



BSI Standards Publication

Eurocode 3 — Design of steel structures

Part 1-13: Beams with large web openings

National foreword

This British Standard is the UK implementation of EN 1993-1-13:2024.

The UK participation in its preparation was entrusted to Technical Committee CB/203, Design & execution of steel structures.

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

Contractual and legal considerations

This publication has been prepared in good faith, however no representation, warranty, assurance or undertaking (express or implied) is or will be made, and no responsibility or liability is or will be accepted by BSI in relation to the adequacy, accuracy, completeness or reasonableness of this publication. All and any such responsibility and liability is expressly disclaimed to the full extent permitted by the law.

This publication is provided as is, and is to be used at the recipient's own risk.

The recipient is advised to consider seeking professional guidance with respect to its use of this publication.

This publication is not intended to constitute a contract. Users are responsible for its correct application.

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The first generation of EN Eurocodes was published between 2002 and 2007, with conflicting British Standards withdrawn in 2010.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UK adoptions of the first generation of EN Eurocodes will be withdrawn by BSI on 30 March 2028.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.

© The British Standards Institution 2024
Published by BSI Standards Limited 2024

ISBN 978 0 580 93644 9

ICS 91.010.30; 91.080.13

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 March 2024.

Amendments/corrigenda issued since publication

Date	Text affected
------	---------------

English Version

Eurocode 3 - Design of steel structures - Part 1-13: Beams with large web openings

Eurocode 3 - Calcul des structures en acier - Partie 1-
13 : Poutres avec grandes ouvertures d'âme

Eurocode 3 - Bemessung und Konstruktion von
Stahlbauten - Teil 1-13: Träger mit großen
Stegöffnungen

This European Standard was approved by CEN on 1 January 2024.

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

Contents

	Page
European foreword	4
0 Introduction.....	5
1 Scope.....	8
2 Normative references.....	10
3 Terms, definitions and symbols	11
3.1 Terms and definitions	11
3.2 List of symbols.....	12
4 Basis of design.....	17
4.1 General.....	17
4.2 Verifications.....	17
4.3 Methods of design for <i>Vierendeel</i> bending.....	18
4.3.1 Equivalent rectangular opening method.....	18
4.3.2 Alternative methods	18
4.4 Tolerances and manufacture.....	18
5 Materials	18
5.1 General.....	18
5.2 Welding.....	18
6 Durability.....	19
7 Structural Analysis	19
7.1 Methods of analysis.....	19
7.2 Member stiffness for global structural analysis	19
7.3 Serviceability	21
7.4 Classification for global bending.....	21
7.5 Section classification of Tees subject to <i>Vierendeel</i> bending	21
7.6 Section classification of longitudinal stiffeners.....	22
8 Ultimate Limit States	22
8.1 General Requirements for all openings.....	22
8.1.1 General.....	22
8.1.2 Geometric limits for unstiffened web openings.....	23
8.1.3 Geometric limits for web openings with stiffeners	23
8.2 Shear resistance at web opening positions	24
8.3 Bending resistance of a beam with web openings	25
8.3.1 General.....	25
8.3.2 Buckling resistance of the compressed Tee for long openings	25
8.4 Resistance of the Tee sections in <i>Vierendeel</i> bending	26
8.5 Web buckling next to widely spaced openings	28
8.5.1 General.....	28
8.5.2 Web buckling.....	29
8.6 Rules for closely spaced openings	30
8.6.1 General.....	30
8.6.2 Web-post bending.....	30
8.6.3 Web-post buckling.....	32
8.6.4 Web-post shear.....	33

8.7 Longitudinally stiffened openings..... 34

8.7.1 Scope of the rules for openings with longitudinal stiffeners..... 34

8.7.2 Additional verifications for stiffened openings..... 34

8.7.3 Global bending resistance for stiffened openings 34

8.7.4 *Vierendeel* bending resistance for stiffened openings 35

8.7.5 Web buckling for widely spaced stiffened openings 35

8.7.6 Web-post buckling for closely spaced stiffened openings..... 35

8.7.7 Openings with transverse stiffeners..... 36

8.8 Additional requirements for other cases..... 36

8.8.1 End-posts..... 36

8.8.2 Loads applied over or close to the openings..... 38

8.9 Alternative method for *Vierendeel* bending for circular openings..... 39

8.10 Alternative method for stability of web-post between circular openings 40

8.11 Alternative method for sinusoidal openings 43

8.11.1 General 43

8.11.2 *Vierendeel* bending..... 43

8.12 Lateral torsional buckling 44

9 Serviceability limit states 45

Bibliography 47

European foreword

This document (EN 1993-1-13:2024) has been prepared by Technical Committee CEN/TC 250 “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.

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 the EN 1993 series

The EN 1993 series applies to the design of buildings and civil engineering works in steel. 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 and geotechnical design.

The EN 1993 series is concerned only with requirements for resistance, serviceability, durability and fire resistance of steel structures. Other requirements, e.g. concerning thermal or sound insulation, are not covered.

EN 1993 is subdivided in various parts:

EN 1993-1, *Design of Steel Structures — Part 1: General rules and rules for buildings;*

EN 1993-2, *Design of Steel Structures — Part 2: Bridges;*

EN 1993-3, *Design of Steel Structures — Part 3: Towers, masts and chimneys;*

EN 1993-4, *Design of Steel Structures — Part 4: Silos and tanks;*

EN 1993-5, *Design of Steel Structures — Part 5: Piling;*

EN 1993-6, *Design of Steel Structures — Part 6: Crane supporting structures*;

EN 1993-7, *Design of steel structures — Part 7: Sandwich panels*.

EN 1993-1 in itself does not exist as a physical document, but comprises the following 14 separate parts, the basic part being EN 1993-1-1:

EN 1993-1-1, *Design of Steel Structures — Part 1-1: General rules and rules for buildings*;

EN 1993-1-2, *Design of Steel Structures — Part 1-2: Structural fire design*;

EN 1993-1-3, *Design of Steel Structures — Part 1-3: Cold-formed members and sheeting*;

NOTE Cold formed hollow sections supplied according to EN 10219 are covered in EN 1993-1-1.

EN 1993-1-4, *Design of Steel Structures — Part 1-4: Stainless steel structures*;

EN 1993-1-5, *Design of Steel Structures — Part 1-5: Plated structural elements*;

EN 1993-1-6, *Design of Steel Structures — Part 1-6: Strength and stability of shell structures*;

EN 1993-1-7, *Design of Steel Structures — Part 1-7: Plate assemblies with elements under transverse loads*;

EN 1993-1-8, *Design of Steel Structures — Part 1-8: Joints*;

EN 1993-1-9, *Design of Steel Structures — Part 1-9: Fatigue*;

EN 1993-1-10, *Design of Steel Structures — Part 1-10: Material toughness and through-thickness properties*;

EN 1993-1-11, *Design of Steel Structures — Part 1-11: Tension components*;

EN 1993-1-12, *Design of Steel Structures — Part 1-12: Additional rules for steel grades up to S960*;

EN 1993-1-13, *Design of Steel Structures — Part 1-13: Beams with large web openings*;

EN 1993-1-14, *Design of Steel Structures — Part 1-14: Design assisted by finite element analysis*.

All subsequent parts EN 1993-1-2 to EN 1993-1-14 treat general topics that are independent from the structural type like structural fire design, cold-formed members and sheeting, stainless steels, plated structural elements, etc.

All subsequent parts numbered EN 1993-2 to EN 1993-7 treat topics relevant for a specific structural type like steel bridges, towers, masts and chimneys, silos and tanks, piling, crane supporting structures, etc. EN 1993-2 to EN 1993-7 refer to the generic rules in EN 1993-1 and supplement, modify or supersede them.

0.3 Introduction to EN 1993-1-13

EN 1993-1-13 gives guidance and recommendations for the design of beams with large web openings.

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 1993-1-13

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 1993-1-13 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 1993-1-13 through notes to the following clauses:

1.1.3(1)	8.1.2(1)	8.1.3(2)	9(5)
----------	----------	----------	------

The National Annex can contain, directly or by reference, non-contradictory complementary information for ease of implementation, provided it does not alter any provisions of the Eurocodes.

1 Scope

1.1 Scope of EN 1993-1-13

1.1.1 General

(1) This document gives supplementary provisions that extend the application of EN 1993-1-1 and EN 1993-1-5 to the design of rolled and welded steel sections with various shapes of web openings. The following cases are considered:

- rolled or welded beams with single or widely spaced web openings;
- rolled or welded beams with closely spaced web openings;
- cellular beams with circular openings made by cutting and re-welding two parts of steel sections that may be different in dimensions;
- beams with hexagonal and sinusoidal openings made by cutting and re-welding two parts of steel sections that may be different in dimensions.

(2) This document applies to uniform members with I or H profiles, which are symmetric about the weak axis. It does not apply to non-prismatic or curved beams although the same principles can apply.

(3) This document applies to steel beams with web openings that are subjected to sagging (positive) or to hogging (negative) bending moments.

(4) This document covers the verification of the resistance at the openings and their effects on the global behaviour of the beam, including lateral torsional buckling.

(5) Alternative methods are presented for beams with circular openings and with sinusoidal openings in which the forces and resistances are calculated by increments around or along the openings and which are suitable for computer methods.

(6) This document applies to web slenderness, h_w/t_w , not exceeding 121ε . The local checks at and between adjacent openings apply to web slenderness up to this limit. The material parameter ε is defined in EN 1993-1-1:2022, 5.2.5(2).

NOTE The limit of 121ε is the limit of a Class 4 web for a steel section with equal flanges. It is used as a convenient limit for the application of this document, including mono-symmetric sections.

(7) This document does not cover fatigue. In case of fatigue, EN 1993-1-9 applies.

(8) This document does not cover fire design. For the design in case of fire, EN 1993-1-2 applies.

(9) This document does not cover the buckling verification of members with web openings under axial force.

1.1.2 Shapes of web openings

(1) The different shapes of web openings that are considered in this document are shown in Figure 1.1.

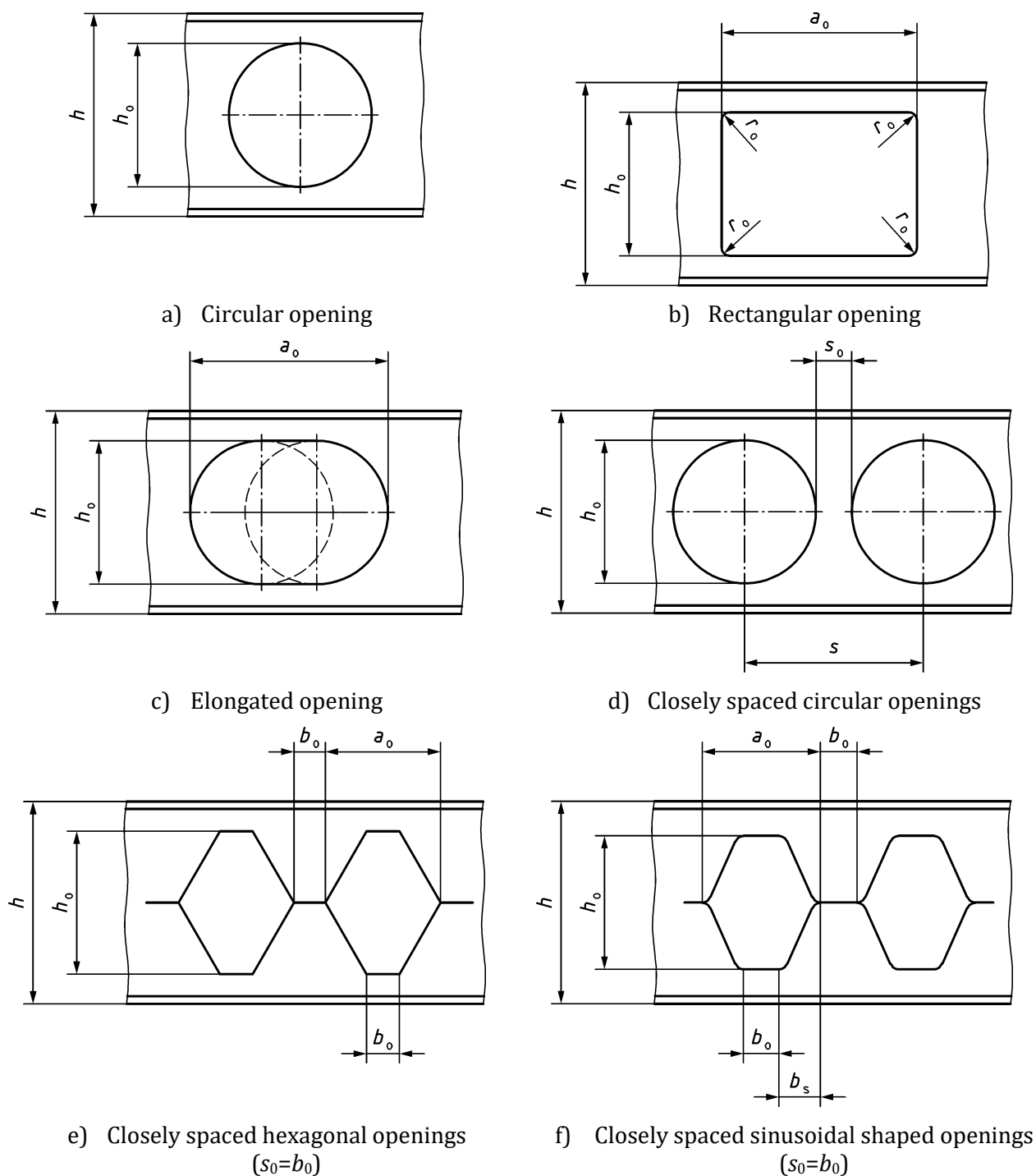
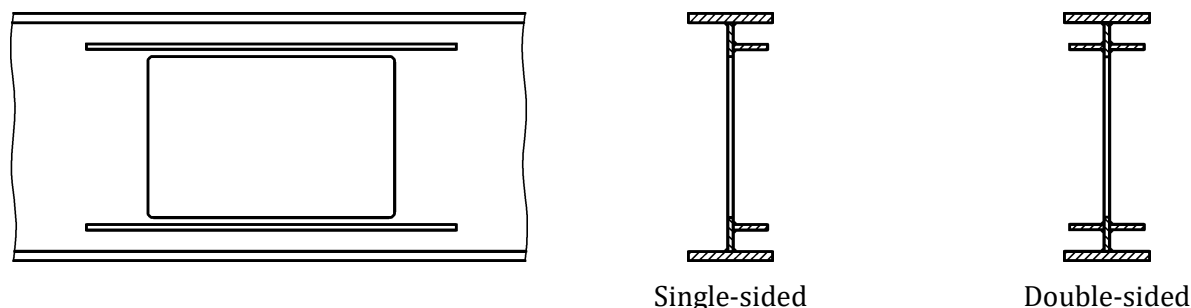


Figure 1.1 — Different shapes of web openings in steel beams

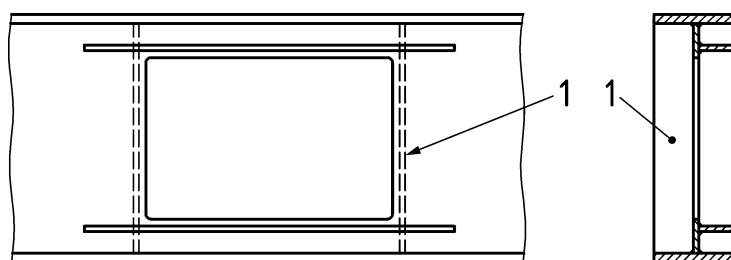
1.1.3 Stiffened openings

(1) This document also covers openings in the web of beams that are reinforced by longitudinal stiffeners and/or transverse stiffeners on one or both sides of the web, see Figure 1.2.

NOTE The National Annex can give rules for alternative types of stiffener.



a) Longitudinal stiffeners on one or both sides of the web



b) Transverse stiffeners combined with longitudinal stiffeners on opposite sides of the web

Key

1 transverse stiffener

Figure 1.2 — Stiffening of openings in beam webs

1.2 Assumptions

(1) Unless specifically stated, EN 1990, the EN 1991 series and EN 1993-1-1 apply.

(2) The design methods given in EN 1993-1-13 are applicable if:

- the execution quality is as specified in EN 1090-2, and
- the construction materials and products used are as specified in the relevant parts of the EN 1993 series, or in the relevant material and product specifications.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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.

NOTE See the Bibliography for a list of other documents cited that are not normative references, including those referenced as recommendations (i.e. in 'should' clauses), permissions ('may' clauses), possibilities ('can' clauses) and in notes.

EN 1090-2, *Execution of steel structures and aluminium structures — Part 2: Technical requirements for steel structures*

EN 1990, *Eurocode — Basis of structural and geotechnical design*

EN 1991 (all parts), *Eurocode 1 — Actions on structures*

EN 1993-1-1:2022, Eurocode 3 — Design of steel structures — Part 1-1: General rules and rules for buildings

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1.1

asymmetric section

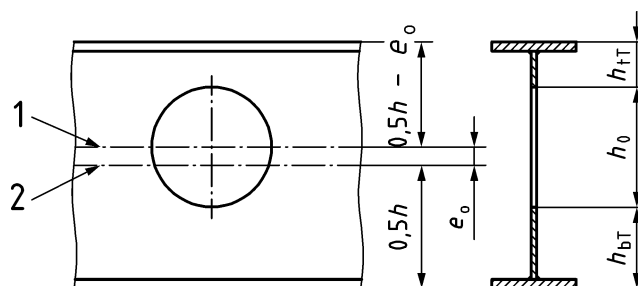
steel section with different dimensions of the top and bottom Tees

3.1.2

eccentricity of opening

distance e_o of the centre of the opening from the mid-height of the steel section

Note 1 to entry: e_o is positive when the mid-height of the opening is above the mid-height of the section and is negative below the mid-height of the section, see Figure 3.1.



Key

- 1 mid-height of the opening
- 2 mid-height of the section

Figure 3.1 — Definition of eccentricity of a web opening

3.1.3

Tee

cross-section composed of the flange and the part of the web above or below the opening

3.1.4

Vierendeel bending

local bending of Tees caused by the transfer of shear force across the opening

3.1.5

web-post

part of the web between adjacent openings, as shown in Figure 3.2

3.1.6

end-post

part of the web located between the opening and the beam end or adjacent support, as shown in Figure 3.2

3.1.7**widely spaced web openings**

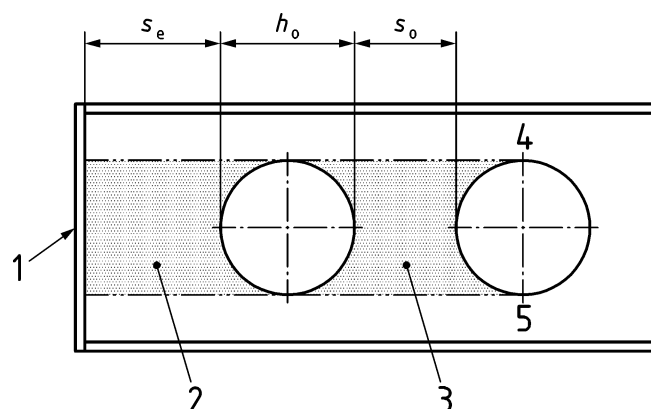
openings where web buckling next to the openings is not influenced by adjacent openings

3.1.8**closely spaced web openings**

openings where web buckling is influenced by the adjacent openings, as defined in 8.6.1

3.1.9**stiffened Tee**

Tees with longitudinal stiffeners welded to the web and with suitable anchorage on both sides of the opening

**Key**

- 1 end plate
- 2 end-post
- 3 web-post
- 4 top Tee
- 5 bottom Tee

Figure 3.2 — Definition of web-post and end-post for the case of circular openings

3.2 List of symbols

a_{eff}	Effective length of an opening for buckling and deflection calculations
a_{eq}	Equivalent length of an opening for <i>Vierendeel</i> bending
a_o	Overall length of an opening
a_v	Anchorage length of stiffener past an opening end
A_{bT}	Cross-sectional area of bottom Tee
A_s	Cross-sectional area of stiffener
A_{tT}	Cross-sectional area of top Tee
$A_{V,bT}$	Shear area of bottom Tee
$A_{V,tT}$	Shear area of top Tee
b_o	Width of the horizontal part of a hexagonal or sinusoidal opening, see Figure 1.1