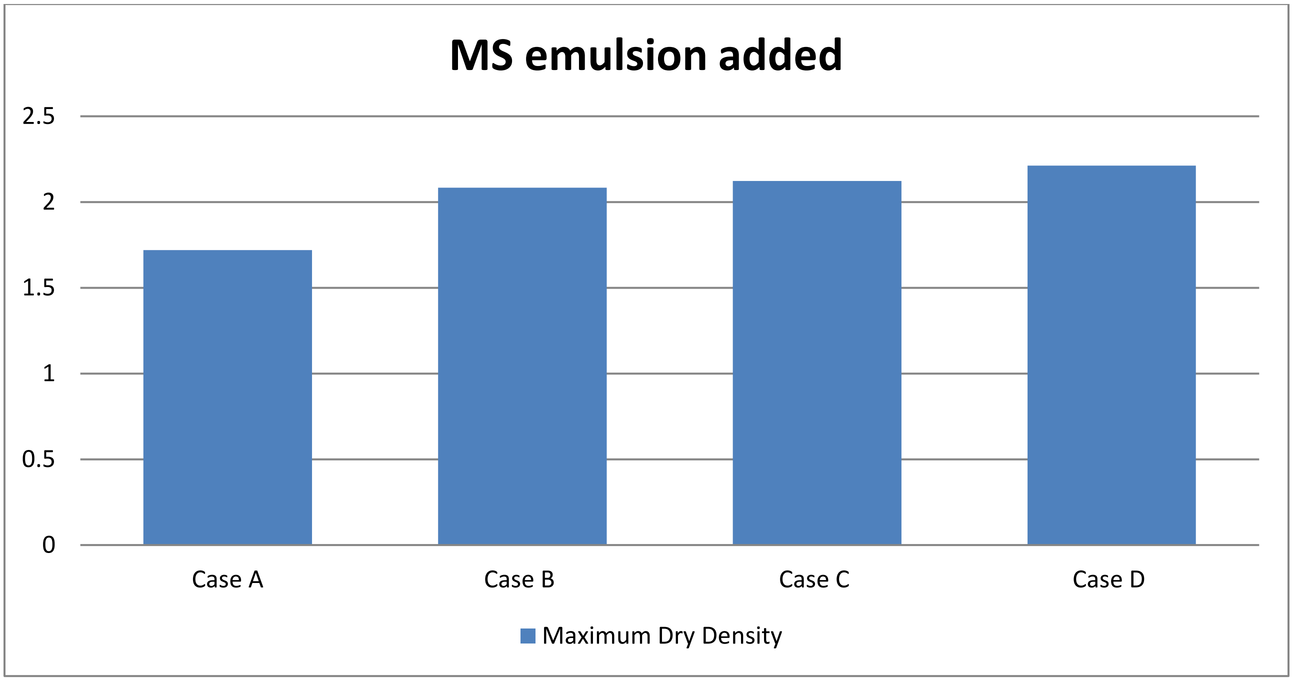

Figure 4.8.4 Variation of MDD for MS emulsion added

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

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%

S.No	Penetration dial gauge reading	Penetration	Guage readings	
			Dial guage reading	Proving readings
1	0	0	0.00	0.00
2	50	0.5	1.21	33.00
3	100	1.0	2.12	57.81
4	150	1.5	2.15	85.09
5	200	2.0	3.15	114.00
6	250	2.5	4.18	140.18
7	300	3.0	7.44	203.72
8	350	3.5	10.23	279.90
9	400	4.0	12.87	351.00
10	450	4.5	17.54	478.36
11	500	5.0	21.70	591.87
12	600	6.0	26.14	712.91
13	700	7.0	28.45	755.91
14	1000	10.0	35.14	958.37
15	1250	12.5	47.58	1279.64

Table 4.9 CBR test results for Case A

Case (B)

4.10.(i) Normal available soil tested with 3% SS emulsion added

Volume of Mould used 2250cc

Maximum dry density from Proctor's test = 2.08 g/cc

Optimum moisture content = 10.45%

S.No	Penetration dial gauge reading	Penetration	Guage readings	
			Dial guage reading	Proving readings
1	0	0	0.00	0.00
2	50	0.5	1.19	33.00
3	100	1.0	2.08	57.81
4	150	1.5	2.12	82.18
5	200	2.0	2.98	112.00
6	250	2.5	3.45	135.48
7	300	3.0	4.07	200.05
8	350	3.5	6.79	265.18
9	400	4.0	10.18	320.32
10	450	4.5	11.87	418.65
11	500	5.0	17.50	519.74
12	600	6.0	21.08	702.66
13	700	7.0	25.14	724.92
14	1000	10.0	35.07	942.73
15	1250	12.5	46.56	1227.54

Table 4.10.(i) CBR test results for Case B Normal available soil tested with 3% SS emulsion added

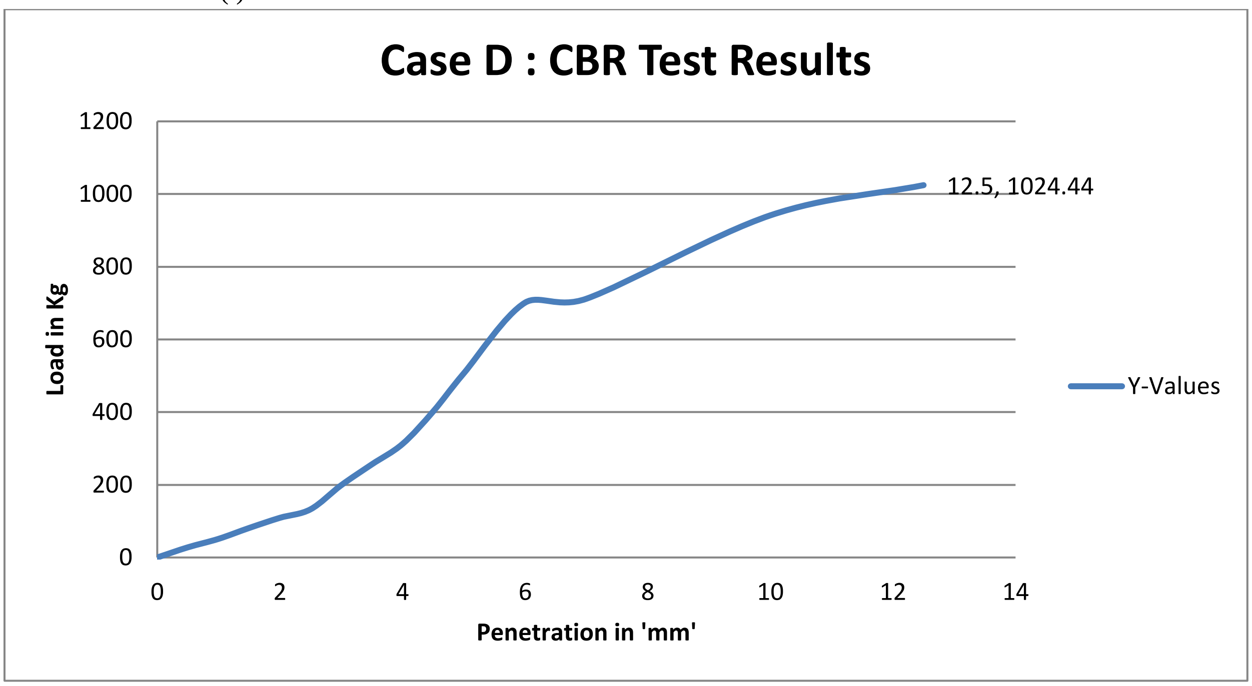

Figure 4.12 (i) CBR test results for Case D Normal available soils tested mixing with 3% of SS emulsion and 2% of cement added and wait 5 hour before testing.

CBR for 2.5mm penetration =20.22% CBR for 5mm penetration=12.83%

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.

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