Properties of Aggregated Soil
- Effect of confining pressure -

団粒化土の力学特性　ー拘束圧の影響ー

Aggregated soil is a chemically-improved soil that consists of double pores where the macro-pores allow water to flow through easily which improves water infiltration, and the micro-pores can retain water to slowly release back to the atmosphere through evaporation. Since aggregated soil is a relatively new material, its properties need to be well understood before its application in large-scale projects. In this study, its mechanical properties under various confining pressure is being studied using triaxial apparatus. The microstructure of aggregated soil is also studied using scanning electron microscope.

細粒土を凝集した粒で構成されマクロ間隙とミクロ間隙を有する団粒化土は、高い透水性を有する一方で団粒内のミクロ間隙に水を保持することができる。団粒化土は現状では歩道やグラウンドなどに使われているが今後大規模土にな適用を検討するにあたって、その特性の把握が求められている。ここでは、一連の三軸試験によりその力学特性と拘束圧の関係を検討した。また走査型電子顕微鏡を用いて、団粒化土の微細構造を調べた。

1) Introduction

Urban areas, with their increased paving, buildings, and other infrastructure, can lead to the reduced permeability of the surface, which can cause more rainwater to run off on the ground surface, leading to flash flooding and other issues. Aggregated soil is a type of chemically-improved soil that exhibits a dual-pore structure. This structure consists of macro-pores, which facilitate the easy flow of water, enhancing water infiltration into the soil. Additionally, the soil contains micro-pores that have the ability to retain water, gradually releasing it back into the atmosphere through the process of evaporation. Aggregated soil is made using 4 ingredients: base soil, cement, polymer and water. The term “aggregated soil” is derived from the aggregation process after combining with cement and a crumbing agent.

(2) Methodology and Apparatus

Triaxial apparatus arrangement

The triaxial apparatus employed a strain-controlled, small-sized setup. It incorporated essential components such as an AC servo motor, a reduction gear system, as well as electromagnetic clutches and brakes.

Saturation by double vacuuming method

To enhance saturation of the specimen, specimen is first vacuumed. De-aired water is then allowed to flow through the specimen from the bottom to the top.
Back pressure is then applied to further saturate the specimen.

Consolidation and shearing

The specimen undergo triaxial compression under various confining pressure of 50kPa, 100kPa, 200kPa and 400kPa. Following the consolidation phase, the specimen is subjected to drained triaxial compression with an axial strain rate of 0.2 mm per minute.

(3) Sample Preparation

Mixing proportion

Specimen	Cement	Polymer	Water	Compaction degree
AS80	80 kg/m3	1.5 liter/m3	16.5%	95 %

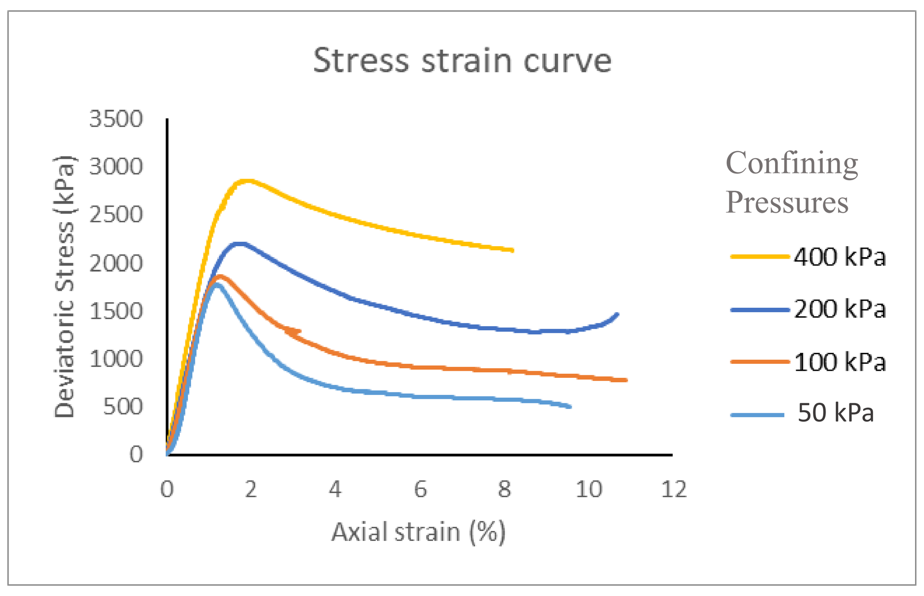
Using the mixing proportion in the table above, aggregated soil is made by mixing all components together. After that, initial cure is required for initial setting of cement and allow the crumbs to be firmer before compacting into molds.
After initial curing phase, the sample is being compacted into mold with compaction degree of 95%. To ensure consistency and uniformity throughout the whole specimen, the under compaction method is utilized. Following that, the specimen is cured in a moisture box for 28 days before testing.

Base soil (Masado) Freshly mixed AS Compacted into mold Specimen

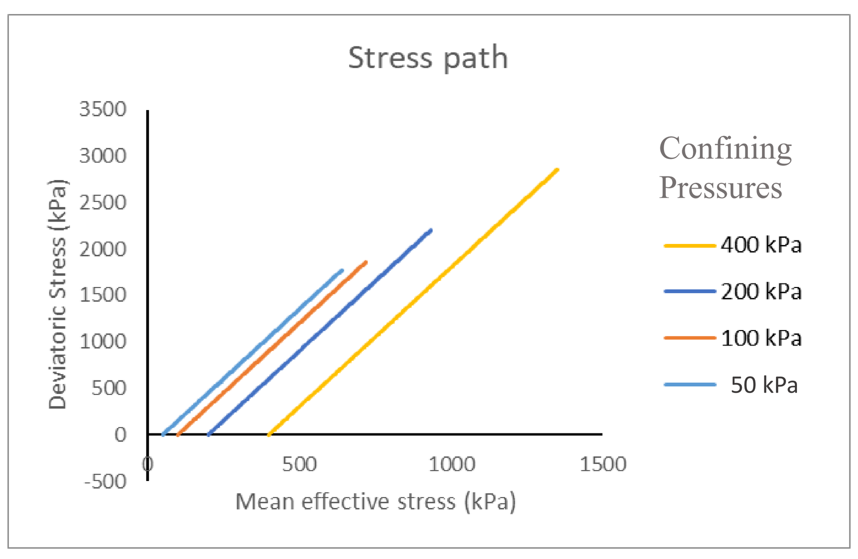
(4) Experimental Results

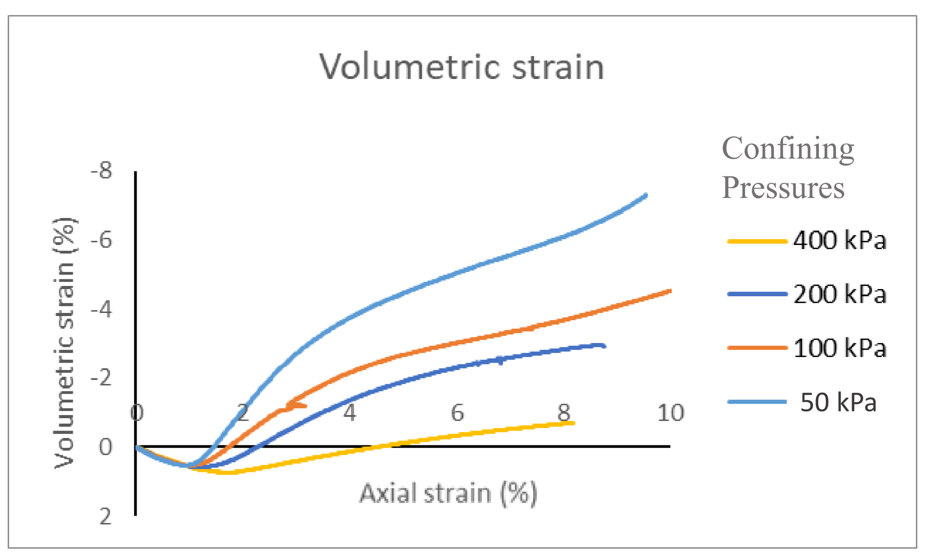
Aggregated soil strengthens as confining pressure increases. It shows a clear peak strength at lower confining pressures as expected for dense soil. As confining pressure rises, the peak strength diminishes while the residual strength remains close.

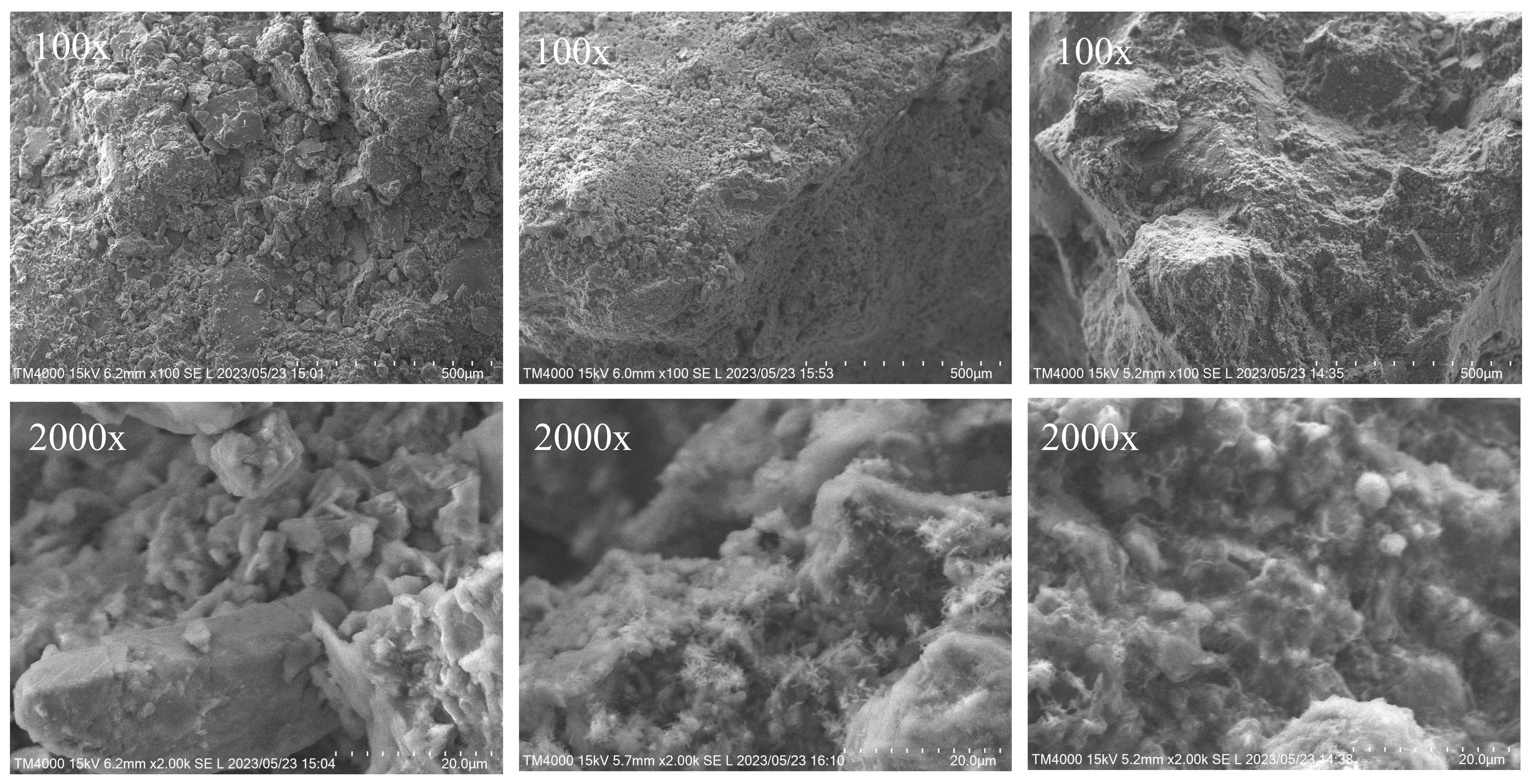
At low confining pressure, the material demonstrates a high peak strength, indicating strong cementation and specimen integrity.



The specimen expands considerably at low confining pressure, shown by a high volumetric strain.
In contrast, the volumetric strain decreases with high confining pressure.







Untreated soil Aggregated soil @2h Aggregated soil @28d

The microstructure of aggregated soil was analyzed using scanning electron microscope (SEM) to gain insights into its composition. In the case of untreated soil (Masado), the observation revealed that smaller particles were loosely attached to larger particles, appearing separate from one another. However, when polymer and cement were introduced during mixing, the particles exhibited a cohesive behavior and formed a unified structure. Remarkably, at a magnification of 2000x, the SEM images unveiled the presence of etringite, a product of cement hydration, even in the freshly mixed aggregated soil.

For further information, contact below.
Prof. Reiko Kuwano
Bw-304, Institute of Industrial Science, the University of Tokyo
TEL：+81-3-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp

Chhoeur Pryalen(2023)
桑野研究室
東京大学 生産技術研究所 Bw-304
電話: 03-5452-6843
E-mail: kuwano@iis.u-tokyo.ac.jp