Application of Waste Tyre-Tube Chips with Fine Sand for Subbase Construction of Roads

Joyanta Maity, Bikash Chandra Chattopadhyay, Debdip Sarkar, Debanjan Chakraborty

***Abstract*—Brickbats are conventionally used in the construction of subbases of flexible roads. However, use of brick bats in construction of road subbase is being discouraged due to environmental as well as economic reasons. On the other hand, the disposal of waste rubber tyre-tube has become a demanding work. In such conditions, fine sand mixed with randomly distributed waste rubber tyre-tube can be used to increase strength and decrease deformability in road construction in a cost- effective manner. However, extensive research is needed to study the behaviour of randomly mixed waste rubber tyre-tube with sand before their application in practice. This paper presents the stabilization of fine sand using randomly distributed waste rubber tyre at varying lengths and percentages by weight of sand. Compaction tests and California Bearing Ratio (CBR) tests were conducted to investigate the behavior of fine sand mixed with waste rubber tyre-tube. From the test results, it was observed that with the increase in percentage of waste tyre-tube chips in sands, maximum dry density decreases whereas optimum moisture content increases. Further, the CBR value of the composite at OMC, increased with increase in percentage of waste tyre-tube.**

***Index Terms*— Tyre-tube chips, Health hazards, Deformability, California Bearing ratio (CBR) test.**

I. INTRODUCTION

Large amount of waste tyres which is being produced at increasing rate in present days, as a result of their increasing use in daily human usage, is presenting challenging problem to society due to disposal problem of such waste, occasional hazards due to fire accident on such tyre waste, and environmental pollution (Murti and Krishnan, 2011). In India itself nearly 100 million tons of tyres are discarded every year. South Korea, USA and Canada, produce an estimated value of yearly such waste on nearly 300 million tons, together (Naval et.al, 2013). Continuous accumulation of such waste without any planned disposal system, gives rise to high pressure on shrinking land available for human use due to increasing land for accommodating undisposed tyre waste and creates pollution and social problems associated with dump yards for such waste everywhere.

The growing need for evolving suitable method of disposal of such huge waste, has been felt over last few decades in industrial countries and countries of growing economy. Further there is a growing understanding of the important merits of such rubber waste which could be utilized in suitable way for reuse in practice. Materials of waste tyres have low density, high strength, and are of hydrophobic nature, low thermal conductivity, high durability, resilence and high frictional strength (Ayothiraman et.al., 2011). Thus scrap tyres with so many advantages are valuable resource material and should not be left alone and proper method of their reuse will be beneficial for economic growth of the country.

Over last few decades, several methods for utilizing the waste materials have been attempted. These methods are in mainly three different areas as described below.

(a) Addition of rubber tyre chips in Foundation Medium:
Use of rubber tyre chips along with sand in different proportion has been examined by many researchers as better backfill and more cost-effectiveness. Model surface footing tests on unreinforced and reinforced foundation medium with different fiber contents indicated that fiber reinforcement of 0.75% shows maximum improvement in the bearing capacity nearly by 50% (Naval and Kumar, 2013).

(b) Addition of chips in backfill for retaining walls:
Several investigations have been reported on using soil-tyre chips mixture as backfill to reduce lateral earth pressure. Even such tyre chips have been mixed with local weak soils to improve engineering properties and thus overcoming the ill effects of such weak soils (Murti and Kishore, 2011).

(c) Use of chips in construction of landfill leachate collection system:
As a result of development of the rubber tyre materials from different raw materials, these rubber tyre chips have been unique properties such as resilience, strength, absorbance capacity of different chemicals and their products. These tyre materials may be used as construction material in cases where such properties will be great benefit, for example in construction of landfill leachate collection system. As a result of use of shredded tyre chips in landfill leachate collection system, is now getting fastest growing market application. A detailed benefits and application possibility has been reported elsewhere (Kaushik et al., 2012).

However, most extensive possibility of consuming tyre waste by large volume and thereby solving the problem of the disposal of such waste in great volume, possibly lies in their use as fill material for highway construction, which are taking at a huge rate all over the world, for fast development of infra structure. The rubber tyre chips having resilience, hight weight and high strength, may be used with locally available soils in suitable proportion to achieve maximum gain in quality and decrease in cost of construction of such highways. However, proper engineering analysis is necessary for such exercise.

Several studies have been made with waste rubber tyre to observe the characteristics of soil-waste rubber tyre mix composites. Lee et al. (1999)[3], Rao and Dutta, (2001)[4] etc. studied on the stress-strain relations and strength behaviour of sand-rubber tyre chips mix composites. They observed higher strength of soil-waste rubber tyre mix composites due to increase in percentage of rubber chips up to a certain limit.

In the present study, an experimental programme has been undertaken to investigate the beneficial effects of mixing rubber tyre chips on engineering properties of locally available sands. Different percentages and varying lengths of scrap cycle tyre-tube chips have been used to identify the cost effective possible use in highway construction.

II. Proposed Investigation

Materials Used:

Sand: Locally available fine sand was used in this experimental study. The sand is classified as 'SP' as per IS classification. The physical properties of different sands used are given in Table 1.

Waste tyre tube chips: Waste tyre tubes were collected from local market and processed in the laboratory by cutting into small pieces of various sizes of 13mm x 13mm, 3mm x 25mm, and 13mm x 38mm as shown in fig.1. Waste tyre tube chips were mixed randomly with fine sand as shown in fig.2, at different percentages of 1%, 3%, 5%, 7%, 9%, and 10%.

Fig. 1 Waste tyre-tube cut into small pieces

Fig. 2 Waste tyre-tube chips randomly mixed with fine sand

Table 1: Physical Properties of Fine Sand

Properties	Fine Sand
Classification (IS)	SP
Specific gravity	2.61
Coefficient of uniformity, C_u	2.13
Maximum dry density (gm/cc)	1.51
Optimum moisture content (%)	13.5
Unsoaked California bearing ratio (%)	8.1
Soaked California bearing ratio (%)	7.2

B. Test Programme:

In this study to investigate the effect of inclusion of waste tyre-tube chips on compaction and strength characteristics of locally available fine sand, standard Proctor test and unsoaked CBR tests were conducted for fine sand mixed with randomly distributed varying percentages and lengths of waste tyre-tube chips. All the tests were conducted as per relevant I.S. codal provision [1, 2].

III. Experiment and Result

Standard Proctor test and unsoaked CBR tests have been conducted in the laboratory as per I. S. Codal provision, for different series of fine sand- tyre tbe chips composite. The results of these tests are given in the table 2.

Table 2: Summary of Results of compaction and unsoaked CBR tests

Description of Mix	Width x length (mm)	MDD	OMC	Unsoaked CBR
Fine sand		1.510	13.5	8.2
Fine sand + 1% WTC	13 x 13	1.505	14	12.9
Fine sand + 3% WTC		1.496	14.6	13.9
Fine sand + 5% WTC		1.485	14.8	18.7
Fine sand + 7% WTC		1.478	15.3	21.7
Fine sand + 9% WTC		1.460	15.6	21.9
Fine sand + 10% WTC		1.452	15.9	21.6
Fine sand + 1% WTC	13 x 25	1.502	14.2	12.4
Fine sand + 3% WTC		1.493	14.7	13.5
Fine sand + 5% WTC		1.482	14.9	17.4
Fine sand + 7% WTC		1.474	15.5	20.3
Fine sand + 9% WTC		1.459	15.7	20.5
Fine sand + 10% WTC		1.451	16.2	19.9
Fine sand + 1% WTC	13 x 38	1.500	14.3	10.5
Fine sand + 3% WTC		1.491	14.8	11.4
Fine sand + 5% WTC		1.478	15.1	14.4
Fine sand + 7% WTC		1.470	15.7	17.3
Fine sand + 9% WTC		1.456	15.9	17.8
Fine sand + 10% WTC		1.447	16.3	17.4

3.1 Compaction characteristics:

The Standard Proctor tests were conducted as per IS 2720 (Part-VII) on fine sand- waste tyre-tube chips mix composites to determine the optimum moisture content (OMC) and maximum dry density (MDD). The fine sand is mixed with randomly distributed waste tyre-tube of varying percentages (1%, 3%, 5%, 7%, 9%, and 10%) and sizes (13mm x 13mm, 13mm x 25mm, and 13mm x 38mm) and standard proctor test were conducted on these mixtures. The OMC and MDD values obtained from the standard Proctor test are given in table 2 and variation of MDD and OMC with percentage of waste tyre tube chips are shown in fig. 3 and 4 respectively. From these figures, it can be observed that with the increase in percentage of waste tyre-tube chips, the MDD value of fine sand- waste tyre-tube chips mix composites decreases whereas OMC value increases significantly. The decrease in MDD is due to the light weight nature of crumb rubber in comparison with soil.

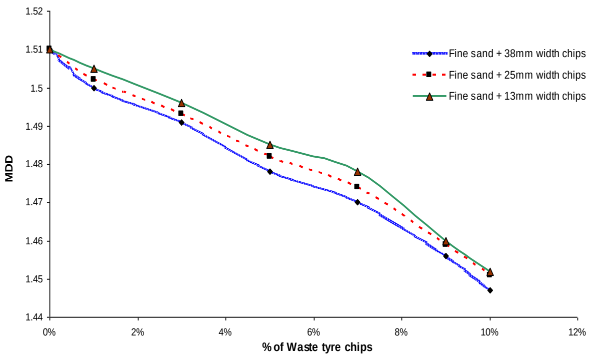

Fig. 3: Variation of MDD with % of tyre chips.

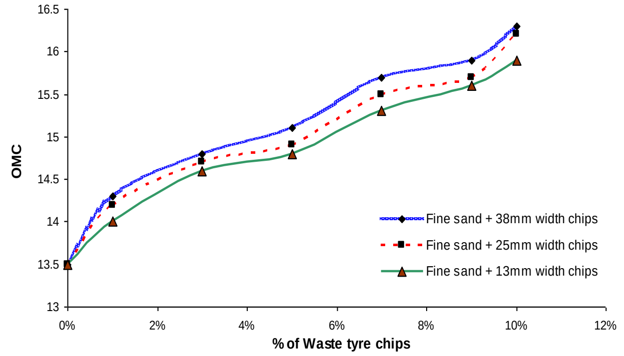

Fig. 4: Variation of OMC with % of tyre chips.

3.2 Strength characteristics:

Unsoaked CBR tests were conducted as per IS: 2720 (Part-X) on fine sand- waste tyre-tube chips mix composites to evaluate the strength characteristics of fine sand stabilized with waste tyre-tube chips. Randomly distributed waste tyre-tube of varying percentages (1%, 3%, 5%, 7%, 9%, and 10%) and sizes (13mm x 13mm, 13mm x 25mm, and 13mm x 38mm) were mixed with fine sand. The unsoaked CBR values obtained from the laboratory CBR test are given in table 2 and the variation of unsoaked CBR with percentage of tyre chips is shown in fig.5.

From the figure, it is observed that the CBR values of sand-tyre tube chips mix composite increases with increase of percentage of tyre tube chips and reaches a maximum value and after that it decreases slowly with further inclusion of waste tyre tube chips within the range of the testing programme. The maximum unsoaked CBR value of fine sand obtained from the laboratory test is 21.9% for addition of 9% waste tyre tube chips size of 13mm x 13mm.

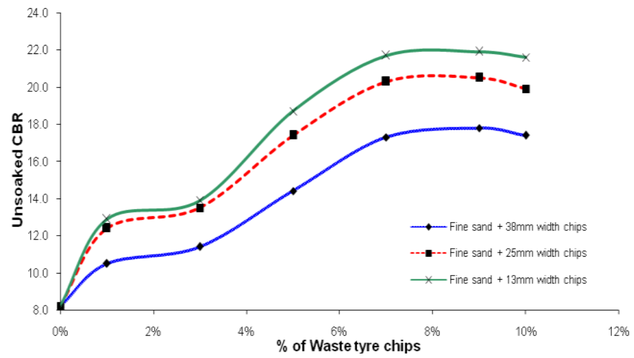

Fig. 5: Variation of unsoaked CBR with % of tyre chips.

IV. Conclusion

On the basis of the results of experimental investigation made above, following conclusions may be drawn.

1. It was observed that the maximum dry density decreased with the increase in percentage of waste tyre-tube chips. This is due to light weight nature of waste tyre-tube chips. On the otherhand, the optimum moisture content increased with the increase in percentage of waste tyre-tube chips.
2. There is a considerable increase in the unsoaked CBR value for fine sand due to mixing of randomly distributed waste tyre-tube chips. The maximum improvement in unsoaked CBR value is due to addition of waste tyre tube chips size of 13mm x 13mm. And optimum percentage of waste tyre tube chips is 9% of the dry weight of sand for all sizes of waste tyre tube chips used. Further the addition of waste tyre-tube chips to soils lead to a decrease in CBR values.

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