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X-RAY TOMOGRAPHY AND COMPRESSIVE STRENGTH OF A HIGHLY SWELLING CLAY: SMECTITE

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Summary: Clay soils are problematic as structural materials, due to their variability in water absorption and swelling behaviours. Repeated wetting and drying cause cracking which reduce the load-bearing capacity of the soils and can lead to collapse. In this work we investigate a strongly swelling clay type, Smectite, using high resolution X-ray tomography of the same sample after repeated wetting and drying cycles, and correlate this with mechanical compression testing.

1. INTRODUCTION

Some clays are known to swell when exposed to water which can be problematic for structural purposes [1]. As a soil type, clay is characterized by fine grains and becomes elastic at appropriate water attenuation levels [2]. Smectite in particular is known as a highly swelling clay due to its high cation exchange capacity and water attenuation capabilities [3]. In this work, Smectite was investigated with emphasis on its compressive mechanical properties as a function of repeated wetting and drying cycles.

2. EXPERIMENTAL METHOD

The experiments were performed at the Stellenbosch University CT Scanner Facility [4]. Dry Smectite was sourced and a range of similar small cores were prepared for both microCT and ex-situ mechanical loading. All of the cores were subjected to wetting and drying cycles. The first batch of cores were CT scanned at different stages during the wetting and drying. Image analysis was performed in Volume Graphics VGStudioMax 3.0. Mechanical load tests were performed on a second batch of cores at different intervals during the wetting and drying cycles.

3. RESULTS

X-ray tomography images of a small-grained soil similar to clay is shown in Figure 1. From left to right are images of the same sample loaded to 1.5 kN where failure occurred and a second cycle until failure occurred again. In the investigation of Smectite, a simple strategy was employed: wetting and drying cycles were imaged without any loading, to quantify the volume changes and cracking occurring due to swelling and drying, while traditional mechanical compression tests were done on similar samples at different stages of wetting and drying. This provides a correlation between bulk changes observed by microCT and reduced mechanical properties measured by mechanical testing.

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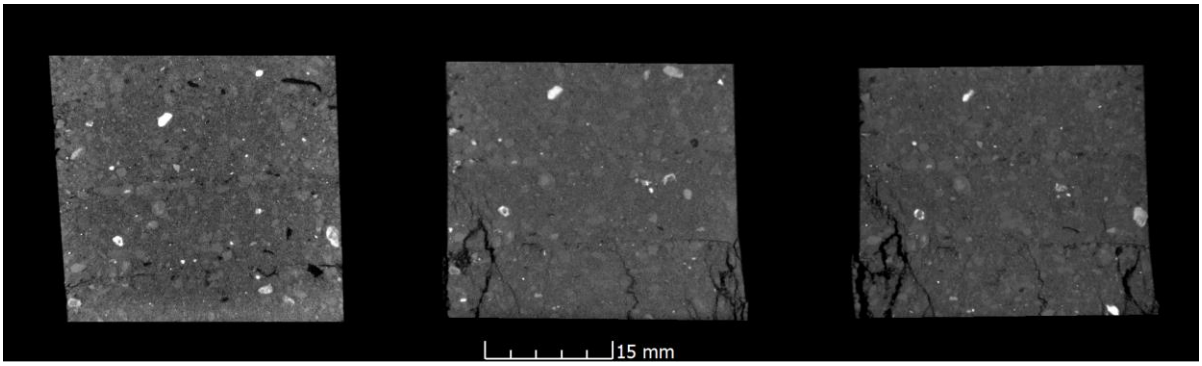

Figure 1: CT images of the same fine-grained soil sample (similar to a clay), being progressively loaded (ex-situ) with cracks forming as the load increases. First failure occurred at 1.5 kN in this case shown in the middle image. Further loading increases the cracking as shown to the right.