DISMANTLING INTERNAL CONCRETE STRUCTURES IN AN OPERATING NUCLEAR RESEARCH REACTOR

Frédérique FRERY
Institut Laue Langevin
6 rue Jules Horowitz – BP 156 – 38042 Grenoble Cedex 9 – France
frery@ill.fr

Abstract

The Institut Laue-Langevin is an international research organisation leading the world in neutron science and technology. Since 1971 it has been operating the ILL High Flux Reactor, the most intense continuous neutron source on Earth.

The second general review of the safety of the ILL reactor was launched in 1995. Between 1995 and 2002 a number of studies were carried out on the seismic resistance of the reactor building based on both simplified and more sophisticated models. In 2002, at the end of the review, the Safety Authorities asked the ILL to perform a seismic study of the installation buildings based on more conventional calculation methods; it also asked the Institut to demonstrate the reliability of the equipment important to safety in the event of an earthquake.

A team was set up at ILL to manage the programme. Its mission was to identify the solutions capable of demonstrating the resistance of the installations, to present the reinforcement work envisaged to the Safety Authorities, and to manage the programme of work itself.

When the HFR was built, a series of technical structures was built around the periphery of the floor at reactor pool level. A study showed that these structures would lack stability under earthquake conditions and could damage the concrete reactor containment, an element important to safety in the event of an earthquake, as well as the concrete floor slab on which they are sited.

Given the high cost of reinforcing these areas it was decided in November 2003 that they would be dismantled. These structures weighed over 1000 tonnes; their removal therefore also had the advantage of discharging the floor slab at reactor pool level.
The first phase of dismantling was carried out between August and December 2004. The second phase is planned from August 2005 to March 2006.

The article details the constraints associated with a dismantling programme in the immediate vicinity of the reactor pool, both during reactor operations and in the long shutdowns also used for maintenance operations on the reactor block; it explains the problems encountered and the solutions adopted.

1. CONTEXT

1.1. Presentation of the ILL

The Institut Max von Laue - Paul Langevin is an international research organisation and world leader in neutron science and technology. Since 1971 it has been operating the ILL HFR (High-Flux Reactor), the most intense continuous neutron source in the world.
The ILL is governed by an international cooperation agreement between France, Germany and the United Kingdom; the fourth ten-year extension to the agreement was signed at the end of 2002, thus ensuring that the Institute will continue to operate until at least the end of 2013.

In 2002 the facility underwent a general safety review, including an assessment of the impact of a safe shutdown earthquake. A broader programme for upgrading the installations and improving safety levels is now under way, part of which involves the dismantling of internal concrete structures in the reactor operations hall.

1.2. Description of the installations

The reactor building houses the reactor vessel, which itself houses the fuel element. The reactor vessel is immersed in a cylindrical pool providing radiological shielding and ensuring the system's thermal inertia. The vessel is connected to the heavy water coolant circuit. The reactor pool is connected to a storage pool (known as the canal), which is used for fuel element handling operations and for storing irradiated elements prior to their disposal.
During normal operation of the HFR, the confinement of the building is provided by an inner concrete and an outer metal wall; the space between the two walls is maintained at overpressure.

1.3. Safety functions required of the reactor building in the event of an earthquake

To satisfy the safety objectives of limited radiological consequences during an earthquake, the safety functions to be guaranteed are:

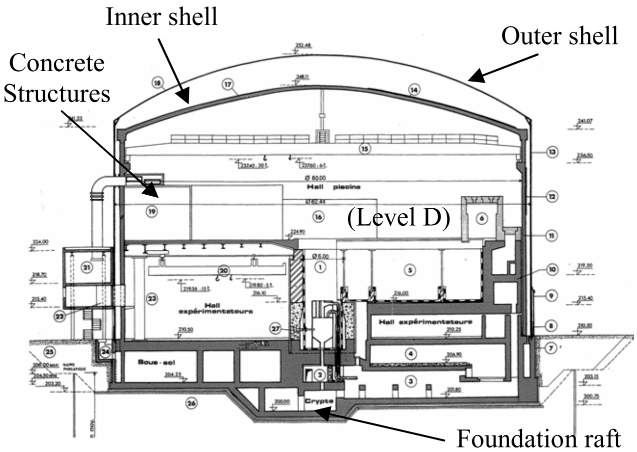
- perfect control of the fuel element reactivity;
- evacuation of residual power without losing the water in the pool and canal (an emergency water make-up system for these pools has been installed);
- continued containment: in the event of an earthquake, the overpressure between the two reactor shells is not guaranteed. An emergency air filtering and extraction system capable of continued operation after an earthquake is to be installed to prevent an increase in air pressure inside the reactor.

The reactor building itself must be stable enough to ensure adequate support for all items of equipment identified as being important for safety.
The containment must also maintain a level of leak-tightness compatible with the emergency air extraction system installed.
Finally, the reactor building must remain stable and prevent structures and equipment from turning into projectiles and threatening the operation of safety-related equipment.

2. DESCRIPTION OF THE BUILDING

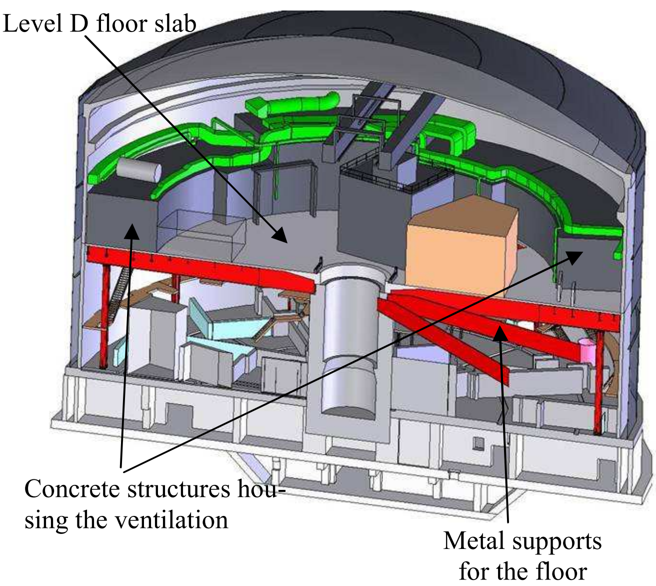
The building consists of a cylindrical concrete shell of 60 m diameter and 40 m height (inner shell); the total mass of the building is about 55 000 tons. Its basement is a very rigid, circular foundation raft composed of thick slabs and support walls.
The centre of the raft supports the core of the reactor and houses the pool and reactor vessel.

Figure 1 - Sectional view of the reactor building



Above the canal and the core is a concrete floor slab (floor of reactor operations hall), which covers the entire surface of the building. The centre of this slab is embedded in the core and maintained by structural steelwork – horizontal beams supported by columns around the edge of the floor. The hall above is known as Level D.

Figure 2 - Cross section of one view of the reactor building



3. REASONS FOR DISMANTLING THE MASONRY STRUCTURES INSIDE THE REACTOR

When the reactor was built, a number of masonry buildings were constructed on the concrete floor slab on Level D. These buildings provide utility and equipment rooms, e.g. mechanical workshop, rooms for storing spare parts and new fuel, and in particular rooms housing the air supply and conditioning equipments of the reactor building ventilation system.

Figure 3 – View of part of the masonry structures around the edge of the reactor building

The buildings in question are of mixed design, comprising a structural steel framework (columns and beams), masonry filling, and floors made of joists and hollow blocks. Although the buildings are not classified as safety related elements, they could damage the concrete containment wall or the floor slab if they became unstable in the event of an earthquake.

The analysis of the buildings drawings and the investigations carried out showed that the structures were not anchored into the concrete slab but simply placed on it, and that the structure detailing did not meet the anti-earthquake requirements (façade slenderness ratio, wall thickness, lack of rebar in the tie beams). The reinforcement to be carried out so that the buildings structures meet the earthquake requirements would have involved a great deal of work and expense. It was therefore decided in autumn 2003 to dismantle these buildings and replace them with lightweight structures.

As well as solving the problem of possible damage being done to the containment wall or the floor slab by these buildings, their removal would also make it possible to:

- lighten the load on the Level D floor slab by a mass of more than 1 000 tonnes which is good for the overall reactor building stability;
- clear the space around the edge of Level D for the creation of an tangential link between the floor slab and the inner containment wall (see ILL paper "Strengthening of the ILL reactor building").

4. DISMANTLING OPERATIONS

The work on dismantling the masonry buildings on the Level D floor slab was divided into two phases:

- phase 1 from July 2004 to January 2005: dismantling of those rooms which did not contain components of the reactor building ventilation system (engineering workshop, rooms for storing spare parts, room for storing new fuel);
- phase 2 from July 2005 to March 2006: dismantling of those rooms containing ventilation components, an equipment room housing the instrumentation and control unit for the fuel handling columns, and the upper floor of the rear area of the hot cell.

4.1. Preparation

Before the actual dismantling of the buildings could begin, it was necessary to:

- remove all the equipment fitted or stored on the roofs of the buildings;
- divert the power and fluid distribution networks (electrical cables, mains water, demineralised water and compressed air supplies) running on the buildings;
- dismantle the ventilation ducts placed on the roofs and establish temporary connections for the duration of phase 1 and up to the start of phase 2;
- clean the walls and floors of the buildings.

Figure 4 – View of part of the networks to be diverted prior to phase 1 of the dismantling operations

The major part of this preparatory work was carried out during reactor operations.

4.2. The constraints of the dismantling operations and the solutions adopted

Due to the particular environment in which the dismantling operations would be carried out, a certain number of constraints had to be taken into consideration:

- risk of dispersal of dust;
- removal of waste (pipes, debris, etc.);
- noise, vibrations;
- fixed dates for dismantling work.

4.2.1. Non-dispersal of dust

One of the seemingly impossible challenges of these operations is the necessity to contain the dust generated by the demolition of the buildings. Indeed, because the buildings are situated in the reactor operations hall, the reactor pool and the canals for the handling and storage of spent fuel are just a few metres away from the work zone. In addition, maintenance work on the reactor block has to be carried out during the long reactor shut down in order not to impact the HFR availability and is requiring a dust-free environment.
In order to keep the reactor operations level as dust-free as possible, the emphasis is placed

on demolition methods which generate a minimum of dust such as wet drilling, wet sawing and hydraulic nibbling.

Figure 5 – Hydraulic nibbling of walls

These cutting methods also require the setting-up of a water retention and recovery system to prevent the water from seeping through to the floor below (experimental level).

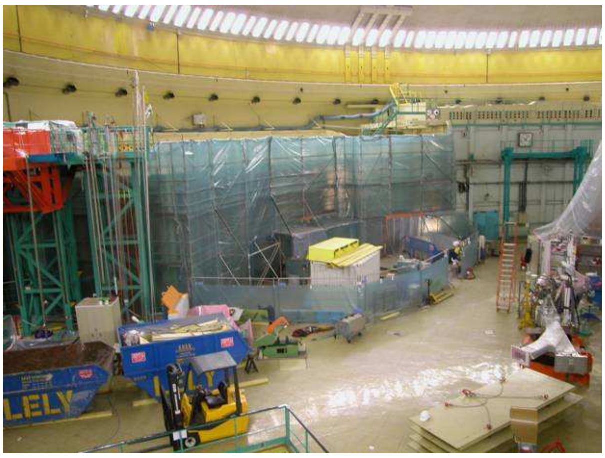
Figure 6 – Wet sawing of roofs of buildings

Moreover, the work site has to be fully contained during both phases of the dismantling operations.

The containment set up for phase 1 was in two parts:

- a static part in which the entire work zone (excluding the roofs) was isolated by means of polyethylene sheeting fixed to a scaffolding structure;
- a dynamic part involving a filtered suction system.

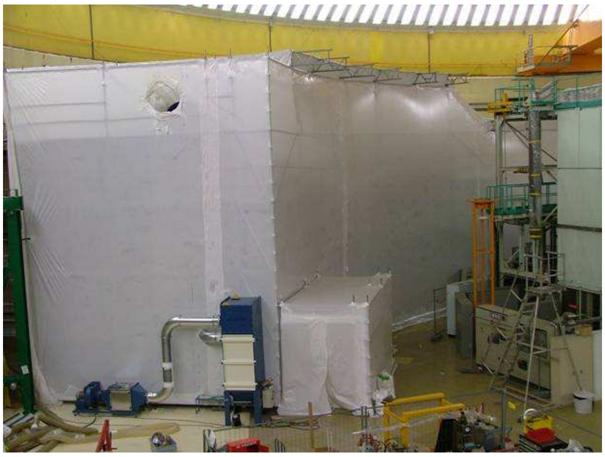
Figure 7 – Containment of structures during phase 1 of dismantling operations



The dust dispersal limitation for phase 1 was not as strict as for phase 2 and there was some visible presence of dust outside the work zone. Thus the containment system for phase 2 has been reviewed and improved.
The containment set up for phase 2 is in two parts:

- a static part in which the entire work zone, including the roofs, is isolated by means of a heat-shrinkable plastic sheeting fixed to a scaffolding structure;
- a dynamic part involving a filtered suction system with automatic filter cleaning.

Figures 8 and 9 - Containment of structures during phase 2 of dismantling operations



In this way, the work zone is completely isolated from the rest of the reactor operations level, with two air locks for entering and leaving the containment :

- a personnel air lock in two parts: dust-free zone and work zone;
- an air lock for bringing in equipment.

Figure 10 – View of personnel access air lock

Figure 11 – Containment of roofs of buildings during phase 2 of dismantling operations

In addition, the dust levels in the area around the work zone are monitored continuously. Three dust level thresholds have been defined:

- real-time level;
- average level over a 10-minute period;
- average level over a 24-hour period.

When any of these thresholds is exceeded, a message is sent by e-mail and by telephone to the ILL staff members in charge of operations. Depending on the circumstances, dismantling operations may be suspended.

4.2.2. Removal of demolition debris

Because the space around the work zone in the reactor operations level is limited, debris from the dismantling work must be removed from the reactor building as the work progresses. This is facilitated by the fact that both phases 1 and 2 of the dismantling operations were scheduled during reactor shutdown periods, making it possible to open the truck loading bay: the empty 8 m^3 skips are placed in the work zone, filled with debris, covered with plastic sheeting, then lowered to the experimental level (same level as outside roads) through an opening in the floor of the reactor operations hall, and finally removed from the reactor building via the truck loading bay on the experimental level.

Figure 12 – Removal of a skip of debris using the overhead crane

The conventional debris from the dismantling operations is checked several times before being removed to a landfill:

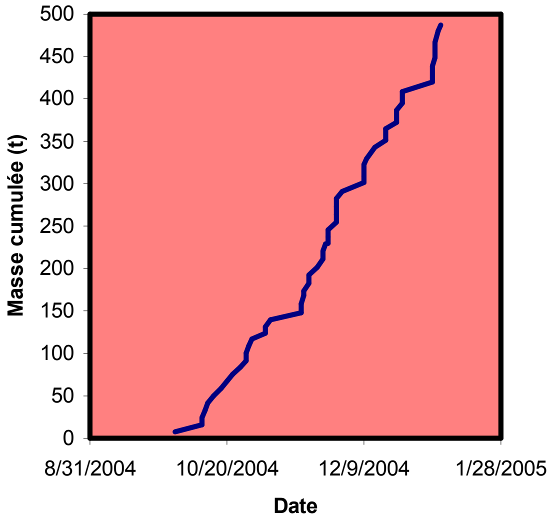
- radiological monitoring of walls and floors of buildings prior to dismantling;
- manual radiological inspection of the demolition debris skips on leaving the reactor building by the ILL's Health Physics Service;
- radiological monitoring of the skips under the radiation detection portal located on the CEA/Grenoble site.

4.2.3. Limiting noise and vibrations – Keeping to schedule (phase 2)

Because the dismantling operations are being carried out at the same time as other work on the reactor block, it is essential that the demolition work generates as little noise and vibrations as possible on the floor slab of the reactor operations hall.

Moreover, because the dates of the shutdown and restart of the reactor are fixed, work on dismantling the rooms containing ventilation components and the instrumentation and control unit for the fuel handling columns must be completed in a maximum of 5 months. This represents the removal of around 700 tonnes of debris, compared to the 480 tonnes of debris removed in just under 4 months during phase 1 of the operations.

Figure 13 – Debris removal curve

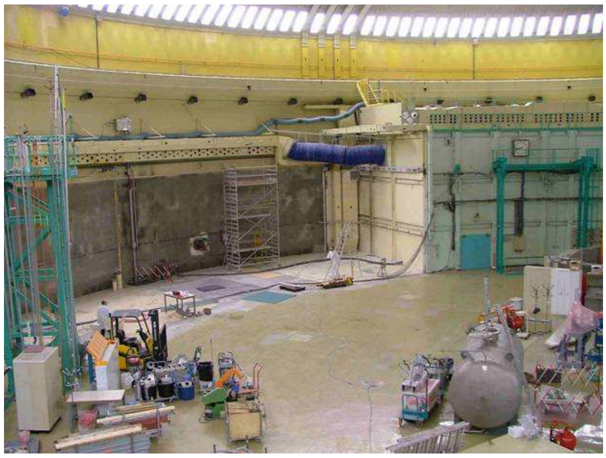


For the various reasons outlined above, phase 2 of the dismantling operations is being carried out in two 8-hour shifts: from 6am to 2pm and from 2pm to 10pm. Those operations which generate the most noise and vibrations are carried out as a matter of priority outside working hours, in order to cause as little disruption as possible to the other work going on in the reactor building.

5. CONCLUSIONS AND PROSPECTS

Phase 1 of the dismantling operations was carried out successfully from July 2004 to January 2005. The only aspect of the work which was not entirely satisfactory was the dust levels recorded in the reactor operations level.

Figures 14 and 15 – Views of the zones dismantled during phase 1



Around 400 m^2 of rooms were demolished and 480 tonnes of debris were removed from the reactor building in just under 4 months.

Phase 2 of the dismantling operations is currently under way. In the light of feedback from phase 1, improvements have been made to the containment system for preventing the dispersal of dust and suitable measures have been introduced to limit the transfer of dust from the work zone to Level D (setting-up of double air locks, changing of clothes, cleaning and covering of all equipment brought out of the work zone). The work on dismantling the 330 m^2 of the three–storied building situated on the level D floor slab and removing the 700 tonnes of debris will be completed by the end of December 2005 at the latest. The space created on Level D will enable the installation, starting in January 2006, of new air supply and conditioning units for the reactor building ventilation system.

The restart of the reactor is scheduled for the beginning of June 2006.