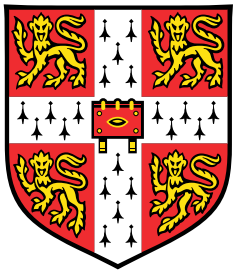
Static and Dynamic Performance of Biochar Enhanced Cement Stabilised Peat



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Abstract

Peat is a type of soft soil with very high organic and water contents. It lacks any kind of structure, which makes it extremely compressible and weak. These are highly undesirable physical characteristics when considering a site for construction, as they significantly increase the risk of large differential settlement. In countries like Malaysia and Indonesia where peat covers about 8 and 14% of the land areas, it is not always possible to avoid construction on peaty regions. Geotechnical engineers have developed several techniques to circumvent the issue and build safely on peatland. One of the most common techniques uses chemical binders with cementitious properties where hydration reactions create bonds reinforcing and strengthening the peat soil matrix. Among the selection of binders available, Ordinary Portland Cement is the most common due to its wide availability. Past experiences and research have reported the cement stabilisation of peat to be largely effective. However, one of the main disadvantages is the large quantity of binders required before stabilisation is effective, making it uneconomical.

Sand is often used as a supplementary material in cement stabilisation of peat in an effort to reduce the amount of binder required. However, both sand and cement are produced or mined from rapidly depleting natural resources. Therefore, in recent years, there has been a concentrated effort to research the use of alternative materials from more sustainable sources or recycled waste materials. Biochar is a product of pyrolysis where biomass is decomposed in the absence of oxygen and has been widely researched for its exceptional soil amendment qualities to improve crop yields, carbon sequestration potential and the ability to remediate contaminated lands. No research has been conducted on its potential use as a supplementary material in chemical soil stabilisation. In the early stages of this investigation, a proof of concept study was set up to evaluate its potential in cement stabilised peat. The outcome of the study was overwhelmingly positive with the biochar enhanced cement stabilised peat performing noticeably better even at a very low dosage (10%).

The main objectives of this investigation are to evaluate the static and dynamic performance of biochar enhanced cement stabilised peat. The results of the static tests show that biochar crushed to a size smaller than 75 μm performs significantly better than sand as a filler. Samples with 10% cement and 40% biochar matched the performance of the control sample with 20% cement only, without biochar. This gives confidence that biochar has the potential to partially replace cement binder while retaining similar performance for a more cost-effective and environmentally friendly application. Scanning electron microscopy (SEM) and X-ray powder diffraction (XRD) tests were used to study how the mechanisms of hydration change to the inclusion of biochar. The micrographs from SEM confirmed that the inclusion of biochar crushed to a size smaller than 75 μm produced a much more homogenous soil matrix which correlates to a performance increase. The results from XRD also showed a decrease in C_2S clinker material in the biochar enhanced samples which is a good indication of an increased hydration. The findings from the bender elements tests and cyclic triaxial tests showed that the shear stiffness increased with the inclusion of biochar. And finally, the increase in performance in biochar samples translated to a small amount of cumulative plastic strain under cyclic loading.