Hydro-Mechanical Modeling of Over-Pressured Porous Media: Insights into Fluid Effects on the Uplift at Zhong Liao Tunnel, Taiwan

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Abstract

The northern exit of Zhong Liao Tunnel on Highway 3 has experienced significant uplift since its construction in 2000. The high uplift velocity zone lies between the Chishan Fault and Chegualin Fault. Between 2000 and 2016, this region had risen by a total of 130 cm while undergoing shortening by 90 cm, a rate that cannot be solely attributed to pure tectonic movement. Drilling records within this area have revealed the presence of high excess fluid pressure layers in the Gutingkeng mudstone formation. The over-pressured mudstone might be related to the severe uplift zone according to previous studies. To model the deformation of mudstone containing over-pressured fluids, we employed a 2D hydro-visco-elasto-plastic numerical geodynamic model. Furthermore, we incorporated strain-rate- and fracture-dependent porosity into the model, which introduces positive feedback between deformation and porosity increase and produces drastic weakening at high strain rate areas. This effect produces larger uplift velocity and reduces the spacing between the two faults, bringing the model results in closer agreement with observed field data. Our research highlights the importance of using two-phase modeling approaches to account for porous and fluid effects when simulating and predicting complex geological processes.

Keywords: Zhongliao tunnel, Chishan fault, Gutingkeng mudstone, Numerical Simulation, Fluid-solid coupling, Hydro-mechanical