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utjeng@ utq.edu.iq

The Influence of Tunnels on the Surface Structure

Saja Abdulsttar Joudah[†], Kadhim Jawad Abdulkadhim [‡]

[†]Civil Engineering , Thi_Qar University, Iraq , Sajaaal@gmail.com .
[‡] Civil Engineering , Thi_Qar University , Iraq , Email.

Abstract

The influence of a tunnel must be considered while developing nearby structures in order to prevent the likelihood of tunnel damage. Such an evaluation necessitates a thorough understanding of the soil-structure interaction of buried and surface structures. The focus of this work is study of effect pre-existing of tunnel on shallow foundations. Based on the following criteria: 1. The impact of tunnel depth 2: The influence of foundation sizes on soil carrying capacity, where a practical investigation was undertaken to demonstrate the effect of each of the components described above. The tunnel was made of aluminum. It was placed within sandy soil. The results shows that the tunnel's depth has an impact it is apparent that the lower the depth, the greater the soil carrying capacity, Where three depths were employed, which are 15 , 30, 45 cm measured from the bottom of the used foundations, respectively. The ultimate bearing capacity of the soil increases as the size of the foundation increase.

Keywords: Bearing capacity , influence of tunnel , settlement .

1. Introduction

In recent years, urbanization has accelerated, attracting more people to metropolitan areas. This push has increased the population density of major cities. As a result, innovator must use both subsurface and above-drifting surface spaces wisely. Typically, subterranean space is offered for speedy moving and storing reasons due to a scarcity of suitable land or congested ground transportation, as a consequence of which travel time is decreased and a more habitual environment. More metro tunnels are being built at an exponential rate due to rising urbanization and increased demand for the metro rail system. Because tunnels pass through a variety of geological circumstances and overburden pressures, appropriate tunnel construction is critical to their long-term stability.

Many structures have been developed and built near existing tunnels in recent years to take use of the limited space available in congested metropolitan areas. It is critical in the design of the project to guarantee that any existing subsurface transit infrastructure near the suggested construction location can continue to work securely both during and after construction. If the erection of a structure affects the integrity of an existing tunnel, substantial damage may occur, necessitating costly repairs and time waste. As a result, understanding the interaction and influence of a newly constructed building covering an old subterranean tube is critical for stability. Building superstructures above and alongside the tunnel is a delicate and demanding undertaking. The impact of building construction on existing tunnels has been studied using theoretical and empirical methodologies, laboratory experiments, field observations, and, in latest decades, sophisticated computational analysis. Nevertheless, each of them has made a different contribution to our understanding of how the building projects near the tunnel have affected the area. Many researchers had thoroughly investigated the interactions between the tunnel and the buildings, excavations, piles, and shallow foundations**[1].**The eccentricity of the foundation and the impact of the tunnel's overburden, however, have not received much research. The impact of piling on an existing tunnel **[2,3]** and the impact of tunneling on the pile foundation [4,5,6] have both been investigated as aspects of the interaction between the pile foundation and the tunnel. Using cutting-edge analytical techniques, Liang et al. **[7,8]** investigated the effects of building basement (pit) excavation near existing tunnels, a common occurrence in Chinese cities **[9].**

2. . Material Model

2.1. Soil, Raft and tunnel

The test model was built with a variety of materials, including sandy soil, a raft, and an aluminum tube. The soil sample was collected from the Thi Qar Governorate in southern Iraq and categorized according to the standard as well graded (SW), as indicated in Figure (1). Many laboratory experiments were performed on it, as shown in Table (1), which demonstrates the material characteristics for experimental modeling. The raft model was composed of aluminum alloy. And the usage of metal with a square cross section (10)cm as tunnel model. Table (2) shows the characteristics of the aluminum utilized for the tunnel.

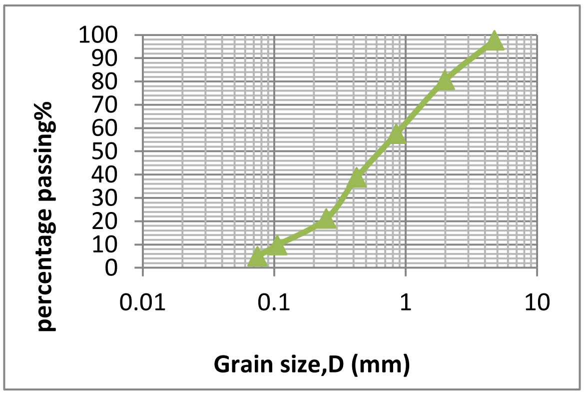

Fig.1 Sieve analysis of sandy soil

Table 1 Physical characteristics of sand.

Property	value	Standard of the tests
Specific gravity(Gs)	2.65	ASTM D 854
D10 mm	0.108526316	
D30 mm	0.3375	ASTM D 422 and ASTM D 2487
D60 mm	0.97	
Uniformity coefficient(Cu)	cu=8.94	
Curvature coefficient(Cc)	Cc=1.08	
Classification of soil(USCS)	SW	
Maximum dry unit weight(KN/m^3)	18.53	ASTM-D-1557 Modified Effort
Minimum dry unit weight(KN/m^3)	15.3	
Maximum void ratio		
Minimum void ratio		
The angle of internal friction	35	ASTM D3080

Table 2 Mechanical characteristics of the Aluminum utilized

Property	Value
Minimum yield strength (N/mm)	241
Minimum ultimate yield strength	214
(N/mm)	12%
Minimum % of elongation	69
Modulus of elasticity (N/mm)	0.33
Poisson's ratio	

2.2. Experimental Study

The experimental model studying was carried out using the following raft sizes: (25 25) cm, (25 x 10) cm, foundation thickness of 1.2 cm, and the tunnel dimensions: cross section area (10*10) cm, length 80cm, and thickness 2mm with three tunnel depth (15 ,30 ,45)cm.

3. Test Setup

A experimental test model was prepared in the laboratory to simulate reality, as displayed in Figure (2), which contains of a soil tank with dimensions of 800×800×600 mm. This tank was placed in an iron structure to resist the applied forces. This structure contains a hydraulic jack with a capacity of 50 tons installed at the end of it a load cell with a capacity of 5 tons. The cell was associated to a data logger to measure the load on the raft. Accurate strain gauges was also used, and they were attached to the tunnel and connected to a data logger to measure the strains in the tunnel. And use (LVDT) 100 mm, and connect it to the data logger to measure the Settlement at the centerline of the raft model.

Figure.2 Experimental setup.

4. Tunneled Raft Models

Model for the tunnel in this study were created using smooth aluminum hollow sections with 2 mm thicknesses and a square cross section(100) mm, there are three depth of tunnel to the e detection effect of presence of tunnel on shallow foundation. also used two models of the raft in the test (25x10x1.2)cm and (25x25x1.2)cm.

5. Density proofing method

the soil used in the test is sandy soil, the soil is compacted into a steel container as 12 layers with a height 5cm by using a steel tamping hammer with evenly dispersed strokes with density (1.708g/cm) and to ensure minimal cementation of the soil before tests, the hygroscopic water content of 3% was added to the sand before compaction and pouring .

6. Application of Vertical Load:

A vertical load was applied using a mechanical jack. The test was continued recording a continuous settlement of the tunnel raft under specific load incremental.. The value of applied load was read using a load cell, while the central Settlement of the raft was measured using LVDT of (LIN: ±0.1%) resolution, and the value of strain in tunnel was read using the strain gage. The above steps were repeated for each test.

Table 3 details of study

Dimension of foundation (cm)	Location of tunnel (cm)	Ultimate Load (kN)	Bearing capacity (Qu) kN/m^3
25×10	---	2. 95	118
	15	6.3	525
	30	4.05	162
	45	3.2	128
25×25	---	8.3	132.8
	15	16.25	260
	30	12	192
	45	10.1	161.6

7. Results and Discussion

The data was recorded using a data logger connected to a computer, and the data was plotted load _ settlement after examining the model (the tunnel under the raft foundation) and for three depths15, 30 , 45 cm as well as the condition in the absence of a tunnel. In the analysis application Excel. In this experiment, two foundations were used, the first with dimensions (25 x 25 x 1.2) cm, and the second with dimensions (25 x 10 x 1.2) cm**.**

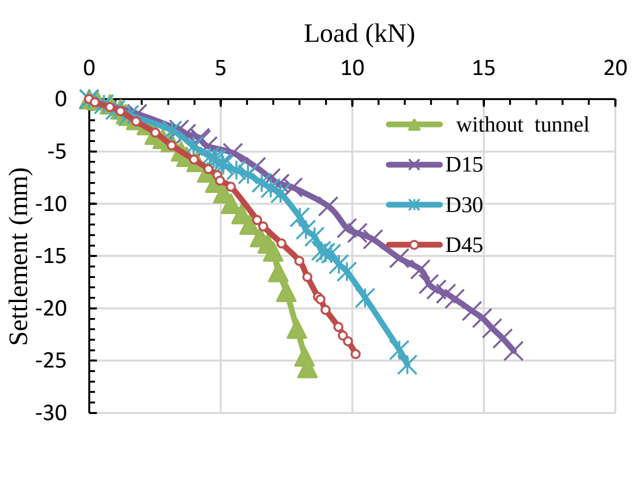

Figure. 3 load –settlement curve for raft (25*25), three depths [15,30,45]

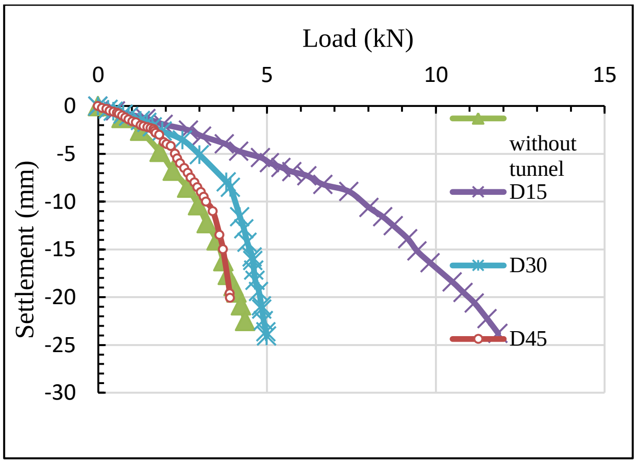

Figure. 4 load –settlement curve for raft (25*10), three depths [15,30,45]

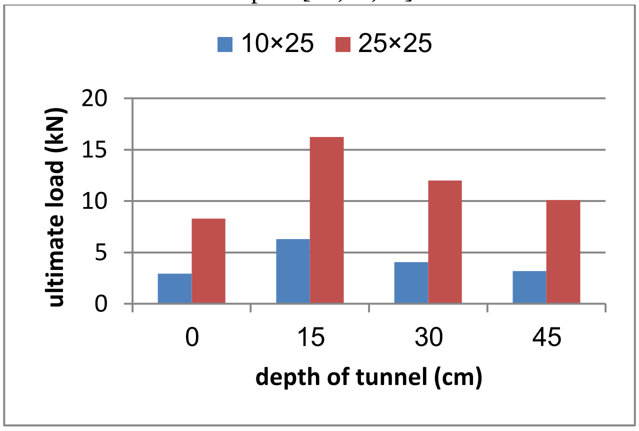

Figure .5 Ultimate Load Capacity

Conclusions

By observing the above results, the following can be concluded:

1- Figures (3,4) that show how the tunnel's depth has an impact . It is apparent that The depth of 15 cm was the largest contributor to increasing the load carrying capacity of the soil Table (3)

2- The settlement of the tunnel- raft and its load capacity clearly depends on the dimensions of raft and the location of tunnel

4- The ultimate load carrying capacity of the soil increases Table (3) as the depth of the tunnel decreases Figure (5).

5- The ultimate load carrying capacity of the soil increases as the dimensions of the foundation increase Figure(5).

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