CEN/TC 250

Date: 2023-08

prEN 1991-1-6:2024

Secretariat: BSI

Eurocode 1 — Actions on structures — Part 1-6: Actions during execution

*Eurocode 1 — Einwirkungen auf Tragwerke — Teil 1-6: Einwirkungen während der Bauausführung*

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

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European foreword

This document (prEN 1991-1-6:2024) 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 CEN Enquiry.

This document will supersede EN 1991-1-6:2005.

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.

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 Eurocodes 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)**

EN 1991 specifies actions for the structural design of buildings, bridges and other civil engineering works, or parts thereof, including temporary structures, in conjunction with EN 1990 and the other Eurocodes.

EN 1991 does not cover the specific requirements of actions for seismic design. Provisions related to such requirements are given in EN 1998 (all parts), which complement and are consistent with EN 1991.

EN 1991 is also applicable to existing structures for their:

— structural assessment,

— strengthening or repair,

— change of use.

NOTE 1 In these cases additional or amended provisions can be necessary.

EN 1991 is applicable for the design of structures where materials or actions outside the scope of the other Eurocodes are involved.

NOTE 2 In this case additional or amended provisions can be necessary.

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** **1991-1-6**

prEN 1991-1-6 provides guidance and general rules on the determination of actions relevant for the design of the execution of buildings and other civil engineering works, including geotechnical structures.

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

prEN 1991-1-6 provides complementary guidance on the application of other Parts of EN 1991 during execution.

**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.

**0.5 National Annex for** **prEN** **1991-1-6**

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

The national standard implementing prEN 1991-1-6 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 choice is given in this standard, the choice can be specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

National choice is allowed in prEN 1991-1-6 through notes to the following clauses:

|  |  |  |  |
| --- | --- | --- | --- |
| 6.1(3) | 6.2.1(1) | 6.2.2(1) | 7.4(1) |
| B.5(2) | B.7(2) |  |  |

National choice is allowed in prEN 1991‑1-6 on the application of the following informative annexes:

None

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

# Scope

## Scope of prEN 1991-1-6

(1) prEN 1991-1-6 provides guidance and general rules on the determination of actions relevant for the design of buildings and civil engineering works, including geotechnical structures, for their execution stage.

NOTE Actions for design during execution include those that only arise from execution activities and act during execution, termed construction actions (for example personnel and hand tools, auxiliary structures, equipment and elements used during execution), and others that are present during the service life of the completed structure (for example self-weight, wind, etc.) but which can act differently and/or have different values during execution.

(2) prEN 1991-1-6 provides guidance and general rules for the determination of actions for the design of auxiliary structures, elements and equipment used during execution in case they are designed to the Eurocodes and not to other European Standards.

NOTE Other European Standards (e.g. EN 12810, EN 12811, EN 12812) provide specific rules for certain types of auxiliary structures, equipment and elements used during execution.

(3) prEN 1991-1-6 gives rules for buildings and bridges during execution to supplement the provisions in EN 1990.

NOTE For combination rules for execution, see EN 1990.

## Assumptions

(1) The general assumptions given in EN 1990 apply.

(2) The application of this document follows the limit state principle and is based on the partial factor method, unless explicitly prescribed differently.

(3) The verification of buildings and civil engineering structures in transient design situations is undertaken in accordance with the Eurocodes, accounting for the interaction with any auxiliary structures, elements and/or equipment.

(4) When using European product standards covering auxiliary structures, equipment and elements used during execution, it is assumed that the design basis, design requirements and, if provided, the safety and operational design limits specified in these product standards are taken into account.

(5) Adequate planning, documentation, communication, control and supervision are provided during execution, involving all relevant parties.

NOTE Execution of a structure can involve interaction between several parties from diverse engineering fields, responsible for the design, fabrication, transportation and execution of different subsystems used during the execution of a structure.

# 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, Eurocode — Basis of structural and geotechnical design

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

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

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

prEN 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 machinery

EN 1992‑1-1, Eurocode 2 — Design of concrete structures – Part 1-1: General rules, rules for buildings, bridges and civil engineering structures

EN 1993‑1-1, Eurocode 3 — Design of steel structures — Part 1-1: General rules and rules for buildings

EN 1993‑2, Eurocode 3 — Design of steel structures — Part 2: Steel bridges

EN 1994‑1-1, Eurocode 4 — Design of composite steel and concrete structures — Part 1-1: General rules and rules for buildings

EN 1995‑1-1, Eurocode 5 — Design of timber structures — Part 1-1: General rules and rules for buildings

EN 1997 (all parts), Eurocode 7 — Geotechnical design

EN 1998 (all parts), Eurocode 8 — Design of structures for earthquake resistance

EN 1999‑1-1, Eurocode 9 — Design of aluminum structures — Part 1-1: General rules

# Terms, definitions and symbols

## Terms and definitions

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

3.1.1

execution

all activities carried out for the physical completion of the work including procurement, the inspection and documentation thereof

Note 1 to entry: The term covers work on site; it can also signify the fabrication of parts off site and their subsequent erection on site.

[SOURCE: EN 1990:2023, 3.1.1.8]

3.1.2

construction works

everything that is constructed or results from construction operations

Note 1 to entry: The term covers both buildings and civil engineering works. It refers to the complete construction works comprising structural members, geotechnical elements and elements other than structural.

[SOURCE: EN 1990:2023, 3.1.1.1]

3.1.3

structure

part of the construction works that provides stability, resistance and rigidity to meet the safety, serviceability and durability requirements

Note 1 to entry: This definition includes structures that comprise one member or a combination of connected members.

[SOURCE: EN 1990:2023, 3.1.1.2]

3.1.4

construction action

action that only arises from construction operations and only acts during construction phases, including execution

Note 1 to entry: The term excludes accidental actions.

3.1.5

auxiliary structures and equipment used during execution

any structure and equipment which is part of the structural system that provides the stability, resistance and rigidity to the construction works during execution, after which, is usually removed

Note 1 to entry: Examples are formwork, propping systems, falsework, retaining walls, cofferdam, bracing, movable scaffolding systems, launching nose, launching gantries, hydraulic jacks and counterweights.

Note 2 to entry: Auxiliary structures and equipment used during execution can impose actions during execution on the construction works.

3.1.6

auxiliary elements used during execution

any element which can only impose actions on the construction works during execution, after which, is usually removed

Note 1 to entry: An example is scaffolds.

Note 2 to entry: These elements are usually in contact with the construction works during execution but do not form part of the structural system that provides the stability, resistance and rigidity to the construction works during execution.

Note 3 to entry: These elements can only impose actions throughout execution, e.g. permanent, variable or fatigue actions as well as accidental actions, namely by the weight of the elements, by the wind acting on the elements or by collapsing onto the construction works.

3.1.7

supported construction

structural members or parts of the structure being executed or other items in temporary states, which are supported by an auxiliary structure or equipment used during execution

3.1.8

general scour depth

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

3.1.9

local scour depth

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

## Symbols

For the purposes of this document, the following symbols apply in addition to those given in EN 1990, as relevant.

### Latin upper-case letters

|  |  |
| --- | --- |
| *A*deb | area of obstruction (accumulation of debris) |
| *F*deb | horizontal forces exerted by the accumulation of debris |
| *F*cb,k | characteristic values of concentrated execution loads *Q*cb |
| *F*wa | horizontal forces exerted by currents on a vertical surface |
| *Q*c | construction actions (general symbol) |
| *Q*ca | construction action due to working personnel and hand tools |
| *Q*cb | construction action due to storage of moveable items |
| *Q*cc | construction action due to auxiliary structures, equipment and elements used during execution in position for use |
| *Q*cd | construction action due to heavy vehicles and heavy moveable auxiliary structures, equipment and elements used during execution usually wheeled or tracked |
| *Q*ce | construction action from the accumulation of waste materials |
| *Q*cf | other construction actions |

### Latin lower-case letters

|  |  |
| --- | --- |
| *b* | width of an immersed object |
| *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 representing construction action *Q*ca |
| *q*cb,k | characteristic values of the uniformly distributed loads representing construction action *Q*cb |
| *q*cc,k | characteristic values of the uniformly distributed loads representing construction action *Q*cc |
| *v*wa | is the maximum speed of the current, in m/s |

### Greek lower-case letters

|  |  |
| --- | --- |
| *ρ*wa | density of water |
| µmin | minimum coefficient of friction |
| µmax | maximum coefficient of friction |

# Design situations

(1) Design situations shall be selected appropriately to reflect the operational conditions foreseen during the execution of the structure, including any revisions to the execution processes.

NOTE 1 For the selection of design situations, see EN 1990:2023, 5.2.

NOTE 2 Operational conditions during execution depends on several factors including methods, techniques and/or sequences of execution, structural solution, location of the structure.

NOTE 3 Depending on the execution methods used, there can be an instantaneous application of actions resulting in significant effects. For example, when complete bridge spans are assembled at ground level and lifted or slid into place (e.g. in pre-cast bridges built by the full span method), or in a concrete bridge deck when all the loads are transferred instantaneously to the foundations once the temporary supports are removed.

NOTE 4 The effects of a specific action, as well as the stiffness and resistance of the structural system, can be very different during execution from the corresponding values used in the design of the completed structure.

(2) The relevant design situations should be selected considering whether they apply to the overall structure, to the part of the structure being executed, to the auxiliary structure, to the equipment used during execution or to individual structural members.

(3) During execution, all critical load cases in each relevant design situation shall be identified.

NOTE When assessing critical load cases during execution, aspects to consider can include:

— evolution of the structural system (e.g. joining; addition, removal or movement of supports; connections, members, parts of the structure; auxiliary structure and equipment used during execution);

— changes to the geometrical configuration of the structure (e.g. from the longitudinal and transversal slopes, plan curvature of a bridge deck and from the slope of the foundation ground);

— second order effects (e.g. in high-rise buildings and slender bridge piers); and

— local effects (e.g. in bridges built by incremental launching method).

(4) Design situations involving fatigue should be considered in specific cases such as structures exposed to galloping, aeroelastic instability, vortex excitation and other resonance wind action effects, as well as structures or parts of structures that can be reused multiple times.

(5) Design situations involving fatigue may, in general, be neglected in the design of structures that have short design service lives (i.e. typically less than one year).

(6) Where appropriate, the design should be updated using data obtained by structural monitoring and material testing during the execution stages.

NOTE Typical examples are measuring of deflections and cable forces in the case of incrementally launched, balanced cantilevered and cable stayed bridges.

# Classification of actions

## General

(1) All relevant actions to be considered during the execution of a structure shall be identified and classified for each selected design situation [see EN 1990 and relevant parts of EN 1991 (all parts), except EN 1991-1-2 and EN 1991-4), EN 1997 (all parts) and EN 1998 (all parts)].

NOTE 1 The identification and classification of the relevant actions to be considered during the execution of a structure are dependent on the methods, techniques and/or sequences of execution, structural solution, location of the structure, etc.

NOTE 2 The identification and classification of actions during the execution also depends on the type of structure under consideration. Relevant actions for the design of the structure being executed can arise from auxiliary structures, equipment and elements used during execution (e.g. weight of equipment, actions due to friction, hoisting and climbing). Conversely, relevant actions for the design of auxiliary structures and equipment used during execution can arise from the execution of the structure (e.g. creep, shrinkage, hydration and prestressing actions on reinforced concrete structures).

(2) During execution, actions may have more than one classification depending on the design situation. Different classifications for the same action should be as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

NOTE For example, wind is classified as a variable action if a threshold wind speed is specified during casting of a concrete structural member. Wind is treated as an accidental action if wind speed values higher than the specified threshold value can occur during concrete casting. In such a case, wind actions are to be combined with the concrete casting actions in an accidental design situation. For threshold values, see 6.1(4).

(3) For the design of the auxiliary structures and equipment used during execution, the self-weight of the supported construction should be treated as a variable action when its effects are unfavourable and its value varies over time during execution stages.

NOTE Before hardening, the self-weight of the concrete acts as a construction action and is classified as a variable action. After hardening, the self-weight of the concrete acts as an action other than a construction action and is classified as a permanent action. Alternatively, and as a conservative simplification, the self-weight of the concrete can be considered to always act as a construction action and to always be classified as a variable action.

## Construction actions

(1) Construction actions shall be identified and classified for each selected design situation.

NOTE Table 5.1 provides guidance on the classification of construction actions.

Table 5.1 — Guidance on the classification of construction actions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Related clause in this document** | **Action** | **Classification** | | | |
|  |  | **Variation in time** | **Origin** | **Spatial variation** | **Nature** |
| 6.2 | Personnel and hand tools | Variable | Direct | Free | Static / dynamic |
| 6.2 | Storage of movable items | Variable | Direct | Free | Static / dynamic |
| 6.2 | Auxiliary structures, equipment and elements used during execution | Variable | Direct | Fixed / Free | Static / dynamic |
| 6.2 | Heavy vehicles and heavy moveable auxiliary structures, equipment and elements used during execution | Variable | Direct | Free | Static / dynamic |
| 6.2 | Accumulation of waste materials | Variable | Direct | Free | Static / dynamic |
| 6.2 | Other | Permanent / variable | Direct | Fixed / free | Static / dynamic |
| NOTE Examples of construction actions that can be classified as “Other”: effects from temporary supports, temporary hangers or suspension devices, actions from temporary prestressing, hydration of concrete, imposed deformations, handling, certain actions occurring during casting of fresh concrete. | | | | | |

(2) When construction actions are classified as fixed, tolerances for possible deviations from the theoretical position should be used as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

(3) When construction actions are classified as free, limits of the area where they can be moved or positioned should be used as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

## Actions other than construction actions

(1) Actions other than construction actions shall be identified and classified for each selected design situation.

NOTE Table 5.2 provides guidance on the classification of actions other than construction actions.

Table 5.2 — Guidance on the classification of actions other than construction actions

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Related clause in this document** | **Action** | **Classification** | | | |
| **Variation in time** | **Origin** | **Spatial variation** | **Nature** |
| 6.3.1 | Self-weight a | Permanent/ variable | Direct | Fixed / free | Static |
| 6.3.2 | Imposed loads | Variable / accidental | Direct | Free | Static / dynamic |
| 6.3.3 | Snow | Variable / accidental | Direct | Fixed | Static / dynamic |
| 6.3.4 | Wind | Variable / accidental | Direct | Fixed | Static / dynamic |
| 6.3.5 | Thermal | Variable | Indirect | Fixed | Static |
| 6.3.6 | Shrinkage and ageing | Permanent | Indirect | Free | Static |
| 6.3.7 | Traffic | Variable / accidental | Direct | Free | Static / dynamic |
| 6.3.8 | Accidental | Accidental | Direct / Indirect | Free | Static / dynamic |
| 6.3.9 | Water b | Permanent/ variable/  Accidental | Direct | Fixed / free | Static / dynamic |
| 6.3.10 | Atmospheric icing | Variable / accidental | Direct | Fixed | Static / dynamic |
| 6.3.11 | From cranes and machines c | Variable / accidental | Direct | Fixed / free | Static / dynamic |
| 6.3.12 | Geotechnical d | Permanent / variable | Direct / Indirect | Fixed | Static |
| 6.3.13 | Prestressing e | Permanent / variable | Direct | Fixed | Static |
| 6.3.14 | Pre- deformations | Permanent / variable | Indirect | Free | Static |
| 6.3.15 | Seismic | Variable / accidental | Direct | Free | Dynamic |
| a For the classification of the self-weight of structural members and elements other than structural, see EN 1991‑1‑1.  b For the classification of water actions, see other parts of EN 1991 and EN 1997-1.  c For the classification of actions from cranes and machines, see EN 1991-3.  d For the classification of geotechnical actions, see EN 1997-1.  e Prestressing actions should be classified as permanent actions, unless in localized regions (e.g. anchor region and other discontinuities regions) where they cause significant unfavourable effects, in which case they should be classified as variable actions. For guidance on how to apply the “single source principle” to prestressing actions, see EN 1990. | | | | | |

# Characteristic values of actions during execution

## General

(1) The characteristic value of a climatic action should be determined considering the anticipated duration of the execution activity under analysis.

NOTE 1 The characteristic value of a climatic action is determined from the guidance provided in Table 6.1 (NDP) unless the National Annex gives different guidance.

NOTE 2 For rules on updating the probabilistic model to determine the characteristic value of a climatic action, see the relevant part of EN 1991.

Table 6.1(NDP) — Guidance for the determination of the characteristic values of the climatic actions

|  |  |
| --- | --- |
| **Duration of the activities** | **Method for determining characteristic values** |
| ≤ 5 days | The characteristic values are determined based on reliable meteorological data covering a period that extends over the entire planned maximum duration of the activity under analysis. |
| ≤ 1 year (but > 5 days) | The characteristic values are taken as specified in the applicable part of EN 1991 (i.e. based on an annual probability of exceedance of 0,02), accounting, when applicable, for seasonal variations by seasonal factors. |
| > 1 year | The characteristic values are taken as specified in the applicable part of EN 1991 (i.e. based on an annual probability of exceedance of 0,02), but neglecting seasonal factors. |

(2) Threshold values (or a range of values) of a specific climatic action may be used if specified by the relevant authority and agreed for a specific project by the relevant parties.

NOTE Providing a threshold value (or a range of values) of a climatic action can be relevant in cases where the decision to start or continue an execution activity is made dependent on checking whether values of that action meet the threshold value.

(3) When determining actions for the design of structures or parts of structures that can be dismantled in order to be reused, such as certain auxiliary structures and equipment used during execution, the reference period introduced in subclause 6.1 (1) shall be equal to their design service life, taking account of the intended maximum number of reuses of each structure and inspection and maintenance between uses.

NOTE EN 1990:2023, Annex C gives rules to determine equivalent reliability requirements for different periods, e.g. target reliability values defined for one year that are equivalent to target reliability values defined for the design service life.

(4) The combination rules for buildings during execution given in Annex A, which complement those given in EN 1990, shall be followed.

## Construction actions

### General

(1) Characteristic values of construction actions, including vertical and horizontal components where relevant, shall be determined according to EN 1990, taking into account the different execution stages, as appropriate.

NOTE 1 The characteristic values of construction actions, *Q*c, can be obtained from Table 6.2(NDP), unless the National Annex specifies different values.

NOTE 2 The characteristic values of construction actions on certain auxiliary structures and elements used during execution are as specified in other European Standards (e.g. EN 12810, EN 12811, EN 12812).

Table 6.2 (NDP) — Representation of construction actions (*Q*c) and characteristic values

| **Construction actions** | | | **Representation** | **Characteristic value** |
| --- | --- | --- | --- | --- |
| **Type** | **Symbol** | **Examples** |  |  |
| 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 and applied to cause the most unfavourable effects. | *q*ca,k = 1,0 kN/m2 |
| Storage of movable items | *Q*cb | Building and execution materials, precast elements, auxiliary structures, equipment and elements used during execution, vehicles. | Modelled as free actions. Represented as appropriate by (not acting simultaneously):  — a uniformly distributed load *q*cb;  — a concentrated load *F*cb. | Guidance can be found in other parts of EN 1991.  For bridges:  — *q*cb,k ≥ 0,2 kN/m2;  — *F*cb,k ≥ 100 kN  Where *F*cb,k may be applied over a nominal area for detailed design. |
| Auxiliary structures, equipment and elements used during execution in position for use | *Q*cc | Formwork panels, scaffolding, falsework, machinery, containers, travelling forms, launching girders, self-climbing formwork, counterweights, bearings, hydraulic jacks. | Information on these actions should be obtained from the supplier with due consideration of the dynamic effects.  Unless more accurate information is available, the actions may be modelled by a uniformly distributed load. | *q*cc,k ≥ 0,5 kN/m2 |
| Heavy vehicles and heavy moveable auxiliary structures, equipment and elements used during execution | *Q*cd | Cranes, lifts, vehicles, lift trucks, power installations, heavy hoisting devices. | Information on these actions should be obtained from the supplier, with due consideration of the dynamic effects. | Guidance can be found in other parts of EN 1991. |
| Accumulation of waste materials a | *Q*ce | Surplus execution materials, excavated soil, or demolition materials. | Taken into account by considering possible mass effects on horizontal, inclined and vertical elements (such as walls). | Accumulation of waste materials a |
| Other | *Q*cf | Construction actions other than the above, for example:  — effects from temporary supports;  — temporary hangers or suspension devices;  — actions from temporary prestressing;  — certain actions occurring during casting of fresh concrete (see 6.2.2);  — imposed deformations (see 6.2.3);  — hydration of concrete (see 6.2.4); and  — actions from handling (see 6.2.5). | Taken into account and modelled according to the planned execution stages, including the consequences of those stages (e.g. loads and reverse load effects due to particular processes of execution, such as assemblage). | |
| a These actions can vary significantly, and over short periods, depending on aspects like types of materials, climatic conditions, build-up rates and clearance rates. | | | | |

(2) For certain types of structures, minimum values of vertical and/or horizontal construction actions should be used as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

NOTE See also 7.2 for lateral forces.

(3) Construction actions may be grouped and treated as a single multi-component variable action where the construction process dictates that they can co-exist.

(4) Where construction actions cannot occur concurrently due to the implementation of control measures, they may not be taken into account in the relevant combinations of actions simultaneously.

### Construction actions 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 applicable.

NOTE 1 For the specific weight of fresh concrete, see prEN 1991-1-1:2023, Table A.1.

NOTE 2 Characteristic values of construction actions during casting of concrete can be taken from Table 6.3(NDP) unless the National Annex specifies different values.

Table 6.3 (NDP) — Characteristic values of construction actions during casting of concrete

|  |  |  |
| --- | --- | --- |
| **Action** | **Loaded area** | **Load in kN/m2** |
| (1) | Outside the working area | 0,75  Covering *Q*ca |
| (2) | Inside the working area 3 m ⨯ 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  Covering *Q*ca and *Q*cf |
| (3) | Actual area | Self-weight of the formwork and other auxiliary structures, equipment and elements used during execution (*Q*cc) and the weight of the fresh concrete for the design thickness (*Q*cf) |
| Dimensions in millimetres | | Dimensions in millimetres |
| NOTE 1 Actions (1), (2) and (3), are intended to be applied to cause the most unfavourable effects, which can be symmetrical or not.  NOTE 2 The loads’ values in Table 6.3(NDP) only allow for concrete to be dropped by no more than 1 m height and also a heap height not greater than three times the depth of the slab (subject to a maximum load of 1,75 kN/m2), considering an area equal to 1 m2.  NOTE 3 This table does not cover cases like self-levelling concrete or precast products, where other load values are to be defined. | | |

(2) Pressures from the fresh concrete should be taken into account.

NOTE Specific information on calculation of pressures from the fresh concrete can be found in relevant national standards and other relevant technical publications.

### Imposed deformation actions

(1) Where relevant, imposed deformation actions and effects shall be considered in the design as specified in the relevant parts of EN 1992 to EN 1999, as applicable.

NOTE Imposed deformations are typically applied for improving the performance of the structure, to properly position the structure or to correct its geometry. They can result from, for example, movements imposed through hydraulic jacks, chains, ropes or cables, including hangers.

(2) Imposed deformations actions and effects should be checked against design criteria by measuring forces and deformations or displacements during execution.

### Hydration of concrete actions

(1) In concrete or steel-concrete structures, the actions and effects from hydration of concrete should be determined as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

NOTE 1 Guidance can be found in EN 1992-1-1 and EN 1994-1-1, as applicable.

NOTE 2 Temperature can rise significantly during hardening of a massive cast in place concrete structure, with consequent thermal effects.

NOTE 3 Significant thermal effects can also result from accelerated curing introduced by steaming or other methods.

(2) The unfavourable effects of hydration actions may be mitigated by appropriate adequate design options (e.g. concrete composition, sequence of execution, structural detailing, pre-deformations and imposed deformations, as appropriate).

### Actions from handling

(1) Actions from handling (e.g. hoisting, sliding, transport or storage) should be determined as specified- 1-1 by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

NOTE Cases where these actions can be relevant are on-site lifting or rotating operations of large or heavy members, which can induce significant second-order deformations, in particular on connections.

(2) Actions from handling should take the actual support conditions and dynamic or inertia effects due to vertical and horizontal accelerations into account, where appropriate.

(3) Actions induced by cranes shall be determined according to EN 1991-3.

### Other actions

(1) The actions due to movements (e.g. displacements, deformations, vibrations) of members or equipment (e.g. elastic shortening) during execution should be considered in the design.

(2) The actions due to friction should be considered in the design, taking into account dynamic action effects where appropriate.

NOTE Actions due to friction can be significant for the design during execution of bridges that are built using the incremental launching method.

(3) Actions over each support due to friction should be determined based on the use of appropriate values of friction coefficients, *µ*min and *µ*max, and applied to cause the most unfavourable effects. The event of a blockage of a bearing should be considered when relevant.

NOTE 1 Unless more accurate values are available from tests for movements on very low friction surfaces (e.g. PTFE – polytetrafluoroethylene), the values of the friction coefficients are given in the relevant European Standards (e.g. EN 1337, EN 12812, EN 15129).

NOTE 2 Annex B provides the design value of the sum of all longitudinal loads due to friction for bridges built using the incremental launching method.

## Actions other than construction actions

### General

(1) Actions other than construction actions shall be determined according to the relevant standards as identified in the following clauses, taking into account the different execution stages as appropriate.

(2) The specific rules for bridges during execution given in Annex B shall be followed.

### Self-weight

(1) The self-weight of structural members and elements other than structural shall be determined according to EN 1991-1-1.

NOTE See EN 1990 for specific considerations of how to define the characteristic values of the self-weight and other permanent actions.

### Imposed loads

(1) Imposed loads, when relevant to execution, shall be determined according to EN 1991-1-1.

### Snow actions

(1) Snow actions shall be determined according to EN 1991-1-3.

(2) The rules for reduction of snow loads during execution of bridges under certain conditions given in Annex B shall be followed when relevant.

### Wind actions

#### General

(1) Wind actions shall be determined according to EN 1991-1-4.

NOTE The dynamic characteristics of the structure can vary over the execution phase.

(2) When determining wind actions, the exposed areas of structural members, auxiliary structures, equipment and elements used during execution shall be taken into account.

NOTE For example, the exposed area of a netted access scaffold connected to a bridge pier.

#### Minimum design wind speed

(1) For the design during execution, a minimum design wind speed should be as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

(2) The specific rules for bridges built by the balanced cantilever method given in Annex B shall be followed when relevant.

#### Working wind speed

(1) For the design during execution, a maximum wind speed (often termed working or service wind speed) may be defined in the design and specified in the project documentation.

NOTE 1 The working wind speed is the wind speed until which safe working conditions can be assumed and above which execution activities are to be stopped.

NOTE 2 Guidance on working wind speeds can be found in EN 12811 for scaffolds and in EN 12812 falsework.

(2) The working wind speed shall not be lower than the minimum design wind speed (see 6.3.5.2), where applicable.

#### Seasonal factor for auxiliary structures, equipment and elements

(1) For auxiliary structures, equipment and elements used during execution, the seasonal factor defined in EN 1991-1-4, *c*season, should be taken equal to 1,0.

### Thermal, shrinkage and ageing actions

(1) Thermal actions and effects shall be determined according to EN 1991-1-5.

(2) The unfavourable effects of thermal actions may be mitigated by appropriate adequate design options (e.g. sequence of execution, structural detailing, pre-deformations and imposed deformations, as appropriate).

(3) In concrete or steel-concrete structures, the actions and effects from shrinkage and ageing (e.g. creep and relaxation), shall be considered in the design as specified in EN 1992-1-1 and EN 1994‑1‑1 as applicable.

NOTE 1 Plastic shrinkage occurs before the concrete has hardened.

NOTE 2 Drying and autogenous shrinkage, and ageing actions are relevant after concrete has hardened.

NOTE 3 Actions and effects due to shrinkage and ageing, depend on several factors such as the type of concrete, the methods, sequences and time of concreting, the meteorological parameters, the curing of concrete, the age of concrete when actions are imposed, the type of restraints, etc.

(4) The unfavourable effects of shrinkage and ageing actions may be mitigated by appropriate adequate design options (e.g. concrete composition, sequence and time of concreting, structural detailing, pre- deformations and imposed deformations, as appropriate).

(5) Specific shrinkage and ageing tests may be performed to accurately estimate their actions and effects during execution.

### Traffic actions

(1) Traffic actions, when relevant to execution, shall be determined according to EN 1991-1-1 and EN 1991-2, as applicable.

### Accidental actions

(1) Accidental actions, when relevant to execution, should be determined as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

NOTE 1 Examples of accidental actions include fires, fall of structural parts (e.g. member, counterweight, auxiliary structure or equipment used during execution), impact from objects (e.g. vehicle, temporary element used during execution), failure of members (e.g. bracing), failure of connections, failure of supports (e.g. temporary tower, tie-down, guide, buffer), failure of ground (e.g. differential soil settlement) or failure of equipment used during execution (e.g. very large or very small restriction to movements provided by a bearing, failure of a hydraulic jack or a hydraulic unit), wind speeds higher than the working wind speed specified during casting of concrete members.

NOTE 2 Guidance on accidental actions can be found in other parts of EN 1991 (namely EN 1991-1-7), in EN 1992 to EN 1999.

NOTE 3 Annex B defines accidental actions for certain bridges.

(2) Abnormal concentrations of storage of movable items should not be considered as accidental actions.

NOTE See also 6.2.1 and 6.3.8.

(3) Dynamic and inertia contributions shall be determined where relevant.

NOTE See 7.5 for guidance on dynamic effects.

(4) Where relevant, actions originated by human impact (e.g. stumbling, falling) should be determined according to EN 1263, EN 12810, EN 12811, EN 13374, as applicable.

### Actions caused by water

#### General

(1) Actions due to water, including groundwater, should be represented as hydrostatic pressures and hydrodynamic effects, as relevant.

NOTE In general, phenomena covered by hydrodynamic effects are:

— the hydrodynamic force due to currents on immersed objects;

— forces due to wave actions;

— water effects caused by an earthquake (tsunamis); and

— breakup of ice or debris by river flooding.

(2) Actions caused by water should be determined based on water levels.

(3) Water levels should be as specified by the relevant authority or, where not specified, be agreed for a specific project by the relevant parties.

#### Actions exerted by currents

(1) The following is only applicable if small areas of the flow cross section are blocked by the construction. Otherwise, a more detailed evaluation of the influence on the upstream water levels shall be undertaken.

(2) Actions exerted by currents on immersed structures should be applied in the direction of the flow.

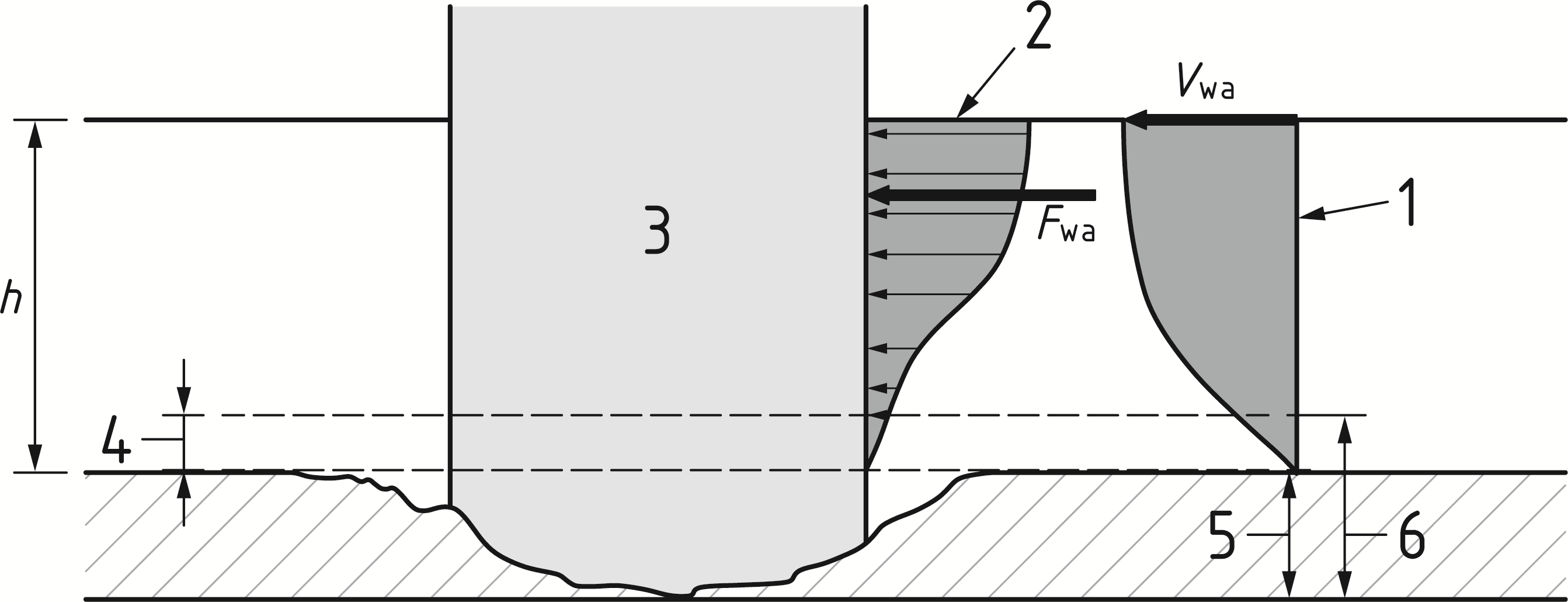
(3) Actions exerted by currents on immersed structures should be determined based on current speed, water level and shape of the structure.

(4) The magnitude of the total horizontal force *F*wa exerted by currents on a vertical surface (immersed structures) should be determined by Formula (6.1) and applied at 5/7×*h*, see Figure 6.1.

 (6.1)

where

|  |  |  |  |
| --- | --- | --- | --- |
|  | *k* | is the shape factor, where | |
|  |  | *k* =2,2 | for an object of square or rectangular horizontal cross-section; |
|  |  | *k* =1,2 | for an object of circular horizontal cross-section if *b*vwa ≤ 0,5; and |
|  |  | *k* =0,70 | for an object of circular horizontal cross-section if *b*vwa > 0,5. |
|  | *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; | |
|  | *v*wa | is the maximum speed of the current, in m/s; | |



**Key**

|  |  |
| --- | --- |
| 1 | current speed (v) |
| 2 | current pressure (p) |
| 3 | object |
| 4 | general scour depth |
| 5 | local scour depth |
| 6 | total scour depth |

Figure 6.1 — Pressure and force due to currents

NOTE In deriving Formula (6.1) a parabolic diagram of the current speed is assumed.

(5) The total horizontal force *F*wa may be used to check the stability of bridge piers and cofferdams, etc.

(6) The effect of scour should be taken into account for the design where relevant (i.e. for erodible river beds).

(7) A more refined method than that expressed by Formula (6.1) should be used as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

(8) Where relevant, the accumulation of debris should be taken into account. For a rectangular object (e.g. cofferdam), this should be represented by a horizontal force *F*deb determined by Formula (6.2) and applied at the centre of the area of obstruction.

 (6.2)

where

|  |  |  |
| --- | --- | --- |
|  | *k*deb | is a debris density parameter equal to 666 kg/m3; |
|  | *A*deb | is the area of obstruction presented by the trapped debris, in m2; |
|  | *v*wa | is the maximum speed of the current over the depth of the debris, in m/s. |

NOTE In deriving Formula (6.2), a uniform diagram of the current speed over the depth of the debris is assumed with a value equal to the maximum current speed.

(9) A more refined method than that expressed by Formula (6.2) should be used as specified by the relevant authority or, where not specified, may be agreed for a specific project by the relevant parties.

#### Actions due to ice

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

(2) Actions due to ice may be considered as uniformly distributed load acting in the direction of current flow equal for the highest or lower water levels, whichever causes the most unfavourable effects.

#### Actions exerted by waves

(1) Actions exerted by waves, when relevant, shall be determined according to prEN 1991-1-8.

#### Other actions exerted by water

(1) Where relevant, actions exerted by water involving failure by uplift (buoyancy), failure by heave, failure by internal erosion or failure by piping shall be determined according to EN 1997-1.

(2) Actions from rainwater should be taken into account in cases where there can be collection of water.

NOTE This can be relevant in cases of ponding effects from, for example, inadequate drainage, imperfections of surfaces, deflections of the structure and/or failure of dewatering devices.

(3) Actions exerted by water caused by an earthquake should be taken into account where relevant.

### Atmospheric icing actions

(1) Actions due to atmospheric icing, when relevant, shall be determined according to prEN 1991‑1-9.

### Actions from cranes and machines

(1) Actions from cranes and machines, when relevant, shall be determined according to EN 1991‑3.

### Geotechnical actions

(1) The characteristic values of geotechnical parameters, soil and earth pressures, and of the movements of the ground supporting the foundations shall be determined according to EN 1997 (all parts).

NOTE Differential movements at the foundations can cause important internal force redistributions. These movements can occur as a result of differences in the behaviour (e.g. stiffness and resistance) of the soil/foundation element under the applied actions, in particular in very stiff structures (e.g. with significant bracing) or in cases where stiffness is not well distributed within the structure.

(2) Geotechnical investigations should be performed ahead of the execution. Particular care should be taken when the execution can adversely affect neighbouring structures.

(3) The effect of varying water table levels during execution should be considered in the design.

(4) When ground improvement techniques are necessary, actions stemming from its execution should be considered.

### Prestressing actions

(1) Prestressing actions and effects shall be considered in the design according to EN 1992-1-1 as applicable, taking into account the interactions between the structure being executed and the auxiliary structures and equipment used during execution.

(2) The sequence and details of the prestressing actions during execution shall be considered in the design and specified in the project documentation.

(3) Prestressing actions and effects should be checked against design criteria by measuring forces, deformations or displacements during execution.

### Pre-deformation actions

(1) Pre-deformation actions and effects, when relevant, shall be considered in the design as specified in EN 1990, as well as in EN 1992-1-1, EN 1993-1-1, EN 1993-2, EN 1994-1-1, EN 1995‑1‑1, EN 1999-1-1, as applicable.

NOTE 1 Pre-deformations are initial imperfections introduced during fabrication of structural members (e.g. pre-cambering set by the shape of the formwork).

NOTE 2 Imposed deformations (e.g. movements imposed through hydraulic jacks, chains, ropes or cables) are dealt with in 6.2.3.

NOTE 3 Deformations introduced from handling operations are dealt with in 6.2.5.

(2) Where appropriate, pre-deformations effects should be checked against design criteria by measuring forces and deformations during fabrication.

### Seismic actions

(1) Seismic actions shall be determined according to EN 1998 (all parts).

# Additional considerations on actions during execution

## Actions induced by imperfections

(1) Where appropriate, actions induced by local and global imperfections should be determined by taking the different execution stages into account.

NOTE 1 Imperfections can be caused by assembly and execution tolerances (e.g. gaps or geometrical misalignments in components (such as prestressing ducts), members, connections and supports), as well as by displacements and deformations during handling, assembly and execution (e.g. pre-deformations, imposed deformations, ground settlements).

NOTE 2 Imperfections (e.g. load eccentricities) can result in second-order effects and imbalances of internal forces from those of the perfect state.

(2) The value and configuration of imperfections during execution should be taken into account when determining actions where relevant.

NOTE 1 The value and configuration of imperfections depend on the type of structure and execution methods used. In general, in bridges and high-rise buildings, the effects of geometrical imperfections during execution are significant.

NOTE 2 EN 1990, as well as EN 1992-1-1, EN 1993-1-1, EN 1993-2, EN 1994-1-1, EN 1995-1-1, EN 1999‑1‑1 provide design rules for taking into account imperfections.

NOTE 3 Other European Standards (e.g. EN 12810, EN 12811, EN 12812) can provide supplementary guidance to determine value and configuration of imperfections for certain types of auxiliary structures, equipment and elements used during execution during execution.

NOTE 4 Annex B provides values of geometrical imperfections over bridge bearings.

## Lateral forces for stability verification

(1) Where relevant, minimum variable lateral forces should be determined and applied at locations to cause the most unfavourable effects on a structure, to enable verification of the adequacy of its lateral stability at each execution stage.

NOTE 1 Typically, the approaches used to introduce variable lateral forces are:

a) notional forces given as a percentage of the vertical actions from all relevant combinations of permanent and variable gravitational loads (e.g. self-weight, imposed actions, construction actions); and

b) systems of equivalent forces derived from the relevant parts of EN 1992 to EN 1999.

NOTE 2 The National Annex can set the approach to determine the values of minimum variable lateral forces and/or their respective values. In the absence of specific information, the following apply for buildings:

— the notional force can be taken as equal to 2,5 % of the maximum value of vertical loads from all relevant combinations of permanent and variable gravitational loads for each floor;

— each notional force is applied at locations to cause the most unfavourable effects; and

— the notional forces of each floor are combined by considering them acting simultaneously in all relevant lateral directions, one at a time.

NOTE 3 Minimum variable lateral forces are particularly important when designing auxiliary structures and equipment used during execution. Other European standards (e.g. EN 12812 for falsework design) can provide design rules on the values of the equivalent forces to be applied.

(2) The minimum variable lateral forces should be applied to the structure considering the latter is in its perfect geometrical configuration.

## Dynamically applied actions

(1) Actions’ effects in the structure should be determined considering dynamic and inertia contributions, as appropriate.

NOTE 1 Dynamic contributions can include impacts of objects, fall of objects, aerodynamic effects due to passing vehicles, including trains.

NOTE 2 Inertia contributions can include the effect of construction actions or other actions (e.g. effect of the weight of fresh concrete during execution with movable scaffolding systems).

NOTE 3 See also 7.1.3 of EN 1990:2023 and other relevant parts of EN 1991 (in particular EN 1991-1-7), EN 1997 and EN 1998 on how to adequately consider the dynamic and inertia contributions when determining the actions’ effects in the structure.

(2) In cases where the use of a dynamic amplification factor is applicable and when a dynamic analysis is not performed, the value of the dynamic amplification factor to be applied to the static load values should be taken as equal to 2, unless otherwise specified by the relevant authority or, where not specified, as agreed for a specific project by the relevant parties.

NOTE This dynamic amplification factor is not intended to be used to determine the effective force of a falling mass by multiplying its weight, because the ‘amplification’ for such impact situations is likely to be greater.

1. (normative)  
     
   Supplementary rules for buildings during execution
   1. Use of this Annex

(1) This Normative Annex provides supplementary rules to those given in Clause 6 for buildings during execution.

* 1. Scope and field of application

(1) This annex covers combination rules for buildings during execution, which are complementary to the general rules given in EN 1990.

* 1. Combination of snow, wind and construction actions

(1) Snow loads and wind actions should not be considered simultaneously with loads arising from construction activity (i.e. loads due to working personnel) unless specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

NOTE For a specific project it can be relevant to agree the requirements for snow loads and wind actions to be taken into account simultaneously with other construction actions (e.g. actions due to heavy equipment or cranes) during some transient design situations.

* 1. Combination of lateral forces and gravitational loads

(1) Minimum variable lateral forces should be combined with permanent and variable gravitational loads (e.g. imposed actions, construction actions) and with accidental actions, and should not be combined with other non-gravitational loads (e.g. wind actions, indirect actions).

* 1. Combination of deformations and imperfections

(1) Where relevant, the deformations from thermal actions and shrinkage actions should be combined with geometrical imperfections.

(2) Related variable actions may be grouped and treated as a single multi-component variable action in terms of establishing the appropriate representative values and partial factors in combinations of actions.

1. (normative)  
     
   Supplementary rules for bridges during execution
   1. Use of this annex

(1) This Normative Annex provides additional rules to those given in 6.2.6(3), 6.3.1(3), 6.3.4(2), 6.3.5.2(2), 6.3.8(1), 7.1(2) for bridges during execution.

* 1. Scope and field of application

(1) This Normative Annex covers specific rules for bridges during execution, including:

— geometrical imperfections over bridge bearings;

— reduction of the values of snow loads under certain conditions during execution;

— wind pressures on bridges built by balanced cantilever method;

— accidental actions for bridges built by in-situ balanced cantilever and by balanced cantilever with precast segments; and

— friction during incremental launching of bridges.

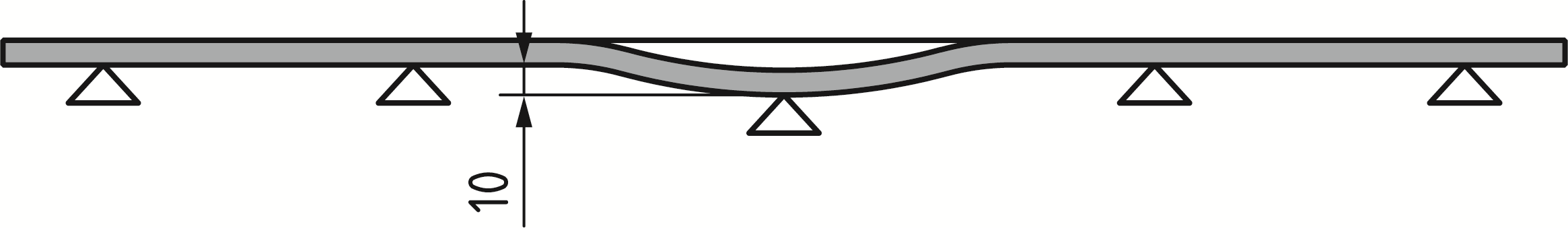
NOTE For combination rules for execution, see EN 1990:2023, A.2.

* 1. Design values of geometrical imperfections over bridge bearings

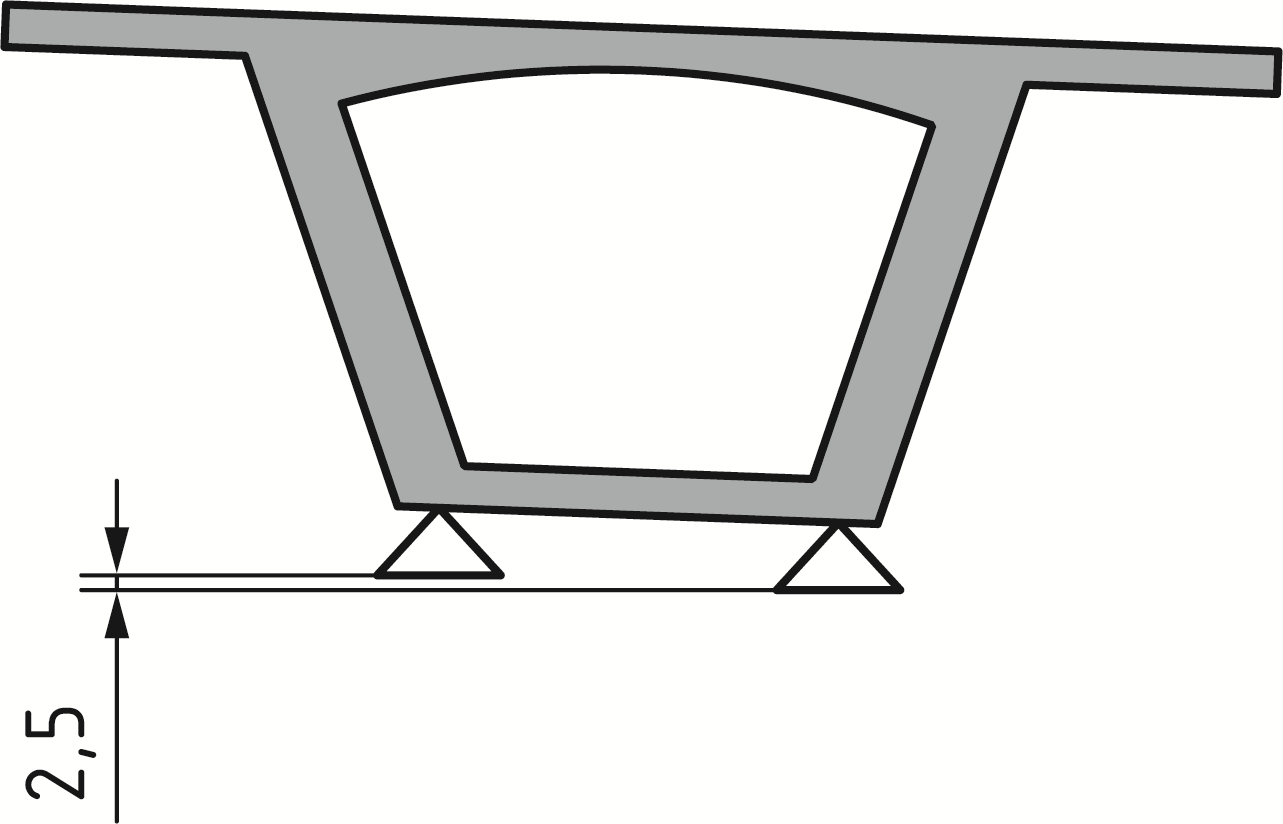
(1) For the incremental launching of bridges, the design values for vertical geometrical imperfections over bridge bearings (see Figure B.1) should be taken as follows, unless otherwise specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties:

— ±10 mm longitudinally for one bearing, the other bearings being assumed to be at the theoretical level [Figure B.1 a)];

— ±2,5 mm in the transverse direction for one bearing, the other bearings being assumed to be at the theoretical level [Figure B.1 b)].



a) Longitudinal geometrical imperfection



b) Geometrical imperfection in the transverse direction

Figure B.1 — Vertical geometrical imperfections over bridge bearings for bridges built by the incremental launching method (values in mm)

NOTE 1 The imperfections in the longitudinal and transverse directions are considered separately.

NOTE 2 See Annex G of EN 1990:2023 for misalignments of sliding and rolling bearings.

* 1. Snow actions

(1) When daily removal of snow (also on weekends and holidays) is required for the start or continuation of an execution activity, and safety measures for removal are provided, the characteristic value of the snow action may be considered to be 30 % of the value determined according to EN 1991-1-3 for the design of the completed structure for persistent design situations, unless otherwise specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

(2) For the verification of the static equilibrium, and when justified by climatic conditions and anticipated duration of the execution phase, the characteristic value of the snow action may be assumed to be uniformly distributed in the areas causing unfavourable effects and may be equal to 75 % of the value determined according to EN 1991-1-3 for the design of the completed structure for persistent design situations, unless otherwise specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

* 1. Wind actions

(1) For the verification of the ultimate limit state of loss of static equilibrium for bridges built by the balanced cantilever method, unbalanced wind pressures should be considered in the design.

(2) A minimum wind pressure, positive or negative, acting only on one of the cantilevers should be considered in the design.

NOTE The minimum wind pressure is 200 N/m2 unless the National Annex provides a different value.

* 1. Accidental actions

(1) For the verification of ultimate limit states in bridges built by in-situ balanced cantilever, an accidental action should be considered in the design arising from the fall of one travelling formwork (partially or fully loaded, as appropriate depending on the execution stage being analysed), including dynamic effects.

(2) For the verification of ultimate limit states in bridges built by balanced cantilever with precast segments, an accidental action should be considered in the design arising from the fall of one segment, including dynamic effects.

* 1. Friction during incremental launching of bridges

(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, and taken to be not less than a percentage of the maximum value of vertical loads from all relevant combinations of permanent and variable gravitational actions (e.g. self-weight, imposed actions, construction actions), and should be applied to cause the most unfavourable effects.

NOTE The percentage is 10 % unless otherwise specified in the National Annex.

Bibliography

**References contained in recommendations (i.e. through “should” clauses)**

The following documents are referred to in the text in such a way that some or all of their content, although not requirements strictly to be followed, constitutes highly recommended choices or course of action of this document. Subject to national regulation and/or any relevant contractual provisions, alternative standards could be used/adopted where technically justified. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

EN 1263 (all parts), Temporary works equipment — Safety nets

EN 12810 (all parts), Facade scaffolds made of prefabricated components

EN 12811 (all parts), Temporary works equipment

EN 13374, Temporary edge protection systems — Product specification — Test methods

**References contained in permissions (i.e. through “may” clauses)**

The following documents are referred to in the text in such a way that some or all of their content, although not requirements strictly to be followed, expresses a course of action permissible within the limits of the Eurocodes. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

None

**References given in possibilities (i.e. "can" clauses) and notes**

The following documents are cited informatively in the document, for example in "can" clauses and in notes.

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

EN 1337, Structural bearings

EN 12812, Falsework — Performance requirements and general design

EN 15129, Anti-seismic devices