Model Footing Tests on Geofabric Reinforced Granular Fill Overlying Soft Clay

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ABSTRACT: Model footing tests were carried out to determine the effect of a single layer of geosynthetic reinforcement on the bearing capacity of shallow foundations. The tests were conducted with square footings resting on compact sand layer overlying a soft clay subgrade. The effects of size of the footing and reinforcement material properties on the ultimate bearing capacity and settlement of reinforced soil beds have also been discussed.

1 INTRODUCTION

When shallow foundation has to be constructed on very soft and low frictional soils such as clays, the traditional method of soil stabilization consits of providing a stiffer load-bearing base such as a compact granular fill over the soft subgrade. For very soft subgrades, the required fill thickness is often quite high resulting in increased cost. In the present investigation, the effectiveness of a single layer of geosynthetic reinforcement placed at the sand-clay interface is studied through extensive laboratory model tests on square footings of different sizes. Three different type of geosynthetics are used as reinforcement in order to study the effect of their properties on the performance of footings on reinforced soil beds.

2 EXPERIMENTAL PROGRAM

The laboratory model footing tests were performed in a square tank of size 1200 × 1200 × 900 mm. The general view of the experimental set-up is shown in Fig. 1. The model footings were prepared from 25 mm thick mild steel plate and were of rough bottom surface. A self straining reaction frame together with a

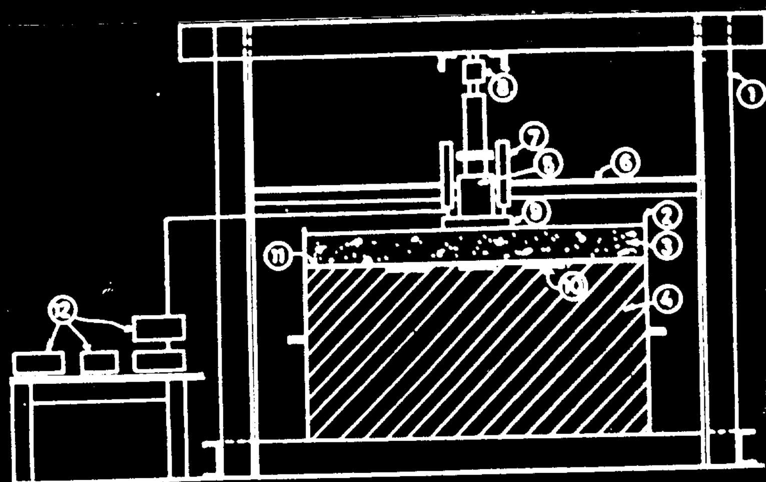

FIG. 1. EXPERIMENTAL SET-UP FOR MODEL FOOTING TESTS
(1) Reaction frame, (2) Steel tank, (3) Sand, (4) Clay subgrade, (5) Hydraulic jack, (6) Slotted angle, (7) LVDT, (8) Load cell, (9) Model footing, (10) Pressure transducer, (11) Reinforcement layer, (12) Indicators and Recoders

hydraulic jack was used for load application. The settlement of footing was measured using two LVDT's (linear voltage displacement transducers) placed diametrically opposite. An electronic load cell connected to a digital read-out was used to record the applied load on footing. The soft subgrade was prepared using marine clay and locally available Mumbra sand was used as fill material. The properties of these soils are reported in Table.1. Three different type of geosynthetics in the form of two varieties of locally available Netlon Geogrid meshes (Geogrid-I and Geogrid- II) and a locally available non-woven Geotextile were used

Table 1 Characteristics of soft and fill soil.

Property	Mumbra Sand	Marine Clay
Unit Weight, KN/m^3	17.30	18.35
Relative Density, %	85.0	—
Friction Angle, deg.	41.0	0.0
Uniformity Coefficient	2.94	—
Average Particle Size, mm	0.42	—
Undrained Cohesion, KPa	—	10.0
Degree of Saturation, %	—	94.0

as reinforcement.Table.2.indicates the salient properties of reinforcements used.

Table 2 Properties of Reinforcement

Reinforcement Type	Mesh Aperture Size mm	Structural Weight g/m^2	Tensile Strength KN/m
Geotextile	Non-woven sheet	300.0	8.40
Geogrid-I	8.0 X 6.0	730.0	7.68
Geogrid-II	27 X 27	660.0	5.80

The parameters varied are;

(i) thickness of the backfill material,H.

(ii) size of the square footing,

(a) 152.4 mm × 152.4 mm

(b) 228.6 mm × 228.6 mm

(c) 304.8 mm × 304.8 mm.

3 TEST RESULTS AND DISCUSSION

Fig.2 illustrates the effect of thickness of sand layer on soft soil with and without a reinforcement layer.It can be seen that for both unreinforced and reinforced cases, ultimate bearing capacity of the layered system increases with increase in thickness of the sand layer upto a maximum value corresponding to $(H/B)_{cr}$ and with furthur increase in the thickness of the sand layer

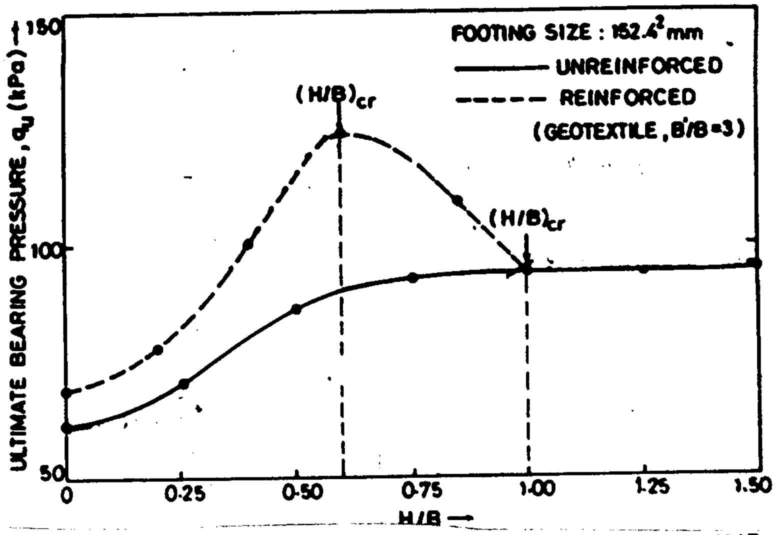

FIG. 2. VARIATION OF ULTIMATE BEARING PRESSURE WITH H/B

beyond $(H/B) > (H/B)_{cr}$there is a negligible improvement.However,with the inclusion of a reinforcing layer at the sand-clay interface,the $(H/B)_{cr}$ value is reduced to 0.6 as against 1.0 for unreinforced case,with a subsequent increase in the ultimate bearing capacity by about 30% as compared to unreinforced system.

Fig.3 shows the variation of bearing capacity ratio (BCR) with H/B for different types of reinforcement used.The interpretation of non-dimensional BCR is as follows:

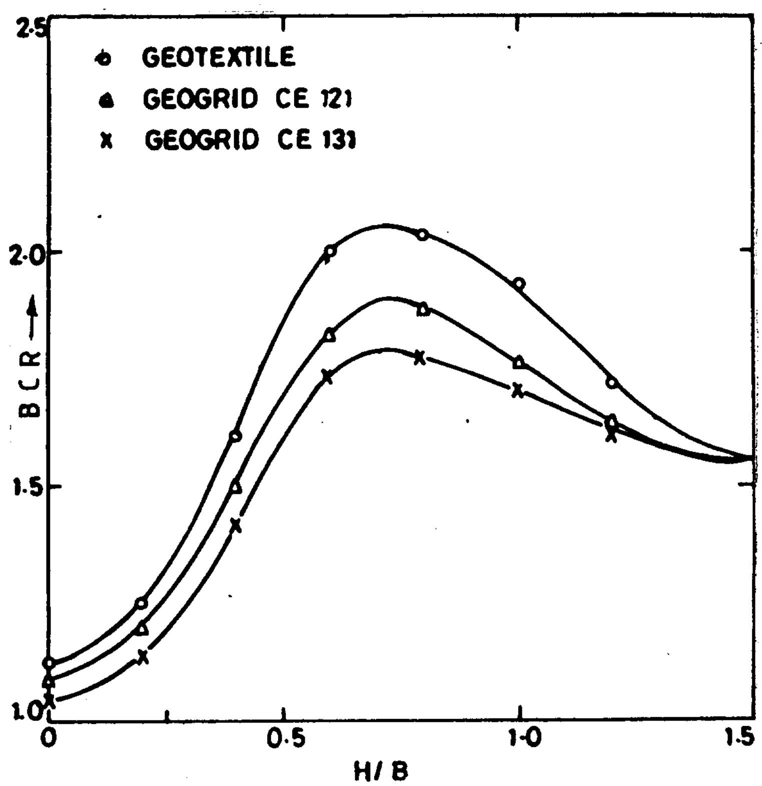

FIG. 3. VARIATIONS OF BEARING CAPACITY RATIO WITH H/B

$$BCR = q/q_o \quad (1)$$

Where,

$$q = q_o + q_1 + q_2 \quad (2)$$

q_o = ultimate bearing capacity at $(H/B) = 0$, (clay only).

q_1 = ultimate bearing capacity with a sand layer of thickness H only.

q_2 = ultimate bearing capacity with a reinforcement layer at a given H/B value.

It is evident fron Fig.3 that reinforcement with geotextile has yielded maximum BCR value which is approximately 30% higher than Geogrid-I and 50% more than Geogrid-II at $(H/B)_{cr}$.The superior performance of the geotextile may be attributed to it's higher charecteristic tensile strength as compared to the geogrids (Table.2). Moreover,due to presence of aperture in the grid structure,there are chances of soft clay being extruded through the grid (which was evident during the model tests) and the bond between the grid and granular layer being minimised.Hence the geotextile which is in plane sheet form acts as a seperator between fill and clay and the contribution of the membrane forces are more significant in addition to the reinforcing action,which results in better performance than the geogrids,especially on soft clay subgrades.

Fig.4 shows the load-settlement curves for all the three sizes of footing.It can be seen that for any given settlement,the corresponding bearing pressure is more for larger size footing,in both reinforced and unreinforced cases.

The variation of BCR with variation in percent settlement (S/B) is shown in Fig.5 for all the three footing sizes.It is obvious that the BCR has remained nearly constant for all three sizes. This shows that the relative improvement exhibited by the reinforced soil beds with small model footings may not change appreciably with large prototype footings.

4 CONCLUSIONS

1.The ultimate bearing capacity of shallow footings on soft clays can be substantially improved by the inclusion of a reinforcing layer at suitable location.

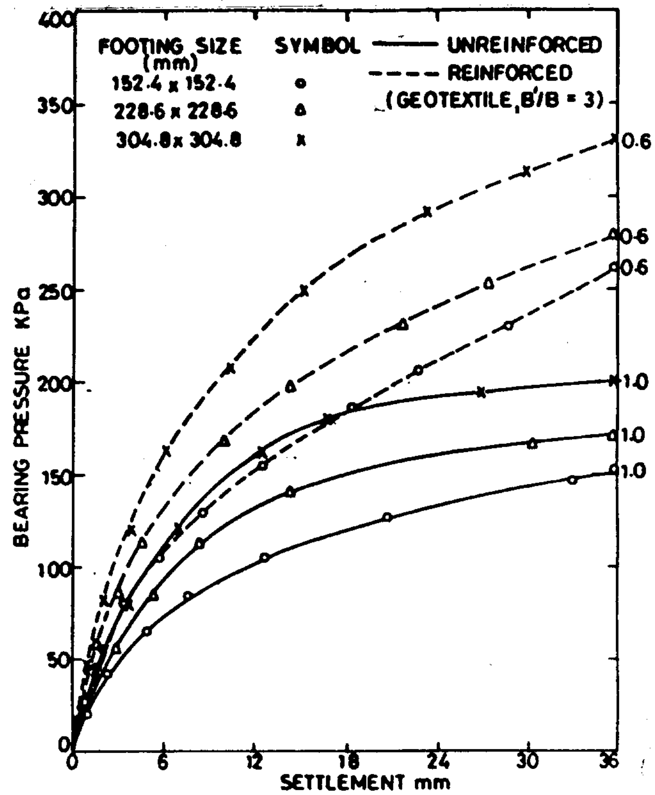

FIG.4. PRESSURE SETTLEMENT RELATIONSHIPS FOR DIFFERENT SIZES OF FOOTING

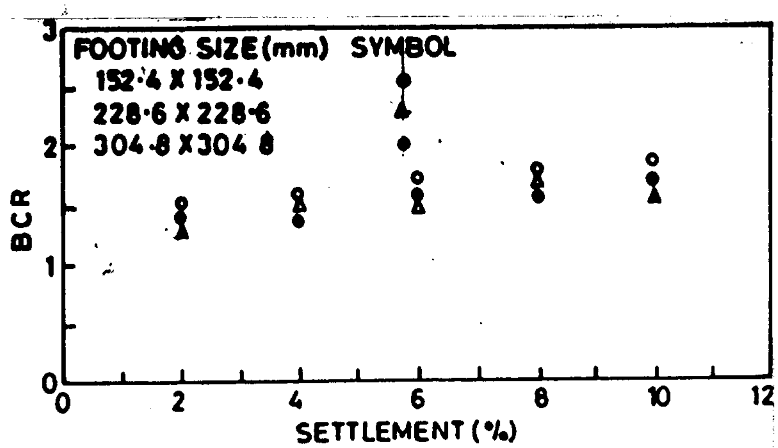

FIG 5. BEARING CAPACITY RATO - SETTLEMENT CURVES FOR DIFFERENT SIZES OF THE FOOTINGS.

2. A geotextile is most ideally suited than geogrids when footings are located on sand above soft clay subgrade.

3.The primary properties of the reinforcement material that affect the performance of footings on reinforced soil beds are their tensile strength,elastic modulus and aperture size.

4.The size of the footing does not have any significant effect on the performance of the footings on reinforced soil beds.

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