

Editorial

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Carbon capture, use and storage (CCUS) will play a major role in reducing carbon emissions in the future and provide a pathway for reaching the 2 degree goal made in The Paris Agreement on 12 December 2015 (UNFCC, 2015). Despite the fact that the way forward is tough, the discipline of environmental geotechnics is duty-bound to achieve not only this goal, but environmentally sustainable development. We need to aim for delaying the impacts of CO₂ emissions made in past decades, and target restoring our living environments for the future. CCUS is expected to become capable of capturing 1.5 Gt CO₂ in 2030 and 6.3 Gt CO₂ in 2050, according to the International Energy Agency. The necessity of CCUS has been emphasised by the policies and legislation of Europe, making it clear that the field of environmental geotechnics has much to contribute, ranging from: (a) the use of naturally occurring fibres as soil reinforcing binders; (b) improving predictions of material degradation, desiccation crack, and rheological behaviour; and (c) developing more microorganism-inspired soil-reinforcing approaches as alternatives to traditional ground improvement technologies. Additionally, the recycling and reuse of municipal solid waste have been in the spotlight recently due to their great potential to reduce CO₂ emissions by serving as subgrade material in road embankment construction.

Many urban lands around the world are experiencing the degradation of mechanical properties and water retention abilities due to acid rain- and irrigation-induced contamination (Kirui *et al.*, 2021; Hu *et al.*, 2021; Wang *et al.*, 2022). Their restoration and reuse still need to be addressed, since currently available remediation technologies are criticised for the high risk of secondary pollution they pose, as well as their low maneuverability. In the context of CCUS, root water uptake (RWU) and reinforcement have gained heightened interest due to their ability to mitigate carbon emissions, especially if the potential failure plane is triggered within shallow depths by lower-precipitation events. The naturally occurring fibres themselves, however, are prone to rapid degradation, which restricts their application horizon. Furthermore, microbial-induced carbonate precipitation (MICP) has been widely applied to treat calcareous sands to prevent them from being crushed when subjected to external forces. No comprehensive studies have yet been conducted concerning how MICP treatment interacts with native microorganisms (Xue *et al.*, 2021b) and their implications on reinforcing efficiency.

I am very pleased to present this 'In-Focus' issue on 'Modelling and simulation in geoenvironmental engineering', which includes two

papers (Nguyen *et al.*, 2022; Zheng *et al.*, 2022) related to the thermo-hydro-mechanical behaviour of saturated soils and degradation of natural fibre drains. The others that follow cover a range of diverse topics in this broad research area, including the investigation of desiccation cracks due to the combined effects of initial water content and layer thickness on bentonite clay, improving dune sand the MICP technology, investigating changes in low-frequency attenuation responses of sands during formation of biofilms, highlighting the hydrological benefit of vegetation by way of root water uptake (RWU) in delaying rainfall-induced slope failures, and rheological modelling towards understanding the mechanical properties of geogrids under long-term and low-stress load.

Ta *et al.* (2022) investigated changes in low-frequency seismic responses of sands during microbial formation of soft viscous biofilms. In this study, a series of resonant column experiments were conducted with two bacteria, namely *Shewanella oneidensis* and *Leuconostoc mesenteroides*, while monitoring changes in the wave velocities and damping ratios associated with biofilm formation in sands. The study suggested that monitoring seismic attenuation can be applied to detect the formation of biofilms as a key indicator, and the biofilms also modify the seismic attenuation responses of sands.

Urease performance was evaluated through standard tests by Bahmani *et al.* (2022), thereby screening urease-producing bacteria from local alkaline soils. To enhance our understanding of the performance of screened bacteria, *Sporosarcina pasteurii* was introduced as the control sample. The bacteria with the best performance were screened out by 16S ribosomal ribonucleic acid sequencing. Results showed that the dune sand treated by *Bacillus* sp. UTMC 2623 resisted wind erosion more effectively than the untreated dune sand. Scanning electron microscopy (SEM) images and X-ray diffraction (XRD) aimed to observe calcite precipitation formation and indicated precipitation of calcite throughout the sand column.

Desiccation cracks in clay soil are deemed crucial in affecting the performance of clay liners, engineered landfills and more. The paper by Mohammad *et al.* (2022) investigates desiccation cracks caused by the combined effects of initial water content and layer thickness on bentonite clay. Results showed that the interplay between the

initial water content and layer thickness has a significant effect on the formation and prevention of desiccation cracks. The authors developed a theoretical model on the basis of critical cracking thickness to predict the phase boundary that distinguishes cracked samples from non-cracked ones. Results also showed great potential for applying this study's findings to clay liner designs.

The paper by Patil *et al.* (2022) investigates the hydrological benefit of vegetation by way of RWU in preventing reinfall-induced slope failures in Guam. Two historical cases were studied with three different scenarios. Results indicated that matric suction could be developed within shallow depths, helping to prevent slope failure during lower-precipitation events. However, this effect ceases in the event of saturation due to long-duration precipitation. Results also showed that the mechanical root reinforcement effect is a crucial factor in improving safety even after saturation.

A non-linear, four-parameter viscoelastic–plastic model to characterize the mechanical properties of geogrids under long-term and low-stress load is presented by Yi and Du (2022). The authors reported that there are two stages applied to the stress analysis of the whole reinforced tailings complex: the first stage (E-VP model) corresponds to the elastic state of tailings during which the stress of geogrids decreased with time, and the second stage (P-VP model) is identical to the plastic state during which the stress of geogrids remains constant. Results indicated that the plastic strain ϵ_p and viscosity coefficient η of geogrids, as well as internal friction angle ϕ of tailings, largely affect the plastic arrival time t_p of the reinforced tailings complex.

Naturally occurring jute and coconut fibres have been applied extensively to geoengineering due to their biodegradation properties (Xue *et al.*, 2021a). These materials, however, can decompose very quickly when subjected to, for example, chemicals. Nguyen *et al.* (2022) estimated the influence of degradation of natural fibre drains on soil consolidation using the finite-element method (FEM), which utilises a subroutine capable of describing the reduction in drain capacity over time. Its suitability was verified through applications to cases considering the rate and time-dependent form of degradation. Results showed that the dissipation of excess porewater pressure can be interrupted if drains decay too early, particularly when the drain capacity falls below 0.03 m³/d.

Understanding that the freezing and thawing of soil are dynamic thermos-hydro-mechanical (THM) coupled processes is of great necessity for providing appropriate design deliverables. The paper by Zheng *et al.* (2022) proposed a fully coupled thermo-hydro-mechanical freezing (THM-F) model, as well as the derivation of theoretical aspects pertaining to the governing equations, which included the thermos-mechanical decomposition treatment of the solid phase. The fully coupled THM-F model was verified by examples from purely freezing, THM and THM-F perspectives. The heat and mass transfer, thermodynamic relations and the formation of frost heave were the focus of this study. The migration of pore fluid from the unfrozen zone to the freezing area and the clogging of pore space by ice lenses were also investigated. The

model demonstrated its potential for capturing various coupled physical phenomena during freezing—for example, the latent heat effect, groundwater flow alterations and mechanical deformation.

All the papers related to these 'In Focus' issue and general issues represent significant efforts to provide people with more powerful tools to deal with more complex and challenging infrastructure projects for the benefit of quality of life. It is my sincere hope that the content of these papers can inspire more people to dedicate themselves to developing revolutionary concepts to not only promote sustainable designs and construction, but also to reduce the negative impacts on our living environments.

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