SLOVENSKI STANDARD
SIST-TS CEN/TS 19100-2:2022

01-februar-2022

Projektiranje steklenih konstrukcij - 2. del: Projektiranje steklenih elementov pod vplivom obtežb izven ravnine elementov

Design of glass structures - Part 2: Design of out-of-plane loaded glass components

Bemessung und Konstruktion von Tragwerken aus Glas - Teil 2: Querbelastete Bauteile

Conception et calcul des structures en verre - Partie 2 : Calcul des composants en verre chargés perpendiculairement

Ta slovenski standard je istoveten z: **CEN/TS 19100-2:2021**

ICS:

91.080.99 Druge konstrukcije Other structures

SIST-TS CEN/TS 19100-2:2022 **en,fr,de**

TECHNICAL SPECIFICATION
SPÉCIFICATION TECHNIQUE
TECHNISCHE SPEZIFIKATION

CEN/TS 19100-2

November 2021

ICS 91.080.99

English Version

Design of glass structures - Part 2: Design of out-of-plane loaded glass components

Conception et calcul des structures en verre - Partie 2 : Calcul des composants en verre chargés perpendiculairement

Bemessung und Konstruktion von Tragwerken aus Glas - Teil 2: Querbelastete Bauteile

This Technical Specification (CEN/TS) was approved by CEN on 25 July 2021 for provisional application.

The period of validity of this CEN/TS 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 CEN/TS can be converted into a European Standard.

CEN members are required to announce the existence of this CEN/TS in the same way as for an EN and to make the CEN/TS available promptly at national level in an appropriate form. It is permissible to keep conflicting national standards in force (in parallel to the CEN/TS) until the final decision about the possible conversion of the CEN/TS into an EN is reached.

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, Turkey 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. CEN/TS 19100-2:2021 E

Contents

Page

European foreword

This document (CEN/TS 19100-2:2021) 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.

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 has been prepared under Mandate M/515 issued to CEN by the European Commission and the European Free Trade Association.

This document has 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 this document.

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 organizations of the following countries are bound to announce this Technical Specification: 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, Turkey 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

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 CEN/TS 19100 (all parts)

CEN/TS 19100 applies to the structural design of mechanically supported glass components and assemblies of glass components. 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.*

CEN/TS 19100 is subdivided into three parts:

— *Part 1: Basis of design and materials*

— *Part 2: Design of out-of-plane loaded glass components*

— *Part 3: Design of in-plane loaded glass components and their mechanical joints*

0.3 Introduction to CEN/TS 19100-2

CEN/TS 19100-2 applies to the structural design of out-of-plane loaded glass components in conjunction with CEN/TS 19100-1.

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 CEN/TS 19100-2

This document gives values within notes indicating where national choices can be made. Therefore, a national document implementing CEN/TS 19100-2 can have a National Annex containing all Nationally Determined Parameters to be used for the assessment of buildings and civil engineering works in the relevant country.

When not given in the National Annex, the national choice will be the default choice specified in the relevant Technical Specification.

The national choice can be specified by a relevant authority.

When no choice is given in the Technical Specification, in the National Annex, or by a relevant authority, the national choice can be agreed for a specific project by appropriate parties.

National choice is allowed in CEN/TS 19100-2 through the following clauses:

4.1 (1) NOTE

4.2.1 (2) NOTE

4.2.1 (3) NOTE 2

4.2.2 (1) NOTE

4.2.3 (1) NOTE 2

4.2.3 (1) NOTE 3

4.3.1 (2) NOTE

4.3.1 (3) NOTE

4.3.2 (6) NOTE 1

4.3.2 (6) NOTE 2

4.3.2 (7) NOTE 1

4.3.3 (2) NOTE 3

Clause 9 (3) NOTE

Clause 9 (6) NOTE

10.3.2 (11) NOTE

10.3.3 (3) NOTE

10.4 (3) NOTE 2

National choice is allowed in CEN/TS 19100-2 on the application of the following informative annexes:

Annex A Determination of the effective thickness according the enhanced effective thickness approach (EET)

Annex B Verification of the natural frequency of the glass component

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 CEN/TS 19100-2

(1) CEN/TS 19100-2 gives basic structural design rules for mechanically supported glass components primarily subjected to out-of-plane loading. Out-of-plane loaded glass components are made of flat or curved glass components.

NOTE Out of plane loads are loads acting normal (e.g wind) to or having a component (e.g dead load, snow, ...) acting normal to the glass plane.

1.2 Assumptions

(1) The assumptions of EN 1990 apply to CEN/TS 19100-2.

(2) This document is intended to be used in conjunction with EN 1990, EN 1991 (all parts), EN 1993-1-1, EN 1995-1-1, EN 1998-1, EN 1999-1-1 and EN 12488.

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. through 'should' clauses) and permissions (i.e. through 'may' clauses).

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

CEN/TS 19100-1:2021, *Design of glass structures - Part 1: Basis of design and materials*

3 Terms, definitions and symbols

3.1 Terms and definitions

For the purposes of this document, the terms and definitions given in CEN/TS 19100-1:2021 and the following apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1.1
chord shortening
difference of the length of the chord of the bent glass component compared to the original length of the glass component

3.1.2
clamp
support, connected to the glass pane with transmission of forces and moments

3.1.3
point fixing
fixing system where glass is locally supported by fixing points, generally through holes in the glass pane

3.1.4
point fixing system
system defined as both the glass and the fitting, taking into account the glass combination, the stiffness of the fitting, its interface with the glass

3.1.5
cantilever system
system clamping a glass component continuously along one glass edge

3.1.6
undercut hole
blind hole with recess in one glass ply

3.2 Symbols and abbreviations

A_i area of the cross-section of the i-th ply

D_{abs} flexural stiffness at the layered limit

D_{full} flexural stiffness at the monolithic limit

J_i moment of inertia of the i-th glass ply

J_{eq} equivalent moment of inertia of the laminated package, assuming an intermediate value between J_{abs} and J_{full}

L variable used for any kind of distance

M bending moment

a short edge of the glass component

b large edge of the glass component

d_i distance of the centroid of the i-th plate from the centroid of the cross-section of the laminated package

$\hat{h}_w$ deflection-effective thickness

$\hat{h}_\sigma$ stress-effective thickness

h_{IG} equivalent thickness of the IGU

h_{int} interlayer thickness

$\hat{h}_{int,i;\sigma}$ effective thicknesses for calculating the maximum stresses at the interface in the i-th ply

n_1 first mode of vibration

s minimum nominal mechanical edge cover or edge support depth

t_p remaining time to occurrence of total failure of the glass component

Ω_i number of vibration loops according the small glazing size length

Ω_j number of vibration loops according the big glazing size length

η_B non-dimensional coefficient depending on the geometry of the beam, on the loading and boundary conditions and on the mechanical properties of glass and interlayer

χ curvature due the bending moment M

Ψ values of coefficient for different loading and boundary conditions

4 Basis of design

4.1 Requirements

(1) For an out-of-plane loaded glass component the Limit State Scenario (LSS) should be chosen according to CEN/TS 19100-1:2021, 4.2.4.

NOTE For a glass component the LSS can be set by the National Annex, see CEN/TS 19100-1:2021, 4.2.4.

(2) Special attention shall be paid to robustness of the structure, see CEN/TS 19100-1 and EN 1990.

(3) When ensuring sufficient robustness, depending on the function, importance and installation position (e.g. height over ground or floor resp., vertical or non-vertical), care shall be taken on the following aspects:

— risk of injuring people in case of glass failure;

— risk of damage of other components in case of glass failure;

— careful choice of glass type and interlayer, which in combination or independently provide the necessary robustness of the glass component during the lifetime and after breakage;

— providing adequate cross-sectional redundancy by sufficient number of plies of the glass component;

— protection measures;

— realistic design, calculation and detailing.

(4) In case of laminated glass the shear interaction provisions as given in CEN/TS 19100-1:2021, 7.2.2 should be used. Guidance can be taken from Annex A of this document or from EN 16612.

(5) In case of fracture of a ply or of a component the consequences for the safety and integrity of adjoining structure, components and people shall be analysed and verified.

NOTE Countries are encouraged to establish tables with typical glass component assemblies depending on application and supports.

4.2 Fracture Limit State (FLS) verification

4.2.1 General

(1) In the FLS sufficient safety during impact shall be verified (failsafe verification), see CEN/TS 19100-1:2021, 4.2.3 (2).

(2) In the FLS, an appropriate load combination should be used for the static loading that arises during the event of impact.

NOTE The load combination in the FLS is the accidental load combination according to EN 1990 unless the National Annex gives a different load combination.

(3) In the FLS the supported glass component may be verified by experimental testing (4.2.2) or alternatively, by a theoretical assessment (4.2.3) provided equivalence is given.

NOTE 1 Verification can include reference to previously executed tests or calculations.

NOTE 2 The National Annex can specify type of impactor, energy, ambient temperature and acceptance criteria.

4.2.2 Verification of the Fracture Limit State by testing

(1) If the FLS is verified by experimental testing, this may be performed either on the original (as built) structure in situ or on an appropriate test specimen or on an appropriate equivalent laboratory specimen. Further provisions may be as specified by the relevant authority or, where not specified, agreed for a specific project by the relevant parties.

NOTE Provisions on experimental testing can be given in the National Annex.

(2) If testing is not performed by using the original component on the original structure in situ, it shall be ensured that the used equivalent test specimen or equivalent laboratory specimen including all relevant details correspond to the original structure including supports, load introduction, etc.

(3) The tests shall be planned and evaluated such that clear conclusions with regard to safety and reliability can be drawn. Attention should be paid to the required number of tests.

NOTE 1 The lower the number of tests the higher the margin between mean value of the test results and the design resistance.

NOTE 2 So far current EN 1990 does not give complete guidance on glass specific testing.

(4) After experimental testing on original built structure in situ, it should be checked whether the structure still complies with its original resistance.

(5) The test results shall be evaluated by a transparent and reproducible procedure assessing safety and reliability according to the requirements of EN 1990.

4.2.3 Verification of the Fracture Limit State by theoretical assessment

(1) If the FLS is verified by a theoretical assessment all static and dynamic effects originating from impact and/or damage/fracture of parts of the glass component or of the whole shall reasonably be taken into account for the short time of impact.

NOTE 1 Generally, a theoretical assessment in the FLS is performed by a transient numerical simulation.

NOTE 2 A method for the numerical verification of impact effects can be given in the National Annex.

NOTE 3 Further provisions for the theoretical assessment in the FLS can be given in the National Annex.

(2) The applicability of the theoretical model shall be validated.

NOTE Normally, the applicability of a theoretical model is validated by experimental benchmark tests.

4.3 Post Fracture Limit State (PFLS) verification

4.3.1 General

(1) In the PFLS sufficient safety after fracture for a limited period of time shall be verified (verification of residual resistance of the glass component or verification of an alternative load path). The fracture may be of one or several glass plies or of the component.

NOTE The resistance of the glass component in the Post Fracture Limit State (PFLS) is influenced by the type of glass (e.g. breakage pattern, type of interlayer, number of plies), the size of the glass component and its support.

(2) In the PFLS an appropriate load combination should be used.

NOTE The load combination in the PFLS is the accidental load combination according to EN 1990 and CEN/TS 19100-1 unless the National Annex gives different specification.

(3) Aspects that should be considered for the determination of the time period can originate from the following: time to secure the environment, temporary support, time to replace, time to remove the load etc. The time limited characteristic variable actions may be reduced according to EN 1991-1-6.

NOTE Post fracture time periods in the PFLS can be set by the National Annex.

(4) In the PFLS the glass component can be verified by experimental testing (4.3.2) or alternatively by a theoretical assessment (4.3.3), provided equivalence is given.

NOTE 1 Due to the viscoelastic properties of the interlayers and the complex mechanical behaviour of the broken glass laminate, the verification can sometimes only be done by testing of the original glass component including its supports.

NOTE 2 Verification can include reference to previously executed tests or calculations.

4.3.2 Verification of the Post Fracture Limit State by testing

(1) If the PFLS is verified by experimental testing, this may be performed either on the original (as built) structure in situ or on appropriate test specimen or on an appropriate equivalent laboratory specimen.

(2) Additional requirements for 4.3.2 (1) may be as specified by the relevant authority or, where not specified agreed for a specific project by the relevant parties.

(3) If the PFLS is verified by experimental testing on the original (as built) structure in situ, after experimental testing the intact initial state should be restored.

(4) If testing is not performed by using the original component on the original structure in situ, it shall be ensured, that the used equivalent test specimen or equivalent laboratory specimen including all relevant details correspond to the original structure including supports, load introduction, etc.

(5) Experimental tests should be planned and evaluated such that clear conclusions with regard to safety and reliability can be drawn. Special attention should be paid to the required number of tests.

NOTE The lower the number of tests the higher the margin between mean value of the test results and the design resistance.

(6) To determine the residual load bearing capacity time the glass component should be loaded by an appropriate load pattern with an appropriate magnitude.

NOTE 1 If the load pattern is a distributed load p, the value of p is 0,5 kPa unless the National Annex gives different values.

NOTE 2 The National Annex can specify requirements on breakage of further glass plies.

(7) The remaining time t_p to occurrence of total failure of the glass component shall meet the requirements, see 4.3.1.

NOTE 1 The value of t_p can be set in the National Annex.

NOTE 2 Apart from the breakage of the glass cross-section, total failure can also occur due to different failure mechanisms, e.g. slipping from supports, tearing of the interlayer, excessive deformation.

(8) After experimental testing on original built structure in situ, it should be checked whether the structure still complies with its original resistance.

4.3.3 Verification of the Post Fracture Limit State by theoretical assessment

(1) Alternatively to 4.3.2, a theoretical assessment of the PFLS may be performed. Here all relevant actions, time and ambient effects after the fracture event for the specified residual time period shall be taken into account.

(2) Generally, in case of accessibility, the glass ply directly in contact with actions should be assumed as fractured (e.g. the upper ply of a glass roof or a glass floor).