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Design Aid Composite Columns

Design tables for composite columns under cold and fire conditions

Table of Content

Impressum

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1 | Introduction

The use of composite columns made of an external tubular section filled of concrete with an encased I-section has many advantages: rapidity of erection (no formwork, no rebars), high resistance for a limited size and good behavior under fire. The present document is aimed at reporting the simple calculation methods developed in order to evaluate the bearing capacity of composite tubular columns with an encased I-section at room temperature and under fire conditions (R60, R90 and R120).

The calculation of the resisting compression force of these columns at room temperature without eccentricities does not necessitate any new development as a complete simple method is defined in the current EN 1994-1-1.

For cases with an eccentric loading, the M-N interaction curve of the section must be calculated in order to apply the EN 1994-1-1 resistance criteria. In the present work, this M-N interaction curve has been calculated by dividing the column cross-section into a large number of stripes and by calculating through an automatic procedure the plastic M-N internal forces for a large amount of positions of the plastic neutral axis.

Finally, a similar procedure has been applied to determine the M-N interaction curve after 60 minutes, 90 minutes and 120 minutes of an ISO fire. The distribution of temperature in the section are evaluated by ignoring the surrounding steel tube and on the basis of isothermal curves defined in the EN 1992-1-2 for concrete columns. The contribution of the surrounding steel tube is also ignored in the calculation of the resistance and stiffness of the column.

The design tables are presented for several values of the buckling length: at room temperature, 2.35m, 2.52m, 2.8m, 3.36m, 3.6m and 4m are considered; at elevated temperatures, 2.35m, 2.52m and 2.8m are considered as the buckling length of a composite column is reduced to 0.7 L in these conditions (see 4.3.5 (10) in EN 1994-1-2:2005).

The three types of calculations are described in detail hereafter in example cases (Chapter 2 to 4). The design tables for all the geometries considered are given in Chapter 5. As a validation of these results, comparisons are given between values obtained from the analytical method and from numerical simulations performed with SAFIR software (see cases 5.1 to 5.4).

2 | Resistance of the composite columns at room temperature under axial compression

<u>Geometrical and mechanical properties of the example case</u>:

External tubular section: 559x8.8, S235 Steel Grade
Internal H-section: HD 320x245, S460M Steel Grade
C30/37 Concrete Grade
Buckling Length: 3.6 m

<u>Calculation of the design compression resisting force</u>:

Yield strength of the H-section:
$$t_f = 40\,mm \quad \rightarrow \quad f_{yk} = 430\ MPa$$

Ratio of permanent loads SLS: $N_G / N_{G+Q} = 0.8$ (assumption)

Ratio of permanent loads ULS:
$$\left(N_G / N_{G+Q}\right)_d = \frac{\gamma_G * 0.8}{\gamma_G * 0.8 + \gamma_Q * 0.2} = 0.783$$

Creep coefficient for concrete for inside conditions (RH = 50%; $h_0 = h_{0,max}$): 1.9 (see blue line on Figure 1).

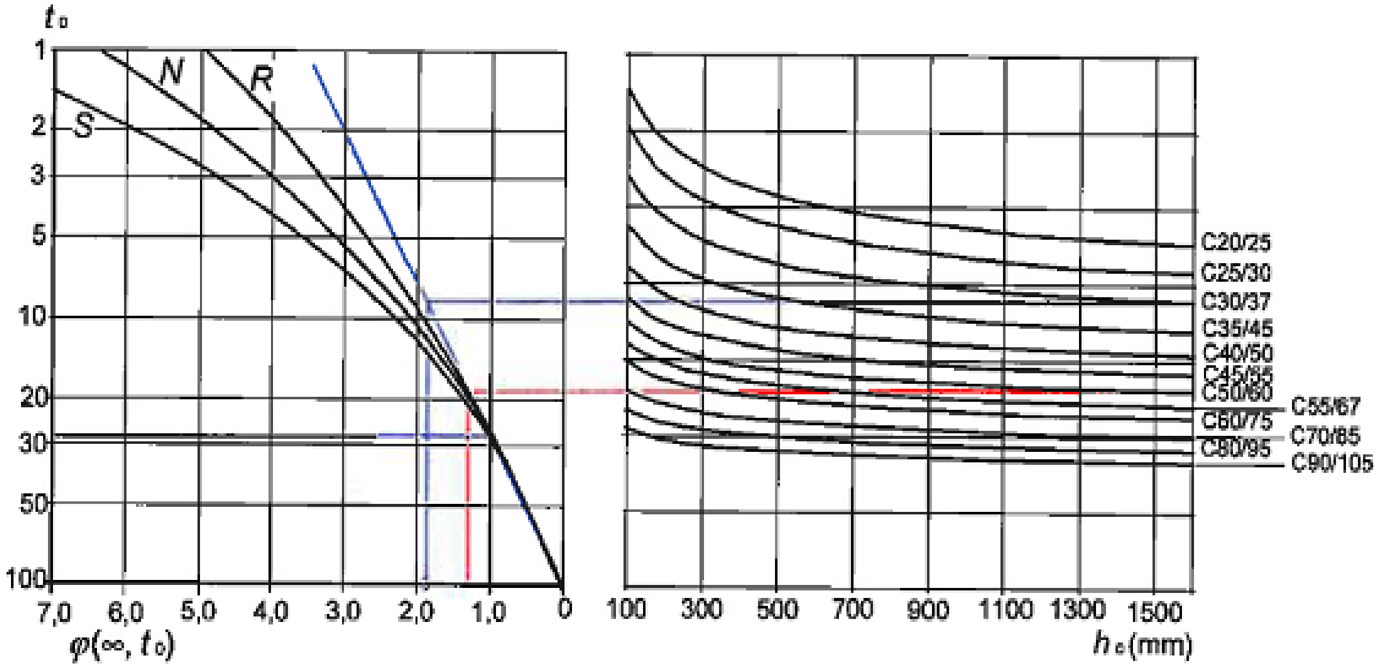

Figure 1: Method for determining creep concrete coefficient (RH = 50%) according to EN 1992-1-1:2004

Modulus of elasticity of concrete:

$$E_{c,eff} = E_{cm} \frac{1}{1+\left(N_{G,Ed}/N_{Ed}\right)*\varphi_t} = 12867\ MPa$$

The buckling of the composite column is calculated only in the weak axis:

Effective flexural stiffness:

$$(EI)_{eff,z} = K_o\left(E_a\, I_{a,z} + K_{e,II}\, E_{c,eff}\, I_{c,z}\right) = 169\,342\ kNm^2$$

Coefficients K_o and $K_{e,II}$ are taken equal to 0.9 and 0.5 in order to account for member imperfections (see § 6.7.3.4. of the EN 1994-1-1:2004).

Critical normal force for weak axis:

$$N_{cr,z} = \frac{\pi^2 * EI_z}{L^2} = 128962\ kN$$

Characteristic plastic resistance in compression:

$$N_{pl,Rk} = A_a * f_{yd} + A_c * f_{cd} = 22961\ kN$$

Design plastic resistance in compression:

$$N_{pl,Rd} = A_a * f_{yd}/\gamma_{M,0} + A_c * f_{cd}/\gamma_c = 20971\ kN$$

The increase of concrete strength caused by confinement is taken into account by ignoring the 0.85 factor applied on concrete strength (applicable to all composite columns with tubular sections). However, the η coefficients applicable to circular sections (see § 6.7.3.2. (6) in EN 1994-1-1) have not been considered as a safe assumption.

Reduced slenderness in the weak axis:

$$\bar{\lambda}_z = \sqrt{\frac{N_{pl,Rk}}{N_{cr,z}}} = 0.422$$

Imperfection factor: $\alpha = 0.34$ (buckling curve b according to Table 6.5 in EN 1994-1-1:2004)

Buckling reduction factor:

$$\chi_z = \frac{1}{\phi_z + \sqrt{\phi_z^2 - \bar{\lambda}^2}} = 0.917$$

$$where \quad \phi_z = 0.5*\left[1 + \alpha\left(\bar{\lambda} - 0.2\right) + \bar{\lambda}^2\right] = 0.627$$

Design buckling resistance to compression:

$$N_{b,Rd} = \chi * \left(A_a * f_{yd}/\gamma_{M,1} + A_c * f_{cd}/\gamma_c\right) = 17819\ kN$$

3 | Resistance of the composite columns at room temperature under eccentric compression

The M-N interaction curve is calculated according to the procedure described hereafter:

- Discretization of the section in horizontal stripes and calculation of the cross-section area of each material included in each stripe ;
- Calculation of the plastic axial forces that each stripe can resist in tension or compression
- Calculation of internal forces M-N for a large amount of positions of the plastic neutral axis (fully plastic assumption) ;
- Drawing of the M-N interaction curve by connecting all the points of the M-N diagram.

This method necessitates the implementation of a small routine in order to obtain the non-linear M-N interaction curve. The EN 1994-1-1 proposes a simplified method for composite columns composed of an I-profile embedded in reinforced concrete: the non-linear curve is replaced by a polygonal diagram defined by four points (see § 6.7.3.2 (5) in EN 1994-1-1:2004). In the present work, the design tables will be obtained by use of the non-linear M-N interaction curve. However, the polygonal diagram is presented in the example case for quick hand-made calculations of configurations that are not included in the design tables.

<u>Geometrical and mechanical properties of the example case</u>:

External tubular section: 406.4x8.8, S235 Steel Grade
Internal H-section: HEM 200, S355 Steel Grade
C50/60 Concrete Grade
Buckling Length: 3.36 m
Eccentricity of the loading: d/10 = 40.64 mm

<u>Calculation of the design compression resisting force</u>:

Yield strength of the H-section:

$$t_f = 25mm \quad \rightarrow \quad f_{yk} = 355\,MPa$$

Design plastic resistance in compression:

$$N_{pl,Rd} = A_a * f_{yd} / \gamma_{M,0} + A_c * f_{cd} / \gamma_c = 10633\,kN$$

Axial force in point C:

$$N_{pm,Rd} = A_c * f_{cd} / \gamma_c = 3520\,kN$$

(assumption polygonal curve)

Bending moment associated in point C (weak axis): 802 kNm

It should be mentioned that the point C obtained by the non-linear interaction curve is (N = 3344 kN and M = 812 kNm). Figure 2 shows that the difference between non-linear and polygonal curves is significant, especially in the weak axis that is usually the decisive one.

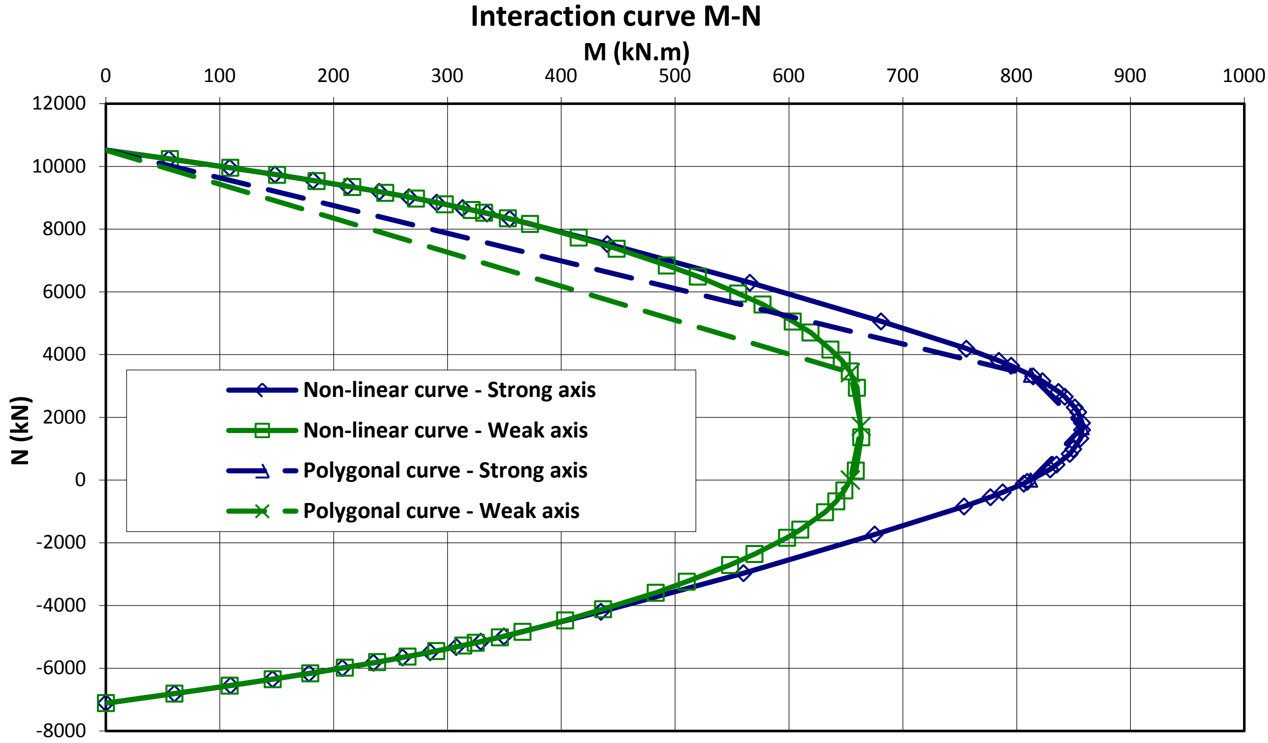

Figure 2 : M-N interaction curves for a composite column in strong and weak axis

Ratio of permanent loads SLS: $N_G / N_{G+Q} = 0.8$ (assumption)

Ratio of permanent loads ULS:

$$\left(N_G / N_{G+Q}\right)_d = \frac{\gamma_G * 0.8}{\gamma_G * 0.8 + \gamma_Q * 0.2} = 0.783$$

Creep coefficient for concrete for inside conditions (RH = 50%; $h_0 = h_{0,max}$) : 1.4
(see blue line on Figure 1).

Modulus of elasticity of concrete:

$$E_{c,eff} = E_{cm} \frac{1}{1 + \left(N_{G,Ed} / N_{Ed}\right) * \varphi_t} = 17656\ MPa$$

Effective flexural stiffness:

$$(EI)_{eff,z} = K_o \left(E_a I_{a,z} + K_{e,II} E_{c,eff} I_{c,z}\right) = 56595\ kN.m^2$$

Coefficients K_o and $K_{e,II}$ are taken equal to 0.9 and 0.5 in order to account for member imperfections. (see § 6.7.3.4. of the EN 1994-1-1:2004)

Critical normal force for weak axis:

$$N_{cr,z} = \frac{\pi^2 * EI_z}{L^2} = 49477\ kN$$

Total eccentricity:

$$e = e_o + e_a = d/10 + L/200 = 40.6 + 16.8 = 57.4\,mm$$

The accidental eccentricity e_a is defined according to Table 6.5 in EN 1994-1-1:2004

First-order design bending moment (acting in weak axis) under N_{Sd} = 6000 kN (assumption):

$$M_{z,Sd,1} = N_{Sd} * e = 344\,kNm$$

Factor accounting for second-order effects:

$$k = \frac{\beta}{1 - N_{Ed} / N_{cr,eff,z}} = 0.75 \geq 1 \quad \rightarrow \quad k = 1$$

Second-order design bending moment (acting in weak axis) under N_{Sd} = 6000 kN (assumption):

$$M_{z,Sd,2} = M_{z,Sd,1} * k = 344\,kNm$$

Plastic bending moment of the section under N = N_{Sd}: $M_{pl,N,Rd} = 461\,kNm$

Resistance criteria of the section in weak axis:

$$\frac{M_{Ed,z}}{M_{pl,N,Rd,z}} = 0.75 \leq \alpha_M = 0.9$$

The coefficient α_M is 0.9 for S235 and S355 steel grades and 0.8 for S420 and S460 steel grades.
The resistance criterion shows that the resistance of the composite columns with an eccentricity e_o = d/10 is higher than 6000 kN. An iterative procedure allows to determine N_{Rd} = 7224 kN.

4 | Resistance of the composite columns at elevated temperature

Geometrical and mechanical properties of the example case:

External tubular section: 559x8.8, S235 Steel Grade
Internal H-section: HD 320x127, S460M Steel Grade
C30/37 Concrete Grade
Buckling Length: 0.7*3.6m = 2.52m
Eccentricity of the loading: d/10 = 40.64 mm

4.1 | Thermal analysis

The distribution of temperature in the section has a direct impact on the flexural stiffness and plastic resistance of the composite column. In order to keep the calculation method simple the temperature profiles given in the Annex A of the EN 1992-1-2:2004 for circular columns (Figures A-17 to A-20; d = 300 mm) are employed as follows:

- The surrounding concrete that is submitted to a temperature higher than 500°C is removed and not taken into account in the mechanical calculation. The thickness of the removed concrete perimeter is respectively 27mm, 37mm and 50 mm for R60, R90 and R120 criteria (see Figure A-20 of EN 1992-1-2:2004).
- The temperature of the steel H-section is considered as uniform and evaluated by use of Figures A-17 to A-19 for the concrete cover of the flange at a distance b/4 of the flange extremity.
- The temperature of concrete without the external hot perimeter is assumed to be equal to the steel H-section.

This simplified method slightly overestimates temperatures in the section: the temperature profiles of the EN 1992-1-2:2004 are given for 300mm-large columns without steel H-section. In larger sections, the heat used to increase the temperature of the core (steel H-section and concrete) leads to significantly lower temperatures than those predicted by Eurocode temperature profiles. This effect is more significant for large columns, massive steel profiles and long fire exposures.

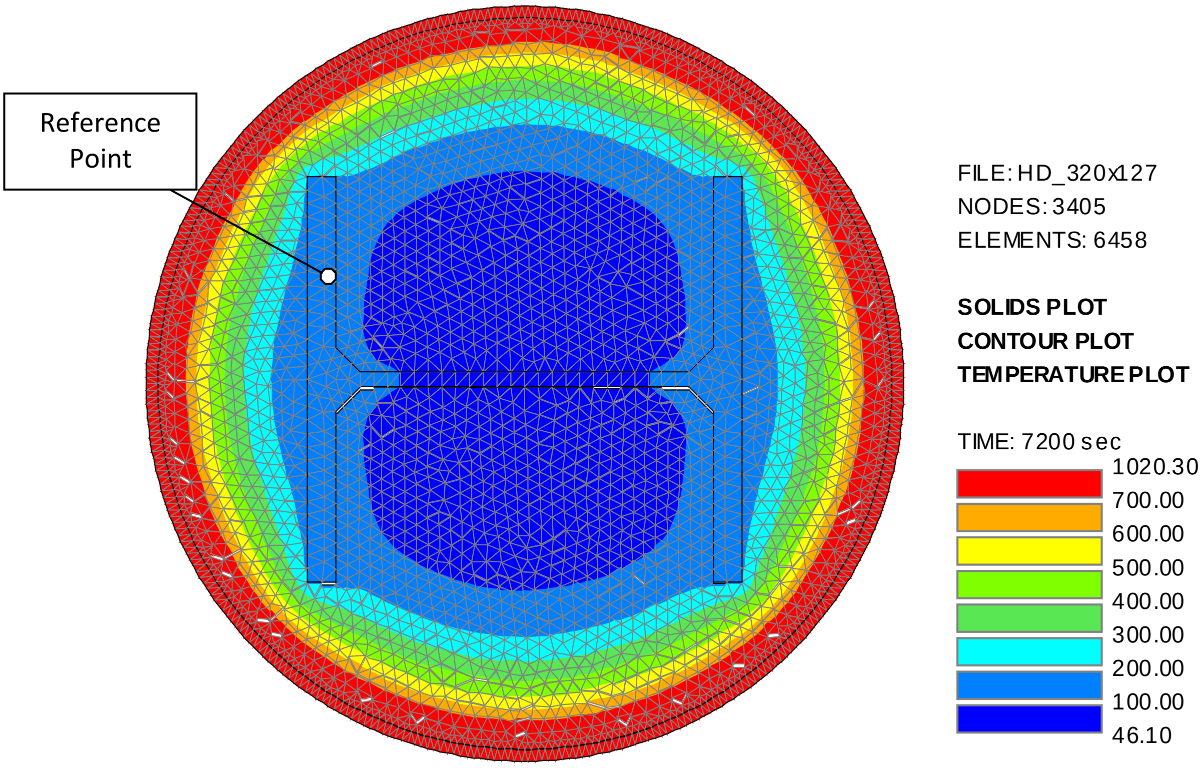

Figure 3: Distribution of temperature in a 559 mm-large composite column after 120 minutes

In the present example case, a numerical thermal simulation performed with SAFIR software respectively leads to temperatures equal to 68°C (instead of 84°C), 113°C (instead of 143°C) and 158°C (instead of 272°C) after 60, 90 and 120 minutes of ISO-fire.

<u>Assumptions of the SAFIR simulations</u>:

Coefficient of convection on heated surfaces: 25 W/mK

Coefficient of convection on cold surfaces: 4 W/mK

Emissivity of steel: 0.7

Specific mass of concrete (including moisture content): 2400 kg/m^3

Water content of concrete: 96 kg/m^3 (4%)

Conductivity of concrete: lower limit defined in EN 1992-1-2:2004 § 3.3.3.

4.2 | Mechanical analysis

At elevated temperature, no calculation method are given in the last version of the Eurocodes for the resistance of composite columns made of a concrete-filled tubular section with an embedded H-section under axial or eccentric compression forces. Indeed, the informative Annex H dealing with this type of composite columns has been rejected by the European authorities because leading to unsafe results.

The calculation method presented hereafter and used to determine the design tables is based on the method for columns under eccentric loads at room temperature and recommendations of the European norms dedicated to the calculation of steel and concrete structures under fire (EN 1991-1-2:2002, EN 1992-1-2:2004, EN 1993-1-2:2005 and EN 1994-1-2:2005).

The M-N interaction curves of the residual section (without steel tube and external concrete ring) after 60, 90 and 120 minutes of ISO fire are calculated in a similar way to what has been done at room temperature. However, the stress-strain diagrams of steel and concrete defined in the Eurocodes at elevated temperatures are non-linear. The following assumptions have been made as simplifications:

The simplified stress-strain diagram of steel is elastic-plastic with a yield plateau for a stress:

$$\sigma_a = \frac{\left(k_{p,\theta} + k_{y,\theta}\right) f_{yk}}{2 * \gamma_{M,fi}}.$$

The elasticity modulus considered in the calculation of the column flexural stiffness is $E_{a,\theta} = k_{E,\theta} * E_{a,20°C}$ (see Figure 4).

The simplified stress-strain diagram of concrete is elastic-plastic with a yield plateau for a stress:

$$\sigma_c = \frac{0.85\, f_{c,\theta}}{\gamma_{M,fi}}.$$

The elasticity modulus considered in the calculation of the column flexural stiffness is the ratio between this value σ and the strain ε related to this stress σ in the diagram defined in the EN 1992-1-2 (see Figure 5).

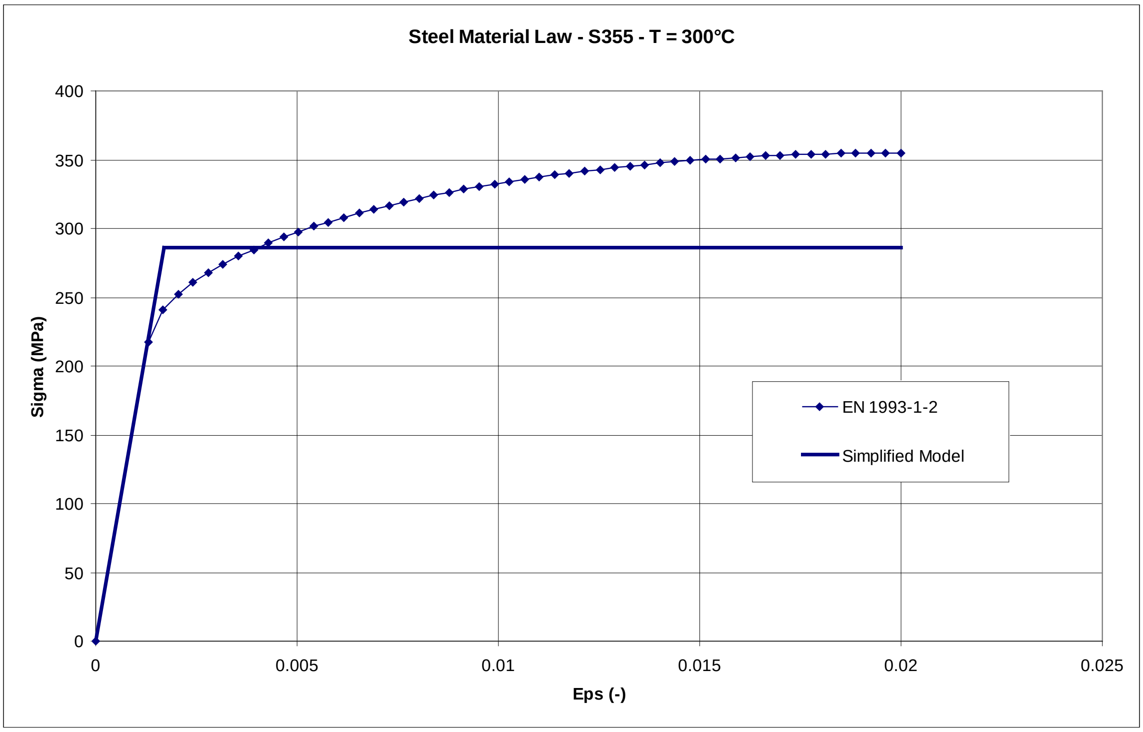

Figure 4: Comparison between EN 1993-1-2 and simplified material laws (Grade S355 – T = 300°C)

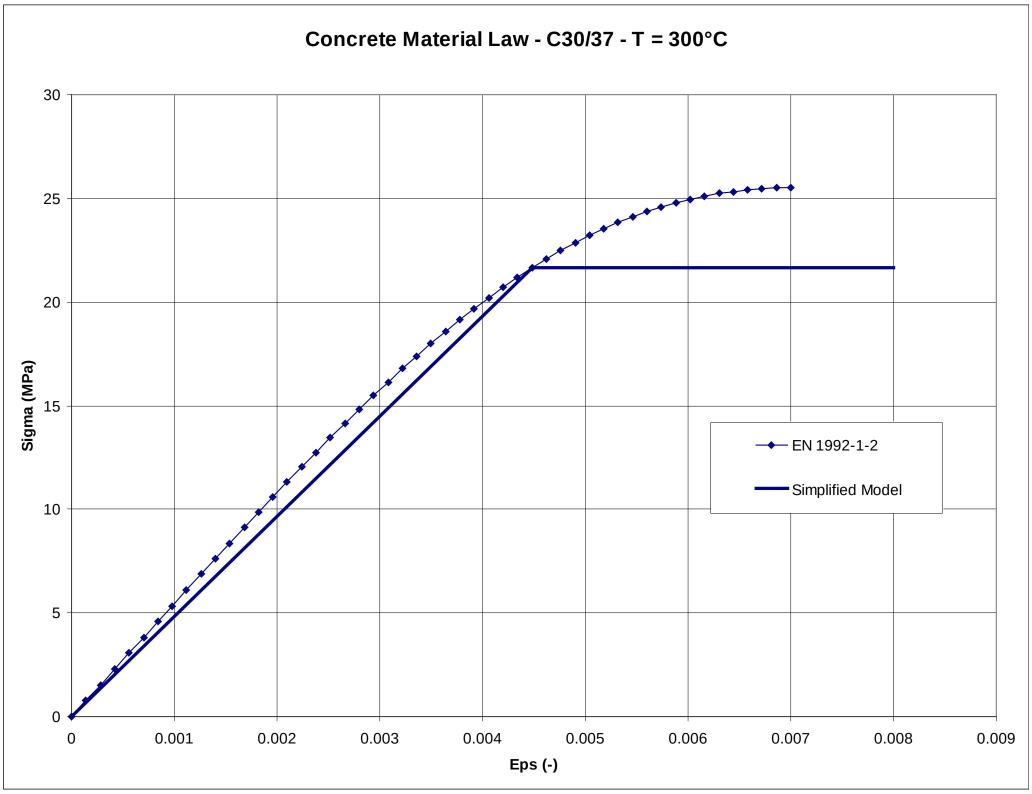

Figure 5: Comparison between EN 1992-1-2 and simplified material laws (Grade C30/37 – T = 300°C

<u>Calculation of the design compression resisting force</u>:

Yield strength of the H-section: $t_f = 20.5mm \quad \rightarrow \quad f_{yk} = 440\ MPa$

$$T_{a,60} = T_{c,60} = 84°C \quad ; \quad T_{a,90} = T_{c,90} = 143°C \quad ; \quad T_{a,120} = T_{c,120} = 271°C$$

$$\sigma_{a,60} = \frac{\left(k_{p,\theta} + k_{y,\theta}\right) f_{yk}}{2 * \gamma_{M,fi}} = 440\ MPa \quad ; \quad \sigma_{a,90} = 422\ MPa \quad ; \quad \sigma_{a,120} = 367\ MPa$$

$$E_{a,60} = k_{E,\theta}\, E_{a,20°C} = 210000\ MPa \quad ; \quad E_{a,90} = 200965\ MPa \quad ; \quad E_{a,120} = 173982\ MPa$$

$$\sigma_{c,60} = \frac{0.85\, f_{c,\theta}}{\gamma_{M,fi}} = 25.5\ MPa \quad ; \quad \sigma_{c,90} = 25.0\ MPa \quad ; \quad \sigma_{c,120} = 22.4\ MPa$$

$$E_{cm,60} = k_{E,\theta}\, E_{a,20°C} = 4091\ MPa \quad ; \quad E_{cm,90} = 4086\ MPa \quad ; \quad E_{cm,120} = 4076\ MPa$$

The calculation procedure is given in detail after 120 minutes of an ISO fire. This procedure is absolutely similar for 60 or 90 minutes.

Design plastic resistance in compression:

$$N_{pl,120,Rd} = \frac{A_a * \sigma_{a,120}}{\gamma_{M,fi}} + \frac{A_c * \sigma_{c,120}}{\gamma_{c,fi}} = 8527\ kN$$

Axial force in point C:

$N_{pm,Rd} = A_c * f_{cd} / \gamma_c = 2606\ kN$

(assumption polygonal curve)

Bending moment associated in point C (weak axis): 484 kNm

It should be mentioned that the point C obtained by the non-linear interaction curve is (N = 2988 kN and M = 483 kNm). Figure 6 shows that the difference between non-linear and polygonal curves is again significant after 120 minutes ISO fire in the weak axis. Figure 7 plots the non-linear curves obtained at room and elevated temperatures for the section considered in this example case in the weak axis.

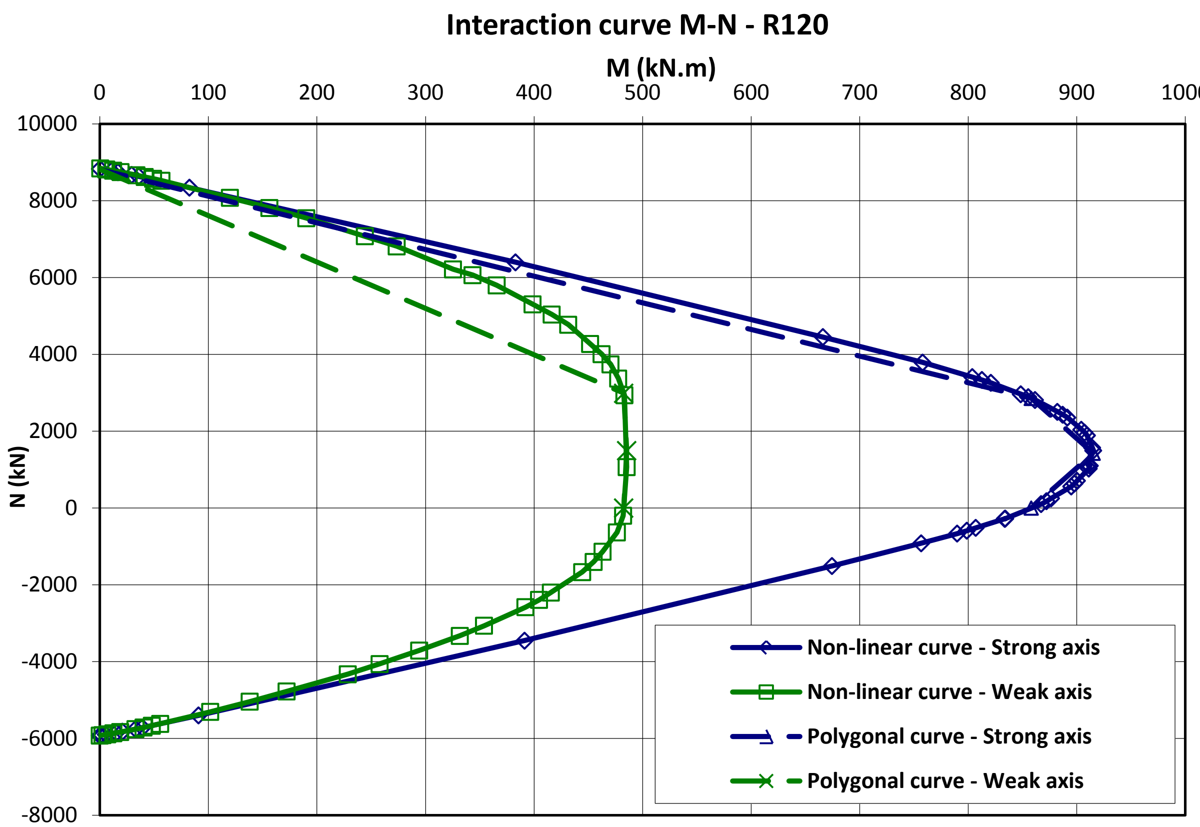

Figure 6 : M-N interaction curves for composite column in strong and weak axis after 120 minutes ISO fire

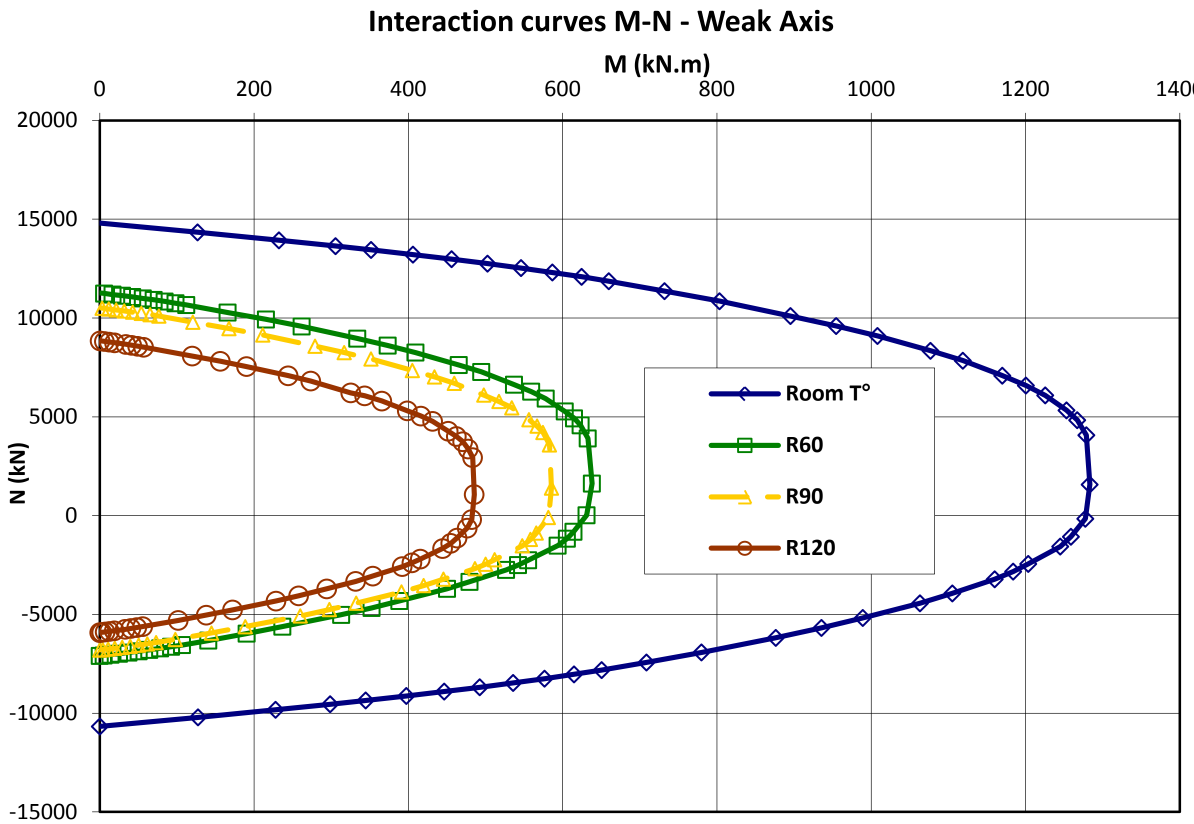

Figure 7: M-N interaction curves for a composite column at room and elevated temperatures

Effective flexural stiffness:
$$\left(EI\right)_{eff,z,120} = K_o\left(E_{a,120}\, I_{a,z} + K_{e,II}\, E_{cm,120}\, I_{c,z}\right) = 20963\, kNm^2$$

Coefficients K_o and $K_{e,II}$ are taken equal to 0.9 and 1.

Critical normal force for weak axis:
$$N_{cr,z,120} = \frac{\pi^2 * EI_{z,120}}{L^2} = 32581\, kN$$

Total eccentricity:
$$e = e_o + e_a = d/10 + L/500 = 40.6 + 16.8 = 61\, mm$$

The accidental eccentricity e_a is taken equal to L/500, instead of L/1000, in order to neglect the effect of residual stresses.

First-order design bending moment (acting in weak axis) under N_{Sd} = 5000 kN (assumption):
$$M_{z,Sd,1} = N_{Sd} * e = 305\, kNm$$

Factor accounting for second-order effects:
$$k = \frac{\beta}{1 - N_{Ed}/N_{cr,eff,z}} = 0.78 \geq 1 \quad \rightarrow \quad k = 1$$

Second-order design bending moment (acting in weak axis) under N_{Sd} = 5000 kN (assumption):
$$M_{z,Sd,2} = M_{z,Sd,1} * k = 305\, kNm$$

Plastic bending moment of the section under $N = N_{Sd}$: $M_{pl,N,Rd} = 401 kNm$

Resistance criteria of the section in weak axis:
$$\frac{M_{Ed,z}}{M_{pl,N,Rd,z}} = 0.76 \leq \alpha_M = 0.8$$

The coefficient α_M is kept equal to 0.9 for S235 and S355 steel grades and 0.8 for S420 and S460 steel grades at elevated temperatures.

The resistance criterion shows that the resistance of the composite columns with an eccentricity e_o = d/10 is higher than 5000 kN. An iterative procedure allows to determine $N_{Rd,120}$ = 5265 kN.

This method is not developed for sections with a diameter smaller than 400 mm. It was observed by use of SAFIR software that the influence of thermally-induced stresses on the fire resistance of the column was important and that the developed method could lead to unsafe predictions of the design resisting compression forces.

5|Design Tables

5.1|406.4x8.8 Tube (S235 Steel Grade), HEM 200 encased profile (S355 Steel Grade)

Buckling Length L= 2.35 m			
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**8189**
		R60	**5932**
		R90	**5223**
		R120	**4403**
C30/37	d/10	Cold	**6580**
		R60	**3843**
		R90	**3357**
		R120	**2810**
C30/37	d/5	Cold	**4929**
		R60	**2507**
		R90	**2188**
		R120	**1826**
C50/60	0	Cold	**9441**
		R60	**7059**
		R90	**6139**
		R120	**5056**
C50/60	d/10	Cold	**7501**
		R60	**4640**
		R90	**3984**
		R120	**3243**
C50/60	d/5	Cold	**55853**
		R60	**3007**
		R90	**2573**
		R120	**2085**

Buckling Length L= 2.52 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**8113**	8193	0.99
		R60	**5880**	5892	1.00
		R90	**5175**	5123	1.01
		R120	**4363**	4439	0.98
C30/37	d/10	Cold	**6537**	6744	0.97
		R60	**3828**	4152	0.92
		R90	**3344**	3684	0.91
		R120	**2799**	3258	0.86
C30/37	d/5	Cold	**4902**	5211	0.94
		R60	**2499**	3023	0.83
		R90	**2180**	2705	0.81
		R120	**1819**	2416	0.75

Buckling Length L= 2.52 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C50/60	0	Cold	**9344**	9467	0.99
		R60	**6983**	7344	0.95
		R90	**6067**	6369	0.95
		R120	**4998**	5508	0.91
C50/60	d/10	Cold	**7455**	7786	0.96
		R60	**4622**	5241	0.88
		R90	**3968**	4583	0.87
		R120	**3230**	4006	0.81
C50/60	d/5	Cold	**5549**	5974	0.93
		R60	**2996**	3788	0.79
		R90	**2565**	3342	0.77
		R120	**2077**	2948	0.70

Buckling Length L= 2.8 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**7985**	8036	0.99
		R60	**5765**	5652	1.02
		R90	**5073**	4835	1.05
		R120	**4277**	4127	1.04
C30/37	d/10	Cold	**6473**	6626	0.98
		R60	**3797**	3925	0.97
		R90	**3318**	3444	0.96
		R120	**2781**	3014	0.92
C30/37	d/5	Cold	**4855**	5202	0.93
		R60	**2486**	2903	0.86
		R90	**2168**	2568	0.84
		R120	**1810**	2269	0.80
C50/60	0	Cold	**9180**	9291	0.99
		R60	**6790**	7068	0.96
		R90	**5898**	6022	0.98
		R120	**4867**	5101	0.95
C50/60	d/10	Cold	**7378**	7650	0.96
		R60	**4382**	4965	0.88
		R90	**3782**	4286	0.88
		R120	**3107**	3700	0.84
C50/60	d/5	Cold	**5492**	5966	0.92
		R60	**2981**	3642	0.82
		R90	**2550**	3169	0.80
		R120	**2067**	2762	0.75

Buckling Length L= 3.36 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**7713**	7692	1.00
	d/10	Cold	**6343**	6354	1.00
	d/5	Cold	**4768**	5122	0.93
C50/60	0	Cold	**8828**	8904	0.99
	d/10	Cold	**7224**	7336	0.98
	d/5	Cold	**5385**	5878	0.92

Buckling Length L= 3.6 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**7590**	7562	1.00
	d/10	Cold	**6287**	6227	1.01
	d/5	Cold	**4730**	5052	0.94
C50/60	0	Cold	**8666**	8726	0.99
	d/10	Cold	**7157**	7192	1.00
	d/5	Cold	**5338**	5798	0.92

Buckling Length L= 4 m					
406.4x8.8 Tube (S235), HEM 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**7372**	7249	1.02
	d/10	Cold	**6193**	6006	1.03
	d/5	Cold	**4665**	4915	0.95
C50/60	0	Cold	**8380**	8410	1.00
	d/10	Cold	**7052**	6937	1.02
	d/5	Cold	**5266**	5638	0.93

5.2|406.4x8.8 Tube (S235 Steel Grade), HEB 200 encased profile (S355 Steel Grade)

Buckling Length L= 2.35 m			
406.4x88 Tube (S235), HEB 200 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**6811**
		R60	**4466**
		R90	**3936**
		R120	**3246**
C30/37	d/10	Cold	**5535**
		R60	**2885**
		R90	**2515**
		R120	**2047**
C30/37	d/5	Cold	**4226**
		R60	**1837**
		R90	**1591**
		R120	**1290**
C50/60	0	Cold	**8139**
		R60	**5652**
		R90	**4919**
		R120	**3962**
C50/60	d/10	Cold	**6511**
		R60	**3702**
		R90	**3180**
		R120	**2527**
C50/60	d/5	Cold	**4916**
		R60	**2355**
		R90	**2002**
		R120	**1569**

Buckling Length L= 2.52 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**6753**	6784	1.00
		R60	**4423**	4576	0.97
		R90	**3892**	4008	0.97
		R120	**3208**	3453	0.93
C30/37	d/10	Cold	**5504**	5682	0.97
		R60	**2873**	3191	0.90
		R90	**2505**	2809	0.89
		R120	**2039**	2449	0.83
C30/37	d/5	Cold	**4202**	4506	0.93
		R60	**1830**	2279	0.80
		R90	**1586**	2024	0.78

Buckling Length L= 2.52 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method	**Safir** (kN)	**Ratio**
C50/60	0	Cold	**8059**	8118	0.99
		R60	**5563**	6121	0.91
		R90	**4832**	5339	0.91
		R120	**3890**	4643	0.84
C50/60	d/10	Cold	**6472**	6778	0.95
		R60	**3567**	4339	0.82
		R90	**3064**	3756	0.82
		R120	**2445**	3238	0.76
C50/60	d/5	Cold	**4887**	5322	0.92
		R60	**2347**	3067	0.77
		R90	**1995**	2677	0.75
		R120	**1563**	2329	0.67

Buckling Length L= 2.8 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**6654**	6666	1.00
		R60	**4317**	4394	0.98
		R90	**3790**	3787	1.00
		R120	**3124**	3192	0.98
C30/37	d/10	Cold	**5453**	5596	0.97
		R60	**2775**	3012	0.92
		R90	**2414**	2617	0.92
		R120	**1971**	2254	0.87
C30/37	d/5	Cold	**4164**	4498	0.93
		R60	**1820**	2188	0.83
		R90	**1577**	1920	0.82
		R120	**1278**	1672	0.76
C50/60	0	Cold	**7926**	7979	0.99
		R60	**5316**	5889	0.90
		R90	**4607**	5055	0.91
		R120	**3721**	4281	0.87
C50/60	d/10	Cold	**6409**	6674	0.96
		R60	**3335**	4106	0.81
		R90	**2862**	3501	0.82
		R120	**2287**	2975	0.77
C50/60	d/5	Cold	**4842**	5314	0.91
		R60	**2333**	2945	0.79
		R90	**1982**	2534	0.78
		R120	**1553**	2175	0.71

Buckling Length L= 3.36 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**6447**	6410	1.01
	d/10	Cold	**5350**	5394	0.99
	d/5	Cold	**4090**	4446	0.92
C50/60	0	Cold	**7640**	7478	1.02
	d/10	Cold	**6282**	6432	0.98
	d/5	Cold	**4752**	5254	0.90

Buckling Length L= 3.6 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**6353**	6294	1.01
	d/10	Cold	**5306**	5301	1.00
	d/5	Cold	**4061**	4398	0.92
C50/60	0	Cold	**7510**	7541	1.00
	d/10	Cold	**6230**	6318	0.99
	d/5	Cold	**4715**	5195	0.91

Buckling Length L= 4 m					
406.4x88 Tube (S235), HEB 200 encased profile (S355)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**6189**	6087	1.02
	d/10	Cold	**5235**	5136	1.02
	d/5	Cold	**4010**	4298	0.93
C50/60	0	Cold	**7279**	7299	1.00
	d/10	Cold	**6143**	6119	1.00
	d/5	Cold	**4654**	5072	0.92

5.3 | 559x8.8 Tube (S235 Steel Grade), HD320x127 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
559x8.8 Tube (S235), HD320x127 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**12527**
		R60	**9494**
		R90	**8811**
		R120	**7357**
C30/37	d/10	Cold	**9794**
		R60	**6342**
		R90	**5834**
		R120	**4810**
C30/37	d/5	Cold	**7370**
		R60	**4133**
		R90	**3785**
		R120	**3109**
C50/60	0	Cold	**15091**
		R60	**12209**
		R90	**11227**
		R120	**9257**
C50/60	d/10	Cold	**11712**
		R60	**8239**
		R90	**7494**
		R120	**6075**
C50/60	d/5	Cold	**8719**
		R60	**5321**
		R90	**4806**
		R120	**3874**

Buckling Length L= 2.52 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**13631**	13439	1.01
		R60	**10923**	11705	0.93
		R90	**10176**	11105	0.92
		R120	**8540**	10468	0.82
C30/37	d/10	Cold	**10245**	10674	0.96
		R60	**6851**	8316	0.82
		R90	**6337**	7896	0.80
		R120	**5265**	7447	0.71
C30/37	d/5	Cold	**7389**	8024	0.92
		R60	**4292**	5611	0.76
		R90	**3956**	5375	0.74
		R120	**3278**	5120	0.64

Buckling Length L= 2.52 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C50/60	0	Cold	**16270**	16110	1.01
		R60	**13629**	15170	0.90
		R90	**12584**	14338	0.88
		R120	**10435**	13506	0.77
C50/60	d/10	Cold	**12041**	12834	0.94
		R60	**8631**	10922	0.79
		R90	**7884**	10271	0.77
		R120	**6447**	9622	0.67
C50/60	d/5	Cold	**8582**	9568	0.90
		R60	**5353**	7322	0.73
		R90	**4864**	6925	0.70
		R120	**3956**	6542	0.60

Buckling Length L= 2.8 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**13478**	13238	1.02
		R60	**10881**	11524	0.94
		R90	**10135**	10878	0.93
		R120	**8501**	10176	0.84
C30/37	d/10	Cold	**10158**	10624	0.96
		R60	**6818**	8157	0.84
		R90	**6304**	7685	0.82
		R120	**5239**	7200	0.73
C30/37	d/5	Cold	**7331**	8018	0.91
		R60	**4275**	5596	0.76
		R90	**3938**	5356	0.74
		R120	**3262**	5088	0.64
C50/60	0	Cold	**16067**	15886	1.01
		R60	**13536**	14957	0.90
		R90	**12490**	14060	0.89
		R120	**10355**	13183	0.79
C50/60	d/10	Cold	**11938**	12778	0.93
		R60	**8590**	10770	0.80
		R90	**7846**	10044	0.78
		R120	**6415**	9342	0.69
C50/60	d/5	Cold	**8514**	9559	0.89
		R60	**5329**	7305	0.73
		R90	**4842**	6902	0.70
		R120	**3940**	6513	0.60

Buckling Length L= 3.36 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**13163**	12826	1.03
	d/10	Cold	**9992**	10424	0.96
	d/5	Cold	**7216**	8002	0.90
C50/60	0	Cold	**15646**	15422	1.01
	d/10	Cold	**11736**	12544	0.94
	d/5	Cold	**8381**	9538	0.88

Buckling Length L= 3.6 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**13023**	12646	1.03
	d/10	Cold	**9920**	10315	0.96
	d/5	Cold	**7172**	7990	0.90
C50/60	0	Cold	**15457**	15215	1.02
	d/10	Cold	**11655**	12416	0.94
	d/5	Cold	**8325**	9527	0.87

Buckling Length L= 4 m					
559x8.8 Tube (S235), HD320x127 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir (kN)**	**Ratio**
C30/37	0	Cold	**12783**	12340	1.04
	d/10	Cold	**9804**	10114	0.97
	d/5	Cold	**7093**	7972	0.89
C50/60	0	Cold	**15131**	14866	1.02
	d/10	Cold	**11513**	12176	0.95
	d/5	Cold	**8230**	9510	0.87

5.4 | 660x10 Tube (S235 Steel Grade), HD400x314 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
660x10 Tube (S235), HD400x314 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**22405**
		R60	**18945**
		R90	**18485**
		R120	**17908**
C30/37	d/10	Cold	**17432**
		R60	**13089**
		R90	**12721**
		R120	**12282**
C30/37	d/5	Cold	**13055**
		R60	**9020**
		R90	**8755**
		R120	**8420**
C50/60	0	Cold	**25999**
		R60	**22599**
		R90	**21843**
		R120	**20897**
C50/60	d/10	Cold	**19961**
		R60	**15673**
		R90	**15063**
		R120	**14330**
C50/60	d/5	Cold	**14852**
		R60	**10709**
		R90	**10270**
		R120	**9721**

Buckling Length L= 2.52 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**25548**	25374	1.01
		R60	**22530**	23646	0.95
		R90	**22064**	22887	0.96
		R120	**21482**	21999	0.98
C30/37	d/10	Cold	**18985**	19103	0.99
		R60	**14826**	17068	0.87
		R90	**14478**	16674	0.87
		R120	**14056**	16206	0.87
C30/37	d/5	Cold	**13645**	13858	0.98
		R60	**9842**	12176	0.81
		R90	**9602**	11897	0.81
		R120	**9306**	11561	0.80

Buckling Length L= 2.52 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C50/60	0	Cold	**29086**	28846	1.01
		R60	**26187**	28382	0.92
		R90	**25423**	27369	0.93
		R120	**24467**	26292	0.93
C50/60	d/10	Cold	**21379**	21952	0.97
		R60	**17279**	20521	0.84
		R90	**16697**	19857	0.84
		R120	**15991**	19188	0.83
C50/60	d/5	Cold	**15248**	15870	0.96
		R60	**11370**	14498	0.78
		R90	**10971**	14044	0.78
		R120	**10488**	13565	0.77

Buckling Length L= 2.8 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**25294**	24,994	1.01
		R60	**22450**	23402	0.96
		R90	**21987**	22589	0.97
		R120	**21406**	21632	0.99
C30/37	d/10	Cold	**18850**	19080	0.99
		R60	**14775**	17035	0.87
		R90	**14428**	16575	0.87
		R120	**14002**	16023	0.87
C30/37	d/5	Cold	**13557**	13850	0.98
		R60	**9808**	12160	0.81
		R90	**9568**	11876	0.81
		R120	**9273**	11536	0.80
C50/60	0	Cold	**28775**	28479	1.01
		R60	**26107**	28114	0.93
		R90	**25341**	27025	0.94
		R120	**24380**	25898	0.94
C50/60	d/10	Cold	**21218**	21926	0.97
		R60	**17219**	20489	0.84
		R90	**16639**	19794	0.84
		R120	**15929**	19031	0.84
C50/60	d/5	Cold	**15148**	15854	0.96
		R60	**11330**	14476	0.78
		R90	**10933**	14021	0.78
		R120	**10457**	13538	0.77

Buckling Length L= 3.36 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**24775**	24254	1.02
	d/10	Cold	**18578**	18907	0.98
	d/5	Cold	**13381**	13826	0.97
C50/60	0	Cold	**28137**	27726	1.01
	d/10	Cold	**20911**	21750	0.96
	d/5	Cold	**14949**	15823	0.94

Buckling Length L= 3.6 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**24546**	23936	1.03
	d/10	Cold	**18463**	18774	0.98
	d/5	Cold	**13299**	13814	0.96
C50/60	0	Cold	**27855**	27394	1.02
	d/10	Cold	**20781**	21599	0.96
	d/5	Cold	**14856**	15810	0.94

Buckling Length L= 4 m					
660x10 Tube (S235), HD400x314 encased profile (S460M)					
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method	**Safir** (kN)	**Ratio**
C30/37	0	Cold	**24156**	23406	1.03
	d/10	Cold	**18273**	18500	0.99
	d/5	Cold	**13177**	13794	0.96
C50/60	0	Cold	**27371**	26831	1.02
	d/10	Cold	**20566**	21294	0.97
	d/5	Cold	**14718**	15783	0.93

5.5 | 508x8.8 Tube (S235 Steel Grade), HEM 260 encased profile (S355 Steel Grade)

Buckling Length L= 2.35 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**12820**
		R60	**10397**
		R90	**9604**
		R120	**8081**
C30/37	d/10	Cold	**10083**
		R60	**6862**
		R90	**6299**
		R120	**5264**
C30/37	d/5	Cold	**7476**
		R60	**4544**
		R90	**4160**
		R120	**3472**
C50/60	0	Cold	**14872**
		R60	**12434**
		R90	**11373**
		R120	**9439**
C50/60	d/10	Cold	**11565**
		R60	**8286**
		R90	**7509**
		R120	**6159**
C50/60	d/5	Cold	**8510**
		R60	**5459**
		R90	**4929**
		R120	**4032**

Buckling Length L= 2.52 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**12725**
		R60	**9765**
		R90	**9421**
		R120	**8993**
C30/37	d/10	Cold	**9594**
		R60	**6302**
		R90	**6020**
		R120	**5698**
C30/37	d/5	Cold	**7074**
		R60	**4092**
		R90	**3904**
		R120	**3683**

Buckling Length L= 2.52 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C50/60	0	Cold	**14751**
		R60	**11832**
		R90	**11268**
		R120	**10573**
C50/60	d/10	Cold	**11082**
		R60	**7755**
		R90	**7288**
		R120	**6749**
C50/60	d/5	Cold	**8126**
		R60	**5013**
		R90	**4694**
		R120	**4325**

Buckling Length L= 2.8 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**12565**
		R60	**9718**
		R90	**9367**
		R120	**8931**
C30/37	d/10	Cold	**9509**
		R60	**6272**
		R90	**5991**
		R120	**5671**
C30/37	d/5	Cold	**7019**
		R60	**4075**
		R90	**3888**
		R120	**3667**
C50/60	0	Cold	**14547**
		R60	**11728**
		R90	**11161**
		R120	**10463**
C50/60	d/10	Cold	**10983**
		R60	**7716**
		R90	**7251**
		R120	**6714**
C50/60	d/5	Cold	**8058**
		R60	**4989**
		R90	**4674**
		R120	**4306**

Buckling Length L= 3.36 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**12234**
	d/10	Cold	**9342**
	d/5	Cold	**6907**
C50/60	0	Cold	**14122**
	d/10	Cold	**10788**
	d/5	Cold	**7925**

Buckling Length L= 3.6 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**12086**
	d/10	Cold	**9273**
	d/5	Cold	**6862**
C50/60	0	Cold	**13930**
	d/10	Cold	**10708**
	d/5	Cold	**7868**

Buckling Length L= 4 m			
508x8.8 Tube (S235), HEM 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**11829**
	d/10	Cold	**9162**
	d/5	Cold	**6786**
C50/60	0	Cold	**13596**
	d/10	Cold	**10579**
	d/5	Cold	**7776**

5.6|508x8.8 Tube (S235 Steel Grade), HEB 260 encased profile (S355 Steel Grade)

Buckling Length L= 2.35 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**9996**
		R60	**7255**
		R90	**6781**
		R120	**5591**
C30/37	d/10	Cold	**7978**
		R60	**4776**
		R90	**4416**
		R120	**3595**
C30/37	d/5	Cold	**6035**
		R60	**3075**
		R90	**2828**
		R120	**2285**
C50/60	0	Cold	**12191**
		R60	**9447**
		R90	**8728**
		R120	**7101**
C50/60	d/10	Cold	**9552**
		R60	**6301**
		R90	**5735**
		R120	**4586**
C50/60	d/5	Cold	**7146**
		R60	**4017**
		R90	**3629**
		R120	**2874**

Buckling Length L= 2.52 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**9927**
		R60	**6866**
		R90	**6528**
		R120	**6111**
C30/37	d/10	Cold	**7683**
		R60	**4450**
		R90	**4172**
		R120	**3832**
C30/37	d/5	Cold	**5812**
		R60	**2806**
		R90	**2615**
		R120	**2391**

Buckling Length L= 2.52 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C50/60	0	Cold R60 R90 R120	**12097** **9043** **8480** **7790**
C50/60	d/10	Cold R60 R90 R120	**9273** **5990** **5528** **4961**
C50/60	d/5	Cold R60 R90 R120	**6921** **3750** **3429** **3056**

Buckling Length L= 2.8 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold R60 R90 R120	**9813** **6820** **6476** **6051**
C30/37	d/10	Cold R60 R90 R120	**7625** **4426** **4149** **3811**
C30/37	d/5	Cold R60 R90 R120	**5766** **2792** **2603** **2380**
C50/60	0	Cold R60 R90 R120	**11939** **8938** **8371** **7676**
C50/60	d/10	Cold R60 R90 R120	**9199** **5954** **5485** **4929**
C50/60	d/5	Cold R60 R90 R120	**6865** **3731** **3411** **3042**

Buckling Length L= 3.36 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**9578**
	d/10	Cold	**7509**
	d/5	Cold	**5680**
C50/60	0	Cold	**11612**
	d/10	Cold	**9048**
	d/5	Cold	**6760**

Buckling Length L= 3.6 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**9474**
	d/10	Cold	**7461**
	d/5	Cold	**5642**
C50/60	0	Cold	**11465**
	d/10	Cold	**8986**
	d/5	Cold	**6717**

Buckling Length L= 4 m			
508x8.8 Tube (S235), HEB 260 encased profile (S355)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**9294**
	d/10	Cold	**7377**
	d/5	Cold	**5582**
C50/60	0	Cold	**11210**
	d/10	Cold	**8880**
	d/5	Cold	**6642**

5.7|559x8.8 Tube (S235 Steel Grade), HD320x245 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold R60 R90 R120	**18903** **16602** **15184** **13046**
	d/10	Cold R60 R90 R120	**13927** **10537** **9588** **8210**
	d/5	Cold R60 R90 R120	**9854** **6828** **6212** **5308**
C50/60	0	Cold R60 R90 R120	**21360** **19081** **17341** **14715**
C50/60	d/10	Cold R60 R90 R120	**15606** **12190** **10985** **9262**
C50/60	d/5	Cold R60 R90 R120	**10985** **7842** **7070** **5945**

Buckling Length L= 2.52 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold R60 R90 R120	**18762** **16559** **15142** **13010**
C30/37	d/10	Cold R60 R90 R120	**13851** **10507** **9561** **8187**
C30/37	d/5	Cold R60 R90 R120	**9808** **6811** **6197** **5295**

Buckling Length L= 2.52 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C50/60	0	Cold	**21189**
		R60	**19037**
		R90	**17298**
		R120	**14675**
C50/60	d/10	Cold	**15514**
		R60	**12151**
		R90	**10954**
		R120	**9236**
C50/60	d/5	Cold	**10933**
		R60	**7823**
		R90	**7052**
		R120	**5930**

Buckling Length L= 2.8 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**18526**
		R60	**16485**
		R90	**15074**
		R120	**12952**
C30/37	d/10	Cold	**13724**
		R60	**10457**
		R90	**9515**
		R120	**8148**
C30/37	d/5	Cold	**9732**
		R60	**6786**
		R90	**6174**
		R120	**5275**
C50/60	0	Cold	**20903**
		R60	**18964**
		R90	**17227**
		R120	**14608**
C50/60	d/10	Cold	**15372**
		R60	**12094**
		R90	**10902**
		R120	**9191**
C50/60	d/5	Cold	**10842**
		R60	**7794**
		R90	**7022**
		R120	**5904**

Buckling Length L= 3.36 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**18038**
	d/10	Cold	**13474**
	d/5	Cold	**9580**
C50/60	0	Cold	**20305**
	d/10	Cold	**15092**
	d/5	Cold	**10659**

Buckling Length L= 3.6 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**17819**
	d/10	Cold	**13373**
	d/5	Cold	**9513**
C50/60	0	Cold	**20037**
	d/10	Cold	**14972**
	d/5	Cold	**10579**

Buckling Length L= 4 m			
559x8.8 Tube (S235), HD320x245 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**17440**
	d/10	Cold	**13200**
	d/5	Cold	**9407**
C50/60	0	Cold	**19569**
	d/10	Cold	**14783**
	d/5	Cold	**10453**

5.8|610x10 Tube (S235 Steel Grade), HD360x134 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold R60 R90 R120	**15852** **12243** **11398** **9594**
C30/37	d/10	Cold R60 R90 R120	**11983** **8024** **7429** **6211**
C30/37	d/5	Cold R60 R90 R120	**8836** **5187** **4786** **3990**
C50/60	0	Cold R60 R90 R120	**19100** **15536** **14350** **11951**
C50/60	d/10	Cold R60 R90 R120	**14154** **10211** **9355** **7696**
C50/60	d/5	Cold R60 R90 R120	**10307** **6494** **5923** **4854**

Buckling Length L= 2.52 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold R60 R90 R120	**157600** **12218** **11374** **9571**
C30/37	d/10	Cold R60 R90 R120	**11929** **8003** **7409** **6194**
C30/37	d/5	Cold R60 R90 R120	**8798** **5175** **4774** **3980**

Buckling Length L= 2.52 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C50/60	0	Cold	**18978**
		R60	**15506**
		R90	**14321**
		R120	**11925**
C50/60	d/10	Cold	**14090**
		R60	**10187**
		R90	**9333**
		R120	**7671**
C50/60	d/5	Cold	**10257**
		R60	**6478**
		R90	**5908**
		R120	**4842**

Buckling Length L= 2.8 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**15609**
		R60	**12177**
		R90	**11334**
		R120	**9534**
C30/37	d/10	Cold	**11838**
		R60	**7972**
		R90	**7377**
		R120	**6167**
C30/37	d/5	Cold	**1741**
		R60	**5153**
		R90	**4757**
		R120	**3966**
C50/60	0	Cold	**18775**
		R60	**15457**
		R90	**14274**
		R120	**11882**
C50/60	d/10	Cold	**13987**
		R60	**10148**
		R90	**9293**
		R120	**7638**
C50/60	d/5	Cold	**10183**
		R60	**6455**
		R90	**5883**
		R120	**4824**

Buckling Length L= 3.36 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**15300**
	d/10	Cold	**11669**
	d/5	Cold	**8625**
C50/60	0	Cold	**18359**
	d/10	Cold	**13780**
	d/5	Cold	**10041**

Buckling Length L= 3.6 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**15164**
	d/10	Cold	**11599**
	d/5	Cold	**8576**
C50/60	0	Cold	**18175**
	d/10	Cold	**13696**
	d/5	Cold	**9977**

Buckling Length L= 4 m			
610x10 Tube (S235), HD360x134 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**14933**
	d/10	Cold	**11480**
	d/5	Cold	**8498**
C50/60	0	Cold	**17859**
	d/10	Cold	**13553**
	d/5	Cold	**9878**

5.9|610x10 Tube (S235 Steel Grade), HD360x162 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**17168**
		R60	**13685**
		R90	**12691**
		R120	**10738**
	d/10	Cold	**12931**
		R60	**8987**
		R90	**8294**
		R120	**6982**
	d/5	Cold	**9491**
		R60	**5858**
		R90	**5397**
		R120	**4530**
C50/60	0	Cold	**20364**
		R60	**16923**
		R90	**15578**
		R120	**13039**
C50/60	d/10	Cold	**15073**
		R60	**11142**
		R90	**10185**
		R120	**8444**
C50/60	d/5	Cold	**10932**
		R60	**7168**
		R90	**6528**
		R120	**5392**

Buckling Length L= 2.8 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**16898**
		R60	**13607**
		R90	**12615**
		R120	**10672**
C30/37	d/10	Cold	**12778**
		R60	**8929**
		R90	**8243**
		R120	**6936**
C30/37	d/5	Cold	**9388**
		R60	**5824**
		R90	**5365**
		R120	**4503**

Buckling Length L= 2.52 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C50/60	0	Cold	**20231**
		R60	**16890**
		R90	**15548**
		R120	**13010**
C50/60	d/10	Cold	**15009**
		R60	**11117**
		R90	**10158**
		R120	**8424**
C50/60	d/5	Cold	**10879**
		R60	**7151**
		R90	**6513**
		R120	**5382**

Buckling Length L= 2.8 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**16898**
		R60	**13607**
		R90	**12615**
		R120	**10672**
C30/37	d/10	Cold	**12778**
		R60	**8929**
		R90	**8243**
		R120	**6936**
C30/37	d/5	Cold	**9388**
		R60	**5824**
		R90	**5365**
		R120	**4503**
C50/60	0	Cold	**20011**
		R60	**16835**
		R90	**15494**
		R120	**12961**
C50/60	d/10	Cold	**14893**
		R60	**11070**
		R90	**10119**
		R120	**8384**
C50/60	d/5	Cold	**10805**
		R60	**7126**
		R90	**6489**
		R120	**5359**

Buckling Length L= 3.36 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**16554**
	d/10	Cold	**12594**
	d/5	Cold	**9266**
C50/60	0	Cold	**19559**
	d/10	Cold	**14677**
	d/5	Cold	**10647**

Buckling Length L= 3.6 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**16403**
	d/10	Cold	**12518**
	d/5	Cold	**9213**
C50/60	0	Cold	**19359**
	d/10	Cold	**14587**
	d/5	Cold	**10584**

Buckling Length L= 4 m			
610x10 Tube (S235), HD360x162 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	**N_{rd}** (kN) simplified method
C30/37	0	Cold	**16145**
	d/10	Cold	**12388**
	d/5	Cold	**9118**
C50/60	0	Cold	**19015**
	d/10	Cold	**14434**
	d/5	Cold	**10478**

5.10 | 660x10 Tube (S235 Steel Grade), HD400x216 encased profile (S460M Steel Grade)

Buckling Length L= 2.35 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**21130**
		R60	**17580**
		R90	**17119**
		R120	**16538**
C30/37	d/10	Cold	**15773**
		R60	**11510**
		R90	**11159**
		R120	**10730**
C30/37	d/5	Cold	**11453**
		R60	**7523**
		R90	**7280**
		R120	**6995**
C50/60	0	Cold	**24874**
		R60	**21420**
		R90	**20666**
		R120	**19722**
C50/60	d/10	Cold	**18279**
		R60	**14082**
		R90	**13500**
		R120	**12784**
C50/60	d/5	Cold	**13116**
		R60	**9103**
		R90	**8705**
		R120	**8219**

Buckling Length L= 2.52 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**21032**
		R60	**17547**
		R90	**17085**
		R120	**16501**
C30/37	d/10	Cold	**15701**
		R60	**11483**
		R90	**11133**
		R120	**10705**
C30/37	d/5	Cold	**11403**
		R60	**7506**
		R90	**7267**
		R120	**6978**

Buckling Length L= 2.52 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C50/60	0	Cold	**24721**
		R60	**21382**
		R90	**20627**
		R120	**19683**
C50/60	d/10	Cold	**18195**
		R60	**14055**
		R90	**13469**
		R120	**12749**
C50/60	d/5	Cold	**13064**
		R60	**9087**
		R90	**8685**
		R120	**8205**

Buckling Length L= 2.8 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**20813**
		R60	**17492**
		R90	**17029**
		R120	**16441**
C30/37	d/10	Cold	**15596**
		R60	**11439**
		R90	**11095**
		R120	**10667**
C30/37	d/5	Cold	**11326**
		R60	**7479**
		R90	**7242**
		R120	**6953**
C50/60	0	Cold	**24467**
		R60	**21320**
		R90	**20564**
		R120	**19614**
C50/60	d/10	Cold	**18072**
		R60	**14001**
		R90	**13417**
		R120	**12694**
C50/60	d/5	Cold	**12974**
		R60	**9054**
		R90	**8654**
		R120	**8175**

Buckling Length L= 3.36 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**20411**
	d/10	Cold	**15381**
	d/5	Cold	**11177**
C50/60	0	Cold	**23947**
	d/10	Cold	**17821**
	d/5	Cold	**12800**

Buckling Length L= 3.6 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**20235**
	d/10	Cold	**15293**
	d/5	Cold	**11116**
C50/60	0	Cold	**23711**
	d/10	Cold	**17711**
	d/5	Cold	**12736**

Buckling Length L= 4 m			
660x10 Tube (S235), HD400x216 encased profile (S460M)			
Concrete	**Excentricity**	**Fire**	N_{rd} (kN) simplified method
C30/37	0	Cold	**19935**
	d/10	Cold	**15144**
	d/5	Cold	**11012**
C50/60	0	Cold	**23325**
	d/10	Cold	**17531**
	d/5	Cold	**12613**

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