

Eurocode 1: Basis of design and actions on structures —

Part 1: Basis of design —

**(together with United Kingdom
National Application Document)**

ICS 91.040

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Committees responsible for this Draft for Development

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- British Constructional Steelwork Association
- British Iron and Steel Producers' Association
- British Masonry Society
- Concrete Society
- Department of the Environment (Building Research Establishment)
- Department of the Environment (Property and Buildings Directorate)
- Highways Agency
- Institution of Structural Engineers
- National House Building Council
- Royal Institute of British Architects
- Steel Construction Institute

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National foreword

This publication has been prepared by Subcommittee B/525/1. It comprises the English language version of ENV 1991-1:1994 *Eurocode 1: Basis of design and actions on structures — Part 1: Basis of design*, as published by the European Committee for Standardization (CEN), together with the corresponding National Application Document (NAD). The NAD has been prepared for use in the design of buildings and civil engineering works to be constructed in the United Kingdom.

ENV 1991-1 results from a programme of work sponsored by the European Commission to make available a common set of rules for the structural and geotechnical design of buildings and civil engineering works. The full range of codes covers the basis of design and actions, the design of structures in concrete, steel, composite construction, aluminium alloy, timber and masonry and also geotechnical and seismic design.

An ENV, or European Prestandard, is made available for provisional application, but does not have the status of a European Standard. The aim is to use the experience gained to modify the ENV so that it can be adopted as a European Standard.

The values of certain parameters in the ENV Eurocodes may be set by CEN Members so as to meet requirements in national regulations. The numerical values of these parameters in the ENV are indicated as “boxed” or by [].

During the ENV period, reference should be made to the supporting documents listed in the National Application Documents (NADs).

Generally, the purpose of the NADs in DD ENV Eurocodes is to provide essential information, particularly in relation to safety, to enable the corresponding ENVs to be used for the design of buildings and civil engineering works to be constructed in the UK. The requirements of the NADs take precedence in the UK over the corresponding provisions in the ENVs. However, the purpose of the NAD to Eurocode 1: Part 1 is somewhat different, as discussed in the text below.

There is no equivalent British design code to DD ENV 1991-1. Unlike other design codes for various structural materials which contain detailed recommendations for design, ENV 1991-1 contains only general structural criteria which are material independent. However, the “Basis of design” sections of ENV 1992 to ENV 1996 contain material common to ENV 1991-1; these Eurocodes (ENV 1992 to ENV 1996) with their UK NADs contain sufficient information to enable designs to be effected without recourse to ENV 1991-1. ENV 1997-1 *Geotechnical design* does require recourse to ENV 1991-1, but only for the definition of some terms and symbols, and not for quantitative values.

This situation will change when the ENV Eurocode Prestandards are converted into full EN Eurocode Standards. Material currently in ENV 1992 to ENV 1997 which is also covered by ENV 1991-1 will then be removed and the corresponding relevant provisions of ENV 1991-1 will apply. One implication is that the same partial factors for loads and the same load combination factors will apply to all structural materials, which is not currently the case.

Numerical values of coefficients in the UK NADs to ENV 1992 to ENV 1997 have been calibrated to give an acceptable degree of conformity to current British Standards. By contrast, the coefficients given in the UK NAD to ENV 1991-1 are not always in accordance with current British Standards, nor with the UK NADs to ENV 1992 to ENV 1997, although this is not expected to result in other than minor differences in most circumstances. The differences between the loading codes referred to in DD ENV 1991-1 and those referred to in DD ENV 1992 to DD ENV 1997 may result in more significant differences. Where differences remain, the “Basis of design” sections of ENV 1992 to ENV 1997 (as modified by the applicable UK NAD) should take precedence over DD ENV 1991-1 during the ENV trial application stage.

This NAD also provides clarification to certain clauses which were considered ambiguous; these clarifications are not intended to change the original intention of the drafters of ENV 1991-1.

The main reasons for publishing the UK NAD to Eurocode 1: Part 1 are as follows.

- a) For essentially informative purposes, to enable structural designers in the UK to familiarize themselves with the contents of ENV 1991-1, which, as referred to above, has no existing equivalent British Standard.
- b) Following from a), to enable UK comments on ENV Eurocode 1: Part 1 to be obtained during its ENV period, so that these can be considered during the conversion to an EN.
- c) To provide information in cases where the “Basis of design” sections of DD ENV 1992 to DD ENV 1997 require amplification, for example under unusual circumstances not adequately covered by those Eurocodes.
- d) To provide definitions for certain terms and symbols used in DD ENV 1997-1.
- e) To enable comparative designs to be performed which compare the approach of ENV 1991-1 with those of DD ENV Eurocodes predating ENV 1991-1.

Compliance with DD ENV 1991-1:1996 does not of itself confer immunity from legal obligations.

For consideration of the conversion of ENV 1991-1 into a full European Standard, it is important to get as much feedback as possible from practising engineers. Such feedback is therefore strongly encouraged, and users of this document are invited to comment on its technical content, ease of use and any ambiguities or anomalies. These comments will be taken into account when preparing the UK national response to CEN on the question of whether the ENV can be converted into an EN.

Comments should be made in writing to the Secretary of Subcommittee B/525/1, BSI, 389 Chiswick High Road, London W4 4AL, quoting this document, the reference to the relevant clause and, if possible, a proposed revision.

Summary of pages

This document comprises a front cover, an inside front cover, pages i to x, the ENV title page, pages 2 to 52 and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

National Application Document

**for use in the UK with
ENV 1991-1:1994**

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Introduction

This National Application Document (NAD) has been prepared by Subcommittee B/525/1. It has been developed from:

- a) a textual examination of ENV 1991-1;
- b) a comparison with the material independent sections of the following DD ENV Eurocodes.

DD ENV 1992-1-1:1992

DD ENV 1993-1-1:1992

DD ENV 1994-1-1:1994

DD ENV 1995-1-1:1995

DD ENV 1996-1-1:1995

DD ENV 1997-1:1995

1 Scope

This National Application Document is issued to enable the use of ENV 1991-1 in the circumstances discussed in the national foreword, for conditions pertinent to the UK.

2 Informative references

This National Application Document refers to other publications that provide information or guidance. Editions of these publications current at the time of issue of this standard are listed on page ix, but reference should be made to the latest editions.

3 Partial load factors, combination factors and other values

The tables and equations of ENV 1991-1:1994 listed below should be replaced with tables and equations in this NAD, as is shown in Table 1. In all other cases, the “boxed” values (see item 25 of the foreword to ENV 1991-1:1994) should be used.

Table 1 — Table and equation substitutions

ENV 1991-1	This NAD
Table 2.1: Design working life classification	Table 1: Notional classification of design working life
Equation 9.10a and 9.10b: special combination rules for ultimate limit state	Equation 9.10a and 9.10b should not be used, pending calibration work

4 Loading codes

Where punished, the UK national implementation of the appropriate Part of Eurocode 1 (e.g. DD ENV 1991-2-3) should be used for applications within the scope specified. Where such DD ENVs are not available, the appropriate equivalent standards listed in the NADs to DD ENV 1992 to DD ENV 1997 should be adopted.

5 Reference standards

Standard referred to in ENV 1991-1	Equivalent standard to be used in the UK
ISO 2631	ISO 2631
ISO 8930:1987	ISO 8930:1987
ISO 6707-1:1989	ISO 6707-1:1989
ISO 3898:1987	ISO 3898:1987
ENV Eurocode Prestandard	Equivalent DD ENV (see also clause 4 above)

6 Additional recommendations

6.1 Sub-clause 1.5 Definitions

- a) **1.5.4.3** A new definition should be added:

“nominal value of a material property: a characteristic value established from an appropriate document such as a European Standard or Prestandard.”

- b) **1.5.5.2** A new note should be added:

“NOTE The design value of a geometrical property is generally equal to the characteristic value. However, it may differ in cases where the limit state under consideration is very sensitive to the value of the geometrical property, for example when considering the effect of geometrical imperfections on buckling. In such cases, the design value will normally be established as a value specified directly, for example in an appropriate European Standard or Prestandard. Alternatively, it can be established on a statistical basis, with a value corresponding to a more extreme fractile (i.e. a rarer value) than applies to the characteristic value.”

6.2 Clause 8. Design by testing

- a) **8.1** A new paragraph should be added “(5) This section includes for fatigue within its scope.”.

- b) **8.3** The final paragraph of (2) should be replaced with: “The field of application of the partial factor used in method a) should be similar to the tests under consideration.”.

6.3 Clause 9. Verification by the partial factor method

a) **9.3.2** A new note should be added to (2) as follows:

NOTE Information on appropriate values of γ_{sd} for the analysis of bridges is given in BS 5400-1.”

b) (3)b) The phrase: “the partial factor is applied” should be replaced by the phrase: “the partial factor γ_F is applied.”.

c) **9.4.2** In (3)a) equations (9.10a) and (9.10b) should not be used, pending calibration work.

In (6) a note should be added at the end of the paragraph:

“NOTE For example, in the design of a section subject to both bending moment and axial force due to a single action, the axial force may be reduced by 20 % if it is a favourable action effect.”.

d) **9.4.3** The second sentence of (2)P should be replaced by the following:

NOTE Examples of where this may apply are as follows.

i) When considering Case A of Table 2 for the static equilibrium of balanced cantilevers.

ii) When considering Case B of Table 2 for the bending strength needed within a span of a multispan beam which has adjacent span lengths that differ greatly.”

6.4 Annex A to Annex D (informative)

Annex A to Annex D need further development work before they can be considered adequately validated for design purposes.

6.5 Table 2.1

Table 2.1 should be replaced by the one listed below.

Table 2.1 — Notional classification of design working life

Class	Notional design working life (years)	Examples
1	1–5	Temporary structures
2	25	Replaceable structural parts, e.g. gantry girders, bearings
3	50	Buildings and other common structures, other than those listed below
4	100	Monumental buildings, and other special or important structures
5	120	Bridges

List of references (see clause 2)

Informative reference

BSI standards publication

BRITISH STANDARDS INSTITUTION, London

BS 5400, *Steel, concrete and composite bridges*.

BS 5400-1:1988, *General statement*.

Eurocode 1 — Basis of design and actions on structures — Part 1: Basis of design

Eurocode 1 — Bases du calcul et actions sur les
structures —
Partie 1: Bases du calcul

Eurocode 1 — Grundlagen der
Tragwerksplanung und Einwirkungen
auf Tragwerke —
Teil 1: Grundlagen der Tragwerksplanung

This European Prestandard (ENV) was approved by CEN on 1993-05-28 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 of whether the ENV can be converted into a 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.

CEN members are the national standards bodies of Austria, Belgium, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.

CEN

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

Central Secretariat: rue de Stassart 36, B-1050 Brussels

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 harmonized technical specifications for products and for methods of testing their performance are 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 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) Separate subcommittees have been formed by CEN/TC 250 for the various Eurocodes listed above.
- (9) This Part of ENV 1991 is intended to develop for a broader field of application the rules already published in sections 1 and 2 of Parts 1.1 of ENVs 1992, 1993 and 1994. It is being published as European Prestandard ENV 1991-1.
- (10) This prestandard is intended for experimental application and for the submission of comments.
- (11) After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future actions.
- (12) Meanwhile feedback and comments on this prestandard should be sent to the secretariat of CEN/TC 250 at the following address:

BSI
British Standards House
389 Chiswick High Road
London W4
England

or to your national standards organization.

Purpose of this Part of Eurocode 1

Technical objectives

- (13) This Part of Eurocode 1 describes the principles and requirements for safety, serviceability and durability of structures. It is based on the limit state concept used in conjunction with a partial factor method. Regarding modifications of the proposed method, see (24) of the foreword.
- (14) For the design of new structures, this Part is intended to be used, for direct application, together with:

- the other Parts of ENV 1991;
- the design Eurocodes (ENVs 1992 to 1999).

NOTE The above mentioned European Prestandards are either published or in preparation.

- (15) This Part also gives guidelines for the aspects of structural reliability relating to safety, serviceability and durability:

- for design cases not covered by ENVs 1991 to 1999 (other actions, structures not treated, other materials);
- to serve as a reference document for other CEN TC's concerned with structural aspects.

- (16) It is intended that the material-independent clauses in section 2 of the design Eurocodes will be superseded by this Part of ENV 1991 at a future stage (EN stage).

Intended users

(17) This prestandard is intended for the consideration of more categories of users, than are the other Eurocodes. The categories include:

- code drafting committees;
- clients (e.g. for the formulation of their specific requirements on reliability level and durability);
- designers and contractors, as for other Eurocodes;
- public authorities.

Intended uses

(18) This prestandard is intended for the design of structures within the scope of the Eurocodes.

(19) As a guidance document, for the design of structures outside the scope of the Eurocodes, this prestandard may be used when relevant for:

- assessing other actions and their combinations;
- modelling material and structural behaviour;
- assessing numerical values of the reliability format.

(20) Numerical values for safety factors and other safety elements are given as indications. Together with the material-dependent indicative values given in the design Eurocodes, they provide an acceptable degree of reliability, assuming that an appropriate level of workmanship and of quality assurance is achieved. Therefore, if this Part is used as a reference document by other CEN/TCs the same indicative values should be taken.

Division into main text and annexes

(21) Because of the various categories of use mentioned above, this Part is divided into a main text and a series of annexes. This division also takes into account the development expected during the ENV period.

(22) The main text includes most of the principal and operational rules necessary for direct application for designs in the field covered by ENV 1991, and ENVs 1992 to 1999. The principal provisions for bridges are also included.

(23) The annexes are informative only. Other background information and items for further development during the ENV period may be published separately in a CEN report.

National Application Documents (NADs)

(24) It is intended that, during the ENV period, this prestandard is used for design purposes, in conjunction with the particular National Application Document valid in the country where the designed structures are to be located.

The National Application Documents are intended to authorize experimental use of the Eurocodes as prestandards for design during the ENV period, with due consideration for the current regulations and codes relevant in individual countries, and to facilitate these uses. The NADs may also introduce modifications of the partial factor method in this prestandard. Establishing the NAD is the responsibility of the national competent authorities.

In particular each NAD may specify whether the annexes can be used fully or partly in connection with the main text and what are then the specific conditions for their application, e.g. the application of 3.4(3), and of 8.3(1) together with Annex A.

(25) In particular, for this prestandard attention should be paid to:

- confirming or amending the numerical values identified as “boxed” or by []; it is recommended that modifications are introduced only where considered to be necessary; however, for those countries in which reliability differentiation measures are already codified there is no objection to numerical amendments intended to supplement this Eurocode by such operational measures;
- considering the variety of intended users and uses of this prestandard [see (17) above], with regard to the existing national professional organizations and the respective responsibilities of each category of user.

Intended future developments of this Part

(26) The objective of this Part is to ensure the consistency of design rules for a wide set of construction works made of various materials. It should be understood that this is a long-term objective which will be reached progressively. At the present stage the objective is limited to:

- ensuring the consistency between the Eurocodes already published or in preparation, without contradicting them;
- covering the structures treated in the same Eurocodes in less detail for those for which Parts of Eurocodes are in preparation, e.g. for bridges, silos, etc. Therefore it should be understood that by publication of the present version of this Part it is not intended to inhibit the work of development and improvement of the reliability format.

In parallel with the publication of new Parts of Eurocodes during the ENV period, it is envisaged that some developments may be made to some items, e.g:

- more precise definition of differentiated reliability levels;
- numerical revision, probabilistic justification of numerical values of partial factors and possibly supplementing this method with a probabilistic approach;
- more precise consideration of various types of limit state equations, soil-structure interaction, non-linear analysis, dynamic actions and the associated analysis and reliability verification format;
- assessment and re-design of existing structures.

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Section 1. General

1.1 Scope

- (1) This Part 1 of ENV 1991 establishes the principles and requirements for safety and serviceability of structures, describes the basis for design and verification and gives guidelines for related aspects of structural reliability.
- (2) Part 1 of ENV 1991 provides the basis and general principles for the structural design of buildings and civil engineering works including geotechnical aspects and shall be used in conjunction with the other parts of ENV 1991 and ENVs 1992 to 1999. Part 1 relates to all circumstances in which a structure is required to give adequate performance, including fire and seismic events.
- (3) Part 1 of ENV 1991 may also be used as a basis for the design of structures not covered in ENVs 1992 to 1999 and where other materials or other actions outside the scope of ENV 1991 are involved.
- (4) Part 1 of ENV 1991 is also applicable to structural design for the execution stage and structural design for temporary structures, provided that appropriate adjustments outside the scope of ENV 1991 are made.
- (5) Part 1 of ENV 1991 also gives some simplified methods of verification which are applicable to buildings and other common construction works.
- (6) Design procedures and data relevant to the design of bridges and other construction works which are not completely covered in this Part may be obtained from other Parts of Eurocode 1 and other relevant Eurocodes.
- (7) Part 1 of ENV 1991 is not directly intended for the structural appraisal of existing construction in developing the design of repairs and alterations or assessing changes of use but may be so used where applicable.
- (8) Part 1 of ENV 1991 does not completely cover the design of special construction works which require unusual reliability considerations, such as nuclear structures, for which specific design procedures should be used.
- (9) Part 1 of ENV 1991 does not completely cover the design of structures where deformations modify direct actions.

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 2631, *Evaluation of human exposure to whole-body vibration*.

ISO 8930:1987, *General principles on reliability for structures — List of equivalent terms*.

ISO 6707-1:1989, *Building/civil engineering — Vocabulary — Part 1: General terms*.

ISO 3898:1987, *Basis of design for structures — Notations — General symbols*.

NOTE The following European Prestandard 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 loads*.

ENV 1991-2-5, *Eurocode 1: Basis of design and actions on structures — Part 2.5: Thermal actions*.

ENV 1991-2-6, *Eurocode 1: Basis of design and actions on structures — Loads and deformations imposed during execution*.

ENV 1991-2-7, *Eurocode 1: Basis of design and actions on structures — Part 2.7: Accidental actions*.

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 Assumptions

The following assumptions apply:

- The choice of the structural system and the design of a structure is made by appropriately qualified and experienced personnel.
- Execution is carried out by personnel having the appropriate skill and experience.
- Adequate supervision and quality control is provided during execution of the work, i.e. in design offices, factories, plants, and on site.
- The construction materials and products are used as specified in this Eurocode or in ENVs 1992 to 1999 or in the relevant supporting material or product specifications.
- The structure will be adequately maintained.
- The structure will be used in accordance with the design assumptions.
- Design procedures are valid only when the requirements for the materials, execution and workmanship given in ENVs 1992 to 1996 and 1999 are also complied with.

1.4 Distinction between principles and application rules

(1)P Depending on the character of the individual clauses, distinction is made in this Part 1 of ENV 1991 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) The principles are identified by the letter P following the paragraph number.

(4)P The application rules are generally recognized rules which follow the principles and satisfy their requirements. It is permissible to use alternative rules to the application rules given in this Eurocode, provided that it is shown that the alternative rules accord with the relevant principles and have at least the same reliability.

(5) In this Part of ENV 1991 the application rules have only a paragraph number, e.g. as this paragraph.

1.5 Definitions

For the purposes of this prestandard, the following definitions apply.

NOTE Most definitions are reproduced from ISO 8930:1987.

1.5.1 Common terms used in the Structural Eurocodes (ENVs 1991 to 1999)

1.5.1.1

construction works

everything that is constructed or results from construction operations

NOTE This definition accords with ISO 6707-1. The term covers both building and civil engineering works. It refers to the complete construction worlds comprising structural, non-structural and geotechnical elements.

1.5.1.2

type of building or civil engineering works

type of construction works designating its intended purpose, e.g. dwelling house, retaining wall, industrial building, road bridge

1.5.1.3

type of construction

indication of principal structural material, e.g. reinforced concrete construction, steel construction, timber construction, masonry construction, composite steel and concrete construction

1.5.1.4

method of construction

manner in which the execution will be carried out, e.g. cast in place, prefabricated, cantilevered