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Fire performance assessment of HPLWC hollow core slabs through full-scale furnace testing

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ABSTRACT

High-Performance Light-Weight Concrete (HPLWC) is used for many structural applications when superior strength and low self-weight of the structural components are required. Among these applications there are thin floor structures, like hollow core slabs, that require characteristics of lightness, relatively high resistance and superior durability. Although the fire performance of normal strength concrete hollow core slabs has been extensively studied, the behavior of HPLWC hollow core slabs has not been suitably investigated.

The paper reports the results of two full-scale furnace tests on HPLWC hollow core slabs. Each of them involved one panel with an applied load and one without load. The evolution of temperature inside the slabs was measured along with the load bearing capacity under fire conditions. During the first test severe spalling occurred in the loaded slab while during the second one, performed on slabs cured for some months under dry conditions, spalling did not occur. Finite elements simulations were also carried out in order to support the interpretation of the experimental results. Experimental and numerical investigations gave insight into the fire performance of HPLWC hollow core slabs and highlighted the influence of dry curing conditions in reducing the spalling and increasing the fire resistance.

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1. Introduction

Pre-stressed concrete hollow core slabs have been manufactured for several years using normal weight–normal strength concrete.

The flexural behavior of pre-stressed normal strength concrete (NSC) hollow core slabs under fire conditions has been deeply investigated in the last years and can be considered satisfactory if the onset of twisting moment is prevented through suitable design provisions.

Some doubts still stand about the shear strength, as remarked by Van Hacker [1], Fellinger [2], Borgogno and Fontana [3], who developed extensive surveys on this topic. Bailey and Lennon [4] showed that the small-scale standard fire tests, used to assess fire endurance, can be very unrealistic and may ignore the beneficial effects of the whole building behavior. The authors also highlighted the role of the connection details on the full-scale fire behavior and recommended special attention be paid to the boundary restraints during the furnace tests, in order to accurately simulate the conditions in real structures. Aguado et al. [5], during full-scale fire bending tests, highlighted four types of cracking that occurred in hollow core slabs: thermal cracking, flexural cracking, splitting cracking and longitudinal cracking.

Several authors focused their research on the realistic and reliable analytical modeling of a hollow core floor system under fire. Min et al. [6,7] developed a multi-spring connection element which considers the discontinuity between the prestressed steel tendons of hollow core slabs and the supporting beams. Chung et al. [8–11] proposed an analytical model consisting of a grillage system of beam elements in order to include the effect of thermal expansion in both direction and vertical cracking in the flanges. The results of their simulations showed that rotationally rigid end and side connections provided better fire resistance than rotationally flexible ones.

During the last years the use of High Performance Light-Weight Concrete (HPLWC) has been considered to manufacture hollow core slabs. In fact the characteristics of lightness, relatively high strength and superior durability make this material suitable for many structural applications.

HPLWC shows ambivalent features about fire performance because of its low thermal diffusivity, due to the aggregates low density and the latent heat of the free water, as highlighted in Refs. [12,13]. On one side, the reduced diffusivity may be considered a favorable property in case of exposure to fire, because it prevents heat from reaching the reinforcements and the internal concrete.

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