UNIVERSITI TEKNOLOGI MARA

STRUCTURAL BEHAVIOUR OF CONCRETE FILLED STIFFENED STEEL TUBES COLUMN

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Thesis submitted in fulfillment of the requirements
for the degree of
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Candidate's Declaration

I declare that the work in this thesis was carried out in accordance with the regulations of University Teknologi MARA. It is original and the result of my own work, unless otherwise indicated or acknowledge as referenced work. This thesis has not been submitted to any other academic institution for any other degree or qualification.

In the event that my thesis be found to violate the conditions mentioned above, I voluntarily waive the right of conferment of my degree and agree to be subjected to the disciplinary rules and regulations of University Teknologi MARA.

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Abstract

A concrete filled steel tubes(CFST) column is constructed by filling a hollow structural steel tube with concrete. As one of structural element, CFST column has high load bearing capacity, excellent earthquake-resistance, good ductility, high fire resistance and its higher stiffness delay the onset of local buckling. Besides that, the steel tube can function as a permanent formwork as well as reinforcement, thus more economical. The promising features of CFST steel column as an excellent earthquake resistance might be of interest for structural engineers or designers in finding solution to the increasing threat of near and far-field earthquakes in our country. Composite columns of this type have a very good potential to be used in structural applications.

The enhancement of a CFST column in terms of its structural properties is the result of the confinement provided by the steel tube to the concrete core. The confinement effect is very effective in a round section because the effective radial tension develops effective hoop tension in the tube, whereas the flat sides of a rectangular tube are not effective in resisting perpendicular pressure. The effect of confinement in CFST can be utilized in using thinner walls (large B/t ratio), which can reach the yielding strength before local buckling. In this thesis, the behaviour of concrete filled thin-walled stiffened square tube columns was studied. Use of thin-walled square or rectangular concrete filled tubes is more advantageous compared to circular CFST despite its lower axial load-bearing capacity. Architects find them aesthetically desirable for they blend well with the in-filled walls and engineers find them structurally desirable for they allow beams to frame into them easily. However, when square or rectangular tubes are used, sufficient stiffening measures are highly desirable, especially for thin-walled steel sections. The available literature indicates that strength and ductility are equally important on CFST stiffeners design. Nevertheless, a CFST stiffener that possesses both characteristics is still lacking, therefore a novel stiffening method called tab stiffeners are used to stiffen square built-up steel tubes, which are anticipated to have higher strength and ductility is proposed in this study.

This study also investigates on the potential of utilizing concrete filled square thin walled steel sections with a newly proposed stiffening system where both longitudinal stiffeners and tab stiffeners are provided. The study involves an intensive amount of experimental work. The experimental program consists of three phases. In the first phase a series of push-out tests was conducted on short square concrete filled built-up steel tube (CFBST) columns to determine the optimum tab stiffeners spacing of the stiffening system in improving the bond strength at the concrete-steel interface. The second phase looks at the evaluation of the behaviour of short square and octagonal CFBST columns with longitudinal stiffeners and tab stiffeners at the optimum spacing when subjected to axial load under three loading conditions namely, on the entire section, on the steel tube only and on the concrete core only. The behaviour of slender CFBST columns loaded concentrically and eccentrically is studied in the third phase. Finally, a design recommendation for the ultimate axial load capacity of the composite column is proposed.

From the push out test, it was found that the optimum tab stiffeners spacing is 100mm centre to centre which gave the bond strength of 0.6MPa at the steel-concrete interface. The test results from the compression test of short CFBST column with tab stiffeners showed an improvement of the load bearing capacity especially when loaded on the entire section. It was also observed that the local buckling mode is improved due to better confinement at the mid-sidewall of the steel tubes. From the test results of slender CFBST column, it was observed that most of the column specimens with eccentricity failed by overall buckling. It was also found that the ultimate strength capacity decreased with increasing eccentricities. The ductility of short and slender CFBST column was evaluated and found to be just moderate. All the test results are validated by the theoretical values according to the equations from several design codes namely, ACI (1999), BS5400 (1998) and EC4 (2004). It was found that the EC4 provide the closest prediction of the ultimate capacity of CFBST. Therefore, a design recommendation is developed based on slight modification of the design code EC4.

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