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Behaviour of geogrid reinforced earth retaining walls

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ABSTRACT: The investigation as presented in this paper describes the stress-strain relationships of reinforced earth retaining walls using Netlon geogrids as reinforcement and ferrocement panels as facing elements. The backfill material used was river sand. Model retaining walls for different combinations of vertical spacings of reinforcement were constructed and their behaviour were observed for different surcharge loads. The stress-strain relationships and surcharge load Vs settlement curves have been presented for different reinforcement spacings. It has been concluded that significant reduction in lateral deformation of the wall as well as considerable reduction in vertical settlement of backfill material have been observed in the retaining walls. It will be safe and economical to construct retaining walls with geogrids as reinforcement in situations where there is a likelihood of excessive lateral deformations owing to surcharge loads.

1 INTRODUCTION

During the past 25 years, there has been extensive research work, following the discovering of 'Reinforced Earth' technique by Henri Vidal, which has resulted in the development of a large number of theoretical concepts and a better understanding of the behaviour of actual structures. Thus Construction of retaining walls by successive fill layers using this technique has gained popularity all over the world.

In many engineering problems it is necessary to know accurately both the strength and behaviour during deformation of the materials in use. The study of these material properties forms the subject of the strength of materials and discloses widely varying characteristics for different materials. Satisfying theories and consequent predictions of the behaviour are dependent on making simplifying assumptions and approximations about the observed stress-strain relationships. The stress-strain behaviour of reinforced soil depends on the type and form of reinforcing elements and the interaction between the soil and reinforcement. The objective of this study is to examine the stress-strain relationships of geogrid confined in loose river sand when subjected to short term loadings.

During the last decade, a number of retaining walls have been constructed with geogrids as reinforcement. Reinforced soil retaining walls incorporating geogrids have been constructed in Europe, Hongkong, Malayasia,North America and China. Considerable economy has been achieved in both construction time and over all cost.

Several investigators have worked in this area of stress-strain behaviour of reinforced sand (Schlosser and Buhan, 1990; Fukushima et al, 1988) and on creep characteristics of woven and non-woven geotextile reinforced soil (Holtz et al, 1982).

2 MATERIALS USED

The materials used for conducting the tests include: the geogrid manufactured by M/s NETLON, made of high density polyethylene and marketed under the name CE 121; river sand passing through 4.75mm sieve.

Table 1 illustrates the specifications for the geogrid and the properties of sand used for backfill.

3 PARAMETERS SELECTED

Tests on model retaining walls for different ratios of reinforcement spacing (S_V) to height of wall (H),i.e., S_V/H=0.25 to 1, were carried out. The effect of vertical spacing of the geogrids on the lateral deformation of the wall and the vertical settlement of the backfill under various surcharge loads have been studied. In all the above tests, the ratio of length of the reinforcement (L) to the height of wall (H), i.e., H/L=0.8 has been adopted (Jones, 1987).

Table 1. Specifications of Materials

GEOGRID	
Type	: CE121
Dimensions	
Width	: 2m
Mesh aperture size	: 8 x 6mm
Mesh thickness	: 3.3 mm
Tensile strength	
Max.load (kN/m)	: 7.68
SAND	
specific gravity	: 2.67
Minimum dry unit weight (kN/m^3)	: 14.20
Maximum dry unit weight (kN/m^3)	: 17.00
Angle of internal friction (ϕ)	: 36^o

4 EXPERIMENTAL INVESTIGATION

Investigations were undertaken to study the stress-strain relationships of the reinforced earth retaining wall with sand as backfill under different combinations of parameters as described earlier. The experimental set up and the procedure of conducting the tests are described below:

4.1 Experimental Set Up

A series of experiments were conducted to study the stress-strain relationships of reinforced earth retaining wall. The laboratory model was constructed in a stiff wooden box of size 1400 x 800 x 900 mm,specially fabricated for the purpose. The edges of the box were stiffened by Indian standard angles. On one side of the box, a plexiglass plate is fixed to facilitate observations. The top of the box and the front side are kept open to fill the back fill material and fixing the facing element respectively. In order to simulate the field condition, the end restraint effect was avoided. A 100 kN loading frame was used to transfer the loads through the hydraulic jack. The load was distributed on the backfill uniformly over an area of 1000mm x 800mm in plan, by using a thick wooden plank of same dimensions.

5 TEST PROCEDURE

The model wall, 1000mm long, 800mm wide and 800mm high was constructed using incremental facing system. First the bottom row of precast ferrocement channel was placed in position. Sand is filled in lifts of 100 mm and compacted to a density of 14.2 kN/m^3 by little tamping. Next, the second set of channels were placed above the first row of channels , breaking the vertical line of joints. These channels were connected to the first row of channels using bolts and nuts. As the backfill proceeded up to the level of geogrid reinforcement, the geogrids were lightly tensioned, prior to placing by a small quantify of fill on the free end. The procedure was continued until the top of the wall was reached. To avoid lateral movement of the wall during construction, arrangements were made to support the wall by using proper wooden supports. After the model is constructed, the temporary support was removed. The dial gauges were placed at various positions along the height of the wall, in the central portion of the model wall. Similarly the dial gauges were fixed at four corners on the top to the backfill,for recording the vertical settlement of the backfill. The external load was applied through the hydraulic jack. The lateral deformations as well as vertical deformations were measured by the dial gauges of sensitivity, 0.01mm. Tests were conducted under various surcharge loads ranging from $20kN/m^2$ to $125kN/m^2$. At each surcharge load, the deformations were recorded in the lateral and vertical direction and then the strains at different points, along the height of the wall, were computed, from the observed values of deformations.

6 RESULTS AND DISCUSSION

The relationships between the stress and lateral strain of the wall, under various surcharge loads, for the case of one layered geogrid reinforced model retaining wall has been presented in fig.1. It has been observed that the lateral strain of the wall increases, as the height of the wall increases for each increment of the load and this increase has been found to be maximum at the top of the wall. The shape of the curves is similar for all the load increments. The percent lateral strain decreases as the number of layers of geogrid increases, and these deformations are significantly reduced to a minimum value at the top of the wall, indicating that the geogrids placed in the upper part of the wall prevents the deformations effectively as the geogrid offers good interface friction with the backfill. Also, from fig.2, that the reduction of lateral strain, with the increase in the number of reinforcement layers, has been found to be 43.6%, 66.7% and 84.5%, for two layers, three layers and four layers when compared to one layer only. Fig.3, shows the relationship between lateral strain and stress at the top of the wall, corresponding to a depth of 0.8m from the wall bottom. Further, the reduction in lateral strain is also primarily due to the fact that the angle of shearing resistance increases with more reinforcement layers. The effect of good interlocking between the backfill and reinforcement mobi-

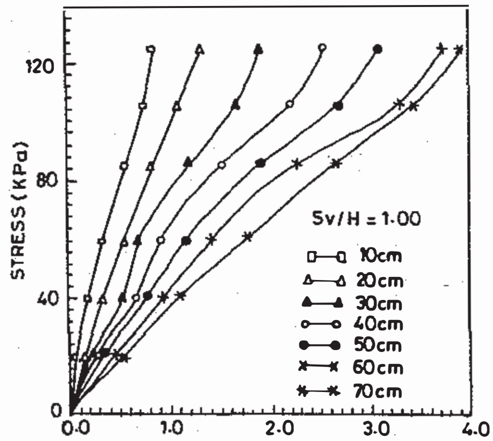

Fig.1 : Relationship between stress Vs % lateral strain for Sv/H = 1.00

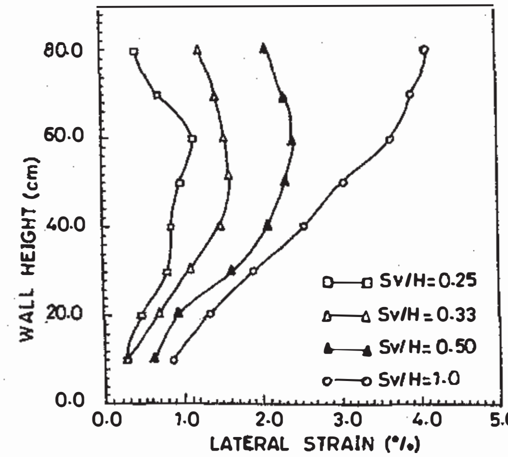

Fig. 2: Relationship between wall height Vs % lateral deformation at maximum surcharge for Sv/H = 0.25 to 1.0.

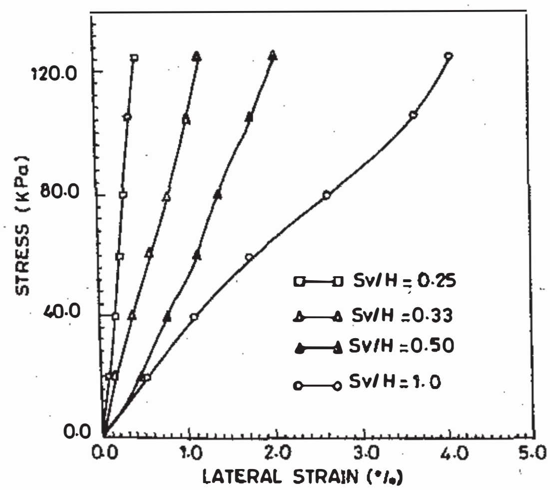

Fig.3: Relationship between stress Vs % lateral strain for Sv/H = 0.25 to 1.00. (0.8m from bottom of wall).

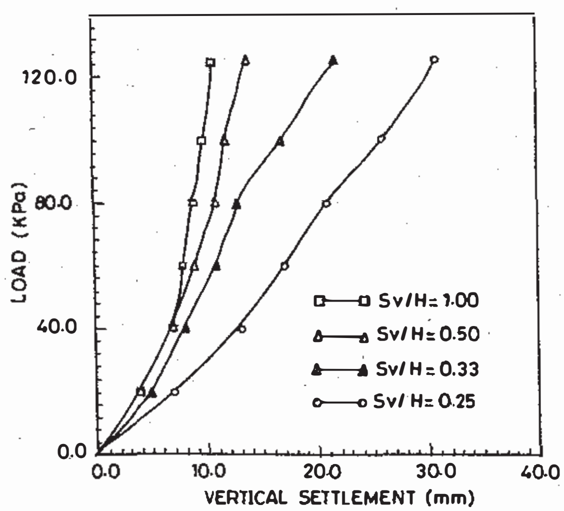

Fig.4 : Relationship between load Vs settlement for Sv/H = 1.00 to 0.25.

lises friction which minimises the lateral earth pressures on the wall.

Fig.4 represents the relationship between surcharge load and vertical settlement of backfill, for various reinforcement layers (S_v/H= 0.25 to 1). It has been observed that there is a gradual reduction of vertical settlement with the increase in reinforcement layers. The magnitude of reduction in vertical settlement (at maximum surcharge loads) is 29%, 48% and 64.5% for two layers, three layers and four layers of reinforcement respectively, when compared to the single layer of reinforcement. This reduction in vertical settlement is due to the densification of high friction fill between the reinforcement layers, with the densified layers acting as slabs.

7 CONCLUSIONS

Based on the investigation conducted, the following conclusions are drawn.

1. Significant reduction (75%) in lateral deformation of the wall has been found to occur with the increase in the number of reinforcement layers.
2. The vertical settlement of the backfill material has been reduced considerably (60%) with the increase in the number of reinforcement layers.
3. It will be safe and economical to construct retaining walls with geogrids as reinforcement, in situations where there is likelihood of excessive lateral deformations owing to surcharge loads.

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