INTERACTION CURVES FOR CONCRETE FILLED SQUARE STEEL TUBE COLUMNS UNDER AXIAL COMPRESSION AND UNIAXIAL BENDING

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Abstract - The Eurocode 4 simplified method for design of composite columns was adopted in the present work to developed the axial compression – uniaxial bending interaction curves for twelve different sections of concrete filled square steel tube columns, which are the most common used in constructions. Different material properties were considered in these interaction curves to cover a large range of options for use in practical situations. The effect of steel reinforcement was neglected for all cases that considered and therefore the constructed interaction curves are on the safe side. It was observed that the CFST column section resistance for compression can be increased significantly with the increase of concrete strength, whereas, the increase of the steel strength developed overall increase in the resistance of the CFST column sections to the applied combination of axial compression and uniaxial bending.

Keywords - CFST, Interaction Curves, Eurocode4, Composite Columns.

I. INTRODUCTION

The concrete-filled steel tubular (CFST) column, like any other composite structure, offers numerous structural benefits, including high strength and fire resistances, favorable ductility and large energy absorption capacities. These advantages have been widely exploited and have led to the extensive use of concrete filled tubular structures in civil engineering structures. CFST column, as any column, may be subjected to combinations of axial compression and bending moment, rather than pure axial loading. Several analytical approaches have been conducted to determine the resistance of such columns to combined compression and bending moment with the help of the interaction curve of their cross sections.

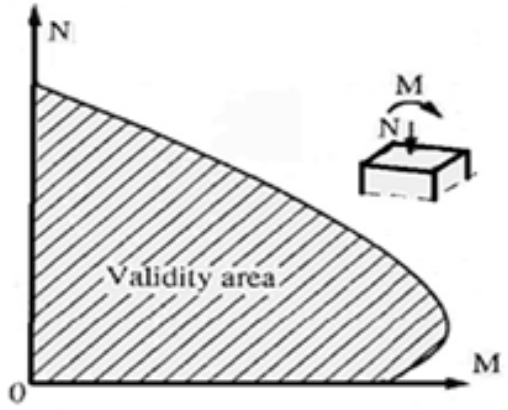

Fig.1 Typical axial compression–uniaxial bending interaction curve for CFST columns

The interaction curve of a column represents the relation between the column axial section resistance to compression and the resistance to bending. In a typical interaction curve of CFST columns, there is no continuous reduction in the bending resistance of column section with increase of the applied axial load, as for virgin steel columns. Where, and as shown in Fig.1, the bending resistance of CFST column cross section may be increased with the presence of axial compression. Actually, the construction of a composite cross section interaction curve is a very time consuming. Therefore, this paper presents practical interaction curves, by using the simplified design method of Eurocode 4, for different dimensions of CFST square columns that most common used in construction, considering different combinations of material properties.

II. METHODOLOGY

Theoretically, the axial compression-uniaxial bending interaction curve for a column cross section can be found by considering different positions of the natural axis over the whole cross section and by determining the internal action effects from the resulting stress distributions. This approach can be carried out only by computer analysis [1]. Whereas, in the simplified method of Eurocode 4, it is only need four to five points to construct a polygonal diagram, as shown in Fig.2, that may be used instead of the exact interaction curve. But, this simplified method is applicable to the design of composite columns under several conditions. The mean two conditions are the columns cross section must be symmetrical about its principal axes and the column relative slenderness must be equal or less than two. Fig.2 also shows the stress analysis of the CFST square column cross section at the four points of interaction diagram, which specified by the simplified method of Eurocode 4, assuming rectangular stress blocks and concrete zones under tension as cracked. In order to determine the location of plastic neutral axis of the composite section, it was also assumed that the resulting axial compression is equal to zero [2], $N_{pl,Rd}$ represents the plastic resistance of column cross section to axial compression, while, $M_{pl,Rd}$ is the plastic resistance of column cross section

to uniaxial bending.

It must be noted that, with the neglect of the steel reinforcement effect and in the absence of bending, the plastic resistance of a composite column cross section to axial compression can be calculated as [3].

$$N_{pl,Rd} = A_s f_{yd} + A_c f_{cd}$$

where As and Ac are areas of steel section and concrete, respectively, f_{yd} and f_{cd} are the corresponding design strength of steel and concrete.

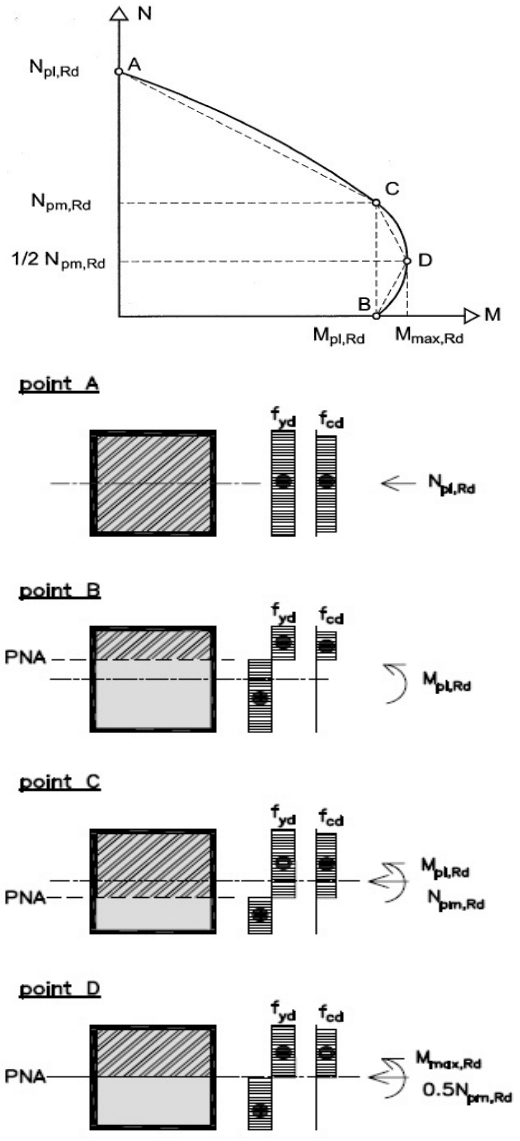

Fig.2 Simplified interaction curve and corresponding stress distributions of the CFST square column cross section

On the other hand, the plastic resistance of composite column cross section in the presence of bending moment along with axial compression is represented as a point within the interaction curve of that section. Therefore, a column cross section will have sufficient resistance if subjects to any combination of applied design axial compression and bending lies inside the area enclosed by that interaction curve.

III. INTERACTION CURVES

As explained previously, the construction of interaction curves for a composite column cross section is a very time consuming, therefore, the present work displayed the interaction curves that developed according to the simplified method of Eurocode 4, for most common used CFST square column sections with different material properties [4]. The effect of steel reinforcement was neglected for all cases that considered and therefore the constructed interaction curves are on the safe side. Table 1 shows the details of the CFST column cross sections that considered in the present study, whereas the Figs.3 to 26 represent the corresponding interaction curves for these sections.

No.	Column Dimensions (mm)	Yield Strength of Steel Tube (MPa)	Characteristic Strength of Concrete (MPa)				
			20	30	40	50	60
1	150 × 150 × 4	235					
		275					
2	150 × 150 × 6	235					
		275					
3	200 × 200 × 5	235					
		275					
4	200 × 200 × 8	235					
		275					
5	250 × 250 × 6.3	235					
		275					
6	250 × 250 × 8	235					
		275					
7	300 × 300 × 6.3	235					
		275					
8	300 × 300 × 10	235					
		275					
9	350 × 350 × 8	275					
		355					
10	350 × 350 × 12	275					
		355					
11	400 × 400 × 10	275					
		355					
12	400 × 400 × 14.2	275					
		355					

Table 1: Details of the selected CFST square column cross sections

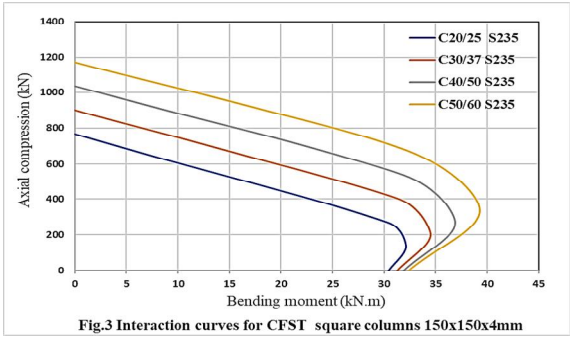

Fig.3 Interaction curves for CFST square columns 150x150x4mm

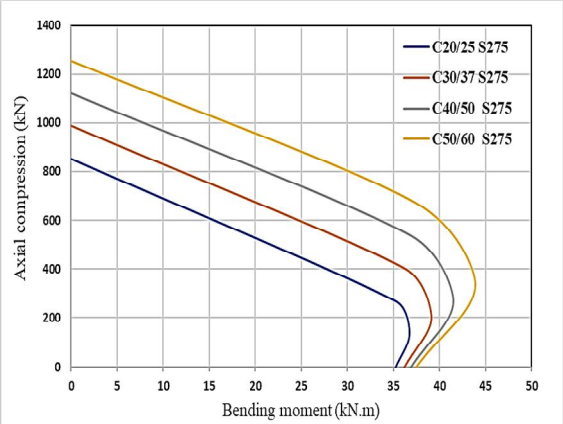

Fig.4 Interaction curves for CFST square columns 150x150x4mm

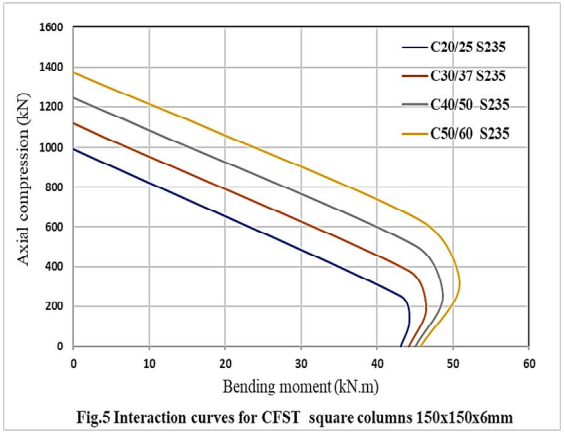

Fig.5 Interaction curves for CFST square columns 150x150x6mm

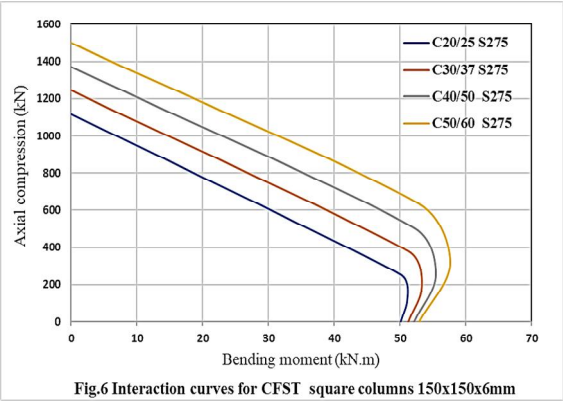

Fig.6 Interaction curves for CFST square columns 150x150x6mm

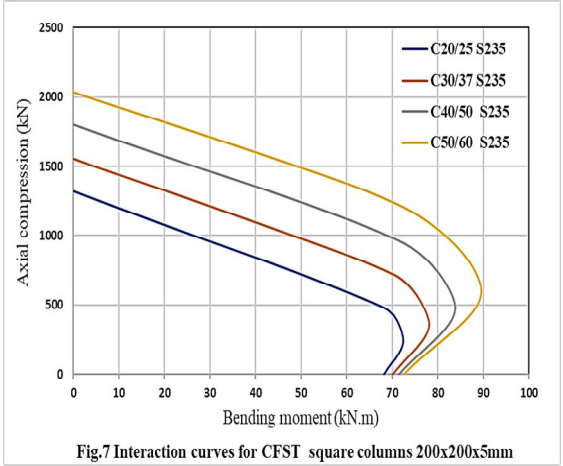

Fig.7 Interaction curves for CFST square columns 200x200x5mm

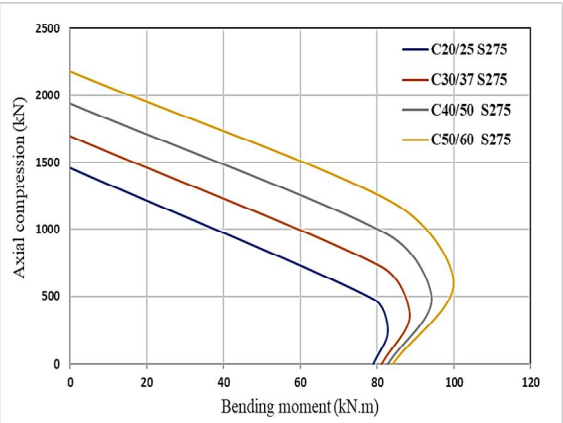

Fig.8 Interaction curves for CFST square columns 200x200x5mm

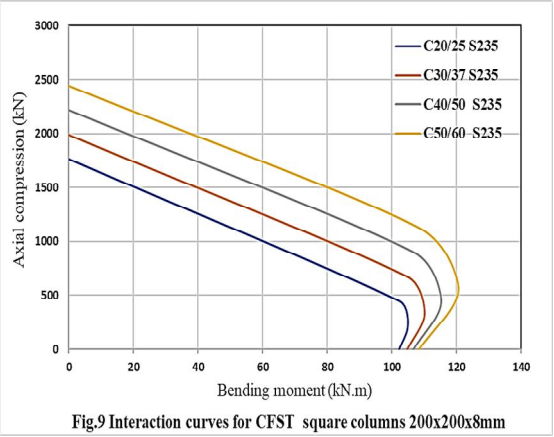

Fig.9 Interaction curves for CFST square columns 200x200x8mm

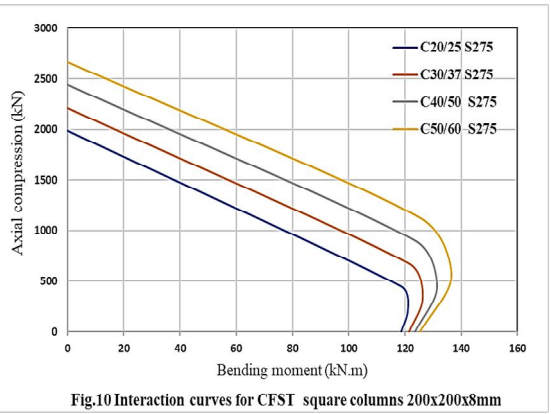

Fig.10 Interaction curves for CFST square columns 200x200x8mm

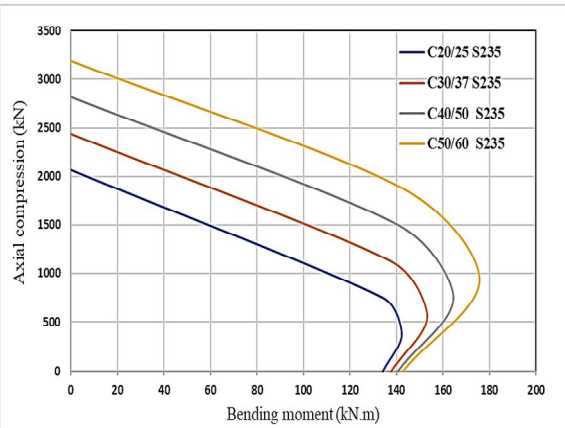

Fig.11 Interaction curves for CFST square columns 250x250x6.3mm

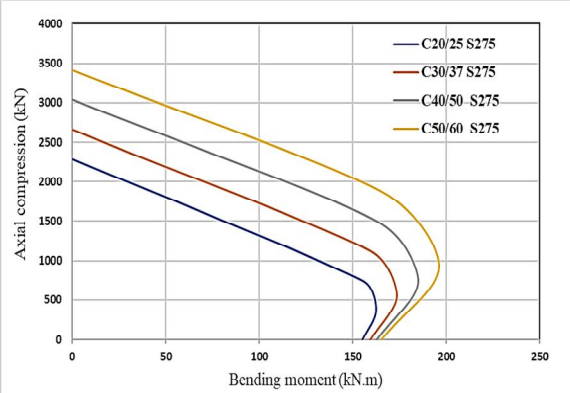

Fig.12 Interaction curves for CFST square columns 250x250x6.3mm

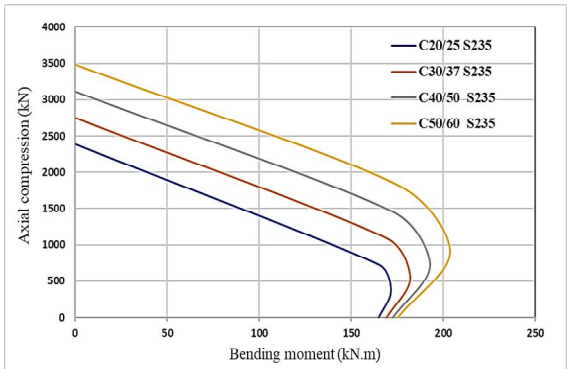

Fig.13 Interaction curves for CFST square columns 250x250x8mm

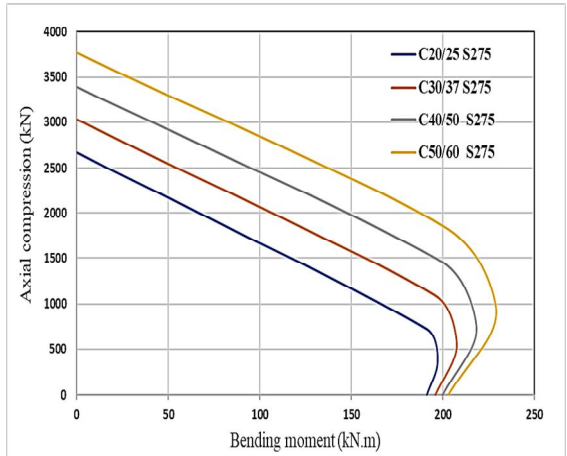

Fig.14 Interaction curves for CFST square columns 250x250x8mm

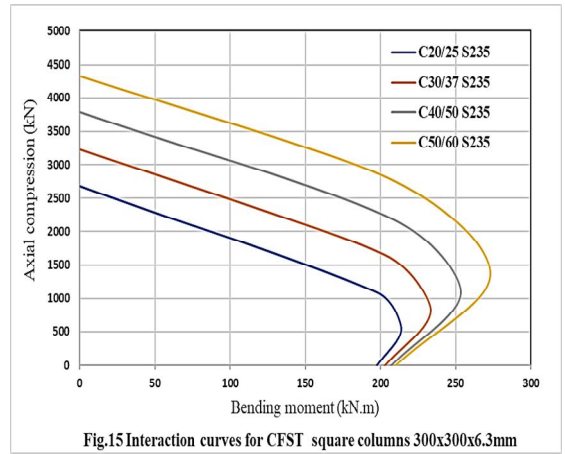

Fig.15 Interaction curves for CFST square columns 300x300x6.3mm

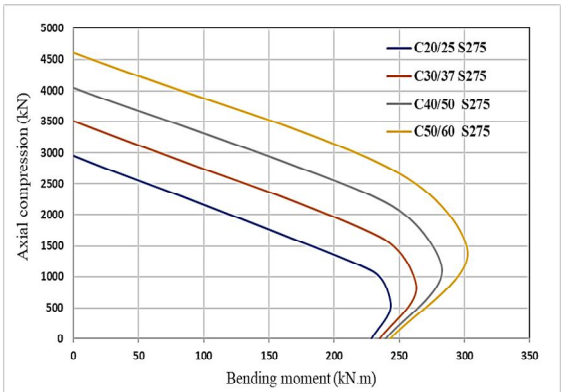

Fig.16 Interaction curves for CFST square columns 300x300x6.3mm

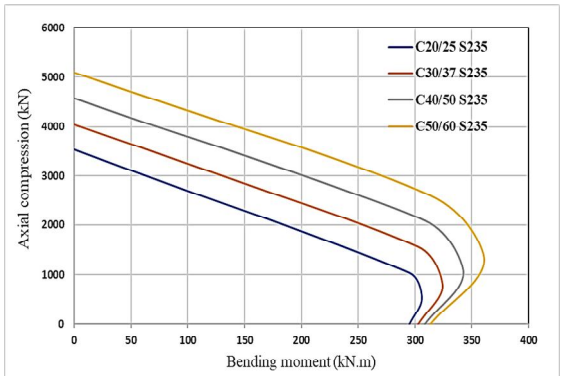

Fig.17 Interaction curves for CFST square columns 300x300x10mm

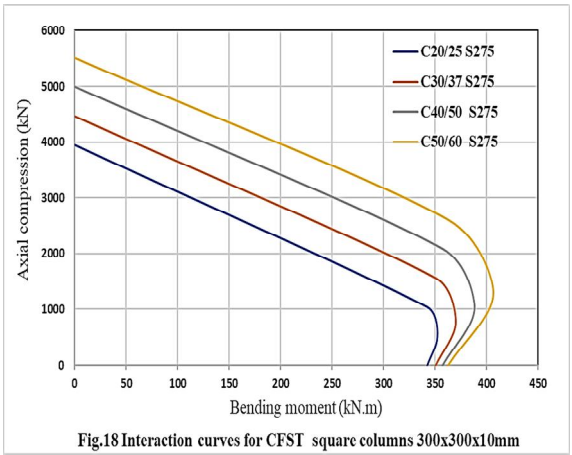

Fig.18 Interaction curves for CFST square columns 300x300x10mm

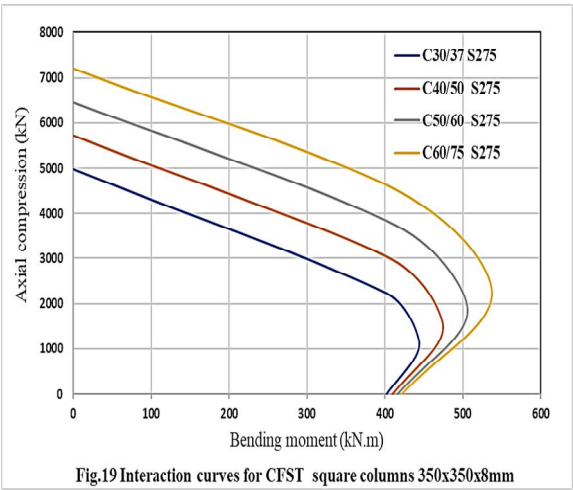

Fig.19 Interaction curves for CFST square columns 350x350x8mm

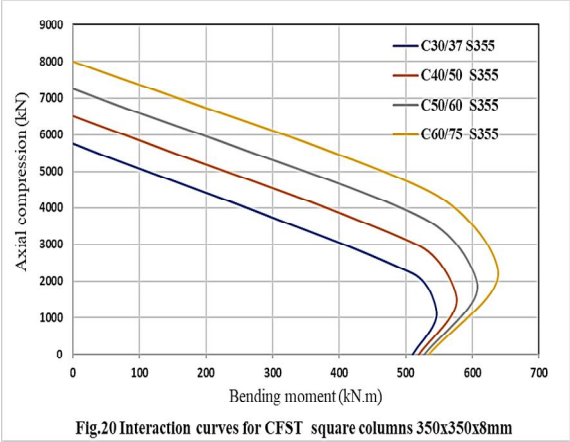

Fig.20 Interaction curves for CFST square columns 350x350x8mm

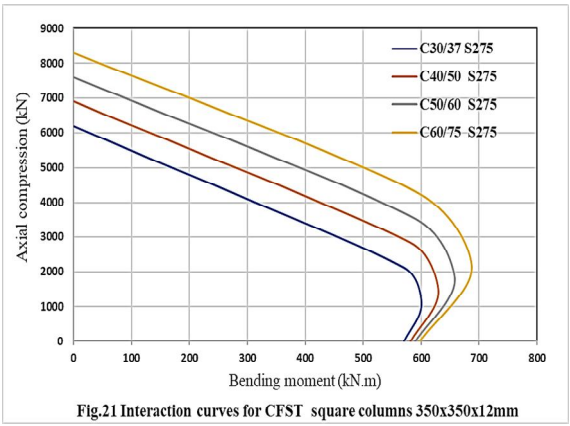

Fig.21 Interaction curves for CFST square columns 350x350x12mm

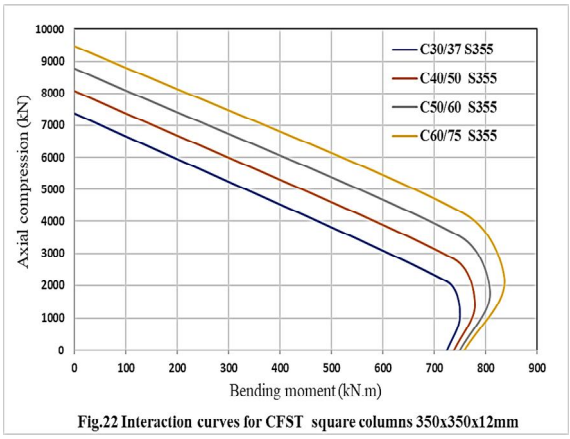

Fig.22 Interaction curves for CFST square columns 350x350x12mm

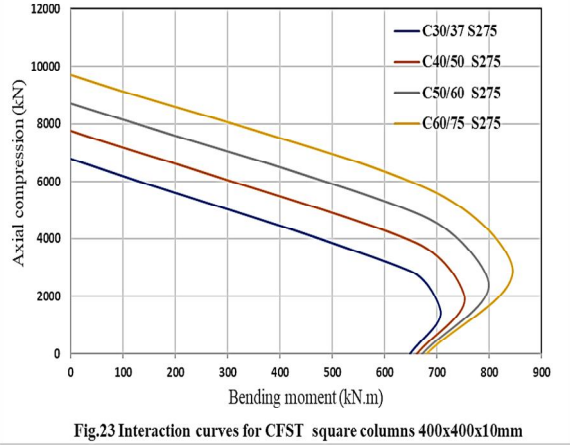

Fig.23 Interaction curves for CFST square columns 400x400x10mm

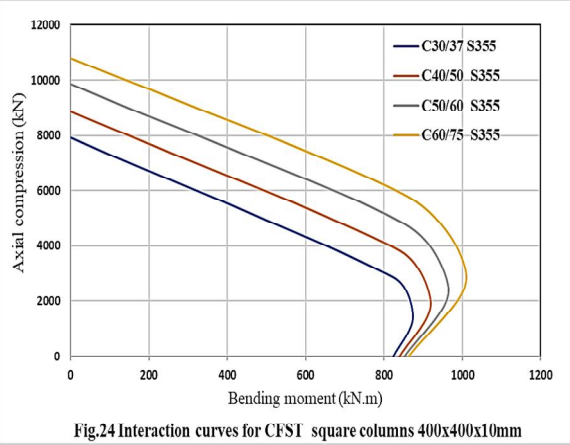

Fig.24 Interaction curves for CFST square columns 400x400x10mm

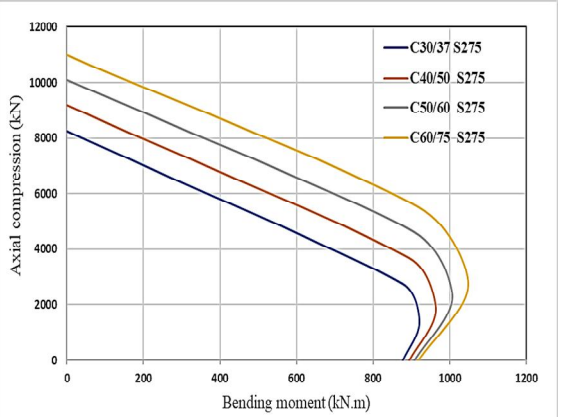

Fig.25 Interaction curves for CFST square columns 400x400x14.2mm

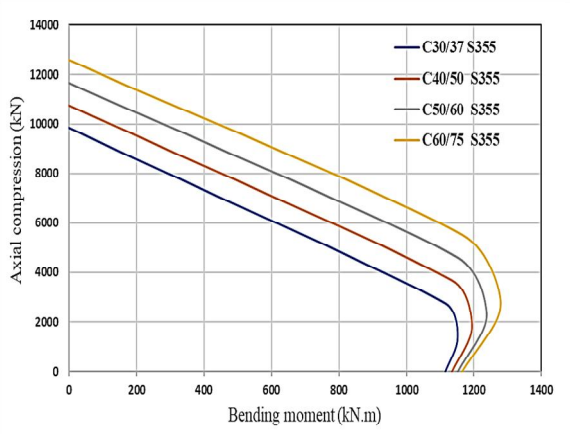

Fig.26 Interaction curves for CFST square columns 400x400x14.2mm

CONCLUSION

The applied compression – uniaxial bending interaction curves were constructed in the present work for most twelve-common used CFST square column sections. Different steel section and concrete strengths were adopted here. It was observed that the CFST column section resistance for compression can be increased significantly with the increase of concrete strength. On the other hand, the increase of the steel strength developed overall increase in the resistance of the CFST column sections to the applied combination of axial compression and uniaxial bending.

REFERENCES

[1] Schleich J. B. and Chantrain Ph., 1998, "Simplified version of Eurocode 4 for usual buildings", A report submitted by Technical Steel Research, European Communities, Luxembourg.

[2] Kostic S. M, Stosic S., and Stajanovic B., 2011, "Contribution to the analysis of composite steel and concrete columns", Building Materials and structures, Vol. 64, pp. 3-16.

[3] Designers' guide to EN 1994, 2004, "EUROCODE 4: Design of Steel and Concrete Composite Structures", Part 2: General Rules and Rules for Bridges, CEN.

[4] Morino S. and Tsuda K, 2003, "Design and Construction of Concrete-Filled Steel Tube Column System in Japan", Earthquake Engineering and Engineering Seismology, Vol. 4, No. 1. Pp.51-73.

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