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Fire safety engineering — Performance of structures in fire

Part 8: Example of a probabilistic assessment of a concrete building

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Part 8: Example of a probabilistic assessment of a concrete building

Ingénierie de la sécurité incendie — Performance des structures en situation d'incendie —

Partie 8: Exemple d'évaluation probabiliste d'un bâtiment en béton

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Contents

Page

Foreword ... **iv**

Introduction ... **v**

1 Scope ... **1**

2 Normative references ... **1**

3 Terms, definitions and symbols ... **1**
3.1 Terms and definitions ... 1
3.2 Symbols ... 1

4 Design strategy for fire safety of structure ... **3**

5 Quantification of the performance of structures in fire ... **4**
5.1 STEP 1: Scope of the project for fire safety of structure ... 4
5.1.1 Built-environment characteristics ... 4
5.1.2 Fuel loads ... 7
5.1.3 Mechanical actions ... 7
5.2 STEP 2: Identifying objectives, functional requirements and performance criteria for fire safety of structures ... 9
5.3 STEP 3: Trial plan for fire safety of structures ... 9
5.4 STEP 4: Design fire scenarios and design fires ... 9
5.5 STEP 5: Thermal response of the structures ... 9
5.6 STEP 6: Mechanical response of the structures ... 10
5.6.1 Structural model ... 10
5.6.2 Stochastic variables ... 11
5.6.3 Probabilistic evaluation of the column load bearing capacity ... 13
5.7 STEP 7: Assessment against the fire safety objectives ... 14
5.7.1 Example assessment 1: full probabilistic analysis — user-calculated analysis ... 14
5.7.2 Example assessment 2: full probabilistic analysis — listed fragility curve ... 18
5.7.3 Example assessment 3: semi-probabilistic assessment ... 20
5.8 STEP 8: Documentation of the design for fire safety of structures ... 22

Bibliography ... **24**

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Foreword

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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).

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This document was prepared by Technical Committee ISO/TC 92, *Fire safety*, Subcommittee SC 4, *Fire safety engineering*.

A list of all parts in the ISO 24679 series can be found on the ISO website.

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

This document provides an example of the application of ISO 24679-1. The procedure in this document is intended to follow the principles outlined in ISO 24679-1. The clauses of ISO 24679-1 which are considered relevant to this document are identified and the clause titles are kept the same and in the same order.

The purpose of this document is to demonstrate the application of the steps outlined in ISO 24679-1 for fire safety engineering, performance of structures in fire, applying probabilistic methods.

The analysis shows how the achievement of the fire safety objectives, with respect to structural fire resistance, can be demonstrated through probabilistic analysis. The building is based on a demonstration case for Eurocode 2[2] and is thus conformant with the design requirements of EN 1992-1-2[5]. For this type of building, a probabilistic analysis would generally not be performed. However, probabilistic analysis can demonstrate the achievement of the fire safety objectives for situations which are not conformant with standard design guidance.

This document only presents an example application of a probabilistic analysis. More advanced applications considering system behaviour and stochastic fire exposure are possible. These more advanced procedures will generally result in an improved understanding of the reasonably foreseeable structural behaviour in case of fire, and can, for example, be used for an in-depth analysis of the post-fire structural performance.

Probabilistic methods make engineering assumptions more explicit. This pushes the engineer to question their competence and promotes an in-depth communication with stakeholders on the intended structural performance in case of fire.

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Fire safety engineering — Performance of structures in fire —

Part 8: Example of a probabilistic assessment of a concrete building

1 Scope

This document provides an example of a probabilistic assessment of a concrete building by revisiting the structural fire analysis of the concrete building presented in ISO/TR 24679-6, using probabilistic approaches. Specifically, the most heavily-loaded concrete column is analysed probabilistically, using the evaluation in ISO/TR 24679-6 as a starting point.

This report only addresses the fire safety objectives related to the structural performance. The analysis within this document therefore forms only part of the overall building fire safety strategy.

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 24679-1, *Fire safety engineering — Performance of structures in fire — Part 1: General*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24679-1 apply.

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

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

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

3.2 Symbols

e	average eccentricity
E	load effect
E_d	design value of E
E_k	characteristic load
f	out-of-straightness
f_{ck}	characteristic concrete compressive strength

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f_{yk}	characteristic steel yield strength
G	dead load
G_F	dead load façade
G_k	characteristic value of the permanent load effect
K_E	model uncertainty for the load effect
K_R	model uncertainty for the resistance effect
L	column height
$N_{ED,fi}$	design load
p_s	reliability (i.e. probability of failure in the case of a given fire exposure)
p_f	failure probability
$p_{f,t}$	target maximum failure probability
P	axial load
P_{max}	load bearing capacity of the column
$P_{max,num}$	numerical evaluation of P_{max}
P_{Gk}	characteristic permanent load
P_{Qk}	characteristic imposed load
P_T	total axial load
Q	dominant live load effect
Q_k	characteristic value of the imposed load effect
R	resistance effect
R_d	design value of R
R_k	characteristic resistance
V	coefficient of variation
V_E	coefficient of variation for the load effect
V_R	coefficient of variation for the resistance effect
Z	limit state function
β	reliability index
β_t	target reliability index
γ_0	safety factor
γ_E	load factor
γ_R	resistance factor

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ε	surface emissivity of the member
μ	mean value
μ_E	mean value for the load effect
μ_R	mean value for the resistance effect
σ	standard deviation
σ_E	standard deviation for the load effect
σ_R	standard deviation for the resistance effect
Φ	out-of-plumbness; the standard normal cumulative distribution function
χ	load ratio (characteristic live load effect relative to total characteristic load effect)
Ψ	combination factor for the live load effect
Ψ_{fi}	fire design variable action combination factor
Ø	reinforcement bar diameter

4 Design strategy for fire safety of structure

The built environment of this example is an office building, as considered in ISO/TR 24679-6. The structural elements are composed of concrete.

For the concrete columns, the tabulated fire resistance, under standard thermal action (ISO 834) in accordance with EN 1992-1-2 is 90 min, while the calculated fire resistance using simplified calculation methods is 180 min, as specified in Eurocode 2.[2]

The safety level (i.e. probability of failure) associated with a tabulated or calculated standard fire resistance is not known. Consequently, there is a possibility that the structure does not behave as expected during fire exposure, notably because:

— the expectations did not account for the failure probability;

— the real fire conditions and structural behaviour do not match the concept of fire resistance under standard fire exposure.

These shortcomings can be reduced by:

— conducting a detailed analysis taking into account potential fire scenarios and structural behaviour for the building system in question, as applied in ISO/TR 24679-6, where the fire was defined taking into account Reference [3]; or

— conducting a probabilistic assessment of the failure probability for an isolated structural element exposed to a standard fire, as applied further; or

— a combination of both of the previous bullet points, for example, a full probabilistic analysis of a structural system, taking into account uncertainties in the fire development and structural response. This level of analysis can be very computationally expensive.

In the following clauses, a probabilistic assessment is carried out for the example concrete building (specifically, for the most loaded concrete column), demonstrating confidence in the achievement of the fire safety objectives.

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