Draft for Public Comment

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Interested committees:

Title: Draft BS EN 1991-1-7. Eurocode 1 - Actions on structures

Part 1-7: General actions - Accidental actions

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Introduction

This draft standard is based on national and international discussions. Your comments on this draft are invited and will assist in the preparation of the consequent standard.

For international standards, comments will be reviewed by the relevant UK national committee before sending the consensus UK vote and comments to the international committee, which will then decide appropriate action. If the international standard is approved, it is usual for the text to be published as a British Standard.

For national standards, comments will be reviewed by the relevant UK national committee and the resulting standards published as a British Standard.

UK Vote

Please indicate whether you consider the UK should submit a negative (with supporting technical reasons) or positive vote on this draft. Please indicate if you are aware of any reason why this draft standard should not be published as a British Standard.

Submission of Comments

- **Annotated drafts are not acceptable and will be rejected.**
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Template for comments and secretariat observations

Date: xx/xx/20xx	Document: ISO/DIS xxxx

1	2	(3)	4	5	(6)	7
MB	Clause No./ Subclause No./Annex **(e.g. 3.1)**	Paragraph/Figure/ Table/Note	**Type of comment**	**Commend (justification for change) by the MB**	**Proposed change by the MB**	**Secretariat observations on each comment submitted**
	3.1	Definition 1	ed	Definition is ambiguous and needs clarifying.	Amend to read '...so that the mains connector to which no connection...'	
	6.4	Paragraph 2	te	The use of the UV photometer as an alternative cannot be supported as serious problems have been encountered in its use in the UK.	Delete reference to UV photometer.	

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EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

DRAFT
prEN 1991-1-7

September 2023

ICS 91.010.30

English Version

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

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

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

This draft European Standard is submitted to CEN members for enquiry. It has been drawn up by the Technical Committee CEN/TC 250.

If this draft becomes a European Standard, 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.

This draft European Standard was established by CEN 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 CEN-CENELEC Management Centre has the same status as the official versions.

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Recipients of this draft are invited to submit, with their comments, notification of any relevant patent rights of which they are aware and to provide supporting documentation.

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Full document details: 23/30457267 DC

Contents

Page

European foreword 4
0 Introduction 5
1 Scope 8
1.1 Scope of prEN 1991-1-7 8
1.2 Assumptions 8
2 Normative references 8
3 Terms, definitions and symbols 8
3.1 Terms and definitions 8
3.2 Symbols 12
4 Basis of design 13
4.1 General strategies 13
4.2 Accidental design situations — strategies for identified accidental actions 13
4.3 Accidental design situations — use of consequence classes 14
5 Impact 16
5.1 Field of application 16
5.2 Classification of actions 17
5.3 Representation of actions 17
5.4 Accidental actions caused by road vehicles 17
5.5 Accidental actions caused by forklift trucks 21
5.6 Accidental actions caused by derailed rail traffic under or adjacent to structures 21
5.7 Accidental actions caused by ship traffic 24
5.8 Accidental actions caused by helicopters 27
6 Internal explosions 28
6.1 Field of application 28
6.2 Representation of action 28
6.3 Principles for design 29
Annex A (informative) Actions for tying systems and key members 31
A.1 Use of this Annex 31
A.2 Scope and field of application 31
A.3 Horizontal ties 31
A.4 Vertical ties 34
A.5 Key members 34
Annex B (informative) Information on risk assessment 35
B.1 Use of this annex 35
B.2 Scope and field of application 35
B.3 Description of scope, assumptions and limitations of a risk analysis 35
B.4 Methods of risk analysis 36
B.5 Risk evaluation and acceptance 37

Documents
Document Sharing Hub

Full document details: 23/30457267 DC

B.6 Risk mitigating measures 39
B.7 Reconsideration 39
B.8 Communication of results and conclusions 39
B.9 Applications to buildings and civil engineering structures 39
Annex C (informative) Dynamic design for impact 47
C.1 Use of this annex 47
C.2 Scope and field of application 47
C.3 General 47
C.4 Impact dynamics 48
C.5 Impact from aberrant road vehicles 49
C.6 Impact by ships 52
Annex D (informative) Internal explosions 56
D.1 Use of this annex 56
D.2 Scope and field of application 56
D.3 General 56
D.4 Natural gas explosions 56
D.5 Dust explosions in rooms, vessels and bunkers 57
D.6 Explosions in road and rail tunnels 59
D.7 Dust, gas and vapour/air explosions in energy ducts 60
Annex E (informative) Actions from debris 64
E.1 Use of this annex 64
E.2 Scope and field of application 64
E.3 Actions from debris 64
Bibliography 66

Documents
Document Sharing Hub
Full document details: 23/30457267 DC

European foreword

This document (prEN 1991-1-7:2023) has been prepared by Technical Committee CEN/TC 250 "Structural Eurocodes", the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

This document is currently submitted to the CEN Enquiry.

This document will supersede EN 1991-1-7:2006.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

In comparison with the previous edition, the following technical modifications have been made:

a) Transferring design strategies for robustness and related rules to EN 1990;

b) providing consistency between text and technical information on impact;

c) limiting the scope of Annex A to rules and actions for tying systems and key members; and

d) inserting technical clarifications in Annex C.

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Full document details: 23/30457267 DC

0 Introduction

0.1 Introduction to the Eurocodes

The structural Eurocodes comprise the following standards generally consisting of a number of Parts:

— EN 1990 Eurocode — Basis of structural and geotechnical 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 structure

— 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

— New parts are under development, e.g. Eurocode for design of structural glass

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1991 (all parts)

(1) EN 1991 (all parts) specifies actions for the structural and geotechnical design of buildings, bridges and other civil engineering works, including temporary structures, in conjunction with EN 1990 and the other Eurocodes.

(2) EN 1991 (all parts) does not cover seismic design. Provisions for structures in seismic regions are given in EN 1998.

(3) EN 1991 (all parts) is also applicable to existing structures for:

— structural assessment,

— strengthening or repair,

— change of use.

NOTE In these cases, additional or amended provisions are necessary.

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Full document details: 23/30457267 DC

(4) EN 1991 (all parts) is also applicable for the design of structures where materials or actions outside the scope of the other Eurocodes are involved.

NOTE In this case, additional or amended provisions are necessary.

(5) EN 1991 is subdivided in various parts:

EN 1991-1-1, *Eurocode 1 — Actions on structures — Part 1-1: Specific weight of materials, self-weight of construction works and imposed loads for buildings*

EN 1991-1-2, *Eurocode 1 — Actions on structures — Part 1-2: Actions on structures exposed to fire*

EN 1991-1-3, *Eurocode 1 — Actions on structures — Part 1-3: Snow Loads*

EN 1991-1-4, *Eurocode 1 — Actions on structures — Part 1-4: Wind Actions*

EN 1991-1-5, *Eurocode 1 — Actions on structures — Part 1-5: Thermal Actions*

EN 1991-1-6, *Eurocode 1 — Actions on structures — Part 1-6: Actions during execution*

EN 1991-1-7, *Eurocode 1 — Actions on structures — Part 1-7: Accidental actions*

EN 1991-1-8, *Eurocode 1 — Actions on structures — Part 1-8: Actions from waves and currents on coastal structures*

EN 1991-1-9, *Eurocode 1 — Actions on structures — Part 1-9: Atmospheric icing*

EN 1991-2, *Eurocode 1 — Actions on structures — Part 2: Traffic loads on bridges and other civil engineering works*

EN 1991-3, *Eurocode 1 — Actions on structures — Part 3: Actions induced by cranes and machines*

EN 1991-4, *Eurocode 1 — Actions on structures — Part 4: Silos and tanks*

0.3 Introduction to prEN 1991-1-7

prEN 1991-1-7 describes principles and application rules for the determination of accidental actions on buildings and other civil engineering works. The following actions are included:

— impact forces from vehicles, rail traffic, ships and helicopters;

— actions due to internal explosions of combustible gases and dust as well as of vapour-air-mixture; and

— actions for tying systems and key members.

NOTE Other Eurocodes can cover specific accidental actions.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

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0.5 National Annex for prEN 1991-1-7

National choice is allowed in this standard where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing prEN 1991-1-7 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

The National choice is allowed in prEN 1991-1-7 through the following clauses:

4.1(2)	4.2(1)	4.3(1) – 2 choices	4.3(2)
5.1(1) – 2 choices	5.2(2)	5.3(3)	5.4.1(1) – 3 choices
5.4.1(2) – 2 choices	5.4.1(3)	5.4.2(2) – 2 choices	5.4.2(3)
5.4.2(5)	5.5(2)	5.6.1(1)	5.6.2.2(1) – 2 choices
5.6.2.3(1)	5.6.2.4(1)	5.6.2.4(2)	5.6.2.4(3)
5.6.2.4(4)	5.6.2.4(5)	5.6.2.4(6)	5.6.2.5(1)
5.6.3(1)	5.6.3(3)	5.7.1(3)	5.7.1(5)
5.7.2(1)	5.7.2(2) – 2 choices	5.7.2(5)	5.7.2(6)
5.7.2(7) – 2 choices	5.7.3(1)	5.7.3(2)	5.7.3(3)
5.7.3(4)	5.7.3(5) – 2 choices	5.7.3(6) – 2 choices	5.8(2)
6.3.1(1)	A.1(1)	A.3.1(4)	A.3.2(3)
A.3.2(4)	A.3.3(1)	A.4.3(1) – 2 choices	A.5(1)
B.1(1)	C.1(1)	D.1(1)	D.6(3)
E.1(1)			

National choice is allowed in prEN 1991-1-7 on the application of the following informative annexes:

Annex A	Annex B	Annex C	Annex D

The National Annex can contain, directly or by reference, non-contradictory complementary information (NCCI) for ease of implementation, provided it does not alter any provisions of the Eurocodes.

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1 Scope

1.1 Scope of prEN 1991-1-7

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

NOTE 1 Identifiable accidental actions include impact from vehicles and internal explosions.

NOTE 2 Rules on impact from vehicles travelling on a bridge deck are given in prEN 1991-2.

(2) prEN 1991-1-7 also covers actions and rules for tying systems and key members; information on risk assessment; dynamic design for impact; actions for internal explosions; actions from debris.

1.2 Assumptions

(1) The general assumptions of EN 1990 apply to prEN 1991-1-7.

(2) prEN 1991-1-7 is intended to be used in conjunction with EN 1990, EN 1991 (all parts) and the other Eurocode parts for the design of structures.

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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in “should” clauses), permissions (“may” clauses), possibilities (“can” clauses), and in notes.

EN 1990:2023, *Eurocode — Basis of structural and geotechnical design*

EN 1991 (all parts), *Eurocode 1 — Actions on structures*

3 Terms, definitions and symbols

For the purposes of this document, the terms and definitions given in EN 1990 and the following terms, definitions and symbols apply.

NOTE Other specific symbols, especially treated in informative annexes, are given within the text.

3.1 Terms and definitions

3.1.1 General terms relevant to accidental actions

3.1.1.1
burning velocity
velocity of flame propagation relative to that of the unburned dust, gas or vapour that is ahead of the flame front

3.1.1.2
consequence class
categorization of the consequences of structural failure in terms of loss of human lives or personal injury and of economic, social, or environmental losses

[SOURCE: EN 1990:2023, 3.1.2.33]

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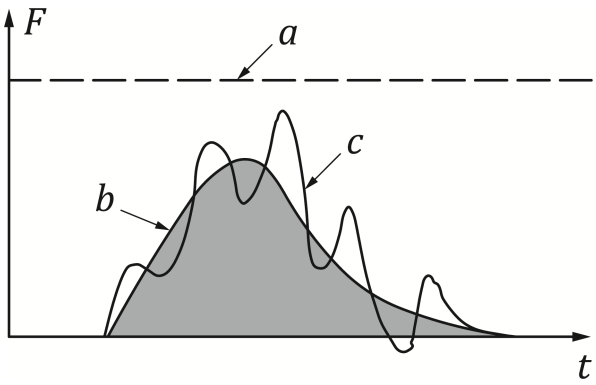
3.1.1.3
deflagration
propagation of a combustion zone at a velocity that is less than the speed of sound in the unreacted medium

3.1.1.4
detonation
propagation of a combustion zone at a velocity that is greater than the speed of sound in the unreacted medium

3.1.1.5
dynamic force
force that varies in time and which has the potential to 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 — Dynamic force

3.1.1.6
equivalent static force
alternative representation for a dynamic force including the dynamic response of the structure (see Figure 1.1)

3.1.1.7
flame speed
speed of a flame front relative to a fixed reference point

3.1.1.8
flammable limit
minimum or maximum concentration of a combustible material in a homogeneous mixture with a gaseous oxidizer that will propagate a flame

3.1.1.9
impacting object
object impacting upon a structure (e.g. vehicle, ship, etc.) during an accidental action

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3.1.1.10
key member
structural member upon which the stability of the remainder of the structure depends

3.1.1.11
load-bearing wall construction
non-framed masonry cross-wall construction mainly supporting vertical loading, including lightweight panel construction comprising timber or steel vertical studs at close centres with particle board, expanded metal or alternative sheathing

3.1.1.12
localized failure
part of a structure that is assumed to have collapsed, or been severely disabled, by an event

3.1.1.13
risk
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

3.1.1.14
robustness
ability of a structure to withstand events like impact, explosions, fire or the consequences of human error, without being damaged to an extent disproportionate to the original cause

3.1.1.15
substructure
part of a building structure that supports the superstructure

Note 1 to entry: 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.

3.1.1.16
superstructure
part of a building structure that is supported by the substructure

Note 1 to entry: 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.

3.1.1.17
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

3.1.1.18
explosion
rapid chemical reaction of dust, gas or vapour in the air, leading to high temperatures and high overpressures, and whose pressures propagate as waves

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3.1.2 Specific terms relevant to Annex B

3.1.2.1
consequence
possible result of an (in risk analysis usually unwanted) event

Note 1 to entry: Consequences can be verbally or numerically expressed in terms of loss of life, injury, economic loss, environmental damage, disruption to users and the public, etc. Both immediate consequences and those that arise after a certain time has elapsed are to be included.

3.1.2.2
hazard scenario
critical situation at a particular time consisting of a leading hazard together with one or more accompanying conditions which leads to an unwanted event (e.g. complete collapse of the structure)

3.1.2.4
risk acceptance criteria
acceptable limits for probabilities of certain consequences of an undesired event, expressed in terms of annual frequencies

Note 1 to entry: These criteria are normally determined at national level to reflect the level of risk considered to be acceptable to people and society.

3.1.2.5
risk analysis
systematic approach for describing and/or calculating risk

Note 1 to entry: Risk analysis involves the identification of undesired events, and the causes, likelihoods and consequences of these events.

3.1.2.6
risk evaluation
comparison of the results of a risk analysis with the acceptance criteria for risk and other decision criteria

3.1.2.7
risk management
systematic measures undertaken by an organization in order to attain and maintain a level of safety that complies with defined objectives

3.1.2.8
undesired event
event or condition that can cause loss of life, injury, economic loss, environmental damage, disruption to users and the public, etc.

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3.2 Symbols

3.2.1 Latin upper-case letters

C	force term for helicopter impact
F	collision force
F_{dx}	horizontal equivalent static or dynamic design force (frontal force, usually in the direction of the normal travel)
F_{dy}	horizontal equivalent static or dynamic design force (lateral force, usually perpendicular to the direction of the normal travel)
F_{max}	maximum pressure developed in a contained deflagration of an optimum mixture
F_R	frictional impact force
W	sum of the net weight and hoisting load of a loaded forklift truck

3.2.2 Latin lower-case letters

a	height of the application area of a collision force
b	width of the application area of a collision force
b_{Pier}	width of bridge pier
d	distance from the structural member to the centre line of the road or track
h	height of (resulting) collision force
h_0	clearance between the road surface and the underside of the bridge deck, below which an impact on the superstructure needs to be taken into account without any reduction
h_1	clearance between the road surface and the underside of the bridge deck, above which no impact needs to be considered
ℓ	ship length
r_F	reduction factor
s	distance from structural member to the point where the vehicle leaves the trafficked lane
m	mass
x	direction of (normal) travel or track
y	direction perpendicular of (normal) travel or track
v	velocity (i.e. v_0 is an initial moving velocity)

3.2.3 Greek lower-case letters

α	inclination angle
Δh	difference between h_1 and h_0
μ	friction coefficient

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4 Basis of design

4.1 General strategies

(1) Structures shall be designed for the relevant accidental design situations in accordance with EN 1990:2023, 5.2(3).

NOTE The strategies to be considered for accidental design situations are illustrated in Table 4.1, which is identical to Table E.1 of EN 1990:2023.

Table 4.1 — Strategies for Accidental Design Situations

Design for accidental actions (EN 1991) **Explicit design of the structure (e.g. against explosion, impact)**		**Design for enhanced robustness (EN 1990)** **Strategies based on limiting the extent of damage**		
Design structure to resist the action[a]	Prevent or reduce the action e.g. protective measures, control of events	Alternative load paths either providing adequate deformation capacity and ductility or applying prescriptive design rules	Key elements i.e. designing selected members to resist notional action(s)	Segmentation i.e. separation into parts
[a] Structural design against identified accidental actions can incorporate specifically designed members, which fall partially or fully, provided their failure does not lead to further structural collapse as agreed with the authorities (for strategies and methods to limit the extent of damages, see E.3 and E.4 in EN 1990:2023)				

(2) 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.

NOTE The decision criteria when such a collapse is acceptable can be given in the National Annex.

(3) Where appropriate, alternative load path design may be considered as an economic design method for accidental actions.

NOTE The application of either a vertical load on more than one column or a horizontal load on more than one beam allows for a redistribution of the action, if necessary. This can have also an effect on the load-bearing resistances in the event of an impact or explosion.

4.2 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 of the risk; and

— the level of acceptable risk.

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NOTE 1 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.

NOTE 2 Levels of acceptable risks can be given in the National Annex.

(2) A localized 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 can involve the safe evacuation of persons from the premises and its surroundings.

NOTE 2 For bridge structures, such emergency measures can 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); and/or

c) ensuring that the structure has sufficient robustness by adopting the robustness rules in EN 1990.

NOTE Protecting the structure by reducing the effects of an accidental action or preventing an action from occurring can be difficult. This is because an action is dependent upon factors which, over the design working life of the structure, can be outside the design assumptions. Preventative measures can involve periodic inspection and maintenance during the design working life of the structure.

(4) The safety of the structure immediately following the occurrence of the accidental action shall be addressed within an accidental design situation, for example where the evacuation of people is needed

4.3 Accidental design situations — use of consequence classes

(1) The strategies for accidental design situations may be based on the following consequence classes as set out in EN 1990.

— CC1 Low consequences of failure

— CC2 Medium consequences of failure

— CC3 High consequences of failure

NOTE 1 In some circumstances it can 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 2 The National Annex can provide a categorization of structures according to the consequences classes in 4.3(1).

NOTE 3 Table 4.2 (NDP) gives the classification of consequences classes for internal explosions for different building types and occupancies, unless the National Annex gives a different categorization.

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Table 4.2 (NDP) — Categorization of consequence classes for internal explosions.

Consequence class	Description of consequence class	Example of categorization of building type and occupancy [a]
CC 3	High	All buildings defined above as Class 2 Lower and Upper Consequences Class that exceed the limits on area and number of storeys All buildings to which members of the public are admitted in significant numbers Stadia accommodating more than 5 000 spectators Buildings containing hazardous substances and/or processes
CC 2b Upper Risk Group	Medium high	Hotels, flats, apartments and other residential buildings greater than 4 storeys but not exceeding 15 storeys Educational buildings greater than single storey but not exceeding 15 storeys Retailing premises greater than 3 storeys but not exceeding 15 storeys Hospitals not exceeding 3 storeys Offices greater than 4 storeys but not exceeding 15 storeys All buildings to which the public are admitted and which contain floor areas exceeding 2 000 m^2 but not exceeding 5 000 m^2 at each storey Car parking not exceeding 6 storeys
CC 2a Lower Risk Group	Medium low	5 storey single occupancy houses Hotels not exceeding 4 storeys Flats, apartments and other residential buildings not exceeding 4 storeys Offices not exceeding 4 storeys. Industrial buildings not exceeding 3 storeys Retailing premises not exceeding 3 storeys of less than 1 000 m^2 floor area in each storey Single storey educational buildings All buildings not exceeding two storeys to which the public are admitted and which contain floor areas not exceeding 2 000 m^2 at each storey
CC 1	Low	Single occupancy houses not exceeding 4 storeys Agricultural buildings Buildings into which people rarely go, provided no part of the building is closer to another building, or area where people do go, than a distance of 1,5 times the building height

[a] For buildings intended for more than one type of use, the "consequence class" should be that relating to the most onerous type. In determining the number of storeys, basement storeys may be excluded, provided such basement storeys fulfil the requirements of "Consequences Class 2b Upper Risk Group".

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(2) Accidental design situations for the different consequence classes given in 4.3(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 EN 1999, as applicable, are met;

— CC2: depending upon the specific circumstances of the structure, a simplified analysis by equivalent static 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 methods such as dynamic analyses, non-linear structural modelling and interaction between the load and the structure.

NOTE The National Annex can give reference to appropriate design approaches for higher and lower consequences classes.

(3) Preventative and/or protective measures are intended to remove or to reduce the probability of damage to the structure. Their effect can be reflected in the design by, for example, assigning the structure to a lower consequence class or using lower design forces.

5 Impact

5.1 Field of application

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

— impact from road vehicles (excluding collisions on lightweight structures) (see 5.4);

— impact from forklift trucks (see 5.5);

— impact from trains (excluding collisions on lightweight structures) (see 5.6); and

— impact from ships (see 5.7);

— the hard landing of helicopters on roofs (see 5.8).

NOTE 1 Accidental actions on lightweight structures which are excluded from the field of application above (e.g. gantries, lighting columns, footbridges) can be provided in the National Annex.

NOTE 2 For impact loads on kerbs and parapets and on bridge decks due to derailment, see prEN 1991-2.

NOTE 3 The National Annex can give guidance on issues concerning the transmission of impact forces to the foundations.

(2) 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 road or railway or waterway traffic.

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

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Full document details: 23/30457267 DC

5.2 Classification of actions

(1) Actions within the scope of this document shall be classified as accidental actions in accordance with EN 1990:2023, 8.3.3.4.

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

NOTE The National Annex can specify the treatment of accidental actions which are not classified as free actions.

5.3 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 can also be relevant.

NOTE 3 Guidance on dynamic design for impact is given in Annex C.

(2) For structural design the actions due to impact may be represented by an equivalent static force giving the equivalent action effects in the structure. This simplified model may be used for the verification of static equilibrium, for strength verifications and for the determination of deformations of the impacted structure.

(3) The application of the dynamic or equivalent static horizontal design forces F_{dx} and F_{dy} should be defined.

NOTE F_{dx} does not act simultaneously with F_{dy}, unless the National Annex defines different rules for the application of F_{dx} and F_{dy}.

(4) For structures which are designed to absorb impact energy by elastic-plastic deformations of members (i.e. soft impact), the equivalent static loads may be determined by taking into account both plastic strength and the deformation capacity of such members.

NOTE For further information, see Annex C.

(5) For structures for which the energy is mainly dissipated by the impacting body (i.e. hard impact), the dynamic or equivalent static forces may be determined from subclauses 5.4 to 5.8.

NOTE Some information on parameters for masses and velocities of impacting objects as a basis for a dynamic analysis can be found in Annex C.

5.4 Accidental actions caused by road vehicles

5.4.1 Impact on supporting substructures

(1) Design values for actions due to impact on the supporting structures (e.g. columns and walls of bridges or buildings) adjacent to various types of roads should be defined.

NOTE 1 Equivalent static design forces for hard impact can be taken from Table 5.1 (NDP), unless the National Annex gives different values.

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Full document details: 23/30457267 DC

Table 5.1 (NDP) — Equivalent static design forces due to vehicular impact on members supporting structures over or adjacent to roadways

Category of traffic	Force F_{dx}[a] [kN]	Force F_{dy}[b] [kN]
Motorways and country national and main roads	1 000	500
Country roads in rural area	750	375
Roads in urban area	500	250
Courtyards and parking garages with access to: — Cars — Lorries[c]	50 150	25 75

[a] x = direction of normal travel.
[b] y = perpendicular to the direction of normal travel.
[c] The term "lorry" refers to vehicles with maximum gross weight greater than 3,5 kN.

NOTE 2 The National Annex can prescribe the force as a function of distance s from the structural member to the point where the vehicle leaves the trafficked lane and d the distance from the structural member to the centre-line of the road or track. Information on the effect of the distance s, where applicable, can be found in Annex C.

NOTE 3 The National Annex can define types or members of the structure that can be neglected for vehicular collision.

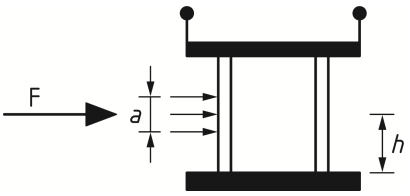
NOTE 4 For impact from traffic on bridges, see prEN 1991-2.

NOTE 5 For guidance on accidental actions caused by road vehicles on bridges also carrying rail traffic, see UIC Code 777-1R.

(2) For impact on the supporting structures, the applicable area of resulting collision force F should be specified.

NOTE 1 For impact from lorries, the collision force F can be applied at any height h between 0,5 m to 1,5 m above the level of the carriageway or higher where certain types of protective barriers are provided (see Figure 5.1). The application area is b = 1,50 m (width) by a = 0,5 m (height) or the member width, whichever is the smaller. The National Annex can give different values.

NOTE 2 For impact from cars, the collision force F can be applied at h = 0,50 m above the level of the carriageway (see Figure 5.1). The application area is b = 1,50 m (width) by a = 0,25 m (height) or the member width, whichever is the smaller. The National Annex can give different values.



Key

a is the height of the force application area

h is the location height of the resulting collision force F

Figure 5.1 — Collision force on supporting substructures near traffic lanes for bridges and supporting structures for buildings

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Full document details: 23/30457267 DC

(3) Barriers and parapets in car parking areas, often connected with the supporting structure which are fall-protecting or enclosing structural members (e.g. protective devices) and their connecting means, should be designed using a horizontally free force and an impact area.

NOTE The collision force acting on barriers and parapets in car parking areas is F = 40 kN in a height of 0,5 m above the surface of the roadway and an impact area of b x a = 0,5 x 0,2 m; an impact energy of 5,5 kNm can be used as equivalent. The National Annex can give different values.

5.4.2 Impact on superstructures

(1) Design values for actions due to impact from lorries and/or loads carried by the lorries on members of the superstructure should be defined, unless adequate clearances or suitable protection measures to avoid impact are provided.

(2) On vertical surfaces, the design impact actions shall be equal to the equivalent static design forces due to impact. For $h_0 \leq h \leq h_1$, these values may be multiplied by a reduction factor r_F.

NOTE 1 The equivalent static design forces F_{dx} are given in Table 5.2 (NDP), unless the National Annex gives different values.

NOTE 2 The values of clearances h_0 and h_1 may be taken as 5,0 m and 6,0 m, respectively, unless the National Annex gives different values.

(3) When determining available clearance h, the effect of future re-surfacing, vertical sag curve and deflection of the bridge, and expected settlements should be considered.

Table 5.2 (NDP) — Equivalent static design forces due to impact on superstructures

Category of traffic	Equivalent static design force F_{dx}[a] [kN]
Motorways and country national and main roads	500
Country roads in rural area	375
Roads in urban area	250
Courtyards and parking garages	75
[a] x = direction of normal travel	

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