BRITISH STANDARD

BS EN
1991-1-7:2006
+A1:2014
Incorporating corrigendum February 2010

Eurocode 1 — Actions on structures —

Part 1-7: General actions — Accidental actions

ICS 91.010.30

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BSI Documents Document Sharing Hub British Standards

Full document details: BS EN 1991-1-7:2006+A1:2014

National foreword

This British Standard is the UK implementation of EN 1991-1-7:2006+A1:2014, incorporating corrigendum February 2010. It supersedes BS EN 1991-1-7:2006, which is withdrawn.

The start and finish of text introduced or altered by corrigendum is indicated in the text by tags. Text altered by CEN corrigendum February is indicated in the text by [AC1⟩ ⟨AC1].

The start and finish of text introduced or altered by amendment is indicated in the text by tags. Tags indicating changes to CEN text carry the number of the CEN amendment. For example, text altered by CEN amendment A1 is indicated by [A1⟩ ⟨A1].

CEN amendment A1:2014 introduces a revised informative Annex, Annex D. The UK committee noted technical errors in subclause D.4 regarding explosions in ducts. Annex D of BS EN 1991-1-7:2006+A1:2014 can therefore be used only if it is complemented by further guidance available in the forthcoming PD 6688-1-7.

The structural Eurocodes are divided into packages by grouping Eurocodes for each of the main materials, concrete, steel, composite concrete and steel, timber, masonry and aluminium, this is to enable a common date of withdrawal (DOW) for all the relevant parts that are needed for a particular design. The conflicting national standards will be withdrawn at the end of the coexistence period, after all the EN Eurocodes of a package are available.

In the UK, the following national standards are superseded by the Eurocode 1 series. These standards will be withdrawn on a date to be announced.

Eurocode	**Superseded British Standards**
EN 1991-1-1	BS 6399-1:1996
EN 1991-1-2	none
EN 1991-1-3	BS 6399-3:1998
EN 1991-1-4	BS 6399-2:1997, BS 5400-2:2006
EN 1991-1-5	BS 5400-2:2006
EN 1991-1-6	none
EN 1991-1-7	BS 5400-2:2006
EN 1991-2	BS 5400-1:1998, BS 5400-2:2006
EN 1991-3	none
EN 1991-4	none

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 29 September 2006

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Amendments/corrigenda issued since publication

Date	Comments
30 April 2010	Implementation of CEN corrigendum February 2010
31 July 2014	Implementation of CEN amendment A1:2014

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The UK participation in its preparation was entrusted by Technical Committee B/525, Building and civil engineering structures, to Subcommittee B/525/1, Actions (loadings) and basis of design.

A list of organizations represented on this subcommittee can be obtained on request to its secretary.

Where a normative part of this EN allows for a choice to be made at the national level, the range and possible choice will be given in the normative text, and a Note will qualify it as a Nationally Determined Parameter (NDP). NDPs can be a specific value for a factor, a specific level or class, a particular method or a particular application rule if several are proposed in the EN.

To enable BS EN 1991-1-7:2006+A1:2014 to be used in the UK, the latest version of the NA to this Standard containing these NDPs should also be used. At the time of publication, it is NA+A1:2014 to BS EN 1991-1-7:2006 +A1:2014.

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

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1991-1-7:2006+A1

June 2014

ICS 91.010.30

English Version

Eurocode 1 - Actions on structures - Part 1-7: General actions - Accidental actions

Eurocode 1 - Actions sur les structures Partie 1-7: Actions générales - Actions accidentelles

Eurocode 1 - Einwirkungen auf Tragwerke - Teil 1-7: Allgemeine Einwirkungen - Außergewöhnliche Einwirkungen

This European Standard was approved by CEN on 9 January 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the Central Secretariat or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the Central Secretariat has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.

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Foreword

This European Standard (EN 1991-1-7:2006) has been prepared on behalf of Technical Committee CEN/TC250 “Structural Eurocodes”, the Secretariat of which is held by BSI.

CEN/TC 250 is responsible for all Structural Eurocodes.

This European Standard supersedes ENV 1991-2-7:1998.

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 January 2007 and conflicting national standards shall be withdrawn at the latest by March 2010.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard: Austria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

Foreword to amendment A1

This document (EN 1991-1-7:2006/A1:2014) has been prepared by Technical Committee CEN/TC 250 “Structural Eurocodes”, the secretariat of which is held by BSI.

This Amendment to the European Standard EN 1991-1-7:2006 shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by June 2015, and conflicting national standards shall be withdrawn at the latest by June 2015.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN [and/or CENELEC] shall not be held responsible for identifying any or all such patent rights.

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Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on Article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

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In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement[1] between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links de facto the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products – CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of parts:

EN 1990	Eurocode	Basis of structural design
EN 1991	Eurocode 1:	Actions on structures
EN 1992	Eurocode 2:	Design of concrete structures
EN 1993	Eurocode 3:	Design of steel structures
EN 1994	Eurocode 4:	Design of composite steel and concrete structures
EN 1995	Eurocode 5:	Design of timber structures
EN 1996	Eurocode 6:	Design of masonry structures
EN 1997	Eurocode 7:	Geotechnical design
EN 1998	Eurocode 8:	Design of structures for earthquake resistance
EN 1999	Eurocode 9:	Design of aluminium structures

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at a national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognise that Eurocodes serve as reference documents for the following purposes:

– as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement N°1 – Mechanical resistance and stability – and Essential Requirement N°2 – Safety in case of fire;

– as a basis for specifying contracts for construction works and related engineering services;

– as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs).

[1] Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on Eurocodes for the design of building and civil engineering works (BC/CEN/03/89).

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The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents[2] referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standards[3]. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving a full compatibility of these technical specifications with the Eurocodes.

The Eurocode Standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National Standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National Annex (informative).

The National Annex (informative) may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e.:

– values and/or classes where alternatives are given in the Eurocode;

– values to be used where a symbol only is given in the Eurocode;

– country specific data (geographical, climatic, etc) *e.g.* snow map;

– procedure to be used where alternative procedures are given in the Eurocode.

It may also contain:

– decisions on the application of informative annexes;

– references to non contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and harmonised technical specifications (ENs and ETAs) for products

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works[4]. Furthermore, all the information accompanying the CE marking of the construction products which refer to Eurocodes shall clearly mention which Nationally Determined Parameters have been taken into account.

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[2] According to Article 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for hENs and ETAGs/ETAs.

[3] According to Article 12 of the CPD the interpretative documents shall:
a) give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary;
b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc.;
c) serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.

The Eurocodes, de facto, play a similar role in the field of the ER 1 and a part of the ER 2.

[4] See Article 3.3 and Article 12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

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Additional information specific to EN 1991-1-7

EN 1991-1-7 describes Principles and Application rules for the assessment of accidental actions on buildings and bridges. The following actions are included:

– impact forces from vehicles, rail traffic, ships and helicopters,

– actions due to internal explosions,

– actions due to local failure from an unspecified cause.

EN 1991-1-7 is intended for use by:

– clients (e.g. for the formulation of their specific requirements on safety levels),

– designers,

– constructors, and

– relevant authorities.

EN 1991-1-7 is intended to be used with EN 1990, the other parts of EN 1991 and EN 1992 – 1999 for the design of structures.

National Annex

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1991-1-7 should have a National Annex containing all Nationally Determined Parameters to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

The National choice is allowed in EN 1991-1-7 through clauses[5]:

Paragraph	Item
2 (2)	Classification of accidental actions
3.1(2)	Strategies for accidental design situations
3.2(1)	Level of risk
3.3(2)	Notional accidental action
3.3(2)	Limit of local failure
3.3(2)	Choice of strategies
3.4(1)	Consequences classes
3.4(2)	Design approaches
4.1(1)	Definition of lightweight structures
4.1(1)	Transmission of impact forces to foundations
4.3.1(1)	Values of vehicle impact forces
4.3.1(1)	Impact force as a function of the distance from traffic lanes

[5] It is proposed to add to each clause of the list what will be allowed for choice: value, procedures, classes.

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4.3.1(1)	Types or elements of structure subject to vehicular collision
4.3.1(2)	Alternative impact rules
4.3.1(3)	Conditions of impact from road vehicles
4.3.2(1)	Clearances and protection measures and design values
4.3.2(1)	Reduction factor r_F
4.3.2(1)	Impact actions on underside of bridge decks
4.3.2(2)	Use of F_{dy}
4.3.2(3)	Dimension and position of impact areas
4.4(1)	Value of impact forces from forklift trucks
4.5(1)	Type of rail traffic
4.5.1.2(1)	Structures to be included in each exposure class
4.5.1.2(1)	Classification of temporary structures and auxiliary construction works
4.5.1.4(1)	Impact forces from derailed traffic
4.5.1.4(2)	Reduction of impact forces
4.5.1.4(3)	Point of application of impact forces
4.5.1.4(4)	Equivalent static forces
4.5.1.4(5)	Impact forces for speeds greater than 120 km/h
4.5.1.5(1)	Requirements for Class B structures
4.5.2(1)	Areas beyond track ends
4.5.2(4)	Impact forces on end walls
4.6.1(3)	Classification of ship impacts
4.6.2(1)	Values of frontal and lateral forces from ships
4.6.2(2)	Friction coefficients
4.6.2(3)	Application area of impact
4.6.2(4)	Impact forces on bridge decks from ships
4.6.3(1)	Dynamic impact forces from seagoing ships
4.6.3(3)	Friction coefficients
[AC1⟩ 4.6.3(4)P ⟨AC1]	Dimension and position of impact areas
4.6.3(5)	Forces on superstructure
5.3 (1)P	Procedures for internal explosion
A.4 (1)	Details of effective anchorage

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Section 1 General

1.1 Scope

(1) EN 1991-1-7 provides strategies and rules for safeguarding buildings and other civil engineering works against identifiable and unidentifiable accidental actions.

(2) EN 1991-1-7 defines:

– strategies based on identified accidental actions,

– strategies based on limiting the extent of localised failure.

(3) The following subjects are dealt with in this part of EN 1991:

– definitions and symbols (Section 1);

– classification of actions (Section 2);

– design situations (Section 3);

– impact (Section 4);

– explosions (Section 5);

– design for consequences of localised failure in buildings from an unspecified cause (informative Annex A);

– information on risk assessment (informative Annex B);

– dynamic design for impact (informative Annex C);

– internal explosions (informative Annex D).

(4) Rules on dust explosions in silos are given in EN 1991-4.

(5) Rules on impact from vehicles travelling on the bridge deck are given in EN 1991-2.

(6) EN 1991-1-7 does not specifically deal with accidental actions caused by external explosions, warfare and terrorist activities, or the residual stability of buildings or other civil engineering works damaged by seismic action or fire, etc.

NOTE See also 3.1.

1.2 Normative references

(1) This European Standard incorporates by dated or undated reference provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed hereafter. For dated references, subsequent amendments to, or revisions of, any of these publications apply to this European Standard only when incorporated in it by amendment or revision. For undated references, the latest edition of the publication referred to applies (including amendments).

NOTE The Eurocodes were published as European Prestandards. The following European Standards which are published or in preparation are cited in normative clauses or in NOTES to normative clauses.

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EN 1990	Eurocode: Basis of structural design
EN 1991-1-1	Eurocode 1: Actions on structures Part 1-1: Densities, self-weight, imposed loads for buildings.
EN 1991-1-6	Eurocode 1: Actions on structures Part 1-6: Actions during execution
EN 1991-2	Eurocode 1: Actions on structures Part 2: Traffic loads on bridges
EN 1991-4	Eurocode 1 : Actions on structures Part 4: Silos and tanks
EN 1992	Eurocode 2: Design of concrete structures
EN 1993	Eurocode 3: Design of steel structures
EN 1994	Eurocode 4: Design of composite steel and concrete structures
EN 1995	Eurocode 5: Design of timber structures
EN 1996	Eurocode 6: Design of masonry structures
EN 1997	Eurocode 7: Geotechnical design
EN 1998	Eurocode 8: Design of structures for earthquake resistance
EN 1999	Eurocode 9: Design of aluminium structures

1.3 Assumptions

(1)P The general assumptions given in EN 1990, 1.3 apply to this part of EN 1991.

1.4 Distinction between Principles and Application rules

(1) P The rules given in EN 1990, 1.4 apply to this part of EN 1991.

1.5 Terms and definitions

(1) For the purposes of this European Standard, general definitions are provided in EN 1990, 1.5. Additional definitions specific to this part are given below.

1.5.1
burning velocity
rate of flame propagation relative to the velocity of the unburned dust, gas or vapour that is ahead of it.

1.5.2
consequence class
classification of the consequences of failure of the structure or part of it.

1.5.3
deflagration
propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium.

1.5.4
detonation
propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium.

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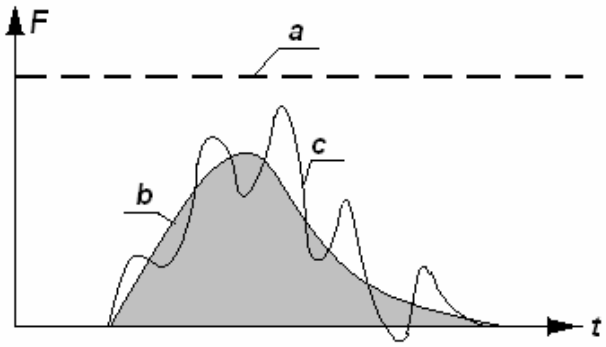
1.5.5
dynamic force
force that varies in time and which may cause significant dynamic effects on the structure; in the case of impact, the dynamic force represents the force with an associated contact area at the point of impact (see Figure 1.1).



Key :
a : equivalent static force
b : dynamic force
c : structural response

Figure 1.1

1.5.6
equivalent static force
an alternative representation for a dynamic force including the dynamic response of the structure (see Figure 1.1).

1.5.7
flame speed
speed of a flame front relative to a fixed reference point.

1.5.8
flammable limit
minimum or maximum concentration of a combustible material, in a homogeneous mixture with a gaseous oxidiser that will propagate a flame.

1.5.9
impacting object
the object impacting upon the structure (i.e. vehicle, ship, etc).

1.5.10
key element
a structural member upon which the stability of the remainder of the structure depends.

1.5.11
load-bearing wall construction
non-framed masonry cross-wall construction mainly supporting vertical loading. Also includes lightweight panel construction comprising timber or steel vertical studs at close centres with particle board, expanded metal or alternative sheathing.

1.5.12
localised failure
that part of a structure that is assumed to have collapsed, or been severely disabled, by an accidental event.

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1.5.13
risk
a measure of the combination (usually the product) of the probability or frequency of occurrence of a defined hazard and the magnitude of the consequences of the occurrence.

1.5.14
robustness
the ability of a structure to withstand events like fire, explosions, impact or the consequences of human error, without being damaged to an extent disproportionate to the original cause.

1.5.15
substructure
that part of a building structure that supports the superstructure. In the case of buildings this usually relates to the foundations and other construction work below ground level. In the case of bridges this usually relates to foundations, abutments, piers and columns etc.

1.5.16
superstructure
that part of a building structure that is supported by the substructure. In the case of buildings this usually relates to the above ground construction.In the case of bridges this usually relates to the bridge deck.

1.5.17
venting panel
non-structural part of the enclosure (wall, floor, ceiling) with limited resistance that is intended to relieve the developing pressure from deflagration in order to reduce pressure on structural parts of the building.

1.6 Symbols

(1) For the purpose of this European Standard, the following symbols apply (see also EN 1990).

Latin upper case letters

F	collision force
F_{dx}	horizontal static equivalent or dynamic design [AC1] force on the front side of the supporting structure (frontal force) [AC1]
F_{dy}	horizontal static equivalent or dynamic design [AC1] force on the lateral side of the supporting structure (lateral force) [AC1]
F_R	frictional impact force
[AC1] *text deleted* [AC1]	
K_{St}	deflagration index of a dust cloud
P_{max}	maximum pressure developed in a contained deflagration of an optimum mixture
P_{red}	reduced pressure developed in vented enclosure during a vented deflagration
P_{stat}	static activation pressure that activates a vent opening when the pressure is increased slowly

Latin lower case letters

a	height of the application area of a collision force
b	width of an obstacle (*e*.g. bridge pier)
[AC1] d	distance from the structural element to the centre-line of the road or track [AC1]

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h clearance height from roadway surfacing to underside of bridge element; height of a collision force above the level of a carriageway

ℓ ship length

r_F reduction factor

s [AC1] distance from the structural element to the point where the vehicle leaves the trafficked lane [AC1]

m Mass

v_v Velocity

Greek lower case letters

μ friction coefficient

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Section 2 Classification of actions

(1)P Actions within the scope of this part of EN1991 shall be classified as accidental actions in accordance with EN 1990, 4.1.1.

NOTE Table 2.1 specifies the relevant clauses and sub-clauses in EN 1990, which apply to the design of a structure subjected to Accidental Actions..

Table 2.1 - Clauses in EN 1990 specifically addressing accidental actions.

Section	Clause/Sub-clause
Terms and definitions	1.5.2.5, 1.5.3.5, 1.5.3.15
Basic requirements	2.1(4), 2.1(5)
Design situations	3.2(2)P
Classifications of actions	4.1.1(1)P, 4.1.1(2), 4.1.2(8)
Other representative values of variable actions	4.1.3(1)P
Combination of actions for accidental design situations	6.4.3.3
Design values for actions in the accidental and seismic design situations	A1.3.2

(2) Accidental actions due to impact should be considered as free actions unless otherwise specified.

NOTE The National Annex or the individual project may specify the treatment of accidental actions which are not classified as free actions.

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Section 3 Design situations

3.1 General

(1)P Structures shall be designed for the relevant accidental design situations in accordance with EN 1990, 3.2(2)P.

(2) The strategies to be considered for accidental design situations are illustrated in Figure 3.1.

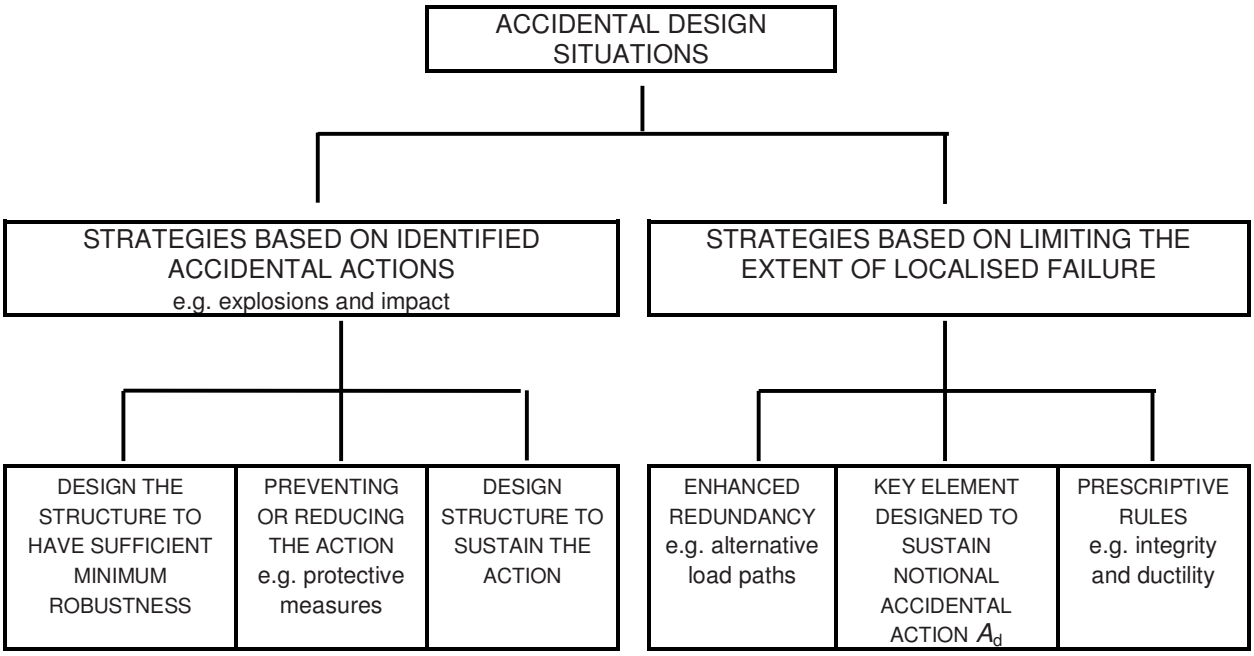

Figure 3.1 - Strategies for Accidental Design Situations

NOTE 1 The strategies and rules to be taken into account are those agreed for the individual project with the client and the relevant authority.

NOTE 2 Accidental actions can be identified or unidentified actions.

NOTE 3 Strategies based on unidentified accidental actions cover a wide range of possible events and are related to strategies based on limiting the extent of localised failure. The adoption of strategies for limiting the extent of localised failure may provide adequate robustness against those accidental actions identified in 1.1(6),or any other action resulting from an unspecified cause. Guidance for buildings is given in Annex A.

NOTE 4 Notional values for identified accidental actions (e.g. in the case of internal explosions and impact) are proposed in this part of EN 1991. These values may be altered in the National Annex or for an individual project and agreed for the design by the client and the relevant authority.

NOTE 5 For some structures (e.g. construction works where there is no risk to human life, and where economic, social or environmental consequences are negligible) subjected to accidental actions, the complete collapse of the structure caused by an extreme event may be acceptable. The circumstances when such a collapse is acceptable may be agreed for the individual project with the client and the relevant authority.

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3.2 Accidental design situations - strategies for identified accidental actions

(1) The accidental actions that should be taken into account depend upon:

– the measures taken for preventing or reducing the severity of an accidental action;

– the probability of occurrence of the identified accidental action;

– the consequences of failure due to the identified accidental action;

– public perception;

– the level of acceptable risk.

NOTE 1 See EN 1990, 2.1(4)P NOTE 1.

NOTE 2 In practice, the occurrence and consequences of accidental actions can be associated with a certain risk level. If this level cannot be accepted, additional measures are necessary. A zero risk level, however, is impracticable and in most cases it is necessary to accept a certain level of risk. Such a risk level can be determined by various factors, such as the potential number of casualties, the economic consequences and the cost of safety measures, etc.

NOTE 3 Levels of acceptable risks may be given in the National Annex as non contradictory, complementary information.

(2) A localised failure due to accidental actions may be acceptable, provided it will not endanger the stability of the whole structure, and that the overall load-bearing capacity of the structure is maintained and allows necessary emergency measures to be taken.

NOTE 1 For building structures such emergency measures may involve the safe evacuation of persons from the premises and its surroundings.

NOTE 2 For bridge structures such emergency measures may involve the closure of the road or rail service within a specific limited period.

(3) Measures should be taken to mitigate the risk of accidental actions and these measures should include, as appropriate, one or more of the following strategies:

a) preventing the action from occurring (e.g. in the case of bridges, by providing adequate clearances between the trafficked lanes and the structure) or reducing the probability and/or magnitude of the action to an acceptable level through the structural design process (e.g. in the case of buildings providing sacrificial venting components with a low mass and strength to reduce the effect of explosions);

b) protecting the structure against the effects of an accidental action by reducing the effects of the action on the structure (e.g. by protective bollards or safety barriers);

c) ensuring that the structure has sufficient robustness by adopting one or more of the following approaches:

1) by designing certain components of the structure upon which stability depends as key elements (see 1.5.10) to increase the likelihood of the structure's survival following an accidental event.

2) designing structural members, and selecting materials, to have sufficient ductility capable of absorbing significant strain energy without rupture.

3) incorporating sufficient redundancy in the structure to facilitate the transfer of actions to alternative load paths following an accidental event.

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NOTE 1 It may not be possible to protect the structure by reducing the effects of an accidental action, or preventing an action from occurring. This is because an action is dependent upon factors which, over the design working life of the structure, may not necessarily be part of the design assumptions. Preventative measures may involve periodic inspection and maintenance during the design working life of the structure.

NOTE 2 For the design of structural members with sufficient ductility, see Annexes A and C, together with EN 1992 to EN 1999.

(4)P Accidental actions shall, where appropriate, be applied simultaneously in combination with permanent and other variable actions in accordance with EN 1990, 6.4.3.3.

NOTE For ψ values, see Annex A of EN 1990.

(5)P The safety of the structure immediately following the occurrence of the accidental action shall be taken into account.

NOTE This includes the consideration of progressive collapse for building structures. See Annex A.

3.3 Accidental design situations – strategies for limiting the extent of localised failure

(1)P In the design, the potential failure of the structure arising from an unspecified cause shall be mitigated.

(2) The mitigation should be reached by adopting one or more of the following approaches:

a) designing key elements, on which the stability of the structure depends, to sustain the effects of a model of accidental action A_d;

NOTE 1 The National Annex may define the model which may be a concentrated or a distributed load with a design value of A_d. The recommended model for buildings is a uniformly distributed notional load applicable in any direction to the key element and any attached components (e.g. claddings, etc). The recommended value for the uniformly distributed load is 34 kN/m^2 for building structures. ⟦AC1⟩ Reference is made in A.8. ⟨AC1⟧

b) designing the structure so that in the event of a localised failure (e.g. failure of a single member) the stability of the whole structure or of a significant part of it would not be endangered;

NOTE 2 The National Annex may state the acceptable limit of "localised failure". The indicative limit for building structures is 100 m^2 or 15 % of the floor area, whichever is less, on two adjacent floors caused by the removal of any supporting column, pier or wall. This is likely to provide the structure with sufficient robustness regardless of whether an identified accidental action has been taken into account.

c) applying prescriptive design/detailing rules that provide acceptable robustness for the structure (e.g. three-dimensional tying for additional integrity, or a minimum level of ductility of structural members subject to impact).

NOTE 3 The National Annex may state which of the approaches given in 3.3 are to be considered for various structures. ⟦AC1⟩ *Text deleted* ⟨AC1⟧

3.4 Accidental design situations – use of consequence classes

(1) The strategies for accidental design situations may be based on the following consequences classes as set out in EN1990.

– CC1 Low consequences of failure

– CC2 Medium consequences of failure

– CC3 High consequences of failure

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NOTE 1 EN 1990 Annex B provides further information.

NOTE 2 In some circumstances it may be appropriate to treat some parts of the structure as belonging to a different consequence class, e.g. a structurally separate low rise wing of a building that is serving a less critical function than the main building.

NOTE 3 Preventative and/or protective measures are intended to remove or to reduce the probability of damage to the structure. For design purposes this can sometimes be taken into consideration by assigning the structure to a lower consequence class. In other cases a reduction of forces on the structure may be more appropriate.

NOTE 4 The National Annex may provide a categorisation of structures according to the consequences classes in 3.4(1). A suggested classification of consequences classes relating to buildings is provided in Annex A.

(2) Accidental design situations for the different consequences classes given in 3.4(1) may be considered in the following manner:

– CC1: no specific consideration is necessary for accidental actions except to ensure that the robustness and stability rules given in EN 1990 to EN1999, as applicable, are met;

– CC2: depending upon the specific circumstances of the structure, a simplified analysis by static equivalent action models may be adopted or prescriptive design/detailing rules may be applied;

– CC3: an examination of the specific case should be carried out to determine the level of reliability and the depth of structural analyses required. This may require a risk analysis to be carried out and the use of refined methods such as dynamic analyses, non-linear models and interaction between the load and the structure.

NOTE The National Annex may give reference to, as non conflicting, complementary information, appropriate design approaches for higher and lower consequences classes..

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Section 4 Impact

4.1 Field of application

(1) This section defines accidental actions due to the following events:

– impact from road vehicles (excluding collisions on lightweight structures) (see 4.3);

– impact from forklift trucks (see 4.4);

– impact from trains (excluding collisions on lightweight structures) (see 4.5);

– impact from ships (see 4.6);

– the hard landing of helicopters on roofs (see 4.7).

NOTE 1 Accidental actions on lightweight structures which are excluded from the field of application above (e.g. gantries, lighting columns, footbridges) may be referred to in the National Annex, as non contradictory complementary information..

NOTE 2 For impact loads on kerbs and parapets, see EN 1991–2.

NOTE 3 The National Annex may give guidance on issues concerning the transmission of impact forces to the foundations as non contradictory complementary information. See EN 1990, 5.1.3 (4).

(2)P For buildings, actions due to impact shall be taken into account for:

– buildings used for car parking,

– buildings in which vehicles or forklift trucks are permitted, and

– buildings that are located adjacent to either road or railway traffic.

(3) For bridges, the actions due to impact and the mitigating measures provided should take into account, amongst other things, the type of traffic on and under the bridge and the consequences of the impact.

(4)P Actions due to impact from helicopters shall be taken into account for buildings where the roof contains a designated landing pad.

4.2 Representation of actions

(1) Actions due to impact should be determined by a dynamic analysis or represented by an equivalent static force.

NOTE 1 The forces at the interface of the impacting object and the structure depend on their interaction.

NOTE 2 The basic variables for impact analysis are the impact velocity of the impacting object and the mass distribution, deformation behaviour and damping characteristics of both the impacting object and the structure. Other factors such as the angle of impact, the construction of the impacting object and movement of the impacting object after collision may also be relevant.

NOTE 3 See Annex C for further guidance.

(2) It may be assumed that the impacting body absorbs all the energy.

NOTE In general, this assumption gives conservative results.

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