DEVELOPMENT OF FIBRE REINFORCED CONCRETE OVERPACKS IN FRANCE

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ABSTRACT

Radioactive waste conditioning is a major step in the processes implemented in nuclear installations. The objective is to contain under conditions as satisfactory as possible for man and environment the radioactive materials contained in nuclear waste, containment integrity having to be guaranteed over very long periods.

Medium-level (ML) and even very low-level (LL) waste is no exception to this rule. COGEMA thus conducted research work for many years and developed an original process to condition waste in containers reinforced with metal fibres, called fibre concrete containers.

This process, welcomed by the French Safety Authorities and ANDRA, the French Radioactive Waste Management Agency, presently appears to be the best process for low-level and medium-level solid waste conditioning.

WHY FIBRE-CONCRETE ?

Extensive research work was conducted on the incorporation of various fibres in materials such as mortar, cement or concrete, so as to enhance their mechanical properties.

Those materials, and more particularly fibre reinforced concrete, are more and more successfully used in Germany, the USA, Japan, Great Britain and France.

The incorporation of fibres in concrete has the following major advantages:

- the matrix is reinforced, thus providing better tensile, bending, impact fatigue and abrasion strength,
- rupture strength is improved--(a less fragile and more ductile material is thus obtained),
- concrete microcracking is reduced, which is the key to long term containment of nuclear waste,
- the corroding, conventional carbon steel used for armored concrete is replaced by a non-corroding amorphous metal fibre in the case of fibre concrete (French patent). This last point is of utmost importance to guarantee material durability and, as a consequence, long-term waste containment integrity.

In view of the advantages of fibre concrete, a research and development program was initiated early as in 1985 so as to define:

- the optimum fibre concrete formulation (proportions of water, sand, cement, aggregates, additives and fibres),
- the type of fibre,
- the waste encapsulation method,
- the shape of the fibre concrete containers (cubical, cylindrical).

Those high-integrity containers will receive ANDRA's "High Performance" seal of approval. They have a lifetime consistent with the Institutional Control Period of low-level and medium-level waste disposal facilities, i.e. 300 years (See in appendix "the main properties of the fibre concrete and container").

PRODUCT LINE

Fibre concrete containers can be tailored to the specific needs of each customer, as regards: (Fig. 1)

- geometry (cylindrical, cubical, etc.),
- dimensions,
- wall thickness,
- closure system,
- gripping system,
- surface finish of outer walls.

Fibre concrete containers being produced by moulding, customization is relatively easy. (Figs. 2, 3, 4)

Four typical containers are currently available:

* Sogefibre, a subsidiary of Société Générale pour les Techniques Nouvelles (SGN) and Société Générale d'Entreprise (SGE), is in charge of producing fibre concrete containers for nuclear waste producers and of developing and promoting this new material: the fibre reinforced concrete (Research and development of new products).

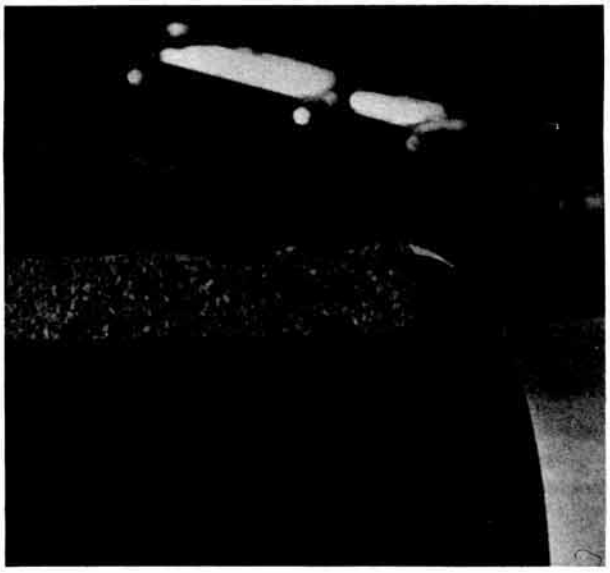

Fig. 1. Cylindrical containers, section.

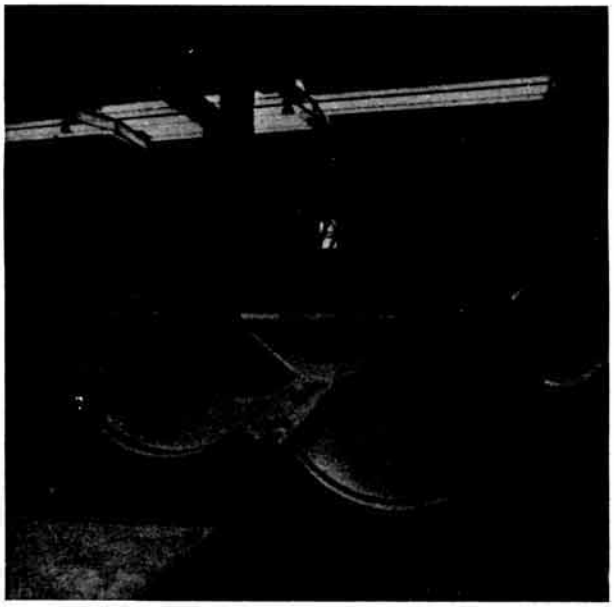

Fig. 2. Cylindrical container.

- 3 cylindrical containers:
  - CBF-C1: interior diameter: 690, height: 1 200 mm;
  - CBF-C2: interior diameter: 850, height: 1 500 mm;
  - CBF-C3: interior diameter: 850, height: 3 000 mm;
- 1 cubical container:
  - CBF-K: 1 700 x 1 700 x 1 700 mm

Series fabrication started on those bases in July 1990. (Figs. 4, 5,6)

Our product line will next include two additional types:

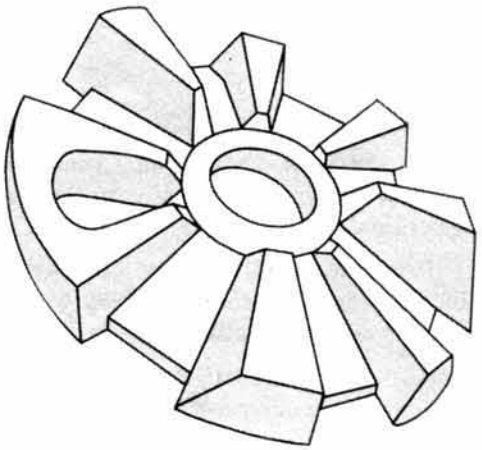

Fig. 3. Fibre concrete container CBF-C1 anti-float cover.

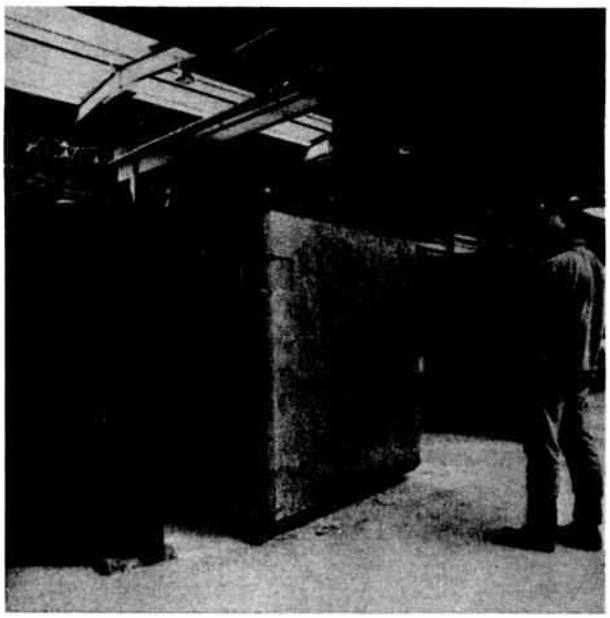

Fig. 4. Cubical container: 1,7 x 1,7 x 1,7 m.

- nestable containers fitting within another to increase the biological shield thickness and prevent external contamination,
- containers adapted to dismantling works: smooth outer walls, several handling means available and wall thickness adapted to the different kinds of waste to be conditioned...

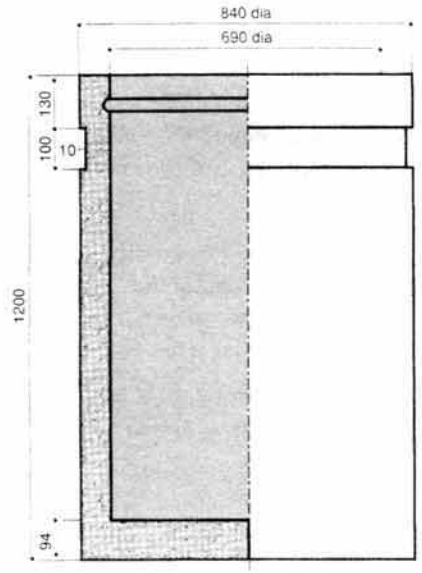

Fig. 5. Fibre concrete container CBF-Cl. Study of a specific COGEMA's container.

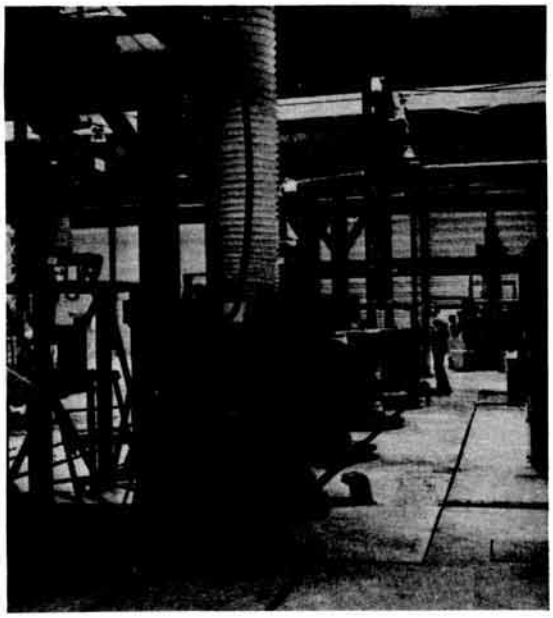

Fig. 6. Removal of cylindrical containers from molds.

VALOGNES PLANT (FRANCE-MANCHE)

The quantity of containers required at the La Hague reprocessing plant, and above all the necessity to control their quality to satisfy ANDRA specifications, involved very stringent control by the COGEMA Group so that containers could be procured to the La Hague plant in sufficient quantity and quality.

This led to the construction of a plant in Valognes, France, in the vicinity of La Hague.

This plant started in operation in July 1990. It has a rated capacity of 12,000 containers per year that can be increased to satisfy the potential needs of other clients in the nuclear or non-nuclear fields, since this new material, developed for applications in the La Hague reprocessing plant of spent fuel, involving high quality control and high quality assurance levels, can assuredly find applications in other sectors of the industry (prefabrication, thin concrete walls, environmental protection, etc.).

The quality assurance procedures implemented in the Valognes plant (french standard "AQ2") are focused on the following major points:

- very stringent control of specifications of raw materials received (cement, sand, aggregates, fibres, etc.),
- control of process parameters (proportioning of concrete ingredients, mixing time, etc.),
- systematic measurement of concrete shrinkage and mechanical resistance on test samples,
- dimensional and visual inspection of products,
- product traceability.

APPENDIX

MAIN PROPERTIES OF THE FIBRE CONCRETE AND CONTAINER

FIBRE CONCRETE PROPERTIES

a. Specific gravity:

- approx. 2.4

b. Mechanical properties

PROPERTY	VALUE AFTER 28 DAYS
Compressive strength	> 50 MPa
Tensile strength	> 4.5 MPa
Shrinkage	< 0.3 mm/m
Weight loss	< 35 kg/m^3

c. Permeability to nitrogen:

- < 5.10^{-18} m^2

d. Containment capability:

- Water containing tritium: effective diffusion factor: < $1.5.10^{-3}$ cm^2/d (about 10^{-5} to 10^{-4} cm^2/d)

- Cesium: effective diffusion factor:
  $< 10^{-3}$ cm^2/d
  (about 10^{-6} to 10^{-5} cm^2/d)

CONTAINER PROPERTIES
(Cylindrical container H: 1.20 m - ϕ: 0.84 m)

a. Drop test

- Drop from a 1.20 m high platform:
  - spalling over a 22 cm length of the impact edge, 2 to 3 cm wide,
  - no microcracks (detected by sound measurement).
- Drop from a height of 1.20 m onto one edge, due to as sling failure:
  - 10 cm concrete flake,
  - spalling over 40 cm,
  - no microcracks.

b. Keying strength (upper shell/wrapping *concrete joint*)

They were no visible faults nor measurable faults (checked by sound measurement) following application of a 1000 kN load to the upper face of the container.

c. Resistance to crushing

A load is applied over a 22 cm wide section of the container generatrix, with the container resting on two cylindrical supports, lying along two generatrices; the distance between these supports depends on the container diameter.

Microcracking was only found after application of 800 kN. Clear cracking began to occur at 985 kN.