2.9 Robustness of car parks under localised fire: Tests on joints subject to thermal and mechanical loading

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ROBUSTFIRE PROJECT

Robustness of car parks under localised fire:
Tests on joints subject to thermal and mechanical loading

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PURPOSE and SCOPE OF THE PROJECT

- **EUROPEAN RFCS ROBUSTFIRE PROJECT**
  - New design criteria of car parks with sufficient robustness under localised fire
  - Practical design guidelines

- **4 MAIN OBJECTIVES**
  - State of the art (behaviour of joints and columns under fire; design of open car parks subject to a localised fire)
  - Behaviour study of the frame elements directly affected by the localised fire (Experimental tests and numerical models)
  - Numerical models and simplified analytical models of the fire response of critical structural components (Columns, connections, composite beams)
  - Robustness assessment approach for steel composite open car parks under localised fire

OVERVIEW OF THE 7 EXPERIMENTAL TESTS ON JOINTS

- **7 EXPERIMENTAL TESTS**
  - 1 REFERENCE TEST at ambient temperature
  - 5 TESTS at high temperatures (500°C and 700°C)
  - 1 DEMONSTRATION TEST under fire (increase of temperature up to the failure of the joint)

- **OBJECTIVE**
  - To observe the combiNeD bending momEnt and axial LOADs in the heated joint when calenary action developed in the frame after the loss of the column

OVERVIEW OF THE 7 EXPERIMENTAL TESTS ON JOINTS

<table>
<thead>
<tr>
<th>STUDY CASES</th>
<th>Axial Restrained</th>
<th>Temperature</th>
<th>Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>TEST n°1 (REFERENCE TEST)</td>
<td>Spring</td>
<td>20°C</td>
<td>Joint M-N curve</td>
</tr>
<tr>
<td>TEST n°2/TEST n°3</td>
<td>X</td>
<td>500-700°C</td>
<td>Joint properties</td>
</tr>
<tr>
<td>TEST n°4/TEST n°5</td>
<td>Total</td>
<td>500-700°C</td>
<td>Joint M-N curves</td>
</tr>
<tr>
<td>TEST n°6</td>
<td>Spring</td>
<td>700°C</td>
<td></td>
</tr>
<tr>
<td>TEST n°7 (DEMONSTRATION TEST)</td>
<td>Spring</td>
<td>&gt;700°C</td>
<td></td>
</tr>
</tbody>
</table>

- **4 STEPS**
  - 1: Initial load
  - 2: Localised fire
  - 3: Loss of the column
  - 4: Max load capacity

TESTING ARRANGEMENT

- **ELEVATION View**

- Car park beam span ≥ 10 000 mm

Steel column: S460
Joint beam: J20
Concrete: C25/30
Nominal section: 111
Car Load: 25kN/m
**STEP 1: Initial loads**

- **APPLICATION OF THE INITIAL VERTICAL LOAD**
  - Applied load: 223 kN
  - Stroked: 62 mm

**STEP 2: Localised Fire**

- **ELEVATION View (Tests at high temperatures – Ceramic pad heating elements)**
  - Heated zone

**STEP 3: Loss of the column**

**STEP 4: Max load capacity**

**SIMPLIFIED SUB-STRUCTURE MODELLING**

- **Connector elements**
- **Concrete slab**

<table>
<thead>
<tr>
<th>Check of the Actuator</th>
<th>ABAQUS</th>
<th>Actuator cap.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total horizontal displacement of the beam (tension + compression)</td>
<td>15 mm</td>
<td>168 mm</td>
</tr>
<tr>
<td>Horizontal reaction of the beam – Compression (kN)</td>
<td>14 kN</td>
<td>435 kN</td>
</tr>
<tr>
<td>Horizontal reaction of the beam – Tension (kN)</td>
<td>743 kN</td>
<td>933 kN</td>
</tr>
</tbody>
</table>

Check of the Hydraulic Jack B

- **ABAQUS**
- **Hydraulic jack cap.**

- **Vertical force applied**
  - 320 kN
  - 1000 kN
  - OK

- **Vertical displacement**
  - 108 mm
  - 280 mm
  - OK

Check of the Load Cell C

- **ABAQUS**
- **Load cell cap.**

- **Axial force in the column (kN)**
  - 477 kN
  - 1000 kN
  - OK

**NUMERICAL MODEL OF THE BOLTED CONNECTION**

- **3D solid and contact elements**
  - **IN DEVELOPMENT**