INTERACTION OF UNDERGROUND TUNNEL AND EXISTING SHALLOW FOUNDATIONS AFFECTED BY NORMAL FAULTS

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Keywords: Normal fault, Shallow foundation, Underground tunnel, Interaction

In major earthquakes, permanent ground deformations due to fault movements cause serious damage to the foundations and structures. Although many of structural seismic design codes have recommended avoiding the construction of structures in the adjacent to active faults, it is not always a viable option. For example, the lifeline facilities such as gas tunnels, water supply tunnels and transportation tunnels, due to their extensive length, often cannot avoid crossing active faults. Previous studies have so far confirmed the fact that the presence of a tunnel near active fault can change the zone of large deformations on the ground surface (Lin et al., 2007; Baziar et al., 2014; Saeedi Azizkandi et al., 2019). This study investigates the interactions of underground tunnel and existing shallow foundation affected by normal fault using the finite element method. For this purpose, an elasto-plastic constitutive model adopted by Mohr–Coulomb as a failure criterion was employed to simulate the soil behavior. The numerical analysis was conducted under two-dimensional plane strain condition by the ABAQUS software. The ability of numerical simulations in predicting the faulting effects on surface and underground structures was validated using centrifuge model tests conducted by Bransby et al. (2008) and Nabizadeh et al. (2014).

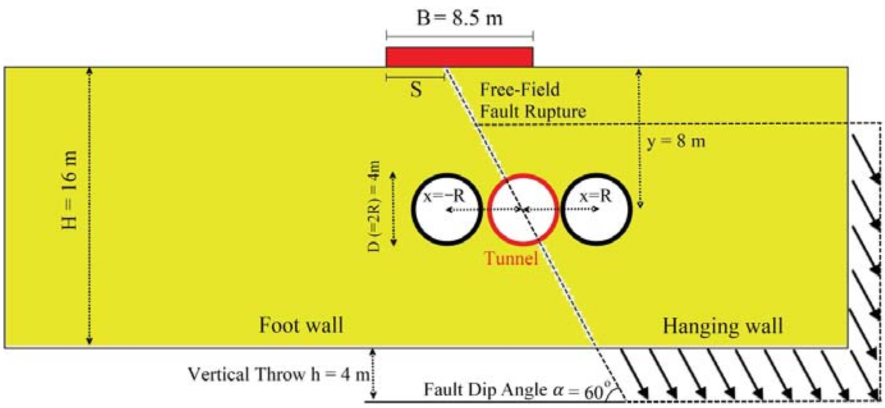

Figure 1. Schematic conf guration of the studied problem.

The foundation width (B) and thickness were 8.5 m and 1 m, respectively, placed in different positions (S/B). Parameter S indicates the distance between the left corner of the foundation and the fault outcrop on the surface in free-field condition. A tunnel with diameter of D=4 m and thickness of t=0.24 m was placed at different coordinates relative to free-field fault rupture path (Figure 1).

The results show that the existence of a tunnel, in some cases, can increase the foundation rotation. Figure 2 shows the results of the numerical analysis for the position of the tunnel, which has been the most rotation of foundation at h=4 m. It illustrates the existence of a tunnel changes the fault rupture path. In some positions (S/B=-0.25, 0.25, 0.5 and 1.25), the width of shear zone was wider in the soil profile and on the ground surface, compared to the cases without a tunnel. For S/B=-0.25 and 0, the tunnel causes to change the level of damage, based on the foundation rotation, from negligible (0≤θ<1°) to severe and threatening stability, respectively (Figure 3). The foundation experiences the most rotation (θ=12.4°) when it is positioned at S/B=0.25 and tunnel is located at x=-R.

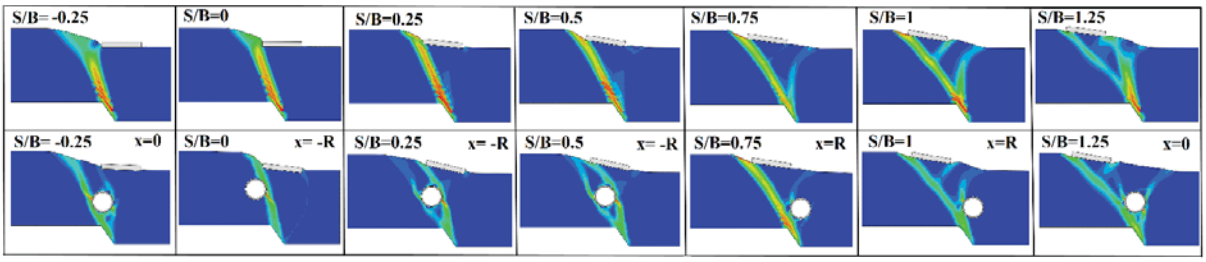

Figure 2. The effect of the presence of a tunnel with diameter of D=4 m, embedded in depth of y=8 m, on normal fault–foundation interaction (FE computed plastic strain contours) at h=4 m.

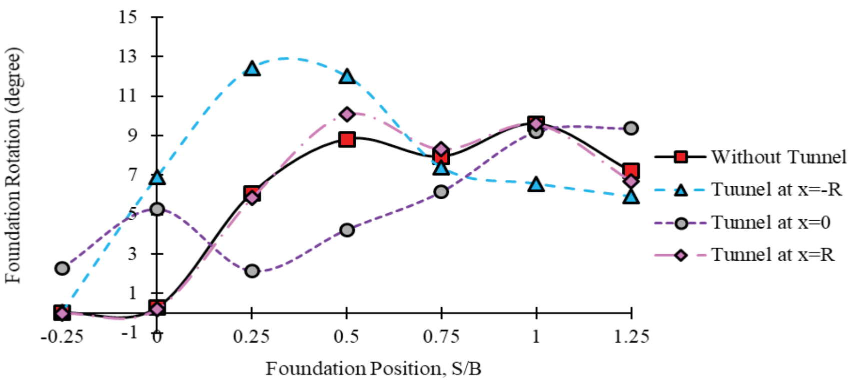

Figure 3. Foundation rotation due to the fault rupture.

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