Dynamic Behavior of Geogrid-Reinforced Soil

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ABSTRACT

Geosynthetic materials particularly geogrids are widely used as reinforcement and is a proven technology for enhancing the performance of the foundation soil system under monotonic loadings. But the dynamic behavior of the reinforced foundation soil has not been well understood so far, and therefore dynamic loads (square wave pulse) of frequencies 0.2, 0.6 and 1 hertz under an amplitude of displacement of 2mm have been studied by carrying out dynamic plate loading tests on both unreinforced and the reinforced sandy beds. The size of the square plate is 150mm x 150mm x 30mm.

It has been observed that there is considerable effect of the number of reinforcement layer (N), the size of the reinforcement (b), spacing of the reinforcement (u, Δz) and frequency of loading on the dynamic bearing capacity of the subgrades. There is substantial reduction in settlement of the reinforced subgrades as well due to inclusion of geogrid in the foundation soil. The percentage increase in the dynamic bearing capacity due to 4 layers of geogrid inclusion is about 200 to 250 percent. There is however, not much influence of operating frequencies (f) of the machine on the dynamic bearing capacity. It has been found that the critical value of u/B is 0.25 and irrespective of the number of reinforcing layers and operating frequency of the machine, the value of dynamic bearing capacity is found to be higher at all settlements value. As u/B value further increases, the dynamic bearing capacity starts decreasing.

INTRODUCTION

The experimental investigation have revealed that the placing of geogrids horizontally in the subgrades, provide an effective way to increase its bearing capacity (eg., Binquet and Lee 1975 a, Fragaszy and Lawton 1984. Guido et al 1986; Verma and Pandya, 1997). More recently Omar, M. T. et al (1994) have conducted laboratory model tests on a surface square footing on a sandy bed and suggested the critical value of the depth of reinforced zone (d) as 1.20 times the width of the footing.

Das, B. M. and Shin, E.C. (1994) carried out low - frequency dynamic cyclic load test on a strip foundation resting on the geogrid - reinforced saturated clay and concluded that the full depth geogrid reinforcement can reduce the permanent settlement of a foundations by about 20 to 30 %. Guido. V.A. et al (1994) test results show a positive effect of geogrid reinforcement on a sandy subgrade under dynamic cyclic load. There is considerable variation in the dynamic bearing capacity of the subgrade due to variation in the number of layers of reinforcement (N), size of reinforcement (b) and the frequency and amplitude of the dynamic loading. Chang, D.T et al (1998) found that the geogrid reinforcement was highly effective in increasing the stiffness of the subgrades. Verma and Santhakumar (1999) analysed the data of Guido (1994) and gave a mathematical relationship between settlement and load cycles.

EXPERIMENT

A series of dynamic plate loading tests were performed in a square ferrocement tank 1.0 m wide and 0.90 m deep. The soil used was a poorly graded locally available river sand. The properties of sand used are as under :-

$$C_u = 2.61,\ C_c = 0.837,\ D_{50} = 0.50 \text{ mm}$$
$$D_{10} = 0.23\text{mm and } G = 2.69$$

The angle of internal friction of sand was found to be 32° at the unit weight of 15 kN/m^3. The test tank was filled in lifts by gravity raining technique and the unit weight of the subgrade was found to be 15 kN/m^3. The NETLON CE - 131 geogrids (Table 1) were cut in the square size, varying b/B ratio and placed in the sandy subgrade concentrically below the plate in different layers. The geometric parameters varied during dynamic plate loading tests were u, Δz, b, N and d as shown in Fig. 1.

The dynamic cyclic loading (square wave pulse) of different frequencies were applied by an INSTRON hydraulic jack connected to a hydraulic power unit and data were acquired by data acquisition system. The loading system was strain controlled and dynamic loading was applied vertically and concentrically to a square M. S. plate 150mm wide and 30mm thick located at the surface of the earth-bed. The settlement and corresponding dynamic loads were continuously acquired by data acquisition system for an amplitude of displacement of 2mm.

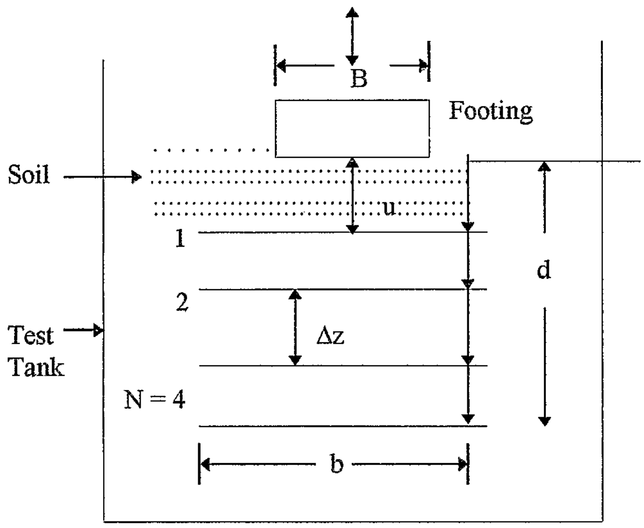

Fig. 1 Geometric parameters of a geogrid - reinforced foundation

The detailed description of the dynamic plate loading tests for both unreinforced and reinforced soil beds are described as under :

<u>Test Series A</u> :

The test series consisted of dynamic plate loading tests on unreinforced sandy bed. The dynamic cyclic load (square wave pulse) having amplitude of displacement 2mm and of different frequencies were applied for number of cycles. The dynamic loads corresponding to different cycles were acquired by data acquisition system.

<u>Test Series B</u> :

This test series consisted of dynamic plate loading tests on geogrid - reinforced sandy beds. The dynamic loads of the reinforced soil beds and corresponding settlements were acquired by data acquisition system. The results of the test in non dimensional form are given in Table 2. Dynamic bearing capacity ratio (DBCR) is the ratio of dynamic bearing capacity of the reinforced bed to that of unreinforced bed at a settlement ratio (s/B) of 3.8 percent.

Table 1 : Properties of geogrid

Reinforceme nt type	Size of grid (mm)	Thickness (mm)		Repute strength (kN/m)
		Joints	Ribs	
CE-131	27 x 27	5.7	3.0	5.80

Table - 2 : Dynamic bearing capacity ratio

Sr.No.	N	u/B	Δz/B	b/B	f(Hz)	DBCR
1	1	0.25	-	3	0.2	1.1
2	1	0.35	-	3	0.2	1.1
3	4	0.25	0.25	3	0.2	3.0
4	4	0.35	0.35	3	0.2	2.5
5	1	0.25	-	3	0.6	1.7
6	2	0.25	0.25	3	0.6	2.4
7	4	0.25	0.25	3	0.6	3.5
8	1	0.25	-	3	1.0	1.8
9	1	0.35	-	3	1.0	1.7
10	4	0.25	0.25	3	1.0	3.3

TEST RESULTS :

- <u>Effects of Number of Layers of Reinforcement (N)</u>

To compare the test results, the dynamic bearing capacity ratio (D.B.C.R) which is defined as the ratio of dynamic bearing pressure of the reinforced soil beds (q_{dr}) to the dynamic bearing pressure of the unreinforced soil beds (q_{do}) at a given settlement of 5.7mm are calculated, because the dynamic ultimate load for the unreinforced bed is corresponding to the settlement of 5.7mm. The variation of the D.B.C.R. with the number of reinforcing layers is given in Table 2 and it is found that D.B.C.R. increases linearly with the increase in number of reinforcement layer. D.B.C.R. for N = 4 is greater than 3 at s = 5.7mm i.e. s/B = 3.8%, for all frequencies , which proves the effectiveness of geogrid reinforcement in the dynamic environment. It is also observed that the percent increase in dynamic bearing pressure for N = 1 is 10%, 70% and 80% for f = 0.2 Hz 0.6 Hz and 1 Hz respectively. Therefore 4 number of geogrid layers increases the dynamic behaviour of the bed significantly.

- <u>Effects of depth ration (u/B)</u>

Table 2 shows the variation of DBCR with u/B and indicates that DBCR at s/B = 3.8% is higher at u/B = 0.25. This indicates that lower value of u/B yields higher dynamic bearing pressure and therefore placing geogrid reinforcement closer to the footing would enhance the bearing pressure compared to higher value of u/B.

- Effect of Frequency (f)

The dynamic bearing capacity ration (D.B.C.R.) gets influenced by the operating frequencies of the machine (f) and for N = 1 and u/B = 0.25, the value of DBCR increases from 1.1 to about 1.8 for the increase in f. Thus there is appreciable change in DBCR due to change in frequency of the dynamic - cyclic load. However, as N value increases to 4, the operating frequencies of the machine do not influence the dynamic bearing capacity significantly.

CONCLUSION

The following conclusions can be drawn from the test results :

- There is increase in the dynamic load carrying capacity of the sandy subgrade when the number of reinforcing layers increases to four by 200%, 250% and 230% at f = 0.2, 0.6 and 1 Hz respectively.

- The optimum value for the distance to the first layer of reinforcement (u) in present investigation is 0.25 times the width of the footing.

- Due to increase in the frequency of loading from 0.2 Hz to 0.6 Hz, the dynamic bearing pressure of the reinforced foundation soil system goes up significantly.

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