EFFECT OF THE SIZE OF SAND PEDESTALS ON BEARING CAPACITY OF FOOTINGS IN SOFT SOILS

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The effect of the thickness as well as the breadth of the pedestal on the bearing capacity of the footing has been studied and an economical size of the pedestal has been suggested. The study has been confined to models only. The soil used for this study was a very soft clay having plasticity index 70 per cent and having 68 per cent of its particles less than 2 micron size.

Whenever single footing is required to be placed on any soft soil of considerable thickness, either piles are given or deep foundations are provided. Sometimes the footing is placed much below the ground level and the pit is filled back with the excavated soil. Instead of filling the foundation pit with the excavated soil, at times, sand is used to fill up the pit. The problem whether there would be improvement in the bearing capacity and settlement of footing, if the footing is placed over a sand pedestal of the size which is to be made in the soil strata, has been studied in the laboratory through models and the results have already appeared[1]. In the present work the size effect of the pedestal has been studied and attempt has been made to suggest an economical size of the pedestal for such a footing.

MATERIALS USED

Soil

The soil consisted of 100 per cent of minus B.S. No. 200 sieve size particles out of which 68 per cent of the particles were smaller than 2 micron size. The plastic limit and the liquid limit were 60 per cent and 129·8 per cent respectively. The specific gravity of the soil particles was 2·676. The vane shear strength at 118 per cent m.c. (moisture content) was 40 gm/cm.^{2} and at 182 per cent m.c. it was 12·3 gm/cm^2. Two series of tests have been conducted, one at 182 per cent m.c. and the other at 118 per cent m.c.

Sand

The sand used was of uniform size passing through B.S.S. No. 25 and retained in No. 36. It was washed before use. The specific gravity of the sand particles was 2·68. The average moisture content of the sand in the pedestal was 20 per cent which gave a voids ratio $e_i = 0\cdot54$ and relative density 0·60 approximately.

The angle of internal friction of the dry sand was approximately 44° as obtained from direct shear tests.

Footing

The model footing was of polished teak wood having the size 2·54 cm. × 2·54 cm. × 0·32 cm. (1″ × 1″ × 1/8″). The soil being very soft, metal footing was not used because the self weight of such footing was considerable.

PREPARATION OF SPECIMENS

The mould used for the study was C.B.R. mould. Each mould was filled with soil in 3 layers with required consistency, each layer having been given 50 falls on a wooden platform. The specimen thus made was pressed in a 5 ton press for 5 minutes after which it was left submerged in a water tank for a period of one month. The last sample was in water for about 3 months.

To prepare the pedestal, a hole of the required size was cut carefully at the centre of the specimen such that the sides remained vertical and the depth did not exceed the desired value. The sand was placed inside the hole in a wet stage and rodded by a knife. During rodding operation water from the sand used to come out. Each hole was filled by sand in three instalments. After filling the hole the surface of the sand mass was made plane and the extra sand was removed from the surface.

The specimens were tested under submerged condition. The loading was done by lever arrangement that are normally employed in consolidation tests, but of an improved type.

OBSERVATION, RESULTS AND DISCUSSION

Table 1 gives the details about all the specimens prepared in both the series. Examination of these data reveals that the specimens of any one series are almost identical in nature and thus could be taken to behave identically under similar conditions.

TABLE 1

DETAILS OF VARIOUS SPECIMENS USED IN THE EXPERIMENT

Specimen No.	Wet density gm/cm.^{3}	m per cent (m.c.)	Initial voids ratio (e)	Vane-shear strength gm/cm.^{2}	Remarks
1	1·27	182·0	4·49	12·3	First series, remoulded strength 10·8 gm/cm.^{2}
2	1.27	182.2	4.49	12·8	
3	1·27	182·4	4·48	12·3	
4	1·27	180·5	4·49	13·8	
5	1·27	181·2	4·49	13·0	
6	1·27	183·0	4·49	12·3	
1	1·36	117·6	3·15	40·04	Second series, remoulded strength 30·8 gm/cm.^{2}
2	1·36	118·5	3·17	40·04	
3	1·38	118·0	3·15	40·04	
4	1·36	118·2	3·16	40·04	
5	1·38	118·4	3·16	40·04	
6	1·37	117·8	3·15	40·04	

TABLE 2

VALUES OF μ FOR DIFFERENT TYPES OF PEDESTALS

Pedestal size		μ (per cent)
Breadth (B)	Depth (D)	
$1 \cdot 0B_f$	$2 \cdot 0B_f$	61
$1 \cdot 5B_f$	$1 \cdot 0B_f$	65
	$1 \cdot 5B_f$	73
	$2 \cdot 0B_f$	78
$2 \cdot 0B_f$	$0 \cdot 5B_f$	59
	$1 \cdot 0B_f$	88
	$1 \cdot 5B_f$	93
	$2 \cdot 0B_f$	$97 \cdot 5$

$\mu = \frac{\text{Observed value of bearing capacity}}{\text{Theoretical value of bearing capacity.}}$

The bearing capacity of the footing for any specific case has been found out from the load settlement curve as indicated[2,3] in the Fig. 1. The bearing capacity increases with increase either in thickness or in breadth of the pedestal.

When the bearing capacity of the footing is calculated on the assumption that the entire soil specimen is of sand only and it is of the same relative density as in the sand pedestal, then from Terzaghi's formula for a surface square footing, for $\gamma_{sub} = 1 \cdot 215$ and $N\gamma = 260$, "Bearing Capacity" of the footing comes to 2080 gms. The observed value was 2025 gms. for the case when the pedestal size was $2B_f \times 2B_f \times 2B_f$ (B_f is the breadth of the footing $= 2 \cdot 54$ cm. in this study) which came to $97 \cdot 5$ per cent of the theoretical value calculated on the assumption that the entire specimen is sand only. Table 2 shows the values for other sizes of the pedestal. This observation suggests that when the pedestal size becomes $2B_f \times 2B_f \times 2B_f$ the footing above the pedestal behaves as if it was over a subsoil of sand only having a relative density equal to that of the sand in the pedestal. This condition develops, most likely, due to the stress concentration with-

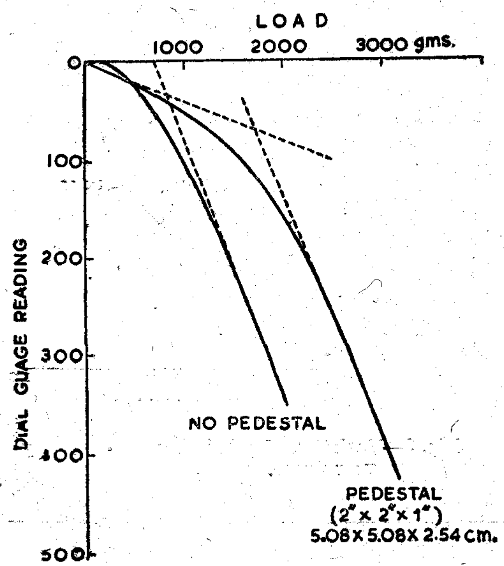

Fig. 1—Load settlements curve.

in the sand zone. Such stress concentration within the top layer has been speculated in theoretical analysis done for a double layer system using Burmister's formulae[4]. The gain in bearing capacity, which has been defined as the ratio between the bearing capacity of the footing with pedestal to that of the footing without pedestal, has been plotted against breadth of the pedestal in Fig. 2. From this figure it is seen that the curve for $D = 1\cdot5B_f$ is closer to curve for $D = 2\cdot0B_f$ than to curve for $D = 1\cdot0B_f$ which indicates that for a given breadth of the pedestal, when the thickness is more than $1\cdot5B_f$ the resulting gain in bearing capacity is not as much as what it is for cases when $D < 1\cdot5B_f$, for same increase in thickness. All the three curves in Fig. 2 are some what parallel to each other indicating that the rate of 'gain in bearing capacity' with increase in breadth of the pedestal is almost same for different thickness of the pedestal within the observed values.

Fig. 3 is obtained when gain in bearing capacity versus volume of the pedestal is plotted. Points obtained from tests having $B = 2\cdot0B_f$ are remaining in a separate curve, (No. 2) from that for the rest of the points, curve No. 1. When the breadth of the pedestal is equal to twice the footing breadth, the pedestal behaves more like a 'flexible mat' than a footing*. In such cases the footing was seen to have punched into the sand pedestal at failure, unlike the situation that developed at failure when $B = 1\cdot5B_f$ or $1\cdot0B_f$. When $B = 1\cdot5B_f$ or $1\cdot0B_f$, the pedestal punched into the soil along with the footing. The failure pattern for $B = 2\cdot0B_f$, $D = 0\cdot5B_f$ is shown in Fig. 4. Thus the situation at failure being different for $B = 2\cdot0B_f$, from $B = 1\cdot5B_f$ or $1\cdot0B_f$, the points are remaining in a separate curve for these cases. The rate of gain per unit volume is higher for curve No. 2 than that for curve No. 1. Both the curves intersect at a point where the volume is equal to roughly $2\cdot25\ (B_f)^3$ and the gain is $1\cdot78$. As it appears from the trend of the curve No. 2 if the thickness would further reduce the gain would have decreased very rapidly and may be, when $V = 1\cdot5\ (B_f)^3$ or near about that value, equal to unit. But for $V = 1\cdot5\ (B_f)^3$ the gain is $1\cdot52$ in curve No. 1. Thus it could be concluded that for smaller volume the pedestal is more effective if the thickness is increased keeping breadth

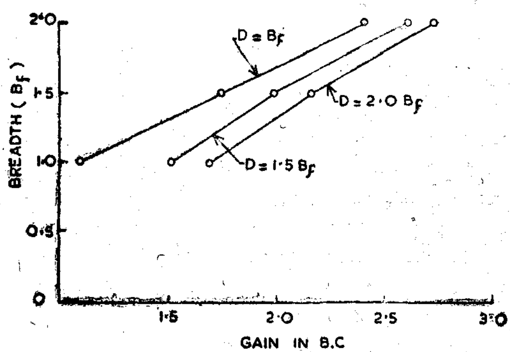

Fig. 2—Variation of gain in bearing capacity against breadth.

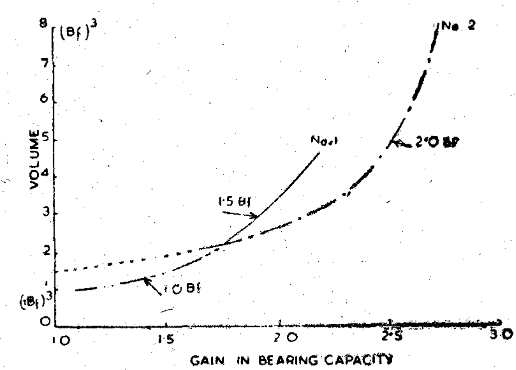

Fig. 3—Variation of gain in bearing capacity vs volume.

*From three different tests three different values of gain have been obtained, for pedestal size 5·08 cm. × 5·08 cm. × 5·08 cm. and these are 2·73, 2·79 and 3·0. The lowest one has been considered.

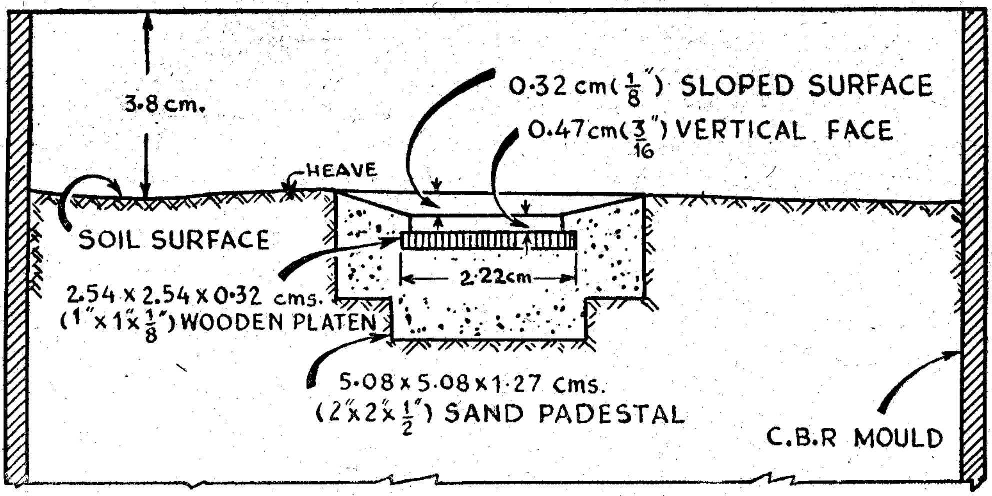

Fig. 4—Failure pattern when $B = 2 \cdot 0B_f$.

constant at $B = 1 \cdot 0B_f$, instead of keeping thickness constant at $D = 1 \cdot 0B_f$ and increasing the breadth. But when the volume of the pedestal is to be more than $2 \cdot 25\ (B_f)^3$ that is when higher gain is desired, it is better to keep $B = 2 \cdot 0B_f$ to derive better advantage for same cost. The economical size of the pedestal when gain per unit volume of sand is considered, is when $B = 1 \cdot 5B_f$ and $D = 1 \cdot 0B_f$, or having dimensions near about these values.

CONCLUSIONS

The gain in bearing capacity increases with increase either in breadth or in thickness of the pedestal.

When the thickness of the pedestal is equal to $1\frac{1}{2}$ times the breadth of the footing, the effect due to further increase in thickness is not as much as what it is for values less than $D = 1 \cdot 5B_f$.

When the breadth of the pedestal is twice the breadth of the footing and the thickness is not less than 50 per cent of the breadth of the footing, the pedestal behaves like a 'fixible mat', and gives higher gain in bearing capacity than what it should have been for other sizes of the pedestal having same volume of materials.

The economical size of the pedestal is when its breadth is 150 per cent of that of the footing and its thickness is equal to the breadth of the footing.

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