BS EN 1999-1-5:2023

BSI Standards Publication

Eurocode 9 — Design of aluminium structures

Part 1-5: Shell structures

bsi.

National foreword

This British Standard is the UK implementation of EN 1999-1-5:2023. It supersedes BS EN 1999-1-5:2007, which will be withdrawn on 30 March 2028.

The UK participation in its preparation was entrusted to Technical Committee B/525/9, Structural use of aluminium.

A list of organizations represented on this committee can be obtained on request to its committee manager.

National choice is allowed in this standard where explicitly stated within notes. The National Annex to this standard contains the national choices to be used for buildings and civil engineering works constructed in the UK.

The first generation of EN Eurocodes was published between 2002 and 2007, with conflicting British Standards withdrawn in 2010. This document forms part of the second generation of EN Eurocodes.

The second generation of EN Eurocodes is expected to be published between 2023 and 2026. These documents are being published as soon as they are available. This is being done to enable users to prepare for the transition from the first generation to second generation of EN Eurocodes.

UK adoptions of the first generation of EN Eurocodes will be withdrawn by BSI on 30 March 2028. Until that date, the first generation documents should be considered as the applicable standards for buildings and civil engineering works constructed in the UK unless otherwise specified by the relevant authority or in the specification for a particular project.

This standard is intended to be used with its National Annex and other referenced documents, including other second generation Eurocodes, as an interdependent suite of documents.

While the use of provisions in this standard in conjunction with first generation Eurocodes is not precluded, it should be undertaken with care and should only be done when users are satisfied that it will not result in a lower level of reliability than the minimum level set in the first generation Eurocodes and associated UK National Annexes.

Contractual and legal considerations

Published by BSI Standards Limited 2023

ISBN 978 0 539 13051 5

ICS 13.220.50; 91.010.30; 91.080.10

Compliance with a British Standard cannot confer immunity from legal obligations.

This British Standard was published under the authority of the Standards Policy and Strategy Committee on 31 August 2023.

Amendments/corrigenda issued since publication

Date	Text affected

EUROPEAN STANDARD

NORME EUROPÉENNE

EUROPÄISCHE NORM

EN 1999-1-5

March 2023

ICS 91.010.30; 91.080.17

Supersedes EN 1999-1-5:2007

English Version

Eurocode 9 - Design of aluminium structures - Part 1-5: Shell structures

Eurocode 9 - Calcul des structures en aluminium - Partie 1-5 : Coques

Eurocode 9 - Bemessung und Konstruktion von Aluminiumtragwerken - Teil 1-5: Schalentragwerke

This European Standard was approved by CEN on 2 January 2023.

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-CENELEC 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-CENELEC Management Centre has the same status as the official versions.

CEN members are the national standards bodies of Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and United Kingdom.

EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

CEN-CENELEC Management Centre: Rue de la Science 23, B-1040 Brussels

Ref. No. EN 1999-1-5:2023 E

Contents

Page

European foreword

This document (EN 1999-1-5:2023) has been prepared by Technical Committee CEN/TC250 “Structural Eurocodes”, the secretariat of which is held by BSI. CEN/TC 250 is responsible for all Structural Eurocodes and has been assigned responsibility for structural and geotechnical design matters by CEN.

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 September 2027, and conflicting national standards shall be withdrawn at the latest by March 2028.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. CEN shall not be held responsible for identifying any or all such patent rights.

This document supersedes EN 1999-1-5:2007.

The main changes compared to the previous edition are listed below:

— Some reorganization of the text and its coherence with EN 1999-1-1 and the other Eurocodes;

— Update of Annex A on buckling formulae for cylinders, cones and spheres;

— New, more accurate formulation for imperfection reduction factors given in Annex A, related to unstiffened and stiffened shells under axial load, circumferential pressure and shear, including the case of axial compression with coexistent internal pressure;

— Better fitting of buckling curves against benchmarked available data, also considering the addition of a new material class in EN 1999, which led to three buckling classes A, B and C;

— Improvement of wording.

The first generation of EN Eurocodes was published between 2002 and 2007. This document forms part of the second generation of the Eurocodes, which have been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

The Eurocodes have been drafted to be used in conjunction with relevant execution, material, product and test standards, and to identify requirements for execution, materials, products and testing that are relied upon by the Eurocodes.

The Eurocodes recognize the responsibility of each Member State and have safeguarded their right to determine values related to regulatory safety matters at national level through the use of National Annexes.

Any feedback and questions on this document should be directed to the users’ national standards body. A complete listing of these bodies can be found on the CEN website.

According to the CEN-CENELEC Internal Regulations, the national standards organisations of the following countries are bound to implement this European Standard: Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Republic of North Macedonia, Romania, Serbia, Slovakia, Slovenia, Spain, Sweden, Switzerland, Türkiye and the United Kingdom.

0 Introduction

0.1 Introduction to the Eurocodes

The Structural Eurocodes comprise the following standards generally consisting of a number of Parts:

— EN 1990 Eurocode: Basis of structural and geotechnical 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

— New parts are under development, e.g. Eurocode for design of structural glass

The Eurocodes are intended for use by designers, clients, manufacturers, constructors, relevant authorities (in exercising their duties in accordance with national or international regulations), educators, software developers, and committees drafting standards for related product, testing and execution standards.

NOTE Some aspects of design are most appropriately specified by relevant authorities or, where not specified, can be agreed on a project-specific basis between relevant parties such as designers and clients. The Eurocodes identify such aspects making explicit reference to relevant authorities and relevant parties.

0.2 Introduction to EN 1999 (all parts)

EN 1999 (all parts) applies to the design of buildings and civil engineering and structural works made of 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.

EN 1999 (all parts) 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.

EN 1999 (all parts) does not cover the special requirements of seismic design. Provisions related to such requirements are given in EN 1998, which complements, and is consistent with EN 1999.

Eurocode 9 is subdivided in various parts:

— EN 1999-1-1 Eurocode 9 — Design of Aluminium Structures — Part 1-1: General rules;

— EN 1999-1-2 Eurocode 9 — Design of Aluminium Structures — Part 1-2: Structural fire design;

— EN 1999-1-3 Eurocode 9 — Design of Aluminium Structures — Part 1-3: Structures susceptible to fatigue;

— EN 1999-1-4 Eurocode 9 — Design of Aluminium Structures — Part 1-4: Cold-formed structural sheeting;

— EN 1999-1-5 Eurocode 9 — Design of Aluminium Structures — Part 1-5: Shell structures.

0.3 Introduction to EN 1999-1-5

This document applies to the structural design of aluminium structures, stiffened and unstiffened, that have the form of a shell of revolution or of a round panel in monocoque structures.

0.4 Verbal forms used in the Eurocodes

The verb “shall” expresses a requirement strictly to be followed and from which no deviation is permitted in order to comply with the Eurocodes.

The verb “should” expresses a highly recommended choice or course of action. Subject to national regulation and/or any relevant contractual provisions, alternative approaches could be used/adopted where technically justified.

The verb “may” expresses a course of action permissible within the limits of the Eurocodes.

The verb “can” expresses possibility and capability; it is used for statements of fact and clarification of concepts.

0.5 National annex for EN 1999-1-5

National choice is allowed in this standard where explicitly stated within notes. National choice includes the selection of values for Nationally Determined Parameters (NDPs).

The national standard implementing EN 1999-1-5 can have a National Annex containing all national choices to be used for the design of buildings and civil engineering works to be constructed in the relevant country.

When no national choice is given, the default choice given in this standard is to be used.

When no national choice is made and no default is given in this standard, the choice can be specified by a relevant authority or, where not specified, agreed for a specific project by appropriate parties.

National choice is allowed in EN 1999-1-5 through the following clauses:

— N/A

National choice is allowed in EN 1999-1-5 on the application of the following informative annexes:

Annex B

1 Scope

1.1 Scope of EN 1999-1-5

(1) EN 1999-1-5 applies to the structural design of aluminium structures, stiffened and unstiffened, that have the form of a shell of revolution or of a round panel in monocoque structures.

(2) EN 1999-1-5 covers additional provisions to those given in the relevant parts of EN 1999 for design of aluminium structures.

NOTE Supplementary information for certain types of shells is given in EN 1993-1-6 and the relevant application parts of EN 1993 which include:

— Part 3-1 for towers and masts;

— Part 3-2 for chimneys;

— Part 4-1 for silos;

— Part 4-2 for tanks;

— Part 4-3 for pipelines.

(4) The provisions in EN 1999-1-5 apply to axisymmetric shells (cylinders, cones, spheres) and associated circular or annular plates, beam section rings and stringer stiffeners, where they form part of the complete structure.

(5) Single shell panels (cylindrical, conical or spherical) are not explicitly covered by EN 1999-1-5. However, the provisions can be applicable if the appropriate boundary conditions are duly taken into account.

(6) Types of shell walls covered in EN 1999-1-5 can be (see Figure 1.1):

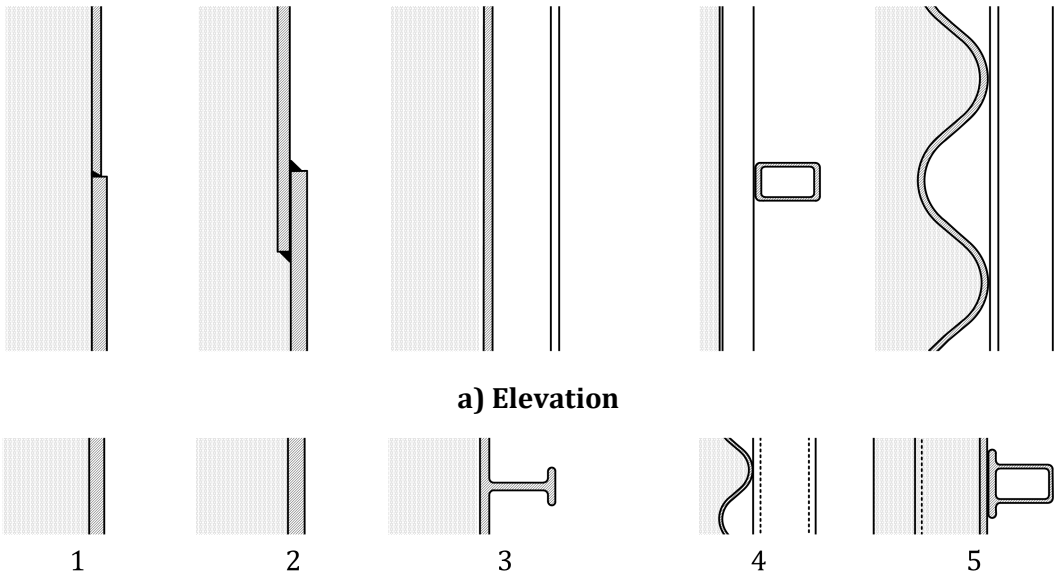
— shell wall constructed from flat rolled sheet with adjacent plates connected with butt welds, termed “isotropic”;

— shell wall with lap joints formed by connecting adjacent plates with overlapping sections, termed “lap-jointed”;

— shell wall with stiffeners attached to the outside, termed “externally stiffened” irrespective of the spacing of stiffeners;

— shell wall with the corrugations running up the meridian, termed “axially corrugated”;

— shell wall constructed from corrugated sheets with the corrugations running around the shell circumference, termed “circumferentially corrugated”.



Key

1 Isotropic (unstiffened)
2 Lap-joined
3 Externally stiffened
4 Axially corrugated
5 Circumferentially corrugated

Figure 1.1 — Illustration of cylindrical shell form

(7) The provisions of EN 1999-1-5 are intended to be applied within the temperature range defined in EN 1999-1-1. The maximum temperature is restricted so that the influence of creep can be neglected. For structures subject to elevated temperatures associated with fire, see EN 1999-1-2.

(8) EN 1999-1-5 does not cover the aspect of leakage.

1.2 Assumptions

(1) The general assumptions of EN 1990 apply.

(2) The provisions of EN 1999-1-1 apply.

(3) The design procedures are valid only when the requirements for execution in EN 1090-3 or other equivalent requirements are complied with.

(4) For the design of new structures, EN 1999 is intended to be used, for direct application, together with EN 1990, EN 1991, EN 1992, EN 1993, EN 1994, EN 1995, EN 1997 and EN 1998.

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

— European Standards for 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*;

— EN 1090-3, *Execution of steel structures and aluminium structures — Part 3: Technical requirements for aluminium structures*.