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Strain softening of siltstones in consolidation process using a constant strain-rate loading system

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The mechanical behavior of soft rocks is dominated by the mechanical properties of the rock itself. Because soft rocks have different physical properties to hard rocks, it is essential to understand the mechanical behavior of soft rocks when tunnels and huge structures are constructed in these. Strain softening is the mechanical behavior of soil and rock materials and is important in understanding soft rock foundation. To investigate the mechanical behavior of siltstone, a sedimentary soft rock, we performed the one-dimensional consolidation tests (hereafter called K0-consolidation test) using a constant strain-rate loading system. We also took high-resolution X-ray CT images of the test specimens before and after the consolidation tests to observe the consolidation deformation. Using Quaternary siltstones distributed in the Boso Peninsula, central Japan as specimens, strain softening in the consolidation process was confirmed in some formations using two test machines at Kyoto University and Nagoya Institute of Technology.

All specimens yielded and the consolidation curves showed over- and normal-consolidation areas. Some specimens' stress decreased suddenly at increasing strain just before yielding, which can be regarded as a real strain softening because no strain localization could be confirmed within specimens. The stress at the time of the softening differed even for specimens taken from the same formation. Furthermore, the micro-focus X-ray CT images indicated that the specimens had no macro cracks inside. This suggests that strain softening is not due to brittle failure in local areas but due to the softening of the framework structure of the siltstone itself. The samples used in this study are siltstone taken from the Quaternary forearc basin, whose development is related not only to consolidation but also tectonic effects such as horizontal compaction accompanied by plate subduction. Therefore, it is possible that the strain softening confirmed in this study reflects the micro cracks and internal structure that developed during siltstone formation.