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**Seismic assessment and retrofit of  
concrete structures**

*Évaluation sismique et réhabilitation de structures en béton*

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## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see [www.iso.org/directives](http://www.iso.org/directives)).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see [www.iso.org/patents](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the WTO principles in the Technical Barriers to Trade (TBT) see the following URL: [Foreword - Supplementary information \(standards.iteh.ai\)](http://Foreword - Supplementary information (standards.iteh.ai))

The committee responsible for this document is ISO/TC 71, *Concrete, reinforced concrete and pre-stressed concrete*, Subcommittee SC 7, *Maintenance and repair of concrete structures*.

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## Introduction

Earthquakes bringing damage to structures have occurred frequently in many areas of the world. Heavy damage caused by earthquakes are concentrated on vulnerable structures. Due to these damaging earthquakes, human lives are lost and confusion in everyday life and stagnation of economic activities occur.

As the result of the direct action of earthquakes, structures may collapse or overturn in earthquake-prone areas. However, given a main shock occurs, it is expected that through seismic assessment and retrofit of concrete structures, human life losses, economical losses, and structural collapses could be mitigated and/or prevented and quick recovery could be attained.

In some nations, such as Japan and USA, the framework for the identification of vulnerable structures before and after an earthquake, seismic retrofit decision-making and construction exists. In addition, the standards for seismic assessment technology and for seismic retrofit technology are already established in those nations. Furthermore, technical manuals, in order to apply the standards to practical work, are established. Therefore, based on these standards, the social system is built where a country, a district and a local administrative agency (authorities), the owner of the structure, a user, a retrofit designer, a retrofit work supervisor, a retrofit work supplier, and other people concerned on this matter share a purpose of the seismic retrofit and the information about the effect of seismic retrofit, and the owner of the structure can judge the necessity of appropriate retrofit, and a seismic retrofit execution is carried out smoothly.

However, it is not so frequent that a huge earthquake disaster occurs in a specific country or an area. These conditions disturb conducting seismic assessment, seismic retrofit work, and smooth social decision making to conduct seismic retrofit. As a result, it is feared that the earthquake disaster will expand and the recovery from the disaster will be delayed when a large earthquake disaster happens once.

Therefore, it is necessary to establish a principle of seismic assessment, decision making for seismic retrofit, the framework of the procedure for screening the vulnerable structures, and seismic retrofit execution. This International Standard provides comprehensive principle on the evaluation of the seismic damage/expected damage of existing reinforced concrete structures and repair/retrofit. In other words, this International Standard provides the standard work items related to seismic assessment and retrofit, and standard procedures in each stage, and makes contents and the scope of each duty clear.

In this International Standard, the seismic performance of existing reinforced concrete structures is expressed in terms of the intensity of earthquake motions that will lead the structures to the safety limit state<sup>1)</sup> in principle. As the result, whether the existing RC structures fulfill the provisions of the design standard in the specific country or area does not matter. That is the feature of this International Standard.

The retrofit can be also conducted based on seismic performance, not on whether the seismic retrofit meets an existing standard. Because this International Standard set such a rational performance requirement mentioned above, the vulnerable parts which should be reinforced are clearly identified.

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1) Ultimate limit state is mainly considered. However, other limit states may be considered such as seismic damage control limit state when time history analysis is used.

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# Seismic assessment and retrofit of concrete structures

## 1 Scope

The purpose of this International Standard is to reduce the risk of seismic damage by structural collapse or turnover during a seismic event.

This International Standard provides frameworks and principles of methods of detailed seismic assessment and the judgment, seismic retrofit plan and design, seismic retrofit execution of existing reinforced concrete structures before the occurrence of a severe earthquake and of the structures struck by an earthquake.

This International Standard is applicable to reinforced concrete structures and pre-stressed concrete structures that have been designed on the basis of the structural design criteria set in a specific country or region. It is not applicable to either unreinforced concrete structures or masonry structures.

## 2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

There are no normative references.

## 3 Terms and definitions

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[96fc95d6a1/iso-16711-2015](https://standards.iteh.ai/catalog/standards/sist/cc450319-8119-46f8-a04a-96fc95d6a1/iso-16711-2015)

For the purposes of this document, the following terms and definitions apply.

### 3.1

#### **assessment**

set of activities performed in order to verify the reliability of an existing structure for future use

[SOURCE: ISO 13822:2010]

### 3.2

#### **collapse**

loss of the load-carrying capacity of a component or member within a structure or of the structure itself

### 3.3

#### **damage control limit state**

ability of a structure or structural element to be repaired physically and economically when damaged under the effects of considered actions

### 3.4

#### **design documents**

results of structural calculation and design drawings

### 3.5

#### **design service life**

period for which the structure is assumed to be in adequate condition for its intended purpose or function with anticipated maintenance but without requiring substantial repair being necessary

**3.6**

**inspection**

conformity evaluation by observation and judgment accompanied as appropriate by measurement, testing or gauging.

[SOURCE: ISO 16311-2:2014]

Note 1 to entry: For structures, this evaluation consists of actions collecting information on the current state of a structure through observation and simplified non-destructive or destructive testing supplemented with materials and structural testing, as required.

**3.7**

**investigation**

collection of information through inspection, document search, load testing and other testing

[SOURCE: ISO 16311-1:2014]

**3.8**

**limit of displacement**

allowable deformation of the structure in terms of parameters such as inter-story drift and overall horizontal displacement, to control excessive deflection, cracking and vibration

**3.9**

**limit state**

critical state specified using a performance index, beyond which the structure no longer satisfies a design performance requirement

[SOURCE: ISO 19338:2014]

**3.10**

**maintenance**

set of activities taken to check, evaluate, and preserve/restore structural performance so as to satisfy in service performance requirements

[SOURCE: ISO 16311-1:2014]

**3.11**

**structural repair**

restoration of a structure or its components to an acceptable condition by the renewal or replacement of worn, damaged or deteriorated components

[SOURCE: ISO 13823:2008]

Note 1 to entry: Repair is adopted to restore structural performance and to mitigate safety risks up to the initially required design level and to achieve the intended service life.

**3.12**

**restorability (or reparability)**

ability of a structure or structural element to be repaired physically and economically when damaged under the effects of considered actions

[SOURCE: ISO 19338:2014]

**3.13**

**life safety performance level**

ability of a structure or structural element to ensure no casualty to users of, and people around, the structure, within the limits of acceptable probability

[SOURCE: ISO 19338:2014]

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**3.14****seismic capacity**

force or displacement defined for the limit states

Note 1 to entry: Multiple limit states could be selected besides the life safety limit state, such as acceptable economic loss limit state, reparability limit state, immediate occupancy limit state, or functionality limit state.

**3.15****performance objective**

required performance level (e.g. life safety) for a given earthquake hazard level (e.g. an earthquake with a 10 % probability of exceedance in 50 years)

**3.16****seismic damage**

physical evidence of inelastic deformation, cracks or spalling of a structural component caused by an earthquake

**3.17****seismic retrofit**

restoring or improving the seismic performance of a pre- or post-earthquake existing structure to meet the seismic performance objective, including “structural repair” and “strengthening”

**3.18****serviceability**

ability of a structure or structural elements to provide appropriate behaviour or functionality in use under the effects of considered actions at serviceability limit state

[SOURCE: ISO 19338:2014]

**3.19****service life**

actual period during which a structure meets the prescribed performance requirement

[SOURCE: ISO 16311-1:2014]

**3.20****strengthening**

measures taken to improve structural performance relating to load bearing capacity and deformation of an existing structure and/or its members

[SOURCE: ISO 16311-1:2014]

## 4 Framework of Assessment and Retrofit

The seismic assessment and retrofit of an existing structure should obey the following procedures after identifying the performance requirements and drafting an overall plan from investigation through detailed seismic assessment, construction and documentation. The schematic of the process is shown in [Figure 1](#). Details of each item are described after [Clause 5](#). All of these items are not necessarily executed; the procedure should be initiated in order from (1), but it may be finished at any stage according to the specific situation under consideration.

### (1) Preliminary assessment

The possibility of a structure's collapse or turnover under severe earthquake should be assessed based on the comprehensive information of the structure, such as design documents at the time of design, history of usage and the construction's compliance with the design standard. The inspection of the seismic performance should be carried out in consultation with the client (the owner, the authority, etc.), if the seismic performance is suspected or not clearly adequate.

### (2) Detailed seismic assessment

In order to make them clear, those are seismic capacity of an existing RC structure or PSC structure and vulnerable parts in it, detailed seismic assessment should be conducted. And also, the necessity of the seismic retrofit should be determined by comparing the evaluated seismic performance and the seismic performance objectives. The planning of the seismic retrofit should be carried out in consultation with the client (the owner, the authority, etc.), if the deficiency in seismic performance is confirmed.

### (3) Planning of seismic retrofit

The plan of the seismic retrofit including outline of the retrofit and construction method should be determined. The validity of the plan should be verified by estimating the seismic performance of the structure after construction. The seismic retrofit execution should be then carried out in consultation with the client (the owner, the authority, etc.), taking into consideration the estimated cost for construction work.

### (4) Seismic retrofit execution

The construction method for each structural member should be determined in compliance with the seismic retrofit plan. The construction should be then carried out under the proper supervision and the quality control of the work. The procedure of the work should be documented in a report.

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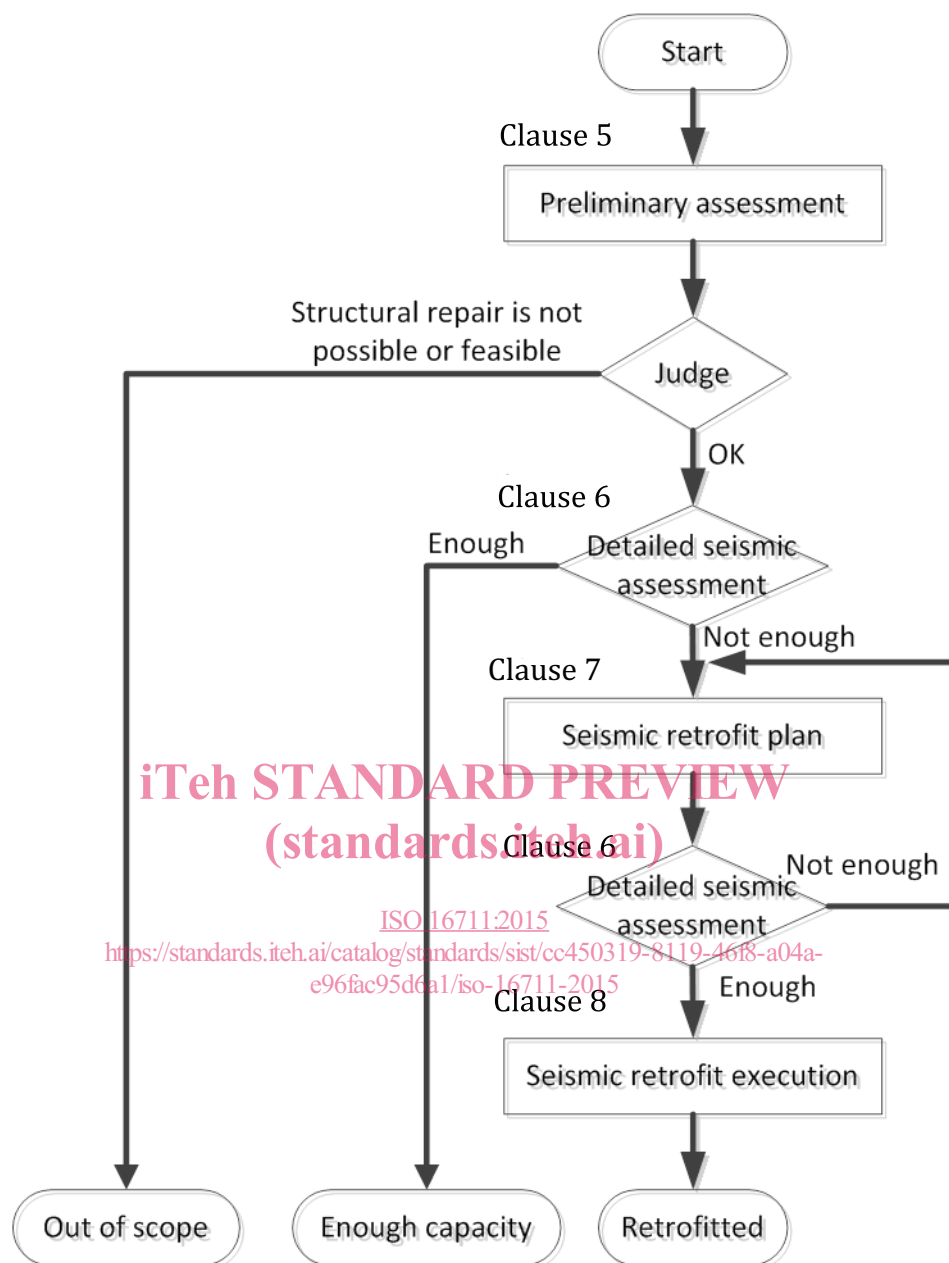


Figure 1 — Procedure of detailed seismic assessment and retrofit

Detailed seismic assessment, retrofit design and execution, construction management and inspection should be conducted by a competent person with the appropriate qualifications, as required by national, regional or local regulations.

## 5 Preliminary assessment

### 5.1 General

The preliminary inspection of a structure is conducted to judge the necessity of the detailed seismic assessment and retrofit of the structure in advance. In the preliminary inspection, necessary information to decide the execution of detailed seismic assessment and retrofit is collected by the inspection of the structure regarding the assessment items in 5.2.