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Tehran Subway Tunnel Settlement Analysis by Using Analytical, Experimental and Numerical Methods (Case Study: Station of Imam Ali University)

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Abstract: In The recent decades, the use of underground spaces including tunnels, railway, subway, cavern, underground spaces and others had great growth. Geological and geotechnical site conditions vary in different projects, requires different design, calculation and implementation methods also requires that the past experience and scientific and technical principles consistently applied. In this article we have tried to use the method of analytical, numerical and experimental investigation of the subway tunnel subsidence station of Imam Ali university.

Keywords—Tehran Subway, Tunnel subsidence, Station of Imam Ali University, Ground Surface subsidence, Plaxis 3D Tunnel Software.

I. Introduction

Today, in the big cities, urban subways and tunnels as one of the most important and most urban transport infrastructure networks are considered. However, the implementation of such major projects in the country who spent considerable cost to build them, may always be challenges. The most noticed part of this challenges is the implementation phase and the operation of these spaces and subsidences that during and after the operation occurred in underground spaces, is [i]. The method used in this study, The computational method is based on the use of finite element software that The assumption of elastic behavior for the Terrestrial environment to be taken [ii]. In this research, station of Imam Ali University in the second line of Tehran Subway has been studied The second line of Tehran Subway has a length of 24 km. The subway line is an east-west direction that is at the intersection of Imam Khomeini and Vali Asr Street near the University of Imam Ali university. Figure (1), Geographical location of subway station of Imam Ali University indicates second line of Tehran subway [iii].

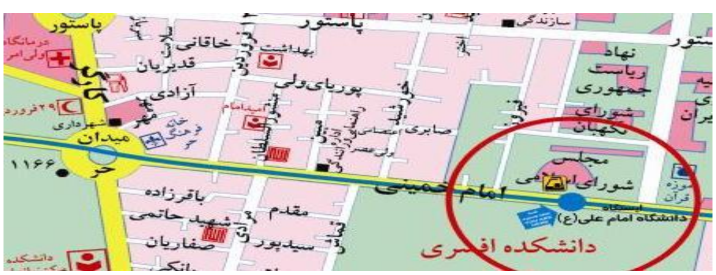

Figure 1. The geographical position of the subway tunnel station of Imam Ali university [iii].

Station tunnel Imam Ali university in the second line of Tehran Subway is located at 16 km. The radius of the circular cross section of the tunnel is equal 4.6 meters. Groundwater level at the station located at a depth of 25 meters above the ground. Figure (2), shows the final section of Tehran Subway tunnel at the second line.

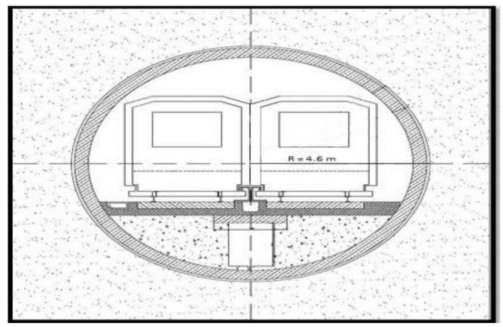

Figure 2. The final section of Tehran Subway tunnel at the second line[iii].

According to the excavations carried out in this area that has been done to identify the soil of this station, Type of soil Composed of gravel, sand and fine-grained soil. Group soils include GM-GC and SM-SC and fine-grained soils ML and CL can be seen. Kind of soil and geotechnical parameters Boreholes drilled relate to studied cross section (Subway station of Imam Ali university) In Table (1) and Table (2) are presented[iii].

Table 1. geotechnical Parameters of boreholes layers TP.429 station of Imam Ali university[iii].

Poisson's ratio	Elastic Modulus (KN/m^2)	Cohesion (KN/m^2)	Angle of internal friction (^{o})	Saturated specific weight (KN/m^2)	Dry Specific weight (KN/m^2)	Soil Type	Depth (meter)
0.32	330000	5	32	21	18	Fill	0-2
0.3	825000	1	35	22	18	Gravel	2-11.4
0.35	650000	3	34	18	15	Sand	11.4-12.2
0.33	230000	3	30	17	14	Silt	12.2-13.4
0.31	700000	2	34	20	16	Sand	13.4-17.6
0.3	825000	1	35	22	19	Gravel	17.6-22

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Table 2. geotechnical Parameters of boreholes layers BH.C station of Imam Ali university [iii].

Poisson's ratio	Elastic Modulus (KN/m²)	Cohesion (KN/m²)	Angle of internal friction (°)	Saturated specific weight (KN/m²)	Dry Specific weight (KN/m²)	Soil Type	Depth (meter)
0.32	330000	5	32	21	18	Fill	0-2
0.33	620000	4	34	20	17	Sand	2-4.80
0.3	825000	1	35	22	18	Gravel	4.80-10
0.35	650000	3	34	18	15	Sand	10-12.2
0.33	230000	3	30	17	14	Silt	12.2-14
0.31	670000	3	34	21	18	Gravel	14-15
0.31	700000	2	34	20	16	Sand	15-17.6
0.3	825000	1	35	22	19	Gravel	17.6 - 20
0.31	600000	3	33	20	18	Sand	20-25

Figure 3, shows the geotechnical section of subway station of Imam Ali university at 15 + 945 kilometer that located on the second line of Tehran subway[iii].

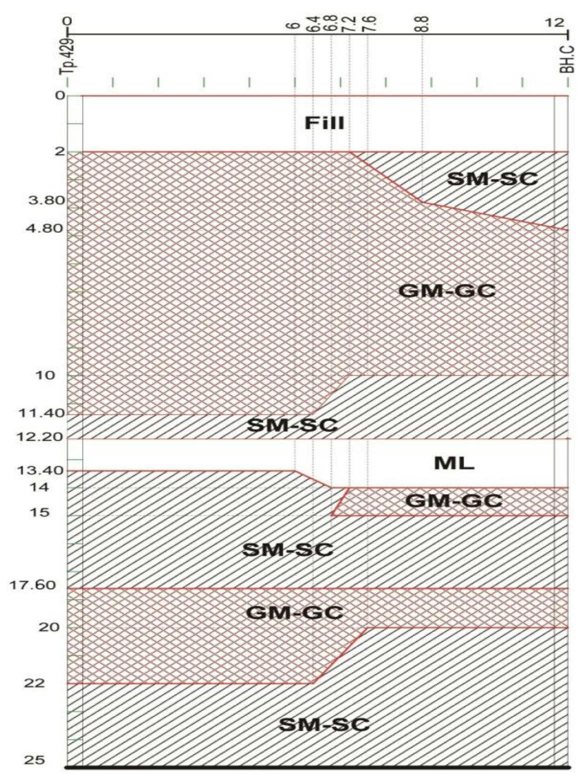

Figure 3.Geotechnical section of Imam Ali university station [iii].

Loganathan and Poulos are analytical methods for calculating ground subsidence in the subway station of Imam Ali university.

$$g\times a_0)+g^2) \div (4\times a_0{}^2))\times 100\%$$
$$\varepsilon_0 = ((((1)$$

In relation (1), ε_0 Earth subsidence, a_0 Tunnel radius and g is gap parameter that by Lee and colleagues (1992) is defined as follows:

$$g = G_p + U_{3D} + \omega \quad (2)$$

In equation (2) as shown in Figure 4, G_p is a distance (gap) physical, U_{3D} parameter is Three-dimensional elasto-plastic deformation at in front of tunnel and ω parameter consider Skills of executives.

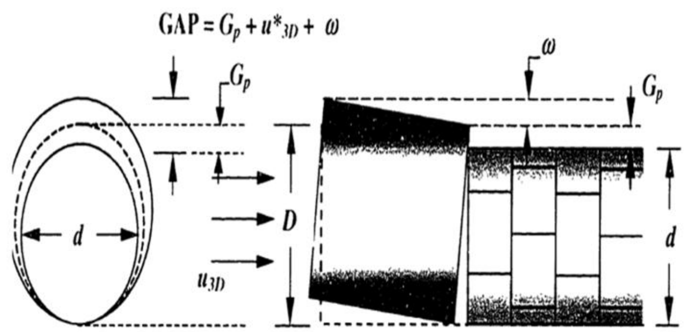

Figure 4. tunnel leading under the influence of all factors of land subsidence include more drilling, and less operator skill [iv].

physical gap intended for the second line of Tehran subway will be equal to 280 mm.

$$g = G_p+U_{3D}+\omega = 280 + 0 + 0 = 280\text{mm} \quad (3)$$

Table 3. The results of ground surface subsidence by using Loganathan and Poulos methods.

S_{max} (mm)	Gap Measure (mm)	Correction factor	Tunnel (m) Depth
0.111	19.6	0.07	15.90
0.159	28	0.1	15.90
0.816	140	0.5	15.90
1.156	196	0.7	15.90
1.682	280	1	15.90

The maximum subsidence rate increases with increasing the correction factor for 0. 07, 0.1, 0.5, 0.7, respectively 0.111, 0.159, 0.816 and 1.156 mm is calculated. Also for a gap of 280

Unit	Building Elastic	Pile toe Elastic	Cover Elastic	Name Type	Parameter Behavior
KN/m	1×10^{10}	2×10^{6}	8.2×10^{6}	EA	Normal Difficulty
$KN.m^2/m$	1×10^{10}	8×10^{3}	8.380×10^{4}	EI	Flexural rigidity
m	3.464	0.219	0.35	d	Equivalent thickness
KN/m/m	25	2.0	38.150	W	Volumetric weight
______	0.0	0.2	0.15	υ	Poisson's ratio

mm The maximum amount of subsidence equal to 1.682 mm occurs [iv].

Table 4. Plates materials.

II. Material and Methodology

Peck imperical method:

In equation (4) that are provided by peck, Surface subsidences in a transverse section are closed to an inverted Gaussian distribution, which is defined by two important parameters: Svmax and i [ix].

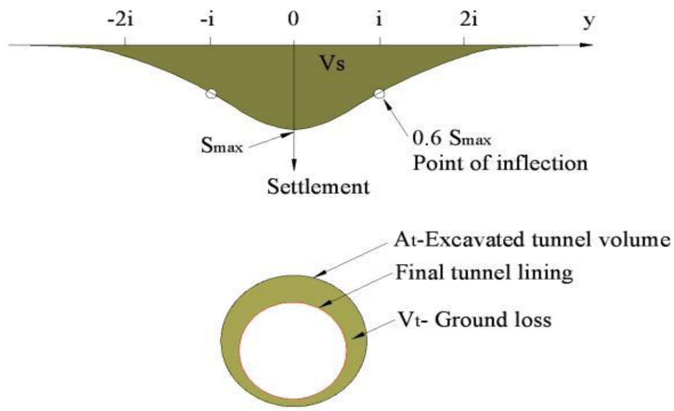

Figure 5. Transverse subsidence – Gaussian curve [viii].

$$S_{v(y)} = S_{v,max} \times \exp\left((-1)\times(y^2\div(2\times i^2))\right) \quad (4)$$

$S_{v(y)}$ - is the surface subsidence

$S_{v,max}$ - is the maximum settlement above tunnel axis

i- is the horizontal distance from the tunnel axis to the point of inflection of the settlement trough

y-is the horizontal distance from the tunnel axis [v].

$$\text{Peck: } i/R = (Z_0 / 2R)^n \qquad n = 0.8\text{-}1 \quad (5)$$

Z_0 = Distance from the tunnel to the surface

R = Tunnel Radius

Given that the relationship proposed by Mr. Peck, parameter (i) has the main role [vi]. Due to the profile of the subsidence for a constant volumetric subsidence, With increasing parameter (i) of 7.13 to 7.96, The maximum subsidence rate of 3.27 mm to 2.93 mm and 0.34 mm in size has decreased.

Subway tunnel subsidence analysis of Imam Ali university with the help of numerical methods (Plaxis 3D Tunnel software):

Plaxis software is a numerical analysis software that with finite element method modeling and analyzes geotechnical issues and to calculate the stability and deformation caused in the geotechnical structures used.

In this study, by using the software Plaxis 3D Tunnel to checking

Subway tunnel subsidence of Imam Ali university has been paid. These subsidences can be created due to the continuous nature of the soil is transferred to the surface earth. Results from in vitro and in situ studies show the land area is in very good agreement with the mohr-coloumb model behavior in the software. So in order to model the behavior of the soil, has been used this model behavior [vii].

Dimensions of Three-dimensional model is: 24 m in the X direction, 25 m in the Y direction, 20 m in the Z direction. In figure 6, Subway tunnel of Imam Ali university, according to the data in Table 4 has been modeled by using Plaxis 3D software.

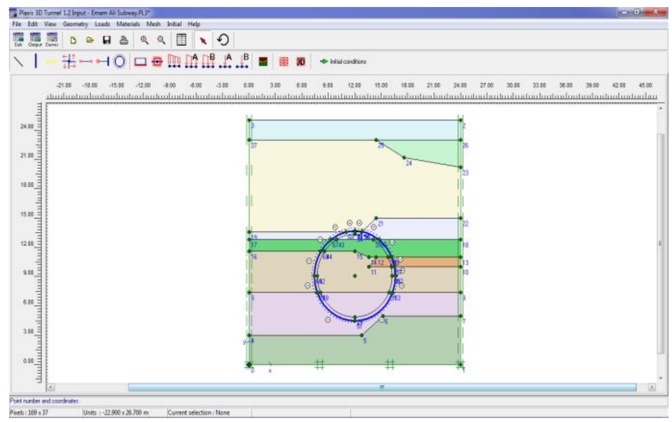

Figure 6. The subway station tunnel modeling of Imam Ali university by Plaxis 3D tunnel software.

In figure (7) General subsidences took place in the shade shown. Due to this figure The maximum amount of settlement is obtained 1.77 mm that the roof of the tunnel subway station of Imam Ali university has occurred.

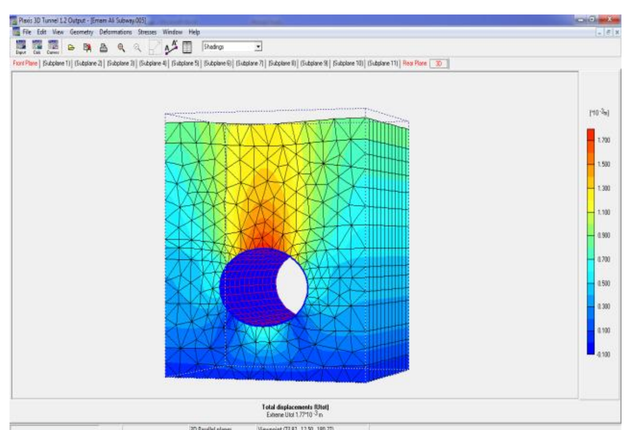

Figure 7. The general subsidense has been created that in the shadow of the software shown.

Figure (8) shows the displacement of the tunnel that the maximum value occurred in the tunnel roof and the amount is equal to 1.77 mm.

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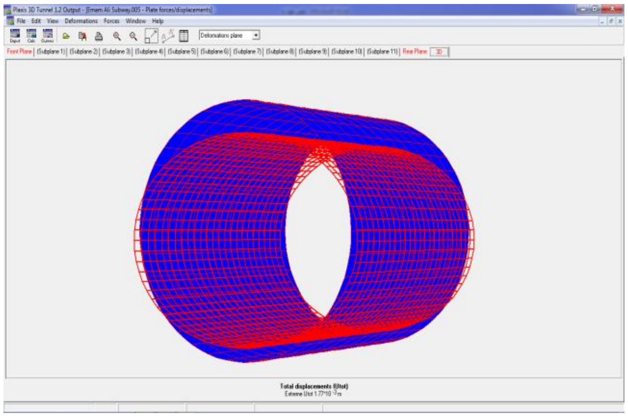

Figure 8. The general displacement that happened to tunnel.

In figure (9) displacement directions took place in the tunnel wall shows. Because the size of the arrows in the roof of the tunnel is larger therefore it can be concluded that the maximum displacement equal to 1.77 mm happened in the tunnel roof.

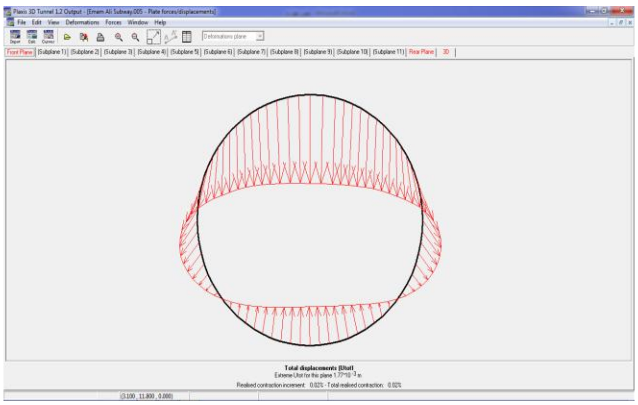

Figure 9: arrows shows displacement directions that occurred in the tunnel.

III. Results

The various methods of experimental, analytical and numerical analysis of underground structures subsidence and ground surface subsidence there, Requires that before using any of these methods, the number of parameters to determine the geological and geomechanical study area is [x]. In this paper, the evaluation and analysis of the Tehran subway tunnel subsidence and, in particular, stations of Imam Ali university Check out and subway tunnel station of Imam Ali university as a case study, a three-dimensional evaluation of analytical, numerical and experimental was. In this section the results of numerical, analytical and experimental studies are presented in this paper :

1. Based on the assessments conducted subsidence using analytical, numerical and experimental specified, Measurement of the maximum level subsidence with analytical and numerical methods are much closer together, So that the maximum settlement amount equal to 1.68 mm analytical methods and with the Numerical methods (using software) is equal to 1.77 mm. Therefore it can be concluded that the results of analytical and numerical methods is a lot closer to reality.

2. In the experimental method peck the maximum subsidence equal to 3.24 mm is obtained, In comparing the analytical and numerical methods can be found on this matter the settlement amount is calculated on the experimental method, Of the subsidence that happened in reality is much more And with a high safety margin has been declared.

3. Based on the results obtained by numerical methods (Plaxis 3D tunnel software) can be reached as a result that the maximum subsidence at a subway station of Imam Ali university, Tehran, on the crown (roof) of the tunnel occurs. However, due to the continuous nature of the soil, ground surface subsidence occurs, but much less than what happened in the tunnel crown.

4. If there are buildings on the ground near the subway can this subsidence occurred at ground level and damage to structures on the ground surface. and cause irreparable damage.

IV. Conclusion

Effective parameters include trailer weight, TBM length, TBM weight, Friction angle of the soil, Greater degree of the moment soil consolidation, Soil permeability, Features of cement hydration, Breast press, Injection pressure, convergence parameter Elastic modulus of the soil and the depth of the tunnel that the pressure parameters breast, Injection pressure, convergence, Elastic modulus of the soil and the depth of the tunnel have the most impact on subsidence.

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References

i. *Hasan Madani, Tunnel construction (stability analysis), Volume III, Fourth edition, Tehran Polytechnic, Amirkabir university publications,2010.*

ii. *M. Heidari, M. Vafaiyan, N. Shariatmadari, The effect of the surface slope, external load and the cross section of the tunnel on the amount of land subsidence from tunnel excavation.*

iii. *Railways Company of Tehran and Suburbs.*

iv. *H. Karimnia, H. Mirzaei Nasirabad, SH. Zare, Predict ground subsidence under the influence of mechanized tunneling between number of stations 11 and 12 at first Tehran subway line, with using experimental, analytical and numerical methods, page 413 to page 424, Journal of transportation engineering, Third edition, 2014.*

v. *Franzius. J. N, Behavior of building due to tunnel induced settlement. Ph.D. dissertation, Imperial College of Science, Technology and Medicine, 2003.*

vi. *Sweeney.P, A study of interaction effects due to bored tunnels in clay, Ph.D. thesis , Massachusetts Institute of Technology, 2006.*

vii. *Plaxis 2D, Edited by R.B.J Brinkgereve, Delft university of technology &Plaxis b.v the Netherlands, 2002.*

viii. *Zhao Jian, Rock Mechqnics and tunnel Engineering, Course lecture-Settlement in soft ground tunnelling.*

ix. *Erdem & Solak, Underground Space Use: Analysis of the Past and Lessons for the Future, 2005 Taylor & Francis Group, London, ISBN 04 1537 452 9.*

x. *Moldovan, A., Popa, A., The influence of different tunnel cross sections on surface settlement, Civil Engineering & Architecture, 56, p.7-14, 2013.*