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ASCE Standards on Structural Condition Assessment and Rehabilitation of Buildings

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ABSTRACT: The American Society of Civil Engineers (ASCE) Committee on Structural Condition Assessment and Rehabilitation of Buildings prepares standards in three areas; structural condition assessment, assessment of the building envelope, and assessment of buildings for seismic considerations. The first standard completed is ASCE 11-90 *Standard Guideline for Structural Condition Assessment of Existing Buildings*. Current work of the committee includes revising ASCE 11, drafting a standard on assessment of the building envelope, and conversion of various documents of the Federal Emergency Management Agency (FEMA) related to seismic evaluation of buildings to standards.

KEYWORDS: preservation, rehabilitation, standards, building technology, buildings, evaluation

The American Society of Civil Engineers (ASCE) Committee on Structural Condition Assessment of Buildings was established in 1982 based on a request from the Building and Fire Research Laboratory (BFRL) of the National Institute of Standards and Technology (NIST). Research at NIST in the late 1970s identified the need for technical guidelines for those involved with assessing the structural condition of existing buildings. ASCE was ideally suited to undertake this task because its membership included related civil engineering disciplines: structural, materials, construction, and geotechnical engineering. The committee operates under ASCE regulations for standards committees that require a balance in representation of producers, users, and general interest members when balloting takes place. Balance is not required of individual subcommittees for balloting purposes.

The results of this standardization effort culminated in the publication of ASCE 11 *Standard Guideline for Structural Condition Assessment of Existing Buildings* in 1990 [*1*].

The scope of the committee was expanded in 1990 to include two new activities: seismic rehabilitation and assessment of the exterior envelope. The committee title was changed to Structural Condition Assessment and Rehabilitation of Buildings and the following revised scope was adopted: "To identify engineering issues, develop solutions, and prepare consensus standards for the condition assessment and rehabilitation of buildings. This will include the assessment of the condition of materials, components and systems; identification of risks and setting of priorities; and selection and implementation of strengthening techniques."

The committee was restructured to include three subcommittees: Subcommittee on Structural

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Condition Assessment of Existing Buildings, Subcommittee on Condition Assessment of the Building Envelope, and Subcommittee on Seismic Rehabilitation of Buildings.

The purpose of this paper is to describe the specific activities of these subcommittees and how the results of their efforts will promote the preservation and rehabilitation of structures.

Subcommittee on Structural Condition Assessment of Existing Buildings

This subcommittee is responsible for maintaining and updating ASCE 11 that provides guidelines and a methodology for assessing the structural condition of existing buildings constructed of concrete, metals, masonry, and wood. The standard was prepared as a guideline in that it provides general guidance to engineers in preparing comprehensive information for clients such as building owners, prospective purchasers, tenants, regulatory officials, and others. ASCE 11 is not intended for regulatory reference, because it is not written in mandatory language.

The process of assessing the structural condition of a building consists of assembling and systematically analyzing information and data regarding the building in order to determine structural adequacy. The standard establishes an assessment procedure, including the potential scope of the investigation, testing and other assessment methods, and the format of the report of the condition assessment.

The general structural assessment and evaluation procedure recommended in ASCE 11 is shown in Fig. 1. The scope and intent of the standard and general definitions are included in Chapter 1, and Chapter 2 provides nonmaterial specific information on assessment procedures. Due to the potential cost of a comprehensive structural assessment of a building, a multilevel approach is recommended. As is evident in Fig. 1, the basic process entails a preliminary assessment followed by a detailed assessment, if required. The preliminary assessment provides the initial analytical data for estimating the structural adequacy of an existing building and for establishing the need and priority for a more detailed analysis. A detailed assessment is performed if the need is determined by the findings of the preliminary assessment or if required by regulators or the client. The results of the detailed assessment are summarized in a report with a recommended course of action, for example, accept the building as-is, strengthen to correct deficiencies identified, change the use of the building, or phase the building out of service. Cost studies may be needed in making these decisions.

Chapter 3 contains information on concrete, masonry, metals, and wood including physical properties (strength, chemical composition, etc.) and physical conditions (discoloration, deterioration, etc.) requiring assessment, and available assessment test methods. Descriptions of these test methods are presented in a tabular format shown typically in Table 1 for concrete. For each test method listed, information is given on possible applications, principles of operation, user expertise required, advantages of the method, and limitations of operation. Additionally, references are provided where more information can be obtained.

Chapter 4 contains guidance on the evaluation of structural materials and systems based on data collected during the assessment. ASCE 11 recognizes that final decisions are made by qualified experts who must ultimately take professional responsibility. To assist in the evaluation the condition assessment methods and supporting references are related to the material properties and physical condition using a matrix format shown typically in Fig. 2. Assessment procedures are listed on the horizontal axis, and the physical conditions or material properties are shown on the vertical axis. Intercepts indicate the availability of an assessment method for the condition or property.

Chapter 5 provides guidance on preparing the report of the structural condition assessment. The level of detail in the report will vary depending on the scope of the condition assessment.

Under ASCE regulations for standards committees, ASCE 11 must be reviewed, revised if

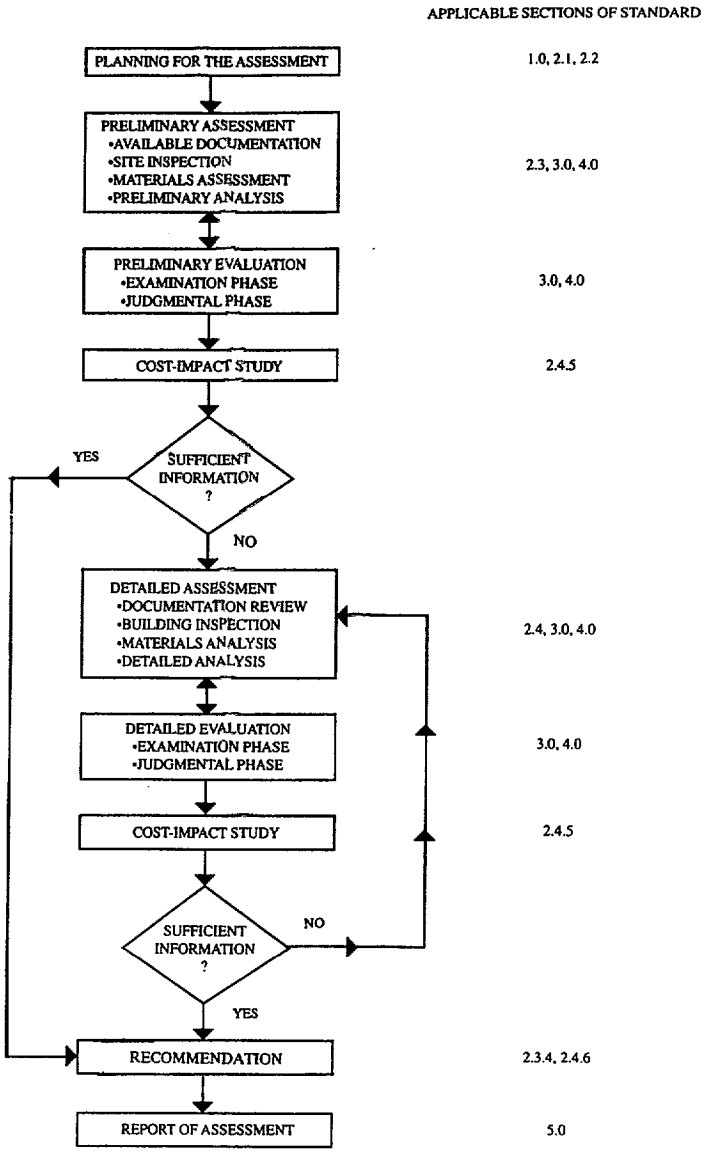

FIG. 1—*General structural assessment and evaluation procedure for existing buildings* [1].

necessary, and reconfirmed by 1995. This review is underway by the subcommittee and the following improvements are being planned:

1. Assessment methods and references will be updated.
2. Illustrations (photographs, sketches, etc.) of structural problems will be added.
3. Additional information on evaluation methods will be included.

Subcommittee on Condition Assessment of the Building Envelope

Rationale for Activity

General aging of the building stock, failure of some materials, systems and application techniques, and inadequate maintenance contribute to the deterioration of the building envelope. "Building envelope" is defined as the exterior surface of a building providing protection from the weather. This deterioration process often results in the need for costly rehabilitation work if not addressed immediately.

Concern for public safety is often the motivation for repairs to building envelopes. Pieces falling from cornices, walls, and ornamentation have resulted in facade inspection regulations in some of the larger U.S. cities. More stringent requirements have been incorporated into the model building codes to reflect increased wind, snow, and seismic design loadings for which many existing buildings were not designed. These loads apply to both the building structure and its cladding.

Relatively little has been written with respect to the methodology of assessing the condition of the building envelope as a whole. At the time of completion of ASCE 11, there was no standard available for this purpose, and the committee was not aware of any organization developing such a document. Much of the rehabilitation of building exteriors was being done without the guidance of a collective knowledge of experts. The committee determined that a standard for the condition assessment of the building envelope similar to ASCE 11 would be of considerable value, and work was initiated.

Scope of Subcommittee Activities

The new Subcommittee on Condition Assessment of the Building Envelope was authorized by ASCE in 1990. The objective of the subcommittee is to identify needs and to develop standard guidelines containing procedures for the condition assessment of the envelope of existing buildings, and to compile the gathered information into a written document available as a reference resource for practitioners in this field. The initial meeting was in the fall of 1990 and since then the subcommittee has met twice a year in conjunction with national meetings of the ASCE. Members of the committee include architects, engineers, and architectural conservators. Various interests are represented including building assessors, consultants, regulatory officials, code officials, and Federal, state, and local government representatives.

For coordination of efforts and direction, ASTM Committee D8 on Roofing, Waterproofing, and Bituminous Materials; and ASTM Committee E6 on Performance of Building Constructions have been invited to participate and are being kept advised of subcommittee activities.

Scope of the Standard

The subcommittee began with a format paralleling ASCE 11 and focused on materials for various building envelope applications. After much discussion, this was changed to the approach outlined in Table 2 and summarized here.

TABLE 1—*Typical presentation of test methods in ASCE 11-90* [1]; *description of test methods for concrete.*

Method	Applications	Principle of Operation	User Expertise	Advantages	Limitations	References
Acoustic emission	Continuous monitoring of structure during service life to detect impending failure; monitoring performance of structure during proof testing.	During crack growth or plastic deformation, rapid release of strain energy produces acoustic (sound) waves that can be detected by sensors attached to surface of test object.	Extensive knowledge required to plan test and to interpret results.	Monitors structural response to applied load; capable of detecting onset of failure; capable of locating source of possible failure; equipment is portable and easy to operate.	Expensive test to run; can be used only when structure is loaded and when flaws are growing; interpretation of results requires an expert; currently largely confined to laboratory; further work required.	C20, C33, C36
Acoustic impact	Used to detect debonds, delaminations, voids, and hairline cracks.	Surface of object is struck with the frequency, through transmission time, and damping characteristics of resulting sound giving indication of presence of defects; equipment may vary from simple hammer or drag chain to sophisticated trailer-mounted electronic equipment.	Low level of expertise required to use, but experience needed for interpreting results.	Portable equipment; easy to perform; electronic device not needed for qualitative results.	Geometry and mass of test object influence results; poor discrimination; reference standards required for electronic testing.	C33, C36

Core testing	Direct determination of concrete strength; concrete evaluation of condition of aggregate, cement, and other components.	Drilled cylindrical core is removed from structure; tests may be performed on core to determine compressive and tensile strength, torsional properties, static modulus of elasticity, etc.	Obtaining drilled core is routine; moderate level of expertise required to test and evaluate results.	Most widely accepted method to reliably determine strength and quality of in-place concrete.	Process of drilling and analyzing cores is expensive; coring damages structures and many may be required; analysis of cores is time-consuming.	C1, C3, C5, C6, C8, C40
Cover meters/ pachometers	Cover meters measure depth of reinforcement cover in concrete; pachometers measure cover and size of reinforcement, and locations of delaminations	Presence of steel in concrete affects magnetic field of probe; closer probe is to steel, the greater the effect.	Moderate; easy to operate; training needed to interpret results.	Portable equipment, good results if concrete is lightly reinforced.	Difficult to interpret results if concrete is heavily reinforced or if wire mesh is present.	C20, C33

References (C) (see section 3.2.5)	5	13, 32, 33, 37, 42	3	33	2	8	20, 21, 25, 28	14, 18, 33, 44	4, 12	1, 3, 5, 6 8, 40	7, 22, 26, 30, 38, 45, 46, 47	9, 20, 35, 36	31		
Chemical and Physical Properties / Evaluation Procedure	Air Content Test	Cast-in-Place Procedure (Pull-Out Test)	Cement Content Test	Electrical Resistance Measurements	Flexural Tests	Freeze-Thaw Test	Gamma Radiography	Nuclear Moisture Meter	Petrographic Analysis	Tests on Concrete Cores	Ultrasonic Pulse	Windsor Probe	Pull-Off Testing		
Acidity									●						
Air Content	●						●		●						
Alkali-Carbonate Reaction									●						
Alkali-Silica Reaction									●						
Cement Aggregate Reaction									●						
Cement Content			●						●						
Chemical Content									●						
Chloride Content									●	●					
Compressive Strength		●								●	●	●	●		
Contaminated Aggregate									●						
Contaminated Mixing Water									●						
Creep										●					
Density							●			●					
Elongation										●					
Modulus of Elasticity											●	●			
Modulus of Rupture					●										
Moisture Content				●				●							
Permeability									●						

EVALUATION OF PROPERTIES OF CONCRETE

FIG. 2—*Typical presentation of evaluation procedures in ASCE 11-90* [1].

Part I of the standard includes five sections:

1. Section 1.0 includes the scope and intent of the standard, purpose, qualifications, agreements, and general definitions.

TABLE 2—*Outline of the standard for condition assessment of the building envelope* [1].

Outline of Standard
Part I
1.0 General
2.0 Building envelope systems, component features, and materials
3.0 Assessment procedure and field condition assessment
4.0 Evaluation of performance
5.0 Report
Part II
Individual materials, properties, and testing
Part III
Appendix

2. Section 2.0 describes six general envelope categories, their intended functions, and performance criteria.

   (*a*) Roof systems are interacting roof components, exclusive of the roof deck, designed to weatherproof and, normally, to insulate the top surface of a building. Low slope and steep slope systems and materials are included.
   (*b*) Balcony systems are exterior platforms supported at the exterior wall of the building by internal structure, sometimes combined with external supports. Balconies may have a waterproofing component.
   (*c*) Plaza deck systems are structures with a waterproof membrane applied to a horizontal surface that is intended to receive pedestrian or vehicular traffic or landscaping. Some systems employ a wearing surface to protect the membrane.
   (*d*) Bearing wall systems are those supporting any vertical load in addition to their own weight. Therefore, the exterior wall serves a structural function as well as being an enclosure. Various wall types, components, and materials are included.
   (*e*) Non-bearing wall systems are those not intended to support vertical loads other than their own weight, such as curtain walls and panel walls. Various wall types, components, and materials are included.
   (*f*) Foundation wall system is that part of the building envelope partially or wholly in contact with the soil. It is usually a load-bearing wall, often with a waterproofing coating or membrane, and may have a drainage component. Various foundation wall types, components, and materials are included.

   System and component features required to achieve a desired effect or performance are considered next in the assessment. Examples are aesthetic treatment, durability, fire resistance, serviceability, thermal resistance, and water infiltration. These are generally covered by reference to documents prepared by other organizations. Lastly, there is a brief definition of barrier wall systems, cavity wall systems, veneer walls, and rain screen walls.
3. Section 3.0 describes the procedure for the field assessment of the entire building envelope or specific components. This could include field observations, data collection, and on-site testing. This is a systematic procedure beginning with a review of background information and preliminary observations to identify key components and problem areas. All elements of the building envelope may be included in the observations, or they could be limited to specific areas established in the scope of the assessment. A preliminary condition assessment would be made based upon the observations and collected data and, possibly, a cost study. Conclusions and recommendations would be covered in the preliminary report.

   A detailed condition assessment would follow if the need was determined by the pre-

liminary assessment. This would include prioritization of areas to be investigated, detailed exterior and associated interior observations, probes, and field and laboratory testing. Detailed findings, conclusions, cost impact studies, and recommendations would be summarized in a report to the client.

4. Section 4.0 is intended to include analysis of collected data and evaluation of the performance of the systems, components, and materials. This section has been deferred and may evolve into a different form as the standard is prepared.
5. Section 5.0 is a guideline for preparing the report of the condition assessment. The report for a preliminary assessment will be limited to the scope of that engagement, while that for a detailed assessment will be more comprehensive in content.

Part II of the standard will include information on individual materials including properties, test methods, and references where more detailed information may be found. Descriptions of assessment methods will be shown in a tabular format similar to that used in ASCE 11.

Part III will include appendices of supporting information.

Status of Standard

The subcommittee met in April 1993 where the following progress was reported:

1. Sections 1.0 and 5.0 are basically the same as found in ASCE 11-90 except modified somewhat in response to recommendations by subcommittee members.
2. Section 2.0 has been outlined and revised in accordance with subcommittee discussion. Text has been developed and submitted for subcommittee review.
3. Section 3.0 was approved in outline form and the text is being written.
4. Section 4.0 has been deferred until the other sections are further advanced.
5. Work has begun on Part II that will be a formidable task entailing considerable time and effort.
6. Part III will be prepared after the other parts of the standard are finished.

The goal of the subcommittee is to complete the ASCE consensus process in a timely manner so that the document will be available as a reference resource to those engaged in condition assessments of the building envelope.

Subcommittee on Seismic Rehabilitation of Buildings

Rationale for Activity

The Subcommittee on Seismic Rehabilitation of Buildings was established to assist in the consensus processing of documents prepared by the Applied Technology Council (ATC) of the Structural Engineers Association of California (SEAOC). These documents were prepared with funding from the Federal Emergency Management Agency (FEMA). The ASCE Committee on Structural Condition Assessment and Rehabilitation of Buildings that addresses concerns related to existing buildings was a logical home for seismic considerations within the ASCE standards program.

Scope of Subcommittee Activities

The initial activity of the subcommittee was to subject the draft document, ATC-28 [2], to a consensus review. ATC-28 is intended to bring forth all the issues that should be considered

in developing seismic guidelines for the rehabilitation of existing buildings to be prepared by FEMA. These issues are grouped in the following categories:

1. Issues of Scope
2. Implementation and Format Issues
3. Issues of Coordination with Other Efforts
4. Legal and Political Issues
5. Social Issues
6. Economic Issues
7. Historic Building Issues
8. Research and New Technology Issues
9. Seismicity and Mapping Issues
10. Issues of Engineering Philosophy and Goals
11. Issues in the Development of Specific Provisions
12. Nonstructural Element Issues

Each issue within these broad categories is specifically stated and various approaches for resolving the issue are given. This information along with the recommended alternative for resolving the issue were subjected to the ASCE consensus review. This included formal balloting at the subcommittee, committee, and Society levels; and full consideration and resolution of resulting negatives. Resolution meant that the negative was found persuasive and the item was revised and reballoted; the voter withdrew the negative, in which case it was agreed that the concerns of the individual would be shared with the guideline writers; or the negative was deemed nonpersuasive and no changes were made. The availability of the draft ATC 28 document for review was advertised widely through publications and newsletters of organizations interested in existing buildings ranging from school administrators to historic preservation organizations.

An example of an issue under the category of Historic Building Issues was "How will the guidelines deal with historic buildings: by including or excluding them?" ATC 28 recommended that the guidelines should not exclude buildings that have a historic designation in their scope. This position was confirmed through the ASCE consensus process.

The result of this activity is a consensus on the issues to be considered in the development of the national model seismic rehabilitation guidelines. The document resulting from this initial subcommittee activity is FEMA 237 [*3*], and FEMA is using it to prepare a guideline for Seismic Rehabilitation of Existing Buildings.

The subcommittee has taken on the new task of processing FEMA 178 [*4*] as a standard. This document, prepared under the National Earthquake Hazards Reduction Program (NEHRP), has been processed through the Building Seismic Safety Council consensus process. It is intended to provide engineers involved in the seismic evaluation of existing buildings with guidance concerning the potential earthquake-related risk to human life posed by a building or building component. Appendices A and B of FEMA 178 contain a list of evaluation statements that are either true or false for a given structure. Statements that are found to be true identify issues that are acceptable according to the criteria of the handbook. The main body of the handbook provides specific guidance in the investigation. An example of a true/false question under the Building System is "Redundancy: The structure will remain laterally stable after the failure of any single element (Sec. 3.2)." If true for a building, Section 3.2 provides specific guidance for investigation of the issue.

The initial efforts of the subcommittee concerning FEMA 178 are to consider turning the true/false statements into code enforcement statements. As an ASCE standard, it could then be considered by code groups for inclusion in appropriate documents.

Conclusions

The need to reuse the existing building stock is driving the development of standards related to condition assessment, and the work of the ASCE Committee on Structural Condition Assessment and Rehabilitation of Buildings is an important contribution. ASCE 11-90 [*1*] provides state-of-the-art information to those who must make critical technical decisions concerning the condition of a structure. Extension of the committee's activities to include assessment of the building envelope and concerns unique to seismic rehabilitation are responses to critical needs within the construction community.

Acknowledgment

The material in Tables 1 and 2 and Figs. 1 and 2 is reproduced by permission of ASCE from ASCE 11-90, *Standard Guideline for the Structural Condition Assessment of Existing Buildings*, 1990.

References

[*1*] *Standard Guideline for the Structural Condition Assessment of Existing Buildings*. ASCE 11-90, American Society of Civil Engineers, New York, 1990.

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