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First and second lining vibration design of urban tunnels in Tehran ABAQUS software

Mahdi Kasiri Ghahi [1] and Ali Sanaeirad[2]

1 Department of Engineering , College of geotechnic , Khomein Branch, Islamic Azad University, Khomein, Iran
2 Department of Civil Engineering Faculty of Engineering Arak University Markazi Province Iran

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ABSTRACT

Abstract: Nowadays, a great portion of transportation is being accomplished through underground structures. As such structures are embedded into the ground and there is a remarkable interaction between them and the surrounding soil, very little attention has been paid to the impact of earthquake on these structures. With respect to the increase in rate of transportation as well as decrease in depth to the ground surface, the safety of these structures against earthquake need to be taken into account much more carefully. Due to the importance and diversity of this issue, design of tunnel linings has been widely investigated so far. In this respect, one of the questions that arises in engineers' minds is regarding the time duration of stresses release after excavation until execution of the concrete lining. Accounting for the stiffness of the permanent lining, in the beginning of the analyses, is so conservative such that in case of soil or rock mass with high overburden, irrational results will be obtained. The main objectives of this research is to obtain seismic and dynamic results of metro tunnels supported by concrete linings and specify the significant and effective parameters on seismic design of such underground structures. By means of applying two types of vibration including periodic loads as well as base excitation using accelerograms, the impact of surcharge on seismic response of the lining was studied. Among the results, the maximum displacement was related to the KN60 surcharge. Regarding the effect of soil elasticity modulus on displacements, it can be concluded that increase in this modulus, reduces the displacements and the considerable reduction takes place when the increase is in the range of 20 to 40 MPa. Moreover, increasing the Poisson ratio led to a little increase in dynamic response of the lining

Keyword:
Lining, Tunnel, Abacus, FEM, stress and displacement

*** Corresponding author: k_mahdi50@yahoo.com**

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INTRODUCTION

Nowadays, underground structures are assumed a significant portion of the duty of transportation and storage. According to these structures being buried in their interaction with the surrounding soil, the effect of the earthquake on these structures will not too concerned [1]. Resistance of the connections between segments is very important. This is largely due to the inability of joints with the same stiffness of the main segment [1-2].scattered studies are done by various scientists to survey the effect of joint care and segments on the lining resistance analysis. One of the primary surveys was done by Wood . Wood in 1975 suggested that an effective moment of inertia lining due to the joint effect reduce, the influence of this parameter depends on the number of segments and structure of the joints. Various tests to check and analyze the impact of joint in lining behavior has been don. In this study, the problems of power leakage caused by water flowing underground tunnels were studied. Firstly, the effect of seepage forces acting on the cover of a shallow drainage tunnel was studied. The results of a case study conducted in the Seoul Metro Line No. 5 were compared. The effective stress acting on the tunnel was investigated [3]. Kim and colleagues in 2006 study and predict the load to the tunnel and the tunnel has been created tensions, the design load applied to the tunnel with regard to the number of tunnels is estimated [4]. Teachavorasinskun and colleagues in 2010 examined the effect of segments connection were assumed in Lining tunnels . A simple method to evaluate segmental tunnel as well as the use of numerical methods FEM were built, segmental common effect, the number of pieces and the modulus of the soil in this study is investigated. Common was shown by a series of springs called angular joint stiffness [5]. Wongsaroj et al in 2011are involved with the modeling of the tunnel and its response to applied loads[6]. modulus of elasticity and Poisson coefficient tunnel will be discussed. applied Load , is the acceleration of earthquake records that the overhead amount of that is considered variables an the movement of the tunnel is examined .

2- Validation

Circular lining tunnel are considered one new approach in design of tunnels in urban structure that the basic application of that in underground spaces specially the subways, as we know, the cross-section of the tunnel is more the sensitivity to earthquakes is greater. one of the reasons of local greatness of tunnels in interactions and subway stations are this ,that this article explores the interaction between the lining of the tunnel that the results of analysis by solving theory by Einstein (19 7Sehwartz 9)is compared and geometry model conditions is modeled by the Flac3d program . in this study selected strain type is a small strain as the model without holding system is applied ,all movement toward the tunnel will occur with applying holding system ,all movement will tend to be outside the tunnel. Elastic behavior model is the one which its situ stress is vertical 600 kPa and horizontal is 300 kPa. Tunnel is maintained with 125 mm shotcrete lining. Their research is done for both modes of interaction Lining- tunnel, a non-slip mode (no relation to shear displacement) and another is full slip (with the loss of shear stress). The results of numerical analysis is compared with presented theory solution by Schwartz theory and Einstein (1979). The main objective of the study with Flac3D application a 3-dimensional analysis of the area (period) 3000 meters of water transmission tunnel in Nosoud Kermanshah and are finding the amount of horizontal and vertical displacement. The modeling process in this project are as follows: - modeling of the rock mass - tunnel digging -creation of interface between slurry and lining .obtained results from Schwartz et are as follows[1]:

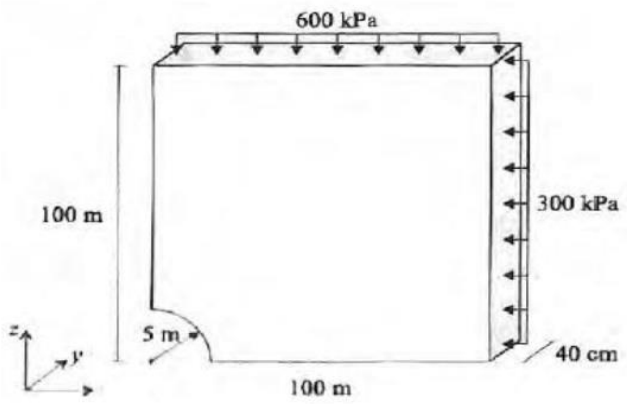

Figure1: Geometric model in Schwartz et al [1] is studies

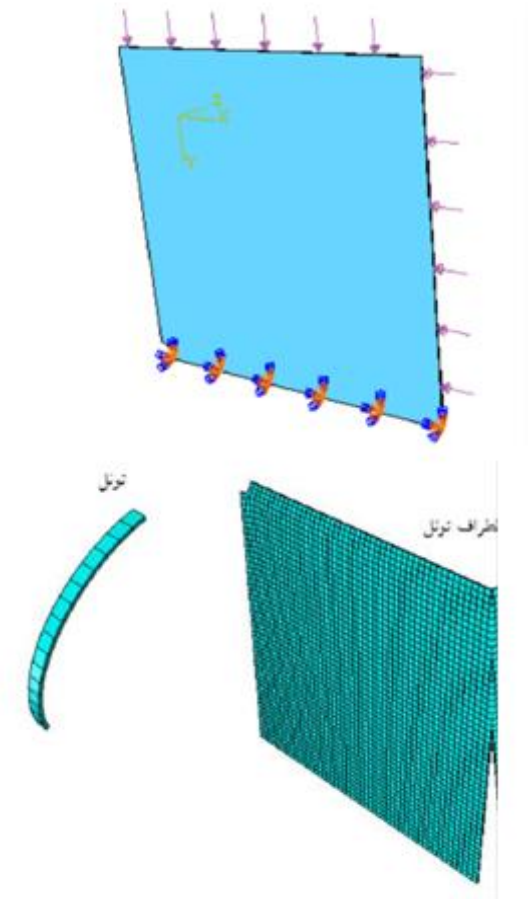

Figure 2: Loading on tunnel and surrounding soil in Abacus [7]

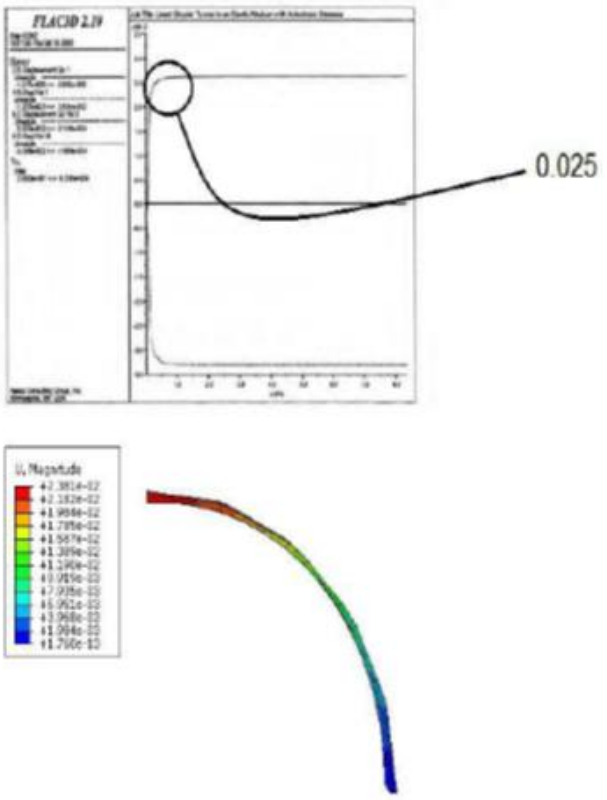

Figure 3: displacement on the tunnel

In this chapter we will consider outlines of components, materials and different stages of modeling and evaluating software outputs. Materials used and dumped and the way of modeling and variables each described. In order to assess the dynamic effects of various parameters on the side of the concrete lining is required to extract the frequency characteristics of these structures. Because natural fixed structures such as hardness, natural periodicity (frequency) are effective in dynamic analysis. In the next section the effects of overhead or lateral pressure will investigated on the call side lining check-out. At the end of this chapter ,the effects of soil modeling and effective parameters will assessed on the dynamic response of structures .In saturated soils, effective stress is used instead of the total stress. Because water doesn't have shear strength and only are solid crystals that tolerate stress. Table 1 shows the mechanical properties of clay .

Table 1: Elastic mechanical features and clay plastic

Special weight	elastic module (degree)	poisson quotient
45	5	0.45
angle of friction (mpa)	cohesion (KN/m3)	
6	18	

3-Method

Mechanical properties of concrete

For concrete elastic mechanical properties (elastic modulus and Poisson's ratio) 0.15, 23GPa values is used . Concrete curved plastic zone to push and pull, is respected like figure (4)

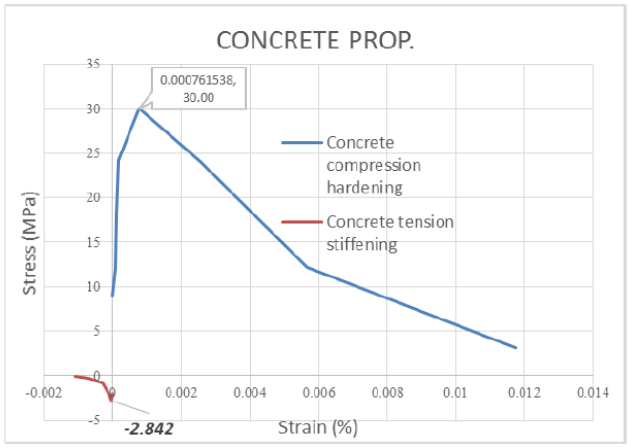

Figure 4: Concrete curved plastic zone

Among the different types of steel, steel construction tip is selected for this purpose. To use this type of steel in Abaqus parameters its necessary to do changes on this parameters . figure 5 shows the assembling part of model of this study.

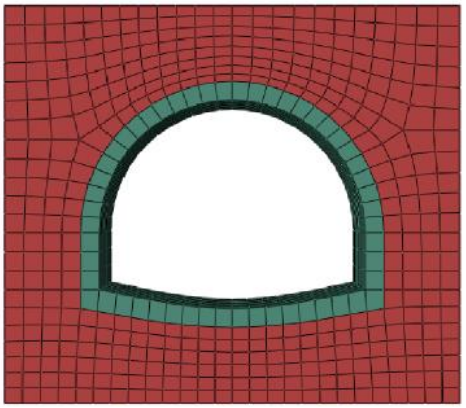

Figure5: Assembling the components and materials allocated to them

In models that the contact between the components should be defined, define the pair of surfaces and mechanical properties for them. Connections and interaction model Mesh model and assign proper structural elements suitable component, The definition of analysis steps, Create boundary conditions and loading . In Figures 6 you see lining models with a height of 6.5 meters and a thickness of 0.5.

Removable lining canopy under time intermittent

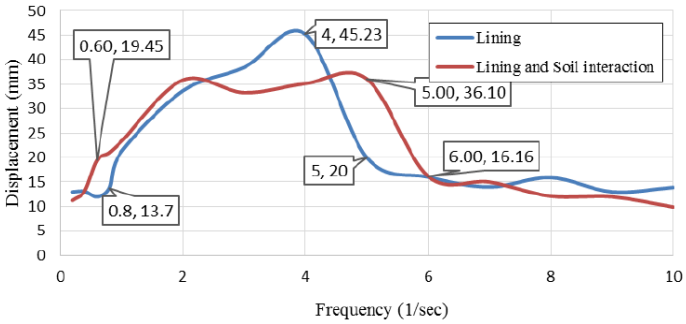

Figure 6: Call (removable) concrete lining both with and without interaction with the surrounding soil in millimeters

As figure 6 shows , load frequency in response of structure ,has the remarkable effect as in lining model without physical effect modeling of soil , Structure in the range of 8.0 to 5 Hz resonance frequency and at a frequency of 4 Hz to 23/45 mm maximum amount is reached. . In the second

case that has been interaction of soil physical model within the 8.0 to 6 Hz resonant frequency and times of 5 Hz to 10/36 mm maximum amount is reached. In this section, first, structure is under the overhead effect, after applying overhead lining structures under the side effects of stimulation.

- ✓ Force 200KN AC amplitude and frequency range 1.0 to 10 Hz
- ✓ Vibration under acceleration following the Bam mapping and Manjil-Rudbar.

Figures 7 and 8 show the values of stress in the lining and the soil. As it stands walls of lining has the highest stress in the range of 14 to 16 MPa.

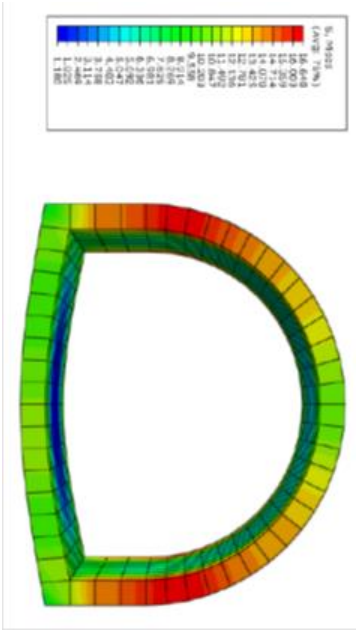

Figure7: Van-Misses stress distribution in the lining of the criteria under overhead 20kN / m

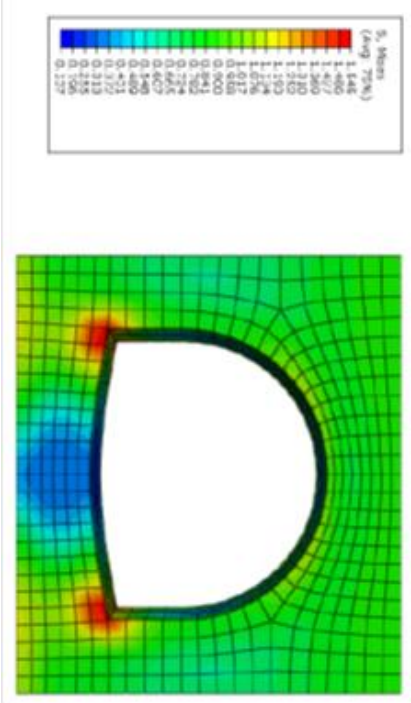

Figure8: Van-Misses stress distribution in the soil under the burden of criteria 20kN / m

figure 9 shows the overhead of the maximum response (displacement) under a load of intermittent lining , as can clearly see , the maximum displacement related to 60 KN load and the amount of it is 3.46 ,displacement decrease with decreasing load . In this figure, the maximum displacement of the overhead lining under a load of side intermittent is shown. As its clear by increased of overhead also increased the maximum amount of movement so that the overhead 60kN, has come to 46.89mm.

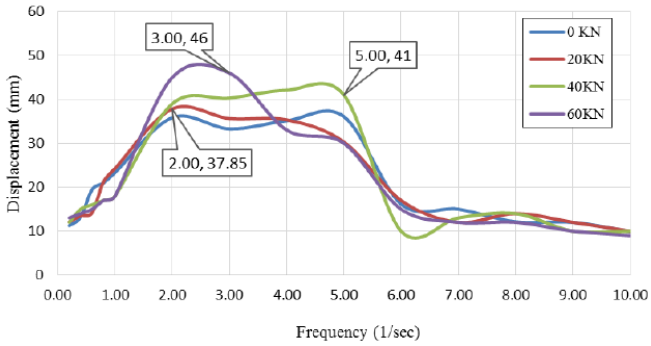

Figure 9: Overhead of the maximum response (displacement) under a load of intermittent lining

In next step ,lining model was affected by Bam and Manjil-Rudbar earthquake acceleration and records .history response of time lining under the pressure of both vibration with value overload of zero ,20,40,60 KN is shown on 10 ,11 figures and figures 12 and 13 show the stress distribution . According to time history of lining displacement we can say that increases in overload are increased the value of displacement and stress of lining maximum. As in the mode without overload, displacement values are equal to 130, 149 respectively in millimeters. While applying overload 60 KN on meter, these values were up to 297, 507 respectively for acceleration and records in Bam and Manjil - Rudbar in millimeter.

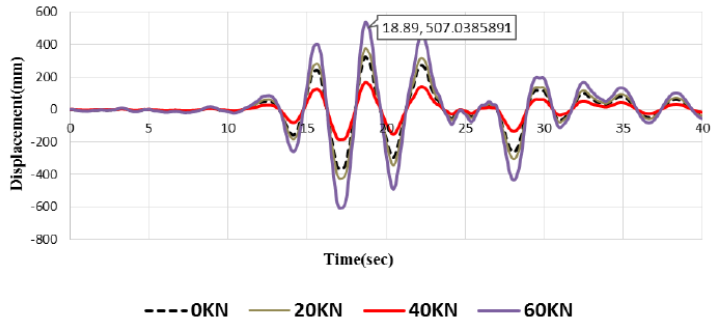

Figure 10: Overload effects in lining displacement under acceleration-record earthquake in Bam

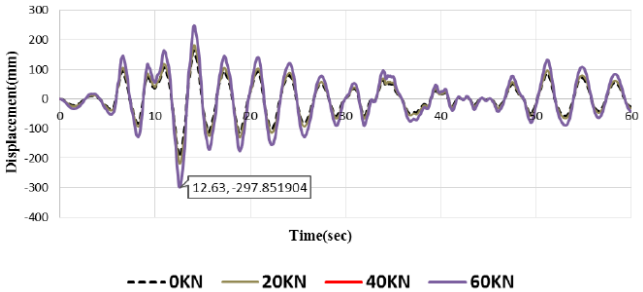

Figure 11: overload effects in lining displacement under acceleration –record earthquake in Manjil-Rudbar

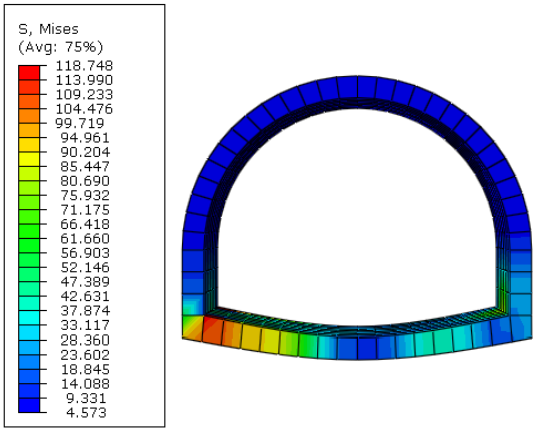

Figure12: stress distribution in lining under the effect of Bam earthquake in 15 seconds – overload 20KN

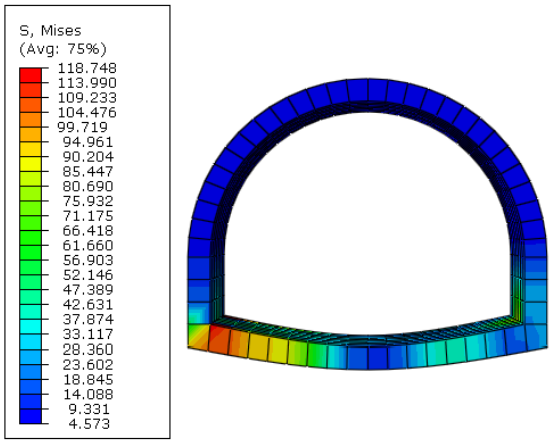

Figure 13: stress distribution in soil under the effect of Bam earthquake in 15 seconds –overload 20KN

Several researches are examined the effects of soil material on vibration response lining. In this section the effect of elastic parameter of soil is searched (elastic module and poison ratio) too .in maximum lining response (displacement) under Bam earthquake vibration .range of searched variable parameters is available in Table 2.

Table 2: mechanical elastic and plastic features of soil

Angle of friction		poision quotient
elastic module	special weigh	
5		0.20-0.50
5-50 MPa	18kN /m3	

First Assuming the Poisson's ratio Young's modulus effects are reviewed. Component seismic shift in the direction of vibration in figure 14. As can see been 10 earthquake in seconds .

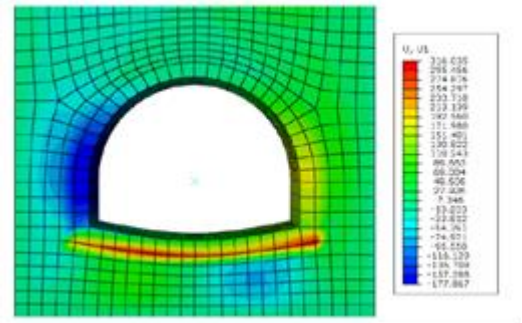

Figure 14: U1 displacement component in second, 10 earthquake Bam

As its shown in figure 15, increase of elastic quotient , maximum value of displacement are reduced that value in change in range of 20 to 40 megapascal has more value .

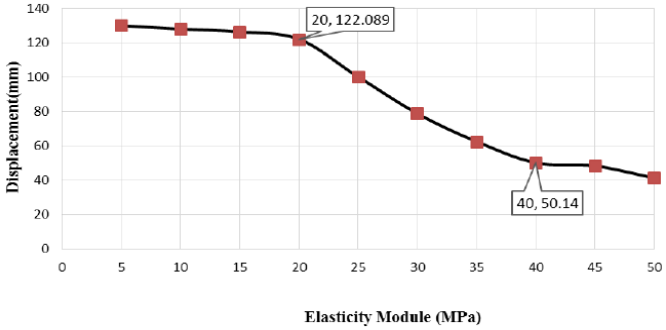

Figure 15: elastic quotient effect in maximum response under Bam earthquake vibration

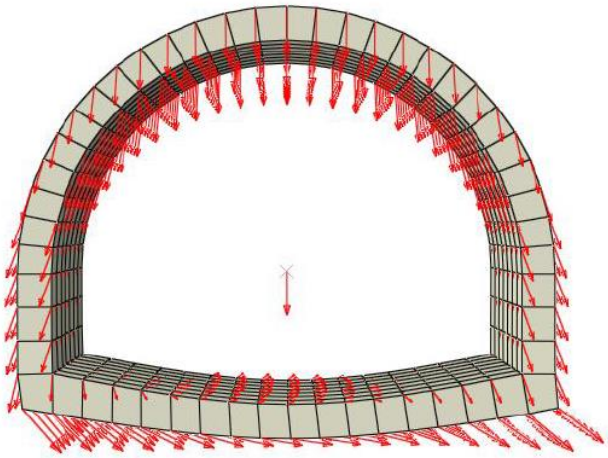

Figure 16: All that overhead and vibration displacement of the lining of the Bam earthquake

E=25MPa و $\vartheta = 0.30$

In the next step to keep the elastic quotient, the changes effect of poison ratio was examined. Changes effect of poison quotient in range of 0.5-0.2 is mentioned in figure 17.

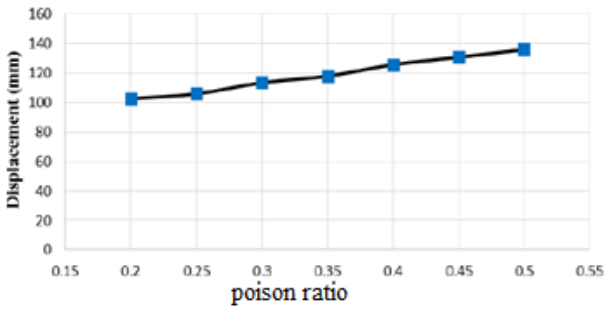

Figure 17: effect of poison ratio in maximum response of lining dynamic

5. Conclusion:

- Results of research shows that the frequency of applied load is effective in structure response . this effect with use of an alternative load with variable frequency and acceleration – record of Bam earthquake and Manjil –Rudbar is showed with concept of different frequency .

- It was shown that physical modeling effects the interaction between soil and structure response and interaction can't displaced with an equal load. As to investigate of this effect, maximum response of both affected approaches with alternative sinusoidal and variable frequency from 10 Hz to 0.1 Hz was examined. Structure maximum displacement with physical modeling, interaction of soil and structure was equaled 25 % more.
- Applying two kinds of alternative load vibration and floor stimulation with record acceleration , overload effects in lining vibration response was investigated . among samples maximum of displacement is related to overload 60KN that included the most value .

6- References

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