Propagation of dip-slip fault rupture through uniform soil cover

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Abstract

Substantial research work has been carried out after the earthquakes that caused damage to buildings due to earthquake ground shaking while less attention is given to the damage as a result of permanent ground failure caused by the propagation of an earthquake fault rupture. However, case histories from the recent earthquakes revealed significant damage occurred to the infrastructure as a result of fault-foundation interaction and that there exists a quite subtle interaction mechanism between the fault rupture and infrastructure. Moreover, there were many instances of satisfactory performance of buildings in such events.

The seismic codes (e.g Eurocode 8) correctly require that construction must be prohibited within the ‘‘immediate vicinity’’ of active faults, at least not without a specialized analysis and design. However, uncertainties associated with permanent ground deformation during the earthquake makes it more catastrophic because once the fault rupture emerges to the surface the next time it is not necessary that the fault rupture will follow the same path. Fault rupture propagates through the plane of weakness in the shear zone as a result of the previous fault rupture. The problems in designing structures become even greater when the fault trace in the bedrock is covered by recent alluvial deposits of considerable thickness (i.e. a few tens of meters). In such a case, even if the bedrock fault dip angle and the potential fault displacement are well established by a seismo-tectonic study, it remains unclear whether the fault rupture reach the ground surface and where would it be located and what will be the width of fault dislocation zone.

In order to understand the propagation of dip-slip fault through uniform soil cover lying over a bed rock, series of tests were performed in a split box. Split box is specially designed box where both normal and reverse faults tests can be conducted at various dip angles. Medium dense, dry sand is used in all the tests and is pluviated in the box to get the relative density, Dr $\approx$ 60 %. Digital images were taken as the fault rupture propagated into the soil for later image analysis using Geo-PIV technique. The effect of varying soil depth and fault angle from the bed rock on shape and location of normal and reverse fault on the surface was studied in detail. The propagation of fault rupture was found to be progressive as observed in previous studies. Initially, a small amount of displacement produced only general distortion in the soil. With further increase in fault displacement, deformation is associated along a shear localization, starting from the base of the soil layer and propagating upward. The reverse fault rupture decreased its dip as it approached the ground surface whereas the normal fault rupture increased its dip near the surface. The fault angle in the soil is primarily a function of dilation angle and dilates more near the surface with low effective stresses. The width of deformation zone is found to be a function of soil depth and it reduced as the soil depth increased. In both reverse and normal fault tests steep dip angles from the base produced pronounced fault scarp at the surface and required less displacement from the base for a fault to reach the surface. These model tests have provided further insight about the fault propagation and a hope that buildings can be designed and sighted in suitable place in order to avoid substantial damage.