

An analysis of the best strength characteristics (CBR) of gravel soil with 10% bitumen emulsion addition

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ABSTRACT

In this investigation, bitumen emulsion has been added in an effort to enhance the gravel soil's qualities. An effort has been made to use the emulsion to increase the CBR values of gravel soil in an effort to increase strength, which might prove to be more effective and 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 little amount of cement was applied to improve soil stability. The major goal of this research is to use bitumen emulsion to enhance the gravel soil's strengthening abilities. Bitumen emulsion is added in increments of 2%, 4%, 8%, and 10% to gravel soil to boost its strength. The characteristic properties of soil i.e specific gravity, plastic, liquid limit, plasticity index and CBR value of gravel soil with bitumen emulsion was studied. From tests it is observed that excellent soil strength results by using bitumen emulsion. Mixing conditions for gravelly soil with bitumen emulsion have been first attempted. The results show the best strength properties (CBR) of gravel soil at 10% of adding bitumen emulsion.

Keywords: High way crash analysis, infrastructure, residents.

INTRODUCTION

A gravel road is described as an unpaved road with a surface made of gravel that has been excavated from a riverbed or the bed of a watercourse. These roads are common in less developed countries and may sometimes be referred to as "unmetal roads" in rural parts of more developed countries like Canada and the United States and New Zealand. Even though they are often referred to as "dirt roads," this phrase is more frequently used to describe partially built roads without any surface material. A gravel road is regarded as an all-weather road if it is adequately built and maintained. Since dirt is one of the most often utilized commodities in construction industry present in nature. Fundamentally all the constructions are supported by the soil. Extensive age routine of the roadway constructions is overall influenced by the toughness of the sub grade soil. The sub grades used on site commonly do not offer the provision needed to attain satisfactory routine in the effects of traffic loads among rise in conservational stresses.

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 sub grade 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 sub grade. 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 sub grade is normally stressed to certain minimum level of stresses due to the traffic loads. Sub grade 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 sub grade soil is characterized for its strength for the purpose of design of any pavement. 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. There are different types of additives available.

Soil Stabilization

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. 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. There are different types of additives available. Not all additives work for all soil types. Generally, an additive may be used to act as a binder, after the effect of moisture, increase the soil density. Following are some most widely used additives: Portland cement, Quicklime or Hydrated Lime, Fly Ash, Calcium Chloride, Bitumen etc. But, mechanical soil stabilization alludes to either compaction or the introduction of sinewy and other non-biodegradable reinforcement of soil. This practice does not oblige compound change of the soil and it is regular to utilize both mechanical and concoction intends to attain detailed stabilization. There are a few routines used to accomplish mechanical stabilization like compaction, combining, soil reinforcement, expansion of graded aggregate materials and mechanical remediation. Any land-based structure depends upon its foundation characteristics. For that reason, soil is a very critical element influencing the success of a construction project. Soil is the earliest part of the foundation or one of the raw materials used in the whole construction process. Therefore the main thing related to us 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.

Particle Size Distribution:

The composition of soil particles are of a variety of sizes and shapes. The range of particle size present in the same soil sample is from a few microns to a few centimetres. Many physical properties of the soil such as its strength, permeability, density etc are depended on different size and shape of particles present in the soil sample. Sieve analysis which is done for coarse grained soils only and the other method is sedimentation analysis used for fine grained soil sample, are the two methods of finding Particle size distribution. Both are followed by plotting the results on a semi-log graph where ordinate is the percentage finer and the abscissa is the particle diameter i.e. sieve sizes on a logarithmic scale.

The sieve analysis for coarse grained soil has been conducted. Well graded or poorly graded are mainly the types of soil found. Well graded soils have different particles of different size and shape in a good amount. On the other hand, if soil has particles of some sizes in excess and deficiency of particles of other sizes then it is said to be poorly or uniformly graded. The results from sieve analysis of the soil when plotted on a semi-log graph with particle diameter or the sieve size in millimeter as the X-axis with logarithmic axis and the percentage finer as the Y-axis. This semi-log graph gives a clear idea about the particle size distribution. From the help of this curve, D₁₀ and D₆₀ are resolute. This D₁₀ is the diameter of the soil below which 10% of the soil particles lie. The ratio of, D₁₀ and D₆₀ gives the uniformity coefficient (C_u) which in turn is a measure of the particle size range in the soil sample.

LITERATURE SURVEY

Any land-based structure depends upon its foundation characteristics. For that reason, soil is a very critical element influencing the success of a construction project. Soil is the earliest part of the foundation or one of the raw materials used in the whole construction process. Therefore, the main thing related to us 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. 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.

J.P.Serfass et al. [1] said that the cold mixes are evaluative materials in their early life. The author prepared two types of cold mixes and evaluated material characteristics at different states: fresh mature and aged. The author incorporated different curing procedures and the effect of temperature, relative humidity and time have been evaluated. The mechanical behavior has been characterized by compressive strength and stiffness modulus. The author used 0/14mm grave-emulsion, made of semi crushed alluvial aggregates, with 4.0% of 70/100 residual bitumen and 0/10mm dense-graded asphalt concrete made of crushed genesis with 5.0% of 70/100 residual bitumen. The result obtained from the tests the author conclude that to obtain cold mixes in a mature state, it is proposed that they are cured 14 days at 350c – 20% relative humidity as this procedure does not cause any deterioration to the specimen and he also proposed to keep the existing standardized curing 14 days at 180c – 50% relative humidity as curing to fresh state.

Marandi and Safapour [2] 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.

Paul et al. [3] 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

Cokca et al. [4] concentrated on the impacts of compaction dampness content on the shear quality of an unsaturated mud. In this study, the impacts of compaction dampness substance and soaking on the unsaturated shear quality parameters of mud were investigated. Experiments were carried out on specimens compacted at optimum dampness content, on the dry side of optimum and on the wet side. It was found that edge of erosion reductions quickly with increasing dampness substance, the union segment of shear quality attained its top worth at around optimum Moisture substance and afterward diminishes.

Hussain [5] did an excellent work to establish the correlation between CBR value and un-drained shear strength value from Vane Shear Test. It was shown that undrained shear strength value and CBR value increased with increasing plasticity index. Finally it was achieved that shear strength and CBR value is inversely proportional to the water content of that material. 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.

RELATED STUDY

An emulsion is a dispersion of small droplets of one liquid in another liquid. Oil-in-water (O/W) emulsions are those in which the continuous phase is water and the disperse (droplet) phase is a water- insoluble oily liquid. Water-in-oil (W/O) emulsions are those in which the continuous phase is oil and the disperse phase water. W/O emulsions are sometimes called inverted emulsion. Multiple phase emulsions can be formed in which the dispersed droplets themselves contain smaller droplets of a third phase, usually the same liquid as the continuous phase. Bitumen emulsions are normally of the O/W type although inverted emulsions based on cut-back bitumen's have special applications. There is evidence that bitumen can form multiple W/O/W emulsions. Emulsions containing from 40 to 80 % bitumen are brown liquids with consistencies ranging from that of milk to heavy cream. The droplets normally range from 0.1 to 20 microns in diameter.

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 (micro surfacing and chip seal) and it was concluded that the emulsion system had less environmental impact than a thin hot mix overlay

Framework of the study:

Selection of material and methodology those are the first criteria for any type of experimental investigation. To know the soil physical properties following tests are conducted like specific gravity test, grain size distribution test by sieve analysis and plastic limit and liquid limit test. After that the important part is to choose mixing procedure and the cases or different conditions for conducting the next tests. To determine the maximum dry density of the material modified proctor test has been conducted. But the actual goal is to increase the strength. So CBR test are conducted in different cases and conditions and make a comparative experimental study. So the methodology is how to achieve maximum bearing capacity or maximize the CBR value.

MANUFACTURE OF BITUMEN EMULSIONS:

Bitumen emulsion can be produced either in a batch or an in-line process plant. The batch process involves at least two process steps water phase (soap) preparation and the actual emulsion production. The water phase is prepared in a tank into which heated water, emulsifier and other emulsion chemicals are metered and the solution properly mixed. In the emulsion production process, the bitumen and the pre-made water phase are dosed to the colloid mill. If solvent is to be added to the bitumen, then a batch tank is needed for bitumen as well, or the solvent must be dosed in-line. In the batch plant the emulsion production itself involves only a few material flows, which allows manual process control. However, proper metering of the various components is decisive for the quality of the emulsion and automatic or semi-automatic control will make the manufacturing more efficient and reduce human error. Furthermore, the chemicals used may be hazardous as well as corrosive, which means closed dosage systems rather than open tanks and portable pumps are preferable in order to ensure safe work and environmental conditions. In the in-line process the water heating and all material dosage are done continuously using individual dosage pumps for each material. No batch tanks are used. Instead, the water phase system must further be designed to provide sufficient reaction time for the chemicals so that adequate neutralization and solution take place before the water phase meets the bitumen. The process needs to be automatically controlled using flow meters for all material dosage except acid, which should be controlled by the pH in the water phase. Various special additives such as latex, SBS or bitumen dope may be used and will then require special components and technical solutions. Latex for example is shear sensitive and may coagulate in pumps and lines. SBS modified bitumen’s usually require the emulsion to be produced above the boiling point of water, which requires production under pressure and cooling before release to atmospheric pressure in the storage tank.

THE EMULSIFICATION PROCESS:

Emulsification involves the break-up of the bitumen into droplets. This process is opposed by the internal cohesion and viscosity of the bitumen and the surface tension which resists the creation of new interface. Droplets also have a tendency to coalesce (rejoin). To achieve a small particle size in the emulsion, it is necessary not only to apply mechanical energy in the right way in order to create small drops, but also to prevent their coalescence once formed. The particle size of the resulting emulsion can be related to the design of the mill head, mill rotor speed, the gap between rotor and stator, the dwell time in the mill, the concentration and type of emulsifier and the emulsification temperature. Normally the highest practical temperature is used to prepare the emulsion in order to reduce the bitumen viscosity. Bitumen is heated to 110–160° C until it has a viscosity of 500 cSt or less for pumping into the mill. The water phase is also heated to 30–70° C to dissolve the emulsifiers and to achieve the required emulsification temperature after mixing with the bitumen. In colloid mills, which are not pressurized, this temperature is limited to 100° C, but in modern pressurized equipment may reach 120° C or higher. For good emulsion quality the bitumen phase should have a viscosity less than 10,000 cSt at the emulsification temperature, which means pressurized systems are preferred for hard or highly polymer modified bitumen’s

METHODOLOGY

Various material resources and approaches are the benchmarks to some class of investigational studies. In the direction of differentiate the substantial properties of soil following laboratory tests are performed like specific gravity, plastic limit, liquid limit test and particle size distribution test by sieve analysis. Subsequently the substantial measure is to select the intercourse method and the circumstances or miscellaneous environments for leading the following tests. In the direction of defining the greatest drydensity of the substance standard proctor test is being directed. However, the definite objective is to raise the strength. So California Bearing Ratio experiments are directed within diverse environment and circumstances and to formulate a relative investigational study. Consequently, the approach is how to attain superlative bearing capability or exploit the California Bearing Ratio value. Here, in the succeeding page various approach measures is shown in the flow diagram arrangement.

Bitumen Emulsion:

Bituminous materials or asphalts are extensively used for roadway construction, primarily because of their excellent binding characteristics and water proofing properties and relatively low cost. Bituminous materials consists of bitumen which is a black or dark colored solid or viscous cementitious substances consists chiefly high molecular weight hydrocarbons derived from distillation of petroleum or natural asphalt, has adhesive properties, and is soluble in carbon disulphide. Tars are residues from the destructive distillation of organic substances such as coal, wood, or petroleum and are temperature sensitive than bitumen. Bitumen will be dissolved in petroleum oils where unlike tar.



Fig.3.1. Bitumen emulsion sample4

RESULTS EXPLANATION

DURABILITY TEST

These test methods cover procedures for determining the soil-cement losses, water content changes, and volume changes (swell and shrinkage) produced by repeated wetting and drying of hardened soil-cement specimens. The specimens are compacted in a mould, before cement hydration, to maximum density at optimum water content using the compaction procedure described in Test Methods. Generally, two methods are used for determining the durability of a stabilized sample. One is using ASTM D-559 and ASTM D-560 and another method is given by IRC SP-89 2010. In this study SP-89 method is used to study the durability of the stabilized sample. Prepare two identical set (containing 3 specimens each) of UCS specimen which are cured in a normal manner at constant moisture content for 7 days. When both sets are 14 days old, they are tested for UCS. The strength of the set immersed in water as a percentage of the strength of set cured at constant moisture content is calculated. This index is a measure of the resistance to the effect of water on strength. If this value is lower than 80 percent it is considered that the stabilizer content is low and its value should be increased.

C.B.R. Test

The CBR is the measure of resistance of a material to infiltration of a standard plunger under controlled thickness and dampness conditions. This is a to a great degree typical test to appreciate the sub-level quality before development of roadways. The test has been comprehensively explored for the field association of adaptable asphalt thickness need. In a far-reaching way testing is done taking after IS: 2720 The test includes bringing on a round and barrel shaped plunger of 50mm distance across to enter an asphalt part material at 1.25mm/moment. For the most part the CBR esteem at 2.5mm infiltration is higher and this worth is adopted is characterized as the proportion of the test burden to the standard burden,

communicated as rate for a given entrance of the plunger. This worth is communicated in rate. Standard heap of diverse infiltration is talked about some time.



Figure: C.B.R. TEST

The first criteria for any form of research investigation are sample collection and methodology. For the knowledge of the physical properties of the soil following experiments, the gravity test, extreme analysis and the plastic limit test and liquid limit experiments are carried out. The crucial part then is to select the mixing phase and the cases and conditions for the next experiments. The substance adjusted proctor test was performed to determine the maximum dry density. Nevertheless, the real goal is to increase power. CBR experiments are conducted in different situations and environments and a comparative longitudinal analysis is carried out. And the approach is how the maximum possible potential is reached or how the CBR benefit is maximized

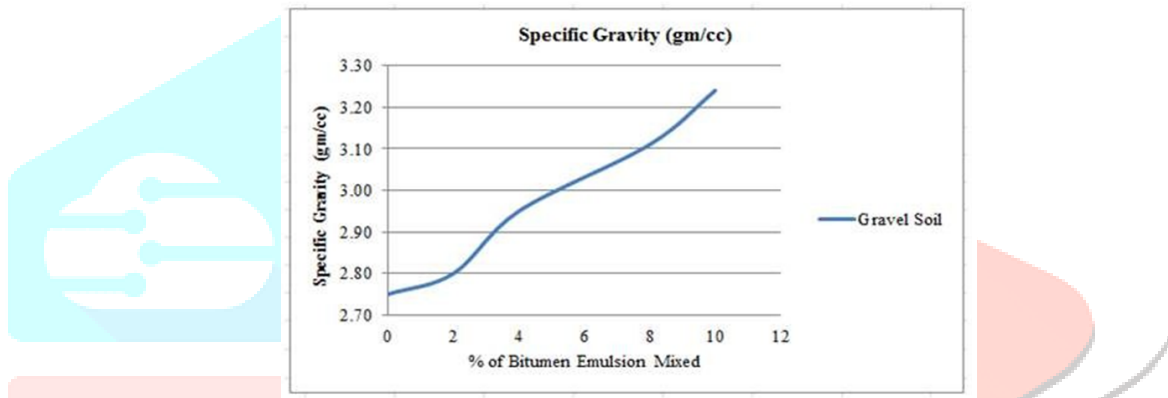


Fig.4.1. Specific Gravity of Gravel Soil & Bitumen Emulsion Mixed Soil

In areas of the country that receive a high amount of moisture, the problem is greatly reduced. Arid or semi-arid regions such as the desert southwest and much of the Great Plains region in the United States are prone to long periods of dry weather. Many regions around the world can have similar weather patterns. Dust can bring complaints in these areas especially if there are residences located directly adjacent to or near the road. The quality and type of gravel has a great effect on the amount of dust. For example, some limestone gravels will produce significant dust in a dry condition. But, some natural deposits of gravel that have some clay in the mix of material can take on a strong binding characteristic that will produce much less dust. Still, in prolonged dry weather, dust will be produced by virtually any paved surface! Whether to provide some type of dust control or not can be a hard decision to make. If traffic is high enough, road dust can impact the health of people and animals. There will be pressure to control the dust. On the other hand, the cost can be prohibitive and hard to justify if traffic volume is very low. The cost-benefit of doing this needs to be carefully considered. Most methods of dust control require annual treatment and it must be factored into annual maintenance costs.



Fig.4.2. Field demonstration of surface gravel with an outstanding binding characteristic

CONCLUSION

If MS bitumen emulsion is used properly, it is evident from this study that the California Bearing Ratio (CBR) of the sub grade would significantly improve. The soil emulsion mix appears to work best when left for around five and a half hours after mixing. The CBR value in this specific experimental investigation has risen by up to 50% compared to the CBR of unaltered soil. It is obvious that this sort of stabilization may be applied in gravel soil roads or in the shoulder area of highways after observing its economic cost and stabilization quality enhancement.

When bitumen emulsion and gravel soil are combined, the soil's specific gravity rises.

Similarly, for Liquid, Plastic limit and plasticity index also increased.

The maximum dry density is occurred at optimum moisture content (12%) from compaction test.

From the results it is clear that there is a considerable improvement in California Bearing Ratio (CBR) of sub-grade due to use of bitumen emulsion. It is observed that the best results are obtained when the soil emulsion mix is left for soaking after mixing the bitumen. The CBR value of stabilized gavel soil is increased 50% compared to the normal gravel soil

Hence the stabilization of gravel soil with bitumen emulsion gives the better strength to sub grade soil in pavement design.

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