Action TU0904
Integrated Fire Engineering and Response

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University "Ss. Cyril and Methodius" Faculty of Civil Engineering, Skopje, Macedonia

Axial Restrain Effects on Fire Resistance of Statically Indeterminate RC Beams

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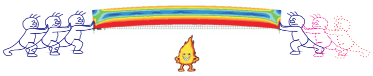
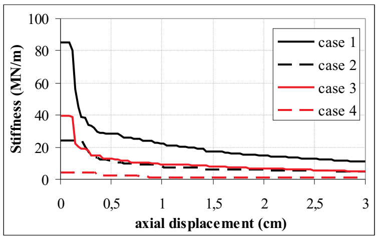
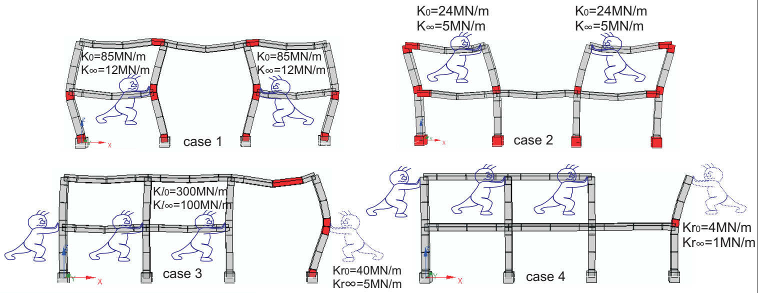
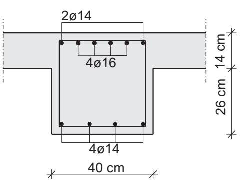
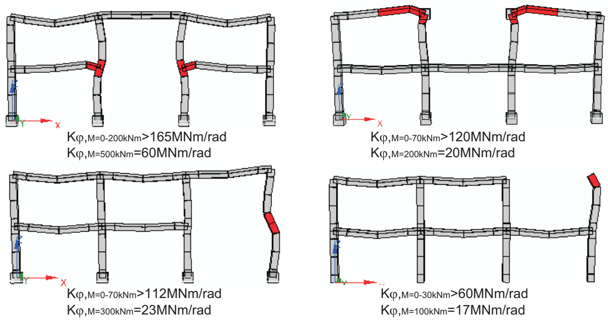


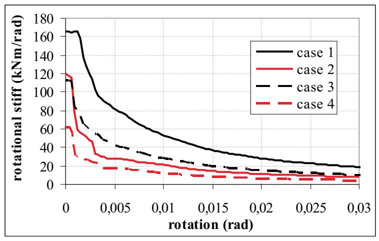
Reinforced concrete beams as a part of space frame structural systems are axially restraint elements. The level of axial restrain depend on many factors, such as: type of structural system, dimensions of surrounding elements (beams and columns), their lengths, type of connections, characteristics of used structural materials, etc. At the beginning of fire loading, axial restraints are maximal. During the time, as a result of high temperatures and nonlinear temperature distribution in the cross sections of the heated elements, modulus of elasticity of steel and concrete decreases, internal forces are redistributed and additional cracks appear. These initiate decrease of columns and beams stiffness and reduction of axial restrain effects.



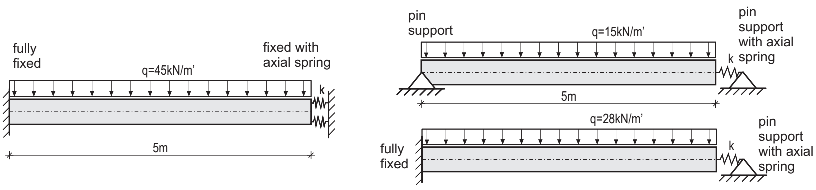


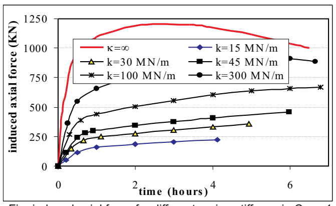




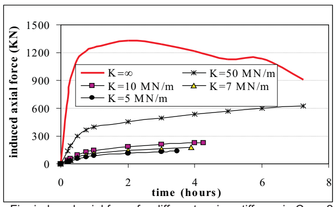


In order to investigate the influence of axial stiffness restrain on the fire resistance of reinforced concrete beams, few numerical parametric analyses are performed. The beam is analysed as one span beam with different end boundary conditions (pin-pin, pin-fixed and fixed-fixed). For all three cases the reinforcement is taken in such a way that the stresses in steel bars due to nominal load q are approximately 60% of the yield strength, for the negative moment reinforcement, and 45%, for the positive moment reinforcement. The variable stiffness in axial direction is achieved by spring element at one end of the beam. The spring stiffness is varied from K=0 MN/m to K=∞.

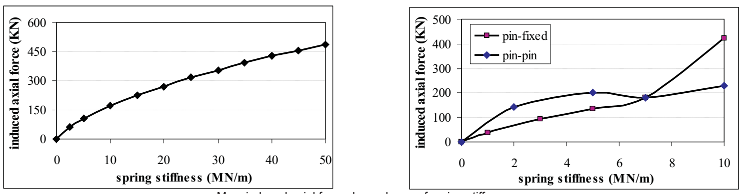




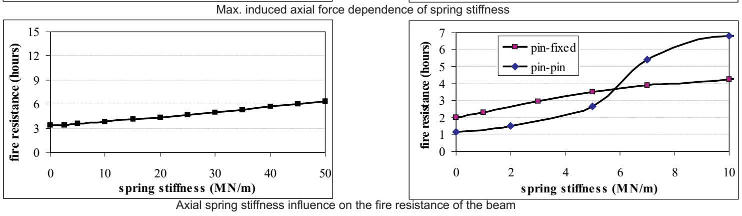
Fire induced axial force for different spring stiffness in Case 1 (fixed-fixed ends)



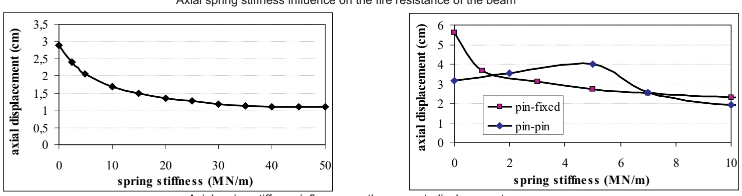
Fire induced axial force for different spring stiffness in Case 2 (pin-fixed ends)



Max. induced axial force dependence of spring stiffness

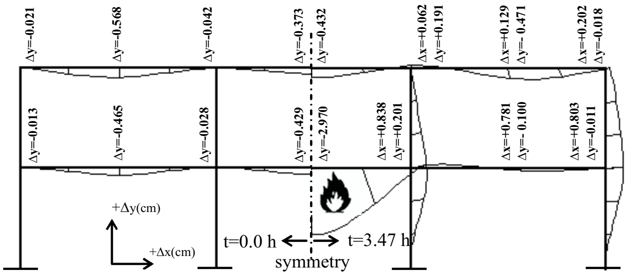


Axial spring stiffness influence on the fire resistance of the beam



Axial spring stiffness influence on the support displacement

To define the fire resistance of a beam as a separate unite, isolated from the structure, the appropriate time dependent boundary conditions should be applied to the beam ends. A satisfactory accuracy is achieved by comparing the results obtained by analysing the beam as a separate element (fire scenario FS1) with the results obtained by analysing the whole structure (fire scenario FS2).



	fire scenario	axial displacement on one side Δx (cm)	vertical deflection in the middle Δy(cm)	negative moment M_1(KNm)	moment at the middle of spam, M_2(KNm)	induced axial force N (KN)
t=0.0	FS1	0	0.413	-100.57	39.16	0
	FS2	0	0.429	-101.55	38.17	0
t=1.0	FS1	-0.572	1.301	-164.6	-25.40	-114
	FS2	-0.584	1.344	-165.6	-26.27	-128
t=2.0	FS1	-0.700	2.087	-152.66	-14.00	-139
	FS2	-0.707	2.171	-152.40	-13.01	-140
t=3.47	FS1	-0.805	2.966	-136.36	1.90	161
	FS2	-0.838	2.970	-136.3	2.57	147
t=3.75	FS1	-0.827	3.213	-132.6	5.05	166

According to the results, complete or even partial restraints of end supports displacements in axial direction dramatically change, for better, the fire resistance of this type of structures. This is mainly attributed to the axial force induced due to the support restraints. Generally speaking, the axial compression force increases the fire resistance of the structure.
Since a physical testing program for investigating the response of a large variety of structural elements under differing restraint, loading, and fire conditions is impractical and expensive, analytical studies supported by the results of physical experiments could efficiently provide the data needed to resolve questions related to the design of structures for fire safety.