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Comparison of load carrying capacity of strip footing resting on sand bed reinforced with H-V Inserts & Geocells

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Abstract
A series of laboratory plate load tests were conducted on model strip footing resting on sand reinforced with horizontal, single sided, double sided horizontal vertical (H-V) reinforcement and geocells. Load settlement behavior of soil reinforced with horizontal strips, horizontal strips attached with vertical strips on upper side, horizontal strips attached with vertical strips on upper and lower side and geocells, load carrying capacity and effect of variation of height of vertical members of single sided, double sided H-V reinforcements and geocells were studied at a depth of 0.8 B, B is width of footing.

An increase of about 57% in load carrying capacity was observed when horizontal reinforcement was placed at depth of 0.8B. If horizontal strips with 1cm high vertical strips on upper side are placed at the same depth a increase of 227% was observed. If the height of vertical strips was increased to 2cm, the increase of 283% in load carrying capacity was observed but a decrease trends was found if height of vertical strips was further increase to 3cm. A vertical strip on lower side was also introduced with 2cm vertical strips on upper side as a H-V reinforcement and increase of about 359 % in bearing capacity was observed. Similarly height of the geocell was varied from 1 to 3 cm and increase in the load carrying capacity was observed from 115% to 250%.

Keywords: H type reinforcement, HV1& HV2 Type reinforcement, Geocell, Unreinforced soil,

INTRODUCTION
The concept of mechanically stabilized earth has been widely used in highways, embankments, ground improvement and etc for decades. The effect of geosynthetics and metal reinforcement has been extensively studied by various investigators. The concept of multi directional reinforcement

was first introduced by Lawton et al (1993) through laboratory investigation on sand reinforced with geo jack. M.X, Zhang et al (2006) performed series of triaxial test using 3D reinforcement with varying height of vertical member [15]. Juan Hou et al 2010 conducted the laboratory model test on sand reinforced with galvanized iron strip single sided horizontal-vertical reinforcement [2]. Juan Hou et al (2016) calculated the ultimate bearing capacity of horizontal-vertical reinforcement based on the failure mode and mechanism of sand bed reinforced with horizontal-vertical reinforcement [3]. M. Harikumar et al (2016) conducted a laboratory plate load test on model footing resting on the sand reinforced with plastic multidirectional reinforcement [6]. Sujit Das Kumar et al (2001) conducted the plate load test on soil reinforced with geocell and observed that soil shows the failure even at settlement of 50% of width footing and ultimate bearing capacity was observed 8 times the unreinforced soil [5]. S.N moghaddas Tafreshi et al (2010) conducted the laboratory test on strip footing resting on sand reinforced with geocell and planer geotextile reinforcement [13]. Researchers investigated the effect of reinforcement on bearing capacity of soil. In most of the investigations it was concluded that H-V reinforcement has an extra advantage over horizontal reinforcement, as it offer additional passive resistance and also increases the confinement of the soil.

In this current study, laboratory plate load test was conducted on strip footing resting on sand reinforced with horizontal reinforcement, single sided horizontal vertical (H-V1) reinforcement, double sided horizontal vertical reinforcement (H-V2) reinforcement and geocells. The effect of the height of variation of vertical member of single, double sided H-V reinforcement and geocell was studied at a depth of 0.8B, which was fixed as per literature survey. A comparison of load settlement response and load carrying capacity was made between horizontal, single sided, double sided H-V reinforcement and geocell. Galvanized iron metal strip of 2mm wide used as Horizontal, H-V1 and H-V2 type reinforcement and plastic pipe of diameter 6.35 cm and 1 mm thick was used as geocell.

TEST MATERIAL

Sand

Locally available crushed sand obtained from the premises of GNDEC Ludhiana, India was oven dried and used for the current study. The minimum and maximum dry unit weight of sand was found to be 16.75 KN/m^3 and 19.20 KN/m^3 and average dry unit weight of 18.22 KN/m^3 was maintained. As per USCS classification sand was poorly graded and properties of sand are listed below in table 1. The grain size distribution of sand is given in Fig. 1.

Table-2 Properties of sand

Soil	C_u	C_c	*Rd*	*G*	$\varphi°$
Sand	3	0.8	63%	2.63	36

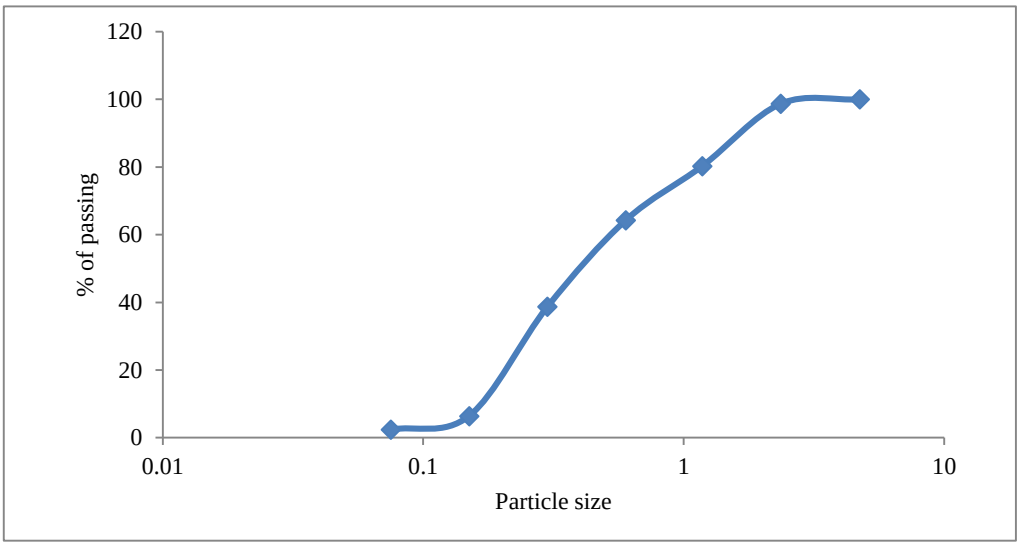

Fig. 1Particle size distribution

Reinforcement

A 2mm thick and 20mm wide galvanized iron metal strips is used as a H Type reinforcement, H-V1 type reinforcement and H-V2 type reinforcement are shown in Fig. 2a and geocell was formed by tying plastics pipes by bending wire is shown in Fig. 2b C/c Spacing (b) between the H, H-V1, H-V2 type reinforcement was kept constant at 0.45B where B is the width of strip footing.

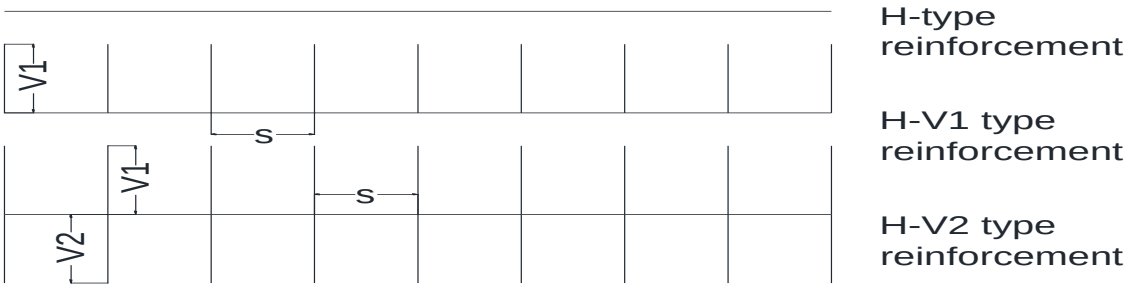

Fig. 2a H, H-V2 & H-V2 type reinforcement

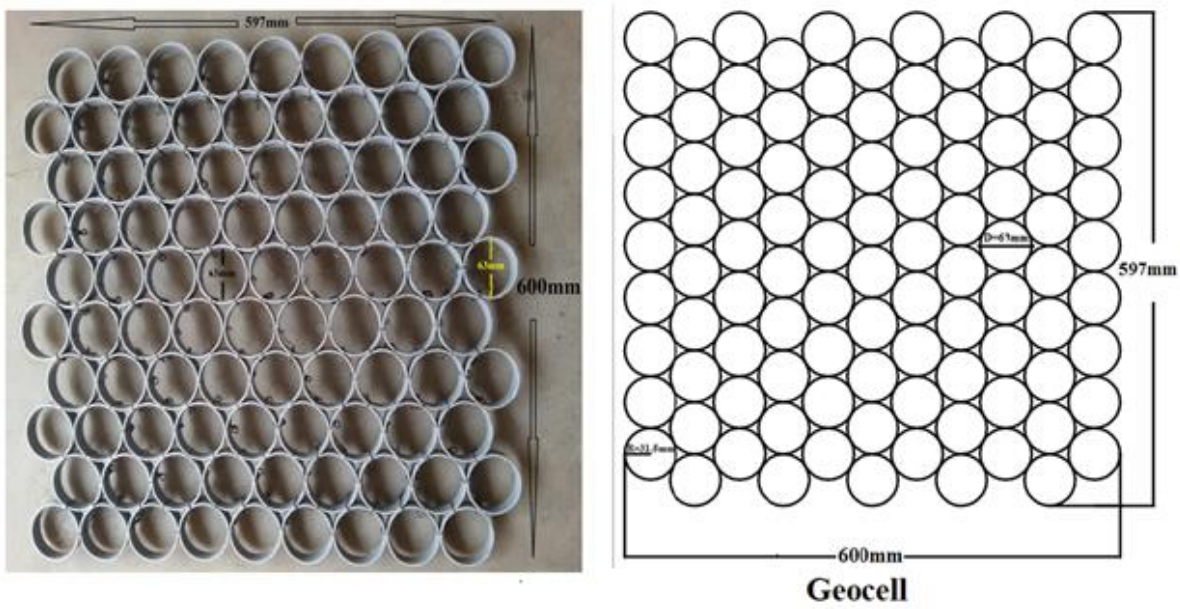

Fig. 2b Geocell

Test Setup

A test tank of size 1500mm length, 600mm width and 800 mm height was used. To eliminate the lateral deflection under axial load on footing the longitudinal side of walls of the test tanks were strengthened by means of stiffeners. Width of tank kept as per IS 1882-1982 guidelines, which states that minimum width of tank should be 5 times width of footing in order to reduce scale effect. A hand operated hydraulic jack of 350 KN is used to apply load. . The hydraulic jack was fixed to the horizontal cross beam. Cylindrical column was used to transfer the load from hydraulic jack to the footing. Load cell having maximum capacity of 250 KN was used to measure the load applied by hydraulic jack on the footing

Settlement was recorded by means of two LVDT which was fixed at opposite ends with a least count of 0.01mm. A wooden strip footing of size 110mm width, 50mm thickness, and length of the footing was kept equal to width of the tank to maintain the plain stain conditions.

Sand was poured into the tank by means raining technique. In order to get desired relative density height of the fall was determined by performing trails of varying height.

Following parameters were investigated: Variation of height of vertical member V1 of H-V1 type reinforcement from 1 to 3 cm, in case of H-V2 type reinforcement V1 was fixed at 2 cm and variation of height of V2 from 1 to 3 cm and in case of geocell height was varied from 1 to 3 cm. Length of the H, H-V1, H-V2 reinforcement and geocell was fixed at 6B. Spacing between the vertical members of the H-V1 and H-V2 type reinforcement was kept at 7.5cm. Fig. 3 shows the test setup.

Fig. 3 Test setup

Test Procedures

The inner face of tank was smoothened in order to reduce side friction. Bottom of the footing was kept rough and sides were polished. The sand was filled in layer thickness of 5 cm. The density was checked continuously by inserting a known volume container. The load was applied at strain rate of 1mm/min. The loading was continued until 40 mm settlement was obtained. The reinforcement was kept at a fixed depth of 0.8B. Each test was performed twice. Line diagram of test setup is shown in Fig. 4.

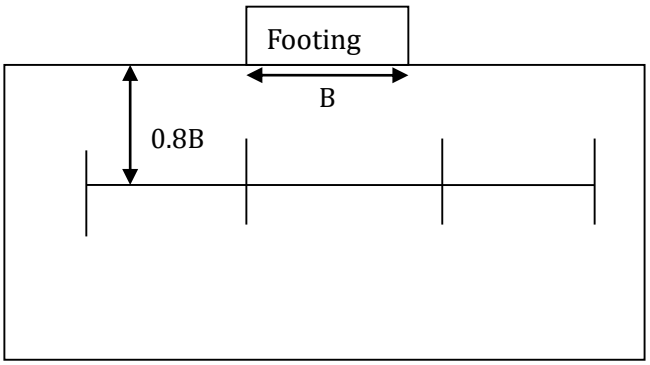

Fig. 4 Line diagram of test setup

Results & Discussions

Load settlement curves are drawn for each case and ultimate for each case was calculated by double tangent method. The load settlement curves for unreinforced soil as shown in Fig.5 the ultimate load was found to be 4.33 KN. The load bearing capacity was determined by dividing the load by area of footing and found to be 65.26 KN/m2.

An increase of 57 % in load carrying capacity was observed when sand was reinforced with H type reinforcement. When H-V1 type inserts with V1 as 1 cm was introduced, 227% increase in load carrying capacity was observed. Because

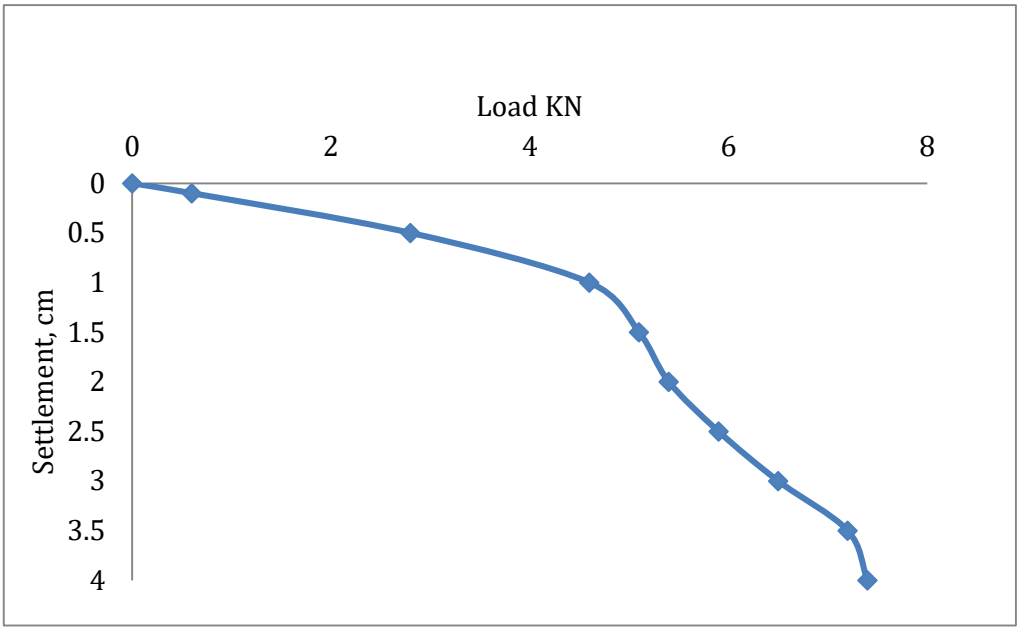

Fig. 5 Load settlement behavior of unreinforced sand

H-V1 type reinforcement increase confinement and passive resistance of soil against shearing significantly.

It also provide the lateral resistance to the lateral displacement of the foundation soil and redistribute the load to the wider area, thus minimizing the stress concentration.Vertical portion of reinforcement act as the retaining wall. Load carrying capacity of soil further increased to 283% when V1 was kept 2cm and start decreasing with further increase in V1 to 3cm. Because as V1 increased to 3 cm Vertical member of H-V1 type reinforcement started deflecting and hence reduced passive resistance of soil against shearing.

The same trends in load carrying capacity were observed with H-V2 type reinforcement. In this case V1 was fixed at 2 cm, V2 was varied from 1 to 3cm. When V2 was 1 cm, load carrying capacity was increased to 324%. Max increase in Load carrying capacity was found to be 359% when V1 & V2 are 2cm each. H-V2 type reinforcement provides the passive resistance against sharing on upper and lower side of horizontal member, due to presence of double sided vertical members. Further increasing V2 to 3 cm decrease in load settlement response and load bearing capacity of soil was observed. Because vertical members were started deflecting and reduced the load settlement response of the soil.

Soil reinforced with geocell with 1 cm height load carrying capacity was increased by 115%. On height was increased further to 2cm increase in load bearing capacity was observed 163% and further increasing the height to 3cm 250% increase in load bearing capacity was observed. Geocell increase the confinement of soil significantly. Fig. 6 (a), (b) & (c) shows load settlement response of H type, H-V1 & H-V2 type reinforcement and geocell at depth of 0.8B and effect on BCR respectively is shown in Fig. 7. Table 2 shows the variation load carrying capacity of soil reinforced H type, H-V1 type, H-V2 type reinforcement and geocell at depth of 0.8B, where B is width of footing.

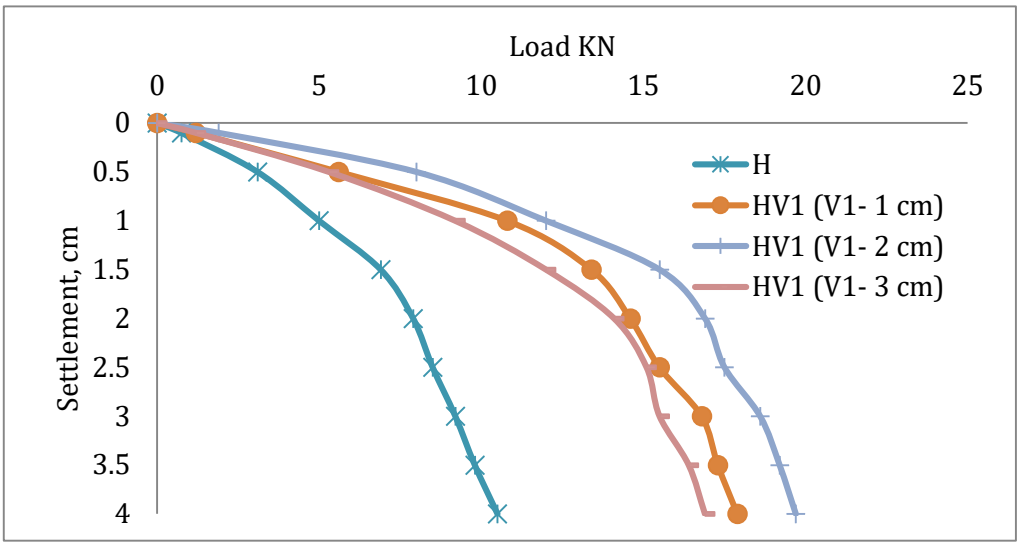

Fig. 6a Load settlement response of H & H-V1 type of reinforcement.

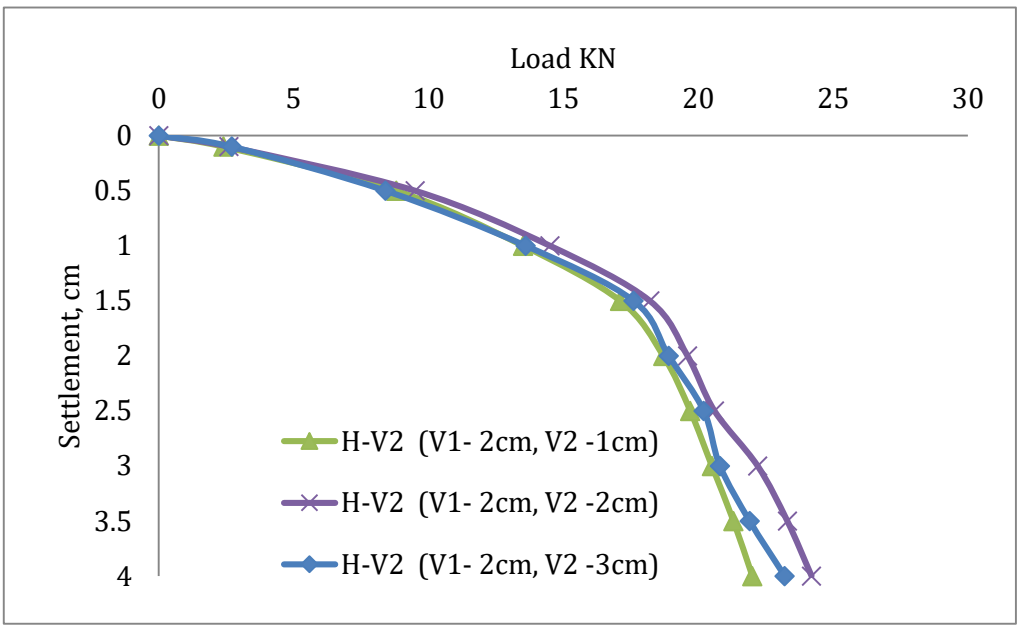

Fig. 6b Load settlement behavior of H-V2 type reinforcement

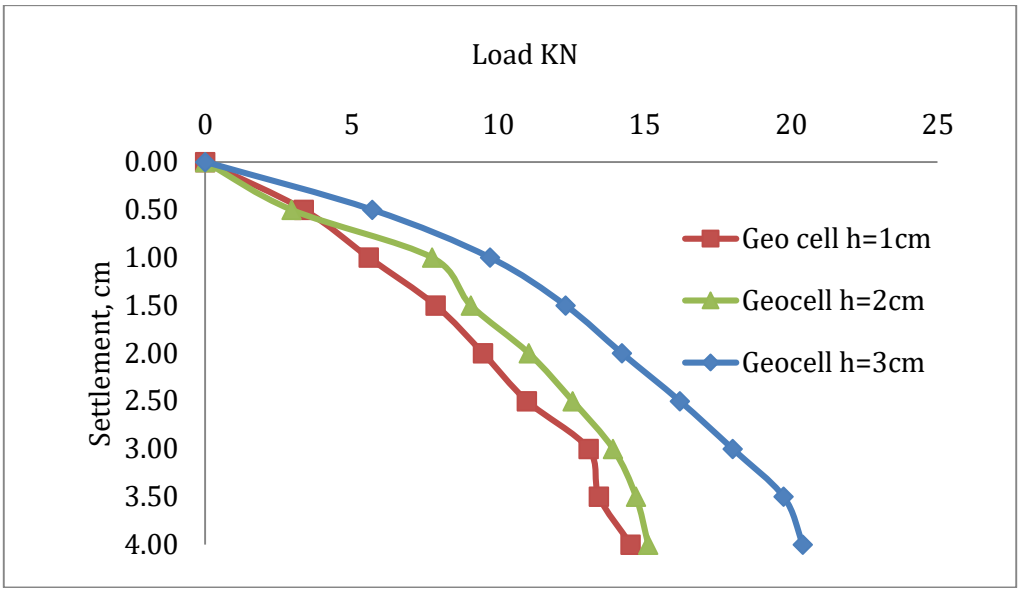

Fig. 6c Load settlement behavior of Geocell

Fig. 7 BCR v/s type reinforcement.

Conclusions

Following conclusions may be derived with the present study:

When horizontal reinforcement was used, significant increase in load settlement response was observed as compared to unreinforced soil. Soil reinforced with H-V1 type of reinforcement, increase in settlement response was observed as height vertical member V1 increased to 2 cm. Further increasing the height the of V1 resulted drop in load settlement response.

Table 2 Load carrying capacity of different types of reinforcement

Type of reinforcement	Unreinforced	H Type	HV1 (V1=1cm)	HV1 (V1=2cm)	HV1 (V1=3cm)	HV2 (V1-2,V2-1cm)	HV2 (V1-2,V2-2cm)	HV2 (V1-2,V2-3cm)	Geocell h=1cm	Geocell h=2cm	Geocell h=3cm
Units	KN/m2										
Load Carrying Capacity	65.26	104	214	251	217	277	300	285	140	171	228

In case of H-V2 type reinforcement fixed at 2 cm, as V2 increased to 2 cm significant increase in load settlement response and load carrying capacity of soil was observed. Further increasing V2 resulted drop in the load settlement response and load carrying capacity of soil.

In case of geocell increasing the height load carrying capacity increases significantly but not as H-V2 type reinforcement.

It has been cleared that H-V2type reinforcement with V1-2cm & V2-2cm is more effective than H, H-V1 & geocell.

The maximum increase was BCR also observed with H-V2 type reinforcement with V1 and V2 as 2cm high.

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REFERENCE

Azzam, W.R, Nasr, A.M et al (2015): Bearing capacity of shell strip footing on reinforced sand, Journal of Advanced Research., 6, pp. 727-737.

Chen, Qiming, Murad, Abu-Farsakh, et al (2015): Ultimate bearing capacity analysis of strip footings on reinforced soil foundation, Soils and Foundations., 55, pp. 74-85.

Ciceka, Elif, Gulerb, Erol, Yetimoglua,Temel et al (2015): Effect of reinforcement length for different geosynthetic reinforcements on strip footing on sand soil. Soils and Foundations., 55, pp. 661-677

Das, B.M (2013): Principals of Foundation Engineering, Cengage Learning

Dash Sujit Kumar, Krishansawamy N.R., Rajagopal K: Bearing capacity of strip footing supporting on geocell reinforced soil., Geotextile and Geomembrane . vol. 19, pp. 235-256.

Harikumar, M., Sankar, N., Chandrakaran, S. et al (2016) : Behaviour of model footing resting on sand bed reinforced with multidirectional reinforcing elements., Geotextiles and geomembranes. 44, pp. 568-578.

Hou et al (2010): Bearing capacity and mechanism of soil bed reinforced with horizontal vertical inclusions on strip shallow foundation., Doctor of sciences thesis.

Houa, Juan, Zhang, Meng-xi, Dai, Zhi-heng, Li, Jia-zheng, Zeng, Feng-fan et al (2015): Bearing

capacity of strip foundations in horizontal-vertical reinforced soils., Soil and foundations 55, pp. 74-85

Ismail, Kamal Mohamed Hafez et al (2014): Ibrahim"Bearing capacity of circular footing resting on granular soil overlying soft clay. , HBRC Journal 12, pp. 71-77.

Kumar, Jyant, Chakrabort, Manash et al (2015): Bearing capacity of circular foundation on layered sand clay material., Soil and foundations. 55, pp. 1058-1068

Raj, P. Purushothama (1999): Ground Improvement Techniques., Laxmi Publications (P) LTD.

Nazir, Ashraf kamal, Azam, Wasim R. et al (2010): Improving bearing capacity of soft clay with sand pile with/without skirts., Alexandria Engineering Journal 49, pp. 371-377.

Tafreshi, S.N. Moghaddas Dawson A.R. Comparision of bearing capacity of a strip footing on strip footing on sand with geocell and with planar forms of geotextile reinforcement". Geotextile and Geomembrane., 28, pp. 72-84.

Wakil, Amr Z. EL et al (2013): Bearing capacity of skirt circular footing on sand., Alexandria Engineering Journal 52, pp:359-364.

Zhang,, M.X. Javadi, A.A., Min, X. et al (2006): Triaxial tests of sand reinforced with 3D inclusions., Geotextiles and Geomembranes 24 pp. 201-209.

Zhang, M.X., Zhoua, H., Javadi, A.A., Wang, Z.W. et al (2008): Experimental and theoretical investigation of strength of soil reinforcedwith multi-layer horizontal–vertical orthogonal elements., Geotextiles and Geomembranes 26, pp. 1-13.