Behaviour of strip footing on reinforced granular soil

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Abstract

This paper represents the laboratory test results of behavior in term of settlement and bearing capacity on reinforced and unreinforced sandy soil bed with variation in first layer of reinforcement, number of reinforcement layers, relative density and width of reinforcement layer. The different results are compared here in form of graphs. Failure pattern of soil is also discussed here.

Keywords: *bearing capacity, settlement, strip footing, la boratory test, model test.*

INTRODUCTION

A reinforced sandy soil is a soil bed having horizontal layers of geo-synthetics i.e. geogrid, geocomposits geomembranes, geocells, geonets, geojutes, etc. The granular soil has low tensile strength and therefore reinforcement is beneficial for that purpose. Thus the reinforcement is mainly beneficial to increasing shear strength of granular soil, and other advantages are long term durability, cost effectiveness, fast track construction, structural flexibility, etc.

According to Huang C.C. and Tatsuoaka F(1990), there are two failure mechanism for reinforced bed:-

(1) An anchoring mechanism and (2) A strain Restraining mechanism. In this paper, both mechanisms are tested for reinforced ground. The other main advantage of reinforcement in granular soil is reducing the settlement. For soil with highly uneven settlement, this technic is very useful in reducing the settlement.

Reinforced soil concept is mainly used in stabilizing the earth, earth walls, reinforced slopes and embankment, reinforced foundation, Road base, etc.

A homogeneous deep Sandy ground with tensile-reinforcement layers horizontally placed below a footing, a series of plane strain model tests with a strip footing were performed. The effects of reinforcement layer width, relative density of granular soil depth of layer immediately below foundation are observed. The failure modes of reinforced sandy bed are observed in these experiments (fig.6).

TEST MODEL

Arrangemrnt Of Test Model

A model test was conducted in a tank having size 1000mm long, 500mm wide and 800mm high. A rigid strip footing 80mm wide and had length as width of tank was used. Thus the section formed at the end was a typical section at any length of strip (fig.1). the load was applied on the footing with the help of mechanical jack. One proving ring and two dial gauges were used for recording the results.

In the granular bed, geojute was placed at different depths below the footing. Different depth of first layer (u) and different width of reinforcement layer (b) with different relative density (D_r) were used. The loads were measured by proving ring and the deformation with dial gauges

This test arrangement is illustrated in fig.1, strip foundation was placed on the surfsce of the granular soil, and the reinforcement layer was placed as shown in fig.1. The distance between two layers of reinforcement is Δz, the width of foundation is B and width of reinforcing layer is b. (fig.2)

In this experiment, geojute has been used as a reinforcing element (fig.3)

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Fig. 1 Experimental set-up

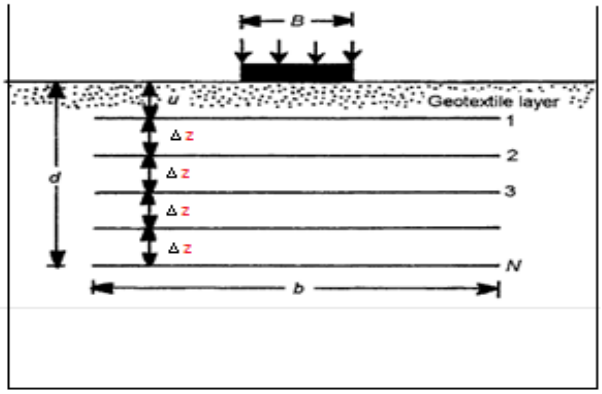

Figure 1 Reinforcing element

Material properties

The soil used for model test has D_{30} = 560µm, D_{10}=390µm, D_{60} =1000µm and Cu =2.56, Cc= 0.841. therefore it is a poorly graded sand.

Specific gravity of soil is 2.63. Maximum density of sand is 1.83 g/cc and minimum density of soil is 1.54g/cc. The model bed is prepared for different relative densities i.e. 30% (1.61 g/cc) and 50% (1.67 g/cc). The cohession of soil is zero and friction angle is 33^o and 35^o for 30% and 50% relative density respectively.

Mass per unit area of geojute is 46.69g and its thickness is 2.16mm.

Fig. 2 Reinforcing material

Test procedure

- Model test tank's height was divided into 7 parts with a rise of each layer as 100 mm. In each part, calcuted weight of sand was poured to achieve relative density of 30% or 50%.
- Tank was filled up to the height of 700 mm.
- Then model strip footing were placed with taking care of the center of strip and model tank.
- The load was applied to the footing in the steps and maintain constant.
- Two dialguages were placed diagonally opposite for recording the settlement.
- A proving ring of 1 ton capacity was connected to the mechanical jack. The model strip footing was loaded incrementally at the rate of 28.5 kg (20 div as per prooving ring constant).
- At the end of each load increment the vertical settlement was noted down.
- The loading was continued till the proving ring shows failure of the soil bed.

Thus, for each experiment, the model was prepared by this method.

TEST RESULT AND DISCUSSION

Following table shows the brief test results in different conditions.

Table 1 summery of the test results for N=3 & ΔZ=100mm

SR No	Dr(%)	u (mm)	b	Qulti	s/B (%)
1	30%	-	-	264	34
2	50%	-	-	464	37
3	30%	100	6B	286	13
4	30%	50	6B	528	28
5	30%	100	3B	257	12
6	30%	50	3B	543	34
7	50%	100	6B	543	11
8	50%	50	6B	543	13
9	50%	100	3B	486	11
10	50%	50	3B	571	18

Table 1 shows the ultimate load carrying capacity (Q_{ulti}) and settlement ratio (s/B) in percentage.

The different signs used in graph and table are:

u = the depth of first reinforcement layer beneath strip footing in mm

b = width of reinforcement layer

Dr = relative density

B = width of footing

s/B = ratio of settlement to footing width in percentage

Q_{ulti} = load at failure in kN

N = No. of reinforcement layer

The load-settlement graph for relative densities of 50% and 30% are shown in fig.4 & 5. It can be seen that there is substaincial reduction in settlement and significant improvement in load carrying capacity due to geojute reinforcement.

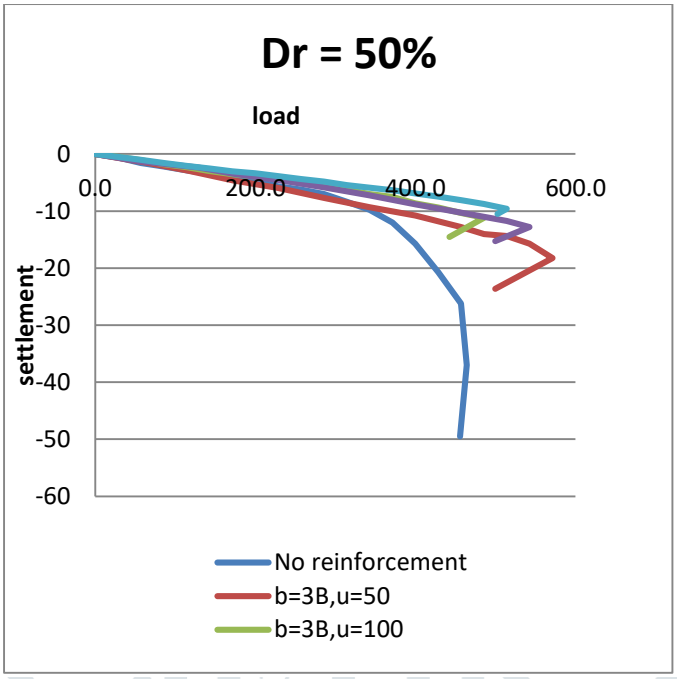

Fig. 4 Graph for relative density 50%

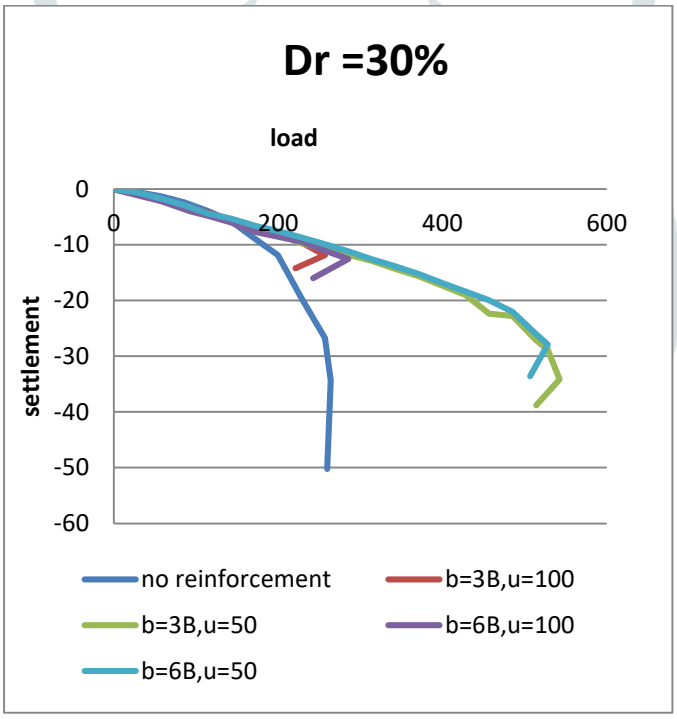

Figure 2: load settlement curve for D_r = 30%

The load carrying capacity at the settlement of 8mm of footing width is shown in table 2

.

We never allow the foundation to settle more than 5 to 10% of its width therefore the table for comparison is shown below

Table 2 *Load increased due to reinforced bed for relative density 30%*

Sr No	S(mm)	Load At Unreinforced Condition(Kg)	Reinforced Load(Kg)	Remark	Increased Load (%)
1	8	163.3	202	u=100,b=3B	23.7
2	8	163.3	197.1	u=50,b=3B	20.7
3	8	163.3	181.85	u=100,b=6B	11.4
4	8	163.3	220.8	u=50,b=6B	35.2

Table 2 result shows that there is increase in load carrying capacity from 16 to 48% for three layers of geojute reinforcement

Table 3 *Load increased due to reinforced bed for relative density 50%*

Sr No	S(mm)	Load At Unreinforced Condition(kg)	Reinforced Load(kg)	Remark	Increased Load (%)
1	8	306	382	u=100,b=3B	24.8
2	8	306	296.8	u=50,b=3B	-3.0
3	8	306	453	u=100,b=6B	48.0
4	8	306	370	u=50,b=6B	20.9

Table 3 result shows that there is increase in load carrying capacity from 11 to 35% for three layers of geojute reinforcement

By studding graphs and tables we can conclude following,

- There is no such different ultimate load and settlement for 3B and 6B width of reinforcement.
- For medium dense sandy soil change in u is not effective but in loose sandy soil, CBR increases up to 80% to 100% at ultimate load condition
- Settlement reduces 60% to 70% in reinforced condition compared to unreinforced condition.
- All failure condition for reinforced bed is local shear failure (fig. 7).

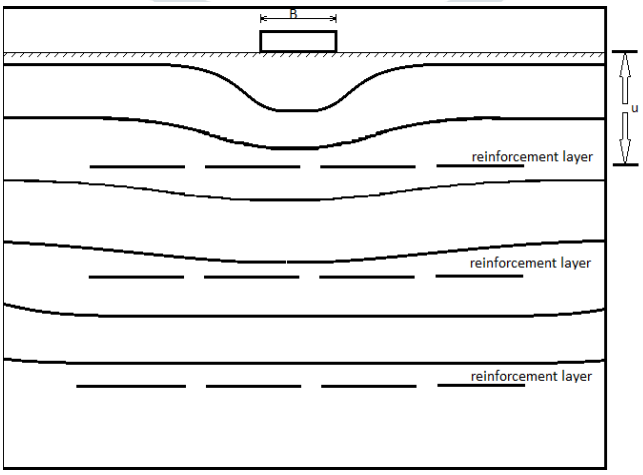

Figure 3 : failure pattern for reinforced sandy bed

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