Decontamination and dismantling of radioactive concrete structures

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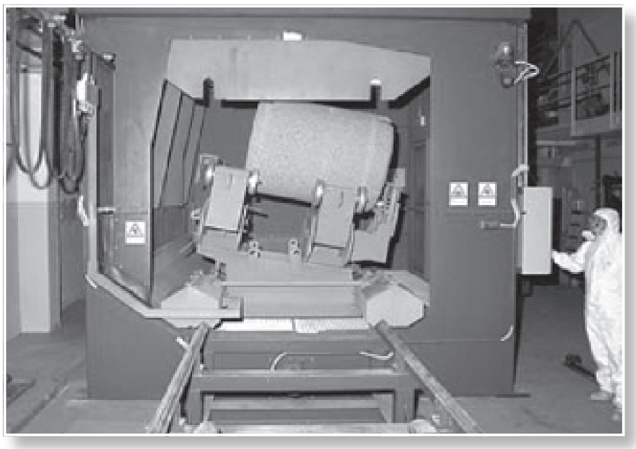
The treatment and disposal of contaminated concrete is a major issue for almost all decommissioning projects due to the very large quantities of material which may be involved. The selection and use of different dismantling and decontamination techniques can significantly influence the total amount of contaminated material that needs to be managed. For example, if a contaminated building is fully demolished, all debris is considered contaminated and requires special handling. In the event that a surface removal technique is first used to separate the contaminated concrete, the volume of material requiring disposal as radioactive material will be significantly reduced, though care will be needed in case of possible non-superficial contamination along cracks and in pipe penetrations.

Significant increases in the volume of concrete to be handled in the near future may be expected given the growing trend towards prompt decommissioning rather than allowing a period of several years of safestore/decay prior to final dismantling. This is because modern technology, improved work processes and emphasis on safety have negated the advantages of long-term decay. Advances in dismantling techniques (including remote dismantling), recycling/re-use, increasing waste storage costs, and improved planning processes have made this approach cost-effective, as well as generally being preferable to the local communities involved.

Decontamination techniques

In recent years, a range of decontamination techniques have been used to reduce substantially the amount of contaminated material for disposal by removing surface contamination of varying depths. The following techniques are used when future land-use scenarios include reuse, when it is impractical to demolish the structure (e.g. a laboratory within a building) or to minimise waste volume:

- Scarifying techniques: the scarification process involves the physical abrading of coated or uncoated surfaces, i.e. the successive removal of multiple layers of contaminated surfaces until reaching a depth at which the surface is uncontaminated.
- Abrasive blasting techniques: these are typically used in conventional industry to clean equipment or surfaces of removable or fixed contaminants, such as grease, rust and paint, and/or to prepare surfaces for coating applications. Depending on the overall objective and the nature of the surface material (e.g. steel, concrete...), the process uses different abrasive media such as plastic, glass or steel beads, or grit, such as garnet, soda or aluminium oxide. Compared to scarifying techniques, these processes may produce significant amounts of secondary waste. The possibility of recycling the abrasive material should always be addressed.
- High-pressure liquid jetting techniques: these comprise high-pressure water jetting (HPWJ) and liquid nitrogen jetting. HPWJ has proved to be a very effective method to clean concrete surfaces and to remove corroded concrete layers, which can strip concrete layers up to several centimetres in a single working step. The main problem arises from the resulting contamination of the water which can, in turn, lead to deep cross-contamination, especially in cracks and joints.



Belgoprocess

Abrasive blasting installation used for the decontamiation of concrete containers.

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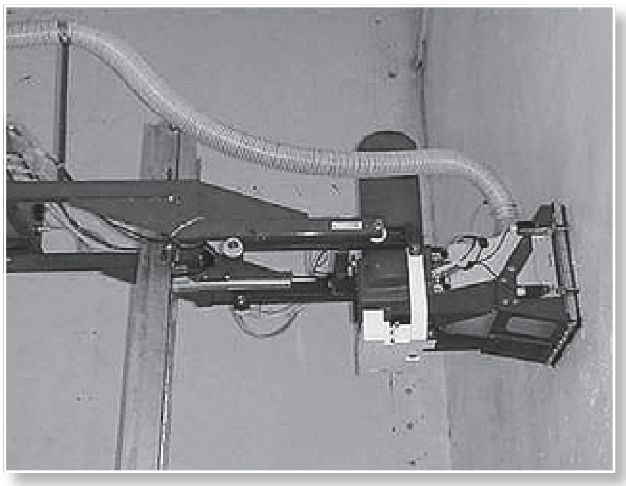
- Laser ablation: the principle of laser ablation (with low power) is based on the rapid heating of the surface causing the superficial layer to expand and spall. The resulting local shockwave is sufficient to eject the paint/coating from the surface. This technology is currently in its demonstration phase; it differs from earlier high energy systems in that the contaminated layer is ejected from the surface rather than burnt.


CEA

Laser ablation on carrier with vacuum.

Dismantling and demolition techniques

Dismantling and demolition techniques are used whenever large quantities or deep layers of activated or contaminated concrete need to be removed. Depending on the plant layout, there are currently a large range of possible well-proven, highly reliable and generally economical techniques. Such techniques may be used, even at an early stage of a decommissioning project, for creating openings and accesses to rooms, e.g. hot cells, or to enlarge existing openings allowing shipment of equipment to the working place or removal of large components. They include:

- Diamond wire sawing: this enables the creation of wall openings and the detachment of large concrete structures. The saw-cut surfaces are very smooth. In contrast to most other cutting techniques, there are few limitations to the size and thickness of the components to be cut. Although diamond wire sawing techniques are normally used with water cooling, they may also be applied in dry conditions. Dust emissions can be reduced using a sealed collection system located at the outlet of the wire.
- Circular sawing: this may be considered as the primary option when very precise cuts are required. Appropriate guiding devices need to be attached to the structure to control the cutting forces and to avoid locking the blade, which reduces the attractiveness of this technique compared to wire sawing. The maximum cutting depth is about one metre.
- Hammering: when massive structures have to be removed, hydraulic hammering is a cost-effective technique (low investment, high yield, simple implementation) but it requires particular attention to safety aspects (structural stability, release of vibration energy, falling rubble, high noise levels). The removal of the activated material in the biological shield is a typical application.
- Drilling and spalling: this technique involves drilling 25-40 mm diameter holes, approximately 75 mm deep, into which a hydraulically operated spalling tool with an expandable tube is inserted. A tapered mandrel is then hydraulically forced into the hole to spread the "fingers" and spall off the concrete. Other options involve the use of spreadable side pistons instead of mandrels or the use of expanding grout. Drilling and spalling is recommended for hard-to-reach areas, for the separation of medium-scale blocks or as preparation for further treatment. Apart from the drilling process, spalling may be considered a quiet, safe and clean technique.
- High-pressure water jet cutting: abrasive water jet technology (AWJ) uses a multifunctional tool that can be used for almost all types of cutting, drilling and removal activities. The advantages are mainly related to the absence of mechanical tools that suffer from interference such as vibrations, thermal stress, seizures, tool abrasion and the condition and shape of the material being cut. Although AWJ cutting has been successfully applied to the underwater dismantling of reactor vessels and is considered an adequate tool for this application, there are certain drawbacks including possible cross-contamination by the contaminated water and the high amount of secondary waste. High-pressure water jet cutting might be considered in special cases or if efficient water and abrasive management is implemented.

Conclusions

Dismantling and demolition works need to be planned and undertaken with due consideration being given to the need for accurate characterisation of the resulting debris, which may be destined for further treatment, free release or disposal. Typically, the choice of the dismantling or decontamination technique for a specific application is determined on a case-by-case basis by considering the advantages and disadvantages of each of the available techniques. A combination of different techniques is often necessary due to the diversity of situations found in the installation being decommissioned.


Belgoprocess

Concrete spalling.

Important considerations when selecting techniques for the decontamination and dismantling of concrete structures are the production of secondary waste, the containment of contamination, safety issues, and the yield and reliability of the techniques. Often, the application of a specific technique is closely connected to the possible use of adequate tool guidance systems to ensure expected standards of accuracy and yield. Special consideration must always be given to avoid causing unacceptable damage to the structure, especially for reasons of building stability.

Experience from decommissioning work undertaken during the past decade has highlighted the following issues related to the choice of concrete decontamination and dismantling techniques:

- When considering the use of scarifying techniques, a major issue is process automation. Scarifying tools are mostly extremely heavy, which tends to limit their size and subsequently their intrinsic performance. For the particular case of reactors, rooms to be decontaminated have highly variable dimensions and geometry. Therefore different (automated) handling devices might have to be considered in order to implement a given decontamination technique in different parts of the facility. For these reasons, manual treatment techniques are still often preferred since these have proven to be the most efficient in terms of global operation yield, though it should be noted that manual scarification is particularly strenuous for operators and therefore requires working with several shifts and regular breaks.
- In recent years, alternatives to strenuous/low-yield mechanical techniques (hammering, scarifying) have been thoroughly investigated (microwave, rebar heating, explosives), though few have proven to be compatible with the constraints of a dismantling project (including nuclear and industrial safety requirements, minimisation of waste volume and economics). However, recent active trials with (low energy) laser and nitrojet processes have demonstrated that both techniques are now mature enough to be implemented on decommissioning projects.
- Techniques currently being used for segmentation, such as diamond sawing and drilling techniques, are still being improved to match the specific needs of dismantling operations, e.g. recent common efforts of diamond tool manufacturers and the decommissioning industry have led to several successful applications of dry sawing of reinforced concrete.
- Abrasive blasting techniques (particularly grit blasting) have proven to be very versatile techniques for both *in situ* decontamination and for dismantled components, e.g. shielding blocks and containers. Concrete layers of several millimetres in thickness can be removed at high production rates provided that an adequate abrasive is chosen and is continuously recycled. Possible cross-contamination of surfaces is an issue to consider when planning the operation. Also, because of the porosity of the concrete, wet techniques which can induce cross-contamination should be avoided.
- Specific (operator) safety issues related to concrete decontamination and dismantling include: dust control/ventilation of the work area, airborne contamination, vibration, noise, projections (of debris and/or abrasives) and falling equipment.
- Different segmentation techniques are likely to be needed to deal with various radiological situations on a particular project, such as different types of contamination and depths of penetration, different quality of concrete, and shapes and size constraints of structures.

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