



HOKKAIDO UNIVERSITY

Title	Laboratory study on mechanical properties of frozen clay through state concept [an abstract of dissertation and a summary of dissertation review]
Author(s)	WANG, Jinyuan
Degree Grantor	北海道大学
Degree Name	博士(工学)
Dissertation Number	甲第12823号
Issue Date	2017-06-30
Doc URL	https://hdl.handle.net/2115/66502
Rights(URL)	https://creativecommons.org/licenses/by-nc-sa/2.1/jp/
Type	doctoral thesis
File Information	Wang_Jinyuan_abstract.pdf, 論文内容の要旨



学 位 論 文 内 容 の 要 旨

博士の専攻分野の名称 博士（工学） 氏名 WANG Jinyuan

学 位 論 文 題 名

Laboratory study on mechanical properties of frozen clay through state concept
(土骨格状態概念に基づく凍結粘土の力学的挙動の実験的研究)

Towards development of a mechanical model that can be part of multi-physical analysis of frozen soils, a program of systematic frozen-unfrozen parallel triaxial tests at different temperatures and strain rates was conducted. The mechanical behavior of the reconstituted high-plasticity clay samples was investigated and interpreted through state concept based on Ladanyi and Morel's (1990) postulate on the unique relationship between the inter-particle "effective" stress and the strain path.

To begin with, constant-condition (i.e., constant strain rate and temperature) compression tests were conducted on frozen Kasaoka clay specimens with normal consolidation prior to freezing. With other conditions set identical, the shear strength linearly increased with a decrease in temperature for the range from -10°C to -2°C, and log-linearly increased with an increase in the strain rate for the range from 0.001%/min to 0.1%/min. Direct comparison of the strain-rate effects between frozen and unfrozen specimens with identical strain paths and states in the soil skeleton clearly indicates that the viscoplasticity derives from that of pore ice. The Critical State lines (CSLs) for clay specimens frozen undrained were mapped by referring to the shear behavior of unfrozen specimens sharing the same strain history. Moreover, reduction of confining pressure after stabilized freezing of frozen specimens turned out to have no significant effect on critical state strength of frozen clay.

By varying-temperature and varying-strain rate compression tests, consistency of stress-strain curves was observed at large strains between varying- and constant-temperature conditions, and less clearly, between varying- and constant-strain rate conditions. The latter observation, if further confirmed, will lead to isotach formation of strain rate effects for the investigated range of strain rate (i.e. up to 0.1%/min), where the behavior is largely ductile. A conceptual interpretative framework invoking temperature- and strain rate-dependent state bounding surfaces and CSLs was proposed to describe frozen soils' behavior under steady and non-steady temperature and strain rate.

Finally, a nondestructive testing method mainly focusing on measurements of stiffness is developed. Different temperatures and axial strain rates were applied in order each time after the specimen was loaded and unloaded in quasi-elastic strain ranges. In the investigated range of conditions, the shear stiffness, averaged from the multiple probes of the same condition, increased linearly with the decrease in temperature, and increased linearly with the logarithmic increase of strain rate.

The above observations of behavioral features of frozen and unfrozen soils, with further experimental work, are expected to lead to construction of a unified framework for describing the behavior under both states and transition between them.