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An experimental behaviour of concrete-filled steel tubular columns

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Abstract

In this paper results of tests conducted on 27 concrete-filled steel tubular columns are reported. The test parameters were the column slenderness, the load eccentricity covering axially and eccentrically loaded columns with single or double curvature bending and the compressive strength of the concrete core. The test results demonstrate the influence of these parameters on the strength and behaviour of concrete-filled steel tubular columns. A comparison of experimental failure loads with the predicted failure loads in accordance with the method described in Eurocode 4 Part 1.1 showed good agreement for axially and eccentrically loaded columns with single curvature bending whereas for columns with double curvature bending the Eurocode loads were higher and on the unsafe side. More tests are needed for the case of double curvature bending.

Notations

D	is the outer diameter of the steel tube
t	is the wall thickness of the steel tube
L	is the column effective length
e_t, e_b	are the load eccentricities at the top and bottom of the column, respectively

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β is the bending moment ratio
f_y is the yield strength of steel
f_c' is the compressive strength of concrete
E_{c0}, E_s are the Young's Moduli of concrete and steel, respectively

1. Introduction

1.1. General

The use of concrete-filled steel tubes in different areas of construction is becoming an attractive solution. It provides not only an increase in the load carrying capacity but also economy and rapid construction, and thus additional cost saving. Their use in multi-storey buildings has increased in recent years owing to the benefit of increased load carrying capacity for a reduced cross section. Moreover, using confinement in the form of a circular steel tube can greatly improve the ductility of normal or high-strength concrete. No formwork or reinforcement is required for the concrete, and its surface is protected from impact and abrasion. The local buckling of the steel wall, due to the relatively small wall thickness, is delayed because it can only buckle outwards.

1.2. Research on concrete-filled steel tubular columns

Experimental studies on concrete-filled steel tubes have been on-going for many decades [1–4]. A review of available experimental studies shows that the main parameters affecting the behaviour and strength of concrete-filled columns are: the geometrical parameters, such as the slenderness, the D/t ratio and the initial geometry of the column [5,6]; the mechanical parameters, such as the strength of the steel and concrete, the loading and boundary conditions and the degree of concrete confinement. The load carrying capacity decreases with increase of the column length and the load eccentricity, while the descending branch of the load–displacement curve is progressing at a smaller rate. Very few experimental data are available for the case of columns with double curvature bending. In such columns the carrying capacity is increased compared to the corresponding loads in single curvature bending [7,8]. The failure is by compressive yielding of steel and crushing of concrete for short columns and an overall instability failure mode by partial compressive yielding of steel and crushing and cracking of concrete for longer columns. For columns with high D/t ratio, failure is by local buckling. For columns under cycling loads, the concrete-filled tubes show a high level of ductility and tenacity; therefore they are a practical solution for constructions subjected to dynamic loads such as earthquakes and wind pressure. More experimental data are needed for concrete-filled tubular columns with height equal to 3–4.0 m, which represent a typical storey height in multi-storey buildings, using different sizes of the cross section and considering the case of double curvature bending.

1.3. Numerical analysis

A Finite Element Method program is made available [1,2] for rectangular concrete-filled steel tubes and extended for circular shaped sections. This program is dedicated for