NUMERICAL ANALYSIS OF FLEXIBLE SHALLOW FOUNDATIONS SUBJECTED TO NORMAL FAULT RUPTURE

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The 1999 earthquake in Turkey and the 2008 Taiwan earthquake were similar in that surface Fault Rupture (FR) was observed in both cases (Anastasopoulos et al., 2007). Although fault rupture can destroy the structures that are located on the FR path, further field studies in Turkey and Taiwan revealed that some structures sustained during a FR. Indeed, the structure deviated the fault path from its initial direction. Such a behavior implies that there are various levels of interactions between the structure exposed to the fault, the structure foundation, soil, and the fault itself (Anastasopoulos et al., 2009). Within this context, this paper elucidates the Fault Rupture-Soil-Foundation-Structure Interaction (FR-SFSI).

There have been several experimental studies and numerical analyses in order to investigate the effect of different factors on the pattern of fault propagation. This foundation is modeled either as a *rigid* element or as a *flexible shallow* element. This work models the interaction of a *flexible shallow foundation* with normal thrust-fault, which is in contradistinction with *rigid element* models prevalent in previous studies. A flexible shallow model demonstratesthe type of stresses and strains produced in the foundation, in addition to characterizing the level of destructiveness of the stresses.

The problem setup is illustrated in Figure 1, wherein a uniform soil deposit is subjected to thrust fault (normal). It is further assumed that the deposit has a depth of H, a vertical component of h, and a dip angle of α at the bedrock. Assuming 2D plane strain conditions, the analyses are performed in two steps. First, the propagation of the fault rupture in the free fiel disoption with an that there is no structure present at this step. Second, a mat foundation of width *bf* carrying a uniformly distributed load *q* is positioned on top of the soil model at a distance of *S* from the free field outcrop. It should be noted that the distance *S* is measured from the hanging-wall edge of the foundation. Finally, the FR-SFSI is examined.

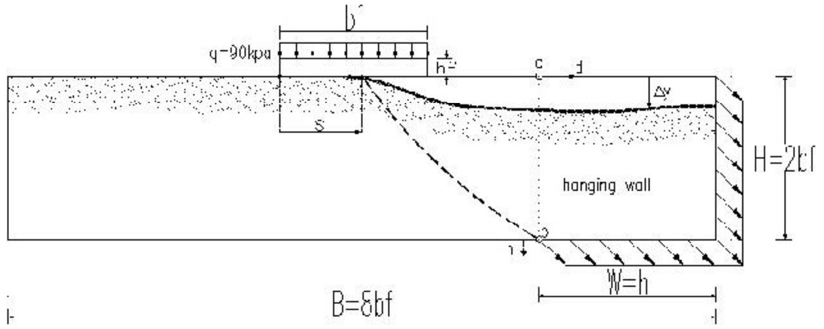

Figure 1. Problem definition and model dimensions: interaction of fault rupture with shallow foundation subjected to uniform load q=90 Kpa

In this model, soil is considered based on an elastoplastic constitutive model with Mohr-Coulomb failure criterion and isotropic strain softening. The latter is achieved by reducing the mobilized friction and dilation angle with increasing octahedral plastic shear strain.

Scale effects are also taken into account through an approximate simplified scaling method. Additionally, pre-yielding behavior is assumed to be elastic, with secant modules linearly increasing with depth. Finally, a dense sand deposit with Poisson's ratio of 0.3 is considered in the analyses.

The flexible foundation with thickness h_f is simulated with shell elements using the ABAQUS finite element software. Additionally, a model of damage plasticity constitutive is considered for the foundation concrete. Table 1 summarizes the properties of the foundation concreteused in the analyses.

Based on the numerical analyses, it has been observed that when the foundation is modeled as a flexible element, the fault deviation is maintained. However, under such circumstances, the foundation experiences significant compressive and tensile stresses. In some cases,such stresses can potentially create cracks or cause a complete destruction of the foundation. It has further been illustrated that increasing the width of the foundation exacerbates such a behavior.

Table 1. Concrete properties

Young's modulus:	E = 31027 MPa
Poisson's ratio:	$\nu = 0.15$
Density:	$\rho = 2643 Kg/m^3$
Dilation angle:	$\psi = 36.31^\circ$
Compressive ultimate stress:	$\sigma_{cu} = 24.1$ MPa
Tensile failure stress:	$\sigma_{t_0} = 2.9$ MPa

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