

Eurocode 1 Basis of design and actions on structures —

Part 2-6: Actions on structures — Actions during execution

ICS 91.010.30; 91.080.01

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National foreword

This Draft for Development is the English language version of ENV 1991-2-6:1997.

This publication is not to be regarded as a British Standard.

It is being issued in the Draft for Development series of publications and is of a provisional nature. It should be applied on this provisional basis, so that information and experience of its practical application may be obtained.

Comments arising from the use of this Draft for Development are requested so that UK experience can be reported to the European organization responsible for its conversion into a European Standard. A review of this publication will be initiated 2 years after its publication by the European organization so that a decision can be taken on its status at the end of its three-year life.

The values of certain parameters in the ENV Eurcodes may be set by CEN members so as to meet the requirements of national regulations. These parameters are designated by □ in the ENV.

According to the replies received by the end of the review period, the responsible BSI Committee will decide whether to support the conversion into a European Standard, to extend the life of the prestandard or to withdraw it. Comments should be sent in writing to the Secretary of BSI Subcommittee B/525/1, Actions (loadings) and basis of design, at 389 Chiswick High Road, London W4 4AL, giving the document reference and clause number and proposing, where possible, an appropriate revision of the text.

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

Cross-references

The British Standards which implement international or European publications referred to in this document may be found in the BSI Standards Catalogue under the section entitled "International Standards Correspondence Index", or by using the "Find" facility of the BSI Standards Electronic Catalogue.

Summary of pages

This document comprises a front cover, an inside front cover, the ENV title page, pages 2 to 32, an inside back cover and a back cover.

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EUROPEAN PRESTANDARD

ENV 1991-2-6

PRÉNORME EUROPÉENNE

EUROPÄISCHE VORNORM

March 1997

ICS 91.010.30

Descriptors: civil engineering, construction, bridges, building codes, computation, setting-up conditions

English version

**Eurocode 1: Basis of design and actions on
structures - Part 2-6: Actions on structures -
Actions during execution**

Eurocode 1: Bases de calcul et actions sur les
structures - Partie 2-6: Actions sur les
structures - Actions en cours d'exécution

Eurocode 1: Grundlagen der Tragwerksplanung und
Einwirkungen auf Tragwerke - Teil 2-6:
Einwirkungen auf Tragwerke - Einwirkungen
während Ausführung

This European Prestandard (ENV) was approved by CEN on 1996-11-29 as a prospective standard for provisional application. The period of validity of this ENV is limited initially to three years. After two years the members of CEN will be requested to submit their comments, particularly on the question whether the ENV can be converted into an European Standard (EN).

CEN members are required to announce the existence of this ENV in the same way as for an EN and to make the ENV available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the ENV) until the final decision about the possible conversion of the ENV into an EN is reached.

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CEN

European Committee for Standardization
Comité Européen de Normalisation
Europäisches Komitee für Normung

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Foreword

Objectives of the Eurocodes

- (1) The Structural Eurocodes comprise a group of standards for the structural and geotechnical design of buildings and civil engineering works.
- (2) They cover execution and control only to the extent that is necessary to indicate the quality of the construction products, and the standard of the workmanship, needed to comply with the assumptions of the design rules.
- (3) Until the necessary set of harmonised technical specifications for products and for methods of testing their performance is available, some of the Structural Eurocodes cover some of these aspects in informative Annexes.

Background to the Eurocode programme

- (4) The Commission of the European Communities (CEC) initiated the work of establishing a set of harmonized technical rules for the design of building works and civil engineering works which would initially serve as an alternative to the different rules in force in the various Member States and would ultimately replace them. These technical rules became known as the "Structural Eurocodes".
- (5) In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updating of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.
- (6) CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

- (7) Work is in hand on the following Structural Eurocodes, each generally consisting of a number of Parts:

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

- (8) A separate sub-committee has been formed by CEN/TC250 for each of Eurocodes listed above.
- (9) This Part of Eurocode 1 has been finalised in accordance with a mandate issued by CEC and is being published as a European Prestandard (ENV) with an initial life of three years.
- (10) This Part of Eurocode 1 is intended for experimental application.

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(11) After approximately two years CEN members will be invited to submit formal comments on this Part of Eurocode 1 to be taken into account in determining future action.

(12) Meanwhile feedback and comments on this Part of Eurocode 1 should be sent to the Secretariat of Sub-committee CEN/TC250/SC1 at the following address:

SIS / BST
Box 49044
S - 100 28 STOCKHOLM
SWEDEN

or to your National Standards Organisation.

National Application Documents (NADs)

(13) In view of the responsibilities of authorities in member countries for safety, health and other matters covered by the essential requirements of the Construction Products Directive (CPD), certain safety elements in this ENV have been assigned indicative values which are identified by or [] ("boxed values"). The authorities in each member country are expected to review the "boxed values" and may substitute alternative definitive values for these safety elements for use in national application.

Besides, where, in some countries, regulations make the consideration of additional or heavier loads mandatory for the safety of people working for execution, it is recommended to mention it in the NAD.

(14) Some of the necessary supporting European or International Standards may not be available by the time this Part of Eurocode 1 is issued. It is therefore anticipated that a National Application Document (NAD) giving any mandatory values to be substituted for "boxed values", referencing compatible supporting Standards and providing guidance on the national application of this Part of Eurocode 1, will be issued by each member country or its Standards Organization.

(15) It is intended that this Part of Eurocode 1 will be used in conjunction with the particular NAD valid in the country in which the construction works are located.

Matters specific to this Prestandard

(16) This Part of Eurocode 1 has been established with two main objectives:

- to give values for some actions from execution which are common for various execution methods, and for other actions to be considered in the transient execution phase;
- to establish frame conditions for actions specific for a particular execution that should be specified in the project specification or justified before execution.

(17) Wherever this Part of Eurocode 1 mentions "unless otherwise specified", it is intended that complementary and/or modifying specifications may be defined for particular projects.

(18) The scope of Eurocode 1 is defined in Clause 1.1.1 and the scope of this Part of Eurocode 1 is defined in Clause 1.1.2. Additional Parts of Eurocode 1 which are planned are indicated in Clause 1.1.3.

(19) This Part of Eurocode 1 is divided into the following 4 sections:

- Section 1 General
- Section 2 Classification of actions
- Section 3 Design situations
- Section 4 Representation of actions

The four sections are complemented by two normative annexes A (buildings) and B (bridges) giving the bases for combinations of actions, including partial load factors and ψ factors, and an informative annex C.

The limits of validity of the contents of these sections are defined in the respective sections.

(20) This Part of Eurocode 1 is intended to cover permanent buildings and civil engineering works during execution as well as some auxiliary structures associated with the construction of buildings and civil engineering works. Specific aspects are developed for these two categories of construction works.

(21) The rules given in this Part of Eurocode 1 are applicable to normal buildings and bridges. They may, however, also be used where appropriate for:

- the execution of special buildings or special bridges;
- transient design situations corresponding to maintenance, repair or demolition of buildings and bridges (see Annexes A and B).

(22) Especially during execution, structural safety and serviceability may be achieved not only by sufficient dimensioning, but also by other measures, such as controlling the construction process and action effects during execution stages. These other measures can be self-sufficient in the case of accidental situations resulting from the execution, or due to personnel (e.g. like fire). The way to take account of such possibilities cannot be codified, which explains the flexibility given in the assessment of representative values of actions.

Note 1 : For example, wind actions may be specifically assessed when information is available about foreseen climatic conditions (by the meteorological offices) during the launching period of a steel bridge.

Note 2 : For workers, fire is primarily a matter of smoke and toxic gases.

(23) During the preparation of this Part of Eurocode 1, it has been noticed that a series of limited complements and amendments to ENV 1991-1 and ENV 1992-1-1 would be useful, especially for the treatment of construction periods. If such modifications are made (e.g. for their conversion into ENs), it may result in some duplications with this Part of Eurocode 1 and therefore a full compatibility should be checked.

Section 1 General

1.1 Scope

1.1.1 Scope of ENV 1991 - Eurocode 1

- (1) P ENV 1991 provides general principles and actions for the structural design of buildings and civil engineering works including some geotechnical aspects and shall be used in conjunction with ENV 1992-1999.
- (2) It may also be used as a basis for the design of structures not covered in ENV 1992-1999 and where other materials or other structural design actions are involved.
- (3) ENV 1991 also covers structural design for construction conditions and structural design for temporary structures. It relates to all circumstances in which a structure is required to give adequate performance.
- (4) ENV 1991 is not directly intended for the structural appraisal of existing construction, in developing the design of repairs and alterations or for assessing changes of use but may be so used where applicable.
- (5) ENV 1991 does not completely cover special design situations which require unusual reliability considerations (e.g. nuclear structures, offshore structures) for which other specified design procedures should be used.

1.1.2 Scope of ENV 1991-2-6 - Actions during execution

- (1) This Part of Eurocode 1 provides principles and general rules for the assessment of actions and environmental influences which should be considered during the execution stage of buildings and bridges.

Note : This Part of Eurocode 1 may be used as guidance for the definition of specifications for other types of construction works.

- (2) This Part of Eurocode 1 also provides rules for the combination of actions during the execution stage of buildings (annex A) and bridges (annex B).
- (3) This Part of Eurocode 1 also gives rules for the assessment of actions and environmental influences which may be applied to auxiliary construction works as defined in 1.4 needed for the execution of permanent buildings and civil engineering works.

Note : In general, auxiliary construction works are the responsibility of the contractor. In some cases (e.g. bridge construction) design of auxiliary construction works may be an essential and demanding task. The frame of the verifications should be defined in the project specification.

- (4) The actions considered in this Part of Eurocode 1 are the following:
 - self-weight of structural and non-structural elements, and permanent actions caused by ground;
 - prestressing, intentional imposed deformations and settlements;
 - temperature and shrinkage actions;
 - wind actions;

- snow loads;
- water actions;
- atmospheric ice loads;
- construction loads;
- seismic actions;
- (some) accidental actions (see also ENV 1991-2-7).

(5) When loads, deformations or special design situations need to be considered which are not completely (e.g. water), or not at all (e.g. ice), codified in this (or other) Part(s) of Eurocode 1 and which are not sufficiently treated in the NADs, complementary rules should be defined in the project specification.

Note : Generally, the design and verification procedures during execution stages are also dependent on the construction works under consideration.

- (6) The following subjects are dealt with in this Part of Eurocode 1:
- common definitions and notation (section 1);
 - classification of actions (section 2);
 - design situations and rules for their identification and definition for a particular project (section 3);
 - rules for the assessment of actions applicable to civil engineering works during execution (section 4).

(7) Provision for the safety of people in and around the construction site is not dealt with.

(8) In this Part of Eurocode 1, several clauses refer to the term "project specification", which should be considered to include all design requirements and assumptions.

1.1.3 Further parts of ENV 1991

(1) Further Parts of ENV 1991 which, at present, are being prepared or planned are given in 1.2.

1.2 Normative references

This European Prestandard incorporates by dated or undated reference, provisions from other standards. These normative references are cited at the appropriate places in the text and publications listed hereafter.

| | |
|---------------|--|
| ISO 3898 1987 | Basis of design for structures. Notations. General symbols. |
|---------------|--|

Note : The following European prestandards which are published or in preparation are cited at the appropriate places in the text and publications listed hereafter.

| | |
|------------|--|
| ENV 1991-1 | Eurocode 1 : Basis of design and actions on structures Part 1 : Basis of Design |
|------------|--|

| | |
|--------------|---|
| ENV 1991-2-1 | Eurocode 1 : Basis of design and actions on structures Part 2.1 : Densities, self-weight and imposed loads |
|--------------|---|

| | |
|--------------|--|
| ENV 1991-2-2 | Eurocode 1 : Basis of design and actions on structures Part 2.2 : Actions on structures exposed to fire |
| ENV 1991-2-3 | Eurocode 1 : Basis of design and actions on structures Part 2.3 : Snow loads |
| ENV 1991-2-4 | Eurocode 1 : Basis of design and actions on structures Part 2.4 : Wind actions |
| ENV 1991-2-5 | Eurocode 1 : Basis of design and actions on structures Part 2.5 : Thermal actions |
| ENV 1991-2-7 | Eurocode 1 : Basis of design and actions on structures Part 2.7 : Accidental actions due to impact and explosions |
| ENV 1991-3 | Eurocode 1 : Basis of design and actions on structures Part 3 : Traffic loads on bridges |
| ENV 1991-4 | Eurocode 1 : Basis of design and actions on structures Part 4 : Actions in silos and tanks |
| ENV 1991-5 | Eurocode 1 : Basis of design and actions on structures Part 5 : Actions induced by cranes and machinery |
| ENV 1992 | Eurocode 2 : Design of concrete structures |
| ENV 1993 | Eurocode 3 : Design of steel structures |
| ENV 1994 | Eurocode 4 : Design of composite steel and concrete structures |
| ENV 1995 | Eurocode 5 : Design of timber structures |
| ENV 1996 | Eurocode 6 : Design of masonry structures |
| ENV 1997 | Eurocode 7 : Geotechnical design |
| ENV 1998 | Eurocode 8 : Earthquake resistant design of structures |
| ENV 1999 | Eurocode 9 : Design of aluminium alloy structures |

1.3 Distinction between principles and application rules

(1)P Depending on the character of the individual clauses, distinction is made in this Part of Eurocode 1 between Principles and Application Rules.

(2)P The Principles comprise:

- general statements and definitions for which there is no alternative;
- requirements and analytical models for which no alternative is permitted unless specifically stated.

(3)P The Principles are identified by the letter P following the paragraph number.

(4)P The Application Rules are generally recognised rules which follow the Principles and satisfy their requirements.

(5)P It is permissible to use alternative design rules, provided it is shown that the alternative rules accord with the relevant Principles and will result in the standards of safety, serviceability and durability of the structure achieved by use of the Application Rules given in this Part of Eurocode 1.

(6) In this Part of Eurocode 1, Application Rules are identified by a number in brackets, e.g. as this paragraph.

1.4 Definitions

For the purposes of this Part of Eurocode 1, general definitions are provided in the relevant Parts of ENV 1991 and in design Eurocodes (ENV 1992 to 1999).

The additional definition given below is specific to this Part.

1.4.1 Auxiliary construction works (*ouvrage auxiliaire, Hilfskonstruktion*): Any construction works associated with the construction process and removed after use (e.g. scaffolding, propping system, cofferdam, bracing, launching nose, etc.).

1.4.2 Construction loads (*charges de construction, Baulasten*): Loads other than those due to climatic or environmental conditions, that have to be considered in design during the construction process (see also 4.8).

1.5 Symbols

(1) For the purpose of this Part of Eurocode 1, the following symbols apply.

Note : The notations used are based on ISO 3898 : 1987

Latin upper case letters

| | |
|------------|--|
| $F_{cb,k}$ | characteristic value of the concentrated load of the system representing moveable storage of construction material on bridge decks during execution (4.8.3) |
| F_h | general notation for the horizontal force transmitted by a bridge deck built by the incremental launching method to the piers (4.8.3) |
| F_{wa} | horizontal force exerted by current water on cofferdams and bridge piers (4.6) |
| Q_c | general notation for construction loads (4.8) |
| Q_{ca} | general notation for loads due to working personal, staff and visitors, with small site equipment (4.8.1) |
| Q_{cb} | general notation for loads due to moveable storage of building and construction material, precast elements, and equipment (4.8.1) |
| Q_{cc} | general notation for heavy equipment in position for use (e.g. formwork panels, scaffolding, falsework, machinery, containers etc.) or during movement (e.g. travelling form, launching girders and nose, counterweight) (4.8.1) |

- Q_{cd} general notation for loads due to cranes, lifts, vehicles, power installation, jacks, heavy control devices, etc.
- Q_{sn} general notation for snow loads (transient situation) (4.5)
- Q_{wa} general notation for water actions (transient situation) (4.6)
- Q_w general notation for wind actions (transient situation) (4.4)
- v_{wa} mean speed of water (m/s)

Latin lower case letters

- $q_{cb,k}$ characteristic value of the uniformly distributed load of the system representing moveable storage of construction material on bridge decks during execution (4.8.3).

Section 2 Classification of actions

(1) For ease of use of this Part of Eurocode 1, some of the Principles and Application rules defined in ENV 1991-1 are quoted in the following.

(2)P The actions to be taken into account during execution shall be classified as:

- permanent, variable or accidental;
- fixed or free;
- static, quasi-static or dynamic;
- direct or indirect;
- uni- or multi-component.

These classifications shall, where relevant, be made separately for any design situation.

Note : Some actions, may have to be differently classified for different execution phases, and therefore for different design situations.

(3) Some classifications are specified in the following Clauses and some others in the design Eurocodes. They should be, as relevant, supplemented for each particular project.

(4) Indirect actions include intentional imposed deformations (e.g. imposed displacements at supports of steel beams) or constrained deformations, e.g. due to shrinkage, uneven settlements or temperature changes. Direct actions should be taken into account in combinations. Depending on the structure and on the limit state under consideration, indirect actions should either be taken into account in combinations or in detailing provisions.

(5)P In case of soil settlement, the settlements (absolute and differential values) to be expected during execution shall be classified as permanent actions (see ENV 1997-1).

(6) Unless otherwise specified, the effects of prestressing during execution should be classified as permanent actions. However, the jack forces during the application of prestressing should be considered as variable actions with regard to the design of the anchorage zones.

(7)P The shrinkage of concrete during execution shall be classified as permanent actions.

(8)P Where the structural system changes during execution, the remaining effects of loads applied in one structural system and removed in subsequent structural system shall be considered as permanent for the construction works with their new structural system.

(9) Where structural members are temporarily propped for the concrete, the effects of propping and unpropping systems should be classified as permanent. Consideration should be given to the effects of the elasticity of the propping systems and their possible deflection due to soil settlement.

(10) Unless otherwise specified, all actions due to construction loads should be considered as variable actions.

Note : In the case of heavy equipment as defined in 4.8.1 (Q_{ec}), this action may be considered as a variable action only during movement. When heavy equipment is in position for use, it is more reasonable to consider it as a permanent action (e.g. self-weight of a travelling form for the construction of a bridge deck). The situations during which construction loads have to be considered as permanent or variable, their representative values and the associated γ factors should be defined, e.g. in the project specification.

(11) Construction loads due to cranes, equipment, scaffolding, etc. should be considered as free or fixed variable actions, depending on their possible location. Where such actions may be considered as fixed, due allowance should be made for possible inaccuracies in their location. Where such actions may be considered as free, the boundaries of their possible location should be defined.

Note 1 : Control measures may be taken in some cases to ensure that the assumed position is maintained during execution.

Note 2 : Particular positions may have to be considered, in some cases, as accidental.

(12)P Where construction loads due to people need to be considered, these loads shall be considered as free variable actions.

(13) Actions due to the handling and positioning of precast structural elements, which are intended to be connected to other parts of a permanent structure, should be considered as static or dynamic variable actions.

Section 3 Design situations and limit states

3.1 General - identification of design situations

(1) During execution, only transient and/or accidental design situations need to be considered. Only in special cases seismic situations should be considered (see 4.9).

Note : Actions, applied during execution stages only, which may have permanent effects should be taken into account for the safety assessment both during the relevant execution stages and design situations after execution.

(2)P Relevant design situations during execution shall be selected as to encompass all conditions which can reasonably be foreseen to occur during the execution of the construction works.

(3) For the various execution stages, the design situations should be identified taking into account that all the following conditions may vary from stage to stage in accordance with the execution process defined in the design and the methods of construction:

- the support conditions;
- the structural system;
- the shape of the structure;
- the degree of completeness, including the non-structural elements.

For a particular design situation, the distribution or/and magnitude of permanent and variable actions may vary.

(4) Comprehensive verification of any limit state in the transient design situation may be omitted if it can be shown that the requirements (of this limit state) are met by the same or another limit state, in the persistent design situation, or during the consideration of another execution phase.

Note : For ordinary buildings, verifications are generally needed only for propping systems and for elements which receive loads from them.

(5) For the consideration of structural members which form part of continuous systems where the actions due to self-weight develop step by step, the ultimate limit state and serviceability limit state verifications should take account of the change of structural system as well as the possible non uniformity of the distributed loads.

(6) Transient and/or accidental design situations should be defined not only for the whole construction works under consideration, but also, if relevant, for individual structural elements during specific execution stages and for auxiliary structures.

Note : The construction phase during which a prefabricated beam is handled is an example of transient design situation for a particular structural element.

(7) For the identification of design situations during execution, time is generally a major parameter: the various execution stages for a particular project are intended to start at given dates and to have given durations. Possible deviations of the timetable or duration of the works, that can normally be foreseen, should be conservatively taken into account.

(8) In general, fatigue need not be considered during execution. However, attention should be paid, where relevant, to effects of possible vibrations excited by wind, which may cause fatigue or other limit states like galloping or, more generally, aeroelastic instability.

Note : Examples are vortex excited slender steel elements, long distance transportation of slender elements, etc.

3.2 Serviceability limit states

(1)P The criteria associated with serviceability limit states shall be defined in the project specification.

Note : Guidance may be found in design Eurocodes.

(2) Unless otherwise specified, limit state requirements for the final stage should be adopted for the execution stage.

(3) Serviceability requirements for auxiliary structures should be defined in order to avoid any deformation and displacement which affect the appearance or effective use of the structure or cause damage to finishes or non-structural elements.

(4) Operations which may cause excessive cracking and/or early deflection during execution and which may violate the durability, fitness for use and/or esthetic appearance in the final stage should be avoided.

(5) Instead of taking account of the load effects due to shrinkage and temperature by means of design, appropriate detailing provisions may be selected to minimize these load effects.

(6) Unless otherwise specified, serviceability criteria requiring the consideration of frequent combinations need not be considered during execution.

Note : For this reason, no value of ψ_1 factors is given in annexes A and B. Where frequent values of some special variable actions need to be considered, these values should be defined in the project specification.

(7) Unless otherwise specified, for concrete bridges, serviceability criteria requiring the consideration of infrequent combinations as defined in ENV 1991-3 need not be considered during execution.

Note : For this reason, no value of ψ'_1 factors is given in annex B.

3.3 Ultimate limit states

(1)P Ultimate limit states shall be considered both for transient and accidental design situations.

(2)P For accidental design situations, the requirement in ENV 1991-1 with regard to the prevention of disproportionate damage shall be met.

Note : 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.

(3) Where seismic situations need to be considered during the execution stage, critical design situations should be selected and, if relevant, agreed upon with the relevant authority.

(4) In such critical design situations, the regularity of an uncompleted structural frame, the possible concentration of stored structural material, etc., should be considered. Attention should also be given to the interaction with construction cranes, etc.

3.4 Assessment of data for design situations

(1) In a general manner, imperfections in the geometry of the structure and of structural members should be considered for the most critical design situations during execution. These imperfections should be defined in the project specification.

Note 1 : Guidance may be found in design Eurocodes.

Note 2 : For concrete structures, see European Standards established by CEN/TC/229 "Precast Concrete Products".

(2) Any transient design situation should be associated with a nominal duration to be generally chosen among the following ones, this nominal duration being equal to or greater than the probable duration of the execution phase corresponding to the design situation under consideration:

- three days;
- three months;
- one year.

Note : A nominal duration of three days, to be chosen for very short execution phases like lifting by crane of a structure, corresponds to the extent in time of reliable meteorological predictions. This choice may be kept for a little longer execution phase if appropriate organizational measures are taken. For a nominal duration of three months, seasonal effects may be, for certain actions, identified. For example, the flood magnitude of a river depends on the period of the year under consideration.

(3) For some climatic actions where characteristic values for persistent situations are defined on the basis of return periods, the characteristic values during execution may be chosen smaller than those for persistent situations if at least one of the following conditions apply:

- the nominal duration of the transient situation is equal to or less than one year, and can be controlled;
- in case of unforeseen events, protective measures can be provided to secure the structure.

(4) Where a transient design situation is associated with a nominal duration of one year, the mean return period of the characteristic values of climatic actions should not be less than [5] years.

Note 1 : For nominal durations of 3 months or 3 days, the concept of mean return period is generally not appropriate and the reduction should depend on the available seasonal and meteorological information.

Note 2 : Some phenomena like creep and shrinkage effects in concrete construction works should generally be assessed on the basis of the expected dates and duration associated with the design situations.

(5) For design situations corresponding to execution phases where the structure or parts of it are subjected to accelerations that may give rise to significant mass effects, these effects should be taken into account for the verification of the various limit states.

Note : Significant accelerations may be excluded where possible movements are strictly controlled. In such a case, the controlling devices should be designed in accordance with the combinations of actions corresponding to the relevant design situations which may be transient or accidental.

(6) Where relevant, water actions should be assessed in conjunction with water levels corresponding to specified or identified design situations.

Note : These actions may commonly be assessed in the same manner as specified in (2) and (3) above.

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

Note : For long construction phases, accidental scour situations may have to be considered for the design of permanent or auxiliary structures immersed in current water.

Section 4 Representation of actions

- (1) In the following, methods are given for the assessment of:
- the most common actions concerning all types of construction works;
 - some specific actions for buildings and bridges.

4.1 Self-weight of structural and non-structural elements, and permanent actions caused by the ground

4.1.1 General

- (1) The self-weight of structural and non-structural elements should be determined in accordance with ENV 1991-2-1, unless more specific data are available.
- (2)P For the verification of structural members during transport or hoisting, the actual support conditions of these members shall be considered and account shall be taken of mass effects due to vertical and horizontal accelerations, where relevant.

Note 1 : Guidance is given in ENV 1991-5 for the assessment of vertical and horizontal accelerations due to transport and hoisting.

Note 2 : Attachments for hoisting materials should be designed for actions according to ENV 1991-5.

- (3) Characteristic values of ground pressure (e.g. on ground floors or basement walls of buildings, piers or abutments of bridges) should be assessed in accordance with ENV 1997.

4.1.2 Buildings

- (1) Actions due to self-weight of non-structural elements may be neglected during execution when it is obvious that the effects of these actions are fully covered by the requirements for the completed structure.

Note : Examples of non-structural elements are partition walls, roofing, claddings, etc.

- (2)P In the construction of in situ concrete multistorey buildings, where freshly cast floors are supported by a propping system that rests on the floors below, a load analysis shall be performed for the selected critical stages of construction.

Note : Depending on the construction procedure used, the supporting slabs may be subjected to loads greater than the imposed loads for which they are designed. In addition to the higher imposed loads, the supporting slabs may not have developed their full strength capacities.

- (3) Unless more specific data are available, the characteristic value of self-weight of formwork should be taken equal to $0,5 \text{ kN/m}^2$.

Note : Formwork design itself is not covered by this Part of Eurocode 1.

4.1.3 Bridges

(1) Unless otherwise specified, where the favourable and unfavourable parts of actions due to self-weight of structural elements need to be considered as individual actions for the verification of static equilibrium, they should be associated with $\gamma_{G,inf} = 0,95$ and $\gamma_{G,sup} = 1,05$ respectively.

These factors may be adjusted for specific cases depending on the level of the quality assurance during execution (see 2.2 (5)-b) of ENV 1991-1).

(2) The values for $\gamma_{G,inf}$ and $\gamma_{G,sup}$ in 4.1.3 (1) may also be used for the verification of systems providing stabilizing actions.

4.2 Prestressing, intentional imposed deformations and settlements

(1) Intentional imposed deformations may, for example, result from:

- prestressing members (e.g. by stays or by tendons);
- predeformations of a structure (e.g. imposed displacements at supports).

(2) Unintentional deformation may, for example, result from:

- soil settlements;
- unevenness of temporary bearings.

Note : At the present stage, the distinction between prestressing and predeformations is not accurately defined and needs some coordination across Eurocodes.

4.2.1 Prestressing

(1)P During execution stages, prestressing forces shall be taken into account with their mean or their characteristic values in accordance with the relevant design Eurocodes, depending on the verification rules defined in this Eurocode for the same type of prestress or in the project specification.

Note : At the present time, such rules for execution stages are not fully defined in design Eurocodes.

4.2.2 Predeformations

(1) In general, predeformations are applied to a particular structure in order to generate action effects for improving its behaviour, so that the particular structural safety and serviceability requirements are met.

Note : Predeformations may have no effect on the ultimate resistance if sufficient rotation capacity is available, and subsequent plastic moment redistributions are possible.

(2)P The application of predeformations during execution shall be performed in a controlled way, e.g. stepwise as assumed in the design calculations or required in the project specification.

(3)P Control of predeformations shall be performed by checking both the deformations and the forces.

Note : The force may be checked either by direct force measurements or indirect stiffness measurements or vibration measurements.

(4) Partial factors for the effects of predeformations should be taken from the relevant parts of ENV 1992 to 1999, depending on the type of structural analysis and the limit state under consideration.

4.2.3 Soil settlements

(1)P Values of soil settlements for the foundations of the structure and of temporary supports during construction shall be derived from soil investigations and, if relevant, from an analysis of soil-structure interaction.

Note : Soil investigations should be carried out to give information on both absolute and differential values of settlements, their time dependency and possible scatter.

(2) Unless otherwise specified, and provided a soil-structure interaction analysis is carried out, the expected values of soil settlements should be used as nominal values for imposed deformations.

4.2.4 Unevenness of temporary bearings

(1) For prestressed bridges built by the incremental launching method, unless other values are given in the project specification, the following values of vertical deflections of temporary bearings should be taken into account:

- ± 10 mm longitudinally for one bearing, the other bearings being assumed to be at the theoretical level (Fig. 4.1 - a);
- $\pm 2,5$ mm transversally for one bearing, the other bearings being assumed to be at the theoretical level (Fig. 4.1 - b).

These values may be adjusted for specific cases depending on the level of the quality assurance (see 2.2(5)-b) of ENV 1991-1).

(2) These two vertical deformations are mutually exclusive and the corresponding values should be considered as characteristic values.

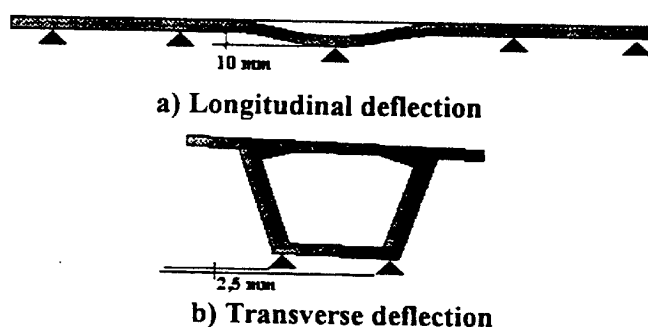


Figure 4.1: Longitudinal and transverse deflections of temporary bearings for bridges built by the incremental launching method

4.3 Temperature and shrinkage actions

(1) Actions due to temperature, in general, and shrinkage of concrete are constrained deformations. They are considered together in this section for the sake of simplicity, although they correspond to different physical phenomena.

Note : Temperature actions may, for example, be due to:

- environmental temperature changes; daily and/or seasonal variations within the envisaged construction period;
- cooling of thick concrete parts after hydration; to be judged in relation to the type of formwork and the time of removal after casting.

(2) Where significant, the actions due to temperature and shrinkage should be taken into account during each execution stage.

Note 1 : In some cases, only the most critical execution stages need to be considered, and temperature and shrinkage effects may be assessed using simplified methods.

Note 2 : For buildings, the actions due to temperature and shrinkage are not generally significant if appropriate detailing has been provided for the persistent design situation.

(3) Climatic temperature actions should be assessed in accordance with ENV 1991-2-5. For some special execution phases (e.g. the closing of various types of bridge decks), the effects of the probable temperature on the day of execution may have to be taken into account.

(4) Drying shrinkage of structural building materials should be assessed in accordance with the relevant design Eurocodes.

(5)P In the case of bridges, for the determination of restraints from temperature, the effects of friction of the bearings which are supposed to permit free movements shall be taken into account on the basis of appropriate representative values.

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

4.4 Wind actions (Q_w)

(1) The characteristic values of wind actions should be assessed in accordance with the methods defined in ENV 1991-2-4 and on the basis of the selected return period.

Note 1 : Attention should be paid to the fact that on internal walls which will be an internal part of the structure after completion, during construction the external pressure coefficients c_{pe} for free-standing walls may have to be applied.

Note 2 : In some cases, wind loads may be considered as accidental actions in combinations during execution, e.g. in cyclonic zones.

(2) Where relevant, the loaded area should include the areas of cranes, falsework, etc., that contribute to the action effects under consideration.

(3) For hoisting or launching operations or other construction stages lasting only a few hours, the project specification should define the maximum wind velocity to be considered in the design. Unless otherwise specified, this wind velocity should not be less than 20 m/s at any height.

(4) Where relevant, the critical wind velocity should be determined for cross wind vibrations, galloping and flutter to ensure that these phenomena will not govern the design during the execution stages.

Note : Rain-wind induced vibrations of slender elements of circular cross-section may need to be considered where relevant.

(5) Unless otherwise specified, the characteristic value of wind forces to be considered for the design of bridges during execution should be assessed on the basis of a nominal return period equal to:

- $\boxed{10}$ years for a nominal duration of the transient situation of one year;
- $\boxed{50}$ years, as for persistent design situations, for a duration greater than 1 year.

(6) Where static equilibrium needs to be considered during the execution phase of a bridge, the values of the characteristic wind pressures on the favourable parts should be reduced by $\boxed{50}$ % (see 10.11 in ENV 1991-2-4).

Note : Attention should be paid to the fact that a static analysis may be insufficient in some cases and more refined models should be adopted.

4.5 Snow loads (Q_{sn})

(1) Snow loads should be assessed in accordance with ENV 1991-2-3, depending on the local situation of the site and on the basis of the selected return period. However, unless otherwise specified, the load to be considered as the characteristic value during execution stages should not be less than $\boxed{50}$ % of the characteristic value determined for persistent design situations.

(2)P For bridges, if daily snow removal (weekends and holidays included) is assured and provisions compatible with the safety requirements for its removal are defined in the project specification, the snow load on the areas from which snow is removed may be reduced to $\boxed{30}$ % of the representative value specified in ENV 1991-2-3.

(3) For bridges, when justified by climatic conditions and by the duration of the execution process, the characteristic snow load, represented by a uniformly distributed load, for the verification of static equilibrium during execution should be considered as composed of a non-symmetrical distribution of snow located in the most unfavourable position. For this verification the snow loads should be assumed to be $\boxed{25}$ % of the characteristic snow load on the ground determined for persistent situations.

4.6 Water actions (Q_{wa})

- (1) In general, actions due to water (free or ground water) should be represented as:
- static pressures;
 - if relevant, hydrodynamic 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) For the sake of simplicity, actions due to water generally may be taken into account in combinations as permanent actions: the variability of water pressure or of water-level should be taken into account by the means of the design situations defined in the project specification. Where actions due to water are to be considered as variable, design values should be directly specified.

(3) Water actions exerted by currents on immersed structures are perpendicular to the contact surfaces, and may induce dynamic effects. They should be determined for the relevant current speed, water depth and shape of the structure, defined in the project specification and depending on the design situation for the construction period under consideration.

(4) The magnitude of the horizontal force exerted by currents on the vertical surface of an immersed object (Fig. 4.2) may be determined by the following expression:

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

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, where relevant, local scour depth in meters;

b is the width of the object in meters;

k is the shape factor:

$k = 0,72$ for an object of square or rectangular horizontal cross-section,

$k = 0,35$ for an object of circular horizontal cross-section.

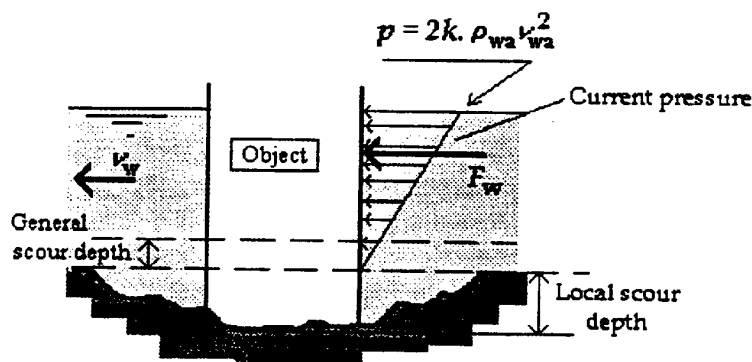


Figure 4.2: Pressure and force due to currents on cofferdams and bridge piers

Note : The total effect of water includes both static and dynamic pressures on each surface.

(5) Actions from rainwater should be considered when either the failure of dewatering devices has to be taken into account or ponding effects may occur either due to imperfections of the surface or deflections.

4.7 Atmospheric ice loads

- (1) Atmospheric ice loads should be specified for the particular project.

Note 1 : Guidance may be found in ENV 1993-3.

Note 2 : An ISO standard on atmospheric ice loads on structures is currently being developed by ISO/TC98/WG3.

4.8 Construction loads (Q_c)

4.8.1 General

- (1) In general, construction loads include:

- working personnel, staff and visitors, with small site equipment (Q_{ca});
- moveable storage of building and construction materials, precast elements, and equipment (Q_{cb});
- heavy equipment in position for use (e.g. formwork panels, scaffolding, falsework, machinery, containers) or during movement (e.g. travelling forms, launching girders and nose, counterweight) (Q_{cc});
- cranes, lifts, vehicles, power installation, jacks, heavy control devices, etc. (Q_{cd}).

- (2) Where relevant, these actions should be assessed in accordance with the project specification.

Note 1 : Where vehicles (e.g. truck-mixers on groundfloors of buildings) may be used, and if not defined in the project specification, the corresponding actions may be assessed with reference to the vehicles or load models defined in ENV 1991-3 (Fatigue Load Model 2).

Note 2 : Information for the assessment of actions due to cranes is given in ENV 1991-5.

4.8.2 Specific construction loads for buildings

- (1) Unless otherwise specified, construction loads due to working personnel, staff and visitors, with small equipment (Q_{ca}) should be modelled by uniformly distributed loads.

- (2)P Where construction equipment (Q_{cb}) may result in concentrated loads, such actions shall be taken into account.

- (3)P Horizontal stability of the construction works during all its construction phases shall be secured either by detailing measures or by designing for the relevant horizontal force.

Note : Bracing is an example of detailing measure.

- (4)P The horizontal load to be considered shall be assessed from wind and from effects resulting from sway imperfections and sway deformations.

- (5) The horizontal stability of the structure may be checked by a simplified method consisting of applying nominal horizontal forces. Unless otherwise specified, the characteristic value of these forces should be taken equal as 1,5 % of the vertical loads resulting from the combination of actions under consideration. They should be applied at the same points as the corresponding vertical loads.

4.8.3 Specific construction loads for bridges

(1) Unless otherwise specified, construction loads due to working personnel, staff and visitors, with small site equipment (Q_{ca}) on bridge decks during execution should be modelled by a uniformly distributed load. This load should be applied on the most unfavourable parts of the relevant areas and, its characteristic value should be taken equal to $1,0 \text{ kN/m}^2$.

(2) The load due to moveable storage of construction materials (Q_{cb}) on bridge decks during execution should be modelled by a loading system including:

- a uniformly distributed load q_{cb} ;
- a concentrated load F_{cb} .

The uniformly distributed load and the concentrated load should be simultaneously considered in the same load case, and applied so as to obtain the most unfavourable effects.

Unless otherwise specified, their characteristic values should be taken equal to:

- $q_{cb,k} = 0,2 \text{ kN/m}^2$;
- $F_{cb,k} = 100 \text{ kN}$.

(3) For bridges built by the incremental launching method, horizontal forces F_h are transmitted by the deck to the supports (bearings and piers) during launching. Unless otherwise specified, the characteristic value of the horizontal force applied at the top of each pier should be taken equal to 10 % of the concomitant vertical force.

Note : In general, the friction coefficient decreases with the movement of the bridge deck; 10 % represents the "static" value of the friction coefficient, when the deck starts moving.

4.9 Seismic actions

(1) During execution, seismic actions need only be taken into account when required by the relevant competent authority or by the project specification. The stages during which verifications have to be performed should be clearly defined in the project specification.

(2) Where seismic actions need be taken into account, they should be determined in accordance with ENV 1998, taking into account the reference period of the transient situation under consideration.

(3)P The design ground accelerations a_g and the importance factor γ_1 (see ENV 1991-1) for the execution phase shall be defined in the project specification.

4.10 Accidental actions

4.10.1 Accidental actions for buildings

(1)P Accidental actions such as impact from construction vehicles, cranes or building equipment (e.g. skip of fresh concrete), local failure of final or temporary supports, etc., which might result in (progressive) collapse of loadbearing structural elements, shall be checked for the relevant limit states.

Note : Measures (inspection on site) should be taken to avoid:

- abnormal concentrations of building equipment and/or building materials on loadbearing structural parts;
- water accumulation (e.g. on steel roofs); such accumulation is mainly possible in the case of a building nearing completion; consequently, this situation is covered by the permanent situation.

(2) Where relevant, the fire exposure should be defined in the project specification.

4.10.2 Accidental actions for bridges

(1)P If one or more of the following loading systems are possible during construction, the limit state to be checked is the prevention of (progressive) collapse.

(2) The action (including dynamic effects) due to the fall of a travelling form during its movement in the case of a bridge built by the cantilever method should be considered as an accidental action.

(3) The action due to the fall of a prefabricated element should be considered as an accidental action and should be taken into account, where relevant.

(4) Actions due to impact from construction vehicles, cranes or building equipment to loadbearing structural parts should be defined in the project specification, where relevant.

(5) The principles of verification in case of local failure of a temporary support of loadbearing structural parts should be defined in the project specification.

Note : This type of accidental design situation includes the possible failure of a stay during the execution phase of a cable-stayed bridge.

Annex A (normative)

Basis of design - supplementary clauses to ENV 1991-1 for buildings

A.1 Combinations of actions for various design situations

A.1.1 Simultaneity of variable actions

A.1.1.1 Mutual simultaneity of the various construction loads (Q_c)

- (1) Where particular construction loads are not physically compatible because of the construction process, they should not be taken into account as simultaneous.
- (2) The simultaneity of particular construction loads may be considered as excluded provided this is specified in the project specification and appropriate control measures are taken.
- (3) Other possibilities of simultaneity of construction loads should be taken into account.

A.1.1.2 Simultaneity of construction loads with other variable actions

- (1) Unless otherwise specified, snow loads and wind actions should be considered as not simultaneous with loads arising from construction activity (e.g. loads due to working personnel). However, the possibility of simultaneity of snow loads and wind actions with other construction loads (e.g. heavy equipment or cranes) should be taken into account.
- (2) Where relevant, thermal and water actions should be considered as simultaneous with construction loads.

Note : Where relevant, some distinctions may be made among the various causes and components of thermal actions.

A.1.2 Transient design situation

A.1.2.1 Ultimate limit state of static equilibrium

- (1) For design situations during which there is a risk of loss of static equilibrium (e.g. during hoisting of prefabricated loadbearing elements), the following combination of destabilizing actions should be considered:

$$\sum_{j \geq 1} G_{kj} + \gamma_P P + \gamma_{Q1} Q_{dst,1k} + \sum_{i > 1} \psi_{0i} \gamma_{Qi} Q_{dst,ik} \quad (A.1)$$

where:

- G_{kj} is the characteristic value of permanent actions with a possible destabilizing effect (e.g. unintentional obliquity of loadbearing prefabricated walls, columns or cladding elements);
- $Q_{dst,1k}$ is the characteristic value of the dominant destabilizing variable action;
- $Q_{dst,ik}$ is the characteristic value of the accompanying destabilizing variable actions.

Note : P is a characteristic or a mean value depending, at the present time, on the project specification.

(2) The values of partial γ factors for permanent actions are given in Table 9.2 of ENV 1991-1. Unless otherwise specified, the γ_Q factors for all variable actions should be taken equal to [1,35].

(3) The values of ψ_0 factors are given in Table A.1 (see A.2).

(4) Where loss of static equilibrium is prevented by stabilizing systems or devices (e.g. struts), their strength and the strength of their connections should be checked in accordance with the rules defined in the relevant design Eurocodes.

A.1.2.2 Ultimate limit state of resistance

(1) Unless otherwise specified, for the verification of ultimate limit states of resistance, the combinations of actions to be considered should be the fundamental combinations, as defined in ENV 1991-1.

Note : Because most actions during execution cannot be assessed with great accuracy, in order to avoid apparent calculation accuracy, preference may be given to the "simplified verification for building structures" equations (without ψ factors), in accordance with ENV 1991-1.

(2) The values of partial γ factors for permanent actions are given in Table 9.2 of ENV 1991-1. Unless otherwise specified, the γ_Q factors for all variable actions should be taken equal to [1,35].

(3) The values of ψ factors are given in Table A.1 (see A.2).

A.1.2.3 Serviceability limit states

(1) Unless otherwise specified, for the verification of serviceability limit states, the combinations of actions to be considered should be the characteristic and the quasi-permanent combinations as defined in ENV 1991-1.

A.1.3 Accidental design situation

(1) The verification of the ultimate limit states of static equilibrium and of strength (rupture) should be performed with the combination of actions according to expression (A.2). Where in special cases one or more variable actions (Q_{ki}) need to be considered simultaneously with the accidental action, their representative values should be defined in the project specification.

$$\sum_{j \geq 1} G_{kj} + P + A_d + \sum_{i \geq 1} \psi_{2i} Q_{ki} \quad (A.2)$$

ψ_2 values are given in Table A.1.

Note : This combination of actions is different from the general combination defined in ENV 1991-1. It is proposed here for the sake of simplicity, to avoid the definition of frequent values of the variable actions for the execution phases. P is a characteristic or a mean value depending, at the present time, on the project specification.

(2) Combinations for accidental design situations either involve an explicit accidental action A (e.g. impact) or refer to a situation after an accidental event (e.g. failure of a temporary support and subsequent change of static system or progressive collapse; $A = 0$).

A.2 ψ factors for buildings

(1) The values of factors ψ_{0i} (for the characteristic combinations) and ψ_{2i} (for the quasi-permanent combinations) for variable actions are given in Table A.1.

Table A.1: ψ factors for buildings during execution

| Direct variable actions | $\psi_0^{1)}$ | ψ_2 |
|--|---------------|----------|
| Construction loads (Q_c) | | |
| Working personel and their equipment, staff and visitors (Q_{ca}) | [0,5] | [0,2] |
| Movable storage of building and construction materials (Q_{cb}) | [0,5] | [0,2] |
| Heavy equipment in position for use or during movement (Q_{cc}) | [0,5] | [0,2] |
| Cranes, vehicles, lifts, power installation (Q_{cd}): | | |
| – frequent use | [0,6] | [0,5] |
| – incidental use | [0,6] | [0] |
| Temperature actions²⁾ | [0,5] | [0] |
| Wind actions²⁾ (Q_w) | [0,5] | [0] |
| Snow loads²⁾ (Q_{sn}) | [0] | [0] |
| Water actions²⁾ (Q_{wa}) | [0,5] | [0] |
| ¹⁾ To be considered only in case of possible simultaneity. | | |
| ²⁾ To be applied to representative values defined in accordance with 3.4 (2) and (3). | | |

Annex B (normative)

Basis of design - supplementary clauses to ENV 1991-1 for bridges

B.1 Combinations of actions for various design situations

B.1.1 Simultaneity of variable actions

B.1.1.1 Mutual simultaneity of the various construction loads (Q_c)

- (1) Where particular construction loads are not physically compatible because of the construction process, they should not be taken into account as simultaneous.
- (2) The simultaneity of particular construction loads may be considered as excluded provided this is specified in the project specification and appropriate control measures are taken.
- (3) Other possibilities of simultaneity of construction loads should be taken into account.

B.1.1.2 Simultaneity of construction loads with other variable actions

- (1) Unless otherwise specified, snow loads and wind actions should be considered as not simultaneous with loads arising from construction activity (e.g. loads due to working personnel). However, the possibility of simultaneity of snow loads and wind actions with other construction loads (e.g. heavy equipment or cranes) should be taken into account.

Note : For cranes, specific safety rules define a wind velocity compatible with use. The corresponding pressure is generally small enough to be neglected in structural verifications.

- (2) Where relevant, thermal and water actions should be considered as simultaneous with construction loads.

Note : Where relevant, some distinctions may be made among the various causes and components of thermal actions.

B.1.2 Transient design situation

B.1.2.1 Ultimate limit state of static equilibrium

- (1) For design situations during which there is a risk of loss of static equilibrium, the following combination of actions should be considered :

$$\sum G_{d,\text{sup}} + \sum G_{d,\text{inf}} + \gamma_P P + \gamma_{Q1} Q_{\text{dst},1k} + \sum_{i>1} \psi_{0i} \gamma_{Qi} Q_{\text{dst},ik} \quad (\text{B.1})$$

where:

- $Q_{\text{dst},1k}$ is the characteristic value of the dominant destabilizing variable action;
- $Q_{\text{dst},ik}$ is the characteristic value of the accompanying destabilizing variable actions.

Note : P is a characteristic or a mean value depending, at the present time, on the project specification. Very varied situations may have to be considered during the execution of a bridge, for which formula (B.1) needs possibly amendments (e.g. for the verification of stabilization stays).

(2) For self-weight of structural and non-structural elements, see 4.1.3.

(3) In general, where a counterweight is used, the variability of the action due to its self-weight should be considered. Unless otherwise specified, this variability should be taken into account by any of the following alternatives:

- applying a partial factor $\gamma_{G\text{inf}} = 0,8$ where the self-weight is not well defined (e.g. containers);
- by considering a variation of its project-defined location, with a value to be specified proportionately to the dimensions of the bridge, where the magnitude of the counterweight is well defined.

Note : For steel bridges during launching, the variation of the counterweight location is often taken equal to ± 1 m.

(4) Unless otherwise specified, the γ factors for all variable loads should be taken equal to [1,35] and $\gamma_P = [1,0]$.

(5) The values of ψ_0 factors are given in Table B.1 (see B.2).

(6) Where loss of static equilibrium is prevented by stabilizing systems or devices (e.g. stays, auxiliary columns), their resistance and/or their stability should be checked in accordance with the rules defined in the relevant design Eurocodes.

B.1.2.2 Ultimate limit states of resistance

(1) The verifications should be based on the fundamental combination with the values of the γ factors for permanent actions given in Annexes C, D and G of ENV 1991-3. Unless otherwise specified, the γ_Q factors for all variable actions should be taken equal to [1,35].

Note : Information on γ_P is provided in the relevant design Eurocodes.

(2) The values of ψ_0 factors are given in Table B.1

B.1.2.3 Serviceability limit states

(1) Serviceability limit states during execution should be defined with reference to design Eurocodes.

(2) Unless otherwise specified, the general format for combinations of actions defined in ENV 1991-1 is applicable.

B.1.3 Accidental design situation

(1) Unless otherwise specified, for design situations during which there is a risk of loss of static equilibrium, the combination of actions to be considered should be based on a single accidental action:

$$\Sigma G_{d,\text{sup}} "+" \Sigma G_{d,\text{inf}} "+" A_d "+" P "+" \psi_{01} Q_{c1,k} "+" \sum_{i>1} \psi_{2i} Q_{ci,k} \quad (\text{B.2})$$

where:

$Q_{cl,k}$ is one of the groups of construction loads defined in 4.8 (i.e. Q_{ca} , Q_{cb} , Q_{cc} or Q_{cd}).

Note : This combination of actions is different from the general combination defined in ENV 1991-1. It is proposed here for the sake of simplicity, to avoid the definition of frequent values of the variable actions for the execution steps. P is a characteristic or a mean value depending, at the present time, on the project specification. Very varied situations may have to be considered during the execution of a bridge, for which formula (B.1) needs possibly amendments (e.g. for the verification of stabilization stays).

(2) Where, in special cases, one or several variable actions need to be considered simultaneously with the accidental action, their representative values should be defined in the project specification.

Note : For example, in the case of bridges built by the cantilevered method, some construction loads may be considered as simultaneous with the accidental action corresponding to the fall of a prefabricated unit.

B.2 ψ factors for bridges

(1) Unless otherwise specified, the ψ factors ψ_{0i} and ψ_{2i} for variable actions are given in Table B.1.

Note : For transient design situations corresponding to maintenance or repair operations, the traffic loads and the relevant ψ factors to be taken into account should be defined in the project specification and Table B.1 should be completed.

Table B.1: ψ -factors for bridges during execution

| | $\psi_0^{1)}$ | ψ_2 |
|---|--|----------|
| Construction loads (Q_c) | | |
| Working personal, staff and visitors with small equipment (Q_{ca}) | [1] | [0,2] |
| Storage of construction material, precast elements etc. (Q_{cb}) | [1] | [1] |
| Heavy equipment etc. (Q_{cc}) | [1] | [1] |
| Cranes, lifts, vehicles etc. (Q_{cd}) | To be defined in the project specification | |
| Horizontal forces (F_h) | [1] | [0] |
| Wind actions²⁾ (where compatible) (Q_w) | [0,8] | [0] |
| Snow loads²⁾ (where compatible) (Q_{sn}) | [0,8] | [0] |
| Temperature and shrinkage effects²⁾ | [0,6] | [0] |
| Water actions (Q_{wa}) | To be defined in the project specification | |

¹⁾ To be considered in case of simultaneity.

²⁾ To be applied to representative values defined in accordance with 3.4 (2) and (3).

Annex C (informative)

Construction loads during casting of concrete

C.1 Construction loads for profiled steel sheeting

(1) The characteristic values of the load densities during casting of concrete on profiled steel sheeting as shuttering are given in Table C.1.

Note : The loads given in Table C1 represent the weight of operatives and concreting plant and take into account any impact or vibration which may occur during construction. The given values are not intended to cover excessive impact or heaping of concrete during casting, or pipeline or pumping loads. If appropriate, an additional load should be defined in the project specification.

Table C.1: Characteristic values of actions due to construction loads during casting of concrete (in addition to the self-weight of the loadbearing element and the weight of the fresh concrete)

| | |
|---|------------------------|
| (a) Inside any working area 3 m by 3 m (or the span length if less) | 1,5 kN/m ² |
| (b) Outside the working area | 0,75 kN/m ² |

(2) Loads (a) and (b), as defined in Table C.1, should be placed to cause the maximum bending moment and/or shear (see Fig. C.1).

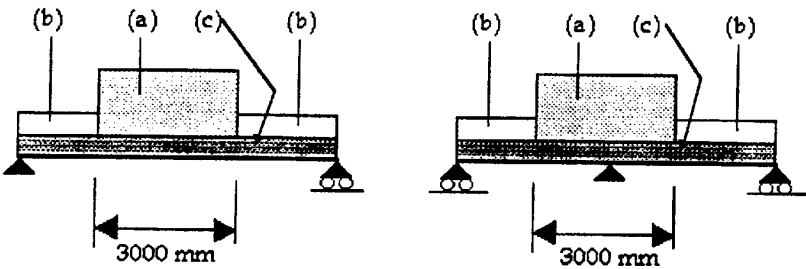


Figure C.1: Examples of load arrangements
For loads (a) and (b), see Table C.1; (c) is the self-weight of the loadbearing element and the weight of the fresh concrete.

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