Hydromechanical Modeling of Urban Road Collapse and Land Subsidence Induced by Underground Facility Failure

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As population of cities grow, the demands of underground developments increase accordingly. However, without careful consideration of urban hydrogeology and soil characteristics, those subsurface constructions could alter urban hydrogeology and consequently induce land deformation on the surface, which are potentially hazardous to local communities.
In particular, land subsidence and sudden road collapse phenomenon are one of major geohazard frequently occurring in many metropolitan cities of which underground facilities become gradually old. In most cases, these surficial collapses are known to be induced by the failure of near surface artificial underground structures and pipelines (e.g. water supply/ sewer lines, subway tunnels); however, exact hydromechanics process of collapsing which incorporated by groundwater and subsurface characteristics is not yet fully understood.
The purpose of this study is (1) to explore the feasible mechanism of land subsidence and road collapse in the urban areas, (2) to develop a hydromechanical model that simulates the moment of failure and quantify the interaction between pore pressure and associated effective stress field. The stability of collapsing area is also inferred using Columb Shear Failure (CSF) potential. Lastly, (3) using 2D and 3D models, a variety of possible scenario are tested to obtain quantitative relations between failure potential and hydrogeologic factors such as precipitation, aquifer heterogeneity and leakage events.
A fully coupled groundwater flow –deformation equation is used for solving an urban collapse problem corresponding to transient pore pressure changes by natural and anthropogenic factors. Preliminary numerical results show that the subsidence pattern and failure potential are closely related to the local fluid pressure change affected by groundwater leakage through cavities created by underground facility damage, and hydromechanical properties of the aquifer play important roles in either mitigating or exacerbating the collapse process.

Keywords: urban road collapse, fully coupled hydromechanical modelling, underground facility failure

