**Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition**
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

COMPARATIVE EXPERIMENTAL STUDY ON THE PERFORMANCE OF 2D & 3D GEOGRID REINFORCED MANUFACTURED SAND (M-SAND) AND RIVER SAND BEDS UNDER STATIC LOAD CONDITION

SRINIVASA RH
Research Scholar, Department of Civil Engineering, University Visvesvaraya College of Engineering (UVCE), Bangalore University, Bengaluru, Karnataka, India. Email: srinivasarh@gmail.com,
ORCID: 0009-0001-3887-2934

S. GANGADHARA
Professor, Department of Civil Engineering, University Visvesvaraya College of Engineering (UVCE), Bangalore University, Bengaluru, Karnataka, India. ORCID: 0009-0004-7678-4494

Abstract

Soil reinforcement is one of the most popular ground modification technique to improve the bearing capacity and reduce the settlement of soil. Cohesionless soil such as Sand and Gravels are best suited material to be used to derive maximum benefit from the Reinforced earth technique. M-Sand (Manufactured sand) is fast replacing the conventional River sand in construction industry. M-Sand is attracting the Engineers, builders due to their cost effectiveness and easy availability with reference to sustainability. M-Sand also find a potential place in the reinforced earth system. However studies made on the utility of M-Sand as a back fill material in reinforced earth is very scanty. Hence in the present study efforts are being made to use M-Sand as a back fill material to evaluate its usefulness. This study presents the results of laboratory tests conducted on square footing resting on geogrid reinforced M-Sand beds subjected to static load condition. Tests were conducted by varying the reinforcement distribution parameters (i.e., Number of reinforcement layers and the spacing between the reinforcement layers). The results shows that, the inclusion of reinforcement layers is effective in improving bearing capacity and in reducing the settlement of footing resting on M-sand Bed.

Keywords: Static Load; M-Sand; River sand; 2D-Geogrid; 3D-Geogrid.

1. INTRODUCTION

Reinforced Earth technique is being extensively used in construction activities as a ground improvement tool for improving the bearing capacity of soil and for reducing the settlement and also as a construction method. Weak soils can be treated and best utilized by using reinforcement techniques. It is understood that, based on overall functioning of properties of this composite (With greater strength and smaller deformability), it is possible to save the construction cost, overcome space constraints, improve structure behavior under destructive conditions like earthquakes.

According to several research woks, employing geogrids is the most effective reinforcement method. Many geotechnical applications have made use of geogrid materials. To assess the effectiveness of geogrid-reinforced sand beds, several researchers have conducted laboratory investigations [1,3–15].

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

In addition, some studies have examined the performance of both two-dimensional geogrid reinforcement and three-dimensional geogrid–PVC pipe reinforcement in sand beds [18]. The behaviour of geocell reinforcement is mainly governed by stress dispersion and soil confinement mechanisms [16]. However, its effectiveness in reducing maximum footing settlement decreases with an increase in geocell height and width [17].

Cohesionless soils such as Sand and Gravels are best suited material to be used to derive maximum benefit from the Reinforced earth technique. The specifications for the backfill soil are very specific, with material like sand being used for this purpose. “Manufactured sand” popularly known as “M Sand” is fast replacing the conventional River sand in construction industry.

M. Sand is attracting the Engineers, builders due to their cost effectiveness and easy availability with reference to sustainability. M sand also find a potential place in the reinforced earth system. However studies made on the utility of M sand as a back fill material is very scanty. In order to assess M sand's utility, attempts are being made to employ it as a backfill material in the current study. The present experimental investigation examines the behavior of manufactured sand (M-sand) beds under static loading using a square footing.

Tests were performed on unreinforced, two-dimensional (2D) geogrid–reinforced, and three-dimensional (3D) pipe geogrid–reinforced M-sand beds compacted to a relative density of 35%. The 2D reinforcement consisted of a hexagonal geogrid with a tensile strength of 7.74 kN/m, arranged in one, two, and three layers (N = 1, 2, and 3) with spacing of S=0.3B, 0.4B, and 0.5B. The 3D pipe geogrid, incorporating circular extruded pipe elements around the apertures, provides a spatial reinforcement system that enhances confinement and load distribution within the soil mass.

The performance of reinforced M-sand beds was systematically evaluated and compared with both unreinforced M-sand beds and river sand beds under identical testing conditions.

The results demonstrate the relative effectiveness of reinforcement, with the 3D pipe geogrid exhibiting improved performance compared to conventional 2D geogrid systems in enhancing the load-bearing capacity and reducing settlement of M-sand foundations.

2. MATERIALS AND METHODOLOGY

2.1 Materials

Backfill material: Expirements are conducted with both M-Sand & river sand. Table 1 presents the properties of both M-Sand and River Sand used in the present investigation According to Indian Standard Soil Classification System (ISSCS), both the M-Sand & River Sands are classified as poorly graded sand (SP).

Fig 1 presents the grain size distribution curves for both M-Sand & River Sand.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

Table 1: Physical properties of backfill material

Sl No.	Properties	Test Result	
		River Sand	M-Sand
1	Clay size & Silt size (%)	0	0
2	Sand (%)	100	100
4	Coefficient of uniformity, Cc	3.03	3.55
5	Coefficient of Curvature, Cu	1.65	0.88
6	Specific Gravity, G	2.68	2.65
8	Max. Dry Density (kN/m^3)	17.98	19.65
9	Min Dry Density (kN/m^3)	14.17	15.96
10	Max. Voids Ratio e_{max}	0.85	0.66
11	Min. Voids Ratio e_{min}	0.46	0.35
12	Angle of internal friction @ 35% RD	34.6	35
13	Soil Classification	SP	SP

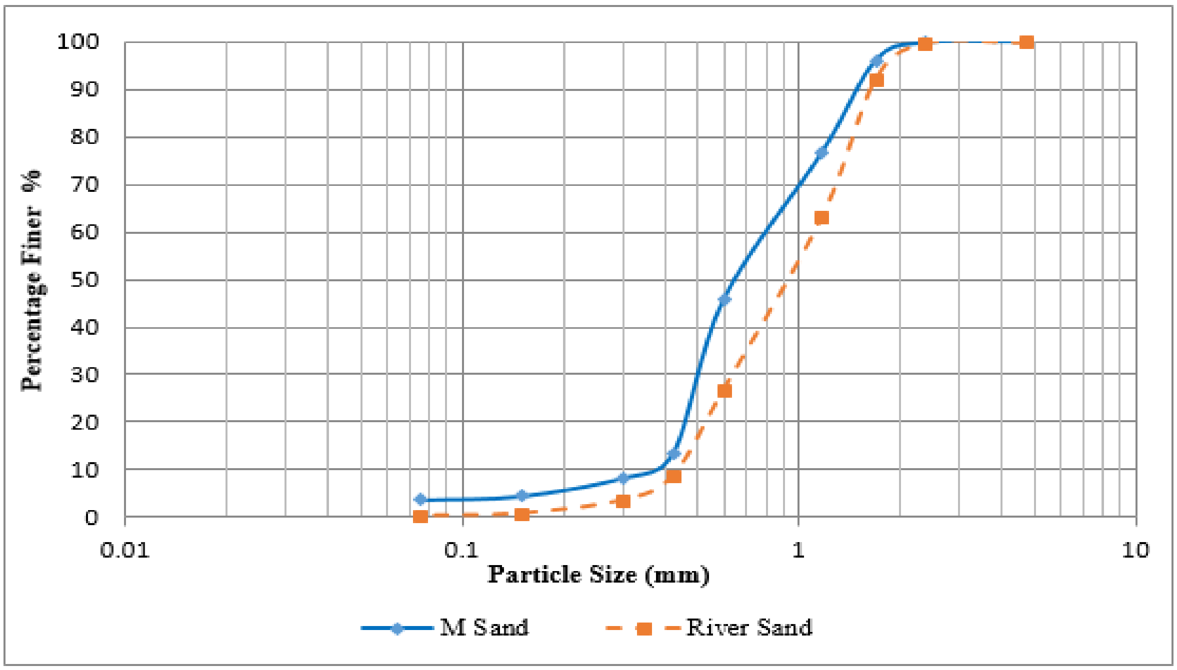


Fig 1: Grain size distribution curve for M-Sand & River Sand

Geogrid: In the present experimental study, Biaxial geogrid is used as reinforcement material. Table 2 presents the properties of the geogrid used.

Table 2: Physical properties of Geogrid used

Sl.No.	Properties	Test results
	Geogrid	
1	Peak tensile strength	7.74 kN/m
2	Structure	Biaxial Hexagonal
3	Aperture size machine direction	25.4 mm

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

4	Aperture size cross machine direction	31.8 mm
5	Rib thickness	3 mm
6	Joint thickness	3 mm

3D Geogrid pipe: The 3D geogrid pipe reinforcement system is done by combining geogrid and PVC pipe components in a composite arrangement as shown in Fig.3.Forming a three-dimensional structure that improves soil confinement and load distribution. Table 3 prasents the properties of the 3D geogrid pipe used.

Table 3: Physical properties of 3D Pipe Geogrid

Sl.No.	Properties	Value
	Pipe	
1	Pipe inside Diameter(mm)	22.4
2	Pipe outside Diameter(mm)	25.4
3	Thickness of Pipe(mm)	3

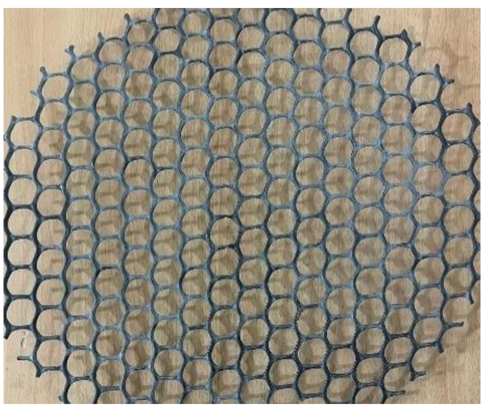


Fig 2: 2D-Geogrid

Fig 3: 3D-Geogrid

2.2 Testing Procedure

(a) Load Frame:

The experimental set up for the static load test consists of a loading frame of 50kN capacity. A 250 mm diameter plate that moves vertically at a rate of 1.06mm/min is placed as a support on the test tank. A cross-beam is provided on top of the supporting plate on which the proving ring is fixed.

Proving ring of 50kN capacity with a least count of 0.0602kN is used to apply the load using a mechanical screw jack. Three dial guages with sensitivity of 0.01 mm are used to measure the settlement of the soil sample in three mutually orthogonal directions.

(b) Other Accessories

The experimental setup consists of,

- Mild steel footing of size 100mm × 100mm and thickness 10 mm

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

Fig 4: Loading Frame for static loading

(c) Preparation of Test Bed

The unreinforced M-sand bed is compacted to a height of 360 mm in 3 equal layers of 120mm each. For the reinforced beds, the 2D-geogrid and 3D-geogrid pipes are placed at predetermined spacing on the compacted M-sand. The reinforcements are provided in the shape of circular discs with a clearance of 5 mm between the reinforcement and the tank wall to avoid friction between the two components. The square footing is placed on the final level surface of the compacted M-sand bed at the center of the circular tank.

3. RESULTS AND DISCUSSION

3.1 Test Results for unreinforcement sand beds

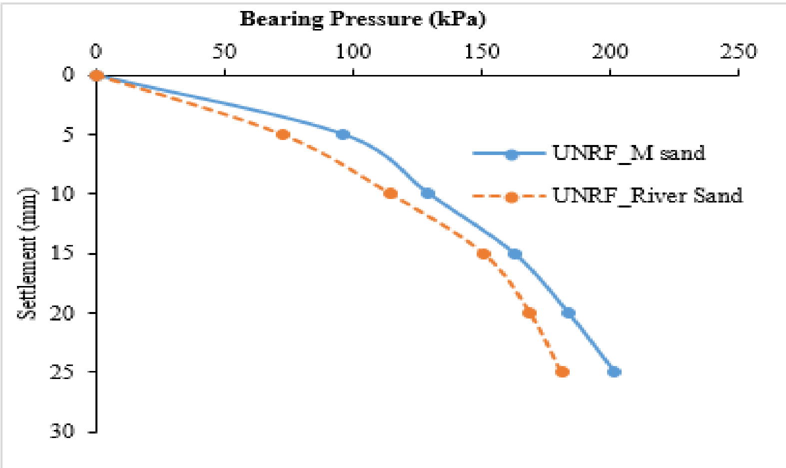


Fig 5: Bearing pressure-settlement curve of the unreinforced M-sand and River sand bed

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

Fig. 5 presents the bearing pressure–settlement Curves for square footings resting on M-sand and river sand beds, compacted to a relative density of 35% subjected to static loading. The tests were conducted in unreinforced conditions to facilitate a direct comparison of material performance. It is seen from fig.5 that there is a close agreement in the load-settlement behavior of footing on both unreinforeced M-Sand & Unreinforced River Sand beds. For example at a bearing pressure of 100 kPa, the footing on unreinforced M sand bed exhibited a settlement of about 6mm whereas its counterpart resting on unreinforced river sand bed experienced a settlement of 7mm. Simillar kind of result is Observed at different bearing pressures also. The Test results are in close agreement with each other. Infact the footing resting on M-sand Bed showed better performance than the footing resting of river sand bed. The superior performance of M-sand may be attributed to its angular particle shape and better interlocking characteristics, which enhance load transfer and resistance against settlement. These findings highlight the suitability of M-sand as an effective alternative to river sand for foundation applications.

The comparable load–settlement response of unreinforced M-sand and river sand indicates similar stiffness at a relative density of 35%. The slightly improved performance of M-sand is attributed to its angular particle shape, which promotes better interlocking and higher frictional resistance, resulting in marginally lower settlement under the same load. This enhances load transfer efficiency and resistance to deformation, confirming that M-sand can effectively perform as an alternative to river sand in foundation applications.

3.2 Test Results for Reinforced Sand beds

3.2.1 Effect of depth of first layer of reinforcement (U)

Fig.6 presents the bearing pressure-settlement curve for a square footing resting on a 2D-geogrid reinforced M-sand bed and a River sand bed, both compacted to a relative density of 35% and subjected to static load. To investigate the impact of the depth of the first layer of reinforcement in the 2D-geogrid system, experiments were conducted using a single layer of reinforcement placed at varying depths (U= 0.3B, 0.4B, and 0.5B). As shown in Fig. 6, for a U=0.3B, the bearing pressures for footings on single-layer 2D-geogrid-reinforced M-sand and River sand at a settlement of 25 mm is 599 kPa and 573 kPa, respectively. For a U=0.4B, the corresponding bearing pressures are 464 kPa for M-sand and 458 kPa for River sand. Similarly, for a U=0.5B, the bearing pressures are 446 kPa for M-sand and 434 kPa for River sand at the same 25 mm settlement. Fig.6 clearly demonstrates that the footing on the 2D-geogrid reinforced M-sand beds performed better compared to the footing on the 2D-geogrid reinforced and unreinforced River sand beds. These results clearly demonstrate that a U/B ratio of 0.3 yields the highest bearing pressure at 25 mm settlement compared to U/B ratios of 0.4 and 0.5 for both M-sand and River sand beds. Therefore, all subsequent experiments were conducted with U/B = 0.3 kept constant for both the sand types.

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

The improved performance at **U/B = 0.3** is attributed to the placement of the geogrid within the active shear zone beneath the footing, enabling effective stress redistribution and mobilization of tensile resistance. This enhances confinement and reduces settlement through a tensioned membrane effect. At greater depths (U/B = 0.4 and 0.5), the reinforcement lies outside the critical failure zone, resulting in reduced soil–geogrid interaction and lower bearing capacity. Additionally, M-sand exhibits higher bearing pressure than river sand due to its angular particles, which promote better interlocking and frictional resistance. Hence, **U/B = 0.3 is identified as the optimum depth** for maximum performance.

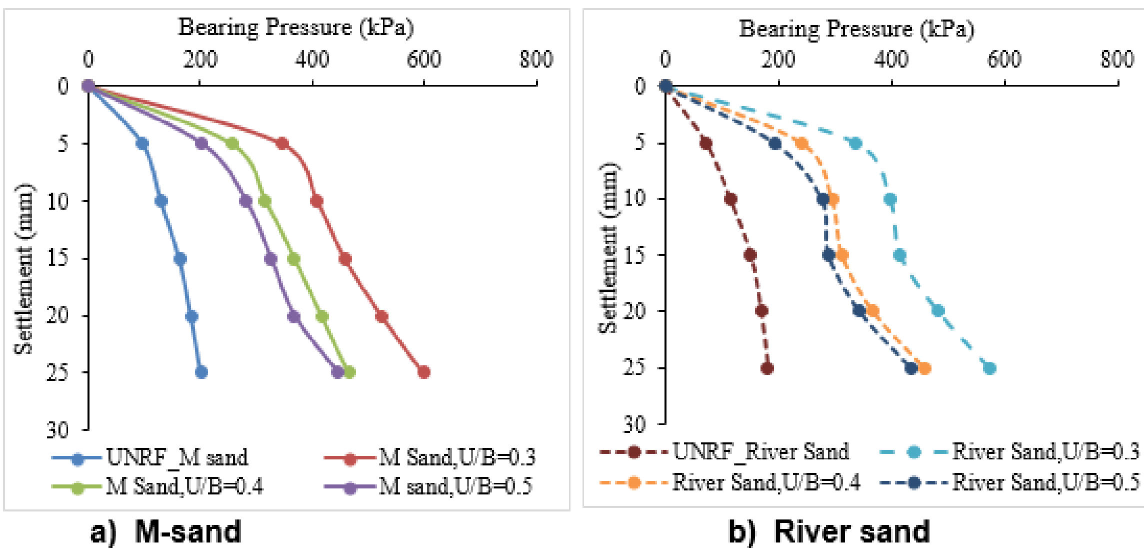
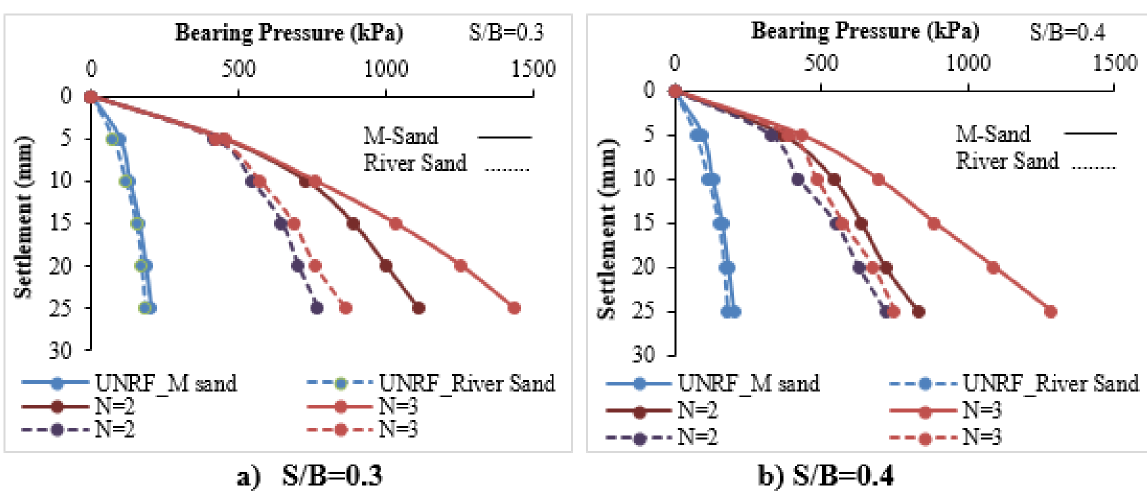
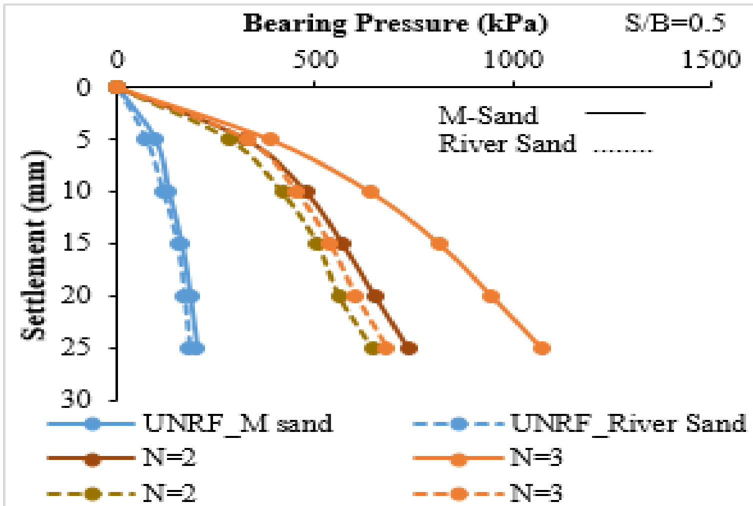


Fig 6: Effect of depth of first layer of geogrid in the reinforced M-sand and River sand beds

3.2.2 Effect of the Number of reinforcement layer (N)



ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140



c) S/B=0.5

Fig 7: Effect of the number of geogrid layers in reinforced M-sand and River sand beds

Fig 7(a)–7(c) present the pressure–settlement responses of a square footing resting on unreinforced and geogrid-reinforced M-sand and River sand beds, each compacted to a relative density of 35%. The data correspond to reinforcement configurations with spacing ratios of 0.3B, 0.4B, and 0.5B, incorporating two and three layers of geogrid reinforcement in both sand types. It is evident from these figures that a reduction in reinforcement spacing, coupled with an increase in the number of reinforcement layers, leads to consistently higher bearing pressures at all levels of settlement. At a settlement of 25 mm, for two-layer reinforcement with $S/B = 0.3$, the bearing pressures are 1108 kPa and 766 kPa for M-sand and River sand beds, respectively. For $S/B = 0.4$, the values decrease to 831 kPa and 718 kPa, while at $S/B = 0.5$ they further reduce to 734 kPa and 645 kPa.

A similar trend is observed for three-layer reinforcement, where at $S/B = 0.3$, M-sand and River sand beds exhibit bearing pressures of 1433 kPa and 862 kPa, respectively. For $S/B = 0.4$, the values decrease to 1282 kPa and 748 kPa, while at $S/B = 0.5$ they reduce further to 1072 kPa and 681 kPa. These results confirm the beneficial role of geogrid reinforcement in enhancing footing performance, with closer spacing and additional reinforcement layers producing the most significant improvements, and with M-sand consistently outperforming River sand under comparable conditions.

The improvement observed in M-sand beds can be attributed to the greater contact area and enhanced interlocking between the geogrid and angular M-sand particles, which improves confinement and load transfer efficiency. Overall, the results indicate that the optimum reinforcement configuration corresponds to three geogrid layers placed at a spacing of $S = 0.3B$, which provides the maximum improvement in bearing capacity.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

3.2.3 Effect of spacing between the reinforcement layers (S)

Fig. 8 presents the bearing pressure–settlement response for a square footing resting on 2D-geogrid reinforced M-sand and River sand beds, each compacted to a relative density of 35% and subjected to static loading. The experiments were conducted with reinforcement spacing ratios of 0.3B, 0.4B, and 0.5B for two and three layers of reinforcement, and the results are evaluated at a settlement of 25 mm.For the case of three reinforcement layers with a spacing ratio of 0.3B, the bearing pressures attained are 1433 kPa for the M-sand bed and 862 kPa for the River sand bed. At S/B = 0.4, the corresponding values decrease to 1282 kPa and 748 kPa, respectively, while for S/B = 0.5, the pressures further reduce to 1072 kPa for M-sand and 681 kPa for River sand.These results clearly indicate that a spacing ratio of 0.3B consistently provides the highest bearing pressure at 25 mm settlement compared to spacing ratios of 0.4B and 0.5B in both M-sand and River sand beds. Therefore, it may be concluded that an S/B ratio of 0.3 represents the optimum reinforcement spacing under the tested conditions.

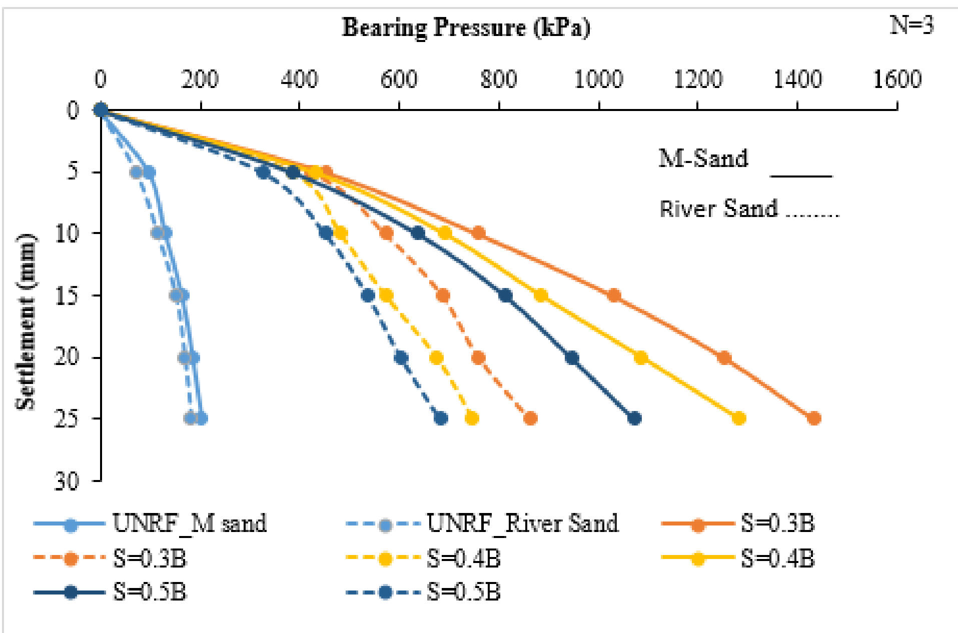


Fig 8: Effect of spacing between the geogrid layers in reinforced M-sand and River sand beds

a) Bearing Pressure Ratio (BPR)

The effect of reinforcement on the bearing pressure of the footing resting on geogrid reinforced sand bed is discussed in terms of the Bearing Pressure Ratio (BPR).

$$BCR = \frac{\text{Bearing pressure of the reinforced soil at a given settlement S}}{\text{Bearing pressure of the unreinforced soil at the same settlement value S}} = q_R/q_o$$ (Binquet and Lee 1975) [2]

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

Fig. 9. Presents Variation of Bearing Capacity Ratio (BCR) with reinforcement spacing (S/B) for a square footing resting on 2D-geogrid reinforced M-sand and River sand beds at 25 mm settlement under two and three layer reinforcement conditions. At a spacing ratio of 0.3B with two layers of reinforcement, the BCR values are 5.49 for M-sand and 4.23 for River sand.

For S/B = 0.4, the corresponding BCR values decrease to 4.12 and 3.96, respectively, while at S/B = 0.5, the values are 3.56 for M-sand and 3.64 for River sand. For the case of three layers of reinforcement, the BCR values at 0.3B spacing increase to 7.10 for M-sand and 4.76 for River sand. At S/B = 0.4, the corresponding values reduce to 6.36 and 4.13, respectively, while at S/B = 0.5, the BCR values further decrease to 5.31 for M-sand and 3.76 for River sand.

These results clearly demonstrate that the lowest spacing ratio (0.3B) provides the highest BCR values for both M-sand and River sand beds, and that the inclusion of an additional reinforcement layer enhances performance compared to the two-layer condition.

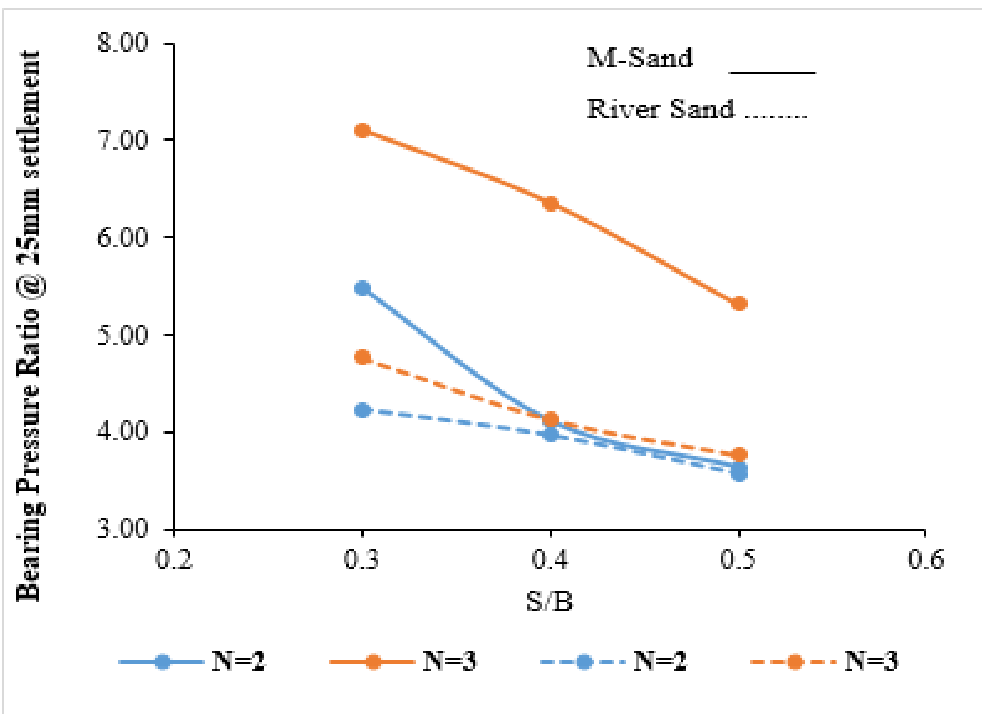


Fig 9: Bearing Pressure Ratio of reinforced M-sand and River sand beds

b) Settlement Ratio (SR)

Settlement Ratio (SR) is defined as $SR=\frac{\text{settlement of reinforced soil at a given bearing pressure}}{\text{settlement of the unreinforced soil at same bearing pressure}}$

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

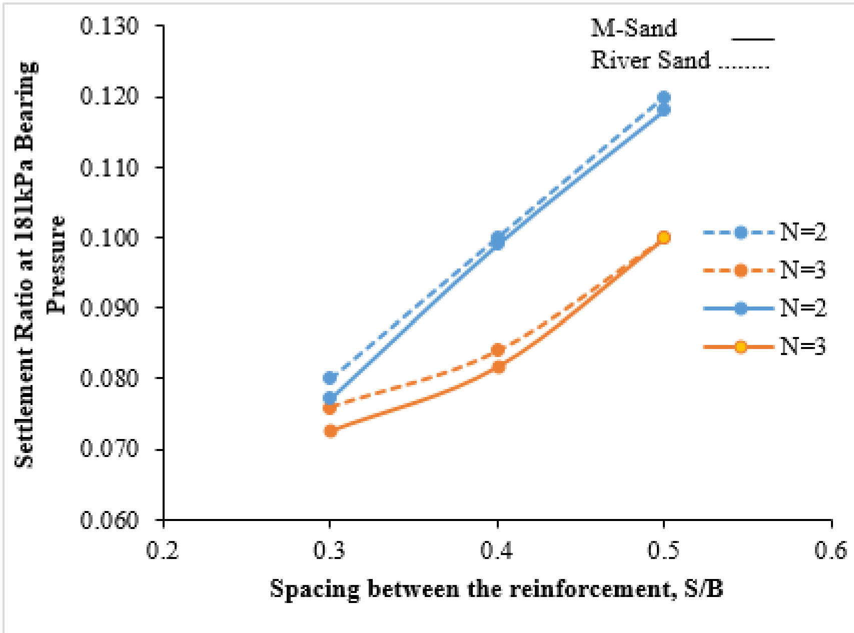


Fig 10: Settlement Ratio of reinforced M-sand and River sand beds (at 181kPa and 202kPa bearing pressure, respectively)

Fig. 10. Presents Variation of Settlement Ratio (SR) with reinforcement spacing (S/B) for a square footing resting on 2D-geogrid reinforced M-sand and River sand beds at 181kPa bearing pressure under two and three layer reinforcement conditions.. From the figure, it is observed that as the spacing between the reinforcement layer decreases there is decrease in the settlement ratio value irrespective of the number of reinforcement layer for both in M-sand and reiver sand sand beds. It is observed that at a spacing ratio of 0.3B with two layers of reinforcement, the SR values are 0.077 for M-sand and 0.080 for River sand, whereas for S/B = 0.4, the corresponding SR values increases to 0.100 and 0.099 for river sand and M-sand beds, respectively, while at S/B = 0.5, the values are 0.118 for M-sand and 0.120 for River sand. For the case of three layers of reinforcement (N=3), the SR values at 0.3B spacing is 0.076 and 0.073 for river sand and M-sand beds, these SR values corresponding to S/B=0.4 and 0.5 is 0.084 & 0.082 for river sand and M-sand beds and 0.100 & 0.100 for river sand and M-sand beds respectively. These results clearly demonstrate that the increase in the number of reinforcement layer and decrease in the spacing ratio (S=0.3B) shows the lower SR values for both M-sand and River sand beds.

3.3 Comparision of 2D and 3D geogrid reinforced foundation bed

Fig. 11 presents the effect of material type and vertical confinement in 3D geogrid reinforcement on the bearing pressure–settlement response of M-sand and river sand beds. The experiments were conducted under static loading conditions for unreinforced, 2D-geogrid-reinforced, and 3D-geogrid-reinforced beds, each comprising three

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

reinforcement layers (U = 0.4B, S = 0.3B, N = 3). At a settlement of 25 mm, footings resting on 3D-geogrid-reinforced beds with vertical confinement (H = 2 cm) exhibited bearing pressures of 2571 kPa for M-sand and 1049 kPa for river sand. In comparison, the corresponding bearing pressures for 2D-geogrid-reinforced beds were 1433 kPa and 862 kPa, while those for unreinforced beds were 238 kPa and 181 kPa, respectively.

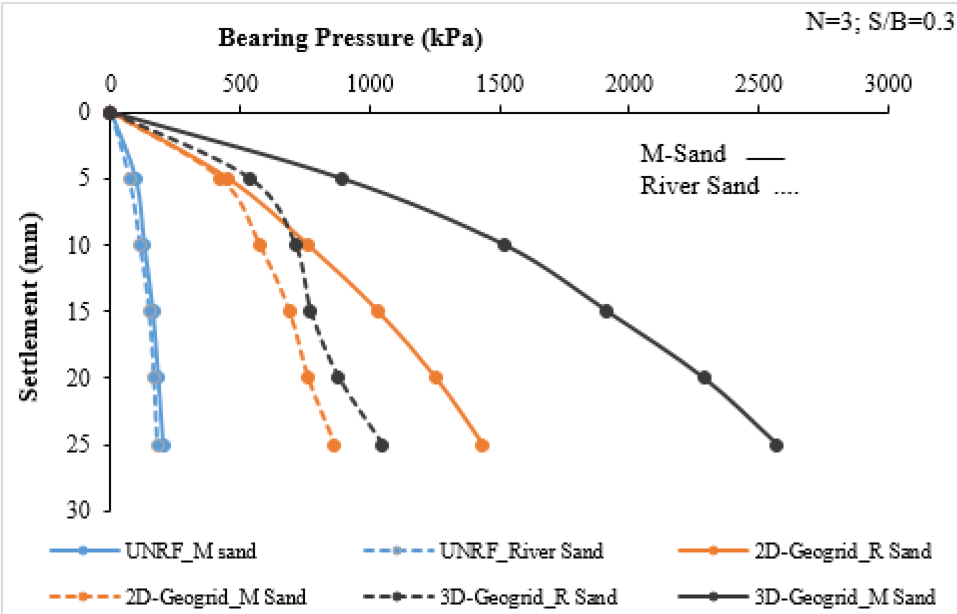


Fig 11: Bearing pressure-settlement curve of the unreinforced, 2D and 3D geogrid reinforced foundation bed

These results clearly demonstrate that the inclusion of vertical confinement in 3D-geogrid reinforcement significantly enhances the bearing pressure, particularly for M-sand beds, compared to both 2D-geogrid reinforced and unreinforced conditions.

a) Bearing Pressure Ratio (BPR)

Fig.12 Presents the Bearing capacity ratio vs 2D and 3D geogrid reinforced M-sand and river sand foundation beds, It is observed from the figure that bearing capacity ratio for 2D geogrid reinforced M-sand bed is 7.10,where as River sand bed is 4.76 at 25mm settlement,similarly for 3D geogrid reinforced M-sand bed is 12.75,where as River sand bed is 5.80 at 25mm settlement.

At a settlement of 25 mm, the Bearing Capacity Ratio (BCR) for the 3D-geogrid reinforced M-sand bed (12.75) is almost 1.8 times higher than that of the 2D-geogrid reinforced M-sand bed (7.10). Similarly, for River sand, the 3D-geogrid reinforcement (BCR = 5.80) provides about a 22% improvement over the 2D-geogrid reinforcement (BCR = 4.76). These comparisons clearly demonstrate that 3D-geogrid reinforcement offers a significant enhancement in load-bearing performance compared to 2D-geogrid reinforcement, with the improvement being more pronounced in M-sand beds than in River sand beds.

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

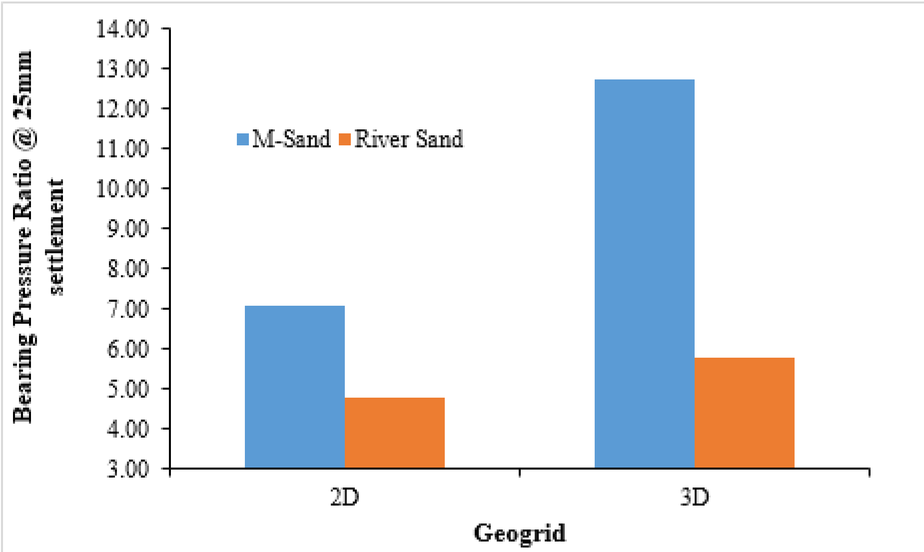


Fig 12: Bearing Pressure Ratio of 2D and 3D geogrid reinforced foundation bed

b) Settlement Ratio (SR)

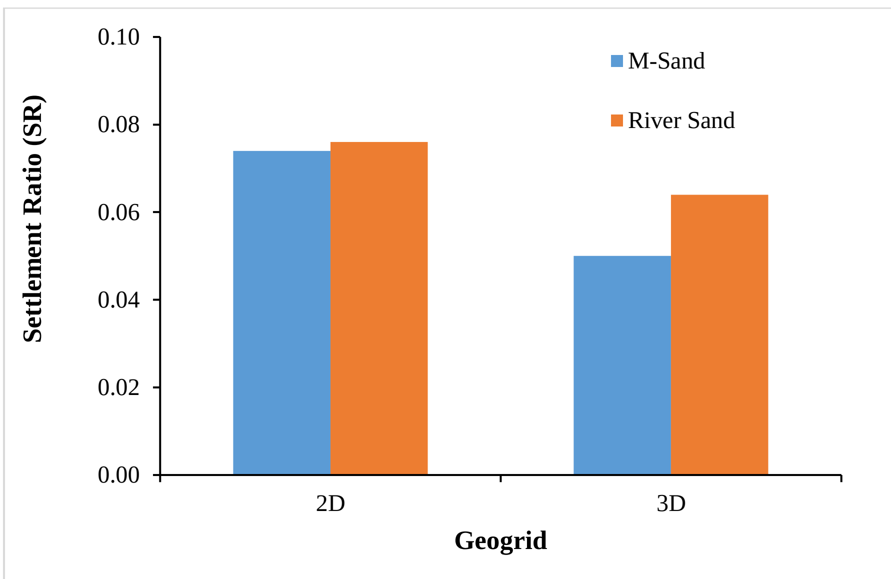


Fig 13: Settlement Ratio of 2D and 3D geogrid reinforced foundation bed

Fig.13 presents the variation of settlement ratio (SR) for 2D- and 3D-geogrid-reinforced M-sand and river sand foundation beds at a Bearing pressure of 181kPa. The SR value of the 2D geogrid-reinforced M-sand bed is 0.070, while that of the corresponding river sand bed is 0.076. In contrast, the 3D geogrid-reinforced M-sand bed exhibits a lower SR value of 0.05, whereas the river sand bed shows an SR value of 0.064 at the same bearing pressure. Overall, at 181kPa bearing pressure, 3D geogrid reinforcement shows

Xi'an Shiyou Daxue Xuebao (Ziran Kexue Ban)/
Journal of Xi'an Shiyou University, Natural Sciences Edition
ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

the lower settlement ratios than 2D geogrid reinforcement for both M-sand and river sand beds, indicating the superior performance of the 3D geogrid system. These results clearly demonstrate that the inclusion of 3D geogrid reinforcement significantly reduces the settlement of footings resting on M-sand beds compared with those resting on 3D geogrid-reinforced river sand beds.

4. CONCLUSION

Based On the results of experiments conducted and presented in this paper, the following conclusions are drawn

1) The experimental results clearly demonstrated that the M-sand can be used as a backfill material in reinforced earth.
2) The bearing pressure of M-sand and river sand beds can be effectively enhanced through the inclusion of reinforcement layers. The bearing pressure of the reinforced sand bed is strongly influenced by the reinforcement configuration. An optimal configuration is achieved with three reinforcement layers at a spacing of 0.3B.
3) In general, 3D geogrid-reinforced M-sand beds exhibit superior execution paralleled with unreinforced and reinforced river sand beds, irrespective of the total of reinforcement sheets and the positioning of the reinforcement under static loading conditions.
4) Higher bearing capacity ratio (BCR) values and lower settlement ratio (SR) values are observed for footings resting on 3D-reinforced M-sand and river sand beds compared with their counterparts resting on 2D-reinforced M-sand and river sand beds. This indicates that the performance of footings on 3D (geogrid–PVC pipe) reinforced beds is superior to that on 2D (plain geogrid) reinforced beds. Furthermore, among the 3D-reinforced systems, the M-sand bed exhibits better performance than the river sand bed

References

1) Abhishek Singh, Phanikumar, B. R, Ram Prasad: “Effect Of Geogrid Reinforcement On Load Carrying Capacity Of A Coarse Sand Bed” International Journal of Civil Engineering and Technology. 7(3), 01–06 (2016).
2) Binquet, J and Lee, K.L.: “Bearing capacity analysis of reinforced earth mass” Journal of Geotechnical Engineering, Div, ASCE, 101(12), 1241-55 (1975).
3) Dewaikar, D.M, Chore, H.S, Gupta, K.G, Kame, G.S.: Behaviour of A Square Footing on Reinforced Soil: An Experimental Study. Indian Geotechnical Conference, Guntur,. 467-471(2009).
4) Durga Prasad B, C. Hariprasad, B. Umashankar.: “Load-Settlement Response of Square Footing on Geogrid Reinforced Layered Granular Beds” Int. J. of Geosynth. And Ground Eng. (2016) 2:36. DOI 10.1007/s40891-016-0070-6(2016).
5) Hanamant, C, Kumar, N, Ravirajgouda P, Sagar H, Basavaraj H.: Behavior of Square Footing Resting on Reinforced Sand Subjected to Static Load. International Journal for Innovative Research in Science & Technology. 3(2), 303-311(2016).

ISSN: 1673-064X
E-Publication: Online Open Access
Vol: 69 Issue 06 | 2026
DOI: 10.5281/zenodo.21160140

6) Imran Khan, Ravi Kumar Sharma.: "Bearing Capacity Evaluation of Square Footing Resting on Reinforced Sand". Journal of Mining and Environment. 14(3), 813-824(2023).

7) Laxmikant Yadu, Dr, R.K. Tripathi.: "Effect of the length of geogrid layers in the bearing capacity ratio of geogrid reinforced granular fill-soft subgrade soil system" 2nd Conference of Transportation Research Group of India (2nd CTRG). Procedia - Social and Behavioral Sciences 104 (2013) 225 – 234 (2013).

8) Madhavi Latha G, Amit Somwanshi.: "Bearing capacity of square footings on geosynthetic reinforced sand. Geotextiles and Geomembranes".27, 281-294 doi:10.1016/j.geotexmem.2009.02.001 (2009).

9) Maruthi & Vijay Kumar G.: "Improving The Load Carrying Capacity Of Square Footing Resting On Geogrid Reinforced Sand" International Research Journal of Engineering and Technology (IRJET). E-ISSN: 2395-0056, p-ISSN: 2395-0072. Volume: 05 Issue: 09 | Sep 2018 (2018).

10) Marto, Mohsen Oghabi, and Amin Eisazadeh.: "The Effect of Geogrid Reinforcement on Bearing Capacity Properties of Soil under Static Load; A Review" EJGE, Vol. 18 (2013).

11) Monir Kazi, Sanjay Kumar Shukla, Daryoush Habibi.: "Effect of Submergence on Settlement and Bearing Capacity of Surface Strip Footing on Geotextile-Reinforced Sand Bed" Int. J. of Geosynth. and Ground Eng. DOI 10.1007/s40891-014-0006-y (2015)

12) Pezhman Fazeli Dehkordi , Mahmoud Ghazavi , Usama F. A. K.: "Bearing capacity-relative density behavior of circular footings resting on geocell-reinforced sand". European Journal of Environmental and Civil Engineering. https://doi.org/10.1080/19648189.2021.1884901 (2021).

13) Phanikumar, B.R, Ram Prasad, Abhishek Singh.: "Compressive load response of geogrid-reinforced fine, medium and coarse sands. Geotextiles and Geomembranes". 27, 183-186 doi:10.1016/j.geotexmem.2008.11.003 (2009).

14) Vaibhav Sharma , Arvind Kumar.: "Influence of relative density of soil on performance of fiber-reinforced soil foundations.Geotextiles and Geomembranes".1-9, http://dx.doi.org/10.1016/j.geotexmem.2017.06.004 (2017).

15) Vinodhkumar Shanmugasundaram , Gowsalya Palanisamy,Balaji Anbazhagan, Gokul Nagarajan.: "Experimental Study of Load Settlement Behaviour of Circular Footing Rested Over M-sand". AIP Conference Proceedings. https://doi.org/10.1063/5.0010996 (2020).

16) Avinash.N, S.Gangadhara, Malashree.: "A Study on the Performance of Surface Footings on 3D Geogrid Reinforced Sand Beds" International Journal of Engineering Research & Technology (IJERT) ISSN: 2278-0181. NCACE-EWIT- 2020 Conference Proceedings.

17) J. O. Avesani Neto, B. S. Bueno and M. M. Futai.: "A bearing capacity calculation method for soil reinforced with a geocell" Geosynthetics International, 2013, 20, No. 3.

18) A. Biswas, A. Murali Krishna and S. K. Dash.: "Influence of subgrade strength on the performance of geocell-reinforced foundation systems" Geosynthetics International, 2013, 20, No. 6