

STABILIZATION OF SOIL USING RUBBER TYRE WASTE

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ABSTRACT

Transport plays an important role in the development of any country. Transportation has several modes of transportation such as road, rail, air and water etc. Among the following modes of transportation, road network is one of the important modes of transportation, it is used by every person in their daily life. Road network construction plays an important role in the development of any country. Roadways consist of several layers, these layers follow each other as base, subgrade, base and surface layer. The base layer is considered one of the most important layers. The construction of any engineering structure on weak subsoil or soil is considered dangerous to human life. Weak soil cannot withstand the high stresses coming from the structure. Therefore, stabilization of the subsoil is necessary for the construction of the engineering structure. The subsoil in the transportation system plays a very important role in transferring the loads originating from the superstructure to the existing ground surface, so it should have the capacity to bear this load. In this experimental study, our aim of work is to stabilize or improve the soil properties of Karnal using rubber tire waste. Waste rubber tires are a type of solid waste and are produced in large quantities in India. This experimental study involves different steps. In the first step of this experimental study, to find out the properties of the soil, we conducted various tests on the soil, such as wet sieve analysis, Atterberg limits, specific gravity, standard Proctor test and California bearing test, after analyzing the results of various tests, we come to the conclusion that the Karnal Soil was a silty soil with low plasticity index and had a lower CBR value of almost 3.4%-3.5%, which is not suitable for a transportation system. In the second step of this experimental study, we mixed rubber tire waste with soil at different percentages according to soil dry weight to improve soil stability. Mixing was done manually. In the third step of this study, we will again perform the standard Proctor test and the California bearing test on soil mixtures with different percentages of waste rubber tires and find out the value of the different result obtained from these two tests. Using these CBR values obtained from the tests, we determine the pavement thickness and also perform a cost analysis of the flexible pavement at 2 msa, 5 msa and 10 msa operation.

Keywords: Superstructure, flexible pavement, rubber tyre waste, major district road, state highways.

1. INTRODUCTION

Transportation is a way of transporting people and goods from one place to another. It is very important in every stage of human civilization. The most used modes of transport in India are road and rail. So there is a need to develop these regimes. Of these types, road transport provides maximum flexibility to passengers. A proper network of communications will help the economic, social, political and cultural development of the country. Roads are classified as National Highways (NH), State Highways (SH), Major District Roads (MDR), Other District Roads (ODR) and Village Roads (VR). Pavements are classified as flexible and rigid. For flexible pavements, there are four types of layers which are as follows: sub-base, sub-base, sub-base and surface layer. On the other hand, a rigid pavement consists of a subgrade, a base layer and a cement concrete slab. The subsoil is prepared from natural soil to support the layers of roadway materials that are placed on top of it. The various roadway loads are received by the subsoil and then dissipated into the earth mass. The subgrade provides support and stability to the roadway and also helps drain water. It is therefore desirable to compact well the upper 50 cm of the subsoil under controlled conditions of maximum dry density and optimal moisture content. If a well-compacted base layer is not prepared, various defects occur on the surface layer. So our quality base layer should be prepared well compacted. In India, researchers have worked to stabilize or improve soil using cement, lime, fly ash and geosynthetics over the past few decades. These additive materials have their own limitations for use, such as non-renewable resources, environmental issues, cost and availability, and also the production of these materials is destructive to natural habitats. Soil properties can therefore be improved by using new materials.

2. OBJECTIVES OF THE STUDY

In this research work, an attempt was made to test the suitability of waste rubber tires for improving soil properties for subsoil or embankment construction. The aim of the research work is to improve the strength characteristics of the Karnal soil by mixing waste from rubber tires in different mixture ratios. The objectives of the research work are given below. To determine the effect on MDD, OMC and soaked CBR values for different proportions of waste rubber tires mixed with soil. To determine pavement thickness value and cost analysis of flexible pavement at different CBR

values. Compare the costs of building a road with a mixed rubber tire subgrade and a parent soil subgrade.

3. LITERATURE REVIEW

Rao and Dutta (2006) conducted research on compressibility and strength behavior of sand chip mixtures. In this research, waste tires can be crushed into chips and easily mixed with granular soil like badarpur sand. In this work, chips were obtained in three different sizes of 10 mm x 10 mm (Type I), 20 mm x 20 mm (Type II) and 20 mm x 10 mm (Type III). It is made from tires for scooters (Type I), passenger (Type III) and also truck tires (Type II). To assess the behavior of the admixtures, compressibility and triaxial compression tests were performed with different chip sizes and chip content. The results obtained from experiments such as General stress-strain-volume change behavior of tire chip-sand mixtures are similar to those of sand. There was some improvement in strength after inclusions were added. Tire chip Type II (with an aspect ratio of 2) shows the best improvement at the least limiting pressure and a chip content of 20%. The addition of chips causes a marginal increase in the value of the shear resistance angle by about 2°. The increase is almost the same for all three types of chips. The value of the cohesive grip increases significantly and with a maximum value of 18 kPa for sand with 20% type III chips. Marathe et al. (2015) conducted research on the stabilization of lithomargic soil using cement and randomly distributed waste crushed chips from rubber tires. In this research, the lithomargic soil is locally known as Shedi soil, which is found at a shallow depth usually below the lateritic soil. These soils tend to destabilize roads that are built on an embankment or bedrock made of lithomargic soil because they do not have the required shear strength. It is therefore necessary to improve the technical properties of this soil before it can be used as a road material. This soil can be stabilized by various chemical and mechanical means. This paper focuses on soil stabilization using common grade 53 cements and randomly distributed crushed tire fragments obtained from waste rubber tires. Rubber, when introduced into lithomargic soil, acts as a stiffening agent and cement provides a binder and improves shear strength by improving the frictional component of this soil. The modified Proctor results showed the highest value of maximum dry density (MDD) and lowest optimum moisture content (OMC) for the test mixes when compacted with 4% shredded rubber and 2% cement, which can be considered as the optimum dosage. Strength is rated based on California Bearing Ratio (CBR) unconfined shear strength and penetration resistance for specimens compacted at maximum proctor density for optimal cement and crushed rubber chip dosage into lithomargic soil. The results obtained from experiments such as The optimum dose of randomly distributed waste tire chips and cement from the modified Proctor test are 4% and 2%. The engineering properties of weakly lithomargic soil can be effectively and economically increased by adding 2% cement and 4% waste shredded rubber.

4. EXPERIMENTAL INVESTIGATION

Laboratory studies were performed in accordance with the relevant IS regulations. After collecting all the material needed for this investigation. Specific gravity, Atterberg limits, and particle size analysis tests were performed to determine the index properties of the parent soil in the shipping laboratory. A standard Proctor test was performed to determine the optimum moisture content and maximum dry density of the soil and the California bearing capacity ratio. The test was conducted to understand the strength parameters of the soil. For the research point of view, standard proctor tests were carried out on the base soil with different proportions of waste rubber tire mixture (0%, 2%, 4%, 6%, 8% and 10%) according to the dry weight of the soil and the California deposit. ratio tests were performed on a base soil with different proportions of waste rubber tire mixture (0%, 2%, 4%, 6%, 8% and 10%) to soil dry matter.

Index Properties Of Soil- Index properties like Atterberg limits, Specific gravity and Particle size analysis have been carried out to identification and classification of soil.

Particle Size Analysis (IS: 2720, PART 4-1985) Particle size analysis is also known as mechanical analysis. It is a method of separation of soils into different fractions based on the particle size. It expresses quantitatively the proportions, by mass, of various sizes of particles present in a soil. There are two stages of analysis dry sieve analysis and wet sieve analysis. The wet sieve analysis is used for fine grained soil. In this investigation soil is fine grained soil. So, the wet sieve analysis is conducted as per IS: 2720, Part 4-1985. Figure 4.1 shows sieve set for wet sieves used in this analysis.

Procedure For Wet Sieve Analysis- If the soil contains a substantial quantity (say more than 5%) of fine particles, a wet sieve analysis is required. All lumps are broken into individual particles. A representative soil sample in the required quantity is taken and dried in oven. In this process 200gm dry soil sample were taken and washed on 75 microns is sieve till the water passing through the sieve is substantially clean. The fraction of sieve retained on sieve was emptied carefully without loss of material in separate trays and oven dried. After dry, the sample is sieved through (10.00 mm, 4.75mm, 425 micron and 75micron). The fraction retained on each sieve was weighted separately and note down in the notebook. And percentage mass of soil within the selected sieve sizes were calculated. Finally, calculated

cumulative percentage passing on each sieve was calculated. And Table 1 shows cumulative % of soil passing through each sieve below.

Table 1. Cumulative % of soil passing through each sieve

| Wet sieve analysis | % passing |
|--------------------|-----------|
| 10mm | 100 |
| 4.75mm | 99.49 |
| 425µ | 96.5 |
| 75µ | 82.58 |

Results

Particle size sand (4.75-.075mm) =21.43 Silt(.002-.075mm) =78.57%

Atterberg Limits

(IS: 2720, PARTS-1985)

Atterberg mentioned that fine-grained soil can exist in four states, namely liquid, plastic, semi-solid and solid. The water content at which a soil changes from one state to another is known as the Atterberg limits. Atterberg limits also known as consistency limits. The consistency of fine-grained soil is defined as the physical state in which it exists. It is used to indicate the degree of strength of the soil. Water content alone is not an adequate soil index property. At the same water content, one soil may be relatively soft while another soil may be hard. However, soils with the same consistency limits behave somewhat similarly. Consistency limits are therefore very important index properties of fine-grained soils. Atterberg's limits are mainly liquid limit, plastic limit and shrinkage limit. Liquid limit and plastic limit are useful for soil identification and classification.

Liquid Limit Test-

The liquid limit is the water content at which the soil changes from a liquid state to a plastic state. At the liquid limit, the soil behaves practically like a liquid, but has a small value of shear strength. The shear strength at this stage is the smallest value that can be measured in the laboratory. The liquid limit test results are shown in Table 2 below.

Procedure Of Experiment-

- Take a representative soil sample weighing approximately 120 g passing through a 425 micron IS sieve and mix thoroughly with distilled water in an evaporating dish to a uniform paste.
- Place a portion of the prepared sample in the cup of the liquid containment device where the cup rests on the base and spread it so that it is 10 mm deep at the deepest point and forms a horizontal surface above the soil.
- Create a groove in the soil by running the grooving tool through the soil from the top of the bowl to the bottom of the bowl.
- Raise and lower the cup at a rate of 2 drops per second. Continue turning until the two halves of the soil sample meet at the bottom of the groove.
- Record the number of drops or blows (N) required to close the groove. • Remove a slice of soil and determine its water content (w).
- Repeat the above steps with a soil sample of slightly higher or lower water content. Whether water is added or removed depends on the number of strokes required to close the groove in the previous sample.

Table 2. Liquid limit test results of soil

| | | | |
|---------------------------------------|--------|--------|--------|
| Determination no. of blows(N) | 15 | 23 | 30 |
| Container no. | 1 | 6 | 10 |
| Weight of container W0(gm) | 18.91 | 18.38 | 17.79 |
| Weight of container + wet soil W1(gm) | 55.24 | 50.10 | 47.51 |
| Weight of container +dry soil W2(gm) | 47.92 | 44.22 | 42.22 |
| Weight of water (W1-W2)gm | 7.32 | 5.88 | 5.29 |
| Weight of oven dry soil (W2-W0)gm | 29.01 | 25.84 | 24.43 |
| Water content w%=(W1-W2)/(W2-W0)*10W | 25.23% | 22.75% | 21.65% |

Resul

The liquid limit of the soil is 22.25%

Plastic Limit Test

The plastic limit of a soil is the water content of the soil below which it causes to be plastic. It brings to crumble when rolled into threads of 3mm diameter. At this water content, the soil loses its plasticity and passes to a semi solid state. Table 3 shows plastic limit test results below.

APPARATUS

- Spatula
- Porcelain evaporating dish about 120mm dia.
- Container to determine moisture content
- Balance, with an accuracy of 0.01g
- Oven
- Ground glass plate-20cm x 15cm
- Rod-3mm dia and about 10cm long

PROCEDURE OF EXPERIMENT

- Take out 30g of air-dried soil from a thoroughly mixed sample of the soil passing through 425µm IS Sieve. Mix the soil with distilled water in an evaporating dish and leave the soil mass for maturing.
- Take about 8g of the soil and roll it with fingers on a glass plate. The rate of rolling should be between 80 to 90 strokes per minute to form a 3mm dia. If the diameter of the threads can be reduced to less than 3mm, without any cracks appearing, it means that the water content is more than its plastic limit. Knead the soil to reduce the water content and roll it into a thread again.
- Repeat the process of alternate rolling and kneading until the thread crumbles.
- Collect and keep the pieces of crumbled soil thread in the container used to determine the water content(w).
- Repeat the process at least twice more with fresh samples of plastic soil each.

Table 3. Plastic limit test result

| Determination no. | 1 | 2 | 3 |
|---------------------------------------|--------|-------|--------|
| Container no. | 41 | 51 | 98 |
| Weight of container W0(gm) | 16.84 | 10.81 | 18.07 |
| Weight of container + wet soil W1(gm) | 27.01 | 24.27 | 27.54 |
| Weight of container +dry soil W2(gm) | 25.40 | 22.12 | 25.93 |
| Weight of water (W1-W2)gm | 1.61 | 2.15 | 1.61 |
| Weight of oven dry soil (W2-W0)gm | 8.56 | 11.31 | 7.86 |
| Water content w%=(W1-W2)/(W2-W0)*10W | 18.80% | 19.0% | 20.48% |

Result- The average of above three values are the plastic limit of the soil = $18.8 + 19 + 20 = 19.42\%$

Plasticity Index

Plasticity Index (Ip or PI) is the range of water content over which the soil remains in the plastic state. It is to the difference between the liquid limit and the plastic limit

Plasticity Index = Liquid limit - Plastic limit. = $22.25 - 19.42 = 2.83$

5. CONCLUSION

In this study, a series of tests were carried out on Karnal soil with and without mixing rubber tire waste. Based on laboratory tests, the following conclusions were drawn:

1. The soil in the Karnal area is a low plasticity silt soil and has an optimum moisture content (OMC) of 10.85%, a maximum dry density (MDD) of 1.99 gm/cc and a California Bearing Ratio (CBR) wetted value of 3.5%.
2. The soil is stabilized using rubber tire waste. The rubber tire content increases from 2% to 10% in increments of 2%. From the Proctor test results, it is observed that with the increase in rubber tire content, the OMC decreases from 10.85% to 9.25% because the rubber tire has less water absorption capacity and the MDD decreases from 1.99 to 1.86 g/cm³. Rubber tire with lighter weight and lower specific gravity (1.05) compared to soil particles.
3. From the results of the CBR test, it is observed that the CBR value soaked in the rubber tire stabilized soil sample increases by 3.50% to 4.89%.

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