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Eccentric load behavior of L-shaped CFT stub columns with binding bars

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ABSTRACT

This paper is concerned with the eccentric load behavior of L-shaped concrete-filled steel tubular (CFT) stub columns with binding bars. Eight specimens with binding bars and one without binding bars were tested to examine the effects of horizontal spacing and diameter of binding bars, load eccentricity ratio, and load angle on the failure modes, bearing capacity and ductility of L-shaped CFT stub columns. Experimental results demonstrate that the local buckling of the steel tube can be postponed by setting binding bars, and the bearing capacity and curvature ductility of the L-shaped CFT stub columns are at most 1.04 and 3.31 times those without binding bars, respectively, and the plane section assumption can also be satisfied. Based on a modified stress–strain relationship of confined concrete, the fiber element analysis is applied to predict the bearing capacity of the specimens, and the predicted results agree well with the experimental ones. Then the parametric studies using the proposed theoretical model are carried out to further study the fundamental behavior of eccentrically loaded L-shaped CFT stub columns with various steel yield strengths, sectional steel ratios, cube strengths of concrete, confinement coefficients of binding bars, sectional aspect ratios and load angles. Finally, simplified interaction formulas are put forward to predict the M_x/M'_x–M_y/M'_y curves for the L-shaped CFT stub columns with or without binding bars subjected to biaxial eccentric load, and the theoretical results predicted by the simplified formulas agree well with those predicted by the fiber element analysis program.

1. Introduction

Concrete-filled steel tubular (CFT) columns have been widely used as lateral load resisting members of high-rise buildings in recent years due to their advanced mechanical and seismic behaviors, such as high strength, stiffness, good ductility and convenience for construction [1]. Extensive investigations have been carried out to study the mechanical performances of circular and special-shaped (including square, rectangle, L-shaped and T-shaped) CFT columns subjected to axial or eccentric load [2–7]. Results show that compared with circular CFT columns, the special-shaped CFT columns generally undergo little increase in strength and inferior increase in ductility, due to little confinement effects on core concrete.

However, special-shaped CFT columns are extensively used as structural members for more convenient construction at beam–column joints, high moment capacity, and aesthetic consideration. To improve the behaviors of square or rectangular CFT columns, especially L-shaped and T-shaped CFT columns, enhancing the confinement effects on core concrete is the key issue, and some stiffening measures have been proposed, and they are summarized as follows: (1) Longitudinal steel strips were welded on the square [8–11], rectangle [9] and L-shaped [7] steel tubes, as shown in Fig. 1(a) and (b). Experimental results showed that the bearing capacity of the composite stub columns could be increased when stiffeners were provided, but the improvement on ductility was not significant for the square or rectangle cross-sections, and the improvement on bearing capacity and ductility could only be observed for the L-shaped cross-sections stiffened by angle-shaped strips with width-to-thickness ratios of the tubes less than 60. (2) Shear studs were welded on the internal surface of the tubes [12]. Experimental results showed that the stiffening scheme could not influence the bearing capacity but enhance the ductility of square CFT columns. (3) Carbon-fiber-reinforced plastic (CFRP) was wrapped outside the steel tube of the CFT columns in the potential plastic hinge regions [13], as shown in Fig. 1(c). Results showed that the seismic behavior of the CFT columns could be significantly improved and local buckling of the steel tubes could be effectively delayed. (4) A set of four incline steel bars (so-called tie bars) was welded at regular spacing along the square tubes [14], as shown in Fig. 1(d). Experimental and nonlinear finite element analysis results showed that this stiffening method helps in enhancing the maximum strength and ductility of the columns. (5) The tubes were filled with steel fiber-reinforced concrete [11]. Experimental results showed that the ductility but not the strength of the columns could be enhanced. (6) Horizontal binding bars were set cross the steel tubes [15], as shown in Fig. 1(e). Extensive experimental investigations of square, rectangular and L-shaped CFT columns with binding bars subjected to axial [16–18] or eccentric [19, 20] loads have been conducted. Results showed that by setting binding bars, for axially loaded specimens, the bearing capacity and ductility of square, rectangular and L-shaped CFT columns could

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