FINITE-ELEMENT ANALYSIS ON THE UNIAXIAL COMPRESSIVE CAPACITY OF HOLLOW PRECAST CONCRETE-FILLED STEEL TUBE (CFST) PILES

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Background

Our group studied hollow CFST piles under flexural and constant axial loads (Thusoo, 2020). It was found that their piles were 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 simulate the shear-flexural behavior to avoid the costly bending tests.

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. Several key mechanism, such as stress distributions and level of confinement, are discussed. Results from FE model will be used to propose uniaxial compressive capacity equation.

Finite-element Model

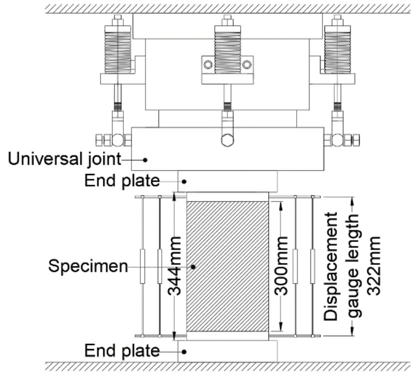


Fig. 2 Schematics of loading system

Fig. 3 Photo of specimen

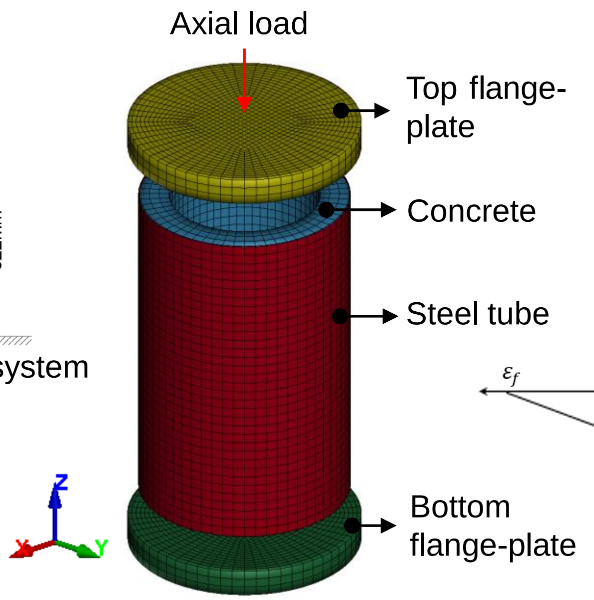


Fig. 4 Three-dimensional finite-element model of hollow precast CFST specimen in LS-DYNA software

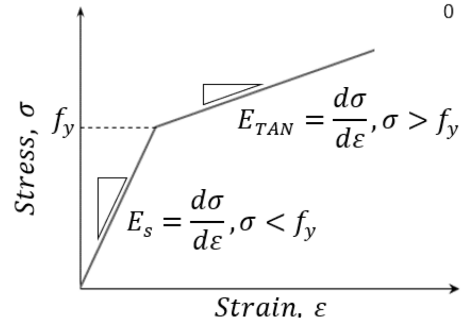


Fig. 5 Steel material model: bilinear with strain hardening

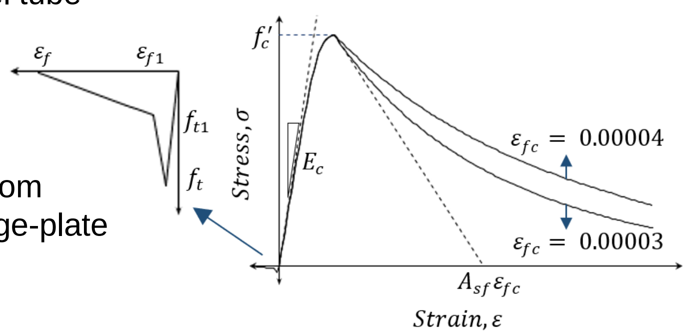


Fig. 6 Concrete material model: concrete damage plasticity model (CDPM) developed by Grassl et al. (2013)

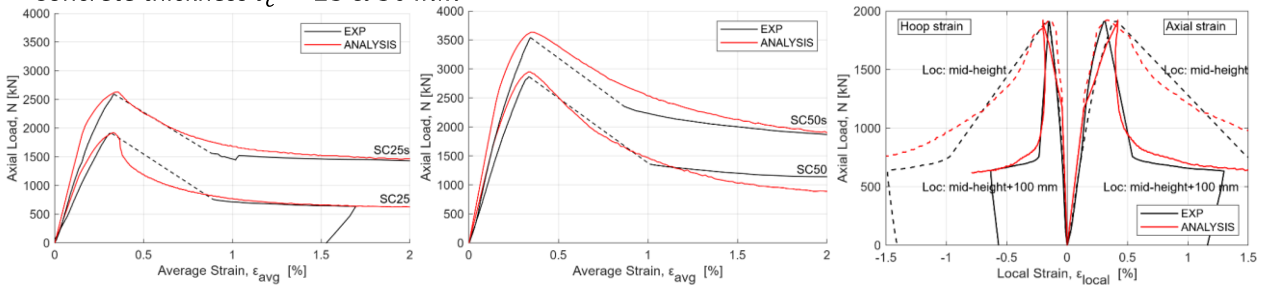
Specimen details:

Diameter $D = 190\ mm$

Steel thickness $t_s = 2.3\ \&\ 5.3\ mm$

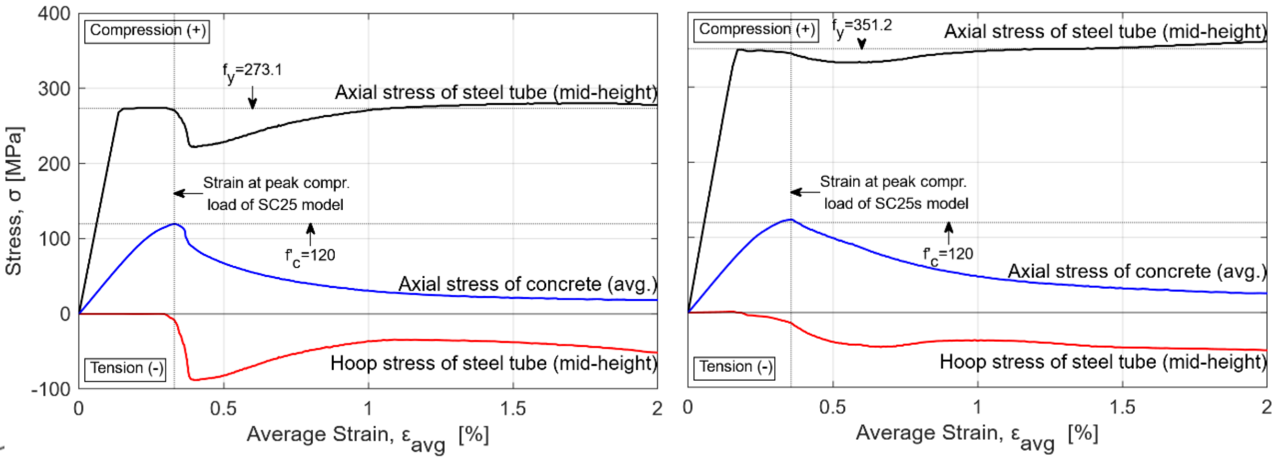
Concrete thickness $t_c = 25\ \&\ 50\ mm$

Results



(a) Global response (b) Local response

Fig.7 Verification of FE model with experimental results



(a) Specimen SC25
$t_c = 25\ mm, t_s = 2.3\ mm$

(b) Specimen SC25s
$t_c = 25\ mm, t_s = 5.3\ mm$

Fig.8 Verification of FE model with experimental results

Previous researches suggested that there is confinement action in hollow CFSTs. However, based on FE results shown in Fig. 8, the presence of confinement in hollow CFSTs with high-strength concrete is minimal. Although the hoop stress at peak compressive capacity is larger for specimen with thicker steel tube, the confined f_c' only has 3% increase from unconfined f_c'.

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 efficient, safe, and earthquake-resilient structures.