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Behaviour of Perfobond shear connectors at high temperatures

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ABSTRACT

In composite steel and concrete construction, the most extensively used and known shear connector is the Nelson or stud connector, automatically welded to the beam flange. Some alternative connectors account for the contribution of the mechanical interlock of the concrete in holes or other indentations drilled in steel plates welded to the beam flange. This is the case of the Perfobond and Crestebond shear connectors recently studied by several authors. However, there is a lack of studies of their performance in fire.

In this paper, we describe a research study on the behaviour of the Perfobond shear connectors under fire conditions. The specimens were first heated from room temperature up to a target temperature and then they were loaded up to failure as a way to assess the connector's shear resistance and its ductility at high temperatures.

The main purpose of this research was to investigate the influence of the number of holes in the Perfobond shear connectors, the presence of transversal reinforcement bars passing through these holes, and the behaviour of two connectors placed side by side at high temperatures. We also compared the behaviour of these connectors at room temperature and at high temperature.

The results of this research showed mainly that the load capacity at high temperatures of these connectors was not as good as at room temperature.

1. Introduction

Steel and composite steel–concrete beams have been extensively used in buildings and bridges. The element that assures the shear transfer between the steel profile and the concrete deck, enabling the composite action to develop, is the shear connector.

The most widely used shear connector is the Nelson or stud (Fig. 1(a)). This type of connector is used worldwide, mainly due to a high degree of automation in workshops or construction sites. However, such connectors have some limitations in structures subjected to fatigue, and their use requires specific welding equipment and a high-power generator in the construction site. In addition, their resistance is somewhat limited, compared to other types of connector, leading quite often to girders designed with partial interaction.

Some alternative shear connectors have been proposed for composite structures, namely by Zellner [1], Machácek and Studnicka [2], and Veríssimo et al. [3], but some of them presented some restrictions in their industrial production, installation, or structural behaviour.

Dealing with the particular technological, economical, or structural needs of specific projects has led to the motivation of developing new products for shear transfer in composite structures. In this context, Perfobond (Fig. 1(b)) is an alternative connector with higher resistance than a stud; it was developed in the 1980s by the German company Leonhardt, Andråand Partners for the design of the third bridge over the Caroni river, in Venezuela [4]. Its development was based on the need for a system that involved only elastic deformations under service loads, with some specific bond behaviour. It is formed by a rectangular steel plate with holes drilled in it, and is welded to the beam flange.

In the recent past, several authors have studied the behaviour of Perfobond connectors at room temperature, namely by the evaluation of results from push-out tests or by the development of numerical models. It was concluded that their structural response is influenced by several geometrical properties, such as the number of holes, the width, length, and thickness of the steel plate, the concrete compressive strength, and the percentage of transverse steel reinforcement present in the concrete slab. Reference is made to the studies of Cândido-Martins et al. [5], Iwasaki et al. [6], Valente and Cruz [7], and Vianna et al. [4,8].

In addition, some analytical models have been proposed to predict the resistance of Perfobond shear connectors. The most relevant models were proposed by Al-Darzi et al. [9], Marecek et al. [10], Oguejiofor and Hosain [11], Ushijima et al. [12], and Veríssimo et al. [3].

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