

DE LA RECHERCHE À L'INDUSTRIE



# INNOVATIONS IN THE LEFCA HOT LAB RENOVATION

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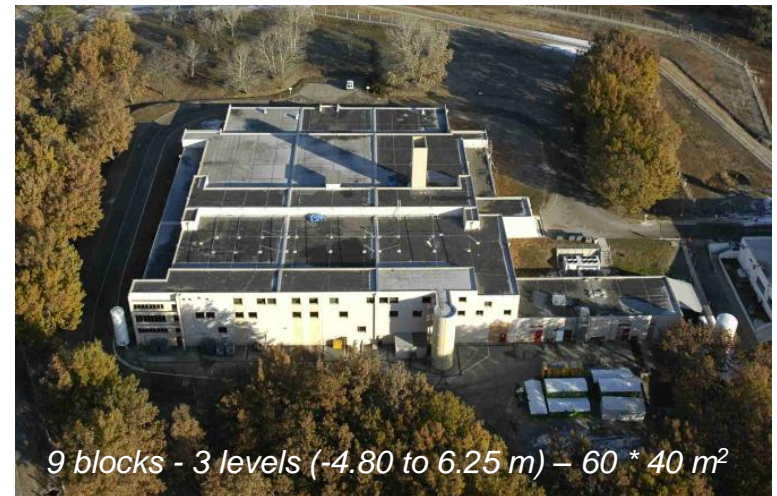
CLAUDE GRAU, CEA, RESPONSIBLE FOR LEFCA CIVIL ENGINEERING

[www.cea.fr](http://www.cea.fr)



HOT LAB - SEPTEMBER 2013

- Nuclear Facility for R&D on nuclear fuel materials (U, Pu, MA)
- 12 Labs and # 70 Glove boxes to handle these fuels
- Commissioned in 1984
- Safety Review in 2003
- A project for renovation works performed from 2005 to 2010



All the renovation works were carried out in coactivity with R&D experimentations

# THE RENOVATION: A LARGE PROJECT (# 12 M€)

- Outside of the Building : standard reinforced concrete process:
  - Horizontal tie beams on south and west facades
  - Extension of walls in the underfloor space of the building
  - ...
- Inside of the Building : innovative process for nuclear industry : Carbon Fibre Fabric
  - Optimal conditions in terms of safety and coactivity
  - Short lead-times
  - Low Cost
  - Limitation of the volume
- Replacement of concrete stack chimney with a lighter steel one
- Removal of polystyrene joints between the concrete blocks to prevent the different blocks comprising lefca from interacting in case of earthquake

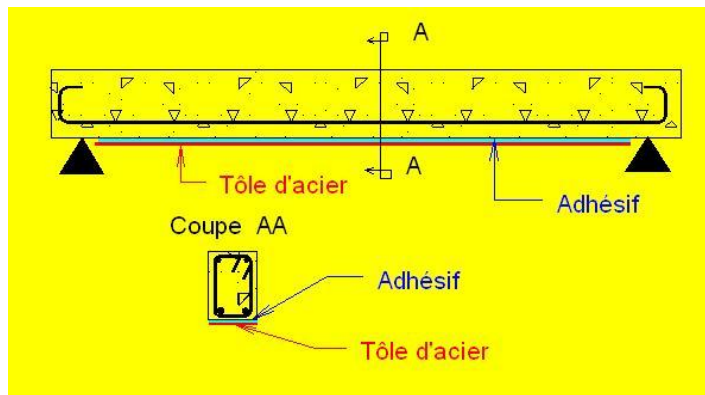


**34 structural components reinforced  
21 in CFF - 13 in concrete - 1 combined CFF/concrete  
about 400 m<sup>2</sup> of CFF installed**

# CARBON FIBRE FABRIC – ORIGINS

- Origin: reinforcement by adding additional bonded rebars as firsts recommended by professor Hermite in 1951
- Technical sheet metal bonded to steel

**Reinforcement principle** : adding additional bonded rebars



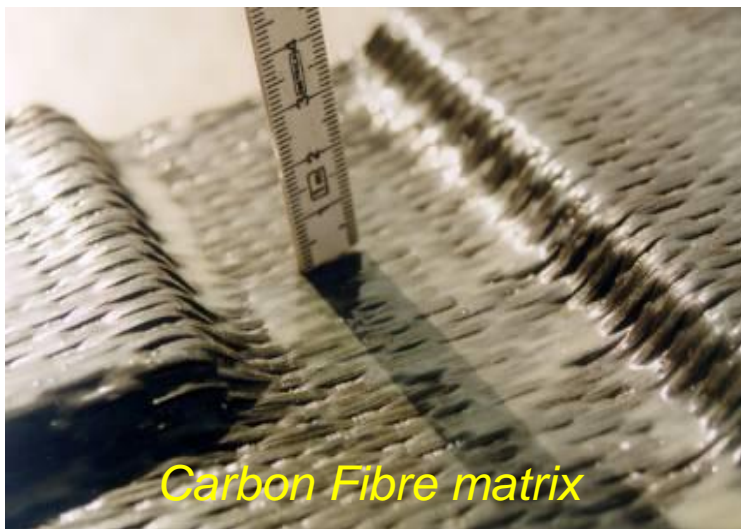
**Complex installation** process due to considerable space restraints and long setting time



→ Introduction of Carbon Fibre Fabric instead of steel plates

# CARBON FIBRE FABRIC – DESCRIPTION OF THE MATERIAL

- A product developed by FREYSSINET Corp. and its NTS subsidiary
- composite material: carbon fibres in a matrix, bound with a synthetic binder
  - Bidirectional matrix : 70 % of fibres in a direction, 30 % in the other
  - Synthetic binder : epoxy resin
    - Bind carbon fibres
    - To ensure adhesion to the substrate after hardening
  - CFF thickness: 0.48 mm



## ■ Improved / steel plates

- Resistance: CFF thickness of 0.48 mm  $\Leftrightarrow$  3 mm of steel
- Better weight reduction : 500 g of CFF  $\Leftrightarrow$  25 kg of steel
- Durability of process: elimination of constraints of corrosion, thermal cycles,...
- New installation possibilities thanks to the fabric flexibility

## ■ Adaptation to:

- All types of loads: bending moments, shearing forces
- All types of geometries: floors, walls, beams
- All types of materials: masonry, reinforced concrete et pre stressed concrete and steel

Particularly suitable reinforcement process for buildings and structures that need to remain operational

- Limitation of the volume reinforcement
  - Advantage in congested environment
  - Minimisation of components that need to be temporarily relocated
  
- Improved conditions in terms of safety / costs / lead times
  - Costs and lead times
  - Without heavy, bulky equipment
  - Without specific conditions (formwork, pressurised concrete inside pump, ...)
  - Only flexible strips and resin for bonding the fabric

CEA chooses to reinforce the LEFCA with CFF

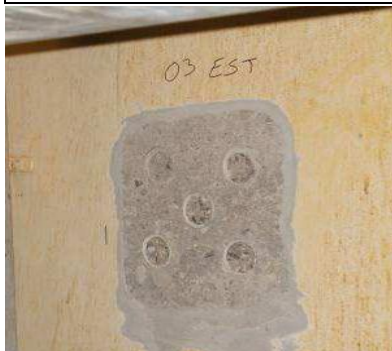
- Collaboration between CEA and Freyssinet on the design and implementation before exchanges with the Safety Authority
  - During 2003 LEFCA Safety Review, Safety authority asks for proven technologies...
  - Working group IRSN (TSO)/CEA/FREYSSINET to issue a specification of CFF use in a nuclear environment
  - 07/2007: Clearance to implement CFF in LEFCA
  - 09/2008: ASN mail to all nuclear operators : no objection for the use of CFF in a nuclear environment
- LEFCA: first Nuclear Facility in CEA to be reinforced with CFF



Preparation of the substrates to obtain a sound, dust free concrete surface:

- The substrate must be mechanically stripped : sandblasting, grinding
- Direct tensile (pull out) test to characterise the substrate

Fragmentation test to check the design assumptions



Anchor holes for inserting wicks

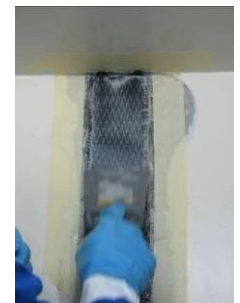
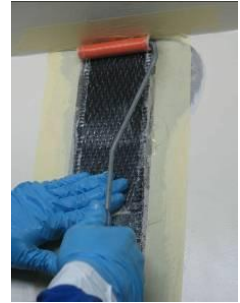


Demolition of concrete slabbing to anchor wicks in the foundation under the slabbing



Preparations on beams and walls

- Location and width are traced on the structure
- First layer of epoxy resin is applied
- CFF strip is applied onto the humid resin
- CFF has to be tightly pressed against the substrate by roller pressing
- Wick is bonded to the concrete by epoxy resin
- Fibres of the tail are fanned out to be incorporated into the matrix of the CFF layer
- Wick is covered with a rectangle of CFF
- A capping layer of resin is applied



# CFF - LAYING IN LEFCA FROM MAY 2009 TO MARCH 2010



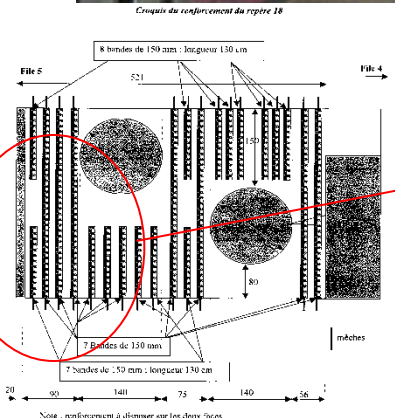
Reinforcement work in offices area



Preparing the substrate in hot cell No. 8



Reinforcement on the surface and underside of a floor.



# REMOVAL OF POLYSTYRENE

- Presence of polystyrene joints → interaction between blocks in case of earthquake
- Diagnostic : presence – thickness – location
  - Thickness : 0 to 4 cm
  - Length : 4.6 m



*Opening of a joint in LEFCA:  
polystyrene and concrete*

- Removal
  - Destruction from the roof terrace
  - Mainly by compressed air and suction at the source
  - Demolition with rigid rods when needed
  - If no joints: sawing operation to create empty area



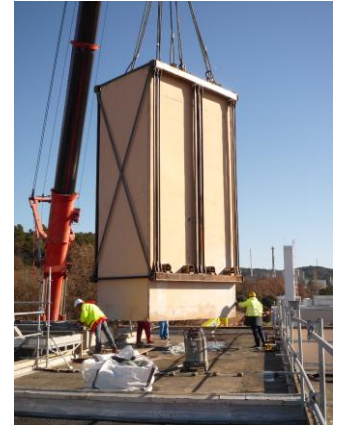
*Removal operation from the roof*

# REPLACEMENT OF THE CONCRETE CHIMNEY STACK

- Replacing the aerial part of the rectangular concrete stack weighing 50 tonnes with a new circular light metal stack weighing 7 tonnes
- Operation took place on 21 January 2010:

1 day  
operation

- The Facility was secured and all ventilations were shut down
- Installing a handling system
- Cutting the base of concrete stack
- Removing with a 650 Tonnes crane
- Flying over the facility
- Monting the new stack on the same day
- Demolition of the old stack – conventional waste



- Carbon Fibres in LEFCA → Confirmation of the feasibility, in a Nuclear Facility, which remains operational
- Process very well adapted to reinforcement in renovations
- Limitation of the amount of reinforcement and laying technic
  - Many advantages in complex environments
  - Minimise offests (the need to temporarily relocate components)
  - Favorable in terms of safety (no heavy handling, simple process), costs and lead times

This first experience with CFF reinforcement has made it possible to envisage applications in other licence nuclear facilities undergoing refurbishment  
(renovation of reactor CABRI used CFF in 2011)

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