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Bases for design of structures — General principles on risk assessment of systems involving structures

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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).

Attention is drawn to the possibility that some of the elements of 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).

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

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 98, *Bases for design of structures*, Subcommittee SC 2, *Reliability of structures*.

This second edition cancels and replaces the first edition (ISO 13824:2009), which has been technically revised. The main changes compared to the previous edition are as follows:

— risk-informed approach has been newly introduced to risk assessment in order to comply with the latest edition of ISO 2394 (ISO 2394:2015);

— requirements for treatment of uncertainty in risk estimation have been updated by introducing requirements related to sensitivity analysis;

— requirements for risk treatment have been updated by emphasizing the importance of optimization of prevention and mitigation measures including emergency preparedness;

— new informative annexes on examples of risk estimation of undesirable consequences caused by human-induced or natural events have been added.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

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Introduction

Systems involving structures in public and private sectors depend on civil engineering technologies and structures. Structures support missions and business functions of whole systems.

Structures are subject to multiple natural, technological and malevolent human-induced hazards. Hazards can have adverse impacts on performance of systems involving structures, quality of life, stakeholders' assets inside or near structures, operations and operability, functions and reputation, structural safety and sustainability of environment.

Given the significance of hazards, it is imperative that all stakeholders such as owners, occupants, designers, operators, regulators at all levels and at all phases of the lifecycle of systems involving structures understand their responsibilities for achieving adequate structural safety, structural functionality and managing risk.

This document provides a common basis for assessing risk relevant to planning, design, assessment, maintenance, decommissioning and removal of structures, in accordance with ISO 31000.

In risk assessment, hazard identification and the estimation of consequence are primary procedures. For these, it is essential to assess the risk of systems involving structures rather than just the structures, since structural failure has significant consequences for systems, and a failure of systems such as fire protection systems can cause serious damages. However, actions for risk treatment are taken within the scope of structural design. Such considerations are reflected in the title of this document.

This document is intended to serve as a basis, along with other relevant standards on risk management, for those assessing risk for systems involving structures.

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Bases for design of structures — General principles on risk assessment of systems involving structures

1 Scope

This document specifies general principles of risk assessment for systems involving structures. The focus is on strategic and operational decision-making related to design, assessment, maintenance and decommissioning of structures. This also includes formulation and calibration of related codes and standards. Systems involving structures can expose stakeholders at various levels in society to significant risks. The aim of this document is to facilitate and enhance decision-making with regard to monitoring, reducing and managing risks, and preparing for emergency in an efficient, cost-effective and transparent manner. Within the broader context of risk management, risk assessment provides decision-makers with procedures to determine whether or not, and in what manner, it is appropriate to treat risks.

This document provides a general framework as well as a procedure for identifying hazards and estimating, evaluating and treating risks of structures and systems involving structures. This document also provides a basis for code writers as well as designers to set reasonable target-reliability levels, such as stated in ISO 2394, based on the result of risk considerations. For existing structures, it is intended that assessment of the risks associated with the events that were not considered in the original design or with changes in use be implemented according to the principles stated in this document. This document can also be used for risk assessment of exceptional structures upon specific adaptation and detailing, the design of which is not usually within the scope of existing codes.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. 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*

3 Terms and definitions

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

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at http://www.electropedia.org/

3.1
acceptable risk
level of *risk* (3.9) that an individual or society accepts or tolerates to secure certain benefits

3.2
cost/benefit analysis
analysis contributing to decision-making on whether to adopt a project or a plan by quantifying and comparing its costs and benefits

3.3
extraordinary event
very rare event that causes very severe consequences

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3.4
failure
state which does not meet required performance objectives due to structural damage and/or loss of function

Note 1 to entry: Failure includes insufficient load-bearing capacity or inadequate serviceability of a *structure* (3.21) or structural member, or rupture or excessive deformation of the ground, in which the strengths of soil or rock are significant in providing resistance.

3.5
hazard
potential source of *undesirable consequences* (3.23)

Note 1 to entry: A hazard can be a *risk* (3.9) source (see ISO Guide 73). Examples of hazards include a possible abnormal action or environmental influence, insufficient strength or stiffness, or excessive detrimental deviation from intended dimensions (see ISO 2394).

3.5.1
hazard identification
process to find, list and characterize *hazards* (3.5)

3.5.2
hazard curve
exceedance probability of a specified *hazard* (3.5) intensity for a specified period of time

3.5.3
hazard screening
process of identifying significant *hazards* (3.5) for consideration during *risk assessment* (3.11) of *systems* (3.22) involving the *structures* (3.21)

3.6
option
possible measure for managing *risk* (3.9)

Note 1 to entry: Doing nothing can be one of the feasible options.

3.7
residual risk
risk (3.9) remaining after *risk treatment* (3.17)

3.8
resilience
ability of a *system* (3.22) to reduce likelihood of *failure* (3.4), to absorb effects of such failure if it occurs and to recover quickly after failure

3.9
risk
effect of uncertainty on objectives

Note 1 to entry: Risk is generally described as a combination of the probability or frequency of occurrence of an event and the magnitude of its consequence.

Note 2 to entry: From the viewpoint of the decision theory, risk is defined as the expected value of all undesirable consequences, i.e. the sum of all the products of the consequences of an event and their probabilities. (see ISO 2394).

[SOURCE: ISO 2394:2015, 2.1.40, modified — Note 1 has been added.]

3.10
risk acceptance
decision to accept a *risk* (3.9) to secure certain benefits

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3.11
risk assessment
overall process of establishment of *structural engineering context* (3.19), definition of *system* (3.22), identification of *hazards* (3.5) and consequences, *risk estimation* (3.15), *risk evaluation* (3.16) and evaluation of treatment *options* (3.6)

3.12
risk communication
exchange or sharing of information about *risk* (3.9) among the decision-makers and *stakeholders* (3.20)

Note 1 to entry: The information can relate to the existence, nature, form, probability, severity, acceptability, treatment or other aspects of risk.

Note 2 to entry: Engineers are the main source for risk information and should encourage decision-makers and stakeholders to communicate with each other. Some engineers are part of, or support, the decision-makers.

3.13
risk control
actions implementing risk-management decisions

Note 1 to entry: Risk control can involve monitoring, re-evaluation and compliance with decisions.

3.14
risk criteria
criteria against which the significance of the results of the *risk* (3.9)analysis is evaluated

Note 1 to entry: The criteria are generally based on regulations, standards, experience, and/or theoretical knowledge used as a basis for risk acceptance.

Note 2 to entry: Risk criteria can depend on associated costs and benefits, legal and statutory requirements, socio-economic and environmental aspects, the concerns of stakeholders, priorities and other inputs to the assessment.

3.15
risk estimation
process of assigning values to the probability of occurrence of events and their consequences

3.16
risk evaluation
process of comparing the estimated *risk* (3.9) with given *risk criteria* (3.14) to determine the significance of the risk

Note 1 to entry: Risk evaluation is the process for assisting in the decision to accept or to treat a risk.

3.17
risk treatment
process of selection and implementation of measures to mitigate *risk* (3.9)

3.18
scenario
description of sequences or combinations of events in time and space and their inter-relationship given the occurrence of a *hazard* (3.5)

3.19
structural engineering context
background or reasons why the *risk assessment* (3.11) is implemented from structural perspectives

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3.20
stakeholder
any individual, group, organization or authority that can affect, be affected by, or perceive itself to be affected by, a *risk* (3.9)

Note 1 to entry: The decision-maker is sometimes categorized as one of the stakeholders.

3.21
structure
arrangement of materials that is expected to withstand certain actions and to perform some intended function

3.22
system
delimited group of interrelated, interdependent or interacting objects that is assessed for a *risk* (3.9)

Note 1 to entry: This definition implies that the system is identifiable and is made up of interacting elements or subsystems, that all elements are identifiable, and that the boundary of the system can be identified.

Note 2 to entry: A system involving structures includes the structural system defined in ISO 2394 as a subsystem.

3.23
undesirable consequence
direct and indirect harm due to structural damage, functionality loss, etc., stated in terms of personal injury, death, environmental damage, societal harm and/or monetary loss

Note 1 to entry: There can be more than one undesirable consequence from an event.

Note 2 to entry: Consequences can be expressed qualitatively or quantitatively.

Note 3 to entry: Both immediate and long-term consequences are included.

3.24
undesirable event
event that can have *undesirable consequences* (3.23)

Note 1 to entry: Undesirable events are sometimes caused by natural, technological and human-induced hazards.

4 Fundamentals of risk assessment of systems involving structures

Risk assessment of system involving structures shall be done within the scope of the prescribed risk management; see Annexes A and B. Risk assessment shall consist of the following elements: the establishment of the structural engineering context, the definition of system, the identification of hazards and consequences, the risk estimation, the risk evaluation and the evaluation of options for risk treatment.

NOTE 1 A risk management process typically consists of the establishment of risk-management goals, a risk assessment, a risk treatment, communication and consultation, and a monitoring and review; see Annex A. The establishment of risk-management goals includes the development of risk criteria; see 9.1.

NOTE 2 A risk management process is not a one-way process but an iterative process; see Annexes A and B.

There shall be thorough communication and appropriate consultation with the stakeholders for each element of the risk assessment. After the risk assessment is complete, its results shall be conveyed in a suitable manner so that appropriate decisions can be made and the stakeholders can understand them. The decision concerning structures shall conform to requirements specified in ISO 2394.

The appropriateness of all elements of the risk assessment shall be reviewed in order to ensure continuous improvement of the risk management process, including risk assessment; see Annexes A and B.

The results of risk assessment shall be documented for future reference to guarantee that decisions are understood and to assist in the continuous improvement of the process; see Clause 11.

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