

Nondestructive Monitoring to Estimate Remaining Life of Nuclear Structures

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OBJECTIVE/PURPOSE: Advancement of methods for determination of remaining life of in-service containment concrete, through non-destructive testing investigation and destructive tests.

FEDERAL STAKEHOLDERS: Canadian Nuclear Safety Commission (CNSC)

Ex-Service Core Samples – Harvest and Test

This task investigates the logistics of obtaining irradiated concrete core specimens from decommissioned nuclear facilities, and testing to validate prevailing hypotheses.

Work Performed:

- Assessed the logistics of core extraction from a typical decommissioned CANDU 6 plant (Gentilly 2).
- Accepted invitation to participate in Gentilly 2 core extraction project.
- Identify and obtain irradiated concrete core specimens.
- Establish destructive testing capability for radioactive concrete specimens.

Expected Outcome:

- Address knowledge-gap(s) in radiation effects on containment concrete, for life extension.
- Establish the capability to accept radioactive concrete specimens for destructive testing of physical characteristics.

Continuous Wave Testing of Concrete

Mainstream ultrasonic testing (UT) uses pulsed energy excitation, to enhance spatial resolution. This application investigates the use of continuous wave (CW) ultrasonic excitation, to gain the benefit of its enhanced sensitivity.

Work Performed:

- Selected test equipment and sample.
- Completed literature review of UT for concrete physical characteristic determination.
- Assembly and testing of instrumentation.
- Perform initial tests with samples under tension.
- Conference paper presentation at ASNT Intl. Symposium.

Expected Outcome:

- CW ultrasonic method for material characterization of concrete in structural applications. • Secure patent (application submitted).

Regression to Start-of-Life – Recover Baseline Information

Non-destructive examination (NDE) of concrete structures depends on finding differences in results as time passes. Comparison of results to baseline measurements allows ageing to be assessed. Baseline results are not always available. This investigation seeks to determine whether baseline conditions can be estimated from later trends in the specific case of ultrasonic pulse velocity and rebound hammer testing.

Work Performed:

- Experimental plan formulated.
- Samples fabricated/re-activated, and stored.
- Baseline NDE tests.
- Second interval NDE tests.

Expected Outcome:

- Demonstration of baseline information recovery from examination of temporal trends in NDE measurements.

Optical Methods– Concrete Examination

Non-contact and contact optical methods of examining concrete for ageing degradation (e.g., cracking, deformation) are investigated. Techniques such as Digital Image Correlation (DIC) and Photonic Sheets* are tested.

Work Performed:

- Determine optical non-destructive examination (NDE) and ageing parameter(s) correlation.
- Selection of testing methods.
- Testing:
 - Contact methods.
 - Non-Contact methods.

Expected Outcome:

- Establish the applicability of optical methods for evaluation of concrete aging in operational structures.

Reinforcement Corrosion– Detection and Monitoring

Ultrasonic transducers are mechanically bonded to steel corrosion coupons made from reinforcement bar steel. The coupons are embedded in the cast concrete. Ultrasonic (UT) thickness gauging of the steel detects the onset of material loss due to corrosion.

Work Performed:

- Reinforcement bar coupons were fitted with UT probes. • Concrete samples were cast, with coupons embedded.
- Beams were cracked to enhance salt-bath corrosion
- Corrosion specimens are monitored on a monthly basis.

Expected Outcome:

- Establish an early corrosion detection method with the precision of ultrasonic thickness gauging (typ. 0.05 mm).

Correlate NDE and Destructive Testing

Non-destructive examination (NDE) of structural concrete does not directly measure the parameters of interest, e.g., compressive strength, elastic modulus, flexural strength, which are determined from destructive tests. This investigation compares the time evolution of NDE results with destructive test results, performed on a structural simulation and simultaneously-cast test cylinders.

Work Performed:

- Experimental plan formulated.
- Samples fabricated and stored.
- Baseline: NDE tests, core extraction, destructive tests.
- Second interval testing (repeat above).

Expected Outcome:

- Establish an improved understanding of the relationship between field-applied NDE test results and physical characteristics of structural concrete.

ACHIEVEMENTS AND SUCCESSES:

- New methods of performing non-destructive examination on structural concrete are being established (optical, CWUT).
- The gap between non-destructive examination and strength measurement of concrete is being bridged.
- The understanding of radiation effects on concrete is being validated and strengthened.

FUTURE WORK:

- Investigation of nuclear radiation effects on concrete.
- Application of novel techniques to in-situ concrete nondestructive examination for engineering assessment.
- Develop a comprehensive engineering approach to using completely non-destructive testing techniques for structural condition management.

COLLABORATIONS:

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