



INTERNATIONAL PRESTRESSED
HOLLOWCORE ASSOCIATION



Fire tests in HOLCOFIRE

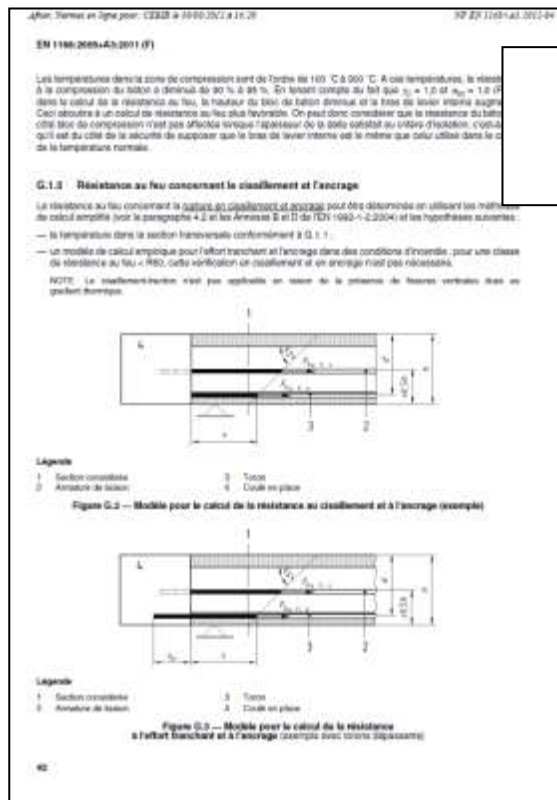
Matthieu Scalliet

Initial issue

- How to plan a fire test ?
- HOLCOFIRE program = 2 series of tests
 - Series G : Fire tests to validate the shear and anchorage capacity according to EN 1168:2005 + A3:2011 Annex G
 - Series R : Fire tests on hollow core floors with restraint conditions

Initial issue

- Series G : Validating the shear and anchorage capacity according to EN 1168:2005

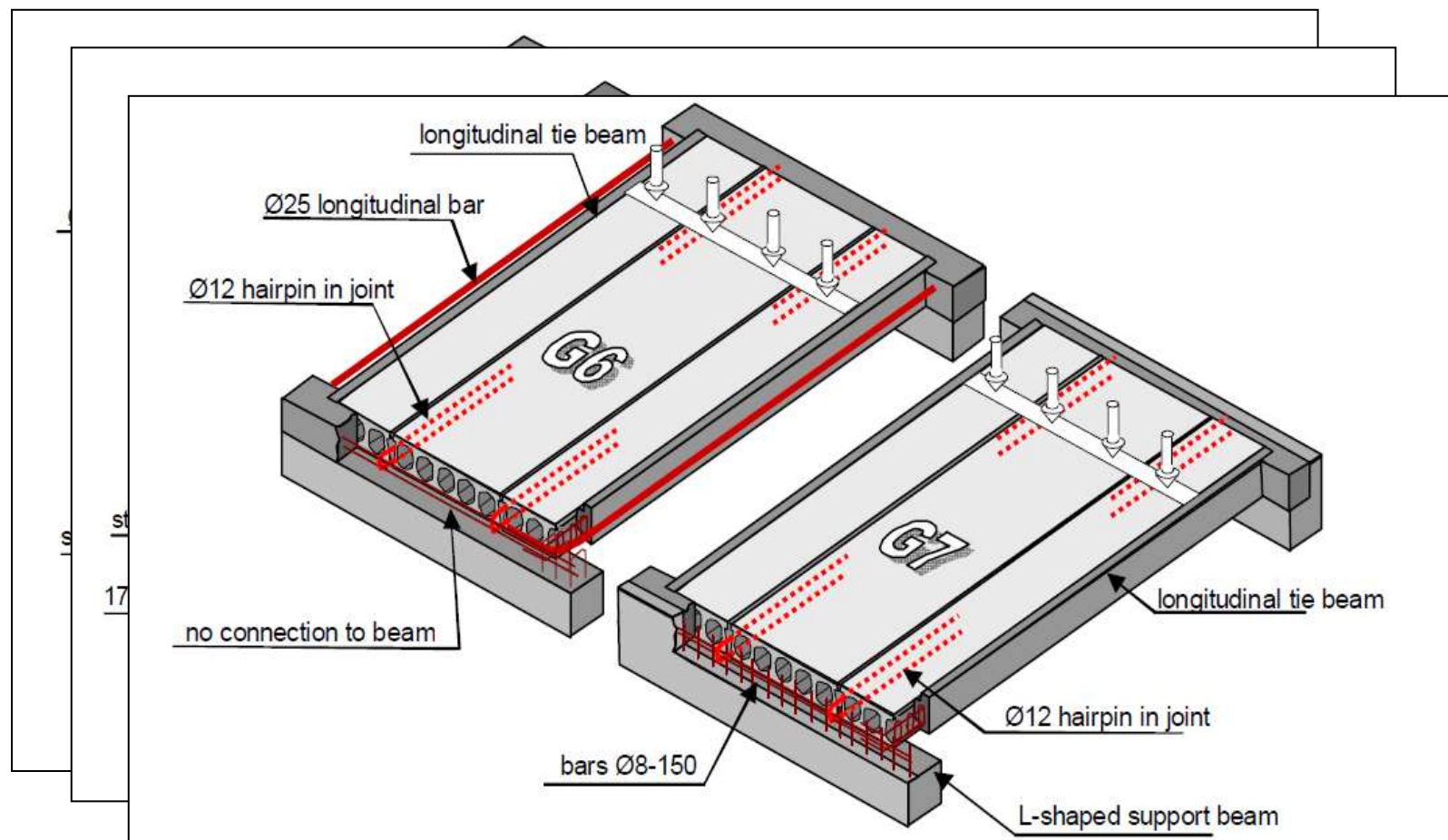


$$V_{Rd,c,fi} = [C_{0.1} + \alpha_k \times C_{0.2}] \times b_w \times d$$

- Testing the validity for different floor configurations
- Testing the influence of specific parameters on the floor behavior :
 - Type of anchorage
 - Structural topping
 - Protruding strand
 - ...

Initial issue

- Series G : Different floor configurations



Initial issue

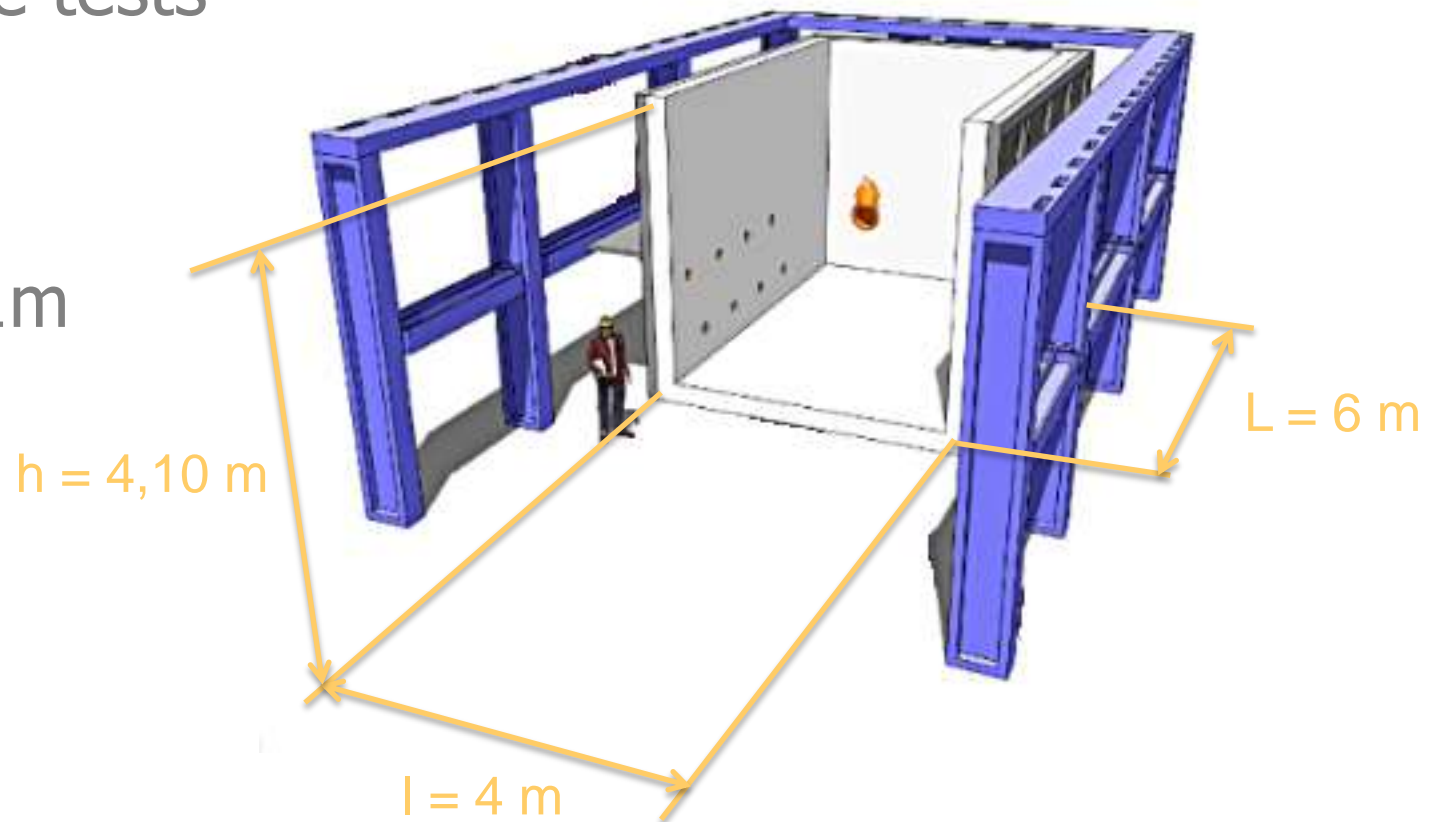
- A long process...
 - Defining the test configuration
 - Function of the series
 - Setting up the specimen
 - Formwork
 - Reinforcement
 - Instrumentation
 - Concrete pouring
 - Storage in a conditioning room
 - Performing the fire test
 - Loading application
 - Fire start
 - Analyzing the results
 - Specimen analysis
 - Test report

Defining the test configuration

- PROMETHEE : A versatile device

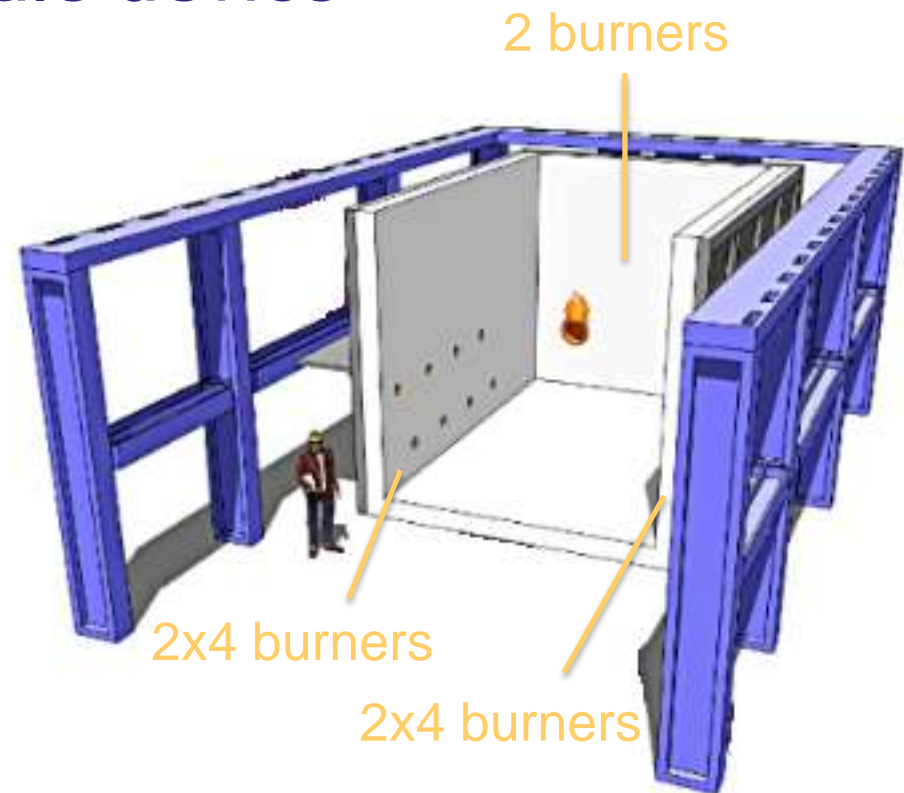
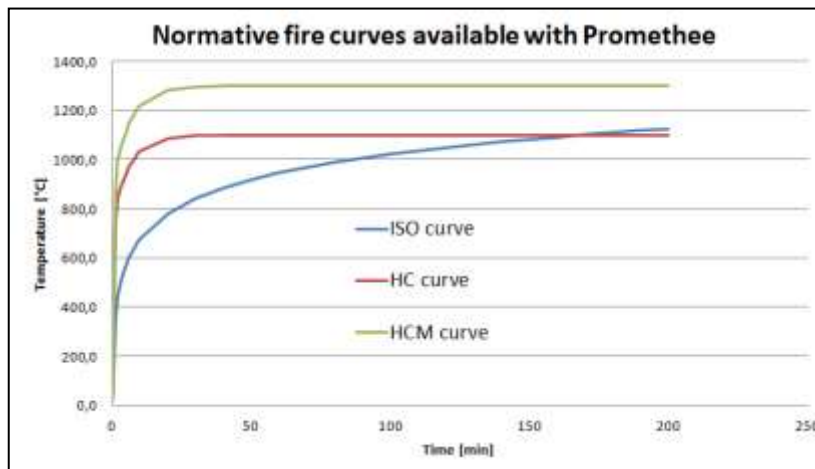
- Full-scale tests

- $L=6\text{m}$
- $l=4\text{m}$
- $h=4,1\text{m}$



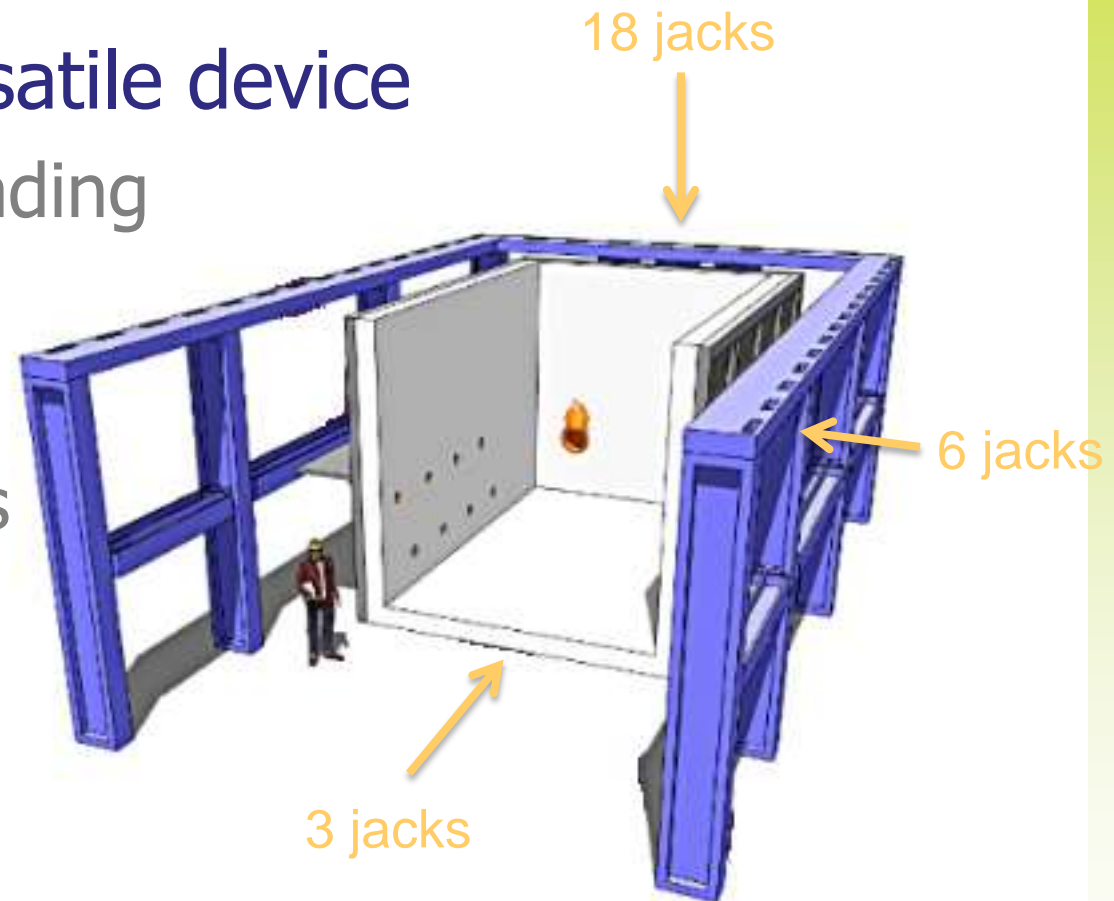
Defining the test configuration

- PROMETHEE : A versatile device
 - Normalized fires
 - ISO 834 curve
 - HC curve
 - HCM curve



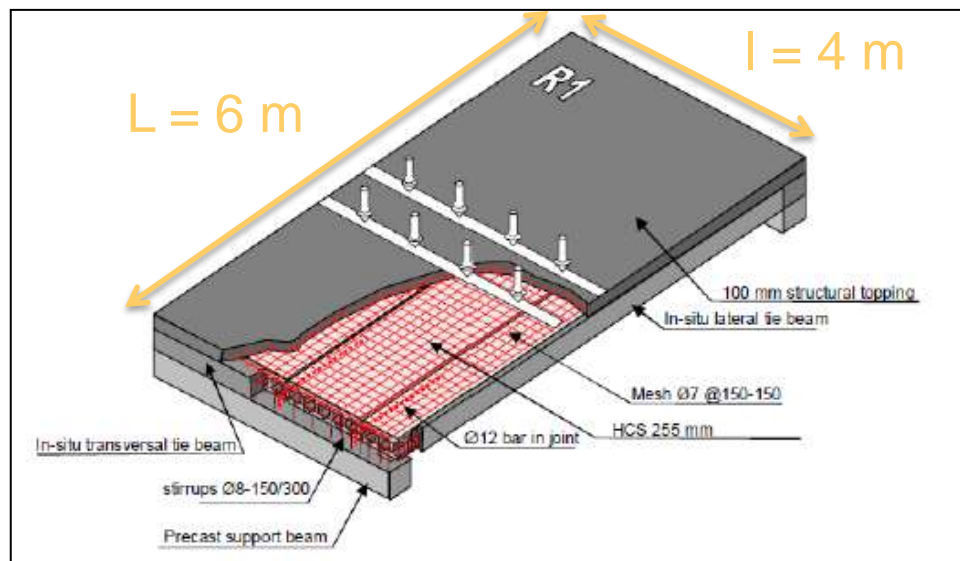
Defining the test configuration

- PROMETHEE : A versatile device
 - Multi-directional loading
 - 18 vertical jacks from 5 to 300T
 - 9 horizontal jacks from 50 to 125T



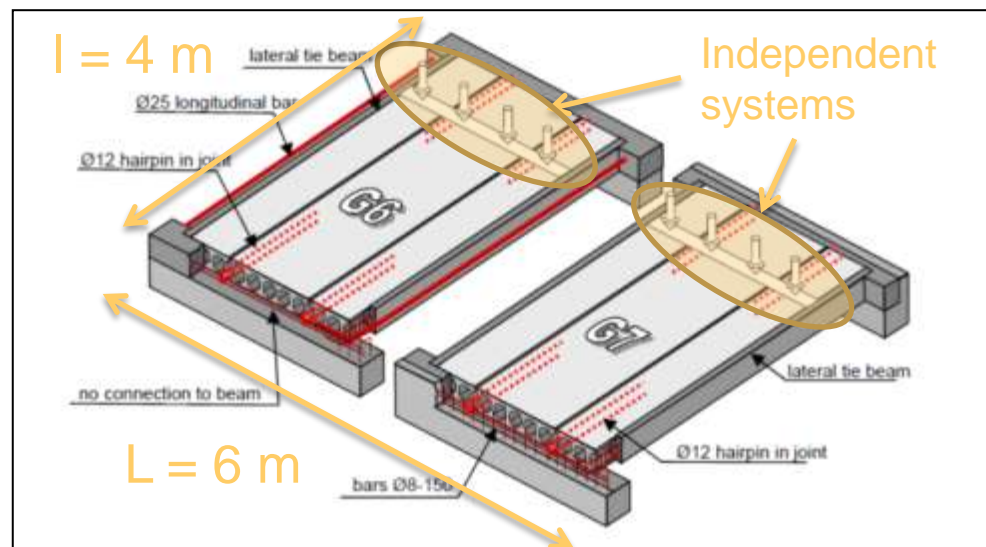
Defining the test configuration

- PROMETHEE : A versatile device
 - Several possible configurations
 - Series R : Using the whole furnace surface
 - Use of the maximum furnace surface (4x6 m²)
 - More realistic floor behavior (stiffness ratio L/h)



Defining the test configuration

- PROMETHEE : A versatile device
 - Several possible configurations
 - Series G : Two different specimens, independently loaded
 - Take advantage of the area 4x6 m² to test 2 floors at a time
 - Need to have independent jacks



The (potential) failure of G6 should not disturb the test of G7

Defining the test configuration

- PROMETHEE : A versatile device
 - Several possible configurations
 - Series G : Two different specimens, independently loaded



Defining the test configuration

- PROMETHEE : A versatile device
 - Thorough initial work needed to use it at its fullest

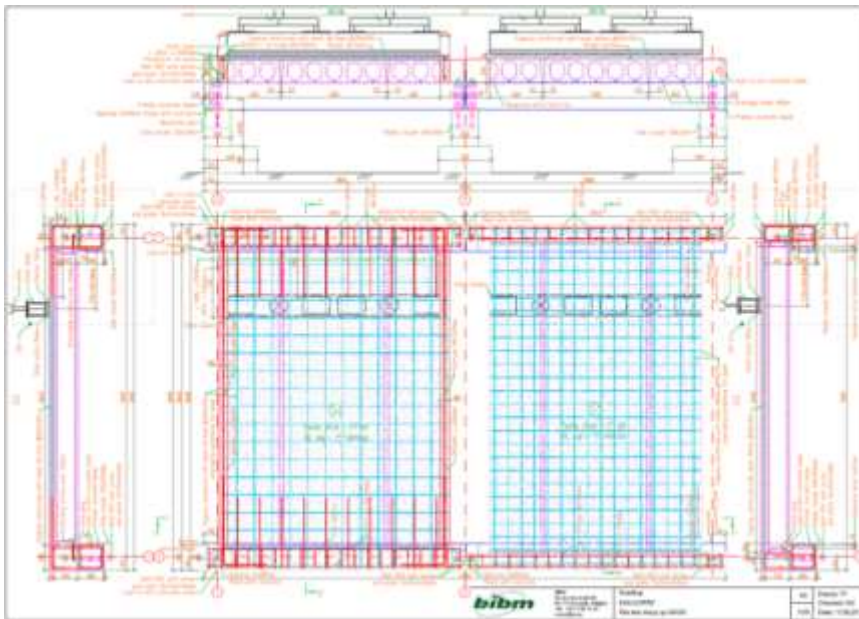


Defining the test configuration

- Conception similar to a building
 - Precise schedule mandatory
 - Time-consuming activities
 - Precast elements reception : beams, slabs...
 - Assembly + formwork
 - Reinforcement (mesh, connections)
 - Instrumentation
 - Concrete pouring (joints, peripheral tie beams, topping)
 - Storage in a conditioned room

Defining the test configuration

- Conception similar to a building
 - Structural definition of the specimen
 - Geometry : length of elements, section
 - Reinforcement

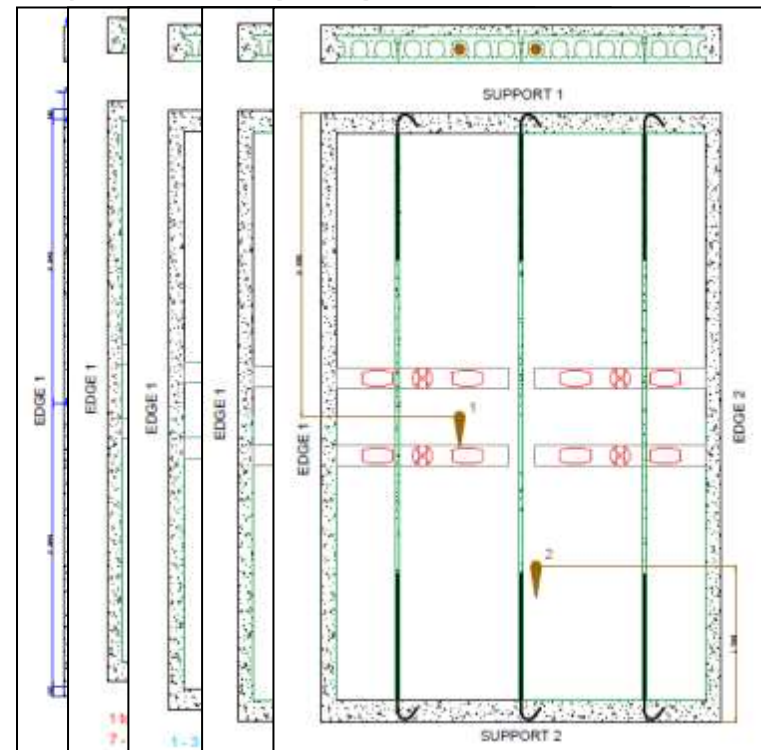


Defining the test configuration

- Conception similar to a building

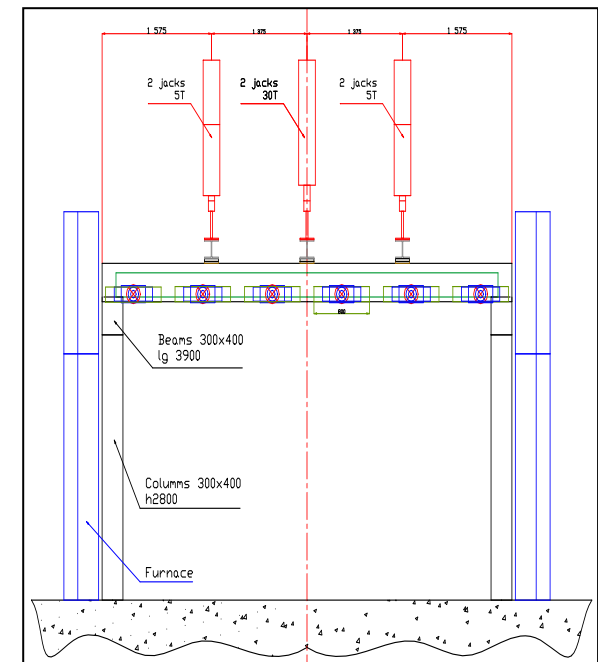
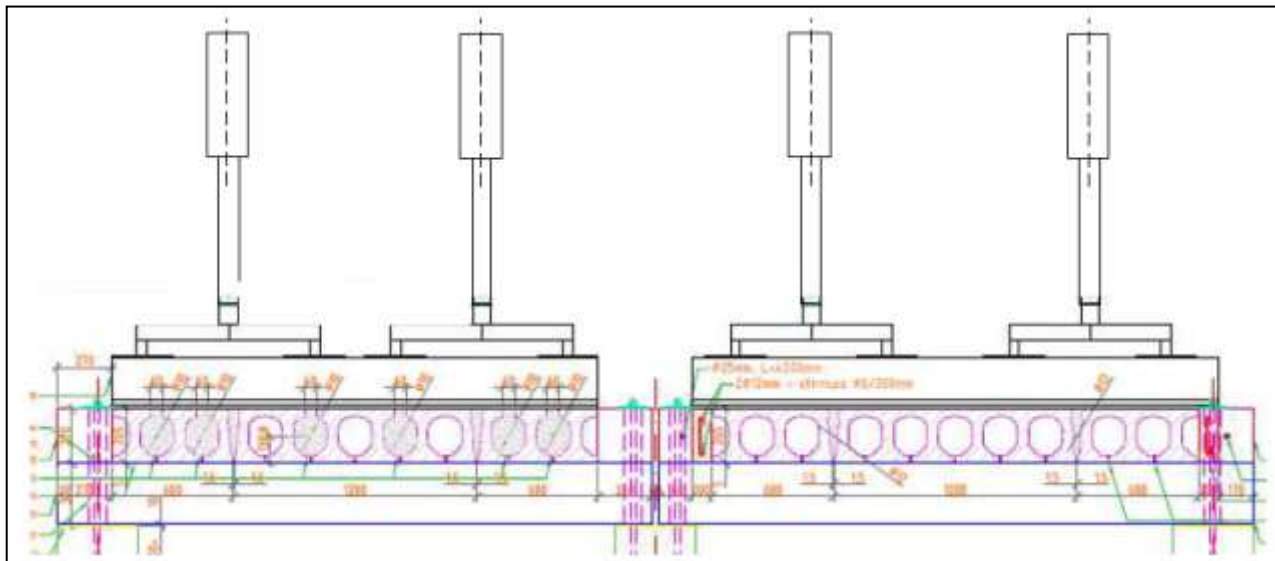
- Position of the instrumentation

- Deflection
- Temperatures
- Stress
- Tendons slippage
- Endoscopic videos



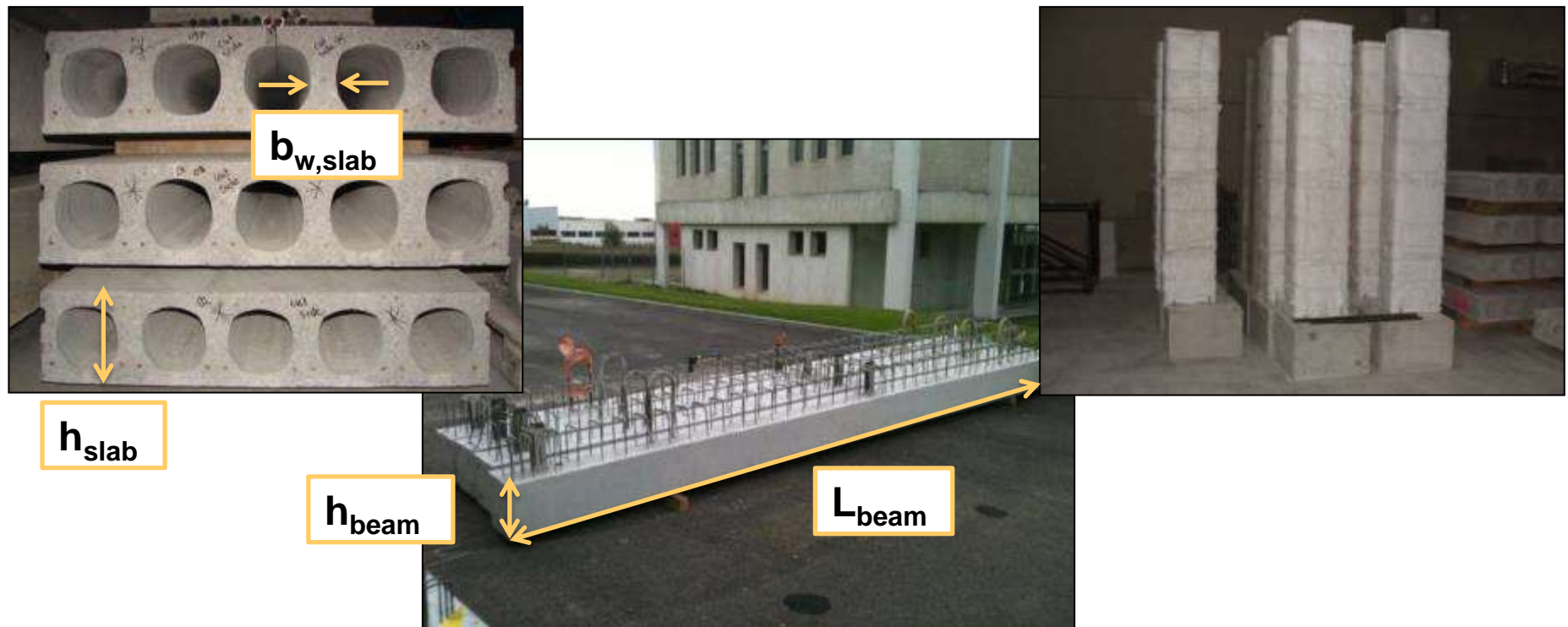
Defining the test configuration

- Conception similar to a building
 - Loading system definition
 - Intensity
 - Position of jacks



Setting up the specimen

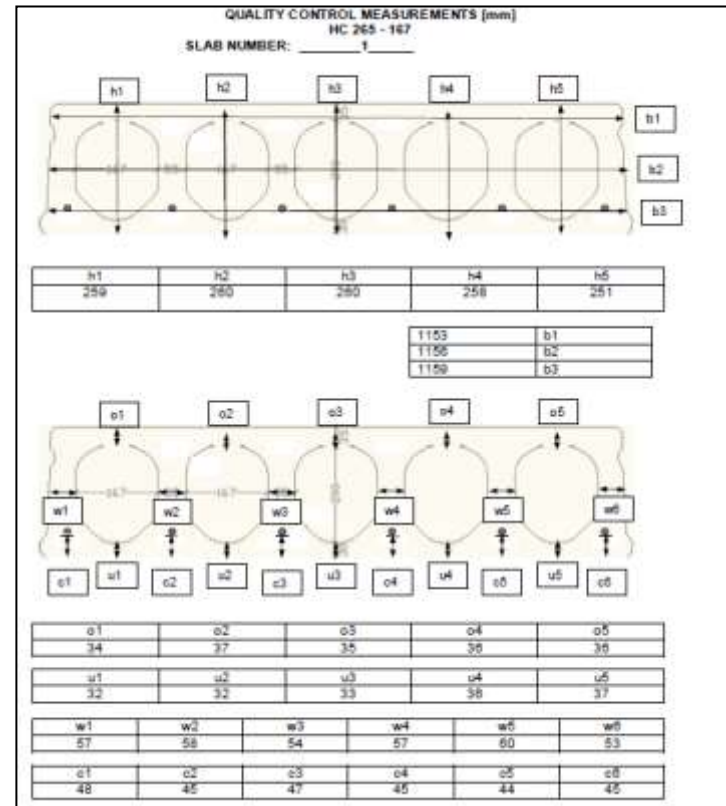
- Product reception
 - Quality control to be performed



Setting up the specimen

- Product reception
 - Geometry measurements

- L_{slab}
- $b_{w,\text{slab}}$
- h_{slab}



Setting up the specimen

- Product reception
 - Concrete resistance tests

CENB HOLCOFIRE Report No. 11 DRI 998 (Test GE - G7)

Annex VI – DOCUMENT 818M #12605232

1 Quality control of materials

1.1 Concrete test hollow core slab
 Determined at 28 days of concrete age
 compressive strength cylinder 20x20 read after 28 days

No.	f_{cm} (N/mm ²)	f_{cm} (N/mm ²)
1	59.1	49
2	60.1	
3	60.1	
4	60.7	
5	60.8	
6	61.3	

Mean cylinder strength (150x300 mm) at 28 days (S.R.23) $f_{c,cyl,28}$
 $f_{c,cyl,28} = 60.0 \text{ N/mm}^2$

axial tensile strength (optional)

No.	f_{ct} (N/mm ²)	f_{ct} (N/mm ²)
1	7.4	9.8
2	8.8	
3	8.8	
4	7.9	
5	7.9	
6	7.9	

Determined at 121 days of concrete age on 17 December 2000. Test cylinders drilled from the tested slab 31, 34 or 35 that were stored outside of the production stockyard

compressive strength cylinder 20x20 read after 121 days

No.	f_{cm} (N/mm ²)	f_{cm} (N/mm ²)
1	68.8	69.8
2	70.1	
3	69.8	
4	69.9	
5	69.1	
6	69.1	

Mean cylinder strength (150x300 mm) at 121 days (S.R.21) $f_{c,cyl,121}$ stored outside
 121 days = 1.094 x 28 days
 $f_{c,cyl,121} = 67.5 \text{ N/mm}^2$
 $f_{c,cyl,121} = 62.5 \text{ N/mm}^2$

axial tensile strength (optional)

No.	f_{ct} (N/mm ²)	f_{ct} (N/mm ²)
1	3.85	5.8
2	3.80	
3	4.08	
4	3.70	
5	3.60	
6	3.76	

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CENB HOLCOFIRE Report No. 11 DRI 998 (Test GE - G7)

Mean, recalculating from 121 days to 28 days gives $f_{c,28} = 61.5 \text{ N/mm}^2 \rightarrow f_{c,28} = 61.5 \text{ N/mm}^2 \rightarrow C50/60$ for the slabs that were stored outside of the production stockyard
 Characteristic determined at 442 days of concrete age on 07 November 2011 drilled from slab #40 of 200 mm length that was stored exactly inside (after curing for one month on outside stockyard, then for one year from 6 October 2010 to 22 September 2011) in the climate room at (20°C, 50% RH), and then a month outside the climate room in normal indoor conditions.

compressive strength cylinder 20x20 read after 121 days

No.	f_{cm} (N/mm ²)	f_{cm} (N/mm ²)
1	73.6	47.01
2	60.1	
3	70.1	
4	60.7	
5	60.8	
6	61.3	

Mean cylinder strength (150x300 mm) at 442 days (S.R.61) $f_{c,cyl,442}$
 442 days = 1.1814 x 28 days
 $f_{c,cyl,442} = 96.2 \text{ N/mm}^2$
 $f_{c,cyl,442} = 48.4 \text{ N/mm}^2$

axial tensile strength (optional)

No.	f_{ct} (N/mm ²)	f_{ct} (N/mm ²)
1	3.91	3.90
2	4.07	
3	4.01	
4	3.82	
5	3.80	
6	3.80	

Mean, recalculating from 442 days to 28 days gives $f_{c,28} = 48.4 \text{ N/mm}^2 \rightarrow f_{c,28} = 48.4 \text{ N/mm}^2 \rightarrow C40/50$. It can be concluded that due to the long storage the target value of C45/55 was not met.

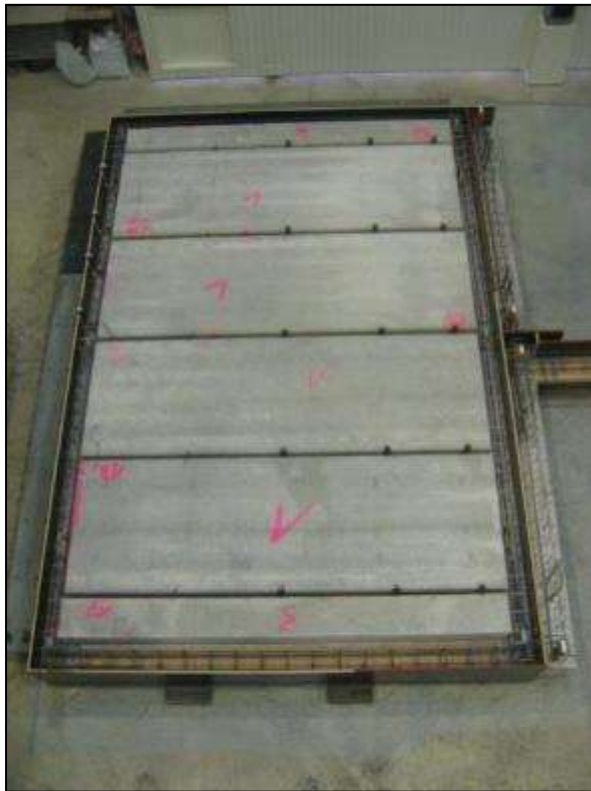
5.2 Frost-resistance test

In test report are available for the six strand coils used in the hollow core slab production (see Appendix 5). The certificates have the average tensile strength of 2310 MPa, 1563 MPa, 1972 MPa, 1560 MPa, 1928 MPa, 1983 MPa. Hence mean tensile strength $f_{tm} = 1951 \text{ N/mm}^2$. Likewise
 = mean 0.1% strength $f_{t0.01} = 1740 \text{ N/mm}^2$
 = mean Young's modulus $E_m = 198 850 \text{ N/mm}^2$

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Setting up the specimen

- Specimen fabrication
 - Formwork and assembly of the floor



Setting up the specimen

- Specimen fabrication
 - Joints filling



Setting up the specimen

- Specimen fabrication
 - Reinforcement



Setting up the specimen

- Specimen fabrication
 - Instrumentation



Setting up the specimen

- Specimen fabrication
 - Topping and peripheral tie beam pouring



Setting up the specimen

- Specimen fabrication
 - Storage in a conditioning room
 - NF EN 1363-1:2013, section 8 :
 - Hygrometry 50%
 - Temperature 23°C
 - Duration 3 months

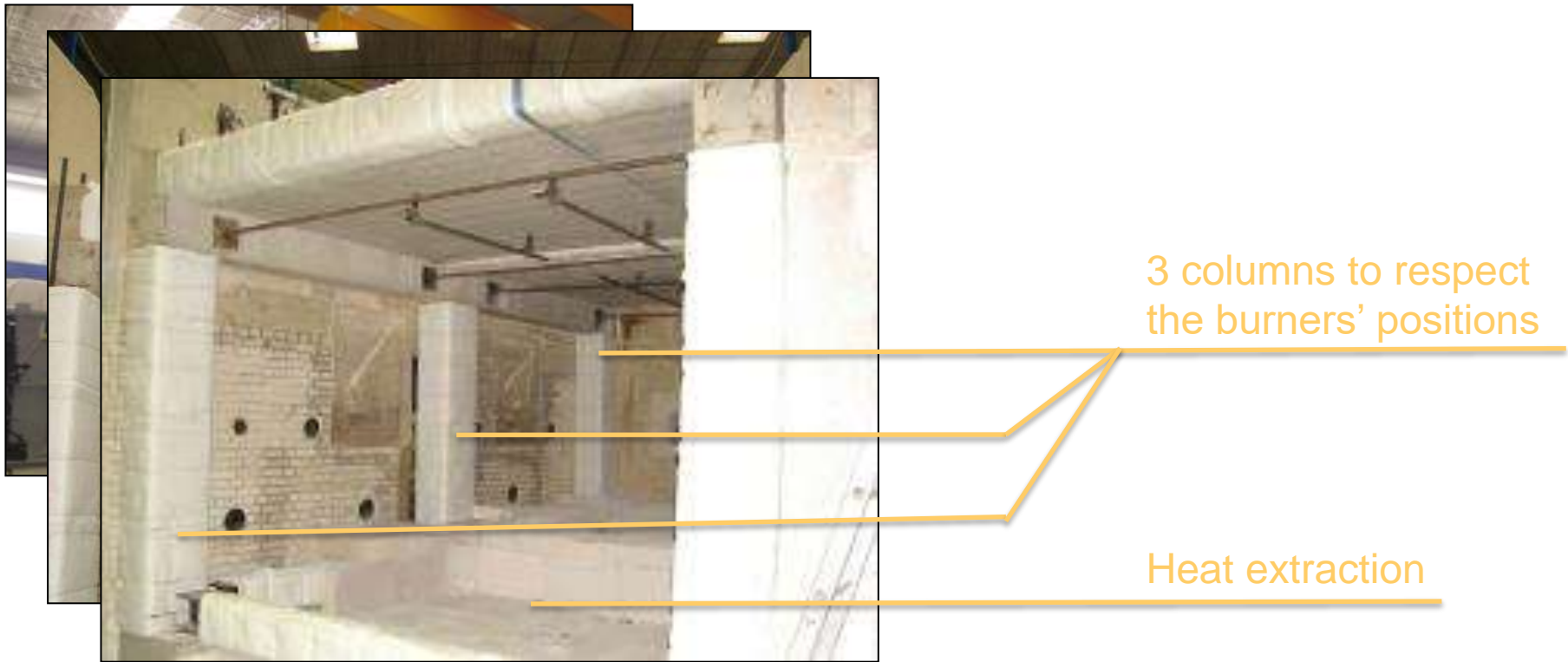


Possibility to use propylene fibers to avoid spalling



Setting up the specimen

- Specimen fabrication
 - Installation of G2 and G3 specimens in the furnace



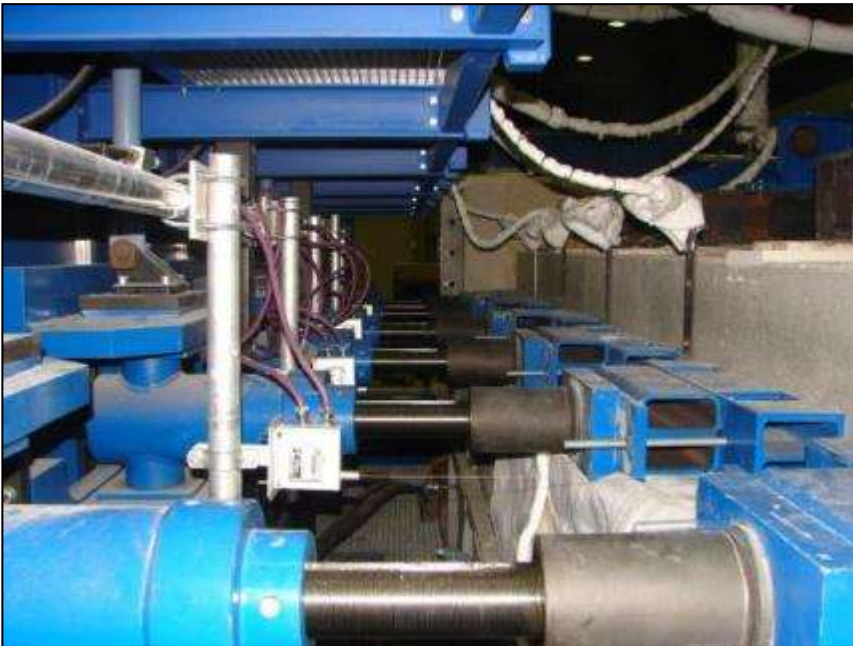
Setting up the specimen

- Specimen fabrication
 - Finalizing instrumentation and applying the load



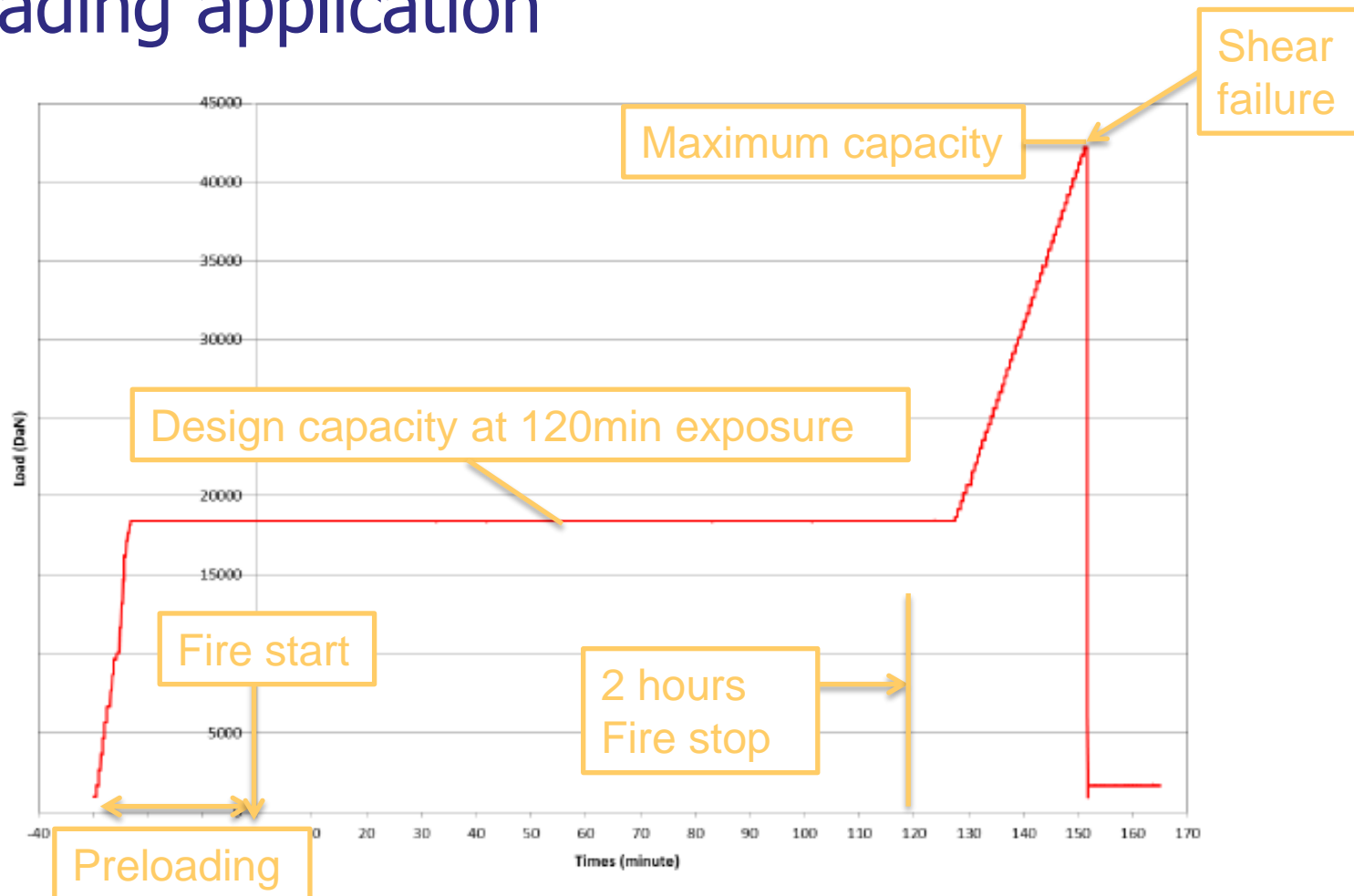
Performing the fire test

- Loading application



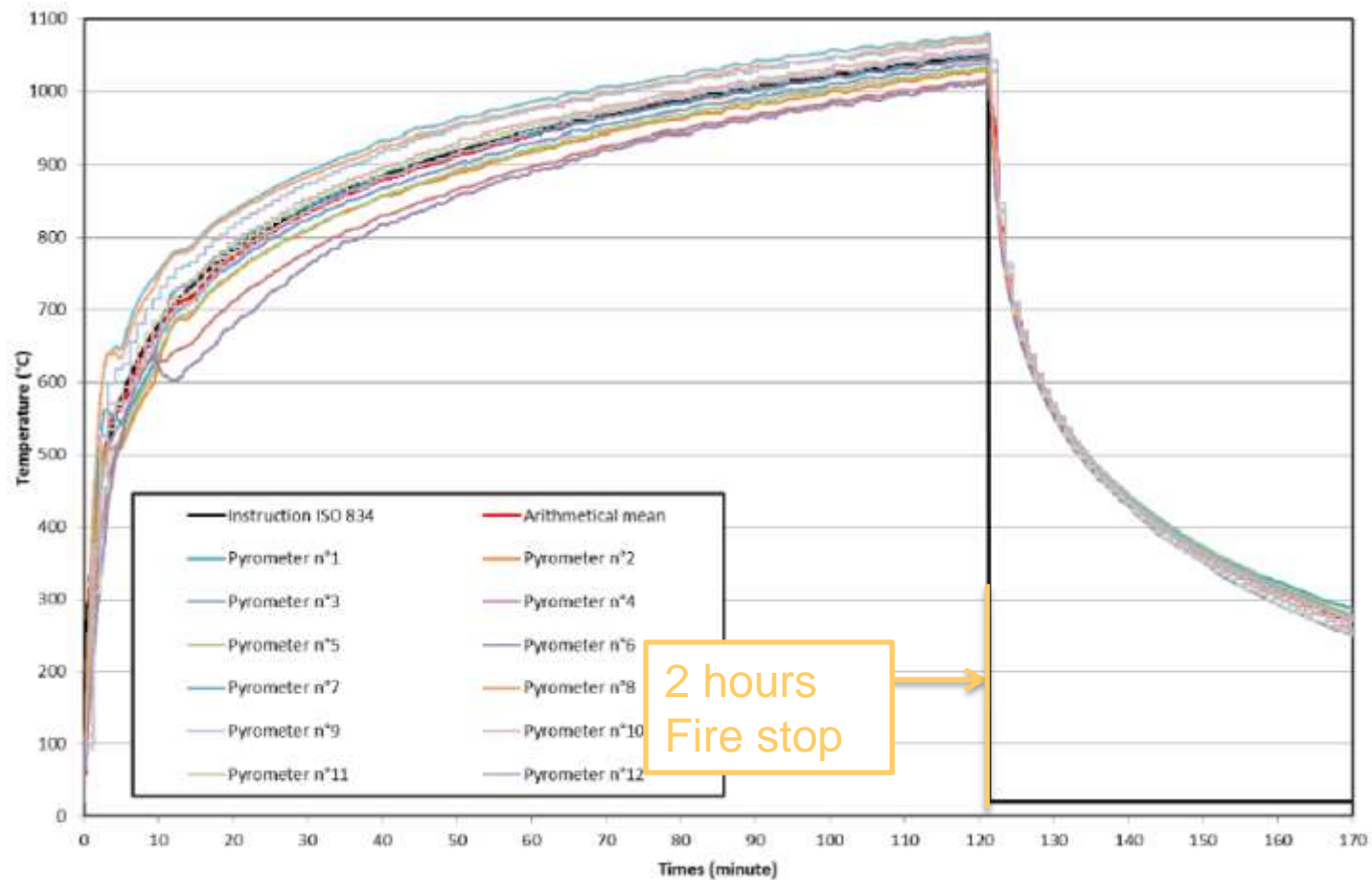
Performing the fire test

- Loading application



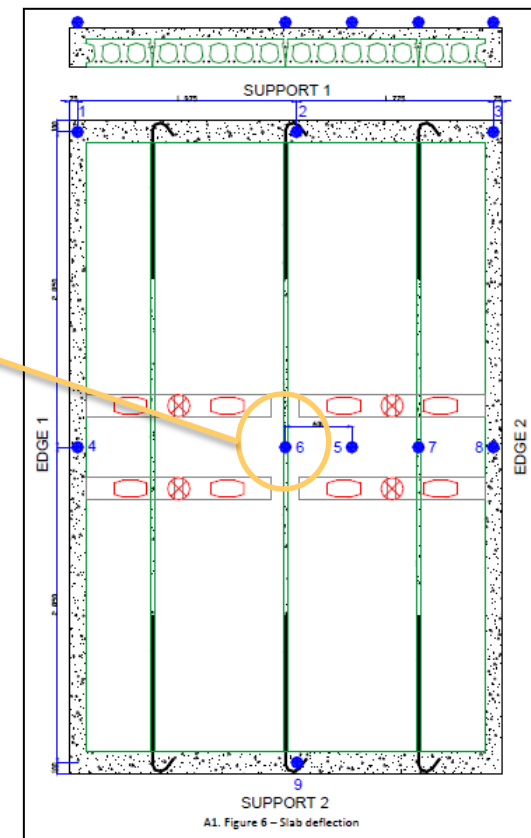
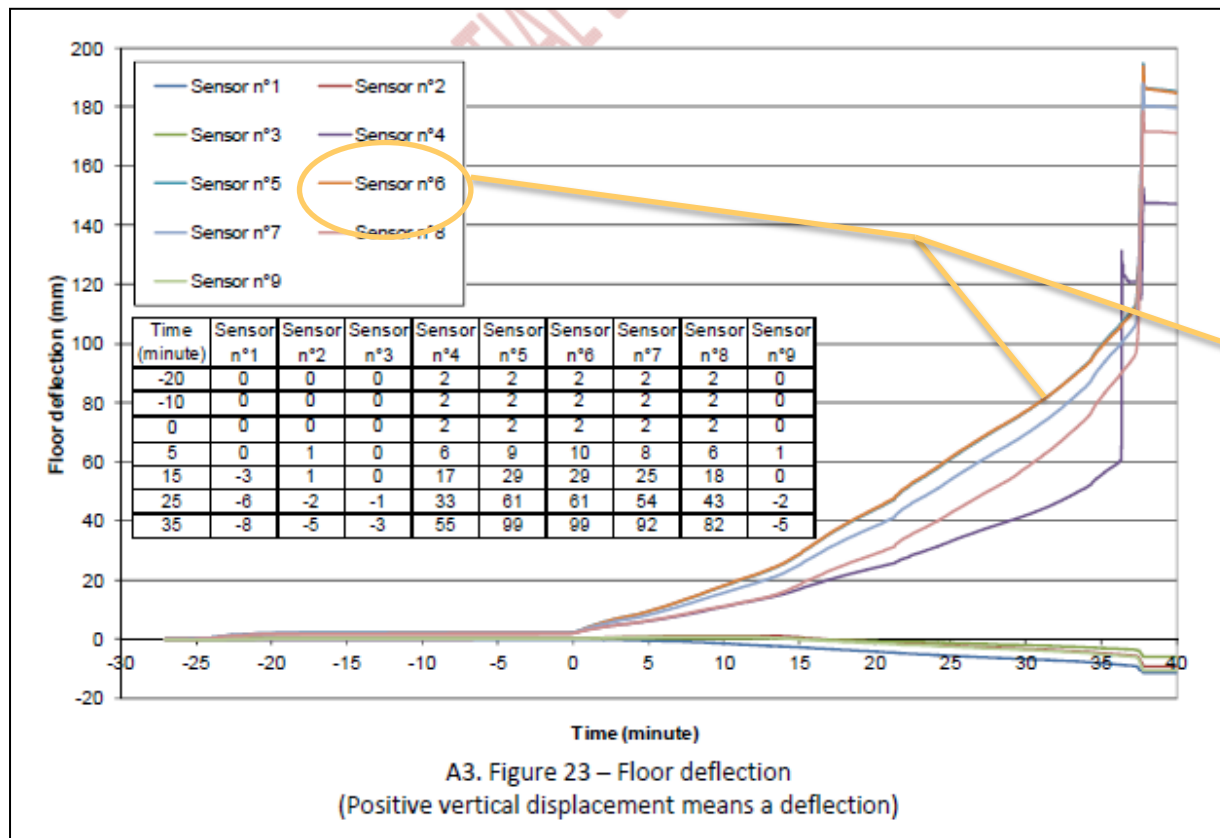
Performing the fire test

- Normalized fire



Performing the fire test

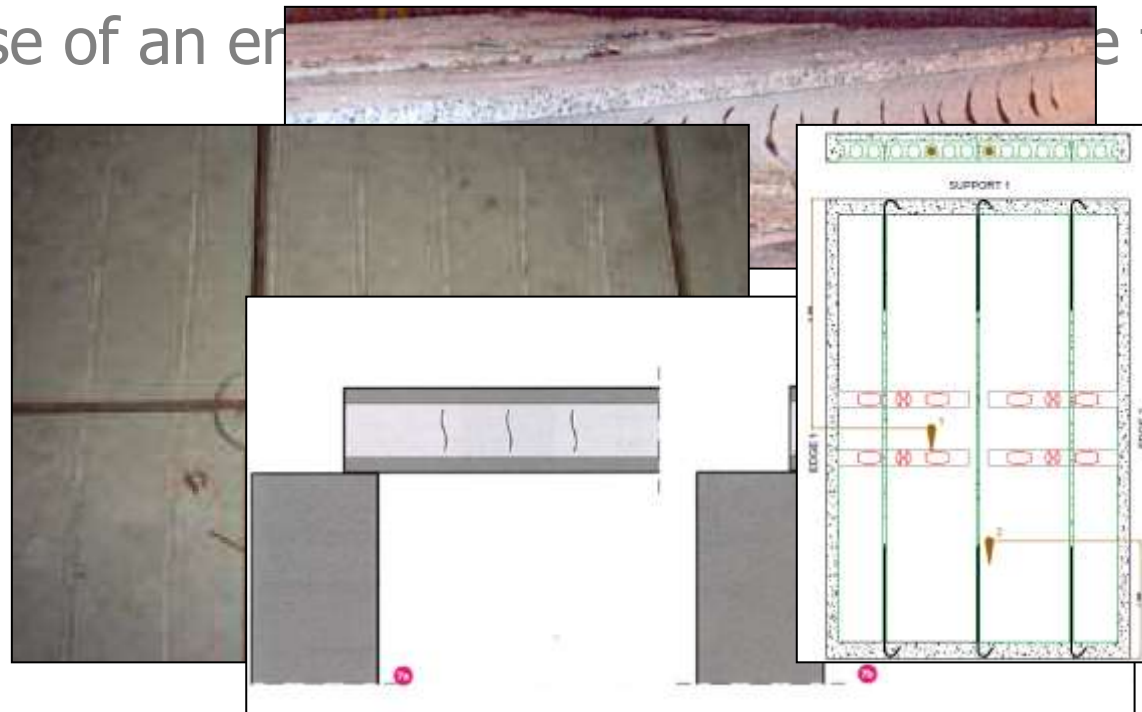
- Displacement monitoring



Performing the fire test

- Endoscopic video

- Objective : observing the occurrence of horizontal cracks in the hollow core as well as vertical cracks in the web
- Use of an endoscopic camera to observe the hollow core



Performing the fire test

- Endoscopic video



Performing the fire test

- Endoscopic video



Performing the fire test

- Endoscopic video



Performing the fire test

- Endoscopic video



Performing the fire test

- Endoscopic video



Performing the fire test

- Endoscopic video



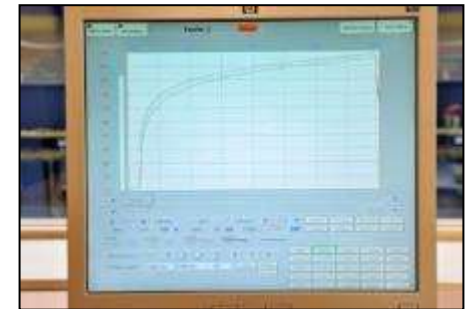
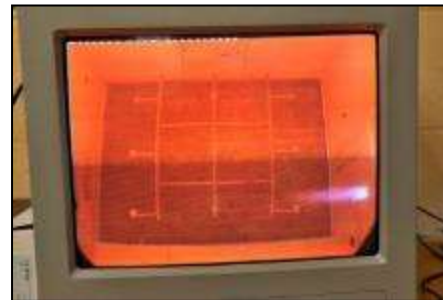
Performing the fire test

- Video inside the furnace



Performing the fire test

- Every data supervised from the coordination room



Analyzing the results

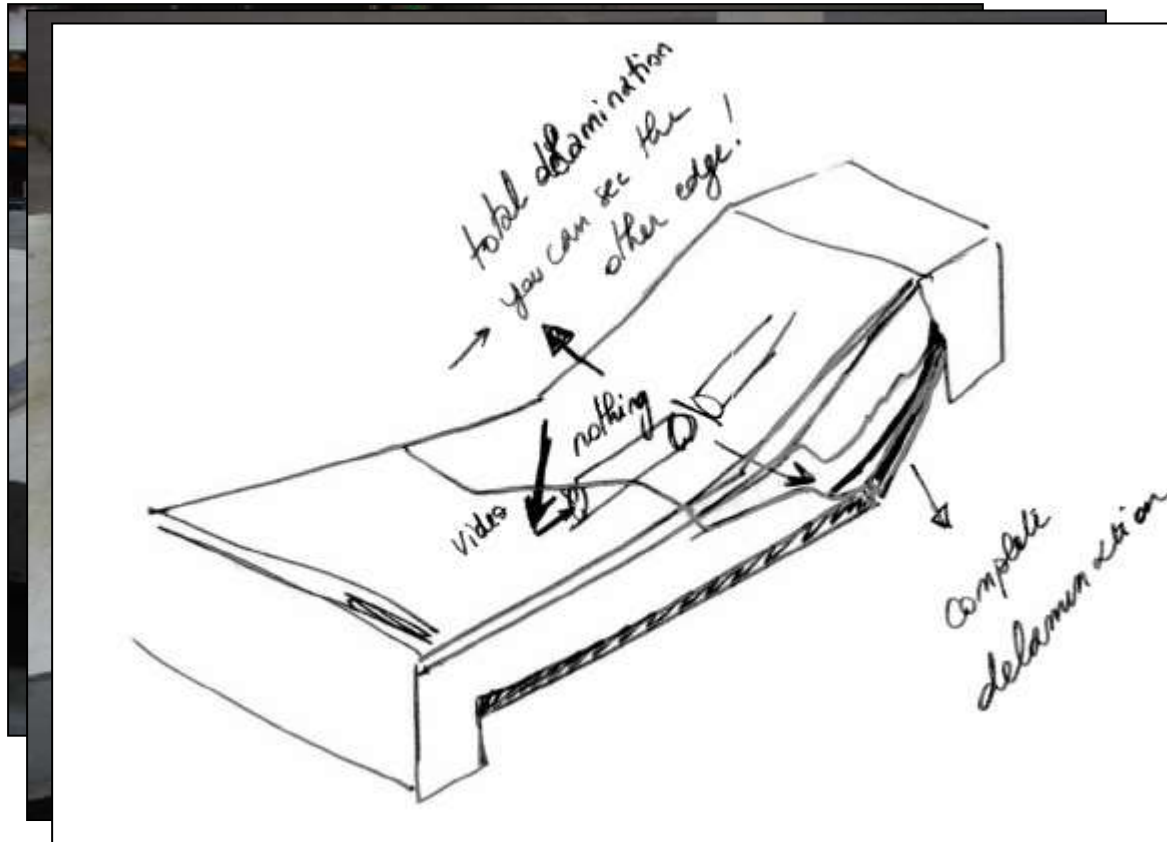
- Specimen investigation



Shear failure
Series G

Analyzing the results

- Specimen analysis
 - Specimen R1



Other examples

- Tunnel segments



Other examples

- Masonry walls



Other examples

- Panels

