

IN-LB

Inch-Pound Units

SI

International System of Units

An ACI Standard

# Code Requirements for Environmental Engineering Concrete Structures (ACI 350-20) and Commentary (ACI 350R-20)

Reported by ACI Committee 350

ACI 350-20



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## **Code Requirements for Environmental Engineering Concrete Structures (ACI 350-20) and Commentary (ACI 350R-20)**

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An ACI Standard

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### PREFACE

The “Code Requirements for Environmental Engineering Concrete Structures” (Code) portion of this document covers the structural design, materials selection, and construction of environmental engineering concrete structures. Such structures are used for conveying, storing, or treating water and wastewater, other liquids, and solid waste. The term “solid waste” as used in the Code encompasses the heterogeneous mass of disposed-of materials, as well as more homogeneous agricultural, industrial, and mineral wastes.

The Code also covers the evaluation of existing environmental engineering concrete structures.

Environmental engineering concrete structures are subject to uniquely different loadings and severe exposure conditions that require more restrictive serviceability requirements and may provide longer service lives than non-environmental structures.

Loadings include normal dead and live loads, earth pressure loads, hydrostatic and hydrodynamic loads, and vibrating equipment loads. Exposures include concentrated chemicals, alternate wetting and drying, high-velocity flowing liquids, and freezing and thawing of saturated concrete. Serviceability requirements include liquid-tightness, gas-tightness, and durability.

Proper design, materials, and construction of environmental engineering concrete structures are required to produce serviceable concrete that is dense, durable, nearly impermeable, and resistant to relevant chemicals, with limited deflections and cracking. This includes minimizing leakage and control over the infiltration of, or contamination to, the environment or groundwater.

The Code presents additional material as well as modified portions of the ACI 318-05, ACI 318-08, and ACI 318-11 building codes that are applicable to environmental engineering concrete structures.

The Commentary discusses some of the considerations of the committee in developing the ACI 350 Code, and its relationship with ACI 318. Emphasis is given to the explanation of provisions that may be unfamiliar to some users of the Code. References to much of the research data referred to in preparing the Code are given for those who wish to study certain requirements in greater detail.

The chapter and section numbering of the Code are followed throughout the Commentary.

Among the subjects covered are: drawings and specifications, inspections, materials, concrete quality, mixing and placing, forming, embedded pipes, joints, reinforcement details, analysis and design, strength and serviceability, flexural and axial loads, shear and torsion, development of reinforcement, slab systems, walls, footings, precast concrete, prestressed concrete, shell structures, folded plate members, provisions for seismic design, and an alternate design method in Appendix A.

The quality and testing of materials used in the construction are covered by reference to the appropriate standard specifications. Welding of reinforcement is covered by reference to the appropriate AWS standard. Criteria for liquid-tightness and gas-tightness testing may be found in ACI 350.1.

**Keywords:** chemical attack; coatings; concrete durability; concrete finishing (fresh concrete); concrete slabs, crack width and spacing; cracking (fracturing); environmental engineering; hydraulic structures; inspection; joints (junctions); joint sealers; liners; liquid; patching; permeability; pipe columns; pipes (tubes); prestressed concrete; prestressing steels; protective coatings; reservoirs; roofs; serviceability; sewerage; solid waste facilities; tanks (containers); temperature; torque; torsion; vibration; volume change; walls; wastewater treatment; water; water-cementitious materials ratio; water supply; water treatment.

## INTRODUCTION

The Code and Commentary includes excerpts from ACI 318 that are pertinent to ACI 350. The Commentary discusses some of the considerations of ACI Committee 350 in developing this Code. Emphasis is given to the explanation of provisions that may be unfamiliar to users of the standard.

This Commentary is not intended to provide a complete historical background concerning the development of the Code, nor is it intended to provide a detailed summary of the studies and research data reviewed by the committee in formulating the provisions of the Code. However, references to some of the research data are provided for those who wish to study the background material in depth.

As the name implies, “Code Requirements for Environmental Engineering Concrete Structures” may be used as part of a legally adopted Code and, as such, must differ in form and substance from documents that provide detailed specifications, recommended practice, complete design procedures, or design aids.

The Code is intended to cover environmental engineering concrete structures but is not intended to supersede ASTM standards for precast structures.

Requirements more stringent than Code provisions may be desirable for unusual structures. The Code and Commentary cannot replace sound engineering knowledge, experience, and judgment.

A code for design and construction states the minimum requirements necessary to provide for public health and safety. ACI 350 is based on this principle. For any structure, the owner or the structural designer may require the quality of materials and construction to be higher than the minimum requirements necessary to provide serviceability and to protect the public as stated in the Code. Lower standards, however, are not permitted.

ACI 350 has no legal status unless adopted by government bodies having the power to regulate building design and construction. Where the Code has been adopted, it cannot present background details or suggestions for carrying out its requirements or intent. It is the function of the Commentary to fill this need. Where the Code has not been adopted, it may serve as a reference to good practice.

The Code provides a means of establishing minimum standards for acceptance of design and construction by a legally appointed building official or designated representatives. The Code and Commentary are not intended for use in settling disputes between the owner, engineer, architect, contractor, or their agents, subcontractors, material suppliers, or testing agencies. Therefore, the Code cannot define the contractual responsibility of the involved parties. General references requiring compliance with ACI 350 in the job specifications should be avoided, as the contractor is rarely in the position of accepting responsibility for architectural and engineering design details. Generally, the drawings, specifications, and contract documents should contain all the necessary requirements to ensure compliance with the Code. In part, this can be accomplished by reference to specific code sections in

the job specifications. Other ACI publications, such as ACI 350.5, “Specifications for Environmental Concrete Structures,” are written specifically for use as part of the contract documents for construction.

ACI Committee 350 recognizes the desirability of standards of performance for individual parties involved in the contract documents. Available for this purpose are the certification programs of the American Concrete Institute, plant certification programs of the Precast/Prestressed Concrete Institute and the National Ready Mixed Concrete Association, and qualification standards of the American Society of Concrete Contractors. Also available are “Standard Specification for Agencies Engaged in Construction Inspection and/or Testing” (ASTM E329) and “Standard Practice for Laboratories Testing Concrete and Concrete Aggregates for Use in Construction and Criteria for Laboratory Evaluation” (ASTM C1077).

### Design aids (general concrete design aids are listed in ACI 318-11):

“Rectangular Concrete Tanks,” Portland Cement Association, Skokie, IL, 1998, 182 pp. (Presents data for design of rectangular tanks.)

“Circular Concrete Tanks Without Prestressing,” Portland Cement Association, Skokie, IL, 1993, 54 pp. (Presents design data for circular concrete tanks built in or on ground. Walls may be free or restrained at the top. Wall bases may be fixed, hinged, or have intermediate degrees of restraint. Various layouts for circular roofs are presented.)

*Concrete Manual*, U.S. Department of Interior, Bureau of Reclamation, eighth edition, 1981, 627 pp. (Presents technical information for the control of concrete construction, including linings for tunnels, impoundments, and canals.)

“Design of Liquid-Containing Concrete Structures for Earthquake Forces,” Portland Cement Association, Skokie, IL, 2002, 60 pp. (Presents design examples for designing for hydrodynamic forces.)

“Moments and Reactions for Rectangular Plates” Engineering Monograph No. 27, United States Department of the Interior, Bureau of Reclamation, 1990, 100 pp. (Presents design aids for rectangular plates.)

## GENERAL COMMENTARY

Environmental engineering concrete structures are subject to stringent service conditions and should be designed for extended service life expectancy and detailed with care. The quality of concrete is important, and rigorous quality control must be maintained during construction to obtain dense, durable concrete suitable for the expected service conditions.

Environmental engineering concrete structures for the containment, treatment, or transmission of liquid such as water and wastewater as well as solid waste disposal facilities, should be designed and constructed to be liquid-tight, and where required, gas-tight, with minimal leakage under normal service conditions.