Editorial

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Since the end of the second decade of the twenty-first century, the world has (finally?) become fully aware of the importance of adopting sustainable strategies for everything we do, from day-to-day consumption to construction. Innovators and researchers are concentrating efforts on the development and optimization of less energy-consuming, less greenhouse gases-emitting, as well as, obviously, better-performing, and cheaper to implement technologies.

This issue of *Environmental Geotechnics* reflects well this shift in global interest for novel approaches to solve known problems, in the field of environmental remediation and soil improvement. The six articles of this issue depict opportunities and limitations offered by innovating materials such as geomembranes or geosynthetic clay liners, soil improvement technologies such as Microbially induced calcite precipitation (MICP) and Microbially induced partial saturation (MIPS), surcharge and vacuum preloading combined with electro-osmosis, and the evaluation of new scientific approaches to characterize, therefore better use natural materials.

The first paper (Li and Fall, 2021) presents the assessment of clay-geomembrane interface friction properties when exposed to freeze-thaw cycles, an important design parameter for containment structures located in regions exposed to freezing temperatures. Geomembranes were first adopted in engineering practice because they offer superior sealing properties at a cost far lower than any alternative solution involving soils. It was later found that this cost-saving is also attached to a far better carbon footprint, compared to structures designed with low permeability soils only, or located on such substrates. These products are now required in most environmental regulations and design guidance around the world.

Polyethylene geomembranes are typically installed over a clayey substrate or a geosynthetics clay liner (GCL), to create a composite liner. Composite liners installed in arctic conditions may involve exposure to freeze-thaw cycles when not adequately covered. The authors of the first paper have investigated the effect of freeze-thaw cycles on interface friction properties. For the particular soil and geomembrane they have evaluated, they found that freeze-thaw cycles can reduce

the friction angle by approximately 1.9° for the clay-geomembrane interface, and 3° for the clay itself. This observation could lead the way to the implementation of new design guidance requiring the interface to always be protected from exposure to freezing temperatures.

In the second paper, Yuan *et al.* (2021) investigate the use of mercury intrusion to qualify structural properties of soils. They have assessed the impact of three test parameters on the quality of the observations, facilitating a better understanding of the microstructures of clays.

Their work offers a possibility to better understand the behavior of clays, and in particular highly expansive clays, when exposed to harsh environments: how are they affected by exposure to chemicals or other environmental conditions? One of the clays investigated by the authors is bentonite, used in the manufacture of GCLs, an important component of composite lining systems, sometimes considered for its ability to retain heavy metals (Lake and Rowe, 2010).

GCLs are prefabricated clay barriers used to create composite liners when clay is not available locally. These products are sold in rolls, therefore their performance is partially affected by the performance of the overlap between each roll. The third paper investigates the flow through overlaps of GCLs. Weerasinghe *et al.* (2021) have conducted a comprehensive review of research done to understand the mechanisms controlling flow through overlaps, how to test them and how to model them.

The factors they have identified as likely to influence the flow at the overlap include the type of GCL (i.e. its structure, type of bentonite and swelling potential, the use of additives in the bentonite) it also includes installation-related issues such as the length of overlap or the use of supplemental bentonite between the layers. Finally, it covers environmental factors such as the effects of temperature on shrinkage potential for the product, the effect of confining stress, and of the lack-of, locally, when a wrinkle exists on an overlying geomembrane.

Their comprehensive literature review offers several directions that could be followed to better understand the performance of GCL overlaps.

In the fourth paper, Wen *et al.* (2021) study microbially induced calcite precipitation (MICP), a technology which aims at improving the mechanical properties of soils and could therefore limit the need to transport high-quality granular materials to build structures on lower quality subgrades. Authors have studied the sensitivity of this process to various conditions. They have assessed the relevance of electrical conductivity and pH to monitor the performance of the technology. Their work can help ensuring optimum precipitation of CaCO_3 and achievement of high unconfined compression strength of sand. These indicators can be easily implemented to different MICP treatment methods to monitor the ureolytic activities and obtain optimum performance in the field.

Another aspect often requiring significant design efforts is the prevention of soil liquefaction, especially in earthquake-sensitive regions. The liquefaction resistance of soils can be improved by introducing gas bubbles in soil, therefore reducing its saturation level and increasing its undrained shear resistance. The fourth paper investigates the various strategies that can be put in place to create gas bubbles or to reduce the saturation level of the soil. Among them, Mousavi *et al.* (2021) found that a high initial nitrate concentration offers superior performance in gas generation, and that it also favors precipitation of CaCO_3 through MICP, and therefore generates additional bearing capacity as well.

Such a soil treatment can prevent replacement of soils is sensitive areas, favor the use of lower quality granular materials, therefore contributes to the reduction of human footprint on the environment.

Improving the performance of natural soils is a concern that is also developed in the sixth paper (Wang *et al.*, 2021), which focuses on land reclamation in marine regions. With the increase of the world population, the need for land reclamation has boomed in several regions, requiring the development of effective strategies to consolidate marine soils in particular, e.g., to build platforms on the sea or on wetlands. Among these solutions, surcharge and vacuum preloading combined with electro-osmosis (surcharge–vacuum–electro-osmosis) is studied by the authors using an analytical method. The paper presents details of the model used, as well as the findings, compared with previous model predictions. They consider the use of Electrical vertical drains (EVD), installed vertically with the loading rate applied vertically as well.

Authors demonstrate that surcharge and vacuum preloading combined with electro-osmosis accelerates the consolidation rate. The horizontal flow plays a dominant role in the consolidation process, limiting the effect of a reduction of the vertical permeability of the soil, and making the spacing between anodes and EVD a critical parameter affecting the performance of the technology.

Overall, it is possible to identify a common denominator for all products and technologies studied in this issue of *Environmental Geotechnics*: they all aim at reducing the carbon footprint and improve the sustainability of construction projects, by limiting the use of noble materials to achieve specific functions expressed in terms of bearing capacity or sealing performance.

Sustainability has become the dominant concern for many governments, and many researchers alike. In 2015, the United Nations have published 17 sustainable development goals covering many if not all aspects of human interaction with the environment. These have been used as a basis for several institutions and researchers to articulate a value proposal for particularly efficient technologies, such as Geosynthetics (IGS, 2021; Touze, 2020). In fact, it can be foreseen that several bidding processes will start to include sustainability considerations in the years to come, which could lead to radical transformations of how we are thinking construction and management of human footprint on the environment. Developing technologies facilitating the use of low-quality materials, reducing the carbon footprint associated to a function on a project, or permitting a better assessment of the properties of soils to facilitate its use in an engineered structure all contribute to a more sustainable world. I therefore thank the contributors to this issue of *Environmental Geotechnics* for their very important contribution to the development of more sustainable and efficient construction techniques.

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