12-15 March 2014, Lulea

# ROTATIONAL CAPACITY OF DAMAGED AND UNDAMAGED STEEL I-BEAMS AT ELEVATED TEMPERATURES

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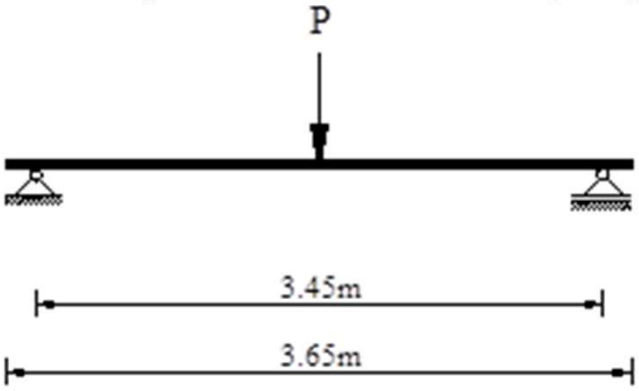
# Introduction-Description of the problem

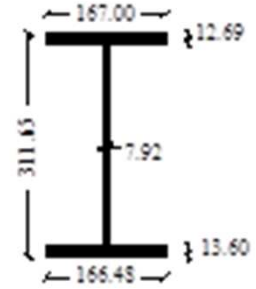
- The global plastic analysis of steel structures requires that at the plastic hinge locations, the cross sections of the members should have rotational capacity greater than the required one
- This problem is handled through the classification of the cross sections
- Several factors may affect the rotational capacity of steel members under fire conditions
- These parameters may lead to premature occurrence of local or lateral torsional buckling in the plastic range, therefore limiting the available rotational capacity

# Validation of the numerical model

## The structural system

**The structural system that is used for the validation is referred to a typical beam specimen of the experimental study by R.B. Dharma and K.H. Tan**




Cross section
UB 305x165x54

## The numerical model

- ✓ **three-dimensional numerical model is developed using the nonlinear finite element code MSC-MARC**
- ✓ **four-node, thick-shell elements**
- ✓ **the nonlinear elastic-plastic stress-strain relationship of steel at elevated temperatures is taken into account**
- ✓ **Initial imperfections are incorporated in the geometry of the steel beam for a more realistic assessment of its behaviour**

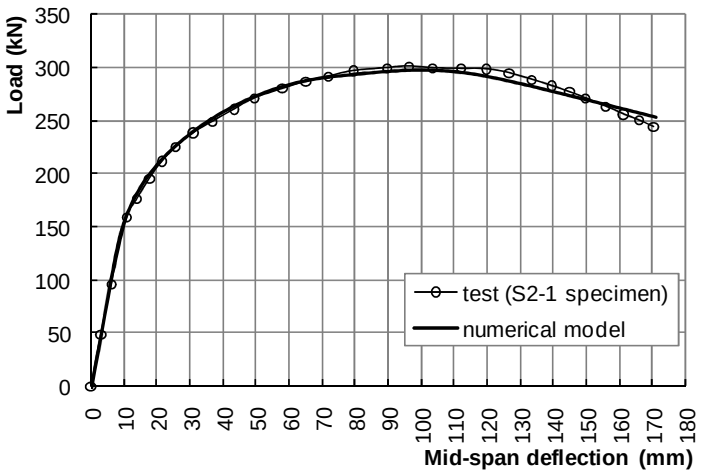
# Validation of the numerical model

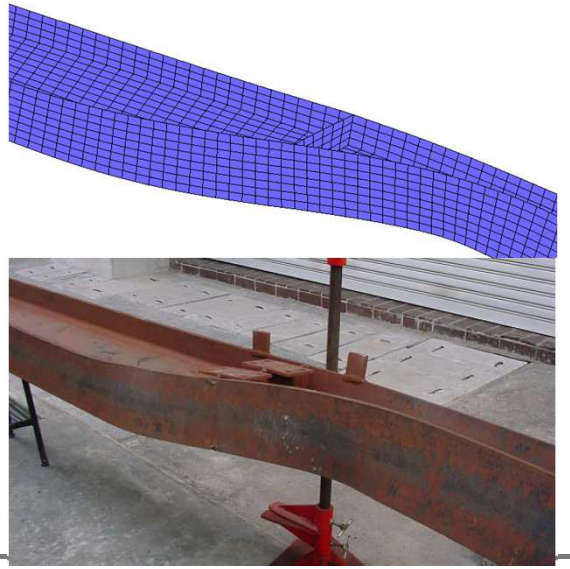
**<u>First stage</u>: the steel beam is heated with a heating rate equal to $7^0$C/min until the desired temperature $T$=$415^0$C is reached.**

**During the heating stage the temperature is uniform along the member.**

**<u>Second stage</u>: the temperature remains constant and the beam is submitted to loading at mid-span until failure**

## Comparison between experimental and numerical results

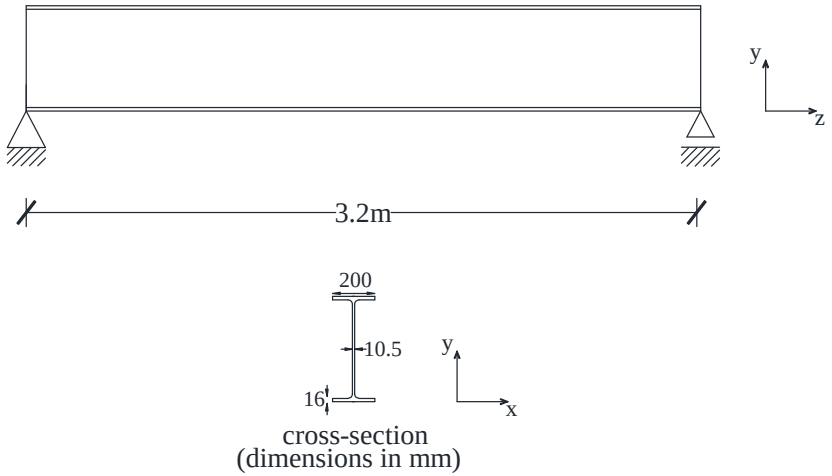


# Parametric analyses

- ✓ **The modelling methodology is further used:**
  - o **in order to conduct parametric analyses for different amplitudes of initial imperfections**
  - o **for the evaluation of the ductility of the structural members that are damaged due to cyclic loading**

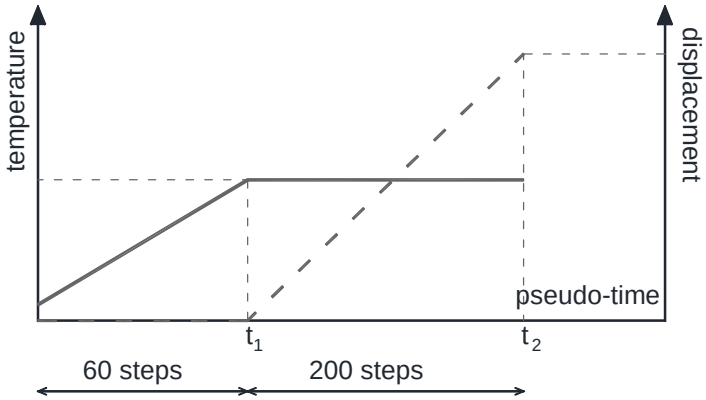
- ✓ **The cyclic loading is used in order to simulate the damage that may be induced in the members due to seismic excitation.**

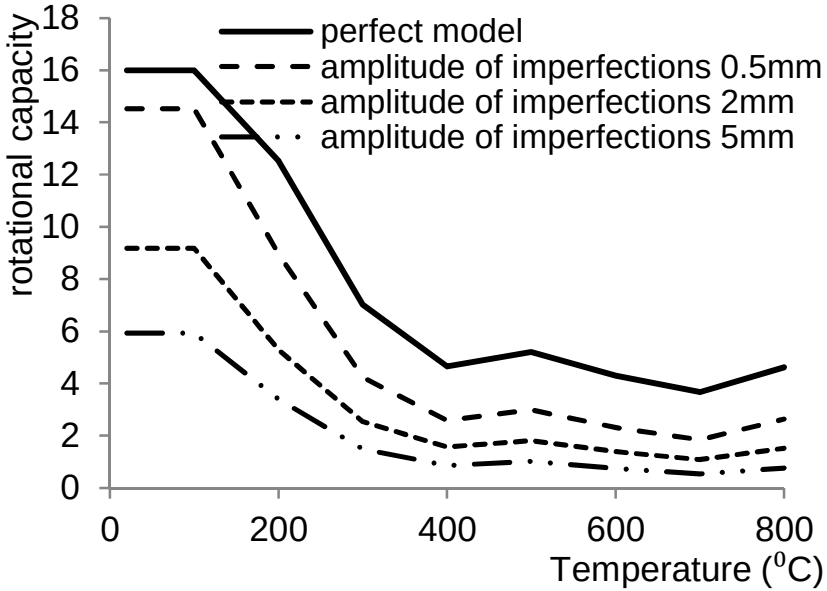


# Parametric analyses

## Rotational capacity at elevated temperatures for undamaged beams

- ✓ **The rotational capacity of beams at elevated temperatures is obtained through virtual three point bending tests.**
- ✓ **The numerical analysis has two different stages**
- ✓ **The numerical test is displacement controlled**

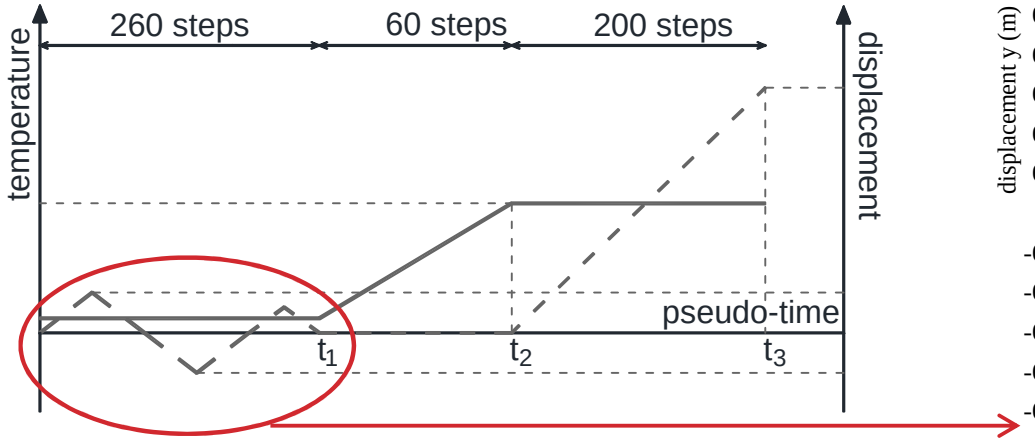


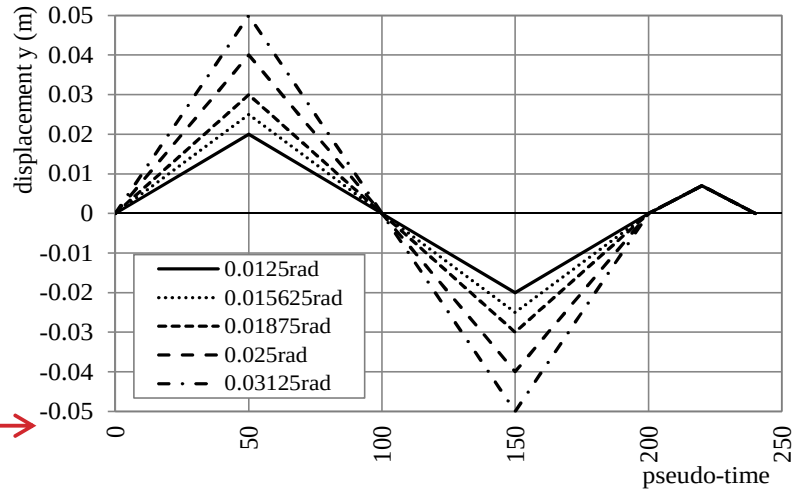



# Parametric analyses

## Rotational capacity of pre-damaged due to cyclic loading beams at elevated temperatures

- ✓ **The numerical analysis has three different stages.**
- ✓ **The first stage is the cyclic loading which introduces some level of damage at the mid-span of the beam in order to simulate the damage that can be induced in the beam during the earthquake loading**
- ✓ **In the second stage the temperature increases until the desired level is reached**
- ✓ **The monotonic loading stage follows, while the temperature remains constant.**

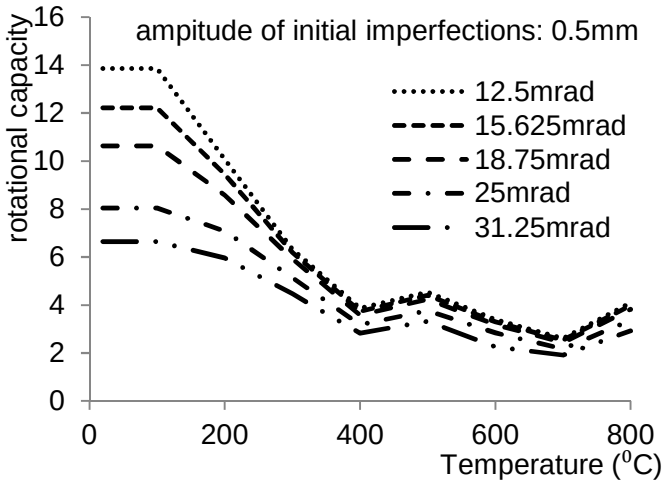


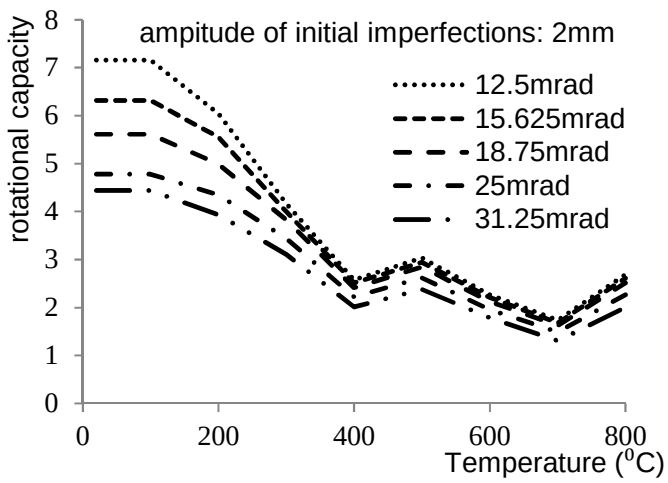



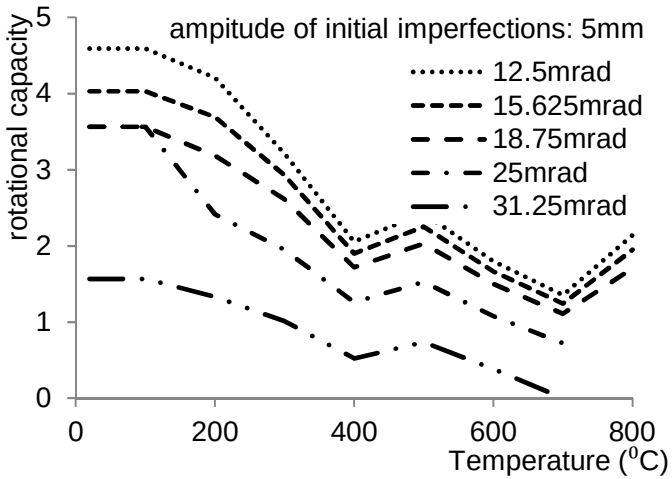

**Five different cyclic loading patterns are studied**

# Parametric analyses

## Rotational capacity of pre-damaged due to cyclic loading beams at elevated temperatures



# Thank you for your attention