論 文 の 内 容 の 要 旨

論文題目　　Degradation of stress-strain properties of sand in undrained torsional shear tests (非排水中空ねじりせん断試験による砂の 強度・変形特性の損傷に関する研究)

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In this study, undrained behavior of saturated Toyoura sand is invested up to the extremely large shear strain. Five series of test was conducted on saturated Toyoura sand by pluviation were performed in a modified torsional shear apparatus capable of achieving double amplitude shear strain (γ_{DA}) exceeding 100% under quasi simple shear condition.

In the first series, the undrained monotonic test was conducted from a relative density of 19% to 72%. A series of the monotonic result showed that with the increase in the relative density, shear strength a quasi-steady-state (QSS), undrained peak strength and residual strength (ultimate steady-state (USS)) increased. However relative density below 23% neither the QSS or USS was observed, and sandy specimen developed extremely large deformation after exceeding the transient peak. The shear strength was recovered after exceeding shear strain of 60% in Dr <23%.

The second series of the test included a multistage, by repeated cyclic loading desired amplitude of damage, the strain was achieved, following an undrained monotonic loading until extremely large shear strain. In the series of multistage stage test, cyclic loading to reach the desired damage strain, followed by an undrained monotonic loading exceeding single amplitude shear strain of 50% showed a continues degradation of shear strength at peak undrained strength irrespective of density state, cyclic stress ratio and confining pressure. At large shear strain, non-uniform deformation became significant along the specimen length.

In the third series of test, the specimen was subjected to the drained initial static shear to simulate slope condition in reversal and non-reversal stress condition. Following that after achieving the desired damage strain, the loading mode was changed to monotonic without opening the drainage valve and continued until extremely large strain. Peak undrained strength degraded irrespective of

the amplitude of initial static shear.

In the fourth series in which the specimen was reconsolidated after achieving desired damage strain showed different characteristic in the effective stress path, with the virgin specimen, however, they reached same undrained peak strength and residual strength.

In the fifth series of test, non-uniformities observed in the specimen was investigated by 3D digital image analysis by VIC 3D. To accurately capture the surface deformation, the undrained monotonic, and a cyclic test followed by monotonic static loading under non-reversal conditions showed the progressive development of shear band(s) and consequently the development of non-uniformities in the specimen. 3D Digital image analysis using VIC 3D captured the progressive development of the shear band and boundary was identified between a uniform and non-uniform deformation. Residual strength in undrained loading is defined on the basis of the comparison of DIC and experimental test results.

From all the series of the test on the saturated Toyoura sand in undrained condition, strength degraded as a result of the formation of the shear band. Strength degradation solemnly depends on the amplitude of damage strain and independent of the cyclic stress or a combination of static shear and cyclic shear.

Two degradation correlation is developed based on the initiation and full formation of the shear band under undrained conditions i-e limiting undrained strength and residual strength.

Modified Newmark stability analysis of Fujimana Dam stability analysis was performed by incorporation the degradation correlations of Toyoura sand. Estimated settlement increased from 0.15m to 2.3m provides a better collapse explanation of Fujinuma Dam.

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