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論 文 要 旨

THESIS SUMMARY

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要旨（英文 800 語程度）
Thesis Summary（approx.800 English Words ）

Cast-in-place concrete-filled steel tube (CFST) piles with thin-walled tubes are widely used as foundations for buildings and bridges in high seismic regions. However, there are limited studies specifically focusing on the structural behavior of CFST piles with thin tubes. This thesis presents a comprehensive study of the axial-flexural and shear performance of CFST piles using large-scale test data and numerical modeling. Experimental studies on CFST piles are assimilated from the literature to understand the ultimate behavior, including the axial-flexural/shear capacity, damage progression, deformation capacity, and failure modes. Using the compiled data, recommendations are provided for the detailed finite-element modeling and efficient fiber-based analysis of CFST piles. The shear performance of CFST piles is investigated through large-scale tests covering different axial load ratios expected under strong earthquakes. The findings from this thesis contribute to the rational seismic design of CFST pile foundations for strong earthquakes.

CFST piles used in Japan generally exceed the maximum permitted diameter-to-thickness ratio (D/t) specified in the current CFST design standards (AIJ CFST recommendations, 2008; AIJ guidelines for foundation members, 2022; AISC 360-16 specification; CSA S16-19; EN 1994-1-1, 2004). A database of 112 large-diameter ($D>300$ mm) CFST piles is compiled from the literature to evaluate the suitability of stress distribution-based and strain compatibility-based approaches in the current CFST standards to compute the moment capacity of CFST piles. In addition, seven sets of most commonly used stress-strain models for the fiber-based analysis of CFSTs are briefly reviewed. The suitability of the stress-strain models to simulate the flexural response is evaluated using the experimental data in the compiled database. Moreover, a simplified procedure is proposed to obtain the idealized moment-curvature response of CFST piles, which do not require any modeling effort. The comparisons show that the plastic stress distribution method of AISC 360-16 can be used to obtain the moment capacity of CFST piles, although the standard limits the application of this method only to CFSTs with 'compact' sections. The stress-strain model set of Sakino et al. (2004) best simulated the moment-curvature response of CFST piles and is suggested to calculate the moment capacity of CFST piles.

A set of stress-strain models for concrete and steel tube are established with simple constitutive relationships. The proposed models implicitly characterize the salient features of individual components (cracking and crushing of concrete, yielding and buckling/hardening of steel tube) and effects of the interaction between concrete and steel tube (concrete confinement, biaxial stress-state of the tube).

Different fiber-based modeling approaches are evaluated in terms of their agreement with the experimental results, along with the strengths and limitations of each approach. The compiled experimental data of large-diameter CFSTs are used to verify the accuracy of the proposed models and modeling approach. The verification results show that the proposed numerical model accurately simulates the axial-flexural response of CFST piles with a wide range of section slenderness, axial load ratios, and material strengths. The model successfully simulates the local and global response of CFST piles and is recommended for design applications.

Next, this thesis provides guidelines for the detailed finite-element modeling and efficient fiber-based analysis of noncompact/slender CFSTs (exceeding the 'compact' *D/t* limit in AISC 360-16) under axial compression. To this end, a finite-element model capable of explicitly simulating the interaction between the concrete and steel tube is developed in LS-DYNA. The accuracy of the proposed model is verified using a database of 96 noncompact and slender CFSTs compiled from the literature. In addition, the suitability of the seven stress-strain model sets to simulate the behavior under axial compression is evaluated using the experimental data in the compiled database and the finite element analysis results. The results show that the proposed finite-element model reasonably simulates the axial compression response of noncompact and slender CFSTs. For the fiber-based approach, stress-strain model set of Sakino et al. (2004) gave the best prediction of the full-range axial load-displacement response.

Finally, this thesis discusses the cyclic shear response of three large-diameter CFST piles ($D=400$ mm, $D/t=89$) tested under different axial load ratios (-0.30, 0.10, and 0.50). Issues concerning the ultimate behavior of CFST piles, such as shear capacity, failure mode, and strength-contribution from steel tube, are discussed in detail. In addition, a detailed finite element (FE) model is developed and validated with the experimental results. This FE model is used to understand the shear-resisting mechanism and examine the strength contribution from concrete and steel tube assumed in the current approaches to compute the shear strength of CFST piles. The results show that CFST piles subjected to high axial compression load can fail in a brittle manner if the shear span ratio is very small ($a/D \leq 0.50$). Only $2/3^{rd}$ of the steel tube cross-section is found to be effective in resisting shear, contrary to the full cross-section commonly assumed in the design standards. Moreover, current approaches to calculate the shear strength of CFST piles give overly conservative estimates of shear capacity.