

# Editorial of Special Issue “Soil–Structure Interaction”

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In today’s world, construction projects tend to be more complex due to one or a combination of the following reasons: climate change impacting design requirements; enhanced material properties; the scarcity of greenfield sites in highly built-up cities, leading to challenging underground construction; easily accessible scientific knowledge; the prowess of computational speed; the advent of new technologies driving innovation; and stringent health and safety requirements to safeguard the public. These factors have since become the new normal, thus increasing the expectations of scientists and engineers to deliver “unimaginable” products as envisioned by clients; however, the one aspect of any construction project that has a common link to these expectations is the ground or foundation that these structures sit on. Serving as a platform for buildings and infrastructure to be founded on, soils and rocks are important geomaterials that are challenging to characterize because they are naturally formed, and thus not subject to any quality control protocol. As such, it is timely that this Special Issue focuses on the complex topic of soil–structure interaction (SSI).

Out of the ten articles, three are state-of-the-art review articles documenting and describing how the concept of SSI is efficiently implemented. In their review of the effects of surface roughness and particle characteristics on soil–structure interactions, Wang et al. [1] found that the influential factors that affect the interface shear mechanism include (i) surface roughness, (ii) particle angularity, (iii) mean particle size, (iv) surface hardness, (v) particle breakage, and (vi) confinement condition. From various past studies and the authors’ own research, it is found that interface shear strength is enhanced with an increment in surface roughness and gradually approaches the actual soil shear strength when the material surface is in a random or ribbed form. Similarly, the increasing peak friction angle progressively approaches the soil internal friction angle until the surface roughness reaches its critical roughness. These observations prove that surface roughness has a negligible influence on the residual friction angle.

In the second review article, Fatehi et al. [2] performed a comprehensive critique on (i) the environmental assessment of biopolymers as binders in soil improvement works, (ii) biopolymer-treated soil characteristics, and (iii) important factors affecting the strength behavior of biopolymer-treated soil. It was discovered that (i) a relatively low content of biopolymer is needed to achieve a comparable compressive strength when the same soil is treated with traditional binders, such as cement and lime, (ii) water content is the single most sensitive parameter that affects biopolymer-treated soil strength development, and that (iii) durability is affected by wetting–drying cycles, freeze–thaw cycles, microorganisms, and ultraviolet radiation.

Riaz et al. [3] reviewed the recent achievements in research on soil–structure interaction (SSI), with a main focus on numerical analyses. Their review defines the characteristics of a wide variety of treatments for SSI, from a basic model to a high-fidelity mode, and is based on the continuum mechanics theory as well as the utilization of high-performance



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computing (HPC). According to continuum mechanics theory, all numerical analyses must resolve a mathematical conundrum that is consistent with the original Lagrangian problem of a soil–structure system. Based on the degree of accuracy and resolution of the needed answer, a suitable numerical analysis can then be selected.

In the three review articles mentioned earlier, it is clear that each article emphasizes the fundamental theories of soil and rock mechanics, supplemented by the use of advanced testing facilities and computing prowess. Detailed, well-documented explanations and references have been provided to allow for the easy comprehension and implementation of SSI techniques in our readers' day-to-day design or research endeavors.

The other seven articles involve original research findings related to common soil–structure interaction problems normally faced by engineers and scientists. In Aloisio et al. [4], non-destructive testing (NDT) using a seismic dilatometer was successfully carried out in a deep borehole to characterize the surrounding soils for the accurate estimation of shear wave velocity. Their paper proposes an enhancement of the standard procedure to address the importance of Lamb waves in soil characterization. The experimental results of the transverse propagating waves showed distinctive dispersion curves that are indicative of the type of Lamb waves. It is likely that the seismic dilatometer results do not refer to the pure shear waves, as is usually accepted in the field of geotechnics, but rather Lamb waves are a more appropriate classification. As a result, the conventional method that derives the shear wave velocity from the cross-correlation of the two signals obtained by two spaced geophones may be unreliable.

Liu et al. [5] explained that clay and sand particles behave in a way that is distinct from other particles, but that silt particles behave in a way that is intermediate between sand and clay. As a result, they investigated the following: (a) the impact of silt contents on the strength of soft soils; (b) the impact of silt contents on the strength of soft soils stabilized by cement; and (c) the microstructure of soft soil specimens with different particle size distributions. To accomplish these goals, a series of tests, including consolidated, isotropic undrained (CIU) triaxial tests as well as unconfined compressive strength (UCS) tests, and SEM images were carried out. In conclusion, there is a correlation between silt content and the behavior of soft soils in their critical states (both clay and silt particles). When the cement percentage is 10%, the unconfined compressive strength for the cement-stabilized specimens increases with the increase in silt content. When the cement percentage reaches 30%, however, the UCS falls as silt content rises. With a cement content ranging from 15 to 25 percent, the UCS rises initially as the silt content rises but falls after the silt content reaches a "saturation" point.

Since processed crushed rocks are frequently used as base or subbase layers, Sun et al. [6] studied the mechanical properties of naturally occurring unbound granular materials (UGMs) driven by their widespread applications. In many specifications and standards, the rutting and settlement caused by base and subbase layers are severely limiting. In order to study the behavior of UGMs under the fluctuation of the degree of saturation (DOS) (59–100%), a series of repeated load triaxial tests (RLTs) was conducted to test the dynamic behavior of the crushed rocks collected from Queensland in Australia, including the resilient modulus and the plastic strain. The OMC and 100% standard proctor maximum dry unit weight conditions were used in the laboratory to properly grade the RLT specimens. The RLT tests revealed that UGM specimens soaked at a higher DOS had a lower resilient modulus and a weaker resistance to high traffic volumes, as well as a significant accumulation of plastic strain.

Pantelidis and Gravanis [7] proposed an elastic settlement analysis method for rigid rectangular footings that was applicable to both clays and sands. The case of clay is distinguished from the case of sand by the use of different contact pressure distributions, whereas the modulus of elasticity for sands increases linearly with depth. Among the most intriguing findings is that sands produce "settlement  $\times$  soil modulus/applied pressure" values that are approximately 10% higher than those produced by clays. Furthermore, for large Poisson's ratio ( $\nu$ ) values, the settlement of rigid footing is closer to the settlement

of respective flexible footing. Finally, corrections for net applied pressure, footing rigidity, and soil nonelastic responses under loading are provided.

Wang et al. [8] reported that one of the most effective methods for accurately estimating pile bearing capacity is by performing a bidirectional static load test (BDSLTL), in which the test pile is divided into two sections by activating a single-loading device welded along the pile shaft. In comparison to conventional static load tests, a BDSLTL eliminates the safety concerns and space constraints imposed by the reaction system (kentledge). The conventional analytical solutions for test piles in preliminary designs, including the Alpha and Beta as well as semiempirical methods, are validated in this paper. In order to predict the load–settlement response in a soil stiffness reduction model, modified closed-form analytical solutions based on Randolph’s analytical method have been successfully used.

In the paper of Al-Atroush et al. [9], field measurements of an axial-loaded large-diameter bored pile installed in OC stiff clay (Alzey Bridge Case Study, Germany) was load-tested to failure to evaluate the quality of two numerical models developed with the aim of simulating pile behavior in both drained and undrained conditions. It was found that the pile diameter influences the ultimate bearing stress below the large-diameter pile base; however, several codes and design standards proposed using constant bearing stress at a specific settlement value (i.e., 5% D) to estimate the ultimate capacity of the LDBP, regardless of pile geometry and without discrimination for any class of cohesive soils. This observation verifies the case study pile performance well.

The use of a 700 mm-diameter contiguous bored pile (CBP) wall for a main basement in a deep excavation project with a cut-and-cover tunnel is described by Chong and Ong [10]. The main basement was deemed “impermeable” due to the presence of cement grout columns between the successive piles behind the CBP wall; however, site observations revealed that the installation of ground anchors unintentionally punctured the wall water tightness, resulting in leakages through the CBP wall and possibly localized groundwater lowering, as evidenced by the relatively large settlements. It was observed that, in the absence of cement grout columns at the cut-and-cover tunnel section, the excavation rate resulted in immediate groundwater drawdown. Settlement caused by the excavation and groundwater drawdown was only slowed after the skinwall was cast to prevent groundwater from flowing through the wall. The unintentional groundwater leak caused minor wall deflection. The maximum settlement-to-maximum deflection ratio is unusual in comparison to that reported in the literature, hence the observed complexity of a soil–structure interaction problem. The analysis also revealed that the corner effect is significant, with smaller settlement recorded at the wall corners.

**Conflicts of Interest:** The authors declare no conflict of interest.

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