# Cyclic Behavior of Unstiffened Double Split-Tee Beam-to-Column Connection

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## Summary

An unstiffened double split-tee beam-to-column bolted connection is one of the “weldless” beam-to-column connections. In the present study, structural performance of steel framework including the unstiffened connection is investigated. Cyclic loading tests of subassemblages including the unstiffened connections are performed, and validities of yield strength prediction by plastic analysis and finite element analysis to predict cyclic behavior are also investigated.

**Keywords:** beam-to-column connection; weldless; split-tee; subassemblage; cyclic behavior.

## 1. Introduction

In most of damaged steel buildings under Hyogo Ken Nanbu Earthquake in 1995, many full-penetration weld connections at beam ends fractured. Since the earthquake, to prevent the brittle fracture, many studies on weldless steel framing system have been conducted in Japan. In the present study, unstiffened (i.e. without stiffening plates) double split-tee bolted beam-to-column connection (Fig. 1) is experimentally investigated by cyclic loading tests (Fig. 2). Finite element analysis to simulate the cyclic behavior is also performed.

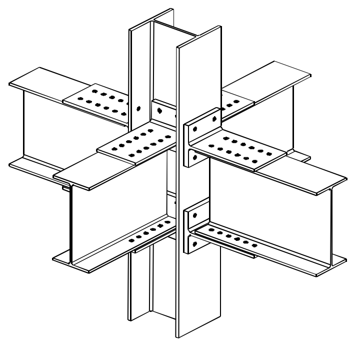

*Fig. 1: Unstiffened double split-tee beam-to-column bolted connection*

## 2. Beam-to-Major Axis Column Connection

T-shaped and cruciform subassemblages with beam-to-major axis column connection are used for cyclic loading tests (Fig. 3). The beam-to-column connection is designed so that out-of-plane deformation of plate elements of the column member may dominate connection behavior. Experimental load-deformation relationship curves show stable hysteretic loops (Fig. 3). Estimated yield strengths by yield line analysis and monotonic load-deformation prediction curves are also shown in the figures; those predictions well correspond to the experimental results.

## 3. Beam-to-Minor Axis Column Connection

T-shaped and cruciform subassemblages with beam-to-minor axis column connection are used (Fig. 5). Experimental load-deformation relationship curves show stable hysteretic loops (Fig. 5). Estimated yield strengths by yield line analysis and cyclic load-deformation prediction curves obtained by finite element analysis (Fig. 4) are also shown in the figures; those predictions well correspond to the experimental results.

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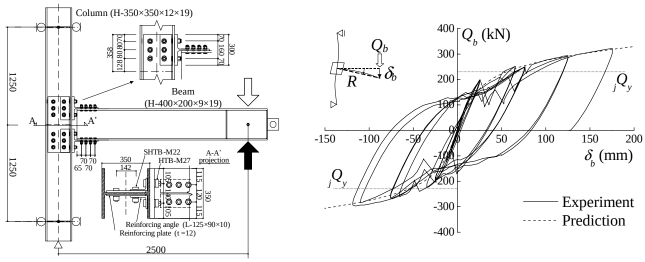
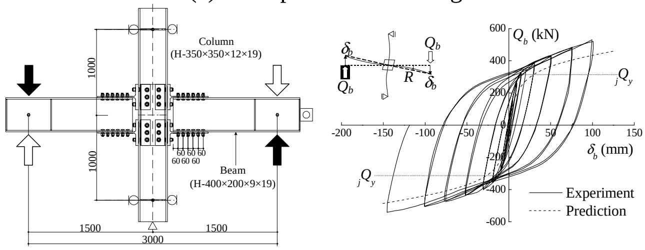
## 4. Conclusions

Structural performance of the unstiffened double split-tee beam-to-column connection is investigated experimentally and analytically. The cyclic loading tests of subassemblages including the unstiffened connections are performed and the specimens show good and stable hysteretic deformation capacity. The yield strengths of the specimens can be estimated by yield line analysis, and cyclic behaviors of the specimens can be numerically simulated by finite element analysis. Based on the knowledge obtained, seismic design of steel frameworks with the unstiffened connection will be investigated.

*Fig. 2: Setup example of loading tests*

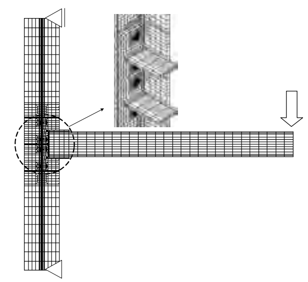



(a) T-shaped subassemblage

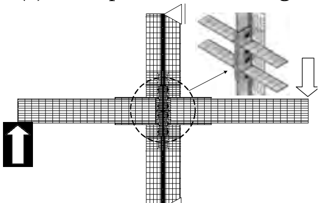



(b) Cruciform subassemblage

*Fig. 3: Load-Deformation Relationships (Beam-to-Major-Axis Column Connection)*

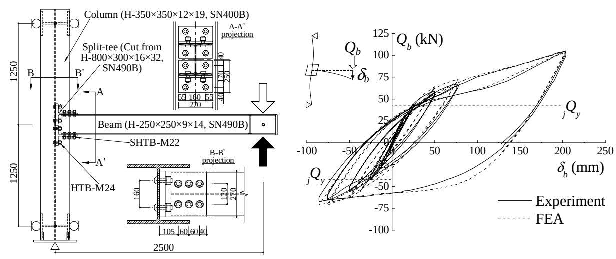


(a) T-shaped subassemblage

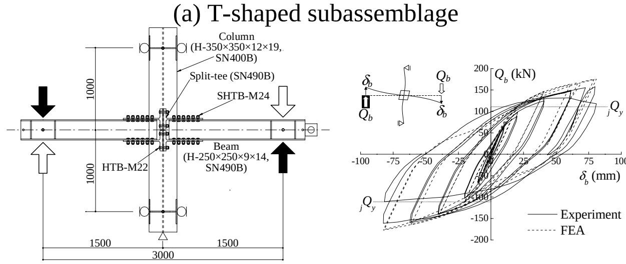


(b) Cruciform subassemblage

*Fig. 4: Finite element models of subassemblages (beam-to-minor-axis column connection)*




(a) T-shaped subassemblage




(b) Cruciform subassemblage

*Fig. 5: Load-Deformation Relationships (Beam-to-Minor-Axis Column Connection)*