Surface Heave Behavior of Geogrid Reinforced Sand Bed

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ABSTRACT— *This paper studies the surface heave phenomena of geogrid reinforced sand bed. Laboratory plate load test were conducted on square footing initially without geogrid and then with the inclusion of geogrid at various depth and spacing. It is observed that the heave is considerably reduced by the inclusion of geogrid. The heave behavior is depended on placement depth, spacing and number of layers of geogrid. The magnitude of reduction in heave is represented by a non-dimensional parameter called heave reduction factor (HRF)..*

Keywords— Heave, Plate load test, Upheaval of sand, Geeogrid reinforced sand

1. INTRODUCTION

Surface heave is caused by the lateral movement of sand due to the applied load. It results in tilting of foundation and influence the bearing capacity of adjacent footing. The settlement of footing cause the adjacent soil mass to move laterally, which in turn cause upward movement of sand. Upward movement of soil exerts a pressure on adjacent structure, cause to the tilting of structure. Dash et al (2001), Latha et al (2009) studied the heave behavior of sand.

Several papers studied the effect of Geogrid on bearing capacity and settlement of sand. This paper studies the effect of geogrid on heave behavior of sand bed.

2. MATERIAL PROPERTIES

The soil used for this study is medium dense sand. The properties of sand were determined as per IS 2720. The effective size (D10) 0.25 mm, uniformity coefficient (Cu) 2. The maximum and minimum dry density was found to be 12.75 and 15.7 kN/m2 respectively. The angle of friction was found to be 37.40. The relative density of sand was fixed to 65% to simulate medium dense condition.

SG5050 biaxial HDPE polymer geogrid was used for the study. The tensile strength and grid aperture size was found to be 50 kN/m and 40x40 mm respectively.

3. TEST SETUP

Plate load was conducted in a steel tank of 750x750x750 mm size. Four sides of tank was braced with MS channel to avoid yielding. Model footing consist of 150x150 mm square steel plate with 25 mm thickness. The base of footing was scratched and punched to simulate the roughness of concrete footing.

A hand operated hydraulic jack was used for loading the footing and a pressure gauge of 100 Kg/cm^2 was fitted to measure the load applied.

4. PREPARATION OF TEST BED

For conducting the plate load test, sand was poured into the testing tank in layers of 50 mm each. Each layer is compacted to achieve the desired relative density of 65%. Geogrid layer was placed as a square mat of 4B (600x600 mm) size at the prefixed depth on the surface of sand bed, where B is the width of footing. Model footing was placed on the sand bed at the center and leveled using spirit level to avoid the chance of eccentric loading. The sand bed and model footing is shown in fig 1.

4.1. Test configurations

A schematic representation of geogrid placement is shown in fig 2. Where u is the depth of placement, h is the spacing between layers and B is the width of footing. The different test configuration adopted for this study is shown in Table 1. Series A studies the effect of depth of placement of geogrid. Series B studies the effect of spacing.

Figure 1: Sand Bed and Model Footing

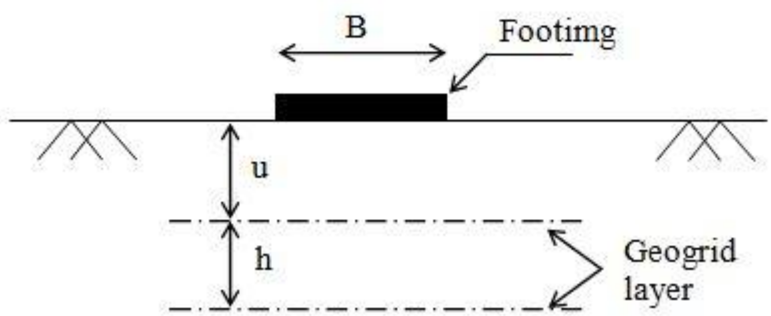

Figure 2: Schematic Representation of Placement of Reinforcement Layer

Table1: Test Configurations

Test Series	Depth, u/B	Spacing, h/B	Constant Parameter
A	0.25	-	Length fixed to 4B
	0.5	-	
	0.75	-	
B	0.5	0.25,0.50,0.75	

5. LABORATORY LOAD TEST

After centering the footing, hydraulic jack was placed over the footing and supported against the reaction frame. Load was applied in equal increment of 100 kPa and the magnitude of loading was measured by a pressure gauge. Each load was maintained until stabilizing the rate of heave. Heave was measured using two dial gauges of 25 mm capacity placed at 1.5B distance away from center of footing on either side. The heave recorded was the average of the two dial gauge readings. The test setup is shown in figure 3.

Figure 3: Test Setup

6. TEST RESULTS AND DISCUSSIONS

6.1. Effect of depth of placement

The load – heave curve for test series A is shown in figure 4. It could be observed that there is significant reduction in surface heave by the inclusion of geogrid. The magnitude of reduction in heave depended on the depth of placement of geogrid. Geogrid develop frictional resistant to lateral the movement which in turn arrest the upward movement. The maximum reduction in heave was found to be for geogrid placed at 0.50B.

6.2. Effect of Spacing of Geogrid

The load- heave curve for series B is shown in figure 5. The heave was found to be reduced for different spacing and the maximum reduction was found to be for 0.75B spacing.

6.3. Effect of Number of Layers

The heave responds for single layer at optimum depth is compared with that of double layer at optimum spacing. The heave behaviour is shown in figure 6.It is observed that the heave is increased by increasing the number of layer.

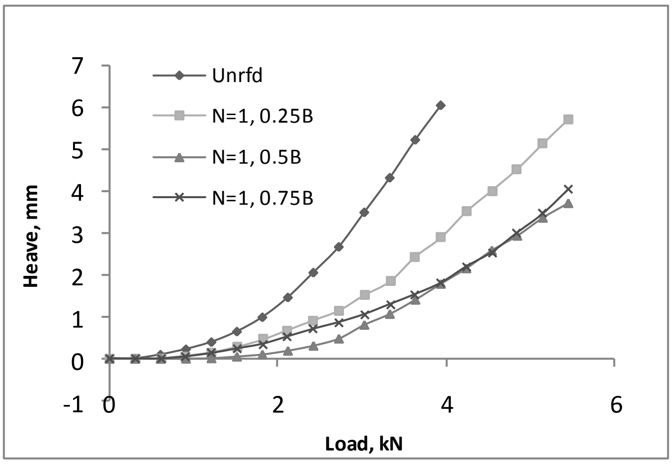

Figure 4: Heave Curve for Test Series A

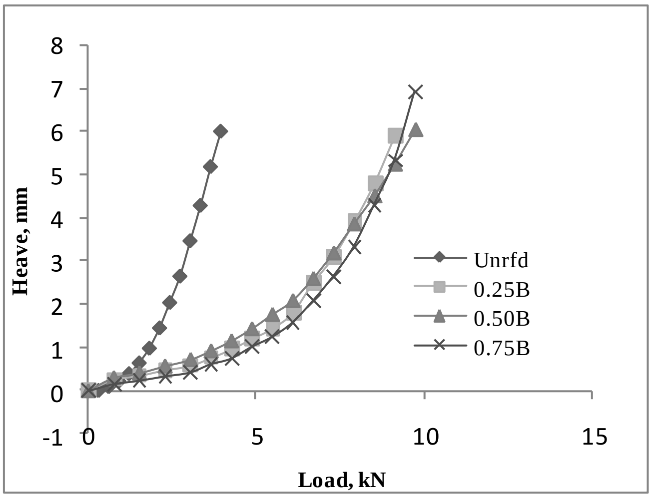

Figure 5: Heave curve for test series B

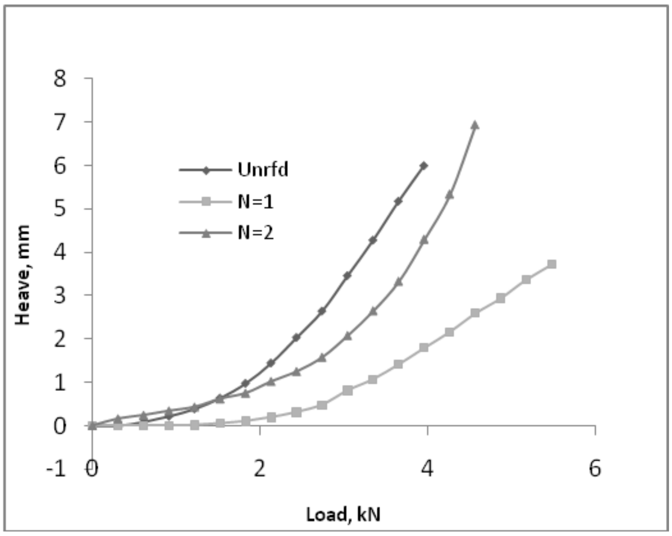

Figure 6: Heave Curve Variation Due to Number of Layer

6.4. Heave Reduction Factor (HRF)

The reduction in heave due to the inclusion of geogrid is represented using a non-dimensional parameter called Heave Reduction Factor (HRF). It is defined as the reduction in heave for reinforced case to the heave of unreinforced case.

HRF = hr – hu / hu

Where hr is the heave of reinforced sand, hu is the heave of unreinforced sand. The Heave Reduction Factor (HRF) for different test series is shown in Table 2.

Table 2: Heave Reduction Factor (HRF)

No of layer	Depth, u/B	Spacing, u/B	HRF %
1	0.25	-	55
	0.5	-	74
	0.75	-	70
2	0.5	0.25	85
		0.5	82
		0.75	88

7. CONCLUSIONS

A series of plate load test was conducted on sand bed with and without geogrid reinforcement to investigate the influence of geogrid on the surface heaving of granular soil. It was observed that the heave is reduced significantly by the inclusion of geogrid reinforcement. Based on the results obtained, the main conclusions are:

- The heave reduction is maximum for 0.5B depth of placement for single layer.
- The Heave Reduction Factor (HRF) for 0.50B depth was found to be 74%.
- In case of double layer, the maximum reduction in heave was found to be for 0.75B and the Heave reduction Factor for 0.75B spacing was found to be 88%.
- It is observed that the heave is increased by the increase of number of layer of reinforcement.

8. ACKNOWLEDGMENT

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