U.S. NUCLEAR REGULATORY COMMISSION

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# REGULATORY GUIDE

OFFICE OF STANDARDS DEVELOPMENT

## REGULATORY GUIDE 1.142

## SAFETY-RELATED CONCRETE STRUCTURES FOR NUCLEAR POWER PLANTS (OTHER THAN REACTOR VESSELS AND CONTAINMENTS)

### A. INTRODUCTION

General Design Criteria 1, "Quality Standards and Records," 2, "Design Bases for Protection Against Natural Phenomena," and 4, "Environmental and Missile Design Bases," of Appendix A, "General Design Criteria for Nuclear Power Plants," to 10 CFR Part 50, "Licensing of Production and Utilization Facilities," require, in part, that structures, systems, and components important to safety be designed, fabricated, erected, and tested to quality standards commensurate with the importance of the safety functions to be performed and that they be designed to withstand the effects of postulated accidents and environmental conditions as well as those effects associated with normal operating conditions. This guide describes a method acceptable to the NRC staff for complying with the Commission's regulations with regard to safety-related concrete structures (other than reactor vessels and containments) for nuclear power plants.

### B. DISCUSSION

ACI Standard 349–76,[1] "Code Requirements for Nuclear Safety Related Structures," was prepared by Committee 349 of the American Concrete Institute (ACI) and was published by the ACI in October 1976. The standard is based on ACI Standard 318–71[1] (ANSI A89.1-1972), "Building Code Requirements for Reinforced Concrete," with modifications to accommodate the loadings and performance requirements peculiar to nuclear power plants. ACI Standard 318 has long been the basis for the design of concrete buildings in the United States and has been used by the NRC staff as a starting point in evaluating the adequacy of concrete structures.

ACI Standard 349–76 delineates requirements for the sizing of concrete structural systems and elements, requirements for construction details, and specifications and tests for materials. The regulatory positions below relate only to Chapters 1 through 19 of that standard. Committee 349 of the American Concrete Institute has in preparation mandatory appendices to ACI Standard 349-76 covering thermal effects, steel embedments, and special provisions for impulsive and impactive effects. Regulatory positions on these appendices will be developed after their adoption by the American Concrete Institute.

### C. REGULATORY POSITION

The practices and requirements described in ACI Standard 349–76, "Code Requirements for Nuclear Safety Related Concrete Structures," are generally acceptable to the NRC staff and provide an adequate basis for complying with the Commission's regulations with regard to the design of safety-related concrete structures other than reactor vessels and containments, subject to the following:

1. The applicability of strength design methods to structures whose principal function is to provide a barrier to contain or retain pressure such as the divider barrier of the ice-condenser of the PWR containment or the drywell of the Mark III BWR containment is questionable. Therefore, for those structures, mere conformance with the requirements of ACI 349–76 is unacceptable to the staff, who will continue to review the design of these structures on a case-by-case basis.

2. When concrete structures are used to provide radiation shielding, the provisions of Sections 5.1 and 10 of ANSI Standard N101.6–1972,[2] "Concrete

FOR COMMENT

[1] Copies may be obtained from the American Concrete Institute, P.O. Box 4754, Redford Station, Detroit, Michigan 48219.

[2] Copies may be obtained from the American Nuclear Society, 555 North Kensington Avenue, La Grange Park, Illinois 60525.

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Radiation Shields," and those of ANSI Standard N101.4–1972,[3] as endorsed by Regulatory Guide 1.54, "Quality Assurance Requirements for Protective Coatings Applied to Water-Cooled Nuclear Power Plants," are applicable.

3. ACI Standard 349–76 lacks specific requirements to ensure ductility of framed structures. Adherence to the requirements of Appendix A to ACI Standard 318–71 is acceptable.

4. Section 5.1.2 permits depositing concrete without the prior removal of water from the place of deposit at the discretion of the owner. Since the presence of water in the place of deposit may seriously affect the strength properties of concrete, it is important that water be removed before concrete is deposited unless a tremie is used.

5. Section 5.4.1 allows concrete that has partially hardened or has been contaminated with foreign materials or remixed after initial set to be reused at the discretion of the engineer. Such a material would be defective and therefore should not be used.

6. In addition to the requirements of Section 1.3.1 of ACI Standard 349–76, the inspectors should have sufficient experience in reinforced and prestressed concrete practice to interpret plans and specifications. The inspectors should be thoroughly familiar with the applicable ACI and ASTM standards. ACI Standard 311–74,[1] "Recommended Practice for Concrete Inspection," should be followed except where the requirements of Section 1.5 of ACI Standard 349–76 control.

7. The frequency of cylinder testing required by Section 4.3.1 of ACI Standard 349–76 is not consistent with generally accepted practice. A test frequency in conformance with ANSI Standard N45.2.5–1974,[4] as endorsed by Regulatory Guide 1.94, "Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants," is acceptable.

8. The minimum pressure-testing requirements for embedded piping of ACI Standard 318–71 have been deleted from ACI Standard 349–76. In order to ensure that minimum pressure-testing requirements are met, the pressure tests of embedded pipes in Section 6.3.2.4 of ACI 349–76 should also satisfy the requirements of Section 6.3.2.4 of ACI 318–71.

9. More conservative load factors are appropriate in accounting for the effects of normal or shutdown thermal loads, postulated pipe break accidents, and an operating basis earthquake (OBE) in combination with a postulated pipe break. The load factors used in Section 9.3.1 of ACI Standard 349–76 are acceptable to the staff except for the following:

a. In load combinations (9), (10), and (11), 1.7 $T_o$ should be used in place of 1.4 $T_o$.

b. In load combination (6), 1.5 $P_a$ should be used in place of 1.25 $P_a$.

c. In load combination (7), 1.25 $P_a$ and 1.25 $E_o$ should be used in place of 1.15 $P_a$ and 1.15 $E_o$, respectively.

d. In load combinations (2) and (10), 1.9 $E_o$ should be used in place of 1.7 $E_o$.

10. Structures must be able to withstand the effects of differential settlement under environmental loads as well as under abnormal loads. Thus, in Section 9.3.2 of ACI 349–76, consideration of the effects of differential settlement should be included in load combinations (1) through (11).

11. The provisions of Section 9.3.3 of ACI Standard 349–76 to account for the effects of transitory loads are not sufficiently general. Thus, in Section 9.3.3 of ACI Standard 349–76, when any load reduces the effects of other loads, the corresponding coefficient for that load should be taken as 0.9 if it can be demonstrated that the load is always present or occurs simultaneously with the other loads. Otherwise, the coefficient for that load should be taken as zero.

12. The provision in Section 9.3.6 of ACI Standard 349–76 permitting local exceedance of section strength under concentrated dynamic loads does not ensure that the section can withstand the associated distributed loadings. Thus, if the provision of Section 9.3.6 of ACI 349–76 permitting exceedance of local section strengths is invoked, it should be demonstrated that section strengths are adequate to accommodate load combinations (7) and (8) without the dynamic loads $Y_j$, $Y_m$, and $Y_r$.

13. The NRC staff would accept the local exceedance of section strength for concentrated tornado-generated-missile loading under load combination (5). However, an analysis should be performed to demonstrate that section strengths are adequate to accommodate load combination (5) without the dynamic load effect of tornado-generated missiles.

[3] ANSI N101.4–1972, "Quality Assurance for Protective Coatings Applied to Nuclear Facilities." Copies may be obtained from the American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017.

[4] ANSI N45.2.5–1974, "Supplementary Quality Assurance Requirements for Installation, Inspection, and Testing of Structural Concrete and Structural Steel During the Construction Phase of Nuclear Power Plants." Copies may be obtained from the American Society of Mechanical Engineers, 345 East 47th Street, New York, N.Y. 10017.

14. ACI Standard 349–76 does not address the subject of openings in slabs and footings. Provisions of Section 11.12 of ACI 318–71 are acceptable for this purpose.

## D. IMPLEMENTATION

The purpose of this section is to provide information to applicants regarding the NRC staff's plans for using this regulatory guide.

Except in those cases in which the applicant proposes an acceptable alternative method for complying with specified portions of the Commission's regulations, the method described herein will be used in the evaluation of submittals in connection with construction permit applications docketed after December 15, 1978, unless this guide is revised as a result of suggestions from the public or additional staff review.

If an applicant wishes to use this regulatory guide in developing submittals for applications docketed on or before December 15, 1978, the pertinent portions of the application will be evaluated on the basis of this guide.



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