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

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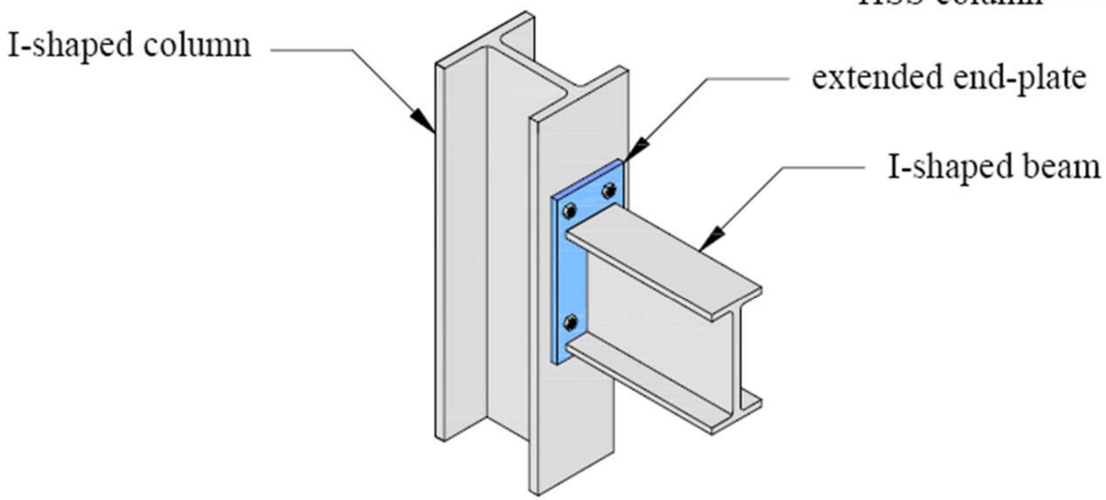
Outline

- Introduction
- Test Objectives
- Details of Connections
- Test Setup and Procedure
- FE Model Description
- FE Model Validation
- Conclusions

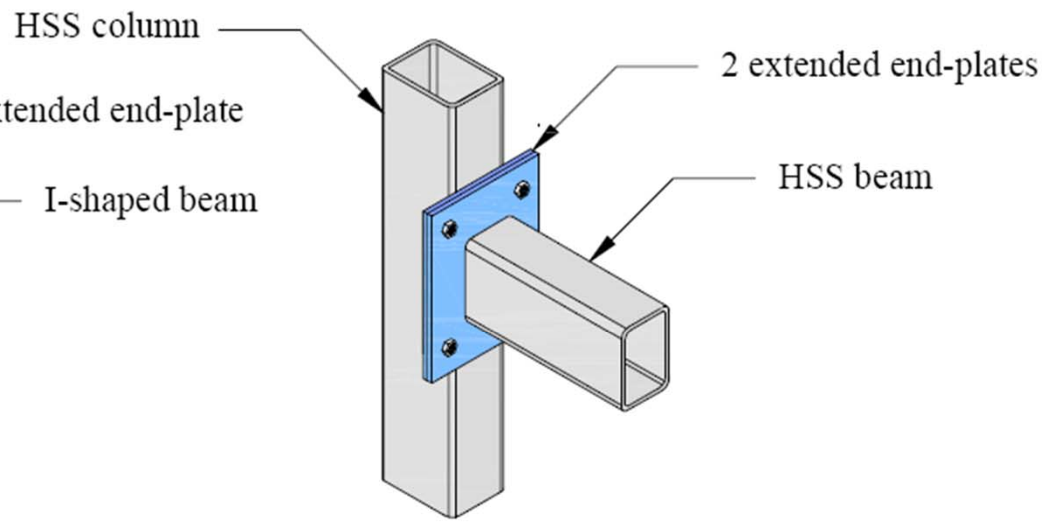
Introduction

- Extensive research has been done on beam-to-column connections between I-shaped sections at both normal and elevated temperatures.
- There is limited research on beam-to-column connections between Hollow Structural Sections (HSS) at normal temperatures.
- Almost no research on beam-to-column connections between HSS steel members has been done at elevated temperatures.

Introduction



Extended end-plate connection between I-shaped sections



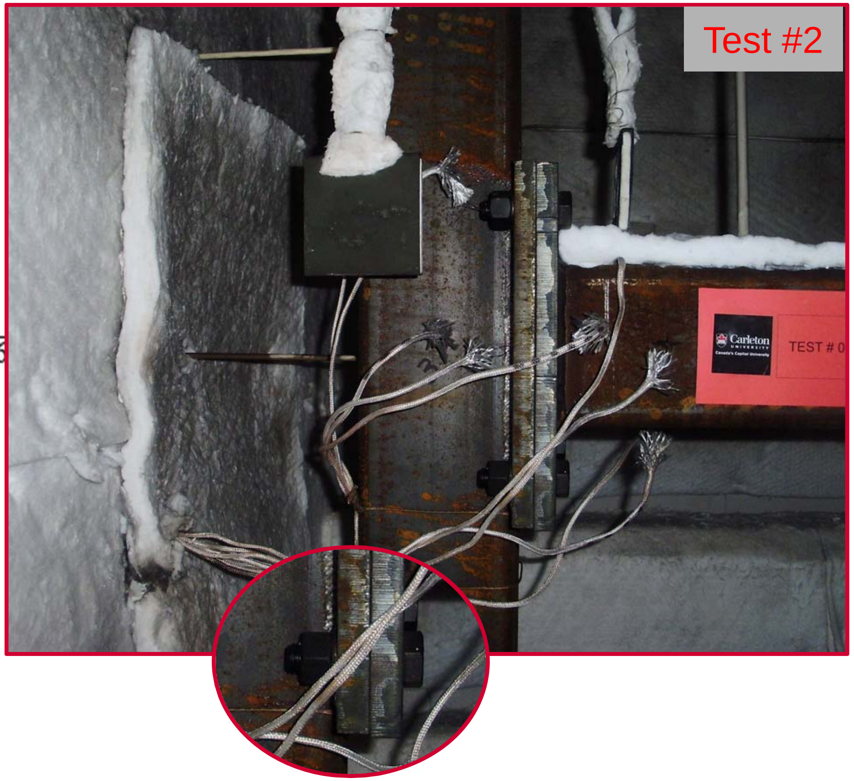
Extended end-plate connection between HSS

Test Objectives

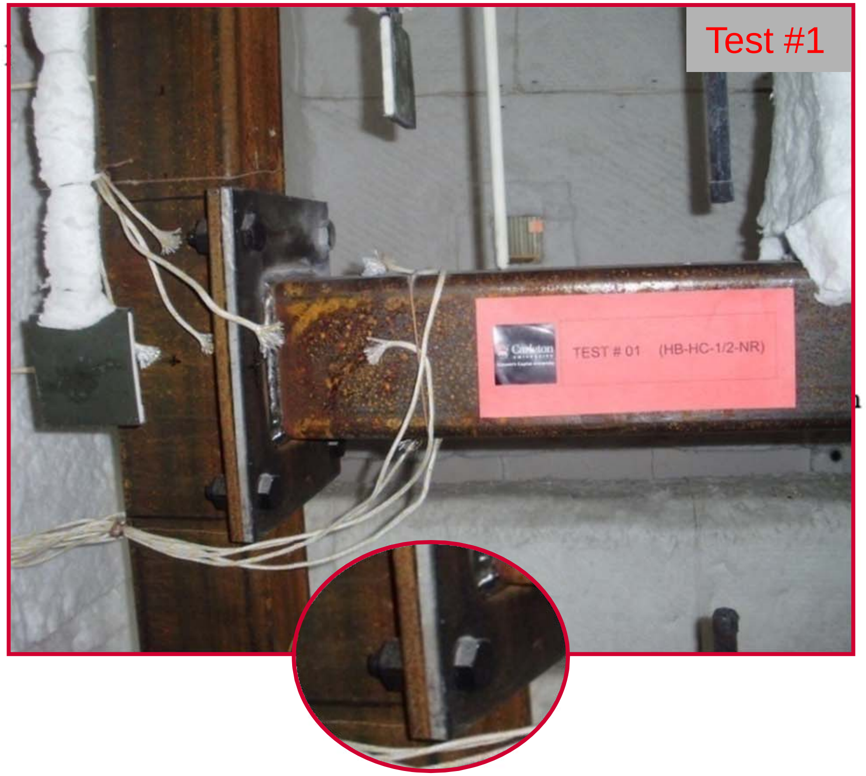
- To investigate the structural behaviour of extended end plate moment connection between unprotected HSS beam and column;
- To investigate the effect of changing the connection end plate thickness on the behaviour of the connected steel beam at elevated temperatures;
- To compare the experimental data for the extended end-plate moment connection between HSS beam and column at elevated temperatures with the predictions of a FE model using ABAQUS.

Test Connections Details

- HSS-to-HSS Extended End-plate Moment Connection



thickness = 19.0 mm (3/4 inch)



thickness = 12.7 mm (1/2 inch)

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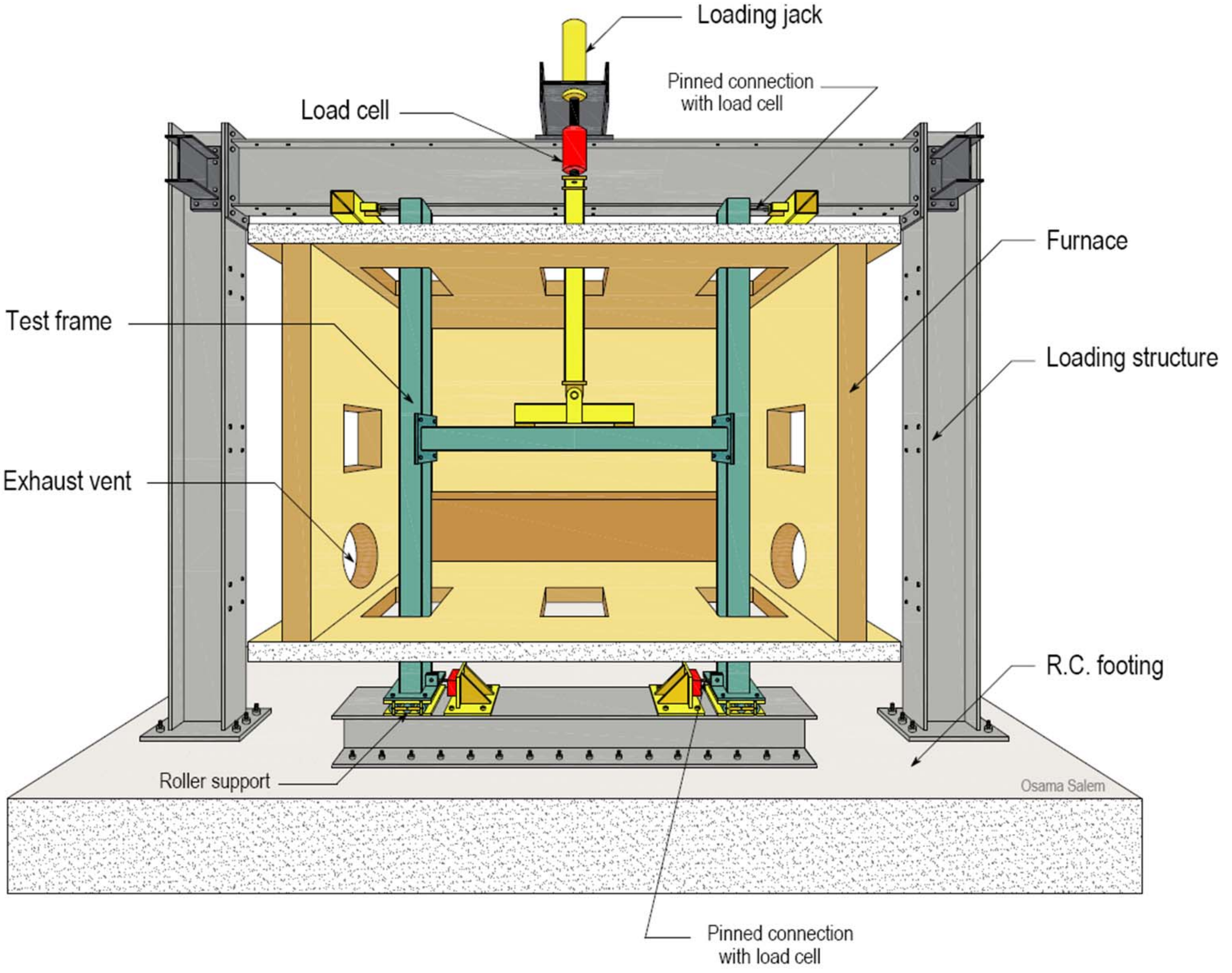
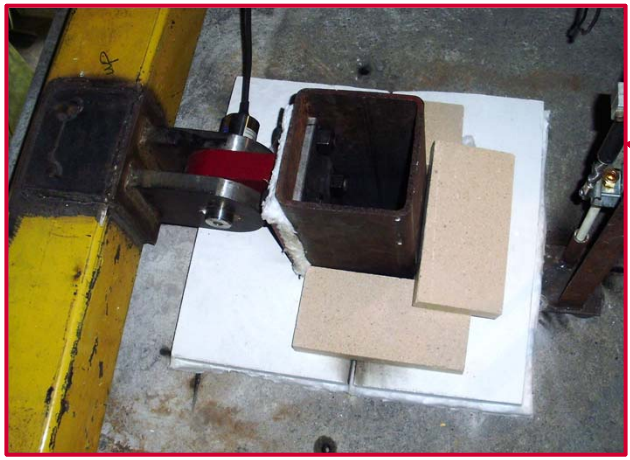
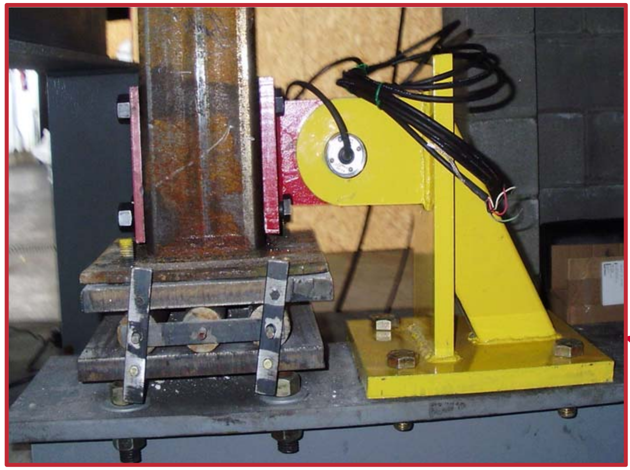
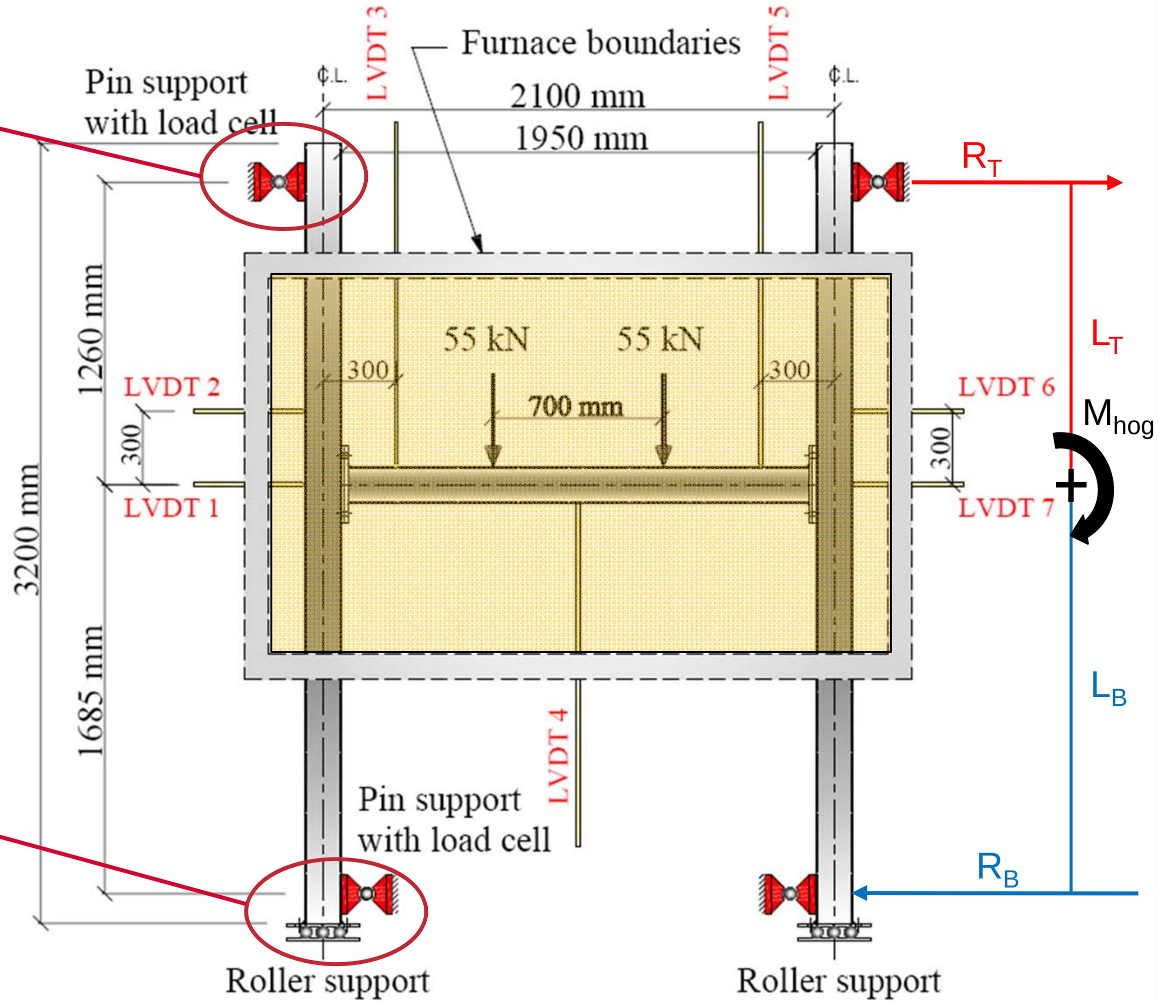
Test Setup and Procedure



Test Setup and Procedure







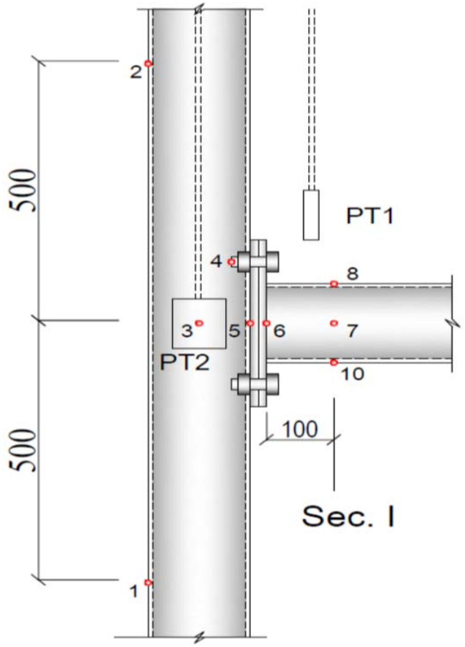
Furnace cross-section view

LVDT : Linear variable differential transducer

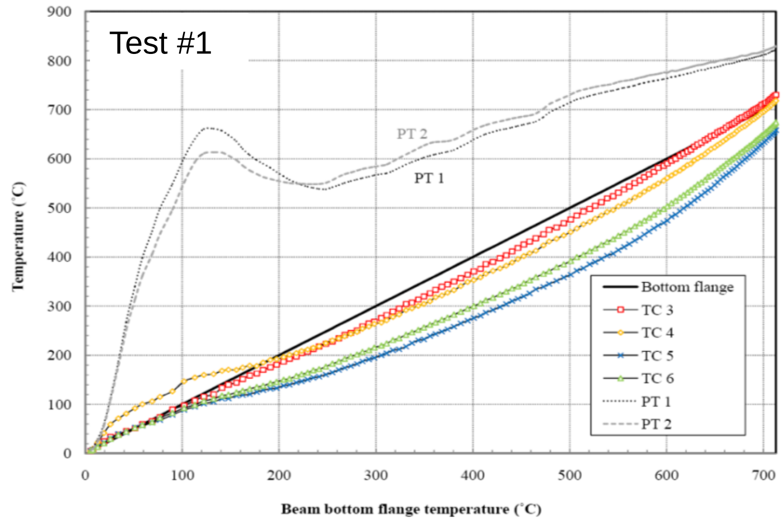
Test Setup and Procedure

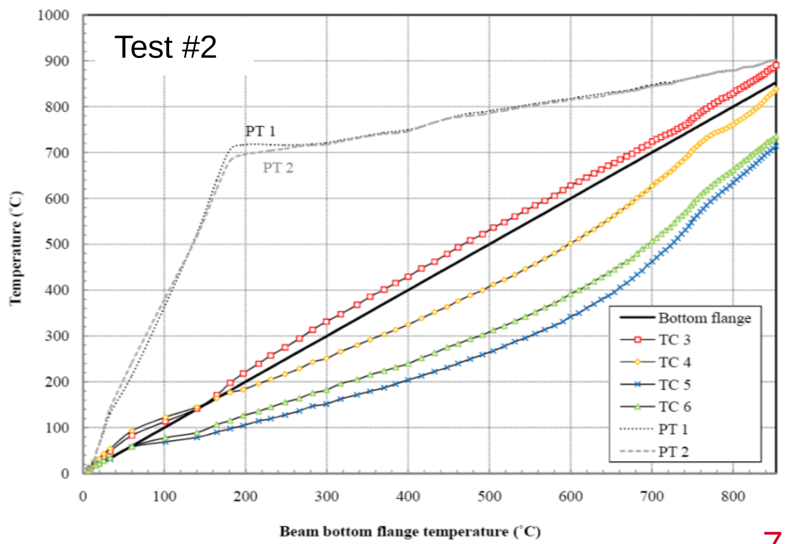
Measuring the test assembly temperatures

- 22 shielded K-type thermocouples were welded to each test assembly at different locations



Thermocouples distribution over the connection area





FE Model Description

- FE Model parts:

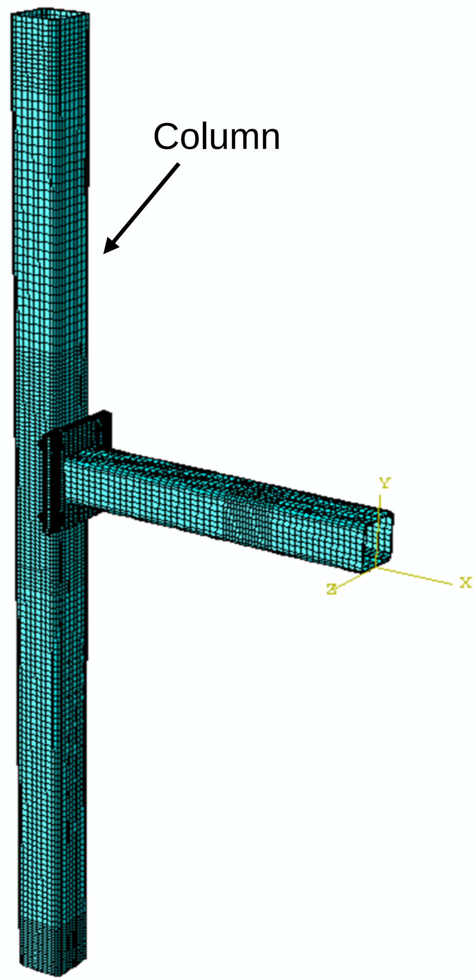
  Column, beam, end plate, and bolt.

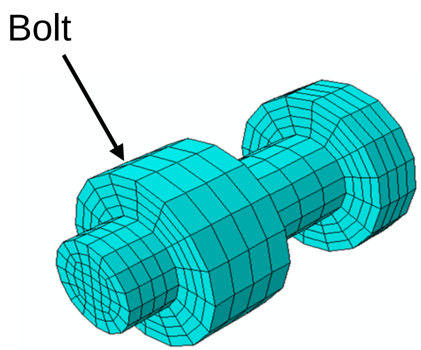
  (Modeled using eight-node hexahedral brick elements (C3D8H))

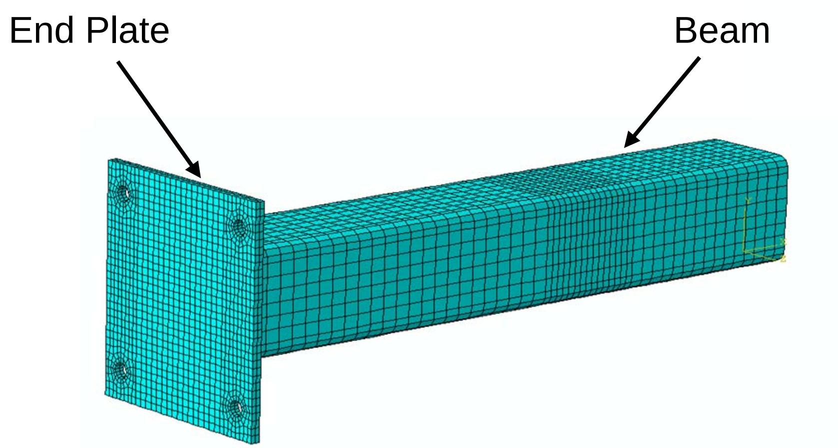
- Contact pairs:

  - Bolt shanks-to-bolt holes
  - Bolt heads-to-beam end plate
  - Nuts-to-column connecting plate
  - Beam end plate-to-column connecting plate

  (Contact was modelled using surface-to-surface interaction)

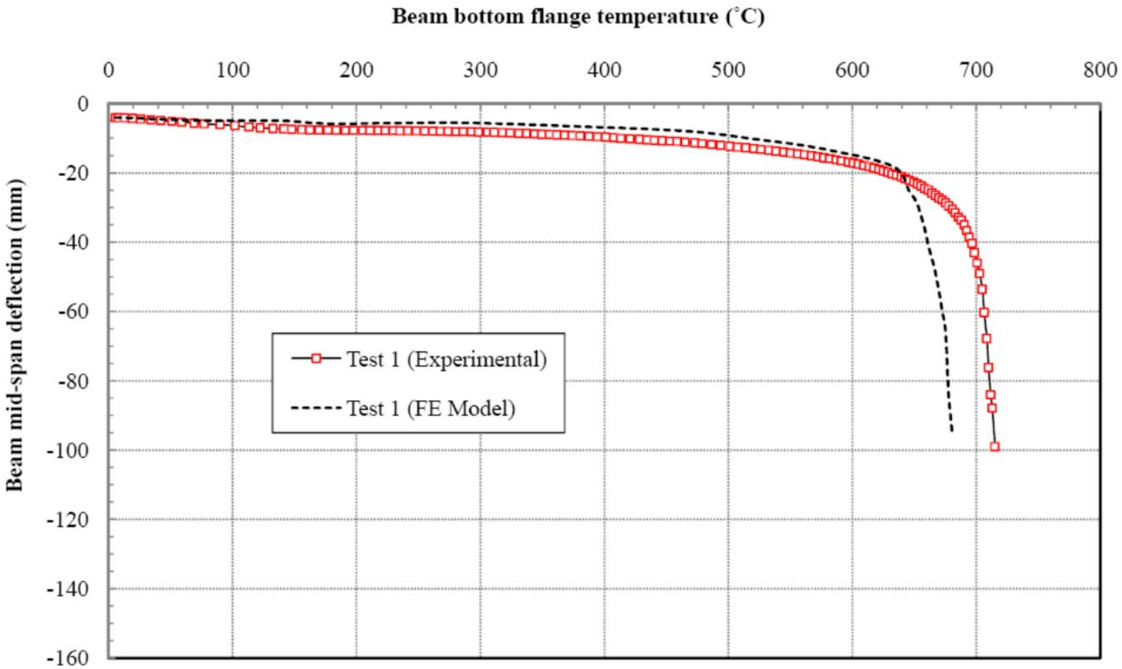






FE Model Validation

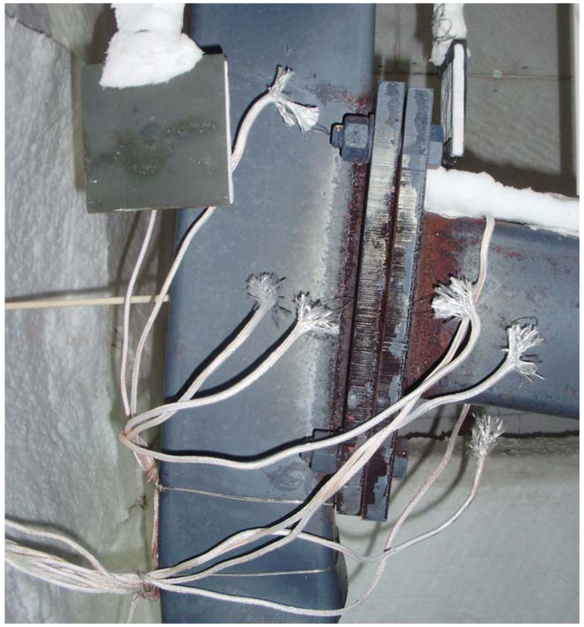
- Test 1 (Beam mid-span deflection)

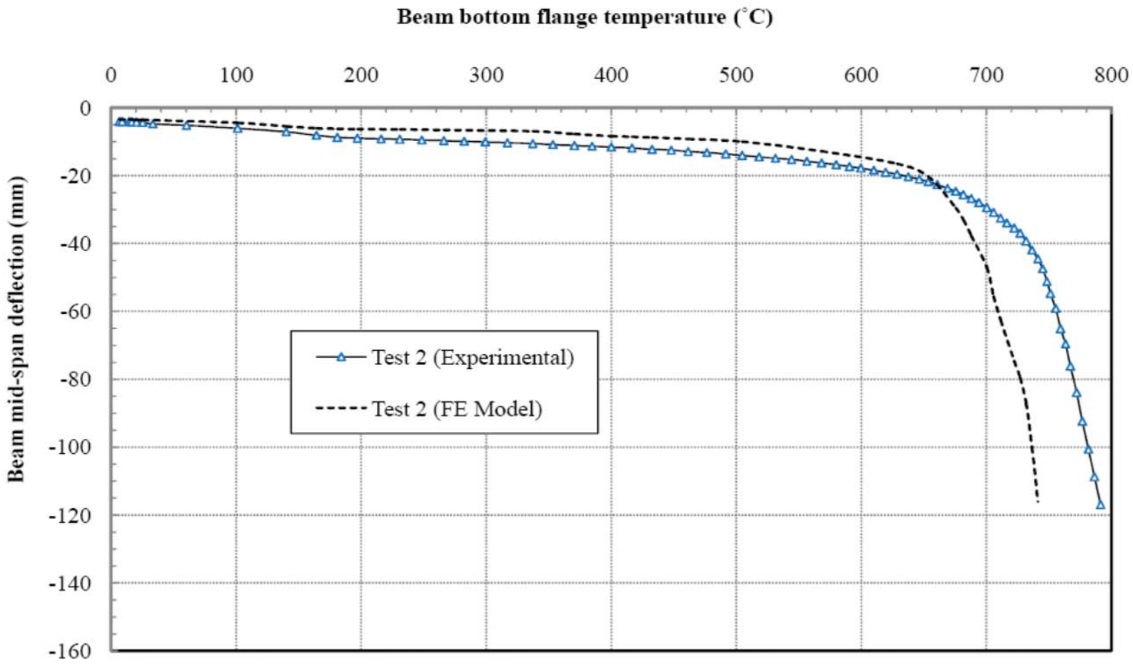


- Test 1 beam reached its limiting deflection (span/20 =100 mm) at beam bottom flange temperature of about 715˚C, while the finite-element model gave a prediction of about 680˚C.

FE Model Validation

- Test 2 (Beam mid-span deflection)





- Test 2 beam reached its limiting deflection (span/20 =100 mm) at beam bottom flange temperature of about 780˚C, while the finite-element model gave a prediction of about 740˚C.

Conclusions

- Both beams with different end plate thicknesses, 12.7 and 19.0 mm, sustained the applied load with mid-span deflections of less than 20 mm for up to a beam bottom flange temperature of about 640°C;
- Increasing the connection end plate thickness from 12.7 to 19.0 mm increased the temperature of the unprotected restrained beam at the time of failure by 65°C;
- The comparisons demonstrated that the FE model simulated the experimental behaviour of the axially-restrained tubular steel beams at elevated temperature very well.

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Thanks