Carleton UNIVERSITY

APPLICATIONS OF STRUCTURAL FIRE ENGINEERING
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Fire Modelling of Axially-Restrained Tubular Steel Beams

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INTRODUCTION

Using unprotected structural steel members in buildings has increased considerably in recent years. According to the performance-based philosophy, this kind of application can be possible since structural steel members have certain inherent ability to resist fire. In this regard, both experimental study and 3D finite-element modelling (using ABAQUS) of unprotected axially-restrained tubular steel beams under transverse loading are presented in this paper.

RESEARCH OBJECTIVES

1. Investigate the structural fire behaviour of unprotected restrained tubular steel beams between two columns using the extended end-plate moment connection;
2. Investigate the effect of changing the connection end plate thickness on the behaviour of the connected steel beam at elevated temperatures;
3. Provide new experimental data for the HSS extended end-plate moment connections to validate the FE model using ABAQUS.

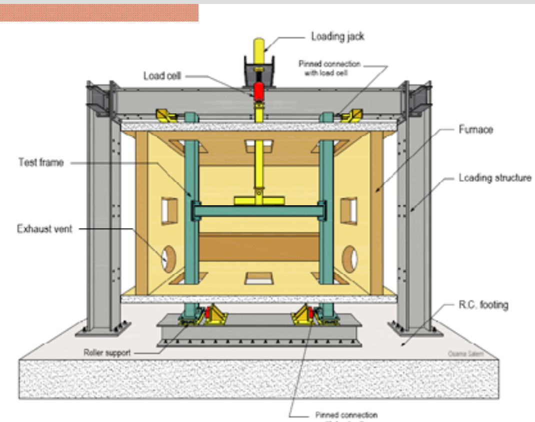


Figure 1 General view of a test assembly inside the furnace

EXPERIMENTAL TESTING

The experimental results that were used to validate the FE model presented in this paper are two large-scale fire-resistance tests. *Figure 1* shows a general view of a test assembly inside the furnace. The furnace is equipped with different thermal and mechanical instrumentation, such as LVDTs, thermocouples, plate thermometers, and load cells. The furnace is efficiently controlled to follow the standard time-temperature curve. Details and dimensions of the test assemblies' beam-to-column connections are illustrated in *Figure 2*. Two different end plate thicknesses were tested, 12.7 mm (1/2 in) and 19.0 mm (3/4 in), in Tests 1 and 2, respectively.

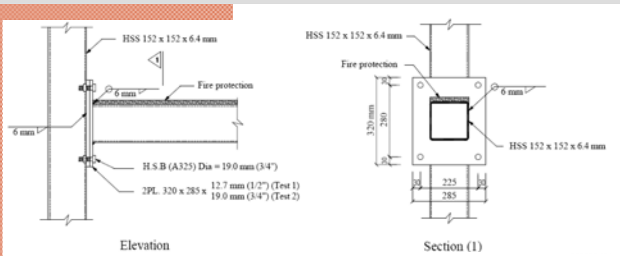
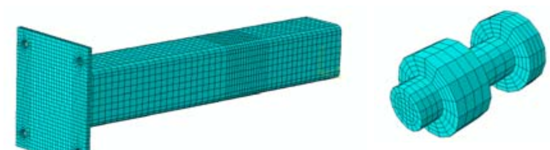


Figure 2 Beam-to-column test connections dimensions and details

FE MODEL DESCRIPTION

The four main parts of the beam-to-column connection; the beam, the end plates, the bolts, and the column were modelled using eight-node continuum hexahedral brick elements (C3D8H in ABAQUS terminology). For the end plate mesh, two elements through the 12.7 mm end plate were used, while three elements were used for the19.0 mm end plate, *Figure 3*.



(a) The beam with its extended endplate (b) The bolt

Figure 3 Finite-element model details

FE MODEL VALIDATION

The experimental results were compared with the predictions of the FE model, where good agreement has been achieved in different measurements. *Figures 4(a)* and *(b)* illustrate a comparison of the connection deformations between the experimental results and the FE model predictions for Tests 1 and 2, respectively. Also a comparison of the beams mid-span deflections is shown in *Figure 5*.

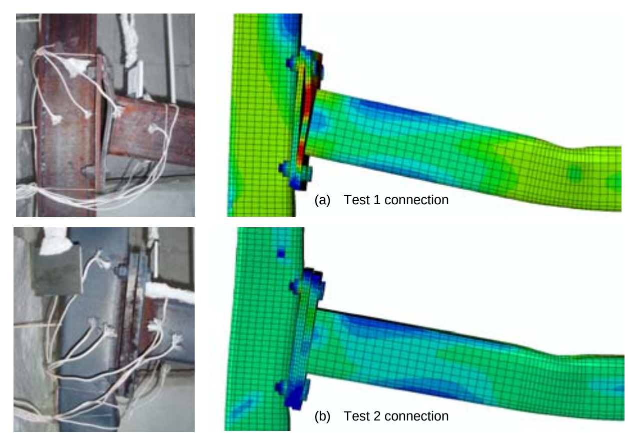


Figure 4 Connection deformations after exposed to standard fire

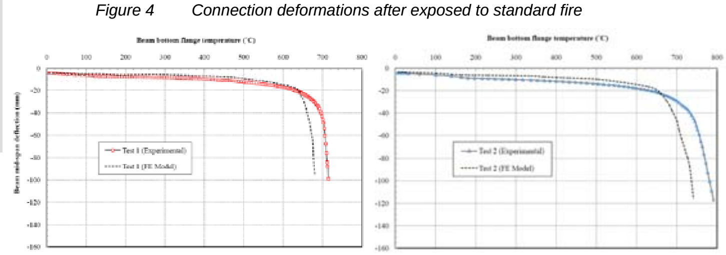


Figure 5 Beams mid-span deflection with respect to beam bottom flange temperature

CONCLUSIONS

Increasing the end plate thickness from 12.7 mm to 19.0 mm has increased the beam critical temperature by about 65˚C. FE model predictions correlated well to the experimental results of the axially-restrained tubular steel beams at elevated temperature.

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