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Experimental Evaluation of Bearing Capacity of Thickness and Embedment Depth of a Ring Footings

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Abstract *for several years structural ring footings have been used for their durability advantages beneath the shallow foundations of maritime structures. However, limited knowledge of the efficiency and use of ring footings as traditional shallow foundations is available. The ability of these foundations was tested in of laboratory testing in this study. The effects of skirt rigidity and depth were analyzed in this sense on the bearing ability of skirted footing models. The test results were then compared with other equations of bearing power. It was determined that using structural ring, both soil-rings and the soil-footing depth would increase their support capability up to 1.62 times, based on the geometry and structural requirements of ring footings.*

The building, since the number of drilling and filling works falls with the ring footings, is distinct from conventional foundations. The soil under the base can also be avoided by using the peripheral ring, and any disruption incurred by excavations in nearby building works can be minimized. Given the theoretical benefits of ring footings, utilization of such constructions seems important for the expenditure and productivity. In the meantime, more studies on the bearing capacity and settling actions of the nearby foundations must be carried out in order to demonstrate their benefits for practical engineers. Several research studies relevant to this subject will be reviewed in the following section.

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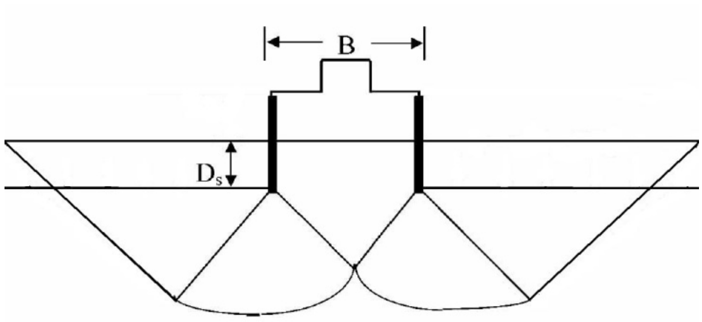

Figure 1. Increase in length of slip lines due to using of ring

the literature in geotechnical engineering, the topic of bearing capacity of low foundations is commonly debated. several approaches for assessing the bearing capacity of foundations embedded in soils have so far been presented. A minimal balancing technique is used in most traditional approaches. Centered on the principle of restricted balance a general scissor mechanism is adopted under a strip base in a homogeneous soil. A limit equilibrium technique is used in most traditional approaches. Centered on the principle of restricted balance a general scissor mechanism is adopted under a strip foundation in a homogeneous soil. A rise in slip length can be accomplished by either increasing the foot width or the depth of the embedding (Das, 2007). The use of structural rings covering the ground can also be an effective way to improve the slip length Fig (1). This kind of structure may also minimize the costs of foundational construction as, in contrast with traditional foundations, excavation and filling operations for the ring foundation are minimized. In addition, the soils can be squeezed from under the footings using the peripheral rings.

Keywords. Ring footing, bearing capacity,height of ring, ring ratio

2. Testing Setup and Materials.

Loading experiments on rolling model foundations in a test box in a rigid steel structure were conducted. For the loading frame, a test box of (1 – 1 – 1) M inside was chosen. With the loading frames available. The test box consists of a solid steel floor and two steel angles sides with metal straps. Other faces were formed to prevent lateral expansion, the inner faces of side walls have been greased and kept on the surface for at least an hour in order to minimize boundary friction (Yung et al., 2004). 30cm wide models based on box dimensions have been introduced to reduce rigid wall impact on the support capability (Salençon, 2002; Bowles, 1996). The foundation was made of aluminum plates that are shown in Figure 2 for their standard specifications. A rigid foundational base and an aluminum plate ring shaped as a box profile consisting of each footing. A number of screws during the model placement in the sand could fix the solid foundation to the ring. The body width was reduced almost to the size of the standing length using two steel profiles of 100 mm width to preserve the smooth strain in the soil under the model foundation. Every end of the foundation is located near the stainless-steel profile in this condition and avoids soil movement in the direction of longitude. Small lubricated films on the contact surfaces of the base ends and the steel profiles were arranged in order to remove friction at their interfaces.

2.1. Materials

In this experimental study, fine sand was included. Figure 3 indicates the grading curve of this sand. D10, D30, and D60 sand grade characteristics were determined to be 0.27, 0.45, and 0.83mm, respectively. The coefficient of uniformity, Cu, was found to be 3.2, and the coefficient of curvature, Cc, was found to be 1.04. According to the unified soil classification system, the sand was categorized as standardized or poorly graded sand, SP.

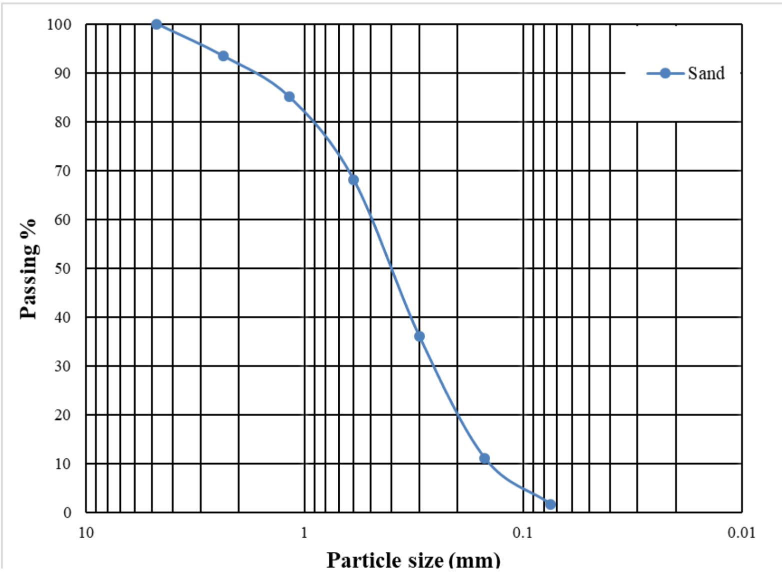

Figure 2. particle size distribution

The sand's specific gravity was estimated at 2.65. The soil's minimum and maximum dry unit weights were estimated to be 16.28 and 18.69 kilograms per cubic meter, respectively. A moderate density condition was obtained at unit weight of 16.8kN/m3 using the sand raining method, which equals 61 percent relative density. The density that can be obtained using this technique is calculated by the strength and homogeneity of the sandy rain, and also the elevation of the drops (Cresswell et al., 1999). When the sandy soil poured inside the testing tank at a flow rate of 22g/sec through with a funnel from a steady height of 60cm, the test density was obtained. The strength characteristics of the sand were identified by direct shear checks. These tests were carried out on 10cm diameter samples at standard stresses 400, 500and 650 kPa at a shear displacement rate of 30 mm/min. The sand's peak friction angle was determined to be 42 degrees on average. To have harsh interactions with sand in footing load experiments, proper sand paper was glued to the anterior and posterior sides of the ring, and also the lower face of the footing. 36o over the same usual stress with the direct shear unit, the tension angle between both the test sand and the abrasive paper has been calculated. This magnitude of the touch angle of friction is nearly equal to the friction angle between cement and soil and can represent actual foundation conditions. ϕδ90. ≈ promoting the recession.

2.2. Test Procedures.

Sufficient sand height was required to prevent possible effects on foot bearing capability of the rigid base of the test box. As such, multiple loading experiments were conducted on a standard model basis at in the test box. These findings showed that the base bearing power was sympathized with almost a steady sand thickness greater than 4B (B; width of model footing). The 4B sand loading was also within the test box to prevent any impact on the foot bearing capability of the solid bottom of the box.

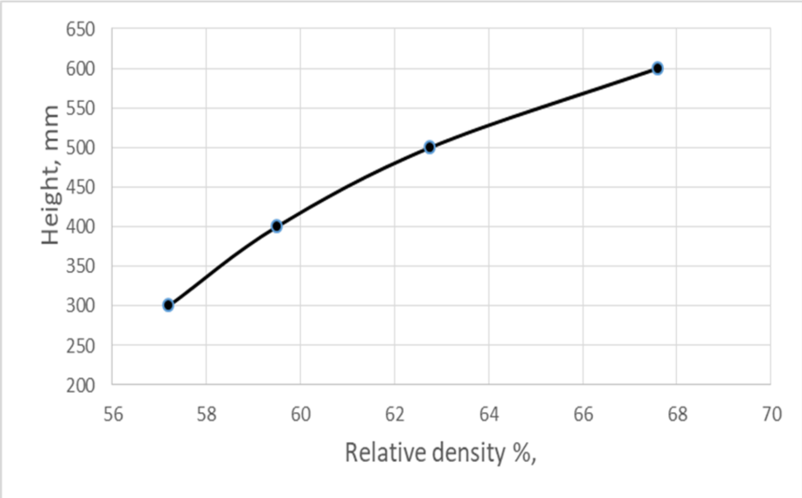

Figure 3 hieght versus relative density

Both internal faces of the test box walls were correctly lubricated to conduct any loading test. The box was then put inside and packed with sand in the loading system of the triaxial appliance. The positioning of the sand was carried out using the sand raining technique to achieve the target height of 4B. The footing ring was then centrally positioned around the box's width. Sand started to rain and the test chamber was expected to be the basis concurrently. After leveling the sandy surface within the ring, the base was carefully tightened by eight screws. The model base was subjected to centric vertical loading at a rate of 1 mm/min with a displacement control system. A 30kN proof ring with 10N accuracy was registered for the applied load at each settlement of 0.5mm. Different levels in the sand bed and loading test are seen in Figure4. Tests were often regarded as being repeatable and while the variation in outcomes was usually less than 5%, the average values for three replications were used to produce more detailed results.

Load cell Mechanic jack Dial guages

Figure 4. instruments used in the experiment

3. Research Results

3.1. Effect of ring Footing ratio d/D on the Bearing Capacity.

The ring ratio have a major impact on bearing capacity in sand as in Table (2) with different ring ratio (0,0.33,0.5,0.67,0.95) and the same external Diameter and height (the dimensions in table 1) because the width of the foundation included in the calculation on the other hand it has no effect on clay soil because of neglecting the angle of internal friction.

Table (1) dimensions for the ring footing

property	**dimension**	**units**
Diameter	10	m
Ring hieght	1	m

Table (2) Effect of ring Footing ratio d/D on the Bearing Capacity

hieght of footing in m	**Qu (KN) Sand**	**Qu (KN) Clay**
d/D = 0.33	**2360**	**310**
d/D = 0.5	**1590**	**310**
d/D = 0.67	**1100**	**310**
d/D = 0.95	**350**	**310**

3.2. Effects of Embedment Depth

Two ring heights were taken for the ring footing to see the influence on bearing capacity.as in Table (5.2) it has been observed that sand case bearing capacity increases as the ring footing height increases to about 50%, and in C clay case the bearing capacity also increases with depth to about 24%. so it is preferable to use the ring footing in a sandy soil.

Table (3) Effect of ring Footing height on the Bearing Capacity

hieght of footing in m	**5**	**10**
Qu (KN) Sand	**3500**	**6000**
Qu (KN) Clay	**400**	**480**

3.3 Effect of Footing Size (B) on the Bearing Capacity.

Table (5.1) shows that in the case of sand, it was concluded that, when the diameter of footing increased from 10 m to 30 m, the ultimate bearing capacity; qu was increased to 10%. The reason for this, is that the width of the footing included in Terzaghi bearing capacity equation,

In sand over clay case shows the same behavior of the sand case because the subsoil influenced bearing capacity is sand.

$H=\frac{B}{2}\tan(45^{\circ}+\frac{\emptyset}{2})$……………………………………1

H= the influenced depth of subsoil

B = width of a shallow foundation,

$\emptyset$ = the angle of soil internal friction.

BOWLES (1996).

In the engineering practice, it is usually assumed that $H = 2B$ (Budowli, 1981.)

bearing capacity in clay is lower than that in the sand and it can be observed that there was no effect of the footing size, the bearing capacity was approximately equals and in clay over sand case the results were the same off clay case.

Table (4) effect of bearing capacity in different Footing Size

Diameter of footing in m	**10**	**30**
Qu (KN) Sand	**3400**	**3700**
Qu (KN) Clay	**400**	**400**

4. Conclusion.

1- Using peripheral structural ring improves the overall foundation performance in terms of increasing bearing capacity, lowering excavation volume, and encompassing the soil in between ring.

2- the bearing capacity of a ring footing increases with the increase of the ring length (L)

3- The theoretical ultimate bearing capacity values decreases as the width B of the footing decreases.

4- It has been observed that the ring footing acts like circular footing when n ratio d/D equal to 0.33 and thereafter the value decreases as d/D ratio increase.

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