Moment Capacity of Large-diameter Concrete-filled Steel Tubes under Pure Bending

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1. Background

Pile foundation were highly damaged during recent earthquakes leading to the strengthening or complete replacement of the building. As the damage of piles during earthquake hampers the functionality and structural health of whole building, they should be designed considering large axial loads and bending moments that occurs during earthquake.

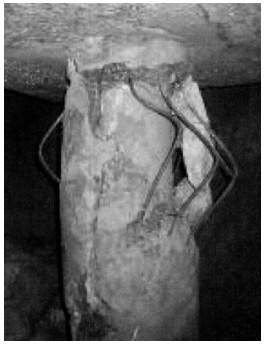

Fig.1: Pile damaged during earthquake

Fig.2: CFST specimen (D=1200mm)

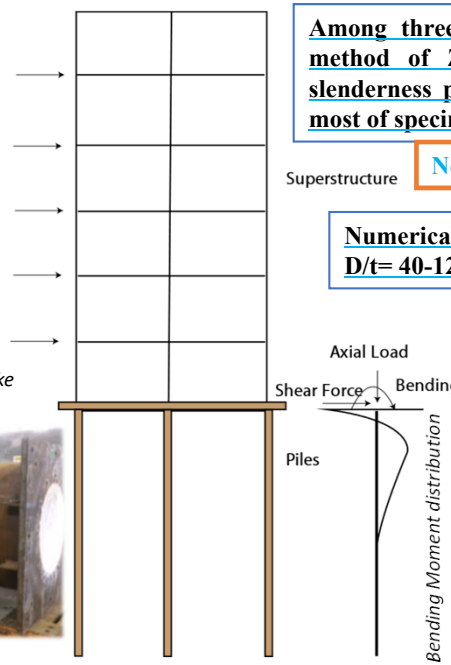

Fig.3: Building Supported by Pile Foundation during earthquake

2. Introduction

Piles should be designed to withstand large axial load due to building load and bending moment due to lateral loads(fig.3). AISC-360 specification recommend bilinear curve (Method C in fig.4) to obtain axial load-bending moment(P-M) interaction curve for CFST members convenient for design of CFST piles.

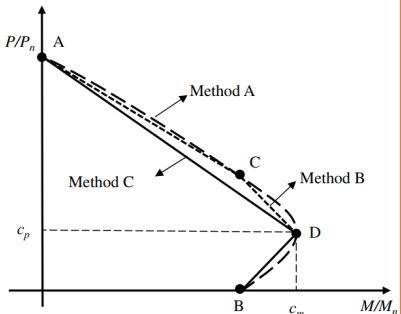

Fig.4: Methods for P-M curve

3. Objectives

- ❑ To evaluate the existing methods* to determine moment capacity of CFST piles under pure bending (especially for large diameter CFSTs like as shown in fig. 2 which are mostly used in Japan)
- ❑ To propose new equation to determine the moment capacity of CFST piles during pure bending
- ❑ To improve the conservatism of AISC-360 method to determine the P-M interaction curve

4. Methodology

Data of large diameter CFST(>300mm) tested under pure bending is collected from literature. The moment capacity of these specimen is determined as per existing methods * and compared with experimental moment capacity.

Among three methods, AIJ guidelines method(2022) give too conservative results, method of Zand yield non-conservative results for specimen of higher section slenderness parameter(8 out of 34) and GB50936-2014 non-conservative results for most of specimen (Fig.5).

Need to develop new method to predict moment capacity under pure bending

Numerical analysis database (of 945 CFST sections) is generated(D=400-1000mm, D/t= 40-120, fy=300-500MPa f'c=20-80MPa using concrete and steel model(Fig:8)

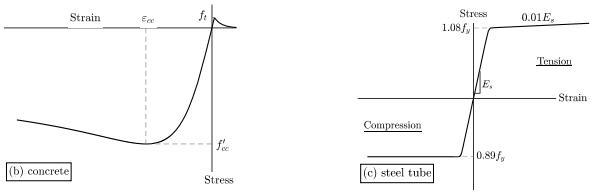

Fig.8 Stress-strain models for concrete and steel tube

Based on linear regression analysis of generated CFST sections and considering all influencing parameters (confinement factor, section slenderness parameter, concrete compressive strength and steel yield strength), new, simple and accurate empirical equation to predict moment capacity of CFST piles under pure bending is developed.

$$M_N = \theta_m \cdot \alpha_{sc} f'_c \cdot Z_{sc},$$
$$\alpha_{sc} = 0.4622 + 2.381\xi - 0.328\lambda - f'_c/200 + f_y/2300$$

P-M interaction curve of a CFST specimen tested under bending with axial load is plotted utilizing the new method to obtain moment capacity under pure bending (Fig.7).

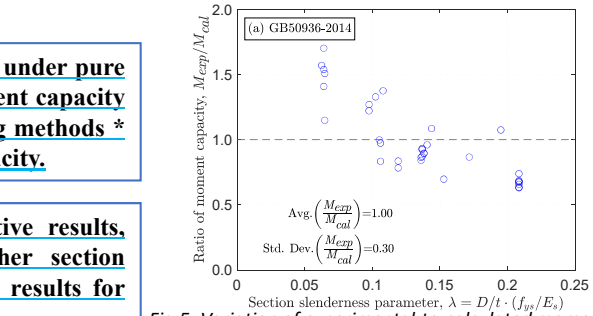

Fig.5: Variation of experimental-to-calculated moment capacity using equations from GB50936-2014

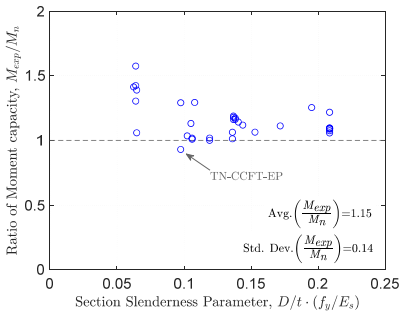

Fig.6: Variation of experimental-to-calculated moment capacity using new equations

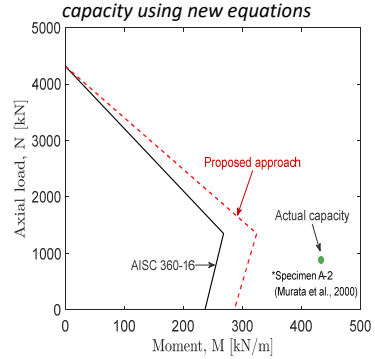

Fig 7: P-M interaction curve for a CFST specimens tested with axial load under bending

5. Conclusion

- ❑ The proposed equation gives reasonably good estimates of the moment capacity (Fig:6)
- ❑ P-M interaction curve plotted using new equation is closer to actual capacity, hence provides less conservative prediction than AISC method (Fig: 7)

Existing methods: 1. AIJ draft guidelines(2022) : Uses sectional analysis method to determine moment capacity. 2. GB50936-2014 and Zand et al.: Provide empirical relation to determine moment capacity

6.Contribution to Society

This research aims to improve the design standards of pile supported building and contribute to resilient build environment.