論文 / 著書情報
Article / Book Information

題目(和文)	砂質土の内部浸食に関する実験的研究と微視的観察
Title(English)	Experimental investigation and microscopic observation on internal erosion of cohesionless soils
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出典(和文)	学位:博士（学術）, 学位授与機関:東京工業大学, 報告番号:甲第10359号, 授与年月日:2016年9月20日, 学位の種別:課程博士, 審査員:髙橋 章浩,北詰 昌樹,竹村 次朗,鼎 信次郎,千々和 伸浩
Citation(English)	Degree:Doctor (Academic), Conferring organization: Tokyo Institute of Technology, Report number:甲第10359号, Conferred date:2016/9/20, Degree Type:Course doctor, Examiner:,,,,
学位種別(和文)	博士論文
Category(English)	Doctoral Thesis
種別(和文)	論文要旨
Type(English)	Summary

（博士課程）
Doctoral Program

論 文 要 旨

THESIS SUMMARY

専攻： Department of	土木工学　専攻	申請学位（専攻分野）： Academic Degree Requested	博士 Doctor of　(Philosophy)
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要旨（英文 800 語程度）
Thesis Summary (approx.800 English Words)

The title of thesis is "experimental investigation and microscopic observation on internal erosion of cohesionless soils", which consists of seven chapters. The objectives of this research are to demonstrate difference in mechanical behavior of soils with and without internal erosion, and to identify key factors that affect mechanical responses of soils due to internal erosion. To achieve these objectives, an image analysis approach is proposed and a plane strain erosion apparatus is developed. By employing them, a series of laboratory experiments are performed and the mechanisms of internal erosion are interpreted.

In Chapter 1 - Introduction - the background, objectives and organization of the dissertation are described.

In Chapter 2 - Literature review - the current researches related to this study are presented. It mainly consists of the following parts: (i) influence of internal erosion on hydro-mechanical behavior; (ii) experimental apparatus for internal erosion tests; (iii) image analysis techniques on internal erosion; and (iv) soil mechanics in triaxial and plane strain tests.

In Chapter 3 - Undrained behaviors of soils subjected to internal erosion by triaxial erosion tests - seepage and subsequent undrained monotonic compression tests are performed to examine the influence of fabric on the mechanical consequences of soils subjected to internal erosion. It is found that the seepage flow not only transports fines away from the specimen, but causes a drastic change of the undrained mechanical behavior due to internal erosion. During the seepage tests, the soil with larger initial fines content shows the larger amount of cumulative eroded soil mass and the larger volumetric strain within the test range. It is demonstrated that the mean effective stress ratio (ratio of mean effective stress at peak to that at initial state) of soil with erosion is different from that of soil without erosion. For the specimens with the same initial fines content, the eroded soil exhibits the larger undrained tangent stiffness compared to that without erosion at a relatively small axial strain level. The soil with erosion shows the larger residual strength than that without erosion. Meanwhile, the eroded soil generates the smaller amount of excess pore water pressure than the uneroded soil before reaching the phase transformation state. It is also noted that, in the effective stress plane, the slope difference between the line connecting the origin to the phase transformation state and that to the undrained peak state is larger for the soil with erosion, indicating an enlarged instability zone induced by internal erosion.

In Chapter 4 - Optical quantification of internal erosion in plane strain physical models - the image analysis approach is proposed and employed in describing the characteristics of internal erosion. One dimensional upward seepage tests are carried out in the mixtures of silica No. 3 and colored silica No. 8 to investigate the features of internal erosion. Image analysis is applied to quantitatively describe the characteristics of soils subjected to the internal erosion. The cumulative eroded soil mass calculated by means of image analysis is generally in accordance with that obtained from independent macroscopic observation, suggesting that image analysis is an effective tool for describing the features of internal erosion. With respect to the observed area, for the gap-graded soils in this research, during an increase in hydraulic gradient, a large amount of fines tends to be transported, but is prone to be stationary under constant flow. The volume of the soil specimen decreases due to internal erosion and, as a result, the coarse particles are oriented horizontally.

In Chapter 5 - Development of plane strain erosion apparatus equipped with visible window - the developed plane strain erosion apparatus is presented. This apparatus is capable of direct investigation of not only the macroscale behavior of soils subjected to internal erosion, but also the microscale features

of particles during seepage and compression tests. The fabricated front visible window and the application of transparent membrane permit the observation on the particles behavior. The earth pressure transducer attached at the back plate allows the measurement of the normal stress in direction of the plane strain. The flexible boundaries provided by the water bladders can effectively avoid the water leakage during the seepage tests. The mechanical responses of the eroded soils can be directly measured by the subsequent drained compression tests with strain rate control manner.

In Chapter 6 - Interpretation on mechanical responses of eroded soils through microscopic observation - the plane strain erosion test results are elaborated and the interpretations on internal erosion are presented. The results demonstrate that the developed plane strain erosion apparatus is applicable of examining the influence of internal erosion on cohessionless soils under plane strain conditions. The repeated cases show similar patterns in the evolution of cumulative eroded soil mass and normal stress in direction of the plane strain, indicating that apparatus can yield consistent results. At small strain level, the normalized secant stiffness for soil with erosion is larger than that for soil without erosion at the same axial strain. Regarding to the medium strain level, the eroded soil shows the smaller strength than the uneroded soil in this study. As for the interpretations of internal erosion from the particulate level, it is noted that at small strain level, the larger amount of fines is cumulated around the contact points among coarse particles, which might be responsible for the larger secant stiffness of eroded soils comparing to that of uneroded soil. At medium strain level, for the soil with erosion, the fines are transported to the voids, leading to the smaller percentage of fines in the contact points among coarse particles, and further the smaller drained strength than that of soil without erosion.

In Chapter 7 - Conclusions and recommendations - the studies from Chapter 3 to Chapter 6 are summarized, and the recommendations for the further research are listed.

This thesis proves that the internal erosion can cause the alternation of mechanical responses of soil, and the mechanism of the alternation is quantitatively analyzed from the microscale level. The results of this research could be employed not only to evaluate the performance of the geotechnical structure subjected to internal erosion, but also to assess the mechanical behavior of granular materials from the particulate level, which could benefit for both the practical engineering and academic research.