



Seismic performance of ductile welded connections using T-stiffener

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ABSTRACT

This study presents the development of the ductile detail of a T-stiffener added to existing moment connections. The seismic behavior of the aforementioned detail was investigated analytically as well as experimentally. A new design criterion is developed for a horizontal element of T-stiffener. Results of this study indicate that the crack propagation is eliminated using the new proposed procedure. This means that by utilizing a fillet weld as a replacement for a CJP groove weld in joining the T-stiffener to a beam flange eliminates crack propagation at the tip of the T-stiffener on the beam flange. In the experimental program, the specimens performed well during the test and reached a total story drift angle of 6% radians before experiencing 20% strength degradation.

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1. Introduction

External T-stiffeners are effective and suitable components for constructing moment-resisting connections with box or concrete filled tube (CFT) columns. Also, the T-stiffener can be used in retrofitting the existing under-designed connection. Fig. 1 illustrates the typical detail of this type of connection and one of its most commonly observed failure modes. There are a number of studies on the behavior of connections and their improvement by the addition of T-stiffeners. Shanmugam et al. [1] and Ting et al. [2] compared the behavior of I-beam to box column connections with different types of external stiffeners using analytical and experimental studies. In their investigations, the connections were subjected to cyclic loadings and their results indicated that using the T-stiffener improves the connection behavior more than the use of external angle stiffeners. The design guidelines for this type of connection were proposed and verified by full scale experiments [3–5]. Also, a number of connections were analyzed by the finite element method for a wide range of dimensions, and the results satisfy the basic design criteria for moment-resisting connections. Similar to the finite element method analysis results, the experimental results indicated that these connections satisfy the basic criteria and provide sufficient strength, stiffness and

rotation capacity. Shin et al. [6] in his study compared both experimentally and analytically the behavior of CFT columns to H beams connections with external T-stiffeners. Three types of failure modes were observed during the tests, including horizontal element failure and vertical element and beam failure. Shin et al. [7] also tested seven CFT beam-to-column connections. To increase ductility and reduce stress concentration at the tip of the horizontal element of the T-stiffener, they implemented RBS cutouts in the beam and drilled a small hole in the horizontal element. Some of the specimens tested demonstrated that the connection can be qualified for special moment-resisting frames in accordance with the AISC seismic provision [8]. However, in some tested specimens, crack propagation was observed. Chen et al. [9] studied the experimental behavior of the reinforced connection with lengthened rib and wing plates. The wing plates are trapezoidal plates which are connected to the beam flange and widen the beam flange at the connection region. In the reinforced connection with wing plates, as in previous research, crack propagation was observed in the tip of the wing plate at the beam flange. Like the horizontal element of the T-stiffener, the wing plate was connected to the beam flange with a CJP groove weld and showed failure modes similar to that of the T-stiffener connection. Yang et al. [10] experimentally compared the cyclic behavior of semi-rigid bolted and fully welded connections. They reported that the fully welded specimen failed due to tearing of the column flange adjacent to the CJP groove weld. Also, the test conducted by Moon et al. [11] revealed that welding failure between the horizontal element of T-stiffener and beam flange triggered the failure of these connections. Mao et al. [12] and Ricles et al. [13,14]

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Fig. 1. Moment-resisting connections retrofitted with T-stiffener and its associated failure mode.

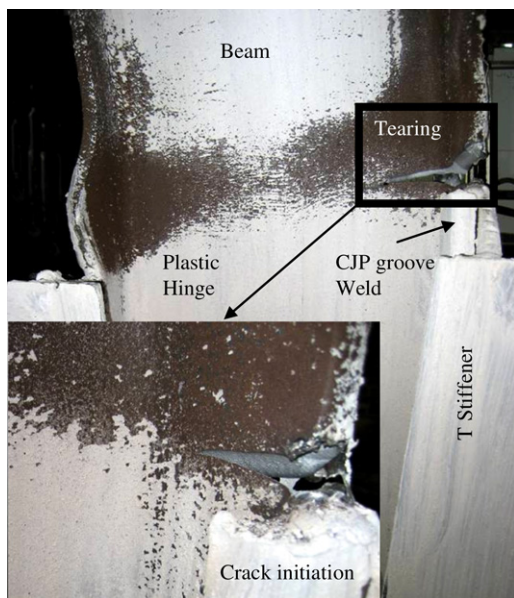


Fig. 2. Observed failure mode in the retrofitted connection with T-stiffener utilizing CJP groove weld to join the horizontal element to the beam flange.

conducted comprehensive experimental and numerical studies in order to provide the ductile detail for welded, non-reinforced moment connections. To develop the study further, the effect of weld metal, weld access hole geometry, beam web attachment, continuity plates and panel zone strength on cyclic ductility were also investigated.

Crack propagation of the T-stiffener was observed at the tip of the horizontal element by Ghobadi et al. [15] (Fig. 2), similar to the studies of the above researchers. They showed that the stress concentration at the heat-affected zone (HAZ) adjacent to the low ductility CJP groove weld causes slight tearing of the beam flange, which ultimately causes failure of the connection. In some cases, tearing of the flange occurs before the 4% story drift ratio

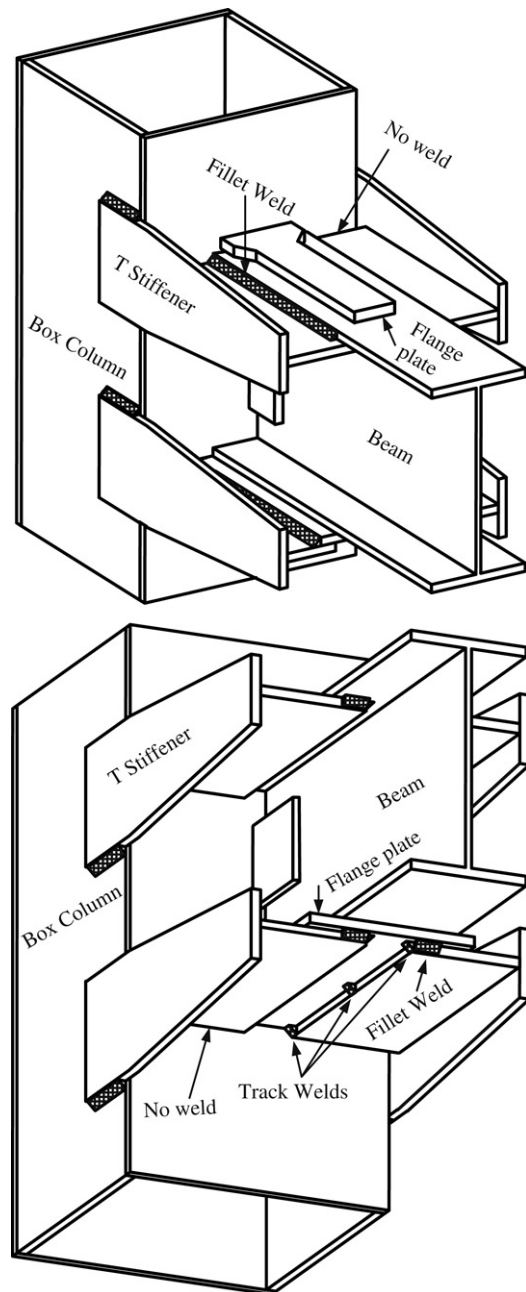


Fig. 3. Proposed joining configuration of the T-stiffener to the flange plate connection, top and bottom view.

is achieved, which results in the failure of the moment-resisting connection before 4% story drift ratio. Hence, it was shown that for a reliable connection, it is much better to eliminate this type of crack propagation in the horizontal element of the T-stiffener.

In the present study, the crack propagation at the tip of the horizontal element of the T-stiffener has been evaluated numerically. Based on the numerical results, a new detail of the joining of the T-stiffener to the beam flange (or flange plate) was developed, which is shown in Fig. 3. This figure shows the fillet welds on the opposite sides of beam flange (or flange plate) are interrupted at the corner of both welds [16]. These types of flange plate connections were tested by Ghobadi et al. [15]. The proposed details for joining the T-stiffener to the existing connections are verified by the nonlinear finite element analysis and experimental tests.

