Fire performance of reinforced concrete slabs: a numerical analysis

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Abstract

The emergence of tensile membrane action as a key load-carrying mechanism has increased experimental and numerical studies on the fire performance of concrete slabs since 2000, however, the different behaviour due to aggregate type is less studied in slabs numerical analysis. This paper presents a numerical analysis of the thermomechanical behaviour of reinforced concrete slabs exposed to fire, using Finite Element Modelling in ATENA and GiD. Results were validated against experimental data from the literature subjecting slabs to ISO834 and hydrocarbon time-temperature curves. 3 calibration steps were done to combine mechanical and thermal behaviours. A parametric analysis was carried out with calcareous and siliceous aggregates to provide information for safer slab design and consequent fewer accidents related to fire situation. The choice of aggregate type must always be considered in design.

Keywords: concrete; fire; finite elements; numerical analysis; ATENA; aggregate.

1 Introduction

The reinforced concrete (RC) slabs have the rebars in their bottom face as a guarantee of structural strength, where the thermal action has greater intensity. When they are cast-in-place, the slabs generally do not have reinforcement needed for crack width control to assure additional resistance if the main bottom reinforcement bars yield.

Recent catastrophes have intensified the search for a thorough understanding of the changes in the mechanical behaviour of concrete when subjected to fire. On May 1st, 2018, the Wilton Paes de Almeida building in Sao Paulo suffered a major fire. The 24-storey building collapsed just over an hour and a half after the start of the fire. The National Museum of Rio de Janeiro, one of the main ones in Brazil, was gutted in a fire on September 2nd, 2018. As no visitation was taking place at the time of the tragedy, there were no victims but 90% of the collection was destroyed.

In a fire situation, many properties of concrete undergo significant changes: physical, chemical, or mechanical. According to Reddy e Ramaswamy [1], the mechanical properties are lost because the high temperature in cement paste removes the chemically bound water and weakens the cement mortar. In many cases, fire-exposed concrete elements may have their layers fragmented due to an explosion of the material, a phenomenon known as spalling.

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