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A Laboratory Study on Use of Bitumen Emulsion in Gravel Road

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ABSTRACT: *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 black soil by adding bitumen emulsion. An attempt has been made to use emulsion for improving the strength of black 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 black soil with CMS Bitumen emulsion have been 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 black soil. Here we use ideal soil of passing 600 microns IS Sieve.*

Key Words: bitumen emulsion, bitumen stabilization, black soil, CBR, liquid limit test, modified proctor test, particle size distribution, plastic limit, pycnometer, sieve analysis, specific gravity

1.INTRODUCTION

The Indian Road Congress encodes the correct define methodologies of the pavement layers based mostly upon the subgrade quality. Subgrade quality is usually communicated as so much as cosmic radiation. That is the American state bearing magnitude relation communicated in rate. Consequently, in all, the pavement and also the subgrade along should sustain the activity volume. During this project domestically obtainable red colored dirt sort gravel soil is taken as experimenting material. Medium setting emulsion (MS) is employed as stabilizing agent in this explicit study. Hydrocarbon sand stabilization is a good method as hydrocarbon makes soil stronger and improves resistance capability against water and frost. The main objective of this experimental study is to enhance the properties of the gravely soil by adding hydrocarbon emulsion as stabilizing agent and tiny bit cement as filler. a trial has been created to use emulsion for up the strength and geotechnical properties of gravel soil. Terribly principally, use of

hydrocarbon emulsion is environmentally accepted. To realize the entire project some experimental investigation is required in laboratory. The experiments that to be conducted are relative density of the soil sample, Grain size Distribution of soil sample and liquid limit plastic limit check to spot the fabric and customary Proctor check to get most dry density and optimum wet content of soil sample, cosmic radiation check of soil sample mix with emulsion and cement.

That the main objective is to maximize the cosmic radiation price by checking some conditions to extend the cosmic radiation price of soil subgrade.

A gravel road is defined as the unpaved road that is provided with gravel surface which has been taken from the river basin site or the watercourse bed. These roads are ordinary roads in the nations which are in less developed stage, and also in the rural areas of developed nations such as Canada and the United States in New Zealand, they may be known as 'un metal roads'. They might be mentioned to as 'dirt roads' in common term, but particular term is used more for half constructed roads where no surface material is added to them. If fully constructed and sustained, a gravel road is considered as an all-weather road.

As we know that the soil is amongst the most generally used materials in construction industry present in nature. Fundamentally all the constructions are supported by the soil.

The defined properties necessitate the site-specific action substitutes and that essentially be accepted over analysis of soil-stabilizer mixtures of soil. In case of elastic or non elastic pavement, both starts from the base or bank of soil, and usually known as sub grade. The sub grade soil may be defined as a deposit of compacted earth, usually the local soil just beneath the crust of the pavement that provides appropriate base to the roadway. The sub grade is typically stressed out to assured smallest of stresses stage developed with the traffic loads. The sub grade soil must be of better quality and suitably compressed in order to apply its strength fully to resist the stresses developed by the traffic loads for a specific pavement. This proves to be economical for complete thickness of the pavement. Instead the sub grade soil is distinguished by its strength and stability intended for the principle of design of the pavements. The advancement of the engineering properties of soil is stated to the soil stabilization. And we have two principal approaches for the soil stabilization. First the machine-driven technique and the other is the addition if chemicals or stabilizer techniques. The soil is an assembly or buildup of earth material naturally, firm usually from the disintegration of rocks or deterioration of the undergrowth that might be exposed rapidly with strength materials in the ground either degenerated due to gentle reaction resources in the laboratory. The supportive soil below the pavement is excellent situated just below the base course are termed as soil sub grade. Deprived of disruption top soil beneath the roadway is termed as consistent sub grade. Compressed sub grade, the compacted soil through reserved growth for the characteristic classes of considerable compactors are used.

Long term performance of pavement structures is altogether affected by the strength and durability of the subgrade soils. 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 of 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. The design of the pavement layers to be laid over subgrade soil starts off with the estimation of subgrade strength and the volume of traffic to be carried. Design of the various pavement layers are very much dependent on the strength of the subgrade soil over which they are going to be laid. Weaker subgrade demands thicker layers whereas stronger subgrade goes well along with thinner pavement layers. In-situ sub-grades frequently don't provide the support required to achieve acceptable performance under the traffic loading with increasing environmental demands. Sub-grade’s performance generally depends on three of the basic characteristics, which are: Load bearing capacity, Moisture content and Shrinkage and/or swelling.

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.

Presently every road construction project will use one or both of these stabilization strategies. The most well-known type of mechanical soil stabilization is compaction of the soil, while the addition of cement, lime, bituminous or alternate executors is alluded to as a synthetic or added substance strategy for stabilization of soil. American Association of State Highway and Transportation Officials (AASHTO) classification system is a soil classification system specially designed for the construction of roads and highways used by transportation engineers. The system uses the grain-size distribution and Atterberg limits, such as Liquid Limits and Plasticity Index to classify the soil properties. The main thing related to soil stabilization is nothing but the process of maximizing the CBR strength of soil for a given construction purpose. So many works have been done on cement, lime or fly ash stabilization. But very few works have been found on bitumen soil stabilization.

2. BITUMEN EMULSION

OVERVIEW OF ASPHALT EMULSION

The use of asphalt emulsions began in the early part of the 20th century. Today 5% to 10% of pavinggrade asphalt is used in emulsified form, but the extent of emulsion usage varies widely between countries. The United States is the world's largest producer of asphalt emulsion.

The advantages of asphalt emulsion compared to hot asphalt and cut back binders are related to the low application temperature, compatibility with other water-based binders like rubber latex and cement, and low-solvent content.

The paper gives an introduction to the chemistry of asphalt emulsion. The role of the emulsion components—asphalt, emulsifiers, acids or alkalis, and additives—in determining the physical properties and reactivity of the emulsion is described. Recent advances in the understanding of the setting process are outlined. The classification of emulsions into grades according to their reactivity, particle charge, and physical properties is explained and typical recipes of various emulsion grades are given. The selection of the correct emulsion grade for the various applications based on emulsion reactivity and physical properties of the emulsion is covered in general terms.

The past 20 years have seen considerable progress in the understanding of how emulsion chemistry influences performance. Consequently formulations can be developed to optimize the performance of the construction material or construction process rather than simply to meet standard specifications. The result has been faster-setting surface treatments, quick-drying tack coats, penetrating emulsion primes that are superior to cut backs, and cold-mixed materials with improved properties.

3. USE OF ASPHALT EMULSION

The first asphalt (bitumen) emulsions used in road construction were prepared in the early part of the 20th century. Today approximately 3 million tons of emulsions are produced in the United States representing about 5% to 10% of asphalt consumption. More than 8 million tons of emulsions are produced worldwide. Emulsion production varies greatly among countries with the United States, France, Mexico, INDIA and Brazil being significant producers (*1*).

ADVANTAGES OF EMULSION

With viscosities in the range 0.5–10 Poise at 60°C, asphalt emulsion is of considerably lower viscosity than asphalt itself (100–4,000 Poise), allowing it to be used at lower temperature. Low-temperature techniques for construction and maintenance reduce emissions, reduce energy consumption, avoid oxidation of the asphalt, and are less hazardous than techniques using hot asphalt. They are also more economical and environmentally friendly than cold techniques using cut back asphalts. The environmental benefit of asphalt emulsion is particularly positive when used for in-place or on-site techniques which avoid the energy usage and emissions associated with heating, drying, and haulage of aggregate. The construction of a roadway with cold techniques has been calculated to consume approximately half the energy of one of similar bearing capacity made with hot-mix asphalt (HMA) (*2*). An environmental impact analysis (EIA) technique called "eco-efficiency" has been applied to emulsion maintenance techniques (microsurfacing and chip seal) and it was concluded that the emulsion system had less environmental impact than a thin hot-mix overlay (*3*).

4. EMULSION DEFINITION

An emulsion is a dispersion of small droplets of one liquid in another liquid. Typical examples include such everyday products as milk, butter, mayonnaise, and cosmetic creams. Emulsions can be formed by any two immiscible liquids, but in most emulsions one of the phases is water. Oil-in-water (O/W) emulsions are those in which the continuous phase is water and the disperse (droplet) phase is an "oily" liquid. Water-in-oil (W/O) "inverted" emulsions are those in which the continuous phase is an oil and the disperse phase is water. Emulsions can have more complex structures. In multiple emulsions, the disperse phase contains another phase which may not have the same composition as the continuous phase (Figure 1).

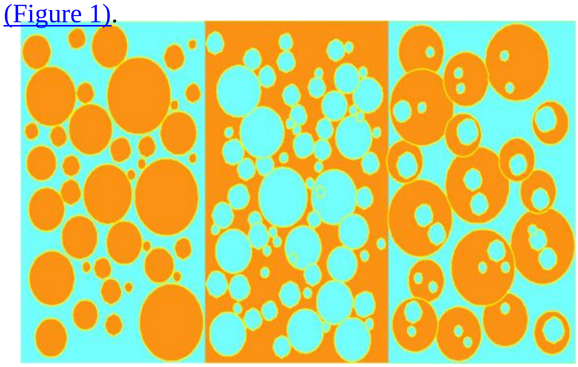

FIGURE 1 Types of emulsions:
(*a*) O/W emulsion, (*b*) W/O emulsion, and (*c*) multiple W/O/W.

Standard bitumen (asphalt) emulsions are normally considered to be of the O/W type and contain from 40% to 75% bitumen, 0.1% to 2.5% emulsifier, 25% to 60% water plus some minor components which are described below. The bitumen droplets range from 0.1–20 micron in diameter. Emulsions with particle

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sizes in this range are sometimes referred to as macro-emulsions. They are brown liquids with consistencies from that of milk to double cream, which depend mostly on the bitumen content and the particle size. Some bitumen droplets may contain smaller water droplets within them; a better description of asphalt emulsion would be a W/O/W multiple emulsion. The viscosity of the emulsion and especially changes in the viscosity of the emulsion during storage are strongly influenced by this internal water phase (*6*,*7*).

Particle size also influences the performance of emulsion. In general, smaller particle size leads to improved performance in both mix and spray applications (*9*). Some recent developments in asphalt emulsion technology have focused on the ability to control the particle size and size distribution of the emulsion during the emulsification process, and consequently to influence the emulsion properties

Macro emulsions are inherently unstable. Over a period of time, which may be hours or years, the asphalt phase will eventually separate from the water. Asphalt is insoluble in water, and breakdown of the emulsion involves the fusion of droplets (coalescence) (Figure 3).

The asphalt droplets in the emulsion have a small charge. The source of the charge is the emulsifier, as well as ionizable components in the asphalt itself. These small charges on the droplets normally provide an electrostatic barrier to their close approach to each other (like charges repel). However, when two droplets do achieve enough energy to overcome this barrier and approach closely then they adhere to each other (flocculate). This flocculation may sometimes be reversed by agitation, dilution, or addition of more emulsifier. Over a period of time the water layer between droplets in a floccule will thin and the droplets will coalesce. The coalescence cannot be reversed. Factors which force the droplets together such as settlement under gravity, evaporation of the water, shear or freezing will accelerate the flocculation and coalescence process, as does anything which reduces the charge on the droplets. Lower viscosity asphalts coalesce more rapidly than high viscosity asphalts. Of course, eventually we want the emulsion droplets to coalesce after the asphalt emulsion has come in contact with the aggregate and been placed on the roadway.

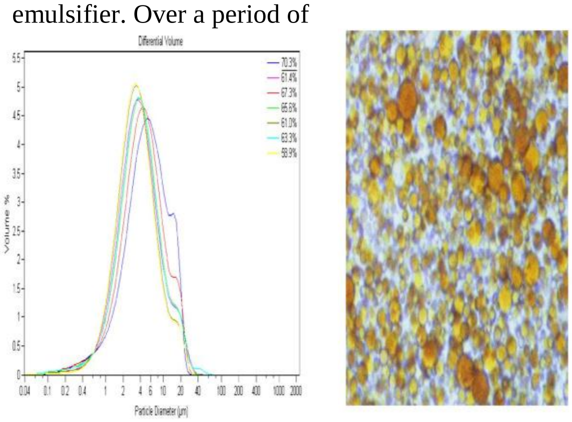

FIGURE 2 (*a*) Typical particle size distributions of asphalt emulsions with different asphalt contents (*13*) and (*b*) micrograph of asphalt emulsion.

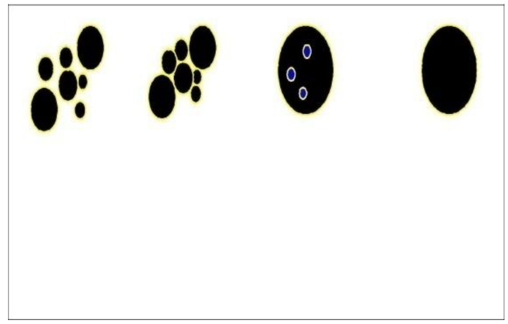

FIGURE 3 Stages in the breakdown of emulsions.

5. RESULTS AND ANALYSIS

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

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.

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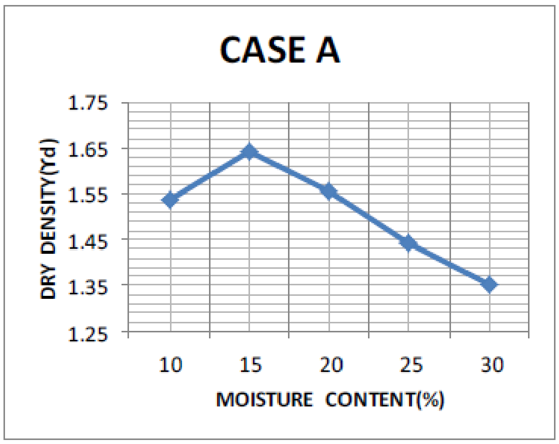
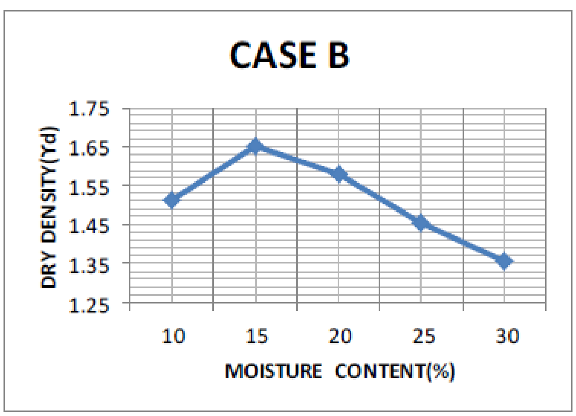
Compaction test

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

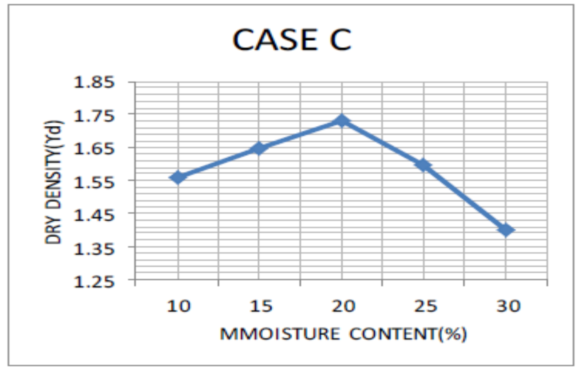
Case A- Normal available tested soil is used for testing.



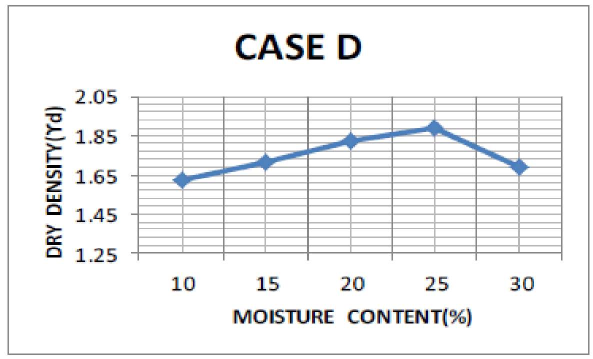
Case B- normal available soil tested with 3% emulsion added



Case C-normal available soil tested with 3% emulsion and 2% cement.



Case D- normal available soil tested with 3% emulsion and 2% cement added and for 4 hours before testing.



CBR test

Here testing is done two different testing condition on previously four cases. So total eight number of CBR value is measured by moulding eight different specimens, two 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 Used proctor test result of case A

Maximum dry density- 1.642 gm/cc

Optimum moisture content- 10%.

CBR test is done in three conditions. First one is in un-soaked 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.

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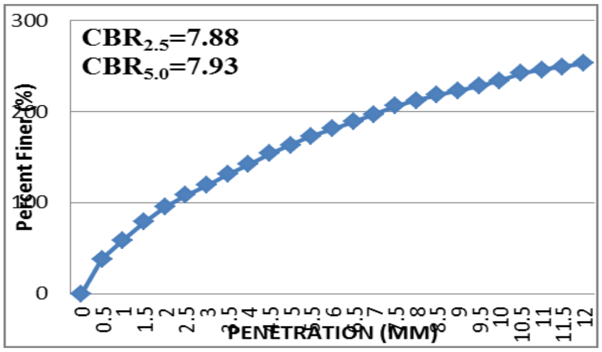
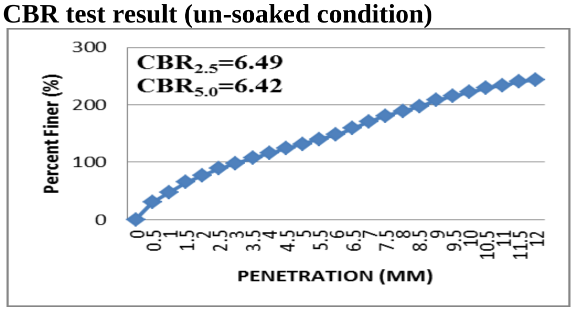
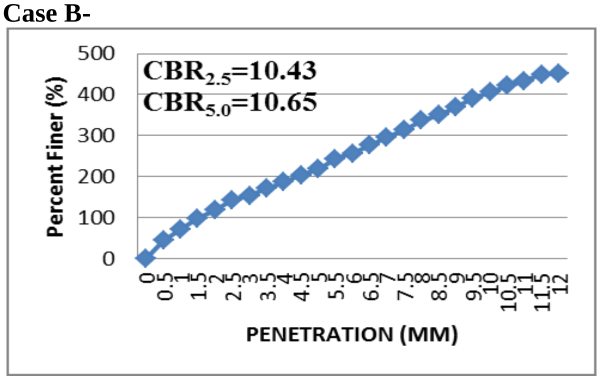


CBR test result (un-soaked condition)

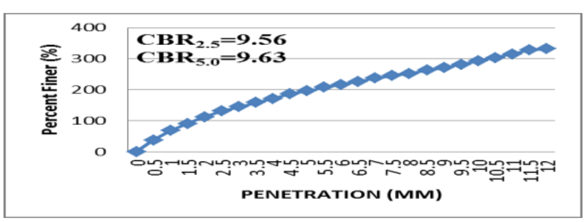


CBR test (2 days soaked)

Case B-



CBR test result (un-soaked condition)

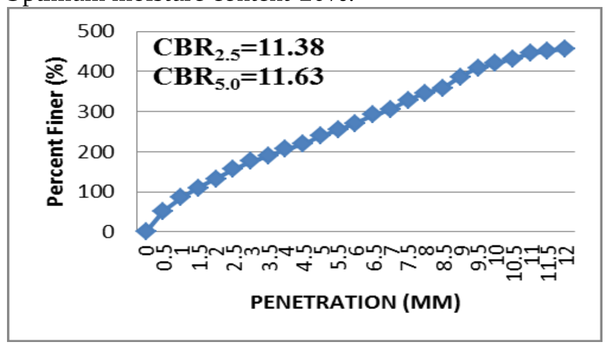


CBR test (2 days soaked)

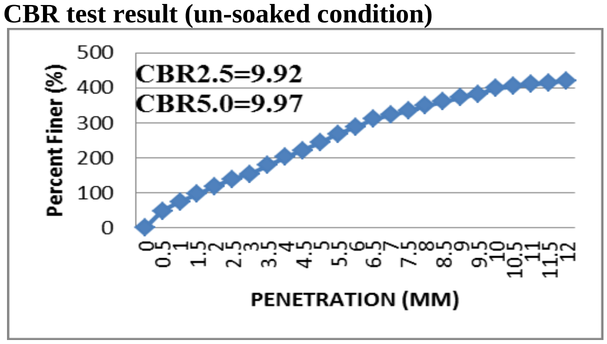
Normal available soil tested with 3% emulsion added. Used proctor test result of case B.
Maximum dry density value- 1.668
Optimum moisture content- 15%.
CBR test is done in three conditions. First one is in un-soaked condition, secondly in two days of soaking condition and lastly in four days of soaking condition. CBR value at 2.5mm penetration and 5mm penetration is calculated.

Case C-

Normal available soil tested with 3% emulsion and 2% cement added Used proctor test case C
Maximum dry density-1.732 gm/cc
Optimum moisture content-20%.



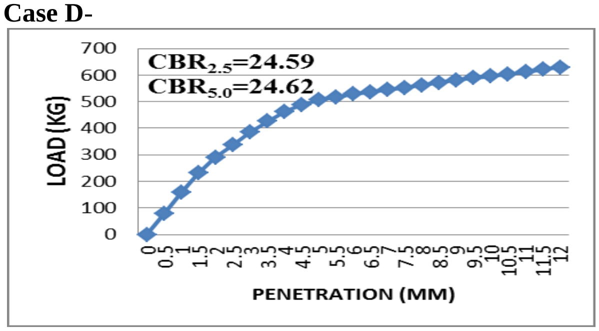
CBR test result (un-soaked condition)



CBR test (2 days soaked)

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.

Case D-



CBR test result (un-soaked condition)

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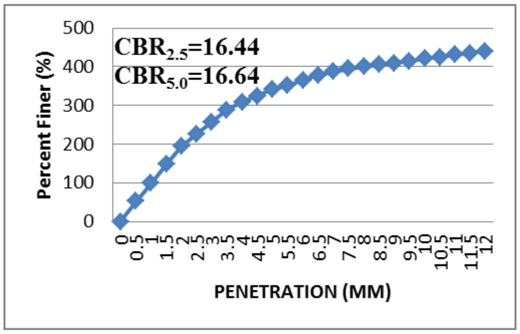

CBR test (2 days soaked)

Normal available soil tested mixing with 3% emulsion and 2% cement and wait for four hours before test. Used proctor test result case D
Maximum dry density value-1.886gm/cc
Optimum moisture content-25%.
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.

6. CONCLUSIONS

From this study it is clear that there is a considerable improvement in California Bearing Ratio (CBR) of subgrade due to use of bitumen emulsion if proper mixing is done, it is seen that it best result are obtained if the soil emulsion mix is left for four hours after mixing. In each case 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. It is clear that this type of stabilization may be applicable in soil or in shoulder portion of highways.

Results are followed-
- Specific gravity of soil is 2.32 its means it is not organic or inorganic soil. (specific gravity of inorganic soil is between 1 to 2 and specific gravity of organic soil is in between 2.3 to 2.6)
- Liquid limit of the soil is 16.28% and plastic limit of soil is 13.7% and plasticity of index of the soil is 2.58%.
- Modified result 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 maximum dry density value from 1.642 to 1.886gm/cc. little bit of fluctuation in optimum moisture content value in different cases.
- subgrade may be defined as a compacted soil layer, generally of naturally occurring local soil , assumed to be 300 mm in thickness, just below the pavement crust provides a suitable foundation for the pavement

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