ARTICLE IN PRESS
ISTRUC-00166; No of Pages 10
Structures xxx (2016) xxx–xxx
Contents lists available at ScienceDirect
Structures
journal homepage: www.elsevier.com/locate/structures

Post-fire Behaviour of Innovative Shear Connection for Steel-Concrete Composite Structures

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ARTICLE INFO

Article history:
Received 23 May 2016
Received in revised form 30 November 2016
Accepted 5 December 2016
Available online xxxx

Keywords:
Composite steel-concrete
Shear connectors
Post-fire behaviour
Experimental studies

ABSTRACT

Steel-concrete composite structures are commonly used in buildings and bridges because it takes advantage of tensile strength of steel and compressive strength of concrete. The two components are often secured by shear connectors such as headed studs to prevent slippage and to maintain composite action. In spite of its popularity, very little research was conducted on steel-concrete composites particularly on headed stud shear connectors in regards to its post-fire behaviour. This research investigates the post-fire behaviour of innovative shear connectors for composite steel and concrete. Three types of connectors were investigated. They are conventional headed stud shear connectors, Blind Bolt 1 and Blind Bolt 2 blind bolts. Push-out test experimental studies were conducted to look at the behaviour and failure modes for each connector. Eighteen push tests were conducted according to Eurocode 4. The push test specimens were tested under ambient temperatures and post-fire condition of 200 °C, 400 °C and 600 °C. The results in ambient temperature are used to derive the residual strength of shear connectors after exposing to fire. This research showed that the headed studs performed well compared to Blind Bolts 1 and 2 at ambient and target temperatures. The stress concentrations around the casing of Blind Bolt 1 were found to cause a reduction in strength of the specimens. Findings from this research will provide fundamental background in designing steel-concrete composites where there is danger of fire exposure.

1. Introduction

Steel-concrete composite beam/slab construction is common practice in bridges and multi-storey buildings due to the combination of compressive strength of concrete and tensile strength of steel [12]. The two components are often secured by shear connectors that greatly influence its strength and ductility [15]. Despite its popularity in these types of constructions, composite members are still a subject of continuous development [16]. One of the areas of interest in the development of composite structures is the shear connectors that bond concrete and steel [16]. Interests in these developments are however limited due to the high cost in setting up in a laboratory environment [8]. Even though the costs of these experiments are monumental, researchers still manage to set up experiments with good results such as conducted by Wang et al. [20] and Alderighi and Salvatore [1] in multi-level framed buildings.

A review of literature shows that research on steel-concrete composite structures has focused behaviour of push-out tests at ambient temperature and at elevated temperature. Push-out tests of composite structures at ambient temperature showed that their strength and ductility were often influenced by their material properties [8,10]. Galjaard and Walraven [10] conducted push-out tests for five different shear connectors: headed studs, continuous perfobond strip, oscillating perfobond strip, waveform strip and T-connector. Similarly, Baran and Topkaya [3] conducted an experimental study on another type of shear connector: channel type shear connector or C-channel. The tests aim was to determine the strength of different sizes of C-channel as shear connector in steel-concrete composite structure [3].

Push-out tests on steel-concrete composite structures utilising headed studs were also conducted at elevated temperatures by Zhao [21], Mirza and Uy [15], Anderson [2], Wang [19] and Imagawa et al. [13] among others. Push-out tests on steel-concrete composite structures utilising continuous perfobond strip [16] and T, T-block and T-perfobond [17] have also been conducted at elevated temperatures.

Most of the research on push-out tests of steel-concrete composite structures focusses on the behaviour of specimens at ambient and elevated temperatures. A review of other types of composite structures such as the concrete-filled steel tubular columns shows that their strength after exposure to fire can be predicted through the development of mechanics models [11]. Future research will focus on the use of post-fire mechanical properties of shear connectors and concrete to predict the post-fire behaviour of steel-concrete composite structures.

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http://dx.doi.org/10.1016/j.istruc.2016.12.001

Please cite this article as: Mashiri FR, et al, Post-fire Behaviour of Innovative Shear Connection for Steel-Concrete Composite Structures, Structures (2016), http://dx.doi.org/10.1016/j.istruc.2016.12.001

This paper focuses on the behaviour of steel-concrete composite structures using innovative shear connectors under post-fire. Post-fire behaviour of steel-concrete composite structures is investigated with a focus on failure in push tests made up of three types of shear connectors; headed studs, Blind Bolt 1 and Blind Bolt 2. Eighteen push-out tests were carried out at ambient temperature and post-fire condition of 200 °C, 400 °C and 600 °C. The results at ambient temperature are used to determine the residual strength of steel-concrete composite structures after exposure to fire.

2. Experimental study

2.1. Experimental set-up and specimen

The test specimens were based on the Eurocode 4 [9] standard and were fabricated in a similar manner as outlined in the standard. However, due to the size limitation of the furnace, all specimens were modified to fit in the furnace. The steel section adopted was a 200PFC and two 200PFC configured as shown in Fig. 1. The width of the slabs for the

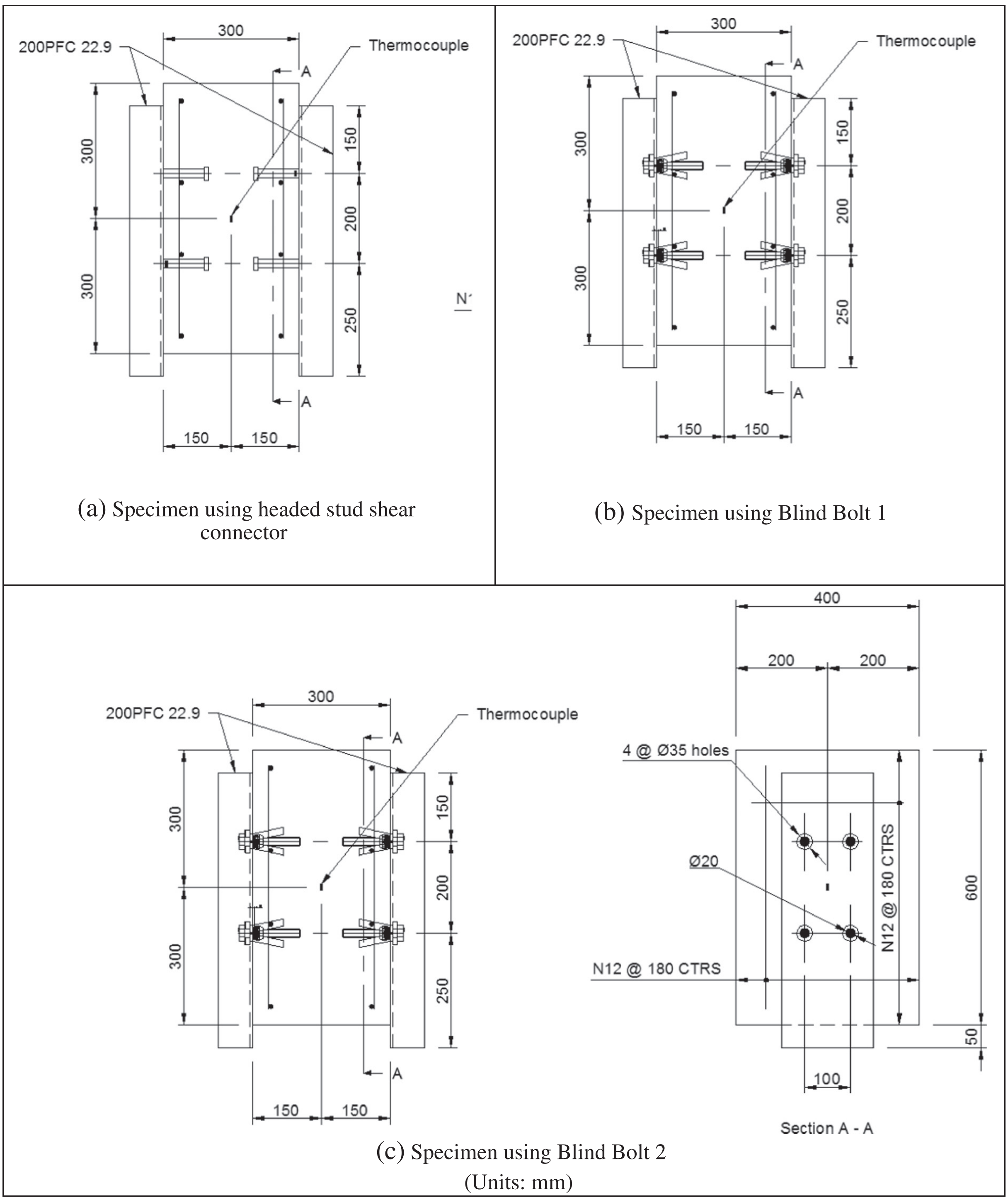

Fig. 1. Push-out test specimens using (a) headed stud shear connectors, (b) Blind Bolt 1 and (c) Blind Bolt 2.