International Conference
APPLICATIONS OF STRUCTURAL FIRE ENGINEERING
Prague 29-30 April 2011

ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

Filippo Gentili
PhD Student, P. E.
filippo.gentili@uniroma1.it

Luca Grossi
Assistant Professor, PhD, P. E.
luca.grossi@uniroma1.it

Franco Bontempi
Full Professor, PhD, P. E.
franco.bontempi@uniroma1.it

Sapienza University of Rome, School of Engineering, Rome, Italy
The quantitative assessment of the structural performance is based on a multiphysics analysis. With the wide adoption of performance-based fire safety design, CFD simulation is becoming a routine practice for obtaining the necessary fire design information.

An adequate representation of fire cannot ignore from the study of some factors:

- **Fuel Properties**;
- **Fuel Location**;
- **Ventilation**.

The numerical data should be compared with experimental results.

**FUEL PROPERTIES**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height</td>
<td>3.05m</td>
</tr>
<tr>
<td>Size</td>
<td>1.2m x 1.2m</td>
</tr>
<tr>
<td>Weight of one pallets</td>
<td>15 kg</td>
</tr>
<tr>
<td>Weight of one stack of pallets</td>
<td>300 kg</td>
</tr>
<tr>
<td>Weight of all stacks</td>
<td>5400 kg</td>
</tr>
<tr>
<td>$HRR_{s,max}$</td>
<td>6810 Mw/m²</td>
</tr>
<tr>
<td>$t_g$</td>
<td>80 s</td>
</tr>
</tbody>
</table>
ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

filippo.gentili@uniroma1.it
ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

SCENARIO 1

ISO 834
Local Collapse: 18 min
Global Collapse: 22 min

FDS
Local Collapse: 9 min
Global Collapse: 9 min

FUEL LOCATION – STRUCTURAL RESPONSE (I)
ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

ISO 834
Local Collapse: 18 min
Global Collapse: 34 min

FDS
Local Collapse: 11 min
Global Collapse: --

filippo.gentili@uniroma1.it
ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

filippo.gentili@uniroma1.it
CONCLUSIONS

- CFD models permit a quite realistic representation of fire scenarios, because it takes into account the distribution of fuel, the geometry and the occupancy of individual compartments in a structure.

- The use of standard fire does not necessarily give conservative results.

- An application on a steel structure shows that CFD allows a more refined representation of the fire compared to an analytical evaluation. It can consider issues relevant to the development of the fire and take into account significant variations of the boundary conditions in time.
ROLE OF CFD IN THE QUANTITATIVE ASSESSMENT OF STRUCTURAL PERFORMANCE IN FIRE SCENARIOS

**CALIBRATION AND OPTIMIZATION**

<table>
<thead>
<tr>
<th>dx</th>
<th>% D*</th>
<th>dx/D*</th>
<th>Number of cells</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3</td>
<td>0.15</td>
<td>6.89</td>
<td>298080</td>
</tr>
<tr>
<td>0.4</td>
<td>0.19</td>
<td>5.17</td>
<td>126360</td>
</tr>
<tr>
<td>0.5</td>
<td>0.24</td>
<td>4.14</td>
<td>64512</td>
</tr>
<tr>
<td>0.6</td>
<td>0.29</td>
<td>3.45</td>
<td>38880</td>
</tr>
</tbody>
</table>

**Temperature [°C]**

**HRR [MW]**

**Smoke Height [m]**
LITERATURE VS EXPERIMENTAL HRR

Analytical curve

\[ HRR_{s,\text{max}} = 919 \cdot (1 + 2.14h_p) \cdot (1 - 0.03M) \]

where

- \( h_p \) is the stack height (m),
- \( M \) is the moisture (%)

Experimental curve