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Light Water Reactor Sustainability Program
Materials Research Pathway Overview

Light Water Reactor Sustainability (LWRS) Program Spring Meeting
April 29-30, 2025

Materials Research Objective

Provide **data and methods** to assess performance, damage, and mitigation options for **systems, structures, and components** that are essential to safe and sustainable operation of nuclear power plants

Approaches

1. Mechanisms of degradation
2. Modeling and simulation
3. Materials harvesting
4. Monitoring of degradation
5. Mitigation strategies

Outcomes

- Reduce uncertainty, outage risk and operation costs
- Improve operation efficiency and reliability
- Inform decisions related to inspection, maintenance and relicensing
- Provide scientific basis for materials aging management

Metals and mitigation

M. Sokolov (ORNL)
RPV

Z. Zhai (PNNL)
Ni-alloy SCC

B. Alexandreanu (ANL)
Ni-alloy SCC & EAF

S. Raiman (UM)
Mitigation of IASCC

M. Gussev (ORNL)
IASCC

Y. Chen (ANL)
Ni-alloy SCC & EAF

T. Lach (ORNL)
Baffle bolt PIE

J. Chen (ORNL)
Weld repair

X. Chen (ORNL)
Harvesting

Concrete degradation

Y. Le Pape (ORNL)
CP-PRA of CBS
Operation beyond 80

E. Tajuelo (ORNL)
Irradiated concrete
Harvesting

H. Sun (ORNL)
Concrete NDE

Cable degradation

L. Fifield (PNNL)
Cable aging and gap analysis

B. Glass (PNNL)
Cable NDE
CP-Cable online monitoring

Emerging areas

X. Chen (ORNL)
Operation beyond 80

Global Collaboration and Partnership

The Japan Concrete Aging Management Program (JCAMP) and more

Joint R&D, technical info. exchange, coordinate research activities, technical support, obtain feedback

EPRI & NRC

Utilities, Trade Org. & Vendors

Technical support, obtain feedback, harvesting

LWRS Materials Research

Collaborative research, explorative study, workforce development

Academia

International Partners

Technical info. exchange, benchmarking, harvesting, obtain feedback, collaborative research

Additional engagement is welcome

Materials Research Areas
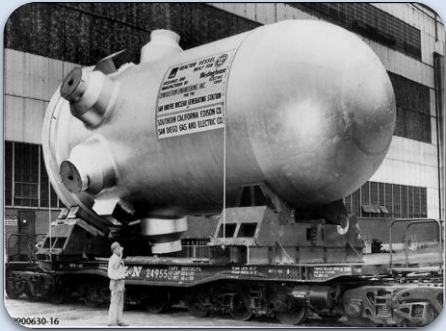
Reactor Pressure Vessel
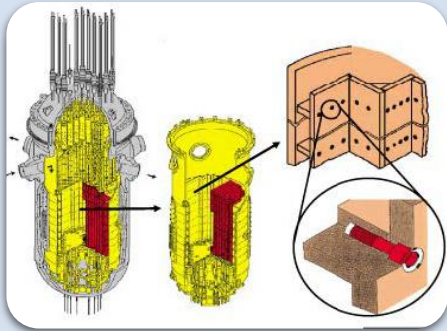
Core Internals & Pressure Boundaries
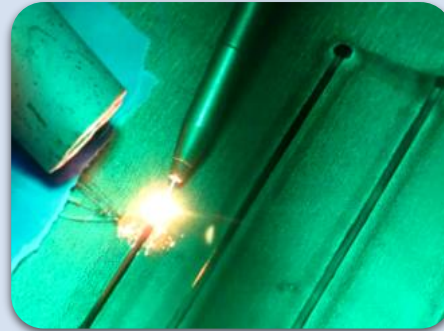
Mitigation Technologies
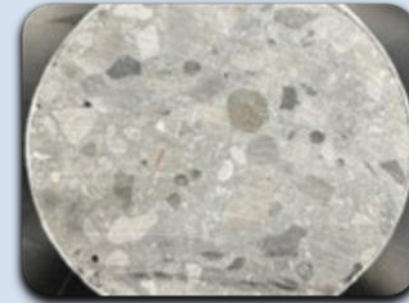
Concrete Degradation

Cable Degradation

Mechanism of irradiation-assisted stress corrosion cracking

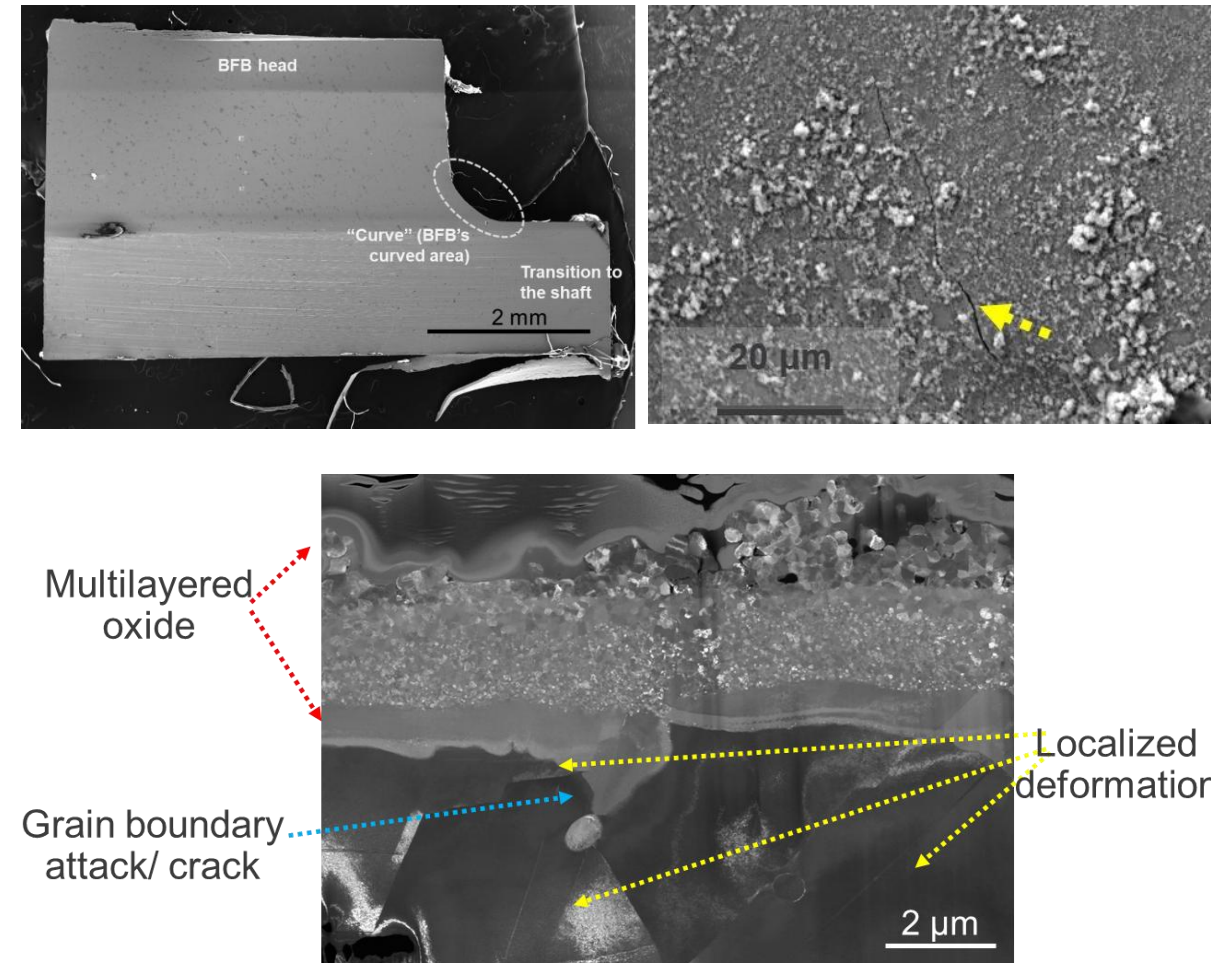## High fluence effect on RPV
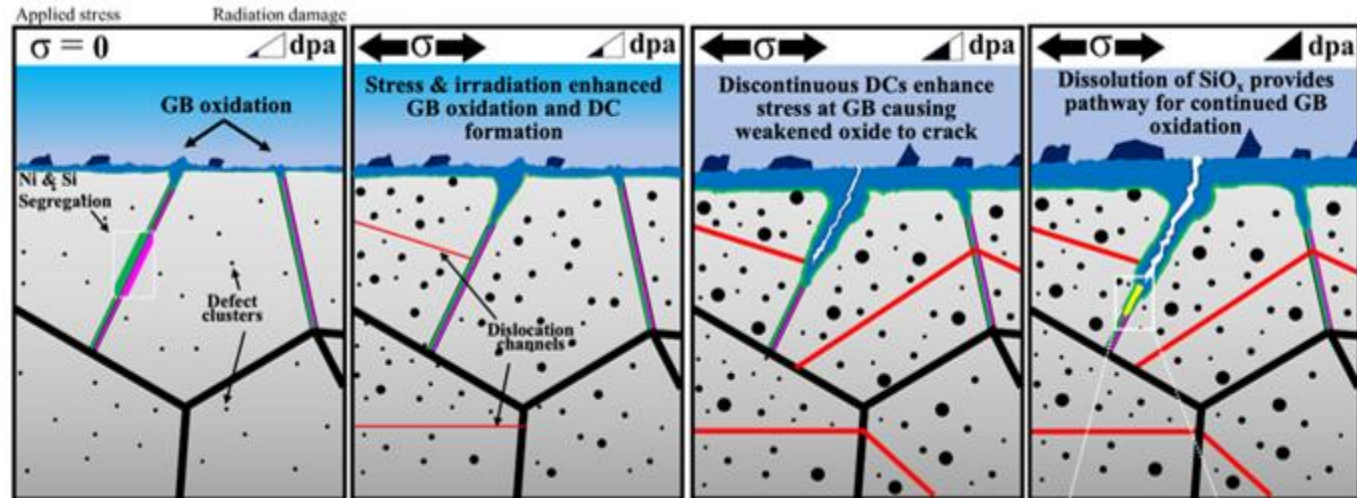
Long-term thermal aging of alloy 690 and its weldment
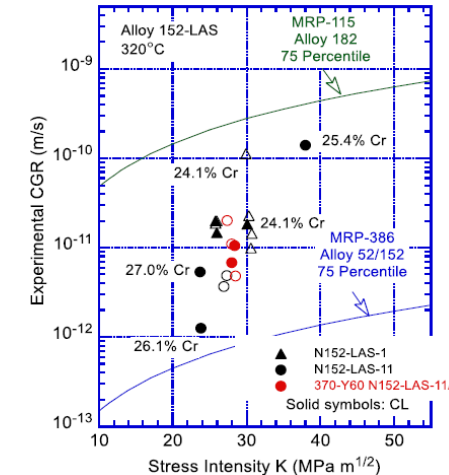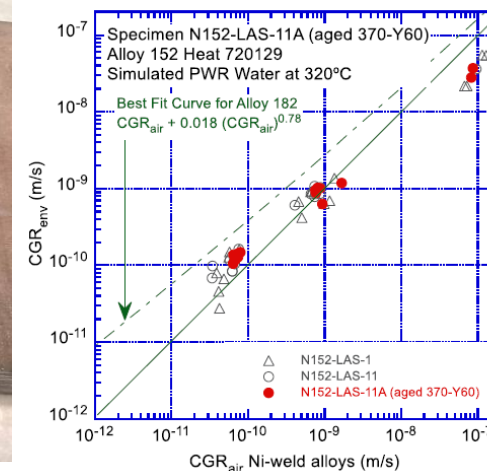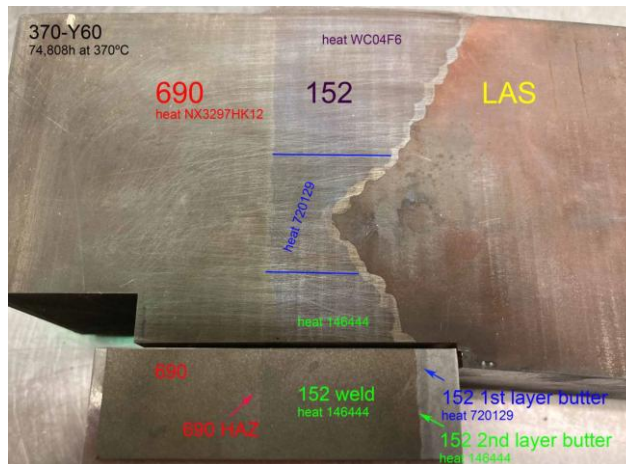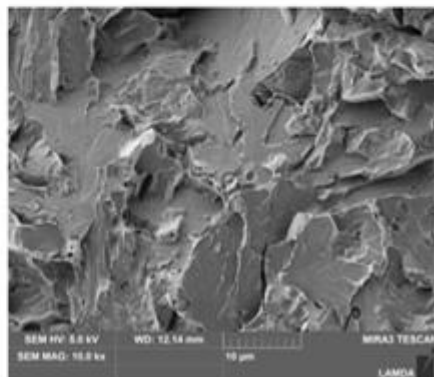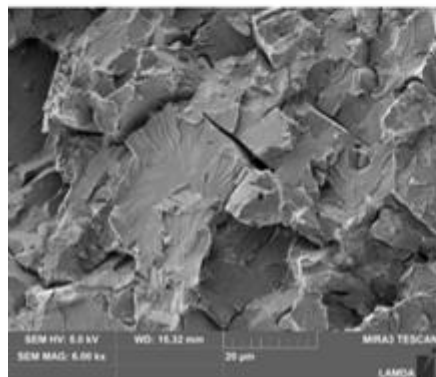
Stress corrosion cracking of metal alloys
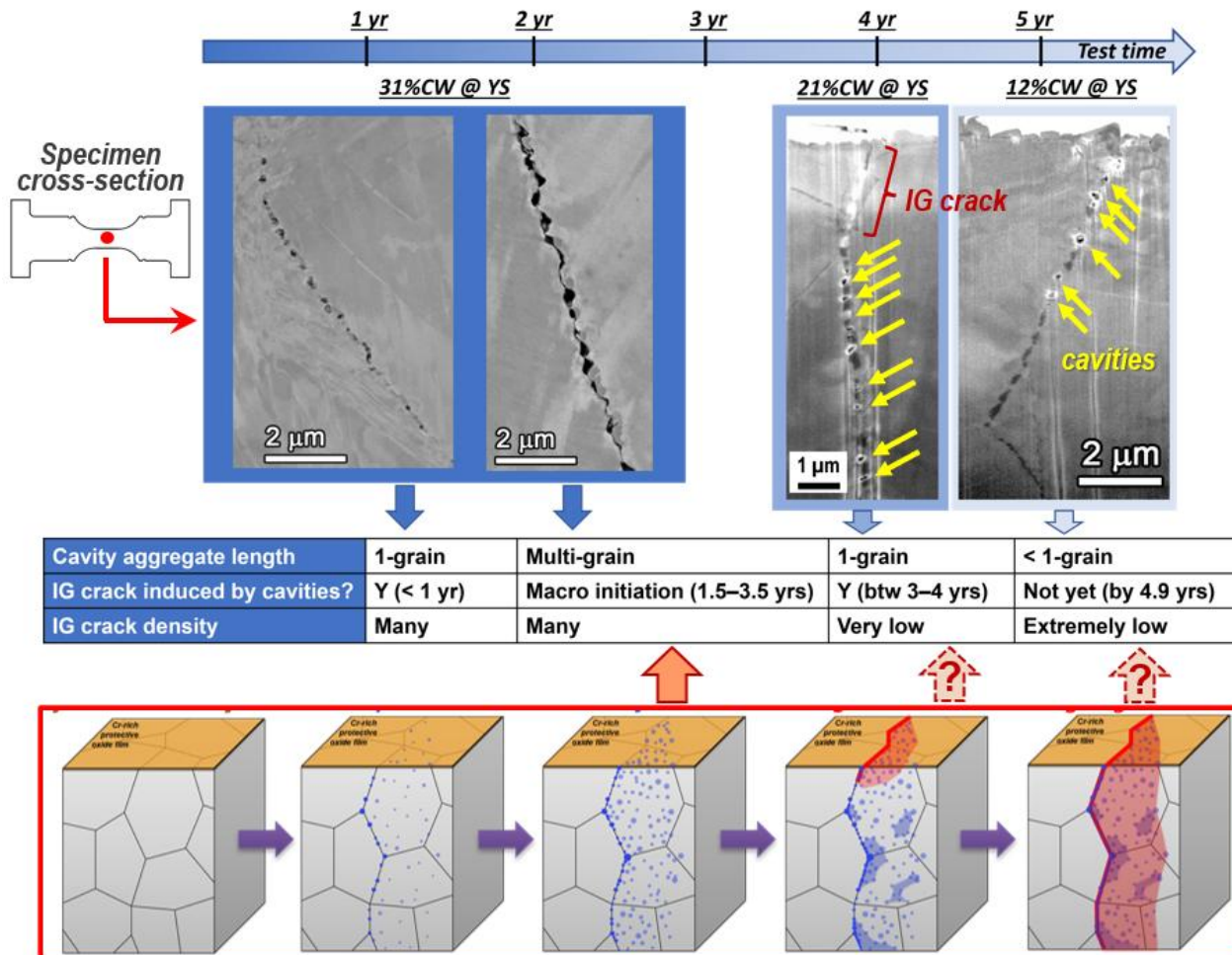
Characterization of harvested baffle former bolts
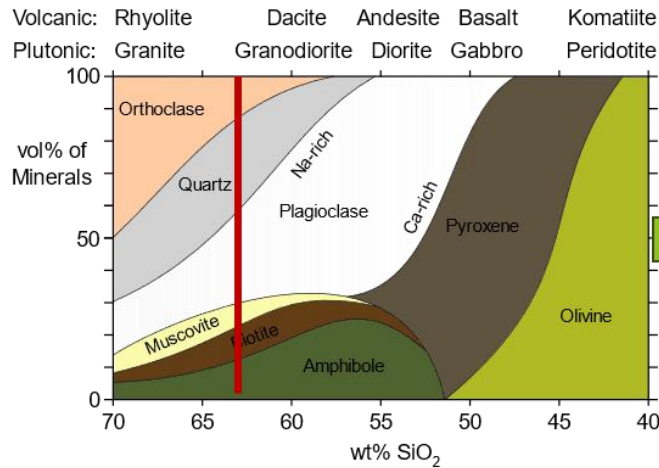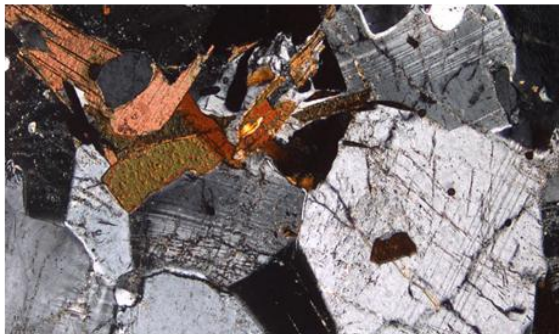
Materials harvesting

Advanced weld repairing
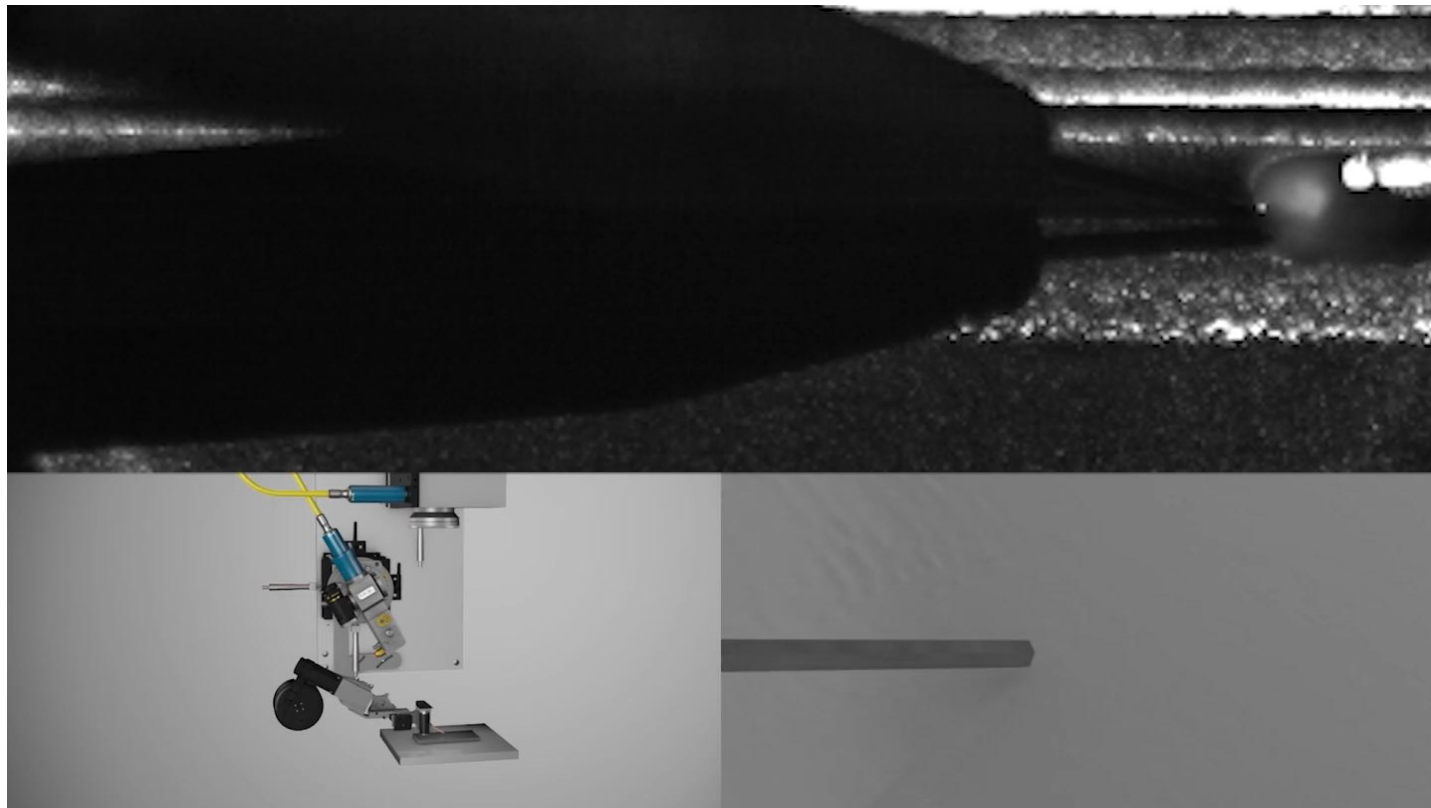
ABSI laser welding technique
(courtesy of EPRI)

Modeling and simulation of irradiated concrete
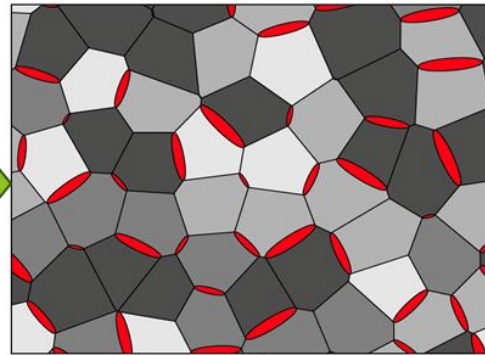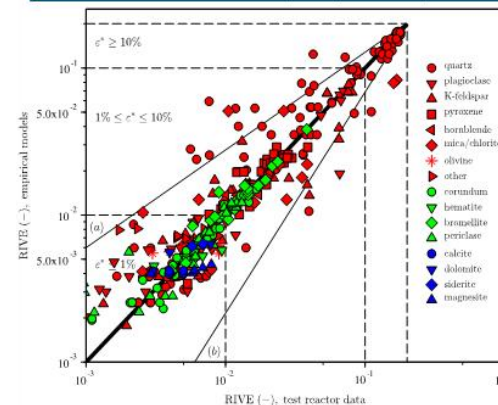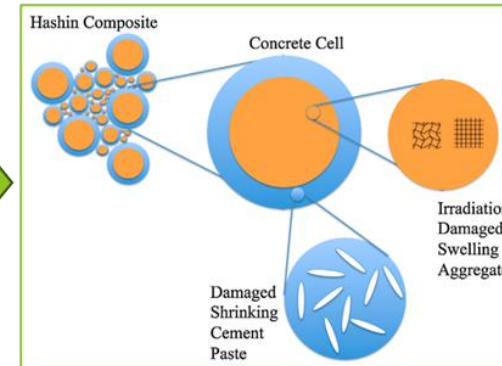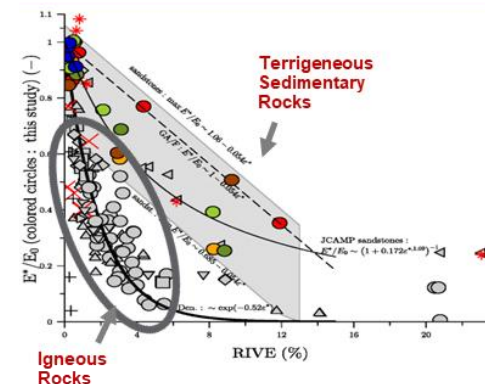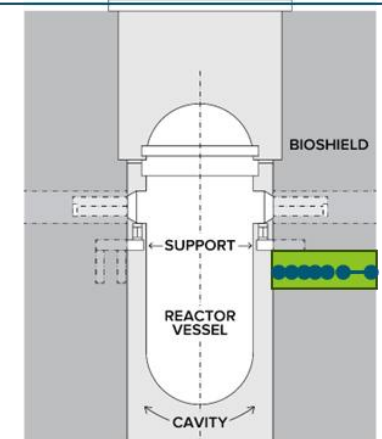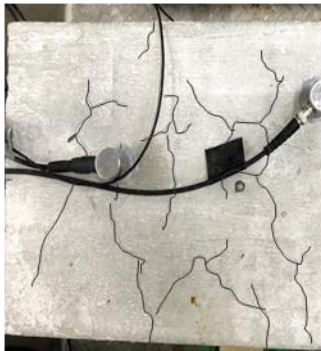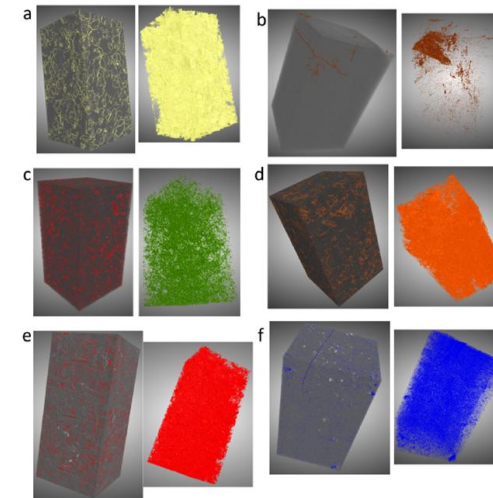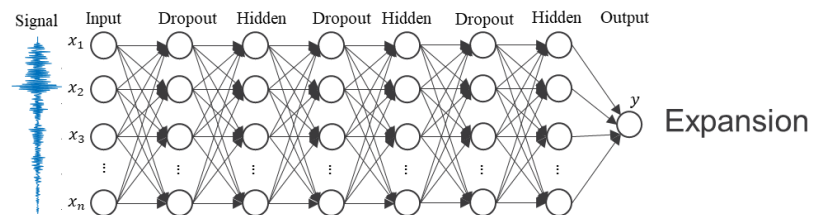
Concrete NDE

Irradiated concrete
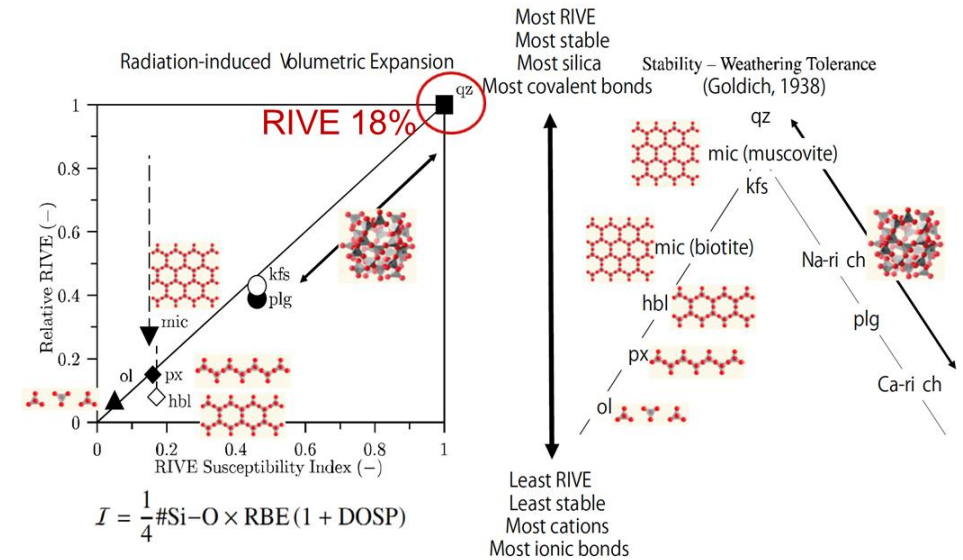
Shallow ML models
e.g. Support Vector Regression (SVR)
**(support vector machine for regression)**

$$\text{Min. } \frac{1}{2}||w||^2 a_0$$

$$\text{Constrain: } |y_i - x_i| < \varepsilon$$

Deep Neural Network (DNN)

Signal   Input   Dropout   Hidden   Dropout   Hidden   Dropout   Hidden   Output

x_1
x_2
x_3
x_n

y Expansion

Input: Extracted and selected features

Input: Time-domain signal and frequency spectrum

$$I = \frac{1}{4}\#\text{Si}-\text{O} \times \text{RBE}(1 + \text{DOSP})$$

Dragonfly processed irradiated 3D rendering: a) GB/E06, b) GF/K06, c) GE/J06, d) GD/H06, e) GC/G06, f) GA/F06.
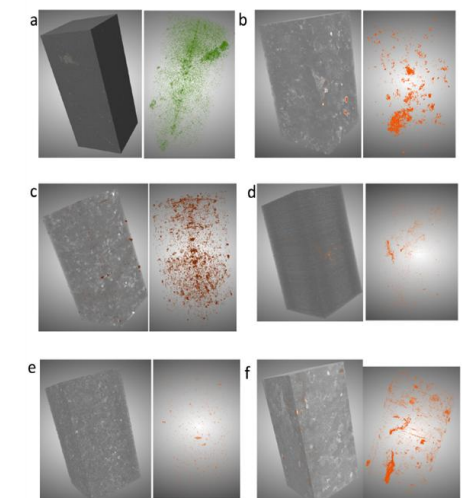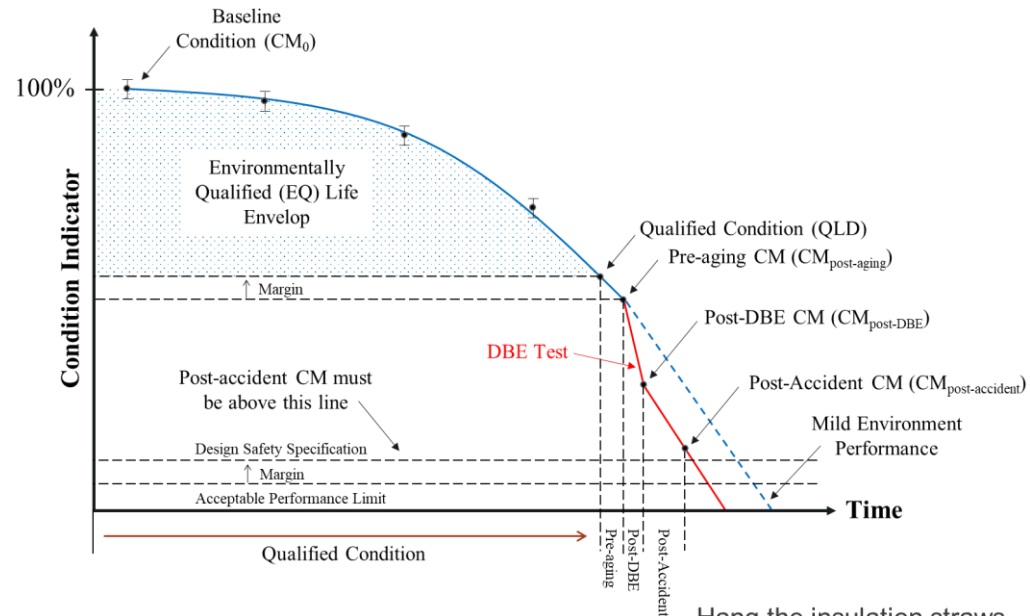
Dragonfly processed pristine 3D rendering: a) GA/F45, b) GD/H45, c) GB/E45, d) GF/K45, e) GE/J45, f) GC/G45.

Cable aging research

Cable NDE and online monitoring
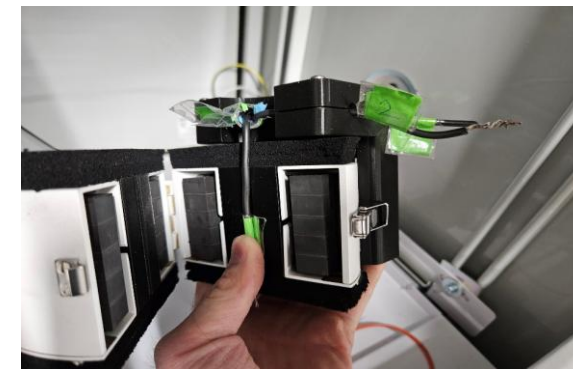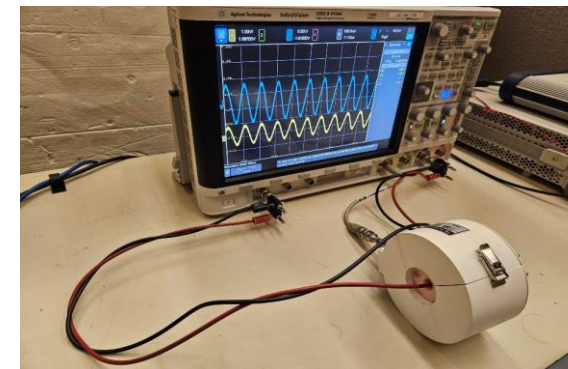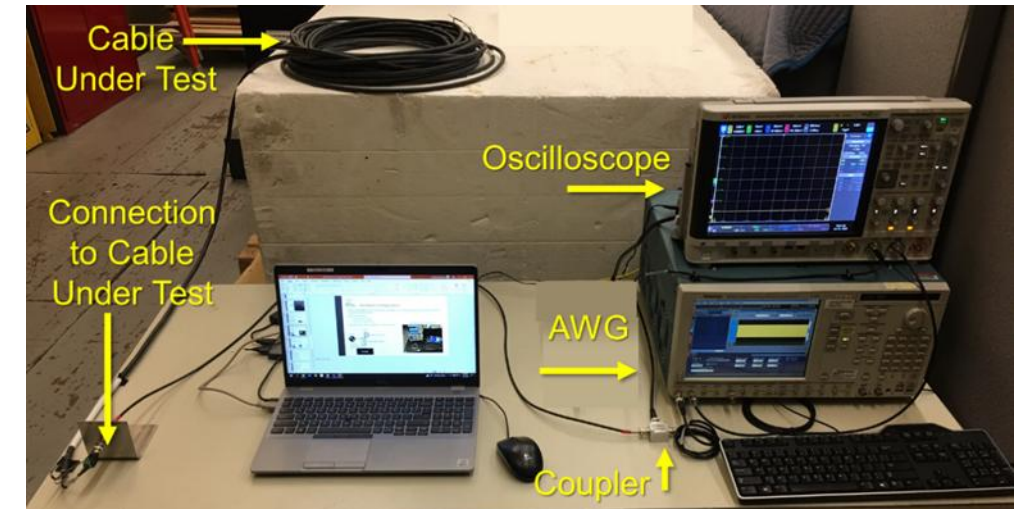
Sustaining National Nuclear Assets

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**Thank you for your attention
Questions?**