Kochi Chapter

Indian Geotechnical Conference
IGC 2022
15th – 17th December, 2022, Kochi

Behaviour of Foundation resting on Soft Clay SubgradeShredded Tire Mixture Using Physical Model Tests

Bikash Kumar Sah[1, 2], Shiv Shankar Kumar[3] and A. Murali Krishna[4]

[1]Research Scholar, Department of Civil Engineering, National Institute of Technology Patna, Bihar – 800005
[2]Assistant Professor, Department of Civil Engineering, Bhagalpur College of Engineering Bhagalpur, Bihar – 813210
[3]Assistant Professor, Department of Civil Engineering, National Institute of Technology Patna, Bihar – 800005
[4]Professor, Department of Civil and Environmental Engineering, Indian Institute of Technology Tirupati, Andhra Pradesh – 517506
[1]bikashs.phd22.ce@nitp.ac.in, [2]bikashkrsah11bce@gmail.com, [3]k.shiv.ce@nitp.ac.in, [4]amk@iittp.ac.in

Abstract. This study presents the improvement of soft clay subgrade utilizing shred tire-sand layer of varying thickness. A series of physical model tests were conducted on different foundation layers consisting of shred tire-sand layers of varying thickness. The foundation layers were made up of the shredded tire-sand mattress overlying soft clay bed. The tests were performed at 80% relative density of sand soil with different percentage mixtures of tyre shreds. The thickness of the sand-tire mixes layer was varied from 0.5D to 1.5D. The bearing capacity of soil was found to be increased by 2.8 times and 1.5 times for the height of shredded tire-sand layer h = 1.5D and h = 0.5D, respectively. Moreover, it was also observed that the settlement of footing decrease with the addiion of reinforcement.

Keywords: Bearing capacity, Tyre Shred, Soft soil, Foundation, Model Test.

1 Introduction

Due to the rapid urbanization in the country and the scarcity of the land for the construction of any types of structures, the geotechnical engineers are often using weak or soft soils for the structural construction, which is really a challenging task for geotechnical engineers. Therefore, looking the safety of the structures, engineers are improving the bearing capacity of weak or soft soils using different stabilizing techniques such as chemical or admixtures like: lime, cement, ground granulated blast furnace slag (GGBS), fly ash (FA), and bottom ash (BA). However, using lime and cement raise environmental concerns and are not preferred nowadays. Recently, several researchers have used an environmental-friendly binder or materials to stabilize the soil (Latifi et al. 2017b; Latifi and Meehan 2017; Rashid et al. 2017; Singh and

Kumar, 2021; Kumar and Shankar, 2022). The implications of several reinforcing techniques as well as reinforcing materials such as geotextiles, geogrid, geonets, geocomposites and geocells have also been used to improve the bearing capacity of weak and soft soils. Cai et al. (2006) have studied the effect of polypropylene fibre and lime admixture on engineering properties of clayey soil. Yoon et al. (2004) have used a single layer of waste tyre mats, in sandy soil to improve the bearing capacity and it was found that the bearing capacity increased whereas, the settlement is decreased by 50%. Further, the application of tire chips towards the improvement of

bearing capacity of soft soils has also been reported by Tafreshi and Norouzi (2012).It was reported that the mixture works better, when a dirt cap layer was on the top of soil in such a way that the tire chip content and reinforcement depth should be 5% by volume and 0.25B, respectively. Anvari and Shooshpasha (2016) have used granulated rubber with soil and reported that the performance was best at the tyre content of 10% by weight when the reinforcement depth and width was 1B and 5B, respectively. Further, Gill et al. (2021) have performed a model test with tyre chips and copper slag and, it was found that the addition of waste tyre chips enhanced the bearing capacity of copper slag. According to earlier studies, it has been observed that the majority of examinations using reinforcements have only taken into the account of soft/loose soils, which is highly variable in actual scenario. Further, to improve the bearing ca- pacity, several studies have been reported about the use of rubber tyre. The shredded tyre is mixed with sand, considering a different way of soil reinforcement to improve the bearing capacity. With the addition of tyre shred the unit weight of mixed material decreased and the behaviour reinforced-sand mixture changes from brittle to ductile. This ductility of sand-tire shred mixture could be advantageous for seismic isolation layer beneath the foundation of any structure. The structural response can be reduced by 40-60% in terms of acceleration and inter layer displacement. Reddy et al. (2016) have also reported that the addition of tire chips in between 30% to 40% by weight significantly enhance the shear strength of sand. Most of the aforementioned studies reported about the improvement of soft soil layer using shredded tyre chips however, the studies on the improvement of soft clay bed using sand-tyre shredded mattress over the soft clay bed are very scanty. Therefore, this study examines the behaviour of a sand-tyre shredded mattress resting on a soft clay bed and to measure its impact on the bearing capacity and settlement of footing.

2 Material Characterization

2.1 Clay and Sand

In this study, clayey soil, collected from IIT Guwahati Campus (near the proposed hostel building), was used to prepare the soft clay. The specific gravity of clay soil (G_c) was found to be 2.63 whereas, the Liquids Limit (LL), Plastic Limit (Wp) and Plasticity Index (PI) was found to be 39%, 19% and 20%, respectively. According to USCS (Soil Classification System), the soil is reported as CI (clay with medium plasticity).

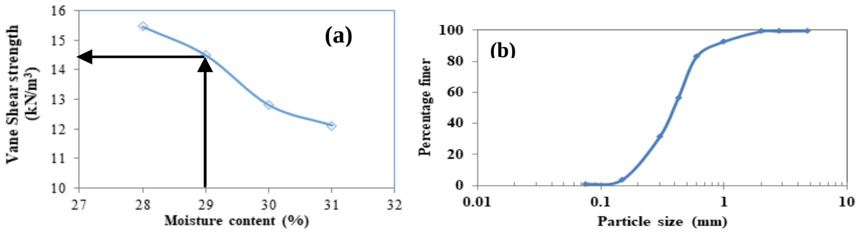

Fig. 1. (a) Variation of shear strength of soil with different moisture content **(b)** particle size

distribution of both clayey and sandy soil

Further, for the consideration of soft soil in this study, the undrained shear strength (S_u) of disturbed soil samples was estimated using vane shear tests. The undrained shear strength (S_u) of the soft clay bed was found to be 14.5 kN/m^2, at the moisture content of 29% (as shown in Fig. 1), which was finally used to prepare the soft soil bed. Further, to prepare the sand layer above the soft clay bed, locally available river sand of a specific gravity (G_s) = 2.67 was used. The maximum and minimum dry density of sand was found to be 17.15 kN/m^3 and 14.47 kN/m^3, respectively. The coefficient of uniformity (C_u) and the coefficient of curvature (C_c) were found to be

2.48 and 1.05, respectively. According to USCS soil classification system, sand is reported as poorly graded sand (SP). To prepare the sand mattress over the clay bed, the relative density (D_r) of 80% for sand was fixed. The angle of internal friction of sand was found to be 39.01^o, at D_r = 80%, using direct shear tests whereas, the same has been found to be nearly 34^o based on the triaxil tests, which reflects that the response of soil depends on the testing methodology.

Table 1. Material Properties

Materials	Properties	Values
Clay	Specific gravity (G_c)	2.63
	Liquid limit (%)	39
	Plastic limit (%)	19
	Plasticity Index (%)	20
	Soil classification (USCS)	CI
Sand	Specific Gravity (G_s)	2.67
	D10 (mm)	0.19
	D30 (mm)	0.30
	D60 (mm)	0.46
	Coefficient of uniformity, C_u	2.48
	Coefficient of curvature, C_c	1.05
	Soil classification (USCS)	SP
	Maximum dry density, γ_{dmax} (kN/m^3)	17.15
	Minimum dry density, γ_{dmin} (kN/m^3)	14.47
	Internal friction angle ϕ (^{o}) by direct shear test	39.01
	Internal friction angle ϕ (^{o}) by triaxial test	34.00
Tyre Shred	Apparent Size (mm)	11 × 12
	Maximum dry density, γ_{dmax} (kN/m^3)	6.4
	Minimum dry density, γ_{dmin} (kN/m^3)	5.3
	Maximum void ratio	0.64
	Minimum void ratio	0.96
	Specific gravity (G_{ts})	1.089

2.2 Tyre Shred

The shred tire, a lightweight material, was obtained from commercial scrap tire supplier has also been used in this study. The size of the tire shred was 11 mm×12 mm, considering the aspect ratio is equal to 1 (A_r = shred length / width). The thickness of shredded tire was 6-7 mm. The water absorption capacity of shredded tire was ranging from 1% to 2.5% (Ahmed, 1993). A photograph of the shredded tires used in this study has been presented in Fig. 2a. The maximum dry density, γ_{dmax} and minimum dry density, γ_{dmin} of tyre shred was found to be 6.40 kN/m^3 and 5.30 kN/m^3, respectively.

2.3 Sand-Tyre shred Mixture

The sand-tyre mattress was prepared, with different percentage of tyre shred mix with sand by mass, over the soft clay bed. Initially the mass of the sand-tyre mixtures is calculated for the known volume of the specimen by evaluating the weight of sand and tyre shred. The sand tire mattress was prepared manually (shown in Fig. 2b) by mixing the different percentage of tire shred: 0%, 2.5%, 5% and 7.5% with sand. Further, it was found that the unit weight of soil-tyre shred mix decreases as the shredding/soil ratio increases. The properties of sand tyre mixture are presented Table 2.

Fig. 2. (a) Shredded tyre of 11×12 mm size **(b)** sand-tyre shred mixture

Table 2. Properties of the sand tire shred mixtures

% Tyre shred	Specific gravity (G_{ts})	Maximum unit weight (kN/m^3)	Minimum unit weight (kN/m^3)	Maximum Void ratio (e_{max})	Minimum Void ratio (e_{min})	Internal friction angle, ϕ(^{o}) Triaxial Test	Internal friction angle, ϕ(^{o}) Direct shear test
0	2.670	17.15	14.47	0.83	0.544	34.00	39.01
2.5	2.581	16.59	14.02	0.84	0.555	37.07	41.02
5	2.519	16.36	13.92	0.809	0.536	38.97	41.99
7.5	2.494	16.04	13.68	0.82	0.554	40.15	43.23

3 Methodology

3.1 Experimental Set up

The model tests were carried out in a steel tank of inner dimensions 1m×1m×1m and, the soft soil foundation bed for model study was prepared in the test tank. The circular footing of diameter (D) 150 mm and thickness 18mm was used. The footing was kept at the centre of the tank for all tests. A manually operated hydraulic jack, loading capacity of 100kN, was used for applying load on the footing. Model tests were conducted on sand bed overlying clay subgrade with and without reinforcement. The surface deformations were measured with the help of dial gauge ((Dg) placed at a distance 0.5D, 1D, 2D, 3D from the centre of footing (shown in Fig. 3a). Dial gauge readings were taken for every 1.0mm settlement of the footing. The strain rate of 2mm/min was used for loading. The bottom surface of footing was kept rough. The prepared soil sample was filled in the tank and levelled it. The footing was placed ona predetermined alignment such that the load from the loading jack would be trans- ferred concentrically to the footing. A spherical hole was made into the footing plateat its centre to accommodate a small steel ball through which vertical loads was trans- ferred uniformly to the footing. The footing is pushed into the soil as per the given strain rate of 2 mm/min. The load transferred to the footing has measured through a pre-calibrated proving ring placed between the ball bearing and the loading jack. The footing settlement was measured through two dial gauges (Dg4 and Dg5) as shown in Fig 3b, placed on either side of the centre line of the footing. The deformation (heave/settlement), of the soil surface on either side of the footing are also measured by dial gauges (Dg1, Dg2, Dg3, Dg6, Dg7 and Dg8) as shown in Fig. 3b. A small plate of perspex sheet (20 mm length × 20mm width × 4mm thickness) has been placed on thesoil surface at required locations where surface deformations are to be measured. At the centre of the top surface of these plates a small spherical hole was made at which the dial gauge spindle rest. The movement of these surface plates recorded through the dial gauges, which later can be reported in the form of heave/ deformation of the soil surface. The footing settlement and the surface deformation data reported, in this study, are the average values of the readings taken at the two different points. In the absence of a clear-cut failure, the load has been applied until a footing settlement of around 40mm is reached.

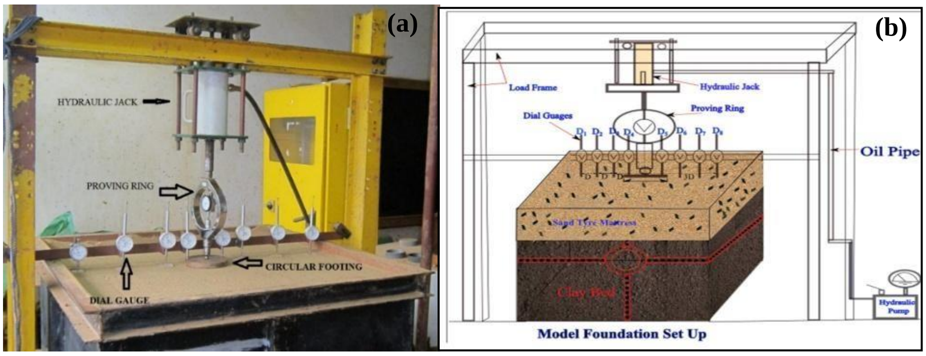

Fig. 3. (a) Photographic view and (b) Schematic view of physical model set up

3.2 Preparation of Shredded Tyre-sand Mattress Overlying the Soft Clay Bed

Figure 4a presents the geometry of shredded tyre–sand mattress overlying the soft clay foundation bed. The photographic view of the same has also been presented in Fig. 4b. For this study, the experiments were planned in a systematic manner to high-light the advantages of the use of shredded tire as reinforcement with sand. To prepare the soft clay bed, the predetermined amount of water was mixed with pulverized soil. After mixing the soil with water, it is kept in air tight container for one week to achieve uniform moisture distribution with in soil sample. The amount of soil needed for a height of 50mm was determined before placing the soil in to the tank. The com-paction energy require for the preparation of 50mm soil bed was also estimated before placing the soil into the tank. After placing the soil in to tank, it is levelled. Compaction has done by allowing free fall the hammer from a predetermined height and number of blows. For uniform compaction, plywood was placed on the surface bed. Further, a series of tests have been performed to determine the drop height and the number of hammer blows required to reach the desired density. In order to verify the uniformity of the test bed, undisturbed samples were collected from different locations of test bed and vane shear test [IS 2720 Part 30-1980] was conducted to determine the in-situ unit weight (γ), moisture content (w) and undrained shear strength (S_u) of the clay soil. The shear strength value at the tested locations in the test tank was almost identical. Figure 4b also reflects the prepared clay bed for the testing.

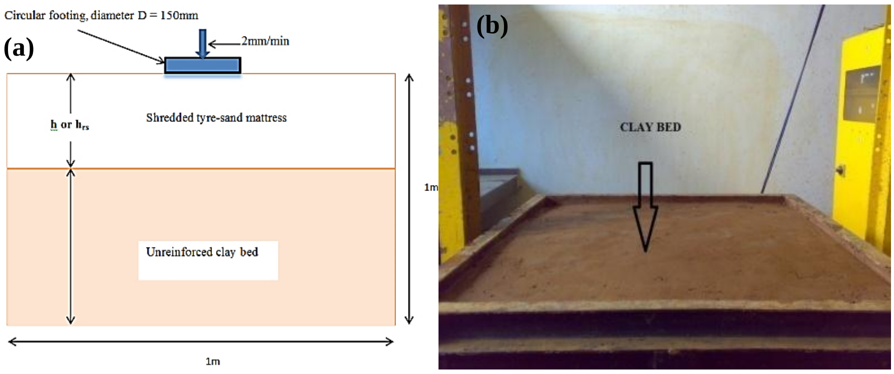

Fig. 4. (a) Geometry of the shredded tyre-sand mattress overlying soft clay bed (b) Photograph of the prepared soft clay bed

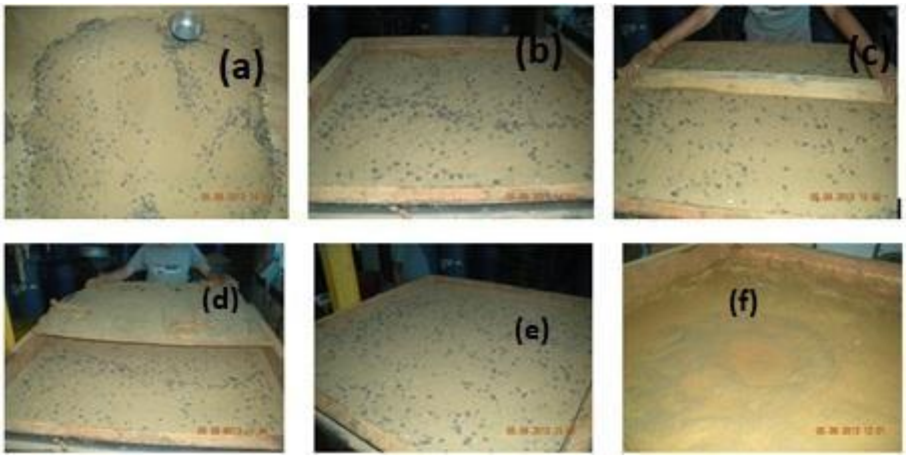

Fig. 5. (a-f) Preparation of shredded tyre-sand mattress overlying soft clay foundation bed

Figure 5 (a-f) presents the preparation of shredded tyre-sand mattress overlying soft clay bed in the steel tank based on the pre-determined volume. Figure 5(f) indicates the response of sand-tyre mixture overlaying the soft clay bed after the loading. The height of free fall compaction technique has been used to prepare the reinforced / unreinforced sand bed over the soft clay subgrade. The compaction energy for different sand layer overlying the clay bed has prior determined. A plain plywood has been placed over the surface of the bed for achieving uniform compaction. A series of trial tests were conducted to fix the height of fall and no of blows of the drop hammer required to achieving the desired density. A process of laying the shredded tyre mattress overlying soft clay foundation bed is shown in Fig 5. The various parameter used in this experimental program such as size of the shredded tyre, relative density of infill sand (D_r), height of tyre-sand mattress (h) and diameter of circular footing (D) has been investigated.

4 Results and Discussion

A series of 32 model plate load tests, includes few repetitive tests, with circular plate of diameter 150 mm were performed. A brief description of test series and investigating parameters are presented in Table 3. The response of the foundation bed of test series A1-A5 has been recorded in terms of bearing pressure–settlement. Further, the results the response of footing were reported in terms of the variations in improvement factor (I_f) and surface settlement/heave with footing Settlement S/D (%) as well as the ultimate bearing pressure with different compositions of shredded tyre-sand mixture.

Table 3. List of the test series and parameters

Series	Soil and Reinforced soil	Details of investigating parameters	
		Constant parameters	Variable parameters
A1	Unreinforced clay	C_u =14.5 kN/m^2	-
A2	Sand overlying soft clay foundation bed	C_u =14.5 kN/m^2 D_r =80%	h/D = 0.5, 1, 1.5
A3	2.5% tyre shred mix with sand overlying soft clay foundation bed	C_u = 14.5 kN/m^2 D_r =80%	h/D = 0.5, 1, 1.5
A4	5% tyre shred mix with sand overlying clay subgrade	C_u =14.5 kN/m^2 D_r =80%	h/D = 0.5, 1, 1.5
A5	7.5% tyre shred mix with sand overlying clay subgrade	C_u =14.5 kN/m^2 D_r =80%	h/D = 0.5, 1, 1.5

To study the response of shredded tyre-sand mattress of varying thickness over the soft clayey foundation bed, the bearing pressure–settlement curve of circular plate load tests is plotted. The behavior of sand with or without shredded tyre (at different % of tyre) are investigated in series (A1-A5), while the undrain shear strength (C_u) of soft clay was kept nearly 14.5 kN/m^2. The response of bearing pressure and improvement factor of unreinforced soil and reinforced soil are presented in Fig. 6. The variations of shredded tyre-sand mattress with different percentage of shredded tyre of layer h/D = 0.5 over the soft clay is shown in Fig 6. The responses of bearing pressure vs footing settlement presented in Fig. 6a shows the non-linear increment with footing settlement for both with and without reinforcement. From Fig. 6a, it can be observed that the bearing pressure of soft clay bed is approximately 69 kN/m^2 whereas, the bearing capacity of sand at D_r = 80% along with the soft clay bed of thickness h = 0.5D is 82 kN/m^2. It can be stated that the bearing pressure of sand overlying the soft clay bed has been increased by 1.19 times for footing settlement, S/D =16%.

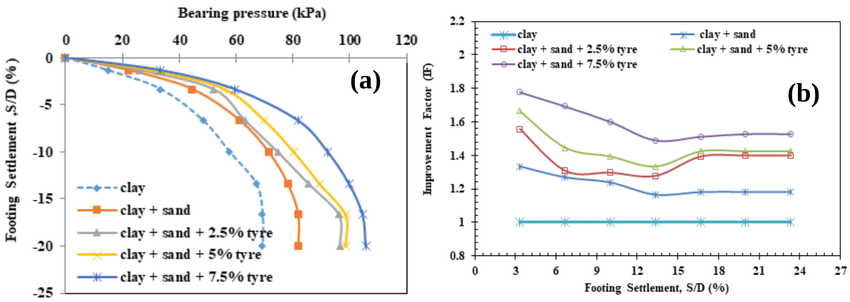

Fig. 6. (a) Variations of bearing pressure and (b) improvement factor of sand layer with or without different percentage tyre shred for the test Series A4-A6, h=0.5D

Further, the bearing capacity of reinforced soil (i.e., sand mixed with shredded tyre chips of 2.5%, 5.0% and 7.5%) over the soft clay bed of thickness h = 0.5D was estimated. The bearing capacity of reinforced soil over the soft clay (h = 0.5D) was found to be 96 kN/m^2, 98 kN/m^2 and 106 kN/m^2, which is approximately 1.39, 1.42 and 1.53 times higher than the bearing capacity of soft clay bed at S/D =16%. Summary of results in terms of bearing capacity improvement factor, at different percentage of shredded tyre chips (i.e., 2.5%, 5.0% and 7.5%), for influence of tyre sand mattress overlying the soft clay subgrade for h = 0.5D, are mentioned in Table 4.

Table 4. Summary of results in terms of bearing capacity improvement factor for influence of tyre sand mattress overlying clay subgrade, h = 0.5D

Soft clay parameter	**Reinforced sand parameter**	**S/D (%)**					
		3.33	**6.67**	**10**	**13.3**	**16.67**	**20**
		Improvement Factor (IF)					
C_u = 14.5 kN/m^2, D_r = 80%	Sand + 0% tyre shred	1.33	1.26	1.23	1.16	1.18	1.18
	Sand + 2.5 % tyre shred	1.55	1.30	1.29	1.27	1.39	1.39
	Sand + 5 % tyre shred	1.66	1.44	1.39	1.33	1.42	1.42
	Sand + 7.5 % tyre shred	1.77	1.69	1.60	1.48	1.51	1.52

It was also observed that the inclusion of shredded tyre beyond 7.5% with sand exhibited higher settlement as well as constrained modulus (low stiffness) during loading. However, increase in shredded tyre percentage beyond 7.5% with sand, causes very minimal increase in bearing capacity in comparison to the bearing capacity of tyre shred (upto 7.5%) mix with sand overlying soft clay bed, which can be neglected. It can also be seen from Table 4 that with the increase in footing penetration (s), the sand layer continues to deform which is mainly responsible for the reduction in the performance improvement factor (IF). Improvement factor is the ratio of footing pressure (q_s) with sand layer over-lying clay subgrade at a given settlement to the corresponding footing pressure (q_o) with soft clay subgrade alone. It can be observed that

IF decreases with increasing the settlement upto 16% of the footing diameter beyond which it remains almost constant as shown in Fig. 6 and, the same has been reported in Table 4.

4.1 Influence of height (h) of reinforced sand overlying soft clay bed

Figures 7(a) and 7(b) present the variations of bearing pressure as well as improvement factor along with the settlement responses of sand bed overlying the soft clay bed for D_r = 80% of sand and different thickness (*h*) soft clay bed. Provision of sand cushion is found to have improved the load carrying capacity of the soft clay bed soil. The dense sand owing to its compact nature tends to restrict footing penetration. When thickness of sand layer is adequate enough to stand against breakage, it facilitates formation of general shear mode of slip plane. In cases of sand layer of 80% relative density and higher thickness the pressure-settlement response shows a gradual increase in bearing pressure with footing settlement (upto 15%) which is typical of punching shear behaviour.

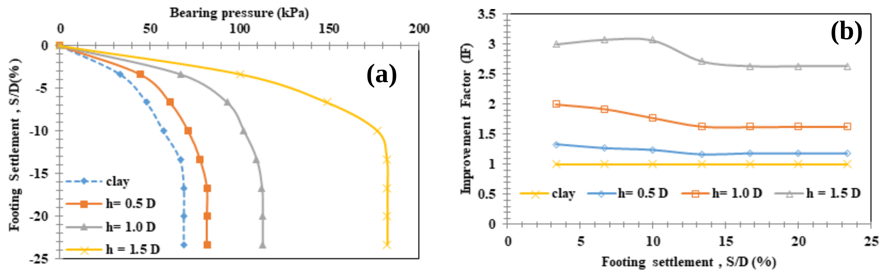

Fig. 7. Variations of (a) bearing pressure response and (b) improvement factor for different height of sand layer

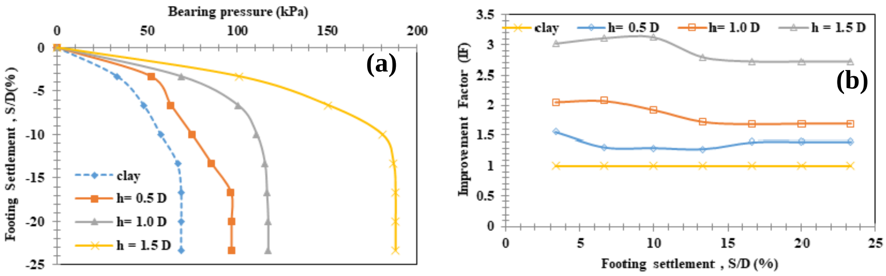

Fig. 8. Variations in (a) bearing pressure and (b) improvement factor for different height of sand-tyre shred mixture at 2.5% of shred tyre

From Figs. 8 (a), 9 (a), 10 (a), it is observed that mixing of different percentage of tyre shred with sand overlying soft bed increases the bearing pressure of unreinforced sand by significantly manner. It is also observed that after mixing of 7.5% tyre shred with sand there is small change in increase in bearing pressure which is negligible. Again, it is observed that bearing capacity increases with the increase of footing settlement S/D (%) upto 16% for different tyre shred sand mattress (*h*) which is varies from 0.5D to 1.5D and after that there is no more significant variation of bearing pressure (kPa).

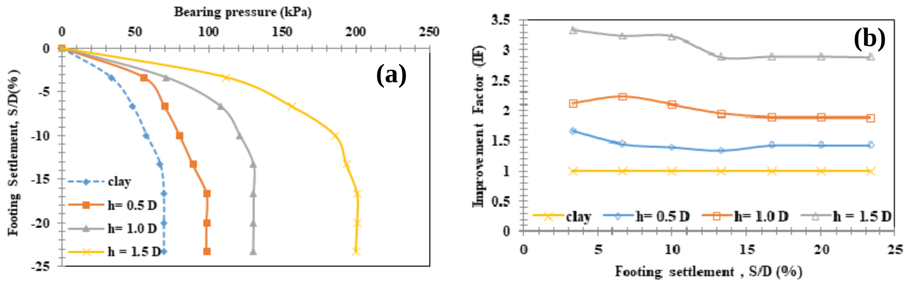

Fig. 9. Variations in (a) bearing pressure and (b) improvement factor for different height of sand-tyre shred mixture at 5% of shred tyre

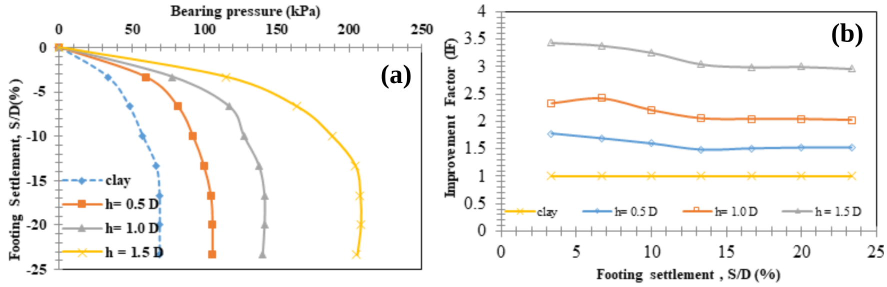

Fig. 10. Variations in (a) bearing pressure and (b) improvement factor for different height of sand-tyre shred mixture at 7.5% of shred tyre

Table 5. Summary of results in terms of bearing capacity improvement factor for influence of different height of reinforcement sand with percentage of tyre shred overlying soft clay bed

Soft clay parameter	**Reinforced sand parameter**	**Thickness**	**S/D (%)**					
			3.33	**6.67**	**10**	**13.3**	**16.67**	**20**
			Improvement Factor (IF)					
S_u = 14.5 kPa, D_r = 80%	Sand + 0% tyre shred	h=0.5D	1.33	1.26	1.23	1.18	1.18	1.18
		h=1.0D	2.00	1.92	1.77	1.63	1.62	1.62
		h=1.5D	2.99	3.07	3.06	2.71	2.63	2.63
S_u = 14.5 kPa, D_r = 80%	Sand + 2.5% tyre shred	h=0.5D	1.55	1.30	1.29	1.27	1.39	1.39
		h=1.0D	2.05	2.07	1.92	1.72	1.68	1.69
		h=1.5D	3.02	3.11	3.12	2.78	2.71	2.71
S_u = 14.5 kPa, D_r = 80%	Sand + 5% tyre shred	h=0.5D	1.66	1.44	1.39	1.33	1.42	1.42
		h=1.0D	2.11	2.23	2.09	1.94	1.88	1.88
		h=1.5D	3.33	3.23	3.22	2.88	2.90	2.88
S_u = 14.5 kPa, D_r = 80%	Sand + 7.5% tyre shred	h=0.5D	1.77	1.69	1.6	1.48	1.51	1.52
		h=1.0D	2.33	2.42	2.2	2.05	2.04	2.04
		h=1.5D	3.43	3.38	3.25	3.04	2.99	3.00

From Figs. 8 (b), 9 (b), 10 (b), it can be observed with the increase in footing settlement, the improvement factor initially starts to reduce and then after Footing settlement at 15% it remains constant for overlying sand and sand tyre mattress layer with different thickness. Further it is also seen that, in case of sand and sand tyre mattress layer with lower thickness overlying Soft clay bed, the improvement factor mostly remains unchanged. It is observed that Improvement factor for only sand mattress overlying soft clay bed for different thickness, h=0.5D, h=1.0D and h=1.5D is 1.18, 1.62 and 2.63, respectively. Following the same process for different mixture of tyre shred with sand with percentage from 0 % to 7.5%, observed improvement factor is shown in Table 5. It is observed that for h = 0.5D, h = 1.0D and h= 1.5D sand thickness with 7.5% tyre shred, ultimate bearing capacity of foundation system increases to 1.5 times, 2.0 times and 2.8 times, respectively.

5 Conclusion

Laboratory model tests have been carried out to investigate the load carrying capacity of foundations in different configurations with soft clay (S_u = 14.5 kPa), sand (D_r =80%) and sand tyre shred mixture. The thickness (*h*) of the sand layer varied from 0.5*D* to 1.5*D*. Circular footing of diameter 150mm and thickness 18mm is used in these investigations. The results of the experimental study showed that the sand tyre shred mattress of different thickness 0.5*D* to 1.5*D*, improved the bearing capacity of soft clay bed significantly and also reduced the settlement. The major findings of this experimental investigation are as follows:

1. Heaving near the footing was found to be decreased whereas, the bearing pressure of soft clay was found to be increased with the addition of shredded tyre with sand. Therefore, it can be stated that the decreased unit weight of tyre-chips might be the reason for lowered settlement and the increased stiffness of sand layer might be responsible for increased bearing capacity.
2. Bearing pressure of soft clay was found to be increased with the varying thickness (h) of reinforced sand (i.e., shredded tyre with sand) overlying soft clay bed. Further, it was also found that the footing settlement decreased with addition of tyre shred sand mixture overlying soft clay bed.
3. The ultimate bearing capacity of soft clay foundation system has been increased up to 1.5 times, 2.0 times and 2.8 times for the reinforced sand thickness (h) = 0.5D, 1.0D and 1.5D with 7.5% tyre shred, respectively. Further, the addition of shredded tyre (i.e., more than 7.5%) with sand, corresponding to the reinforced sand mattress thickness (h)=1.5D, reflects the improvement of bearing capacity of soft clay bed was insignificant.

Acknowledgements

The authors are very thankful to the institute “Indian Institute of Technology Guwahati, Assam”, for providing the facilities to conduct the experiments and their kind support during this study.

References

1. Alamshahi, S. and Hataf, N. (2009). "Bearing capacity of strip footing on sand slopes reinforced with geogrid and grid anchor". Geotextiles and Geomembranes, 27(3), 217-226.
2. Binquet, J. and Lee, K.L. (1975) "Bearing capacity tests on reinforced earth slabs. Journal of Geotechnical Engineering Division", ASCE, 101(12), 1241-1255.
3. Dewaikar, D.M, Gupta, K.G. and Chore, H.S., (2011), "An experimental study into behaviour of circular footing on reinforced soil", Proceeding of the international conference on Advanced science, Engineering and Information Technology 2011.
4. Latha, G. M (2009), "Bearing capacity of square footings on geosynthetics reinforced sand," Geotextile and Geomembranes, 27, 281-291.
5. Hanna, A.M & Meyerhof G.G. (1979), "Ultimate Bearing capacity of Foundation on a Three- Layer soil, with Special Reference to Layered Sand," Canadian Geotechnical Journal, vol. 16, n.2, pp. 412-414.
6. Hanna, A.M (1981), "Bearing capacity of Foundation on a Weak Layer overlying a Strong Deposit." Canadian Geotechnical Journal, vol. 19, No.3, pp. 392-396.
7. Hataf, N. and Rahimi M. M (2006), "Experimental investigation of bearing capacity of sand reinforced with randomly distributed tire shreds", Construction and Building materials", Vol.20, pp. 910-16.
8. Huang, C.C. and Tatsuoka, F. (1990) "Bearing capacity reinforced horizontal Sandy ground," Journal of Geotechnical and Geoenvironmental Engineering, ASCE, 107(6), 819-827.
9. Moghsddas and Nourouzi, (2012), "Bearing capacity of square model footing on sand reinforced with shredded tire – An experimental investigation", Construction and Building materials", Vol.35, pp. 910-16.
10. Omar, M.T., Das, B.M., Yen, S.C., Puri, V.K., and Cook, E.E. (1993). "Ultimate bearing capacity of rectangular foundations on geogrid-reinforced sand," Geotechnical Testing, ASTM, 16(2), 246-252.
11. Singh, S. and Kumar, S.S. (2021). "Behavior of Jute Fibre-Reinforced Sand Using Direct Shear Test for Ground Engineering Application, Proceedings of Indian Geotechnical Conference 2021, December 16-18, 2021, NIT Tiruchirappalli.
12. Kumar, S.S. and Shankar, M. (2022). "Estimation of Energy Absorption Capacity and Geotechnical Characterization of Silty-clay Soil Blended with Tire Fibres, Submitted to National Conference on Structural and Geotechnical Engineering (*NCSGE*)-2022, NIT Jamshedpur.