Experimental Investigation of Ring Footing Laid on Sand Bed Reinforced with Rubber Particles

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Extended Abstract

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Introduction

The ring footings are very important and sensitive due to widespread use in various industries such as oil and gas; so finding some ways for improving the behavior of these types of footings can be very valuable. One of these ways, which is very affordable and also can be help in environmental protection, is the use of granulated rubber that made from disposable materials like scrape tires, as the soil reinforcement. In the present study, the behavior of ring footings with outer constant diameter of 300 mm and variable inner diameters (90, 120 and 150 mm with inner to outer diameter ratio of 0.3, 0.4 and 0.5) placed on unreinforced sand bed and also granulated rubber reinforced bed, has been investigated by field test. The effects of important parameters like inner to outer diameter ratio of ring footing and thickness of rubber-soil mixture on the behavior of ring footing in terms of bearing capacity, settlement and inside vertical stresses of footing bed have been studied and the optimum values mentioned parameters have been determined.

Material and methods

In all tests, a sandy soil was used to fill the test trench which was excavated in the natural bed of the earth with a length and width of 2000 mm and a height of 990 mm. It should be noted that the type of this soil is well-graded sand (SW) according to the Unified Classification System (ASTM D 2487-11). This sand had medium grain size, D_{50}, of 2.35 mm, moisture content of 5.4% and friction angle of 41.7°. The granulated rubber particles with dimensions between 2-20 mm, a mean particle size, D_{50}, of 14 mm and a specific gravity, Gs, of 1.15, have been used in all tests for using in rubber-soil mixture layer.

The loading system consists of several parts such as loading frame for providing reaction force, hydraulic jack, load cell, load transfer system (including loading shaft which was located below Load cell and footing cap which was located under the loading shaft) and rigid steel loading plates with different inner to outer diameter ratios (d/D=0.3, 0.4 and 0.5 and constant outer diameter of 300 mm). Some devices like load cell, LVDT, pressure cell, data logger and unit control were applied to collect the data and control the system. Both soil and rubber-soil mixture layers were compacted by vibrating plate compactor to gain their maximum densities. After preparing the tests, the static load was applied on the system at a rate of 1 kPa per second until 1000 kPa or until backfill failure.

Results and discussion

The results of tests on both unreinforced and rubber reinforced beds indicated that the ring footing with inner to outer diameter ratio (d/D) of 0.4 had the maximum bearing capacity in all settlement levels. This behavior can be related to the arching phenomenon within the internal spaces of ring footing with optimum inner to outer diameter ratio. In fact, when the ring footing with optimum inner to outer diameter ratio is subjected to a certain level of loading, the soil inside the ring seems to be compacted due to interface effect of the two sides of the ring. However, by increasing the inner to outer diameter ratio more than its optimum value, the ring behaves like two independent strip footings without any interface effect and therefore the bearing capacity decreases.

The results of tests showed that the vertical inside stresses in different depths of footing bed (both unreinforced and rubber reinforced beds) decrease with increasing d/D ratio. This stress reduction process can be due to the transfer of stress concentration from the points close to the center of the ring to the outer point because of turning from the ring mode with interface effect to the two independent strip footings that mentioned earlier.

The results of rubber reinforced cases illustrated that, regardless of the footing settlement level and also irrespective of d/D ratio, the bearing capacity of ring footing increases with increasing the thickness of rubber-soil mixture layer (h_{rs}) up to the value equals 0.5 times the outer diameter of ring footing and further increase in this thickness more than mentioned optimum value ($h_{rs}/D=0.5$) can decrease the bearing capacity. Even in some cases of reinforced base ($h_{rs}/D=1$), the bearing capacity can be reduced to the value less than that of unreinforced cases. It can be due to high compressibility of rubber reinforced layers with higher thicknesses than optimum value.

It should be mentioned that the rubber reinforced layer can reduce the vertical inside stresses compared to unreinforced cases. It can be due to this fact that the rubber reinforced layer acts as a wide slab. Such that it can spread the applied loading over a wider area. Also rubber reinforced layer has high capacity of absorbing energy and therefore can decrease the vertical inside stresses.

Conclusion

In the present study the behavior of ring footing placed on rubber reinforced bed have been investigated by field test. The effect of different parameters such as inner to outer diameter ratio of ring footing and the thickness of rubber-soil mixture layer on the bearing capacity, settlement and vertical inside stresses of the footing bed were studied. The result indicates that:

- In both unreinforced and rubber reinforced bed, the ring footing with inner to outer diameter ratio (d/D) of 0.4 had the maximum bearing capacity, regardless of settlement level.

-The vertical inside stresses in different depths of footing bed decrease with increasing d/D ratio.

-The bearing capacity of ring footing increases with increasing the thickness of rubber-soil mixture layer (h_{rs}) up to the optimum value equals 0.5 times the outer diameter of ring footing.

-The vertical stresses can be reduced by using rubber reinforced layer.

Keywords: Ring footing, sand, rubber particle, bearing capacity, vertical stress

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