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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 河内 太志

学 位 論 文 題 名

Description of long-term settlement of peat under unsteady thermo-mechanical field
conditions

(非定常熱・力学条件下における泥炭地盤の長期沈下の記述)

Peat is common in cold regions and Southeast Asian regions. Being deposited in the subsurface, it exhibits large deformation against loads from superstructure (i.e., primary consolidation, Chapter 1.2). The long-term secondary consolidation often continues even after the service of infrastructure, resulting in its deformation. Although previous studies (Chapter 3.3.2) have provided a better understanding of time-dependent characteristics in peat, predicting its field-scale long-term deformation remains challenging. It is potentially because environmental factors have not been considered; the subsurface layer consists of peat is subjected to an unsteady thermal environment due to multiple mechanism (Chapter 1.3). Previous studies on temperature effects (Chapter 3.4.1) have consistently demonstrated soft soils undergo irreversible compression upon heating, suggesting the in-situ unsteady thermo-mechanical conditions alters the long-term behaviour of peat. Nevertheless, the combined effect of temperature and long-term characteristics in peat have not yet been thoroughly investigated, and hence, no model properly describing the field-scale behaviour of peat is available.

Accordingly, the present study aims to develop a description of the long-term settlement of peat under unsteady thermo-mechanical conditions. The thesis adopts the hierarchical framework, progressing from element-level understanding to field-scale application, leading to the following four objectives. The corresponding achievements (Chapter 9) are summarised below.

[1] To accumulate test data on the temperature- and rate- dependency of peat through laboratory testing:

→ In total, 48 temperature-controlled oedometer tests, two triaxial tests, and one thermal

conductivity measurement are presented in Chapter 5 and 6, with details provided in Chapter A1 in the Appendix. The test data cover the extensive field conditions as summarised in Chapter 9.

An important outcome here is that two practical parameters (the coefficient of secondary consolidation and the yield stress), exhibit temperature dependency (Chapter 5).

[2] To establish a general framework for understanding peat behaviour under the unsteady conditions based on the laboratory findings:

→ Based on the systematically designed 39 temperature-controlled oedometer test cases, a framework (isothermal isotach; local isotach) was developed as an extension of the classic isotach theory in Chapter 5 and 6, to consistently interpret the temperature- and rate- dependency of peat under the extensive conditions.

[3] To formulate a constitutive model consistent with the proposed framework.

→ The formulation of the isothermal isotach was already complete based on existing theory (Chapter 3.4.3). In contrast, the formulation of the local isotach could not be achieved within the conventional framework alone. To overcome this limitation, a new module termed Transient Viscosity Suppression (TVS) was introduced by the author (Chapter 7.2.1). By combining this TVS module with the rate dependency during reloading and the isothermal isotach concept, a constitutive model capable of capturing the expected field conditions was successfully established.

[4] To develop a finite element model capable of translating the element-level insights to field-scale conditions.

→ A THM-coupled finite element model formulated in Chapter 8 incorporates the large deformation theory as well as the advanced constitutive model developed in this study. The model was then implemented in Python (Chapter A4) and validated through the comparison to a laboratory test (Chapter 8.2.5).

In appendix, supplemental but meaningful test data are presented; For example, a new

framework for consolidation of peat, i.e., the multi-pore consolidation system, is developed based on the microstructure observations via scanning electron microscope and mercury intrusion porosimetry (Chapter A3).