International Conference
Applications of Structural Fire Engineering
Prague 19-20 February, **2009**

NUMERICAL ANALYSIS OF CONCRETE COLUMNS IN FIRE

[1]Miguel Gonçalves, [2]Jean Marc-Franssen
[1]Vitor Abrantes & [3]João Paulo C. Rodrigues
Depart. of Civil Eng. of Faculty of Engineering of the University of Porto, Portugal[1], University of Liège, ArGEnCo, Liège, Belgium[2] and Depart. of Civil Eng. of Faculty of Sciences and Technology of the University of Coimbra, Portugal [3]

❑ OBJECTIVES

- The evaluation of the behavior of reinforced concrete (RC) columns in fire by means of simplified and the advanced calculation models.
- Proposal of a simplified calculation method (SimFIRc) for the analysis of RC columns in fire.
- The results of SimFIRc are compared with the ones obtained with an advanced calculation method, the finite element model SAFIR, developed by J. M. Franssen, in University of Liège, in Belgium.

❑ CALCULATION PROCESS

- The SimFIRc model was developed for numerical analysis in fire of RC columns subjected to second order effects. It is based in the method of the nominal stiffness, described in EN 1992-1-1, for RC elements at room temperature, with the necessary adaptations for high temperatures .
- The second order effect is calculated through equation (1) which is a function of the first order moment of the critical load and the applied axial load:

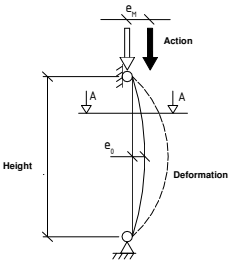
$$M_{Ed} = M_{0Ed} \cdot (1 + \beta / (N_B / N_{Ed} - 1)) \quad (1)$$

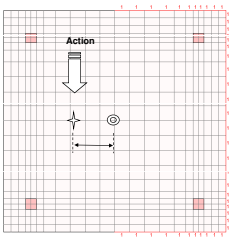
❑ MECHANICAL MODEL

- The interaction diagram can be created with the equations of equilibrium (2) for a certain instant of time:

$$M_{Rd,fi} = \sum_{i=1}^{3} b_{fi}\left[a_i \cdot f_{cd,fi}(\theta_i, \varepsilon_{c,i})\right] \cdot \left[\frac{h}{2} - a_z - \frac{a_i}{2} - a_n\right] - \sum_{k=4}^{6} b_{fi}\left[a_k \cdot f_{cd,fi}(\theta_k, \varepsilon_{c,k})\right] \cdot \left[-\frac{a_k}{2} - a_l\right] + \sum_{j=1}^{m(armad)} A_{sj} \cdot f_{sy,fi}(\theta_j, \varepsilon_{s,j}) \cdot z_j \quad \begin{matrix} n<i \\ l<k \end{matrix}$$

$$N_{Rd,fi} = \sum_{i=1}^{6} b_{fi} \cdot a_i \cdot f_{cd,fi}(\theta_i, \varepsilon_{c,i}) + \sum_{j=1}^{m} A_{sj} \cdot f_{sy,fi}(\theta_j, \varepsilon_{s,j}) \quad (2)$$





❑ EXAMPLES

- Figure 1 presents the loadbearing capacity obtained by the SimFIRc and SAFIR for 30, 60, 90 and 120 minutes of a 8m tall RC column, with a cross-section of 0.3 x 0.3 m², and a distance from the axis of the reinforcement bars to the surface of a=4cm, considering steel reinforcement bars of dia. 4ϕ12, 4ϕ6 and 4ϕ25.
- Figure 2 presents the loadbearing capacity for 30, 60, 90 and 120 minutes of a RC column, with a cross-section of 0.3x0.3m², reinforcement bars with dia. 4ϕ25, a=4cm, and 4, 8 and 12m tall.

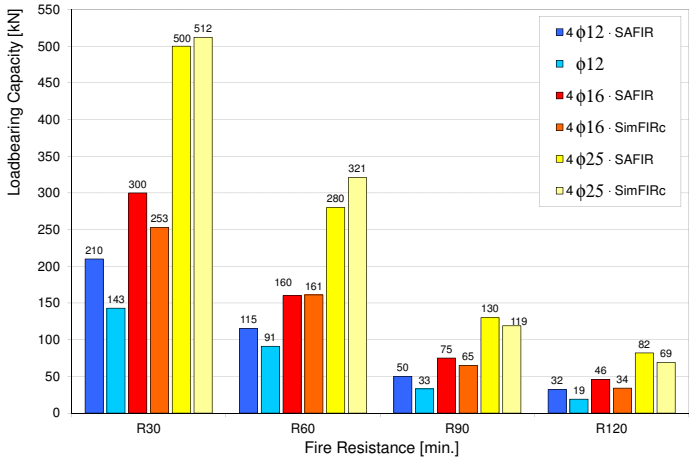


Fig. 1 –Loadbearing capacity of a RC column 8m tall for different fire resistances

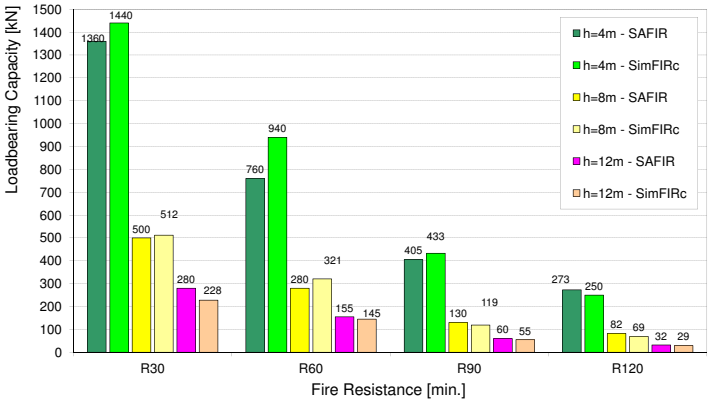


Fig. 2 –Loadbearing capacity of a RC columns with 4, 8 and 12m tall

❑ CONCLUSIONS

- The formulation of EN 1992-1-1 indicated for calculation of the resistance of concrete sections at room temperature was adapted by the author[1] for high temperatures (SimFIRc), being the results at the level of the ones obtained with SAFIR.

Universidade do Porto FEUP Faculdade de Engenharia
Faculdade de Engenharia da Universidades do Porto
Departamento de Engenharia Civil - Secção de Construções Civis. Rua Dr. Roberto Frias, s/n, 4200-465 Porto. PORTUGAL
Telef.: +351 22 508 21 16 Fax: 22 508 19 40

ArGEnCo
SE - Bois, Béton, Feu
Département ArGEnCo
Sart Tilman B52
4000 Liège 1 Belgique
Tél : +32 4 366 92 65
Fax : +32 4 366 95 34

CIEC – Center for Research in Civil Engineering
Research Group on Fire Safety Engineering.
Departamento de Engenharia Civil da Faculdade Ciências e Tecnologia da Univ. Coimbra. Rua Luís Reis Santos. 3030-788 Coimbra. PORTUGAL.
Telef: +351 239 797100. Fax: +351 239 797123.