

**cost** Integrated Fire Engineering and Response  
COST action network number TU0904 in domain Transport and Urban Development  
 14-15 October 2011, Chania, Greece

## Application of Structural Fire Engineering to open and closed car parks of C.A.S.E. Project for L'Aquila


WG1 - E. Nigro  
 WG2 - G. Cefarelli  
 A. Ferraro  
 E. Cosenza  
 G. Manfredi




D.I.ST. - Department of Structural Engineering  
 University of Naples "Federico II"  
 Italy

### Case Study: car parks of C.A.S.E. Project for L'Aquila

The "C.A.S.E. Project for L'Aquila" was developed in L'Aquila (province of Abruzzo, Italy), after the seismic event of 06/04/2009, in response to the housing emergency. It was characterised by the construction of several **seismically isolated buildings**.




Car Park located at the ground floor




Concrete slab  
 Isolation device  
 steel column

### Case Study: Car Parks of C.A.S.E. Project for L'Aquila



Italian prescriptive code (D. M. 01/02/1986)  
**R90**

Sprayed gypsum




The structural safety during the fire exposure, in the **lack of protective coatings on steel columns**, was evaluated through the application of performance-based approach

uncertainties on the effectiveness of coatings maintenance

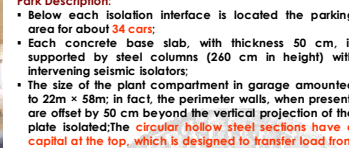
### Case Study: Car Parks of C.A.S.E. Project for L'Aquila

**Park Description:**

- Below each isolation interface is located the parking area for about **34 cars**;
- Each concrete base slab, with thickness 50 cm, is supported by steel columns (260 cm in height) with intervening seismic isolators;
- The size of the plant compartment in garage amounted to 22m x 58m; in fact, the perimeter walls, when present, are offset by 50 cm beyond the vertical projection of the plate isolated. The circular hollow steel sections have a capital at the top, which is designed to transfer load from the isolator unit and to allow the isolator replacement.



CLOSED CAR PARK



OPEN CAR PARK

58 m  
 22 m

### Case Study: Car Parks of C.A.S.E. Project for L'Aquila

The fire scenario is significantly affected, among other things, by:

- the geometry and
- ventilation conditions of the compartment.

As regards the evaluation of number of vehicles involved in the fire and the timing of fire initiation by a car to adjacent one, reference is made to the information provided by following Technical References and Guideline.

#### Technical References and Guideline

**CEC Agreement 7215 - PP/025:** "Demonstration of Real Fire Tests in Car Parks and High Buildings", by CITCM (France), PROFIL-ARBED Recherches (Luxembourg) e TNO (Netherlands), closed 2001

**INERIS Guideline:** "Parcs de stationnement en superstructure largement ventilés. Avis d'expert sur les scénarios d'incendie", Final Report 2001 by INERIS (Institut National de l'Environnement Industriel et des Risques) and by CITCM (Centre Technique Industriel de la Construction Metallique).

**REPORT PARCHEGGI (REPORT ON ITALIAN CAR PARKS):** "Approccio ingegneristico per la sicurezza strutturale in caso di incendio di parcheggi aerei realizzati con struttura di acciaio", Rapporto Interno Finale del 2010, Commissione per la Sicurezza delle Costruzioni di Acciaio in caso di incendio.

### Case Study: Design Fire Scenarios

✓ **Localised Fire Scenarios - Pre-flashover** according to INERIS Guideline

**SCENARIO 11:** 7 vehicles, of which 1 central VAN and 6 cars, that burn with a fire propagation time from car to adjacent one equals to 12 min from the VAN.

**SCENARIO 12:** 4 vehicles, of which 1 central VAN and 3 cars surrounding a column, that burn with a fire propagation time from car to adjacent one equals to 12 min from the VAN.

Propagation time 12min.

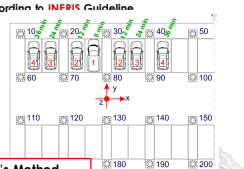
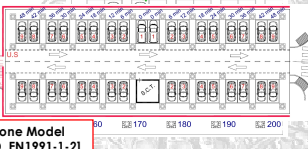
Hasemi's Method [Annex C, EN1991-1-2]

✓ **Generalized Fire Scenario- Post-flashover**

**SCENARIO D1:** 34 vehicles, of which 2 central VAN and 32 cars, that burn with a fire propagation time from car to adjacent one equals to 6 min from the VAN

Propagation time 6 min.

One-Zone Model [Annex D, EN1991-1-2]

### Structural models

Global analyses with non linear software SAFIR2007

**Substructure** **Static scheme**

3D-Detailed analyses with software ABAQUS/standard

**Column**

For each fire scenario, the axial load at the top of column, corresponds to the axial load obtained by the global structural analyses

**Performance Level 4**  
Checks in terms of resistance and limitation of damage (differential vertical displacements in the columns)

### Case Study: Global Analyses Results

Fire scenario L2 - Global Analysis

**Temperatures vs time** **Axial loads vs time**

**Displacements vs time** **Axial load resistance vs time**

There is not structural collapse

### Case Study: Global Analyses Results

**Columns Displacements**

**Vertical displacement (mm)**

The maximum differential vertical displacement (between two adjacent columns), during the fire exposure, is about 16mm (between the column 120 and column 130) and this value corresponds to 2.6 % below the limit value of 5.0 %.

### Conclusions

- ✓ The FSE application to car parks is facilitated by the information about the possible fire scenarios provided by the European Research Project CEC agreement 7215-PP/025 (2001) and from INERIS (2001) guideline.
- ✓ The substructure extension has allowed assessing in an appropriate way both the thermal field and the hyperstatic effects induced by different thermal expansions of steel columns and bending of the concrete reinforced slab.
- ✓ In addition to the global analysis, for each fire scenario, in order to calculate more accurately the thermal field and stresses distribution in the capitals above the columns and to assess the possible local buckling, detailed 3D thermo-mechanical analyses have been conducted with reference to the more stressed and heated column.
- ✓ The thermo-mechanical analyses in fire situations for the described case study showed that the structures, and in particular the steel columns, considered unprotected, satisfy the performance level set to the design fire scenarios, also thanks to an overstrength in normal condition design.

**THANK YOU FOR YOUR ATTENTION**