Bearing Capacity of Ring Footing Erected on Wet Gypseous Soil

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Abstract: In this research, (24) experiments were conducted for a ring basis on gypsum soil submerged in water for 24 hours before the examination, where the ratio of inner diameter / outer diameter (D_i / D_o) is (0, 0.2,0.3, and 0.4) and gypseous soil is of two types: the first soils with a low gypsum content (8.15%) obtained from the Baiji region and the second soils with a high gypsum content (63.42%) from the University of Tikrit. The experiments are conducted using a steel box with dimensions of (900 * 900) mm and a height of (700) mm. The experiments were divided into (12) examinations of flooded soils with low gypsum content using field density (14.87 kN/m^3), and (12) examinations of dry soil with high gypsum content using field density (13.76 kN/m^3). Experiments were conducted on a different depth/diameter ratio of the foundation (D_f/D) (0, 0.5, and 1). The results showed that the ring footing is better than the circular footing. The best ratio was (D_i / D_o = 0.4) for all ratios (D_f/D). Bearing capacity increases with increasing ratio (D_f / D), but this increase is small and gives high subsidence and danger in the initial loading stages that cause the collapse of buildings built on gypsum soil. The tolerability of soils with low gypsum content gave good results compared to the high soil content of gypsum because gypsum dissolves in water in the case of high gypsum-soils.

Keywords: Bearing capacity, Ring footing, Gypseous soil, High gypsum content, Low gypsum content.

Introduction

Gypseous soil covers more than 30% of the area of Iraq, (Al-Dulaimi, 2004), [4]. Gypseous soils mostly founded in Baiji, Mosul, Samarra, Tikrit, Ramadi, Heet, Anna, Fallujah, and Northwest of Baghdad, they may be founded in other zones (Al-Jananbi, 2002) [5]. Gypseous Soils might lead to serious problems with civil work because they show unexpected behavior (Petrukhin and Boldyrev, 1978) [10]. (Mikheev et al, 1973) [13], illustrated that there are a reduction in the value of the angle of internal friction from (ϕ=37^o to ϕ =31^o) of loam with gypsum contentof 20% after 30 days of wetting. investigated the effect of soaking periods on the shear strength parameters (c &ϕ) of gypseous soil, the results introduce that there is an inversely proportional relationship between the cohesion of soil and the soaking periods, Sulaiman et al, (1996) [14]. (Al-Mufty, 1997) [15], If the void ratio is low and water content is not enough, the cohesion will reduce but it is not vanished. (Hataf and Razavi 2003) [9] founded that the maximum bearing capacity of sand (D_i/D_o) was range between (0.2–0.4). (AL- Sumaiday, AL-Tikrity ,2013) [7] used sample of sand for different density and dried in an oven, the best ratio of the ring footing was (D_i/D_o = 0.4). (Snodi ,2010) [11], used the finite element method by (ELPLA) program, many ratios of the inner radius to the outer radius were study, the best ratio was (D_i/D_o =0.2-0.4) and the angle of friction also was studying the best friction angle is (30-35)°. founded that the best bearing capacity for ring footing (D_i/D_o=0.4) on sand soil, (Boushehrian and Hataf, 2009) [8].

2- Experimental Program

2.1. Apparatus and Procedures

2.1.1. The test box

The test box consists of a vertical armrest carried by a horizontal vertical armrest. The load is dropped by means of a manual arm that is moved manually. As well as a (gauge) that reads the dropped load and contains a solid cylindrical column, resting on the footing through which the load is shed. There are (2) gauges for settlement reading The box have dimensions of 900 mm by 900 mm by 700 mm (Figure 1-2). A steel plate is positioned at the bottom of the test box, serving as a foundation for the first layer of soil. This plate allows water to flow through if the box is immersed. Beneath the plate, there is a space along the base where water accumulates after the soil becomes saturated. Additionally, the box features a cylindrical valve that is connected to a plastic tube measuring 500 mm in length. This tube is utilized to monitor the water level during the investigation of footing durability, a technique commonly employed by various researchers using the same test box, (Saleh, 1989) [16], (Tawfeeq,2009) [12], (Al-Azzawi,2010) [2], (Abbas,2019) [1] and (AL-Dorry,2012) [3].

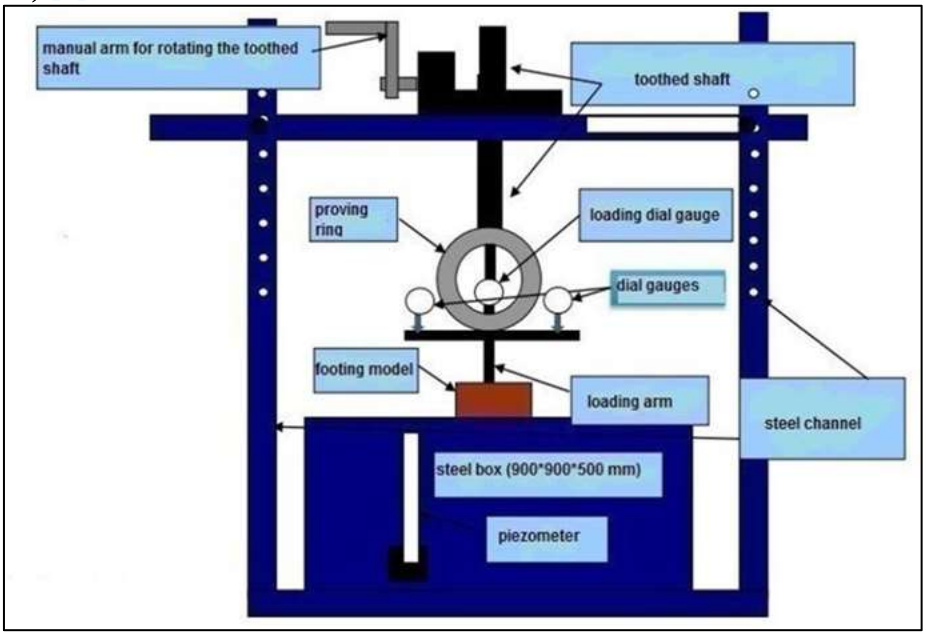

Fig (1). The test box (synthetic).

Fig (2). The test box.

2.1.2. The design or type of footing used in the study.

The diameter of the footing is originally (150) mm, and its thickness is (15) mm. It is made of hard steel. Metal sheets were attached to its sides to prevent soil from entering the footing the columns used to shed the

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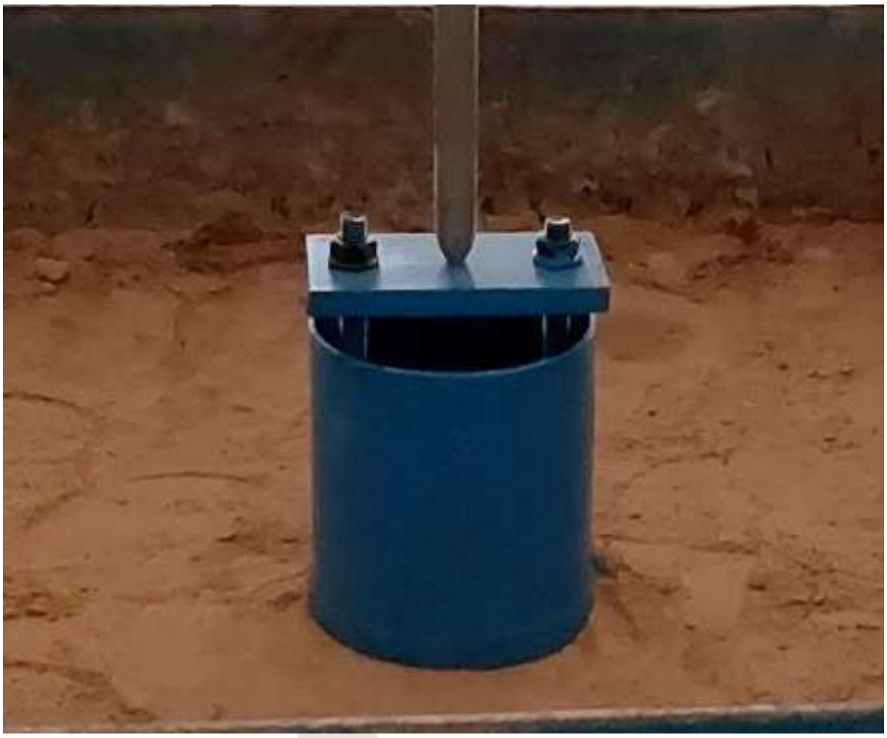
load on the footing were made of hard steel with a diameter of (14) mm and a metal sheet with dimensions of (80 * 40 * 15) mm to shed the load through it to the columns and then to the footing Figure 3.



Fig(3). Footing model.

2.1.3. The soil

Gypesous soil was obtained from the Baiji district and from University of Tikrit at a depth ranging between (1.5-2) meters below the natural ground level, where the upper soil layers were removed. Practical experiments and obtaining the properties of the physical soils and the content of gypsum by the method of (Al-Mufty and Nashat, 2000) [6].

2.1.4. Experimental Procedure

The dimensions of the soil sample for analysis are 900 mm by 900 mm by 500 mm. It is divided into five layers, each with a thickness of 100 mm. To compact the soil, a manual hammer is utilized. This hammer consists of a circular steel disk with a diameter of 200 mm and a thickness of 12.5 mm, connected to a metal tube with a diameter of 25 mm. The total weight of the hammer is 5 kg, which must not exceed the specified limit mentioned in the box. Following the extraction of soil samples, they are compressed to a predetermined size and weight for the purpose of calculating their density and comparing it with the density observed in the field.

In order to attain the desired density, modifications are implemented in the number of strikes delivered by the hammer. If the desired density exceeds the density observed in the field, the number of strikes must be decreased. Conversely, if the density falls short of the field density, the number of strikes should be increased. A permissible deviation percentage of 1% is permitted, allowing for minor fluctuations.

The soil is placed in the box under two different conditions for footings. Firstly, the ratio of the inner diameter to the outer diameter (D_i/D_o) is considered, with values of 0, 0.2, 0.3, and 0.4. Here, Di represents the inner diameter, and do represents the outer diameter. Additionally, the footing depth-to-diameter ratio (D_f/D) is varied, with values of 0, 0.5, and 1. In this case, the variable Df denotes the depth of the footing, while D represents the diameter of the footing. Concerning the process of soil soaking (depicted in Figure 4), the soil is immersed in water for a duration of 24 hours. During this time, the water level should rise to match the height of the soil, as observed through a plastic tube positioned on one side of the container.

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Fig 4. The set of testing, (Soaking case).

3. Results and Discussion

3.1. Results of high gypseous soil:

This result of high gypseous soil for (D_f/D=0,0.5and 1) with different ratio (D_i/D_o=0,0.2,0.3and 0.4) shown in figures 5-7. Founded that improvement in bearing capacity at ratio (D_f/D=0.5) by (63,107,170and 204)%, respectively, Figure 6.

Also the bearing capacity for (D_f/D=1) was improvement by (96,163,170and 267)%, respectively, Figure 7. All the results of improvement for (D_f/D=0.5) and (D_f/D=1) compare with ultimate bearing capacity for (D_f/D=0.0) and (D_i/D_o=0), Figure 5.

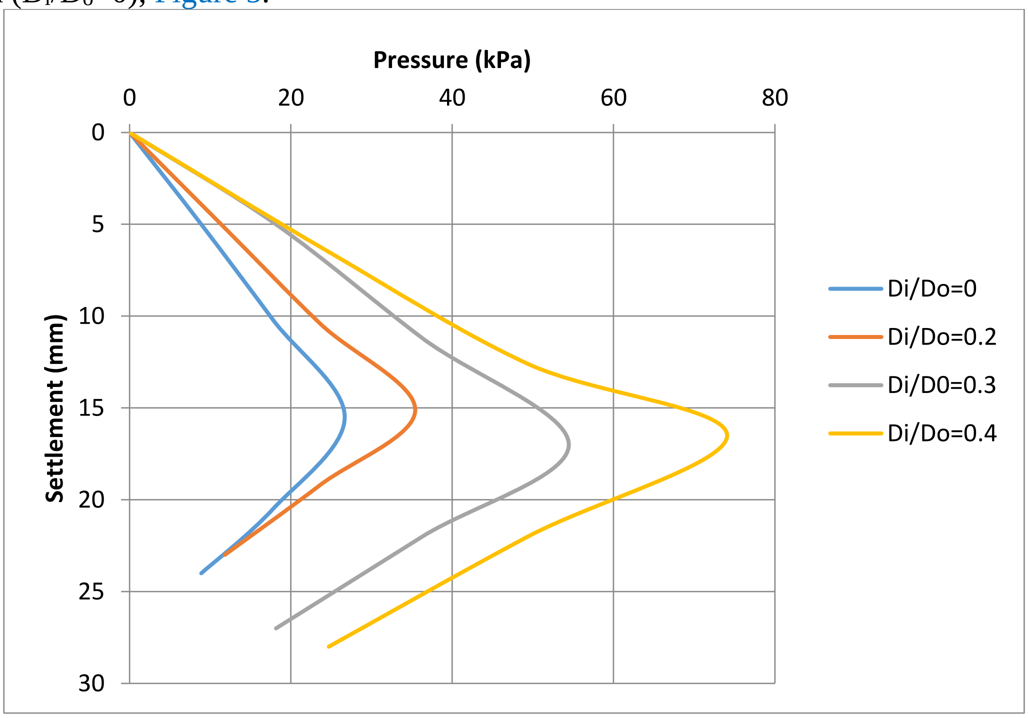

Fig (5) (settlement-pressure) relation (soaking case) for high gypseous soil with field density (D_f/D=0).

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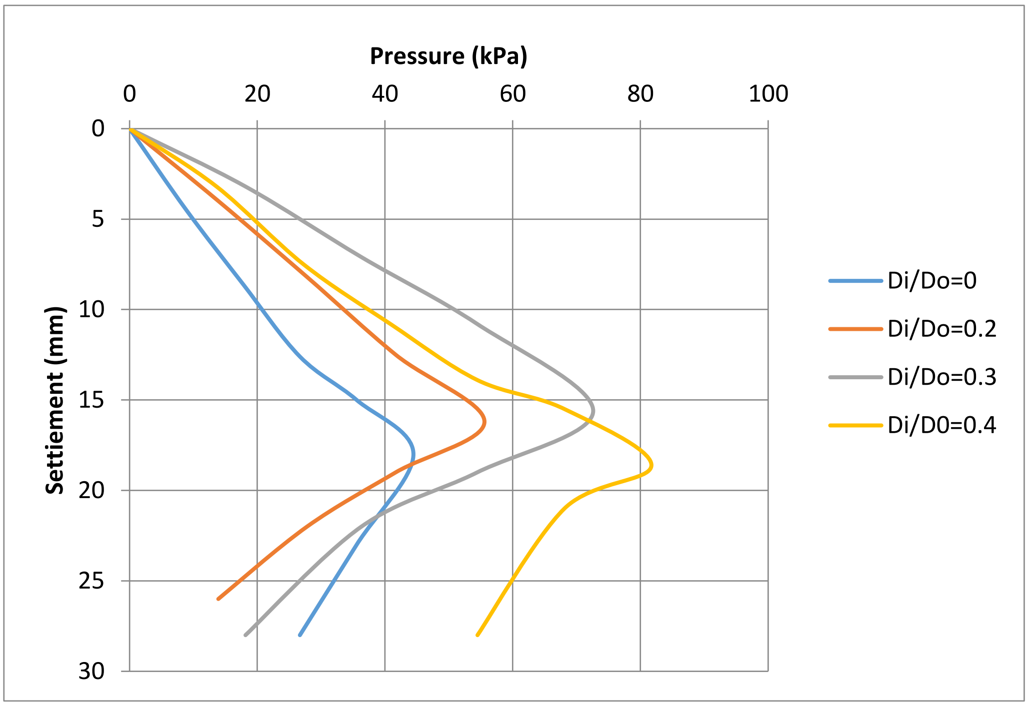
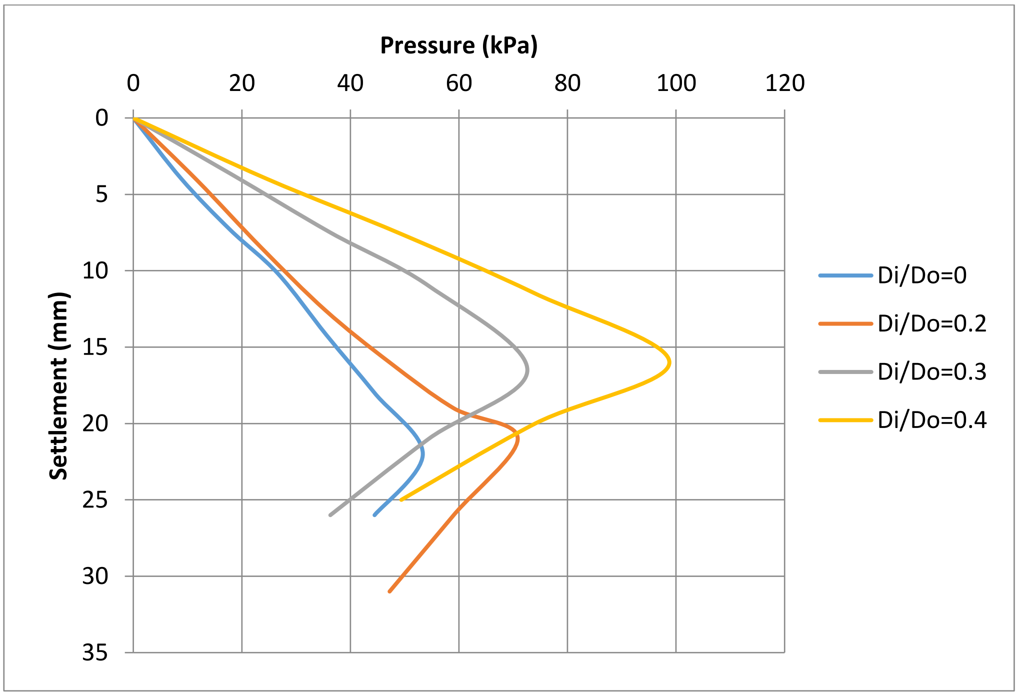


Fig (6) Relationship between (pressure -settlement) (soaking case) for high gypseous soil with field density (D_f/D=0.5).



Fig(7) Relationship between (settlement-pressure) for (soaking case) high gypseous soil with field density (D_f/D=1).

Table (1) shows the bearing capacity for high gypseous soil.

Table (1) ultimate bearing capacity (soaking case) for high gypseous soil.

High Gypseous	**Parameters**	

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soil			Ultimate bearing capacity (kPa)
Density	D_f/D	D_i/D_o	
Field density (13.76 kN/m³)	0	0	27
		0.2	35
		0.3	54
		0.4	74
	0.5	0	44
		0.2	56
		0.3	73
		0.4	82
	1	0	53
		0.2	71
		0.3	73
		0.4	99

3.2. Results of low gypseous soil:

This result of low gypseous soil for (D_f/D=0,0.5and 1) with different ratio (D_i/D_o=0,0.2,0.3and 0.4) shown in figures 8-10. Founded that improvement in bearing capacity at ratio (D_f/D=0.5) by (20,34,107and 125)%, respectively, Figure 9.

Also the bearing capacity for (D_f/D=1) was improvement by (61,114,148and 180)%, respectively, Figure 10. All the results of improvement for (D_f/D=0.5) and (D_f/D=1) compare with ultimate bearing capacity for (D_f/D=0.0) and (D_i/D_o=0), Figure 8.

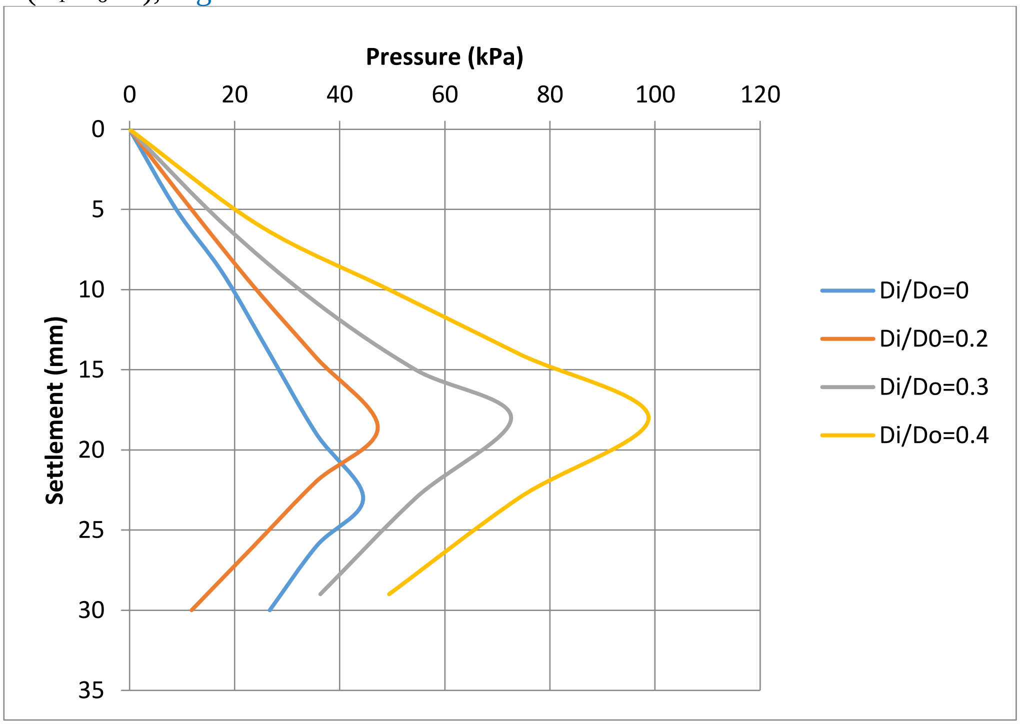

Fig (8) Relationship between (pressure-settlement) with soaking for low gypseous soil with field density (D_f/D=0).

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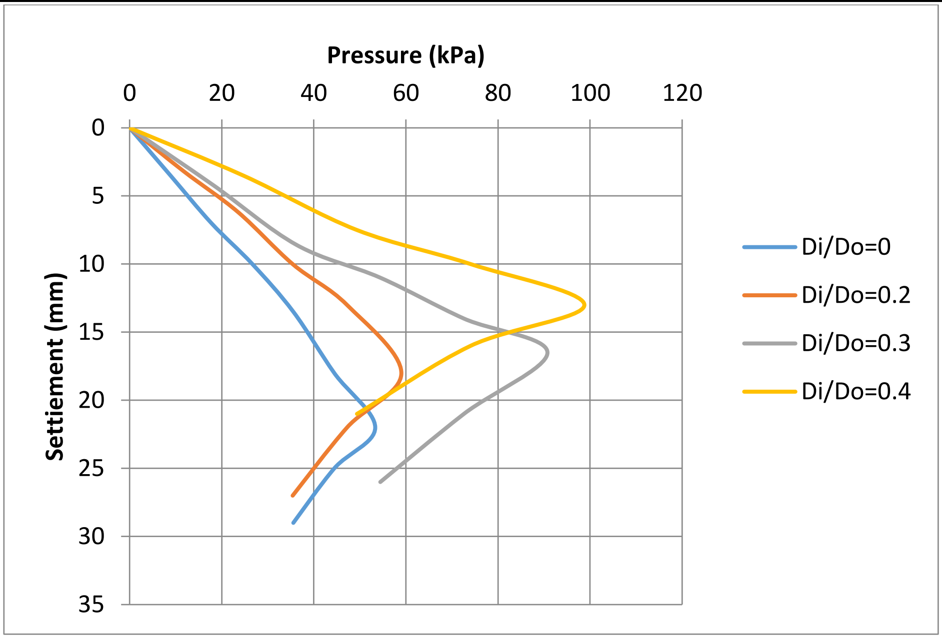

Fig (9) Relationship between (pressure-settlement) for low gypseous soil (soaking case) with field density ((D_f/D=0.5).

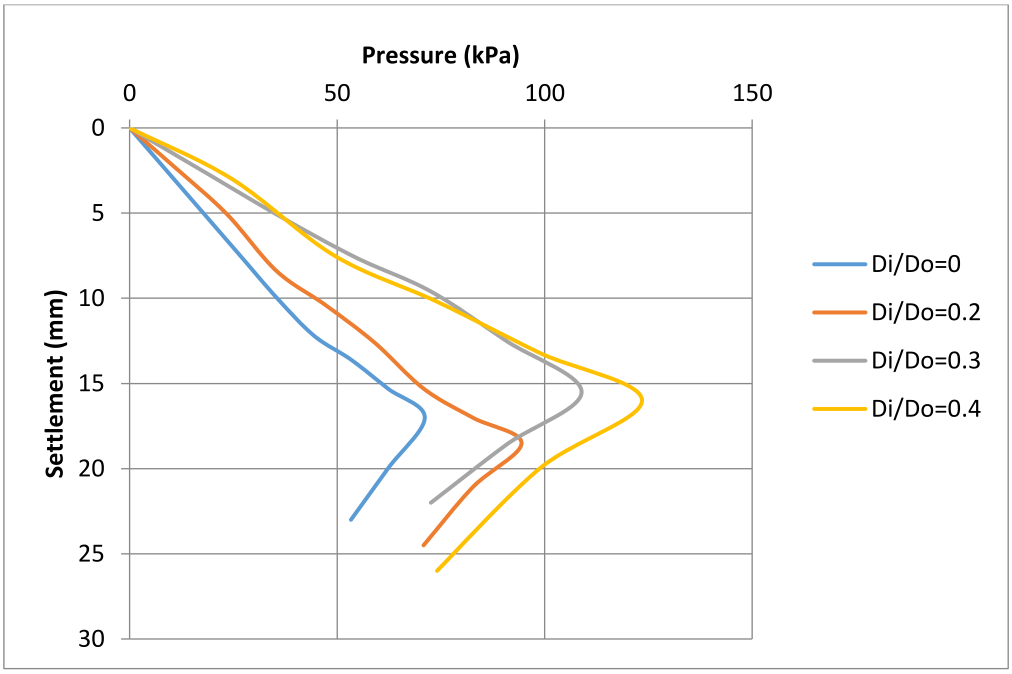

Fig (10) Relationships between (settlement-pressure) for low gypseous soil (soaking case) with field density (D_f/D=1).

Table (2) shows the ultimate bearing capacity for low gypseous soils.

Table (2) "ultimate bearing capacity (soaking case) for low gypseous soil".

Low Gypseous soil	Parameters		Ultimate bearing capacity (kPa)
Density	D_f/D	D_i/D_o	
Field density (14.8	0	0	44
		0.2	47

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		0.3	73
		0.4	99
	0.5	0	53
		0.2	59
		0.3	91
		0.4	99
	1	0	71
		0.2	94
		0.3	109
		0.4	123

3.3. The impact of depth on the bearing capacity of both high and low gypseous soil (soaking case).

Figure 11. shown the bearing capacity for ring footings with a ratio (D_i/D_o=0,0.2,0.3and 0.4) erected on high and low gypseous soils when (D_f/D=0).

Through laboratory experiments, it was found that the endurance increases gradually until it reaches the maximum endurance when it is (D_i/D_o=0.4), which is the best ratio.

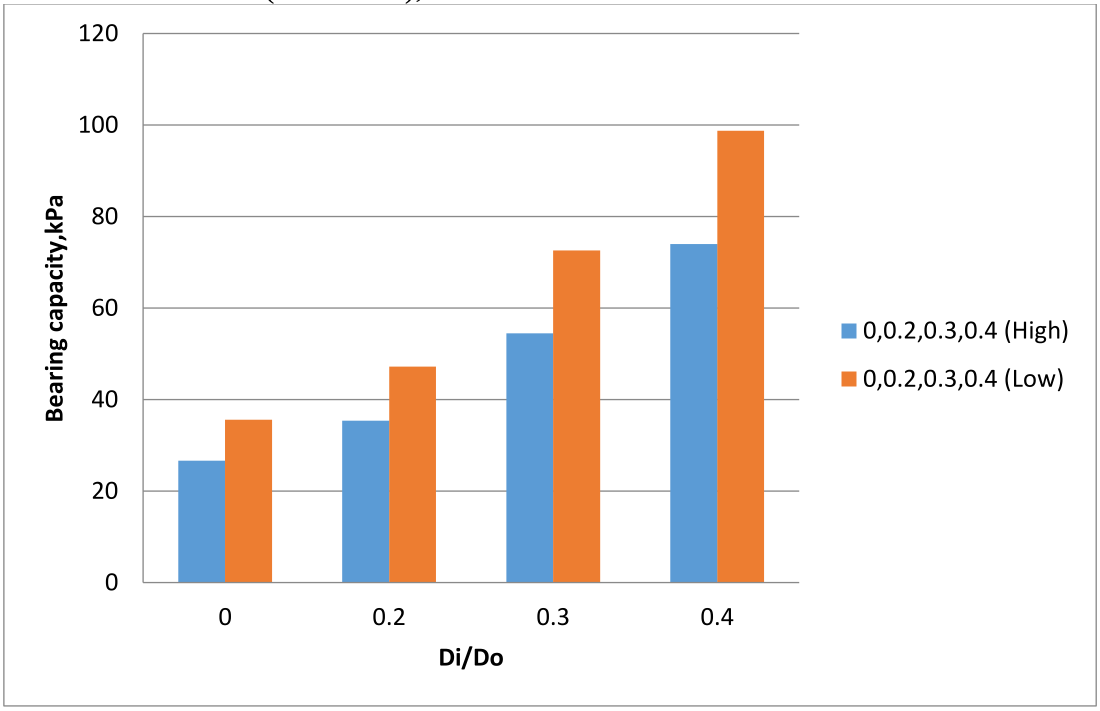

Fig 11. Effect of depth on the Bearing capacity high and low gypseous soils with field density (D_f/D=0.0)

In Figure 12, the bearing capacity of ring footings is depicted for different ratios (D_i/D_o=0, 0.2, 0.3, and 0.4) in both high and low gypseous soils, assuming a depth-to-diameter ratio of (D_f/D=0.5).

Through laboratory experiments, it was found that the endurance increases gradually until it reaches the maximum endurance when it is (D_i/D_o=0.4), which is the best ratio.

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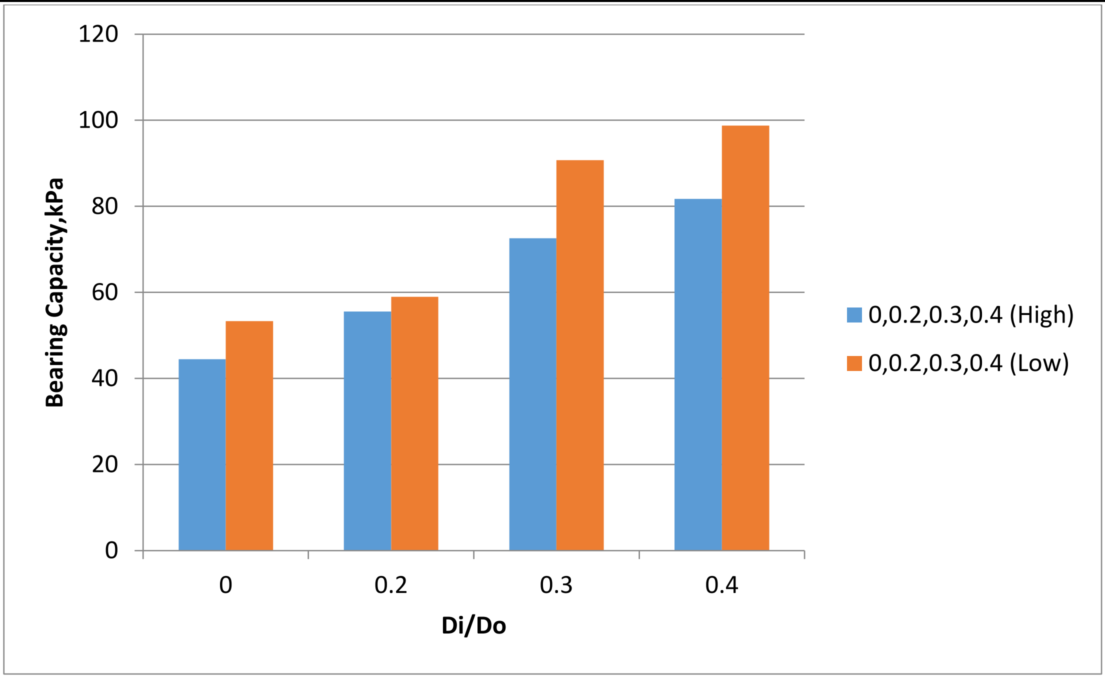

Fig.12. Effect of depth on the Bearing capacity high and low gypseous soils with field density ($D_f/D=0.5$).

Figure 13 shows the bearing capacity of ring footings with a ratio of (D_i/D_o=0,0.2,0.3and 0.4) based on high and low gypseous soils when ($D_f/D=1$).

Through laboratory experiments, it was found that the endurance increases gradually until it reaches the maximum endurance when it is ($D_i/D_o=0.4$), which is the best ratio.

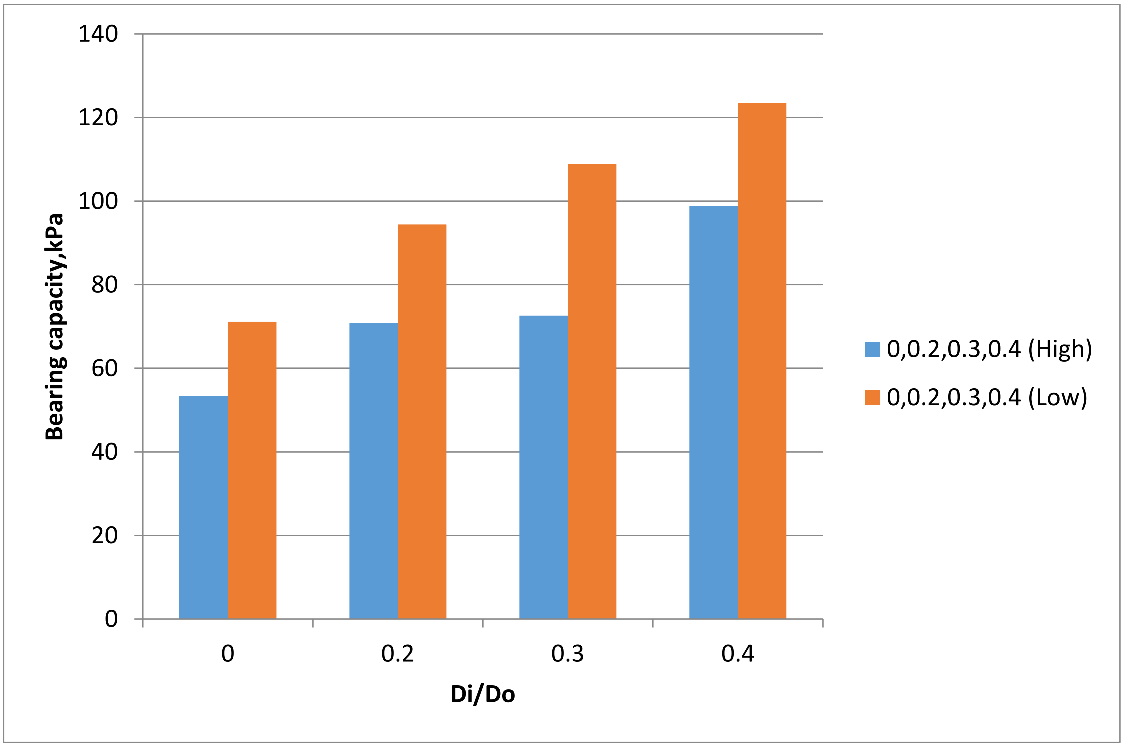

Fig.13. Effect of depth on the Bearing capacity high and low gypseous soils with field density ($D_f/D=1.0$).

4. Conclusion

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1- After compacting the soil in the examination box with the field density and moisture content, the bearing capacity of the footing based on soaking, high-gypsum soil at a depth of (D_f / D = 0.5) for footings with a ratio (D_i / D_o = 0,0.2,0.3and 0.4) improved by (63,107,170and 204)% , respectively,compared with depth (D_f/D=0). Also, the bearing capacity of the aforementioned foundations based on soaking, high-gypsum soil at a depth of (D_f/D=1) improved by (96,163,170and 267) %, respectively, compared with the depth (D_f/D=0) and (D_i/D_o=0).

2- After compacting the soil in the examination box to match the field density and moisture content, the bearing capacity of footings based on soaking, low-gypsum soil at a depth of (D_f/D=0.5) significantly increased. Specifically, for footings with ratios (D_i/D_o=0, 0.2, 0.3, and 0.4), the improvement in bearing capacity was (20,34,107and 125) respectively when compared to a depth of (D_f/D=0). Similarly, for footings based on soaking, high-gypsum soil at a depth of (D_f/D=1), the bearing capacity showed substantial improvements. Specifically, for footings with ratios (D_i/D_o=0, 0.2, 0.3, and 0.4), the improvement in bearing capacity was (61,114,148and 180) respectively when compared to a depth of (D_f/D=0) and (D_i/D_o=0).

3- Endurance increases with increasing depth; However, the bearing capacity is very weak, and the soil fails in the initial bearing stages, and the subsidence is high and dangerous to the engineering structure due to the solubility of gypsum in water.

4- At all depths, the best ratio of the ring footing is (D_i/D_o = 0.4).

5- Low gypsum content soil has higher bearing capacity than high gypsum content soil because they contain less gypsum.

6- The soaking process has a significant influence on shear strength, particularly in gypseous soil. When gypseous soil is soaked, its shear strength parameters (c and ϕ) are notably diminished. The action of wetting and dissolving by the soaking water leads to a substantial decrease in the values of c and ϕ.

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