

Model Tests on Use of Tyre Chips and Fly Ash Chips as a Replacement of Aggregate in Stone Columns

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Keywords: Tyre Chips, Fly Ash Brick Chips, Aggregates, Soft Clay, Stone Columns, Load Carrying Capacity, Settlements, Comparison

Abstract. In order to reduce the generated waste in industry the concept of reusability is adopted as an application in the civil engineering field. In this study, the experiments were performed by using shredded tyre chips, chips of fly ash bricks in partial replacement with aggregates passing through 12.5 mm sieve and retaining on 10 mm sieve (IS-Indian standard). The experiments with partial replacement of stone columns were carried out at various proportions of tyre chips and fly ash brick chips in soft clay. Corresponding settlement rate was noted by loading the stone column gradually through a hydraulic jack for various L/D ratios. On comparison the final results it was concluded that the stone column with replacement of 75% tyre chips and 25% coarse aggregate proved good to carry maximum load and with lower settlement rate than ordinary stone column without replacement.

Introduction

Tyre chips are one of the major wastes generated from the industries now-a-days which alarms to environmental pollution. As major environmental threat is caused by Land filling and burning of tyres, researches are being undergoing to use the tyre chips in effective manner. From survey of the tyres that were scrapped, 43% were burnt as tire-derived fuel, with cement manufacturing the largest user, in another 25% were used to make ground rubber, 8% were used in civil engineering projects, 17% were disposed of in landfills and 8% had other uses. In geotechnical engineering perspective the waste tyre chips [1] has low density, high strength, low thermal conductivity, durability, resilience, high frictional strength and hydrophobic nature.

Reviews about the use of scrap tyres, shredded tyres as a soil mixtures and various evaluation of chemical compositions, sorption capacity, environmental sustainability and reusability of waste tyres in geotechnics has been viewed [2]. When coarse aggregate is partially replaced with waste tyre chips and fly ash chips it helps to improve the strength parameter like load bearing capacity and reduce the settlement characteristics of the Clay soil [3].



Soil sample collection and tests

Soil sample for test is collected from Vellode of erode district. The sample is then distorted to certain range from its solidity and the basic tests were carried out in laboratory. Sieve analysis is done for the collected sample for gradation of the soil and it is classified as fine grained soil of size less than .002mm which belongs to Clay type soil[4].

Characteristics of materials used

Clayey soil

For the study, the soil is taken as Soft Clay. The various index properties of Soft clay such as moisture content, liquid limit, plasticity [5], specific gravity, density and engineering properties such as compressibility, consolidation [6] was carried out in the laboratory as per the procedures recommended by Indian Standards (IS) Codes. The properties of Soft clay is studied [7] and values are showed in the table 1.

Table 1. Properties of Soil

Property of soil	Vellode clay soil
Soil Classification	CI
Specific Gravity	2.5
Liquid Limit (%)	37
Plastic Limit (%)	16
Plastic Index (%)	21

Tyre chips

Radial tyre is used for taking the tyre chips for the experiments shown in Figure1. The scaling Factor used in test is 1/10 .Tyre chips which passes through 12.5 mm sieve and retains on 10mm sieve as per IS codes was taken [8].The properties of Tyre chips is showed in the table 2. Various tests for tyre chips has been carried in laboratory such as water absorption, tensile strength, compression and Specific gravity. For carrying the test with soft clay, various comparative study has been made through the existing researches and experiments [9].Thus the usage of tyre chips not only reduces the waste but it also helps in saving the natural resources, energy and to increase the stability of soft soil[1].



Figure 1. Tyrechips

Table 2. Tyre chips properties

Specific Gravity of tyre chips	1.14%
Water absorption of tyre chips	4%

Coarse aggregate

As the comparison is made with tyre chips and fly ash brick chips the similar size is taken for the coarse aggregate also. The coarse aggregate of size passing through 12.5 mm sieve and retains on 10mm sieve was taken [4]. Flakiness and Elongation properties of coarse aggregates were found. The properties of coarse aggregate [10] is showed in the table 3.

Table 3. Coarse aggregate properties

Specific gravity of coarse aggregate	2.6
Water absorption of coarse aggregate	2.5%
Crushing value of aggregate	12.18

Fly ash brick chips

Fly ash brick chips of size passing through 12.5 mm sieve and which retains on 10mm sieve was taken as an alternate replacement material for coarse aggregate [5]. Basic tests for Fly ash brick chips are carried out at Laboratory [10] and material sizes are shown in table 4.

Table 4. Sizes of materials used

Materials	Size (mm)
Coarse aggregate	10
Tyre chips	10
Fly Ash Brick chips	10
Clay Soil	4.25

Test setup

The Cylinder tank made of cast iron having height of 410 mm was used. It is shown in figure 2 and mould dimensions are shown in table 5 .The wall thickness of the tank was 3mm and diameter of the tank is 250mm.The scaling factor used in test model was 1/10.The diameter of the stone column is 45 mm with the height of 270mm placed at the center of the tank corresponding to L/D ratio(Length of the column to diameter of the column equal to 6).The load was given through the proving ring at a constant rate of 25mm/min vertically over the stone column by placing a circular disc over the column for uniform distribution of load.

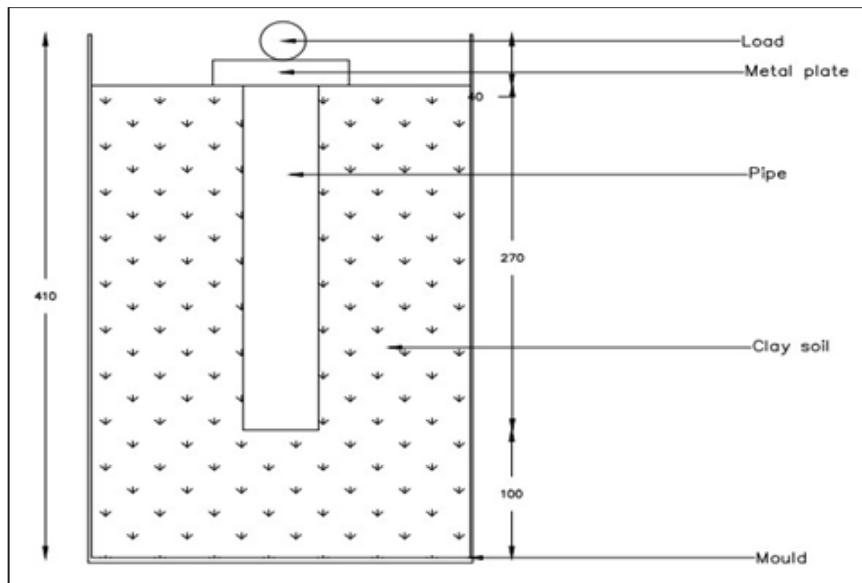


Figure 2. Mould

Table 5. Mould dimensions

Mould Dimensions in mm	
Height	410
Inner diameter of mould	250
Outer diameter of mould	256
Thickness of mould	3
Material of mould	Cast iron

Formation of clay bed

The empty tank is first filled by grease around the inner wall in order to reduce the friction between the clay and cylinder. The water content of soft clay is maintained properly and periodical test was carried.

The soft clay is placed as layers in tank [11] and compacted manually by hands to ensure the even spread of soil inside the tank without Air traps. The clay is filled up to certain height in the tank.

Formation of stone column

The centre of the tank is marked in proper position so that Load can be distributed uniformly. The column is designed in such a way that it can reused. The material used for the pipe column is Polyvinyl chloride (PVC) of diameter 45mm and thickness of 3mm diameter.

The PVC pipe is applied by greases on both sides for friction purpose. At base 100 mm is filled with clay. Then the PVC Pipe column is placed at the centre and tyre chips are placed layer by layer with well compaction with great care to ensure proper compaction [12].

The pipe is fully filled and surrounded with clay uniformly up to height of 270 mm and the pipe was slowly taken out at each layer when outside clay soil is filled uniformly and its behavior is

notes [13]. This procedure is carried out for other proportions of tyre chips, fly ash aggregates and coarse aggregates [14].

Procedure for Testing

The apparatus is placed on the testing machine for testing. The Load is given at center of the column. The L/D ratio considered for the test is 6.

The load was given and respective settlement values are noted[3] shown in figure 3.



Figure 3. A shows the loading of clay soil through hydraulic jack with constantly increasing loading.

Result and discussion

The behavior of Tyre chips, Stone Aggregate and Fly ash brick chips are compared and shown in following bar chart .From the chart it is noted that the load settlement behavior of the proportion is not in linear form. All the test were carried out at carried the same compacted density of 5-7 KN/m³ .The graph of all proportions shows various rates of settlement with respect to load. The proportions are made in order to reuse the waste materials in construction field. As a result of using coarse aggregate as a column filler it gives raise in cost which does not leads to efficiency.

The graph shows the settlement rate of each proportion. It helps to compare the proportions for better usage in construction. On comparison 50% proportions shows good capacity of load bearing. But on specific 75% coarse and 25% tyre chips shows high load bearing capacity along with cost efficiency which make the soft clay more stable than other composition. It is noted that the mechanical properties of coarse and tyre chips with proper proportion shows a better bearing capacity of load as they could withstand for higher load. The crushing properties of coarse and tyre seems to hold good for the soft clay soil.80% of combinations of Coarse Aggregate (80%) with Fly Ash brick chips (20 %) shows that the proportion could hold load better but not as of 75% proportion.

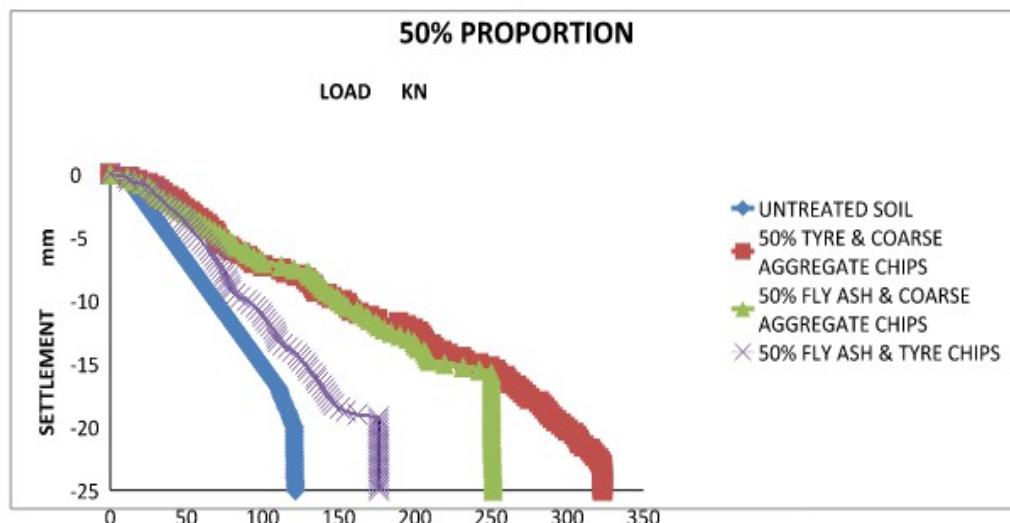


Figure 4. Load vs Settlement for 50% proportion

The above figure 4 shows the various combinations of 50% proportions such as 50%tyre chips and coarse aggregate, 50%fly ash and coarse aggregate, 50% fly ash and tyre chips. The graph gives a clear view of comparison between three proportions with untreated soil with respect to load and settlement. It shows the load increment given to the column and respective settlement rate of the proportion.

From the graph it is inferred that the rate of settlement of coarse aggregate with fly ash proportion withstand high load than fly ash with coarse aggregate proportion. The untreated soil has lesser strength to bear the load given to it due to its nature. The proportion of fly ash and tyre chips fails sooner than other proportion since the fly ash initially crushes faster than coarse aggregate. Along with tyre chips, fly ash combination shows greater settlement at initial stage itself.

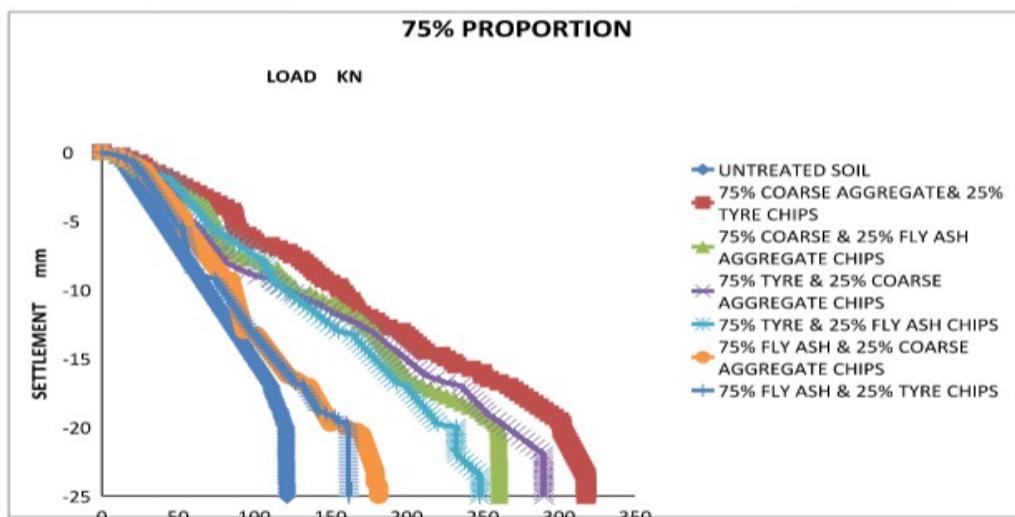


Figure 5. Load vs Settlement for 75% proportion

The figure 5 shows the various combinations of 75% proportions such as Tyre chips (75%) with Coarse Aggregate (25 %), Coarse Aggregate (25%) with Fly Ash brick chips (75 %), Aggregate

(75%) with Fly Ash brick chips (25 %), Tyre chips (25%) with Fly Ash brick chips (75 %), Tyre chips (75%) with Fly Ash brick chips (25 %) and Tyre chips (25%) with Coarse Aggregate (75 %).

The graph gives a clear view of comparison between three proportions with untreated soil .It shows the load increment given to the column and respective settlement rate of the proportion. From the graph it is inferred that the rate of settlement of coarse aggregate with tyre chips proportion withstand high load than other proportions. The untreated soil fails soon as it could not carry load further.

From this it is noted that the mechanical properties of coarse and tyre chips with proper proportion shows a better bearing capacity of load as they could withstand for higher load. The crushing properties of the coarse and tyre seems to hold good for the test shown in figure 6.

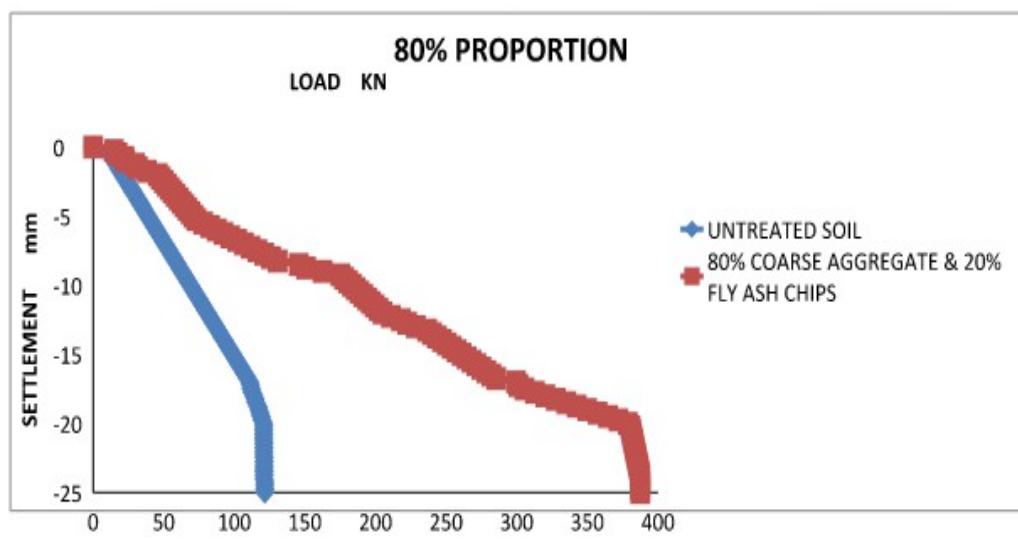


Figure 6. Load vs Settlement for 80 % proportion

The graph shows the combinations of 80% of combinations of Coarse Aggregate (80%) with Fly Ash brick chips (20 %).The graph gives a clear view of comparison between three proportions with untreated soil and the proportion. It shows the load increment given to the column and respective settlement rate of the proportion.

From the graph it is inferred that the rate of settlement of coarse aggregate and fly ash chips is higher than the untreated soil loading capacity shown in figure 6. The untreated soil fails since the soil has lesser strength to bear the load given to it due to its nature.

The figure 7 shows the combinations of 100% proportions such as 100% tyre chips, 100% coarse aggregate, 100% fly ash chips. The graph gives a comparison between three proportions with untreated soil .It shows the load increment given to the column and respective settlement rate of the proportion. From the graph it is inferred that 100% coarse aggregate carries approximately 420 KN load than other proportion. When untreated soil is loaded it gets settled at minimum load due to its property. Next to coarse aggregate, the tyre chips of considered size prove to hold good to withstand load up to certain level.

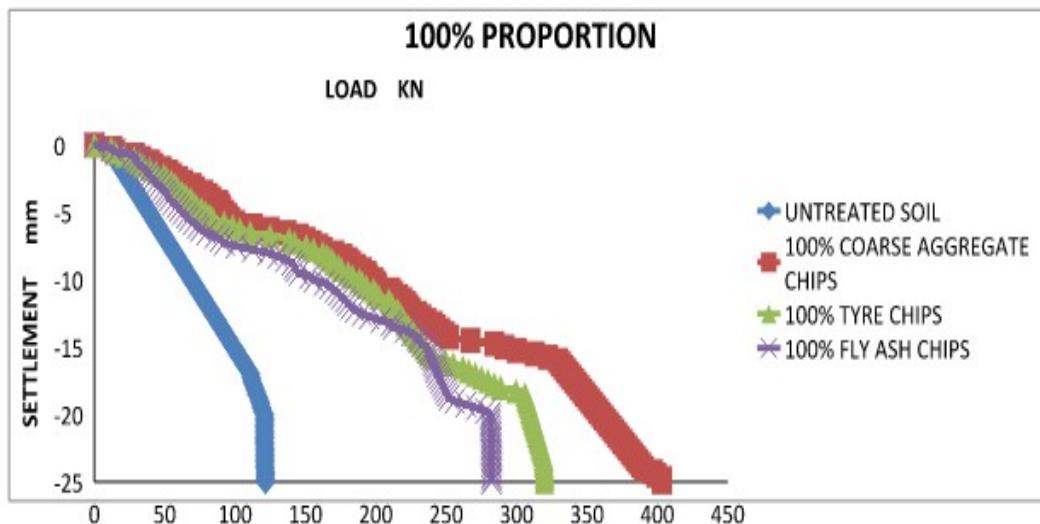


Figure 7. Load vs Settlement for 100 % Proportion

Conclusion

From overall Model test it is observed and noted that the combination 75% tyre chips and 25% coarse aggregate when compared with other combination such as 50% tyre chips and 50% coarse aggregate, 75 % coarse aggregate and 25% tyre chips, 100% tyre chips, 100% coarse aggregate chips, 100 % fly ash brick chips shows a better result and Load Carrying Capacity with lesser settlement rate. From the inferred result, replacement of stone aggregate with specific range will reduce the construction cost and can enhance the strength and settlement capacity of the column [15]. Thus usage of tyre chips does not affect the quality of groundwater and pollute the environment. It can be a better way to reduce the waste material. The graph and the settlements values are based on the test carried out in the laboratory with the objective of reusability of waste materials in construction practice.

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