

Eurocode 9: Design of aluminium structures —

Part 1-1: General rules — General rules and rules for buildings

ICS 91.010.30; 91.080.10

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National foreword

This Draft for Development is the official English version of ENV 1999-1-1:1998.

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 commencement of the review period will be notified by an announcement in *Update Standards*.

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/525/9, Structural use of aluminium, 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 committee 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 National Application Document (14 pages), the ENV title page, pages 2 to 212, an inside back cover and a back cover.

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Contents of National Application Document

	Page
Contents of National Application Document	
National Application Document	
Introduction	3
1 Scope	3
2 References	3
3 Partial safety factors, combination factors and other values	3
4 Loading codes	4
5 Reference standards	4
6 Additional recommendations	4

Tables

1.	Partial Safety Factors	4
2.	Permitted British Standards for Alloys	9
3.	Reference standards common to different product forms	9
4.	Reference standards for Aluminium and Aluminium Alloy Plate Sheet and Strip	10
5.	Reference standards for Aluminium and Aluminium Alloy Drawn Tube	10
6.	Reference standards for Aluminium and Aluminium Alloy Forging Stock & Forgings	10
7.	Reference standards for Aluminium and Aluminium Alloy Bars, Extruded round tubes and sections.	11
8.	Reference standards for Aluminium and Aluminium Alloy Wire	11
9.	Reference standards for Aluminium and Aluminium Alloy Ingots and Castings	12
10.	Reference standards for Aluminium and Aluminium Alloy Longitudinally Welded Tube	12
11.	Reference standards for Aluminium and Aluminium Alloy Solid Extruded Bars and Sections suitable for bright trim/reflector applications	12

12.	Reference standards for Aluminium and Aluminium Alloy Free Cutting Bar and Wire	13
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National Application Document

Introduction

This National Application Document (NAD) has been prepared under the direction of Technical Committee B525, Building & Civil Engineering structures, (by sub-committee B525/9). It has been developed from:

- a) a textual examination of ENV 1999-1-1:1998;
- b) a parametric calibration against BS 8118, supporting standards and test data;
- c) trial calculations

It should be noted that partial safety factors in ENV 1999-1-1 are in general lower than those recommended in BS 8118, but that the load factors in DD ENV 1991-1-1 are higher than those given in BS 8118.

1 Scope

This NAD provides information to enable ENV 1999-1-1:1998 (Eurocode 9 Part 1.1) to be used for the design of buildings and civil and structural engineering works in the UK.

2 References

2.1 Normative References

This NAD incorporates, by reference, provisions from specific editions of other publications. These normative references are cited at the appropriate points in the text. Subsequent amendments to, or revision of, any of these publications apply to this NAD only when incorporated in it by updating or revision.

2.2 Informative References

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

3 Partial safety factors, combination factors and other values

- a) The values for partial load factors (γ) should be those given in DD ENV 1991-1-1: 1996 (Eurocode 1 together with its NAD).
- b) The values for combination factors (ψ) should be those given in DD ENV 1991-1-1: 1996.

- c) The values for partial safety factors (γ_m) should be those given in ENV 1999-1-1 except as listed in table 1 of this NAD

TABLE 1 Partial Safety Factors (γ_m)					
Reference In EC9 : Part 1.1	Definition	Symbol	Condition	Value	
6.6.1(4)	Resistance of welded connections	(γ_m)	Specified quality lower than given in this standard	Boxed In EC9	UK
				1.65	1.6

- d) The values for other boxed values should be those in ENV 1999-1-1.

4 Loading Codes

BS 648: 1964 "Schedule of weights of building materials"
BS 2573: Part 1: 1983 "Rules for the design of cranes"
BS 2573: Part 2: 1980 "Rules for the design of cranes"
BS 5400: Part 2: 1978 "Steel, Concrete and Composite Bridges"
BS 6399: Part 1: 1996 "Code of practice for dead and imposed loads"
BS 6399: Part 2: 1997 "Code of practice for wind loads"
BS 6399: Part 3: 1988 "Code of practice for imposed roof loads"
BS 8100: Part 1: 1986 "Lattice towers and masts"

5 Reference Standards

The supporting standards to be used are listed in Tables 3 to 13.

6 Additional Recommendations

6.1 Guidance on Eurocode 9 : Part 1.1

Note. **6.1.1** to **6.1.4** should be followed when designing in accordance with Eurocode 9 : Part 1.1.

6.1.1 Chapter 2 Basis of Design

- a) Clause 2.3.4 Serviceability limit states.
Re-number as Clause 2.3.3.
- b) Clause 2.5 Fire Resistance
Reference to av ENV 1999-1-2 should be to D.D. ENV 1999-1-2.

6.1.2 Chapter 3 Materials

- a) *Clause 3.2.1*
Range of materials. Use of aluminium alloys listed in the British Standards given in Table 2 is also permitted, subject to the use of the values for 0.2% Proof stress and minimum tensile strength given in British Standard BS 8118 for the alloy in question for calculation of f_o , f_a and f_v in accordance with clause 5.3.5(2). It should also be noted that these values may differ from alloys with the same numerical designation produced in accordance with an EN standard.

NOTE 1: This provision is to enable the use of materials held in stock which were produced prior to the adoption of the EN material standards.

NOTE 2: BS 8118 uses the terms "minimum 0.2% tensile proof stress" and "minimum tensile strength" whereas the corresponding terms in ENV 1999 are "0.2% proof strength" and "ultimate tensile strength"

- b) *Clause 3.2.2.1(2)* insert pr before reference to ENV 1999-1-2 in final line.
- c) *Tables 3.2a to 3.2d incl. Values for strength*
It should be noted that properties vary between different forms of product (with the same numerical designation) that a fabricator may consider as interchangeable e.g. strip v. extruded plate. The designer should ensure that the product form is precisely specified or else use the lower bound figure for design.
- d) *Clause 3.3.4(1)* reference to clause 1.3.3 should be to 1.3.2.
- e) *Clause 3.3.4(2)* replace "Table B.5 and B.6" with "Table B.3".
- f) *Table 3.5 and Table 3.6* replace "table B.5" with "Table B.2" in the NOTE.
- g) *Clause 3.4.3.2 Metal to metal contacts*
Contact between aluminium and copper (or alloys containing copper) is not covered by this clause and is not normally recommended. If used, the protection should be in accordance with clause 7.7.3.2 Procedure Y.

6.1.3 Chapter 5. Ultimate Limit States (Members)

- a) *Clause 5.1.9(3)*

Replace the whole sub-clause with "Fatigue design should be verified using DD ENV 1999 Part 2".

b) *Clause 5.3.3(3)*

Replace the first three lines of sub-section b) with:-

b) a deduction taken as the greater of

$$\sum Ah - s^2 t / (4p)$$

or

$$\sum Ah - 0.65st$$

Where $\sum Ah$ is the sum of the hole areas on the diagonal or zig-zag section considered.

c) *Clause 5.3.3(6)*

Add "which satisfies this limit" at the end of the sentence.

d) *Clause 5.5.2(3)*

Replace the first sentence by the following:

"The severity of softening can be taken into account either by reducing the value of the characteristic strength in the H.A.Z. or by reducing the assumed cross sectional area over which the stresses act"

e) *Clause 5.5.3 and Table 5.2*

The designer should specify the weld process to be used, or alternatively use the lower values.

f) *Clause 5.8.4.1(1)*

Insert " A_1 " between "or" and "in" in the second line of the note.

g) *Table 5.9*

Change the heading from "figure 5.9" to "Table 5.9" on Page 78.

Change the value $0.2D/B$ to $0.02D/B$ in the expression for Y for section type 17.

h) *Clause 5.9.3.1(3)*

Change the $N_{t, Ed}$ to $N_{t, sd}$ in the text.

i) *Clause 5.9.3.2(1)*

The values for η_0 , γ_0 and ε_0 shall be taken as 1.0 and not the alternative higher figures.

The values for W_y and W_z should be based on elastic gross section.

j) *Clause 5.9.3.2(2)*

Replace "5.9.4(5) or (6)" with "5.9.4.5 or 5.9.4.6" in the definition for ω_0 .

- k) *Clause 5.9.4.5(1)*
Change the reference to clause “5.4.2” for P_{HAZ} to clause “5.5.2”.
- l) *Clause 5.10.5(3) a).*
Insert the equation
 $V_{RD} = A_{net} f_v / \gamma_{m1}$ below the heading “clause 1, 2 or 3 cross sections”.
- m) *Clause 5.11.5(1)*
Add the following conditions
 - c) The pitch W of the stiffeners or corrugations does not exceed $0.3L$ (see Figure 5.13).
 - d) Any outstand element is classified as compact in terms of axial resistance.
 - e) Any internal element is classified as compact in terms of shear resistance.
- n) *Clause 5.11.5(3)*
Change the cross reference in the term for I_z from “5.12.7(3)” to 5.12.10.3(3)”

6.1.4 Chapter 6 Connections Subject to Static Loading

- a) *Clause 6.5.4(3)*
Change reference to “6.5.10” to “6.5.11”.
- b) *Clause 6.5.5(7)*
Change reference to “7.5.2(1)” to “7.3.6”.
- c) *Clause 6.5.14.2(1)*
Add figure 1.0 below.
- d) *Clause 6.6.3.1 and Table 6.8*
The designer should be wary of specifying filler metal purely on the grounds of increased strength. (Refer to pr EN 1011-4 for further guidance on suitable filler metal selection.)

If in doubt use the lower figure.
- e) *Clause 6.6.3.2.1(1)*
Change “shall be applied” to “are preferable”.
- f) *Clause 6.6.3.3(3)*
Change “100 times the throat thickness”
to “10 times the throat thickness”

g) *Clause 6.6.3.3(6)*
Change the formula for $L_{W,eff}$ to $L_{W,eff} = (1.125 - 1.25L_W/100a) L_W$

h) *Clause 6.6.3.3(11)*
Change equations (6.38) and (6.39) to

$$\sigma_c \leq \frac{0.85 f_w}{\gamma_{Mw}}$$

$$\sigma_{\perp} \leq \frac{0.85 f_w}{\gamma_{Mw}}$$

j) *Clause 6.6.3.3. (12)*
Change equations (6.40) and (6.42) to

$$a > \frac{0.7}{0.85} \frac{\sigma_t}{f_w/\gamma_{Mw}}$$

$$a > \frac{\tau_t}{f_w / \gamma_{Mw}}$$

TABLE 2. Permitted British Standards for Alloys

BS 1470:1987 Wrought aluminium and aluminium alloys for general engineering purposes: plate, sheet and strip.

BS 1471:1972 Specification for wrought aluminium and aluminium alloys- Drawn tube.

BS 1472:1972 Specification for wrought aluminium and aluminium alloys- Forging stock and forgings

BS 1474:1987 Specification for wrought aluminium and aluminium alloys for general engineering purposes: bars, extruded round tubes and sections

BS 1475:1972 Specification for wrought aluminium and aluminium alloys- Wire

BS 1490:1988 Specification for aluminium and aluminium alloy ingots and castings for general engineering purposes

BS 4300-1:1967 Specification (supplementary series) for wrought aluminium and aluminium alloys Part 1: Aluminium alloy longitudinally welded tube

BS 4300-4:1973 Specification (supplementary series) for wrought aluminium and aluminium alloys for general engineering purposes- Part 4:6463 Solid extruded bars and sections suitable for bright trim/reflector applications

BS 4300-5:1973 Specification (supplementary series) for wrought aluminium and aluminium alloys for general engineering purposes- Part 5:2011 Free cutting bar and wire

BS 4300-12:1969 Specification (supplementary series) for wrought aluminium and aluminium alloys- Part 12:5454 Bar, extruded round tube and sections

BS 4300-15:1973 Specification (supplementary series) for wrought aluminium and aluminium alloys Part 15:7020 Bar, extruded round tube and sections

Table 3 Reference standards common to different product forms

BS EN 515:1993 Aluminium and aluminium alloys- Wrought products- Temper designations.

BS EN 573-3:1995 Aluminium and aluminium alloys- Chemical composition and form of wrought products- Part 3: Chemical composition.

BS EN 573-4:1995 Aluminium and aluminium alloys- Chemical composition and form of wrought products- Part 4: Forms of product.

Table 4: Reference Standards for Aluminium and Aluminium alloy Plate, Sheet and Strip (Replaces BS 1470:1987)

BS EN 485-1:1995	Aluminium and aluminium alloys- Sheet, strip and plate- Part 1: Technical conditions for inspection and delivery.
BS EN 485-2:1995	Aluminium and aluminium alloys- Sheet, strip and plate- Part 2: Mechanical properties.
BS EN 485-3:1994	Aluminium and aluminium alloys- Sheet, strip and plate- Part 3: Tolerances on shape and dimensions for hot rolled products.
BS EN 485-4:1994	Aluminium and aluminium alloys- Sheet, strip and plate- Part 4: Tolerances on shape and dimensions for cold rolled products.

Table 5: Reference Standards for Aluminium and Aluminium Alloy Drawn Tube. (Replaces BS 1471: 1972)

BS EN 754-1:1997	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 1: Technical conditions for inspection and delivery.
BS EN 754-2:1997	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 2: Mechanical properties.
BS EN 754-7:1998	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 7: Seamless tubes, tolerances on dimensions and form.
BS EN 754-8:1998	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 8: Porthole tubes, tolerances on dimensions and form.

Table 6: Reference Standards for Aluminium and Aluminium Alloy Forging Stock and Forgings (Replaces BS 1472: 1972)

BS EN 586-1: 1998	Aluminium and aluminium alloys- Forgings- Part 1: Technical conditions for inspection and delivery.
BS EN 586-2: 1994	Aluminium and aluminium alloys- Forgings- Part 2: Mechanical properties and additional property requirements.
BS EN 603-1: 1997	Aluminium and aluminium alloys- Wrought forging stock- Part 1: Technical conditions for inspection and delivery.
BS EN 603-2: 1997	Aluminium and aluminium alloys- Wrought forging stock- Part 2: Mechanical properties.
BS EN 604-1: 1997	Aluminium and aluminium alloys- Cast forging stock- Part 1: Technical conditions for inspection and delivery.
BS EN 604-2: 1997	Aluminium and aluminium alloys- Cast forging stock- Part 2: Tolerances on dimensions and form

Table 7: Reference Standards for Aluminium and Aluminium Alloy Bars, Extruded Round Tubes and Sections. (Replaces BS 1474: 1987, BS4300-12; and BS 4300-15:1973)

BS EN 755-1: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 1: Technical conditions for inspection and delivery
BS EN 755-2: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 2: Mechanical properties.
BS EN 755-3: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 3: Round bars, tolerances on dimensions and form.
BS EN 755-4: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 4: Square bars, tolerances on dimensions and form.
BS EN 755-5: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 5: Rectangular bars, tolerances on dimensions and form.
BS EN 755-6: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 6: Hexagonal bars, tolerances on dimensions and form.
BS EN 755-7: 1998	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 7: Seamless tubes, tolerances on dimensions and form.
BS EN 755-8: 1999	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 8: Porthole tubes, tolerances on dimensions and form.
EN 755-9:	Aluminium and aluminium alloys- Extruded rod/bar, tubes and profiles- Part 9: Profiles, tolerances on dimensions and form.
EN 12020-1	Aluminium and aluminium alloys- Extruded precision profiles in alloys EN AW 6060/EN AW 6063- Part 1: Technical conditions for inspection and delivery.
EN 12020-2	Aluminium and aluminium alloys- Extruded precision profiles in alloys EN AW 6060/EN AW 6063- Part 2: Tolerances on dimensions and form.

Table 8: Reference Standards for Aluminium and Aluminium Alloy Wire (Replaces BS 1475: 1972)

BS EN 1301-1: 1997	Aluminium and aluminium alloys- Drawn wire- Part 1: Technical conditions for inspection and delivery.
BS EN 1301-2: 1997	Aluminium and aluminium alloys- Drawn wire- Part 2: Mechanical properties.
BS EN 1301-3: 1997	Aluminium and aluminium alloys- Drawn wire-Part 3: Tolerances on dimensions.

Table 9: Reference Standards for Aluminium and Aluminium Alloy Ingots and Castings for General Engineering Purposes. (Replaces BS 1490: 1988)

BS EN 1559-1: 1997	Founding- Technical conditions of delivery- Part 1: General.
EN 1559-4:	Founding- Technical conditions of delivery- Part 4: Additional requirements for aluminium castings (under preparation).
BS EN 1676: 1997	Aluminium and aluminium alloys- Alloyed ingots for remelting- Specifications.
BS EN 1706: 1998	Aluminium and aluminium alloys- Castings- Chemical composition and mechanical properties.

Table 10: Reference Standards for Aluminium and Aluminium Alloy Longitudinally Welded Tube. (Replaces BS 4300-1: 1967)

BS EN 1592-1: 1998	Aluminium and aluminium alloys- HF seamwelded tubes- Part 1: Technical conditions for inspection and delivery.
BS EN 1592-2: 1998	Aluminium and aluminium alloys- HF seamwelded tubes- Part 2: Mechanical properties.
BS EN 1592-3: 1998	Aluminium and aluminium alloys- HF seamwelded tubes- Part 3: Tolerances on dimensions and form of circular tubes.
BS EN 1592-4: 1998	Aluminium and aluminium alloys- HF seam welded tubes- Part 4: Tolerances on dimensions and form for square, rectangular and shaped tubes.

Table 11: Reference Standards for Aluminium and Aluminium Alloy Solid Extruded Bars and Sections suitable for bright trim/reflector applications. (Replaces BS 4300-4: 1973)

BS EN 755-1: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 1: Technical conditions for inspection and delivery.
BS EN 755-2: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 2: Mechanical properties.

Table 11: Reference Standards for Aluminium and Aluminium Alloy Solid Extruded Bars and Sections suitable for bright trim/reflector applications. (Replaces BS 4300-4: 1973) (Cont'd)

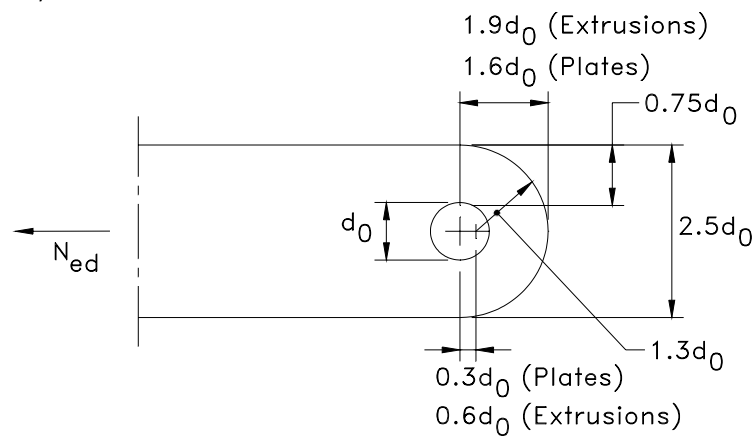
BSEN 755-3: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 3: Round bars, tolerances on dimensions and form.
BS EN 755-4: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 4: Square bars, tolerances on dimensions and form.
BS EN 755-5: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 5: Rectangular bars, tolerances on dimensions and form.
BS EN 755-6: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 6: Hexagonal bars, tolerances on dimensions and form.
EN 755-9	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 9: Profile, tolerances on dimensions and form.

Table 12: Reference Standards for Aluminium and Aluminium Alloy Free Cutting Bar and Wire. (Replaces BS 4300-5: 1973).

BS EN 754-1: 1997	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 1: Technical conditions for inspection and delivery.
BS EN 754-2: 1997	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 2: Mechanical properties.
BS EN 754-3: 1996	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 3: Round bars, tolerances on dimensions and form.
BS EN 754-6: 1996	Aluminium and aluminium alloys- Cold drawn rod/bar and tube- Part 6: Hexagonal bars, tolerances on dimensions and form.
BS EN 755-1: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tubes and profiles- Part 1: Technical conditions for inspection and delivery.
BS EN 755-2: 1997	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 2: Mechanical properties.
BS EN 755-3: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 3: Round bars, tolerances on dimensions and form.
BS EN 755-6: 1996	Aluminium and aluminium alloys- Extruded rod/bar, tube and profiles- Part 6: Hexagonal bars, tolerances on dimensions and form.

FIGURE 1.0 Geometrical conditions in pin connections

Given geometry



$$t \geq 0.7 \left[\frac{N_{ed} Y_{mp}}{f_u} \right]^{\frac{1}{2}} : d_0 \leq 2.5t$$

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Descriptors: civil engineering, steel construction, aluminium, design, building codes, computation, generalities

English version

Eurocode 9: Design of aluminium structures - Part 1-1: General rules - General rules and rules for buildings

Eurocode 9: Conception et dimensionnement des structures en aluminium - Partie 1-1: Règles générales - Règles générales et règles pour les bâtiments

Eurocode 9: Bemessung und Konstruktion von Aluminiumbauten - Teil 1-1: Allgemeine Regeln - Allgemeine Bemessungsregeln und Bemessungsregeln für den Hochbau

This European Prestandard (ENV) was approved by CEN on 26 October 1997 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 a European Standard.

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, Czech Republic, Denmark, Finland, France, Germany, Greece, Iceland, Ireland, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland and United Kingdom.



EUROPEAN COMMITTEE FOR STANDARDIZATION
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EUROPÄISCHES KOMITEE FÜR NORMUNG

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Contents

Foreword	5
1 General	8
1.1 Scope	8
1.2 Distinction between principles and application rules	8
1.3 Normative references	9
1.4 Assumptions	13
1.5 Definitions	13
1.6 SI units	16
1.7 Symbols used in this European Prestandard	16
2 Basis of Design	22
2.1 Fundamental requirements	22
2.2 Definitions and classifications	22
2.3 Design requirements	26
2.4 Durability	28
2.5 Fire resistance	28
3 Materials	29
3.1 General	29
3.2 Structural aluminium	29
3.3 Connecting devices	35
3.4 Durability and corrosion protection	39
3.5 Selection criteria for aluminium alloys	43
4 Serviceability Limit States	45
4.1 Basis	45
4.2 Deflections	45
4.3 Vibrations	47
4.4 Dynamic effects	47
5 Ultimate Limit States (Members)	48
5.1 Basis	48
5.2 Calculation of internal actions	50
5.3 Resistance of cross sections	50
5.4 Classification of cross sections	53
5.5 HAZ softening adjacent to welds	59
5.6 Resistance of beams	62
5.7 Resistance of tension members	70
5.8 Resistance of compression members	70
5.9 Resistance of members with axial force and biaxial bending	80
5.10 Resistance of unstiffened plates	86
5.11 Resistance of stiffened plates	90
5.12 Resistance of plate girders	98
6 Connections Subject to Static Loading	111
6.1 Basis for bolted, riveted and welded connections	111
6.2 Intersections (also valid for welded connections)	112



6.3	Joints loaded in shear subject to vibrations and/or load reversal	112
6.4	Classification of connections	113
6.5	Connections made with bolts, rivets or pins	118
6.6	Welded connections	133
6.7	Hybrid connections	141
6.8	Adhesive bonded connections	141
7	Fabrication and Execution	145
7.1	General	145
7.2	Project specification	145
7.3	Preparation of material	146
7.4	Bolted connection	148
7.5	Welding	149
7.6	Structural adhesives	152
7.7	Protection	152
7.8	Inspection and safety	156
8	Design Assisted by Testing	157
8.1	Basis	157
8.2	Planning of tests	157
8.3	Execution of Tests	158
8.4	Test evaluation	158
8.5	Documentation	158
Annex A:	(normative) Test of Slip Factor	159
A.1	The purpose of testing	159
A.2	Significant variables	159
A.3	Test specimens	159
A.4	Test procedure	160
A.5	Extended creep test	160
A.6	Test results	160
Annex B:	(informative) Materials Selection.	163
B.1	General	163
B.2	Wrought products	163
B.3	Cast products	167
Annex C:	(informative) Calculation of Internal Forces and Moments	168
C.1	Global analysis	168
C.2	Design assumptions	171
C.3	Structural system	172
C.4	Allowance for imperfections	173
C.5	Sway stability	174
Annex D:	(informative) Methods of Global Analysis	180
D.1	General	180
D.2	Assessment of ductility demand	181
D.3	Application of plastic hinge methods	182

Annex E: (informative) Analytical Models for Stress Strain Relationship	187
E.1 Scope	187
E.2 Analytical models	187
Annex F: (informative) Frame Stability	194
F.1 General	194
F.2 Elastic analysis of sway frames	195
F.3 Plastic analysis of sway frames	195
F.4 Column requirements for plastic analysis (without or with hardening)	195
Annex G: (informative) Behavior of Cross Sections Beyond Elastic Limit	197
G.1 General	197
G.2 Definition of cross-section limit states	197
G.3 Classification of cross-section according to limit states	197
G.4 Evaluation of ultimate axial load	198
G.5 Evaluation of bending moment	199
G.6 Prediction of rotation capacity	200
Annex H: (informative) Lateral Torsional Buckling	202
H.1 Elastic critical moment and slenderness	202
H.2 Slenderness	206
Annex J: (informative) Torsional Properties of Thin-Walled Sections	210
J.1 Torsion constant	210
J.2 Position of shear center	210
J.3 Warping constant	210

Foreword

Objectives of the Eurocodes

The Structural Eurocodes comprise a group of standards for the structural and geo-technical design of buildings and civil engineering works.

They are intended to serve as reference documents for the following purposes:

- As a means to prove compliance of building and civil engineering works with the essential requirements of the Construction Products Directive (CPD)
- As a framework for drawing up harmonized technical specifications for construction products.

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.

Until the necessary set of harmonized 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

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".

In 1990, after consulting their respective Member States, the CEC transferred the work of further development, issue and updates of the Structural Eurocodes to CEN, and the EFTA Secretariat agreed to support the CEN work.

CEN Technical Committee CEN/TC 250 is responsible for all Structural Eurocodes.

Eurocode programme

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	Geo-technical design
EN 1998	Eurocode 8	Design of structures for earthquake resistance
EN 1999	Eurocode 9	Design of aluminium structures

Separate sub-committees have been formed by CEN/TC 250 for the various Eurocodes listed above.

This part of the Structural Eurocode for Design of Aluminium Structures, is being issued by CEN as a European Prestandard (ENV) with an initial life of three years.

This Prestandard is intended for experimental practical application in the design of the building and civil engineering works covered by the scope as given in 1.1.2 and for the submission of comments.

After approximately two years CEN members will be invited to submit formal comments to be taken into account in determining future action.

Meanwhile feedback and comments on this Prestandard should be sent to Secretariat of sub-committee CEN/TC 250/SC 9 at the following address:

Secretariat of CEN/TC 250/SC 9
c/o Norwegian Council for Building Standardization
Postboks 129 Blindern
N - 0314 OSLO

or to your national standards organization.

National Application Documents

In view of the responsibilities of authorities in member countries for the safety, health and other matters covered by the essential requirements of the CPD, certain safety elements in this ENV have been assigned indicative values which are identified by ☐. The authorities in each member country are expected to assign definitive values to these safety elements.

Many of the harmonized supporting standards will not be available by the time this Prestandard is issued. It is therefore anticipated that a National Application Document (NAD) giving definitive values for safety elements, referencing compatible supporting standards and providing national guidance on the application of this Prestandard, will be issued by each member country or its Standards Organization.

It is intended that this Prestandard is used in conjunction with the NAD valid in the country where the building or civil engineering works are located.

Matters specific to this Prestandard

General

The scope of Eurocode 9 is defined in 1.1.1 and the scope of this Part of Eurocode 9 is defined in 1.1.2.

In using this Prestandard in practice, particular regard should be paid to the underlying assumptions and conditions given in 1.4.

In developing this Prestandard, background documents have been prepared, which give commentaries on, and justifications for, some of the provisions in the Prestandard.

Use of Annexes

The eight sections of this Prestandard are complemented by a number of Annexes, some normative and some informative.

The normative Annexes have the same status as the sections to which they relate. Most have been introduced by moving some of the more detailed Application Rules, which are needed only in particular cases, out of the main part of the text to aid its clarity.

Concept of Reference Standards

When using this Prestandard reference needs to be made to various CEN and ISO standards. These are used to define the product characteristics and processes which have been assumed to apply in formulating the design rules.

This Prestandard mentions certain "Reference Standards". Where any referenced CEN or ISO standard is not yet available, the National Application Document should be consulted for the standard to be used instead. It is assumed that only those grades and qualities given in section 3 will be used for buildings and civil engineering works designed to this European Prestandard.

Partial safety factors

This Prestandard gives general rules for the design of aluminium structures which relate to limit states of members such as fracture in tension, failure by instability phenomena or fracture of the connections.

Most of the rules have been calibrated against test results in order to obtain consistent values of the partial safety factors for resistance γ_M .

In order to avoid a large variety of γ_M values, two categories were selected:

- γ_{M1} is to be applied to resistance related to the 0,2 % proof strength $f_{0,2}$ (e.g. for all instability phenomena)
- γ_{M2} is to be applied to resistance related to the ultimate tensile stress f_u (e.g. net section strength in tension or bolt and weld resistances).

Fabrication and execution

Section 7 of this Prestandard is intended to indicate some minimum standards of workmanship and normal tolerances that have been assumed in deriving the design rules given in the Prestandard.

It also indicates to the designer the information relating to a particular structure that needs to be supplied in order to define the execution requirements.

In addition it defines normal clearances and other practical details which the designer needs to use in calculations.

Design assisted by testing

Section 8 is not required in the course of routine design, but is provided for use in the special circumstances in which it may become appropriate.

1 General

1.1 Scope

1.1.1 Scope of ENV 1999 Eurocode 9

- (1) ENV 1999 Eurocode 9 applies to the design of buildings, civil and structural engineering works in aluminium. It is subdivided into various separate parts, see 1.1.2.
- (2) This Eurocode is only concerned with the requirements for resistance, serviceability and durability of structures. Other requirements, e.g. concerning thermal or sound insulation, are not considered.
- (3) Execution is covered to the extent that is necessary to indicate the quality of the construction material and products which should be used and the standard of workmanship on site needed to comply with the assumptions of the design rules. Generally, the rules related to execution and workmanship are to be considered as minimum requirements which may have to be further developed for particular types of buildings or civil and structural engineering works and methods of construction.
- (4) ENV 1999 Eurocode 9 does not cover the special requirements of seismic design.
- (5) Numerical values of the actions on buildings and civil and structural engineering works to be taken into account in the design are not given in ENV 1999 Eurocode 9. They are provided in ENV 1991 Eurocode 1 "Basis of design and actions on structures" which is applicable to all types of construction.

1.1.2 Scope of Part 1.1 of ENV 1999 Eurocode 9

- (1) This European Prestandard gives a general basis for the design of buildings and civil and structural engineering works in aluminium alloy.
- (2) The following subjects are dealt with in this initial version of this European Prestandard.
 - Section 1: General
 - Section 2: Basis of design
 - Section 3: Materials
 - Section 4: Serviceability limit states
 - Section 5: Ultimate limit states (members)
 - Section 6: Connections subject to static loading
 - Section 7: Fabrication and execution
 - Section 8: Design assisted by testing
- (3) Most of the contents of Section 1 and Section 2 are common to all Structural Eurocodes, with the exception of some additional clauses which are specific to individual Eurocodes.
- (4) This European Prestandard does not cover:
 - resistance to fire;
 - cases where special measures may be necessary to limit the consequences of accidents;
 - fatigue.

1.2 Distinction between Principles and Application Rules

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

(2) The Principles comprise:

- general statements and definitions for which there is no alternative, as well as
- 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) The Application Rules are generally recognised rules which follow the Principles and satisfy their requirements.

(5) It is permissible to use alternative design rules different from the Application Rules given in the Eurocode, provided that it is shown that the alternative rule accords with the relevant Principles and is at least equivalent with regard to the resistance, serviceability and durability achieved by the structure.

(6) In this Eurocode the Application Rules are identified by a number in brackets, as in this paragraph.

1.3 Normative references

(1)P This European prestandard incorporates, by dated or undated reference, provisions from other publications. These normative references are cited at the appropriate places in the text and the publications are listed below. For undated references the latest edition of the publication referred to applies.

1.3.1 References on aluminium alloys

1.3.1.1 Chemical composition, form and temper definition of wrought products

EN 573-1:1994	Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 1: Numerical designation system.
EN 573-2:1994	Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 2: Chemical symbol based designation system
EN 573-3:1994	Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 3: Chemical compositions
EN 573-4:1994	Aluminium and aluminium alloys - Chemical composition and form of wrought products - Part 4: Forms of products
EN 515:1993	Aluminium and aluminium alloys - Wrought products - Temper designations

1.3.1.2 Technical delivery conditions

EN 485-1:1993	Aluminium and aluminium alloys - Sheet, strip and plate - Part 1: Technical conditions for inspection and delivery
prEN 586-1:1996	Aluminium and aluminium alloys - Forgings - Part 1: Technical conditions for inspection and delivery
prEN 754-1:1996	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 1: Technical conditions for inspection and delivery
prEN 755-1:1996	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 1: Technical conditions for inspection and delivery
prEN 1592-1:1996	Aluminium and aluminium alloys - HF seam welded tubes - Part 1: Technical conditions for inspection and delivery

prEN 12020-1:1995 Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063- Part 1: Technical conditions for inspection and delivery

1.3.1.3 Dimensions and mechanical properties

EN 485-2:1994	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 485-3:1993	Aluminium and aluminium alloys - Sheet, strip and plate - Part 3: Tolerances on shape and dimensions for hot-rolled products
EN 485-4:1993	Aluminium and aluminium alloys - Sheet, strip and plate - Part 4: Tolerances on shape and dimensions for cold-rolled products
prEN 508-2:1996	Roofing products from metal sheet - Specifications for self supporting products of steel, aluminium or stainless steel - Part 2: Aluminium
EN 586-2:1994	Aluminium and aluminium alloys - Forgings - Part 2: Mechanical properties and additional property requirements
prEN 586-3:1996	Aluminium and aluminium alloys - Forgings - Part 3: Tolerances on dimension and form
prEN 754-2:1996	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 2: Mechanical properties
EN 754-3:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 3: Round bars, tolerances on dimension and form
EN 754-4:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 4: Square bars, tolerances on dimension and form
EN 754-5:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 5: Rectangular bars, tolerances on dimension and form
EN 754-6:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 6: Hexagonal bars, tolerances on dimension and form
prEN 754-7:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 7: Seamless tubes, tolerances on dimension and form
prEN 754-8:1995	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 8: Porthole tubes, tolerances on dimension and form
prEN 755-2:1996	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 2: Mechanical properties
EN 755-3:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 3: Round bars, tolerances on dimension and form
EN 755-4:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 4: Square bars, tolerances on dimension and form
EN 755-5:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 5: Rectangular bars, tolerances on dimension and form

EN 755-6:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 6: Hexagonal bars, tolerances on dimension and form
prEN 755-7:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 7: Seamless tubes, tolerances on dimension and form
prEN 755-8:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 8: Porthole tubes, tolerances on dimension and form
prEN 755-9:1995	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 9: Profiles, tolerances on dimension and form
prEN 12020-2:1995	Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063- Part 2: Tolerances on dimensions and form
prEN 1592-2:1994	Aluminium and aluminium alloys - HF seam welded tubes - Part 2: - Mechanical properties
prEN 1592-3:1994	Aluminium and aluminium alloys - HF seam welded tubes - Part 3: - Tolerance on dimensions and shape of circular tubes
prEN 1592-4:1994	Aluminium and aluminium alloys - HF seam welded tubes - Part 4: - Tolerance on dimensions and form for square, rectangular and shaped tubes

1.3.1.4 Aluminium alloy castings

prEN 1559-1	Founding - Technical conditions of delivery - Part 1: General
prEN 1559-2	Founding - Technical conditions of delivery - Part 4: Additional requirements for aluminium alloy castings
prEN 1706:1993	Aluminium and aluminium alloys - Castings - Chemical composition and mechanical properties
prEN190/120	Castings - System of dimensional tolerances and machining allowances

1.3.2 References on welding

EN 287-2:1992	Approval testing of welders - Fusion welding - Part 2: Aluminium and aluminium alloys
EN 288-1:1992	Specification and approval of welding procedures for metallic materials - Part 1: General rules for fusion welding
EN 288-4:1992	Specification and approval of welding procedures for metallic materials - Part 4: Welding procedure tests for the arc welding of aluminium and its alloys
prEN 288-13	Specification and approval of welding procedures for metallic materials - Part 13: Welding procedure test for the arc welding of cast aluminium and combinations of cast to wrought materials
EN 439:1994	Welding consumables - Shielding gases for arc welding and cutting.
prEN 970	Non destructive examination of welds - Visual examination
prEN 1011-1	Welding - Fusion welding of metallic materials - Part 1: General

prEN 1011-4	Requirements for fusion welding of metallic materials - Part 4: Aluminium and aluminium alloys
prEN 1418	Welding personnel. Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanised and automatic welding of metallic materials
EN 30042:1994	Arc-welded joints in aluminium and its weldable alloys - Guidance on quality levels for imperfections
prEN (WI 121127)	Welding consumables - Wire electrodes, wires and rods for arc welding of aluminium and aluminium alloys. Classification
prEN (WI 121214)	Welding consumables - Covered electrodes for manual metal arc welding of aluminium and aluminium alloys. Classification

1.3.3 Other references

ENV 1991-1: 1994	Eurocode 1 - Basis of design and actions on structures - Part 1: Basis of design
ENV 1991-2-1: 1995	Eurocode 1 - Basis of design and actions on structures - Part 2.1: Actions on structures - Densities, self-weight and imposed loads
ENV 1991-2-2: 1994	Eurocode 1 - Basis of design and actions on structures - Part 2.2: Actions on structures imposed to fire
ENV 1991-2-3: 1995	Eurocode 1 - Basis of design and actions on structures - Part 2.3: Actions on structures - Snow loads
ENV 1991-2-4: 1995	Eurocode 1 - Basis of design and actions on structures - Part 2.4: Actions on structures - Wind actions
ENV 1993-1-1: 1992	Eurocode 3: Design of steel structures - Part 1.1: General rules and rules for buildings
ENV 1999-1-2	Eurocode 9: Design of aluminium structures - Part 1.2: Structural fire design
ENV 1999-2	Eurocode 9: Design of aluminium structures Part 2: Structures susceptible to fatigue
ISO 1000:1981	SI units and recommendations for the use of their multiples and of certain other units
ISO 8930:1987	General principles on reliability for structures - List of equivalent terms
ISO 468:1982	Surface roughness. Parameters, their values and general rules for specifying requirements
ISO 11003-1:1993	Adhesives Determination of shear behaviour of structural bonds Part 1: Torsion test method using butt-bonded hollow cylinders
ISO 11003-2:1993	Adhesives Determination of shear behaviour of structural bonds Part 2: Thick-adherend tensile-test method
ISO 468:1982	Surface roughness .Parameters, their values and general rules for specifying requirement
ISO 1302:1992	Technical drawings. Method of indicating surface texture

1.4 Assumptions

(1) The following assumptions apply:

- Structures are designed by appropriately qualified and experienced personnel.
- Adequate supervision and quality control is provided in factories, in plants and on site.
- Construction is carried out by personnel having the appropriate skill and experience.
- The construction materials and products are used as specified in this Eurocode or in the relevant material or product specifications.
- The structure will be adequately maintained (see clause 7.7).
- The structure will be used in accordance with the design brief.

(2) The design procedures are valid only when the requirements for execution and workmanship given in Section 7 are also complied with.

(3) Numerical values identified by $\square$ are given as indications. Other values may be specified by Member Countries.

1.5 Definitions

1.5.1 Terms common to all Structural Eurocodes

(1) Unless otherwise in the following, the terminology used in normative reference ISO 8930: 1987 applies.

(2) The following terms are used in common for all structural Eurocodes with the following meanings:

- **construction works:** Everything that is constructed or results from construction operations. This term covers both building, civil and structural engineering works. It refers to the complete construction comprising both structural and non-structural elements.

- **execution:** The activity of creating a building or civil or structural engineering works. The term covers work on site; it may also signify the fabrication of components off site and their subsequent erection on site.

Note: In English "construction" may be used instead of "execution" in certain combinations of words where there is no ambiguity (e.g. "during construction").

- **structure:** Organised combination of connected parts designed to provide some measure of rigidity and strength. This term refers to load carrying parts.

- **type of building or civil and structural engineering works:** Type of "construction works" designating its intended purpose, e.g. dwelling house, industrial building, road bridge, railway carriage, road vehicle, waterborne structure, mast or tower.

Note: "type of construction works" is not used in English.

- **form of structure:** Structural type designating the arrangement of structural elements, e.g. beam, triangulated structure, tubular structure, arch.

- **construction material:** A material used in construction work, e.g. concrete, steel, timber, masonry, aluminium.

- **type of construction:** Indication of principal structural material, e.g. reinforced concrete construction, steel construction, timber construction, masonry construction, aluminium construction.

- **method of construction:** Manner in which the construction will be carried out, e.g. site welded, prefabricated, cantilevered.

- **structural system:** The load bearing elements of a building or civil or structural engineering work and the way in which these elements are assumed to function, for the purpose of modelling.

(3) The equivalent terms in various languages are given in table 1.1.

Table 1.1: List of equivalent terms in various languages

English	Francais	Deutsch
Construction works	Construction	Bauwerk
Execution	Exécution	(Bau)-Ausführung
Structure	Structure	Tragwerk
Type of building or civil engineering works	Nature de construction	Art des Bauwerks
Form of structure	Type de structure	Art des Tragwerks
Construction material	Matériau de construction	Baustoff; Werkstoff*) (* nur im Stahlbau)
Type of construction	Mode de construction	Bauweise
Method of construction	Procédé d'exécution	Bauverfahren
Structural system	Système structural	Tragsystem

Table 1.1: List of equivalent terms in various languages (continued)

Italiano	Dutch	Espanol
Costruzione	Bouwwerk	Construcción
Esecuzione	Uitvoering	Ejecución
Struttura	Draagconstructie	Estructura
Tipo di Costruzione	Type Bouwwerk	Natureleza de la construcción
Tipo di struttura	Type draagconstructie	Tipo de estructura
Materiale da costruzione	Constructie materiaal	Material de construcción
Sistema costruttivo	Bouwwijze	Modo de construcción
Procedimento esecutivo	Bouwmethode	Procedimiento de ejecución
Sistema strutturale	constructief systeem	Sistema estructural

Table 1.1: List of equivalent terms in various languages (continued)

Portuguese	Swedish	Norwegian
Construção	Byggnadsverk	Byggverk
Execução	Utförande	Utførelse
Estrutura	Bärverk	Bærende konstruksjon
Tipo de edificio ou de obras de engenharia civil	Typ av byggnadsverk	Type byggverk
Tipo de estrutura	Typ av bärverk	Konstruksjonsform
Material de construção	Byggmaterial	Byggemateriale
Tipo de construção	Typ av konstruktion med avseende på material	Konstruksjonstype (etter hovedmateriale)
Processo construtivo	Byggnadssätt	Utførelsesmetode
Sistema estrutural	Bärande system	Bærende system

Table 1.1: List of equivalent terms in various languages (continued)

Suomi	Danish	Ελληνικά
Rakennuskohde	Bygge- og anlægsarbejde	Κατασκευές
Työnsuoritus	Udførelse	Εκτέλεση έργου
Rakenne	Bærende konstruktion	Κατασκευή
Rakennuksen tai maa- ja vesirakennuskohteen tyyppi	Arten af bygge- og anlægsarbejde	Είδος κατασκευής
Rakenteen muoto	Konstruktionsprincip	Είδος ξορέα
Rakennusmateriaali	Konstruktionsmateriale	Υλικο κατασκευής
Rakenteen materiaali	Konstruktionstype	Τροπος εκτελεσης
Rakentamistapa	Udførelsesmetode	Μεθοδος εκτέλεσης
Rakennejärjestelmä	Bærende system	Φορέας

1.6 S.I. units

(1) S.I. units shall be used in accordance with ISO 1000: 1981.

(2) For calculations, the following units are recommended:

- Forces and loads: kN, kN/m, kN/m²
- unit mass: kg/m³
- unit weight: kN/m³
- stresses and strengths: N/mm² (= MN/m² or MPa)
- moments (bending ...): kNm.

1.7 Symbols used in this European Prestandard

1.7.1 Latin upper case letters

<i>A</i>	Accidental action; Area
<i>B</i>	Bolt force
<i>C</i>	Capacity; Fixed value, Factor
<i>D</i>	Damage (fatigue assessment)
<i>E</i>	Modulus of elasticity
<i>F</i>	Action
<i>F</i>	Force
<i>G</i>	Permanent action
<i>G</i>	Shear modulus
<i>H</i>	Total horizontal load or reaction
<i>I</i>	Second moment of area
<i>K</i>	Stiffness factor (<i>I/L</i>)
<i>L</i>	Length; Span; System length
<i>M</i>	Moment in general
<i>M</i>	Bending moment
<i>N</i>	Axial force
<i>Q</i>	Variable action
<i>R</i>	Resistance, Reaction
<i>S</i>	Internal forces and moments (with subscripts <i>d</i> or <i>k</i>)
<i>S</i>	Stiffness (shear, rotational ... stiffness with subscripts <i>v, j</i> ...)
<i>T</i>	Torsional moment; Temperature
<i>V</i>	Shear force, Total vertical load or reaction
<i>W</i>	Section modulus
<i>X</i>	Value of a property of a material

1.7.2 Greek upper case letters

Δ Difference in ... (precedes main symbol)

1.7.3 Latin lower case letters

<i>a</i>	Distance; Geometrical data
<i>a</i>	Throat thickness of a weld; Area ratio
<i>b</i>	Width; Breadth
<i>c</i>	Distance; Outstand
<i>d</i>	Diameter; Depth; Length of diagonal
<i>e</i>	Eccentricity; Shift of centroidal axis
<i>e</i>	Edge distance; End distance
<i>f</i>	Strength (of a material)
<i>g</i>	Gap; Stress gradient coefficient

h	Height
i	Radius of gyration; Integer
k	Coefficient; Factor
l (or ℓ or L)	Length; Span; System length
n	Ratio of normal forces or normal stresses
n	Number of ...
p	Pitch; Spacing
q	Uniformly distributed force
r	Radius; Root radius
s	Staggered pitch, Distance
t	Thickness
u, v, w	Components of deflection
uu	Major axis
vv	Minor axis
xx, yy, zz	Rectangular axes

1.7.4 Greek lower case letters

α (alpha)	Angle; Ratio; Factor
α	Coefficient of linear thermal expansion
β (beta)	Angle; Ratio; Factor
γ (gamma)	Partial safety factor, Ratio
ε (epsilon)	Strain;
η (eta)	Coefficient
ϑ (theta)	Angle; Slope
λ (lambda)	Slenderness ratio; Ratio
μ (mu)	Slip factor; Factor
ν (nu)	Poisson's ratio
ρ (rho)	Reduction factor; Unit mass
σ (sigma)	Normal stress
τ (tau)	Shear stress
Φ (phi)	Rotation; Slope; Ratio
χ (chi)	Reduction factor (for buckling)
ψ (psi)	Stress ratio, Reduction factor
ψ	Factors defining representative values of variable actions

1.7.5 Subscripts

A	Accidental; Area
a	Local capacity of a net section in tension or compression
$a, b, \dots$	First, second ... alternative
b	Bearing, Buckling
b	Bolt; Beam; Batten
C	Capacity; Consequences
c	Cross section
c	Concrete; column
com	Compression
cr	Critical
d	Design; Diagonal
dst	Destabilizing
E	Effect of actions (with d or k)
E	Euler
eff	Effective
e	Effective (with further subscript)
el	Elastic
ext	External

<i>f</i>	Flange; Fastener
<i>fic</i>	Fictitious
<i>g</i> (or <i>gr</i>)	Gross
<i>G</i>	Permanent action
<i>h</i>	Height; Higher; Horizontal
<i>haz</i>	Heat Affected Zone
<i>i</i>	Inner
<i>inf</i>	Inferior; Lower
<i>i, j, k</i>	Indices (replace by numeral)
<i>j</i>	Joint
<i>k</i>	Characteristic
<i>l</i>	Lower
<i>L</i>	Long
<i>LT</i>	Lateral-torsional
<i>M</i>	Material
<i>M</i>	(Allowing for) bending moment
<i>m</i>	Bending; Mean
<i>max</i>	Maximum
<i>min</i>	Minimum
<i>N</i>	(Allowing for) axial force
<i>n</i>	Normal
<i>net</i>	Net
<i>nom</i>	Nominal
<i>o</i>	Hole; Initial, Outer;
<i>o</i>	Overall yielding in tension and compression
<i>o</i>	Point of zero moment
<i>ov</i>	Overlap
<i>p</i>	Plate; Pin; Packing
<i>p</i>	Preloading (force)
<i>p</i>	Partial; Punching shear
<i>pl</i>	Plastic
<i>Q</i>	Variable action
<i>R</i>	Resistance
<i>r</i>	Rivet; Restraint
<i>rep</i>	Representative
<i>S</i>	Internal force; Internal moment
<i>s</i>	Tensile stress (area); overall buckling stability
<i>s</i>	Slip; Storey;
<i>st</i>	Stiff; Stiffener
<i>ser</i>	Serviceability
<i>stb</i>	Stabilizing
<i>sup</i>	Superior; Upper
<i>t</i> (or <i>ten</i>)	Tension, Tensile
<i>t</i> (or <i>tor</i>)	Torsion
<i>u</i>	Major axis of cross-section
<i>u</i>	Ultimate (tensile strength)
<i>ult</i>	Ultimate (limit state)
<i>V</i>	(Allowing for) shear force
<i>v</i>	Shear; Vertical
<i>v</i>	Minor axis of cross-section
<i>vec</i>	Vectorial effects
<i>w</i>	Web; Weld; Warping
<i>x</i>	Axis along member; Extension
<i>y</i>	Axis of cross-section
<i>z</i>	Axis of cross-section
σ	Normal stress

τ	Shear stress
$\perp$	Perpendicular
$\parallel$	Parallel
0,2	0,2 % proof strength

1.7.6 Use of subscripts in this European Prestandard

(1) Strengths and properties of aluminium alloy materials are nominal values, treated as characteristic values but written as below:

$f_{0,2}$	proof strength, simplified notation: f_0
f_{haz}	heat affected zone strength
f_u	ultimate strength
E	modulus of elasticity

(2) To avoid ambiguity, subscripts are given in full in this European Prestandard, but some may be omitted in practice where ambiguity is not caused by their omission.

(3) Where symbols with multiple subscripts are needed, they have been assembled in the following sequence:

- main parameter: e.g. M, N, β
- variant type: e.g. pl, eff, b, c
- sense: e.g. t, v
- axis: e.g. y, z
- location: e.g. 1, 2, 3
- nature: e.g. R, E
- level: e.g. d, k
- index: e.g. 1, 2, 3

(4) Commas are used to separate subscripts into pairs of characters, except as follows:

- Subscripts with more than one character are not sub-divided.
- Example: combinations Rd, Sd etc are not sub-divided.

(5) Where two variant type subscripts are needed to describe a parameter, they may be separated by a comma:

e.g. M, ψ

1.7.7 Conventions for member axes

(1) In general the convention for member axes is:

- $x-x$ - along the member
- $y-y$ - axis of the cross-section
- $z-z$ - axis of the cross-section

(2) For aluminium alloy I members, the conventions used for cross-section axes are:

- generally:

- $y-y$ - cross-section axis parallel to the flanges
- $z-z$ - cross-section axis perpendicular to the flanges

- for angle sections:

- $y-y$ - axis parallel to the smaller leg
- $z-z$ - axis perpendicular to the smaller leg

- where necessary:

- $u-u$ - major axis (where this does not coincide with the yy axis)
- $v-v$ - minor axis (where this does not coincide with the zz axis)

(3) A selection of aluminium alloy extruded sections is given in figure 1.1.

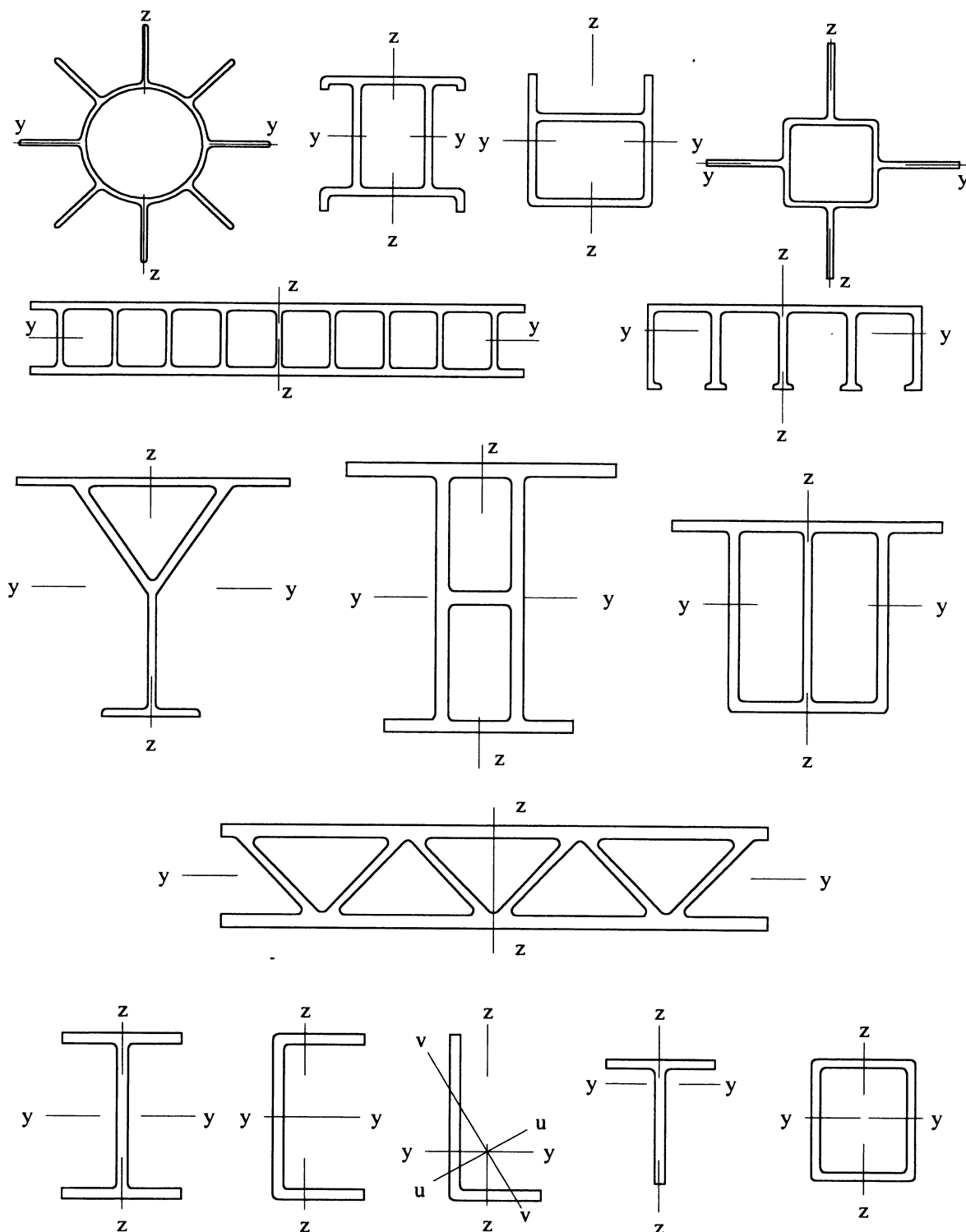


Figure 1.1: Aluminium alloy sections

(4) The convention used for subscripts which indicate axes for moments is:
"Use the axis about which the moment acts."

(5) For example, for an I-section a moment acting in the plane of the web is denoted by M_y because it acts about the cross-section axis parallel to the flanges.

2 Basis of Design

2.1 Fundamental requirements

(1)P A structure shall be designed and constructed in such a way that:

- with acceptable probability, it will remain fit for the use for which it is required, having due regard to its intended life and its cost, and
- with appropriate degrees of reliability, it will sustain all actions and other influences likely to occur during execution and use and have adequate durability in relation to maintenance costs.

(2)P A structure shall also be designed in such a way that it will not be damaged by events like explosions, impact or consequences of human errors, to an extent disproportionate to the original cause.

(3)P The potential damage shall be limited or avoided by appropriate choice of one or more of the following:

- avoiding, eliminating or reducing the hazards which the structure is to sustain
- selecting a structural form which has low sensitivity to the hazards considered
- tying the structure together
- selecting a structural form and design that can survive adequately the accidental removal of an individual element.

(4)P The above requirements shall be met by the choice of suitable materials, by appropriate design and detailing and by specifying control procedures for production, construction and use as relevant for the particular project.

2.2 Definitions and classifications

2.2.1 Limit states and design situations

2.2.1.1 Limit states

(1)P Limit states are states beyond which the structure no longer satisfies the design performance requirements. Limit states are classified into:

- ultimate limit states
- serviceability limit states.

(2)P Ultimate limit states are those associated with collapse, or with other forms of structural failure which may endanger the safety of people.

(3)P States prior to structural collapse which, for simplicity, are considered in place of the collapse itself are also classified and treated as ultimate limit states.

(4)P Ultimate limit states which shall require consideration include:

- loss of equilibrium of the structure or any part of it, considered as a rigid body,
- failure by excessive deformation, rupture, or loss of stability of the structure or any part of it, including supports and foundations.

(5) Serviceability limit states correspond to states beyond which specified service criteria are no longer met.

(6) Serviceability limit states which may require consideration include:

- deformations or deflections which adversely affect the appearance or effective use of the structure (including the proper functioning of machines or services) or cause damage to finishes or non-structural elements
- vibration which causes discomfort to people, damage to the building or its contents, or which limits its functional effectiveness.

2.2.1.2 Design situations

(1) Design situations are classified as:

- persistent situations corresponding to normal conditions of use of the structure
- transient situations, for example during construction or repair
- accidental situations. Accidental situations include exceptional situations that may not be the result of an accident.

2.2.2 Actions

2.2.2.1 Definitions and principal classifications¹

(1)P An action (F) is:

- a force (load) applied to the structure (direct action), or
- an imposed deformation (indirect action); for example, temperature effects or settlement.

(2)P Actions are classified:

a) by their variation in time:

- permanent actions (G), e.g. self-weight of structures, fittings, ancillaries and fixed equipment
- variable actions (Q), e.g. imposed loads, vehicle loads, wind loads, snow loads, wave loads
- accidental actions (A), e.g. explosions, impact from flying masses, impact from collisions.

b) by their spatial variation:

- fixed actions, eg self-weight (but see 2.3.2.3(2) for structures very sensitive to variations in self-weight)
- free actions, which result in different arrangements of actions, eg movable imposed loads, wind loads, snow loads, wave loads.

(3) Supplementary classifications relating to the response of the structure are given in the relevant clauses.

2.2.2.2 Characteristic values of actions

(1)P Characteristic values F_k are specified:

- in Eurocode 1 Part 2 (ENV 1991-2-1, ENV 1991-2-2, ENV 1991-2-3, ENV 1991-2-4) or other relevant loading standards, or
- by the client, or the designer in consultation with the client, provided that the minimum provisions specified in the relevant loading standards or by the competent authority are observed.

(2)P For permanent actions where the coefficient of variation is large or where the actions are likely to vary during the life of the structure (e.g. for some superimposed permanent loads), two characteristic values are distinguished, an upper ($G_{k,sup}$) and a lower ($G_{k,inf}$). Elsewhere a single characteristic value (G_k) is sufficient.

¹ Fuller definitions of the classification of actions will be found in ENV 1991-1-1

(3) The self-weight of the structure may, in most cases, be calculated on the basis of the nominal dimensions and mean unit masses.

(4) For variable actions the characteristic value (Q_k) corresponds to either:

- the upper value with an intended probability of not being exceeded, or the lower value with an intended probability of not being reached, during some reference period, having regard to the intended life of the structure or the assumed duration of the design situation, or
- the specified value.

(5) For accidental actions the characteristic value A_k (when relevant) generally corresponds to a specified value.

2.2.2.3 Representative values of variable actions²

(1)P The main representative value is the characteristic value Q_k .

(2)P Other representative values are related to the characteristic value Q_k by means of a factor ψ .

These values are defined as:

- combination value: $\psi_0 Q_k$ (see 2.3.2.2)
- frequent value: $\psi_1 Q_k$ (see 2.3.4)
- quasi-permanent value: $\psi_2 Q_k$ (see 2.3.4)

(3)P Supplementary representative values are used for fatigue verification and dynamic analysis.

(4)P The factors ψ_0 , ψ_1 and ψ_2 are specified:

- in ENV 1991 Eurocode 1 or other relevant loading standards, or
- by the client, or the designer in consultation with the client, provided that the minimum provisions specified in the relevant loading standards or by the competent authority are observed.

2.2.2.4 Design values of actions

(1)P The design value F_d of an action is expressed in general terms as:

$$F_d = \gamma_F F_k \quad (2.1)$$

where

γ_F is the partial safety factor for the action considered - taking account of, for example, the possibility of unfavourable deviations of the actions, the possibility of inaccurate modelling of the actions, uncertainties in the assessment of effects of actions and uncertainties in the assessment of the limit state considered.

(2) Specific examples of the use of γ_F are given in ENV 1991-1.

² Fuller definitions of representative values will be found in ENV 1991-1.

2.2.2.5 Design values of the effects of actions

(1)P The effects of actions (E) are responses (for example, internal forces and moments, stresses, strains) of the structure to the actions. Design values of the effects of actions (E_d) are determined from the design values of the actions, geometrical data and material properties when relevant:

$$E_d = E(F_d, a_d, \dots) \quad (2.2)$$

where
 a_d is defined in 2.2.4.

2.2.3 Material properties

2.2.3.1 Characteristic values

(1)P A material property is represented by a characteristic value X_k which in general corresponds to a fractile in the assumed statistical distribution of the particular property of the material specified by relevant standards and tested under specified conditions.

(2) In certain cases a nominal value is used as the characteristic value.

(3) Material properties for aluminium structures are generally represented by nominal values used as characteristic values.

NOTE: A guaranteed minimum value can be defined as nominal value, see 3.1. (1).

(4) A material property may have two characteristic values, the upper value and the lower value. In most cases only the lower value need be considered. However, higher values of the 0,2% proof strength, for example, should be considered in special cases where over strength effects may produce a reduction in safety.

2.2.3.2 Design values

(1)P The design value X_d of a material property is generally defined as:

$$X_d = X_k / \gamma_M$$

where

γ_M is the partial safety factor for the material property.

(2)P For aluminium alloy structures, the design resistance R_d is generally determined directly from the characteristic values of the material properties and geometrical data:

$$R_d = R(X_k, a_k, \dots) / \gamma_M \quad (2.3)$$

where

γ_M is the partial safety factor for the resistance.

(3) The characteristic value R_k may be determined from tests. Guidance is given in Section 8.

2.2.4 Geometrical data

(1)P Geometrical data are generally represented by their nominal values:

$$a_d = a_{nom} \quad (2.4)$$

(2) In some cases the geometrical design values are defined by

$$a_d = a_{nom} + \Delta a \quad (2.5)$$

The values of Δa are given in the appropriate clauses.

(3) For imperfections to be adopted in the global analysis of the structure, see Annex D.

2.2.5 Load arrangements and load cases³

(1)P A load arrangement identifies the position, magnitude and direction of a free action, see ENV 1991-1.

(2)P A load case identifies compatible load arrangements, sets of deformations and imperfections considered for a particular verification.

2.3 Design requirements

2.3.1 General

(1)P It shall be verified that no relevant limit state is exceeded.

(2)P All relevant design situations and load cases shall be considered.

(3)P Possible deviations from the assumed directions or positions of actions shall be considered.

(4)P Calculations shall be performed using appropriate design models (supplemented, if necessary, by tests) involving all relevant variables. The models shall be sufficiently precise to predict the structural behaviour, commensurate with the standard of workmanship likely to be achieved, and with the reliability of the information on which the design is based.

2.3.2 Ultimate limit states

2.3.2.1 Verification conditions

(1)P When considering a limit state of static equilibrium or of gross displacements or deformations of the structure, it shall be verified that

$$E_{d,dst} \leq E_{d,stb} \quad (2.6)$$

where:

$E_{d,dst}$ is the design effect of the destabilizing actions
 $E_{d,stb}$ is the design effect of the stabilizing actions.

³ Detailed rules on load arrangements and load cases are given in ENV 1991-1

(2)P When considering a limit state of rupture or excessive deformation of a section, member or connection (fatigue excluded) it shall be verified that

$$E_d \leq R_d \quad (2.7)$$

where:

E_d is the design value of an internal force or moment (or of a respective vector of several internal forces or moments)

R_d is the corresponding design resistance

(3)P When considering a limit state of transformation of the structure into a mechanism, it shall be verified that a mechanism does not occur unless actions exceed their design values, taking account of the respective design values of all structural properties.

(4)P When considering a limit state of stability induced by second-order effects, it shall be verified that instability does not occur unless actions exceed their design values, taking account of the respective design values of all structural properties. In addition, sections shall be verified according to (2) above.

(5)P When considering a limit state of rupture induced by fatigue, it shall be verified that the design value of the damage indicator D_d does not exceed unity, see ENV 1999-2.

2.3.2.2 Combinations of actions

(1)P For each load case, design values E_d for the effects of actions shall be determined from combination rules involving the design values of actions given in ENV 1991-1.

2.3.2.3 Partial safety factors for resistances (Ultimate Limit State)

(1) Partial safety factors for resistances are given in the relevant clauses in Sections 5 and 6.

(2) Where structural properties are determined by testing see Section 8.

(3) For fatigue verifications see prENV 1999-2.

2.3.4 Serviceability limit states

(1)P It shall be verified that

$$E_d \leq C_d \text{ or } E_d \leq R_d \quad (2.8)$$

where:

C_d is a nominal value or a function of certain design properties of materials related to the design effect of actions considered, and

E_d is the design effect of actions, determined on the basis of one of the combinations defined below.

The required combination is identified in the particular clause for each serviceability verification.

(2)P Combinations of actions for serviceability limit states are defined in ENV 1991-1.

(3) Values of γ_M should be taken as 1,0 for all serviceability limit states, except where stated otherwise in particular clauses.

2.4 Durability

(1)P To ensure an adequately durable structure, the following inter-related factors shall be considered:

- the use of the structure
- the required performance
- the expected environmental conditions
- the composition, properties and performance of the materials
- the shape of members and the structural detailing
- the quality of workmanship and level of control
- the particular protective measures
- the likely maintenance during the intended life.

(2) The internal and external environmental conditions should be estimated at the design stage to assess their significance in relation to durability and to enable adequate provisions to be made for protection of the materials (see clause 3.4).

2.5 Fire resistance

(1) For fire resistance, refer to avENV 1999-1-2.

3 Materials

3.1 General

(1) The material properties given in this section are minimum guaranteed values as nominal values to be adopted as characteristic values in design calculations (see 5.3.5).

(2) Other material properties are given in the ENs listed in 1.3.1.3 and 1.3.1.4 and in prENs and ISO Standards.

3.2 Structural aluminium

3.2.1 Range of materials

(1) This European prestandard covers the design of structures fabricated from aluminium alloy material listed in table 3.1a for wrought alloys conforming to the ENs listed in 1.3.1.1, and for the use in structures of cast alloys in table 3.1b conforming to the ENs listed in 1.3.1.4.

Table 3.1a: Wrought aluminium alloys for structures

Alloy designation		Form of product	Durability
Numerical	Chemical symbols		
EN AW-3103	EN AW-Al Mn1	SH,ST,PL,ET	A
EN AW-5083	EN AW-Al Mg4,5Mn0,7	SH,ST,PL,ET,SEP,ER/B,DT, FO	A
EN AW-5052	EN AW-Al Mg2,5	SH,ST,PL	A
EN AW-5454	EN AW-Al Mg3Mn	SH,ST,PL	A
EN AW-5754	EN AW-Al Mg3	SH,ST,PL,FO	A
EN AW-6060	EN AW-Al MgSi	ET,EP,ER/B,DT	B
EN AW-6061	EN AW-Al Mg1SiCu	SH, ST, PL, ET,EP,ER/B,DT	B
EN AW-6063	EN AW-Al Mg0,7Si	ET,EP,ER/B,DT	B
EN AW-6005	EN AW-Al SiMg(A)	EP	B
EN AW-6082	EN AW-Al Si1MgMn	SH,ST,PL,ET,EP,ER/B,DT,FO	B
EN AW-7020	EN AW-Al Zn4,5MgCu	SH,ST,PL,ET,SEP,ER/B,DT	C
Key: SH - Sheet ST - Strip PL - Plate ET - Extruded Tube EP - Extruded Profiles SEP - Simple Extruded Profiles ER/B - Extruded Rod and Bar DT - Drawn Tube FO - Forgings			

Table 3.1b: Cast aluminium alloys for structures

Alloy designation		Durability
Numerical	Chemical symbols	
EN AC-42100	EN AC-Al Si7Mg0,3	B
EN AC-42200	EN AC-Al Si7Mg0,6	B
EN AC-43200	EN AC-Al Si10Mg(Cu)	C
EN AC-44100	EN AC-Al Si12(b)	B
EN AC-51300	EN AC-Al Mg5	A

(2) It may also be used for other structural aluminium alloys listed in EN or ISO Standards, provided that adequate data exist to justify the application of the relevant design and fabrication rules.

(3)P If these adequate data have to be found by tests the test procedures and test evaluation shall conform with 6.5.9.5 and 6.8.3 of this European prestandard and the test requirements shall align with those in the ENs and prENs listed in 1.3.1.

(4) For advice on the selection of aluminium alloys see annex B.

3.2.2 Material properties for wrought aluminium alloys

3.2.2.1 Minimum guaranteed values

(1) The minimum limiting values of the 0,2% proof strength $f_{0,2}$ and the ultimate tensile strength f_u for wrought aluminium alloys for a range of tempers and thicknesses are given in table 3.2a for sheet, strip and plate products; table 3.2b for extruded rod/bar, extruded tube and extruded profiles and drawn tube, table 3.2c for electrically welded tube and table 3.2d for forgings.

(2) The minimum limiting values in table 3.2a to 3.2d may be adopted as characteristic values in calculations for structures subject to service temperatures below 100°C (see 5.3.5). For structures subject to elevated temperatures associated with fire see ENV 1999-1-2:1997.

Table 3.2a: Minimum guaranteed values of 0,2% proof strength $f_{0,2}$ and ultimate tensile strength f_u for wrought aluminium alloys - Sheet, strip and plate

Alloy	Temper	Thickness		$f_{0,2}$ 0,2% Proof strength N/mm ²	f_u Ultimate strength N/mm ²	A_{50} Minimum elongation %
		over	up to			
EN AW-3103	H14	0,2	25	120	140	2
	H16	0,2	4	145	160	1
EN AW-5052	H12	0,2	4	160	210	4
	H14	0,2	2	180	230	3
EN AW-5454	O/H111	0,2	8	85	215	12
	H24/H34	0,2	25	200	270	4
EN AW-5754	O/H111	0,2	100	80	190	12
	H24/H34	0,2	25	160	240	6
EN AW-5083	O/H111	0,2	50	125	275	11
		50	80	115	270	14
	H24/H34	0,2	25	250	340	4
EN AW-6061	T4	0,4	12,5	110	205	12
	T6	0,4	12	240	290	6
EN AW-6082	T4	0,4	12	110	205	12
	T6	0,4	6	260	310	6
		6	12,5	255	300	9
	T651	12	100	240	295	8
EN AW-7020	T6	0,4	12,5	280	350	7
	T651	12,5	40			9 ¹⁾

¹⁾ Based on A not A₅₀

NOTE: The minimum elongation values do not apply across the whole range of thickness given, but generally to the thinner materials. Higher values of elongation usually apply to thicker material. For actual minimum values see the ENs and prENs listed in 1.3.1.3.

Table 3.2b: Minimum guaranteed values of 0,2% proof strength $f_{0,2}$ and ultimate tensile strength f_u for wrought aluminium alloys - Extruded profiles, extruded tube, extruded rod/bar and drawn tube

Alloy	Product form	Temper	Dimension t wall thickness or thickness mm	$f_{0,2}$ 0,2% Proof strength N/mm ²	f_u Ultimate strength N/mm ²	A Minimum elongation %
EN AW-5083	ET, EP,ER/B	F,H112	$t \leq 200$	110	270	12
	DT	H12, H22 H32	$t \leq 10$	200	280	6
		H14, H24 H34	$t \leq 5$	235	300	4
EN AW-6060	EP,ET,ER/B	T5	$t \leq 5$	120	160	8
	EP		$5 < t \leq 25$	100	140	8
	ET,EP,ER/B	T6	$t \leq 15$	140	170	8
	DT		$t \leq 20$	160	215	12
EN AW-6061	ET,EP,ER/B, DT	T6	$t \leq 20$	240	260	8
EN AW-6063	EP,ET,ER/B	T5	$t \leq 3$	130	175	8
	EP		$3 < t \leq 25$	110	160	7
	ET,EP,ER/B	T6	$t \leq 10$	170	215	8
	DT		$t \leq 20$	190	220	10
EN W-6005A	EP/O	T6	$t \leq 5$	225	270	8
			$5 < t \leq 10$	215	260	8
			$10 < t \leq 25$	200	250	8
	EP/H	T6	$t \leq 5$	215	255	8
			$5 < t \leq 15$	200	250	8
EN AW-6082	EP,ET,ER/B	T4	$t \leq 25$	110	205	14
	EP/O, EP/H	T5	$t \leq 5$	230	270	8
	EP/O,EP/H ET	T6	$t \leq 5$	250	290	8
			$5 < t \leq 25$	260	310	10
	ER/B	T6	$t \leq 20$	250	295	8
			$20 < t \leq 150$	260	310	8
	DT	T6	$t \leq 5$	255	310	8
			$5 < t \leq 20$	240	310	10
EN AW-7020	EP/ER/B,DT, ET	T6	$t \leq 15$	280	350	10

Table 3.2b Continued

Key: EP	- Extruded profiles	EP/O	- Extruded open profiles
EP/H	- Extruded hollow profiles	ET	- Extruded tube
ER/B	- Extruded rod and bar	DT	- Drawn tube

NOTE 1: Where values are quoted in **bold** greater thicknesses and/or higher mechanical properties may be permitted in some forms see ENs and prENs listed in 1.3.1.3.

NOTE 2: Where minimum elongation values are given in **bold**, higher minimum values may be given for some forms or thicknesses.

NOTE 3: Where an extruded product employs thicknesses across a thickness range given above, the highest value given may be used provided the manufacturer can support the value by an appropriate quality assurance certificate.

Table 3.2c: Minimum guaranteed values of 0,2% proof strength $f_{0,2}$ and ultimate tensile strength f_u for wrought aluminium alloys - Electrically welded tube

Alloy	Temper	$f_{0,2}$ 0,2% Proof strength N/mm ²	f_u Ultimate strength N/mm ²	A Minimum elongation %
EN AW-3103	Hx65	150	170	3
	Hx85	170	190	2

Table 3.2d: Minimum guaranteed values of 0,2% proof strength $f_{0,2}$ and ultimate tensile strength f_u for wrought aluminium alloys - Forgings (L: long)

Alloy	Temper	Thickness up to mm	Direction	$f_{0,2}$ 0,2% Proof strength N/mm ²	f_u Ultimate strength N/mm ²	A Minimum elongation %
EN AW-5754	H112	150	Longitudinal (L)	80	180	15
EN AW-5083	H112	150	Longitudinal (L)	120	270	12
			Transverse (T)	110	260	10
EN AW-6082	T6	100	Longitudinal (L)	260	310	6
			Transverse (T)	250	290	5

(3) As an alternative, the limiting minimum values specified in ENs and prENs listed in 1.3.1.3 a large range of tempers and thicknesses in addition to those covered in tables 3.2a to 3.2d may be used as characteristic values.

(4) The minimum values of elongation given in table 3.2a to 3.2d are for information only.

3.2.3 Material properties for cast aluminium alloys

3.2.3.1 Minimum guaranteed values

(1) The minimum guaranteed values of the 0,2% proof strength $f_{0,2}$ and the ultimate tensile strength f_u for sand and permanent mould cast aluminium alloys test bars for a range of alloys and tempers are given in table 3.3.

Table 3.3: Minimum guaranteed values of 0,2% proof strength $f_{0,2}$ and ultimate tensile strength f_u for cast aluminium alloys - Castings

Alloy	Casting process	Temper	$f_{0,2}$ 0.2% Proof strength N/mm ²	f_u Ultimate strength N/mm ²	A_{50} Minimum elongation %
EN AC-42100	Sand cast	T6	190	230	2
	Permanent mould	T6	210	290	4
EN AC-42200	Sand cast	T6	210	250	1
	Permanent mould	T6	240	320	3
EN AC-43200	Sand cast	F	80	160	1
	Sand cast	T6	180	220	1
	Permanent mould	F	90	180	1
	Permanent mould	T6	200	240	1
EN AC-44100	Sand cast	F	70	150	4
	Permanent mould		80	170	5
EN AC-51300	Sand cast	F	90	160	3
	Permanent mould		100	180	4
NOTE: Minimum mechanical properties quoted are for separately cast test bars, and not for castings.					

(2) As an alternative, the values specified in the ENs and prENs listed in 1.3.1.4 for a range of casting processes and of other tempers may be used.

(3)P The design rules in this European prestandard shall not be applied to castings. The casting alloys given in table 3.3 should only be used in load bearing structures provided that their suitability and resistance can be determined by testing, see 8.1(2). In addition quality control procedures for the production of the castings shall be to the satisfaction of the engineer.

3.2.4 Dimensions, mass and tolerances

(1)P The dimensions and tolerances of structural extruded products, sheet and plate products, drawn tube, electrically welded tube, wire and forgings, shall conform with the ENs and prENs listed in 1.3.1.3.

(2)P The dimensions and tolerances of structural cast products shall conform with the ENs and prENs listed in 1.3.1.4.

3.2.5 Design values of material constants

(1)P The material constants to be adopted in calculations for the aluminium alloys covered by this European prestandard shall be taken as follows:

- modulus of elasticity $E = 70\,000\text{ N/mm}^2$;
- shear modulus $G = 27\,000\text{ N/mm}^2$;