論文の内容の要旨
Abstract of Dissertation

論文題目　　**SOIL CONFINEMENT IMPACTS ON RC-PILE NONLINEARITY AND DAMAGE CONTROL OF STRUCTURE-PILE SYSTEMS**
(地盤拘束がRC杭の非線形性に及ぼす影響と構造－杭システムの損傷制御)

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While earthquake is a fact which can't be prevented, engineering efforts should be optimized to reach a rational seismic design of all civil structures. Even the past earthquakes caused severe damages to on-ground and underground structures in various places of the world, the civil engineering and researching communities have got a wealthy of knowledge about nonlinear performance of RC structures and soil. Strengthening the nonlinear numerical models of RC and soil might be a powerful tools to predict the potential damage that may happen to structures in case of future severe earthquakes and appropriate counter measure technique could be provided. Since the large scale experiment related to soil structure interaction is costly and consumes lots of time, researchers have tended to use elastic material element to model structural elements like pile, raft, tunnels, and columns which results losing the nonlinearity. The author proposes a small scale RC-pile (5cm diameter) with full RC nonlinearity features to be a good alternative for elastic ones used in research work.

RC pile foundation is widely used to support heavy structures and transmit the gravitational loads to deeper soil. This research work is strongly correlated to the RC-piles interacted with soil and superstructure as well. RC pile is an axially compression loaded reinforced concrete member like RC column which should be avoided from shear failure and limited from flexural failure as well. To increase RC-pile ductility, the flexure failure should happen to RC-pile before shear failure by increasing the RC-pile shear span length. RC-pile shear span length correlated to the relative stiffness between soil and pile.

Small-scale RC-circular piles with 5 cm diameter were produced as an alternative of real ones and loaded by combined shear and flexure under the soil confinement of different magnitudes, and atmospheric condition as well. In order to identify the lateral confinement, SNAP-PINS were newly utilized as a replacement of stirrups for miniature RC members. The experimental results show that soil confinement improves the RC-pile ductility by suppressing the spalling of concrete cover and local buckling of reinforcement, and that the magnitude of soil confinement may reach the level produced by the stirrups inside members. But at the same time, the greater soil confinement was experimentally confirmed to increase in shear forces to RC piles and simultaneously become a risk factor of shear failure, too. The pile flexural and shear failures of RC pile under soil confinement could be successfully simulated using a full three-dimensional finite element. This small scale RC-pile is newly proposed to be used in the future small scale experiment instead of common elastic material ones, while it enjoys the full features of RC nonlinearity.

Experimental verification of a large-scale test on a pile group and a sheet pile quay wall which were subjected to liquefaction-induced large ground deformation conducted by Motamed et al (2009) is carried out to confirm the validity of the nonlinear techniques used in the current research work. the major failure of the steel piles were flexural failure at the pile head and local buckling at the mid-height of the pile. the failure modes were successfully simulated. the lateral displacements history of the soil behind the quay wall and of the superstructure concrete mass show good agreement between experiment and analysis.

The nonlinear seismic responses and damage evolution & control of multi-story buildings supported by group piles in liquefiable soil foundation are investigated. A group piles driven in dry and fully saturated soft sands are considered. The engineering focus is directed to the effect of axial-flexural pile stiffness on the pile-curvature, induced shear force in piles, and the base shear transmitted to the on-ground building structures. The results indicate that piles with low reinforcement ratio have higher safety margin against flexural failure. The structural damage and the induced base shear are clearly decreased by reducing the amount of axial reinforcement (Rft) of piles in the case of dry soil under severe earthquake, but no significant effect is found in case of liquefied soil. Piles with less Rft are preferably accepted due to higher deformability and less induced shear even on liquefiable soil foundations.

The stability control of multi-story buildings supported by rafted piles or only raft in liquefiable soil foundation are analytically investigated. The focus is directed to the effect of permanent use of steel sheet pile wall (SSPW) to protect the existing structures which are supported by RC raft foundation with and without piles on liquefiable soil. The effects of SSPW embedment length were investigated by focusing on the superstructure stability and damage evolution. The results clearly show that, the SSPW could improve the overall stability of the superstructure , but it leads to a higher base shear transmitted to superstructure. For existing multi-story buildings supported by raft or rafted pile foundations on a liquefiable soil, the steel

sheet pile wall bearing on the non-liquefiable soil surface might be an optimum solution for strengthening the building against soil liquefaction.

Finally, Rational design methodology should consider the significant effects of soil confinement which may save large amount of web reinforcement at deeper zones. A RC pile with minimum amount of steel might be best alternative pile under seismic actions. steel sheet pile walls might be a counter measure techniques to control the stability of superstructures supported by liquefiable soil foundations.