

Eurocode 9 - Design of aluminium structures - Part 1-1: General structural rules

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EESTI STANDARDI EESSÕNA

NATIONAL FOREWORD

Käesolev Eesti standard EVS-EN 1999-1-1:2007 sisaldab Euroopa standardi EN 1999-1-1: 2007 ingliskeelset teksti. Käesolev dokument on jõustatud 30.03.2007 ja selle kohta on avaldatud teade Eesti standardiorganisatsiooni ametlikus väljaandes. Standard on kättesaadav Eesti standardiorganisatsioonist.	This Estonian standard EVS-EN 1999-1-1:2007 consists of the English text of the European standard EN 1999-1-1: 2007. This document is endorsed on 30.03.2007 with the notification being published in the official publication of the Estonian national standardisation organisation. The standard is available from Estonian standardisation organisation.
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Käsitlusala: 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.	Scope: 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.
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ICS 91.010.30, 91.080.10

Võtmesõnad:

English Version

Eurocode 9 - Design of aluminium structures - Part 1-1: General structural rules

Eurocode 9 - Calcul des structures en aluminium - Partie 1-1: Règles générales

Eurocode 9 - Bemessung und Konstruktion von Aluminiumtragwerken - Teil 1-1: Allgemeine Bemessungsregeln

This European Standard was approved by CEN on 18 September 2006.

CEN members are bound to comply with the CEN/CENELEC Internal Regulations which stipulate the conditions for giving this European Standard the status of a national standard without any alteration. Up-to-date lists and bibliographical references concerning such national standards may be obtained on application to the CEN Management Centre or to any CEN member.

This European Standard exists in three official versions (English, French, German). A version in any other language made by translation under the responsibility of a CEN member into its own language and notified to the CEN Management Centre has the same status as the official versions.

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Management Centre: rue de Stassart, 36 B-1050 Brussels

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Foreword

This European Standard (EN 1999-1-1:2007) 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.

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

Austria, Belgium, Bulgaria, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, 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 agreement¹ 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 N°1 - Mechanical resistance and stability - and Essential Requirement N°2 - Safety in case of fire;
- as a basis for specifying contracts for construction works and related engineering services;
- as a framework for drawing up harmonised technical specifications for construction products (ENs and ETAs)

The Eurocodes, as far as they concern the construction works themselves, have a direct relationship with the Interpretative Documents² referred to in Article 12 of the CPD, although they are of a different nature from harmonised product standard³. 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 a 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 product harmonised technical specifications (ENs and ETAs)

There is a need for consistency between the harmonised technical specifications for construction products and the technical rules for works⁴. Furthermore, all the information accompanying the CE Marking of the

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

³ According to Art. 12 of the CPD the interpretative documents should :

- 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 should clearly mention which Nationally Determined Parameters have been taken into account.

Additional information specific to EN 1999-1-1

EN 1999 is intended to be used with Eurocodes EN 1990 – Basis of Structural Design, EN 1991 – Actions on structures and EN 1992 to EN 1999, where aluminium structures or aluminium components are referred to.

EN 1999-1-1 is the first part of five parts of EN 1999. It gives generic design rules that are intended to be used with the other parts EN 1999-1-2 to EN 1999-1-5.

The four other parts EN 1999-1-2 to EN 1999-1-5 are each addressing specific aluminium components, limit states or type of structures.

EN 1999-1-1 may also be used for design cases not covered by the Eurocodes (other structures, other actions, other materials) serving as a reference document for other CEN TC's concerning structural matters.

EN 1999-1-1 is intended for use by

- committees drafting design related product, testing and execution standards,
- owners of construction works (e.g. for the formulation of their specific requirements)
- designers and constructors
- relevant authorities

Numerical values for partial factors and other reliability parameters are recommended as basic values that provide an acceptable level of reliability. They have been selected assuming that an appropriate level of workmanship and quality management applies.

National annex for EN 1999-1-1

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 1999-1-1 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 1999-1-1 through clauses:

- 1.1.2(1)
- 2.1.2(3)
- 2.3.1(1)
- 3.2.1(1)
- 3.2.2(1)
- 3.2.2(2)
- 3.2.3.1(1)
- 3.3.2.1(3)
- 3.3.2.2(1)
- 5.2.1(3)
- 5.3.2(3)
- 5.3.4(3)
- 6.1.3(1)
- 6.2.1(5)
- 7.1(4)
- 7.2.1(1)
- 7.2.2(1)
- 7.2.3(1)
- 8.1.1(2)
- 8.9 (3)
- A(6) (Table A.1)
- C.3.4.1(2)
- C.3.4.1(3)
- C.3.4.1(4)
- K.1(1)
- K.3(1)

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 for construction products relevant for aluminium structures
- prEN 1090-1: Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components⁵
- prEN 1090-3: Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures⁵

(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 1999-1-1

(1) EN 1999-1-1 gives basic design rules for structures made of wrought aluminium alloys and limited guidance for cast alloys (see section 3).

NOTE Minimum material thickness may be defined in the National Annex. The following limits are recommended – if not otherwise explicitly stated in this standard:

- components with material thickness not less than 0,6 mm;
- welded components with material thickness not less than 1,5 mm;
- connections with:
 - steel bolts and pins with diameter not less than 5 mm;
 - aluminium bolts and pins with diameter not less than 8 mm;
 - rivets and thread forming screws with diameter not less than 4,2 mm

(2) The following subjects are dealt with in EN 1999 1-1:

Section 1: General

Section 2: Basis of design

Section 3: Materials

⁵ To be published

Section 4: Durability

Section 5: Structural analysis

Section 6: Ultimate limit states for members

Section 7: Serviceability limit states

Section 8: Design of joints

Annex A Execution classes

Annex B Equivalent T-stub in tension

Annex C Materials selection

Annex D Corrosion and surface protection

Annex E Analytical models for stress strain relationship

Annex F Behaviour of cross section beyond elastic limit

Annex G Rotation capacity

Annex H Plastic hinge method for continuous beams

Annex I Lateral torsional buckling of beams and torsional or flexural-torsional buckling of compression members

Annex J Properties of cross sections

Annex K Shear lag effects in member design

Annex L Classification of connections

Annex M Adhesive bonded connections

- (3) Sections 1 to 2 provide additional clauses to those given in EN 1990 “Basis of structural design”.
- (4) Section 3 deals with material properties of products made of structural aluminium alloys.
- (5) Section 4 gives general rules for durability.
- (6) Section 5 refers to the structural analysis of structures, in which the members can be modelled with sufficient accuracy as line elements for global analysis.
- (7) Section 6 gives detailed rules for the design of cross sections and members.
- (8) Section 7 gives rules for serviceability.
- (9) Section 8 gives detail rules for connections subject to static loading: bolted, riveted, welded and adhesive bonded connections.

1.2 Normative references

(1) This European Standard 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 hereafter. For dated references, subsequent amendments to or revisions of any of these publications apply to this European Standard only if incorporated in it by amendment or revision. For undated references the latest edition of the publication referred to applies (including amendments).

1.2.1 General references

prEN 1090-1: Execution of steel structures and aluminium structures – Part 1: Requirements for conformity assessment of structural components⁶

prEN 1090-3: Execution of steel structures and aluminium structures – Part 3: Technical requirements for aluminium structures⁶

1.2.2 References on structural design

EN 1990 Basis of structural design

⁶ To be published

EN 1991	Actions on structures – All parts
EN 1993-1-1	Design of steel structures - Part 1-1: General rules and rules for buildings
EN 1999-1-2	Design of aluminium structures - Part 1-2: Structural fire design
EN 1999-1-3	Design of aluminium structures - Part 1-3: Structures susceptible to fatigue
EN 1999-1-4	Design of aluminium structures - Part 1-4: Cold-formed structural sheeting
EN 1999-1-5	Design of aluminium structures - Part 1-5: Shell structures

1.2.3 References on aluminium alloys

1.2.3.1 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 573-3:2003	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

1.2.3.2 Technical delivery conditions

EN 485-1:1993	Aluminium and aluminium alloys - Sheet, strip and plate - Part 1: Technical conditions for inspection and delivery
EN 586-1:1997	Aluminium and aluminium alloys - Forgings - Part 1: Technical conditions for inspection and delivery
EN 754-1:1997	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 1: Technical conditions for inspection and delivery
EN 755-1:1997	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles - Part 1: Technical conditions for inspection and delivery
EN 1592-1:1997	Aluminium and aluminium alloys - HF seam welded tubes - Part 1: Technical conditions for inspection and delivery
EN 12020-1:2001	Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063- Part 1: Technical conditions for inspection and delivery
EN 28839	Fasteners - Mechanical properties of fasteners - Bolts, screws, studs and nuts made from non-ferrous metals
EN ISO 898-1	Mechanical properties of fasteners made of carbon steel and alloy steel - Part 1: Bolts, screws and studs
EN ISO 3506-1	Mechanical properties of corrosion-resistant stainless-steel fasteners - Part 1: Bolts, screws and studs

1.2.3.3 Dimensions and mechanical properties

EN 485-2:1994	Aluminium and aluminium alloys - Sheet, strip and plate - Part 2: Mechanical properties
EN 485-3:2003	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

EN 1999-1-1: 2007 (E)

EN 508-2:2000	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
EN 586-3:2002	Aluminium and aluminium alloys - Forgings - Part 3: Tolerances on dimension and form
EN 754-2:1997	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
EN 754-7:1998	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 7: Seamless tubes, tolerances on dimension and form
EN 754-8:1998	Aluminium and aluminium alloys - Cold drawn rod/bar and tube - Part 8: Porthole tubes, tolerances on dimension and form
EN 755-2:1997	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
EN 755-7:1998	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 7: Seamless tubes, tolerances on dimension and form
EN 755-8:1998	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 8: Porthole tubes, tolerances on dimension and form
EN 755-9:2001	Aluminium and aluminium alloys - Extruded rod/bar, tube and profiles- Part 9: Profiles, tolerances on dimension and form
EN 12020-2:2001	Aluminium and aluminium alloys - Extruded precision profiles in alloys EN AW-6060 and EN AW-6063- Part 2: Tolerances on dimensions and form
EN 1592-2:1997	Aluminium and aluminium alloys - HF seam welded tubes - Part 2: - Mechanical properties
EN 1592-3:1997	Aluminium and aluminium alloys - HF seam welded tubes - Part 3: - Tolerance on dimensions and shape of circular tubes
EN 1592-4:1997	Aluminium and aluminium alloys - HF seam welded tubes - Part 4: - Tolerance on dimensions and form for square, rectangular and shaped tubes

1.2.3.4 Aluminium alloy castings

EN 1559-1:1997	Founding - Technical conditions of delivery - Part 1: General
EN 1559-4:1999	Founding - Technical conditions of delivery - Part 4: Additional requirements for aluminium alloy castings

EN 1371-1:1997	Founding - Liquid penetrant inspection - Part 1: Sand, gravity die and low pressure die castings
EN 12681:2003	Founding – Radiographic inspection
EN 571-1:1997	Non destructive testing - Penetrant testing - Part 1: General principles
EN 13068-1:1999	Non-destructive testing - Radioscopic testing - Part 1: Quantitative measurement of imaging properties
EN 13068-2:1999	Non-destructive testing - Radioscopic testing - Part 2: Check of long term stability of imaging devices
EN 13068-3:2001	Non-destructive testing - Radioscopic testing - Part 3: General principles of radioscopic testing of metallic materials by X- and gamma rays
EN 444:1994	Non-destructive testing - General principles for radiographic examination of metallic materials by X- and gamma-rays
ISO 8062:1994	Castings -- System of dimensional tolerances and machining allowances
EN 1706:1998	Aluminium and aluminium alloys - Castings - Chemical composition and mechanical properties

1.2.4 References on welding

EN 287-2:1997	Approval testing of welders - Fusion welding - Part 2: Aluminium and aluminium alloys
EN 288-4:1997	Specification and approval of welding procedures for metallic materials - Part 4; Welding procedure tests for the arc welding of aluminium and its alloys
EN 439:1994	Welding consumables - Shielding gases for arc welding and cutting.
EN 970:1997	Non destructive examination of welds - Visual examination
EN 1011-1:1998	Welding - Fusion welding of metallic materials - Part 1: General
EN 1011-4:2000	Welding - Requirements for fusion welding of metallic materials - Part 4: Aluminium and aluminium alloys
EN 1418:1997	Welding personnel. Approval testing of welding operators for fusion welding and resistance weld setters for fully mechanised and automatic welding of metallic materials
EN-ISO 10042	Arc-welded joints in aluminium and its weldable alloys - Guidance on quality levels for imperfections
ISO 18273:2002	Welding consumables - Wire electrodes, wires and rods for arc welding of aluminium and aluminium alloys. Classification

1.2.5 Other references

ISO 1000:1992	SI units and recommendations for the use of their multiples and of certain other units
ISO 31-0:1992	Quantities and units – Part 0: General principles
ISO 3898:1997	Basis of design of structures – Notations – General symbols
ISO 8930:1991	General principles on reliability for structures - List of equivalent terms
ISO 11003-1:2001	Adhesives -- Determination of shear behaviour of structural adhesives -- Part 1: Torsion test method using butt-bonded hollow cylinders
ISO 11003-2:2001	Adhesives -- Determination of shear behaviour of structural adhesives -- Part 2: Tensile test method using thick adherents
EN ISO 1302:2002	Geometrical Product Specification (GPS) - Indication of surface texture in technical product documentation.

- EN ISO 4287:1998 Geometrical Product Specifications (GSP) - Surface texture: Profile method - Terms, definitions and surface texture parameters
- EN ISO 4288:1998 Geometrical Product Specification (GPS) - Surface texture - Profile method: Rules and procedures for the assessment of surface texture.

1.3 Assumptions

- (1) In addition to the general assumptions of EN 1990 the following assumptions apply:
- execution complies with prEN 1090-3

1.4 Distinction between principles and application rules

- (1) The rules in EN 1990 1.4 apply.

1.5 Terms and definitions

- (1) The definitions in EN 1990 1.5 apply.
- (2) The following terms are used in EN 1999-1-1 with the following definitions:

1.5.1

frame

the whole or a portion of a structure, comprising an assembly of directly connected structural members, designed to act together to resist load; this term refers to both moment-resisting frames and triangulated frames; it covers both plane frames and three-dimensional frames

1.5.2

sub-frame

a frame that forms part of a larger frame, but is be treated as an isolated frame in a structural analysis

1.5.3

type of framing

terms used to distinguish between frames that are either:

- **semi-continuous**, in which the structural properties of the members and connections need explicit consideration in the global analysis
- **continuous**, in which only the structural properties of the members need be considered in the global analysis
- **simple**, in which the joints are not required to resist moments

1.5.4

global analysis

the determination of a consistent set of internal forces and moments in a structure, which are in equilibrium with a particular set of actions on the structure

1.5.5

system length

distance in a given plane between two adjacent points at which a member is braced against lateral displacement, or between one such point and the end of the member

1.5.6

buckling length

length of an equivalent uniform member with pinned ends, which has the same cross-section and the same elastic critical force as the verified uniform member (individual or as a component of a frame structure).