NUMERICAL SIMULATION OF HOLLOW PRECAST CONCRETE-FILLED STEEL TUBE (CFST) PILES UNDER UNIAXIAL COMPRESSION

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Background

The author's research group has researched hollow CFST piles under flexural and constant axial loads (Thusoo, 2020). It was found that this pile was very brittle under high axial loads. The most recent AIJ Foundation Guidelines (2022) includes the material models to produce the bending moment–curvature relationship adopted from Thusoo et al. (2021), but the post-peak ductility performance cannot be guaranteed. Accordingly the compressive test results were used to presume the shear-flexural behavior to avoid the costly bending tests.

Test setup for bending test can be seen in Fig. 1

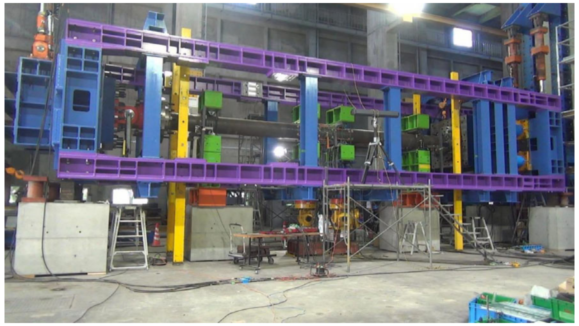


Fig. 1 Bending test of hollow CFST pile

Purpose

The compressive behavior of hollow CFST piles is simulated by 3D finite-element model to investigate the behavior which could not be directly observed during the experiment. Material models and modeling parameters appropriate for simulating the behavior of hollow CFST piles are identified considering the response and mechanisms observed in the experiment.

Finite-element Model

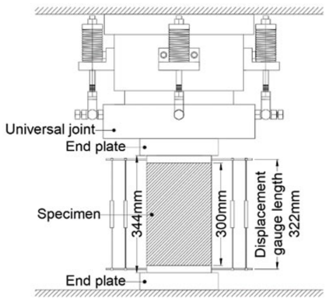


Fig. 2 Schematics of loading system

Fig. 3 Photo of specimen

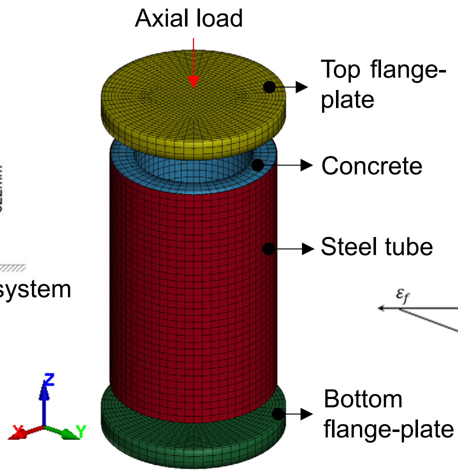


Fig. 4 Three-dimensional finite-element model of hollow precast CFST specimen in LS-DYNA software

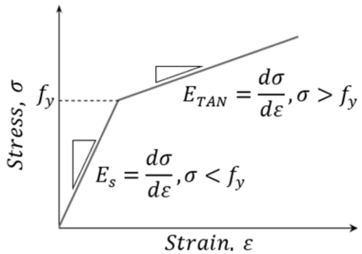


Fig. 5 Steel material model: bilinear with strain hardening

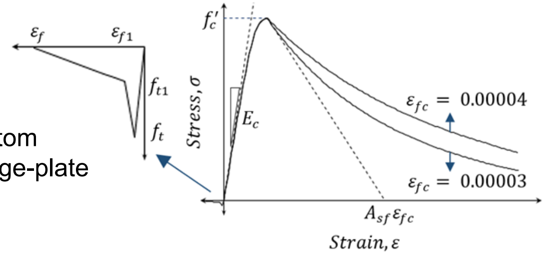
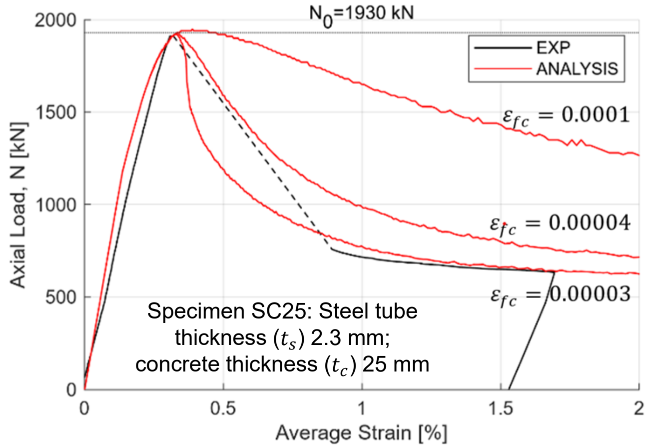


Fig. 6 Concrete material model: concrete damage plasticity model (CDPM) developed by Grassl et al. (2013)

In CDPM model, parameter ε_{fc} is used to control the concrete brittleness in the post-peak region, where value of 0.00003 well-captured the compressive behavior of the four hollow CFST specimens. This value is smaller than the minimum value used for plain solid concrete (ε_{fc} =0.00004) which indicates that even with the presence of steel tube, hollow concrete in CFST sections is more unstable and brittle compared to plain concrete. Using this value, the model can capture the $N - \varepsilon_{avg}$ behavior of four specimens, shown in Fig. 8.

Results



*The dashed line in experimental curve represents no data available due to the sudden capacity loss of specimen.

Fig.7 Effect of parameter ε_{fc} on $N - \varepsilon_{avg}$ response of specimen SC25

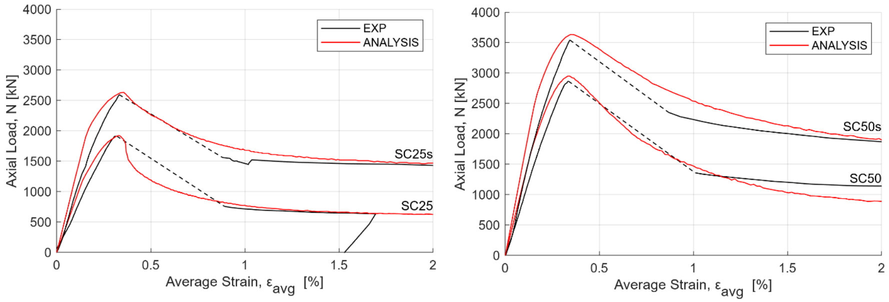


Fig.8 Comparison of $N - \varepsilon_{avg}$ response from analysis and experiment

Conclusion

Results from this study will be used to assess the mechanism of non-ductile post-peak flexural behavior of hollow precast CFST piles under high compressive load, and to propose a method to improve the ductility of hollow precast CFST piles.

Contributions to Society

The findings will be used to update the existing design codes in order to establish more efficient and safe structures.