Canadian Nuclear Safety Commission / Commission canadienne de sûreté nucléaire

OECD/NEA/CSNI CAPS ASCET
Assessment of Structures Subject to Concrete Pathologies

ASCET - Phase I
SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

Neb Orbovic, P. Eng., PMP, Technical Specialist
Canadian Nuclear Safety Commission

US NRC 28th RIC, North Bethesda, MD, USA   March 8 – 10, 2016

nuclearsafety.gc.ca

E-doc #4910640

ASCET- Acronyms

- AAR – Alkali-Aggregate Reaction
- ASCET – Assessment of Structures Subject to Concrete Pathologies
- ASR – Alkali–Silica Reaction
- CAPS – CSNI Activity Proposal Sheet
  - A research program on a specific topic defined and developed in the CSNI
- CSNI – The Committee on the Safety of Nuclear Installations
- EPRI – Electronic Power Research Institute
- DEF – Delayed Ettringite Formation
- IAEA – International Atomic Energy Agency
- IFSTTAR – The French Institute of Science and Technology for Transport, Development, and Networks
- NEA – Nuclear Energy Agency
- NDT – Non-Destructive Testing
- OECD – Organisation for Economic Co-operation and Development
- WG IAGE – Working Group on Integrity and Aging of Structures and Components

ASCET Objective

- Public acceptance of existing nuclear facilities depends on demonstrating adequate structural performance of these facilities during their entire lifetime.
- The goal of the ASCET program, initiated by the WG IAGE of the OECD/NEA/CSNI, is to assess and validate evaluation techniques for nuclear structures with degraded concrete.
- The objective of the CAPS is to lay the foundation of internationally accepted general recommendations for aging management of concrete nuclear facilities subjected to different concrete pathologies/degradation mechanisms.

ASCET Organization

- ASCET Organizing Committee:
  - Neb Orbovic, CNSC, Canada
  - Jake Philip, NRC, USA
  - Andrei Blahoianu, CNSC, Canada
  - Olli Nevander, OECD/NEA
- ASCET Scientific Committee:
  - Prof. Alain Sellier, University of Toulouse, France
  - Prof. Erik Schlangen, Delft University of Technology, Netherlands
  - Prof. Patrice Rivard, University of Sherbrooke, Canada
  - Prof. François Toutlemonde, IFSTTAR, France

ASCET Phase I Time Frame

- The kick-off meeting of ASCET Phase I was held on June 30, 2014 at the EPRI office in Washington, DC
- The final workshop was held at the National Institute of Standards and Technology (NIST), Gaithersburg, Maryland, from June 29 to July 1, 2015.
- Twenty-two high quality presentations were made during the ASCET workshop. They were followed by very productive discussions.
- The final NEA ASCET report will be published during the first semester of 2016.

ASCET Phase I Participants

- **CNSC/UofT, Canada**
- **NRC/NIST, USA**
- **Institut de Radioprotection et de Sûreté Nucléaire (IRSN), France**
- **EDF, France**
- **Radiation and Nuclear Safety Authority (STUK)/VTT, Finland**
- **US Fed. Highw. Admin. USA**
- **Northwestern University, USA**
- **CNS Lavalin/Candu Energy, Canada**
- **SIMCO, Canada**
- **EPRI, USA**
- **Oak Ridge NL, USA**
- **Nuclear Regulatory Authority, Japan**
- **Swedish Radiation Safety Authority (SSM)/Scanscot, Sweden**
- **Hydro-Québec, Canada**
- **US Army Corps of Engineers, USA**
- **Karlsruhe Institute of Technology, Germany**
- **University of Toulouse, Prof. Alain Sellier, France**
- **Delft University , Prof. Erik Schlangen, The Netherlands**
- **University of Sherbrooke, Prof. Patrice Rivard, Canada**
- **IFSTTAR, Dr. François Toutlemonde, France**

ASCET Phase I
Main Work Directions

- Regardless of the type of degradation mechanism, the ASCET work was articulated in the following directions:

1. material testing
2. material modeling
3. structural component testing / destructive testing
4. structural component modeling
5. in-situ structural condition assessment / non-destructive testing
6. structural acceptance criteria for structures with concrete pathologies/degradation mechanisms
7. structural repair

ASCET Phase I
Conclusions and Recommendations #1

- International data base
  - There is a need to create an open international database to bring together information on concrete degradation mechanisms from the worldwide nuclear community.
  - Decommissioned nuclear facilities present an excellent opportunity to use destructive and non-destructive tests in parallel to validate non-destructive examination techniques as well as numerical models.
  - Collaboration with the IAEA and the use of its database would be beneficial for both the IAEA and OECD/NEA Member States.

ASCET Phase I
Conclusions and Recommendations #2

- Combined approach: Material and structural testing
  - Material testing based on cubic or cylindrical samples is not sufficient and can be misleading regarding the overall structural level.
  - Concrete restraint due to the presence of reinforcement and pre-stressing, as well as boundary conditions in the case of concrete expansion, significantly modifies the behaviour in terms of ultimate capacity and displacements.

ASCET Phase I
Conclusions and Recommendations #3

- Data from structural tests: Full-scale structures and reduced scale component tests
  - A discussion during the workshop was related to the relevance of the use of reduced-scale specimens cured in chambers under uniform environmental conditions for the assessment of real structures.
  - The real structures are not in such conditions: the degradation mechanism as well as the temperature and humidity are not uniformly distributed.
  - However, research tests should focus on one parameter at a time; even in simplified conditions it is difficult to find answers to the questions.
  - Moreover, with full-scale structures it is difficult and in most cases impossible to assess their ultimate capacity.

ASCET Phase I
Conclusions and Recommendations #4

- Assessment of the impact of one degradation mechanism on other degradation mechanisms and their coupling
  - The effect of one degradation mechanism on other degradation mechanisms (synergy) was often discussed throughout the workshop.
  - The structural condition is rarely the consequence of a single degradation mechanism, unlike in a laboratory environment.
  - Real structures are exposed to simultaneous action of several degradation mechanisms, and it is not easy to assess their contributions in an overall structural condition.

ASCET Phase I
Conclusions and Recommendations #5

- Development of performance-based criteria
  - Concrete degradation mechanisms are challenging from the point of view of ultimate and serviceability limit states. Sometimes structural integrity is not an issue, but the structure itself can have serious serviceability problems.
  - Current codes and standards do not include degradation mechanisms.
  - Some Member States have developed specific acceptance criteria for structures with concrete swelling (AAR and DEF).
  - There is a need for case studies and feedback on affected structures management so that the acceptance criteria for ultimate and serviceability limit states can be discussed.

ASCET Phase I Conclusions and Recommendations #6

- Aging management and long-term operation programs
  - Électricité de France (EDF) has developed extensive aging management and life-extension programs. This is a risk informed approach which would be useful for regulators. This approach can be standardized for applications worldwide.
  - There is a need to develop a standard risk assessment for durability to answer the question: **"Where do I need to worry and where should the aging management of the structure focus?"** similar to the IFSTTAR five-step methodology: 1) prioritization, 2) initial assessment, 3) monitoring, 4) search for the causes of disorders, 5) forecast and evolution.

ASCET Phase I Conclusions and Recommendations #7

- Development and validation of non-destructive tests (NDTs)
  - Due to difficulties in performing core drilling and other destructive methods in nuclear facilities, non-destructive tests should be developed to identify the damaged zones, the damage magnitude and the impact on the overall structural behaviour.
  - NDTs should address these difficulties. It is necessary to develop a set of NDTs to perform cross-examination of both local areas and global structural response.
  - They should be coupled with reference methods, such as deformation monitoring and crack survey, and calibrated using destructive tests.

ASCET Phase I Conclusions and Recommendations #8

- Simulation tools
  - Simulation is the only tool for predicting behaviour. There is a need for model validation and quantification of uncertainties in input data and the results.
  - An international benchmark on simulations is needed in order to validate models; industrial numerical models that simplify phenomena develop in meso-scale models.
  - ASCET Phase II is proposed for developing and benchmarking the simulation tools. It should benefit from parallel initiatives of the non-nuclear civil engineering community.

ASCET Phase II

- ASCET Phase II will be a blind numerical simulation benchmark of a representative AAR-affected structure:
  - In a first step, a shear wall with advanced AAR will be simulated, under cyclic loading up to the wall failure.
  - In parallel, a shear wall will be simulated with the same geometry and reinforcement under the same loading but built with sound aggregate, to compare the ultimate capacity, displacements and failure modes.
  - The walls are manufactured, cured, and will be tested at the University of Toronto, under CNSC research program.
  - The final workshop of ASCET Phase II could be organized in May 2017, tentatively in Ottawa, Ontario, Canada.

Canadian Nuclear Safety Commission

US NRC RIC 2016

Canadian Nuclear Safety Commission Commission canadienne de sûreté nucléaire

Thank you

nuclearsafety.gc.ca