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EVALUATING PARAMETERS OF BEARING CAPACITY OF RING FOOTINGS

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ABSTRACT

Because of its durability, structural ring footings have been used under the maritime structure's shallow foundations for many years. so, the efficacy and application of shallow foundations ring footings typically are little understood. These footings was tested for the bearing capacity of this research in a laboratory. The impact of ring depth and stiffness on the bearing capacities of ring footing models was studied in this respect. Ring footings design was based on the structural and geometry requirements. it was estimated that using structural rings would increase the support capacities of both soil-rings and soil-footing depth by 1.62 times. The behavior of a ring footing resting on (sand, clay, sand over clay, clay over sand) soil exposed to vertical stresses was investigated in laboratory experiments. A small-scale physical model was built and tested to achieve this goal. included an aluminum circular footing with a diameter of 100 mm and a d/D ratio(the inter diameter to the outer diameter) of (0,0.33,0.5,0.67,0.95) to see how the d/D ratio affected bearing capacity along with different embedding depths to observe how they affect depth and footing size affected bearing capacity. Because the number of drilling and filling operations decreases as it varies from conventional foundations in that it has an increasing number of ring footings. By using the peripheral ring, it is possible to avoid excavating in adjacent construction sites subsurface soil, which reduces the amount of disturbance. This structure appears critical for expense and productivity given the potential advantages of using rings as feet. Meanwhile, further research into the adjacent foundations' bearing capacity and settling activities is needed to show their advantages to practical engineers

KEYWORDS. Footing size, bearing capacity, Ring footing height, ring depth.

1. INTRODUCTION

Ring foundations are often utilized for buildings such as water towers, chimneys, television towers, and silos, among other things. Ring footings are used to support a large number of overhead water tanks. Because of its affordability and appropriateness for certain types of buildings, this kind of foundation is becoming more popular. Ring foundations are often the sole option when the twin conditions of complete use of soil capacity and no stress beneath foundation must be met. To reduce the settlement reinforcements in the vertical directions and improve the bearing capacity and can be used in shallow foundations (Das,1999). To meet the bearing capacity requirements for providing offshore environmental loading to provide the necessary horizontal resistance, rings can be included. The weight is transferred to deeper, usually stronger, soil via the ring footing if we compare it to a surface foundation thus mobilizing higher bearing capacity. Existing literature has been arranged in chronological order in the following sections. to enhance soils' capability Various geotechnical engineering applications have benefited from improvement methods (Bell, 1993).

Fattah, (2021) it was discovered that when the depth of the footing is increased, the soil settlement due to loads is reduced. Fig. 1 shows slip lines length increasing of ring footing. In general, while all other factors are kept constant, the footing carrying capacity improves as the depth of the foundation is increased.

Fattah, (2018) found that for reinforced and unreinforced soil, the bearing capacity increases with increasing (d/D) ratio of ring footing. besides, the results indicated that an optimum ratio of the inner to outer diameter of the ring footing has been indicated which was (0.4), and after this ratio, the bearing capacity starts decreasing.

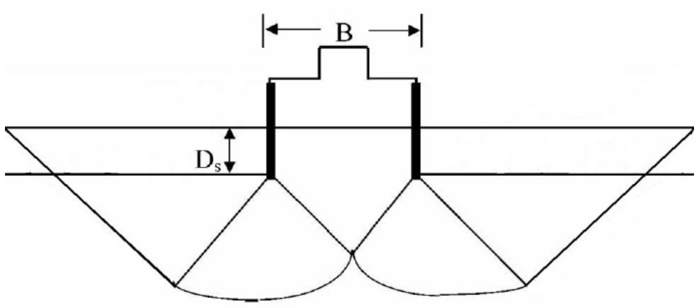


Fig. 1. Slip lines length increasing of ring footing.

For more than eighty years, theoretical and practical study has been conducted to rigorously determine the sand-based shallow foundations flat circular and flat longitudinal strip footings bearing capacity, in addition of conical foundation, have some solutions, while ring footings do not. It makes sense to begin with flat footings in order to better understand ring footings later on. A flat footing is just a particular case of a ring footing that does not have any rings around it. A mix of lower and upper bound theorems is used (Tripathy, 2013).

Chandrawanshi, (2014) preformed model tests on circular foundation resting on medium dense sand with and without ring of different diameters and heights. It was studied the effect of ring diameter on bearing capacity ratio in sand and the effect of ring height on bearing capacity ratio of ring footing in sand It was found that the bearing pressure corresponding to 10% S/D ratio (i.e. 5 mm settlement), remarkably increases when using ring footing to confine the sand. For ring footing with small diameters, the influence was small and reaches an optimum value for a fixed ring diameter with respect to pile diameter and then this phenomenon loses its significance as diameter of ring increases.

Misir and Laman, (2017) have demonstrated bearing capacity regarding circular footing on the granular fill layer over soft clay soil. The bearing capacity was investigated with the use of an empirical estimation approach on the basis of physical modeling on-site and in the laboratory. The formulation was based on 342 field data from twelve field tests.

Murthy, (1970) maintained one footing loaded to its safe bearing limit and the other footing loaded until the soil in shear collapsed

the improvement ratio for various embedding ratios Using a ring in the model footings worked better than embedding the foundations at the same depth as the ring. From 2.91 to 3.68 depending on embedment depth. For the new ring circumstances (full peripheral ring vs partial ring), the least improvement ratio was almost two-fold compared to previously reported improvement ratios of 1.5 to 3 (Al-Aghbari, 2006).

Among the goals of this research is to investigate the behavior of ring footings with varying radius ratios lying on sand reinforced with geocells under the action of a monotonic load.

2. TESTING SETUP AND MATERIALS

Loading tests were carried out a stiff steel structure box on rolling model foundations. A test box with the dimensions (1,1,1) m outside was selected for frame of loading. With the help of the loading frames that are accessible. A bottom of a solid steel is supported by two steel angles on each side, which are held together by metal straps. making up the test box. To reduce boundary friction, other faces were designed to prevent lateral expansion. It was necessary to lubricate the side walls inner faces and leave them for an hour on the surface (Yung et al., 2004).

To minimize the effect of stiff walls on support capacity, wide 35 cm versions have been developed based on box dimensions (Salençon, 2002; Bowles, 1996). Aluminum plates were used for the foundation, which are depicted in Figure 2 for their typical requirements. Each footing is made up of an aluminum ring plate shaped as box contour and strong fundamental base and a few screws may be used to secure the strong base to the ring during placement of the model on sand. maintaining the strain steady in the soil under the foundation model, based two steel profiles were used to reduce the width of the body to a dimension that was almost equal to the standing length of 100 mm width. In this situation, the foundation ends is situated near the sides of the stainless-steel, preventing soil movement in the longitude direction. To eliminate friction at their interfaces, on the contact surfaces of the base ends and steel profiles, lubricated films were applied to provide little lubrication.

2.1. Materials

Fine sand was used in this experimental research. This sand's grading curve is shown in Fig. 3. The sand grade parameters for D60, D30, and D10 founded as (0.26, 0.44, 0.82)mm, in order. This study revealed the uniformity coefficient (3.1), and the curvature coefficient was 1.05. Standardized or badly graded sand (SP) was classified as such according to the Unified Soil Classification System (USCS).

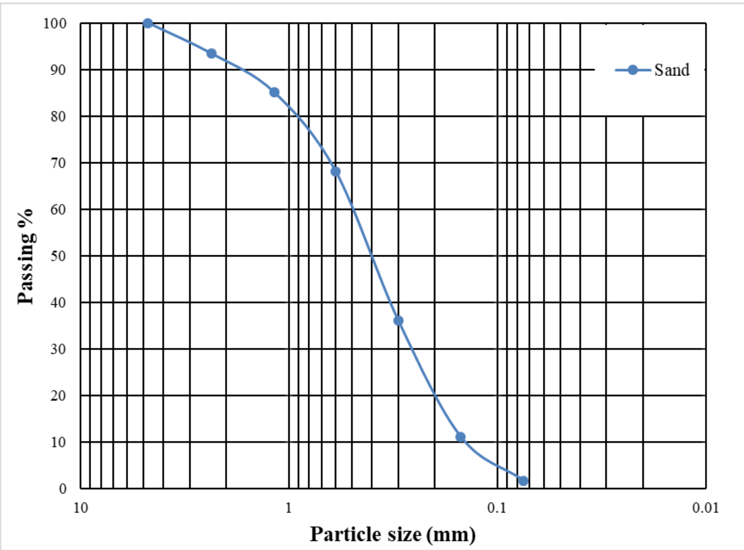


Fig. 2. Particle size distribution.

2.65 is the specific gravity of the sand, according to the calculations. On the basis of these calculations, the dry unit weights of the soil were found (16.28, 18.69)kg/m^2, respectively. The sand raining technique was used to achieve a density condition that's adequate with a 16.8kN/m^3 unit weight, which equals 61 percent relative density. The intensity and regularity of the sandy rain method, as well as the height of the droplets, are all important factors to consider, and they are used to determine the density that may be produced using this method (Cresswell et al., 1999). The density and the strength characteristics of the soil were determined via the use of direct shear testing. Carrying out these tests on samples with a radius of 5cm and under normal stresses of 399, 502, and 645 kPa at a temperature of 20°C. 30 mm/min shear displacement rate .The sand's average peak friction angle was 41 degrees. The ring's front and posterior edges, as well as the footing's bottom face, were all sanded to simulate severe sand interactions during footing stress testing. The size of the friction contact angle is It is roughly equal to the friction angle between cement and dirt, and it may be used to describe and reflect real foundation conditions.

2.2. Test Procedures.

To avoid potential impacts on the stiff base of the test box's bearing capacity, sufficient sand height was needed. As a result, numerous loading tests were carried out in the test box using a conventional model. These results demonstrated that a nearly constant sand layer thickness higher than 4B was associated with a high level of base bearing power (B footing model width). To avoid any effect on the solid bottom of the box's foot bearing capabilities, the 4B loading on sand was likewise contained inside the laboratory box.

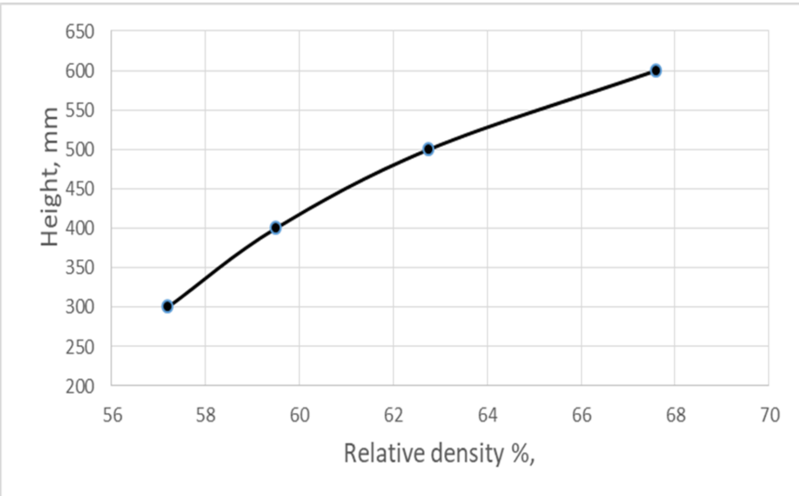
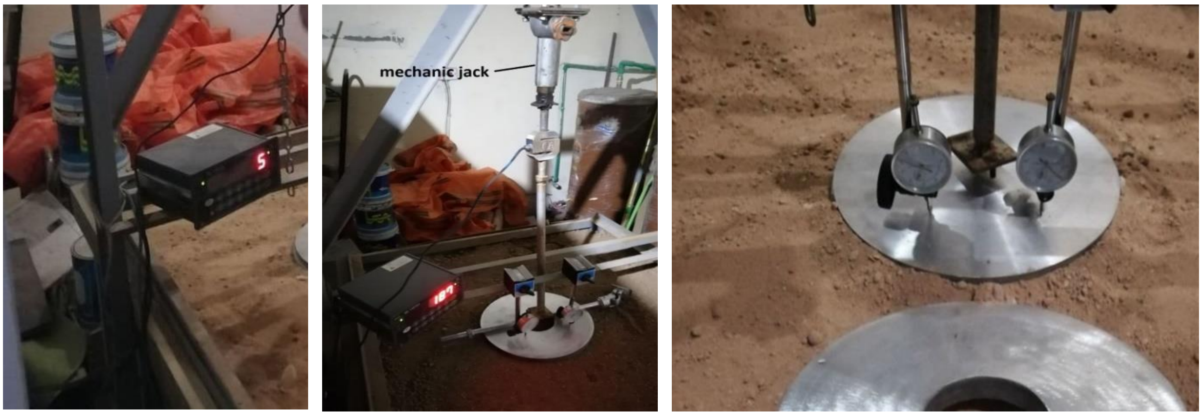


Fig. 3. Height versus relative density.

To perform any test loading, all interior sides. The surfaces of the walls of test box were thoroughly greased. After then, the box was put inside the triaxial appliance's mechanism of loading and to reach the desired height of 4B it was filled with sand., strategically the sand was laid down utilizing the sand raining method. The footing ring was then placed in the center of the box. soil began to fall. The foundation was carefully fastened by eight screws after smoothing the sandy area inside the ring. A displacement control system was used to apply focal loading vertically at steady rate of 1 mm/min to the model base. At each 0.5mm settlement, a 30kN with a 10N precision was used to record the load. Fig. 4 depicts various levels in the sand bed as well as a loading test. the variance in results was averagely was less than 5%, the typical values from three repetitions was utilized to generate comprehensive findings.



Data logger | Jack to apply load | Dial gauges

Fig. 4. The experiment instruments research outcomes.

2.3. Embedment Depth

The ring footing was measured at two different heights to determine how they affected bearing capacity. As shown in Table 3, the bearing capacity of the sand case rises by approximately 50% as the ring footing height increases, and the bearing capacity of the clay case increases by about 24% as the depth increases. In sandy soil, it is recommended to utilize the ring footing.

Table 1. Height of a ring Footing influencing Bearing Capacity.

footing hieght in m	5	10
Sand qu (kn)	4100	5900
Clay qu (kn)	390	500

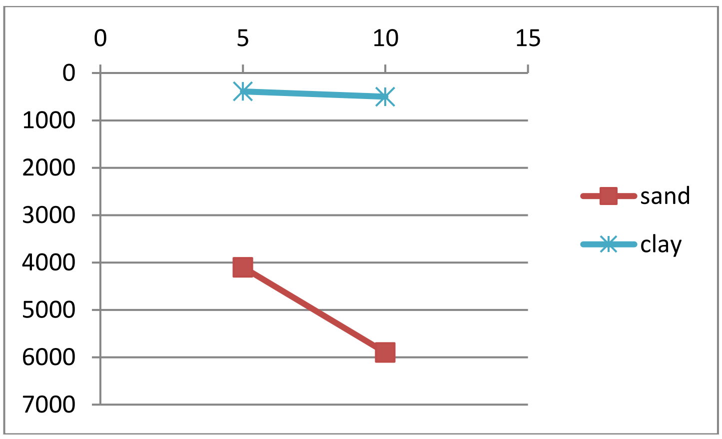


Fig. 5. Bearing Capacity height of footing relationship.

2.4. Bearing Capacity of Ring Footing Influenced by the Footing Size (B).

In the sand, Table 2 indicates that (qu) the ultimate bearing capacity was raised by 10% when the footing's size was increased from 10 to 30 meters when it was widened. Considering that the subsurface affecting bearing capacity is sand, the diameter of footing involved in the Terzaghi equation of bearing capacity in the case of sand over clay shows the same behavior as it does in the sand layout.

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

B = shallow foundation width.

$\emptyset$ = soil internal friction angle.

H= depth of subsoil influence.

In general, mostly believed that bearing capacity when (H = 2B) in sand higher than clay, and the footing size had no effect on bearing capacity, as well Bowles, (1996).

Table 2. Bearing capacity with different Sizes.

footing Diameter in m	10	30
Sand qu (kn)	3350	3650
Clay qu (kn)	390	390

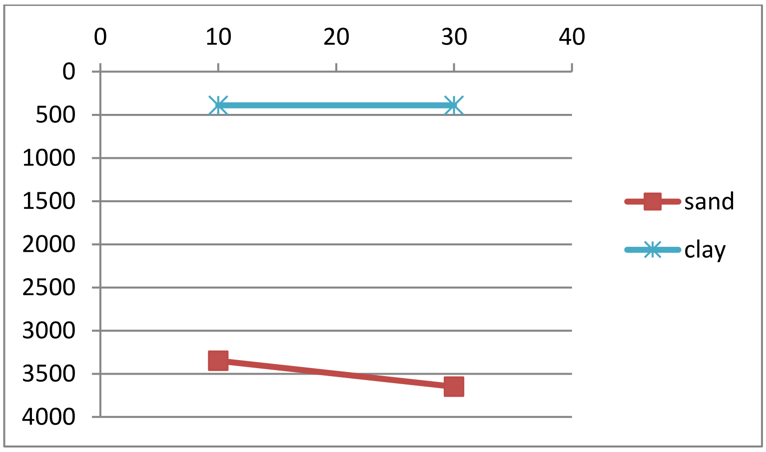


Fig. 6. Bearing Capacity footing size relationship.

2.5. Bearing Capacity of the Ring Footing influenced by (d/D Ratio)

As seen in Table 4 various model ratios (0,1/3,1/2,2/3,0.95) and the exact length and surface area Table 1 the dimensions of the footings), the ring d/D ratio has a significant influence on sandy soil bearing capacity, whereas it has unsignificant impact on bearing capacity on the clay layer due to the neglecting the internal friction angle.

Table 3. Dimensions for the ring footing.

	dimension	units
Radius	5	m
Height of the footing	1	m

Table 4. Bearing Capacity affection of ring Footing (d/D) ratio.

Footing height	Sand qu in kn	Clay qu in kn
d/D = 1/3	2400	400
d/D = 1/2	1600	400
d/D = 2/3	1050	400
d/D = 0.95	400	400

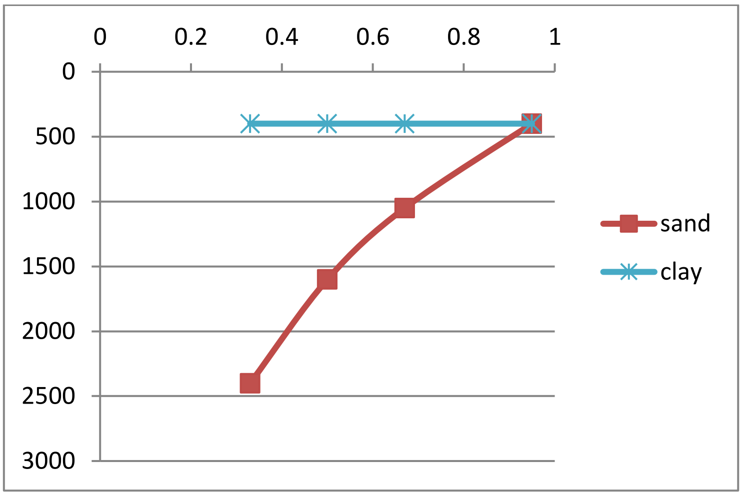


Fig. 7. Bearing Capacity ring Footing (d/D) ratio relationship.

4. CONCLUSION

1. The use of a peripheral structural ring enhances total foundation performance by improving bearing capacity, reducing the volume of the excavation, and in between the rings, the soil is encircled.

2. A ring footing's bearing capacity rises as the ring length increases (L) by mostly 50**%** in the sand and not a significant amount on the clay

3. As the breadth B of the footing get smaller, the potential ultimate bearing capacity values drop by almost 10 **%** in the sand and do not change in the clay that's why the ring footing preferred in the sandy soils. Zhao, L., and Wang, J. H. (2008).

4. When the n ratio d/D equals 0.33, the ring footing behaves as a circular footing, and as the d/D ratio increases, the value drops.

5. The behavior of ring foundation is that of an axisymmetric. When a ring footing is subjected to certain intensity of loading, the soil particles present along the inner periphery of the ring have more freedom of movement than those placed at the center offooting. It seems that the sand present with in the ring zone is relatively more densified than that present near the outer periphery of the footing. For lower d/D ratios; ring footings failed

by general shear failure mode and the soil within the ring zone failed suddenly for such footings. For higher d/D ratios ring footings failed by local shear failure.

6. In the case of a different soil layers considering the stronger soil (sand) and the weaker soil (clay) it has been noticed that there is a distinct variation in bearing capacity than the on soil case.

- Sand over clay: the ultimate bearing capacity is little than the case of a sand soil
- Clay over sand: the ultimate bearing capacity is more than the case of clay soil

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