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PREFACE

Preface for the special issue on geotechnical seismic isolation (GSI)

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Geotechnical Seismic Isolation (GSI) is defined as a category of seismic isolation techniques that are in direct contact with geomaterials and of which the isolation mechanism primarily involves geotechnics (Tsang 2009). The term GSI was coined based on an analogy between conventional "Structural" seismic isolation and new "Geotechnical" seismic isolation. Over the past decade, GSI has diversified and gained momentum through extensive research and development. This special issue aims to give readers a taste of the variety and promise of GSI systems, which are briefly discussed below with respect to their isolation mechanisms, choice of materials and research methodologies.

GSI will lead to a paradigm shift in earthquake-resistant design and retrofit of structures. GSI does not require modifications to the structural systems or architectural features. Instead, minor changes to the foundation systems may be required in some cases. The key to GSI is compliance, intervention and/or separation at the interface between the foundation and surrounding geomaterials, whether natural or modified. This approach enables seismic energy to be dissipated, by various means, before it can reach the structure. This can effectively fulfil the low-damage performance requirement as part of resilience-based seismic design. GSI systems can be classified into three main branches based on their isolation mechanisms:

1. Dynamic soil-foundation-structure interaction and its favourable effects can be facilitated in a controlled manner by modifying the foundation soils to lengthen the natural period of the system and dissipate seismic wave energy without causing undesirable permanent ground deformations. Half of the articles in this special issue focus on GSI systems that are based on this mechanism (Aloisio et al. 2022; Bernal-Sanchez et al.

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2023; Chiaro et al. 2022; Dhanya et al. 2023; Edinçliler and Yildiz 2023; Tsang 2022; Vratsikidis and Pitilakis 2022).

2. Controlled sliding between the structural foundation and surrounding geomaterials can be designed by introducing a low-friction interface to limit the amount of seismic energy transmitted onto the structure. The sliding displacement can be designed to occur within an acceptable range. This GSI mechanism is featured in two articles in this special issue (Banović et al. 2022; Tsiavos et al. 2022).
3. Vibration scattering or filtering, as well as various forms of damping, can be utilised to dissipate seismic energy outside the structure. This special issue presents five different GSI systems of varying configurations that belong to this branch (Forcellini and Alzabeebee 2022; Gatto et al. 2022; Hazarika et al. 2023; Nikitas and Bhattacharya 2023; Somma and Flora 2023).

In addition to reducing structural demands such as inter-storey drift and structural or ground acceleration, GSI can also mitigate liquefaction potential, as demonstrated in the studies conducted by Bernal-Sanchez et al. (2023) and Nikitas and Bhattacharya (2023) based on the use of mixtures of soil and waste tyre rubber granules. This illustrates the potential for GSI to provide a more comprehensive seismic design solution that considers not only structural demands but also soil liquefaction.

A wide range of materials have been explored for creating GSI systems. Amongst these, rubber-soil mixtures have been the most researched materials (Bernal-Sanchez et al. 2023; Chiaro et al. 2022; Dhanya et al. 2023; Forcellini and Alzabeebee 2022; Nikitas and Bhattacharya 2023; Vratsikidis and Pitilakis 2022), whilst there is a case study with the use of whole waste tyres (Hazarika et al. 2023). Meanwhile, other materials have also been investigated, including EPS beads (Edinçliler and Yildiz 2023), geosynthetics (Banović et al. 2022; Dhanya et al. 2023), stone pebbles (Banović et al. 2022), sand, timber and PVC (Tsiavos et al. 2022), polyurethane (Gatto et al. 2022), super absorbent polymers (SAP) (Somma and Flora 2023), as well as various high-damping (Aloisio et al. 2022) and low-modulus materials (Tsang 2022).

On the other hand, investigation of GSI involves utilising a wide range of research tools and skills. This includes analytical and numerical modelling of soil-foundation-structure systems (Aloisio et al. 2022; Chiaro et al. 2022; Forcellini and Alzabeebee 2022; Gatto et al. 2022; Hazarika et al. 2023; Somma and Flora 2023; Tsang 2022). Laboratory testing of material samples has also been carried out (Dhanya et al. 2023; Gatto et al. 2022; Hazarika et al. 2023; Nikitas and Bhattacharya 2023; Somma and Flora 2023), along with characterising geomaterials at the particle scale (Bernal-Sanchez et al. 2023). Shaking table testing (Banović et al. 2022; Dhanya et al. 2023; Edinçliler and Yildiz 2023; Nikitas and Bhattacharya 2023; Tsiavos et al. 2022) and field measurements (Hazarika et al. 2023; Vratsikidis and Pitilakis 2022) have been conducted as well. In addition, practical design models and parameters have been proposed for designing GSI systems (Aloisio et al. 2022; Somma and Flora 2023; Tsang 2022).

Overall, this special issue highlights the promise of GSI to reduce seismic vulnerability of various types of structures, such as buildings, bridges, and embankments. The use of locally available and low-cost materials can also enhance the sustainability and affordability of GSI. This new research area offers unlimited opportunities for geotechnical, structural and material engineers to harness their creativity, uncover their complementary expertise and ignite a new passion.

The submissions to this special issue were by invitation only, with each author limited to contributing one article. We gratefully acknowledge the valuable contributions of all the invited authors from different parts of the world. We also extend our appreciation to the international board of peer reviewers, who provided useful and constructive comments and suggestions. Finally, we would like to thank the Editor-in-Chief, Professor Dr Atilla Ansal, for launching this special issue and making the final decision on each manuscript, and the Executive Editor, Petra van Steenbergen, for her guidance and support throughout the whole process.

In closing, GSI is an emerging category of earthquake protection methods and technologies that aim to enhance infrastructure resilience, promote environmental sustainability, and ensure universal seismic safety for all beings in the world. It contributes to the achievement of several UN Sustainable Development Goals (SDGs), such as the development of resilient infrastructure and cities, the promotion of circular economy, the reduction of greenhouse gas emissions, and the alleviation of poverty and inequality. More information about GSI can be found at the following website: https://www.gsi-global.org/ or https://sites.google.com/view/gsi-global

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