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Report on Evaluation and Repair of Existing Nuclear Safety-Related Concrete Structures

Reported by ACI Committee 349

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This report provides recommendations for the evaluation of existing nuclear safety-related concrete structures. The purpose of this report is to provide the owner, owner's engineering staff, consultants, and others with an appropriate procedure and background for examining concrete structural performance and taking appropriate actions based on observed conditions. Methods of examination, including visual inspection and testing techniques and their recommended applications, are cited. Guidance related to acceptance criteria for various forms of degradation and methods for repair are provided.

Keywords: corrosion; cracking; degradation; inspection; load test; nondestructive testing; nuclear plant; rehabilitation; reinforcement; repair; safety; serviceability; structural design; structural evaluation.

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ACI 349.3R-18 supersedes ACI 349.3R-02 and was adopted and published February 2018.

CHAPTER 1—INTRODUCTION AND SCOPE

1.1—Introduction

Recent structural challenges encountered from events such as the observed alkali-aggregate reactions (AARs)/cracking at Seabrook (U.S. Nuclear Regulatory Commission (U.S. NRC) 2011), cracking and chemical attack at Zion (Gregor and Hookham 1993), and the publicized reports of concrete degradation in domestic plants (Gregor and Hookham 1993; Electric Power Research Institute (EPRI) 1990; Ashar and Bagchi 1995) have highlighted the need for guidance on acceptable structural evaluation and repair methods from a code and regulatory viewpoint. These recommendations can be used to evaluate the condition of concrete structures at any point during their service life and following any imposed damage, aging, or loading event. For post-earthquake evaluations, supplemental guidelines and evaluation criteria, such as those discussed in EPRI TR 3002005284 (EPRI 2015a) and International Atomic Energy Agency (IAEA) Safety Reports Series No. 66 (IAEA 2011), should also be considered.

The evaluation process and techniques used in this report have been revised and updated to cover possible scenarios that could be encountered in nuclear safety-related concrete structures, with insights from the state-of-the-practice in the construction industry included as well. This report provides the user with relevant and more up-to-date information on evaluation and repair of nuclear structures with a focus on those that have been deemed nuclear safety-related. Note that this report provides recommendations for performing an evaluation. The responsible engineer and evaluation team should use engineering judgment in applying these recommendations. Visual inspection is the recommended primary evaluation tool for identification of degradation. A more exhaustive evaluation, using nondestructive examination (NDE) and invasive tests, could be warranted by observations subject to the responsible engineer's evaluation perspective.

1.2—Scope

Chapters 1 and 3 provide the introductory material and general methodology used, respectively. Chapters 4 through 7 and Chapter 9 include new information, expanded coverage, and relevant references for continued research. Chapter 8 provides guidance on the need for repair; use of proven methods, including those recently implemented in specific nuclear plants; and relevant industry references (ACI/ICRI 2013). To ensure that evaluations and any follow-up repairs are properly implemented, it is recommended that the responsible engineer remains in charge throughout the completion of all the tasks up to documentation, including evaluation reports and repair programs as defined herein.

This report supplements the ACI 349 code by presenting a framework for conducting an evaluation and developing any associated repair procedures for nuclear safety-related concrete structures. Before initiating this report, the scope of ACI 349 was self-limited to the design and inspection of newly constructed concrete nuclear structures. As the nuclear power plants in the United States grow older and become susceptible to the adverse effects of aging, their periodic inspection, proper evaluation, and repair have become more important issues. Recent U.S. NRC regulations 10 CFR50.65 and 10 CFR54 (U.S. NRC 2015a,b) require licensees to inspect and evaluate the condition of concrete nuclear structures that may have experienced age-related degradation. Also, following the accident at the Fukushima Daiichi nuclear power plant resulting from the March 11, 2011, Great Tohoku Earthquake and subsequent tsunami in Japan, the NRC established the Near Term Task Force (NTTF) to conduct a review of the NRC processes and regulations, and provide recommendations to the NRC regulatory process to enhance reactor safety. Subsequent to the NTTF findings, the NRC issued a letter under 10 CFR50.54 (U.S. NRC 2015a) on March 12, 2012, requiring owners of every U.S. nuclear power plant to perform seismic (Sezen et al. 2011) walkdowns to identify and address degraded, nonconforming, or unanalyzed conditions, and to verify the current plant configuration with respect to the current design basis and state of knowledge gained since such was prepared on seismic and flood hazards. The evaluation scope herein was tailored to support structural evaluations required by periodic regulatory requests and in support of hazard analyses. Documents including EPRI TR 3002005284 (EPRI 2015a) and NUREG/CR-5042 Supplement 2 (U.S. NRC 1989) should also be considered.

Effective maintenance, modification, and repair of any concrete structure begins with a comprehensive program of inspection and evaluation. This evaluation can include a visual review of previously accomplished repairs or maintenance, and performing condition surveys, testing, mainte-