Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

Concrete Harvesting and Related Research



Workshop on International Concrete Harvesting

2024 October 4

Canadian Nuclear Laboratories | Laboratoires Nucléaires Canadiens

Background

The Nuclear Scene in Canada

- Operating Power Reactors: Pt. Lepreau; Pickering A Units 1 and 4; Pickering B, Darlington; and Bruce A & B.
- Permanently Shutdown Power Reactors: Pickering A Units 2 and 3; and Gentilly 2.
- Permanently Shutdown Prototype Power Reactors: Nuclear Power Demonstration (NPD), Douglas Point, and Gentilly 1.

Note: Pickering A Units 1 and 4 are planned to be shutdown and Pickering B Units 5 to 8 are planned to undergo refurbishment.

Note: Oldest Canadian power reactor (Pickering A Unit 1) has been operating for 53 years.

[References 1 to 5]

Background

The Nuclear Scene in Canada

- Permanently Shutdown Research Reactors: National Research Experimental (NRX), National Research Universal (NRU), and Whiteshell Reactor -1.
- Operating Research Reactors: McMaster Nuclear Reactor, École Polytechnique de Montréal SLOWPOKE-2, Royal Military College of Canada SLOWPOKE-2, and Zero Energy Deuterium (ZED-2).
- Potential for new reactors in Canada:
  - New-large scale nuclear builds (e.g., at the existing Bruce Site)
  - Small modular reactors (e.g., the Darlington New Nuclear Project)
- Canadian CANDU Utilities perform joint research through the CANDU Owners Group.

[References 6 to 10]

Why Harvest Concrete?

Benefits

1. Support continued operation of existing reactors:
    - Concrete structures continue to operate over the life of the reactors (including life-extensions) and are not replaced during refurbishments like other components.
    - Concrete structures are exposed to various conditions (e.g., changing seasons, varying loads, vibrations, cyclic and elevated temperatures due to reactor operations, and radiation from reactor).
    - Questions are asked about the structures' integrity as they continue to operate.
    - Examination of harvested concrete would provide valuable information on structures' integrity.



Why Harvest Concrete?

Benefits



2. Support the decommissioning of shut-down reactors
    - Large amounts of concrete are used in nuclear facilities.
    - No permanent disposal facility exists in Canada for radioactive waste. [Near surface disposal facility (NSDF) for low-level waste has yet to be built at Chalk River.]
    - Need to know concrete volumes that meet clearable, low-level, or intermediate level waste categories and types of radionuclides present.
    - Stakeholders can plan ahead to establish processing facilities to reduce / remove the contamination and change waste classification (where possible).
    - Accurate information on volumes of radioactive waste, radionuclides present and their concentrations are required to plan for safe temporary and permanent disposal facilities.
    - Characterization of harvested concrete would allow planning for decommissioning.

Why Harvest Concrete?

Benefits

3. Provide input to new reactor builds and SMRs.

   - Lessons learned from the operation and decommissioning of nuclear facilities can lead to improvements in the structures for future builds. For example:
     - Should select types of aggregates be used for shielding concrete?
     - Should “replaceable” structures be developed that can be upgraded during refurbishments?
     - How can the activation and contamination of concrete during operation be reduced to lessen radioactive waste during decommissioning?
   - Concrete in nuclear facilities has been exposed to operational environments over a long period of time.
   - Studying harvested concrete will allow determination of improvements to be made to future structures.

Challenges to Harvesting Concrete

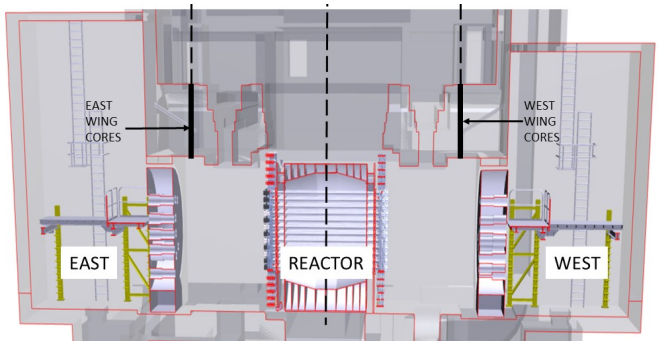
A Research and Development Perspective

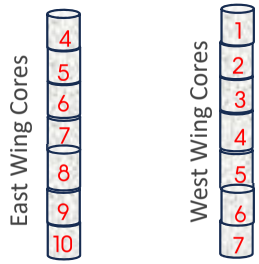
- R&D budgets are typically small and typically not sufficient to cover the costs involved with all the work that is required to harvest cores from a nuclear facility.
- Stakeholders are concerned about potential effects on structures' functions.
- Facility/station staff have their own priorities and deadlines to meet. Requests from R&D staff to harvest may be seen as intrusive and more work on the part of facility/station staff.
- Facilities staff and stakeholders are worried about issues being found that would have consequences for their facilities.
- Narrow focus on what should harvested vs. creating a vast library of harvested concrete.
- Long-term perspective required vs. short-term goals.

Past Work - Harvested Concrete

Concrete Cores from the NPD Reactor Vault

- Cores were obtained from the 9’ (2.74 m) thick concrete slab separating the reactor vault from the fueling machine room - byproduct of two holes to have access to the reactor for inspection.



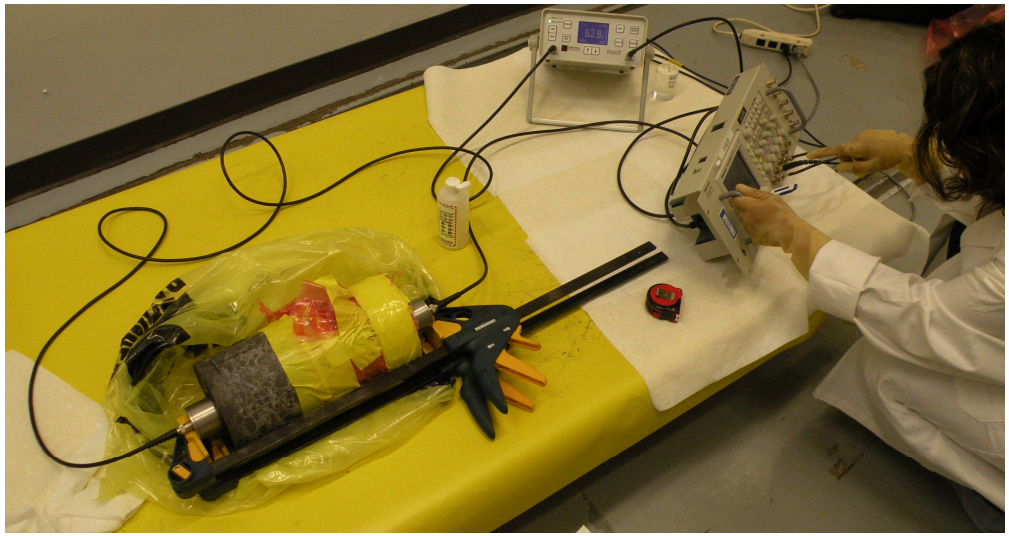


- Cores were made with heavy concrete containing ilmenite-hematite (iron-titanium) aggregates.
- Average density of the concrete based on measurement of the cores was 240 lb/ft^3 (3852 kg/m^3).

Past Work - Harvested Concrete

Concrete Cores from the NPD Reactor Vault

- Approximate fluence levels for locations where the cores were obtained.



- Limited depth of concrete was deemed to be radioactive.

Past Work - Harvested Concrete

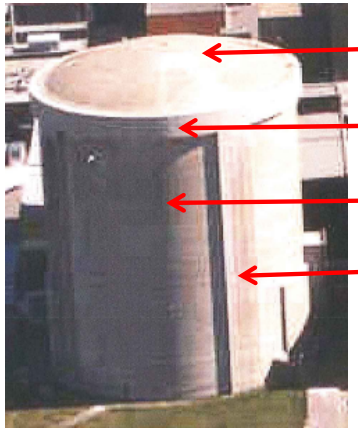
Concrete Cores from the NPD Reactor Vault

- The compressive strength of the core closest to the reactor was within range of the compressive strengths of cores further away from the reactor.
- Compressive strength, modulus of elasticity, and splitting tensile strength were greater than baseline values obtained at the design stage.

Past Work - Harvested Concrete

Gentilly-1 Concrete Containment Building Investigation

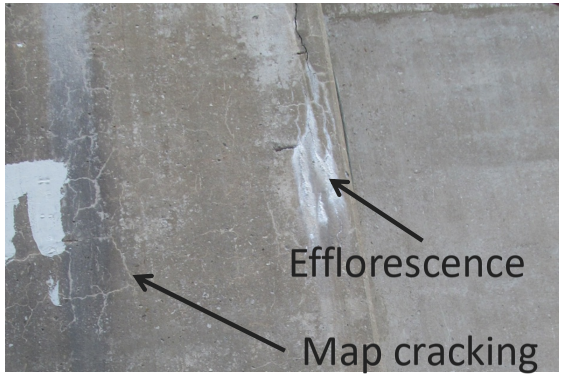
- The investigation involved:
  - Visual observations
  - Field testing
  - Laboratory testing



- Visual Observations:





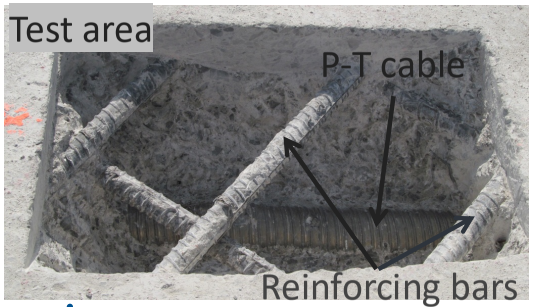


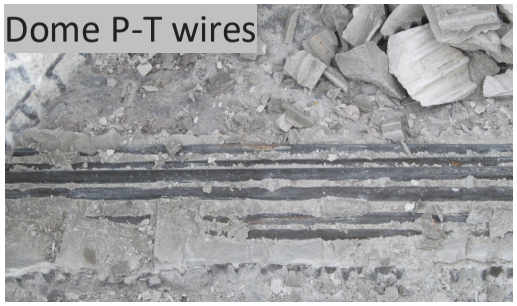
[Reference 11]

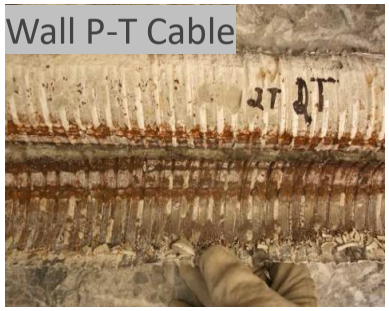
Past Work - Harvested Concrete

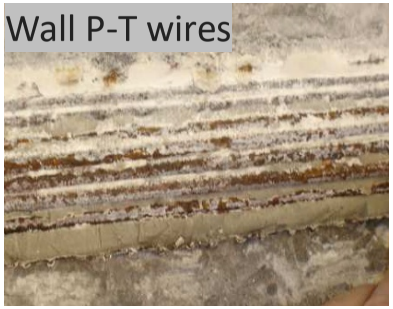
Gentilly-1 Concrete Containment Building Investigation

- Field Testing:
  - Concrete was removed in test areas to expose reinforcing bars and post-tensioned (P-T) cables.
  - Reinforcing bars in wall and dome: good condition & no signs of corrosion.
  - Corrosion was not an issue for P-T wires in the dome.
  - Corrosion in wall P-T wires - attributed to being left ungrouted during construction.
  - Reinforcing bars were in tension instead of compression - likely due to Alkali-Aggregate Reaction.







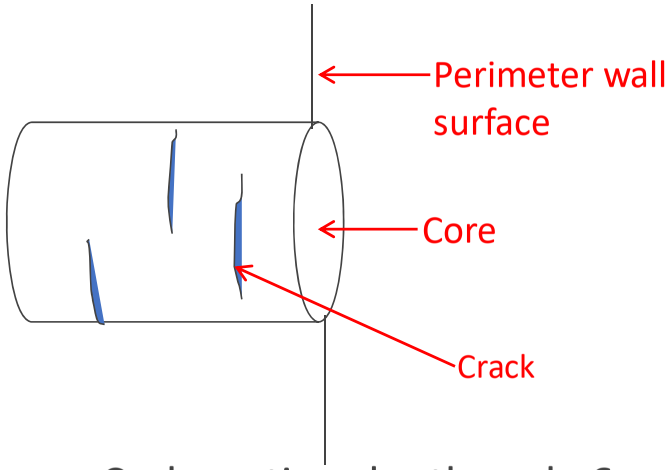


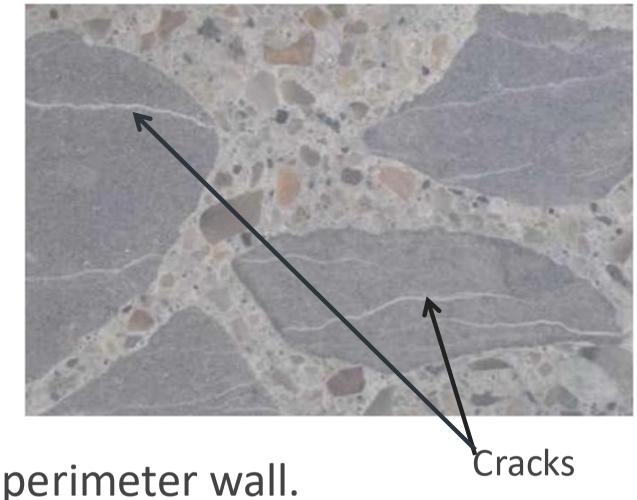
[Reference 11]

Past Work - Harvested Concrete

Gentilly-1 Concrete Containment Building Investigation

- Laboratory Testing
  - Cracks parallel to perimeter wall surface observed in the concrete cores.





  - Carbonation depth: only 6 mm for the perimeter wall.
  - Chloride contamination was not an issue.

[Reference 11]

Opportunities

Potential to Harvest in the Future

- Several reactors are or will be undergoing decommissioning in Canada.
- Opportunities for cost efficiencies through harvesting samples during decommissioning characterization campaigns.
- Need to work with the stakeholders to determine the harvesting opportunities that are available.
- Potential to obtain shield plugs from NRU.
- CNL has harvested concrete cores from a dry-fuel storage canister (held fuel for 23 years and was outside for 44 years).





[Reference 11]

References

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Acknowledgements

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- FST-51100.60.18.06 Non-Destructive Monitoring to Estimate Remaining Life of Concrete Structures
- COG 40517 Condition Assessment of Post-Tensioning Cables (Reference 11)

Questions?

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