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Prestressed slab beams subjected to high temperatures

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ABSTRACT

The results of bending tests up to failure of pre-stressed slab beams, fitted and not fitted with concrete casting, pre-emptively subjected to high temperatures, provide a useful contribution to the study of the fire behavior of the structural elements regarded. Comparisons are made with similar beams not previously subjected to fire tests. The results obtained are interesting in evidencing the mechanical characteristics that can be more affected by fire in the two beam typologies tested.

1. Introduction

Concrete is a building material with a good fire resistance; this characteristic makes concrete more advantageous than other materials for construction. Nevertheless fire effect can affect the strength of the structural elements and the whole structure. Therefore it is important to define the residual resistance of a structure that has been subjected to high temperatures. In particular, in case of prestressed elements it is important to know the residual element properties and if the effect of fire has interested the prestressing cable that is if high temperatures have interested the inner part of the beam up to the prestressing cable.

Many works have been carried out on the residual mechanical properties of concrete after exposure to high temperatures [1–3]. Some experimental studies have been performed on the post-fire behavior of reinforced concrete (RC) members. In [4,5] El-Hawary et al. investigated the flexural and shear behavior of twelve RC beams after exposure to 650 °C for two hours and then cooled by water. Mohamedbhai [6] tested the residual strength of columns and beams specimens after exposure to temperatures up to 1000 °C and cooled in air. The residual strength and stiffness has been also investigated in [7] for columns subjected to eccentric axial loading after exposure to different fire durations. Very little test information is available on the post-fire behavior of RC-loaded columns, especially full-scale tests, mainly due to the scarcity of large column furnaces and the large expense of a full-scale fire test.

The greater or lesser fire resistance of reinforced concrete structures depends, of course, on different factors such as the temperature reached during the event and how it varies in the time during the exposure, the inception of residual stresses, the characteristics of the materials, the age of the conglomerate, and so on [8–11].

The diagnosis on the conditions of the frame is particularly complex in the case of pre-stressed concrete elements because to all other causes of degradation due to the fire, it can be added the possible variation of the pre-stressing state and the eventual detachment between beams and concrete casting of the floor. It should be also considered the different behavior that the structure presents under the action of thermal variations, depending on whether its scheme is isostatic or hyperstatic. So only experimental research can give indications overall really useful to properly frame the phenomenon and provide reliable indications regarding, for example, the static conditions of a structure, which has undergone the fire actions [12–14]. Reliable solutions have been proposed by many authors to improve the strength of RC elements after fire [15] or utilizing fire-retardant materials [16].

In this paper a series of bending tests have been performed on prestressed beam specimens, during the heating treatment and at ambient temperature, after their cooling. The experimental research, carried out at the Laboratory of the Department of Civil Engineering and Architecture of the Polytechnic of Bari, is interesting for the contribution that can provide to the study of the damage produced by the fire on the floors of buildings, and more generally on reinforced concrete structures.

The tests refer to two distinct sets of elements.

The first series of tests is related to the pre-stressed beams with adherents pre-stressed cables (Fig. 1), previously subjected to high temperatures properly controlled and recorded and, subsequently, to cold bending tests whose results are compared with those obtained on similar elements not subjected to heat treatment.

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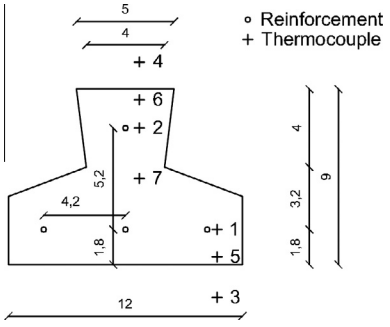

Fig. 1. First series of tests: section of the beam and positioning of the thermocouples.

Fig. 4. First series: positioning of the beam in the oven.

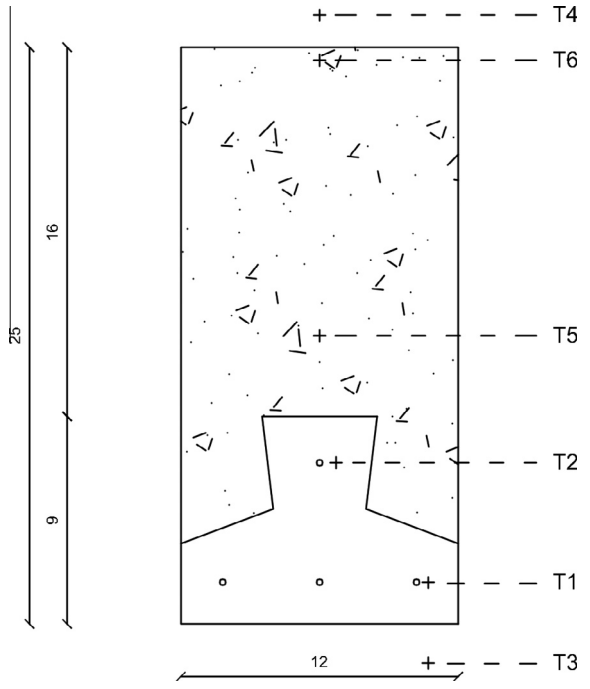

Fig. 2. Second series of tests: section of the beam and positioning of the thermocouples.

Fig. 5. Second series: positioning of the beam in the oven.

Fig. 3. First series: the pre-compressed beam and the supporting structure.

The second series concerns beams equal to the previous ones, provided with a concrete casting that gives a rectangular shape to the cross-section, subjected to the same thermal events (Fig. 2).

To perform the tests a furnace has been specially realized; it has undergone only little changes in the transition from the first to the second series of samplings. The results concern both for comparison purposes, within each series, between beams subjected to different temperatures, and for the purpose of verifying the different cold behavior, within each series, of beams subjected to heat treatment and virgin beams. Finally, the behavior of the individual beams respect to those identical but completed with the conglomerate casting has been compared.

The only aim proposed is to study the behavior of the structural elements considered (prestressed beams) due to the achievement of determined temperatures, measured both outside and inside of the beams in certain points, in particular in correspondence of the pre-stressing reinforcement, which is known to be highly sensitive to the effects of temperature change. During the exposure at