IJESRT: 7(12), December, 2018 ISSN: 2277-9655

International Journal of Engineering Sciences &Research Technology

(A Peer Reviewed Online Journal)
Impact Factor: 5.164

IJESRT

ISSN: 2277-9655
Impact Factor: 5.164
CODEN: IJESS7

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

STABILIZATION OF LATERITE SOIL WITH WASTE TIRE RUBBER

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DOI: 10.5281/zenodo.2294960

ABSTRACT
Solid waste management is one of the major environmental concerns worldwide. Waste tires are being produced and accumulated in large volumes. 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. The potential of using rubber from worn tires in many civil engineering works have been studied for more than 20 years. The Coastal regions in India the lateritic soil is available abundantly and several attempts were made to improve its strength. In this paper an attempt is made to use waste tyre rubber as stabilizing agent in rural road construction in combination with lateritic soil and also intended to find the properties such as density, shear properties and CBR, when lateritic soil is mixed with waste tyre rubber at different mix proportions (5%, 10%, 15% and 20%). Also to know the effect of size of rubber, two different sizes are considered and studied separately. The result have shown that the mix proportions of waste tyre rubber of size less than 2.36mm and in between 2.36 to 4.75mm gives good strength at 15% and 5% respectively.

KEYWORDS: Waste Tyre Rubber (WTR), Compaction test, CBR test, Shear test

1. INTRODUCTION
This study deals with stabilization of soil using granulated rubber sample of different size. Stabilization is the method employed for modifying the properties of soil to improve the civil engineering performance. The main objective is to increase the strength and to reduce the construction cost by using locally available materials such as municipal wastes; scrap tire is one of them. How much wastes scrap tires is produced in India is not known but 40 million vehicles are added in last two years (Chander, 2013).Scrap tyres can be used in several ways either as whole or halved or shredded. They can be used alone as well as embedded or mixed with soils. Geotechnical applications of shredded tyres include embankment fill, retaining wall and bridge abutment backfill, insulation layer to limit frost penetration, vibration damping layer and drainage layer (Das Tapas, 2012).Lateritic soil form a group comprising a wide variety of red, brown, and yellow, fine-grained residual soils of light texture as well as nodular gravels and cemented soils. They may vary from a loose material to a massive rock (Afeez, 2012).They are characterized by the presence of iron and aluminum oxides or hydroxides, particularly those of iron, which give the colors to the soils.

2. BACKGROUND
Stabilization is the method employed for modifying the properties of soil to improve the civil engineering performance. The main objective is to increase the strength and to reduce the construction cost by using locally available materials such as municipal wastes scrap tire is one of them. How much wastes scrap tires is produced in India is not known but one billion vehicles are present in the year 2011. Scrap tires can be used in many ways either as a whole or halved or shredded. They can be used alone, embedded or mixed with soil. Waste tires used in Geotechnical engineering include embankment constructions and subgrade constructions (Oikonomou and Mavridou 2006)

Both accumulation and disposition of wastes results into pollution. Leaching from scrap tires produce toxin and cannot be used underground water. Making use of scrap tires in construction works is not only a beneficial approach for reducing environmental pollution caused by this kind of waste, but also is economically efficient. Waste tires are light materials in road construction projects, fences behind the retaining walls, and thermal

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Impact Factor: 5.164
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insulator. There are advanced techniques that alter scrap tires to pieces with various shapes and sizes, such as tire chips, tire powder, shredded tire, tire crumb, tire buffing, and others (Oikonomou and Mavridou 2006) These materials have specific characteristics that enhance the quality of geotechnical projects. Their most noticeable characteristics are durability, strength, compaction and high frictional resistance.

3. OBJECTIVE OF THE STUDY

- To find the geotechnical properties of lateritic soil.
- To find the geotechnical properties of lateritic soil rubber mixture.
- To determine the optimum moisture content (OMC) and maximum dry density (MDD) for the various mixture.
- To determine the change in CBR and shear strength with addition of different percentages of waste tyre rubber (5%, 10%, 15% and 20%).

4. MATERIALS USED

Soil

Lateritic soils are highly weathered and altered residual soils formed by the in-situ weathering and decomposition of rocks in the tropical and sub-tropical regions with hot, humid climatic conditions. Their formation also consists of leaching out of free silica and bases and accumulation of oxides of iron, aluminum or both. This process is called laterization. Laterites are rich in sesquioxides (iron oxides, aluminum oxides or both) and low silicates but may contain appreciable amounts of kaolinite. Due to the presence of iron oxides lateritic soils are red in colour (Afeez 2012).

Waste Tyre Rubber Materials

Two sizes of waste tyre rubber materials were used in the experimental program.

- The granulated rubber sample with size 2.36-4.75mm.
- The granulated rubber sample size of < 2.36 mm.

5. METHODOLOGY

In this study an attempt is made to find best locally available materials which satisfy the strength criteria of subgrade soils. Following steps are followed during this study.

1 Collection of lateritic soil sample, waste tyre rubber.

2 To conduct following test laboratory tests for the soil sample collected

- Specific gravity test based on IS: 2720 (part 3)-1980.
- Grain size analysis based on IS: 2720 (part 4)-1985 to find the Particle size distribution.
- Atterberg's limit test based on IS: 2720 (part 5)-l 985.
- Standard Proctor tests to determine optimum moisture content and corresponding maximum dry density of the lateritic soil.
- Soaked and unsoaked CBR tests of the lateritic soil in the laboratory by compacting the samples in CBR mould at OMC and ODD.

3 To conduct tests on two different sizes of waste tyre rubber when added to the soil sample at 5%, 10%, 15% and 20% of the soil by weight.

6. RESULTS AND DISCUSSION

Specific Gravity

The IS: 2720 (Part III)-1980 deals with the method of test for determination of specific gravity of soils. Specific gravity tests were conducted for soil, rubber, soil-rubber mixture. The specific gravity of the soil was found to be 2.38 which are within the range for silts and silty soil according to ASTM. Specific gravity of waste tire rubber was found to be 1.15 and which is much more lower that of soil. The specific gravity results for soil and Lateritic soil rubber Mixture are presented in Table 1.

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Table 1: Specific Gravity of the Materials Tested

Materials	RC (%)	Specific gravity
Lateritic soil	0	2.38
<2.36mm size WTR	100	0.96
5% <2.36mm LSR	5	1.917
10% <2.36mm LSR	10	1.869
15% <2.36mm LSR	15	1.824
20% <2.36mm LSR	20	1.714
2.36-4.75mm WTR	100	1.150
3% 2.36-4.75mm LSR	3	2.100
5% 2.36-4.75mm LSR	5	2.060
10% 2.36-4.75mm LSR	10	1.931
15% 2.36-4.75mm LSR	15	1.861
20% 2.36-4.75mm LSR	20	1.818

Grain Size Distribution

Results of the particle size distribution as shown in Figure1indicates that the soil is well graded Gravel with component proportions of gravel, sand, silt and clay are 10, 53, and 38% respectively. The grain size distributions for the soil, Lateritic soil rubber mixtures and Waste tyre rubber materials are plotted in Figure 1.The waste tyre rubber grain size distribution curves show that most rubber particles are less than or equal to the materials nominal particle diameter. The Waste tyre rubber samples are fairly uniform. If the IS system were used, the granulated Waste tyre rubber products would classify as SP and the tire chip Waste tyre rubber products would classify as GP.

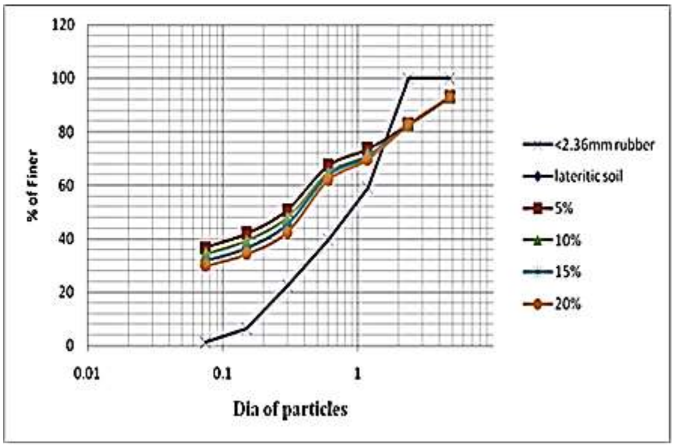


Figure 1: Grain size distribution of soil <2.36mm size, LSR Mixture and WTR.

The grain size distributions for the soil, Lateritic soil rubber mixtures and Waste Tyre Rubber materials are plotted in Figure 2. The Waste tyre rubber grain size distribution curves show that most rubber particles are less than or equal to the materials nominal particle diameter. The Waste Tyre Rubber samples are fairly uniform. If the IS system were used, the granulated Waste tyre rubber products would classify as SP and the tyre chip Waste tyre rubber products would classify as GP.

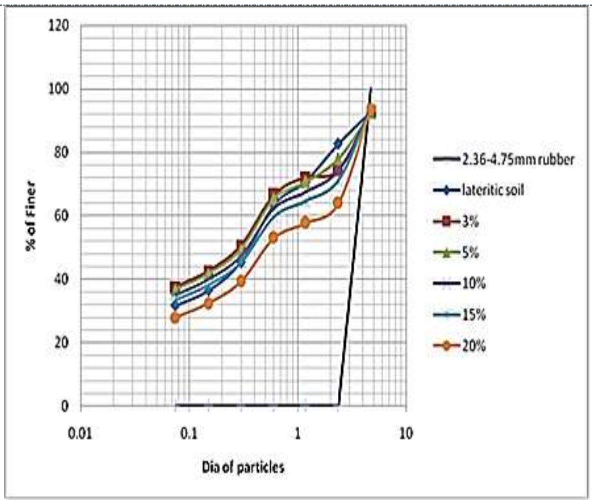
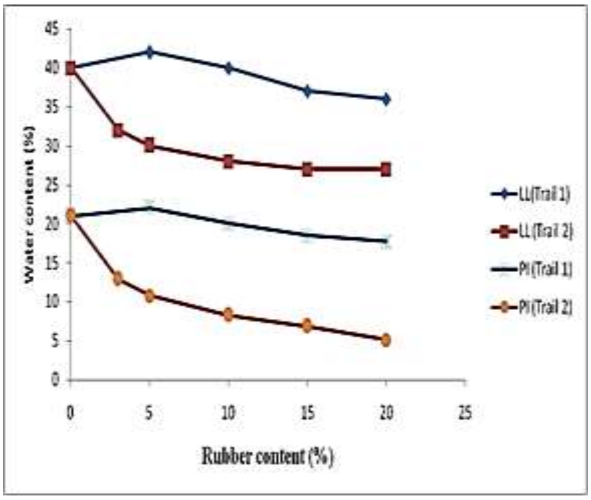


Figure 2: Grain size distribution of soil 2.36-4.75mm, LSR mixture and WTR.

Consistency Limits Test

Liquid limit and plastic limit tests are conducted on lateritic soil and laterite soil rubber mixture. The results of variation of plasticity index with stabilization effect are graphically represented in Figure 3.This shows that, the plasticity index of unstabilized lateritic soil is 21%. Then it gradually fluctuates with different percentage of stabilized mix, decreased considerably on stabilization with waste tyre rubber. It can be observed that variation of plasticity index with different percentage of waste tire rubber mixes reduces compared to stabilized soil. The addition of waste tyre rubber at 5% to 20% reduced the PI from 21% to the least value of 5.14% indicating the optimal mixture of WTR.



Trail 1: <2.36mm size LSR mixture,
Trail 2: 2.36-4.75mm size LSR mixture

Figure 3: Variation of consistency limit

Compaction Test

The test procedure for compaction test has been standardized by IS: 2720 (Part VII)-1983 (light compaction) and IS: 2720 (Part VIII)-1983 (heavy compaction). In this study light compaction test is adopted. Figure 4 shows that the variations of MDD in different percentage waste tire rubber content. The maximum dry density is achieved when <2.36 mm size rubber mixes at 15% and 2.36-4.75mm size rubber mix at 5%. It indicates that the large size of rubber mix at less proportional mix greater density is achieved.

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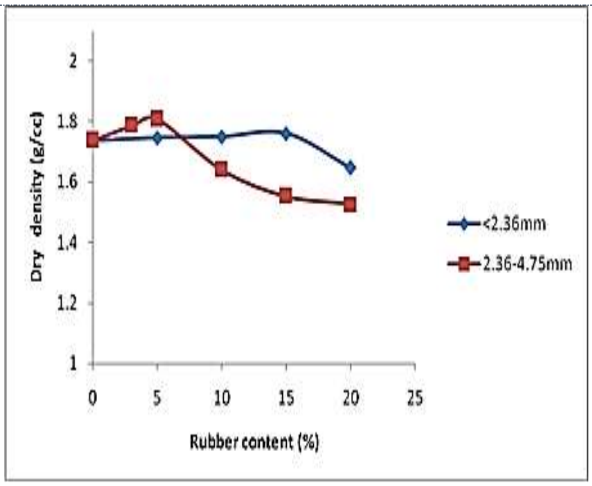

Figure 4: Variation of density with different sizes of rubber content

Shear Test

The values of cohesion (C) and internal friction angle (φ) for both soil and soil-rubber mixture obtained from tests are as shown in figure 5 and 6.The maximum cohesion is observed at 15% rubber content as 39kN/m2 for <2.36mm LSR mixture which is 1.5 times more than that of ordinary soil samples, and 30kN/m2 for 2.36-4.75mm LSR mixture which is 1.15 times more than that of ordinary soil samples. These results showed that rubber content have more effect on soils with low Plasticity Indexes as shown in Figure 3. The variation of internal friction angle with rubber content is illustrated in Fig.5 and 6.

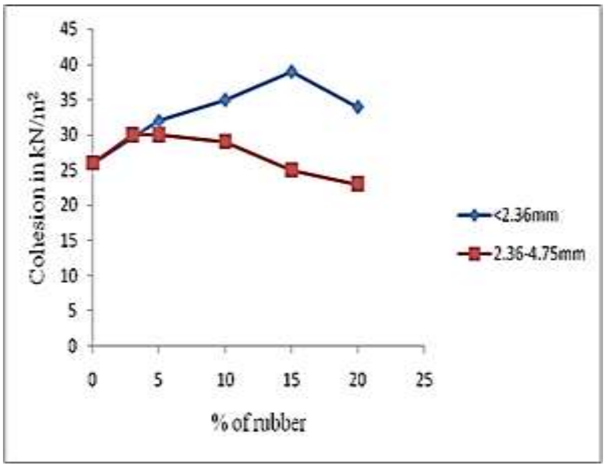

Figure 5: Variation of cohesion with waste tire rubber content

It is observed that the variation of internal friction angle with tire rubber contents is a non-liner variation. In this study the internal friction angle value of different reinforced samples increases, and these values for <2.36mm LSR mixtures ranged from 10° to 24°and also in 2.36-4.75mm LSR mixture ranged from 10° to 24°. This shows that the shear strength of LSR is greater than soil. Moreover, the shear strength increases when tire rubber are added to an optimum amount of 15% (<2.36mm) and 5% (2.36-4.75mm). Adding tire rubber more than this optimum amount, decreases the shear strength, especially at higher normal stresses.

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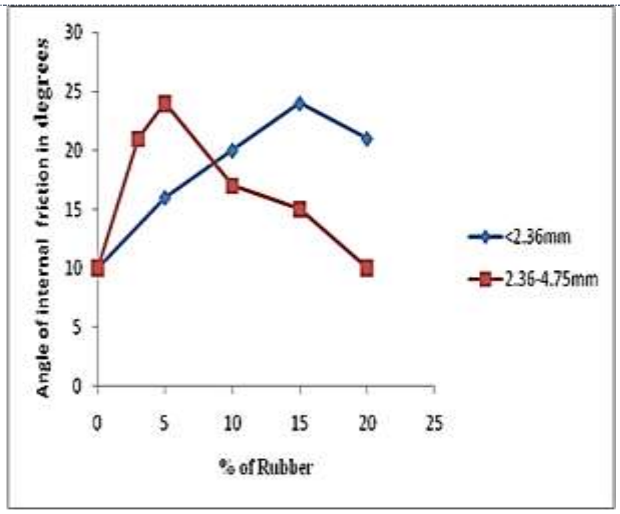

Figure 6: Variation of internal friction angle with waste tire rubber content

CBR Test

It is clear from Figure 7 that with the addition of WTR to lateritic soil, the CBR value of the soil increased from 4.80% at 0% stabilization to 7.10% at 15%(<2.36mm) and 9.44% at 5%(2.36-4.75mm) waste tyre rubber additive. It also can be observed that stabilization with different percentage waste tire rubber shows a gradual improvement in CBR values.

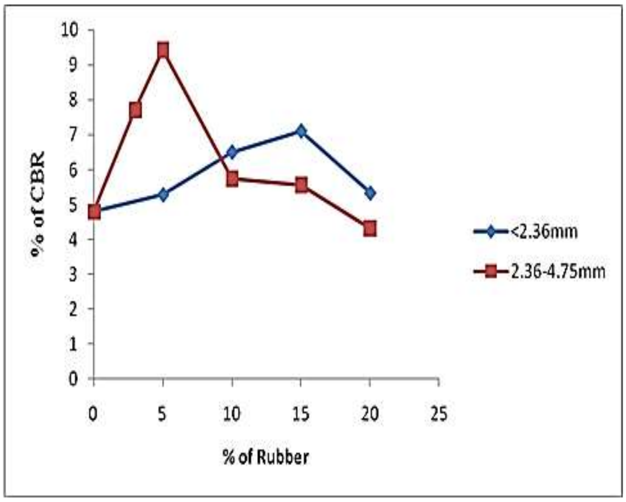

Figure 7:Variation of soaked CBR with different size tyre rubber

With the addition of WTR, the unsoaked CBR value of the soil increased from 7.40% at 0% stabilization to 11.97% at 15% and 14.28% at 15% waste tire rubber additive. California Bearing Ratio test results for 5%, 10%, 15%, and 20% WTR stabilized lateritic soil are 10.53%, 10.97%, 11.97%, 8.83% another size rubber CBR of different percentages are 11.57%, 14.28%, 7.60%, 6.28%, 5.30% respectively as shown in Figure 7. It can be observed that stabilization with different percentage WTR shows a gradual improvement in CBR values. This shows that load bearing capacity of the soil increased with the stabilization mix.

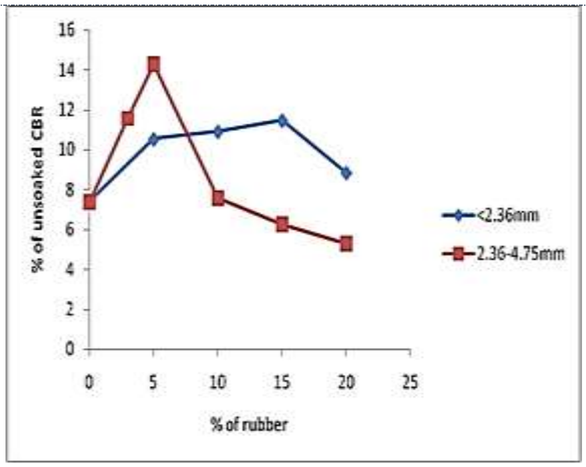

Figure 8: Variation of Unsoaked CBR with different size tyre rubber

7. CONCLUSION

- Percentage of increase in addition of waste tyre rubber to the soil sample causes decreases in liquid limit and plasticity index.
- The OMC value of the lateritic soil decreased from 20% to 18.90% and ODD improved from 1.73g/cc to 1.80g/cc due to stabilization of WTR at 5% of size 2.36-4.75mm. Similarly, for the WTR mixed with lateritic soil at 15% of size <2.36mm decreased considerably from 20% to 13.50% and ODD moderately increased from 1.73g/cc to 1.76g/cc.
- Shear resistance increases with the presence of WTR mix. The rubber content up to 15% of size <2.36mm is increases the internal friction angle 100 to 240 and increases the cohesion from 26kn/m2 to 39 kn/m2. Similarly on increases the rubber content up to 5% of size 2.36-4.75mm increases the internal friction angle from 100 to 240 and increases the cohesion from 26kn/m2 to 30kN/m2.
- Inclusion of WTR into the lateritic soil increases the CBR, addition of WTR up to 15% of <2.36mm size to the lateritic soil shows the improvement in soaked CBR from 4.8% to 7.10% and Unsoaked CBR from 7.4% to 11.47%. Similarly, waste tyre rubber of size 2.36-4.75mm shows improvement in soaked CBR from 4.80% to 9.44% and unsoaked CBR from 7.40% to 14.28% at 5% of WTR.

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CITE AN ARTICLE

Akshatha, B. A., Jain, A., & Ahmed, Z. (2018). STABILIZATION OF LATERITE SOIL WITH WASTE TIRE RUBBER. *INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY*,*7*(12), 181-187.