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Bearing capacity of shallow foundation on reinforced sandy bed

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Abstract— ***This paper represents the laboratory test of sandy bed having relative density 30% and reinforcement width is three times the width of the footing. It is found that the depth of first reinforcement layer (u) more than 0.625B is not beneficial. Bearing capacity and settlement had been measured for u/B = 0.25, 0.4375, 0.625 and for N = 1, 2, 3. The equation for bearing pressure have been generated from practical data.***

Keywords—bearing capacity, settlement, strip footing, laboratory test, model test.

I. INTRODUCTION

A reinforced sandy soil bed is a soil bed having horizontal layers of reinforcing material i.e. geo-grid, geo-composites, geo-membranes, geo-cells, geo-nets, geo-jutes, etc. The granular soil has low tensile strength and 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.

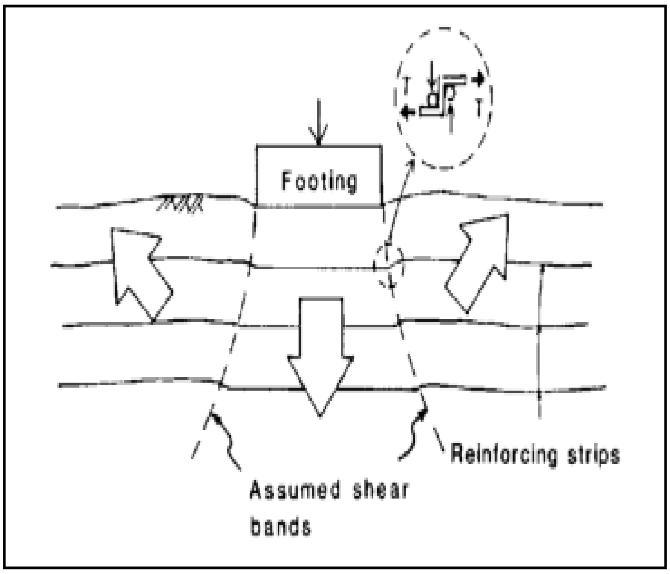

Fig. 1 Load bearing mechanism of reinforced bed

According to Binquet& Lee, the assumed shear band is formed by joining maximum shear stress points. Soil between the shear bands is settled downward and the soil outside the shear bands will move laterally in upward direction as shown in Fig.1.

According to Huang C.C. and Tatsuoaka F, there are two failure mechanism for reinforced soil bed loaded with footing, (i) An anchoring mechanism and (ii) A strain Restraining mechanism. In this paper both mechanisms have been tested for reinforced soil bed. The other main advantage of reinforcement in sandy soil is to reduce the settlement. For soils with highly uneven settlement, this technic is beneficial.

According to K.H.Khing &B.M.Das, the reinforcement layer can increase the bearing capacity of soil bed up to 67 to 70% at a particular settlement.

II. TEST MODEL

A. Arrangement Of Test Model

The tests were carried out in the model tank having dimension of 1000mm long 500mm wide and 800mm high. A rigid strip footing of 80mm wide and 500 mm length, was placed on the soil bed. Thus the section formed at the end is a typical section at any length of strip. Load is applied by mechanical jack at constant interval (Fig.2).

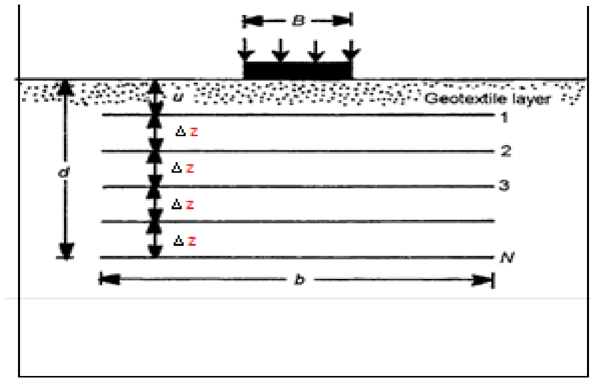

Fig. 2 Graphical view of experimental set up

B = width of footing,

Δz = distance between reinforcement,

b = width of reinforcement layer,

u = first layer depth beneath footing,

N = number of reinforcement and

d = total depth of reinforced layer.

B. Material properties

The soil used for model test has D_{30} = 560µm, D_{10}=390µm, D_{60} =1000µm and C_u =2.56, C_d = 0.841. It is a poorly graded sandy soil.

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 soil bed is prepared for different relative density i.e. 30% (1.61 g/cc) and 50% (1.67 g/cc). Cohesion of soil is zero. And friction angle is 33^o and 35^o for 30% and 50% relative density respectively.

Properties of geo-jute are (i)mass per m^2 area of jute is 46.69g and (ii) thickness of jute is 2.16mm.

C. 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.
- Model strip footing was placed at the centre of the soil bed.
- The load was applied to the footing in the steps and was maintained constant, during the experiment.
- Two dial-gauges were placed diagonally opposite for recording the settlement.
- A proving ring of 10 kN capacity was connected to the mechanical jack. The model strip footing was loaded incrementally at the rate of28.5 kg (20 div as per proving 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.

III. TEST RESULT AND DISCUSSION

TABLE 1COMPARISON FOR U = 20MM WITH N = 1, 2, 3

(D_r=30%,u=20=Δz,b=3B)					
	s/B(%)	u_r	reinforced bed q_u (kN/m^2)		
N			1	2	3
	34	66	71.25	92.5	112.75
% increase			7.954545	40.15152	70.83333
	10	47.25	49	50.75	55
% increase			3.703704	7.671958	16.40212

The Table-1 shows the bearing pressure at s/B 10 and 34% and increment of bearing capacity in percentage. This table is for u=20mm and following tables are for u= 35mm and 50mm.

TABLE 2COMPARISON FOR U = 35MM WITH N = 1, 2, 3

(D_r=30%,u=35=Δz,b=3B)					
	s/B(%)	u_r	reinforced bed q_u (kN/m^2)		
N			1	2	3
	34	66	82	128.25	149.75
% increase			24.24242	94.31818	126.8939
	10	47.25	52.5	65.25	67.5
% increase			11.11111	38.09524	42.85714

TABLE 3COMPARISON FOR U = 50MM WITH N = 1, 2, 3

30,50,50,3B					
	s/B(%)	u_r	reinforced bed q_u (kN/m^2)		
N			1	2	3
	34	66	82	114	135.5
% increase			24.24242	72.72727	105.303
	10	47.25	36.62	48.8	62.25
% increase			-2.4868	3.280423	31.74603

A. Equation generation

TABLE 4EQUATION GENERATION

SR. No.	N	u/B	q_u (kN/m^2)	d/B
1	1	0.625	75	0.625
2	2	0.625	114	1.25
3	3	0.625	135.5	1.875
4	1	0.4375	82	0.4375
5	2	0.4375	128.25	0.875
6	3	0.4375	149.75	1.3125
7	1	0.25	71.25	0.25
8	2	0.25	92.5	0.5
9	3	0.25	112.75	0.75

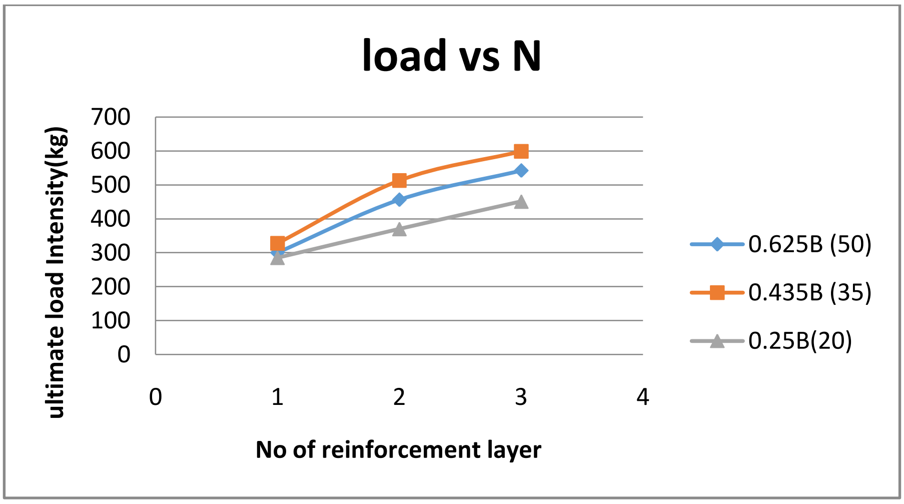

Figure 4 Chart of Load vs settlement for different value of u/B

Above three curves are for bearing capacity of different N for one u/B. As we can see it is increasing up to three layer and the curve becomes straight line after value of N = 3. Thus the equation of the curve is as follow.

- The equation for u/B = 0.625

$Qu =$ -22.4(u/B)^2+104.4(u/B)+18.5…………………………..(1)

- The equation for u/B = 0.4375

$Qu =$ -64.65(u/B)^2+109.57(u/B)+11…………………………(2)

- The equation for u/B = 0.25

$Qu =$ -8(u/B)^2+91(u/B)+49………………………………...(3)

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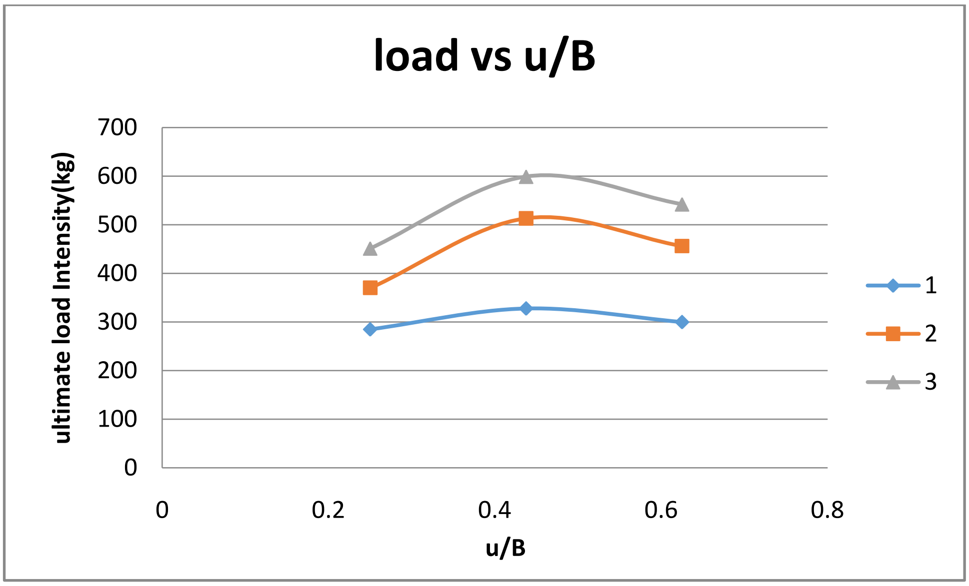

Figure 5: Chart of Load vs u/B for different value of N

Above three curves are for bearing capacity of different u/B for one N. Thus the equation of the curve is as follow.

- The equation for N = 1

  $Qu =$ -252.244(N*u/B)^2+230.89(N*u/B)+29.3……………(4)

  Maximum Qu at here u/B = 0.4573

- The equation for N = 2

  $Qu =$ -711.12(N*u/B)^2+679.55(N*u/B)-32.94……………(5)

  Maximum Qu at here u/B = 0.4778

- The equation for N = 3

  $Qu =$ -728.89(N*u/B)^2+698.45(N*u/B)-16.3………………(6)

  Maximum Qu at here u/B = 0.4691

IV. SUMMARY

- 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, Soil Bearing Ratio(SBR) increases up to 80% to 100% at ultimate load condition
- Settlement reduces 60% to 70% in reinforced condition compared to unreinforced condition.
- The reinforcement is effective for u/B < 0.65
- Equations for Qu are generated for different u and N conditions.
- The maximum benefit is for near u/B = 0.47 for all layer.

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