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Improvement of Soil Characteristics Using Shredded Rubber

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Abstract: *Soil stabilization means alteration of the soil properties by the addition of any other material to meet the specified engineering requirements. Methods for the stabilization are compaction and use of admixtures. Use of shredded rubber tyres in geotechnical engineering for enhancing the soil properties has received great attention in the recent times. The aim of the study was to use the waste material for stabilization of soil in order to reduce the environmental impact. Several reinforcement methods are available for stabilizing soils. In the present investigation, shredded rubber from waste tyres has been chosen as the reinforcement material and cement of 2% and 4% as binding agent. Binding agent which was randomly included into the soil at three different percentages of shredded rubber content, i.e. 5%, 10% and 15% by weight of soil. The investigation has been focused on the strength behaviour of soil reinforced with randomly included shredded rubber. The samples were subjected to California bearing ratio (soaked and unsoaked) and unconfined compression tests. The tests have clearly shown a significant improvement in the shear strength and bearing capacity parameters of the soil.*
Keywords: ***S****tabilization, Shredded rubber, Unconfined compression test, California Bearing Ratio.*

I. Introduction

Solid waste management is the one of the major environmental problem worldwide. In India, the scrap tyres are being generated by the increasing vehicles and accumulated in large volumes causing an increasing threat to the environment. In order to eliminate the negative effect of these depositions and in terms of sustainable development, there is great interest in the recycling of these non-hazardous solid wastes.

Use of shredded tyres in geotechnical engineering for improving the behavior of soil has received great attention in recent times. If scrap tires are used for the construction material instead of burning it would be useful in good manner for both civil and environmental. In recent years, civil engineering applications using scrap tyres are light weight fill, insulation beneath roads, light weight backfill for retaining walls and also to improve the drainage conditions.

The generation of scrap tires has been increased over the years in the India. Recycling of the scrap tyres has been started in India. Civil engineering applications form one of the biggest applications for the recycling of scrap tires. One of the most important characteristics of tire shreds is that they are lightweight materials. When the buildings are constructed on weak and compressible soils, stability and settlement considerations are critical. In recent times, with the rapid civilization increase in the demand for infrastructure and feasible foundation design, which is not applicable due to poor bearing capacity of ground soil stabilization has started to take satisfy these requirements.

The vehicle population of the world is rapidly increasing. In the 20th century automotive growth mainly took part in India. India had an explosion in the number of vehicles, and with more vehicles also causes more scrap. A lot of research work is going on worldwide to cope up with this problem. Waste tyres have characteristics that make them not easy to dispose, and potentially combustible. Huge stockpiles and uncontrolled dumping of tyres, throughout the country, is a threat to public health and environment. One of the alternative ways of disposing of waste tyre is to use them for geotechnical applications, due to following advantages as per the researchers Ayothiraman, and Abilash Kumar Meena.,(2011);Tweedie and Humphrey(1998); Stanford, T.C. (1998), Humphrey and Manion,(1992;Humphrey and Nickels (1997),Humphrey et al., (1997), Humphrey, et al., (1992) and Reddyand Saichek, (1998).

(1) It will help in not only saving huge spaces occupied by waste tyre and tubes, but the environmental health hazards will also be reduced.

(2) The consumption of natural soil will be reduced, there by rendering cost saving benefits.

(3) The various soil properties such as bearing capacity, shear strength, drainage etc. can be improved by reinforcing it with waste tyre rubber.

(4) With the introduction of waste tyre rubber in soil its capacity to absorb and dissipate energy will be enhanced drastically.

(5) Non-biodegradable and thus more durable.

1. Materials And Testing

Formation of Rubber Shreds from Scrap Tyre

Rubber shreds are produced in tyre cutting machines. These cutting machines can slit the tyre into two halves and can separate the sidewalls from the tread of the tyre. Slit tyres have a lot of exposed steel belts. The shredding process results in exposure of steel belt fragments along the edges of the tyre shreds. Production of smaller tyre shreds and tyre chips, which are normally sized from 76 mm down to 13 mm, requires two-stage processing of the tyre shreds (primary and secondary shredding) to achieve adequate size reduction. Secondary shredding result in the production of chips that are more equi-dimensional than the larger size shreds that are generated by the primary shredder, but exposed steel fragments will still occur along the edges of the chips.

2. Sizes of Rubber Shreds

Processed tyre materials are often irregular in shape. Most processed material, like shreds and chips, are disc-shaped. The processed shredded rubber was may not be of regular shape and size. The dimension of the rubber chips were presented as nominal size in this study. Tyre chips having size of 10mm to 20mm and 2mm to 3mm thick after removing steel belting are used extensively. The shredded tyre material used which are free from steel wire or nylon fibres.

3. Method of Testing

The scrap tyre shreds are added to the soil and binding agent of cement 2% and 4% rapidly included and was tested to determine the improvement of soil behaviour and was tested in unconfined compressive test and California bearing ratio test both soaked and unsoaked conditions. The results obtained are mentioned in this paper.

Figures and Tables

Fig 1. Formation of Rubber Shreds from the Cutting Machine

The soil which collected from the site was tested in laboratory. Soil type and its bearing capacity were obtained from the tests. The samples were prepared according to the Indian standards for various tests.

Table 1. Index properties of soil

Property	**Value**
Liquid limit (L.L) %	53.8
Plastic limit (P.L) %	26.5
Plasticity Index (P.I) %	27.3
Maximum dry density (MDD) kN/m^3	17.29
Optimum moisture content (OMC) %	18

II. Unconfined Compression Strength Test

Different samples were prepared for conducting unconfined compressive strength in the laboratory as per IS Code: 2720-10(1991). The soil reinforced shredded rubber with different percentages 0%, 5%, 10% and 15% and 2% and 4%cement and the details of the results were presented below in the figs.2&3.

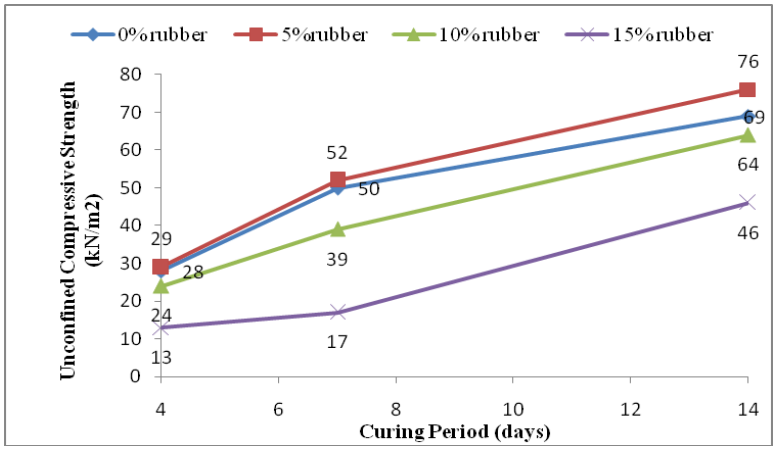

Fig 2 Variation of Unconfined Compression Test Results with 2% Cement and Different % of Shredded Rubber at Different Curing Periods

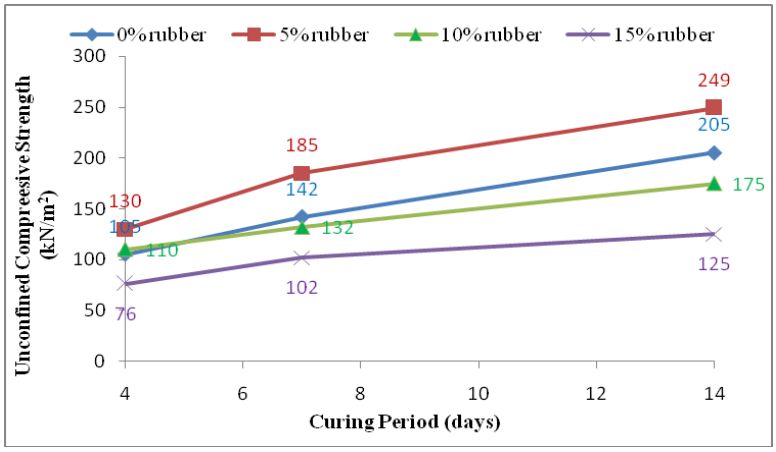

Fig 3 Variation of Unconfined Compression Test Results with 4% Cement and Different % of Shredded Rubber at Different Curing Periods

III. California Bearing Ratio Test (Unsoaked)

Different samples were prepared in the similar lines for CBR soaked and unsoaked tests using soil reinforced shredded rubber and 2% and 4%cement and the details of the results were presented below in the figs.4 to 7. The CBR tests were conducted in the laboratory for all the samples as per I.S.Code (IS: 2720 (Part-16)-1979). The results obtained for the addition of rubber with varying 0%, 5%, 10% and 15% and binding agent with 2%, 4% cement were mentioned below .

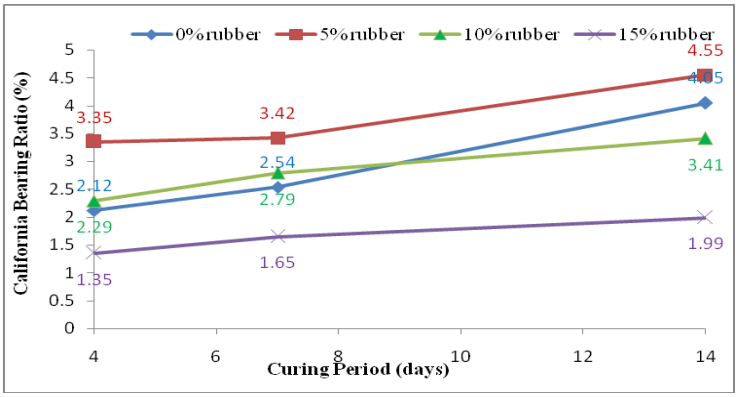

Fig 4 Variation of California Bearing Ratio Unsoaked Test Results with 2% Cement and Different % of Shredded Rubber at Different Curing Periods

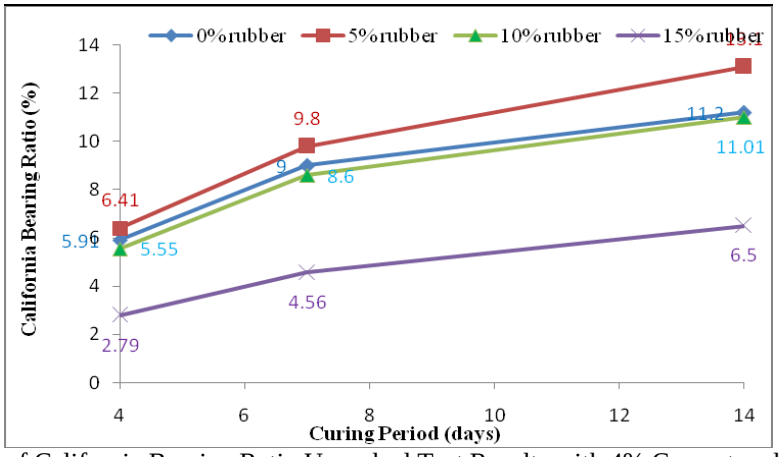

Fig 5 Variation of California Bearing Ratio Unsoaked Test Results with 4% Cement and Different % of Shredded Rubber at Different Curing Periods

IV. California Bearing Ratio Test (Soaked)

The results obtained for the addition of rubber with varying 0%, 5%, 10% and 15% and binding agent with 2%, 4% cement were mentioned below in a chart

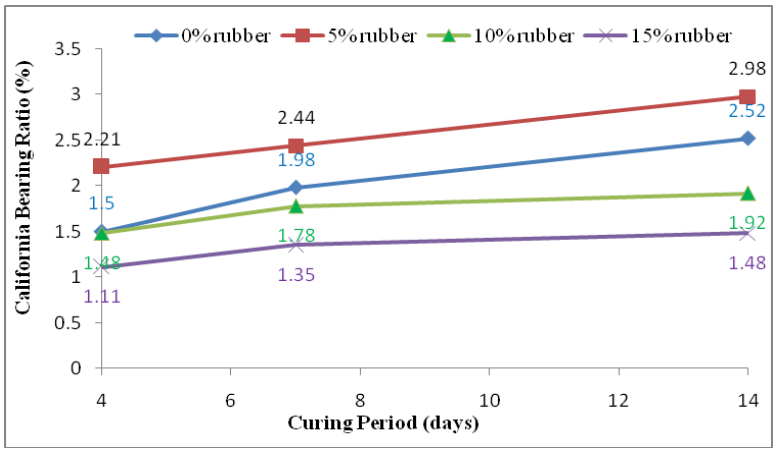

Fig 6 Variation of California Bearing Ratio Soaked Test Results with 2 % Cement and Different % of Shredded Rubber at Different Curing Periods

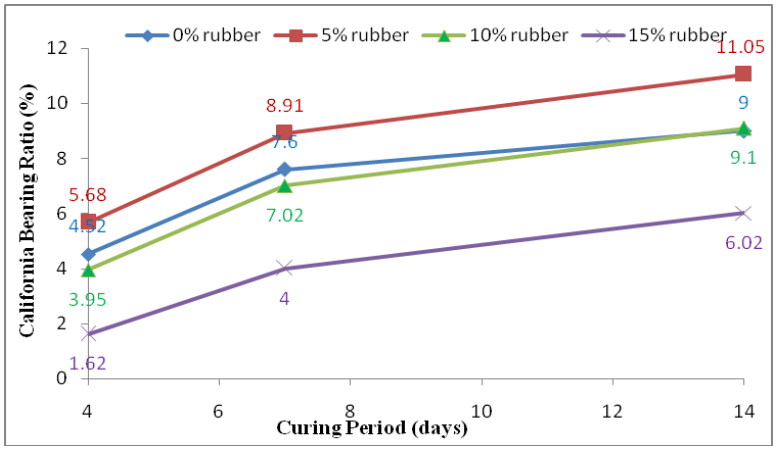

Fig 7 Variation of California Bearing Ratio Soaked Test Results with 4 % Cement and Different % of Shredded Rubber at Different Curing Periods

V. Conclusion

1. The optimum moisture content will be varies about 1% to 2% due to addition of shredded rubber content.
2. The liquid limit and plastic limit are reported as 53.8% and 26.5% respectively.
3. The maximum dry density and optimum moisture content are 17.29kN/m^3 and 18%.
4. According to soil classification IS: 1498-1970, the soil is comes under CH (clay of high plasticity) as the liquid limit is more than 50%.
5. The unconfined compressive strength and California bearing ratio increases with the increase in cement content at an optimum fiber content of 5%.
6. The unconfined compressive strength has increased from 15kN/m^2 to 76kN/m^2 for 2% cement and 249kN/m^2 for 4% cement for black cotton soil.
7. Deep foundations and raft foundations for structures on soil with low bearing capacity can be replaced by shallow foundation with soil stabilized by shredded rubber waste.
8. California bearing ratio has increased from 1.24% to 4.55% for 2% cement and 13.10% for 4% cement for black cotton soil for unsoaked condition.
9. California bearing ratio has increased from 1.24% to 2.99% for 2% cement and 11.05% for 4% cement for black cotton soil for soaked condition.
10. Increases in CBR value significantly reduce the total thickness of the pavement and hence the total cost involved in the project.
11. Shredded rubber fiber can be considered as a good reinforcement material.
12. Upon 4% cement modification, the soil could become non-plastic and showed maximum strength as that of 5% addition of tyre chips could improve the shear strength parameters significantly.
    The above concluded parameters are reported according to limited tests carried in laboratory and are tested only with the addition of 5%, 10%, 15% of rubber shreds which are having dimensions of 10 to 20mm length and 2 to 3mm thickness.

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