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FIRE RESISTANCE TESTS ON CONCRETE COLUMNS WITH RESTRAINED THERMAL ELONGATION

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❑ OBJECTIVE

The main objective of the research project presented in this paper was to study the fire behaviour of reinforced concrete columns with restrained thermal elongation (fig. 1 and 2).

❑ EXPERIMENTAL PROGRAMME

The variables studied in the experimental tests were the longitudinal steel reinforcement ratio, the slenderness of the column and the stiffness of the surrounding structure to the column (table 1).

Table 1 – Parameters of the tested columns

Column Reference	Cross section		Longitudinal Reinforcement		Reinforcement Ratio A_s/A_c [%]
	h × b [mm] × [mm]	Area, A_c [mm²]	Number and Diameter	Area, A_s [mm²]	
P16-10-k13	160 × 160	25600	4ϕ10	314,2	1,23
P16-10-k45	160 × 160	25600	4ϕ10	314,2	1,23
P16-16-k13	160 × 160	25600	4ϕ16	804,2	3,14
P16-16-k45	160 × 160	25600	4ϕ16	804,2	3,14
P25-16-k13	250 × 250	62500	4ϕ16	804,2	1,27
P25-16-k45	250 × 250	62500	4ϕ16	804,2	1,27
P25-25-k13	250 × 250	62500	4ϕ25	1963,5	3,14
P25-25-k45	250 × 250	62500	4ϕ25	1963,5	3,14

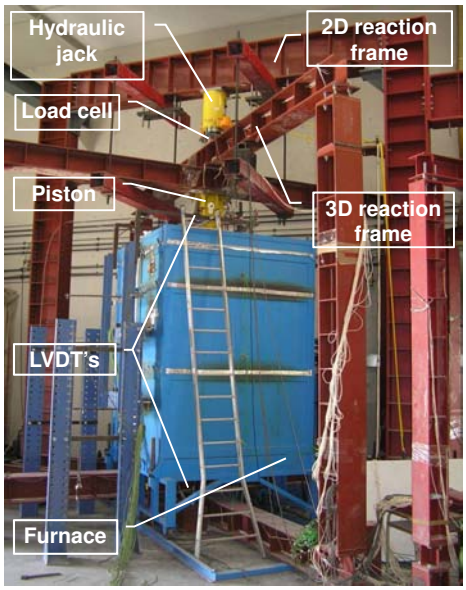

Fig.1 – Experimental set-up

❑ TEST RESULTS

Increasing the stiffness of the surrounding structure from 13 kN/mm to 45 kN/mm lead to an increasing of the restraining forces from 27,4% to 35,4%, for columns 160mm × 160mm , and from 7,5% to 13,5% for columns 250mm × 250mm, respectively for the smaller and higher value of the steel reinforcement ratio (fig. 3).

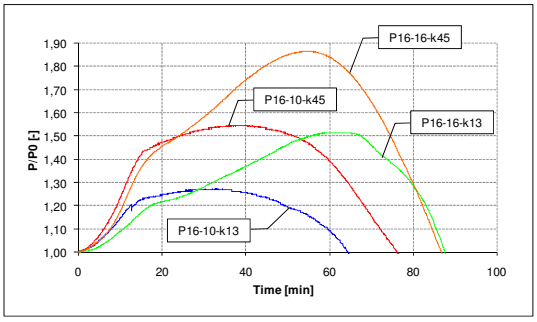

Fig.3 – Restraining forces - columns 160mm × 160 mm

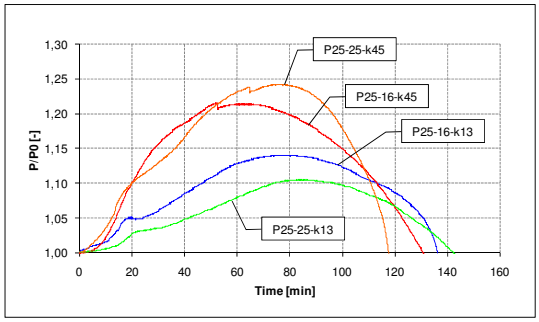

Fig.4 – Restraining forces - columns 250mm × 250mm

Increasing the steel reinforcement ratio lead to:

- increasing on the fire resistance of 29,9% and 13,4%, for columns 160mm ×160 mm, and an increasing of 5,4% and a reduction of 10,4%, for columns 250mm × 250mm, respectively for the stiffness 13 kN/mm and 45 kN/mm;
- increasing on the restraining forces of 23,8% for stiffness 13 kN/mm and 31,7% for stiffness 45 kN/mm, in columns 160×160 mm² while for columns 250mm ×250 mm a reduction of 3,3% for stiffness 13 kN/mm and an increase of 2,7% for stiffness 45 kN/mm was observed (fig. 4).

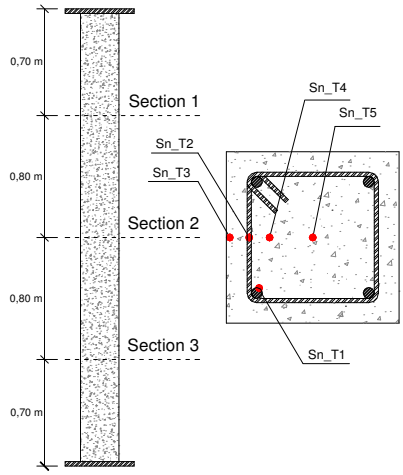

Fig.2 – Location of the thermocouples (n indicates the section number)

❑ CONCLUSIONS

- The increasing of the longitudinal reinforcement ratio has a beneficial effect on the fire resistance of the columns, however the use of bars with 25 mm diameter contradict this tendency;
- The increasing of the stiffness of the surrounding structure lead to an increase on the restraining forces;
- The increasing of slenderness leads to a reduction on the fire resistance, being that reduction more significant for columns with less longitudinal reinforcement ratio;
- Increasing the thermal restraint a general tendency in reduction of the fire resistance is observed;
- In all tests the occurrence of spalling was noticed, being verified the detachment of superficial layers of concrete, however just in one test where the column was subjected to higher serviciability load, presented explosive spalling;
- The spalling was observed mainly in the compressed zones and edges of the columns.

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