Building damage due to sinkhole formation after high precipitation events

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Sinkholes are depressions or hollows in the ground (Fig. 1) that develop in geological regions with the presence of dissoluble rocks such as carbonate (limestone) or evaporite (gypsum and salts) rocks at or near the ground surface. These dissolution processes occur at human time scale and its rate is highly influenced by hydrological processes affected by groundwater recharge and rainfall and conduit permeability of the aquifers. Over the last ten years, there is evidence of an unprecedented number of sinkholes developing in countries like the UK after a sustained yearly increase in rainfall or after short term high precipitation events (flash flooding). Climate change results in a higher uncertainty in the rate and spatial heterogeneity of the dissolution processes due to increased variations in rainfall and groundwater recharge. Further research is needed in this field. Sinkholes can cause severe structural damage or collapse in buildings (see Fig. 1) and therefore reducing the risk can bring a significant societal and economic benefit to local communities.

Advanced ground numerical models will be developed by the PhD student to provide an enhanced understanding of the acceleration of the dissolution processes in the ground due to high precipitation events leading to sinkhole development. The numerically predicted damage of the ground will be applied to complex structural finite element analyses in order to assess local and global damage in building structures. Such analyses will require careful consideration of material nonlinearities and most importantly it will explore the complex water-soil-structure interaction. The methodologies developed during the project will be tested against real case scenarios using field data available. From this work, you will develop forefront research in a field significant in the sector of building safety where the UK has a leading role. You will be developing novel numerical and analytical techniques which could be extrapolated in the future to other types of geohazards affecting critical infrastructure.

Fig. 1: Examples of housing in regions prone to sinkhole formation.

You will be working along with a multi-disciplinary supervisory research team from the specialized areas of advanced structural engineering, soil mechanics and hydraulic modelling using High Performance Computer facilities at University of Surrey. In addition, you will work along with Mott MacDonald (Geotechnical and

Structural Consultancy Firm) with a strong track record in developing innovative solutions in projects where the assessment of ground movements and impacts on infrastructure assets was critical. The guidance from industrial collaborators will be essential toward developing industrially meaningful research outcomes in the project that can be adopted in practice.

Training opportunities:
As part of the PhD, you will interact with Mott MacDonald, through a series of short placements at different key stages of the project. This will provide meaningful training on site and analytical geotechnical investigations normally carried out in projects in regions which are prone to sinkhole formation. This training will be complemented by attending advanced postgraduate modules at University of Surrey related to the PhD topic, attending research seminars and keynote lectures from industry and professional bodies representatives. You will have regular contact with your academic and industrial supervisors.

Student profile:
This project would be suitable for students with an engineering related degree (either undergraduate or postgraduate) or equivalent professional experience in engineering. Good numerical or mathematical modelling skills are desirable as well as having a strong drive to engage into different engineering or environmental science disciplines.

Funding particulars:
Note: CASE funding is pending on confirmation from industrial collaborator. Otherwise eligible students will receive the usual NERC award including stipend and university fees.