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（博士課程）
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論 文 要 旨

THESIS SUMMARY

系・コース： Department of, Graduate major in	土木・環境工学 土木工学	系 コース	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of	（学術） Philosophy
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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words）

The title of the thesis is "Performance of River levee reinforced with Steel Drainage Pipe against Flooding." It consists of seven chapters. The content of each chapter can be summarized as the following:

Chapter 1: Introduction

In this chapter, the unsaturated soil mechanics is briefly introduced, which is followed by the discussion of seepage flow in the unsaturated soil slope. This chapter also discusses various cases of the levees and embankments failure due to the flood-induced seepage. Various types of protection against seepage flow with their advantages and shortcoming are highlighted. The use of a new type of protection with "Steel drainage pipes" is proposed.

Chapter 2: Centrifuge experiments and results

In this chapter, the details of the centrifuge tests and procedures are discussed. Results of a series of the six centrifuge tests are presented. This chapter focuses on simulating the realistic condition of levee subjected to flooding and behavior of levee when provided with the protection. With an increase in flood head, increased seepage flow causes the weakening of the slope starting from the toe region which eventually causes the failure of the levee. When levee is protected with pipes with only drainage or only reinforcement, the resistance of levee against flooding is increased however is not sufficient to protect against the longer and larger flood. With the use of the reinforcement, levee can withstand higher pore water pressure, however, higher pore water pressure can cause erosion of soil especially near pipes.

Chapter 3:1g Physical model test and results

In this chapter, the details of the experiments under an ordinary gravitational field are discussed. In this series of the experiment, as the rising rate of flood water level is maintained the same for all the test, direct comparison among the cases which was not achieved through the centrifuge test can be made. The presence of only reinforcement reduces the depth of the slip surface by 70% compared to the unreinforced case. The steel drainage pipe with the presence of the drainage and reinforcement reduces the maximum pore water pressure by 19% and deformation is completely prevented.

Chapter 4: Numerical simulation of physical model test

The numerical procedure can be only used for the study of soil behavior if it can simulate the realistic condition with acceptable confidence. In this chapter, the numerical procedure based on the soil-water coupled finite element method for the partially saturated soils is validated by using the centrifuge result. The numerical procedure can predict the development of pore water pressure in the model ground both in trend and magnitude. The initiation of the failure and trend of deformation is also captured. Mobilization of the reinforcing force in the pipe, lowering of the phreatic surface through drainage is well predicted by the numerical procedure. All these facts indicate that the numerical procedure used in the simulations is suitable for parametric studies.

Chapter 5: Working mechanism of steel drainage pipe

In this chapter working mechanism of steel drainage pipes that combines the drainage and

reinforcement function is discussed through centrifugal tests and 1g tests. The drainage function of the steel drainage pipe limits the rise of the phreatic surface in the levee and the rise of the pore water pressure, especially near the slope surface. With the specifications of the steel pipe used in the model slope, the reinforcement is mainly provided through the mobilization of the axial force. Resistance against bending also provides additional confinement to the soil in the shallower portion.

Chapter 6: Effectiveness of steel drainage pipes against flooding

In this chapter series of the parametric studies are made by the numerical analysis. In the soil with very low hydraulic conductivity, the installation of the steel drainage pipes does not contribute to the lowering of pore water pressure and consequently to the deformation of the levee. In the unreinforced levee, the rising rate of the flood water level affects the movement of phreatic surface within the levee whereas in the case provided with steel drainage pipes the movement is minimally affected by the rising rate of the flood water level. The maximum deformation in levee with steel drainage pipe is independent of the rising rate of the flood water level; rather, it is dependent on the flood level only. The overall deformation of the slope is more controlled by the location of the phreatic surface within the slope. Thus installation of the steel drainage pipe at lower elevation would be more effective in minimizing deformation in slope subjected to flooding. Closer spacing of steel drainage pipes minimize the levee deformation; however, for the range of the spacing of 2-5 m, the model ground goes under similar deformation within the scope of this study.

Chapter 7: Conclusions and recommendations

Conclusions and recommendations of this study are presented in this chapter.