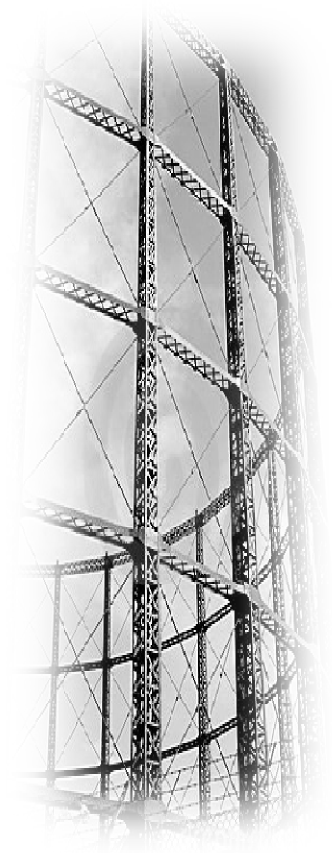
CRITICAL TEMPERATURE OF STEEL FRAME WITH JOINT FLEXIBILITY INCREASING IN FIRE



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COST Action TU0904
Integrated Fire Engineering and Response

RESEARCH OBJECTIVE -THE AUTHOR'S SUGGESTION

To take into consideration the effect, neglected up to the present, that the joint flexibility increases when the steel temperature growths

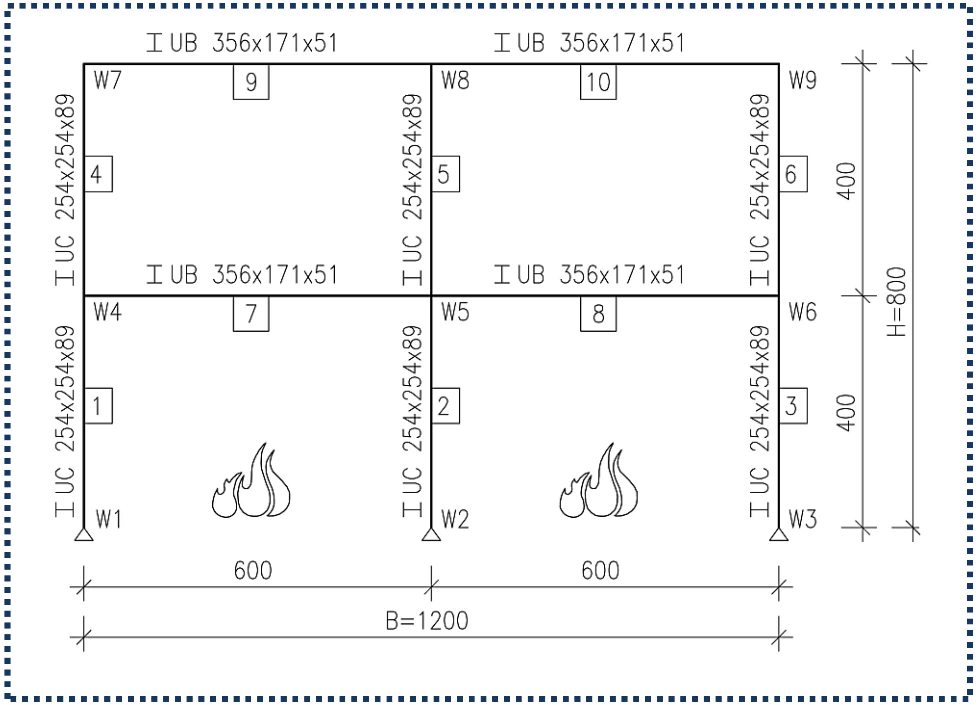
RESEARCH OBJECTIVE

Reliable evaluation of fire resistance for steel-framed load-bearing structure

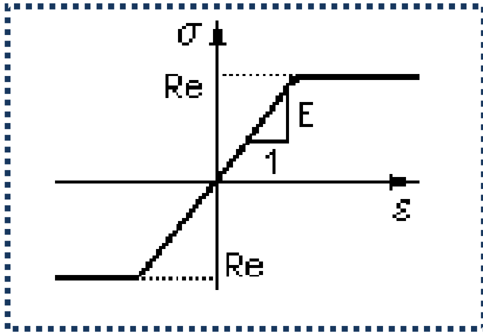
FOUNDATIONS OF THE NUMERICALL MODELLING

AUTODESK ROBOT STRUCTURAL ANALYSIS 2010

Bar elements



Material model



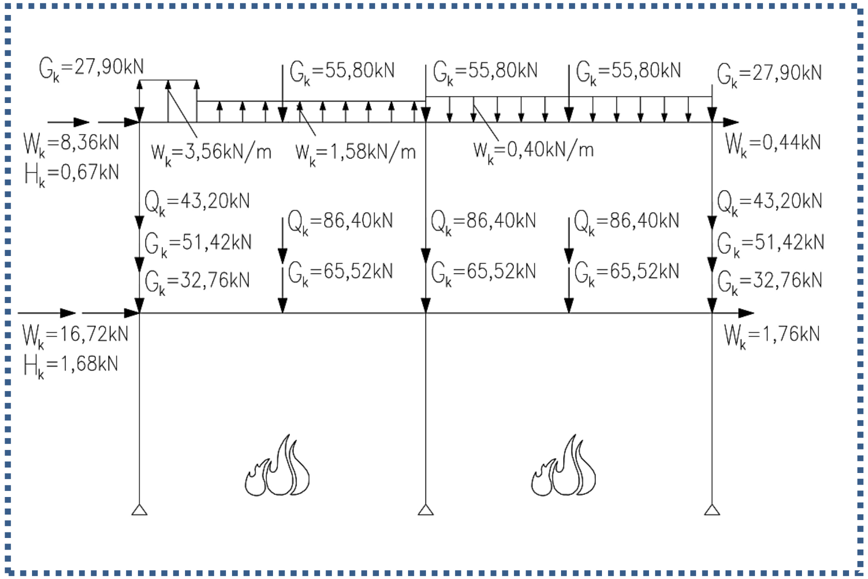
$f_y = 412MPa$ $E_a = 195GPa$

$f_{y,\Theta} = k_{y,\Theta} f_y$ $E_{a,\Theta} = k_{E,\Theta} E_a$

FOUNDATIONS OF THE NUMERICALL MODELLING

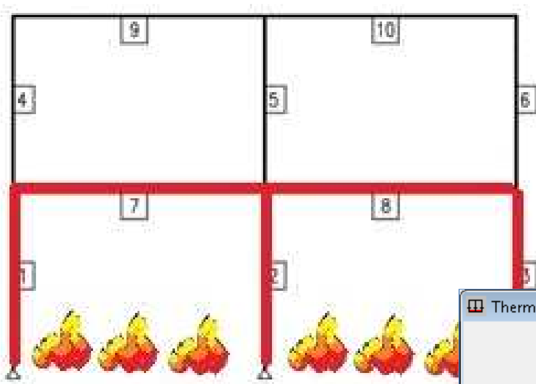
AUTODESK ROBOT STRUCTURAL ANALYSIS 2010

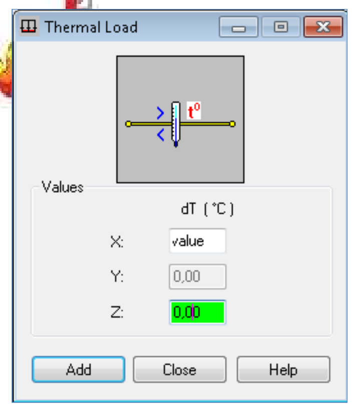
Loads arrangement



$G_k + Q_k \cdot 0{,}6 + W_k \cdot 0{,}2$ + temperature

Fire scenario

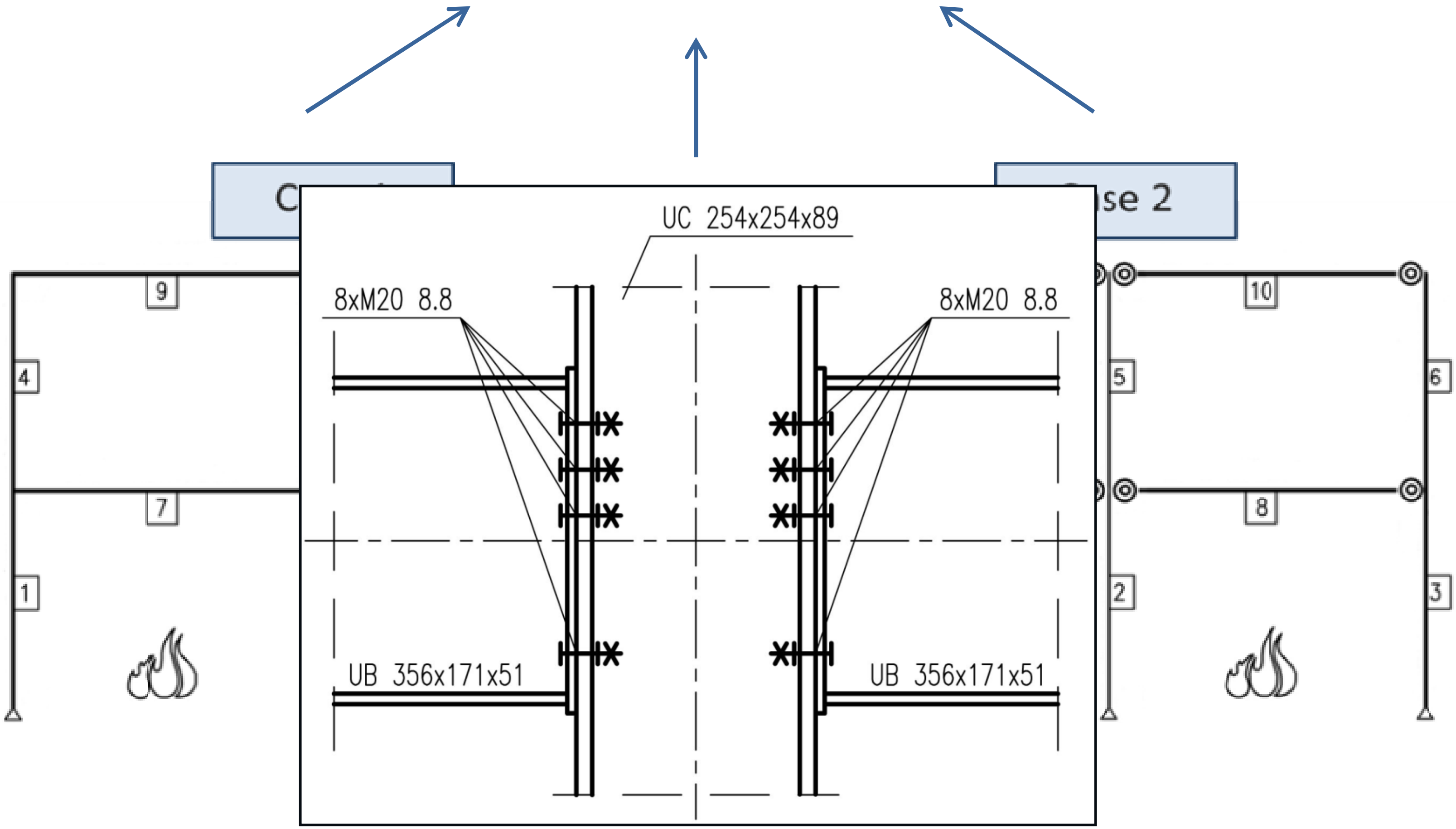




$f_{y,\Theta}$, $E_{a,\Theta}$

FOUNDATIONS OF THE NUMERICALL MODELLING

AUTODESK ROBOT STRUCTURAL ANALYSIS 2010



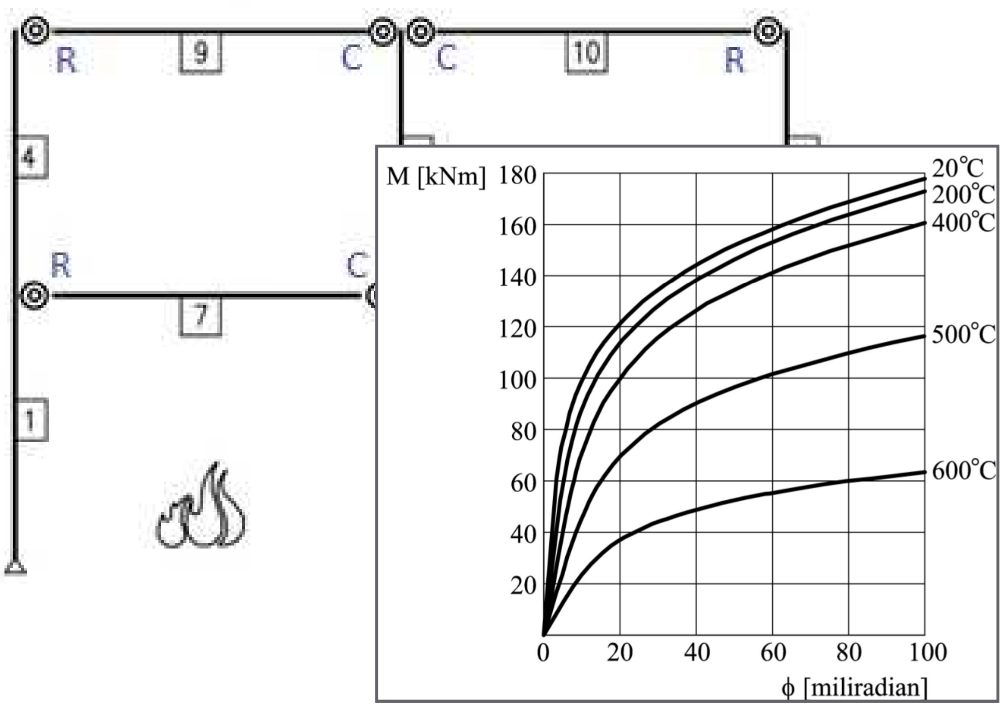
FOUNDATIONS OF THE NUMERICALL MODELLING

AUTODESK ROBOT STRUCTURAL ANALYSIS 2010

Joints modelling

Nonlinearity

- level of a whole member
- level of a member cross-section
- level of the body point



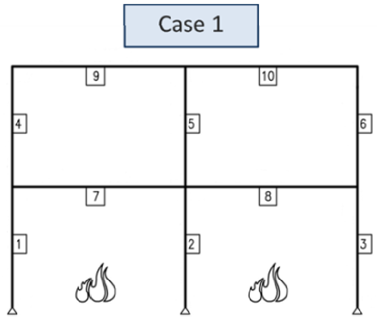
Source: Al-Jabri K.S., Burgess I.W., Lennon T., Plank R.J.: Moment-rotation-temperature curves for semi-rigid joints, Journal of Constructional Steel Research, 61, 2005, pp. 281-303.

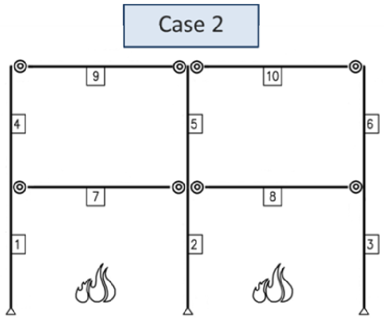
DESIGN TECHNIQUES

Methods of the analysis

First-order analysis

member buckling-lengths are specified





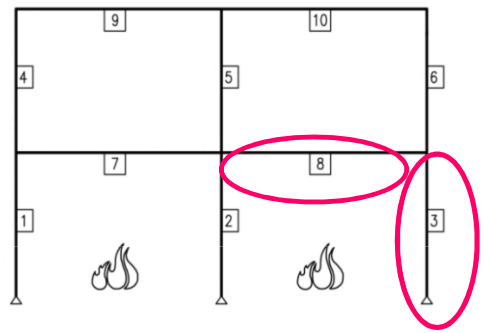
Second-order analysis

simplified second-order analysis

bending moments and internal forces are amplified without the specification of member buckling-lengths

second - order analysis performed by Autodesk Robot Structural Analysis

LIMIT STATE FORMULA



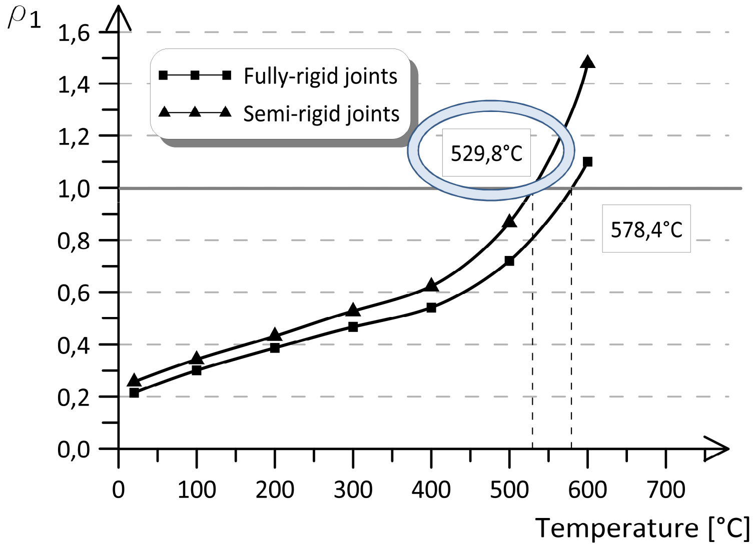
$$\rho_1 = \rho(\Theta_{a,cr}) = \frac{N^{\Theta}_{fi,Ed}}{\chi^{\Theta}_{\min,fi} A k^{\Theta}_{y,\Theta} \dfrac{f_y}{\gamma_{M,fi}}} + \frac{k^{\Theta}_{y} M^{\Theta}_{y,fi,Ed}}{W_y k^{\Theta}_{y,\Theta} \dfrac{f_y}{\gamma_{M,fi}}} = 1$$

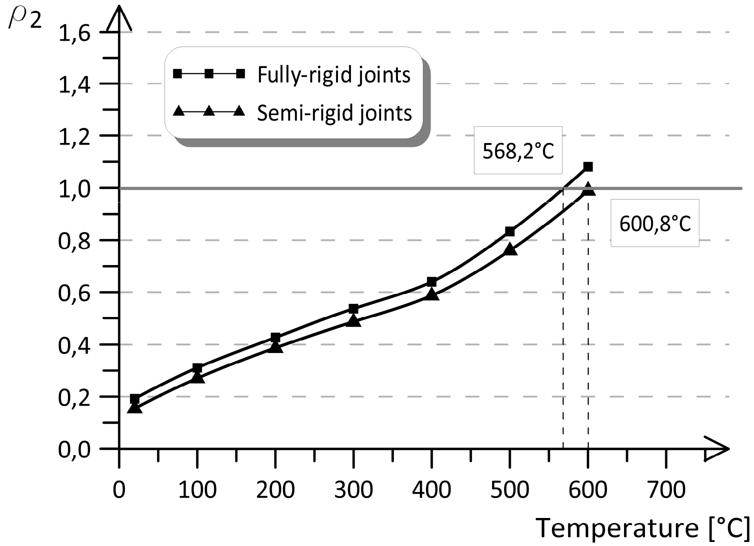
$$\rho_2 = \rho(\Theta_{a,cr}) = \frac{N^{\Theta}_{fi,Ed}}{\chi^{\Theta}_{z,fi} A k^{\Theta}_{y,\Theta} \dfrac{f_y}{\gamma_{M,fi}}} + \frac{k^{\Theta}_{LT} M^{\Theta}_{y,fi,Ed}}{\chi^{\Theta}_{LT,fi} W_y k^{\Theta}_{y,\Theta} \dfrac{f_y}{\gamma_{M,fi}}} = 1$$

Ultimate limit state is reached when: $\rho = \min(\rho_1 , \rho_2) = 1{,}0$

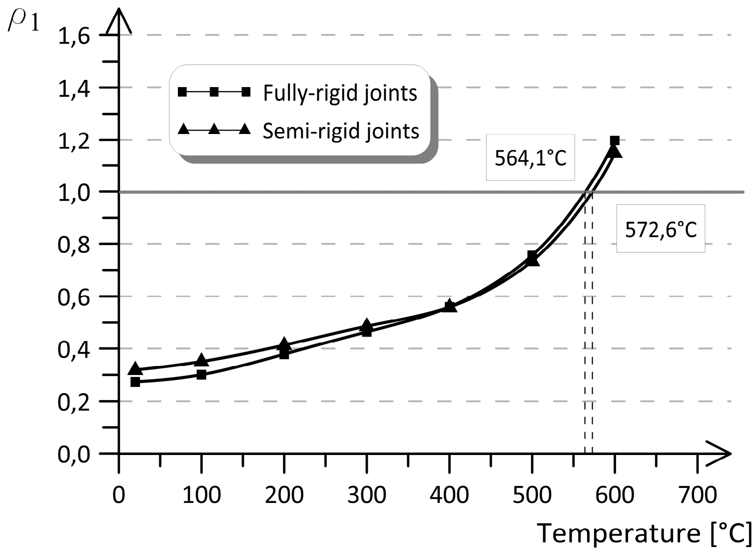
FIRST-ORDER ANALYSIS

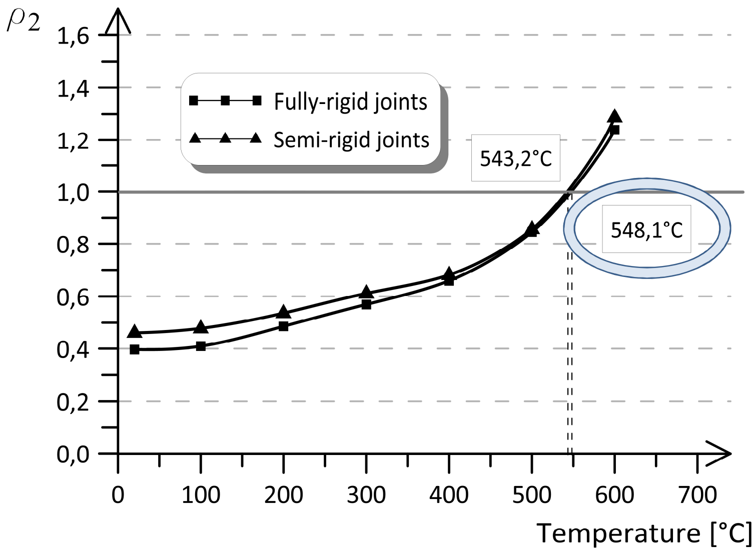
Column number 3





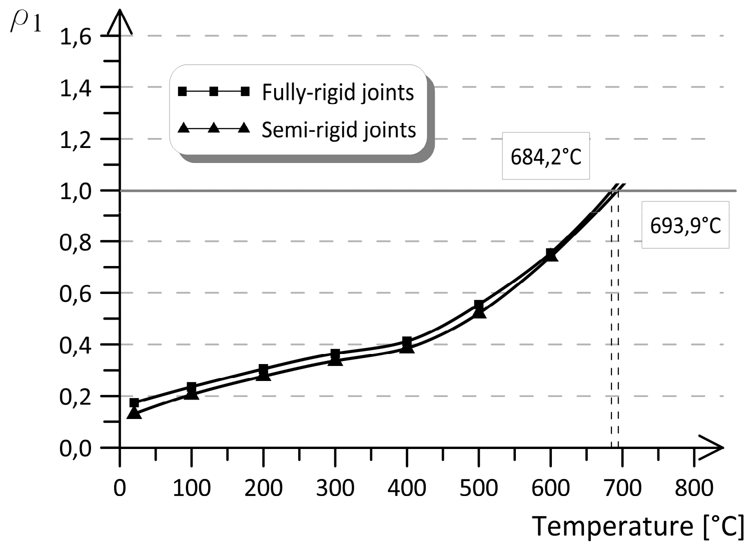
Beam number 8

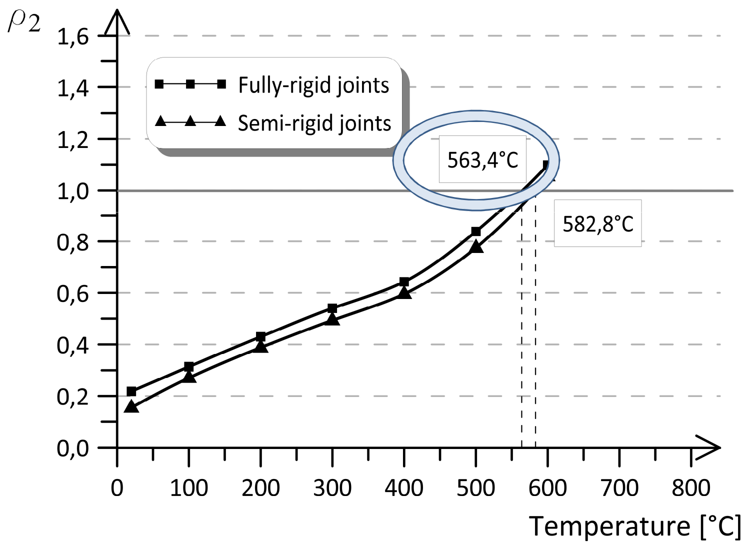




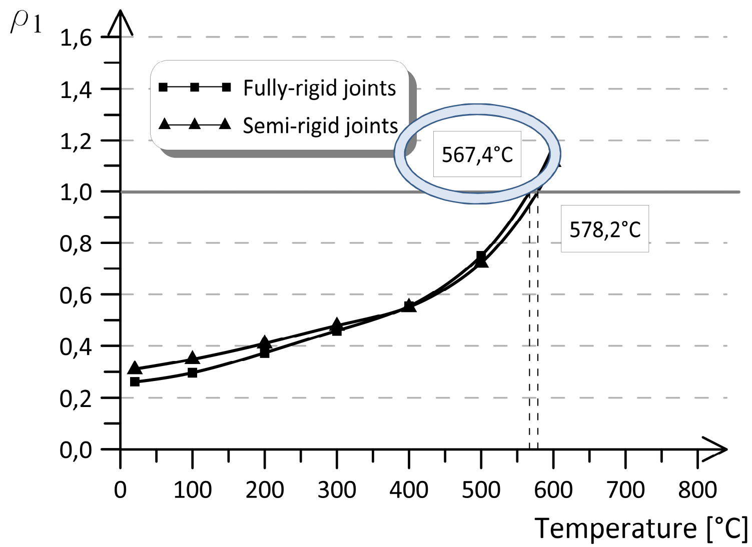
SIMPLIFIED SECOND-ORDER ANALYSIS

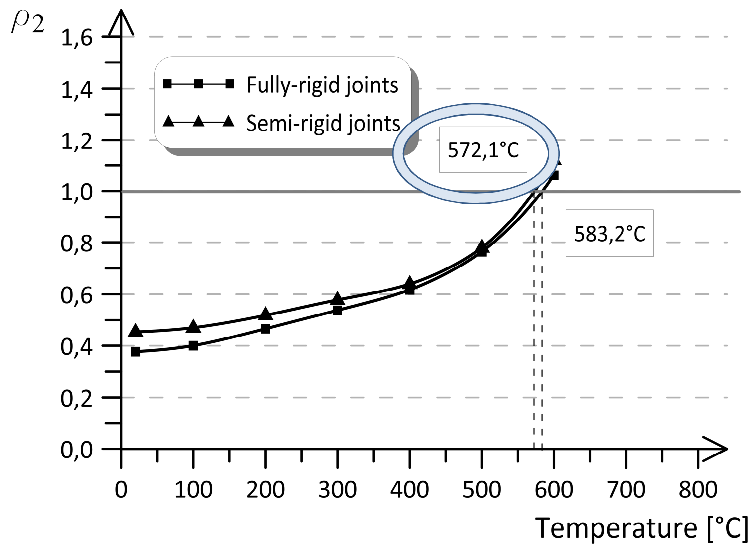
Column number 3





Beam number 8





CONCLUSIONS

- If the simplified second-order approach is used in the frame analysis, then the critical temperature evaluations are obtained, being less restrictive in relation to those taken from the application of the classical first-order theory.
- If the first order frame analysis is performed then considering the real joint flexibility under fire gives, in general, the assessments of conclusive critical temperature being more careful in comparison with those resulting from the acceptance of the full joint stiffness, independent on the real steel temperature.
- When the second order analysis is carried out, taking into account the real joint flexibility under fire, it leads to the assessments of critical temperature being less restrictive both in relation to the column as well as in relation for beam. In such design approach the member effective buckling length is not specified at all; whereas, its specification is of the great importance when the classical first order analysis is performed.

THANK YOU FOR YOUR ATTENTION