

ACI 364.1R-19

Guide for Assessment of Concrete Structures before Rehabilitation

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Guide for Assessment of Concrete Structures before Rehabilitation

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Guide for Assessment of Concrete Structures before Rehabilitation

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This guide presents general procedures for assessment of concrete structures before rehabilitation. Among the subjects covered are preliminary assessment, detailed assessment, review of documentation, field observation and condition survey, sampling and material testing, evaluation, and final report. Evaluation to identify seismic or building code deficiencies is beyond the scope of this guide.

Keywords: assessment; condition survey; deterioration; distress; investigation; rehabilitation; sampling; testing.

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CHAPTER 1—INTRODUCTION AND SCOPE**1.1—Introduction**

The guide outlines the approach and general procedures for the assessment of concrete structures before rehabilitation. This guide should be used in conjunction with **ACI 562**. An assessment, prior to rehabilitation, is generally performed for one or more of the following purposes:

- a) Evaluate the current condition of a structure
- b) Evaluate the extent of deterioration due to environmental conditions
- c) Evaluate structural damage or distress due to applied loadings and support displacements
- d) Verify the structural adequacy and integrity of a structure or selected members within a structure
- e) Assess the capacity of a structure to accommodate increased loads
- f) Determine the feasibility of changing the use of a structure
- g) Modify or restore a structure
- h) Change the appearance of a structure
- i) Estimate the remaining service life of a structure (**ACI 365.1R**)
- j) To assess the safety and structural capability of the structure to support the repair activities and to identify temporary support requirements.

The objective of the condition assessment is to determine the need, type, and extent of the rehabilitation, and to develop the goals of the project. As the initial planning activity, the assessment can also help identify operational and economic requirements that impact the rehabilitation plan.

1.2—Scope

The purpose of this guide is to provide general procedures for the assessment of concrete structures before rehabilitation. Evaluation of structures other than concrete buildings is beyond the scope of this guide, although the approach for condition assessment for such structures may be similar to those outlined in this guide.

This guide is general in character and intended to provide an approach for assessment of a concrete structure to meet one or more of the objectives listed in 1.1. The owner and licensed design professional should understand and agree on the objectives and goals of the assessment prior to the start of the assessment.

The first step in the assessment is the investigation and concludes with the evaluation, at either a preliminary or detailed level, depending upon the project requirements. After completion of the preliminary assessment, a detailed assessment can proceed if deemed desirable or necessary. Assessments generally involve four major tasks: 1) reviewing available pertinent documents; 2) performing field observations and condition assessments; 3) sampling and material testing; and 4) evaluation and structural analysis. Based on results of the investigation, evaluation and analysis can be performed and the results summarized in a report. The flowchart in Fig. 1.2 identifies the methodology and major tasks that are commonly undertaken in an assessment conducted before rehabilitation.

CHAPTER 2—DEFINITIONS

Please refer to the latest version of ACI Concrete Terminology for a comprehensive list of definitions. Definitions provided herein complement that resource.

assessment—process of investigating by systematically collecting information that affects the performance of an existing structure; evaluating the collected information to make informed decisions regarding the need for repair or rehabilitation; detailing of findings as conclusions and reporting recommendations for the examined structural concrete work area (member, system, or structure).

damage—changes in capacity of an existing structure resulting from events, such as loading and displacements.

deterioration—1) physical manifestation of failure of a material; 2) decomposition of material either during testing or exposure to service.

distress—physical manifestation of cracking and distortion in a concrete structure as a result of stress, chemical action, or both.

evaluation—process of determining and judging the structural adequacy of a structure, member, or system for its current intended use or performance objective.

investigation—collection and review of field data for the structure, such as geometry, material properties, conditions, symptoms of distress, extent of damage, measurement of displacements, environmental factors, and reinforcement sizes and placement. Also includes the collection of background data, such as plans, construction records, original and current codes governing existing buildings, and historical events.

rehabilitation—repairing or modifying an existing structure to a desired useful condition.

repair—reconstruction or renewal of concrete parts of an existing structure for the purpose of its maintenance or to correct deterioration, damage, or faulty construction of members or systems of a structure.

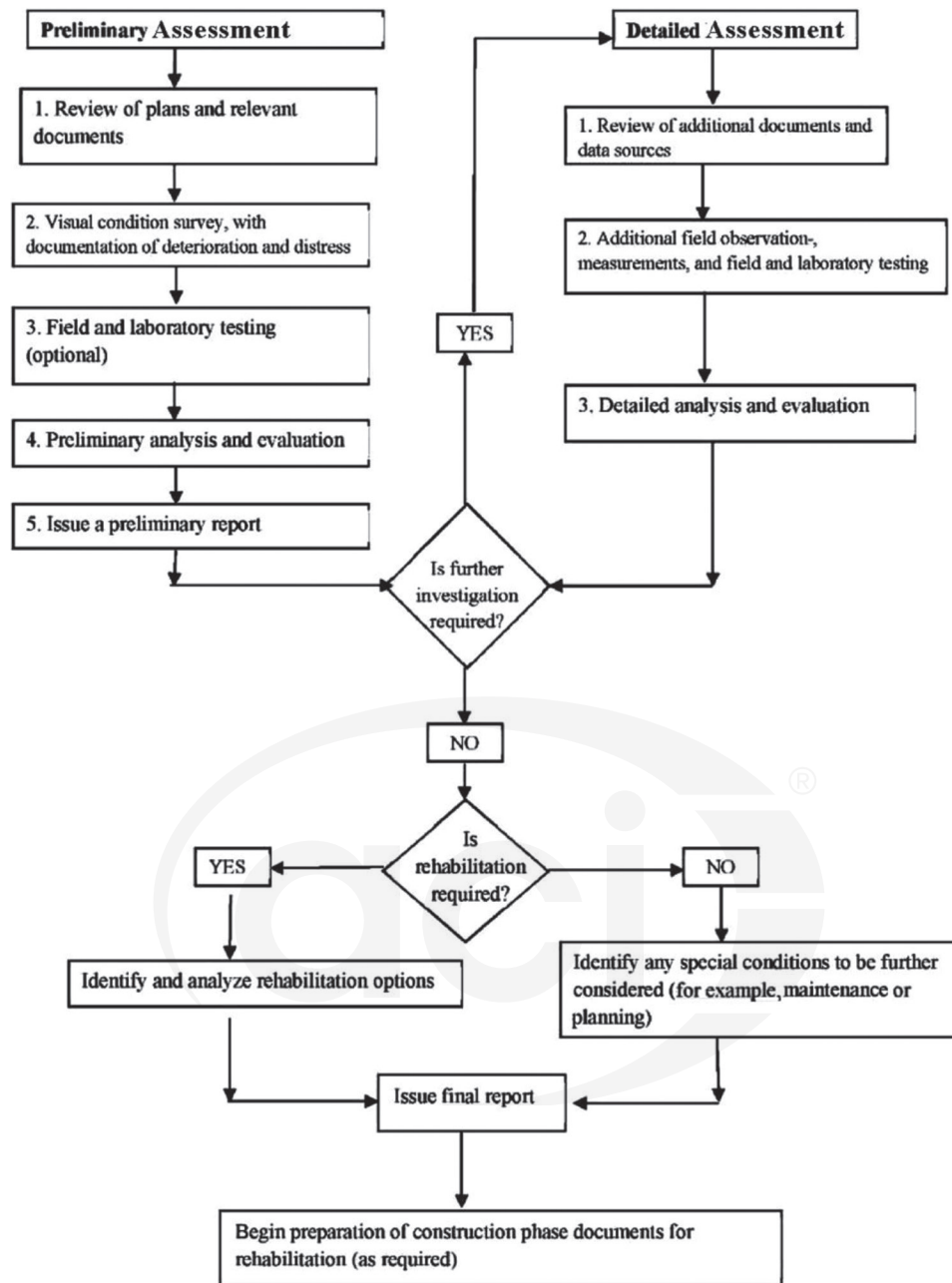


Fig. 1.2—Assessment methodology.

CHAPTER 3—INVESTIGATION

3.1—Introduction

The goal of an investigation is to gather information regarding the existing condition of a structure. An investigation should identify the type and extent of conditions affecting the structure's behavior, performance, or intended function. The investigation should also provide the owner information to assist in the assessment of the feasibility of the required or intended rehabilitation.

Before beginning the investigation, the owner should be consulted and project requirements considered to determine whether a preliminary or detailed investigation is appropriate.

If the original construction, condition of the structure, or similar items are unknown or undocumented, a preliminary investigation may be needed to determine the scope of the investigation. Due to the nature of concrete structures, as-built and existing conditions are frequently hidden beneath the surfaces of the concrete members and not fully known. As a result, the preliminary assessment may not discover these conditions and may not provide sufficient information to fully evaluate the concrete structure. To better evaluate these conditions, a detailed assessment may be needed. Findings of the preliminary and detailed assessments are used in the assessment process, consideration of the various rehabilitation options, and estimation of associated costs.

A scope of work agreed on between the owner and licensed design professional to perform the assessment is recommended, stating the objectives and extent of the assessment. In some cases, the owner and licensed design professional should meet with government agencies to confirm building code(s) of record, historical preservation needs, timelines for code official review of permit application and drawings, anticipated materials of use (especially if newer materials such as carbon fiber reinforcement are being contemplated), and use of special inspections.

If significant distress is observed, the licensed design professional should contact the owner regarding use of the structure, need for an immediate repair, and temporary shoring or stabilization of the observed component or structure experiencing distress. **ACI 562** provides direction on measures to be taken, recommendations to be issued, and requirements.

3.2—Assessment: overview

The assessment should comply with code requirements for concrete structures as described in **ACI 562**.

Preliminary and detailed assessments (Fig. 1.2) often include:

- (a) Document review
- (b) Field investigation
- (c) Sampling and material testing
- (d) Evaluation and analysis
- (e) Reporting

3.3—Preliminary assessment

The preliminary assessment helps to develop an initial understanding of the concrete structure's behavior, condition, and existing performance in consideration of the established objectives for performing the rehabilitation. A preliminary assessment is typically limited to accessible components that are visible or detectable without exploratory openings or specialized equipment. Condition assessment below the concrete surface or concealed components is generally not included in the preliminary assessment. Although concrete sampling (coring) and testing may be included, more often they are deferred to be part of a detailed assessment.

Preliminary assessments are general in nature and may extrapolate or estimate conditions and quantities based on selective examinations in limited locations. The preliminary assessment may provide recommendations for a detailed assessment that includes more comprehensive examinations to achieve the established objectives.

A preliminary assessment may include review of existing construction documents and drawings, visual assessment of the concrete components, obtaining a general understanding of existing conditions, and evaluating the need and priority for a detailed assessment. Localized sampling or testing may also be performed (**Chapters 3 through 6**), but this is more typically performed in the detailed assessment (Fig. 3.3).

A detailed assessment will not be necessary when proposed usage changes involve the same or similar design loads, where extensive documentation on the construction and maintenance of the structure exists, or where minimal



Fig. 3.3—Localized sampling during a preliminary assessment (photo courtesy of Wiss, Janney, Elstner Associates, Inc.).

distress and no unusual conditions exist. In other cases, it may not be needed to proceed with a further detailed assessment, as in the case of significant damage where the structural integrity cannot be economically restored, where it becomes obvious that the owner's objectives cannot be satisfactorily met, or when there is sufficient information gathered in the preliminary assessment to proceed with rehabilitation.

3.4—Detailed assessment

A detailed assessment is performed when the preliminary assessment has identified a need for a more in-depth assessment of the concrete structure's behavior or condition to meet the assessment objectives of **1.1**. The detailed assessment may include additional assessment of the concrete structure, modification of the assessment strategy, and more comprehensive technical and cost analyses. A detailed assessment may be required for the structure as a whole, or for a specific component.

If the preliminary assessment results led to the need for a detailed assessment, it is important to reevaluate the owner's objectives and goals before beginning the detailed assessment. A supplemental scope of work stating the objectives and extent of the detailed assessment is recommended.

CHAPTER 4—DOCUMENT REVIEW

4.1—Introduction

The first step in performing an assessment of a concrete structure is to review available information related to the construction, alterations, repair, and maintenance of the structure. This review process allows the licensed design professional to become familiar with the design of the structure and its evolution over time as part of the assessment, and to minimize the assumptions required to properly evaluate the structure. Information gathered from the document review should be verified during assessment of the structure. The type of structure, type and extent of deterioration, scope of the rehabilitation project, and availability of documents

tion will dictate the nature and quantity of information that should be reviewed. In some cases, documentation may not be available and a detailed assessment (possibly including nondestructive testing, material sampling, and laboratory material studies) may be necessary.

4.2—Design information

4.2.1 Documents and other sources that may contain useful information include:

- a) Construction documents, including drawings, specifications, addenda, submittals, change orders, calculations, and other project correspondence
- b) Shop drawings for formwork, reinforcement, and concrete placement
- c) Quality control records and testing
- d) As-built drawings, photographs, job field records, test data, and correspondence
- e) Construction documents for previous modifications or alterations
- f) Manufacturer's technical information, descriptions of construction materials, patents, and test data
- g) Textbooks available at the time of design
- h) Documentation of prior repairs and maintenance, prior studies, or other history
- i) Design and building codes in effect at the time of design and construction of the structure and any modifications or alterations
- j) Interviews with owner, building manager, and building engineer
- k) Other potential sources for older structures, such as historic handbooks, historic catalogs, standards, newspaper clippings, photographs, and historic structures reports

Information regarding original construction or alterations may be obtained from the owner, the architect or engineer of record, local building departments or regulatory agencies for the governmental entity in which the structure is located, the general contractor, subcontractors, manufacturers, fabricators, and suppliers. Local building department records may be valuable in locating construction documents from an alteration and other related records, such as inspection reports or violation notices. Although gathering all the information listed may not be required for typical assessment and rehabilitation projects, it could be required for more complex and unusual projects.

4.2.2 Historic structures—Buildings may be designated as historic structures at several jurisdictional levels including federal, state, or local, with each jurisdictional entity establishing its own standards and requirements for reviews associated with preservation and rehabilitation. Often, the governing standards have varying requirements and specific definitions that need to be reviewed and considered for each structure.

When working on older structures, it is important to relate the structural system used in the project to the design and construction practices existing at the time of construction. Fortunately, for many older structural designs, there is a substantial amount of available information about design and construction practice in the era being considered.

Historic concrete structural systems were often developed in a competitive commercial atmosphere. Therefore, there were many proprietary reinforcement and forming systems, including many reinforcing bar deformation patterns that were protected by patents and illustrated in catalogs and by trade organizations. Not only were design calculations often presented in tabular form, but the strength of the system was validated by load tests, and the results of tests included in the catalogs. Early textbooks and handbooks, which also include much of this information, are especially helpful. Newspaper clippings and old photographs that describe or illustrate the structural system, construction, or both, of a structure may be helpful during the process of planning for the preservation of historic structures. If a historic structures report has been developed for the project structure, it may contain additional helpful information about the structural system and construction.

4.3—Materials information

Information on original construction and repair and maintenance materials may be available, especially for more recently constructed structures, from the following sources:

- (a) Original construction and repair project specifications and drawings
- (b) Submittals for concrete mixtures, components, and quality control test results
- (c) Submittals for reinforcing and prestressing steel
- (d) Ready mixed concrete supplier historical data on specific mixtures used
- (e) Manufacturers' technical information, installation instructions, and description of construction materials at the time of original construction
- (f) Manufacturers' technical information, installation instructions, and description of repair materials and maintenance materials used on the structure

4.4—Construction information

Construction documents and other records from original construction may be helpful in understanding the construction methods, materials, basis of design, and difficulties encountered during construction; however, it is important to understand that the as-built conditions may vary from those shown in original drawings and specifications. This information is valuable in the assessment process. The following records may be available:

- a) Correspondence, including requests for information and change orders, between members of the construction team, design team, and owner or developer
- b) Concrete batch tickets and truck tickets
- c) Results of tests on fresh and hardened concrete
- d) Quality control data and field inspection reports by a testing agency or others
- e) Drawings and specifications kept on the job, including modifications and change orders
- f) Diaries or journals kept by the construction team, contractor daily field reports, or construction observation reports from owner's representative
- g) Job progress photographs

- h) As-built drawings
- i) Survey notes and records
- j) Inspection records
- k) Material test reports for structural materials used
- l) Information concerning the foundation and soil-bearing capacity, including:
 - i. Geotechnical reports prepared before construction
 - ii. Allowable pressures and foundation type used in the design
 - iii. Soil and foundation work, including backfill and compaction conducted during construction
 - iv. Location of the water table during construction

Pile-driving records and pile cap modification drawings may be helpful. The geotechnical and foundation records may be useful when foundation loadings are to be increased during the rehabilitation, or whenever evidence of foundation movement has been noted. Local geotechnical engineers may be aware of geotechnical and groundwater information for recently built and adjacent structures.

Other possible sources of information regarding recently constructed or repaired structures may be the construction company and owner's representative. More information is often obtained through a personal interview with involved personnel (for example, the construction superintendent). Local newspaper and trade publications may also have provided coverage of the original construction.

4.5—Service history

Documents that relate to the structure's service history should be reviewed to learn as much as possible about the maintenance of the structure and distress, damage, deterioration, and subsequent repairs that have occurred.

The types of information that may be available include:

- a) Records of current and former owners or users of the structure
- b) Maintenance, repair, and remodeling records
- c) Reports from previous assessments or inspections
- d) Reports maintained by owners of adjacent structures
- e) Weather records during construction or storm
- f) Interviews with operation and maintenance personnel
- g) Logs of seismic activity or geologic activity
- h) Insurance reports and records of damage to the structure by fire, wind, snow, water intrusion and floods, overloads, impact, earthquake, or fatigue
- i) Information on operation, occupancy, instances of overloading, and load limits
- j) Records from government or local building departments or departments of licenses and inspection, including inspection reports and reports of violations
- k) Photographs
- l) Local newspapers and trade publications
- m) Documented observed or previously assessed condition

4.6—Project documents

After the project documents are obtained, organizing and cataloging them for present and future use is beneficial for the licensed design professional, owner, contractor, and future users of the building documents.

When original construction documents or repair project documents are not available, the assessment should compensate for the missing information, such as by recording accurate dimensions for structural components, analyzing materials, and locating reinforcing steel through use of nondestructive testing or exploratory openings, as further described in following chapters.

CHAPTER 5—FIELD INVESTIGATION

5.1—Introduction

The field investigation includes observations to verify the accuracy of information obtained from the document review (Chapter 4), together with a condition survey to assess the existing physical condition of the as-built structure. The field investigation is usually carried out by performing the following three tasks:

- a) Preparation and planning
- b) Field verification of as-built construction
- c) Condition survey of the structure

The scope of the field investigation is determined by the project requirements and may need to be phased or refined to meet available schedule and funding constraints. The extent of each of these tasks should be based on existing condition of the structure and the scope of the rehabilitation project. In addition, also consider the type, size, complexity, age, architectural or historic significance, as well as the intended future use of the structure.

If the field evaluation is conducted after a natural disaster, such as a catastrophic wind, seismic, snow, fire, or flood event, review of applicable industry guides or standards such as requirements, [ATC-20-1](#), [ATC-45](#), [ASCE/SEI 31](#), and local governing ordinances is recommended.

5.2—Preparation and planning

Planning for the initial investigation usually begins with a meeting with the owner. The planning meeting can include a discussion of the structure's history, known conditions, as well as prior and current maintenance protocols. The owner can describe access to the facility and express their expectations and concerns. The licensed design professional can then explain in detail the scope of the assessment and anticipated impact of the survey on the structure.

Access and safety during the work for users of the facility, passers-by, as well as those conducting the field investigation and testing should be discussed during preparation and planning. Use of building space or vehicular traffic may have to be barricaded or cordoned off temporarily to accommodate survey and testing operations. Pedestrian or vehicular protections may need to be temporarily installed.

Some structures or portions of structures may be considered confined spaces or require specialized equipment for access. Preliminary planning should also include a review of the site to establish general local conditions and determine if special access equipment or permits are required, if any finishes have to be removed for access, if services of subcontractors are required to provide the equipment, means of access, or if specialized inspection services such as