CONSOLIS

ROMANIAN CONCRETE PRECAST PRODUCERS SEMINAR

Ultra High Performance Fibres Reinforced Concrete- Achievements and Prospects

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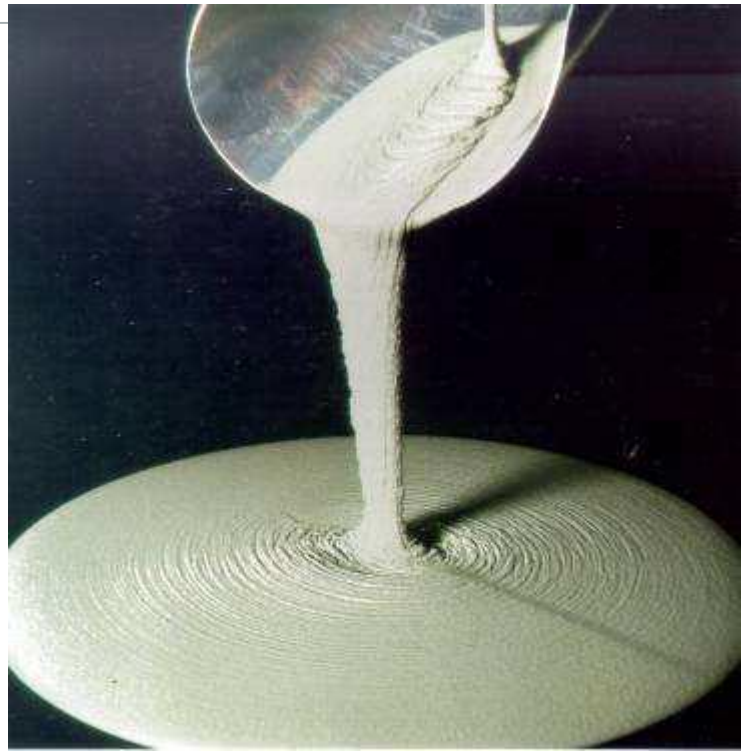
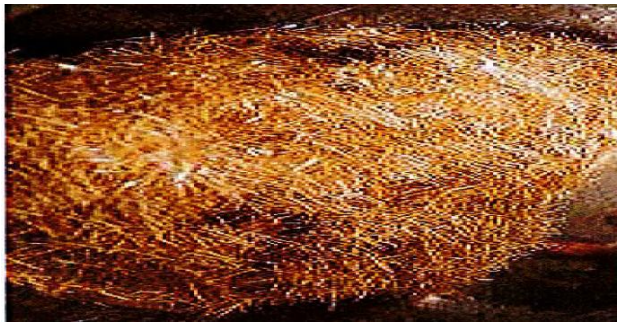
UHPFRC : THE MATERIAL

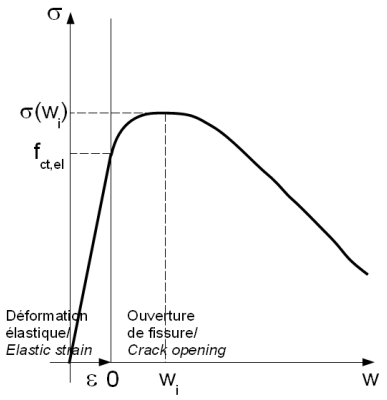
- UHP :
  - Very dense microstructure, with minimum quantity of voids
  - High compactness
  - Ultra high compressive strength :
    from C 130/145 up to C250/265
  - But brittle in the absence of reinforcement
- FRC :
  - Steel fibres d 0,2 mm / length 12 mm
    - Enhanced tensile strength
    - better ductility : ultimate strength close twice the first cracking stress.
    - 150 to 250 Kg pcm, Rc above 200 MPa
  - Other fibres : PP, PVA, Glass…
    - Non structural uses

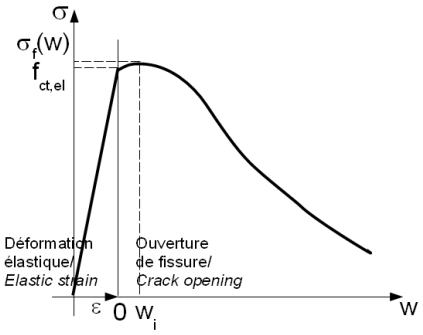


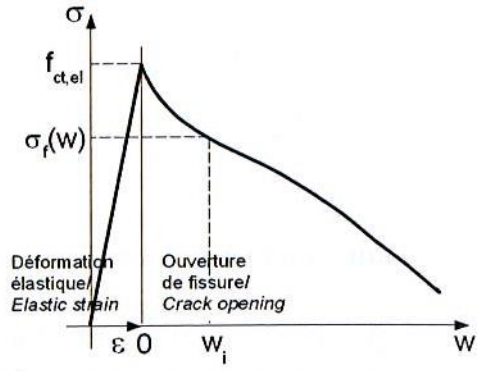


UHPFRC : THE MATERIAL
Main Designation parameters

- RHEOLOGY :
  - to fit the casting process
  - Self placing, Viscous, thixotrope
  - Characterized through flowing tests, maintained workability
- THERMAL TREATMENT :
  - Without
  - Pre-demoulding thermal treatment : similar to current practice with conventional concrete
  - Post-demoulding thermal treatment : typically 90 deg. C in a closed cell during 48 h; often required to reach compressive strength above 200 Mpa; helps to stabilize the material (*shrinkage completed at early age*)
  - Fibres content : governs the post-cracking tensile behaviour, from strain softening to strain hardening.



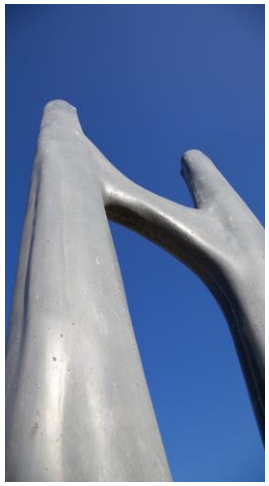


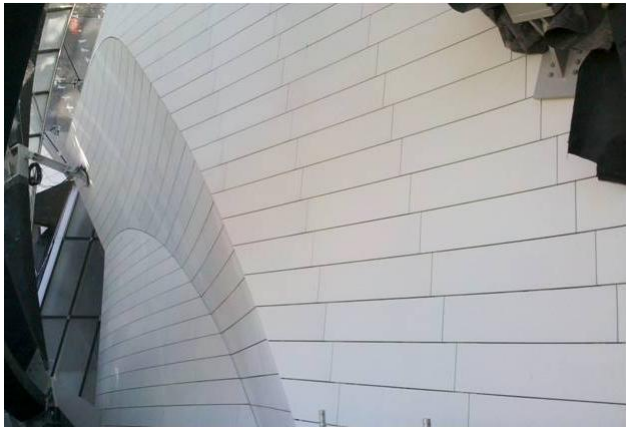


UHPFRC : THE MATERIAL
Main physical performances

- MECHANICAL STRENGTH :
  - It sets the material above conventional high performance concrete : compressive strength typically **around 130 MPa with synthetic fibres, typically around 200 Mpa** with steel micro-fibres. Moreover, **tensile yield strength above 6 Mpa** allows designing light and thin structures.
  - Structural uses call for a minimum C150/165 concrete class

- DURABILITY :
  - Compactness of the cement matrix results in very low porosity, and consequent high protection against agressive environments
  - Practically no need for maintenance



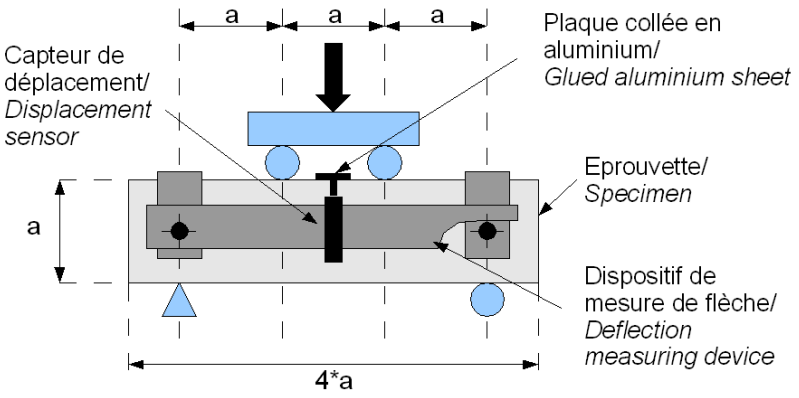


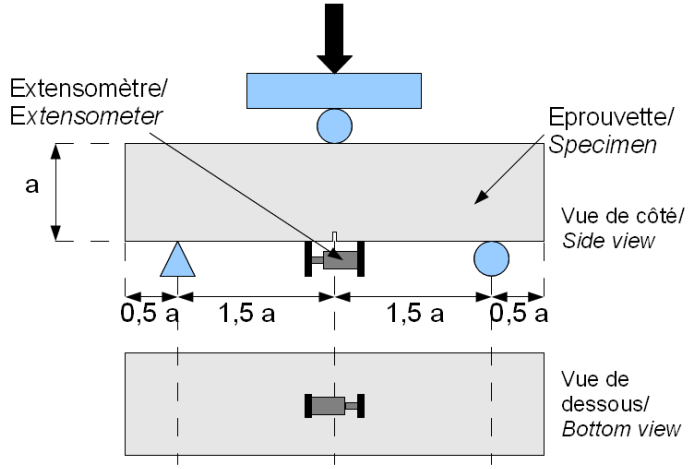
- ASPECT :
  - Very smooth aspect
  - Depending on fibres and additives, a wide range of colours, from deep dark (MUCEM) to bright white (Fondation Louis Vuitton)
  - Unrivaled range of possibilities for shapes.

- FIRE RESISTANCE :
  - Specific mix design mandatorily including PP fibres
  - Tests confirm an excellent fire resistance, helped by the presence of a dense network of steel fibres

UHPFRC : THE MATERIAL
Standards and Tests

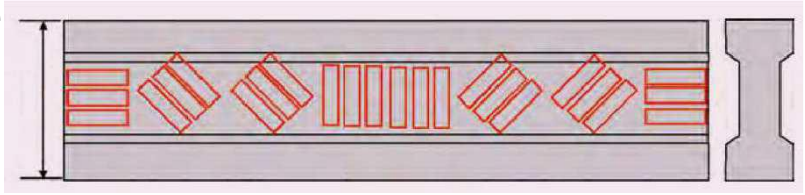
- STANDARDIZATION :
  - Completed in France, in the tube in many other countries, where national recommendations already apply.
  - French standards
    - NF P 18-710 for Design *(based on EC 2)*
    - NF P 18-470 for the Material *(based on EN 206)*
    - NF P 18-451 for Execution
- TESTS :
  - Porosity
  - Gaz permeability
  - Diffusion of chloride ions
  - Specific tensile behaviour type test (measuring the crack mouth opening along with tensile stress, on rectangular prisms.





UHPFRC : THE MATERIAL
Mixing and Placing processes

- MIXING :
  - High energetic mixers are required
  - High precision for dosing of constituents (cement and additives, pre-mix, sand, fibres) is mandatory
  - Accuracy in checking the water content (ratio water/cement typically 0,2)
- MOULDS :
  - Metallic, polyurethane, silicon…; because UHP are expected to give birth to significant shrinkage effects, both the shape of the moulds and the time left before demoulding , must be designed accordingly.
- FIBRES DISTRIBUTION :
  - Orientation of the fibres may be governed by concrete viscosity, pouring process, and type of the fibres; steel fibres may settle in the bottom of the moulds, while synthetic fibres may be subject to floatation.



Example of sawn specimens to determine the K factor in different directions

UHPFRC : ICONIC ACHIEVEMENTS
Jean BOUIN Stadium, Paris, France

20 000 seats stadium
Rudy Ricciotti architect
Completed in 2013
1428 facades panels
1577 roof panels
325 transition panels
73 specific firemen accesses

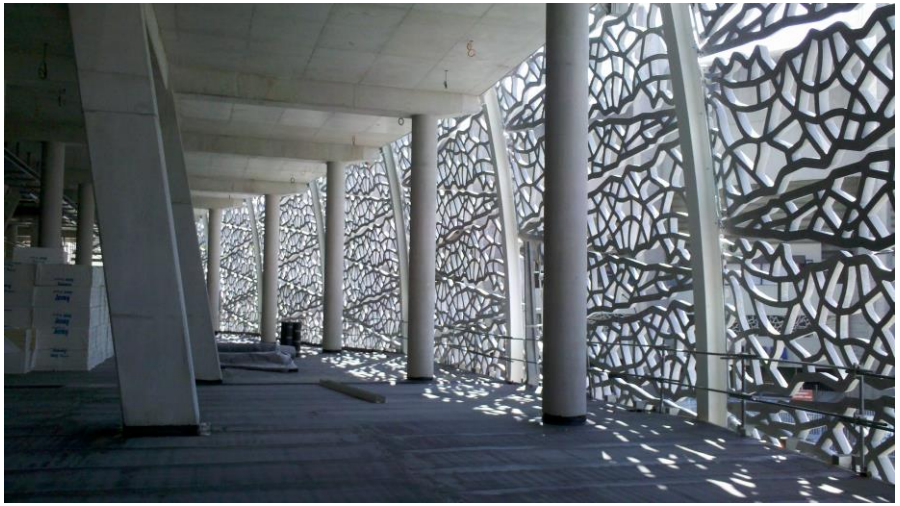
UHPFRC : ICONIC ACHIEVEMENTS
Jean BOUIN Stadium, Paris, France

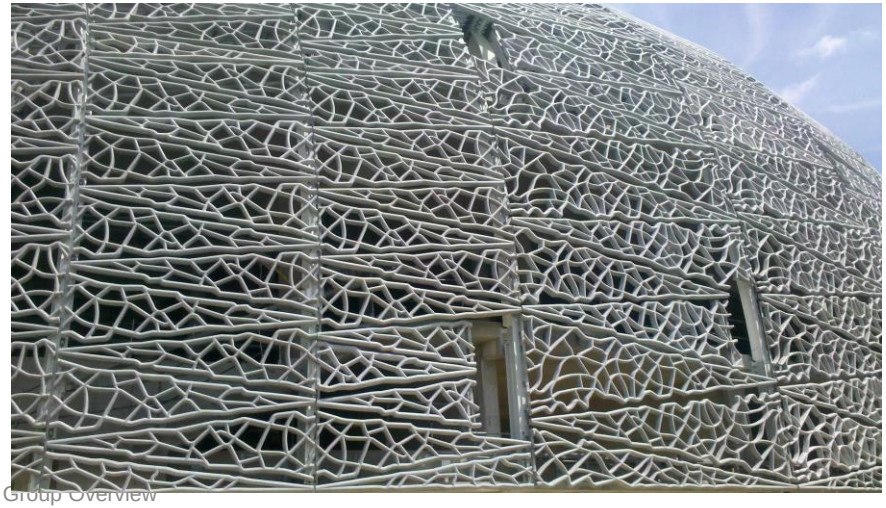
ROOF PANELS

- Watertightness achieved through a specific process combining glass and concrete
- Dual moulds : steel and polyurethane
- Panel spans varying from 2,94 to 9,59 m
- Unit weights from 0,3 to 2,5 tons.

UHPFRC : ICONIC ACHIEVEMENTS
Jean BOUIN Stadium, Paris, France

- FACADES AND TRANSITION PANELS

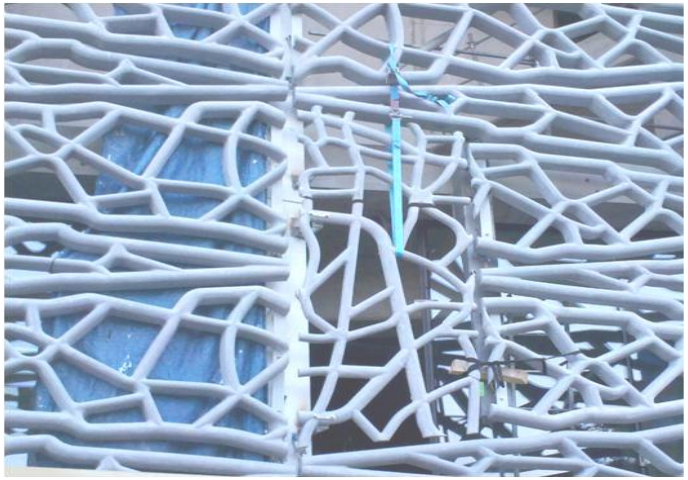




UHPFRC : ICONIC ACHIEVEMENTS
Jean BOUIN Stadium, Paris, France

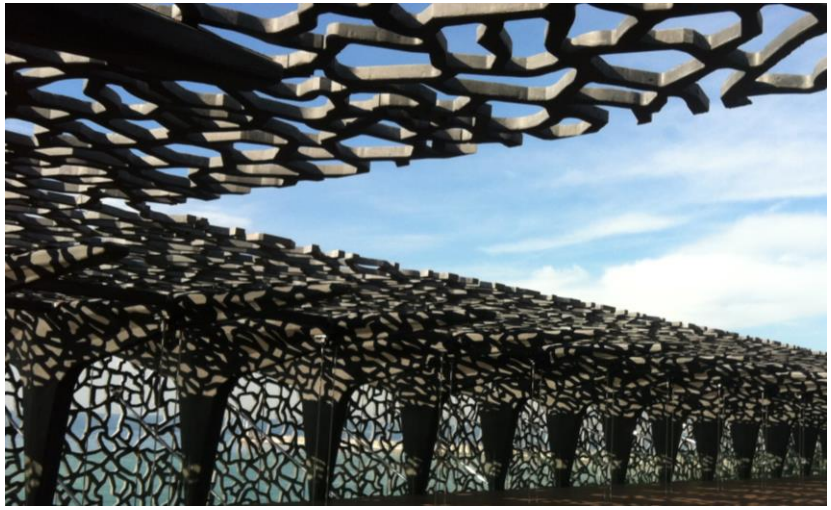
SPECIFIC FIREMEN ACCESSES

- 73 Gates, all different in shape, size and inclination
- Because of the reduced thicknesses of these elements regarding their span, demoulding was not permitted before 48 h after concrete placing
- Specific moulds combining wood, polyurethane and concrete.



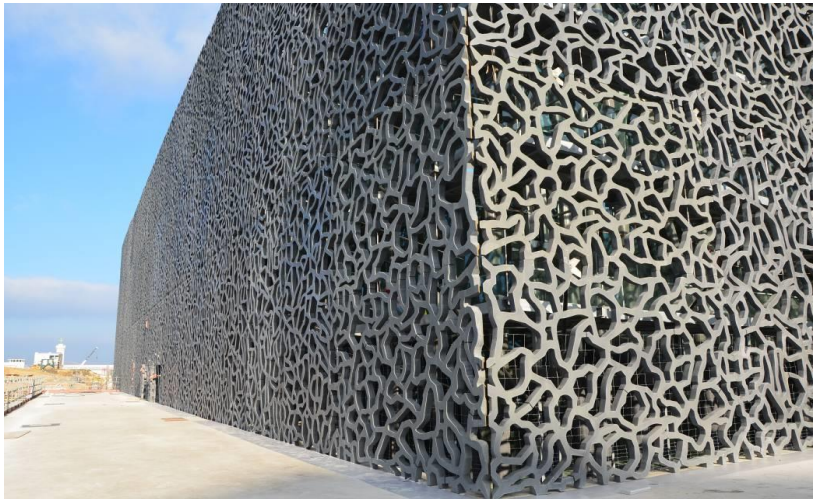
UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

- 15 000 Sqm Museum + Offices, Shops and restaurants, in Marseille
- End of construction June 2013
- Architect Rudy RICCIOTTI
- Consolis UHPFRC products :
  - 400 lattice works facade panels
  - 2 footbridges 75 m span each
  - 308 columns
  - 35 cantilever roof beams



UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

- LATTICE WORKS FOR ROOF AND FACADES
  - 400 Panels, 6x3 m, 7 to 10 cm thick, weighing between 1,5 and 2 tons
  - Vertical casting, provision for an air evacuation system in the reservations for lattice holes.
  - Moulds combining steel and polyurethane (lattice reservations)
  - Integrated global design including connections in the angles



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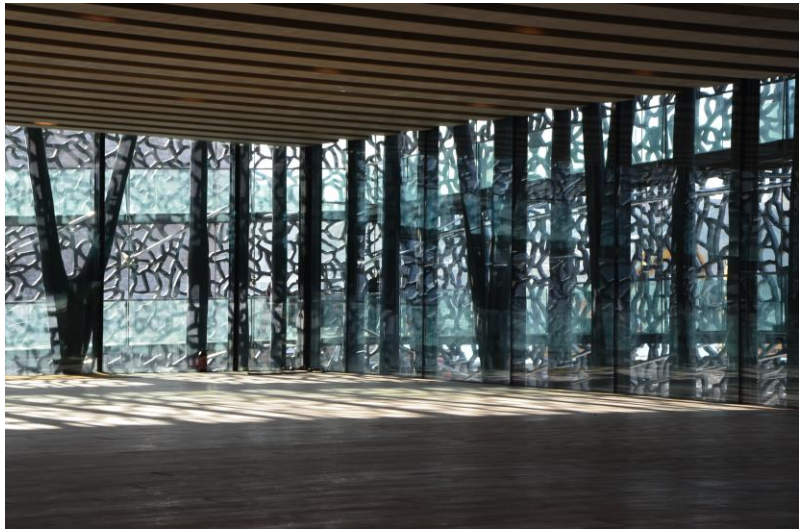
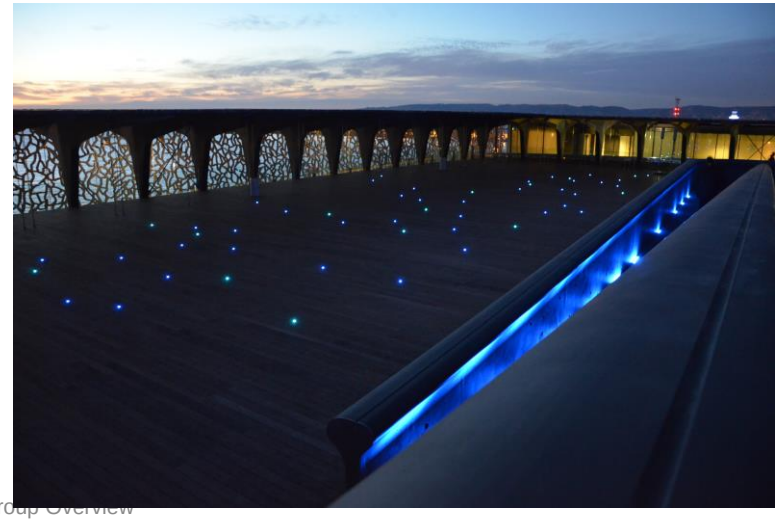




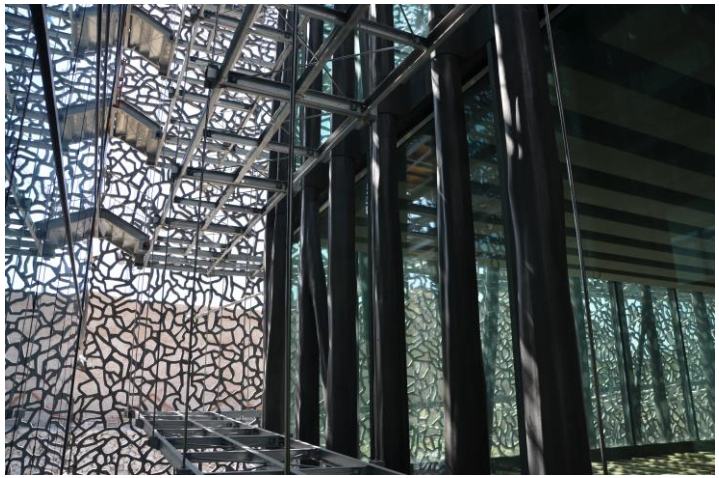
UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

LATTICE WORKS FOR ROOF AND FACADES

UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

COLUMNS :

- Trees 6 to 9 m high
- Unit weight from 2 to 9 tons
- Precast in 20 different moulds : wooden counter moulds carved by an artist, used to shape polyestyher moulds strenghtened by steel frames)
- Vertical reservation pipe in the column core for post tensioning of elements (to overtake earthquake and wind side loads)
- 200 tons post tension in some poles
- Plastic torque devices inserted in joints between the different parts of the columns, so as to accomodate lateral sismic thrusts



UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

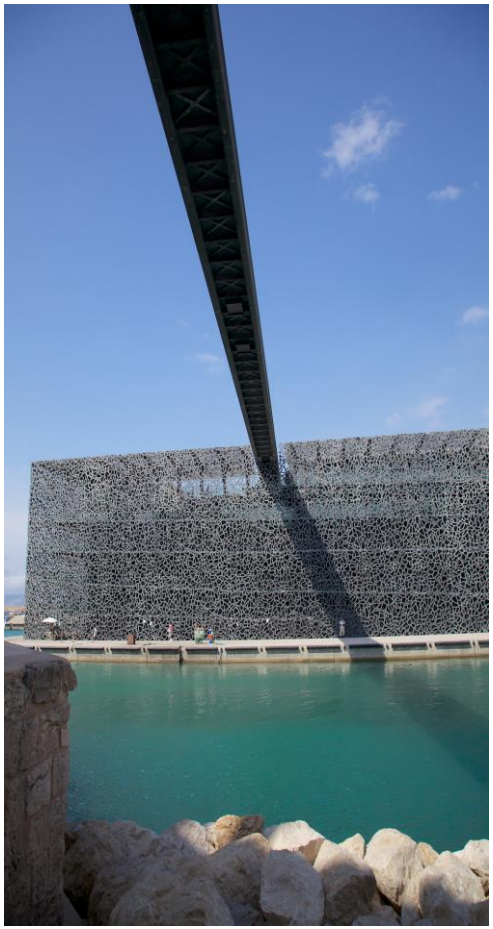
FOOTBRIDGES

- 2 Separate bridges, 75 m span each
- Made by assembling H shaped elements 4,65 m long, unit weight 8,5 tons
- Assembly made by post tension : 0,1 mm plane tolerance requested for the sides to be connected together
- Need for a 3D check
- Post tension in the range of 1000 tons
- Preliminary assembly of the elements on a scaffolding

UHPFRC : ICONIC ACHIEVEMENTS
MUCEM

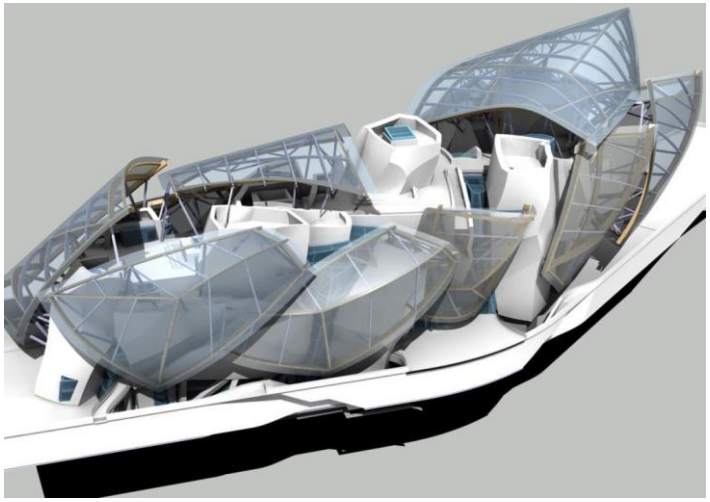
FOOTBRIDGES AND ROOF CANTILEVER BEAMS

- Roof Cantiver beams : 14 m long, 4,5 m high, weighing 9 tons

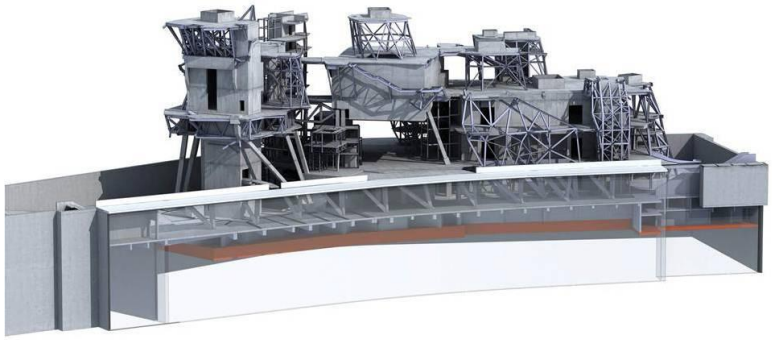


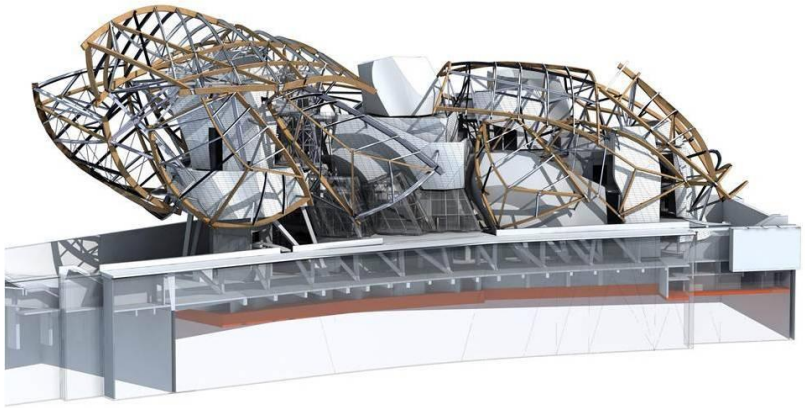
UHPFRC : ICONIC ACHIEVEMENTS
Fondation Louis VUITTON PARIS (Architect Franck Gehry)

- 19 300 facade panels, manufactured in Conflans Ste Honorine and La Crèche, in 2012 and 2013
- Every panel is unique in size, reinforcement and curvature
- Typical average dimensions 1500 x 390 mm, 25 mm thick
- Reinforcement by steel plates on the back sides of the panels
- Production at an average pace of 90 to 120 panels a day
- Silicon framed moulds, combined with lost polystyren shaped pieces, cut and machined in accordance with a 3D design
- 3D checking of each panel
- Level of White checked on each panel



UHPFRC : ICONIC ACHIEVEMENTS
Fondation Louis VUITTON PARIS (Architect Franck Gehry) Erection Steps





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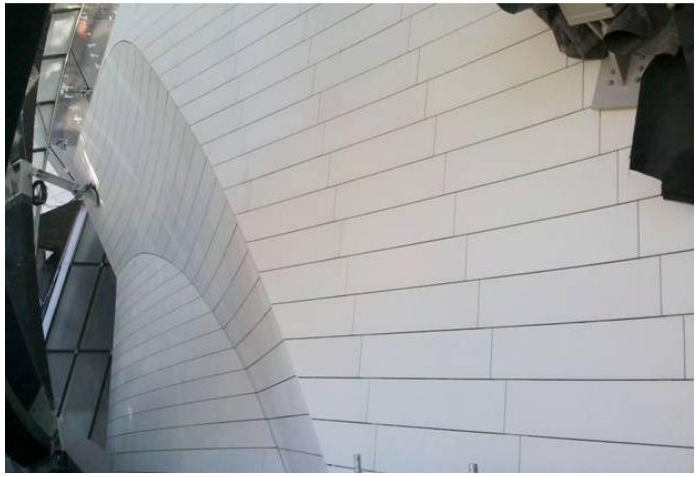

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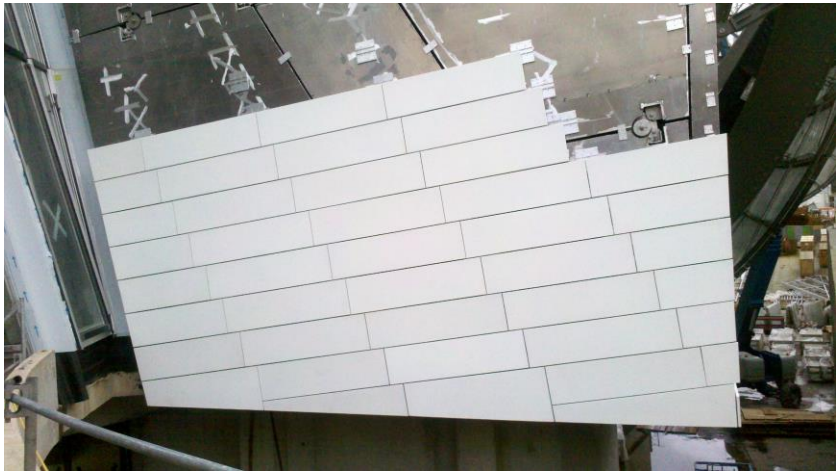
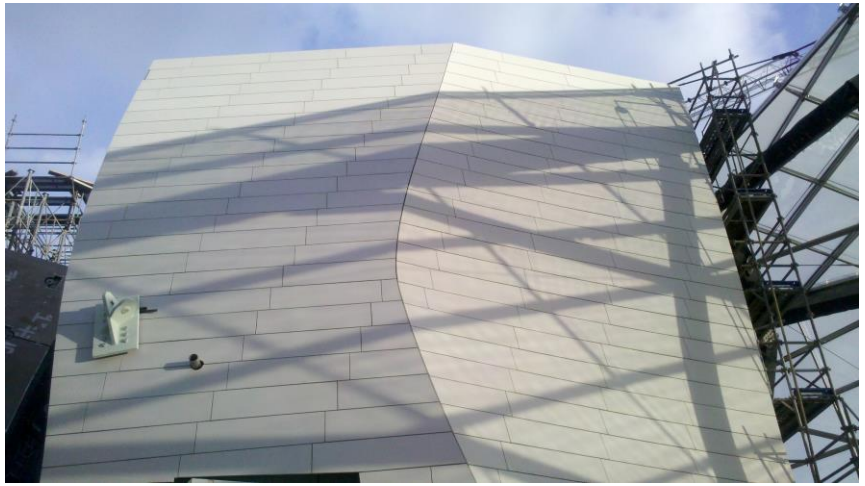


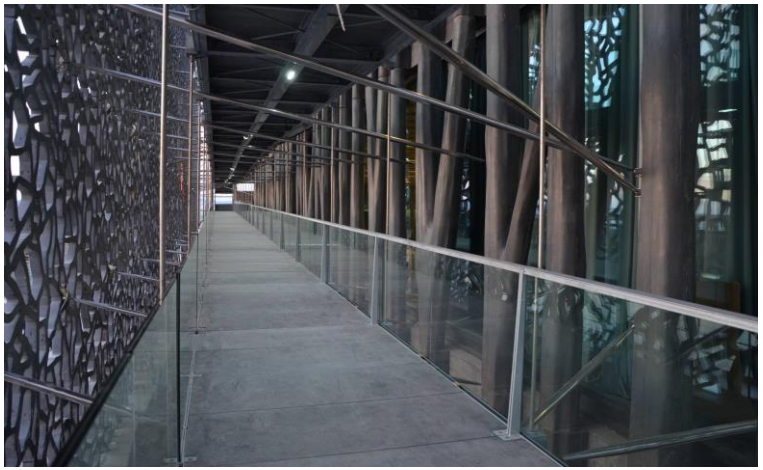


UHPFRC : PROSPECTS FOR THE FUTURE

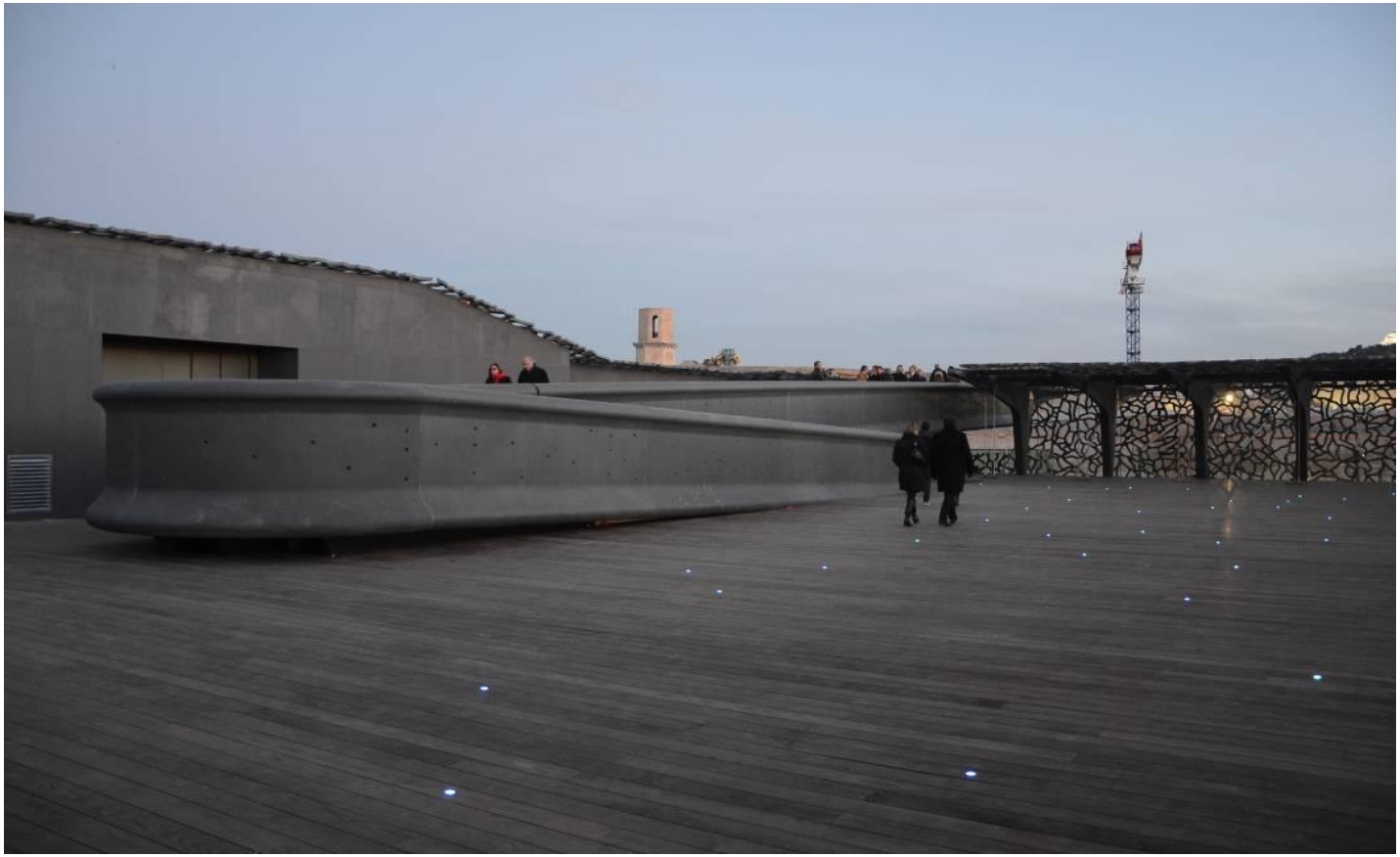
MAIN ACE CARDS FOR UHPFRC :

- **STRUCTURAL** : its high compressive strength makes UHPFRC an ideal partner for prestressed structures. Besides, high mechanical performances allows UHPFRC to compete favourably with steel construction when thin and light components are looked for.
- **DURABLE** :Compact, dense and closed matrix provides both high resistance to aggressive environments and watertightness when required.
- **ARCHITECTURAL** : UHPFRC opens the gate to Architects for complex designs in terms of shapes, textures and colours

UHPFRC : PROSPECTS FOR THE FUTURE



UHPFRC : A STORY TO BE CONTINUED…….



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