Application of Structural Fire Engineering, 19-20 February 2009, Prague, Czech Republic

DIFFERENT TYPES OF PRE-STRESSED HOLLOW CORE PANELS

and their fire resistance according to Eurocodes

Radim Čajka, Pavlína Matečková

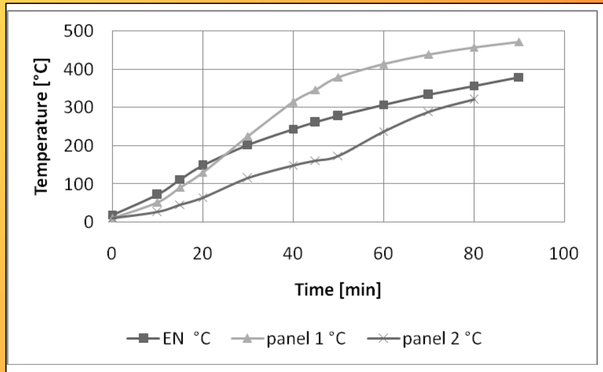
VSB – Technical University Ostrava, Faculty of Civil Engineering, Ostrava, Czech Republic

Heat – exposure model

Air in hollow core

Inverse analysis was elaborated so that temperatures measured during the fire resistance testing and calculated temperatures respond together.

Comlex process of convection in hollow cores is defined in a simplyfied way through substitutive coefficient of thermal conductivity.

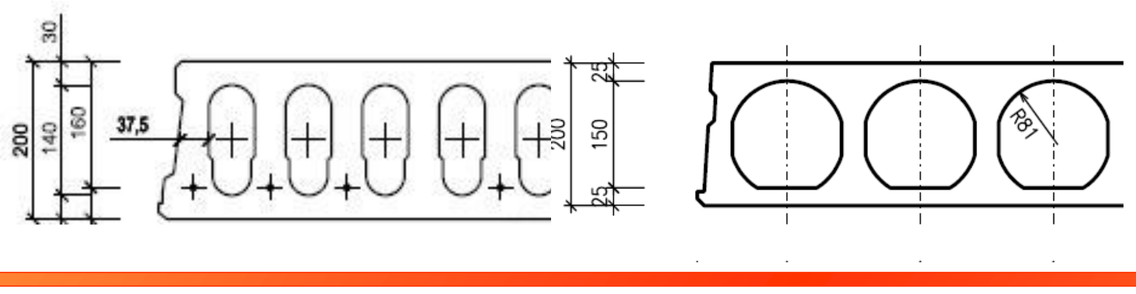


	Bottom of hollow			Unexposed side		
	calculation	measurment		calculation	measurment	
Time	EN	panel 1	panel 2	EN	panel 1	panel 2
min	°C	°C	°C	°C	°C	°C
0	20	12	11	20	11	11
15	102	92	46	21	12	11
30	224	225	115	32	14	15
45	318	347	162	55	23	34
60	390	413	238	84	33	49
90	495	472		148	53	

Measured and calculated temperatures, bottom of hollow, Elematic 200 mm

Different types of panel

Temperatures in reinforcement and temperatures on unexposed side are compared for pre-stressed panel, thickness 200 mm, type Echo with oval hollow core and type Elematic with circle hollow core.



Different types of pre-stressed panel, Echo 200 mm, Elematic 200 mm

	Echo		Elematic	
Time	reinfor.	unexposed	reinfor.	unexposed
min	C	C	C	C
0	20	20	20	20
15	119	21	118	25
30	246	31	261	55
45	333	57	362	102
60	396	90	438	151
75	447	126	498	196
90	489	160	549	237

Type of panel	Elematic		Echo	
Reinforcement	5 x cable 9,3 mm		6 x cable 9,3 mm	
Weight [kg.m^{-2}]	240		315	
Concrete cover [mm]	35	40	35	40
Bearing capacity [kNm]	57,5	55,7	68,56	66,41
Fire resistance [min]	40	50	45	60

Temperatures in cross-section, Echo 200 mm, Elematic 200 mm

Comparison of different types of panel

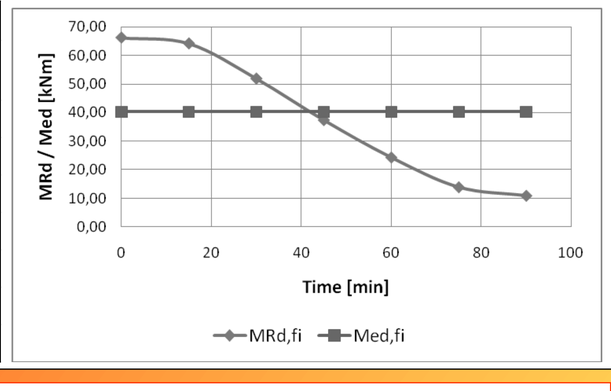
Temperatures both in reinforcement and on unexposed side are more favourable for panel Echo due to higher portion of concrete in cross-section. Insulation limit state is 90 minutes for panel type Echo and 60 minutes for panel type Elematic.

Structural – response model

Load bearing capacity and fire resistance

Mechanical response of pre-stressed cross-section was analysed on the basis of published dependences of concrete and pre-stressing steel mechanical characteristics on temperature. Fire resistance 40 minutes of pre-stressed panel Elematic is determined according to final version of Eurocode 2. As the thermal properties of concrete and parameters of heat transfer are more favourable according to P ENV version of Eurocode, the fire resistance according to P ENV version was stated to value 45 minutes. Laboratory testing of fire resistance was quitted for panel 1 after 65 minutes and for panel 2 after 74 minutes, fire resistance on the basis of laboratory testing was settled 45 minutes.

Time	reinforcement		concrete		$M_{Rd,fi}$	$M_{ed,fi}$
min	Temp C	Strength MPa	Temp C	Strength MPa	kNm	kNm
0	20	1593	20	41,67	66,24	40,22
15	118	1543	25	41,67	64,19	40,22
30	261	1241	55	41,67	51,91	40,22
45	362	889	102	41,64	37,39	40,22
60	438	575	151	40,62	24,31	40,22
75	498	328	196	39,68	13,91	40,22
90	549	257	237	38,04	10,92	40,22



Fire resistance, Elematic 200 mm

Decrease of pre-stressing force

Decrease of pre-stressing force during the fire influences especially deformation of particular panel. Owning to irregular decrease of pre-stressing force and reinforcement strength the bearing capacity of pre-stressing panel could be exceeded. Decrease of pre-stressing force in fire resistance calculation was considered according to *Eq:*

Time	Temp.	ε	E	ΔP	P
min	C		Gpa	kN	kN
0	20	0,000000	195	0,00	284,76
15	118	0,001034	190	50,80	233,96
30	261	0,002675	177	122,38	162,38
45	362	0,003946	163	166,36	118,40
60	438	0,004946	138	176,36	108,40
75	498	0,005767	106	158,74	126,02
90	549	0,006490	93	155,94	128,82

Decrease of pre-stressing force, Elematic 200 mm

$$P(\theta) = A_s . \varepsilon_s(\theta) . E_s(\theta)$$

$P(\theta)$ pre-stressing force versus temperature

A_s area of reinforcement

$\varepsilon_s(\theta)$ specific thermal elongation of reinforcement versus temperature

$E_s(\theta)$ modulus of elasticity of reinforcement versus temperature

SUMMARY

In the paper the fire resistance of pre-stressed hollow core panels is analysed. Calculation of transient thermal array in cross-section is based on inverse analysis and measured and calculated temperatures confrontation. Field of temperature and final fire resistance is compared for different types of pre-stressed panel, Echo 200 mm with oval hollow core and Elematic 200 mm with circle hollow core. Calculated temperatures and final fire resistance are more favourable for panel Echo due to higher portion of concrete in cross-section. Concrete cover was also analysed. Higher concrete cover responds to mildly decrease of load bearing capacity for permanent design situation but significant increase of fire resistance. Decrease of pre-stressing force is also mentioned.