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Contents

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 16, an inside back cover and a back cover.

Foreword

Publishing information

This Published Document has been prepared by BSI Subcommittee B/525/1.

This Published Document is published by BSI and came into effect on 30 April 2007. It was prepared by Subcommittee B/525/1, *Actions (loadings) and basis of design*, under the authority of Technical Committee B/525, *Building and civil engineering structures*. A list of organizations represented on this committee can be obtained on request to its secretary.

Relationship with other publications

This Published Document is a background paper that gives non-contradictory complementary information for use in the UK with BS EN 1991-1-2 and its UK National Annex.

Use of this document

As a guide, this Published Document takes the form of guidance and recommendations. It should not be quoted as if it were a specification and particular care should be taken to ensure that claims of compliance are not misleading.

Any user claiming compliance with this Published Document is expected to be able to justify any course of action that deviates from its recommendations.

Presentational conventions

The provisions in this document are presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is "should".

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

The word "should" is used to express recommendations of this document. The word "may" is used in the text to express permissibility, e.g. as an alternative to the primary recommendation of the clause. The word "can" is used to express possibility, e.g. a consequence of an action or an event.

Notes and commentaries are provided throughout the text of this document. Notes give references and additional information that are important but do not form part of the recommendations. Commentaries give background information.

Contractual and legal considerations

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

Compliance with a Published Document cannot confer immunity from legal obligations.

Introduction

When there is a need for guidance on a subject that is not covered by the Eurocode, a country can choose to publish documents that contain non-contradictory complementary information that supports the Eurocode. This Published Document provides just such information and has been cited as a reference in the UK National Annex to BS EN 1991-1-2.

1 Scope

This Published Document is a background paper that gives non-contradictory complementary information for use in the UK with BS EN 1991-1-2 and its UK National Annex.

This Published Document gives non-contradictory complementary information on:

a) background to the decision made in NA to BS EN 1991-1-2 for combination rules for mechanical actions for structural analysis;

b) guidance on BS EN 1991-1-2:2002, Annex A and Annex B; and

c) replacements for informative annexes BS EN 1991-1-2:2002, Annex C, Annex E and Annex F.

2 Combination rules for mechanical actions for structural analysis [BS EN 1991-1-2:2002, 4.3.1 (2)]

NA to BS EN 1991-1-2 recommends that the representative value of the variable action Q_{L} should be taken as the frequent value $\psi_{1,\mathrm{L}}Q_{\mathrm{L}}$, for certain situations as described in **2**f). The reason for this is given by the following.

a) Based on BS EN 1990:2002, **6.4.3.3** equation 6.11b simplifies to the combination of actions for accidental design situations as:

$$G + A + \psi_{1 \text{ or } 2,L}Q_L + \Sigma\psi_{2,i}Q_i$$

where

G is the permanent action;

A is the accidental action (which may involve an explicit action or refer to the situation after an accidental event such that $A = 0$);

Q_L is the leading variable action (i.e. that which has the largest effect);

Q_i are other variable actions which can be imposed, snow or wind loads;

ψ_1 is the frequent combination factor;

ψ_2 is the quasi-permanent combination factor.

b) In the case of fire, the accidental action A results in increased temperatures and hence reduced resistances of structural members such that $A = 0$ after the accidental event.

c) BS EN 1991-1-2:2002, **4.3.1** (2) allows the use of ψ_1 or ψ_2 in the accidental design situation for fire.

d) The values for ψ given in NA to BS EN 1990:2002, Table NA.A1.1 for buildings are summarized in Table 1.

Table 1 **Summary of values for ψ given in BS EN 1990:2002, Table NA.A1.1**

Action		ψ_1	ψ_2
Imposed loads in buildings	Domestic, residential areas; office areas	0,5	0,3
	Congregation areas; shopping areas	0,7	0,6
	Storage areas	0,9	0,8
	Roofs	0	0
Snow on buildings for sites located at altitude H ⩽ 1 000 m above sea level		0,2	0
Wind loads on buildings		0,2	0

e) Based on a comparison with existing UK practice, two cases related to the following ultimate limit states from BS EN 1990:2002, **6.4.1** have been identified in g).

1) EQU: Loss of static equilibrium of the structure or any part of it considered as a rigid body, where minor variations in the value or the spatial distribution of actions from a single source are significant, and the strengths of construction materials or ground are generally not governing.

2) STR: Internal failure or excessive deformation of the structure or structural members, including footings, piles, basement walls, etc., where the strength of construction materials governs.

f) The recommendation would be that ψ_1 is used for EQU cases and ψ_2 for STR cases. Thus for overturning of otherwise "rigid" perimeter columns during fire at actual or potential site boundaries EQU would be considered with wind included; and for internal structural collapse occasioned by member weakening during fire STR would be considered based on imposed loads without wind or snow.

g) Thus, the loads to apply in the fire limit state in addition to the permanent actions are given in Table 2.

Table 2 **Loads to apply in the fire limit state in addition to the permanent actions for leading variable action ψ_1 or ψ_2**

Case		**EQU (ψ_1 chosen)**	**STR (ψ_2 chosen)**
If imposed (I) loads leading	Domestic, residential; office areas	0,5I	0,3I
	Congregation areas; shopping areas	0,7I	0,6I
	Storage	0,9I	0,8I
	Roofs	0	0
If snow (S) loads leading	Domestic, residential; office areas	0,2S + 0,3I	0,3I
	Congregation areas; shopping areas	0,2S + 0,6I	0,6I
	Storage	0,2S + 0,8I	0,8I
	Roofs	0,2S	0
If wind (W) loads leading	Domestic, residential; office areas	0,2W + 0,3I	0,3I
	Congregation areas; shopping areas	0,2W + 0,6I	0,6I
	Storage	0,2W + 0,8I	0,8I
	Roofs	0,2W	0

3 Guidance on BS EN 1991-1-2 informative annexes

3.1 Parametric temperature–time curves (BS EN 1991-1-2:2002, Annex A)

3.1.1 General

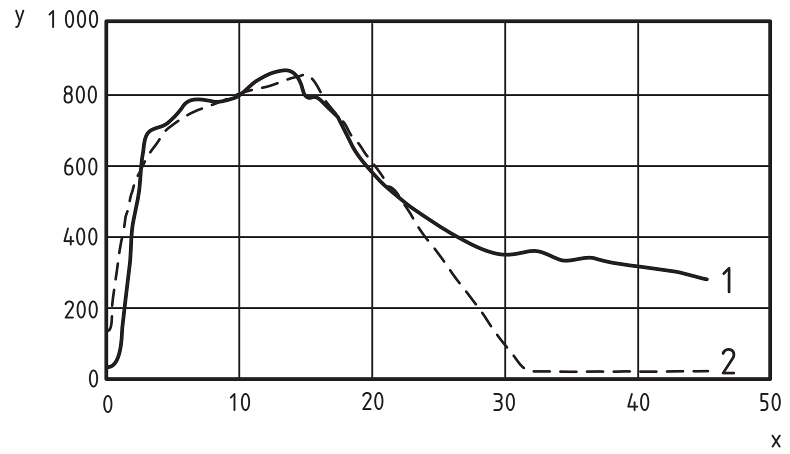
A major exercise was carried out to validate the parametric expressions against well documented fire test data. It was generally found that the temperature–time response predicted by the parametric expressions either closely matched the measured fire curve or over-predicted (safe) response.

A comparison between calculated and measured response for a low fire load is shown in Figure 1.

A comparison between calculated and measured response for a high fire load is shown in Figure 2. While there appears to be a difference in temperature time curves between the calculated and measured response when this is considered in relation to the thermal response of a lightly protected structural member this is not significant.

Figure 1 **Comparison between calculated and measured response for a low fire load**

Fire load, 15 kg/m³; opening factor, 0.06 m$^{1/2}$



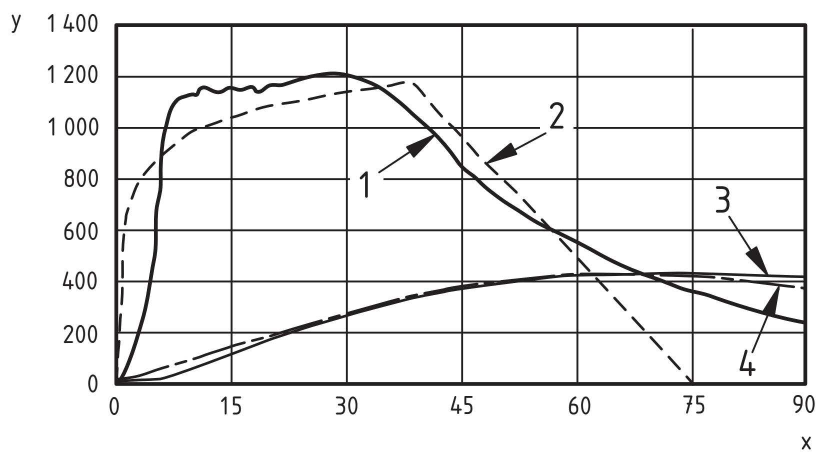
Key

x Time, mins — 1 EC1 calculated

y Temperature, °C — 2 Measured

Figure 2 **Comparison between calculated and measured response for a high fire load**

Fire load, 40 kg/m³; opening factor, 0.07 m$^{1/2}$



Key

x Time, mins

y Temperature, °C

1 Atmosphere, measured

2 Atmosphere, EC1 calculated

3 Steel, measured

4 Steel, EC1 calculated

3.1.2 Non-contradictory complementary information

BS EN 1991-1-2:2002, Annex A may be used with the following complementary information.

a) The calculations may also be applied to fire compartments greater than 500 m^2.

b) The application of the parametric fire may be extended to compartment heights greater than 4 m. However, for tall compartments, the outputs may be particularly onerous and it may be more appropriate to consider using computational fluid dynamics or other similar calculation methods.

c) The insulation factor *b* for the compartment boundaries assumes ambient temperature properties. Elevated temperature values may be used where appropriate reliable data is available.

d) The lower limit of the range of opening factors may be extended from 0,02 $m^{1/2}$ to 0,01 $m^{1/2}$. This broadening of the scope of application of the parametric fires was based on a major calibration/research exercise [1] leading up to the development of the NA to BS EN 1991-1-2. The following is worth noting.

   1) Sensitivity analysis was carried out on the effect of increasing the floor areas.

   2) The 0.01 factor was based upon historical data and calibration against previous analytical studies.

   3) It was demonstrated that by increasing the compartment height the temperature time history of the fires would result in lower temperature (less severe heating curve). This is because the fire load is expressed as a function of the floor area.

3.2 Thermal actions for external members – Simplified calculation method (BS EN 1991-1-2:2002, Annex B)

Annex B may be used with the following complementary information.

a) The method may overestimate the temperatures and this will commonly occur at window heights of around 0.6 m or less irrespective of the window width.

b) Where temperatures of the fire or flames in a building exceed 1 750 K and 1 850 K respectively, the outputs should be considered as overly conservative. These values may be used as upper limits.

c) Calculations may provide a negative flame height, which indicates that the flame tip is no higher than the top of the window.

4 UK replacements for BS EN 1991-1-2 informative annexes

4.1 Localized fires (BS EN 1991-1-2:2002, Annex C)

This annex may not be used. Replacement UK guidance is given in PD 7974-1:2003, **8.2.1.1** to **8.2.1.14**.

4.2 Fire load densities (BS EN 1991-1-2:2002, Annex E)

This annex may not be used. A replacement UK informative annex is given in Annex A.

The UK was unable to accept BS EN 1991-1-2:2002, Annex E. In particular, there is a fundamental disagreement on the use of factors (given in BS EN 1991-1-2:2002, Table E.2) that multiply the design fire load density depending upon other fire safety measures that may be incorporated in the building. In addition the UK could not accept the multiplication factors given in BS EN 1991-1-2:2002, Table E.1.

BS EN 1991-1-2 attempts to apply a risk-based approach through modifying the fire load density. The UK considered the consequences of fire should not be addressed in the engineering calculations but should form part of a separate analysis after the fire related outputs have been obtained. However, it was considered the contribution of an active suppression system restricting the fire size that was acceptable which is already acknowledged within Approved Document B to the Building Regulations 2000 [2].

At some major sites, such as airports, an on-site dedicated fire brigade may exist. In such circumstances it may be appropriate to adjust the fire load calculations to reflect the speed of response and familiarity of the site layout. However, these provisions should form part of the overall fire safety strategy and should not be taken in isolation.

It is intended that Annex A, which contains information from PD 7974-1, may be used to determine the fire load densities for use in calculating fire scenarios, e.g. parametric temperature time relationships, or time equivalent assessments for estimating the period of heating in the BS EN 1363-1 furnace test.

4.3 Equivalent time of fire exposure (BS EN 1991-1-2:2002, Annex F)

This annex may not be used. A replacement UK informative annex is given in Annex B.

Annex A (informative) Fire load densities (BS EN 1991-1-2:2002, Annex E)

NOTE This annex is intended to be used as a replacement for BS EN 1991-1-2:2002, Annex E.

A.1 General

The design value of the fire load $q_{f,d}$ (in MJ/m^2) is defined as:

$$q_{f,d} = q_{f,k} m \delta_1 \qquad \text{(A.1)}$$

where

$q_{f,k}$ is the characteristic fire load density per unit floor area (MJ/m^2) (see **A.2**);

m is the combustion factor (see **A.6**);

δ_1 is a factor of 0,61 that can be applied to take into account sprinklers if installed for life safety purposes.

Additional safety measures such as automatic fire detection and alarm, smoke exhaust, means of escape (simultaneous, phased, pressurized staircases) and fire fighting devices, should be considered as part of the fire safety design strategy for the building and guidance is given in the Building Regulations 2000 [2], BS 5588 and DD 9999.

A.2 Determination of fire load densities

A.2.1 General

The fire load should consist of all combustible contents and the combustible parts of the building fabric including linings and finishes.

The characteristic fire load densities may be determined:

a) from a fire load classification of occupancies is given in **A.3**.

b) for an individual project by performing a fire load survey is given in **A.4**.

NOTE In special cases design values are based on fire resistance requirements given in the Building Regulations 2000 [2].

The fire load classification of occupancies given in **A.3** do not include the combustible parts of the building fabric, linings or finishes.

A.2.2 Definitions

A.2.2.1 The characteristic fire load $Q_{fi,k}$ (in MJ) is defined as:

$$Q_{fi,k} = \Sigma M_{k,i} H_{u,i} \Psi_i = \Sigma Q_{fi,k,I} \qquad \text{(A.2)}$$

where

$M_{k,i}$ is the amount of combustible material (kg);

$H_{u,i}$ is the calorific value (MJ/kg), see Equation (A.4);

Ψ_i is the optional factor for assessing protected fire loads, (see **A.2.3**).

A.2.2.2 The characteristic fire load density $q_{f,k}$ per unit area (in MJ/m^2) is defined as:

(A.3) $$q_{f,k} = Q_{fi,k}/A_f$$

where

A_f is the floor area of the fire compartment or reference space.

NOTE In certain circumstances, the reference area is the inner surface area A_t of the fire compartment. In which case:

$$q_{t,k} = Q_{fi,k}/A_t$$

A.2.2.3 Permanent fire loads, which are not expected to vary during the life of the structure, should be introduced by their expected values resulting from the survey.

A.2.2.4 Variable fire loads, which may vary during the service life of a structure, should be represented by values that are not expected to be exceeded during 80% of time.

A.2.3 Protected fire loads

A.2.3.1 Fire loads in containers, which are designed to survive fire exposure, need not be considered.

A.2.3.2 Fire loads in containments with no specific fire design, but which remain intact during fire exposure, may be considered as follows:

The largest fire load, but at least 10% of the protected fire loads, is associated with $\Psi_i = 1,0$.

If this fire load plus the unprotected fire loads are not sufficient to heat the remaining protected fire loads beyond ignition temperature, the remaining protected fire loads may be associated with $\Psi_i = 0$.

Otherwise, Ψ_i values need to be assessed individually.

A.2.4 Net calorific values

Net calorific values should be determined according to BS EN ISO 1716.

The moisture content of materials H_u (in MJ/kg) may be taken into account as follows:

(A.4) $$H_u = H_{u0}\,(1 - 0{,}01u) - 0{,}025u$$

where

u is the moisture content expressed as percentage of dry weight;

H_{u0} is the net calorific value of dry materials.

Net calorific value of some solids and liquids are given in Table A.1.

NOTE Additional information is provided in the SFPE Handbook of Fire Protection Engineering [3].

Table A.1 **Net calorific values H_u of combustible materials for calculation of fire loads** [a)]

Material type	**Material**	**Calorific value H_u** MJ/kg
Solids	Anthracite	34
	Asphalt	41
	Bitumen	42
	Cellulose	17
	Charcoal	35
	Coal, coke	31
	Cork	29
	Cotton	18
	Grease	41
	Kitchen refuse	18
	Leather	19
	Linoleum	20
	Paper, cardboard	17
	Paraffin wax	47
	Foam rubber	37
	Rubber isoprene	45
	Rubber tyre	32
	Silk	19
	Straw	16
	Wood	18
	Wool	23
	Particle board	18
Liquids	Gasoline (petrol)	44
	Diesel oil	41
	Linseed oil	39
	Methanol	20
	Paraffin (kerosene)	41
	Spirits	29

a) This table is reproduced from PD 7974-1.

Table A.1 **Net calorific values H_u of combustible materials for calculation of fire loads** [a] (*continued*)

Material type	**Material**	**Calorific value H_u** MJ/kg
Plastics	Acrylonitrile butadiene styrene (ABS)	36
	Polymethyl methacrylate (PMMA)	28
	Celluloid	19
	Epoxy	34
	Melamine resin	18
	Phenol formaldehyde	29
	Polyester	31
	Polyester, glass-fibre-reinforced	21
	Polyethylene	44
	Polystyrene	40
	Polyisocyanurate foam	24
	Polycarbonate	29
	Polypropylene	43
	Polyurethane	23
	Polyurethane foam	26
	Polyvinyl chloride	17
	Urea formaldehyde	15
	Urea formaldehyde foam	14

[a] This table is reproduced from PD 7974-1.

A.3 Fire load classification of occupancies

A.3.1 The fire load densities should be classified according to occupancy, be related to floor area, and be used as characteristic fire load densities $q_{f,k}$ (in MJ/m^2), as given in Table A.2.

Table A.2 **Fire load densities $q_{f,k}$ for different occupancies** [a)]

Occupancy	**Fire load density** $q_{f,k}$			
	Average MJ/m²	**Fractile** [b)] MJ/m²		
		80%	90%	95%
Dwelling	780	870	920	970
Hospital	230	350	440	520
Hospital storage	2 000	3 000	3 700	4 400
Hotel bedroom	310	400	460	510
Offices	420	570	670	760
Shops	600	900	1 100	1 300
Manufacturing	300	470	590	720
Manufacturing and storage [c)]	1 180	1 800	2 240	2 690
Libraries	1 500	2 250	2 550	–
Schools	285	360	410	450

a) This table is reproduced from PD 7974-1.

b) The 80% fractile is the value that is not exceeded in 80% of the rooms or occupancy of the survey data. Typically this value may be used in design.

c) Storage of combustible materials at less than 150 kg/m².

A.3.2 The fire load densities given in Table A.1 assume perfect combustion, but in real fires, the heat of combustion is usually considerably less.

A.3.3 The fire loads given in Table A.2 are valid for ordinary rooms in connection with the occupancies given here. Special rooms should be considered in accordance with **A.2**.

A.3.4 The fire loads from the building fabric, linings and finishes should be determined according to **A.2**. These should be added to the fire load densities of **A.3.1** if relevant.

A.4 Individual assessments of fire load densities

A.4.1 In the absence of occupancy classes, the fire load densities may be specifically determined for an individual project by performing a survey of fire loads from the occupancy.

A.4.2 The fire loads and their local arrangement should be estimated considering the intended use, furnishings and installations, variations with time and possible modifications of occupancy.

A.4.3 Where available, a survey should be determined in a comparable existing project, such that only possible differences between the intended and existing project need to be specified by the client.

A.5 Combustion behaviour

The combustion behaviour should be considered as a function of the occupancy and the type of fire load. Where referenced combustion data based upon fire test does not exist, $m = 1{,}0$ should be used.

A.6 Rate of fire growth

A.6.1 The growth phase of many fires can be characterized as increasing proportionally with the square of time measured from an ignition reference time, t_i, as:

$$Q = \alpha(t - t_i)^2 \quad \text{(A.5)}$$

where

Q is the rate of heat release from the fire during the growth phase (kW);

t is the time from ignition (s);

t_i is the time of ignition (s);

α is the fire growth rate parameter (kJ/s^3).

The fire growth parameters are classified according Table A.3:

Table A.3 **Fire growth rate parameters α** a)

Classification	Fire growth rate parameters, α
Slow	0,002 9
Medium	0,012
Fast	0,047
Ultra-fast	0,188

a) This table is reproduced from PD 7974-1.

A.6.2 The fire growth rate parameters represent fire growth starting with a reasonably large flaming ignition source. With a smaller source, there is an incubation period before established flaming occurs.

A.6.3 The design fire growth rates for different occupancies are given in Table A.4.

Table A.4 **Design fire growth rates** a)

Building use	Fire growth rate
Picture gallery	Slow
Passenger stations and termini for air, rail, road or sea travel	Slow
Classroom (school)	Medium
Dwelling	Medium
Office	Medium
Hotel reception	Medium
Hotel bedroom	Medium
Hospital room	Medium
Library	Fast
Theatre (cinema)	Fast
Shop	Fast
Industrial storage or plant room	Ultra-fast

a) This table is supplemented from PD 7974-1:2003, Table 3.

A.6.4 The characteristic fire growth rates given in Table A.4 should be used for general design purposes for different types of occupancies. For mixed building use, the faster growth rate should be adopted.

A.7 Rate of heat release

If the likely peak rate of heat release per unit area can be established for the particular use of a building, the rate of heat release Q (in kW) may be calculated from the fire area (or vice versa) by means of the following equation:

(A.6) $$Q = Q'' A_{fire}$$

where

Q is the total heat release rate from the fire (kW);

Q'' is the total heat release rate per unit area of fire (kW/m^2), recommended values for which are given in Table A.5;

A_{fire} is the area of fire (m^2).

Table A.5 **Heat release rate per unit area of fire for different occupancies** [a)]

Occupancy	**Heat release rate per unit area Q''** kW/m^2
Shops	550
Offices	290
Hotel rooms	249
Industrial	86 – 620 (depending upon fuel and arrangement)

NOTE Information given in this table is predominantly of US origin and therefore may not always be representative of UK occupancies. Further information for specific occupancies is provided in PD 7974-1.

a) This table is reproduced from PD 7974-1.

Annex B (informative) Equivalent time of fire exposure (BS EN 1991-1-2:2002, Annex F)

NOTE This annex is intended to be used as a replacement for BS EN 1991-1-2:2002, Annex F.

B.1 The following approach may be used where the design of members is based on tabulated data or other simplified rules, related to the standard fire exposure.

B.2 The equivalent time of standard fire exposure $t_{e,d}$ (in min) is defined by:

(B.1) $$t_{e,d} = q_{f,d} k_b w_f; \text{ or}$$

$$t_{e,d} = q_{t,d} k_b w_t$$

where

$q_{f,d}$ is the design fire load density according to the UK guidance set out in Annex A;

k_b is the conversion factor according to **B.3**;

w_f is the ventilation factor according to **B.4**, whereby $w_t = w_f(A_t/A_f)$.

B.3 For totally unprotected structural steel Equation (B.1) is restricted to periods of time equivalent up to 30 min.

B.4 Where no detailed assessment of the thermal properties of the enclosure is made, the conversion factor k_b (in min·m²/MJ) may:

a) be taken as 0,09 when q_d is given in MJ/m²; or

b) be related to the thermal property $b = \sqrt{\rho c \lambda}$ of the enclosure according to Table B.1.

For determining b for multiple layers of material or different materials in walls, floor, ceiling, see BS EN 1991-1-2:2002, Annex A (5) and (6).

Table B.1 **Conversion factor k_b depending on the thermal properties of the enclosure**

$b = \sqrt{\rho c \lambda}$ J/m²s^1/2^K	k_b min·m²/MJ
$b > 2\ 500$	0.055
$720 \leqslant b \leqslant 2\ 500$	0.07
$b < 720$	0.09

B.5 The ventilation factor w_f may be calculated as:

(B.2) $$w_f = (6,0/H)^{0,3}[0,62 + 90(0,4 - \alpha_v)^4/(1 + b_v\alpha_h)] \geqslant 0,5$$

where

$\alpha_v = A_v/A_f$ is the area of vertical openings in the façade A_v related to the floor area of the compartment A_t where the limit $0,025 \leqslant \alpha_v \leqslant 0,25$ should be observed;

$\alpha_h = A_h/A_f$ is the area of the horizontal openings in the roof A_h related to the floor area of the compartment A_f;

$b_v = 12,5(1 + 10\alpha_v - \alpha_v^2) \geqslant 10$;

H is the height of the compartment (in m).

For small fire compartments ($A_f < 100$ m²) without openings in the roof, the factor w_f may also be calculated as:

(B.3) $$w_f = O^{-1/2}A_f/A_t$$

where

O is the opening factor according to Annex A.

B.6 It should be verified that:

(B.4) $$t_{e,d} < t_{fi,d}$$

where

$t_{fi,d}$ is the design value of the standard fire resistance of the members, assessed according to the fire parts of BS EN 1992-1-2, 1993-1-2, 1994-1-2, 1995-1-2 to BS EN 1996-1-2 and BS EN 1999-1-2.

B.7 In carrying out a time equivalent analysis due consideration should be given to the changes in ventilation during the fire, which can have a major influence on both the temperatures attained and the duration of heating.

B.8 The numerical outputs from the time equivalent calculations should not be used in isolation and should be considered as part of an overall fire strategy for the building or structure. The fire strategy should address the:

a) awareness of fire and the ability of the occupants to reach a place of safety; and

b) influence of the size and height of the building or structure on the consequences of failure to life safety and neighbouring property.

Without any further consideration to the consequences of failure on life safety and neighbouring property protection, the factors given in Table B.2 may be applied to the outputs from the time equivalent calculations.

The multiplication of the risk factors in Table B.2 was developed to align with the fire resistance periods given in Approved Document B to the Building Regulations 2000 [2] for the general case.

Utilization of these factors with periods given in regulations covering Scotland and Northern Ireland requires selection of suitable occupancy classes against categories given in those regulations.

Table B.2 **Height associated with multiplication risk factors**

Occupancy	**Height associated with multiplication risk factor** m					
	0,65	**1,0**	**1,35**	**2,0**	**2,65**	**3,3**
Residential (dwelling)	–	0–5	5–18	18–30	>30	–
Residential (institutional)	–	–	0–5	5–18	18–30	>30
Residential (other)	–	0–5	5–18	18–30	>30	–
Office	0–5	5–18	18–30	>30	–	–
Retail	0–5	5–18	18–30	>30	–	–
Assembly (high)	0–5	5–18	18–30	>30	–	–
Assembly (med)	0–5	5–18	18–30	>30	–	–
Assembly (low)	0–5	5–18	18–30	>30	–	–
Industrial (high)	0–5	5–18	18–30	>30	–	–
Industrial (low)	0–5	5–18	18–30	>30	–	–

Bibliography

Standard publications

For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

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