ACI 201.1R-08

Guide for Conducting a Visual Inspection of Concrete in Service

Reported by ACI Committee 201

American Concrete Institute®
Advancing concrete knowledge

First Printing
July 2008

American Concrete Institute®
Advancing concrete knowledge

Guide for Conducting a Visual Inspection of Concrete in Service

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. Proper use of this document includes periodically checking for errata at **www.concrete.org/committees/errata.asp** 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.

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 978-0-87031-290-8

Guide for Conducting a Visual Inspection of Concrete in Service

Reported by ACI Committee 201

Russell L. Hill
Chair

Kevin J. Folliard
Secretary

Jon B. Ardahl*	William G. Hime	Stella Lucie Marusin	Niels Thaulow
Andrew J. Boyd	Charles J. Hookham	Mohamad A. Nagi	Michael D. A. Thomas†
Paul W. Brown	R. Doug Hooton	Robert E. Neal	Paul J. Tikalsky
Ramon J. Carrasquillo	Brian B. Hope	Charles K. Nmai	David Trejo
Rachel J. Detwiler	Donald J. Janssen	Karthik H. Obla	Claude B. Trusty, Jr.
Jonathan E. Dongell†	Roy H. Keck	Robert C. O'Neill	Thomas J. Van Dam†
Per Fidjestol	Mohammad S. Khan	David A. Rothstein	Orville R. Werner, II
Harvey H. Haynes	Kimberly E. Kurtis	Mauro J. Scali	Terry J. Willems
Geoffrey Hichborn, Sr.	Joseph F. Lamond	Hannah C. Schell	Michelle L. Wilson†
Eugene D. Hill, Jr.‡	Michael L. Leming	Jan P. Skalny	

*Subcommittee 201-C Chair during revision.
†Subcommittee 201-C members who revised this guide.
‡Deceased.

This guide provides terminology to perform and report on the visual condition of concrete in service. It includes a checklist of the many details that may be considered in making a report and descriptions for various concrete conditions associated with the durability of concrete.

Keywords: chemical attack; concrete durability; corrosion; cracking; deterioration; discoloration; environments; joints; oxidation; popouts; scaling; serviceability; spalling; staining; surface defects; surface imperfections.

CONTENTS

ACI 201.1R-08 supersedes ACI 201.1R-92 (Reapproved 1997) and was adopted and published July 2008.

CHAPTER 1—INTRODUCTION

1.1—Scope

This is a guide for a visual inspection of concrete in service. A visual inspection is an examination of concrete to identify and define many of the various conditions concrete may exhibit during its service life. The visual inspection is typically limited to the surfaces of the concrete structure that are visually accessible.

1.2—Introduction

By completing a visual inspection of the concrete immediately after construction, and through repetition at intervals during the concrete's service life, the visual inspection provides important historical information on performance and durability. The inspection results also aid in early detection of distress and deterioration, enabling repair or rehabilitation before replacement is necessary.

It is important that the inspector properly document any observations related to environmental and loading conditions. Inspections are often supplemented with nondestructive tests, destructive tests, and other investigations, especially when distress and deterioration is observed and information regarding the internal condition of the concrete is needed.

While a visual inspection is most often used in connection with the condition survey of concrete that is showing defects or some degree of distress, its application is recommended for all concrete structures. It is important that the inspector properly document any observations related to environmental exposure (effects from physical loads, deformations, defects, imperfections, and distress), durability, and performance. Concrete material records and construction practices should be collected and reviewed.

The checklist includes items that might have a bearing on the durability and performance of the concrete. Individuals making the survey should not limit their investigation to the items listed, but should review any other contributing factors. Following the guide does not eliminate the need for intelligent observations and the use of sound judgment.

Individuals performing the inspection should be experienced and competent in concrete condition surveys. In addition to written descriptions, sketches of relevant features are valuable and encouraged. Photographs, including a scale to indicate dimensions, are of great value in showing the condition of concrete. Video coverage should be considered for documentation as it provides an enhanced visual dimension that may exceed that of still photography.

The descriptions and photographs provided in Chapter 2 illustrate typical observations encountered during inspections and aid in the preparation of a condition survey report by identifying the characteristics of potential problems and describing their condition. The checklist in Chapter 3 is provided to assist the user to identify the characteristics of potential condition survey findings and their description.

1.3—References

This guide should be used in conjunction with *ACI Concrete Terminology* and the following American Concrete Institute documents.

201.2R Guide to Durable Concrete

207.3R Practices for Evaluation of Concrete in Existing Massive Structures for Service Conditions

224.1R Causes, Evaluation, and Repair of Cracks in Concrete Structures

228.1R In-Place Methods to Estimate Concrete Strength

228.2R Nondestructive Test Methods for Evaluation of Concrete in Structures

311.1R ACI Manual of Concrete Inspection (SP-2)

349.3R Evaluation of Existing Nuclear Safety-Related Concrete Structures

350.1 Tightness Testing of Environmental Engineering Concrete Structures

364.1R Guide for Evaluation of Concrete Structures Before Rehabilitation

437R Strength Evaluation of Existing Concrete Buildings

This guide should also be used in conjunction with the following documents for condition assessment of structures:

1. American Society for Civil Engineers, "Guideline for Structural Condition Assessment of Existing Buildings," SEI/ASCE 11-99, ASCE, Reston, VA, 2000, 160 pp.

2. American Society for Civil Engineers, "Guideline for Condition Assessment of the Building Envelope," SEI/ASCE 30-00, ASCE, Reston, VA, 2000, 64 pp.

3. Mufti, A., "Guideline for Structural Health Monitoring," *Design Manual* No. 2, ISIS Canada, Winnipeg, MB, 2001.

4. AASHTO, "Guide Specifications for Strength Evaluation of Existing Steel and Concrete Bridges," AASHTO, Washington, DC, 1989.

5. "Diagnosis of Deterioration in Concrete Structures," *Technical Report* No. 54, The Concrete Society, Blackwater, Camberley, UK, 2000.

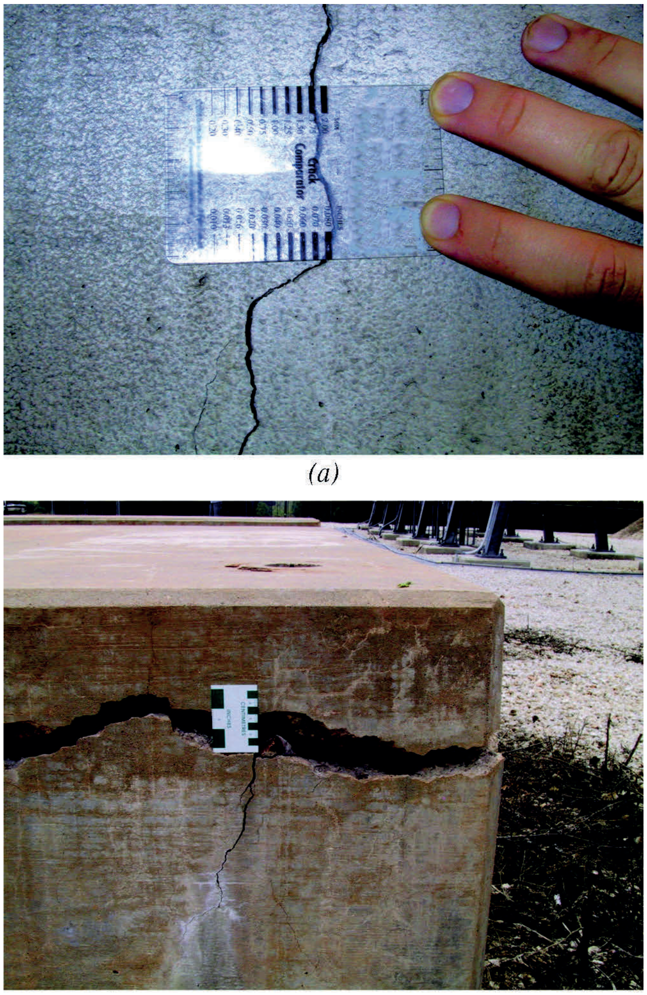
6. "Corrosion of Steel in Concrete: Investigation and Assessment" *BRE Digest* 444, Part 2, in *Concrete Repair Manual*, American Concrete Institute, Farmington Hills, MI, 2003, 2093 pp.

7. AASHTO, *Manual for Condition Evaluation of Bridges*, second edition, AASHTO, Washington, DC, 2003.

8. "Distress Identification Manual for the Long-Term Pavement Performance Project," *Strategic Highway Research Program* SHRP-P-338, Federal Highway Administration, Washington, DC, 1993.

CHAPTER 2—DESCRIPTIONS OF DISTRESS

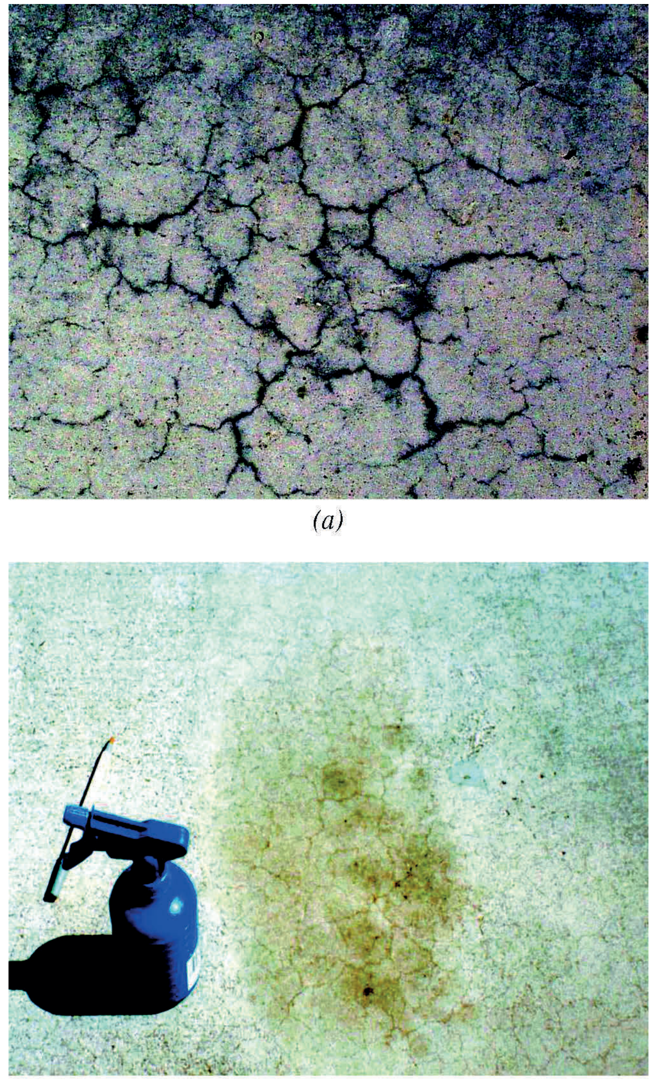
Imperfections and distresses have been categorized and illustrated by photographs, and their severity and extent of occurrence have been quantified where possible. The purpose of the photographs is to standardize the reporting of the condition of the concrete in a structure. Those performing the survey should be thoroughly familiar with the terminology of various types of imperfections and distresses. Figures are provided to illustrate the various types of defects and distresses, along with the cause of deterioration when known.



(a)

(b)

Fig. 2.1.1—Cracks of varying widths.



(a)

(b)

Fig. 2.1.2.2(a) Craze cracking; and (b) craze cracking highlighted with the aid of denatured alcohol.

2.1—Cracking

Crack—a complete or incomplete separation, of either concrete or masonry, into two or more parts produced by breaking or fracturing.

Cracking of concrete should be reported based on crack widths and the type of crack.

2.1.1 *Crack widths*—Examples of cracks of varying widths are shown in Fig. 2.1.1(a) and (b).

2.1.2 *Crack patterns*

2.1.2.1 *Checking*—development of shallow cracks at closely spaced but irregular intervals on the surface of plaster, cement paste, mortar, or concrete. (See also *cracks* and *crazing*.)

2.1.2.2 *Craze cracks*—fine random cracks or fissures in a surface of plaster, cement paste, mortar, or concrete (Fig. 2.1.2.2(a) and (b)).

2.1.2.2.1 *Crazing*—the development of craze cracks; the pattern of craze cracks existing in a surface. (See also *checking* and *cracks*.)

2.1.2.3 *D-cracks*—a series of cracks in concrete near and roughly parallel to joints and edges (Fig. 2.1.2.3(a) and (b)).

2.1.2.4 *Diagonal crack*—in a flexural member, an inclined crack, caused by shear stress, usually at approximately 45 degrees to the axis; or a crack in a slab, not parallel to either the lateral or longitudinal directions (Fig. 2.1.2.4(a) and (b)).

2.1.2.5 *Hairline cracks*—cracks in an exposed-to-view concrete surface having widths so small as to be barely perceptible.

2.1.2.6 *Longitudinal cracks*—a crack that develops parallel to the length of the member.

2.1.2.7 *Map cracking*—1) intersecting cracks that extend below the surface of hardened concrete; caused by shrinkage of the drying surface concrete that is restrained by concrete at greater depths where either little or no shrinkage occurs; vary in width from fine and barely visible to open and well-defined; or 2) the chief symptom of a chemical reaction between alkalis in cement and mineral constituents in aggregate within hardened concrete; due to differential

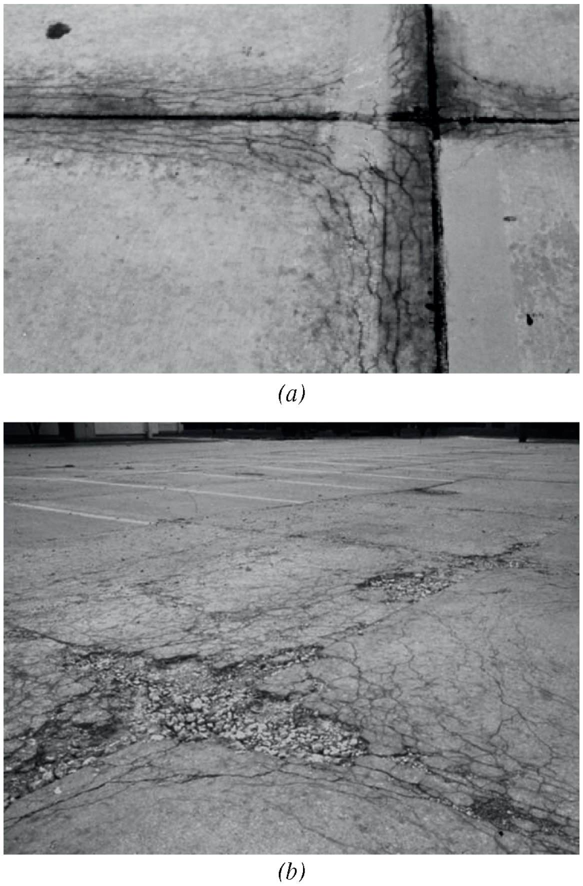


Fig. 2.1.2.3—D-cracks: (a) fine; and (b) severe, with spalling present.

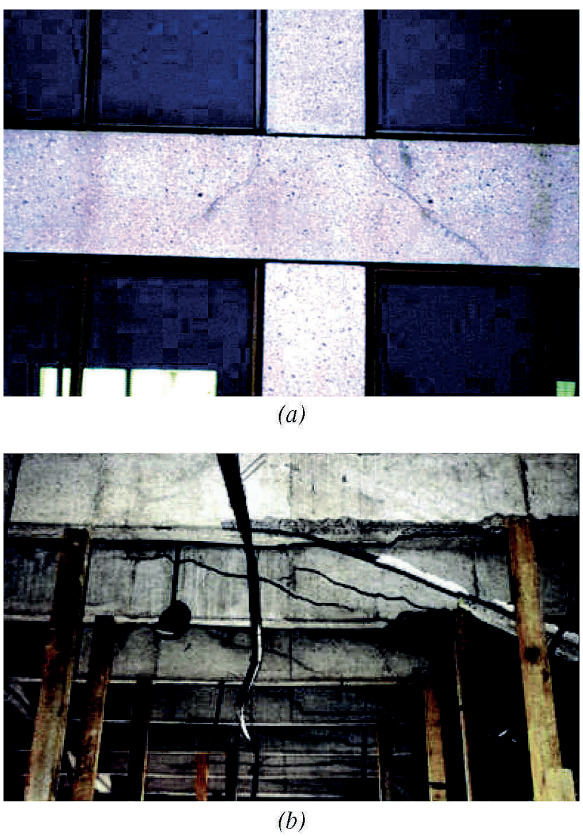


Fig. 2.1.2.4—Diagonal cracking.

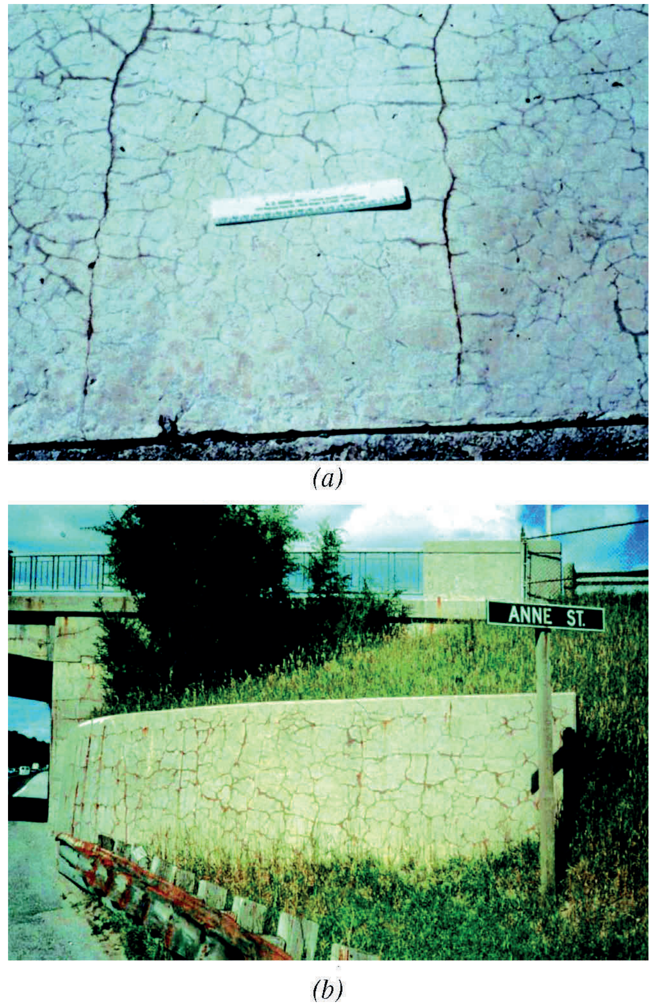


Fig. 2.1.2.7—Map (pattern) cracking.

rate of volume change in different members of the concrete; cracking is usually random and on a fairly large scale and, in severe instances, the cracks may reach a width of 12.7 mm (0.50 in.) (Fig. 2.1.2.7(a) and (b)). (See also *checking* and *crazing*; also known as *pattern cracking*.)

2.1.2.8 *Pattern cracking*—cracking on concrete surfaces in the form of a repeated sequence; resulting from a decrease in volume of the material near the surface, or an increase in volume of the material below the surface, or both. (See *map cracking*.)

2.1.2.9 *Plastic shrinkage cracking*—cracking that occurs in the surface of fresh concrete soon after it is placed and while it is still plastic (Fig. 2.1.2.9(a) and (b)).

2.1.2.10 *Random cracks*—uncontrolled cracks that develop at various directions away from the control joints.

2.1.2.11 *Shrinkage cracking*—cracking of a structure or member due to failure in tension caused by external or internal restraints as reduction in moisture content develops, carbonation occurs, or both (Fig. 2.1.2.11).

2.1.2.12 *Temperature cracking*—cracking due to tensile failure, caused by temperature drop in members subjected to external restraints or by a temperature differential in members subjected to internal restraints (Fig. 2.1.2.12).