

---

---

**Houses — Description of  
performance —**

**Part 2:  
Structural serviceability**

*Constructions d'habitation — Description des performances —  
Partie 2: Aptitude au service de la structure*

STANDARDSISO.COM : Click to view the full PDF of ISO 15928-2:2015



STANDARDSISO.COM : Click to view the full PDF of ISO 15928-2:2015



**COPYRIGHT PROTECTED DOCUMENT**

© ISO 2015, Published in Switzerland

All rights reserved. Unless otherwise specified, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office  
Ch. de Blandonnet 8 • CP 401  
CH-1214 Vernier, Geneva, Switzerland  
Tel. +41 22 749 01 11  
Fax +41 22 749 09 47  
copyright@iso.org  
www.iso.org

# Contents

	Page
<b>Foreword</b> .....	<b>iv</b>
<b>Introduction</b> .....	<b>v</b>
<b>1 Scope</b> .....	<b>1</b>
<b>2 Normative references</b> .....	<b>1</b>
<b>3 Terms and definitions</b> .....	<b>1</b>
<b>4 Structural serviceability performance</b> .....	<b>3</b>
4.1 Objective.....	3
4.2 Performance description.....	3
<b>5 Parameters for the description of performance</b> .....	<b>3</b>
5.1 Parameters for describing actions.....	3
5.1.1 Permanent actions.....	3
5.1.2 Imposed actions.....	4
5.1.3 Wind actions.....	4
5.1.4 Seismic actions.....	4
5.1.5 Snow actions.....	5
5.1.6 Vibration sources.....	5
5.1.7 Impact sources.....	5
5.1.8 Actions derived from fittings.....	5
5.1.9 Other actions.....	5
5.1.10 Combinations of actions.....	6
5.1.11 Ground conditions and movements.....	6
5.2 Parameters for describing structural responses.....	6
5.2.1 General.....	6
5.2.2 Deformation.....	6
5.2.3 Vibration.....	7
5.2.4 Local damage.....	7
5.2.5 Response to impact.....	7
5.2.6 Fittings.....	7
<b>6 Evaluation</b> .....	<b>7</b>
6.1 General.....	7
6.2 Analysis.....	8
6.3 Testing.....	8
6.4 Service experience.....	8
6.5 Combination.....	8
<b>Annex A (informative) Commentary</b> .....	<b>9</b>
<b>Annex B (informative) Structural serviceability examples</b> .....	<b>16</b>
<b>Bibliography</b> .....	<b>18</b>

## 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](#)

The committee responsible for this document is ISO/TC 59, *Buildings and civil engineering works*, Subcommittee SC 15, *Performance description of houses*.

This second edition cancels and replaces the first edition (ISO 15928-2:2005), which has been technically revised.

ISO 15928 consists of the following parts, under the general title *Houses — Description of performance*:

- *Part 1: Structural safety*
- *Part 2: Structural serviceability*
- *Part 3: Structural durability*
- *Part 4: Fire safety*
- *Part 5: Operating energy*

The following part is under preparation:

- *Part 6: Sustainable development contributions*

## Introduction

This part of ISO 15928 is one of a series of standards. The objective of the ISO 15928- series is to identify the methods that will be used to describe the performance of houses. The ISO 15928- series is confined to buildings occupied for residential purposes that may be separated or linked horizontally, but not linked vertically, and which have their own access and do not share any common space.

Each part of ISO 15928 relates to a separate attribute. The parts of ISO 15928 do not specify levels of performance and they are not intended to replace national standards or regulations, but provide a standardized framework to be used for development of national standards and regulations consistent with World Trade Organization (WTO) requirements. The parts of ISO 15928 do not provide design methods and/or design criteria.

Based on the framework provided by the ISO 15928- series, purchasers, regulators and standards-preparers in respective countries can describe their requirements in standardized performance terms, as appropriate. Additionally, the manufacturers/providers can respond by describing the performance of their products in a similar manner.

The purpose of this part of ISO 15928 is to provide a standardized system of describing performance that can be used to specify performance requirements and performance levels, or to rate houses, in terms of structural serviceability.

NOTE The WTO *Agreement on technical barriers to trade*, Clause 2.8, states: "Whenever appropriate, members shall specify technical regulations based on product requirements in terms of performance, rather than design or descriptive characteristics."

[STANDARDSISO.COM](https://standardsiso.com) : Click to view the full PDF of ISO 15928-2:2015

# Houses — Description of performance —

## Part 2: Structural serviceability

### 1 Scope

This part of ISO 15928 sets out a method for describing the structural serviceability performance of houses. It covers objectives, provides performance descriptions, establishes parameter descriptions and outlines evaluation processes.

This part of ISO 15928 is intended for use in the evaluation of the design and construction of houses, in the international trading of houses or their sub-systems, and in developing risk-management tools for the protection of houses.

The ISO 15928- series does not specify a level of performance and it is not intended to provide a design method and/or criteria.

NOTE 1 [Annex A](#) includes background information on this part of ISO 15928, guidance on its use, and suggestions on good practice.

NOTE 2 Details on references referred to in Notes are provided in a Bibliography.

NOTE 3 Structural safety, durability and other attributes are covered in other parts of ISO 15928.

### 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.

ISO 2394, *General principles on reliability for structures*

ISO 6707-1, *Buildings and civil engineering works — Vocabulary — Part 1: General terms*

### 3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 2394, ISO 6707-1 and the following, apply.

#### 3.1 action

force acting on a structure, or cause of deformation imposed on a structure or constrained within it

Note 1 to entry: In North America, the term 'load' is preferred and used in place of 'action'.

Note 2 to entry: In this part of ISO 15928, the term 'load' is used to indicate the value of a force corresponding to an action.

Note 3 to entry: See ISO 6707-1:2014, 9.3.22 for the definition of 'force'.

## ISO 15928-2:2015(E)

### 3.2 component

part of a house that can be identified

EXAMPLE Floor, wall.

Note 1 to entry: Includes fittings.

### 3.3 equipment

<hydraulic, mechanical electrical> device that is provided for use within a house

### 3.4 fitting

structure such as shelving, cupboards, equipment, etc., that is permanently fixed to the ceilings, walls, etc., of a house

### 3.5 house

building occupied for residential purposes and designed as one unit (dwelling) with its own access

Note 1 to entry: The house can be a separate building, or linked horizontally with another house but not linked vertically.

Note 2 to entry: Where houses are linked, each has its own access and does not share any space in common with another.

Note 3 to entry: Where houses are linked, services including those related to energy usage and supply, heating and ventilation may be shared.

Note 4 to entry: Where houses are linked, the wall between the houses is typically designed and constructed to limit the probability of fire spread between houses.

Note 5 to entry: See ISO 6707-1:2014, 3.1.3 for the definition of 'building'.

### 3.6 ground movement

displacement in any direction of the founding stratum by influences not solely dependent on the actions applied by the housing carcass

### 3.7 objective

statement concerning the purpose of the description of performance which is to express user needs

### 3.8 parameters

<structural serviceability> group of variables used to quantitatively describe the structural serviceability performance

### 3.9 performance

behaviour of houses related to use

### 3.10 representative value of an action

value used as a reference for the description of performance

## 4 Structural serviceability performance

### 4.1 Objective

The structural behaviour of a house, for normal use under all expected actions, that may affect the occupants and the functioning of the house, shall be such that the following characteristics of a house shall be kept within levels acceptable to the user:

- a) functioning and appearance of the house and its components;
- b) functioning of the occupants in the house;
- c) functioning of the equipment in the house;
- d) comfort of the occupants.

NOTE The relative importance of each of these characteristics varies and is reflected in the performance requirements that are specified.

### 4.2 Performance description

The performance description is the ability of the whole house and its parts, with an appropriate degree of reliability, to perform within established parameters under all expected actions for normal use in terms of:

- a) local damage, including cracking, (which can affect the efficiency and appearance of the house and its components),
- b) deformation (which can affect the efficient use or appearance of the house or the functioning of the people and equipment),
- c) vibration (which can cause discomfort or affect the activity of occupants or the functioning of equipment).

The structural serviceability performance can be described by the structural actions on the house under normal use and the structural responses under the effect of those actions. Only actions and responses relevant to serviceability issues of concern need to be described.

NOTE 1 The appropriate degree of reliability can be judged with due regard to the possible consequences of serviceability failure and the expense level of effort and procedures necessary to reduce those risk of failure. Aspects that are important in achieving the proper degree of reliability include choice of structural systems, design and analysis, durability design, quality control, maintenance and protective measures.

NOTE 2 Expected actions for normal use can include those arising from soil/structure interaction, probable ground movements, compatibility of connections between subsystems and the effects of openings.

NOTE 3 For the purposes of this part of ISO 15928, the durability of materials is not considered to have a bearing on the structural serviceability performance of the house.

NOTE 4 For design specification, it is necessary to nominate the levels of structural actions and the acceptable limits of the structural responses corresponding to those levels of actions.

## 5 Parameters for the description of performance

### 5.1 Parameters for describing actions

#### 5.1.1 Permanent actions

The permanent actions, other than self-weight, are described by the magnitude(s), expressed in kilonewtons, and the location(s) of the imposed load(s).

### 5.1.2 Imposed actions

The imposed actions are described by the representative values of one or more of the following:

- a) uniformly distributed floor or roof load, expressed in kilonewtons per square metre;
- b) concentrated floor or roof load, expressed in kilonewtons per specified area, expressed in square metres;
- c) concentrated wall impact load, expressed in kilonewtons, applied at a specified height, expressed in metres, above the floor;
- d) uniformly distributed horizontal line load, expressed in kilonewtons per metre, applied at a specified height, expressed in meters, above the floor.

EXAMPLE A hand-rail.

NOTE ISO 2103[1] provides minimum recommended imposed actions for different types of use and occupancy.

### 5.1.3 Wind actions

Wind actions are described by the representative value of the wind velocity, expressed in metres per second, under normal conditions, derived from the basic wind speed, factored as appropriate to take into account local effects, terrain, shielding, topography, site altitude and the like, based on one of the following wind velocity types:

- a) 3 s gust;
- b) 1 min mean (fastest mile);
- c) 10 min mean;
- d) hourly mean.

NOTE ISO 4354[2] provides details on the conversion of wind velocity to wind forces and the conversion between different types of wind velocity.

### 5.1.4 Seismic actions

Seismic actions are described by stating the representative value, under normal conditions, of one of the following parameters:

- a) effective peak ground acceleration, expressed as a fraction of gravity;
- b) base shear coefficient;
- c) horizontal force applied to the structure, in kilonewtons, and its location;
- d) ground acceleration response spectrum for the site;
- e) floor acceleration response (for equipment and fittings).

NOTE 1 Item e) relates to phenomena where equipment and/or fittings cannot be used due to the acceleration.

If either a) or b) is used, then the proportion of the imposed loads to be included in the seismic mass shall also be nominated. The representative value shall be based on a consideration of the seismic activity, the soil characteristics of the construction site and the response behaviour of the structure.

NOTE 2 ISO 3010[3] provides additional information on seismic action on structures.

### 5.1.5 Snow actions

The snow actions are described by stating the representative values, under normal conditions, of the following:

- a) ground snow depth, expressed in metres, derived from the basic snow depth, factored to take into account local effects such as terrain, shielding, topography and the like;
- b) snow density, expressed in kilograms per cubic metre, i.e., the density used in converting the ground snow depth into a load;
- c) duration, in days per year.

NOTE ISO 4355[4] provides information on the conversion of ground snow depths to roof snow loads.

### 5.1.6 Vibration sources

Consideration shall be given to the description of vibration sources inside and outside the house, such as that caused by machinery, vehicular traffic and human activity, if these sources affect the occupants of the house on a regular basis.

NOTE ISO 10137[5] provides information on the description of vibration sources.

### 5.1.7 Impact sources

If these impacts are likely to occur during normal use, consideration shall be given to the description of impact sources due to human activities or the environment in terms of the following:

- a) specified in mass, expressed in kilograms;
- b) specified energy, expressed in joules;
- c) type of impact (soft or hard body impact).

EXAMPLE Accidental human body impacts due to slip, trip and fall (soft body impact) and impacts of falling objects (hard body impact).

NOTE ISO 7892[6] provides information on impact test on vertical building elements.

### 5.1.8 Actions derived from fittings

Consideration shall be given to the description of actions resulting from fittings in terms of a load, expressed in kilonewtons, at a specific location, such as on a ceiling, on a wall or at a distance from a wall.

EXAMPLE Examples of wall-mounted fittings are cupboards and mirrors, and of ceiling-mounted fittings, lights and fans.

NOTE Depending on the situation, an action arising from “fittings” can be categorized as, for example, the following:

- a) imposed action;
- b) vibration sources;
- c) impact sources.

### 5.1.9 Other actions

Consideration shall be given to the description of other actions, if these actions are likely to affect the structural serviceability of the house.

### 5.1.10 Combinations of actions

Consideration shall be given to the description of the combinations of the actions to account for the probability of simultaneous occurrence of two or more actions.

### 5.1.11 Ground conditions and movements

The ground conditions and movements are described by stating the following:

- a) representative values of bearing capacity, either as an allowable or ultimate value, expressed in kilonewtons per square metre, for a given total and differential settlement, expressed in millimetres;
- b) nature and magnitude of expected ground movements, expressed in millimetres, expressed both as a total surface movement and as a differential movement, arising from swelling, consolidation, shrinkage or settlement of the subsoil;
- c) representative stiffness of the soil, expressed in millimetres per kilopascal;
- d) diameter, expressed in metres, and location of any soft spot over which a loss of support to the house is likely to occur, or the distance from the perimeter of the house over which a loss of support is likely to occur.

## 5.2 Parameters for describing structural responses

### 5.2.1 General

For serviceability considerations, structural responses under the effects of the actions can be described in terms of parameters representing deformations, vibrations and local damages.

For design specification, structural serviceability limits under the effects of the actions can be described in terms of limiting values that are based on characteristic values and partial factors for materials. These values shall take into account of the variability of the material properties and the level of reliability for serviceability limit states and the frequency of the actions.

### 5.2.2 Deformation

#### 5.2.2.1 Deflection

Deflections (vertically, horizontally, in-plane, out-of-plane, terminal and medial) are described in terms of the following:

- a) deflection to span ratio or deflection over a defined length;
- b) deflection to storey height ratio;
- c) absolute value, expressed in millimetres.

NOTE 1 Deflection can also be used as a measure of rotation or curvature.

NOTE 2 ISO 4356 [\[7\]](#) provides information on deformation of buildings at the serviceability limit states.

NOTE 3 Deflection can be described as elastic deformation and/or permanent deformation (non-residual/residual).

Consideration should be given to long-term and short-term effects, e.g. creep.

#### 5.2.2.2 Tilt

Tilting is described in terms of angular distortions.

### 5.2.3 Vibration

Vibration response is described in terms of the following:

- a) frequency, expressed in hertz;
- b) acceleration, expressed in metres per square second, velocity, expressed in metres per second, and displacement, expressed in millimetres.

NOTE 1 Refer to ISO 10137 for guidance on serviceability of buildings against vibration.

NOTE 2 Vibrations for the house as a whole and its parts can have different values.

### 5.2.4 Local damage

Local damage is described in terms of cracking and spalling:

- a) cracking:
  - approximate crack width, expressed in millimetres;
  - location and frequency of cracks.
- b) spalling:
  - approximate spall depth, expressed in millimetres, and area, expressed in square metres;
  - location and frequency of spalls.

### 5.2.5 Response to impact

Response to impact is described in terms of the following:

- a) permanent deformation;
- b) permanent displacement in terms of a deflection ratio;
- c) crack width and aggregate crack length, expressed in millimetres;
- d) puncturing;
- e) indentations or displacements, expressed in millimetres;
- f) visible cracks of a given width and an aggregate length, expressed in millimetres.

### 5.2.6 Fittings

The performance of the house to support fittings is described in terms of the following:

- a) its ability to support the actions specified in [5.1.8](#);
- b) damage caused by the loosening and withdrawal of fixing devices.

## 6 Evaluation

### 6.1 General

Evaluation may be carried out by means of the following:

- a) analysis;
- b) testing;

- c) service experience;
- d) combination of the above.

NOTE For materials with recognized engineering properties, evaluation is usually carried out by analysis using appropriate norms and standards.

## **6.2 Analysis**

The assessment of distortions and vibrations of individual structural members shall be determined by methods of structural analysis that take into account equilibrium, general stability, geometric compatibility, and both short- and long-term material properties.

## **6.3 Testing**

Testing shall incorporate a realistic representation of materials, loading conditions, boundary conditions and construction practices. Testing for evaluating structural serviceability shall be full-scale.

## **6.4 Service experience**

Service experience shall comprise a sufficient number of representative examples, exposed to similar or more severe service conditions, together with adequate documentation.

## **6.5 Combination**

A combination of analysis, testing and service experience may be used for evaluation. Simplified analytical procedures using a combination of testing and service experience may be used.

STANDARDSISO.COM : Click to view the full PDF of ISO 15928-2:2015

## **Annex A** **(informative)**

### **Commentary**

#### **A.1 Scope**

The purpose of this part of ISO 15928 is to standardize the method of describing the structural serviceability performance for housing, i.e. to standardize the parameters by which the structural safety aspects of house performance are expressed or defined. This part of ISO 15928 does not specify a level of performance and it is not intended to provide design method and/or criteria.

It is one part of a series of ISO standards designed to facilitate the communication between the specifier (buyer/user) and the provider (seller). Structural serviceability, durability and fire safety attributes are covered in other parts of ISO 15928.

The intent is to provide a standardized system that is to be used to realize performance description.

The objectives of this part of ISO 15928 are as follows:

- a) To facilitate international trade in housing systems and housing products and to exchange housing information and knowledge by eliminating technical barriers.
- b) To facilitate innovation in housing by providing a systematic framework for evaluation and acceptance.
- c) To establish user needs related to structural serviceability in specific technical engineering terms in order to facilitate communication among all stakeholders.

This part of ISO 15928 may also be useful in increasing consumer product awareness and in developing quality systems for houses.

#### **A.2 Normative references**

General building and civil engineering terms are defined in ISO 6707-1. ISO has issued a number of standards for specific serviceability issues, these are listed in the Bibliography.

#### **A.3 Terms and definitions**

In general, the adopted definitions are those given in ISO 6707-1 with regard to buildings. Other terms have the same definitions as in ISO 15928-1.

#### **A.4 Structural serviceability performance**

##### **A.4.1 Objective**

The objective or user's needs for structural serviceability are thought of in terms of the structural behaviour that might affect the functioning of the house, the comfort of the occupants and the appearance of the house. These problems can be caused by environmental agents, such as wind, earthquake, etc., or human activity, such as walking, running, etc. These problems can affect the occupants, the contents of the house or the structure of the house and ultimately the asset value of the house. There are other amenity issues that are not part of structural serviceability, such as noise, light, indoor air quality, etc.

For simplicity, the term “action” is used in this part of ISO 15928 with the same meaning as in ISO 15928-1. Actions caused by human activities can be described using “impact sources” or “vibration sources”.

The relative importance of various serviceability issues can differ according to the difference in culture and living habits of various countries as well as the types of housing provided. The user needs are, therefore, identified by respective countries and/or regions according to their own perceived needs.

### A.4.2 Performance description

Serviceability is considered in relation to local damage (including cracking), deformation and vibration of the structure, as these parameters are affected by structural behaviour. The structural safety and durability characteristics, including maintenance, are considered in separate standards.

The term “action” is used in this part of ISO 15928 with the same meaning as in ISO 15928-1. Actions caused by human activities can be described using “impact sources” or “vibration sources”.

The ‘expected actions for normal use’ refer to the values of actions that have a high probability of occurrence. For example, the serviceability values for wind action are normally expressed in terms of 10-year to 20-year return periods (0,1 to 0,05 annual probability of exceedance), in contrast to the ultimate values of 500-year to 1 000-year return periods (0,002 to 0,001 annual probability of exceedance).

ISO 10137 provides information on the description of vibration sources.

ISO 7892 provides information on impact test on vertical building elements.

The structural action effects under serviceability should not affect the functioning and appearance of the house and its components, the functioning and comfort of the occupants and the functioning of the equipment in the house. They are going to be described by the parameters listed under [Clause 5](#).

The structural response relating to structural serviceability is described in terms of criteria for deformation, vibration, local damage, response to impact and fittings.

Structural serviceability conditions can be either of a reversible or non-reversible nature and therefore it is necessary to establish different criteria for each type. For example, local damage such as cracking is usually irreversible while elastic deformation under wind load is normally reversible. For reversible serviceability condition, the criteria may involve unacceptable exposure time or frequency.

Design for serviceability involves considerable engineering experience and subjective judgment. Specific quantified limits do not always ensure satisfactory in-service behaviour and should be considered only as a guide to design.

A representative value for each of the actions and other parameters that affect serviceability performance is first nominated. The representative value is normally a characteristic value. This value together with the load factor describes the load level to be used in serviceability assessment. For example, a 20-year return value can be selected as the representative value for wind action and a load factor of 1.0. Alternatively, a 50-year return value can be selected as the representative value and a load factor of, say, 0.7. A limiting value for the structural response that is considered to be acceptable under the effect of the specified action can then be selected for the serviceability assessment.

[Table A.1](#) illustrates the relationship among the agents, the representative values of the parameters, the representative values of the actions and the design values of the actions.

**Table A.1 — Examples of agents, parameter, representative and design values**

Agent	Performance parameter	Representative value of the action	Design value for serviceability	Limiting value of structural response
Imposed actions	$Q$ (kPa or kN)	$Q$	$\gamma_Q Q$	Vertical deflection
Wind actions <sup>a</sup>	$V$ (m/s)	$W_{20}, W_{50}$	$\gamma_W W_{50}$ or $W_{20}$	Sway
Seismic actions <sup>b</sup>	$A$ (m/s <sup>2</sup> )	$E_{50}, E_{100}$	$\gamma_E E_{100}$ or $E_{50}$	Storey drift
Snow actions <sup>c</sup>	$D_G, \rho$ (kg/m <sup>3</sup> )	$S_{20}$	$\gamma_S S_{20}$	Vertical deflection
<sup>a</sup> $W_{20}, W_{50}$ are the 20 year and 50 year return values for the wind load, respectively. <sup>b</sup> $E_{50}, E_{100}$ are the 50 and 100 year return values for the seismic load respectively. <sup>c</sup> $S_{20}$ is the 20 year return value for the snow load.				

## A.5 Parameters for the description of performance

### A.5.1 Parameters for describing actions

[Clause 5](#) describes the parameters that define the actions for serviceability assessment. It is not concerned with the design issues that are wholly controlled by the designers. Other actions that need to be considered in design, such as self-weight, etc., are therefore not mentioned here. Some national specifications can use different parameters for the description of the actions; these can still be used, provided that they can be converted into the parameters adopted in this part of ISO 15928.

#### A.5.1.1 Permanent actions

Subclause [5.1.1](#) is intended for specific permanent loads that need to be specified, e.g. water tank, chandelier. Their exact locations should also be specified.

#### A.5.1.2 Imposed actions

ISO 2103 [\[1\]](#) provides representative values for minimum recommended imposed loads for different types of use and occupancy. There is no ISO International Standard for specifying impact load at present but there are ISO International Standards for impact testing (ISO 7892).[\[6\]](#)

#### A.5.1.3 Wind actions

Wind speed has been chosen as the parameter to represent wind action. The alternative is wind pressure; however, it is possible to convert one to the other. The representative value of the wind speed is the value of wind speed with appropriate modifications to account for the local conditions, such as terrain, shielding, etc. This approach is necessary because different methods have been used in national codes to allow for local conditions. The representative value can be expressed in one of a number of types of wind speed. ISO 4354 [\[2\]](#) provides the conversion factor between different types of wind speed as well as the process to convert wind speeds into wind forces.

#### A.5.1.4 Seismic actions

There are various ways of describing seismic action. Peak ground acceleration and base shear coefficient are the most common ways. The representative values of these parameters should be chosen with appropriate consideration to account for the particular load conditions, such as seismicity of the region, soil characteristics of the site and the importance of the building. The dynamic property of the structure, however, is the responsibility of the provider. This approach is necessary because different methods have been used in national codes to allow for these conditions. The approach is consistent with the guidelines given in ISO 3010.[\[3\]](#)

#### A.5.1.5 Snow actions

Ground snow depth and snow density have been chosen as the parameters to represent snow actions. The representative value for ground snow depth is the value of ground snow depth with appropriate modifications to account for the local conditions such as shielding, zoning, etc. This approach is necessary because different methods have been used in national codes to allow for these conditions. The representative value for snow density is the average snow density value used to convert snow depth into snow load. The approach is consistent with ISO 4355.[\[4\]](#)

#### A.5.1.6 Vibration sources

The description of the characteristics of vibration sources is a difficult problem. ISO 10137[\[5\]](#) contains many recommendations on how to describe dynamic actions from various sources.

#### A.5.1.7 Impact sources

ISO 7892[\[6\]](#) contains recommendations for three types of impact: hard bodies, small soft bodies and large soft bodies. It also contains general test procedures for these types of impact. The specifier should select from ISO 7892 the most appropriate test to suit his needs and the corresponding criteria for acceptance. The performance level can be specified in terms of energy levels (without causing cracking, permanent indentation or collapse). Other types of impact, such as the slamming of a door, are not covered in ISO 7892 and might need to be addressed separately.

#### A.5.1.8 Fittings

Walls and ceilings should be able to support the fittings such as light fittings, coat hooks, towel rails, cabinets, cupboards, shelving, etc. at the specified location. Lightweight fittings are not likely required to support the weight of a person but heavy fittings are expected to do so.

#### A.5.1.9 Other actions

Other actions, such as floods, might need to be specified if they are frequently occurred problems.

#### A.5.1.10 Combination of actions

The combinations of actions will be dependent on the chosen design criteria. Distinction should be made between short-term and long-term effects.

For example, the following load combinations are normally considered:

a) long-term combinations:

- $G$
- $G + \Psi_1 Q + (S)$

b) short-term combinations:

- $(W_s \text{ or } E_s)$
- $G + \Psi_s Q$

where

- $E_s$  is the serviceability seismic load;
- $G$  is the permanent (dead) load;
- $Q$  is the imposed (live) load;
- $\Psi_l Q$  is the long-term component of imposed load;
- $\Psi_s Q$  is the short-term component of imposed load;
- $S_s$  is the serviceability snow load;
- $W_s$  is the serviceability wind load.

#### A.5.1.11 Ground conditions and movements

This parameter mainly affects the design of the foundation but can have consequences on the overall performance such as settlement.

The sensitivity of the soil to moisture changes can affect only certain types of construction such as slab on ground.

### A.5.2 Parameter for describing structural response

#### A.5.2.1 General

The structural response relating to structural serviceability is described in terms of criteria for deformation, vibration, local damage, response to impact and fittings.

Structural serviceability conditions can be either of a reversible or non-reversible nature and therefore it is necessary to establish different criteria for each type. For reversible serviceability condition, the criteria may involve unacceptable exposure time or frequency.

Design for serviceability involves considerable engineering experience and subjective judgment. Specific quantified limits do not always ensure satisfactory in-service behaviour and should be considered only as a guide to design.

#### A.5.2.2 Deformation

Deformation limits should be set to control the following:

- a) deformations affecting appearance, such as visible sag of floors and ceilings and visible leaning of walls and columns;
- b) deformations affecting use such as curvature and slope of floors;
- c) deformations associated with oscillations generated by wind and earthquake forces.

[Table A.2](#) is a summary as to what behaviour can be expected at different levels of deformation under static loads.

**Table A.2 — Expected behaviour at different levels of deformation under static loads**

Deformation <sup>a</sup>	Visibility	Typical behaviour
$L/2000$	Not visible	Cracking of brittle materials subjected to hogging movements
$L/1000$	Not visible	Cracking of brittle materials subjected to sagging movements
$H/500$	Not visible	Cracking of partition walls, general architectural damages
$L/300, H/300$	Visible	Cracking in walls, damage to ceiling and flooring, cladding leakage, visually objectionable
$L/200$ to $L/300$ $H/200$ to $H/300$	Visible	Damage to light weight partitions, windows, finishes
$L/100$ to $L/200$ $H/100$ to $H/200$	Visible	Impaired operation of moveable components: doors, windows, sliding partitions
<sup>a</sup> $L$ = span of horizontal member; $H$ = Storey height.		

**A.5.2.3 Comments on vibration**

Vibration due to human activities can be controlled by specifying the limiting dynamic characteristics of the system or by its equivalent static properties such as stiffness and deformation.

**A.5.2.4 Comments on local damage**

When specifying limits on cracking, consideration should be given to the type of building materials involved, the nature of the cracks (through cracks or surface cracks), their reparability and capability of being covered by decoration. For example, damage with reference to walls and floors can be classified as in [Table A.3](#).

**Table A.3 — Example of a general guide for masonry structures**

Description of typical damage with reference to walls	Approximate crack width limit mm
Hairline cracks	0,1
Fine cracks that do not need repair	1
Cracks noticeable but easily filled. Doors and windows stick slightly	2
Cracks can be repaired and a small amount of wall may need to be replaced. Doors and windows stick. Service pipes may fracture. Weather tightness often compromised	Single cracks, 5 to 15; or a number of cracks in a group, 3 or more
Extensive repair work involving replacing sections of walls, especially over doors and windows. Door and window frames distort. Walls lean and bulge noticeably. Service pipes disrupted	15 to 25
<b>Description of typical damage with reference to floors</b>	
Hairline cracks	0,3
Fine but noticeable cracks; slab reasonably level	1
Distinct cracks; slab noticeably curved or change in level	2
Wide cracks; obvious curvature or change in level	2 to 4
Gaps in slab; disturbing curvature or change in level	4 to 10

**A.5.2.5 Comments on response to impact**

If an impact test is specified, then criteria for acceptance of the test results should also be specified in terms of damages (e.g. indentation, cracks or other structural consequences).