

The European Union

EDICT OF GOVERNMENT

In order to promote public education and public safety, equal justice for all, a better informed citizenry, the rule of law, world trade and world peace, this legal document is hereby made available on a noncommercial basis, as it is the right of all humans to know and speak the laws that govern them.

EN 1991-1-6 (2005) (English): Eurocode 1: Actions on structures - Part 1-6: General actions - Actions during execution [Authority: The European Union Per Regulation 305/2011, Directive 98/34/EC, Directive 2004/18/EC]



BLANK PAGE



PROTECTED BY COPYRIGHT

EUROPEAN STANDARD
NORME EUROPÉENNE
EUROPÄISCHE NORM

EN 1991-1-6

June 2005

ICS 91.010.30

Supersedes ENV 1991-2-6:1997
Incorporating corrigendum July 2008

English version

Eurocode 1 - Actions on structures Part 1-6: General actions -
Actions during execution

Eurocode 1 - Actions sur les structures - Partie 1-6: Actions
générales - Actions en cours d'exécution

Eurocode 1 - Einwirkungen auf Tragwerke - Teil 1-6 :
Allgemeine Einwirkungen - Einwirkungen während der
Ausführung

This European Standard was approved by CEN on 13 January 2005.

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, Slovakia, Slovenia, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

	Page
Contents	Page
FOREWORD.....	4
BACKGROUND OF THE EUROCODE PROGRAMME	4
STATUS AND FIELD OF APPLICATION OF EUROCODES.....	5
NATIONAL STANDARDS IMPLEMENTING EUROCODES.....	5
LINKS BETWEEN EUROCODES AND HARMONIZED TECHNICAL SPECIFICATIONS (ENs AND ETAs) FOR PRODUCTS	6
ADDITIONAL INFORMATION SPECIFIC TO EN 1991-1-6	6
NATIONAL ANNEX.....	7
SECTION 1 GENERAL	8
1.1 SCOPE	8
1.2 NORMATIVE REFERENCES.....	8
1.3 ASSUMPTIONS	9
1.4 DISTINCTION BETWEEN PRINCIPLES AND APPLICATION RULES	9
1.5 TERMS AND DEFINITIONS.....	9
1.6 SYMBOLS	10
SECTION 2 CLASSIFICATION OF ACTIONS.....	12
SECTION 3 DESIGN SITUATIONS AND LIMIT STATES.....	14
3.1 GENERAL – IDENTIFICATION OF DESIGN SITUATIONS.....	14
3.2 ULTIMATE LIMIT STATES	15
3.3 SERVICEABILITY LIMIT STATES.....	16
SECTION 4 REPRESENTATION OF ACTIONS	17
4.1 GENERAL	17
4.2 ACTIONS ON STRUCTURAL AND NON-STRUCTURAL MEMBERS DURING HANDLING	17
4.3 GEOTECHNICAL ACTIONS	18
4.4 ACTIONS DUE TO PRESTRESSING	18
4.5 PRE-DEFORMATIONS	18
4.6 TEMPERATURE, SHRINKAGE, HYDRATION EFFECTS	18
4.7 WIND ACTIONS	19
4.8 SNOW LOADS	19
4.9 ACTIONS CAUSED BY WATER	19
4.10 ACTIONS DUE TO ATMOSPHERIC ICING	21
4.11 CONSTRUCTION LOADS	21
4.12 ACCIDENTAL ACTIONS	24
4.13 SEISMIC ACTIONS	24
ANNEX A1	25
(NORMATIVE)	25
SUPPLEMENTARY RULES FOR BUILDINGS.....	25
A1.1 ULTIMATE LIMIT STATES	25
A1.2 SERVICEABILITY LIMIT STATES	25
A1.3 HORIZONTAL ACTIONS	25
ANNEX A2	26
(NORMATIVE)	26
SUPPLEMENTARY RULES FOR BRIDGES	26
A2.1 ULTIMATE LIMIT STATES	26
A2.2 SERVICEABILITY LIMIT STATES	26
A2.3 DESIGN VALUES OF DEFLECTIONS	26
A2.4 SNOW LOADS	26
A2.5 CONSTRUCTION LOADS.....	27
ANNEX B (INFORMATIVE) ACTIONS ON STRUCTURES DURING ALTERATION, RECONSTRUCTION OR DEMOLITION.....	28

BIBLIOGRAPHY.....	28
-------------------	----

Foreword

This European document (EN 1991-1-6), has been prepared by Technical Committee CEN/TC250 "Structural Eurocodes", the Secretariat of which is held by BSI.

This European Standard shall be given the status of national standard, either by publication of an identical text or by endorsement, at the latest by December 2005, and conflicting national standards shall be withdrawn at the latest by March 2010.

CEN/TC250 is responsible for all Structural Eurocodes.

This document will supersede ENV 1991-2-6:1996.

Annexes A1 and A2 are normative and Annex B is informative. This standard includes a Bibliography.

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, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

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 harmonized 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.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement¹ 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

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).

EN 1998	Eurocode 8:	Design of structures for earthquake resistance
EN 1999	Eurocode 9:	Design of aluminium structures

Eurocode standards recognize the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at the 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 recognize 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 harmonized technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents² referred to in Article 12 of the CPD, although they are of a different nature from harmonized product standards³. 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.

The National Annex 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,
- the 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.

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 harmonizing 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 harmonized 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 ER 2.

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

There is a need for consistency between the harmonized technical specifications for construction products and the technical rules for works⁴. 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.

Additional information specific to EN 1991-1-6

EN 1991-1-6 describes Principles and Application rules for the determination of actions to be considered during execution of buildings and civil engineering works, including the following aspects :

- actions on structural and non-structural members during handling;
- geotechnical actions ;
- actions due to prestressing effects ;
- pre-deformations ;
- temperature, shrinkage, hydration effects ;
- wind actions ;
- snow loads ;
- actions caused by water ;
- actions due to atmospheric icing ;
- construction loads ;
- accidental actions
- seismic actions;

EN 1991-1-6 is intended for use by:

- clients (*e.g.* for the formulation of their specific requirements),
- designers and constructors,
- relevant authorities.

EN 1991-1-6 is intended to be used with EN 1990, the other parts of EN 1991 and EN 1992 to EN 1999 for the design of structures.

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.

National annex

This part of EN1991 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 1991-1-6 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.

National choice is allowed in EN 1991-1-6 through clauses:

Clause	Item
1.1(3)	Design rules for auxiliary construction works
2.2 (4) NOTE 1	Positioning of construction loads classified as free
3.1(1)P	Design situation corresponding to storm conditions
3.1(5) NOTE 1	Return periods for the determination of the characteristic values of variable actions during execution
NOTE 2	Minimum wind speed during execution
3.1(7)	Rules for the combination of snow loads and wind actions with construction loads
3.1(8) NOTE 1	Rules concerning imperfections in the geometry of the structure
3.3(2)	Criteria associated with serviceability limit states during execution
3.3(6)	Serviceability requirements for auxiliary construction works
4.9(6) NOTE 2	Loads and water levels for floating ice
4.10(1)P	Definition of actions due to atmospheric icing
4.11.1 (1) Table 4.1	Recommended characteristic values of construction loads Q_{ca} and Q_{cb}
4.11.2 (1) NOTE 2	Construction loads during casting of concrete
4.12(1)P NOTE 2	Dynamic effects due to accidental actions
4.12(2)	Dynamic effects due to falls of equipment
4.12 (3)	Design values of human impact loads
4.13(2)	Seismic actions
Annex A1 A1.1(1)	Representative values of the variable actions due to construction loads
Annex A1 A1.3(2)	Characteristic values of equivalent horizontal forces
Annex A2 A2.3 (1) NOTE 1	Design values of vertical deflections for the incremental launching of bridges
Annex A2 A2.4(2)	Reduction of the characteristic value of snow loads
Annex A2 A2.4(3)	Reduced values of characteristic snow loads for the verification of static equilibrium
Annex A2 A2.5(2)	Design values of horizontal friction forces
Annex A2 A2.5(3)	Determination of friction coefficients μ_{\min} and μ_{\max}

Section 1 General

1.1 Scope

(1) EN 1991-1-6 provides principles and general rules for the determination of actions which should be taken into account during the execution of buildings and civil engineering works.

NOTE 1 This part of EN 1991 may be used as guidance for the determination of actions to be taken into account for different types of construction works, including structural alterations such as refurbishment and/or partial or full demolition. Further rules and guidance is given in Annexes A1, A2 and B.

[AC1] NOTE 2 Rules concerning the safety of people in and around the construction site due to matters outside the scope of this European Standard may be defined for the individual project. [AC1]

(2) The following subjects are dealt with in this part of EN 1991.

Section 1 : General

Section 2 : Classification of actions

Section 3: Design situations and limit states

Section 4 : Representation of actions

Annex A1 : Supplementary rules for buildings (normative)

Annex A2 : Supplementary rules for bridges (normative)

Annex B : Actions on structures during alteration, reconstruction or demolition (informative)

(3) EN 1991-1-6 also gives rules for the determination of actions which may be used for the design of auxiliary construction works as defined in 1.5, needed for the execution of buildings and civil engineering works.

NOTE Design rules for auxiliary construction works may be defined in the National Annex or for the individual project. Guidance may be found in the relevant European standards. For example, design rules for formworks and falseworks are given in EN 12812.

1.2 Normative references

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 publications 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.

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 1991-1-2	Eurocode 1: Actions on structures Part 1-2: Fire actions
EN 1991-1-3	Eurocode 1: Actions on structures Part 1-3: General actions: Snow loads
EN 1991-1-4	Eurocode 1: Actions on structures Part 1-4: General actions: Wind actions
EN 1991-1-5	Eurocode 1: Actions on structures Part 1-5: General actions: Thermal actions
EN 1991-1-7	Eurocode 1: Actions on structures Part 1-7: Accidental actions
EN 1991-2	Eurocode 1: Actions on structures Part 2: Traffic loads on bridges

EN 1991-3	Eurocode 1: Actions on structures Part 3: Actions induced by cranes and machinery
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 1990:2002, 1.3 apply.

1.4 Distinction between Principles and Application rules

(1)P The rules in EN 1990:2002, 1.4 apply.

1.5 Terms and definitions

1.5.1 General

(1) The terms and definitions given in EN 1990:2002, 1.5 apply.

1.5.2 Additional terms and definitions specific to this standard

1.5.2.1

auxiliary construction works

any works associated with the construction processes that are not required after use when the related execution activities are completed and they can be removed (e.g. falsework, scaffolding, propping systems, cofferdam, bracing, launching nose)

NOTE Completed structures for temporary use (e.g. a bridge for temporarily diverted traffic) are not regarded as auxiliary construction works.

1.5.2.2

construction load

load that can be present due to execution activities, but is not present when the execution activities are completed.

1.5.2.3

general scour depth

is the scour depth due to river flow, independently of the presence of an obstacle (scour depth depends on the flood magnitude)

1.5.2.4

local scour depth

is the scour depth due to water vortices next to an obstacle such as a bridge pier.

1.6 Symbols

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

Latin upper case letters

A_{deb}	area of obstruction (accumulation of debris)
F_{deb}	horizontal forces exerted by accumulation of debris
$F_{cb,k}$	characteristic values of concentrated construction loads Q_{cb}
F_{hn}	nominal horizontal forces
F_{wa}	horizontal forces due to currents on immersed obstacles
Q_c	Construction loads (general symbol)
Q_{ca}	construction loads due to working personnel, staff and visitors, possibly with hand tools or other small site equipment
Q_{cb}	construction loads due to storage of moveable items (e.g. building and construction materials, precast elements, and equipment)
Q_{cc}	construction loads due to non permanent equipment in position for use during execution, either static (e.g. formwork panels, scaffolding, falsework, machinery, containers) or during movement (e.g. travelling forms, launching girders and nose, counterweights)
Q_{cd}	construction loads due to moveable heavy machinery and equipment, usually wheeled or tracked (e.g. cranes, lifts, vehicles, lifttrucks, power installations, jacks, heavy control devices)
Q_{ce}	construction loads from accumulation of waste materials (e.g. surplus construction materials, excavated soil or demolition materials)
Q_{ct}	construction loads from parts of a structure in temporary states (under execution) before the final design actions take effect
Q_w	wind actions
Q_{wa}	actions caused by water

Latin lower case letters

b	width of an immersed object
c_{pe}	external wind pressure coefficients for free-standing walls
h	water depth
k	shape factor for an immersed object
k_{deb}	debris density parameter

p	flowing water pressure, which may be current water
$q_{ca,k}$	characteristic values of the uniformly distributed loads of construction loads Q_{ca}
$q_{cb,k}$	characteristic values of the uniformly distributed loads of construction loads Q_{cb}
$q_{cc,k}$	characteristic values of the uniformly distributed loads representing construction loads Q_{cc}
v_{wa}	is the mean speed of the water averaged over the depth, in m/s;

Greek lower case letters

ρ_{wa} density of water

Section 2 Classification of actions

2.1 General

(1)P Actions during execution which include, where appropriate, construction loads and those other than construction loads shall be classified in accordance with EN 1990:2002, 4.1.1.

NOTE Table 2.1 gives the classifications of actions (other than construction loads).

Table 2.1 Classification of actions (other than construction loads) during execution stages.

Related clause in this standard	Action	Classification				Remarks	Source
		Variation in time	Classification / Origin	Spatial variation	Nature (static/dynamic)		
4.2	Self weight	Permanent	Direct	Fixed with tolerance / free	Static	Free during transportation / storage. Dynamic if dropped.	EN 1991-1-1
4.3	Soil movement	Permanent	Indirect	Free	Static		EN 1997
4.3	Earth pressure	Permanent / variable	Direct	Free	Static		EN 1997
4.4	Prestressing	Permanent / variable	Direct	Fixed	Static	Variable for local design (anchorage).	EN 1990, EN 1992 to EN 1999
4.5	Pre-deformations	Permanent / variable	Indirect	Free	Static		EN 1990
4.6	Temperature	Variable	Indirect	Free	Static		EN 1991-1.5
4.6	Shrinkage/hydration effects	Permanent / variable	Indirect	Free	Static		EN 1992, EN 1993, EN 1994
4.7	Wind actions	Variable / accidental	Direct	Fixed/free	Static / dynamic	(*)	EN 1991-1-4
4.8	Snow loads	Variable/accidental	Direct	Fixed/free	Static / dynamic	(*)	EN 1991-1-3
4.9	Actions due to water	Permanent / variable/accidental	Direct	Fixed/free	Static / dynamic	Permanent / variable according to project specifications. Dynamic for water currents if relevant	EN 1990
4.10	Atmospheric ice loads	Variable	Direct	Free	Static / dynamic	(*)	ISO 12494
4.12	Accidental	Accidental	Direct/indirect	Free	Static/dynamic	(*)	EN 1990, EN 1991-1-7
4.13	Seismic	Variable / accidental	Direct	Free	Dynamic	(*)	EN 1990 (4.1), EN 1998

(*): The source documents need to be examined with the National Annexes in which additional relevant information may be provided.

2.2 Construction loads

(1) Construction loads (see also 4.11) should be classified as variable actions (Q_c).

NOTE 1 Table 2.2 gives the classification of construction loads

Table 2.2 Classification of construction loads.

Related clause in this standard	Action (short description)	Classification				Remarks	Source
		Variation in time	Classification / Origin	Spatial variation	Nature (static/dynamic)		
4.11	Personnel and hand tools	Variable	Direct	Free	Static		
4.11	Storage movable items	Variable	Direct	Free	Static / dynamic	Dynamic in case of dropped loads	EN 1991-1-1
4.11	Non-permanent equipment	Variable	Direct	Fixed / free	Static / dynamic		EN 1991-3
4.11	Movable heavy machinery and equipment	Variable	Direct	Free	Static / dynamic		EN 1991-2, EN 1991-3
4.11	Accumulation of waste materials	Variable	Direct	Free	Static / dynamic	Can impose loads on e.g. vertical surfaces also	EN 1991-1-1
4.11	Loads from parts of structure in temporary states	Variable	Direct	Free	Static	Dynamic effects are excluded	EN 1991-1-1

NOTE 2 Table 4.1 gives the full description and classification of construction loads

NOTE 3 Construction loads, which are caused by cranes, equipment, auxiliary construction works/structures may be classified as fixed or free actions depending on the possible position(s) for use.

(3) Where construction loads are classified as fixed, then tolerances for possible deviations from the theoretical position should be defined.

NOTE The deviations may be defined for the individual project.

(4) Where construction loads are classified as free, then the limits of the area where they may be moved or positioned should be determined.

NOTE 1 The limits may be defined in the National Annex and for the individual project.

NOTE 2 In accordance with EN 1990:2002, 1.3(2), control measures may have to be adopted to verify the conformity of the position and moving of construction loads with the design assumptions.

Section 3 Design situations and limit states

3.1 General – identification of design situations

(1)P Transient, accidental and seismic design situations shall be identified and taken into account as appropriate for designs for execution.

NOTE For wind actions during storm conditions (e.g. cyclone, hurricane) the National Annex may select the design situation to be used. The recommended design situation is the accidental design situation.

(2) Design situations should be selected as appropriate for the structure as a whole, the structural members, the partially completed structure, and also for auxiliary construction works and equipment.

(3)P The selected design situations shall take into account the conditions that apply from stage to stage during execution in accordance with EN 1990:2002, 3.2(3)P.

(4)P The selected design situations shall be in accordance with the execution processes anticipated in the design. Design situations shall take account of any revisions to the execution processes.

(5) Any selected transient design situation should be associated with a nominal duration equal to or greater than the anticipated duration of the stage of execution under consideration. The design situations should take into account the likelihood for any corresponding return periods of variable actions (e.g. climatic actions).

NOTE 1 The return periods for the determination of characteristic values of variable actions during execution may be defined in the National Annex or for the individual project. Recommended return periods for climatic actions are given in table 3.1, depending on the nominal duration of the relevant design situation.

Table 3.1 Recommended return periods for the determination of the characteristic values of climatic actions

Duration	Return period (years)
≤ 3 days	2 ^a
≤ 3 months (but > 3 days)	5 ^b
≤ 1 year (but > 3 months)	10
> 1 year	50

^a A nominal duration of three days, to be chosen for short execution phases, corresponds to the extent in time of reliable meteorological predictions for the location of the site. This choice may be kept for a slightly longer execution phase if appropriate organizational measures are taken. The concept of mean return period is generally not appropriate for short term duration.

^b For a nominal duration of up to three months actions may be determined taking into account appropriate seasonal and shorter term meteorological climatic variations. For example, the flood magnitude of a river depends on the period of the year under consideration.

NOTE 2 A minimum wind velocity during execution may be defined in the National Annex or for the individual project. The recommended basic value for durations of up to 3 months is 20 m/s in accordance with EN 1991-1-4.

NOTE 3 Relationships between characteristic values and return period for climatic actions are given in the appropriate parts of EN 1991.

(6) Where an execution stage design prescribes limiting climatic conditions, or weather window, the characteristic climatic actions should be determined taking into account :

- anticipated duration of the execution stage,
- the reliability of meteorological predictions,
- time to organize protection measures.

(7) The rules for the combination of snow loads and wind actions with construction loads Q_c (see 4.11.1) should be defined.

NOTE These rules may be defined in the National Annex or for the individual project.

(8) Imperfections in the geometry of the structure and of structural members should be defined for the selected design situations during execution.

NOTE 1 These imperfections may be defined in the National Annex or for the individual project. See also Annex A2 and EN 1990:2002, 3.5 (3) and (7).

NOTE 2 For concrete structures, see also the appropriate CEN standards, including those on "Precast Concrete Products", developed by CEN/TC229

(9) Actions due to wind excitation (including aerodynamic effects due to passing vehicles, including trains) that are likely to produce fatigue effects in structural members should be taken into account.

NOTE See EN 1991-1-4 and EN 1991-2.

(10) Where the structure or parts of it are subjected to accelerations that may give rise to dynamic or inertia effects, these effects should be taken into account.

NOTE Significant accelerations may be excluded where possible movements are strictly controlled by appropriate devices.

(11) Actions caused by water, including for example uplift due to groundwater, should be determined in conjunction with water levels corresponding to specified or identified design situations, where appropriate.

NOTE These actions may commonly be determined in the same manner as specified in (5) above.

(12) Where relevant, design situations should be defined taking account of scour effects in flowing water.

NOTE For long construction phases, scour levels may have to be taken into account for the design of execution stages for permanent or auxiliary construction works immersed in flowing water, which may include currents. These levels may be defined for the individual project, see 4.9(4).

(13) Actions due to creep and shrinkage in concrete construction works should be determined on the basis of the expected dates and duration associated with the design situations, where appropriate.

3.2 Ultimate limit states

(1)P Ultimate limit states shall be verified for all selected transient, accidental and seismic design situations as appropriate during execution in accordance with EN 1990:2002[??].

NOTE 1 The combinations of actions for accidental design situations can either include the accidental action explicitly or refer to a situation after an accidental event. See EN 1990:2002, Section 6.

NOTE 2 Generally, accidental design situations refer to exceptional conditions applicable to the structure or its exposure, such as impact, local failure and subsequent progressive collapse, fall of structural or non-structural parts, and, in the case of buildings, abnormal concentrations of building equipment and/or building materials, water accumulation on steel roofs, fire, etc.

NOTE 3 See also EN 1991-1-7.

(2) The verifications of the structure should take into account the appropriate geometry and resistance of the partially completed structure corresponding to the selected design situations.

3.3 Serviceability limit states

(1)P The serviceability limit states for the selected design situations during execution shall be verified, as appropriate, in accordance with EN 1990.

(2) The criteria associated with the serviceability limit states during execution should take into account the requirements for the completed structure.

NOTE The criteria associated with the serviceability limit states may be defined in the National Annex or for the individual project. See EN 1992 to EN 1999.

(3)P Operations during execution which can cause excessive cracking and/or early deflections and which may adversely affect the durability, fitness for use and/or aesthetic appearance in the final stage shall be avoided.

(4) Load effects due to shrinkage and temperature should be taken into account in the design and should be minimized by appropriate detailing.

(5) The combinations of actions should be established in accordance with EN 1990:2002, 6.5.3 (2). In general, the relevant combinations of actions for transient design situations during execution are:

- the characteristic combination
- the quasi-permanent combination

NOTE Where frequent values of particular actions need to be considered, these values may be defined for the individual project.

(6) Serviceability requirements for auxiliary construction works should be defined in order to avoid any unintentional deformations and displacements which affect the appearance or effective use of the structure or cause damage to finishes or non-structural members.

NOTE These requirements may be defined in the National Annex or for the individual project.

Section 4 Representation of actions

4.1 General

(1)P Characteristic and other representative values of actions shall be determined in accordance with EN 1990, EN 1991, EN 1997 and EN 1998.

NOTE 1 The representative values of actions during execution may be different from those used in the design of the completed structure. Common actions during execution, specific construction loads and methods for establishing their values are given in this Section.

NOTE 2 See also Section 2 for classification of actions and Section 3 for nominal duration of transient design situations.

NOTE 3 The action effects may be minimized or eliminated by appropriate detailing, providing auxiliary construction works or by protecting/safety devices.

(2) Representative values of construction loads (Q_c) should be determined taking into account their variations in time.

(3) Interaction effects between structures and parts of structures should be taken into account during execution. Such structures should include structures that form part of the auxiliary construction works.

(4)P When parts of a structure are braced or supported by other parts of a structure (e.g. by propping floor beams for concreting) the actions on these parts resulting from bracing or supporting shall be taken into account.

NOTE 1 Depending on the construction procedures, the supporting parts of the structure may be subjected to loads greater than the imposed loads for which they are designed for the persistent design situation. Additionally, the supporting slabs may not have developed their full strength capacities.

NOTE 2 See also 4.11 Construction loads.

(5) Horizontal actions from friction effects should be determined and based on the use of appropriate values of friction coefficients.

NOTE Lower and upper bounds of friction coefficients may have to be taken into account. Friction coefficients may be defined for the individual project.

4.2 Actions on structural and non-structural members during handling

(1) The self-weight of structural and non-structural members during handling should be determined in accordance with EN 1991-1-1.

(2) Dynamic or inertia effects of self-weight of structural and non-structural members should be taken into account.

(3) Actions on attachments for hoisting elements and materials should be determined according to EN 1991-3.

(4) Actions on structural and non-structural members due to support positions and conditions during hoisting, transporting or storage should take into account, where appropriate, the actual support conditions and dynamic or inertia effects due to vertical and horizontal accelerations.

NOTE See EN 1991-3 for the determination of vertical and horizontal accelerations due to transport and hoisting.

4.3 Geotechnical actions

(1)P The characteristic values of geotechnical parameters, soil and earth pressures, and limiting values for movements of foundations shall be determined according to EN 1997.

(2) The soil movements of the foundations of the structure and of auxiliary construction works, for example temporary supports during execution, should be assessed from the results of geotechnical investigations. Such investigations should be carried out to give information on both absolute and relative values of movements, their time dependency and possible scatter.

NOTE Movements of auxiliary construction works may cause displacements and additional stresses.

(3) The characteristic values of soil movements estimated on the basis of geotechnical investigations using statistical methods should be used as nominal values for imposed deformations of the structure.

NOTE It may be possible to adjust the calculated imposed deformations by considering the full soil-structure interaction.

4.4 Actions due to prestressing

(1) Actions due to prestressing should be taken into account, including the effects of interactions between the structure and auxiliary construction works (e.g. falsework) where relevant.

NOTE Prestressing forces during execution may be determined according to the requirements of EN 1992 to EN 1999 and possible specific requirements defined for the individual project.

(2) Loads on the structure from stressing jacks during the prestressing activities should be classified as variable actions for the design of the anchor region.

(3) Prestressing forces during the execution stage should be taken into account as permanent actions.

NOTE See also Section 3.

4.5 Pre-deformations

(1)P The treatment of the effects of pre-deformations shall be in conformity with the relevant design Eurocode (from EN 1992 to EN 1999).

NOTE Pre-deformations can result from, for example, displacements of supports (such as loosening of ropes or cables, including hangers, and displacements of bearings).

(2) Action effects from execution processes should be taken into account, especially where pre-deformations are applied to a particular structure in order to generate action effects for improving its final behaviour, particularly for structural safety and serviceability requirements.

(3) The action effects from pre-deformations should be checked against design criteria by measuring forces and deformations during execution.

4.6 Temperature, shrinkage, hydration effects

(1)P The effects of temperature, shrinkage and hydration shall be taken into account in each construction phase, as appropriate.

NOTE 1 For buildings, the actions due to temperature and shrinkage are not generally significant if appropriate detailing has been provided for the persistent design situation.

NOTE 2 Restraints from the effects of friction of bearings may have to be taken into account (see also 4.1 (5)).

(2) Climatic thermal actions should be determined according to EN 1991-1-5.

(3) Thermal actions due to hydration should be determined according to EN 1992, EN 1994 and EN 1995.

NOTE 1 Temperature can rise significantly in a massive concrete structure after casting, with consequent thermal effects.

NOTE 2 The extreme values of the minimum and maximum temperatures to be taken into account in the design may change due to seasonal variations.

(4) Shrinkage effects of structural building materials should be determined according to the relevant Eurocodes EN 1992 to EN 1999.

(5) In the case of bridges, for the determination of restraints to temperature effects of friction at bearings, that permit free movements, they should be taken into account on the basis of appropriate representative values.

NOTE See EN 1337.

(6) Where relevant, second order effects should be taken into account and the effects of deformations from temperature and shrinkage should be combined with initial imperfections.

4.7 Wind actions

(1) The need for a dynamic response design procedure for wind actions should be determined for the execution stages, taking into account the degree of completeness and stability of the structure and its various elements.

NOTE Criteria and procedures may be defined for the individual project.

(2) Where a dynamic response procedure is not needed, the characteristic values of static wind forces Q_w should be determined according to EN 1991-1-4 for the appropriate return period.

NOTE See 3.1 for recommended return periods.

(3) For lifting and moving operations or other construction phases that are of short duration, the maximum acceptable wind speed for the operations should be specified.

NOTE The maximum wind speed may be defined for the individual project. See also 3.1(6).

(4) The effects of wind induced vibrations such as vortex induced cross wind vibrations, galloping flutter and rain-wind should be taken into account, including the potential for fatigue of, for example, slender elements.

(5) Wind actions on parts of the structure that are intended to be internal parts after its completion (e.g. walls) should be taken into account for execution processes.

NOTE In such cases, the external pressure coefficients c_{pe} may have to be applied (e.g. for free-standing walls).

(6) When determining wind forces, the areas of equipment, falsework and other auxiliary construction works that are loaded should be taken into account.

4.8 Snow loads

(1)P Snow loads shall be determined according to EN 1991-1-3 for the conditions of site and the required return period.

NOTE 1 For bridges see also Annex A2.

NOTE 2 See 3.1 for recommended return periods.

4.9 Actions caused by water

(1) In general, actions due to water, including ground water, (Q_{wa}) should be represented as static pressures and/or hydrodynamic effects, whichever gives the most unfavourable effects.

NOTE In general, phenomena covered by hydrodynamic effects are:

- the hydrodynamic force due to currents on immersed obstacles;
- forces due to wave actions;

- water effects caused by an earthquake (tsunamis).

(2) Actions caused by water may be taken into account in combinations as permanent or variable actions.

NOTE The classification of actions caused by water as permanent or variable may be defined for the individual project, taking account of the specific environmental conditions.

(3) Actions caused by water, including dynamic effects where relevant, exerted by currents on immersed structures should be applied perpendicularly to the contact surfaces. They should be determined for speed, water depth and shape of the structure taking into account the designed construction stages.

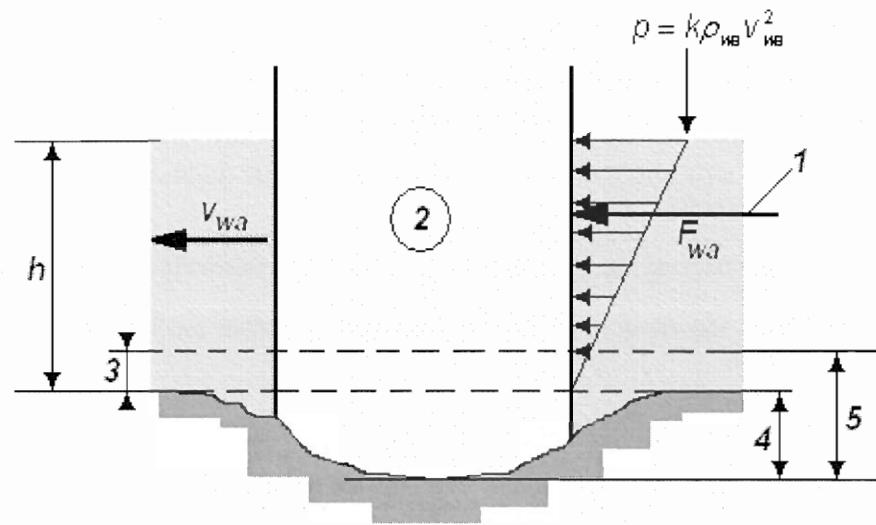
(4) The magnitude of the total horizontal force F_{wa} (N) exerted by currents on the vertical surface should be determined by expression 4.1. See also Figure 4.1.

$$F_{wa} = \frac{1}{2} k \rho_{wa} h b v_{wa}^2 \quad (4.1)$$

where:

- v_{wa} is the mean speed of the water averaged over the depth, in m/s;
 ρ_{wa} is the density of water, in kg/m³;
 h is the water depth, but not including local scour depth, in m;
 b is the width of the object, in m;
 k is the shape factor, where

$k = 1,44$ for an object of square or rectangular horizontal cross-section, and
 $k = 0,70$ for an object of circular horizontal cross-section.



Key

- | | |
|---|--------------------------|
| 1 | Current pressure (p) |
| 2 | Object |
| 3 | General scour depth |
| 4 | Local scour depth |
| 5 | Total scour depth |

Figure 4.1: Pressure and force due to currents

NOTE 1 F_{wa} may be used to check the stability of bridge piers and cofferdams, etc. A more refined formulation may be used to determine F_{wa} for the individual project.

NOTE 2 The effect of scour may be taken into account for the design where relevant. See 3.1(12) and 1.5.2.3 and 1.5.2.4.

(5) Where relevant, the possible accumulation of debris should be represented by a force F_{deb} (N) and calculated for a rectangular object (e.g. cofferdam), for example, from:

$$F_{deb} = k_{deb} A_{deb} v_{wa}^2 \quad (4.2)$$

where:

k_{deb} is a debris density parameter, in kg/m³

v_{wa} is the mean speed of the water averaged over the depth, in m/s;

A_{deb} is the area of obstruction presented by the trapped debris and falsework, in m²

NOTE 1 Expression (4.2) may be adjusted for the individual project, taking account of its specific environmental conditions.

NOTE 2 The recommended value of k_{deb} is 666 kg/m³.

(6) Actions due to ice, including floating ice, should be taken into account where relevant.

NOTE 1 The actions may be considered as a distributed load and acting in the direction of current flow equal to the highest or lower water levels, whichever gives the most unfavourable effects.

NOTE 2 The loads and water levels may be defined in the National Annex or for the individual project.

(7) Actions from rainwater should be taken into account for conditions where there may be collection of water such as ponding effects from, for example, inadequate drainage, imperfections of surfaces, deflections and/or failure of dewatering devices.

4.10 Actions due to atmospheric icing

(1)P Actions due to atmospheric icing shall be taken into account where relevant.

NOTE The representative values of these actions may be defined in the National Annex or for the individual project. Guidance may be found in EN 1993-3 and in ISO 12494.

4.11 Construction loads

4.11.1 General

(1) Construction loads (Q_c) may be represented in the appropriate design situations (see EN 1990), either, as one single variable action, or where appropriate different types of construction loads may be grouped and applied as a single variable action. Single and/or a grouping of construction loads should be considered to act simultaneously with non-construction loads as appropriate.

NOTE 1 See EN 1990 and EN 1991 for advice on the simultaneity of non construction and construction loads.

NOTE 2 Groupings of loads to be taken into account are dependent on the individual project.

NOTE 3 See also Table 2.2.

(2) Construction loads to be included for consideration are given in Table 4.1.

Table 4.1 Representation of construction loads (Q_c)

Construction Loads (Q_c)					
Actions			Representation	Notes and remarks	
Type	Symbol	Description			
Personnel, and hand tools	Q_{ca}	Working personnel, staff and visitors, possibly with hand tools or other small site equipment	Modelled as a uniformly distributed load q_{ca} and applied to obtain the most unfavourable effects.	<p>NOTE 1: The characteristic value $q_{ca,k}$ of the uniformly distributed load may be defined in the National Annex or for the individual project.</p> <p>NOTE 2: The recommended value is $1,0 \text{ kN/m}^2$. See also 4.11.2.</p>	
Storage of moveable items	Q_{cb}	Storage of moveable items, e.g.: <ul style="list-style-type: none"> – building and construction materials, precast elements, and – equipment 	Modelled as free actions and should be represented as appropriate by: <ul style="list-style-type: none"> – a uniformly distributed load q_{cb}; – a concentrated load F_{cb}. 	<p>NOTE 3: The characteristic values of the uniformly distributed load and the concentrated load may be defined in the National Annex or for the individual project. For bridges, the following values are recommended minimum values:</p> <ul style="list-style-type: none"> – $q_{cb,k} = 0,2 \text{ kN/m}^2$; – $F_{cb,k} = 100 \text{ kN}$ <p>where $F_{cb,k}$ may be applied over a nominal area for detailed design.</p> <p>For densities of construction materials, see EN1991-1.</p>	
Non-permanent equipment	Q_{cc}	Non-permanent equipment in position for use during execution, either: <ul style="list-style-type: none"> – static (e.g. formwork panels, scaffolding, falsework, machinery, containers) or – during movement (e.g. travelling forms, launching girders and nose, counterweights) 	Modelled as free actions and should be represented as appropriate by: <ul style="list-style-type: none"> – a uniformly distributed load q_{cc}; 	<p>NOTE 4: These loads may be defined for the individual project using information given by the supplier. Unless more accurate information is available, the loads may be modelled by a uniformly distributed load with a recommended minimum characteristic value of $q_{cc,k} = 0,5 \text{ kN/m}^2$.</p> <p>A range of CEN design codes are available, for example, see EN 12811 and for formwork and false-work design see EN 12812.</p>	
Moveable heavy machinery and equipment	Q_{cd}	Moveable heavy machinery and equipment, usually wheeled or tracked, (e.g. cranes, lifts, vehicles, lift trucks, power installations, jacks, heavy lifting devices)	Unless specified should be modelled on information given in the relevant parts of EN 1991.	<p>Information for the determination of actions due to vehicles when not defined in the project specification, may be found in EN 1991-2.</p> <p>Information for the determination of actions due to cranes is given in EN 1991-3.</p>	
Accumulation of waste materials	Q_{ce}	Accumulation of waste materials (e.g. surplus construction materials, excavated soil, or demolition materials)	Taken into account by considering possible mass effects on horizontal, inclined and vertical elements (such as walls).	<p>NOTE 5: These loads may vary significantly, and over short time periods, depending on types of materials, climatic conditions, build-up rates and clearance rates, for example.</p>	
Loads from parts of a structure in a temporary state	Q_{cf}	Loads from parts of a structure in a temporary state (under execution) before the final design actions take effect (e.g. loads from lifting operations)	Taken into account and modelled according to the planned execution sequences, including the consequences of those sequences (e.g. loads and reverse load effects due to particular processes of construction, such as assemblage)	<p>See also 4.11.2 for additional loads due to fresh concrete</p>	

(3)P Characteristic values of construction loads, including vertical and horizontal components where relevant, shall be determined according to the technical requirements for the execution of the works and the requirements of EN 1990.

NOTE 1 Recommended values of ψ factors for construction loads are given in Annex A1 of this standard for buildings, and in Annex A2 to EN 1990 for bridges.

NOTE 2 Other types of construction loads may need to be taken into account. These loads may be defined for the individual project.

(4)P Horizontal actions resulting from the effects of construction loads shall be determined and taken into account in the structural design of a partly completed structure as well as the completed structure.

(5)P When construction loads cause dynamic effects, these effects shall be taken into account.

NOTE See also 3.1 (10) and EN 1990, Annexes A1 and A2.

4.11.2 Construction loads during the casting of concrete

(1) Actions to be taken into account simultaneously during the casting of concrete may include working personnel with small site equipment (Q_{ca}), formwork and load-bearing members (Q_{cc}) and the weight of fresh concrete (which is one example of Q_{cf}), as appropriate.

NOTE 1 For the density of fresh concrete see EN 1991-1-1:2002 Table A.1.

NOTE 2 Q_{ca} , Q_{cc} and Q_{cf} may be given in the National Annex

NOTE 3 Recommended values of actions due to construction loads during casting of concrete (Q_{cf}) may be taken from Table 4.2, and for fresh concrete from EN 1991-1-1:2002, Table A.1. Other values may have to be defined, for example, when using self-levelling concrete or precast products.

NOTE 4 Loads according to (1), (2) and (3), as given in Table 4.2, are intended to be positioned to cause the maximum effects, which may be symmetrical or not.

Table 4.2 : Recommended characteristic values of actions due to construction loads during casting of concrete

Action	Loaded area	Load in kN/m ²
(1)	Outside the working area	0,75 covering Q_{ca}
(2)	Inside the working area 3 m x 3 m (or the span length if less)	10 % of the self-weight of the concrete but not less than 0,75 and not more than 1,5 Includes Q_{ca} and Q_{cf}
(3)	Actual area	Self-weight of the formwork, load-bearing element (Q_{cc}) and the weight of the fresh concrete for the design thickness (Q_{cf})

(2) Horizontal actions of fresh concrete should be taken into account.

NOTE See also A1.3(2).

4.12 Accidental actions

(1)P Accidental actions such as impact from construction vehicles, cranes, building equipment or materials in transit (e.g. skip of fresh concrete), and/or local failure of final or temporary supports, including dynamic effects, that may result in collapse of load-bearing structural members, shall be taken into account, where relevant.

NOTE 1 Abnormal concentrations of building equipment and/or building materials on load-bearing structural members are not regarded as accidental actions.

NOTE 2 Dynamic effects may be defined in the National Annex or for the individual project. The recommended value of the dynamic amplification factor is 2. In specific cases a dynamic analysis is needed.

NOTE 3 Accidental actions from cranes may be defined for the individual project. See also EN 1991-3.

(2) The action due to falls of equipment onto or from a structure, including the dynamic effects, should be defined and taken into account where relevant.

NOTE The dynamic effects due to such falls of equipment may be given in the National Annex or for the individual project.

(3) Where relevant, a human impact load should be taken into account as an accidental action, represented by a quasi-static vertical force.

NOTE The design value of the human impact force may be defined in the National Annex or for the individual project. Examples of values are :

- a) 2,5 kN applied over an area 200 mm x 200 mm, to account for stumbling effects
- b) 6,0 kN applied over an area 300 mm x 300 mm, to account for falling effects

(4) The effects of the actions described in paragraphs (1), (2) and (3) above should be assessed to determine the potential for inducing movement in the structure, and also the extent and effect of any such movement should be determined, with the potential for progressive collapse assessed.

NOTE: See also EN1991-1-7.

(5) Accidental actions used for design situations should be taken into account for any changes. To ensure that the appropriate design criteria are applied at all times, corrective measures should be taken as work proceeds.

(6) Fire actions should be taken into account, where appropriate.

4.13 Seismic actions

(1) Seismic actions should be determined according to EN 1998, taking into account the reference period of the considered transient situation.

(2) The design values of ground acceleration and the importance factor γ_I should be defined.

NOTE The design values of ground acceleration and the importance factor γ_I may be defined in the National Annex or for the individual project.

Annex A1
(normative)
Supplementary rules for buildings

A1.1 Ultimate limit states

(1) For transient, accidental and seismic design situations the ultimate limit state verifications should be based on combinations of actions applied with the partial factors for actions γ_F and the appropriate ψ factors.

NOTE 1 For values of γ_F and ψ factors see EN 1990, Annex A1.

NOTE 2 Representative values of the variable action due to construction loads may be set by the National Annex, within a recommended range of $\psi_0 = 0,6$ to 1,0. The recommended value of ψ_0 is 1,0. The minimum recommended value of ψ_2 is 0,2 and it is further recommended that values below 0,2 are not selected.

NOTE 3 ψ_1 does not apply to construction loads during execution.

A1.2 Serviceability limit states

(1) For the verification of serviceability limit states, the combinations of actions to be taken into account should be the characteristic and the quasi-permanent combinations as defined in EN 1990.

NOTE For recommended values of ψ factors see A1.1, Notes 1 and 2.

A1.3 Horizontal actions

(1)P Further to 4.11.1 (3), horizontal actions resulting from, for example, wind forces and the effects of sway imperfections and sway deformations shall be taken into account.

NOTE: See also 4.7 and EN 1990:2002, 3.5(7).

(2) Nominal horizontal forces (F_{hn}) may be applied only when such a method can be justified as appropriate and reasonable for a particular case. In such cases, the determined nominal horizontal forces should be applied at locations to give the worst effects, and may not always correspond to those of the vertical loads.

NOTE The characteristic values of these equivalent horizontal forces may be defined in the National Annex or for the individual project. The recommended value is 3 % of the vertical loads from the most unfavourable combination of actions.

Annex A2
(normative)
Supplementary rules for bridges

A2.1 Ultimate limit states

(1) For transient, accidental and seismic design situations the ultimate limit state verifications should be performed.

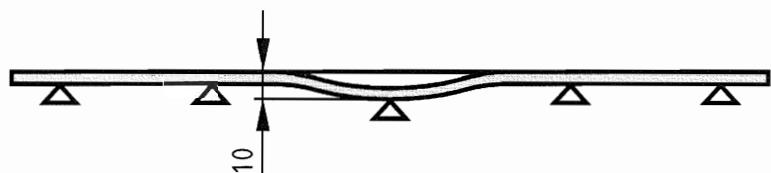
NOTE For values of γ_F and ψ factors see EN 1990, Annex A2.

A2.2 Serviceability limit states

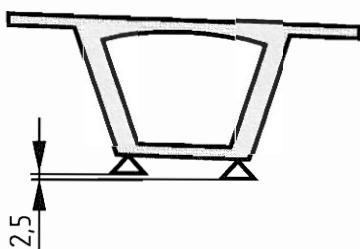
(1) For serviceability limit states the partial factors for actions γ_F should be taken as 1,0 unless otherwise specified in EN 1991 to EN 1999. The ψ factors should be taken as specified in EN 1990, Annex A2.

A2.3 Design values of deflections

(1) For the incremental launching of bridges the design values for vertical deflections (see Figure A2.1) should be defined.



a) Longitudinal deflection



b) Differential deflection in the transverse direction

Figure A2.1 : Deflections of bearings during execution for bridges built by the incremental launching method

NOTE 1 The design values of vertical deflection may be defined in the National Annex or for the individual project. The recommended values are:

- ± 10 mm longitudinally for one bearing, the other bearings being assumed to be at the theoretical level (Figure A2.1a);
- $\pm 2,5$ mm in the transverse direction for one bearing, the other bearings being assumed to be at the theoretical level (Figure A2.1b).

NOTE 2 The deflections in the longitudinal and transverse directions are considered separately.

A2.4 Snow loads

(1) Snow loads on bridges during execution should be based on values specified in EN 1991-1-3 taking account of the required return period (see Section 3).

(2) When daily removal of snow (also on weekends and holidays) is required for the project and safety measures for removal are provided, the characteristic snow load should be reduced compared to the value specified in EN 1991-1-3 for the final stage.

NOTE The reduction may be defined in the National Annex or for the individual project. The recommended characteristic value is 30 % of the characteristic value for permanent design situations.

(3) For the verification of the static equilibrium (EQU), and when justified by climatic conditions and anticipated duration of the construction phase, the characteristic snow load should be assumed to be uniformly distributed in the areas giving unfavourable action effects and should be equal to x % of the characteristic value for permanent design situations resulting from EN 1991-1-3.

NOTE The conditions of application of this rule and the reduced percentage value (x %) may be defined in the National Annex. The recommended value for x is 75%.

A2.5 Construction loads

(1) For the incremental launching of bridges horizontal forces due to friction effects should be determined, and applied between the bridge structure, the bearings and the supporting structures, with dynamic action effects taken into account where appropriate.

(2) The design value of the total horizontal friction forces should be evaluated, should be not less than x % of the vertical loads, and should be determined to give the least favourable effects.

NOTE The value of x % may be specified in the National Annex. The recommended value is 10 %.

(3) The horizontal friction forces at every pier should be determined with the appropriate friction coefficients, μ_{\min} and μ_{\max} .

NOTE 1 The friction coefficients, μ_{\min} and μ_{\max} , may be defined in the National Annex or for the individual project.

NOTE 2 Unless more accurate values are available from tests for movements on very low friction surfaces (e.g. PTFE - polytetrafluoroethylene) the recommended values are :

- $\mu_{\min} = 0$
- $\mu_{\max} = 0,04$

Annex B
(informative)

Actions on structures during alteration, reconstruction or demolition

- (1) Characteristic and other representative values of actions should be determined in accordance with EN 1990.
- (2) The actual performance of structures affected by deterioration should be taken into account in the verification of the stages for reconstruction or demolition. The investigation of structural conditions to enable the identification of the load-bearing capacity of the structure and to prevent unpredictable behaviour during reconstruction or demolition should be undertaken.
- (3) Guidance for the most common actions, and methods for their determination, is provided in section 4. However, some construction loads during reconstruction or demolition may have different characteristics and representations from those shown in Tables 2.2 and 4.1. The effects of such loads on all relevant structures under relevant transient design situations should be verified and taken into account.
- (4) Combinations of actions for various design situations should be as given in EN 1990 and its Annexes A1 and A2.
- (5) Unless more specific information is known the values of γ_f factors recommended for buildings in Annex A1 and EN 1990 Annex A1 and for bridges in EN 1990 Annex A2, may be considered in the design for transient design situations.
- (6) All imposed loads, including traffic loads, should be considered if part of the structure remains in use during its reconstruction or partial demolition. These loads may vary at different transient stages. Traffic loads should include, for example, impact and horizontal forces from vehicles, wind actions on vehicles, and aerodynamic effects from passing vehicles and trains where relevant.
- (7) Reduction of traffic loads from their final design values should not be made unless the structure is monitored and regularly supervised to an appropriate level.
- (8) The reliability for the remaining structure or parts of the structure under reconstruction, partial or full demolition should be consistent with that considered in the Eurocodes for completed structures or parts of structures.
- (9) The actions due to the works should not adversely affect neighbouring structures by, for example, removing or imposing loads that may cause instability.
- (10) Construction loads specific for reconstruction or demolition should be determined taking into account, for example, methods and arrangements of storing materials, the techniques used during reconstruction or demolition, the execution system and the particular stages of work. Construction loads during reconstruction or demolition may also include the effects of storage from demolished or removed materials and/or dismantled elements, including horizontal actions.
- (11) Dynamic effects should be considered where it is anticipated that activities during reconstruction or demolition will cause such effects.

Bibliography

- EN 1337 Structural bearings
- EN 12811 Temporary works equipment
- EN 12812 Falsework. Performance requirements and general design
- ISO 12494 Atmospheric Icing of Structures