

ACI 362.1R-12

**Guide for the Design and
Construction of Durable Concrete
Parking Structures**

Reported by ACI Committee 362



American Concrete Institute®



First Printing
September 2012

American Concrete Institute®
Advancing concrete knowledge

Guide for the Design and Construction of Durable Concrete Parking Structures

Copyright by the American Concrete Institute, Farmington Hills, MI. All rights reserved. This material may not be reproduced or copied, in whole or part, in any printed, mechanical, electronic, film, or other distribution and storage media, without the written consent of ACI.

The technical committees responsible for ACI committee reports and standards strive to avoid ambiguities, omissions, and errors in these documents. In spite of these efforts, the users of ACI documents occasionally find information or requirements that may be subject to more than one interpretation or may be incomplete or incorrect. Users who have suggestions for the improvement of ACI documents are requested to contact ACI via the errata website at www.concrete.org/committees/errata.asp. Proper use of this document includes periodically checking for errata for the most up-to-date revisions.

ACI committee documents are intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. Individuals who use this publication in any way assume all risk and accept total responsibility for the application and use of this information.

All information in this publication is provided “as is” without warranty of any kind, either express or implied, including but not limited to, the implied warranties of merchantability, fitness for a particular purpose or non-infringement.

ACI and its members disclaim liability for damages of any kind, including any special, indirect, incidental, or consequential damages, including without limitation, lost revenues or lost profits, which may result from the use of this publication.

It is the responsibility of the user of this document to establish health and safety practices appropriate to the specific circumstances involved with its use. ACI does not make any representations with regard to health and safety issues and the use of this document. The user must determine the applicability of all regulatory limitations before applying the document and must comply with all applicable laws and regulations, including but not limited to, United States Occupational Safety and Health Administration (OSHA) health and safety standards.

Participation by governmental representatives in the work of the American Concrete Institute and in the development of Institute standards does not constitute governmental endorsement of ACI or the standards that it develops.

Order information: ACI documents are available in print, by download, on CD-ROM, through electronic subscription, or reprint and may be obtained by contacting ACI.

Most ACI standards and committee reports are gathered together in the annually revised ACI Manual of Concrete Practice (MCP).

American Concrete Institute
38800 Country Club Drive
Farmington Hills, MI 48331
U.S.A.
Phone: 248-848-3700
Fax: 248-848-3701

www.concrete.org

ISBN-13: 978-0-87031-785-9
ISBN: 0-87031-785-7

Guide for the Design and Construction of Durable Concrete Parking Structures

Reported by ACI Committee 362

Keith W. Jacobson*, Chair

Erich L. Martz, Secretary

Ralph T. Brown
Girdhari L. Chhabra
Ned M. Cleland
Thomas J. D'Arcy*
James P. Donnelly
Thomas J. Downs*
Boris Dragunsky
Gregory F. Force
Harry A. Gleich
Mohammad Iqbal

Howard R. May*
Martin B. Mikula
David C. Monroe
Thomas E. Nehil
Carl A. Peterson*
Kurt Wagner
H. Carl Walker*
Thomas G. Weil

*Chapter authors and members of the draft review committee.

This guide presents design and construction criteria used to improve the durability of concrete parking structures. Emphasis is placed on key design criteria unique to parking structures, including structural systems, materials, structural design, durability, and construction. Also covered are cast-in-place nonprestressed concrete, cast-in-place post-tensioned concrete, and precast/prestressed concrete structural systems for use in parking structures.

Keywords: concrete durability; construction; corrosion; curing; finishes; freezing-and-thawing resistance; nonprestressed reinforcement; parking structures; post-tensioning; precast concrete; prestressed concrete.

ACI Committee Reports, Guides, and Commentaries are intended for guidance in planning, designing, executing, and inspecting construction. This document is intended for the use of individuals who are competent to evaluate the significance and limitations of its content and recommendations and who will accept responsibility for the application of the material it contains. The American Concrete Institute disclaims any and all responsibility for the stated principles. The Institute shall not be liable for any loss or damage arising therefrom.

Reference to this document shall not be made in contract documents. If items found in this document are desired by the Architect/Engineer to be a part of the contract documents, they shall be restated in mandatory language for incorporation by the Architect/Engineer.

CONTENTS

Chapter 1—Introduction and scope, p. 2

- 1.1—Introduction
- 1.2—Scope

Chapter 2—Definitions, p. 2

Chapter 3—Structural systems, p. 2

- 3.1—General
- 3.2—Cast-in-place post-tensioned concrete systems
- 3.3—Cast-in-place reinforced (nonprestressed) concrete systems
- 3.4—Precast/prestressed concrete systems
- 3.5—Steel and concrete hybrid composite systems
- 3.6—Vehicle guardrail
- 3.7—Pedestrian guardrail
- 3.8—Below-grade parking structures

ACI 362.1R-12 supersedes ACI 362.1R-97 and was adopted and published September 2012.

Copyright © 2012, American Concrete Institute.

All rights reserved including rights of reproduction and use in any form or by any means, including the making of copies by any photo process, or by electronic or mechanical device, printed, written, or oral, or recording for sound or visual reproduction or for use in any knowledge or retrieval system or device, unless permission in writing is obtained from the copyright proprietors.

Chapter 4—Materials, p. 6

- 4.1—General
- 4.2—Concrete
- 4.3—Nonprestressed reinforcement and reinforcement accessories
- 4.4—Prestressing
- 4.5—Embedded items
- 4.6—Surface treatments
- 4.7—Joint materials

Chapter 5—Structural design, p. 10

- 5.1—Design criteria
- 5.2—Lateral-load-resisting systems
- 5.3—Vehicle barriers and guardrails
- 5.4—Deflection and camber
- 5.5—Restraint
- 5.6—Other design requirements

Chapter 6—Durability, p. 13

- 6.1—General
- 6.2—Drainage
- 6.3—Design criteria tables

Chapter 7—Construction, p. 20

- 7.1—General
- 7.2—Cast-in-place concrete construction
- 7.3—Precast concrete construction
- 7.4—Moisture protection
- 7.5—Quality control by contractor/quality assurance by owner

Chapter 8—References, p. 22**CHAPTER 1—INTRODUCTION AND SCOPE****1.1—Introduction**

This guide addresses the design and construction of durable concrete parking structures.

Parking structures are different from other concrete buildings due to their:

- a) Reduced roofing, cladding, and climate control that result in a more severe direct or indirect exposure to rain, snow, sunlight, temperature variations, and airborne chlorides
- b) Vehicular occupancy that imposes heavy moving loads and deposits deicing salts
- c) Ramps between floors for vehicular circulation and enhanced drainage that present unique structural challenges
- d) Large plan size that magnifies the potential for damage caused by restraint of movements and forces associated with volumetric changes

All are factors that influence the durability of parking structures and require consideration in their design. Maintenance of parking structures is essential to durability and longevity. For more information, refer to ACI 362.2R-00.

1.2—Scope

The purpose of this guide is to provide specific information on several of the design aspects and the construction

of parking structures that differentiates them from other concrete structures. This guide should be used with ACI 318-11, ACI specifications, and ACI standards.

Environmental conditions of the geographic location of a parking structure determine the governing criteria used in this guide. Environmental conditions include structure proximity to sea water and frequency of exposure to direct and indirect applications of deicing salts and freezing temperatures. Once the appropriate environmental conditions are determined, this guide provides the necessary durability criteria for parking structure design and construction. Parking structures integrally constructed with surrounding earth-retaining walls or other restraining structures require additional analysis of the restraining forces and lateral soil loads.

CHAPTER 2—DEFINITIONS

ACI provides a comprehensive list of definitions through an online resource, “ACI Concrete Terminology” (<http://terminology.concrete.org>). Definitions provided herein complement that resource.

corrosion inhibitor—a chemical compound, either liquid or powder, usually intermixed in concrete and sometimes applied to concrete, and that effectively decreases corrosion of steel reinforcement.

deicer—chemical such as sodium or calcium chloride, used to melt ice or snow on slabs and pavements by lowering the freezing point.

guardrail, pedestrian—element at the edge of an open-sided walking surface, intended to restrain a pedestrian from falling from the structure to an adjacent lower surface.

guardrail, vehicle—element at the edge of the driving and parking surface, intended to restrain a vehicle from falling from the structure to an adjacent lower surface.

membrane, traffic-bearing—an elastomeric coating capable of withstanding vehicular traffic.

pour strip—a defined zone of concrete placed after and used to temporarily separate adjoining parts of the structure that have been constructed.

pretopped—plant-manufactured, precast, prestressed concrete floor or roof members that do not require a field-placed concrete topping.

tooled joint—a groove tooled into fresh concrete using a concrete jointer tool to create a weakened plane intended to control the location of cracks.

CHAPTER 3—STRUCTURAL SYSTEMS**3.1—General**

Structural concrete is an ideal material to meet the demands of parking structure construction and maintenance. It is specifically recognized by the International Code Council (ICC) (2009 ICC International Building Code) as an appropriate noncombustible material for parking garage construction. In addition to proper design and construction, a disciplined long-term preventive maintenance program is required from the time a parking structure begins operation to ensure the structure will meet service life goals.