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NON-LINEAR DYNAMIC TIME HISTORY ANALYSIS OF UNDERGROUND RECTANGULAR TUNNEL

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Abstract**— In the present paper study of non-linear dynamic analysis of underground rectangular tunnel considering different seismic intensities is carried out and seismic responses of such structure are studied. The tunnel under consideration is modelled with the help of SAP2000 software. The two different time histories (i)El-Centro earthquake (ii)Nepal earthquake have been used. The results of the study show similar variations pattern in Seismic responses such as displacement, velocity and acceleration with intensities (Mw = 6.9) and (Mw=7.8). From the study it is recommended that analysis of underground rectangular tunnel using Time History method becomes necessary to ensure safety against earthquake force. The analysis is performed to compute the displacement and internal force in tunnels that took place in each phase of construction and loading. The earthquake loads are applied to the tunnels during operation.

Keywords**— Time History Analysis, Seismic responses, Underground rectangular tunnel, SAP 2000, Non-Linear Analysis.

INTRODUCTION

Underground structures are becoming more and more prevalent in the modern world because of the decreasing availability of quality above ground space and resources due to fast growing population. As an integral part of the infrastructure of modern society underground structures are used for a wide range of applications including transportation system such as subways and railways, highways, material storage and sewage and water transport (Hashash et al., 2001) [3] tunnels are often encountered in subways and railways as a common type of underground structures. The final support system of underground facilities in seismic zones most be designed to support static overburden loads as well as to accommodate the additional deformations imposed by the earthquake – induced motions.

Non-linear dynamic time history analysis is considered as a type of more rigorous analysis case, and require several analysis steps. The time history analyses in this study use the method of direct integration in SAP2000. The non-linear time history case is continued from the physical state of the tunnel prior to an earthquake under dead load, rather than a zero initial condition state. In the present study a direct integration analysis was utilized, which allows for the time stepping method of solution. The structural parameters of the tunnel are shown below in fig. 1:

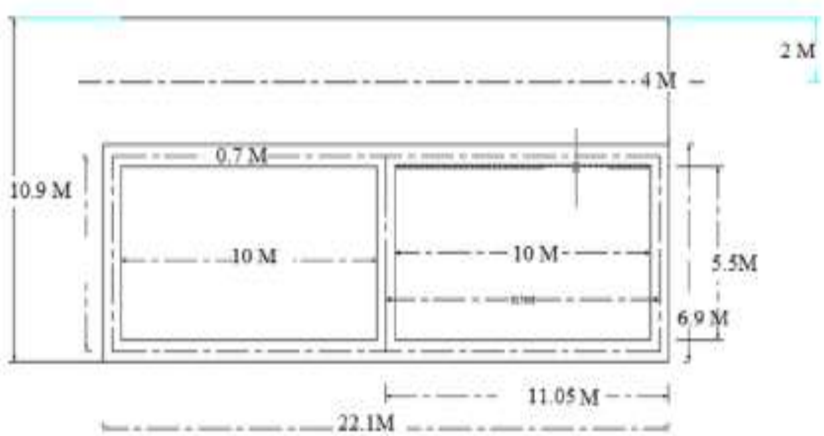


Fig 1: Tunnel Details

- Width of Station Box (W) = 22.1m
- Height of Station Box(H) = 6.9m
- Depth of Soil Layer to the top of station box (D) = 4m

TIME HISTORY ANALYSIS OF EL-CENTRO EARTHQUAKE

The total time span of El Centro earthquake is 40.00 sec., but the period of strong shaking is only 20 sec, which is accounted for in the dynamic analysis. Fig. 2 shows the displacement-time history of the El Centro earthquake showing the whole time history (40 sec), and the period of strong shaking used in the analysis, the first 20 sec. Fig. 3 shows the acceleration-time history for the whole earthquake duration, and that of the period of strong shaking only. Fig. 4 shows the velocity–time history analysis for the whole earthquake duration.

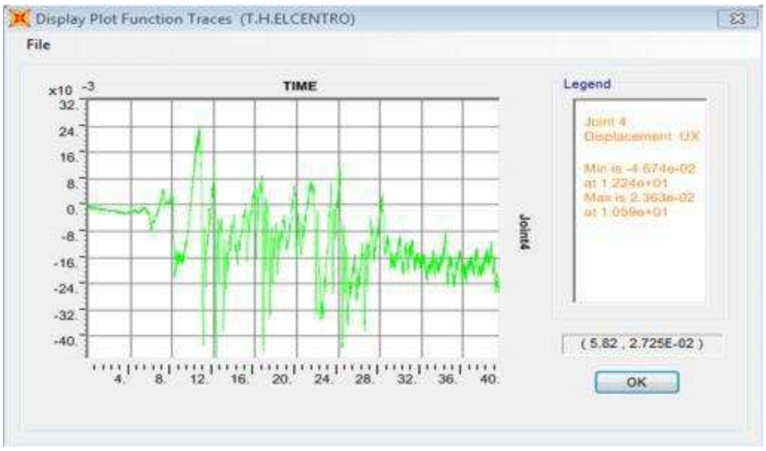
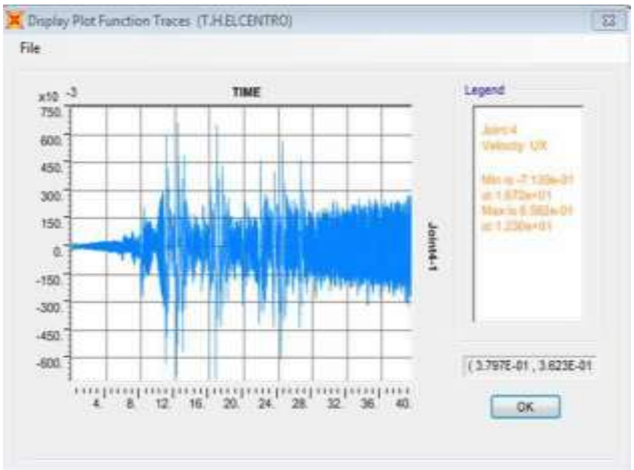


Fig 2: Displacement time history of El-Centro earthquake



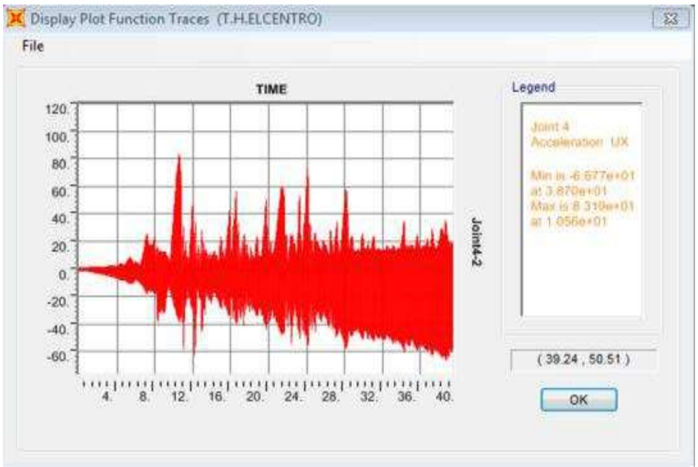


Fig 3: Velocity time history of El Centro earthquake

Fig 4: Acceleration time history of El-Centro earthquake

TIME HISTORY ANALYSIS OF NEPAL EARTHQUAKE (25TH APRIL 2015)

The earthquake occurred on 25 April 2015 at 11:56 a.m. NST (06:11:26 UTC) at a depth of approximately 15 km (9.3 mi) (which is considered shallow and therefore more damaging than quakes that originate deeper in the ground), with its epicentre approximately 34 km (21 mi) east-southeast of Lamjung, Nepal, lasting approximately (50.00 sec). The earthquake 7.8 Magnitude. The maximum response of the structure (Displacement, Acceleration and velocity) are shown in Fig. 5, 6, 7 respectively.

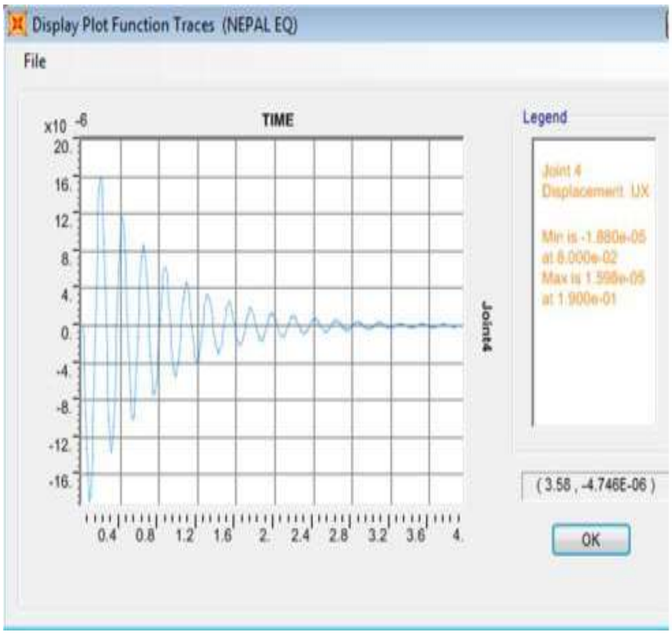


Fig 5: Displacement time history of Nepal earthquake

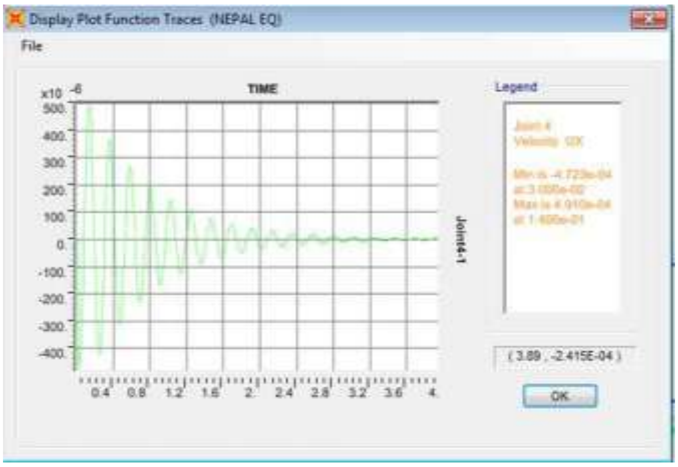


Fig 6: Velocity time history of Nepal Earthquake

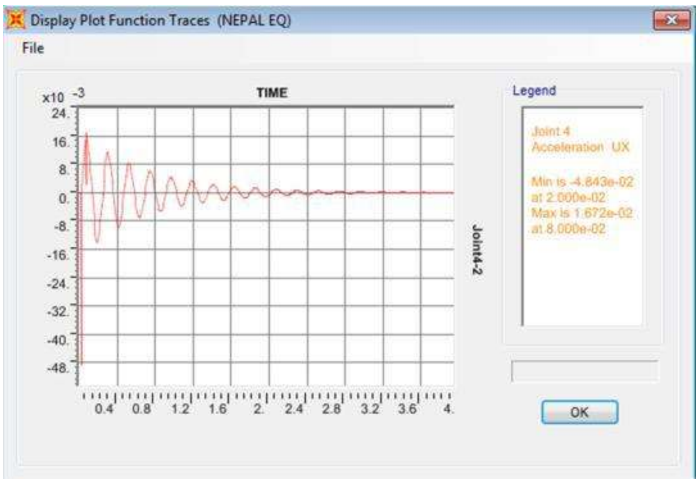


Fig 7: Acceleration time history of Nepal earthquake

CONCLUSIONS

From the analysis done and observation made, when the tunnel is subjected to forces like overlying pressure, lateral earth pressure, live load, Uplift pressure, live surcharge, various stress and moment zones are created. Moment at top slab, bottom slab, interior and exterior wall at each node is calculated.

- Non-linear dynamic time history analysis of El Centro earthquake and Nepal earthquake is computed by the software.
- From the El Centro earthquake maximum displacement is 23.63 mm at 10.59 sec., maximum acceleration is 83.19 m/sec^2 at 10.56 sec and the maximum velocity 0.6582 m/sec at 12.3 sec. is obtained.
- Similarly, from the Nepal earthquake maximum displacement is 0.016 mm at 0.19 sec., Maximum acceleration is 1.672e-2 m/sec^2 at 0.08 sec and the maximum velocity 4.90e-4 m/sec. at 0.14 sec is obtained.

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