1.9 Numerical analyses and experimental tests on structural members in fire situation (short version)

Nigro E., Italy

cost Integrated Fire Engineering and Response

COST action network number TU0904 in domain Transport and Urban Development

Barcelona Workshop 5-6 July 2010

The workshop is organised to collect the results of the national projects in the field of fire engineering and to inform colleagues in the Action of the current status in Countries participating in the action.

Numerical analyses and experimental tests on structural members in fire situation

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Research activities | RC slabs with FRP bars | Composite steel and concrete | Open car parks

➢Experimental fire tests on concrete slabs reinforced with FRP bars:

- ✓ Experimental investigation on the parameters affecting the structural behaviour;
- ✓ Tests on construction details improving performances;
- ✓ Numerical simulation of thermal field and mechanical behaviour;
- ✓ Provide simple calculation models.

➢ Fire analyses of composite steel-concrete frames:

- ✓ Assessment of the behaviour in fire situation of steel and concrete composite structures designed for different seismic zone;
- ✓ Comparisons among single member, substructure and global structural fire analyses of composite steel-concrete frames applying advanced calculation models;
- ✓ Discussion on simple rules for defining substructure limits and boundary conditions.

➢Fire Safety Engineering for open car parks:

- ✓ Examination of criteria for the choice of design fire scenarios;
- ✓ Provide suggestions for Italian Guide Lines on Fire Structural Safety Assessment of Open Car Parks.

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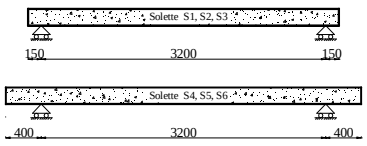
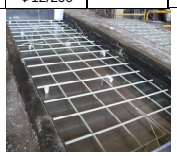
FIRE BEHAVIOUR OF RC SLABS WITH FRP BARS -Experimental program

Slab	Lenght [mm]	Width [mm]	Height [mm]	Cover [mm]	Bottom reinforcement (diameter/spacing) [mm]		Design Bending resistant moment M_{Rd} [kNm]
					longitudinal	transverse	
S1	3500	1250	180	32	Φ12/150	Φ12/200	65
S2							
S3					Φ12/225		46
S4	4000	1250	180	51	Φ12/125	Φ12/200	65
S5							
S6					Φ12/200		46





Top reinforcement
Grid Φ12/200

M_{Rd} → normal temperature according to CNR-DT203/2006.

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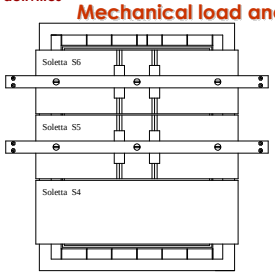
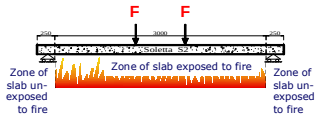
Mechanical load and external instrumentation



S3 and S6 → 60% of M_{Rd} (F=17.5kN)

S2 and S5 → 40% of M_{Rd} (F=17.5kN)

S1 and S4 → 10% of M_{Rd} (own weight)



Thermocouples and displacement transducers

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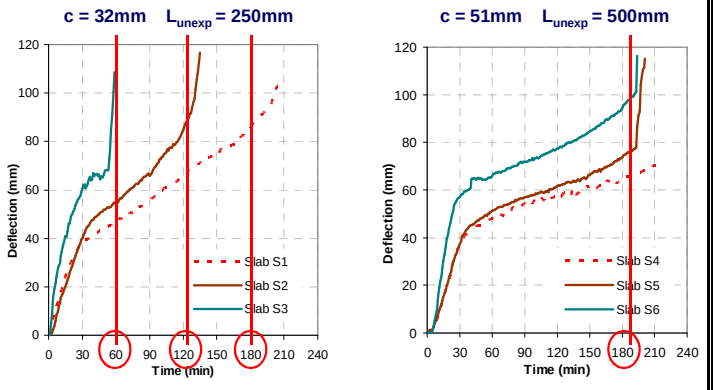
Deflection vs. Time



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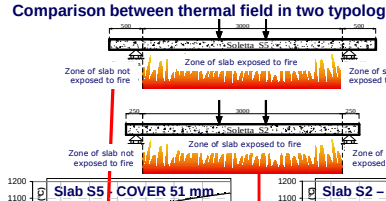
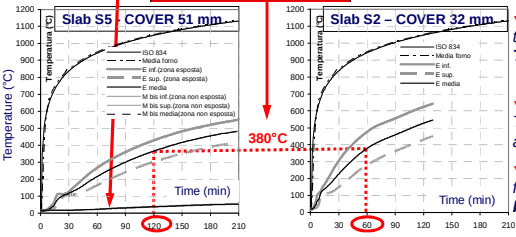
Main remarks on temperatures

Comparison between thermal field in two typologies of slabs





Cover

T_g after about 15min for S2
T_g after about 25min for S5

✓*Cover thickness affects the time needed to achieve* ***T_g in the bars***

✓*In the* ***unexposed zone*** *T_g in the bars is not achieved*

✓*In the zone exposed to fire the* ***overlapping of bars*** *cannot be used*

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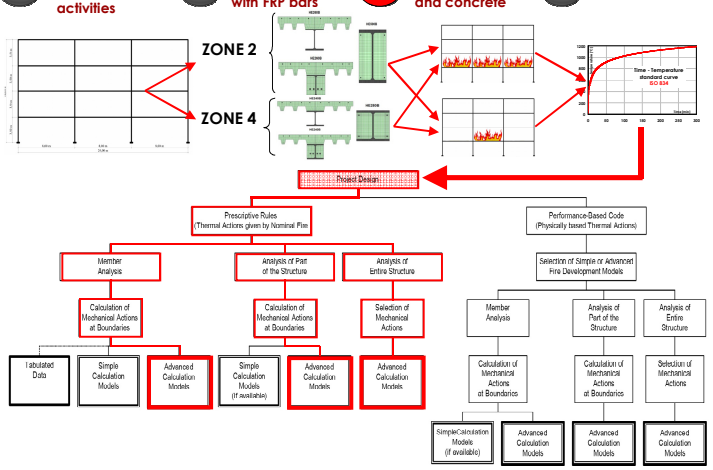

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ANALYSIS OF ENTIRE STRUCTURE

SEISMIC ZONE	SECTION TYPE	FIRE SCENARIO	GLOBAL ANALYSIS	
			Collapse Time	*Failure Section*
2	*Beam:* HE260B / *Column:* HE500B		31.0 min	
			31.0 min	
	Beam: HE260B / *Column:* HE500B		57.2 min	
			162.3 min	
4	*Beam:* HE240B / *Column:* HE280B		28.8 min	
			29.0 min	
	Beam: HE240B / *Column:* HE280B		53.8 min	
			152.4 min	

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ANALISYSIS OF PART OF THE STRUCTURE

FIRE SCENARIO 1

Seismic zone	Substructure Analysis Fire scenario 1	Beam Section Type	
2		31.0 min	57.2 min
4		28.8 min	53.8 min
2		32.0 min	54.2 min
4		30.4 min	53.4 min
2		32.2 min	54.0 min
4		28.6 min	60.6 min

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ANALISYSIS OF PART OF THE STRUCTURE

FIRE SCENARIO 2

Seismic zone	Substructure Analysis Fire scenario 2	Beam Section Type		Substructure Analysis Fire scenario 2	Beam Section Type	
2		31.0 min	57.2 min			
4		28.8 min	53.8 min			
2		31.8 min	162.2 min		32.0 min	162.0 min
4		30.0 min	157.0 min		29.2 min	150.2 min
2		33.0 min	167.0 min		33.5 min	169.0 min
4		36.5 min	>180.0 min		37.5 min	>180.0 min
2		31.0 min	158.0 min		31.0 min	156.0 min
4		27.0 min	127.0 min		29.5 min	134.0 min

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ANALYSIS OF A MEMBER

Seismic zone	Section Type	Fire Scenario	Global Analysis	Single member Analysis
2	*Beam:* HE260B / *Column:* HE500B		57.2 min	111.0 min
			162.3 min	111.0 min
4	*Beam:* HE240B / *Column:* HE280B		53.8 min	60.0 min
			152.4 min	116.0 min

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Italian codes

- **Italian Prescriptive Code**
  - ✓ **D.M.Int 01-02-1986**
    - **R90** for Closed Car Parks
    - **NOT WELL DEFINED** for Open Car Parks
  - ✓ **REPORT PARCHEGGI (REPORT ON ITALIAN CAR PARKS)** "*Approccio ingegneristico per la sicurezza strutturale in caso di incendio di parcheggi aerati realizzati con struttura di acciaio*", Final Report 2010. Commissione per la Sicurezza delle Costruzioni di Acciaio in caso di Incendio.

Submitted for Approval to Italian Department of Fire Brigades

European codes

- **CEC Agreement 7215 - PP/025:** "*Demonstration of Real Fire Tests in Car Parks and High Buildings*", by CITCM (Francia), PROFIL-ARBED Recherches (Lussemburgo) e TNO (Paesi Bassi), closed 2001.
  - ✓ In France **09-05-2006**: "*Règlement de sècuritè contre les risques d'incendie et de panique dans les parcs de stazionnement couverts*" Ministère de l'Inteérieur et de l'Amènagement du territoire.
  - ✓ **Guide Lines** "Parcs de stationnement en superstructure largement ventiles. Avis d'expert sur les scénarios d'incendie", Final Report 2001 by **INERIS** (Institut National de l'Environnement Industriel et des Risques) and by CTICM (Centre Technique Industriel de la Construction Metallique).

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