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Flexural behavior of bolted beam-to-column connections of steel storage racks

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ABSTRACT

This paper presents an experimental investigation of bolted beam-to-column connections of steel storage racks. The conventional beam-to-column connections with and without additional bolts are experimentally tested using the standard cantilever test in order to evaluate the flexural behavior of the connection. Moment-rotation curves of rack's connections obtained from the experiment show a great benefit of additional bolts in terms of moment resistant and ductility. The experimental results show that the strength of bolted beam-to-column connections is higher than the conventional beam-to-column connections by up to 76%. The ductility of the bolted beam-to-column connection is also increased by up to 22%. The study shows that the additional bolts can be applied for the strengthening of beam-to-column connections of steel storage racks.

1. INTRODUCTION

Steel storage racks are wildly used in industry and large public warehouses for storing products. This type of structure has become a common feature in several countries. A structural system of steel storage racks is composed of a perforated thin wall cold-formed open section column, a box beam and beam end connectors. A beam end connector, welded into the ends of the beam, provides a means of connecting the beams and the column together. Steel tabs are often used as connectors. Steel tabs are the hooks in the beam end connector that are engaged into the perorated column at optional heights. Many experimental studies (Markazi et al. 1997: Bernuzzi and Castiglioni 2001; Bajoria and Talikoti 2006) have found that this type of connection has a low of strength which can be classified as a semi-rigid connection. The failure mode is usually the tearing of an outermost steel tab, which is a brittle failure mode.

For practical reasons, it has been found that some of the conventional beam-to-column connections use additional bolts to avoid the accidental unlocking of the

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connections. The bolts are tightened with washers on a slot of perforated columns as shown in Fig. 1. Generally, the strength and thickness of additional bolts is higher than the steel tab, therefore, it is possible that additional bolts may have some improvement on the flexural behaviors of the beam-to-column connections. The main objective of this study is to investigate the flexural behavior of the beam-to-column connections of steel storage racks with additional bolts, which will be referred to as “bolted beam-to-column connections” in this paper. The experimental testing results will be compared with the conventional beam-to-column connections without additional bolts (Asawasongkram et al. 2014) in terms of strength, ductility and failure mode to evaluate the possibility of using additional bolts for strengthening this type of connection.

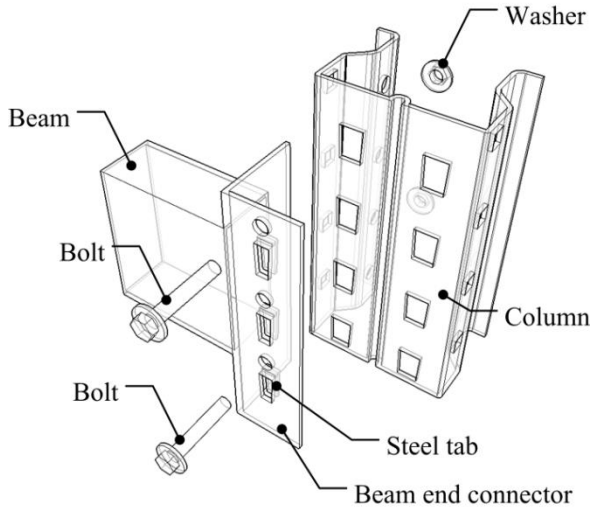


Fig. 1 Bolted beam-to-column connection of steel storage racks

2. EXPERIMENTAL INVESTIGATION

The test specimens are selected from a commercial manufacturer in which their configurations are commonly used in Thailand and other countries. In particular, it consists of a beam-end-connector made of a 3 mm thick angle welded to the end of a box beam. The column and beam are fabricated from cold formed steel. The thickness of column is 2.5 mm. The beam-end-connectors are made of hot rolled steel. The additional bolts are tightened with washers near the topmost tab and bottommost tab which are subjected to a substantial flexural tension and compression. The dimensions of specimens are shown in Fig. 2.

The cantilever test setups are performed according to the international design standard for steel storage racks (AS 4084, 1993; FEM, 1998; RMI, 2008). Fig. 3 shows an arrangement of transducers and a general layout of the experimental setups. Full details of the experimental test setup are available in an earlier paper by the authors (Asawasongkram et al. 2014).

The bolted beam-to-column connections are experimentally tested for ten connection samples which consist of five hogging moments and five sagging moments.

The moment-rotation curves for the connection subjected to hogging moments and sagging moments are presented in Fig. 4a-4b, respectively.

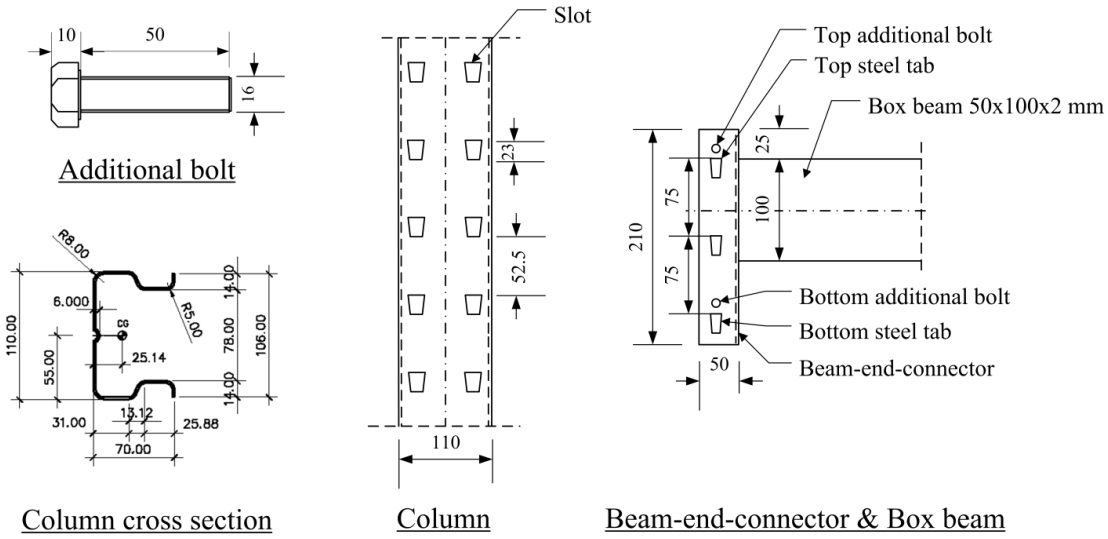
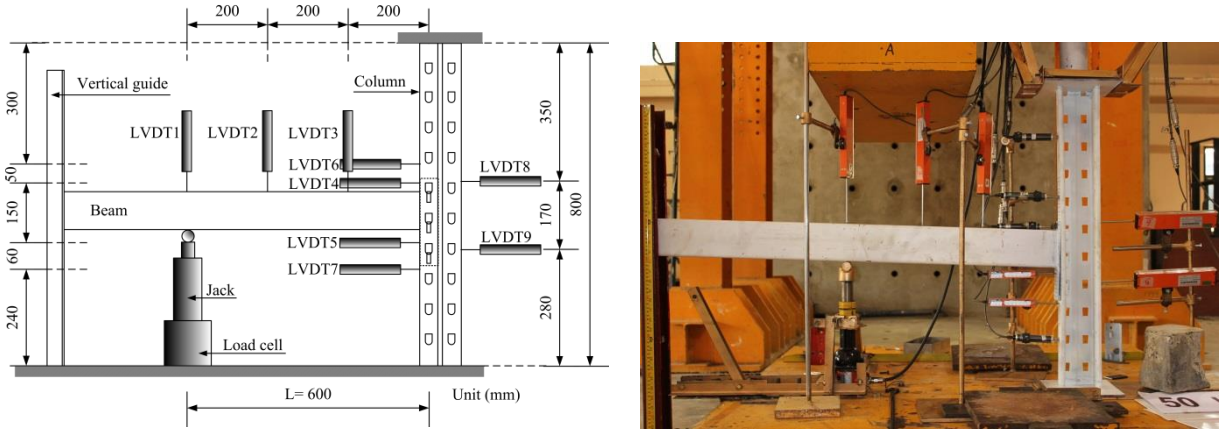


Fig. 2 Dimensions of connection samples (Unit: mm)



a) Transducer arrangement b) Actual test setup

Fig. 3 Cantilever test setup

To simplify the connection behaviors, the experimental moment-rotation curves in Fig. 4 are idealized as a multilinear line shown in Fig. 5. The flexural behavior of the connection up to failures is presented by photos taken from the experimental testing as illustrated in Fig. 6a-6d. According to Fig. 5-6, the flexural behaviors of the connections can be described as follows.