

ACI 546R-14

# Guide to Concrete Repair

Reported by ACI Committee 546



American Concrete Institute  
*Always advancing*



## Guide to Concrete Repair

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](http://www.concrete.org)

# Guide to Concrete Repair

Reported by ACI Committee 546

John S. Lund, Chair

David W. Whitmore, Secretary

James Peter Barlow  
 Michael M. Chehab  
 Marwan A. Daye  
 Michael J. Garlich  
 Paul E. Gaudette  
 Timothy R. W. Gillespie  
 Yelena S. Golod  
 Fred R. Goodwin  
 Harald G. Greve

Ron Heffron  
 Robert F. Joyce  
 Lawrence F. Kahn  
 Brian F. Keane  
 Benjamin Lavon  
 Kenneth M. Lozen  
 James E. McDonald  
 Myles A. Murray  
 Jay H. Paul

Richard C. Reed  
 Johan L. Silfwerbrand  
 Joe Solomon  
 Michael M. Sprinkel  
 Ronald R. Stankie  
 Joseph E. Tomes  
 David A. VanOcker  
 Alexander M. Vaysburd  
 Kurt Wagner

Patrick M. Watson  
 Mark V. Ziegler

*Consulting Members*  
 Peter Emmons  
 Noel P. Mailvaganam  
 Kevin A. Michols  
 Richard Montani  
 Don T. Pyle

*This guide presents recommendations for the selection and application of materials and methods for repairing, protecting, and strengthening concrete structures. An overview of materials and methods is presented as a guide for selecting a particular application. References are provided for obtaining in-depth information on the selected materials or methods.*

**Keywords:** anchorage; coating; concrete repair; joint sealant; placement; polymer; protective systems; repair materials; structural strengthening.

## CONTENTS

### CHAPTER 1—INTRODUCTION, p. 2

- 1.1—Guide use, p. 2
- 1.2—Repair methodology, p. 2
- 1.3—Sustainability, p. 6

### CHAPTER 2—DEFINITIONS, p. 6

### CHAPTER 3—CONCRETE REMOVAL AND SURFACE PREPARATION, p. 6

- 3.1—Introduction, p. 6

- 3.2—Concrete removal, p. 6
- 3.3—Surface preparation, p. 14
- 3.4—Quality control and assurance, p. 17

### CHAPTER 4—REPAIR MATERIALS, p. 17

- 4.1—Introduction, p. 17
- 4.2—Concrete replacements and overlays, p. 17
- 4.3—Crack repair materials, p. 27
- 4.4—Bonding materials, p. 31
- 4.5—Coatings on reinforcement, p. 32
- 4.6—Reinforcement, p. 32
- 4.7—Material selection, p. 33

### CHAPTER 5—CONCRETE AND REINFORCEMENT REPAIR TECHNIQUES, p. 34

- 5.1—Introduction, p. 34
- 5.2—Crack repair, p. 34
- 5.3—Concrete replacement, p. 37
- 5.5—Anchorage, p. 44
- 5.6—Quality control and assurance, p. 45

### CHAPTER 6—PROTECTIVE SYSTEMS, p. 46

- 6.1—Introduction and selection factors, p. 46
- 6.2—Typical problems that can be mitigated with protection systems, p. 46
- 6.3—Total system concept, p. 47
- 6.4—Surface treatments, p. 48

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.

ACI 546R-14 supersedes 546R-04 and was adopted and published September 2014. Copyright © 2014, 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.

6.5—Concrete surface preparation and installation requirements, p. 53

6.6—Joints, p. 54

6.7—Cathodic protection, p. 54

6.8—Chloride extraction, p. 55

6.9—Realkalization, p. 56

## CHAPTER 7—STRUCTURAL REPAIR AND STRENGTHENING, p. 56

7.1—General, p. 56

7.2—Internal structural repair (restoration to original member strength), p. 56

7.3—External reinforcement (encased and exposed), p. 57

7.4—External post-tensioning, p. 59

7.5—Jackets and collars, p. 60

7.6—Supplemental members, p. 61

Special considerations for repair of structural elements, p. 61

7.7—Repair of concrete columns, p. 61

7.8—Repair of concrete beams, girders, and joists, p. 63

7.9—Repair of concrete structural slabs, p. 64

## CHAPTER 8—REFERENCES, p. 65

Authored documents, p. 69

## CHAPTER 1—INTRODUCTION

### 1.1—Guide use

This document provides guidance on removal and preparation, selecting material and application methods for repair, protection, and strengthening of concrete structures. The information is applicable to repairing deteriorated or damaged concrete structures; correcting design or construction deficiencies; and strengthening the structure for new uses or to comply with current, more restrictive building codes.

Current practices in concrete repair are summarized and information provided for the initial planning of repair work and selecting repair materials and methods for various conditions.

### 1.2—Repair methodology

The methodology for repairing a concrete structure typically includes a condition assessment of the structure, designing repairs, developing construction documents, bidding and negotiation processes, and performing the repair work. Preparing a maintenance plan for the repaired structure is also recommended. A basic understanding of the causes of concrete distress, deterioration, or deficiencies is essential to performing meaningful evaluations and completing successful repairs (ACI 364.1R). Once the cause of deterioration or deficiency is determined, the appropriate repair program can be selected to address these conditions. Depending on the cause and extent of the damage, repair is not always warranted.

Assessment of the structure should determine the cause of the deterioration or deficiency and not focus only on the symptoms. For example, cracking can be a symptom of distress that may have a variety of causes, such as restraint

of drying shrinkage, restraint of movement due to thermal cycling, overloading, corrosion of embedded metal, or inadequate design or construction. The cause of distress should be assessed for proper selection and implementation of an appropriate repair program (Fig. 1.2).

**1.2.1 Condition assessment**—The process of repairing a concrete structure starts with the evaluation of existing conditions. The evaluation can be divided into several steps:

a) Reviewing available design and construction documents, previous reports, repair/maintenance records, and test data, if available;

b) Visually examining the existing structure;

c) Performing structural analysis of members in question or the structure in its deteriorated condition;

d) Evaluating corrosion activity;

e) Performing invasive or nondestructive testing, or both;

f) Reviewing physical, chemical, and petrographic analysis results of laboratory-tested concrete samples.

Additional information on conducting condition surveys can be found in ACI 201.1R, 207.3R, 222R, 224.1R, 228.2R, 364.1R, 437R, and 562.

**1.2.1.1 Unsafe conditions**—During the condition assessment, conditions discovered that pose an immediate safety issue should be identified and reported to the owner for mitigation. Local building codes may require that the licensed design professional (LDP) report unsafe conditions to the authorities and typically require that the owner take measures to protect the public safety where hazardous conditions exist. For example, if loose concrete on overhead or vertical surfaces is discovered, access should be limited in the areas adjacent to and below until the hazards are removed or stabilized. If structural members exhibit compromised integrity, these members should be stabilized or the affected areas removed from service.

**1.2.1.2 Global issues**—The performance of a structure depends on maintaining the integrity of the structure and envelope of the building. If the LDP becomes aware of an item of concern outside the assigned scope of work that could compromise the integrity of the structure or jeopardize public safety, the appropriate parties should be notified for implementation of remedial action.

**1.2.1.3 Determination of cause and extent**—During the condition assessment of a structure, the cause of distress, deterioration, or deficiency should be determined. Because many deficiencies are caused by more than one mechanism, a basic understanding of the causes of concrete deterioration is essential to determine what has happened to a particular concrete structure. After completing the assessment, a suitable remedial action plan can be developed, repair applications and materials selected, and contract documents prepared. If a delay occurs between the condition survey and performing the repair work, additional deterioration and distress could occur and consideration should be given to updating the condition survey to minimize variations between estimated and actual quantities of repair work.

**1.2.2 Design considerations**—When designing a concrete repair, strengthening system, or protective system, the LDP should consider the safety and serviceability of the structure