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Behavior of skewed extended shear tab connections part I: Connection to supporting web

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A B S T R A C T

The objective of this study is to investigate the behavior of skewed extended shear tab connections in which plate (shear tab) is welded to supporting member webs (flexible supports). To achieve the study goals, Finite Element Analysis (FEA) for orthogonal configurations of extended shear tab connections were performed using the finite element software, ABAQUS. To validate the finite element models, the FEA results were compared with experimental results obtained from experimental investigation by Sherman and Ghorbanpoor [19]. Then, finite element models for skewed connections at different angles were created, analyzed and investigated. It was observed that skewed and orthogonal configurations have the same failure modes, however, the shear tab's twist increases with increased connection orientation due to additional torsional moment transferred from the supported beam to supporting member. Additionally, it was observed that the connection's vertical displacement slightly decreases as connection orientation increases. Relationships between the shear tab twist and skewed angle as well as and the shear tab vertical displacement and the skewed angle were investigated. It was observed that plate twist-skewed angle relationship can be represented using a linear equation. This equation can be used to relate the shear tab twist of skewed and orthogonal connections. Finally, the shear tab's torsional strength equation in the American Institute of Steel Construction (AISC) manual 14th edition [4] was modified to consider the additional torsional moment added to the shear tab due to the connection orientation.

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1. Introduction

Extended shear tab connection has been introduced in the AISC manual 13th edition [3] to the structural engineering practice as an alternative to the single plate or known as the shear tab connection. The function of this connection is to transfer the shear force from the beam to the supporting member (column or girder). The main advantage of using extended shear tab connections is to avoid coping of beams in the vicinity of the joint to bring the beam close to the web of the supporting member.

Previous studies investigated the behavior of these connections for members joined at right angles, experimentally and analytically. Sherman and Ghorpanboor [19] studied the behavior of different configurations of extended shear tab connections experimentally; they proposed a design procedure that provides sufficient strength and ductility to transfer the shear force from the beam to the supporting member and accommodate the same end beam rotation as a simply supported beam. Their procedure formed the basis of the design section of the extended shear tab connections in the AISC manual [3]. Thornton and Fortney [20] studied the lateral torsional stability of the extended shear tab connections; the authors showed that the eccentricity due to the overlap between the plate and beam longitudinal axes will cause torsional moment on the connection, and this torsional moment is resisted by two components: the plate torsional strength and beam torsional resistance due to the floor or roof slab. The authors proposed an equation that calculates the torsional capacity of the connection in order to determine the need of using stabilizer plates. Rahman et al. [17] presented a three dimensional model to study the behavior of the unstiffened extended shear tab connections. The study focused on two configurations: three bolts unstiffened beam-to-column web configuration, and five bolts unstiffened beam-to-column web configuration. The author concluded that the finite element models presented in their study is a powerful tool in addressing the failure of the unstiffened extended shear tab connection in the plastic region. Mahamid et al. [15] addressed in detail the failure modes and analyses of the stiffened extended shear tab connection. Finite element models were created using ANSYS, these models were compared and verified with experimental study done by Sherman and Ghorbanpoor [19]. The author observed five different failure modes in these connections: bolt shear, shear yielding of the plate, bolt bearing, twist in the shear tab, and web mechanism in the girder web. Mahamid et al. concluded that his model is accurate and unique in examining the behavior of the stiffened extended shear tab connections. Brusi and Jaspart [10,11] introduced

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elementary tee stub connections which can be adopted as benchmarks in the validation process of finite element software packages, and proposed a three-dimensional non-linear finite element model suitable for the analysis of isolated extended end plate connections, their model was validated with experimental results from the literature. Muir and Hewitt [16] outlined the background and development of the design procedure for extended single-plate shear connections presented in the AISC [3], and presented a general design procedure for these connections. Creech [12] addressed the conservative nature of the design procedure presented in the AISC [3] manual and performed a comparison between the AISC [3] design method and design methods proposed by other researchers. Astaneh and McMullin [7,8], and Astaneh and Shaw [6] developed and proposed design procedure for the single plate shear connections. The authors indicated that the connections designed according to the proposed method possess sufficient shear strength, rotational flexibility, and ductility and can be categorized as simple connections. Richard et al. [18] studied the behavior of single plate framing connections, the author indicated that the single plate connection can develop a significant end moment in the beam and supporting member. And the moment developed depends on the configuration and the size of the bolts, the plate thickness, the beam web thickness, the beam span to depth ratio, loading, and relative flexibility of the supporting element. Ashakul [5] investigated the behavior of single plate shear connections using the finite element program ABAQUS. The author showed that the shear stress distribution when a plate reaches the strain hardening stage is not constant throughout the cross section. A relationship for calculating plate shear yielding strength based on this shear distribution was proposed. Skewed connections, in general, are commonly used in practice to frame members in such a way that their axes do not meet at a right angle. Single plates with snug-tight bolts are the most economical skewed connections with excellent dimensional control for 90° to 30° intersection angles [13]. The use of extended shear tab connections for skewed members eliminates the excessive beam ends cutting and modifications which makes this type of connections attractive to engineers and fabricators. In this paper, the behavior of different configurations of skewed extended shear tab connections is presented, and the effect of the connection orientation on the torsional behavior of the connection is investigated using nonlinear finite element analysis.

2. Source of data (experimental research)

In this study, the behavior of skewed extended shear tab connections was investigated analytically using the finite element software ABAQUS [1,2]. In order to check the adequacy of the proposed finite element models, orthogonal extended shear tab connections investigated experimentally by other researchers were used as a reference to validate these models. In part one of this study, a study on the behavior of orthogonal extended shear tab connections with the plate welded to the supporting member web was investigated; Sherman and Ghorbanpoor [19] experimental results was used as a reference to validate the finite element models. In part two, the behavior of orthogonal extended shear tab connections with the plate welded to the supporting member flange was investigated, experimental results by Baldwin Metzger [9] was used to validate the finite element models.

Sherman and Ghorbanpoor [19] studied two types of extended shear tab connections plates welded to the supporting member webs: the unstiffened and stiffened configurations. Fig. 1 shows the difference between the two configurations for the supporting member as a girder type. This paper focuses on the unstiffened configuration. Table 1 and Fig. 2 show geometries and configurations for the unstiffened connections tested by Sherman and Ghorbanpoor [19].

All plates were ASTM A36 Grade 36 steel with 9.525 mm or 12.7 mm thickness. ASTM A325-X bolts were used in short slotted holes. Beams and supporting members were made of ASTM A572 grade 50 steel wide flange sections. E70 electrodes and fillet weld with 7.938 mm thickness were exclusively used for welding both sides of the shear tab to the web of the supporting member. Fig. 3 shows supports location for girders and columns. For all tests, columns were 2.44 m long and supports were placed at 0.3 m from column ends. Also, supporting girders were 3 m long and supports were placed at 0.15 m from girder ends.

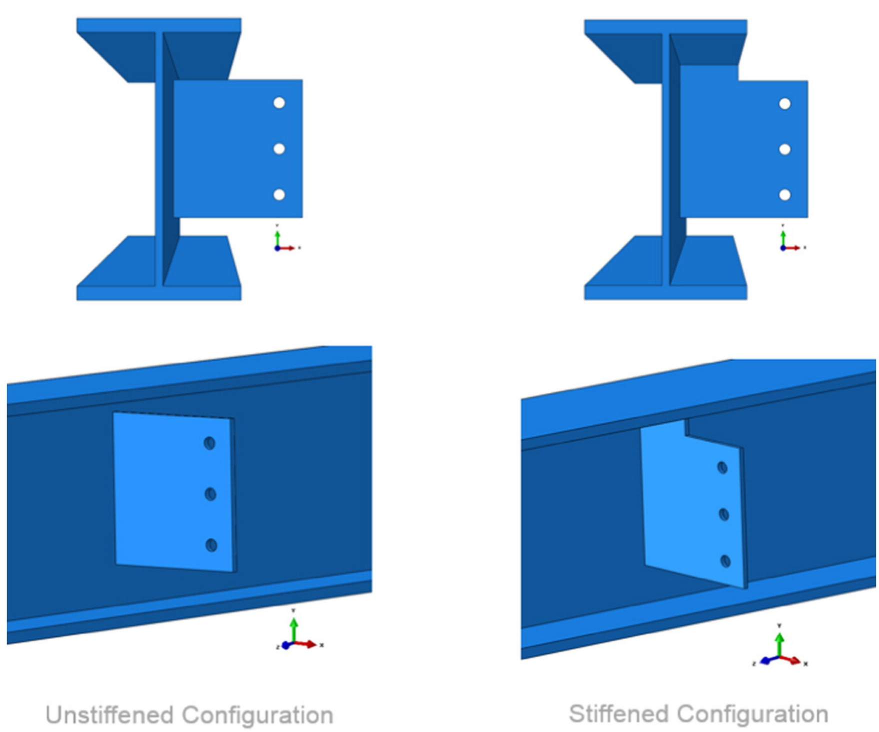

Fig. 1. Stiffened and unstiffened configurations.