Improvement of Silty Soil as Subgrade Material by Stabilization with Bituminous Emulsion

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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, fibres 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.**

INTRODUCTION

The eroded soil is due to the strength of the bonds between the particles that form the soil and can no longer maintain the pressure on it. The load can be in the form of blows and / or sparks from the rains that fall to the soil surface due to friction / erosion caused by the flow of water on the soil surface. In general, soil has the ability to maintain / control pressures, but due to heterogeneous. A soil characteristic there is a type of soil that has insufficient capacity. The minerals of the soil constituted by elements and chemical compounds can react with other chemical substances mixed to him. For soil that has sufficient technical capacity that has chemical potential, the capacity can be increased by adding chemicals (chemical preservation).

Much research has been done on the stabilization of soil with emulsion asphalt, especially on construction. For example (1-2-3-4-5-6-7-8-9-10-11) all find that the stabilization of the soil with emulsion the asphalt can improve the characteristics of the soil. The objective of this study was to analyze the effect of soil stabilization with emulsified asphalt on soil characteristics that can increase its strength to reduce its erosion flow, which is the chemical bond between the minerals in the soil and the emulsified asphalt, the plasticity and cut resistance.

Starting from the base, the soil is a standout among the most abundant building materials in nature. Almost every type of construction is based on or on the ground. The long-term performance of pavement structures is affected by the strength and durability of subsoil soils. In-situ sub-ratings often do not provide the support required to achieve acceptable performance under the traffic load with increasing environmental demands. Despite the fact that stabilization is a well-known option for improving the engineering properties of soil, the properties determined from stabilization change widely due to the heterogeneity in the creation of the soil, the contrasts in the micro and macro structure between the soils, the heterogeneity of the geological reserves and the chemical contrast. In the mixing interactions between the soil and the stabilizers used. These properties require the thought of site-specific treatment alternatives that must be accepted through testing of soil stabilizer mixtures. Whether the pavement is flexible or rigid, it rests on a ground base in an embankment or cut, usually that is called

subsoil. It can be defined as a compacted layer, which is usually found on the local soil just below the crust of the pavement, providing an adequate base for the pavement. The ground in the subsoil is normally subjected to a minimum level of stress due to traffic loads. The subgrade soil must be of good quality and compacted in an appropriate manner to use all its strength to withstand the stresses due to traffic loads in a particular pavement. This carries the economic condition for the total thickness of the pavement. On the other hand, the subsoil floor is characterized by its resistance to the design of any floor. The improvement of the engineering properties of the soil refers to the stabilization of the soil. There are two main methods of soil stabilization. One is the mechanical method and the other is the chemical or additive method. The soil is a gathering or storage of material from the Earth, determined regularly from the decay of rocks or weed rot that could be quickly discovered with force supplies.

In the field or disintegrated by delicate reflexes in the laboratory. The support floor under the pavement and its exceptional course is called inferior quality floor. Without interruption, the ground beneath the pavement is called the regular subclass. The subgrade of compaction is soil compacted by the inhibited development of distinctive classes of substantial compactors. Currently, each road construction project will use one or both stabilization strategies. The best known type of mechanical stabilization of soil is soil compaction, while the addition of cement, lime, bituminous or alternative performers is referred to as a strategy of synthetic or aggregate for soil stabilization. The classification system of the American Association of State Road and Transportation Officials (AASHTO) is a soil classification system specially designed for the construction of roads and highways used by transport engineers. The systemuses grain size distribution and Atterberg limits, such as liquid limits and plasticity index to classify soil properties. There are different types of additives available. Not all additives work for all types of soil. Generally, an additive can be used to act as a binder, after the effect of moisture, increase the density of the soil. The following are some of the most commonly used additives: Portland cement, quick lime or hydrated lime, fly ash, calcium chloride, bitumen, etc. However, the mechanical stabilization of the soil refers to the compaction or introduction of nerves and other Non-biodegradable soil reinforcement. This practice does not require a composite change of soil and it is usual to use both the mechanical and the mixing intention to achieve a detailed stabilization. There are some routines that are used to achieve mechanical stabilization such as compaction, combination, soil reinforcement, expansion of graded aggregate materials and mechanical remediation. Any terrestrial structure depends on its fundamental characteristics. For that reason, the soil is a very critical element that influences the success of a construction project. The soil is the first part of the foundation or one of the raw materials used throughout the construction process. Therefore, the main thing related to us is that soil stabilization is nothing more than the process of maximizing soil resistance.

Emulsified bitumen generally consists of bitumen droplets suspended in water. Most emulsions are used for surface treatments. Due to the low viscosity of the Emulsion compared to the hot applied bitumen, the Emulsion has a good penetration and diffusion capacity. The type of emulsifying agent used in the bituminous emulsion determines whether the emulsion will be anionic or cationic. In the case of cationic emulsions, bituminous droplets carry a positive charge and anionic emulsions have bituminous droplets that are negatively charged. Depending on their setting speed or setting time, which indicates how quickly the water separates from the emulsion or settles, both anionic and cationic emulsions are classified into three different types. These are: fast configuration (RS), medium configuration (MS) and slow configuration (SS). Among them it is very dangerous to work with the emulsion of fast setting, since there is very little time before setting. The setting time of the MS emulsion is almost 6 hours. Therefore, working with the medium setting emulsion is very easy and there is enough time to place the material in the proper place before setting. The setting speed is basically controlled by the type and amount of the emulsifying agent. The main difference between anionic and cationic emulsions is that the cationic emulsion gives up water faster than the anionic emulsion. Over a period of time, which may be years, the long-term asphalt stage will be separated from the water. The asphalt is insoluble in water, and the decomposition of the emulsion includes the combination of drops. The

asphalt droplets in the emulsion have a small charge. The source of the charge is the emulsifier and the ionizable segments in the asphalt itself. However, when two droplets reach enough vitality to overcome this obstacle and approach it almost then they remain attached to each other. For a time, the water layer between the droplets in the flocs will thin out and the droplets will combine. The components that restrict the drops, for example, gravity settlement, water dissipation, cutting or solidification will accelerate the flocculation and mixing process. In this case, mixing the slow-setting bitumen emulsion with the soil is as effective and rapid setting is not easy to work with the soil. So here I use slow setting emulsion as the main stabilizing agent. Today, the main use of bitumen is found in the pavement industry for construction and maintenance. The bituminous emulsions are a dispersion of bitumen in an aqueous continuous stage, settled by the expansion of an emulsifier. They are ready as emulsions at high temperatures; however, they are connected as robust dispersions at full temperatures. In pavement engineering, bitumen elements are commonly added with aggregates. The solid adhesion that occurs between the bitumen and the mineral aggregate allows the bitumen to act as a binder, and the mineral aggregate provides mechanical quality for the road. Since the revision of the current scenario, the bitumen emulsion acts as a key tool mainly for road maintenance and construction. But effectively here the emulsion is going to be used as a soil stabilizing agent.

II LITERATURE SURVEY

Yuehuan et al. (2010) This paper investigates the merit of application worked on foamed bitumen stabilization for Western Australian Pavements. Currently, the popularity of soil cement stabilization had been challenged by a new Innovative soil improvement technique, known as foamed bitumen stabilization. Very few of Work have been done on it and application of this type of stabilization is currently applied in Flexible pavement subgrade stabilization. Numerous Australian roadway and way offices have Committed noteworthy investigation and stores to investigate this system so as to attain a more Adaptable and weakness safe balanced out material suitable for an extensive variety of pavement Conditions. Percent of froth bitumen utilized as 3 to 5 percent. It was one kind of mix design However here after the mix design process stabilization done and CBR quality tried. From those literature review part it can be observed that different types of work had been done previously on bitumen soil stabilization. But in India the number of work on it is very few. Actually in India there is no any appropriate code for bitumen soil stabilization. As from those Papers it is very difficult to get any actual idea about how to mix bitumen emulsion with soil and what will be its actual quantity. This experimental investigation is mainly to make a process for mixing bitumen emulsion with soil.

Chinkulkijniwat and Man-Koksung (2010) This study investigates 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.

Razouki et al. (2002) this paper investigates 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.

Michael (1993) 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.

Paul et al. (2011) suggested an introduction to soil stabilization in pavement taking a mixture of bitumen and well-graded gravel or crushed aggregate. After compaction it gave an exceedingly Steady waterproof mass of subbase or base course quality. The fundamental system involved in asphalt stabilization of fine-grained soils is a waterproofing wonder. Soil particles or soil agglomerates were covered with asphalt that forestalls or abates the entrance of water

which could regularly bring about abatement in soil quality. What's more, asphalt stabilization can enhance durability qualities by making the soil impervious to the unfavorable impacts of water, For example, volume. In non-iron materials, for example, sands and gravel, pounded gravel, and smashed stone, two fundamental systems are dynamic: waterproofing and adhesion. The asphalt Coating on the union less materials gives a film which anticipates or hinders the entrance of water; subsequently reducing the inclination of the material to lose quality in the vicinity of water. The second instrument had been distinguished as adhesion and characteristics of gravelly soils.

Marandi and Safapour (2012) worked on Base Course Modification through Stabilization using cement and bitumen. The main objective of this research was to analyze the use of bitumen emulsion in base course stabilization. So that it was examined as replacement with conventional pavement in regions with low quality materials. Stabilization of soils and aggregates with bitumen shows it differs greatly from cement stabilization. The basic mechanism involved in bitumen stabilization was a waterproofing phenomenon.

Jones et al. (2012) conducted an experimental study on bitumen soil stabilization. Here asphalt Emulsion is a mix of asphalt binder, water, and emulsifying agent. In this case, a series of Indirect Tensile Strength (ITS), Unconfined Compressive Strength (UCS) and Marshal Tests were carried out. It is liquid at ambient temperature to facilitate handling at lower application temperatures. It accelerates breaking of the emulsion and for additional early strength to accommodate traffic during curing of the layer.

Martinet al. (2009) developed a paper deals with foam bitumen stabilization. Foamed bitumen is a mixture of bitumen, air and water. Here 2 percent of cement and 3.5 percent of bitumen foam was used. From here it has been found that Rehabilitation using foamed bitumen had proved to be successful because of its ease and speed of construction, its compatibility with a wide range of aggregate types and its relative immunity to the effects of weather.

A. P. Chritz (2006) discussed about performance evaluation of mixed in place bituminous stabilized shoulder gravel. Here it was showed an economical maintenance of gravel shoulders, a very common problem is facing by highway agencies.

Nikraz (2012) worked on Bitumen-cement Stabilized Layer in Pavement Construction Using Indirect Tensile Strength (ITS) Method. In this study, the goal was to mix and blend Portland concrete and bitumen emulsion with soil for upgrading the quality, strength and durability of the dirt. So as to upgrade the soil quality and decrease its weakness to water, soil stabilization is obliged to be connected to the soil. In accordance with this, enhanced burden exchange was added to the asphalt establishment by having the bond impact which really supports the firmness and Bitumen emulsion impacts which enhance versatility and soil penetrability of the settled layer.

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III. MATERIAL AND METHODS

The method involves improving the soil at the site by applying a stabilizing agent without removing the bulk soil. This technology offers benefits of improving soils for deep foundations, shallow foundations and contaminated sites. The planning of the design mix involves the selection and evaluation

of the engineering properties of the stabilized soil and the improved soil. The purpose is to determine the dimensions of the improved terrain based on the appropriate stability and settlement analyzes to satisfy the functional requirements of the supported structure (Keller Inc.). The technology can be achieved by injecting a cementitious material such as cement and lime in dry or wet form. The choice of using dry or wet mixing methods depends, among other things; the soil conditions in situ, the moisture content in situ, the effectiveness of the binders that will be used and the nature of the construction that will be based. Depending on the depth of the treatment, in situ stabilization can be considered as a method of deep mixing or massive stabilization.

Mechanical stabilization: Mechanic stabilization is accomplished by mixing or blending soils of two or more gradations to obtain a material meeting the required specification. The blended material is then spread and compacted to required densities by conventional means.

Addictive Stabilization: It is achieved by the addition of proper percentages of bituminous emulsion materials to the silty soil the selection of type and determination of the percentage of additive to be used is dependent upon the soil classification and the degree of improvement in soil quality desired generally small amount of additives are required when it is simply desired to modify soil properties such as gradation workability and plasticity. When it is desired to improve the strength and durability significantly larger quantities of additives are used after the additive has been mixed with silty soil, spreading and compaction are achieved by conventional means.

Modification method: Modification refers to the stabilization process that results in improvement in some property of the soil but doesn't by design result in a significant increase in silty soil strength and durability.

Soil stabilization includes multiple alternatives. One option involves the pulverization and homogenization of existing material in situ without the addition of an additive to change or improve the characteristics of the material. This technique is normally performed when the material in situ is adequate and when FDR (FULL DEPTH RECLAMATION) can create a new stabilized base of sufficient thickness and strength for the expected traffic loads. Of course, a surface of some kind must be placed on the stabilized base to protect it.

A second technique of soil stabilization includes the addition of unique additives, such as lime, cement or bitumen. Less common additives include fly ash and mineral filters. The addition of this stabilizing agent was carried out historically dry. In recent years, the emphasis on environmental conditions has led to a more frequent use of additive applications for liquid sludge. The dry stabilizing agent is premixed with water to form a suspension having water content at or slightly below the optimum moisture content for the material being stabilized. The use of the suspension not only drastically reduces the occurrence of dust during the mixing process, but also allows a more accurate and uniform application and mixing of the addictive material that is stabilizing. When the stabilizing agent can be added during the spraying step of the stabilizer, the corresponding reduction in production costs and time can also be reduced.

The deep mixing method involves the stabilization of soils at great depth. It is a technology of soil modification in situ in which a wet or dry binder is injected into the soil and mixed with soft soils in situ (clay, peat or organic soils) by means of a rotating or mechanical mixing tool. Depending on the applications, the following patterns can be produced (Figure 4); Individual patterns, block patterns, panel pattern or stabilized grid pattern. Keep in mind that the goal is to produce the stabilized soil mass that can interact with the natural soil and not, to produce a soil mass that is too rigid as a rigid pile that can carry out the design load independently. Therefore, the increase in strength and stiffness of the stabilized soil should not prevent an effective interaction and the distribution of the load between the stabilized soil and the natural soil. Therefore, the design load must be distributed and carried out partly by natural soil and partly by stabilized soil mass (column).

Proctor standard compaction test

Standard Proctor compaction tests can be performed to evaluate the amount of compaction and the water content required in the field. The water content in which the maximum dry density is reached is obtained from the ratios provided by the tests according to the IS specifications.

Process :

- The empty mold was weighed with the base, but without the collar with precision
- 3 kg of treated silty soil was taken (Silty + variable percentage of plastic) and the air-dried soil was mixed well
- Knowing the natural content, the water was added as much as required to make the water content from 6% to 10%, and mixed well
- The collar was placed and the mold was filled with this mixture to approximately half (more than 1/3) in height and smooth the surface by pressing gently.
- The mold filled with earth together with the collar was mounted on the automatic compactor.
- The humid soil treated with Silty was compacted in 3 layers with the rammer of 4.89 kg of weight and a free fall of 45 cm with 25 no. of blows of uniform distribution to each layer for a compact energy of 1000 cc 2700 kJ / m3
- The surface of the floor was scratched with a spatula before placing the next layer
- The collar was removed and excess dirt was removed.
- All loose soil outside the mold was removed and the weight of the mold was taken with the base plate and the floor.
- The representative sample was conserved by water content.
- For the treated soil, the previous procedure remains the same, except that the soil was mixed with 4%, 8%, 12% and 16% plastic.

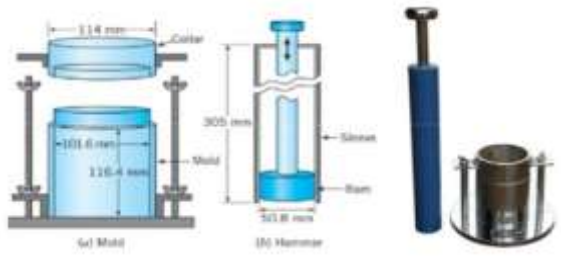

Fig. Standard Proctor Compaction Test Apparatus

The CBR value of a soil is an index that is related to the resistance of the soil. The test was performed in accordance with IS 2720 (Part 16) -1987.

The CBR samples were prepared with different percentages of plastic (0%, 4%, 8%, 12% and 16%) according to the IS specifications. The standard proctor compaction method was adopted with the help of Auto compactor. A water content of 1% + OMC was added for the preparation of the sample. This was to repair the loss of water during mixing. The CBR samples were poured and immersed in water for 4 days and the test was performed after soaking the sample. This was considered a soiled CBR test in the case of soil samples with plastic.

Process :

- 5 kg of treated Silty soil was taken (Silty + variable percentage of plastic) and the air-dried soil was mixed well.
- Knowing the WTO, water was added and mixed thoroughly with the treated Silty soil.
- The mold filled with earth together with the collar was mounted on the automatic compactor.
- The humid soil treated with Silty was compacted in 5 layers with the rammer weighing 4.89 kg and a free fall of 45 cm with 56 no. of blows of uniform distribution to each layer for a compact energy of 1000 cc 2700 kJ / m3
- The surface of the floor was scratched with a spatula before placing the next layer.
- The collar was removed and excess dirt was removed.
- All loose soil outside the mold was removed.
- The prepared samples were analyzed during 4 days (soaked).
- The prepared samples were analyzed at a penetration rate of 1.25 mm / minute.
- A graph of penetration v / s load was graphed and the value of CBR was calculated at 2.5 mm and 5 mm.

Fig. CBR Test Apparatus

IV. RESULTS AND DISCUSSION

This chapter explains the methodology used find the performance of the properties of materials as well as the emulsion mix have very much importance in the design and construction of a long lasting pavement. The experimental methodology used for the study starts with the first step of selection of materials and extends to the different tests conducted on the emulsion and the soil. The tests are conducted according to the standards specified in the relevant codes. Silt soil is finer than sand, but still feels gritty. Silt is commonly found in floodplains and is the soil component that makes mud. Soils with a lot of silt make excellent farm land, but erode easily. This is the soil blown away in dust storms and carried downstream in floods.

Material collection is the primary step for the subsequent steps to be carried out accordingly. The materials to be collected are

1. Additive: Emulsion slow setting (SS1).
2. Soil: Soil samples are collected all along the project corridor.

Soil : Silty soil sample was taken from Rajahmundry village as can be seen in fig .4.1

Soil sample was taken in its original and distributed forms. Sample of original soil was taken by using pipe of diameter 7.5 cm with length 30 cm. Distributed soil sample was taken at the depth of 0 to 50 cm.

Cationic Emulsion: Emulsion type SS1 used especially for soil stabilization was obtained from Silica manufacturers Fig 4.2. The concentrations of emulsified asphalt used in this study were 1.5%, 3% and 4.5% respectively toward dry soil weight. The term cationic is derived from the migration of particles of asphalt under an electric field also. The droplets migrate toward the cathode (negative electrode), and hence the emulsion is called cationic. The cationic emulsifying agent functions similarly to the anionic; the negative portion of the head floats around in the water leaving a positively charged head. This imparts a positive charge to all the droplets. Since positives repel each other, all the droplets repel each other and remain as distinct asphalt drops in suspension. A typical cationic emulsifying agent is shown below along with a diagram showing the orientation of the agent at the asphalt-water interface and the positive charge imparted to each drop.

Fig. Bitumen Emulsion

IV. CONCLUSIONS

- Occurrence of the silty soils are commonly available type of soil in around the study of sieve analysis, compaction, CBR and permeable can also be done for other type soils which are available at different locations where roads are to be laid.
- The silty soil stabilization with bituminous emulsion is also being done with foamed bituminous emulsion, lime, fly ash, cement, cinder and combinations.

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