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"Improvement in Bearing Capacity of Shallow Foundation by Using Geogrides"

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Abstract: *The present investigation was undertaken to study the behavior of reinforced sand in improving the bearing capacity and settlement resistance under square footing circular footing. A series of laboratory model test has been carried out to investigate the bearing capacity of the square footing and circular footing resting on reinforced sand bed. Locally available river sand was used along with 'geo-grid' as a reinforcing material. It can be concluded that by a suitable arrangement of the reinforcing geo-grid, the bearing capacity and settlement resistance of sand is improved as compared to the unreinforced sand. The estimation of load carrying capacity of footing is the most important step in the design of foundation. The test results showed that the beneficial use of geo-grid reinforcement in terms of increasing in the bearing capacity and minimizing the settlement. A wooden tank of size 250mm×250mm×250mm is used for conducting model tests.*

Keywords: *Sand reinforcement, Geo-grid, Ultimate bearing capacity, Square footing and Circular footing settlement.*

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I. Introduction

Soil is the integral part of the civil engineering practices, which can be used as a construction material in building construction practices. Construction of every structure may need the analysis of soil before starting of construction.

Foundation is the lower most part of the super structure which is resting on soil surface at different depths. It receives the overall load from the super structure and distributes uniformly to the ground, the total performance of a structure depends on performance of a foundation. So it should be strong enough to resist the load from super structure. The performance of the foundation depends on the performance of the soil below the foundation, the performance of the soil below the foundation depends upon strength of the soil. It means that the soil should have enough ultimate bearing capacity to resist the load from the foundation and to distribute the load to bellowed ground. The design of foundation depends upon the ultimate bearing capacity and the settlement of the soil below the foundation.

Reinforcing technique is a type of ground improvement by providing metallic, synthetic fibers in the soil to improve the engineering behavior of the soil. Reinforcement of the soil is a specified method for improving the mechanical properties of the soil such as shear, compression, hydraulic conductivity and density. The ground improvement by providing reinforcement was also in practice in olden days. Babylonians were built ziggurats more than three thousand years ago using the principle of soil reinforcement. A part of the Great Wall of China is also an example of reinforced soil construction. Dutch & Romans had used soil reinforcing technique to reinforce willow animal hides & dikes. Basic principles of under lying reinforced soil construction were completely investigated by Henry Vidal of France who demonstrated its wide application & developed the rational design procedure. Next modification of soil reinforcement was conceived by Lee, in 1973 he suggested set of design parameters for a reinforced soil structure.

In this study, the experimental studies were carried on cohesionless soil in conjunction with cohesive soil reinforced with Geo-grids have been presented. Tests have been conducted with the provision of Geo-grids in four layers at various spacing & the results have been compared with the results of unreinforced condition of sand only. The main advantage of reinforced soil was improving of bearing capacity, reducing differential settlements and tilting of footing, ease of construction and good economy. The main objective of using geosynthetics is to improve physical, mechanical, and hydraulic properties of soils.

II. Materials Used

SAND:

The medium used in the present study is Netravati river sand, Thokotte. The angle of internal friction (∅) obtained from the laboratory direct shear test. The dry unit weight 1.69 gm/cc & Angle of internal friction is 33º.

GEO-GRIDS:

Geo-grids made up of basalt were used as the reinforcement material in the sand bed for the model tests.

Table 1: Physical Properties of Geo-grid

Physical properties	**Values**
Aperture shape	Square
Aperture size	25.4 mm×25.4mm
Thickness	2 mm
Density	0.897 g/cc
Mass per unit area	0.066 g/cm^2
Tensile strength	7 KN/m^2

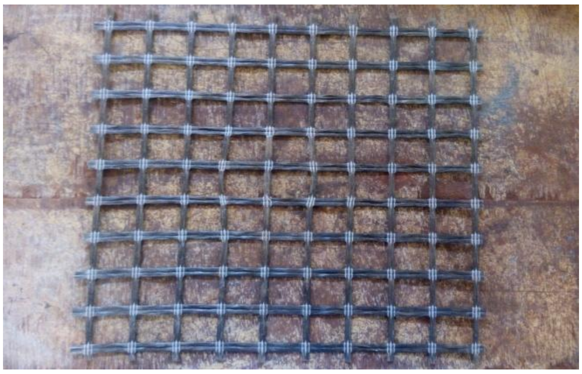

Fig 1: Geo-grid used in this study

MODEL FOOTING:

The model square footing used was a made of cast iron 150 mm x 150 mm size and 5mm thickness and circular footing of diameter 92mm and 10mm thickness.

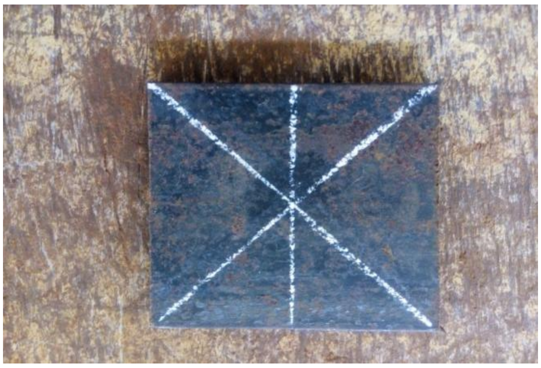

Fig 2: Model Square footing

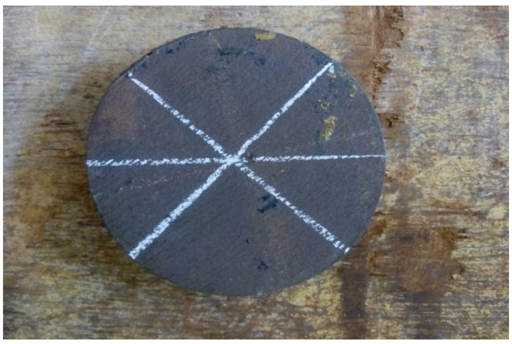

Fig 3: Model Circular footing

III. Literature Review

Hemantkumar Ronad (2014),"An experimental study of square footing resting on geo-grid reinforced sand" and concluded that the beneficial use of geo-grid reinforcement in terms of increasing in the bearing capacity and minimizing the settlement, at an optimum depth of reinforcement, however for the higher density of the soil gives maximum bearing capacity.

Dr M S Dixit et al (2014), "Effect of reinforcement on bearing capacity and settlement of sand" and concluded that the results from laboratory model tests on square footings resting on sand with and without reinforcement are presented. The effect of bearing capacity of sand below the footing for square plate with variation in size, depth to width ratio and the effect of permissible settlement is evaluated.

ARahman al-sinaidi et al (2006), "Improvement in bearing capacity of soil by geogrid - an experimental approach" and concluded that the field observations proved that the geo-grid-reinforced system creates an enhancement to the very soft/soft soils and minimizes the differential settlement. The geo-grid-reinforced system is more economic and attractive and demonstrates superior performance compared with most other ground improvement techniques and is optimal for rapid construction and/or strict total and differential settlements of the structure and/or a thick and newly placed fill.

Nagaraj T K et al (2010),"Experimental Study on Load Settlement Behavior of Sand Foundations" The results have shown that the bearing capacity or the load settlement behavior of foundation soil is dependent on shape and size of the footing. Square footings have shown better load settlement behavior indicating higher load carrying capacity at a given settlement

IV. Experimental Study

In the present study the model tests were conducted in the laboratory using the wooden box tank which was designed keeping in mind the size of model footing to be tested and the zone of influence. The inside length, width and height of the wooden tank are 250 mm, 250 mm and 250 mm respectively. The model footings used for the tests were square and circular in shape. The square footings were made of 5mm thick cast iron plate of sizes 100mm×100mm, and circular footing was made of 10mm thick cast iron plate of size 92mm diameter. The footing was loaded by a hand operated screw jack supported against a reaction frame on a static loading unit.

Fig 4: Static Loading

Fig 5: Square footing Test Setup

Fig 6: Circular footing Test Setup

V. Results And Discussion

In the present study includes observations and discussions of the experiments carried out to examine optimum depth of reinforced zone, density of the soil, checking improvement of bearing capacity, strength improvement ratio, settlement reduction factor.

Table 2: Effect Of U/B Ratio On Bearing Capacity With Only Sand For Square Footing

Settlement in mm	Load (kN/m²) u/B = 0.47	Load (kN/m²) u/B = 0.76
0	0	0
1	35	20
2	59	34
3	102	55
4	145	78
5	171	102
6	200	138
7	210	153
8	249	162
9	255	182
10	293	189
11	299	210
12	314	215
13	321	230
14		249

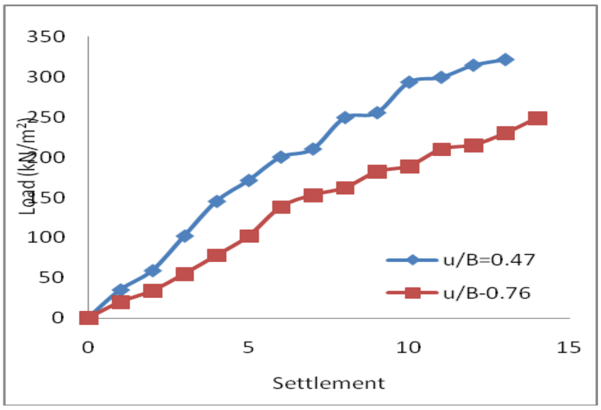

Fig 7: Effect of U/B Ratio on Bearing Capacity of Square Footing

Table 3: Effect Of Number Of Geogrid Layers With Sand Bed Under Square Footing

Settlement	Load (kN/m²) 1 layer	Load (kN/m²) 2 layer	Load (kN/m²) 3 layer	Load (kN/m²) 4 layer
0	0	0	0	0
1	30	41	50	35
2	53	96	70	70
3	103	145	140	200
4	140	170	165	380
5	175	196	210	325
6	199	225	248	329
7	220	250	265	350
8	248	262	305	362
9	256	259	310	390
10	290	305	307	400
11	301	320	340	
12	320	348		

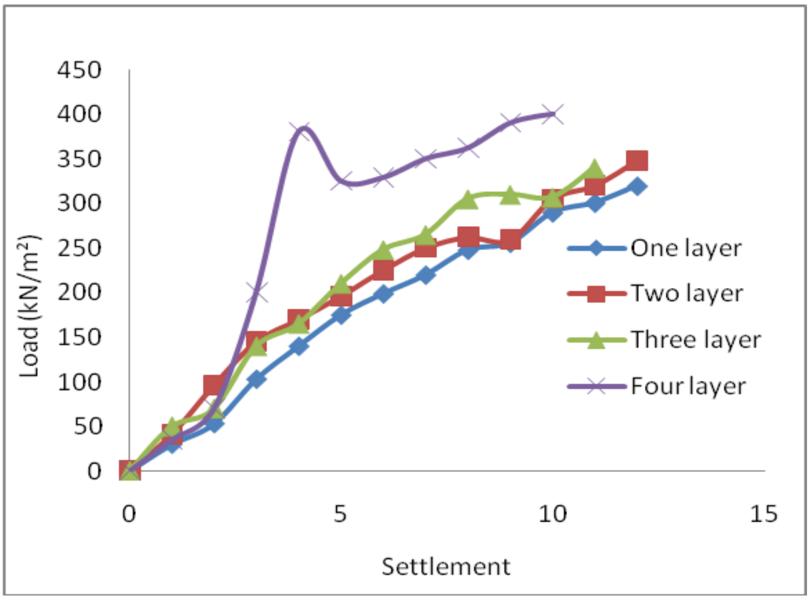

Fig 8: Number of Layers under Square Footing

Table 4: Effect Of U/B Ratio On Bearing Capacity With Only Sand For Circular Footing

Settlement	Load (kN/m²) u/B = 0.54	Load (kN/m²) u/B = 0.86	Load (kN/m²) u/B = 1.08
0	0	0	0
0.5	10.11	7.98	9.04
1	16.5	15.45	13.8
1.5	22.33	26.6	18.62
2	27.8	32	21.8
2.5	32.45	35.64	28.728
3	40	41	33.5
3.5	43.09	43.7	37.77
4	46.8	45.8	41.49
4.5	50	48.94	45.75
5	52.68	52.68	47.35
5.5	57.45	53.73	50
6	60	56.39	51.1
6.5	60.12	57.98	56.39
7		59.58	57.45
7.5		60.648	58.52

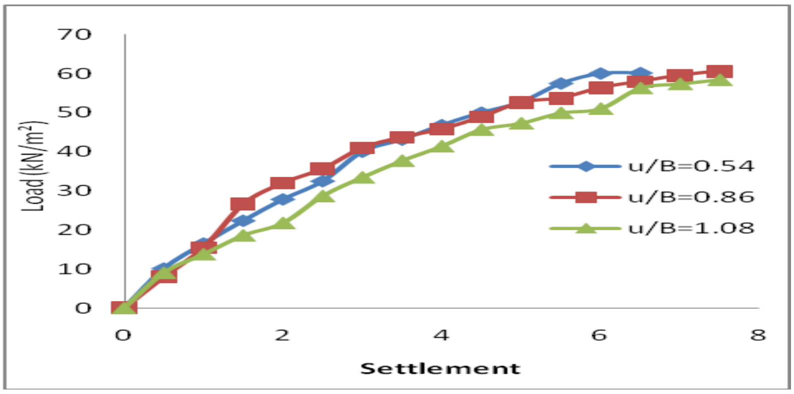

Fig 9: Number of Layers under Circular Footing

Table 4: Effect Of Number Of Geogrid Layers With Sand Bed Under Circular Footing

Settlement in mm	One layer	Two layer	Three layer	Four layer
0	10.11	12.8	13.3	18.62
0.5	16.5	18.1	25.1	30.856
1	22.34	22.34	36.71	42.56
1.5	27.7	30.9	51.1	55.33
2	32.5	41.5	60.64	63.31
2.5	39.4	48.94	67.032	70.76
3	43.1	55.33	67.56	72.35
3.5	46.816	59.1	69.16	73.95
4	50	63.31	71.29	
4.5	52.7	64.4		
5	57.5			
5.5	59.1			
6	60.12			

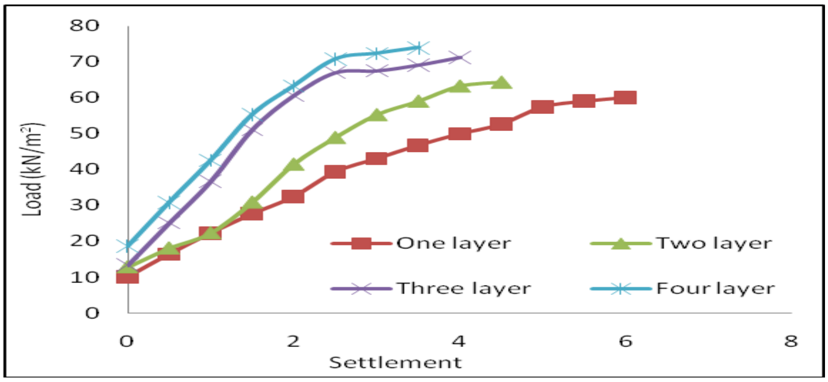

Fig 10: Effect of U/B Ratio on Bearing Capacity of Circular Footing

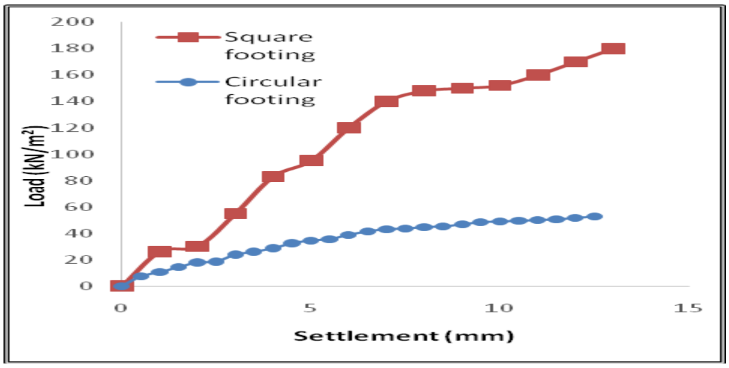

Fig 11: Comparison of Square and Circular Footing in Unreinforced Sand Only

From the above graph we have to know that the load carrying capacity of square footing is comparatively more than circular footing in unreinforced condition. The bearing capacity of only sand bed under square footing was 143.25KN/m^2 and under circular footing was 77.48KN/m^2.

VI. Conclusion

The results of laboratory model tests conducted to determine the ultimate bearing capacity of a square and circular footing supported by multi-layered geo-grid reinforced sand bed subjected to vertical centric load have been reported. Tests have been conducted on medium dense sand. From the above results we can conclude that reinforced sand have 30% more load carrying capacity than unreinforced sand under square footing and 10% more in circular footing. As u/B ratio increases the load carrying capacity of sand bed goes on decreases by 3 to 5% in square footing and 1to 2% decreases in circular footing, it means depth from base footing to first layer of reinforcement increases the load carrying capacity decreases. The load carrying capacity of sand increases by 5% to 10% with increase in number layer of reinforcement under both square and circular footings. The inclusion of lateritic soil layer increases the load carrying capacity of sand by 10% under square footing and 30% under circular footing in reinforced and unreinforced condition. When compared to the behavior of square and circular footing under reinforced and unreinforced condition the square footing performs good and have high load carrying capacity than circular footing.

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