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Extended application of results from fire resistance tests - Part 8: Beams

Erweiterter Anwendungsbereich der Ergebnisse aus Feuerwiderstandsprüfungen - Teil 8: Balken

Application étendue des résultats des essais de résistance au feu - Partie 8 : Poutres

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13.220.50	Požarna odpornost gradbenih materialov in elementov	Fire-resistance of building materials and elements
91.060.99	Drugi stavbni elementi	Other elements of buildings

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COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: Avenue Marnix 17, B-1000 Brussels

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Foreword

This document (EN 15080-8:2009) has been prepared by Technical Committee CEN/TC 127 “Fire safety in buildings”, the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by April 2010, and conflicting national standards shall be withdrawn at the latest by April 2010.

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1 Scope

This part of EN 15080 identifies the parameters and factors that affect the fire resistance of beams and need to be taken into account when considering extended application of results of beams tested in accordance with EN 1365-3. It also gives the methodology to be used when preparing an extended application, including rules and calculation methods which can be applied to establish the resultant influence of a variation in one or more parameters and to determine the field of extended application.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 338, *Structural timber — Strength classes*

EN 1194, *Timber structures — Glued laminated timber — Strength classes and determination of characteristic values*

EN 1363-1:1999, *Fire resistance tests — Part 1: General Requirements*

EN 1365-3:1999, *Fire resistance tests for loadbearing elements — Part 3: Beams*

EN 10025-1, *Hot rolled products of structural steels — Part 1: General technical delivery conditions*

EN 10025-2, *Hot rolled products of structural steels — Part 2: Technical delivery conditions for non-alloy structural steels*

EN 10080–1, *Steel for the reinforcement of concrete – Weldable reinforcing steel — Part 1: General requirements*

prEN 10138-1, *Prestressing steels — Part 1: General requirements*

EN 13501-2*, Fire classification of construction products and building elements — Part 2: Classification using data from fire resistance tests, excluding ventilation services*

EN ISO 13943:2000, *Fire safety — Vocabulary (ISO 13943:2000)*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in EN ISO 13943:2000, EN 1363-1:1999 and EN 1365-3:1999, together with the following apply.

3.1
test result
outcome of a testing process and its associated procedures detailed within EN 1365-3 (which may include some processing of the results from the testing of a number of specimens). A test result is expressed in terms of one or more fire performance parameter(s)

3.2
direct field of application of test results
outcome of a process (involving the application of defined rules) whereby a test result is deemed to be equally valid for variations in one or more of the product properties and/or intended end use application(s)

NOTE The direct field of application of test results are presented in EN 1365-3.

3.3
extended field of application of test results
outcome of a process (involving the application of defined rules that may incorporate calculation procedures) that predicts, for a variation of a product property and/or its intended end use application(s), a test result on the basis of one or more test results to the same test standard, i.e. to EN 1365-3

3.4
classification
process defined in EN 13501-2, whereby the fire performance parameters obtained from the results of one test, or a set of tests, or from a process of extended application, are compared with limiting values for those parameters that are set as criteria for achieving a certain classification

NOTE The relevant classes and related criteria for fire resistance are specified in Commission Decisions (2000/367/EC, 2000/147/EC and 2001/671/EC).

3.5
reference test
fire resistance test according to EN 1365-3 on a beam from which the test result is used for the process of extended application

NOTE There may be more than one reference test.

3.6
parameter
aspect of the reference scenario that may vary in practice and may result in a change of the fire resistance performance

NOTE Examples are the load level and the span.

3.7
modelling factor
factor determined for a considered relevant structural failure mode on basis of the assessment of the reference test(s), which takes into account the differences between the test results and calculated results, and which is used to adjust the results of the extended application

3.8
calculated structural resistance
resistance to bending or shear of a beam in a fire test calculated at the end of the test

3.9
effective structural resistance
predicted resistance to bending or shear of a beam for use in an extended application

3.10
relative resistance
ratio of the bending or shear resistance of a beam in a fire resistance test to the resistance at normal temperatures calculated with all safety factors taken as unity

3.11
target classification
fire resistance that the extended application is required to achieve

4 Basis and methodology of establishing the extended application

4.1 General

An extended application analysis is required when the application of a beam is not covered by the field of direct application given in the classification document of the product.

The situation of (a) fire test(s) carried out according to EN 1365-3 will be referred to as the "reference test" and "reference scenario". The result of a test, i.e. the fire resistance with respect to the load bearing capacity, will be referred as "$t_{ref,fi}$".

If more than one reference test is available, all the tests may be used for the extended application provided that the tests all have the same mechanical boundary conditions and have all been carried out using the same fire curve.

NOTE It is possible that in the classification report all reference beams are classified with the same classification "R_{ref}" although the actual test results ($t_{ref,fi}$) given in the test reports may differ.

4.2 Basic principles

4.2.1 General

It is assumed that extended application is made by appropriately qualified and experienced persons in the field of structural fire design.

The reference test(s) shall be well documented, i.e. an insight into the performance of the test specimen(s) and the mode of failure, leading to R_{ref}, are available.

Three analyses (described in 4.3, 4.4 and 4.5) should be carried out where appropriate. It shall be decided whether:

— field of application can be extended, maintaining the classification R_{ref} or changing the classification and if so, by how much;

— extension is not possible (new tests are required).

Any predicted increase in fire resistance shall not exceed the lesser of 15 min and 20 % of the target classification.

NOTE This is illustrated in A.3.

4.2.2 Basis of the extended application

An adequate understanding of the structural and thermal performance, as well as an understanding of other relevant features, shall be achieved based on the scope of the required extended application. For minor or obvious extensions to the reference test, the depth of analysis required may be reduced.

4.2.3 Mode of failure

Any assessment shall consider the possibility that the mode or cause of failure, such as structural collapse in bending or failure of a fire protection system, might change and that the mode or cause of failure in a fire test may no longer be critical if one or more parameters are changed.

If a change of failure mode is expected, then extended application is not possible unless additional information is available.

NOTE For additional information see A.1.

4.2.4 Methods of analysis

When analysing the reference test(s), the rules given in the Eurocodes shall be used if applicable. Additional rules are given in this standard. These are also applicable in cases where the Eurocodes do not fully cover the construction to be assessed. Other calculation models, as well as empirical rules, shall be validated on the basis of similar tests as the reference test(s). Historic data and ad hoc tests may be used to supplement to the information of the reference test(s).

4.3 Basic thermal analysis

If the extended application is intended to be for a cross section of a size or shape different from the reference test(s) or for a different resistance time or another nominal fire curve, then a thermal assessment shall be made. The analysis should lead to an understanding of the temperature distribution and material strength variation throughout the beam.

The analysis may take the form of a finite element or finite difference thermal analysis. In limited circumstances, when a dimension is changed, it may be possible to show, using a simple calculation, that the temperature distribution measured in the test can be conservatively used for the modified cross section.

For timber beams, it may be sufficient to analyse the charring depth instead of carrying out a complete thermal analysis. Where a thermal analysis is carried out, the position of the char-line shall be taken as the position of the 300 °C isotherm.

4.4 Basic structural analysis

4.4.1 General

The structural behaviour of the reference test(s) and of the situation to be assessed shall be analysed. The depth of structural analysis will depend on the complexity of the beam and the extent of the proposed extended application. For any assessment the same failure modes states should be considered as were considered for normal temperature design. These include:

— Bending (including lateral torsional buckling).

— Vertical shear.

— Horizontal shear.

NOTE 1 It is not normally necessary to consider deformations. See A.7.

The assessment shall also include:

— Connections, either mechanical or glued, between parts of the construction.

— Boundary conditions.

— Material properties versus temperature.

NOTE 2 As an illustration of the depth of structural analysis required, the report on the analysis for the vertical shear check on a steel beam might simply say, “The shear is low enough to have no influence on the bending strength - no check required”.

4.4.2 Modelling factor

Any assessment shall take into account the accuracy of the structural model used. Models which overestimate the load resistance of the reference test(s), shall have a modelling factor applied when used to make an assessment for extended application.

In making any assessment, the effective structural resistance shall be determined as follows:

$$R_{\text{eff}} = R \times k_{\text{mf}} \tag{1}$$

where

R_{eff} is the effective structural resistance;

R is the calculated structural resistance;

k_{mf} is the modelling factor.

For a single reference test, the modelling factor is defined as:

$$k_{mf} = \frac{F}{R} \quad \text{but not greater than 1,0} \tag{2}$$

where

F is the applied load or moment in the reference test.

For more than one reference test:

$$k_{mf} = \frac{1}{n}\sum\frac{F_i}{R_i} \quad \text{but not greater than 1,0} \tag{3}$$

where

F_i is the applied load or moment in the reference test I;

R_i is the calculated structural resistance of test i calculated using the measured temperature distribution;

n is the number of tests.

and with each individual value:

$(F_i / R_i) \leq 1,3$

If the value of (F_i / R_i) exceeds 1,3 then that test should not be used as part of the assessment of extended application.

NOTE 1 If the measured temperature distribution is not sufficiently comprehensive to allow the structural resistance to be adequately predicted then it may be supplemented with computed temperatures.

NOTE 2 If the value of (F_i / R_i) exceeds 1,3, there may be something wrong with the test data or with some aspect of the engineering model being used so the particular test may be considered unreliable.

4.4.3 Material properties

The reference test(s) should be assessed using measured material strength. If the actual material strength is not available then the strength should be taken from Table 1.

In making any assessment of extended application, mean material properties shall be assumed. If the actual mean value is unknown, then values for the mean strength should be taken from Table 1.

NOTE The values in Table 1 are conservative values for the mean strength.

For additional information see A.1.

Table 1 — Conservative values for mean strength

Material	Mean strength[(a)]
Concrete compressive strength	f_{ck} + 8 N/mm^2
Reinforcement steel to EN 10080 for concrete	$f_{sk} \times 1,1$
Prestressing steel to EN 10138-1 for concrete	$f_{pk} \times 1,1$
Hot rolled structural steel to EN 10025 parts 1 and 2	$f_y \times 1,1$
Timber - Structural timber, strength classes C14 to C40 to EN 338	$f_k \times 1,5$
- glued laminated timber, all strength classes to EN 1194	$f_k \times 1,3$
- LVL	$f_k \times 1,25$
Other materials	to be estimated
(a) $f_{i\,k}$ and f_y are the characteristic strength values (5 % fractile).	

4.5 Analysis of other features

Where relevant phenomena not assessed in 4.3 and 4.4 shall be taken into account.

NOTE These may include such things as the stickability of fire protection materials and spalling of concrete. For spalling of concrete, reference should be made to EN 1992-1-2:2004, subclauses 4.5 and 6.2.

The stickability of fire protection materials should be either:

assessed using the methods given in ENV 13381,

or

be based on clear evidence of the performance of the material and fixing system in at least two fire tests.

5 Critical parameters

5.1 General

The parameters listed in 5.2 to 5.6 may affect the fire performance, i.e. the value of $R_{ref,}$ and shall be taken into account when preparing an extended application. The specific constructional parameters vary depending upon the nature of the beam being considered.

NOTE 1 The list in this section is not definitive; in special cases other parameters may also be appropriate.

NOTE 2 The review in Annex A of parameters and of corresponding factor and factor influences, is only given for the common thermal, common mechanical and common constructional parameters.

5.2 Common thermal parameters

1) Nominal gas temperature time curves.

2) Number of exposed faces.

5.3 Common mechanical parameters

1) Mechanical load.

2) Distribution of mechanical load.

3) Axial restraint.

4) Rotational restraint.

5) Lateral restraint.

5.4 Common constructional parameters

1) Span.

2) Dimensions of cross section.

3) Shape of cross section.

4) Surface dimensions of bearings.

5) Position and size of holes.

5.5 Specific constructional parameters for beams without applied fire protection

5.5.1 Concrete beams

The following specific parameters can be distinguished:

a) Concrete specification

NOTE 1 This will normally include:

1) Type of concrete, i.e. normal weight or lightweight concrete.

2) Type of concrete aggregate, i.e. siliceous, calcareous or lightweight.

3) Strength of concrete.

b) Specification of reinforcement

NOTE 2 This will normally include:

1) Type of reinforcement, i.e. reinforcing steel, prestressing bars, wires or strands.

2) Characteristic strength of the reinforcing or prestressing steel.

3) Is the steel hot rolled or cold worked or quenched and tempered?

4) The ductility characteristics of the reinforcing steel.

c) Degree of any prestressing.

d) Bond and anchorage properties of the reinforcing or prestressing steel, i.e. ribbed or plain surface.

e) Bonded versus unbonded tendons (post tensioned beams).