Compare different methods of seismic design of highway Wise in Tehran (capital of Iran)

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Abstract— In recent years, the development and frequency of seismic damage underground structures, seismic analysis and design of underground structures has been more and more attention. Especially in large-Osaka Kobe earthquake in 1995, some subway stations and tunnels were severe injury, the first about the damage caused by the earthquake is the modern amenities underground. After this, the scientists examined the underground seismic and thereby causes damage theory based analysis and design methods to be carried out. The purpose of this research is analytic closed-form solutions with plaxis software for the axial force and moments in a deformation folding cover circular tunnel under the intersection of excitation seismic slip, the uncertainties and effects of various parameters on their results. As well as case studies and parametric and comparing the results of studies.

Index Terms— seismic analysis, subway, underground structures, earthquake

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1 Introduction

Underground facility built in areas affected by the earthquake activity in both the static load and resist earthquakes. A review of the historical effects of earthquakes on these structures can be seen that failure rate is lower than ground structures. In the recent earthquakes such as the 1995 Kobe earthquake while Japan, Taiwan Chi Chi earthquake in 1995, earthquakes in 1999 Kukayly Turkey, underground structures damaged in the 1995 earthquake in Kobe. More than 30 tunnels have experienced minor damage about 10 tunnels were needed to ensure reciprocity (Asakura and Sato, 1996). Chichi earthquake in 1999 in Taiwan, a total of 50 tunnels damage have been reported. Of these, 26 tunnels were slightly damaged, damage was moderate, 11 tunnels and 13 tunnel was severely damaged (Wang et al., 2000). It is seen that the tunnel safety in seismic active areas of the tunnel is still a major problem for engineers.

The purpose of this research is analytic closed-form solutions for the axial force and moments in a deformation folding cover circular tunnel under the intersection of excitation seismic slip, the uncertainties and effects of various parameters on their results. As well as case studies and parametric and comparing the results of studies.

2 Engineering approach to seismic analysis and design

2.1 Review Stage

Detailed submission guidelines can be found on the author
The effect of earthquakes on underground structures can be classified into two categories: the vibration of the earth and ground rupture.

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Important factors affecting vibration damage: 1. shape, size and depth of structure 2. the soil profile 3. Structures ground 4. vibration intensity [John and Zahrah; 1987].
For many underground structures, adjacent soil inertia of the inertia of the structure is greater. Measured by Okamoto of the seismic response of a tunnel immersed tube tunnel over the earthquake that call by call land adjacent to his mood prevails, not the inertia characteristics of the tunnel structure. The focus seismic design of underground utilities, the free area of ground deformation and interaction with structures that are designed for this surface structure that is focused on the structure of its inertia, is contrary [Okamoto et al; 1973].
This led to the development of design methods like seismic deformation method that explicitly examines led ground deformation. For example, a search Kawashima on seismic behavior and design of underground structures in soft ground with an emphasis on the development of seismic deformation method is presented [Kawashima; 1999].
The behavior of a tunnel often exposed to a beam of elastic deformations imposed by the surrounding land adjacent approximated. Three types of ground deformation structural response to seismic excitation states (Owen and Scholl, 1981):
1) axial compression and expansion
2) longitudinal bending
3) depletion and elongated oval distortion (folding)
Axial deformation in the tunnel by the components of seismic waves that stimulate parallel to the axis of the tunnel and cause expansion and contraction (tension and pressure) is frequently arise. By bending deformation of the components of seismic waves, producing minor provocations perpendicular to the longitudinal axis are produced. Design considerations for axial and bending deformations are generally in line with the axis of the tunnel [Kramer; 1996]. Deformations oval or elongated tunnel structure, perpendicular or nearly perpendicular to the tunnel axis as shear waves spread, from the fracture cross-section of the tunnel lining, spreads. Design considerations for this type of deformation in the transverse direction. The overall behavior of buried

structures affected by the deformation of the coating such as a two-dimensional plane strain condition of the sub. Figure (1) tunnel under the deformation modes of seismic waves show.

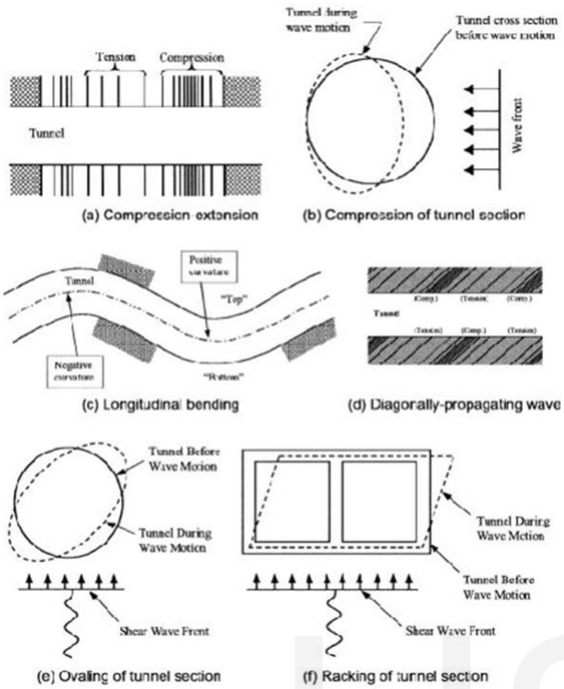

Figure 1- Tunnel deformation modes of seismic waves

Figure above diagonal waves, different parts of the structure subjected to axial compression and displacement of non in phase are the result of wave reflection in the structure. In general, the larger displacements larger wavelength dependent, if the maximum curvature with shorter wavelengths are relatively small displacement amplitude [Kuesel; 1969].

3 Wise tunnel seismic behavior

Underground structures in general to earthquake-resistant structures above ground are considered, however when a tunnel is experiencing a severe vibration, may possibly be damaged. For example, it is reported that in the 1995 Kobe earthquake, more than 30 tunnels have experienced minor damage and about 10 tunnels were needed to ensure reciprocity. Chichi earthquake in 1999 in Taiwan, a total of 50 tunnels damage have been reported. Of these, 26 were slightly damaged tunnel, 11 tunnels were moderate and 13 were badly damaged tunnel (Wang et al., 2000). It can be seen that the safety of the tunnel in the mountains in active seismic zones of the tunnel is still a major problem for engineers.
In this project, two methods were used to assess seismic Wise tunnel. The first method uses analytical equations and other methods using finite element software Plaxis modeling and evaluation of seismic shear deformation is performance.

4 Analytical methods

In this section, we listed the results of the analysis for the tunnel Wise ODE and MDE used in both the earthquake and compare with finite element relations.
table (1) and (2) Specification wise tunnel cover and soil surrounding the tunnel to show. The shear stress and shear modulus values for both MDE and ODE's earthquake in the seismic loading were calculated in the table (3) have been brought.

Table 1- details the tunnel cover Wise

Lining Parameter	Value
Young's modulus , E_l(KN/m2)	**28249500**
Area(per unit width)	**0.6 m^2 / m**
Moment of inertia (I)	**0.018 m^4 / m**
lining thickness(t)	**0.6 m**
Poisson ratio	**0.35**

Table 2- in the soil profile analysis

	Poisson ratio	Young's modulus
Soil TYPE	ν_m	**Es(kN/m2)**
Elastic	0.3	**70000**

Table 3- levels of shear stress, shear strain and shear modulus for the ODE earthquake and MDE

	MDE	ODE
(kN/m^2)τ	96	**157**
γ	0.00388	**0.00095**
G (kN/m^2)	8.67×10^4	**1.65×10^5**

4.1 ODE earthquake mode

The analysis of relationships in ODE earthquake in Tables (4) to (6) are summarized.

Table 4- axial force and bending moment up on the basis of Wang for earthquake ODE

$M_{max\backslash}$ (kN - m)	T_{max}(kN)	K2	K1	C	F
760	607	2.277	1.5324	0.0247	0.2623

Table 5- axial force and bending moment up on the basis of Wu & Penzein for earthquake ODE

M_{max} (kN- m)	T_{max} (kN)	R	α	E_l (Kn/m2)	M_{max} (kN- m)
109	87	2.524038	0.030095	2.82E+07	109

Table 6- axial force and bending moment up on the basis of Bobet for earthquake ODE

M_{max} (kN - m)	T_{max}(kN)	Δ'	C	F	ν_m
684	612	3.8161	0.02470	0.26235	0.35

4.2 MDE EARTHQUAKE MODE

In this case, the result of an analysis of the tables (7) to (9) are summarized.

Table 7- axial force and bending moment up on the basis of Wang for earthquake MDE

M_{max}(kN - m)	T_{max}(kN)	K2	K1	C	F	t(m)
446	363	2.3040	1.537	0.024073	0.24263	0.6

Table 8- axial force and bending moment up on the basis of Wu & Penzein for earthquake MDE

M_{max} (kN - m)	T_{max}(kN)	R	α	E_l(Kn/m2)
429	349	2.459152	0.057275	2.82E+07

Table 9- axial force and bending moment up on the basis of respect for earthquake MDE Bobet

M_{max} (kN - m)	T_{max}(kN)	Δ'	C	F	ν_m
402	366	3.77029	0.024073	0.24263	0.35

5 FINITE ELEMENT METHOD

In this section the results of finite element analysis software has been wise tunnel model. The forms (2) to (4) the results of the static analysis, is presented under 13.5 meters of overburden.

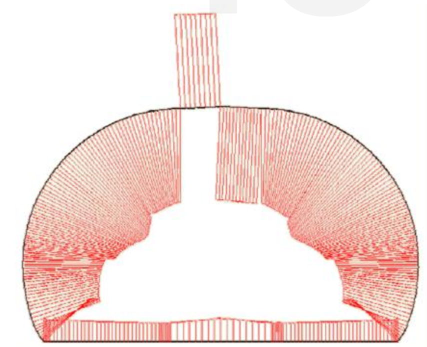

Figure 2- diagrams axial force loads Dead + Soil + Live

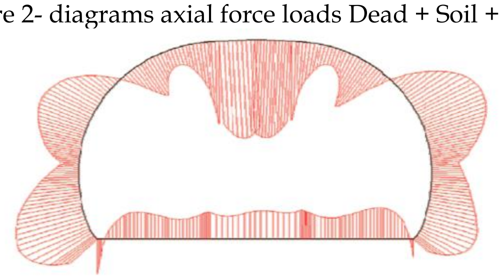

Figure 3- loads the bending moment diagram Dead + Soil + Live

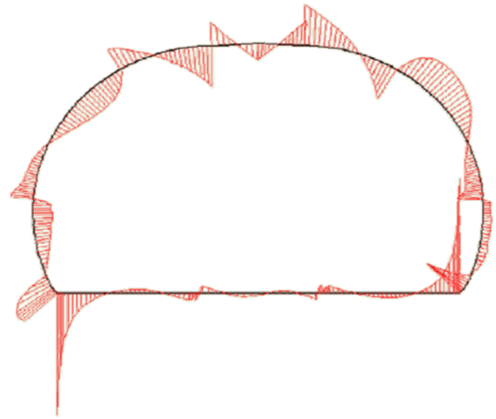

Figure 4- Diagram of shear loads Dead + Soil + Live

Values of axial forces, bending moments and shear forces on the table (10) and 9 school Figure (5) is extracted. The following contracts for bending moments and axial forces are taken into account.

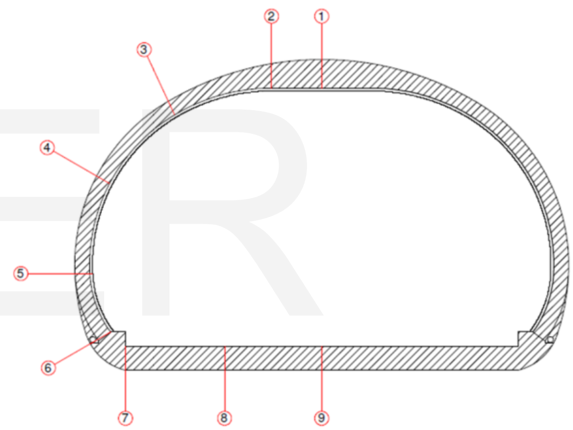

Figure 5-section form transverse forces

Table 10- derived from the cross sections required software version

SECTION	**PLAXIS Static Analysis - (DEAD+SOIL+live)**		
	P (kN)	M(kN-m)	**V(kN)**
1	850	163	**45**
2	853	152	**-107**
3	893	74	**59**
4	1026	-64	**-42**
5	835	-32	**51**
6	549	-65	**94**
7	193	16	**77**
8	172	37	**5**
9	209	52	**5**

Following the results of the seismic analysis The model is presented. Figure (6) contours horizontal deformation model under quasi-static analysis of seismic shear stress at the show.

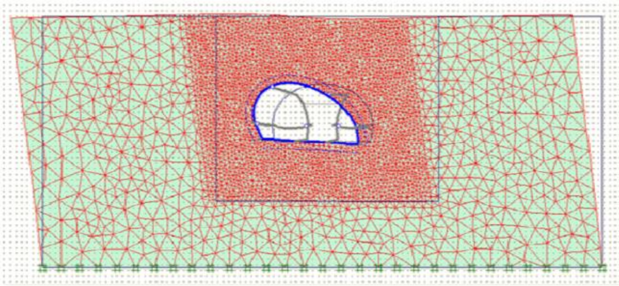

Figure 6- deformed mesh in quasi-static analysis of seismic

Table 11- extracted from the respective cross sections under earthquake modeling ODE

SECTION	PLAXIS Static Analysis - (DEAD+SOIL+live)		
	P (kN)	M(kN-m)	**V(kN)**
1	0	0	**0**
2	335	-17	**6**
3	879	-118	**1**
4	858	-97	**13**
5	364	-22	**36**
6	-636	436	**269**
7	-616	348	**297**
8	-383	43	**13**
9	1	1	**1**

Table 12- extracted from the respective cross sections under earthquake modeling MDE

SECTION	PLAXIS Static Analysis - (DEAD+SOIL+live)		
	P (kN)	M(kN-m)	**V(kN)**
1	0	0	**10**
2	206	-1	**25**
3	547	-129	**7**
4	534	-112	**-16**
5	221	-23	**6**
6	-417	382	**-113**
7	-395	321	**211**
8	-250	38	**-3**
9	0	1	**-6**

6 Compare the Results of the Analytical Method and Finite Element Method

This section compares the results of the seismic analysis of tunnel lining has been paid. The tables (13) and (14) the maximum amount of axial forces and bending of analytical and finite element methods in two ODE earthquake and MDE were estimated in this chapter, have been organized. In the form of (7) to (10) as well as the results of four earthquakes respectively ODE and MDE shown.

Table 13- Maximum values of axial forces and bending of analytical and finite element methods in earthquake ODE

Method	T_{max}(kN)	M_{max}(kN - m)
Wang	607	**760**
wu & penzien	87	**109**
Bobet	612	**684**
FEM	879	**436**

Table 14- Maximum values of axial forces and bending of analytical and finite element methods in earthquake MDE

Method	T_{max}(kN)	M_{max}(kN - m)
Wang	363	**446**
wu & penzien	349	**429**
Bobet	366	**402**
FEM	547	**382**

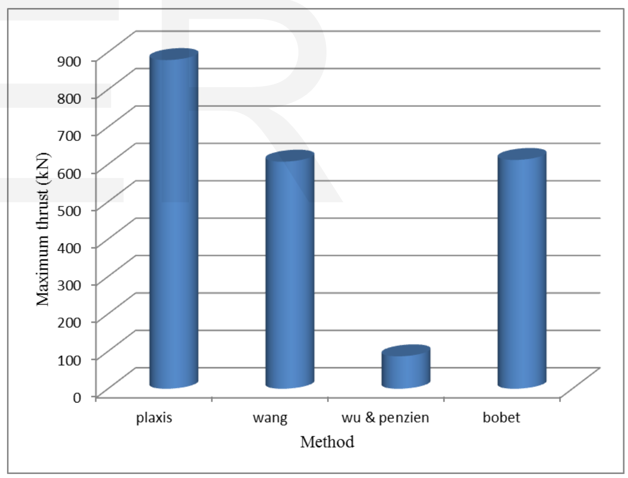

Figure 7- maximum axial force in the earthquake ODE

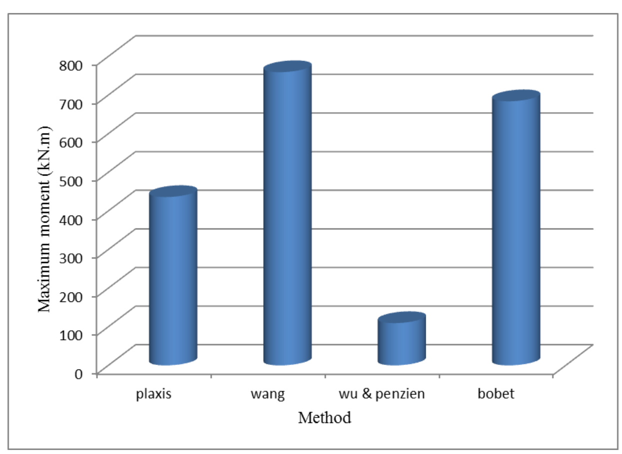

Figure 8- maximum bending moment in the earthquake ODE

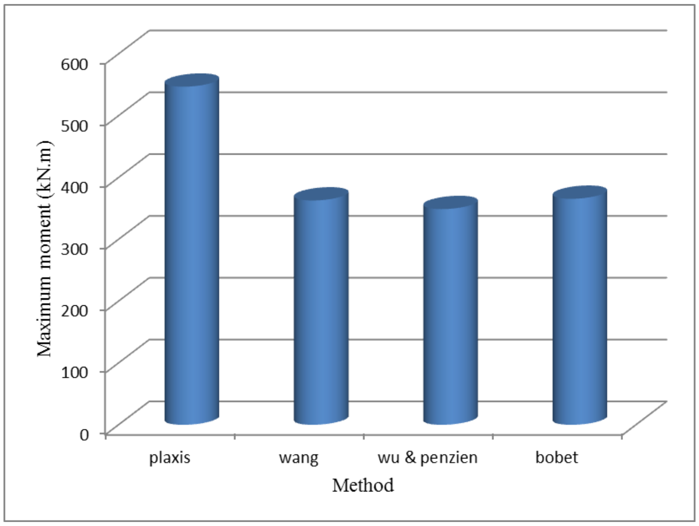

Figure 9- maximum axial force in the earthquake MDE

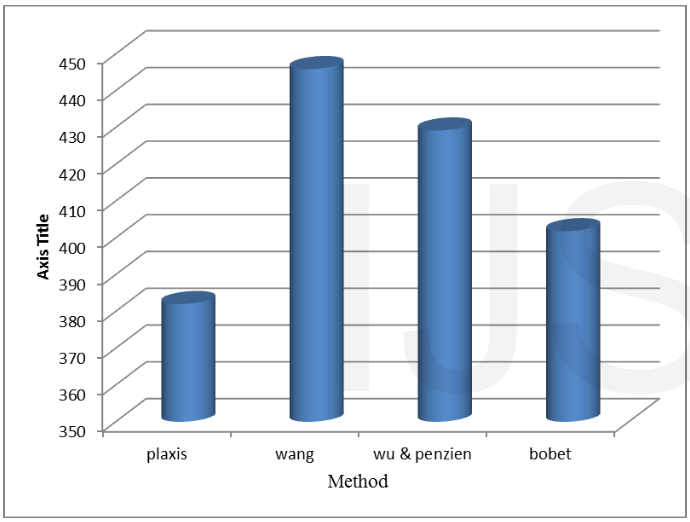

Figure 10- maximum bending moment in the earthquake MDE

As is clear from the above figure, the amount of axial force in analytical methods, finite element analysis at both lower than earthquake is ODE and MDE. However, the amount of bending moment in the analytical methods except in the case of Wu & Penzien earthquake ODE, in other cases, the results of finite element analysis more.

4 Conclusion

According to analysis by analytical and finite element method with software PLAXIS can be deduced the following results:

1) According to the model analysis can be concluded that the results of the seismic analysis of the results of this relationship MDE ratio under earthquake ODE, are more accurate. For as in the tables can be seen, the percentage difference between the results of analytical and finite element analysis under MDE earthquake to earthquake ODE has been lower doses.

2) As can be seen in the figure and table, axial forces in finite element analysis is less analytical values. For these analytical results if you use the tunnel design due to the lower axial forces in the direction of confidence is lower for the tunnel.

3) The results and what is evident in the figures and tables, the values of bending moments in the relations of the finite element analysis under earthquake ODE larger amounts. So if these values used for the design of the tunnel, cross-cover tunnel is very uneconomical.

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