Proceedings of the 4th ACPMG 2024
4th Asia-Pacific Conference on Physical Modelling in Geotechnics
11-13 December 2024, Abu Dhabi, UAE

Exploring the Impact of Physical Modelling on Land Subsidence in Geotechnical Engineering: A Review

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ABSTRACT: Land subsidence is a challenge in various countries. Various infrastructures, historical buildings, heritage sites, and other structures are facing the new challenge of land subsidence. Most researchers in geology, remote sensing, geodesy, hydrology, and related fields are conducting various studies and projects on land subsidence. They are measuring and predicting land subsidence in different countries. This is one step in addressing land subsidence. The second step is finding solutions for using subsided areas for the building industry, construction, agriculture, and other purposes. In this context, a few researchers have conducted various physical modeling studies in different countries. In this research, the role of physical modeling of land subsidence in geotechnics is reviewed. The role of geotechnical engineering is very important in the treatment of land subsidence. The development of ground improvement techniques or new deep foundation methods for protecting various structures must be tested in physical modelling and numerical simulations. According to the literature review, this approach is necessary for advancing land subsidence management and geotechnical engineering.

1 INTRODUCTION

Various countries such as the USA, Netherlands, Italy, China, Iran, Indonesia, Mexico, etc., are facing land subsidence in various areas. A number of these countries, including Iran, the USA, and China, are experiencing land subsidence due to groundwater pumping (Yazdi and Niroumand, 2021). Iran, in particular, faces significant problems with land subsidence in various regions because most infrastructures, historical buildings, heritage sites, and other structures are at risk of destruction and damage. Most researchers in fields such as geodesy, geology, remote sensing, and related sciences are conducting various studies on land subsidence (Yazdi and Niroumand, 2021). However, there is a need for new approaches in geotechnical engineering to address this crisis, as most buildings and industries are related to civil engineering and the construction industry. It is essential to protect or predict the requirements for safeguarding these buildings and infrastructures against land subsidence. This represents a significant gap in the protection of buildings and infrastructures against land subsidence. To develop solutions and address this gap, various physical modeling tests and numerical simulations are needed to understand the reasons for land subsidence at both laboratory and field scales. This can help in the future management of land subsidence and the protection of various buildings and infrastructures. The role of deep foundations and ground improvement techniques in protecting buildings and infrastructures against land subsidence needs to be controlled through various physical modeling tests. Various aspects of earthquakes, geotechnical engineering, and land subsidence are closely integrated and need to be clarified from different perspectives. This clarification requires various tests, physical modeling, and numerical simulations. In this research, a review of various case studies and research studies on the physical modeling of land subsidence up to this point is presented.

2 PHYSICAL MODELLING OF LAND SUBSIDNECE

He et al. (2020) studied the vertical deformation of soils based on the extraction and recharge of groundwater. This research used a model box with dimensions of 1,400 mm (long) × 1,000 mm (wide) × 1,200 mm (high). This study aimed to gain new insights into the behavior of pore water pressure and the deformation in various soils, such as sand and clay layers, during groundwater pumping. A displacement monitoring system used in this research.

Xu et al. (2019) evaluated earth fissures using physical modeling. They aimed to understand the mechanism of ground fissure formations (Figures 1 and 2). Their tests involved repeated groundwater pumping and impounding in various physical modeling systems.

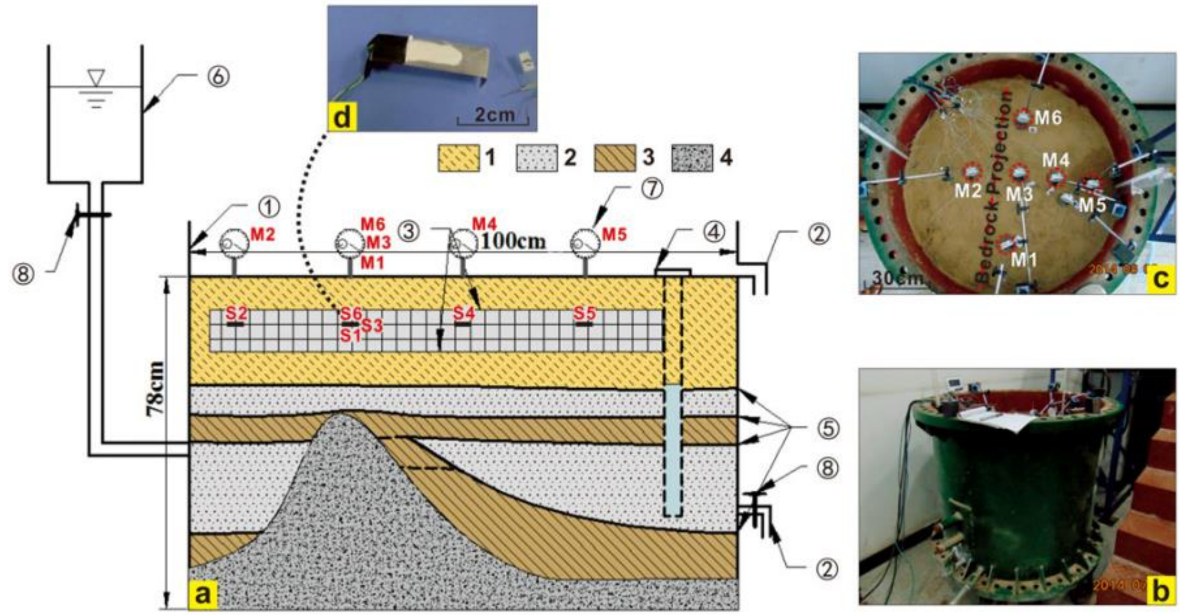
Zhang et al. (2022) evaluated pumping-induced earth fissures. They used physical modeling to assess earth fissures. Earth fissures occurred due to excessive groundwater pumping, which resulted in various fissures appearing on the earth's surface.

Gong et al. (2020) investigated the performance of pumping-induced land subsidence and earth fissures. They used physical modeling for their evaluations. They examined groundwater levels and their relationship with the development of subsidence and earth fissures in the bedrock-ridge area during pumping.

Di et al. (2022) investigated the mechanism of land subsidence due to groundwater exploitation by physical modelling. They used the particle image velocimetry (PIV) technology for analysis of land subsidence mechanism that it used in various applications failure mechanism in geotechnical engineering before.

Cui and Jia (2018) evaluated the efefcts of building load and groundwater pumping by physical modeeling. They evalauted the role of building loads on land subsidence in this study.

According to these examples and several studies by various researchers on the physical modeling of land subsidence, the importance of physical and numerical modeling in the future of land subsidence in geotechnical engineering is very clear. Given the various issues and challenges of land subsidence in over 60 countries, it is crucial to find new methods based on physical and numerical modeling to protect the earth against land subsidence. Additionally, it is essential to protect foundations, infrastructures, buildings, and related elements from land subsidence Niroumand and Nikkhahnasab (2019).



(a) Structure diagram, (b) front view,

(c) top view, (d) strain gage. 1—silt, 2—fine sand, 3—clay, 4—bedrock (concrete). ①—model box (steel plate), ②—water outlet (with filter), ③—wire net, ④—well, ⑤—waterproof material, ⑥—water storage tank, ⑦—dial gauge, ⑧—water valve.

Figure 1. Physical modelling of fissures (Xu et al., 2019)

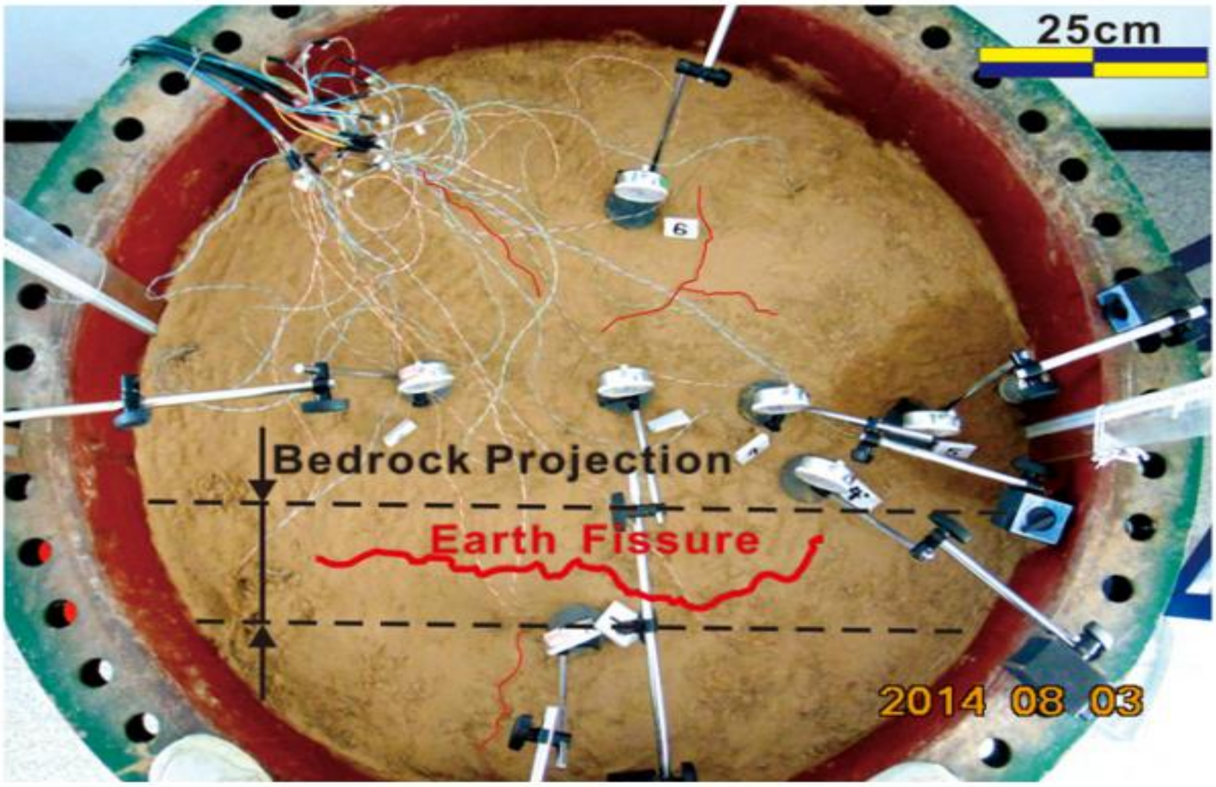


Figure 2. Earth fissures in physical modelling (Xu et al., 2019)

3 CONCLUSIONS

According to this research, the importance of physical modeling in geotechnical engineering and the evaluation of various ground improvement techniques and deep foundations, as well as the effects of water recharge in various soil layers and related topics in geotechnics and land subsidence, are crucial for the future of land subsidence management and the protection of infrastructures and buildings, from historical to modern types. Physical modeling can conduct various tests on different samples and soil layers under various conditions. It can test different techniques for the protection of foundations and soil layers on various scales and can discover new techniques for different issues. Physical modeling can also reduce the existing costs of land subsidence management, which must be prepared by various governments for treatment and protection.

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