PD CEN/TS 19101:2022



BSI Standards Publication

Design of fibre-polymer composite structures

bsi.

National foreword

This Published Document is the UK implementation of CEN/TS 19101:2022.

The UK participation in its preparation was entrusted to Technical Committee B/525, Building and civil engineering structures.

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

The UK committee draws users' attention to National Annex NA, which provides further guidance to assist users in the application of this document.

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.

This publication is not to be regarded as a British Standard.

© The British Standards Institution 2023
Published by BSI Standards Limited 2023

ISBN 978 0 539 13572 5

ICS 91.010.30

Compliance with a Published Document cannot confer immunity from legal obligations.

This Published Document was published under the authority of the Standards Policy and Strategy Committee on 30 April 2023.

Amendments/corrigenda issued since publication

Date	Text affected

TECHNICAL SPECIFICATION

SPÉCIFICATION TECHNIQUE

TECHNISCHE SPEZIFIKATION

CEN/TS 19101

November 2022

ICS 91.010.30

English Version

Design of fibre-polymer composite structures

Calcul des structures en matériaux composites

Bemessung von Tragwerken aus Faserverbund-Kunststoffen

This Technical Specification (CEN/TS) was approved by CEN on 22 August 2022 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, 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

© 2022 CEN All rights of exploitation in any form and by any means reserved worldwide for CEN national Members.

Ref. No. CEN/TS 19101:2022 E

Contents

Page

European foreword 5
0 Introduction 6
1 Scope 7
2 Normative references 9
3 Terms, definitions, symbols and abbreviations 10
3.1 Terms and definitions 10
3.2 Symbols and abbreviations 21
3.3 Symbols for member axes 46
4 Basis of design 50
4.1 General rules 50
4.2 Principles of limit state design 50
4.3 Basic variables 50
4.4 Verification by the partial factor method 52
4.5 Design assisted by testing 61
5 Materials 62
5.1 Glass transition temperature 62
5.2 Composite materials 62
5.3 Core materials 64
5.4 Adhesives 66
6 Durability 67
6.1 General 67
6.2 Environmental conditions 68
6.3 Effects and measures for specific environmental conditions 69
6.4 Effects of combined environmental conditions 72
6.5 Measures for connections and joints 72
7 Structural analysis 73
7.1 Structural modelling for analysis 73
7.2 Global analysis 80
7.3 Imperfections 82
7.4 Methods of analysis 86
8 Ultimate limit states 88
8.1 General 88
8.2 Ultimate limit states of laminates 88
8.3 Ultimate limit states of profiles 96
8.4 Ultimate limit states of sandwich panels 107
8.5 Creep rupture 128
9 Serviceability limit states 131
9.1 General 131
9.2 Deflections 131
9.3 Vibrations 133
9.4 Matrix cracking 134
10 Fatigue 134
10.1 General 134

10.2 Fatigue actions ... 135
10.3 Fatigue verification ... 135
10.4 Fatigue testing ... 136
11 Detailing ... 138
11.1 General ... 138
11.2 Profiles ... 138
11.3 Sandwich panels and member laminates ... 138
11.4 Bolted connections ... 140
11.5 Adhesive connections ... 143
12 Connections and joints ... 143
12.1 General rules ... 143
12.2 Bolted connections ... 144
12.3 Bolted joints ... 163
12.4 Adhesive joints and connections ... 165
12.5 Hybrid joints and connections ... 170
Annex A (informative) Creep coefficients ... 171
A.1 Use of this annex ... 171
A.2 Scope and field of application ... 171
A.3 Pultruded composite profiles ... 171
A.4 Composite laminates ... 172
A.5 Core materials ... 172
Annex B (informative) Indicative values of material properties for preliminary design ... 174
B.1 Use of this annex ... 174
B.2 Scope and field of application ... 174
B.3 General ... 174
B.4 Fibres ... 174
B.5 Resins ... 175
B.6 Core materials ... 176
B.7 Ply properties ... 178
B.8 Laminate properties ... 188
Annex C (normative) Buckling of orthotropic laminates and profiles ... 191
C.1 Use of this annex ... 191
C.2 Scope and field of application ... 191
C.3 General ... 191
C.4 Elastic buckling of orthotropic laminates ... 192
C.5 Elastic buckling of profiles ... 196
Annex D (normative) Structural fire design ... 215
D.1 Use of this annex ... 215
D.2 Scope and field of application ... 215
D.3 Assumptions ... 215

D.4 Basis of design 215
D.5 Material properties 220
D.6 Tabulated design data 229
D.7 Simplified design methods 230
D.8 Advanced design methods 230
Annex E (informative) Bridge details 232
E.1 Use of this annex 232
E.2 Scope and field of application 232
E.3 General 232
E.4 Bridge bearings 232
E.5 Expansion joints 232
E.6 Parapets 234
E.7 Adhesive deck-girder connections 234
E.8 Crash barrier fixations 234
Bibliography 236

European foreword

This document (CEN/TS 19101:2022) 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.

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, Türkiye and the United Kingdom.

0 Introduction

0.1 Introduction to CEN/TS 19101

This document for the design of fibre-polymer composite structures, which was prepared in line with the Eurocodes, is 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 1 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.

NOTE 2 Fibre-polymer composites are also commonly referred to as fibre-reinforced polymers (FRP) or as composites.

0.2 Verbal forms used in this Technical Specification

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.

0.3 National Annex to CEN/TS 19101

This Technical Specification gives values within notes indicating where national choices can be made. Therefore, a national document implementing CEN/TS 19101 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 19101 through the following clauses:

4.3.1.2(4), NOTE 2	4.4.6(1), NOTE	4.4.6(2), NOTE	4.4.6(3), NOTE
4.4.7.1(2), NOTE	4.4.7.1(3), NOTE	8.5(2), NOTE 4	10.3(1), NOTE 1
12.4.5.1(1), NOTE 1	D4.5(1), NOTE		

National choice is allowed in CEN/TS 19101 on the application of the following informative annexes:

Annex A	Annex B	Annex E

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 19101

(1) This document applies to the design of buildings, bridges and other civil engineering structures in fibre-polymer composite materials, including permanent and temporary structures. It complies with the principles and requirements for the safety, serviceability and durability of structures, the basis of their design and verification that are given in EN 1990.

NOTE In this document, fibre-polymer composite materials are referred to as composite materials or as composites.

(2) This document is only concerned with the requirements for resistance, serviceability, durability and fire resistance of composite structures.

NOTE 1 Specific requirements concerning seismic design are not considered.

NOTE 2 Other requirements, e.g. concerning thermal or acoustic insulation, are not considered.

(3) This document gives a general basis for the design of composite structures composed of (i) composite members, or (ii) combinations of composite members and members of other materials (hybrid-composite structures), and (iii) the joints between these members.

(4) This document applies to composite structures in which the values of material temperature in members, joints and components in service conditions are (i) higher than -40 °C and (ii) lower than T_g - 20 °C, where T_g is the glass transition temperature of composite, core and adhesive materials, defined according to 5.1(1).

NOTE 1 Composite structures have a temperature-dependent behaviour. The temperature-dependence of the properties of composite, core and adhesive materials is considered through a conversion factor for temperature, η_c, as defined in 4.4.7.2, which depends on the T_g and the maximum material temperature in service conditions (T_s).

NOTE 2 5.1(1) defines requirements for the T_g of composite, core and adhesive materials as a function of the T_s.

(5) This document applies to:

(i) composite members, i.e. profiles and sandwich panels, and

(ii) bolted, bonded and hybrid joints and their connections.

NOTE 1 Profiles and sandwich panels can be applied in structural systems such as beams, columns, frames, trusses, slabs, plates and shells.

NOTE 2 Sandwich panels include homogenous core and web-core panels. In web-core panels, the cells between webs can be filled (e.g. with foam) or remain empty (e.g. panels from pultruded profiles).

NOTE 3 This document does not apply to sandwich panels made of metallic face sheets.

NOTE 4 Built-up members can result from the assembly of two or more profiles, through bolting and/or adhesive bonding.

NOTE 5 The main manufacturing processes of composite members include pultrusion, filament winding, hand layup, resin transfer moulding (RTM), resin infusion moulding (RIM), vacuum-assisted resin transfer moulding (VARTM).

NOTE 6 This document does not apply to composite cables or special types of civil engineering works (e.g. pressure vessels, tanks or chemical storage containers).

(6) This document applies to:

(i) the composite components of composite members, i.e. composite plies, composite laminates, sandwich cores and plates or profiles, and

(ii) the components of joints or their connections, i.e. connection plates or profiles (e.g. cleats), bolts, and adhesive layers.

NOTE 1 Composite components are composed of composite materials (i.e. fibres and matrix resins) and core materials. Components of joints and their connections are also composed of composite, steel or adhesive materials.

NOTE 2 The fibre architecture of composite components can comprise a single type of fibres or a hybrid of two or more types of fibres.

NOTE 3 This document does not apply to composite components used for internal reinforcement of concrete structures (composite rebars) or strengthening of existing structures (composite rebars, strips or sheets).

(7) This document applies to composite materials, comprising:

(i) glass, carbon, basalt or aramid fibres, and

(ii) a matrix based on unsaturated polyester, vinylester, epoxy or phenolic thermoset resins.

NOTE This document does not apply to composite materials comprising a matrix based on thermoplastic resins.

(8) This document applies to the core materials (i) polymeric foams, and (ii) balsa wood.

NOTE 1 The core of sandwich panels can be reinforced by composite webs and inserts.

NOTE 2 This document does not apply to honeycomb cores.

(9) This document applies to thermoset adhesives, including epoxy, polyurethane, and acrylic resins.

NOTE This document does not apply to thermoplastic adhesives.

(10) This document applies to other types of fibres, thermoset resins, homogeneous cores and thermoset adhesives than those specified in 1.1(6)-(9), provided that their mechanical and physical properties are obtained from appropriate testing according to Clause 5, and that they are in line with the other relevant clauses of this document.

1.2 Assumptions

(1) The assumptions of EN 1990 apply to this document.

(2) This document is intended to be used in conjunction with EN 1990, EN 1991 (all parts), EN 1997 (all parts), EN 1998 (all parts), ENs, EADs and ETAs for construction products relevant to composite structures.