7

Orf, Tracy

From: Giantelli, Joseph
Sent: Thursday, October 08, 2009 3:14 PM
To: Bernardo, Robert
Subject: CONCRETE STRUCTURES AND OPERATING EXPERIENCE

Check this out!

The Management of Aging in Nuclear Power Plant Concrete Structures

http://www.tms.org/pubs/journals/JOM/0907/naus-0907.html

CONCRETE STRUCTURES AND OPERATING EXPERIENCE

Concrete Structures

All commercial nuclear power plants in the United States contain concrete structures whose performance and function are necessary for protection of the safety of plant operating personnel and the general public, as well as the environment. The basic laws that regulate the design (and construction) of nuclear power plants are contained in Title 10 of the CFR, which is clarified by documents such as Regulatory Guides, U.S. Nuclear Regulatory Commission NUREG reports, and Standard Review Plans.

A myriad of concrete-based structures are contained as part of a lightwater reactor (LWR) plant to provide foundation, support, shielding, and containment functions. Typical safety-related concrete structures contained in LWR plants may be grouped into four general categories: primary containments, containment internal structures, secondary containments/reactor buildings, and other structures. Only information related to primary containment structures for pressurized-water (PWR) and boiling-water reactor (BWR) plants is summarized here. (Information on other concrete structures is provided elsewhere.[1])

Of the PWR plants that have been licensed for commercial operation in the United States, approximately 80% use either reinforced or prestressed concrete primary containments. The concrete containments are of three different functional designs: subatmospheric (reinforced concrete), ice condenser (reinforced concrete), and large/dry (reinforced and prestressed concrete). The primary differences between these containment designs relate to volume requirements, provisions for accident loadings/pressures, and containment internal structures layout. The PWR containment structure generally consists of a concrete basemat foundation, vertical cylindrical walls, and dome. Leak tightness of a containment is provided by a steel liner attached to the containment inside surfaces. Exposed surfaces of the carbon steel liner are typically painted to protect against corrosion and to facilitate decontamination should it be required. Depending on the functional design (e.g., large dry or ice condenser), the concrete containments can be on the order of 40 m to 50 m in diameter and 60 m to 70 m high, with wall and dome thicknesses from 0.9 m to 1.4 m, and base slab thicknesses from 2.7 m to 4.1 m. Figure 1 presents the Trojan nuclear plant cooling tower and post-tensioned concrete containment prior to decommissioning and demolition. Pressurized-water reactor plants that utilize a metallic primary containment (large dry and ice condenser designs) are usually contained in reinforced concrete "enclosure" or "shield" buildings that, in addition to withstanding environmental effects, provide radiation shielding and particulate collection, and ensure that the free-standing metallic primary containment is protected from the natural environment.

Of the BWR plants in the United States, approximately 30% utilize either reinforced or prestressed concrete primary containments. Boiling-water reactor containments, because of provisions for pressure suppression, typically have "normally dry" sections (dry well) and "flooded" sections (wet well) that are interconnected via piping or vents. Boiling-water reactor plants that utilize steel primary containments have reinforced concrete structures that serve as secondary containments or reactor buildings. These structures generally are safety-related because they provide additional radiation shielding; provide resistance to environmental and operational loadings; and house safetyrelated mechanical equipment, spent fuel, and the primary metal containment. Although these structures may be massive in cross section in order to meet shielding or load-bearing requirements, they generally have smaller elemental thicknesses than primary containments because of reduced exposure under postulated accident loadings.

A/12

Operating Experience

In general, the performance of nuclear power plant safety-related concrete structures has been very good. However, there have been a few isolated incidences of degradation that primarily occurred early in life and have been corrected.[2] Causes generally were related either to improper material selection or construction/design deficiencies. Examples of some of these problems include low concrete compressive strengths, voids under the post-tensioning tendon bearing plates, cracking of post-tensioning anchor heads, **containment dome delaminations**, misplaced steel reinforcement, post-tensioning system button-head deficiencies, and water-contaminated corrosion inhibitors.

Several incidences of degradation related to environmental effects have occurred. Examples include corrosion of steel reinforcement in water intake structures, corrosion of post-tensioning tendon wires, leaching of tendon gallery concrete, low prestressing forces, and leakage of corrosion inhibitors from tendon sheaths. Other aging-related problems include cracking and spalling of containment dome concrete due to freezing and thawing, and corrosion of containment liners. As the plants age incidences of degradation are expected to increase, primarily due to environmental effects. Additional information on degradation of U.S. nuclear power plant concrete structures is available,[3,4] as well as problem areas experienced with nuclear power plant concrete structures in other countries.[5]

Remedial Methods

Deterioration of reinforced concrete generally will result in cracking, spalling, or **delamination** of the cover concrete. Whenever damage is detected, corrective actions are taken to identify and eliminate the source of the problem thereby halting the degradation process. A remedial measures strategy is formulated based on the consequence of damage (e.g., affect of degradation on structural safety), time requirements for implementation (e.g., shutdown requirements, immediate or future safety concern), economic aspects (e.g., partial or complete repair), and residual service life requirements (e.g., influences action taken). Basic guidance on the repair of degraded structures is available.[22] Improved guidance, however, is desired relative to assessment of defects (e.g., cracks) as well as information on the performance and effectiveness of subsequent repairs (e.g., durability of repair materials).

Joe Giantelli
Reactor Systems Engineer
Operating Experience Branch
NRR/ADRO/DIRS/IOEB
301-415-0504
joseph.giantelli@nrc.gov