Behavior Of Concrete Slab Supported By A Voided Sandy Soil

Muhammed Abed Attiya, Laith Jawad Aziz, Ola Mazen Mekki

Abstract: Slab supported by a soil media is a widely used form of constructions in the civil engineering. When a cavity forms -due to gypsum dissolution- below the slab, a loss of support case or weak supporting condition will occur. In this paper, an experimental model has been tested in the laboratory to discus the load deflection curve of a real case of slab on soil. A good agreement obtained when simulating the experimental result by a numerical analysis program (ANSYS). Parametric studies have been made to show the effect of forming a cavity of different depths, various diameters, changing the slab thickness, and variation the concrete compressive strength. From this research, it can be concluded that forming a cavity of (D/T) = 0.13 (cavity depth to total depth of soil) causes to reduce the slab capacity by (148%) when comparing with a soil without cavity, and using a cavity of (d/B) =1 (cavity diameter to slab width) leads to reduce the slab failure load by (212.5%) when comparing with a soil without cavity. The failure load versus cavity depth and diameter has been obtained. The concrete compressive strength vs failure load of slab has been drawn.

Index Terms: concrete slab, voided soil, numerical model, ANSYS simulation, case study, sandy soil, gypsum dissolution.

1 INTRODUCTION

The voided soil is a widely separation problem effects at the first degree on the concrete slabs rest on. the cavities form inside the soil media (due to gypsum dissolution) in different shapes and sizes (as shown in fig (1)) [1]. The gypsum represents (6.7%) of the whole lands of the earth [2]. Gypsum soils (which are the soils that contain more than 2% of gypsum content) are a strong kind of soil and have good properties when it is dry. The worse matter is when construct a heavy building on it (especially hydraulic structure) then the soil gets wet. In that case, a gigantic loss of strength will happen and the worst is when the water flows inside the soil causing reduce of mass by gypsum leaching. Briefly, leaching is phenomenon in which soluble materials and salt remove from soil due to water flowing. [3] Actually, it is difficult to get an integral nature between concrete slabs and soil action because of the complexity of soil itself. Soil is rightly a non-homogeneous and anisotropic medium, it behaves as a non-linear state, and moreover, its properties may change and vary with climate and time [4]. In contact of concrete which is can be analyzed as an isotropic, linear behavior. In this study, an experimental model has been tested in the laboratory on soil without cavities. Also, a numerical model of soil without cavity has been analyzed. The parametric study of the numerical models is pertained to the following:

- Cavity depth.
- Cavity diameter.
- Concrete slab thickness
- Concrete slab compressive strength.

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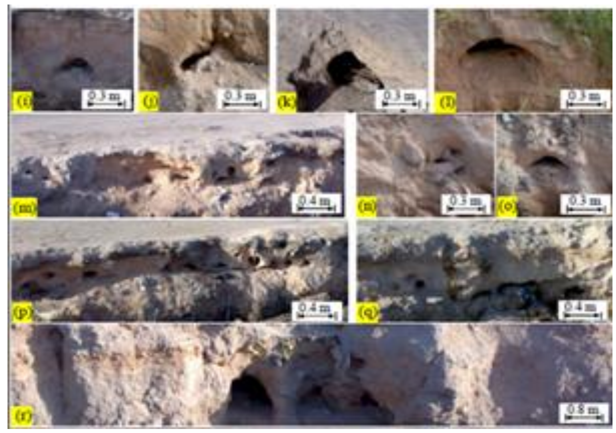

Fig. 1 *cavities in soil media*

2 PILOT MEASUREMENT

The elastic theory method [5] shows that, the applied stresses on a soil media spreads vertically, horizontally, and laterally in z-direction. In this research, and according to that theory, a wooden box of dimension (1500*1500*1300mm) was made and used for containing a sandy soil. The concrete slab is placed on the top surface of the soil. As the elastic theory suggests, the load which is transferred vertically to the soil from a square footing equals (7%) of the total applied load at depth of 2.5B (where B is the footing width). The fig (2) explained a wooden box container of (1500*1500*1300 mm) dimensions contains a compacted sandy soil of (18.6 KN/m^3).

Fig. 2 *Concrete slab during the test*

3 EXPERIMENTAL TEST RESULTS

The concrete slab was of (600*600*40 mm) tested by a square bearing plat of (200*200*20mm). the compressive strength of concrete was (30 MPa) in (28 days). The deflection was measured at slab center. The experimental results for plain concrete slab without cavity are illustrated in fig (3) with the numerical result too. From fig. (3), it is clearly to observe that the numerical analysis results are greater than the experimental one for the same model by (1.07). This matter can be explained by the following, the numerical concrete slab is more ideal than the real concrete slab. During casting process of concrete many micro cracks forms randomly inside the concrete block due to shrinkage. Also, the water of the mixture evaporation leads to forming capillary paths in the concrete body. The micro cracks and the capillary paths connected under loading and causes a larger deflection than the ideal numerical model as well as faster failure.

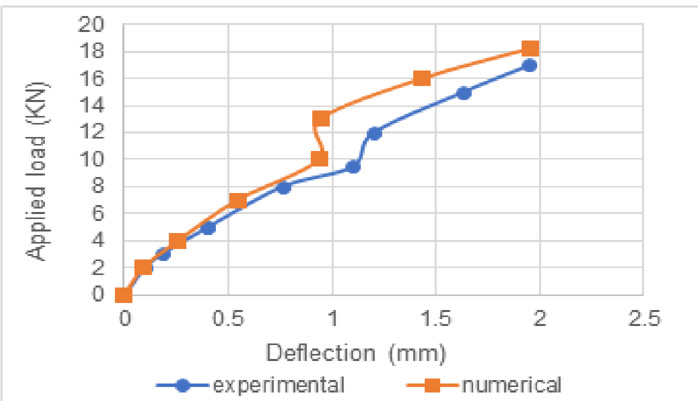

Fig. 3 *Experimental load-deflection curve of the model with numerical simulation result*

4 Case Study Modelling and Results

A cavity at depth (350 mm) from the soil surface was simulated in the numerical program as a cylindrical space inside the soil media as shown in fig (4). The Druker- Prager (DP) model used for representing the soil continuum. The TARGET170 and CONTACT 174 were used to model the interface between the soil and concrete slab.

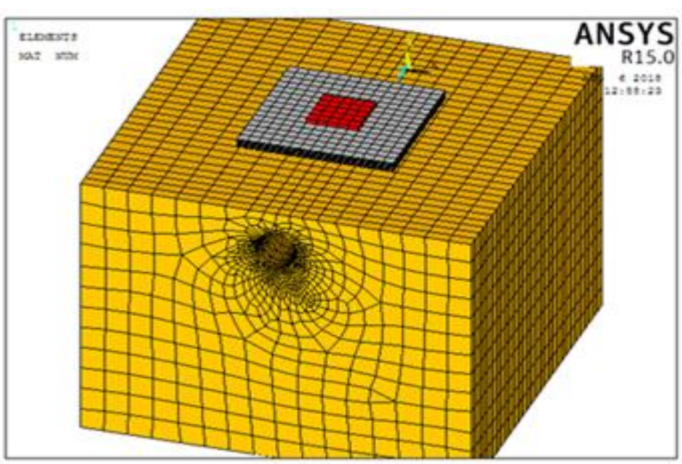

Fig. 4 *slab on voided soil numerical model*

4.1 cavity diameter

Seven numerical models were analyzed with different cavity diameters (0,100, 200, 300, 400, 500 and 600 mm). The fig (5) explained the failure load versus cavity diameters. Due to soil weakness, a graduate drop in the failure load is shown from the curve as a linear decreasing. The load versus deflection curve for the tested specimens are sown in fig (6).

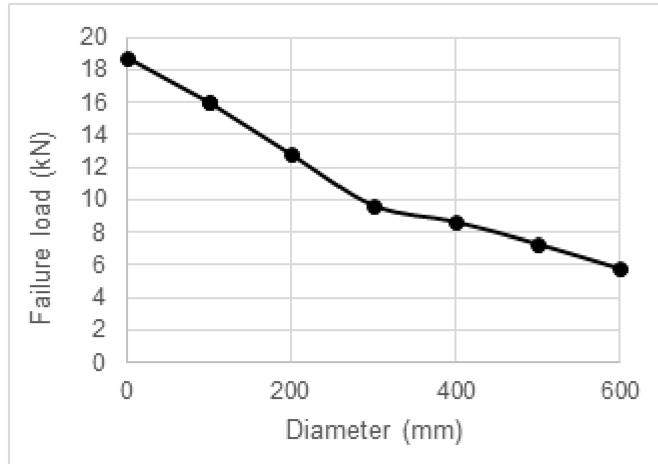

Fig. 5 *slab failure load versus cavity diameter*

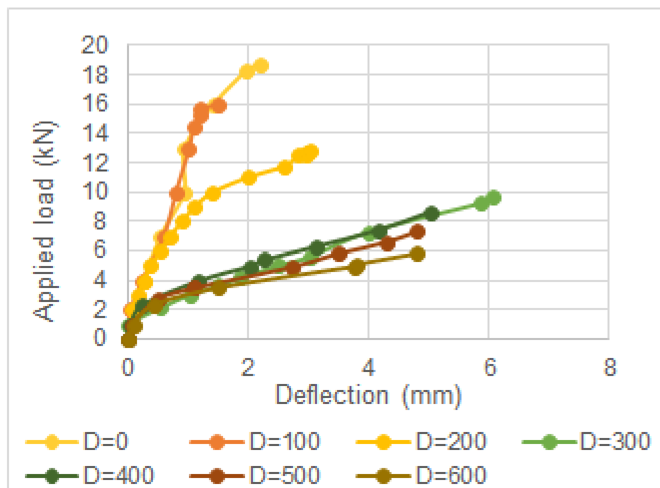

Fig. 6 *Load - deflection curve of the slab for different cavity sizes*

4.1 cavity depth effect

Six numerical models were tested for explaining the effect of cavity depth on the bearing capacity of the concrete slab. A cavity of (300 mm) were simulated at different depth (155, 200, 350, 400, 500, and 600mm) measured from the top surface of the soil to the cavity center. The ultimate load versus cavity depth curve is plotted for each model in fig (7). Based on the figure values, the ultimate load is increased with increasing the cavity depth, this behavior occurs because dissolving the effect of cavity when its more far. The figure (8) shows the load deflection curves of the slab for the study models.

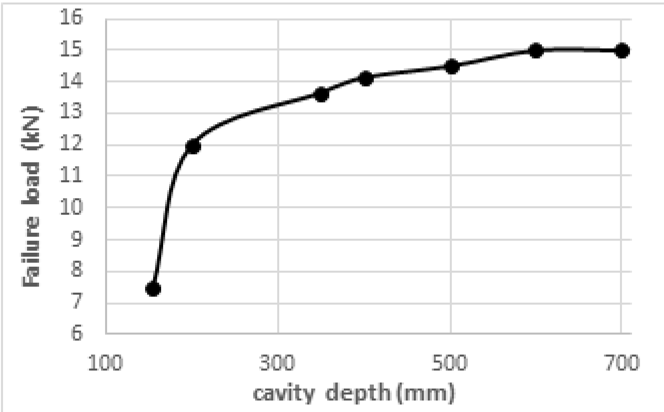

Fig. 7 *Slab failure load with different cavity depths*

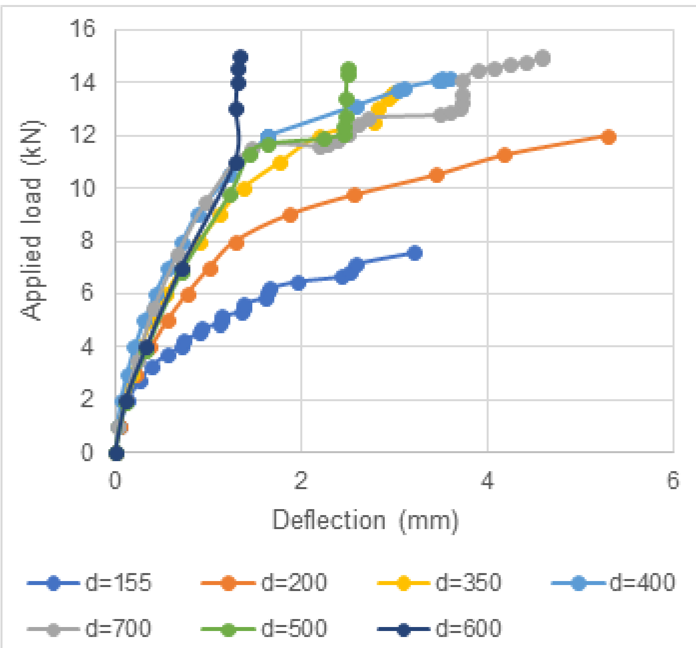

Fig. 8 *Load versus deflection curves for different cavity depths*

4.2 concrete slab thickness effect

The soil media in this study was with a cavity of (200mm) diameter and (250mm) depth. In order to study the effect of slab thickness variation, three different slabs thicknesses were done (15, 40, 80 mm). the load deflection curve of the study is explained in fig (9). Depending on the fig (9), it can be found that, the ultimate failure load of the cases of thin and thick slab were (9.12 KN) and (13.95KN) respectively. The ultimate load for thick slab does not mean the load of slab failure, but rather the cavity collapse. While the failure load in the case of thin plate represents the slab failure. The slab case of (40mm) thickness gives a result located between the thick and thin slab.

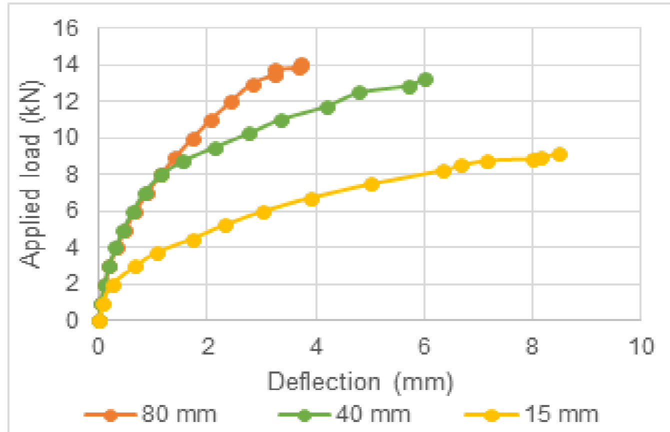

Fig. 9 *Increasing slab thickness effect*

4.3concrete slab compressive strength

The effect of compressive strength value on the ultimate slab bearing capacity has been studied in this section. Values of compressive strength equals (20, 27, 37 ,45, 55 MPa) has been tested on a soil with cavity diameter equals (160 mm) and depth equals (350 mm) form the surface of the soil. The result of slab behavior is shown in fig (10). The failure load versus compressive strength curve is shown in fig (11).

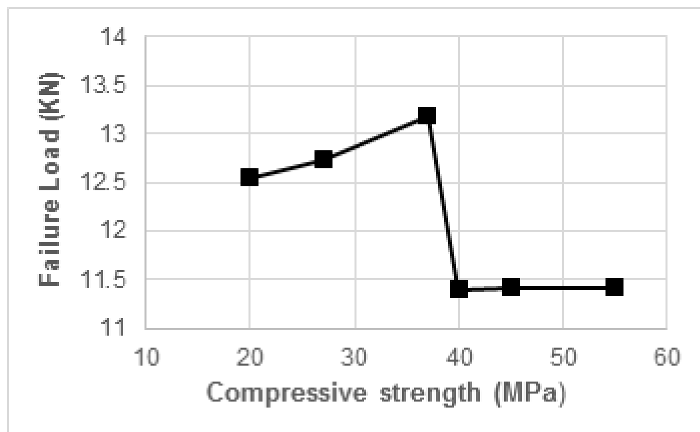

Fig. 10 *Concrete compressive strength effect on slab failure load*

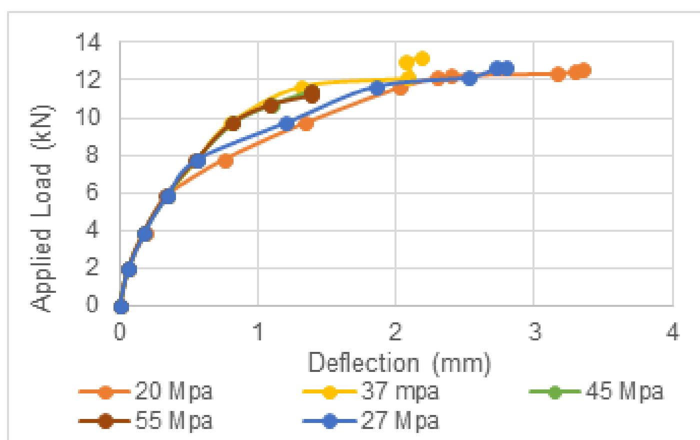

Fig. 11 *Load- deflection curve for multi f'c values*

ACI- committee 360 [6] recommends specified amounts of (f'c) when designing the slab on grade members, because by the compressive strength value, the load transfer into the ground. In this study, it has been found that, the larger (f'c) leads to lower ultimate load, because the larger (f'c) means more stresses transform to the soil, and as a result, the cavity collapse will occur faster than the concrete slab models. In another word, the stronger slab neither resists the applied load nor deflects by it, but it just transfers the load into the weakness and compressible media (which is the soil). For (f'c) equals (37Mpa), a best balance state in resisting load occurs for this type of soil.

5 CONCLUSION

- forming voids in the soil leads to decrease the failure load of slab by a magnitude depends on the cavity depth and diameter together.
- Increasing the cavity depth rises the failure load gradually till reaches to the state of no effect.
- Cavity of (D/T) = 0.13 (cavity depth to total depth of soil) causes to reduce the slab capacity by (148%) when comparing with a soil without cavity.
- Using a cavity of (d/B) =1 (cavity diameter to slab width) leads to reduce the slab failure load by (212.5%) when comparing with a soil without cavity.
- In the other hand, rising the concrete compressive strength and slab thickness incrementing leads to transfer all the load to the soil media which will cause cavity collapse.
- changing slab thickness from (40 to 15 mm) lessens the failure load of slab by (45%), while alteration slab thickness from (40 to 80mm) produced slab collapse at (14kN) for (d/D) =0.8 (diameter to depth ratio of cavity).

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