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SIST ENV 1999-1-1:2002
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Evrokod 9 - Projektiranje konstrukcij iz aluminijevih zlitin - 1-4. del: Hladno oblikovane konstrukcijske ploļ evine

Eurocode 9 - Design of aluminium structures - Part 1-4: Cold-formed structural sheeting

Eurocode 9 - Bemessung und Konstruktion von Aluminiumtragwerken -Teil 1-4: Kaltgeformte Profiltafeln

Eurocode 9 - Calcul des structures en aluminium - Partie 1-4: Les structures a plaques formées a froid

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ICS:

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ICS 91.010.30; 91.080.10

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English Version

Eurocode 9 - Design of aluminium structures - Part 1-4: Cold-formed structural sheeting

Eurocode 9 - Calcul des structures en aluminium - Partie 1-4: Les structures à plaques formées à froid

Eurocode 9 - Bemessung und Konstruktion von Aluminiumtragwerken -Teil 1-4: Kaltgeformte Profiltafeln

This European Standard was approved by CEN on 12 November 2006.

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Foreword

This European Standard (EN 1999-1-4:2007) has been prepared by Technical Committee CEN/TC250 « Structural Eurocodes », the secretariat of which is held by BSI.

This European Standard shall be given the status of a national standard, either by publication of an identical text or by endorsement, at the latest by August 2007, and conflicting national standards shall be withdrawn at the latest by March 2010.

This European Standard supersedes ENV 1999-1-1:1998, ENV 1999-1-2:1998 and ENV 1999-2:1998.

CEN/TC 250 is responsible for all Structural Eurocodes.

According to the CEN/CENELEC Internal Regulations, the national standards organizations of the following countries are bound to implement this European Standard:

Austria, Bulgaria, Belgium, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italia, Latvia, Lithuania, Luxemburg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom

Background of the Eurocode programme

In 1975, the Commission of the European Community decided on an action programme in the field of construction, based on article 95 of the Treaty. The objective of the programme was the elimination of technical obstacles to trade and the harmonisation of technical specifications.

Within this action programme, the Commission took the initiative to establish a set of harmonised technical rules for the design of construction works, which, in a first stage, would serve as an alternative to the national rules in force in the Member States and, ultimately, would replace them.

For fifteen years, the Commission, with the help of a Steering Committee with Representatives of Member States, conducted the development of the Eurocodes programme, which led to the first generation of European codes in the 1980s.

In 1989, the Commission and the Member States of the EU and EFTA decided, on the basis of an agreement[1] between the Commission and CEN, to transfer the preparation and the publication of the Eurocodes to the CEN through a series of Mandates, in order to provide them with a future status of European Standard (EN). This links de facto the Eurocodes with the provisions of all the Council's Directives and/or Commission's Decisions dealing with European standards (e.g. the Council Directive 89/106/EEC on construction products - CPD - and Council Directives 93/37/EEC, 92/50/EEC and 89/440/EEC on public works and services and equivalent EFTA Directives initiated in pursuit of setting up the internal market).

The Structural Eurocode programme comprises the following standards generally consisting of a number of Parts:

EN 1990	Eurocode 0:	Basis of Structural Design
EN 1991	Eurocode 1:	Actions on structures
EN 1992	Eurocode 2:	Design of concrete structures
EN 1993	Eurocode 3:	Design of steel structures
EN 1994	Eurocode 4:	Design of composite steel and concrete structures
EN 1995	Eurocode 5:	Design of timber structures
EN 1996	Eurocode 6:	Design of masonry structures
EN 1997	Eurocode 7:	Geotechnical design
EN 1998	Eurocode 8:	Design of structures for earthquake resistance
EN 1999	Eurocode 9:	Design of aluminium structures

[1] Agreement between the Commission of the European Communities and the European Committee for Standardisation (CEN) concerning the work on EUROCODES for the design of building and civil engineering works (BC/CEN/03/89).

Eurocode standards recognise the responsibility of regulatory authorities in each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level where these continue to vary from State to State.

Status and field of application of Eurocodes

The Member States of the EU and EFTA recognise that Eurocodes serve as reference documents for the following purposes:

- as a means to prove compliance of building and civil engineering works with the essential requirements of Council Directive 89/106/EEC, particularly Essential Requirement No.1 – Mechanical resistance and stability, and Essential Requirement No 2 – Safety in case of fire
- as a basis for specifying contracts for the execution of construction works and related engineering services
- as a framework for drawing up harmonised technical specifications for construction products (En's and ETA's)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents[2] referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standards[3]. Therefore, technical aspects arising from the Eurocodes work need to be adequately considered by CEN Technical Committees and/or EOTA Working Groups working on product standards with a view to achieving full compatibility of these technical specifications with the Eurocodes.

The Eurocode standards provide common structural design rules for everyday use for the design of whole structures and component products of both a traditional and an innovative nature. Unusual forms of construction or design conditions are not specifically covered and additional expert consideration will be required by the designer in such cases.

National standards implementing Eurocodes

The National Standards implementing Eurocodes will comprise the full text of the Eurocode (including any annexes), as published by CEN, which may be preceded by a National title page and National foreword, and may be followed by a National annex [informative].

The National Annex (informative) may only contain information on those parameters which are left open in the Eurocode for national choice, known as Nationally Determined Parameters, to be used for the design of buildings and civil engineering works to be constructed in the country concerned, i.e. :

– values for partial factors and/or classes where alternatives are given in the Eurocode;
– values to be used where a symbol only is given in the Eurocode;
– geographical and climatic data specific to the Member State, e.g. snow map;
– the procedure to be used where alternative procedures are given in the Eurocode;
– references to non-contradictory complementary information to assist the user to apply the Eurocode.

Links between Eurocodes and harmonised technical specifications (EN's and ETA's) for products

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works[4]. Furthermore, all the information accompanying the CE Marking of the

[2] According to Art. 3.3 of the CPD, the essential requirements (ERs) shall be given concrete form in interpretative documents for the creation of the necessary links between the essential requirements and the mandates for harmonised ENs and ETAGs/ETAs.

[3] According to Art. 12 of the CPD the interpretative documents shall :

a) give concrete form to the essential requirements by harmonising the terminology and the technical bases and indicating classes or levels for each requirement where necessary ;

b) indicate methods of correlating these classes or levels of requirement with the technical specifications, e.g. methods of calculation and of proof, technical rules for project design, etc. ;

c) serve as a reference for the establishment of harmonised standards and guidelines for European technical approvals.

The Eurocodes, *de facto*, play a similar role in the field of the ER 1 and a part of ER 2.

[4] see Art.3.3 and Art.12 of the CPD, as well as clauses 4.2, 4.3.1, 4.3.2 and 5.2 of ID 1.

construction products which refer to Eurocodes shall clearly mention which Nationally Determined Parameters have been taken into account.

National Annex for EN 1999-1-4

This standard gives alternative procedures, values and recommendations for classes with notes indicating where national choices may have to be made. Therefore the National Standard implementing EN 1999-1-4 should have a National Annex containing all Nationally Determined Parameters to be used for the design of aluminium structures to be constructed in the relevant country.

National choice is allowed in EN 1999-1-4 through clauses:

2(3)
2(4)
2(5)
3.1(3)
7.3(3)
A.1(1)
A.3.4(3)

1 General

1.1 Scope

1.1.1 Scope of EN 1999

(1)P EN 1999 applies to the design of buildings and civil engineering and structural works in aluminium. It complies with the principles and requirements for the safety and serviceability of structures, the basis of their design and verification that are given in EN 1990 – Basis of structural design.

(2) EN 1999 is only concerned with requirements for resistance, serviceability, durability and fire resistance of aluminium structures. Other requirements, e.g. concerning thermal or sound insulation, are not considered.

(3) EN 1999 is intended to be used in conjunction with:

- EN 1990 "Basis of structural design"
- EN 1991 "Actions on structures"
- European Standards construction products relevant for aluminium structures
- EN 1090-1: Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components[5]
- EN 1090-3: Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures[5]

(4) EN 1999 is subdivided in five parts:

EN 1999-1-1 Design of Aluminium Structures: General structural rules.

EN 1999-1-2 Design of Aluminium Structures: Structural fire design.

EN 1999-1-3 Design of Aluminium Structures: Structures susceptible to fatigue.

EN 1999-1-4 Design of Aluminium Structures: Cold-formed structural sheeting.

EN 1999-1-5 Design of Aluminium Structures: Shell structures.

1.1.2 Scope of EN 1999-1-4

(1)P EN 1999-1-4 gives design requirements for cold-formed trapezoidal aluminium sheeting. It applies to cold-formed aluminium products made from hot rolled or cold rolled sheet or strip that have been cold-formed by such processes as cold-rolled forming or press-breaking. The execution of aluminium structures made of cold-formed sheeting is covered in EN 1090-3.

NOTE The rules in this part complement the rules in other parts of EN 1999-1.

(2) Methods are also given for stressed-skin design using aluminium sheeting as a structural diaphragm.

(3) This part does not apply to cold-formed aluminium profiles like C-, Z- etc profiles nor cold-formed and welded circular or rectangular hollow sections.

(4) EN 1999-1-4 gives methods for design by calculation and for design assisted by testing. The methods for the design by calculation apply only within stated ranges of material properties and geometrical properties for which sufficient experience and test evidence is available. These limitations do not apply to design by testing.

(5) EN 1999-1-4 does not cover load arrangement for loads during execution and maintenance.

[5] To be published

1.2 Normative references

(1) The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

1.2.1 General references

EN 1090-1:	Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components[6]
EN 1090-3:	Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures[6]

1.2.2 References on structural design

EN 1990	Eurocode 0 - Basis of structural design
EN 1991	Eurocode 1 – Action on structures – All parts
EN 1995-1-1	Eurocode 5: Design of timber structures - Part 1-1 General rules and rules for buildings
EN 1999-1-1	Eurocode 9: Design of aluminium structures - Part 1-1 General structural rules

1.2.3 Materials and materials testing

EN 485-2:1994	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 508-2:2000	Roofing products from metal sheet - Specification for self-supporting products of steel, aluminium or stainless steel sheet - Part 2: Aluminium
EN 1396:1996	Aluminium and aluminium alloys - Coil coated sheet and strip for general applications - Specifications
EN 10002-1	Metallic materials - Tensile testing - Part 1: Method of test at ambient temperature
EN 10088	Stainless steels - Part 1: List of stainless steels

1.2.4 References on fasteners

EN ISO 1479	Hexagon head tapping screws
EN ISO 1481	Slotted pan head tapping screws
EN ISO 15480	Hexagon washer head drilling screws with tapping screw thread
EN ISO 15481	Cross recessed pan head drilling screws with tapping screw thread
EN ISO 15973	Closed end blind rivets with break pull mandrel and protruding head
EN ISO 15974	Closed end blind rivets with break pull mandrel and countersunk head
EN ISO 15977	Open end blind rivets with break pull mandrel and protruding head
EN ISO 15978	Open end blind rivets with break pull mandrel and countersunk head
EN ISO 15981	Open end blind rivets with break pull mandrel and protruding head
EN ISO 15982	Open end blind rivets with break pull mandrel and countersunk head
ISO 7049:1994	Cross recessed pan head tapping screws

1.2.5 Other references

EN ISO 12944-2	Paints and varnishes - Corrosion protection of steel structures by protective paint systems - Part 2: Classification of environments

[6] To be published

1.3 Terms and definitions

Supplementary to EN 1999-1-1, for the purposes of EN 1999-1-4, the following definitions apply:

1.3.1

base material

the flat sheet aluminium material out of which profiled sheets are made by cold forming

1.3.2

proof strength of base material

the 0,2 % proof strength f_o of the base material

1.3.3

diaphragm action

structural behaviour involving in-plane shear in the sheeting

1.3.4

partial restraint

restriction to some extent of the lateral or rotational displacement of a cross-section part, that increases its buckling resistance

1.3.5

restraint

full restriction of the lateral displacement or rotational movement of a plane cross-section part, that increases its buckling resistance

1.3.6

slenderness parameter

a normalised, material related slenderness ratio

1.3.7

stressed-skin design

a design method that allows for the contribution made by diaphragm action in the sheeting to the stiffness and strength of a structure

1.3.8

support

a location at which a member is able to transfer forces or moments to a foundation, or to another structural component.

1.3.9

effective thickness

a design value of the thickness to allow for local buckling of plane cross section part.

1.3.10

reduced effective thickness

a design value of the thickness to allow for distortional buckling of stiffeners in a second step of the calculation procedure for plane cross section parts, where local buckling is allowed for in the first step .

1.4 Symbols

(1) In addition to those given in EN 1999-1-1, the following main symbols are used:

Section 1 to 6

C rotational spring stiffness;
k linear spring stiffness;
θ rotation;
b_p notional flat width of plane cross-section part;
h_w web height, measured between system lines of flanges;
s_w slant height of web, measured between midpoints of corners;
χ_d reduction factor for distortional buckling (flexural buckling of stiffeners);
φ is the angle between two plane elements;
ϕ is the slope of the web relative to the flanges.

Section 8 Joints with mechanical fasteners

d_w diameter of the washer or the head of the fastener;
$f_{u,min}$ minor ultimate tensile strength of both connected parts;
$f_{u,sup}$ ultimate tensile strength of the supporting component into which a screw is fixed;
f_y yield strength of supporting component of steel;
t_{min} thickness of the thinner connected part or sheet;
t_{sup} thickness of the supporting member in which the screw is fixed;

(2) Further symbols are defined where they first occur.

1.5 Geometry and conventions for dimensions

1.5.1 Form of sections

(1) Cold-formed sheets have within the permitted tolerances a constant thickness nominal over their entire length and have a uniform cross-section along their length.

(2) The cross-sections of cold formed profiled sheets essentially comprise a number of plane cross-section parts joined by curved parts.

(3) Typical forms of cross-sections for cold formed profiled sheets are shown in Figure 1.1.

(4) Cross-sections of cold formed sheets can either be unstiffened or incorporate longitudinal stiffeners in their webs or flanges, or in both.

1.5.2 Form of stiffeners

(1) Typical forms of stiffeners for cold formed sheets are shown in Figure 1.2;

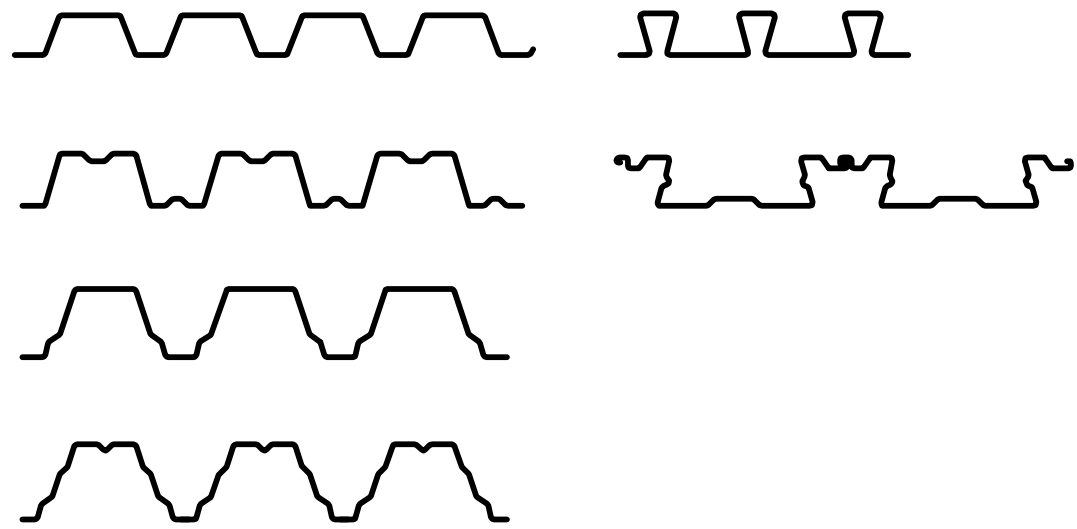

Figure 1.1 - Examples of cold-formed sheeting

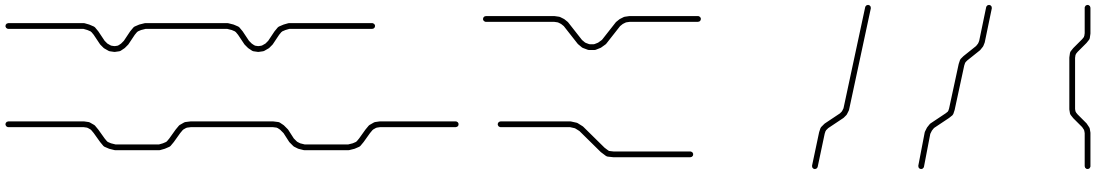

Figure 1.2 - Typical intermediate longitudinal stiffeners

1.5.3 Cross-section dimensions

(1) Overall dimensions of cold-formed sheeting, including overall width b, overall height h, internal bend radius r and other external dimensions denoted by symbols without subscripts, are measured to the outer contour of the section, unless stated otherwise, see Figure 5.1.

(2) Unless stated otherwise, the other cross-sectional dimensions of cold-formed sheeting, denoted by symbols with subscripts, such as b_p, h_w or s_w, are measured either to the midline of the material or the midpoint of the corner.

(3) In the case of sloping webs of cold-formed profiled sheets, the slant height s is measured parallel to the slope.

(4) The developed height of a web is measured along its midline, including any web stiffeners.

(5) The developed width of a flange is measured along its midline, including any intermediate stiffeners.

(6) The thickness t is an aluminium design thickness if not otherwise stated. See 3.2.2.

1.5.4 Convention for member axis

(1) For profiled sheets the following axis convention is used in EN 1999-1-4:

- y-y axis parallel to the plane of sheeting;
- z-z axis perpendicular to the plane of sheeting.

2 Basis of design

(1)P The design of cold-formed sheeting shall be in accordance with the general rules given in EN 1990 and EN 1999-1-1.

(2)P Appropriate partial factors shall be adopted for ultimate limit states and serviceability limit states.

(3) For verification by calculation at ultimate limit states the partial factor γ_M shall be taken as follows:

- resistance of cross-sections and members to instability: γ_{M1}
- resistance of cross-sections in tension to fracture: γ_{M2}
- resistance of joints: γ_{M3}

NOTE Numerical values for γ_{Mi} may be defined in the National Annex. The following numerical values are recommended for buildings:

$\gamma_{M1} = 1{,}10$

$\gamma_{M2} = 1{,}25$

$\gamma_{M3} = 1{,}25$

(4) For verifications at serviceability limit states the partial factor $\gamma_{M,ser}$ should be used.

NOTE Numerical values for $\gamma_{M,ser}$ may be defined in the National Annex. The following numerical value is recommended for buildings:

$\gamma_{M,ser} = 1{,}0$.

(5) For the design of structures made of cold-formed sheeting a distinction should be made between "**Structural Classes**" dependent on its function in the structure defined as follows:

Structural Class I: Construction where cold-formed sheeting is designed to contribute to the overall strength and stability of the structure, see 6.3.3;

Structural Class II: Construction where cold-formed sheeting is designed to contribute to the strength and stability of individual structural components;

Structural Class III: Construction where cold-formed sheeting is used as a component that only transfers loads to the structure.

NOTE 1 National Annex may give rules for the use of Structural Classes and the connection to Consequence Classes in EN 1990.

NOTE 2 For Structural Class I and II the requirement for execution should be given in the execution specification, see EN 1090-3

3 Materials

3.1 General

(1) The methods for design by calculation given in EN 1999-1-4 may be used for the structural alloys in the tempers listed in table 3.1.

(2) For design by calculation given in EN 1999-1-4 the 0,2 proof strength f_o should be at least $f_o = 165$ N/mm^2.

(3) Aluminium sheet and strip used for cold-formed profile sheeting should be suitable for the specific cross section depending on cold forming and cold forming process.

NOTE For other aluminium materials and products see National Annex.

3.2 Structural aluminium alloys

3.2.1 Material properties

(1) The characteristic values of 0,2 proof strength f_o and tensile strength f_u have been obtained by adopting the values for minimum $R_{p0,2}$ and R_m direct from the relevant product standards.

(2) It may be assumed that the properties in compression are the same as those in tension.

(3) If partially plastic moment resistance is utilised, the ratio of the characteristic ultimate tensile strength f_u to the characteristic 0,2 proof strength f_o should be not less than 1,2.

(4) The material constants (modulus of elasticity etc) should be taken as given in EN 1999-1-1.