A novel approach for detailed spatio-temporal land subsidence prediction coupling 3D engineering geological modeling in Hanoi city

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ABSTRACT

Land subsidence as one of the geohazards, land subsidence causes various damages to roads, bridges, buildings, underground infrastructures, and may alter groundwater flows and rivers. Various methods and techniques have been proposed for land subsidence prediction that commonly used categorised as: empirical methods, semi-theoretical approach, and theoretical approach. Land subsidence predictions all use engineering geological conditions as principles because the compaction and expansion of compressible sediments induce subsurface deformations and subsidence of the ground surface. However, the engineering geological conditions are commonly represented in traditional way as drilling records, cross sections, and 2D maps. Several engineering geological characteristics are still not so well estimated in these traditional representations, especially for detailed spatio-temporal land subsidence predictions. Overcome this, a 3D engineering geological model is constructed based on 2D maps and more than 1500 engineering geological drilling records with physico-mechanical properties of 11000 samples and 17000 in-situ tests from constructive projects in Hanoi city during the last 20 years. The exhaustive engineering geological conditions are reproduced with total 21 high-resolution engineering geological layers, the bottom one is the Neogene sediment bedrock. They are integrated to groundwater information to provide input data for detailed spatio-temporal land subsidence prediction using a self-developed tool of 3D SubPro 2015. With calculated capacity of big data, it was applied to all soil columns entire Hanoi city, at every time-step of fluctuating water table within 34 year from 12/1995. The spatio-temporal land subsidence prediction was validated based on monitoring data at stations for reliable results. This approach could be determined as a novel approach for a detailed assessment and prediction of spatio-temporal land subsidence in the study area. The tool of 3D SubPro 2015 could also be applied to other study areas.

Keywords: Geological Engineering Model, Spatio-Temporal Land Subsidence; Hanoi; 3D SubPro 2015

1. Introduction

Land subsidence could be defined as a gradual lowering or deformation of the ground surface due to subsurface compaction, consolidation, and collapse (Bartolino and Cole 2002). It has become a global problem that many parts of the world have to face. As one of the geohazards, land subsidence causes various damages to roads, bridges, buildings, underground infrastructures, and may alter groundwater flows and rivers. Various methods and techniques have been proposed for land subsidence prediction. They consist of three commonly used categories as: empirical methods, semi-theoretical approach, and theoretical approach.

In fact, the compaction and expansion of compressible sediments induce subsurface deformations and subsidence of the ground surface. Thus, engineering geological conditions of the Quaternary sediments play an important role in land subsidence predictions. However, the engineering geological conditions are commonly represented in traditional way as drilling records, cross sections, and 2D maps. Normally, several engineering geological characteristics are still not so well estimated in these traditional representations. To can predict of detailed spatio-temporal land subsidence, it is necessary a novel approach as coupling with a 3D model by high-resolution engineering geological conditions.

2. Land subsidence and engineering geological study in Hanoi city

There were some researched projects of land subsidence in Hanoi, but they are most used the empirical methods and the semi-theoretical approach. The fist one was conducted based on the land subsidence monitoring from 1989-1995 and 1995-2015 (HIBT 2006, 2007, 2014). Some other ones using numerical

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