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Parametric Study for Performance Evaluation of Concrete Filled Steel Composite Circular Members According to Design Codes

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Abstract

The Concrete Filled Steel Tubular (CFST) members offer many structural features and have been widely used in civil engineering structures. Available in many different shapes, but most important circular, rectangular and square, etc. The CFST structures offer numerous structural benefits, including high strength, favorable ductility, and highly absorbable to withstand external shocks. They have proven to be economically as well as providing for the rapid construction and thus additional cost savings. The circular CFST members included normal strength concrete filled circular structural sections. In this study the parameters; diameter (D), thickness (t), yield stress (f_y), and compressive strength of concrete (f_c') show their effects on the members and their comparison, according to calculation equations of the American (AISC360-16) and European (EC4-2004) codes for the design of which parameter effects performance of circular CFST members under axial compression and flexure.

Keywords: Circular CFST members, Axial strength, Flexure strength, Parametric study, Design codes.

1. Introduction

Concrete Filled Steel Tube (CFST) is a composite member which consists of a hollow steel pipe filled with concrete (Gore, et al.). The Circular Concrete Filled Steel Tubes (CCFST) section withstands applied load through the composite job of steel and concrete. The benefits of composite action between concrete and steel increase the strength of CCFST section. Thus, becoming popular in the last days and being used in structures such as bridges, buildings, electricity towers etc. In the past years, several studies have been done on CCFST members, these studies indicated that the CCFST sections possess strength, stiffness properties, and high ductility. These properties are considered to be important, especially for the multi-story buildings. Therefore, the behavior of buildings with CCFST sections needs to be studied (Han, et al. 2004). Concrete is one of the most important materials involved in the construction of civil engineering. Moreover, it is a favorite material because it is low-cost, durable and high-tech, easy to manufacture. In recent years, there have been some significant developments in the field of concrete technology (Bozkurt, et al. 2017, Davraz, et al. 2017). Steel is one of the most widely used materials in structural applications because of its high strength in endurance for external shocks, high rigidity, and average cost. With these attractive properties, Steels are the most commonly used materials in buildings, forming structures, etc. (Abakay, et al 2017, Acar et al. 2017). The current paper represents an attempt to investigate the effect of different parameters on the ultimate axial and flexural capacities of CCFST sections according to the AISC360-16 and EC4-2004. The investigated parameters considered in this study; (D) diameter, (t) thickness, yield stress (f_y), and compressive strength of concrete (f_c').

2. Design Code Factors and Limitations

In this study, the (D) and (t) were chosen from according to EN 10219 standard, Not to exceed the limits of the AISC360-16 and EC4-2004 codes. According to standard EN 10219, value domain $(D\ mm)$ = (21.3-339.7) and value domain $(t\ mm)$ = (2.0-12.7), are calculated with values f_y (235, 275, 355) MPa and f_c' (20, 30, 40, 50, 60) MPa, respectively, and so with the rest of the values. The length of column $(L\ mm)$ = 3000 is taken constant. Limitations for each code;

AISC CODE

Concrete Compressive Strength (MPa) $21 \leq f_c' \leq 70$

Steel Yield Strength (MPa) $f_y \leq 525$

EC4 CODE

Concrete Compressive Strength (MPa) $20 \leq f_{ck} \leq 50$

Steel Yield Strength (MPa) $235 \leq f_y \leq 460$

3. Generalized Linear Design Model

An alternative to the typical data conversion approach is followed by the standard lower squares analysis of the converted response is the use of the generalized linear model. A generalized linear model is basically a regression model (an experimental design model is also a regression model) which can be used for determination percent contributions of parameters (Montgomery, D. C. 2017).

4. Results and Conclusion

By applying the generalized linear model to the data set created using the excel sheet, 5445 analysis was performed on each code columns and beams. Table 1 shows the final influence of each parameter on the axial and flexural strength of the CCFST member according to AISC 360-16 and EC4-2004 code.

Table 1. Results and percent contributions for axial load and bending moment capacities according to AISC360-16 and EC4-2004

Factors	AISC 360-16		EC4-2004	
	% of Total		% of Total	
	$M_n\ (kN.m)$	$P_n\ (kN)$	$M_n(kN.m)$	$P_n\ (kN)$
$(D)\ mm$	66.53	82.98	64.73	40.74
$(t)\ mm$	26.25	10.40	27.47	31.69
f_c'/f_{ck} (MPa)	0.07	1.46	0.00	3.75
$f_y\ (MPa)$	1.31	0.40	1.58	16.45

There are many important parameters that affect the capacity of CCFST members, such as the geometric characteristics $(D)$and (t)that has a large effect on the resistance of the section. By observing the results in Table 1, $(D)$and (t) has a significant effect on CCFST members as opposed to less influential factors $(f_c', f_{ck}\ and\ f_y)$ Columns and beams diameter and thickness are different contributions on capacity calculations of design codes. These conflicts are established on the accounting confinement of concrete. Pre-designed CCFST beams and columns are the most important points for design engineers to determine the diameter or thickness of a column or beam.

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