An Experimental study on stabilization of the sub base layer by the use of Bitumen emulsion

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***Abstract*--This experimental study aims to investigate the effectiveness of bitumen emulsion in stabilizing the sub-base layer of road construction. The sub-base layer plays a crucial role in providing structural support and preventing deformation of the road surface. In this research, bitumen emulsion is introduced as a stabilizing agent to enhance the mechanical properties of the sub-base layer. The study involves laboratory testing of different sub-base materials treated with varying concentrations of bitumen emulsion. The mechanical characteristics, including strength, durability, and moisture susceptibility, are evaluated through standard testing procedures. The experimental results will provide insights into the optimal dosage of bitumen emulsion required for achieving the desired stabilization effects. The findings of this research have implications for the improvement of road construction practices, especially in areas where sub-base layer stability is a critical factor. The use of bitumen emulsion as a stabilizing agent offers a potential sustainable solution, contributing to the longevity and performance of road infrastructure.**

***Index Terms*— sub-base layer, bitumen emulsion, stabilization, road construction, mechanical properties, laboratory testing.**

I. 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 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. These properties 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 on an embankment or cutting, normally that is known as subgrade. It may be defined as a compacted layer, generally occurring local soil just beneath the pavement crust, providing a suitable foundation for the pavement. The soil in subgrade is normally stressed to certain minimum level of stresses due to the traffic loads. Subgrade soil should be of good quality and appropriately compacted so as to utilize its full strength to withstand the stresses due to traffic loads for a particular pavement. This leads the economic condition for overall pavement thickness. On the other hand the subgrade soil is characterized for its strength for the purpose of design of any pavement.

Improvement of soil engineering properties is referred to soil stabilization. There are two primary methods of soil stabilization. One is mechanical method and the other one is chemical or additive methods. Soil is a gathering or store of earth material, determined regularly from the breakdown of rocks or rot of undergrowth that could be uncovered promptly with force supplies in the field or disintegrated by delicate reflex means in the lab. The supporting soil beneath pavement and its exceptional under course is called sub grade soil. Without interruption soil underneath the pavement is called regular sub grade. Compacted sub grade is the soil compacted by inhibited development of distinctive sorts of substantial compactors.

II. 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.

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.

III. 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.

3.1.2 Soil :

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

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

Compaction Test (Modified Proctor Test)

Fig 3.1.Modified Proctor test apparatus

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.

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

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

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

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.

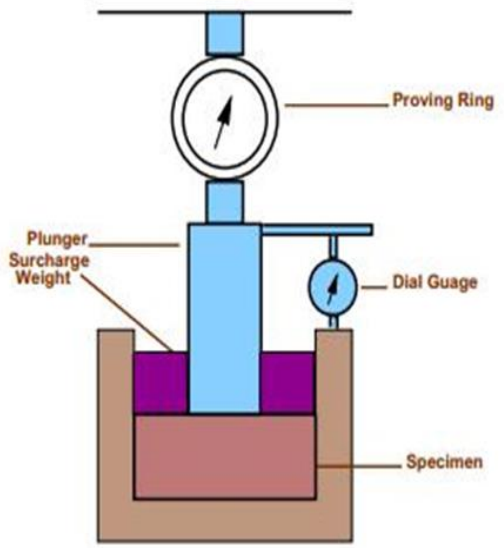

Fig. 3.2. California Bearing Ratio Testing Machine
CBR value is calculated by this formula:
C.B.R. = (Test load /Standard load) 100 %

IV. 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

Table 4.5 Proctor compaction test results for Case A

Trail no.	Wt. of compacted soil (kg)	Optimum Moisture content (OMC) %	Dry density(γd) gm/cm3
1	1725.58	8.33	1.590
2	1805.35	9.25	1.650
3	1915.1	11.62	1.720
4	2044.77	12.88	1.820
5	1845.28	13.62	1.620
6	1635.81	14.50	1.430

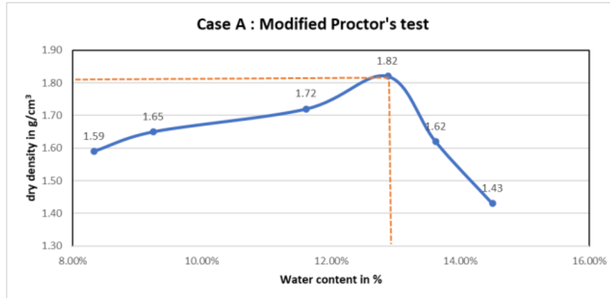

Figure : Proctor compaction test results for Case A

Results and Discussions about Case A, Case B, Case C, Case D:

From the previous modified proctor results it is strictly showing how the dry density value for the same material is going to increase from case A to case D, which is the change of maximum dry density value from 2.026 gm/cc up to 2.2 gm/cc. Little bit of fluctuation in optimum moisture content value in different cases. This dry density value is a very important physical property in case of stability of subgrade soil. Bellow the variation of maximum dry density in those special cases are shown bar wise.

It is clearly noticed from the above results, the MS emulsion added to soil will give maximum dry density in all the cases when compared to SS and RS emulsions of bitumen. The variation of dry density for MS emulsion added is shown in following figure.

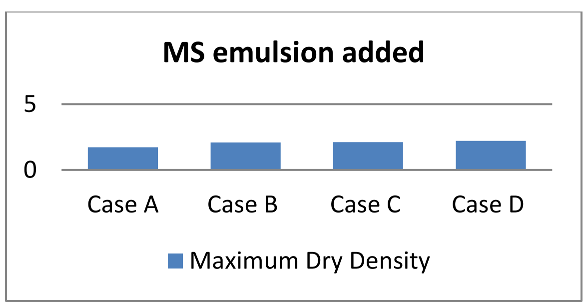

Figure: Variation of MDD for MS emulsion added

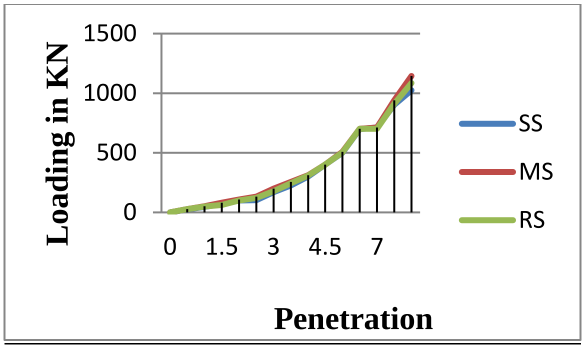

Figure: Variation of CBR test results for CASE (D) for SS, MS and RS

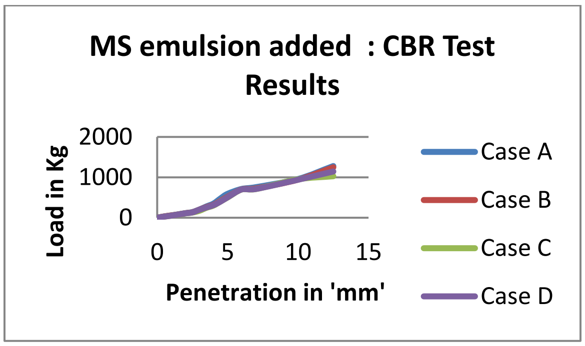

Figure: Variation of CBR test results for MS emulsion added

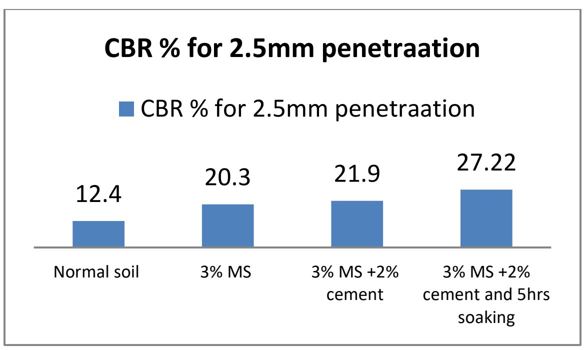

Figure : Variation of CBR value for 5mm penetration results for MS emulsion added to soil from Case A to Case D

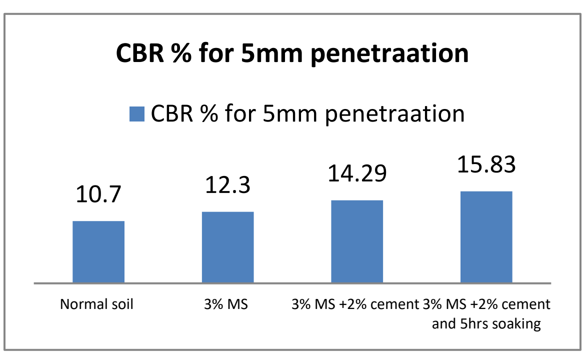

Figure :Variation of CBR value for 2.5mm penetration results for MS emulsion added to soil from Case A to Case D

V. CONCLUSION

- Standard Procter test results achieved after mixing Normal soil with 3% of MS emulsion, the dry density is 2.1 g/cc which is 4% higher than other two samples (SS and RS)
- Standard Procter test results achieved after mixing Normal soil with 3% of MS emulsion and 2% of cement, the dry density is 2.15 g/cc which is 4.8% higher than other two samples (SS and RS)
- Standard Procter test results achieved after mixing Normal soil with 3% of MS emulsion and 2% of cement and awaited for 5 hours, the dry density is 2.15 g/cc which is 2% higher than other two samples (SS and RS)
- CBR test results achieved after mixing Normal soil with 3% of MS emulsion, the CBR achieved is 20.3% which is 7.4% higher than the other two samples (SS and RS).
- CBR test results achieved after mixing 3% of MS emulsion and 2% of cement, the CBR achieved is 21.9% which is 7% higher than the other two samples (SS and RS).
- CBR test results achieved after mixing 3% of MS emulsion and 2% of cement and awaited for 5 Hours, the CBR achieved is 27.22% which is 24% higher than the other two samples (SS and RS).
- 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 best results are obtained if the soil emulsion mix is left for about five 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.
- Based on above experimentation and results for the given for the soil stabilization is more effective when 3% of MS emulsion and 2% cement is added to the soil and waited 5 hours.

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