BS EN 12369-2:2011

BSI Standards Publication

Wood-based panels — Characteristic values for structural design

Part 2: Plywood

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National foreword

This British Standard is the UK implementation of EN 12369-2:2011. It supersedes BS EN 12369-2:2004 which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee B/541, Wood based panels.

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

This publication does not purport to include all the necessary provisions of a contract. Users are responsible for its correct application.

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Wood-based panels - Characteristic values for structural design - Part 2: Plywood

Panneaux à base de bois - Valeurs caractéristiques pour la conception des structures - Partie 2: Contreplaqué

Holzwerkstoffe - Charakteristische Werte für die Berechnung und Bemessung von Holzbauwerken - Teil 2: Sperrholz

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Foreword

This document (EN 12369-2:2011) has been prepared by Technical Committee CEN/TC 112 “Wood-based panels”, the secretariat of which is held by DIN.

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of an identical text or by endorsement, at the latest by December 2011, and conflicting national standards shall be withdrawn at the latest by December 2011.

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

This document supersedes EN 12369-2:2004.

This standard is intended to be used in conjunction with EN 1995-1-1:2004.

Compared to EN 12369-2:2004, the following changes have been made:

a) The scope has been limited;

b) Where no values were available, this document provides, for tension and compression, strength and stiffness values derived from bending classes in each direction and taking the surface appearance class into account;

c) This document gives more relevant values for shear properties in relation to the density of the wood species in the panel;

d) The range of density, from 350 kg/m^3 to 750 kg/m^3, corresponds to data used to determine the correlation between these shear properties and density;

e) The characteristic value of the density is determined by using the results of Factory Production Control (FPC).

This European Standard is one of a series specifying characteristic values of wood-based panels for structural design. The other parts of this series are listed in the Bibliography.

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, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland and the United Kingdom.

1 Scope

This European Standard provides information on the characteristic values for use in designing structures incorporating wood-based panels. The characteristic values given in this standard are to be used in accordance with EN 1995-1-1.

When utilizing the classification system for derivation of plywood characteristic values, this European Standard can only be applied with reference to EN 636.

This European Standard includes the characteristic values of the mechanical properties for plywood complying with EN 636 in bending, tension, compression, panel shear and planar shear. EN 636 classifies bending properties into two sets of classes, one for stiffness and another for strength. Stiffness and strength in tension and compression are related to the same properties in bending.

For shear properties, fixed values determined by correlation to density are provided.

Where optimised values are needed, the characteristic values are determined directly by testing in accordance with EN 789 and EN 1058 or by combination of testing according to the latter two standards and calculation according to prEN 14272.

This European Standard applies to panels complying with the three following conditions:

— 5 layers or more and 6 mm overall thickness and more;

— the ratio of the cumulative thickness of veneers in alternate directions does not exceed 2,5;

— wood species with a mean density greater than 350 kg/m^3 and not exceeding 750 kg/m^3.

2 Normative references

The following referenced documents are indispensable for the application 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.

EN 310, *Wood-based panels — Determination of modulus of elasticity in bending and of bending strength*

EN 323, *Wood-based panels — Determination of density*

EN 326-2, *Wood-based panels — Sampling, cutting and inspection — Part 2: Initial type testing and factory production control*

EN 635-2, *Plywood — Classification by surface appearance — Part 2: Hardwood*

EN 635-3, *Plywood — Classification by surface appearance — Part 3: Softwood*

EN 636:2003, *Plywood — Specifications*

EN 1995-1-1:2004, *Eurocode 5: Design of timber structures — Part 1-1: General — Common rules and rules for buildings*

ISO 3131, *Wood — Determination of density for physical and mechanical tests*

3 Terms and definitions

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

3.1
characteristic value
value of a material property relating to limit state design,, for use in the design of timber structures, elements, assemblies and component in accordance with EN 1995-1-1

NOTE 1 As defined in EN 1995-1-1, this value corresponds to a specified percentile of the assumed distribution of the property under consideration.

NOTE 2 For plywood determined as stipulated in this document.

3.2
service class
NOTE Three service classes are defined in EN 1995-1-1.

3.2.1
service class 1
conditions of exposure resulting in moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air exceeding 65 % for only a few weeks per year

NOTE In these conditions the moisture content of coniferous plywood can be expected not to exceed 12 %.

3.2.2
service class 2
conditions of exposure resulting in moisture content in the materials corresponding to a temperature of 20 °C and the relative humidity of the surrounding air exceeding 85 % for only a few weeks per year

NOTE In these conditions the moisture content of coniferous plywood can be expected not to exceed 18 %.

3.2.3
service class 3
conditions of exposure resulting in higher moisture content in the materials than in service class 2

NOTE In these conditions the moisture content of coniferous plywood can be expected to exceed 18 %.

3.3
load duration class
class characterized by the effect of a constant load acting for a certain period of time in the life of the structure

NOTE 1 For a variable action, the appropriate class is determined on the basis of an estimate of the interaction between the typical variation of the load with time and the rheological properties of the materials.

NOTE 2 For strength and stiffness calculations, actions are assigned to one of the load-duration classes given in Table 1, derived from EN 1995-1-1.

Table 1 — Load duration classes

Load duration class	Order of accumulated duration of characteristic load	Examples of loading
Permanent	More than 10 years	Self weight
Long-term	6 months to 10 years	Storage
Medium-term	1 week to 6 months	Imposed load
Short-term	Less than 1 week	Snow [a] and wind
Instantaneous	—	Accidental load

[a] In areas which have a heavy snow load for a prolonged period of time, part of the load should be regarded as medium-term

3.4
lay-up
thickness and arrangement of the plies

3.5
composition
factors compounding the lay-up plus the combination of wood species

4 Symbols

4.1 Main symbols

E Modulus of elasticity (defined as stiffness in EN 1995-1-1:2004), (N/mm^2)

f Strength (N/mm^2)

G Modulus of rigidity (N/mm^2)

k Retention factor in strength (k_{mod}) or stiffness (k_{def}) after a period of time relative to initial values. Values are included in EN 1995-1-1

ρ Density of a wood species or of plywood (kg/m^3)

0 In the direction of the grain of the outer layer of plywood

90 Perpendicular to the grain of the outer layer of plywood

4.2 Subscripts

c Compression

k or 05 Characteristic (5th percentile)

m Bending

r Planar shear

t Tension

v Panel shear

w Wood species

p Panel

mean or 50 Mean (50^{th} percentile)

mod related to modification factor for strength

def related to modification factor for deflection

5 General

In this standard the 5^{th} percentile defines the characteristic value for:

— strength;

— density;

— modulus of elasticity where buckling, as an example, may be expected in service.

Otherwise the 50^{th} percentile defines the characteristic value of the modulus of elasticity.

The characteristic value is derived in panels with moisture content as determined by a temperature of 20 °C and a relative humidity of 65 %.

The characteristic value of a property is to be used in design according to EN 1995-1-1.

Where panels are structurally used under service class 1, 2 and 3 conditions, performance values inferred by the classification and listed in Table 2 and 3 shall be modified according to the service class and the duration of load (k_{mod}, k_{def}).

Manufacturers utilising the EN 636 classification system for determination of characteristic values may present these values in a format similar to that in Annex A.

The characteristic values shall be supported by the following information:

— product description;

— product specifications;

— service class or classes in which the panel can be used;

— details of the veneer species and grade, and of the composition;

— density of the panel.

6 Characteristic values for plywood

6.1 Introduction

Characteristic values for plywood can be determined by one of two distinct methods as described in Clause 1. The following tables in this clause provide the characteristic values for plywood based on the EN 636 Classification System.

The class values given in these tables shall be modified appropriately for service class and load duration in accordance with the requirements of EN 1995-1-1.

NOTE A data analysis has provided a conservative property relationship:

- to bending for tension and compression values and;

- to density for shear values.

See Annex B for more information on this relationship.

6.2 Bending, tension and compression

6.2.1 General

Testing according to EN 310 and application of the procedure in EN 326-2 for internal control enables the classification of the panels according to their composition and performances.

Characteristic values are provided for bending strength (see Table 2) and bending stiffness (see Table 3) for the classes as defined by the EN 636 Classification System. Tables 1 and 2 in EN 636:2003 give the current threshold performance levels required to be achieved for the purpose of classification.

Although classification for strength and stiffness are independent of each other, the characteristic values for tension and compression in both cases are derived from bending strength.

The surface appearance class, as defined in EN 635-2 and EN 635-3 shall be taken into account both for modulus and strength. Declared characteristic values shall also make reference to these surface appearance classes.

6.2.2 Strength

Class characteristic values for strength in bending, tension and compression, based on class limits as defined in EN 636 are listed in Table 2.

Table 2 — Class characteristic values for strength in bending, tension and compression

Class[a]	Characteristic strength values (N/mm^2 or MPa)		
	Surface grain direction [a]		
	0 and 90	0	90
	bending	Tension and compression	
	$f_{m,05}$	$f_{t\text{-}c,05}$	
F3	3	1,2	1,5
F5	5	2	2,5
F10	10	4	5
F15	15	6	7,5
F20	20	8	10
F25	25	10	12,5
F30	30	12	15
F40	40	16	20
F50	50	20	25
F60	60	24	30
F70	70	28	35
F80	80	32	40

[a] Class is to be identified for both parallel to grain (0) and perpendicular to grain (90) directions.

The F classes for strength are defined in EN 636:2003

6.2.3 Modulus of elasticity

Class limits for modulus of elasticity in bending and tension-compression are listed in Table 3.

Table 3 — Classification for modulus of elasticity in bending, tension and compression

Class[a]	**Mean modulus (N/mm^2 or MPa)**		
	Surface grain direction [a]		
	0 and 90	0	90
	bending	Tension and compression	
	$E_{m,50}$	$E_{t\text{-}c,50}$	
E5	500	250	400
E10	1 000	500	800
E15	1 500	750	1 200
E20	2 000	1 000	1 600
E25	2 500	1 250	2 000
E30	3 000	1 500	2 400
E40	4 000	2 000	3 200
E50	5 000	2 500	4 000
E60	6 000	3 000	4 800
E70	7 000	3 500	5 600
E80	8 000	4 000	6 400
E90	9 000	4 500	7 200
E100	10 000	5 000	8 000
E120	12 000	6 000	9 600
E140	14 000	7 000	11 200

[a] Class is to be identified for both parallel to grain (0) and perpendicular to grain (90) directions

The E classes for modulus of elasticity are defined in EN 636

The 5th percentile values for stiffness shall be taken as X times the mean values above:
X = 0,67 for panels containing wood species with a mean density less than 640 kg/m^3
X = 0,84 for panels wholly made of hardwood with a mean density at least equal to 640 kg/m^3

NOTE Factors derived from EN 338:2003, Annex A.

6.3 Shear properties

The properties of plywood such as panel shear modulus (G_v), strength in panel shear (f_v) and planar shear (f_r), are related to the density of the wood species used.

In case of single species panel, density is determined according to EN 323 and expressed as $\rho_{p,mean}$.

For panels combining more than one wood species, the density shall be determined by the species with the lower density in the composition. The property values to be taken shall be those of the bottom of the range of density the wood species belongs to and expressed as $\rho_{w,mean}$.

The mean density of the species may be determined according to ISO 3131.

When the 5th percentile characteristic density of the species is known the mean value can be derived using the following equation:

$$\rho_{w,mean} = \rho_{w,05} / 0{,}823$$

NOTE 5th percentile ratio derived from Table 1 in EN 338:2003.

The values of the properties are listed in Table 4.

If combinations of wood species groups are used the value from the lowest wood species group shall be used.

For densities in-between the tabled ones, the value of the nearer lower limit shall be taken to determine the relevant property.

Table 4 — Shear properties

$\rho_{w,mean}$	G_v	f_v	G_r	f_r
kg/m^3	N/mm^2			
350	220	1,8	7,3	0,4
400	270	2,7	11	0,5
450	310	3,5	16	0,6
500	360	4,3	22	0,7
550	400	5,0	32	0,8
600	440	5,7	44	0,9
650	480	6,3	60	1,0
700	520	6,9	82	1,1
750	550	7,5	110	1,2

6.4 Characteristic density

The determination of the characteristic density of the panels is described in EN 636.

Annex A
(informative)

Format for the presentation of characteristic values

Plywood according to EN 13986
Complying with EN 636
For use un service class N according to EN 1995-1-1:2004
Manufactured by:
The characteristic values given below are determined according to:
EN 789 and EN 1058
prEN 14272
or are derived in accordance with EN 12369-2
(Delete two options)

Table A.1

Thickness (mm)	**Number of layers**	**Characteristic strength (N/mm^2 or MPa) and density (kg/m^3)**								
		Density	**Bending**		**Tension**		**Compression**		**Shear**	
									Panel	**Planar**
			$f_{m,0}$	$f_{m,90}$	$f_{t,0}$	$f_{t,90}$	$f_{c,0}$	$f_{c,90}$	f_v	f_r
		---	---	---	---	---	---	---	---	---

Table A.2

Thickness (mm)	**Number of layers**	**Mean modulus of elasticity (N/mm^2 or MPa)**							
		Bending		**Tension**		**Compression**		**Shear**	
								Panel	**Planar**
		$E_{m,0}$	$E_{m,90}$	$E_{t,0}$	$E_{t,90}$	$E_{c,0}$	$E_{c,90}$	G_v	G_r
		---	---	---	---	---	---	---	---

The 5th percentile values for stiffness are taken as:

— 0,67 times the mean values above for panels made of, fully or partly, softwood species

— 0,84 times the mean values above for panel made of hardwood species with a mean density at least equal to 640 kg/m^3

NOTE Derived from EN 338:2003, Annex A.

Relevant information for the application of this standard:

— classification of the panel in accordance with EN 636:2003, Clause 4;

— composition of the panel claiming to belong to a given class;

— mean density of the panel.

Annex B
(informative)

Information about the conversion factors

NOTE The conversion factors were derived from data published before as material for previous drafts of EN 12369-2.

B.1 Tension – Compression

B.1.1 General

For each panel type, as defined in the above drafts, the average of the property (strength and modulus of elasticity in bending, tension and compression) was calculated for all the Tabled thickness along the face grain and across.

Then in each direction, the ratio of the mean for tension upon bending was calculated (for modulus and strength) and the same was made for compression.

Then, for all the panel types, for the ratios thus obtained, the 5th percentile value was calculated using normal and log-normal distributions.

B.1.2 Strength

The analysis of the results leads to the following conversion factors, given in Table B.1.

Table B.1 — Conversion factors for the derivation of characteristic values for tension and compression strengths based on bending strength

Properties	f_t/f_m		f_c/f_m	
Grain direction	0	90	0	90
Normal distribution	0,51	0,56	0,48	0,63
Log-normal distribution	0,49	0,54	0,46	0,62
Rounded values	0,40	0,50	0,40	0,50

The rounded values were taken to derive Table 2 class values for tension and compression strength.

B.1.3 Modulus of elasticity

For tension and compression the Tables of performances provided the same values in both grain directions. The analysis of the results leads to the following conversion factors, given in Table B.2.

Table B.2 — Conversion factors for the derivation of characteristic values for modulus of elasticity in tension and compression based on bending strength

Properties	$E_{t,c}/E_m$	
Grain direction	0°	90°
Normal distribution	0,64	0,93
Log-normal distribution	0,63	0,86
Rounded values	0,40	0,80

The rounded values were taken to derive Table 3 class values for tension and compression modulus.

B.2 Shear properties

The documented properties were:

— strength in panel shear (f_v);

— planar shear (f_r);

— modulus of elasticity for panel shear (G_v) only.

For each panel type, a single value was provided for each these properties together with the mean density.

For each of these properties a linear correlation was established with density, the standard deviation corresponding to the ordinate and it lower estimate were calculated in order to have a 5th percentile value for the ordinate. The following relation was used:

$$V_{pk0} = a + b \times \rho_{0mean} - \Delta_0 \quad \text{(B.1)}$$

where

V_{pk0} is the 5th percentile value for the property p;

a, b respectively are ordinate and slope of the regression line;

Δ_0 is derived from equation (B.2)

Using (B.1) lead to the following equations:

Panel shear modulus	Planar shear modulus
$G_{v0} = 0.83 \times \rho_{0mean} + 54 - \Delta_0$	$G_{r0} = \exp\left(\frac{6.7}{1000} \times \rho_{0mean} + 0.47 - \Delta_0\right)$
Panel shear strength	Planar shear strength
$f_{v0} = \frac{14}{1000} \times \rho_{0mean} - 0.5 - \Delta_0$	$f_{r0} = \exp\left(\frac{2.4}{1000} \times \rho_{0mean} - 0.70 - \Delta_0\right)$
$\Delta_0 = t_{05} \times \left(1 - r^2\right) \times \left(\frac{n-1}{n-2}\right) \times S_p \times \left(1 + \frac{1}{n} + \frac{\left(\rho_0 - \overline{\rho}\right)^2}{\sum_{i=1}^{i=n}\left(\rho_i - \overline{\rho}\right)^2}\right)^{\frac{1}{2}}$ (B.2)	

Where

r is the coefficient of correlation between property p and density;

t_{05} is the Student coefficient so as to have a 5th percentile value (single sided distribution);

S_p is the standard deviation of the property p.

These equations were used to derive Table 4 values for shear properties.

Bibliography

[1] EN 338:2003, *Structural timber — Strength classes*

[2] EN 789, *Timber structures — Test methods — Determination of mechanical properties of wood based panels*

[3] EN 1058, *Wood-based panels — Determination of characteristic 5-percentile values and characteristic mean values*

[4] EN 12369-1, *Wood-based panels — Characteristic values for structural design — Part 1: OSB, particleboards and fibreboards*

[5] EN 12369-3, *Wood-based panels — Characteristic values for structural design — Part 3: Solid-wood panels*

[6] EN 13986, *Wood-based panels for use in construction — Characteristics, evaluation of conformity and marking*

[7] prEN 14272, *Plywood — Calculation method for some mechanical properties*

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