Effects of Concrete Age-Related Degradation Mechanisms on the Response of SSCs in Nuclear Facilities

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A critical component of maintaining and improving the regulatory framework governing nuclear safety in the US is adequately managing the age and condition of nuclear facilities and their supporting infrastructure. Many of the existing nuclear facilities built and commissioned decades ago are made of reinforced concrete, which is known to be susceptible to age-related degradation under certain conditions. Yet, these facilities are expected to remain operational for additional decades, often exceeding their original design life while exposed to changing external natural hazards. As an example of the magnitude of this challenge, 41% of NNSA Infrastructure exceeds sixty years, and 57% is categorized as being in poor condition.

This presentation describes an engineering methodology to manage concrete-related degradation in aging facilities to improve screening efforts that reduce the number of facilities to be evaluated, understand risk better, conduct safety improvements, and extend their service life. The development and implementation of this methodology can assist the DOE in providing a more comprehensive response to DNFSB Recommendation 2020-1, Nuclear Safety Requirements, sub-recommendation on Aging Infrastructure “to develop and implement an integrated approach, including requirements, for the management of aging infrastructure…”

Some of the most important age-related degradation mechanisms affecting concrete facilities are physical or chemical. Physical mechanisms relate to frost, fire, freeze-thaw attack, etc. Chemical mechanisms include delayed ettringite attack, leaching, and alkali-silica reaction (ASR). Concrete degradation could result in rebar corrosion. The proposed engineering methodology has been successfully implemented in the ongoing management of ASR in a US nuclear power plant. The ACRS issued a letter to the NRC regarding this facility, stating that the ACRS agrees with the staff’s conclusions that programs related to ASR are acceptable. This methodology can also benchmark against some of the DOE’s aging infrastructure management practices.

This presentation provides an example of proof-of-concept implementation for developing a methodology to evaluate the effect of various concrete age-related degradation mechanisms on the response of SSCs in DOE nuclear facilities. This methodology is rooted in the abovementioned NRC-approved engineering methodology for Seismic Category I structures in a nuclear power plant.