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PARAMETRIC STUDY OF CIRCULAR CFT COLUMN CAPACITY ACCORDING TO EUROCODE 4

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Summary: *In the paper, a simplified method for design of circular composite CFT columns according to the European standard for deisgn of composite steel and concrete structures – Eurocode 4 is presented. Veri¬fication of the column section capacity under axial compression and bending is based on the concept of limit states and determination of the N-M interaction curve. For eight the most common in practice CFT columns, continuous N-M interaction curves are constructed. In addition, for these selected sections, the influence of the variation of the concrete and steel classes on the column cross-section capacity is analyzed. Given interaction curves simplify the design of composite columns and the choice of dimensions of CFT column and its steel and concrete classes.*

Keywords: *CFT columns, interaction curves, Eurocode 4*

1. INTRODUCTION

Circular composite concrete filled steel tube (CFT) columns, Fig. 1a, are widely used in practice because of their numerous advantages over pure steel or reinforced concrete columns: higher capacity and ductility, better resistance against fire, etc. Analysis of composite CFT columns, in accordance with the Eurocode 4 (EC4) [1], is based on the limit state concept. Under the most unfavorable combination of actions, section forces in all column cross-sections should not exceed the column cross-section resistance. For circular CFT columns with uniform cross-section over the column length, the simplified design method of EC4 can be applied if relative slenderness $\bar{\lambda}$ satisfies the condition $\bar{\lambda} \leq 2.0$ and the maximal cross-sectional area of the longitudinal reinforcement is

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between 0.3% and 6% of the area of concrete [1, 2]. In practice, these conditions are usually satisfied. In addition, for circular CFT columns the effects of local buckling may be neglected for a steel section when the following condition is satisfied $d/t \leq 90 \cdot 235/f_y$ [1, 3].

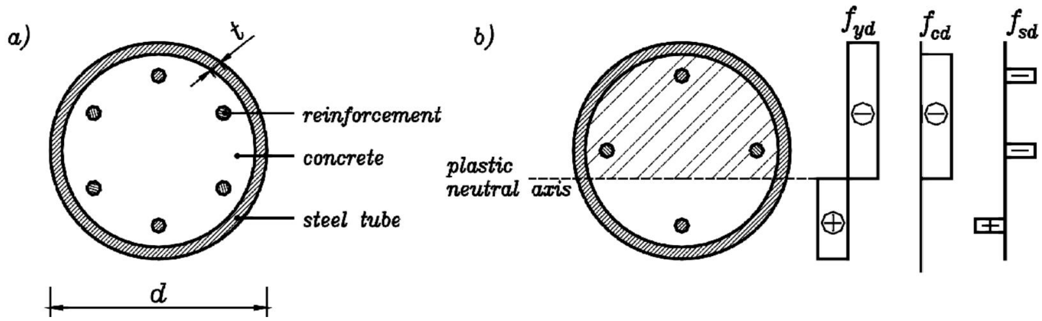

Figure 1. a) CFT column cross-section; b) Stress distribution at an ultimate limit state

2. RESISTANCE OF A COLUMN CROSS-SECTION UNDER COMPRESSION AND BENDING

In the absence of bending, the resistance of the fully plastified cross-section to axial load $N_{pl,Rd}$ is equal to the sum of the axial resistances of each part of the composite section, i.e. steel section, concrete and reinforcement:

$$N_{pl,Rd} = A_a \cdot f_{yd} + A_c \cdot f_{cd} + A_s \cdot f_{sd} \tag{1}$$

Where A_a, A_c and A_s are area of steel section, concrete and reinforcement, respectively, and f_{yd}, f_{sd}, f_{cd} are the corresponding design strengths of steel, concrete and reinforcement steel. It should be noticed that, in contrast to the composite columns with encased steel section, there is no reduction of the concrete design strength because of confinement effects of the steel tube. Besides, when relative slenderness $\bar{\lambda}$ does not exceed *0.5* and when the eccentricity of loading is less than *0.1d*, the increased strength of concrete can be taken [3].

In the presence of bending moment, the composite CFT column cross-section resistance $N_{pl,Rd}$ decreases. In this case, the relation between the axial section resistance to compression $N_{pl,Rd}$ and the resistance to bending $M_{pl,Rd}$ is given by the interaction curve (Fig. 2a). A column cross section has a sufficient resistance when subjected to the design axial force N_{Ed} and the design bending moment M_{Ed} if the point (N_{Ed}, M_{Ed}) is inside the area limited with the interaction curve.

Construction of the interaction curve can be done point by point, placing the plastic neutral axis into the different positions. For each of these positions, assuming the rectangular stress block diagram (Fig. 1b), the resulting axial force and the bending moment can be found. In order to obtain the continuous interaction curve, the plastic neutral axis needs to be moved in small steps, which is very time consuming process without the use of a computer. Therefore, EC4 [1] allows to approximate the continuous interaction curve with the polygonal curve, calculating only four characteristic points on the curve – points A, B, C and D, Fig. 2b. Figure 2c shows the corresponding stress distributions for each of these four points (h_n is the distance of the plastic neutral axis from the section centroid and can be determined from the condition that the resulting axial force is equal to zero) [4].

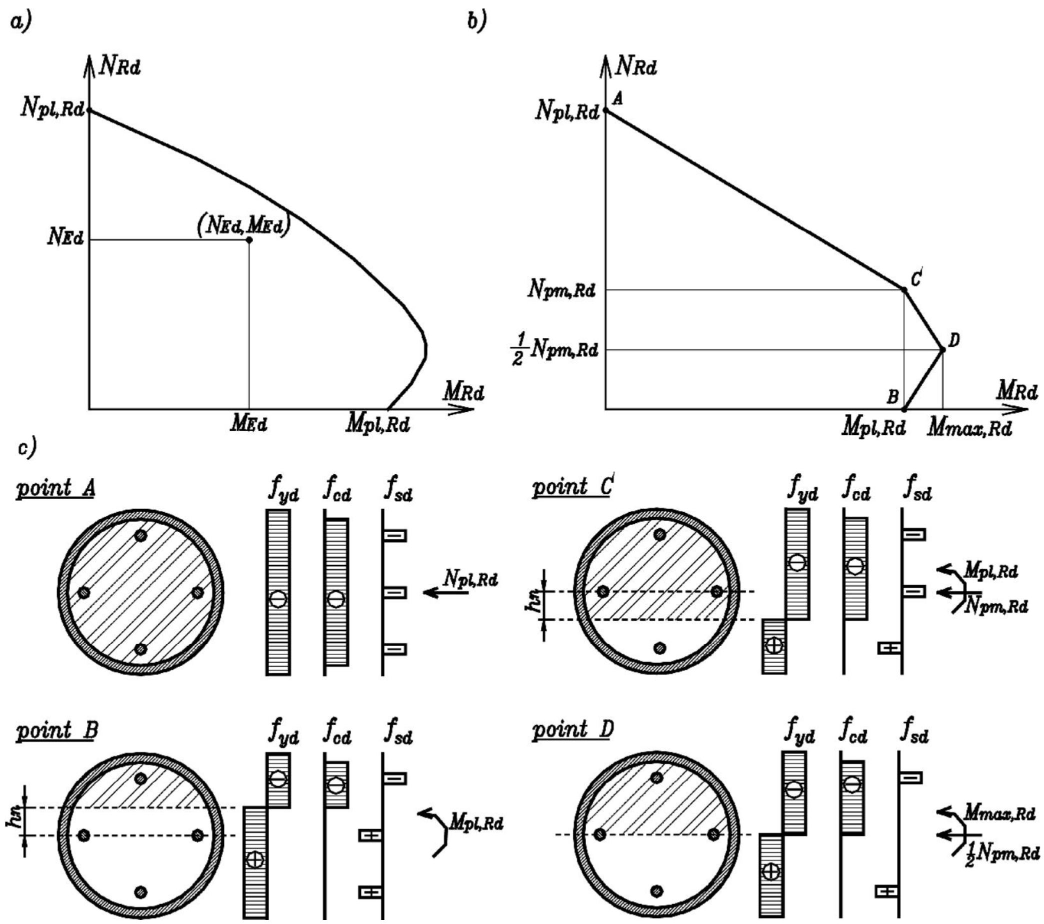

Figure 2. a) N-M continuous interaction curve;
b) Approximate polygonal N-M interaction curve according to EC4;
c) Stress distributions for characteristic points on the interaction curve

3. INTERACTION CURVES

As mentioned before, construction of the N-M interaction curve is a very time-consuming step in the design of composite column. Therefore, in this paper, practical interaction curves for the most common dimensions of circular CFT columns, the most used steel and concrete classes are constructed.

The circular steel tubes with the following dimensions are selected: d=219.1 mm, t=5 mm and t=6.3 mm; d=273.0 mm, t= 6.3 mm and t=7.1 mm; d=323.9 mm, t=6.3 mm, t=7.1 mm; d=355.6 mm, t=7.1 mm, t=8 mm. For each of the studied steel tube sections, interaction curves are constructed with variation of concrete classes C20/25, C30/37 and C40/50, and S235 steel class. In addition, for each of the considered steel tube sections and for concrete class C30/37, interaction curves are constructed for steel classes S275 and S355. These curves are plotted in Figs. 3-6.

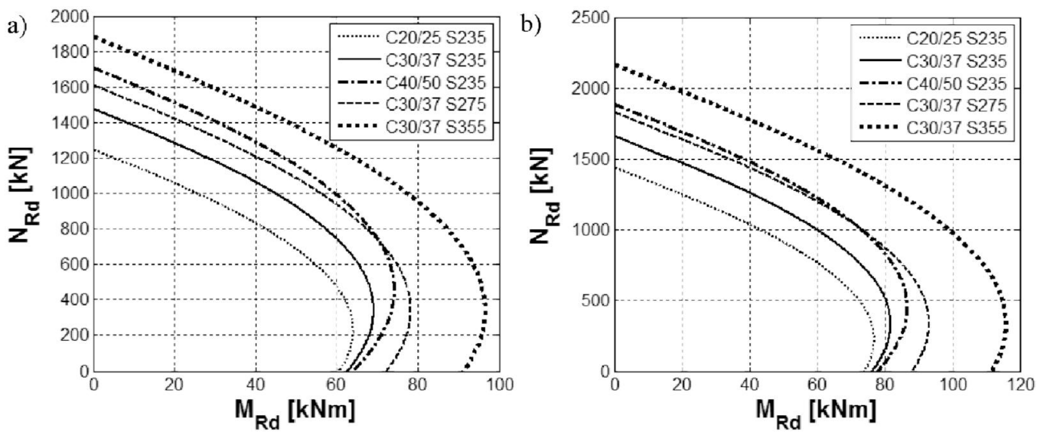

Figure 3. Interaction curves for CFT columns d=219.1 mm: a) t=5 mm; b) t=6.3 mm

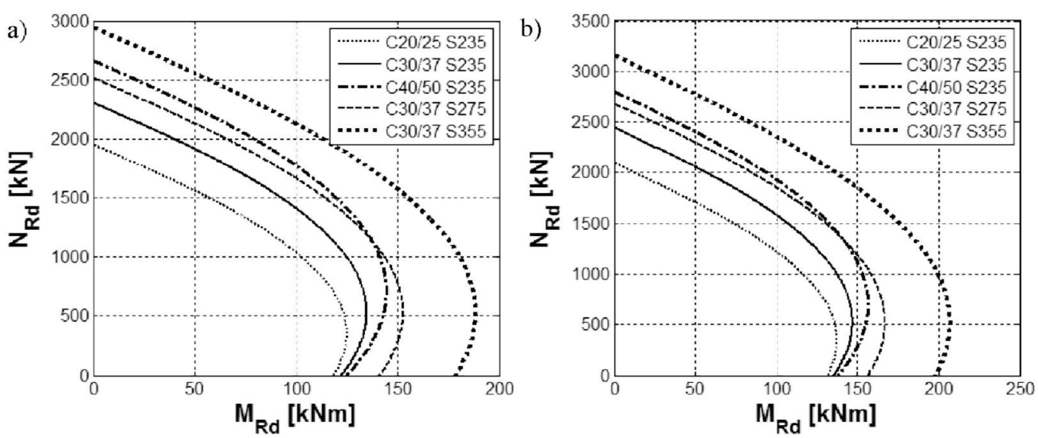

Figure 4. Interaction curves for CFT columns d=273.0 mm: a) t=6.3 mm; b) t=7.1 mm

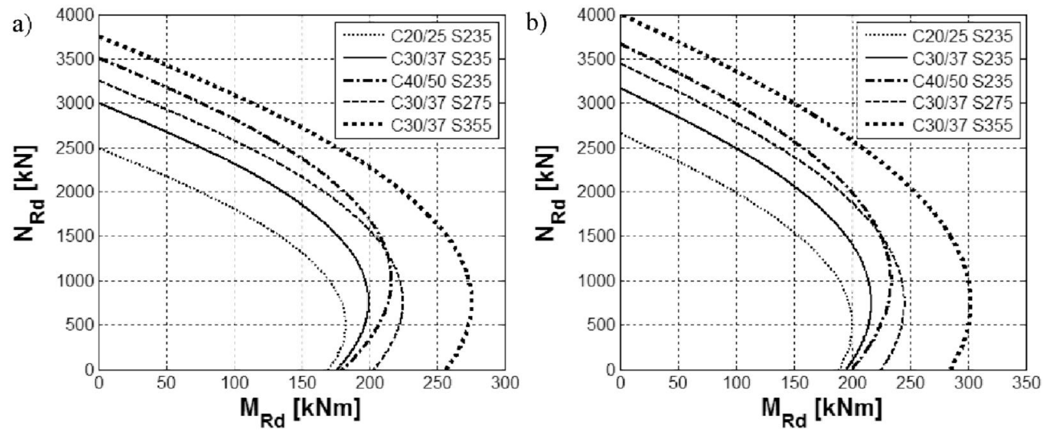

Figure 5. Interaction curves for CFT columns d=323.9 mm: a) t=6.3 mm; b) t=7.1 mm

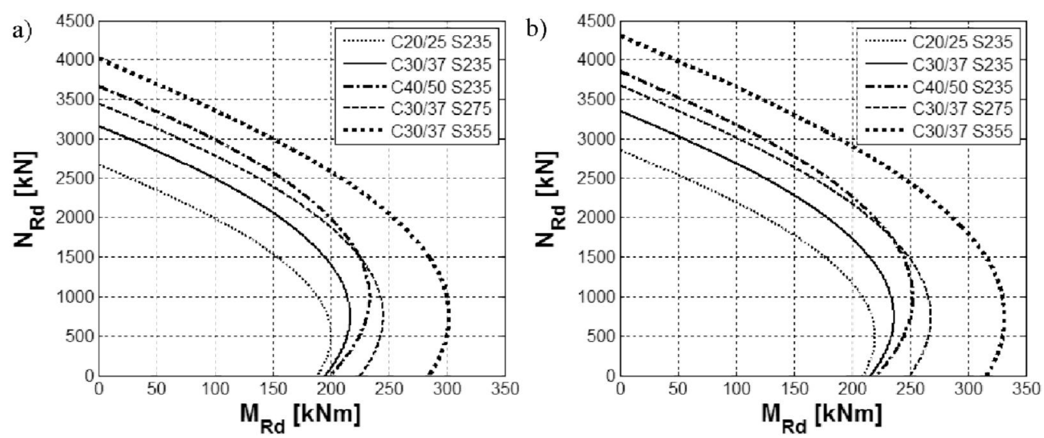

Figure 6. Interaction curves for CFT columns d=355.6 mm: a) t=7.1 mm; b) t=8 mm

In all considered cases, reinforcement is neglected and the calculated interaction curves are, therefore, on the safe side. Using the given interaction curves, design of circular CFT columns is simplified and number of iterations during design due to variation of section dimensions (diameter and thickness) and material properties (steel and concrete classes) is reduced.

4. CONCLUSION

Eurocode 4, under specific conditions, allows use of the simplified design method for design of CFT columns. Column section resistance under the compression and bending is verified using the N-M interaction curve. In this paper, the continuous interaction curves for the most common dimensions of the circular CFT sections are constructed.

Varying material parameters, i.e. higher classes of steel and concrete, section resistance increases. Increment in concrete class effects mostly section axial capacity, while higher steel classes increase overall section capacity, both bending and axial.

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ПАРАМЕТАРСКА АНАЛИЗА НОСИВОСТИ КРУЖНИХ CFT СТУБОВА ПРЕМА ЕВРОКОДУ 4

Резиме: *У раду је приказана упрошћена метода прорачуна кружних спрегнутих CFT стубова према важећем европском стандарду за прорачун спрегнутих конструкција од челика и бетона – Еврокоду 4. Провера и контрола носивости попречног пресека спрегнутог стуба се заснива на контроли граничних стања и одређивању N-M интеракционе криве. За осам попречних пресека кружних челичних профила који се најчешће примењују у пракси, конструисане су континуалне криве интеракције. Такође, за изабране профиле извршено је варирање класе бетона и класе челика. Приказане криве интеракције су погодне за практичну примену будући да поједностављују прорачун и избор димензија челичног пресека и класе челика и бетона код кружних спрегнутих CFT стубова.*

Кључне речи: *CFT стубови, криве интеракције, Еврокод 4*