



Fire tests on composite steel-concrete beams prestressed with external tendons

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ABSTRACT

This paper presents an experimental study on fire resistance of composite steel-concrete beams prestressed with external tendons. A total of four beams were tested under combined fire load and positive moment. Parameters investigated include load level, prestress level and type of cable strands configuration. Results show that the tested beams without fire protection had fire resistance of 20 min to 30 min. The fire resistance of composite steel-concrete beams prestressed with external tendons was highly influenced by the stress in the cable strands. The tested beams with bent-up cable strands had more fire resistance than the tested beams with straight cable strands. Prestress level had little influence on failure temperature of the tested beams, but the slack of cable strands induced failure of the test beams at high temperature. Furthermore, a finite element (FE) model was developed and successfully used to predict the fire behavior of the prestressed composite steel-concrete beams.

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1. Introduction

In comparison with the conventional non-prestressed composite steel-concrete beams, prestressed composite beams have several advantages, including elastic behavior under heavier loads, increased ultimate capacity, reduced structural steel weight, more crack resistance (of concrete), and improved fatigue and fracture behavior [1]. Composite beams prestressed with external tendons are mainly used in bridge engineering and mostly used to strengthen existing structures [2], while they have also been used in building structures [3].

To date, there are several studies on the behavior of prestressed composite beams. Saadatmanesh et al. [1,4] analytically and experimentally studied the behavior of prestressed composite steel-concrete beams. Two tendon configurations were considered: straight tendon below the lower flange of the I steel section (for positive moment) and straight tendon below the upper flange (for negative moment). Troitsky et al. [5] analytically and experimentally studied the behavior of simply supported prestressed composite

steel-concrete beams. Three tendon configurations were considered: straight (above the lower flange), bent up and short straight (below the lower flange). Ayyub et al. [6] experimentally studied the behavior of prestressed composite steel-concrete beams under positive moments. Various tendon types and configurations were considered. Chen [7] experimentally studied the behavior of prestressed composite steel-concrete beams under negative moments. Lorenc and Kubica [2] experimentally studied the influence of shear connection flexibility on the behavior of prestressed composite steel-concrete beams. However, there is few experimental data on fire behavior of prestressed composite steel-concrete beams. Kang et al. [8] reported fire tests on prestressed composite beams with corrugated webs. Key test variables were the cover thickness of the fire protection material applied to the bottom flange of corrugated webs. The study found that prestressed composite beams with relatively thin fire protection material cover thickness, compared with the non-prestressed slim-floor composite beam, satisfied the required fire performance criteria in the ISO 834 standard.

Previous studies show that prestressed structures are more sensitive to fire than the non-prestressed structures [9–11]. When exposed to fire, the external tendons may become slack due to thermal expansion and, consequently, the prestressed structures with external tendons may fail at a rapid rate. Although the fire behaviors of conventional composite steel-concrete beams have been

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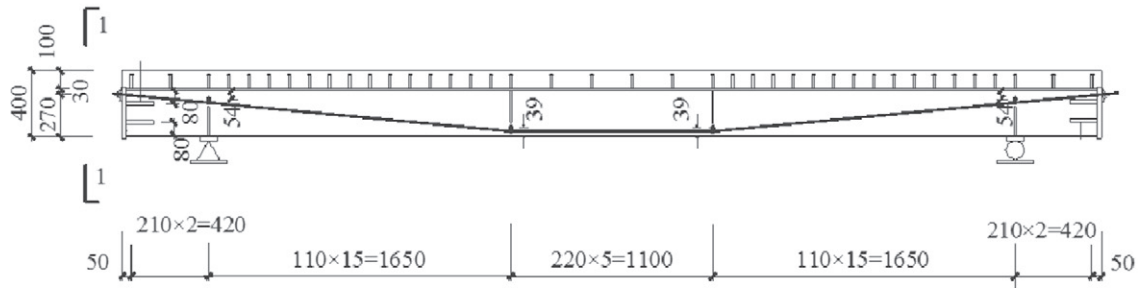
well investigated and design methods are developed for composite steel-concrete beams [12], it's still necessary to study the fire behavior of prestressed composite steel-concrete beams because of the significant differences between the behaviors of non-prestressed and prestressed beams. This paper reports an experimental study on the fire behavior of composite steel-concrete beams prestressed with external tendons.

Table 1
Summary of fire test cases.

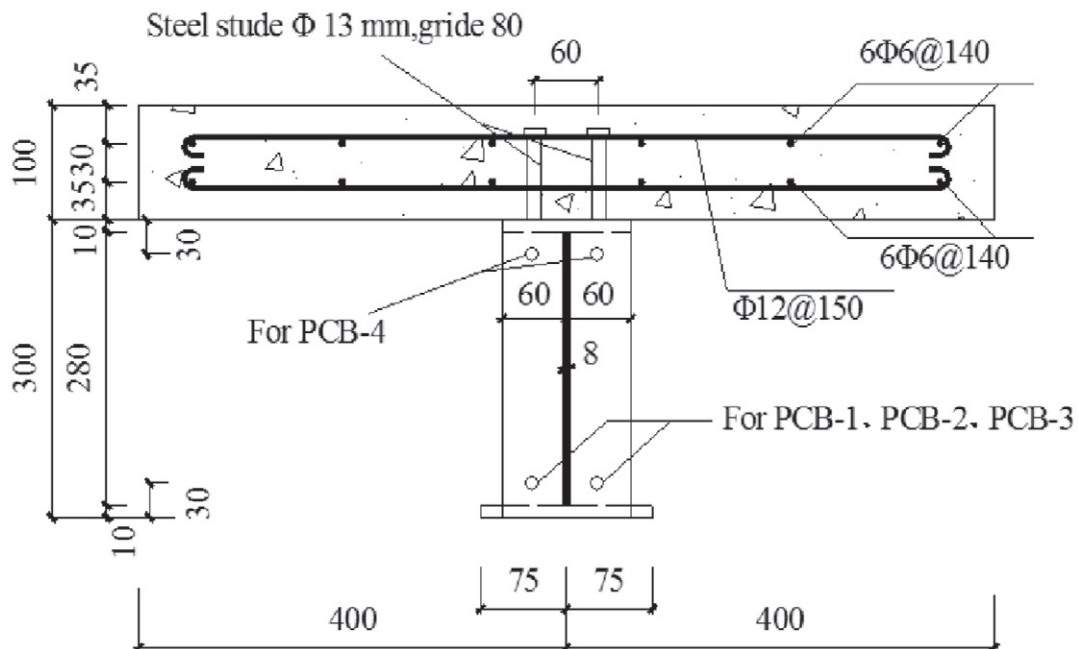
Beam	Cable configuration	Load ratio	Prestress ratio
PCB-1	Straight	0.35	0.7
PCB-2	Straight	0.35	0.6
PCB-3	Straight	0.22	0.7
PCB-4	Bent up	0.22	0.7



(a) Beams PCB-1 to PCB-3



(b) Beam PCB-4



(c) Traverse section 1-1

Fig. 1. Details of prestressed composite beams.

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