

ACI 308R-16

Guide to External Curing of Concrete

Reported by ACI Committee 308



American Concrete Institute
Always advancing



Guide to External Curing of Concrete

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 <http://concrete.org/Publications/DocumentErrata.aspx>. 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
Phone: +1.248.848.3700
Fax: +1.248.848.3701

www.concrete.org

Guide to External Curing of Concrete

Reported by ACI Committee 308

David M. Suchorski, Chair

Erik Holck, Vice Chair

Lawrence Homer Taber*, Secretary

Voting Members

Dale P. Bentz
Dianne Carey
Jennifer K. Crisman
Jonathan E. Dongell
Michael Faubel
Dale Fisher

Sidney Freedman
Michael G. Hernandez
John C. Hukey
Cecil L. Jones
Frank A. Kozeliski
Ronald L. Kozikowski Jr.

Mauricio Lopez
Darryl Manuel
Steven F. McDonald
Mike Murray
John W. Roberts
Philip A. Smith

Richard E. Van Horn
Jody R. Wall
Daniel Webber
John B. Wojakowski

*Chair of document subcommittee.

Consulting Members

Ralph C. Bruno
James N. Cornell II

Ben E. Edwards
Jerome H. Ford

R. Doug Hooton

David E. Hoyt

This guide reviews and describes practices, procedures, materials, and monitoring methods for the external curing of concrete and provides guidance for specifying curing procedures. Current curing techniques are presented and commonly accepted methods, procedures, and materials are described. Methods are given for curing structures and buildings, pavements and other slabs-on-ground, and for mass concrete. Curing methods for several specific categories of cement-based products are discussed in this document.

The materials, processes, quality control measures, and inspections described in this document should be tested, monitored, or performed as applicable only by individuals holding the appropriate ACI certifications or equivalent.

Keywords: cold weather construction; curing compound; hot weather construction; mass concrete; reinforced concrete; sealer; shotcrete; slabs-on-ground.

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, p. 2

- 1.1—Introduction, p. 2
- 1.2—Curing, p. 2
- 1.3—Curing and hydration of portland cement, p. 2
- 1.4—Deliberate curing procedures, p. 5
- 1.5—Curing-affected zone, p. 10
- 1.6—Concrete properties influenced by curing, p. 11
- 1.7—Effects of elevated temperature, p. 12
- 1.8—Sustainability, p. 14

CHAPTER 2—DEFINITIONS, p. 15

CHAPTER 3—CURING METHODS AND MATERIALS, p. 15

- 3.1—Scope, p. 15
- 3.2—Use of water for curing concrete, p. 15
- 3.3—Initial curing methods, p. 15
- 3.4—Final curing measures, p. 16
- 3.5—Termination of curing measures, p. 20
- 3.6—Cold-weather protection and curing, p. 20
- 3.7—Hot-weather protection and curing, p. 21

ACI 308R-16 supersedes ACI 308R-01 and was adopted and published May 2016.

Copyright © 2016, 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.

- 3.8—Accelerated curing, p. 21
- 3.9—Minimum curing requirements, p. 21
- 3.10—Temperature limits during curing, p. 22

CHAPTER 4—CURING FOR DIFFERENT TYPES OF CONSTRUCTION, p. 23

- 4.1—Pavements and other slabs on ground, p. 23
- 4.2—Buildings, bridges, and other structures, p. 23
- 4.3—Mass concrete, p. 24
- 4.4—Curing colored concrete floors and slabs, p. 25
- 4.5—Specialty constructions, p. 25

CHAPTER 5—MONITORING CURING AND CURING EFFECTIVENESS, p. 25

- 5.1—General, p. 25
- 5.2—Evaluating environmental conditions, p. 25
- 5.3—Means to verify application of curing, p. 28
- 5.4—Impact of curing procedures on immediate environment, p. 28
- 5.5—Impact of curing procedures on moisture and temperature within concrete, p. 29
- 5.6—Maturity method, p. 29
- 5.7—Assessing curing effectiveness, p. 29

CHAPTER 6—REFERENCES, p. 30

Authored references, p. 31

CHAPTER 1—INTRODUCTION

1.1—Introduction

The principles and practices of external curing are applicable to all types of concrete construction. This document does not fully address curing for specialty concrete and special construction techniques (refer to 4.5), nor does it fully address internally cured concrete. For additional information on internally cured concrete using preconditioned absorptive lightweight aggregates, refer to **ACI (308-213)R**. Curing measures, in general, are specified in **ACI 308.1**. Curing measures directed toward the maintenance of satisfactory concrete temperature under specific environmental conditions are addressed in greater detail in **ACI 305R**, **ACI 306R**, **ACI 301**, and **ACI 318**.

The fundamental principles of external curing remain the same as in the past; however, new research and methods of curing are presented herein. Topics such as internal curing, curing at elevated temperatures, sustainability, curing of moisture-sensitive flooring, sensors for mass concrete curing, and new curing monitoring techniques have been added or enhanced in this document.

1.2—Curing

Curing is an action taken to maintain moisture and temperature conditions in a freshly placed cementitious mixture to allow hydraulic cement hydration and, if pozzolans are used, pozzolanic reactions to occur so that the potential properties of the mixture may develop. A mixture is properly proportioned and adequately cured when the properties of the in-place concrete equal or exceed the

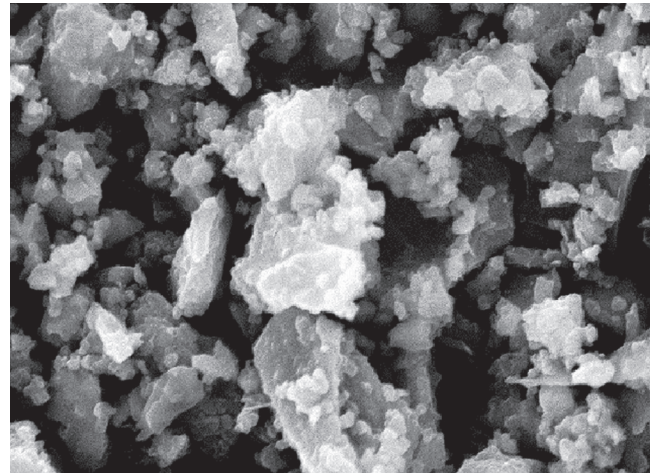


Fig. 1.3.1a—Unhydrated particles of portland cement—magnification 2000× (Soroos 1994).

design properties of the concrete. The curing period begins at placing and continues until the desired concrete properties have developed. The objectives of curing are to prevent the loss of moisture from concrete and maintain a favorable concrete temperature for a sufficient period of time. Proper curing allows the cementitious material within the concrete to properly hydrate. Hydration is the chemical reaction that leads to changes that take place when portland cement reacts with water. Both at depth and near the surface, curing has a significant influence on the properties of hardened concrete, such as strength, permeability, abrasion resistance, volume stability, propensity for early-age cracking, and resistance to freezing and thawing and deicing chemicals.

The term “curing” has also been used in a more general sense to describe the process by which hydraulic cementitious concrete matures and develops hardened properties over time as a result of the continued hydration of the cementitious materials in the presence of sufficient water and heat. While all concrete hydrates to varying levels of maturity with time, the rate and extent to which this development takes place depends on the natural environment surrounding the concrete and on the measures taken to modify this environment by limiting the loss of water, heat, or both, from the concrete; externally providing moisture and heat; or incorporating special materials in the mixture design.

1.3—Curing and hydration of portland cement

1.3.1 Hydration of portland cement—Portland-cement concrete is a composite material in which aggregates are bound in a porous matrix of hardened cement paste. At the microscale, the hardened paste is held together by bonds that develop between the products of the reaction of cement with water and mechanically interlocks the aggregate. Similar products are formed from the reactions between cement, other cementitious materials, and water.

The cement-water reaction includes both chemical and physical processes that are collectively known as the hydration of the cement (Taylor 1997). As the hydration process continues, the strength of the interparticle bonding increases,