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Behavior of beam-to-column welded connections in steel structures after fire

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Abstract

Beam-to-column welded connections are widely used in steel structures, and the post-fire behavior of connections is of great importance to the resistance of steel structures after fire. Five beam-to-column welded connections made up of Q345B steel were first heated to specified temperature levels, and then cooled to ambient temperature and tested to failure under lateral force. Five temperature levels from 500℃ to 900℃ were considered, and natural cooling was employed in the test. Test at ambient temperature was also conducted for bench mark comparison. The results show that failure mode of connection specimens changes from beam flange buckling to the butt weld cracking after the connections exposed to 500℃ to 900℃ high temperatures. The effects of exposed temperature on bending bearing capacity and rotation ability of beam-column welded connections are discussed. These results are compared to existed results from research on mechanical properties of post-elevated temperature of butt welds and fillet welds after fire. These results can provide reference for detection and safety assessment of post-fire steel structures.

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Keywords: Welded connections; Bending bearing capacity; fire; butt weld; safety assessment

1. Introduction

Steel structures are easy to lose strength and stiffness under fire exposure, but inspection reports from fire incidents indicate that in most cases fire exposed steel structures retain much of their load bearing capacity after

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cooling. Therefore, in many cases fire exposed steel structures can be reused after structural safety appraisal and retrofit. So it is imperative to ascertain the post-fire residual capacity of steel structures.

Bolted and welded connections are widely used in steel framed buildings and are of great importance to fire resistance of steel structures. Numerous studies on the behavior of fire exposed bolted and welded connections are reported in the literature [1-5]. However, only few studies are undertaken on the post-fire behavior of connections [6-13]. In the case of welded connections, chemical composition of base metal and filler metal are different, and the effects of heating and cooling are similar to tempering and annealing, thus different transformations in the metal structures may occur in the base metal and the weld region. Therefore data on the residual mechanical properties of different weld types and beam-to-column welded connections is required for assessment of residual load-bearing capacity of fire-exposed steel structures. Till now, studies on the residual strength of fire-exposed S355JR butt welds [10], A588 transverse fillet welds [11], Q235 transverse fillet welds [12] and Q345 butt and fillet welds [13] are reported. However there is a lack of research on post-fire behavior of beam-to-column welded connections. This paper presents results from tests on five beam-to-column welded connection specimens made of Q345 steel after exposed to 500℃ to 900℃ high temperatures. Suggestions are proposed to evaluate temperature induced bending bearing capacity degradation in beam-to-column welded connections.

2. Experimental program

2.1. Test specimens

A total of six specimens were tested, including five specimens exposed to temperature levels from 500℃ to 900℃ and one specimen at ambient temperature for bench mark comparison. Test specimens were designed in accordance with GB50017 [14], so that failure at room temperature would occur in the base metal. Natural cooling was employed for all the specimens. Specimens were made from Q345B steel, with a measured ultimate strength of 531 MPa and measured yield strength of 353 MPa. Cross-section of the columns was H300×300×10×15mm, and cross-section of the beams was H300 × 150 × 6.5 × 9mm. The beam and column flanges were connected with the all-through butt welds, and the beam web and the column flange were connected with double-sided fillet welds. The welding process adopted was CO_2 gas shielding arc welding and the electrode type was ER50-6, with a nominal ultimate strength of 550 MPa and nominal yield strength of 430 MPa. Dimension of the beam-to-column welded connection specimen is shown in Fig. 1.

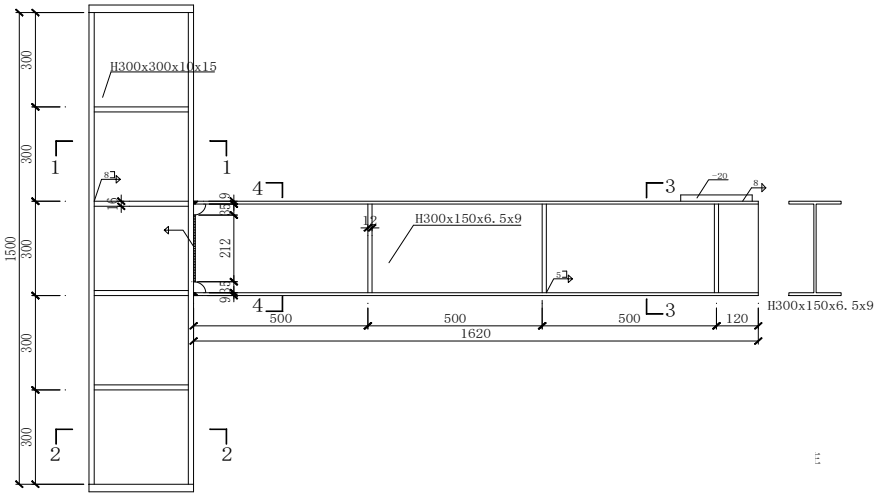

Fig. 1. Dimension of beam-to-column welded connection