LIKELY-CLEAN CONCRETE DISPOSITION AT CHALK RIVER LABORATORIES

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ABSTRACT

The vast majority of wastes produced at nuclear licensed sites are no different from wastes produced from other traditional industrial activities. Radiation and contamination control practices ensure that the small amounts of waste materials that contain a radiation and or contamination hazard are segregated and managed appropriately according to the level of hazard. Part of the segregation process involves additional clearance checks of wastes generated in areas where the potential to become radioactively contaminated exists, but is very small and contamination control practices are such that the wastes are believed to be "likely-clean". This important clearance step helps to ensure that radioactive contamination is not inadvertently released during disposition of inactive waste materials.

Clearance methods for bagged likely-clean wastes (i.e. small volumes of low density wastes) or discreet non-bagged items are well advanced. Clearance of bagged likely-clean wastes involves measuring small volumes of bagged material within purpose built highly sensitive bag monitors. For non-bagged items the outer surfaces are scanned to check for surface contamination using traditional hand-held contamination instrumentation. For certain very bulky and porous materials (such as waste concrete), these traditional clearance methods are impractical or not fully effective. As a somewhat porous (and dense) material, surface scanning cannot always be demonstrated to be conclusive. In order to effectively disposition likely-clean concrete, both the method of clearance (i.e. conversion from likely-clean to clean) and method of disposition have to be considered.

Likely-clean concrete wastes have been produced at Chalk River Laboratories (CRL) from demolitions of buildings and structures, as well as small amounts from site maintenance activities. A final disposition method for this material that includes the secondary clearance check that changes the classification of this material from likely-clean to clean has to date not yet been developed. This has not historically represented a significant problem because the volumes of waste concrete being generated have been low, and capacity in sand-trench storage facilities was available. Now that decommissioning has started to ramp up, and sand-trench storage is no longer available, a solution for this high volume waste stream is more urgently required. Establishing that slab concrete is likely-clean is a significant accomplishment requiring a combination of review of records and measurements of 100% of all exposed surfaces. Establishing likely-clean concrete is clean requires more effort, and based on discussions and benchmarking to date, the most promising way forward involves crushing to check for absorbed contamination.

This paper will present CRL's chosen method of Concrete Crushing as a means of both completing the clearance of this material as well as preparing it for reuse as the optimum disposition. It will also discuss the progress of implementation.

1. INTRODUCTION

Wastes generated in areas where the potential to become radioactively contaminated exists, but is very small are deemed "likely-clean" after initial monitoring. These wastes undergo a secondary clearance monitoring step to confirm that they are indeed "clean" before final disposition. This important clearance step helps to ensure that radioactive contamination is not inadvertently released as inactive waste.

Concrete waste slabs, due to their size, shape and density are not able to be cleared through traditional methods. Surface scanning cannot always be demonstrated to be conclusive. In order to effectively disposition likely-clean concrete, both the method of clearance and method of disposition are considered.

Chalk River Laboratories, Waste Management Division has implemented an effective method to disposition concrete slabs at acceptable cost. An added benefit is that the material is rendered fit for reuse. This paper presents the results of addressing this challenge.

2. THE CHALLENGE

Likely-clean concrete wastes are produced at Chalk River Laboratories (CRL) from demolitions of buildings and structures, and to a lesser extent from site maintenance activities. A final disposition method for this material that includes the secondary clearance check that changes the classification of this material from likely-clean to clean was, until recently, not available. This has not historically represented a significant problem because the volumes of waste concrete being generated have been low, and capacity in sand-trench storage facilities was available for use. Decommissioning have started to ramp up, and sand-trench storage are no longer available; a solution for this high volume waste stream is more urgently required. CRL anticipates over 142,000 m^3 of likely-clean concrete waste to be generated by decommissioning activities over the next sixty years. To visualize the volume of waste concrete requiring a solution, imagine over 100 football fields laid out side by side and 0.25 m (10") thick of likely-clean concrete. Although this volume is daunting the real challenge is that the waste receivers expect it in spurts, as low as a few m^3 on some years to as much as 18,000 m^3 on other years, averaging out to approximately 2300 m^3 yearly. In addition to CRL having a finite amount of land that could be used to store waste, AECL has adopted the waste hierarchy of decision making that raises the priority given to Prevent and Reuse above Reduce and Recycle, with disposal as the least attractive option.

Establishing that slab concrete is likely-clean is a significant accomplishment requiring a combination of review of records and measurements of 100% of all exposed surfaces, this may also be supplemented by sampling and analysis. This is required to address any and all concerns and requirements from the compliance programs established at AECL that ensure that all regulatory requirements are being complied with (Radiation Protection Program, Environment Protection Program, and Waste Management Program). Note that identifying materials as likely-clean involves risk-based judgment and that not all items that in principle could be identified for clearance would present acceptable risk. For example, if the history of the item indicates that radioactive materials could have penetrated or may be on the surface of waste items, but radioactive survey cannot find a trace of the material, then these materials "may" be declared as likely-clean, based on the circumstances and informed assessment of risk by compliance program staff. Conservative decision making is inherent in business dealings at CRL and robust control has been considered and implemented as part of the concrete clearance and reuse processes.

Establishing likely-clean concrete is clean requires more effort, and based on discussions and benchmarking to date, the most promising way forward involves crushing to check for absorbed contamination. Health Physics had defined "Likely-Clean Concrete Waste" as "the surface being free of contamination", leaving the interior of the dense material suspect. To declare the waste clean the interior must be exposed to remove all doubt from the assay and a final determination made.

AECL has chosen Concrete Crushing as the method to achieve a means of both completing the clearance of this material as well as preparing it for reuse as the optimum disposition for CRL. AECL is not alone in this choice as other Nuclear Facilities throughout the world have also chosen to crush their concrete waste. What stands AECL apart from most is the approach taken based on issues specific to the Chalk River site. Consideration parameters such as costs, total and yearly waste volumes and characterization technologies have all contributed to selecting crushing/pulverizing as the chosen disposition method of likely-clean concrete waste. This paper describes AECL's disposition path for the CRL site, how this decision was made, the techniques and technologies used and the way ahead.

Note that only a small fraction of the total waste concrete from decommissioning is anticipated to be too active to be cleared. The estimated volume of active concrete slabs that will require storage as radioactive waste is less than 10,000 m^3. Examples of where radioactive concrete would originate include facilities where close contact with radioactive contamination (such as hot cells or sections of floors where spills did occur) or were subjected to significant neutron irradiation (e.g. biological shielding around a nuclear reactor).

2.1 Identification and Assessment of Options

A Pre-Project Initiation process was the tool used to capture, study, and develop problems and ideas to seek the best solution for a final disposition for CRL's likely-clean concrete waste. In this case the pre-project entailed a high level Feasibility Study followed by a developed, selected Concept.

The Feasibility Study was conducted with input from numerous departments and studies. Options considered:

A. Provision of concrete crushing for reuse capability located at CRL;
B. Interim storage followed by disposal in future Very Low Level Waste (VLLW) facility;
C. Interim storage in Shielded Modular Above Ground Storage (SMAGS) units followed by Disposal in Geological Waste Management Facility (GWMF);
D. Interim storage in Modular Above Ground Storage (MAGS)-like units followed by disposal in GWMF; and
E. Transfer to USA nuclear waste treatment and disposal facility.

Three other strategies were considered and not assessed in the study. In general, the reasons for not assessing included a dependence on poor radiation protection or environmental protection practices:

1. Status quo, would have continued accumulation of waste in laydown areas without a disposition path, which perpetuates a poor standard of housekeeping and site performance;
2. Conversion of likely-clean concrete slabs to clean concrete slabs (technology currently not available) and disposal of slabs in CRL on-site inactive landfill, which is a wasteful use of the CRL inactive landfill (an important site asset with a finite capacity); and
3. Conversion of likely-clean concrete slabs to clean concrete slabs (technology currently not available) and disposal in off-site inactive landfill, which is prohibitively expensive due to tipping fee for the estimated volume.

A ranking exercise was undertaken which weighed each of the options with Option A being the overwhelming favourite. The criteria used in the formal ranking exercise were:

1. Alignment with AECL priorities and objectives;
2. Public relations;
3. Health, Safety, Environment impacts;
4. Operability/Maintainability of CRL equipment; and
5. Net Present Cost.

Option A, *"Provision of Concrete Crushing for Reuse Capability located at CRL*", had been selected as the best feasible solution. The net present cost of concrete crushing was over a factor of 10 less costly than the next closest option, disposition in VLLW facility.

The Concept Document is the follow-on to the feasibility study. The concept builds upon the chosen option selected during the Feasibility Study. The concept is developed using the option selected and recommendations made. This particular project determined how to "crush the concrete for reuse". To determine an acceptable means of crushing for reuse the following criteria were considered: Public Demand (Reduce, Recycle, and Reuse) and what product would be acceptable for reuse; Technologies available for size reduction of waste concrete; and characterization/clearance requirements.

On-line research of large industrial crushing operations, nationally and internationally augmented by visits to local smaller crushing plants provided sufficient information to determine that a "Green Approach" is the way governments are conducting their business to meet the insatiable demands of the public for environmentally friendly industries. Countries around the globe and in Canada use recycled concrete to save infrastructure costs and landfill space. CRL has numerous dirt roads, fire breaks and various works that require an aggregate material, some course and others finer grade aggregate. The plan is to stockpile the clean course aggregate created from the crushing operation for use by CRL. By reuse of this material CRL saves direct costs on the purchase and delivery of new gravel as well as the cost to store waste concrete in a VLLW facility or landfill which demonstrates AECL's commitment to "Reduce, Reuse and Recycle".

The estimated amount of waste concrete generated by decommissioning alone over the next 60 years is a significant liability to AECL. The preferred option of crushing and re-use could reduce that amount of liability by approximately 80%. AECL recognizes that failure to declare likely-clean concrete as clean will add to CRL's site liability and jeopardize radioactive waste management storage facilities.

3. DECISION OF WHEN AND HOW TO REDUCE THE CONCRETE

Concrete waste from decommissioning activities are typically cut into slabs, by the generator, and small enough to be transported to the waste receiver. However they are still too thick and of a size that cannot be assayed. When a large scale concrete crushing plant is utilized to crush the waste concrete to an effective size to be assayed, some pre-treatment (further size reduction) is required to feed the hopper of a crushing plant. A pulverizing attachment on an excavator is commonly used to perform this type of duty and reduce the waste to a manageable size. AECL had decided to investigate the opportunity of using this typical pre-treatment step (pulverizing) as the entire crushing operation and avoid the costly overhead of a large scale crushing plant. Characterization had confirmed that a drum containing concrete aggregates of ≤ 0.15 m (6") diameter particles could be confidently assayed by subjecting the samples to a "High Sensitivity, Low Background Isotope Specific Gamma-emitting Spectroscopy Analysis". This confirmed that pulverizing alone was adequate to meet AECL requirements as well as being practical and justified.

The decision now made as to when and how to reduce the concrete waste, the focus could shift to what specific equipment could handle the task, how would the waste receiver control the concrete from receipt to release and what residual risks crushing/pulverizing may create.

3.1 Determining Equipment Requirements

The following three considerations aided in determining the requirements for the most appropriate technology for further consideration:

1. CRL decommissioning activities would produce over 140,000 m^3 of likely-clean waste concrete over the next 60 years however the waste receivers could expect to receive it in spurts as low as a <u>few thousand cubic meters yearly</u>. Therefore the size of the crushing operation would be a factor in that it only needs to crush a relatively small volume yearly;
2. Whatever concrete is crushed has to be safely reduced in size to 0.15 m (6") or less in diameter to take advantage of the technologies used by Characterization; and
3. The concrete aggregate produced by the crushing operation should be reusable to satisfy public demand, CRL's future liabilities and environmental stewardship.

3.1.1 <u>Yearly Concrete Volume</u>

It was determined that the low yearly volume to be crushed directly affects cost. Several international nuclear facilities have already addressed their particular challenges with the large volumes of waste concrete by creating a crushing and sorting operational plant modeled somewhat after the technology used by the construction and demolition industry. These operations involve large concrete crushing plants housed in a controlled ventilated facility. This has proved successful for their needs; however, very costly, typically stretching into the million(s) of dollar range. These plants have steady large volumes of concrete to crush, as opposed to CRL's yearly varying volumes. At CRL, there is the opportunity to use pulverizing only when considering the small annual volumes to be processed and thereby avoiding the expense of a crushing plant.

The selected approach is simple and economical: pulverize the concrete slabs in the open air using an attachment on CRL's excavator. The trade off being control from **receipt to release** of the waste by:

- Restricting the input waste material to clean or likely-clean concrete only;
- Controlling the waste by recording, sorting, sampling and releasing the material by batch; and
- Operating the pulverizing equipment in a secured compound.

Figure 1. Multi-Processor with Pulverizer attached to CRL excavator

The cost to procure and start up a pulverizing operation is a fraction of that to establishing a concrete crushing plant. This is not to say further crushing by a plant would not happen and in fact for some reuse of the concrete aggregate further crushing of the determined clean concrete is required (contracted services will suffice as the need builds).

3.1.2 Requirements Met

The cost to pulverize and then immediately assay the likely-clean concrete waste is reasonable therefore the next point to be considered is the requirements to meet this. The overall requirement of this project is to enable reducing the volume of likely-clean waste concrete currently stored on CRL property and any future waste concrete that will arise from the decommissioning of facilities or waste generated through routine maintenance activities. The reduction would be by crushing for reuse. To accomplish this, attention must be paid to the equipment to be used for this operation and the samples required for characterization.

The option selected is to pulverize or crumble the waste concrete to a size that can be confidently analyzed and a final waste stream determined. Characterization requires 0.15m (6") diameter or smaller aggregates containerized in a 210 L (45 gal) drum for their section to assay. The selected sample aggregates are to come from a controlled batch pile so that the determination can be made for that pile.

To initially reduce the concrete size a pulverizer would be used. The pulverizing equipment must be capable of significantly reducing the size of the 0.25m (10") plus thick reinforced waste concrete slabs to 0.15 m (6") diameter aggregates. To reduce costs, equipment duplication (i.e. excavator) and fully utilize existing resources, an existing excavator owned and operated by CRL is being used for pulverizing. The pulverizing equipment or tool would be part of a multi-processor system that enables full use of CRL's excavator in which the attachments are mounted.

3.1.3 Risk of Dust

Dust generated during pulverizing operations requires a dust suppression system to be implemented. This equipment must enable water droplets to agglomerate with dust generated during the pulverizing to effectively suppress the dust and prevent it from becoming airborne.

The dust suppression system and crushing equipment must be relatively simple to operate to limit the human resources required during setup and operation.

All equipment must be portable and self contained to allow for work at varying CRL locations if requested.

Figure 2. Portable Water Misting System

3.1.4 Dispositioned Product

The requirement for characterization resulting from the employment of this approach is a sample drum of ≤ 0.15 m (6") likely-clean concrete aggregates to be characterized using a "High Sensitivity, Low Background Isotope Specific Gamma-emitting Spectroscopy Analysis" with a Germanium Detector.

Figure 3. Germanium Detector – Q Square

The concrete aggregate produced by the pulverizing operation is 0.15 m (6") and under in size and has been declared clean for reuse. This material is suitable as a sub-base for roads and parking lots or retention material in areas such as embankments or on fire breaks. Further refinement of the aggregate offers many more uses. The reuse of this concrete waste is the most desirable outcome that satisfies the waste minimization hierarchy, CRL's future liabilities and environmental stewardship.

3.2 Overview of the Operation

AECL has procured an attachment called a Multi-Processor for CRL's existing excavator. The attachment is mounted (by means of a quick coupler) to the end of the stick (where the bucket would attach). The excavator is outfitted with new hydraulic lines, controls and safety screens as part of the procurement. One of the tools that mount to the new Multi-Processor is called a Hydraulic Concrete Pulverizer. This tool crushes the slabs of waste concrete between its massive hydraulically driven jaws causing the concrete to fail and crumble away from any reinforcing bars within it. The clean reinforcing bars will be sent off-site for recycling. The smaller aggregate sizes can then be containerized for characterization later.

During pulverizing a small amount of dust is created, so to ensure all the likely-clean concrete and associated dust are retained in a localized controlled area, until it can be assayed, a portable dust suppression system also referred to as a Water Misting System is employed. This system was procured at the same time as the Pulverizer for use in consort with it. This dust suppression system is specifically designed to reduce water droplets to the size of dust particles to allow them to agglomerate with the concrete dust to prevent them from becoming airborne. The amount of water utilized in this process is so small that there will not be any collectable run-off.

Concrete is collected and separated in batches of identified likely-clean concrete slabs, taken from a secure storage location where the identity and history of each concrete slab has been recorded. The piles of pulverized material are picketed with signs that identify the source of the material, to aid in any post characterization investigation that may be required if previously hidden contamination is discovered post processing. Samples are taken from the pulverized concrete and further characterized using highly sensitive gamma spectroscopy to confirm that the batches of crushed concrete meet the criteria for clearance. Following a successful result from gamma spectroscopy, the pickets can then be removed and the cleared crushed concrete directed for reuse. Throughout this process, monitoring and oversight by qualified Radiation Protection staff is carried out commensurate with the level of identified risk.

In the unlikely event an unfavourable result from gamma spectroscopy is encountered, the material from that batch will be quarantined, pending Health Physics investigation carried out to identify the source of the contamination in order to prevent recurrence. The investigation will include consideration of extent of condition (i.e. do other slabs from that originating location need to be quarantined also, should they be rechecked prior to crushing, should the history records be re-examined, etc.) and address the small potential of contamination spread from crushing of this batch. Water misting provides considerable mitigation of the potential for contamination spread. Once the investigation has been completed, the failed batch of material will be directed to storage as radioactive waste.

4. BENEFITS REALIZED

The most significant benefit to this operation is the reduction in CRL's site liability. Several other benefits are realized:

- Significant cost savings in capital investment and operation when compared to building a ventilated crushing plant;
- CRL will see a reduction in the amount of pit run that would have to be purchased;
- Potential site improvements from re-use of concrete aggregate from process. The pulverizing operation will produce on average enough concrete aggregates to lay over ½ km of road per year, given that CRL has over 26 km of dirt roads that could be improved with this aggregate this makes this improvement a real possibility;
- Recovery of desirable land from elimination of concrete laydown areas. Using the recycled concrete aggregates protects natural resources and eliminates the need for disposal;

- As an acceptable substitute for gravel, finely crushed concrete waste aggregate can and is used widely both nationally and internationally as a base for new concrete. Utilizing clean re-cycled concrete aggregates for new concrete has been tested and found to provide acceptable levels of strength in its application; and
- Reduction in water use by the deployment of the mobile Water Misting System eliminates any concern for containment or readily available water source. The traditional method of saturating a concrete cutting operation with water to mitigate dust would leave the work site flooded.

5. LESSONS LEARNED

As CRL builds experience in pulverizing and characterizing likely-clean concrete it is expected that more lessons will arise. Thus far the following have been learned from the design and implementation stages of this operation:

- Stringent control of the concrete laydown areas. Necessary to avoid the cost of redundant radiological surveys that would be required should concrete with different or unknown origins become mixed with the controlled piles;
- Scheduling CRL's only excavator has proven to be challenging as the pulverizing operation requires its use for 3 to 5 weeks. Thought should be given to dedicating an excavator if the amount of pulverizing is substantial;
- Identifying Canadian Standards as a requirement when procuring products manufactured outside of Canada. The particular Mobile Water Atomizer (dust suppression system) procured by CRL is manufactured in the UK which meant that an Electrical Safety Authority (ESA) inspection was required to operate the unit in Canada. The ESA inspection was completed without issue and the system certified for use within a few weeks after receipt; and
- Detailed consideration for shipping. This dust suppression system was manufactured and created in the UK, to be shipped out of Liverpool. Due to its irregular shape it could not fit into a standard marine container resulting in a switch in shipping lines and combined with bad weather had caused several weeks delay in shipping. However once the unit arrived on the Canadian East Coast it was fairly smooth sailing transporting it to Chalk River. The mast on the unit could have been lowered which would have created added work at this end, the trade off may have been worth stronger consideration.

6. SUMMARY

It is only nuclear facilities that are concerned with the potential for radioactive contamination in waste concrete. Concrete waste generated in non-nuclear activities would be free of radioactive contamination and would not be given any more thought than "does the cost justify crushing or dumping".

Waste processors of nuclear facilities throughout the world face the daunting reality that the concrete waste poses a somewhat unique challenge to dispose of, in that the interior of the concrete must be exposed to confirm it to be either active or clearable and that no contamination has found its way below the clean surfaces. Concrete crushing/pulverizing of concrete that is known to be clean is not new. However, using this equipment in conjunction with a controlled environment to crush "likely-clean" concrete that is subsequently cleared has not been used previously by AECL. CRL not unlike most nuclear facilities will continue to be confronted with massive volumes of concrete generated primarily by decommissioning activities and it is CRL's chosen method of crushing and characterizing that is believed will set the stage for a brighter legacy to leave behind.

The reuse of waste concrete is recognized as an environmentally responsible alternative that doesn't add to landfill sites. It demonstrates clearly AECL's commitment to the environment, its fiscal responsibilities to the public, and work place infrastructure improvements for the employees.