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Numerical Analysis of the Influence of Spalling in Slender RC Columns

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Extended Abstract

When the internal pore pressure increases due to water evaporation, reinforced concrete elements (RC) exposed to fire can experience spalling causing a loss of concrete and a subsequent loss of resistance of the cross-section. Parameters affecting the occurrence of spalling can be material related, geometry related, or ambient related ([1] [2]).

The lack of instrumentation and consistent data results in mainly circumstantial conclusions being drawn about the probability of spalling and the causes producing it. Spalling is a stochastic phenomenon usually happening within the first 30 min of fire exposure and can affect any area of an exposed RC element, both at section level and over the element length. The range of time occurrence seems to be quite well determined for the worst case scenarios in which the reduction of the effective cross-section can have serious consequences on the fire resistance of RC elements ([1]-[3]), being the worst case scenario when spalling results in the complete loss of concrete cover, directly exposing the reinforcement to the heat source.

The effect of load eccentricity and the effectiveness of reinforcing bars in limiting spalling have been studied recently by different authors [2][4]. Also some researchers have developed models focused on predicting the occurrence of spalling. [5] but given the stochastic nature of the phenomenon it is not easy to draw solid conclusions.

On the contrary, the work presented in this paper does not deal with modelling the mechanism of occurrence of spalling. It is assumed that spalling occurs, and its effects on the performance of the columns are analysed after its occurrence.

This paper presents a study into the effects of spalling on RC columns when it affects either the corner of the cross-section or one of the sides. After a sectional analysis, the influence of the location of spalling over the column length is also studied. To this end, an advanced numerical model for the effect of spalling on the fire resistance of slender RC columns exposed to fire is developed. To carry out this research the computer program SAFIR [6] for the analysis of structures subjected to fire was chosen. The model is validated against experimental data for the behaviour of slender RC columns under bending exposed to fire. In this research, the influence of several parameters is studied. For both types of spalling the spalling initiation time has no remarkable effect when the fire exposure time is 45 min or greater. However, for required fire resistance times of 90 min or higher, the effect of surface spalling is more harmful. The negative effect of spalling on the RC cross-section resistance can be quantified by an additional fire exposure time, which ranges between 0-30 min. In general, for the cases analysed, when the spalling is located at mid-length column, its effects are more damaging.

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