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Stabilising soil sustainably: could biopolymers be used instead of cement?

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Soil stabilisation and the process of strengthening the physical properties of soil is fundamental to the construction process of infrastructure such as roads, runways and earth dams. Many chemical additives currently used in soil stabilisation are associated with adverse environmental effects and this study examines the use of biopolymers, such as xanthan gum and guar gum, as more sustainable alternatives. The researchers have run a series of laboratory experiments to evaluate the viability of these two types of biopolymers for use as additives for collapsible soil stabilisation, and found that both could be used in place of conventional additives to improve soil strength, permeability and collapse potential.

Soil density can affect many of its mechanical properties, including settlement rate (i.e. vertical movement), bearing capacity, permeability, etc. Soil stabilisation and the process of strengthening its physical properties is therefore fundamental. Soil stabilisation is a requirement in many geotechnical engineering applications, including road construction, slope stabilisation, erosion control, foundation and embankment treatment and coastal line improvement. While stabilisation can be achieved by mechanical, physical and electrical processes, chemical methods are the most common.

The most widely used soil-strengthening additives, such as cement, have negative impacts on the environment. Significant amounts of carbon dioxide (CO_2) and nitrogen oxide (NOx) gases are emitted during the production of cement, which is consequently responsible for 5–7% of the world's carbon dioxide emissions and accounts for 12–15% of the total energy consumed in the global industrial sector[1].

The use of polymers of biological origin, or biopolymers, has therefore been proposed as a more environmentally friendly and sustainable alternative. Biopolymers are stable, carbon neutral and renewable. However, experiments investigating their impact on soil behaviour have been limited, and primarily restricted to non-collapsible soils. This represents a knowledge gap, especially since collapsible soils — those that can withstand high pressure until wet, when they may shrink in volume suddenly and significantly — cover significant areas around the world, and are among the most problematic of soil types.

This study evaluated the viability of two biopolymers — xanthan gum and guar gum — as environmentally-friendly additives with which to stabilise collapsible soils. A series of laboratory experiments (including compaction, consolidation, permeability and tests to reveal the shear strength of the soil at different confining stresses) were performed to quantify changes in the strength, permeability and collapse potential of biopolymer-treated soils over a timescale of 28 days. Changes in the soil's microstructure were also tracked using scanning electron microscopy (SEM).

Both biopolymers successfully improved the strength of collapsible soil by decreasing its maximum dry density, permeability and collapsible potential. Xanthan gum was found to be superior to guar gum in improving soil behaviour, but the results suggest that both biopolymers could be effective in strengthening collapsible soils, and are therefore potential substitutes for conventional chemical soil additives.

These findings are of relevance to policymakers and stakeholders involved in efforts to develop more sustainable geotechnical engineering initiatives. However, it should be noted that further studies are required to evaluate the durability of the biopolymer effect over longer timescales and under different environmental conditions, including variations in temperature and moisture.

1. Gutiérrez AS *et al.* (2017). Improved selection of the functional unit in environmental impact assessment of cement. *J Clean Prod* 168:463–473.