3.12 Nonlinear analysis of steel frames to consider fire after earthquake scenarios (short version)

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Integrated Fire Engineering and Response
COST ACTION TU0904 – WG3

Nonlinear analysis of steel frames to consider fire after earthquake scenarios

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Introduction

- According to the current design codes, the design of structures is performed independently for the seismic and thermal actions.
- The case of fire resulting just after an earthquake event has been witnessed by the international community after the major earthquakes in recent years (Kobe-Japan earthquake 1995, Northridge earthquake 1994, etc.) being not covered by any design code.
- Fire design codes make the assumption that at the beginning of the fire event, the structure is still in the elastic region of material behaviour, and that all the measures for fireproofing are active (fire coatings, paints, sprinkler systems, etc.).
- However, this assumption is not valid when the structures are damaged by seismic events, which are followed by the outbreak of fire.

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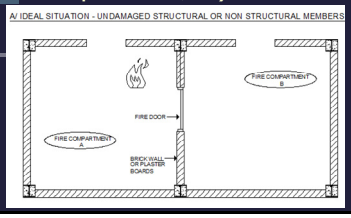
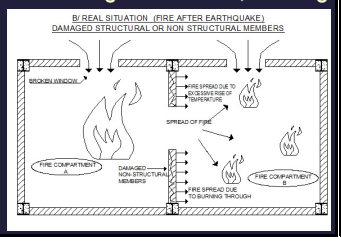
Introduction

Earthquakes may cause damage to structural and non-structural elements.

- For the structural components the damage can be either brittle or ductile ➔ the structure will be in a completely different state from that which has been considered in the design against fire.
- The damage to non-structural elements due to earthquake, may limit the resistance of structures in fire (e.g. cracking of fireproof cladding, peeling of fireproof painting due to intense plastic deformation, sprinkler failure etc).
- Seismic damages may significantly affect the conditions for growth and spread of fire (e.g. breakage of windows allowing free air inflow, blocking of fireproof doors, etc).





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Organization of the project

1. Definition of performance requirements for combined actions(fire after earthquake)
2. Simulation of natural fire under the consideration of damage induced by seismic events (development of various thermal scenarios)
3. Numerical simulation of "damaged" members and structures in elevated temperatures
4. Analysis of model structures, designed according to the current codes, in the fire after earthquake scenarios .
5. Study of protection measures
6. Development of design guides for practical applications

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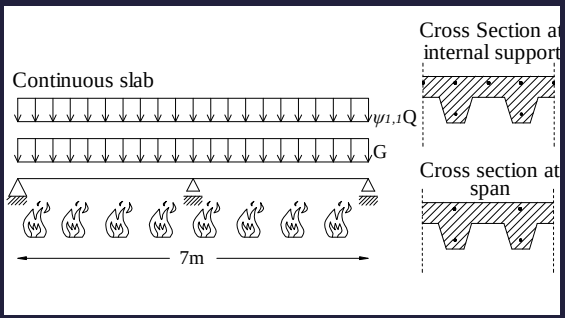
Numerical simulation of the fire behaviour of structural components

1. Thermo-mechanical analysis of continuous composite slabs under fire conditions (Presentation by Daphne Pantousa in WG1)



The aim of the analysis is the study the fire performance of the composite slab that is designed according to EC4.

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Numerical simulation of the fire behaviour of structural components

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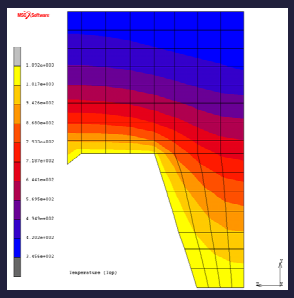
Results of heat transfer analysis

The temperature distribution is obtained by means of isotherms of the cross section



Results of mechanical analysis

The results of the numerical analysis indicate that the failure occurs at the 165 minute

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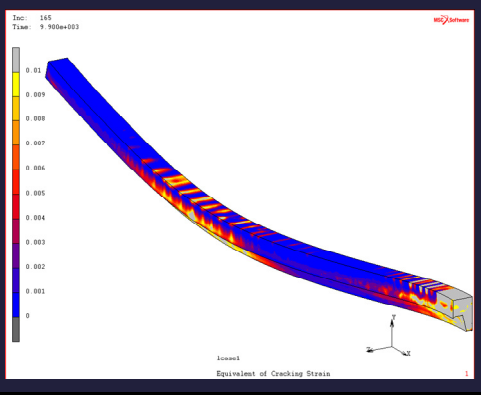
Numerical simulation of the fire behaviour of structural components

1

Results of mechanical analysis

Development of cracking strain during the analysis



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Numerical simulation of the fire behaviour of structural components

2. **Numerical simulation of steel I-beams at elevated temperatures**
(simulation of tests performed by Ronny Budi Dharma, Kang-Hai Tan)

- The main objective of this study is to validate the presented numerical model of the steel beam, against published experimental results.
- The second target is to investigate the main parameters that affect the behaviour of steel beams in elevated temperatures.

The experimental program

The test beams, which are simply supported, are submitted to point loading

The test conducted in two successional stages

1. During the heating stage the furnace temperature increased up to the desired value and maintained this temperature until the end of the test.
2. The loading stage started when the temperature distribution along the specimen was uniform.

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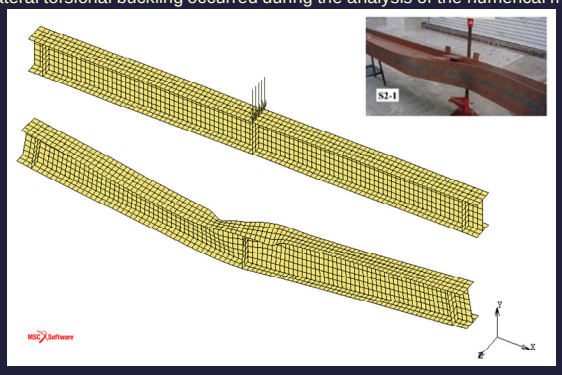
Numerical simulation of the fire behaviour of structural components

2

Results of thermo - mechanical analysis

Lateral torsional buckling occurred during the analysis of the numerical model.



The deformed shape of the steel beam after the test which is presented to the first figure is similar with the corresponding shape that we can obtain from the numerical analysis.

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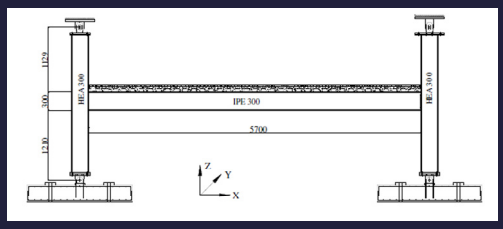
Numerical simulation of the fire behaviour of structural components

3. **Numerical simulation of a steel sub-frame in fire**
(simulation of tests performed by Aldina Santiago , Luis Simoes da Silva, Paulo Vila Real and Milan Veljkovic)

The main objective of this study is to validate the presented numerical model of the steel beam, against published experimental results.



This structural model corresponds to an experimental fire test programme carried out at the University of Coimbra in Portugal . It also corresponds to a representative substructure of the 7th Cardington fire compartment test

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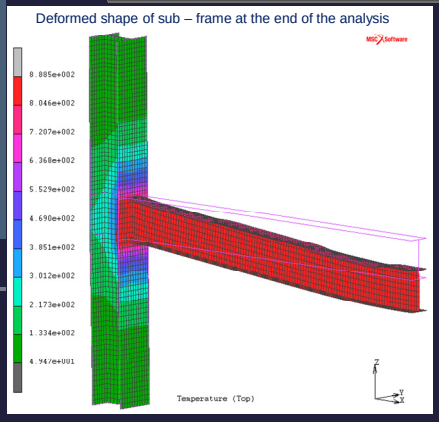
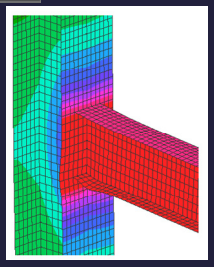
Numerical simulation of the fire behaviour of structural components

3

Results of thermo - mechanical analysis

Deformed shape of sub – frame at the end of the analysis





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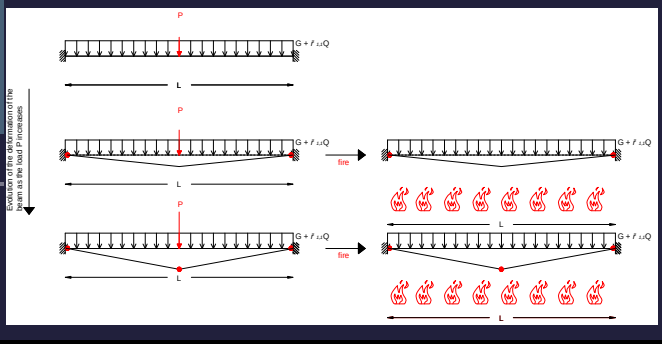
Fire behaviour of damaged structural components

1. **Numerical simulation of a damaged steel I-beam submitted to fire**

The main objective of this study is to investigate the fire performance of o steel I- beam, for various levels of damage caused by an imposed mechanical load



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