Soil Reinforcement with Waste Tire Chips

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Abstract- The volume of waste tires is normally generated in every society, which directly impact on the environment and causing serious problems. One of the possible alternatives for this waste tires are to use in geotechnical engineering applications. To this aim, this paper presents the results of laboratory study on the effect of tire chips on the properties of two different types of soils (clay and sand). Unconfined compressive test, swell consolidation test and CBR test were carried out with different percentages of tire chips (0%, 5%, 10%, 15%, 20%)and clay admixture whereas unconsolidated untrained triaxial test were conducted on sand-tire chips admixture having 0%, 5%, 7%, 9%, 13%, 16% of tire chips. These tests were employed to investigate the effect of strength parameters such as secant modulus, ultimate yield stress and strain and optimum percentage of tire chips for clay and sandy soil. In all cases, by adding tire chips in sand up to 13% increased shear strength, stiffness and energy absorption capacity whereas 15% chip contents was optimum to reinforce the clayey soil.

Indexed Terms- triaxial test, unconfined test, CBR test, consolidation test. Performed for clay- tire chips mixture. This study

I. INTRODUCTION

Over billions scrap tires are generated annually in all over the world and it poses serious health, fire hazards and environmental problems. Scrap tires does not decompose therefore, reuse of scrap tires has been paid attention in civil engineering applications. Many economically, environmentally feasible alternatives have been investigated for recycling of scrap tires. Reinforced earth techniques has been gaining popularity in the field of civil engineering due to its highly versatile and flexible nature. For instance waste tires are cut into tire chips, reinforce with soil and increases the shear strength of soil. This reinforced soil can be used in the construction of earth dams, foundation bed, retaining walls, construction of pavements and other applications. Most important property due to which waste tires used in civil engineering applications is that tire chips/ shreds are non-biodegradable, durable, light weight, and high strength material. In the investigation of suitability of soil tire chips mixture for geotechnical applications a shear strength of such mixtures seems to be their most important mechanical property. Many research work has been carried out to understand the strength characteristics of soil- tire chips/ shreds mixtures by means of laboratory experiments: direct shear test, triaxial test and unconfined compressive tests. Objective of the present study is to obtain the applicability of tire chips to modify the geotechnical properties of soil. This can be obtained by various laboratory test such as triaxial test for sand- tire chips mixture whereas unconfined compressive test, CBR, consistency limits and consolidation tests were also focused on the mechanical behaviour of soil tire chips mixture particularly on the evaluation of the optimum percentage of tire chips, influence of confining pressure and normal stress.

II. EXPERIMENTAL PROGRAM AND METHODOLOGY

- Materials

Two types of soil sample (sandy and clay soil) were used during experimental study. According to Indian Standard Classification system sand and clay was used, figure 1 shows the grain size distribution curve of sand, clay and tire chips. Sand showed coefficient of uniformity Cu and coefficient of curvature Cc as 1.5 and 1.04 respectively. Table 1 shows the Index properties of soils and tire chips. Atterberg's limit were evaluated for clay soil in which liquid limit and plastic limit of clay soil was 72 % and 35% respectively. Scrap tire obtained from the vehicles were used in this study. Tires were prepared with special machinery where scrap tires were crushed into pieces having average size of 5.5 mm. Tire chips having specific gravity of 1.05, unit weight of 6.42 kN/m^3 and uniformity coefficient and curvature coefficient obtained from particle size distribution curve was 2.22 and 0.67respectively.

Table 1.Index property of Sand and Clay

S.No.	Property	Sand	Clay
1	Specific Gravity	2.65	2.1
2	Maximum Dry density	15.5	14.8
3	Optimum Moisture Content	13.5	24

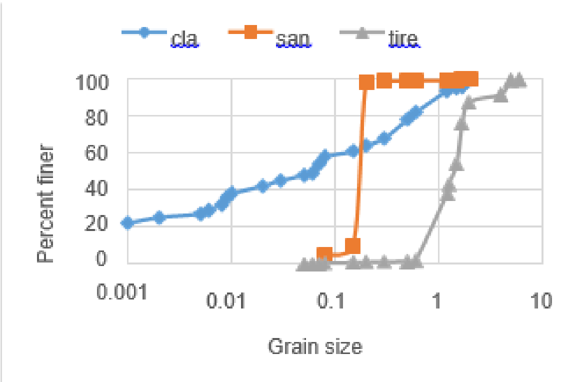

Figure 1. Particle size distribution curve of soils and tire chips

Sample preparation were done by mixing the different percentage of tire chips (by weight) in soil and compacted with standard compaction methods. Laboratory experiments were done at optimum water content and studied the shear characteristics of soil.

III. TESTING APPARATUS AND EXPERIMENTAL PROCEDURES

- Triaxial Test

Strength characteristics of sand- tire chips mixture were studied on triaxial compression test apparatus and procedure of testing was according to IS: 2720 (part XI-1971). Unconsolidated undrained test was carried out for sample size of about 37.5 mm in diameter by 75mm in height for confining pressure of 20,50, 100 kN/m^2. Proving ring reading are generally taken corresponding to axial strains until failure or 20%strain.

- CBR test

CBR test were conducted in the laboratory as per IS: 2720 (part VI, 1979) for all samples of clay- tire chip mixture. The required percentage of waste tire chips by dry weight of clay soil was mixed uniformly with required water content corresponding to optimum water content and compacted to maximum dry density. CBR test penetrate the specimen in the mould at the rate of 1.25 mm per minute and load required for a penetration of 2.5 mm was determined.

2.2.5 Unconfined Test

Unconfined compressive test as per IS 2720 (part X, 1973) were conducted on cohesive soil- tire chip mixture to determine the unconfined compressive strength and found the optimum percentage of tire chips to stabilize the cohesive soil. Prepare the sample by mixing tire chip content at different percentage (0%, 5%, 10%, 15%, and 20%) with clay. Test were conducted on optimum moisture content and maximum dry density.

- Consolidation test

The consolidation characteristics of clay-tirechips mixture were required to predict the magnitude and the rate of settlement. Compression index and coefficient of consolidation were obtained from consolido meter having 50mm in diameter and 20mm thick as per IS 2720 (part XV-1986). Take initial dial gauge reading and apply an initial load and allow till there was no change in dial gauge reading. Increase the load up to the desired pressure and record the dial gauge reading. After load increment, decrease the load to 1/4 of the last load and record dial gauge reading. Compression index, swelling potential and swelling pressure was determined.

IV. RESULTS AND DISCUSSION

Shear strength characteristics of sandy soil reinforce with tire chips were evaluated through unconsolidated undrained triaxial test having various percentages of tire chips (0%,5%, 7%,9%,13%, and 16%) by weight. Stress-strain curve from triaxial test are shown in figure 2 for all six percentages of tire chips and confining pressure of 100 kN/m^2. It can be noticed from figure 2 that by increasing the percentage of tire chips upto 13% in sand, deviator stress were increased but the deviator stress was lowered by increasing the percentage of tire chips more than 13 %. Figure 3 and 4 shows the results of deviator stress and ultimate deviator stress for different percentage of tire chips at different confining pressure. Results obtained from these test showed that deviator stress and ultimate deviator stress increases upto 13% and after increasing percentage of tire chips value of stresses decreased.

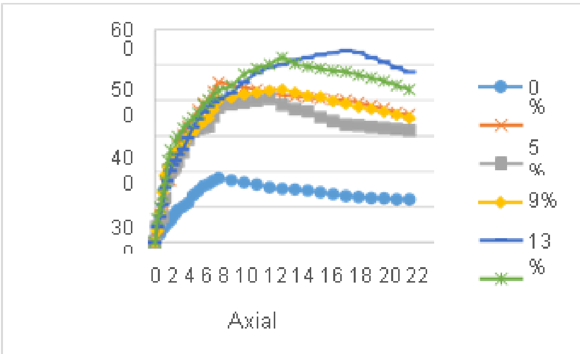

Figure 2: Stress-Strain curve for confining pressure of 100 kN/m^2 for different percentage of tire chips

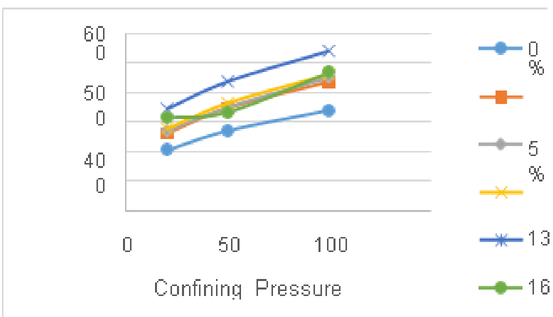

Figure3: Effect of tire chips on deviator stress at failure for different composition

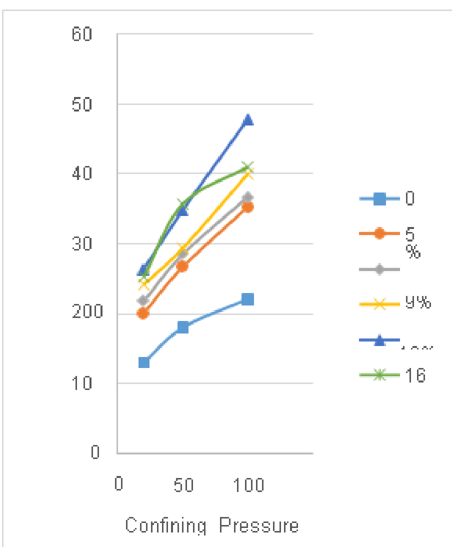

Figure 4: Effect of tire chips on ultimate deviator stress at failure for different composition

California bearing ratio is expressed as a percentage of the actual load causing the penetrations of 2.5 mm to the standard loads. CBR test was done on various percentage of tire chips mixed in clay soil at optimum moisture content and maximum dry density as shown in figure 8. Results obtained from CBR tests that by increasing the percentage of tire chips in clay soil CBR value decreases. From compaction and CBR tests it was observed that as the amount of tire mixed in clay increases, the contact between the clay particles reduce, and the behaviour of the specimen was controlled by mixing tirechips.

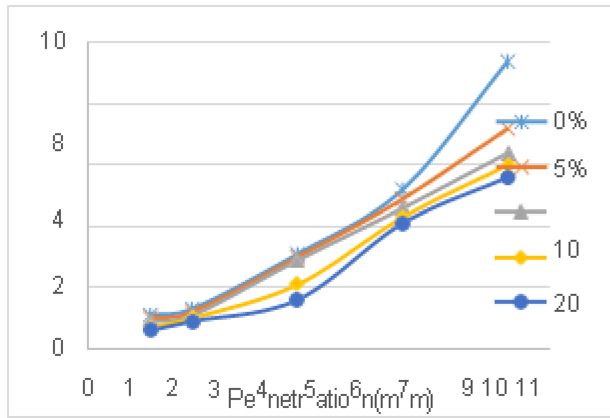

Figure 8: Load -Penetration curve of clay-tire chip admixtures in CBRtest

Unconfined compressive tests were conducted on clay-tire chips mixture prepared at an optimum moisture content and maximum dry density obtained corresponding to that particular clay-tire chip mixture. Clay soil was mixed with tire chips of 0%, 5%, 10%, 15% and 20% by weight of soil and unconfined compressive test were conducted on these mixtures. The stress-strain curve obtained from the unconfined compressive test was shown in figure 10 for different percentage of tire chips in clay soil. From the figure it reveals that as the percentage of tire chips increases greater strength was obtained up to 15% of tire chips after that strength was reduced.

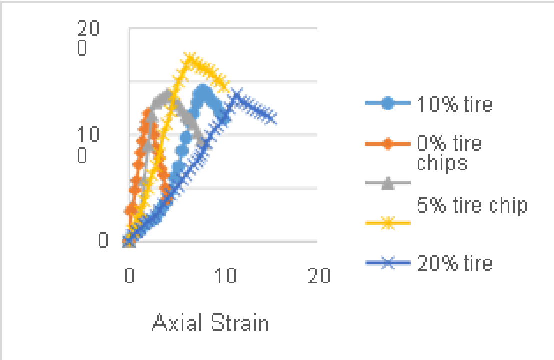

Figure 10: Unconfined compressive test result for clay tire chips admixture

Consolidation test was performed on all compacted mixture of tire chips and clay. Dial gauge reading were taken at different interval and calculate the change in void ratio. Swelling potential was obtained from the ratio of increase in thickness of sample to the initial thickness whereas swelling pressure were determined as pressure corresponding to the initial void ratio. Figure 11shows that swelling pressure decreases by increasing the tire chip content in clay soil whereas Figure 12 shows that, swell potential was also decreased by increasing the tire chip content. An additional test to find out compression index and recompression index were also obtained from consolidometer for composite samples.

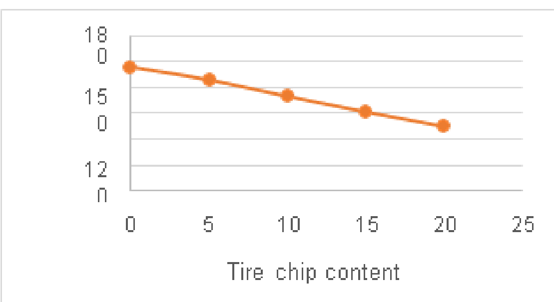

Figure 11: Effect of clay tire admixture on Swell Pressure

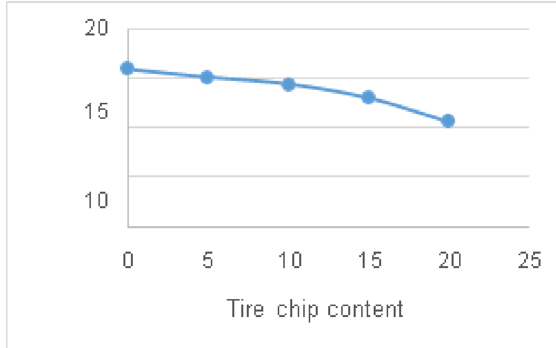

Figure 12: Effect of clay tire admixture on Swell Potential

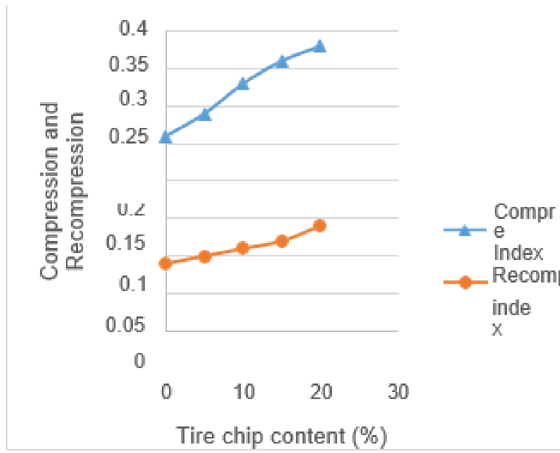

Figure13: Effect of clay tire admixture on Compression and Recompression index

ratio on a semi log graph whereas recompression index is the slope of the void ratio versus log p during unloading condition. Figure 13 shows the values of compression and recompression index for different sample and found that indexes was increased by increasing the tire content in clay soil.

CONCLUSION

The present study evaluate the optimum mixing of tire chips in soil (sand and clay) tire chip mixture through laboratory investigations. Evaluation of experimental results obtained that shear strength characteristics, energy absorption and brittleness index of sand tire chip mixture were influenced by percentage of tire chips, normal stress and confining pressure and addition of tire chips to sand upto 13 % resulted in significantly increased shear strength, energy absorption and stiffness. This optimum mixture will provide better compressibility and high load carrying capacity and results light weight material in comparison to sand alone. Unconfined compressive test results showed that tire chips upto 15% in clay-tire chips mixtures can result in greater strength and improved ductility. Compression and recompression index also increases with tire chips percentage. Value of CBR reduces by increasing the percentage of tire chips and increases the compressibility. Mixing of 15% tire chips in clay soil reduces the swelling potential upto 25% and swelling pressure upto65%.

Therefore results shows that compressibility of clay-tire chip mixture was significant and should be accounted for in the design of earthworks and other engineering applications.

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