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HIERARCHICAL APPROACH TO THE CALCULATION ASSESSMENT OF FIRE RESISTANCE OF REINFORCED CONCRETE BEAMS

The study on fire resistance assessment was carried out on a reinforced concrete beam with a cross-sectional area of 300x600 mm, rectangular in cross-section, with a single two-row reinforcement: 4Ø22A400S. The beam was made of concrete of class C30/35, the distance to the axis of the lower level of reinforcement was 50 mm, to the axis of the upper level of reinforcement - 120 mm, the level of the operating load was 0.5 of the destructive load. The heating conditions were taken from three sides. The compliance of the fire resistance class of the studied structure with R120 was checked using the tabular and zone methods.

Using the tables with the minimum dimensions and distances from the reinforcement axis of freely supported beams made of unstressed and prestressed reinforced concrete [6, 7], it was found that for a reinforced concrete beam width of 300 mm, the minimum distance from the reinforcement axis should be at least 55 mm (Table 1). Thus, the insufficient distance from the axis of the first row of reinforcement does not allow the studied structure to meet the fire resistance class R120.

Table 1

Normalized fire resistance	Minimum dimensions, mm						
	Possible combinations a and b_{min}, where a – the average distance to the reinfocement axis, and b_{min} – beam width				Beam wall thickness, b_w		
					Class WA	ClassWB	Class WC
R30	b_{min}=80 a=25	120 20	160 15*	200 15*	80	80	80
R60	b_{min}=120 a=40	160 35	200 30	300 25	100	80	100
R90	b_{min}=150 a=50	200 45	300 40	400 35	110	100	100
R120	b_{min}=200 a=65	240 60	300 55	500 50	130	120	120
R180	b_{min}=240 a=80	300 70	400 65	600 60	150	150	140
R240	b_{min}=280 a=90	350 80	500 75	700 70	170	170	160

When performing calculations using the zone method, a mechanical calculation was performed that takes into account the reduced cross-section of the investigated reinforced concrete beam and the reduced mechanical properties of the reinforcement under the influence of the standard fire temperature mode. The load-bearing capacity of the investigated structure in fire for 120 min (MRd,fi=96.6 kNm) is greater than the effective load in fire (MEd,fi=91.5 kNm). The condition of fire resistance is met, i.e. according to the zone method it was found that the reinforced concrete beam corresponds to the fire resistance class R 120, but the limit of compliance of the bearing capacity of the structure is close to the level of the effective load, while this reinforced concrete beam is loaded with 50% of the destructive indicator.

The refined calculation method for assessing the fire resistance of the studied reinforced concrete beam was performed by computational experiments using the finite element method [10].

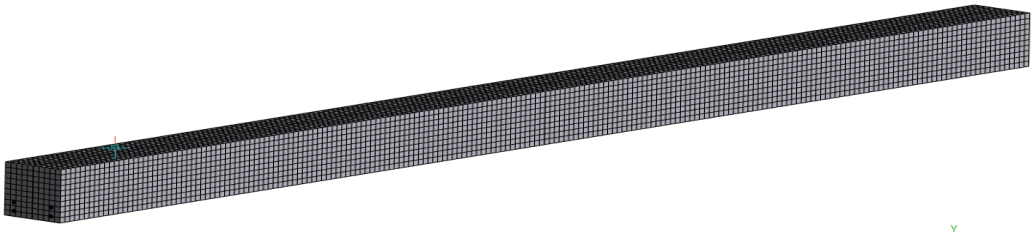

Figure 1. Finite element model of a reinforced concrete beam with a rectangular cross-section and a single double-row reinforcement with a cross-section of 300 mm x 600 mm.

According to the results of the computational experiment, it was found that the critical deflection of the reinforced concrete beam is 260.12 mm and occurs at 139.15 minutes of the computational experiment, which is a sign of the onset of the fire resistance boundary state in terms of loss of bearing capacity [4].

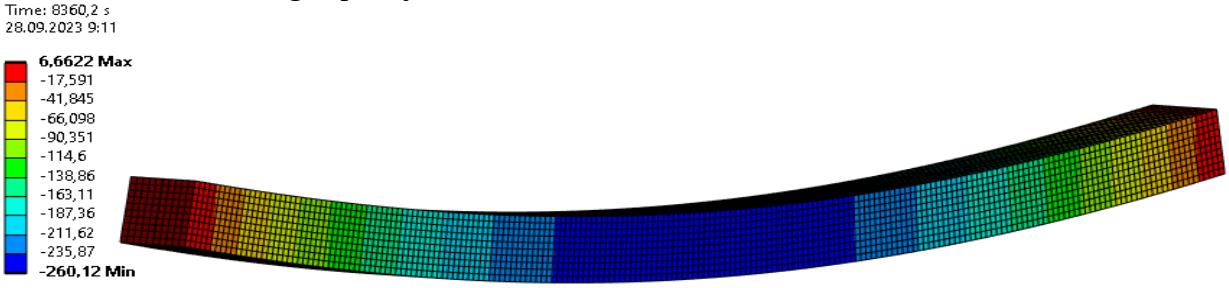

Figure 2 - Deflection (mm) of a reinforced concrete beam with a section of 300 mm x 600 mm at 139.15 minutes of fire exposure.

Thus, due to the hierarchical approach, it is possible to assess fire resistance using methods of different accuracy and complexity, which affects the obtaining of reliable results of fire resistance indicators of such reinforced concrete beams.

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