

Specifying wood-based panels for structural use

This Wood Information Sheet (WIS) covers the following wood-based panels intended for structural use:

- cement bonded particleboard
- fibreboard
- oriented strand board (OSB)
- resin bonded particleboard (also known as chipboard)
- plywood
- solid wood panels.

Boards of these types, intended for use in construction, fall under the scope of the harmonised Standard *BS EN 13986 Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking* [1] and must therefore carry a CE mark.

Exova BM TRADA recommends *Eurocode 5* [2] for structural design of timber. However, this WIS includes a summary of variations when using *BS 5268-2 Structural use of timber. Code of practice for permissible stress design, materials and workmanship* [3], which was withdrawn by BSI in 2009.

This WIS is an overview of the subject with signposts to more detailed sources that are listed at the end.

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Key points

- From 1st July 2013 manufacturers (or their representatives in the EU) must apply the CE mark across the entire EU, to comply with the Construction Products Regulation (CPR).
- The harmonised Standard for wood-based panels for structural use is *BS EN 13986*.



Figure 1: Wood-based panels, from top: cement bonded particleboard, chipboard, MDF, hardboard, plywood and OSB

Key points continued

- Products outside the scope of *BS EN 13986* may be CE marked through a European Technical Assessment.
- *BS EN 13986* refers to a series of EN product Standards for specifications and requirements for each panel type, otherwise known as technical classes.
- If a manufacturer wishes to claim better performance values, they can apply the CE mark and declare their own values.
- Properties that must be assessed are bending strength and stiffness, bond quality/internal bond, durability, formaldehyde and pentachlorophenol. Additional properties may be required depending on the use.
- An important consequence of the CPR is that manufacturers of panels for use in construction must now CE mark their products and supply a Declaration of Performance (DoP) presenting the properties of the product. For structural (load-bearing) panels this would normally include at least one characteristic strength or stiffness value needed for design using Eurocode 5. Currently, the DoP can include 'No Performance Determined' (NPD) against many properties, but it is expected that a future revision of *BS EN 13986* will make more properties mandatory.

CE Marking

 1234-CPD-5678
Any Company P O Box ?? Any Town Country 05
EN 13986 EN 636-2 S E1 “Wall sheathing” 600 kg/m³, 9mm Reaction to fire: Class D-s2,d0

Figure 3: CE marked OSB wall sheathing

Prior to the introduction of the CPR in July 2013, CE marking of panels was voluntary in the UK. Since that time, it has been mandatory to apply the CE mark across the entire EU (including the UK) for any construction product covered by a ‘harmonised’ European Standard, such as *BS EN 13986*.

CE marking is described in more detail in the TRADA’s *WIS 2/3-56: CE marking: implications for timber products* [4].

BS EN 13986 refers to a series of EN product Standards for specifications and requirements for most panel types otherwise known as technical classes, for example OSB/3 or P5. The exception to this is plywood. These Standards set out minimum properties and quality control procedures for different grades of panel, according to:

- their purpose, such as load-bearing or heavy duty loadbearing
- the service class conditions in which they are suitable for use, such as dry, humid or exterior conditions.

Table 1 lists the technical classes of panels suitable for use in appropriate structural (loadbearing) applications according to *BS EN 13986*.

For products within the scope of *BS EN 13986*, but not within a technical class (such as OSB/3) because, for example, they are outside the thickness ranges or perhaps the manufacturer simply wishes to claim higher values, the manufacturer can apply the CE mark and declare his own specification values according to Table 14 of *BS EN 13986* without reference to a technical class.

The current version of *BS EN 13986* includes an amendment issued in 2015 that brings it into line with CPR. Manufacturers are now required to have available a Declaration of Performance (DoP), presenting technical information on their product. These will include information on relevant characteristics as outlined below. Specifiers and purchasers should always obtain this information to ensure that the material being offered meets their requirements.

If a product does not fall under the scope of a harmonised Standard it is not necessary to CE mark. However, if desired, products outside the scope of *BS EN 13986* may be CE marked through a European Technical Assessment (ETA) using a European Assessment Document (EAD). Under CPR, the EAD replaces the European Technical Approval Guideline (ETAG) and the Common Understanding of Assessment Procedure (CUAP) used under the CPD.

Performance characteristics

BS EN 13986 sets out the required performance characteristics (properties) for panels in various applications, although not all of the applications are structural. It lists structural components under the following categories:

- internal use as structural components in dry conditions
- internal use as structural components in humid conditions
- external use as structural components
- use as structural floor and roof decking on joists as well as structural wall sheathing on studs.

The performance characteristics may have been tested by the manufacturer and maintained through a production quality control process, or in some cases, standard values listed in *BS EN 13986* may be used. These standard values are sometimes referred to as Classified Without Further Testing (CWFT).

Properties that must be assessed:

- bending strength and stiffness (quality control tests)
- bond quality/internal bond (quality control tests)
- durability – moisture resistance, thickness swelling (quality control tests)
- formaldehyde – a constituent of some adhesives, particularly aminoplastic resins (certain types of panel may not require testing if no formaldehyde-containing materials are added during, or post-production). For more details see *BS EN 13986* Annex B
- pentachlorophenol (only if materials used contain more than 5 ppm PCP). For more details see *BS EN 13986* Clause 5.18.

Table 1: Technical classes of panel listed in BS EN 13986 as suitable for structural applications

Panel type	Standard	Technical class
Cement bonded particleboard	<i>BS EN 634-2 Cement-bonded particleboards. Specifications. Requirements for OPC bonded particleboards for use in dry, humid and external conditions</i> [5]	Modulus of elasticity class 1 or 2
Fibreboards	<i>BS EN 622-2 Fibreboards. Specifications. Requirements for hardboards</i> [6]	HB.LA Load-bearing, dry HB.HLA1 load-bearing, humid HB.HLA2 heavy duty load-bearing, humid
	<i>BS EN 622-3 Fibreboards. Specifications. Requirements for medium boards</i> [7]	MBH.LA1 load-bearing, dry MBH.LA2 heavy duty load-bearing, dry MBH.HLS1 load-bearing, humid * MBH.HLS2 heavy duty load-bearing, humid *
	<i>BS EN 622-4 Fibreboards. Specifications. Requirements for softboards</i> [8]	SB.LS load-bearing, dry * SB.HLS load-bearing, humid *
	<i>BS EN 622-5 Fibreboards. Specifications. Requirements for dry process boards (MDF)</i> [9]	MDF.LA load-bearing, dry MDF.HLS load-bearing, humid *
OSB	<i>BS EN 300 Oriented strand boards (OSB). Definitions, classification and specifications</i> [10]	OSB/2 load-bearing, dry OSB/3 load-bearing, humid OSB/4 heavy duty load-bearing, humid
Particleboard (resin bonded)	<i>BS EN 312 Particleboards. Specifications</i> [11]	P4 load-bearing, dry P5 load-bearing, humid P6 heavy duty load-bearing, dry P7 heavy duty load-bearing, humid
Plywood	<i>BS EN 636 Plywood. Specifications</i> [12]	EN 636-1 S structural, dry EN 636-2 S structural, humid EN 636-3 S structural, exterior
Solid wood panels	<i>BS EN 13353 Solid wood panels (SWP). Requirements</i> [13]	BS EN 13353 Solid wood panels (SWP). Requirements ¹
* Fibreboards suitable only for structural applications where there are instantaneous or short-term loads only. This is indicated by the "S" in the type classification.		

Properties where standard values may be used

For some properties, *BS EN 13986* lists generic values (CWFT) that a manufacturer may declare without testing their product. These are:

- reaction to fire (*BS EN 13986* gives values for certain products mounted with or without an air gap)
- water vapour permeability (*BS EN 13986* gives values for certain products)
- airborne sound insulation and sound absorption (*BS EN 13986* gives values for certain products)
- thermal conductivity (*BS EN 13986* gives values for certain products)
- characteristic values of strength and stiffness (these are provided separately in *BS EN 12369*, see *Design considerations* below or manufacturer's data)
- mechanical durability – creep and duration of load (*Eurocode 5* gives modification factors)
- biological durability (*BS EN 335 Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products* [14] contains guidance).

Properties required for a particular end use

Depending upon the end use, additional criteria need to be defined:

- Floor and roof decking on joists – soft body impact and concentrated load tests should be carried out 'if required'. The procedures are described in *BS EN 12871 Wood-based panels. Performance specifications and requirements for load bearing boards for use in floors, walls and roofs* [15]. These tests are only relevant to panels spanning between supports, so would not be relevant where the panels are fully supported or where there is no concentrated load or impact requirement.
- Wall sheathing – soft body impact tests should be carried out 'if required'. The procedures are given in *BS EN 596 Timber structures. Test methods. Soft body impact test of timber framed walls* [16], and are to be carried out as described in *BS EN 12871*. Racking resistance tests to *BS EN 594 Timber structures. Test methods. Racking strength and stiffness of timber frame wall panels* [17] may also be required if the wall is to provide racking capacity to the structure.

These performance-based tests for floors, walls and roofs are carried out on small sections of components and the results are only relevant to the construction tested (such as panel type and

thickness, and joist/stud spacings). Such data may be provided by the manufacturer, but NPD is currently still an option. Part of the BS EN 12871 testing is for impact which is a pass or fail test, the other part is a point load test. An engineer uses characteristic values derived from the point load test to verify that, for a given span, a product is thick enough for the imposed point load.

Design

In the case of floor and roof decking, and wall sheathing, structural design calculations using Eurocode 5 require design stresses and performance-based values.

An important consequence of the CPR is that manufacturers of CE Marked products intended for structural use should now specify characteristic values of parameters needed for design using Eurocodes. Although most wood-based panels have generic characteristic values given in BS EN 12369, plywood is produced in a wide variety of species and lay-ups, and manufacturers must specify characteristic values for each type of plywood. Currently, however, NPD is still an option so the range of properties claimed by different manufacturers is very variable.

BS EN 12369 Wood-based panels. Characteristic values for structural design is in three parts:

- Part 1: OSB, particleboards and fibreboards [18], which includes the oriented strand boards OSB/2, OSB/3 and OSB/4, particleboards P4, P5, P6 and P7, and fibreboards HB.HLA2, MBH.LA2, MDF.LA and MDF.HLS
- Part 2: Plywood [19], which gives characteristic values of mechanical properties for plywood in bending, based on a series of strength classes and modulus classes. It includes advice on determining characteristic values in tension and compression by a combination of testing and calculation. Conservative values for shear are included
- Part 3: Solid wood panels [20], which includes SWP/1 S, SWP/2 S and SWP/3 S.

For products not listed in BS EN 12369 or where a manufacturer thinks their product will perform better than the generic values it lists, characteristic values may be determined by testing in accordance with BS EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels [21] and calculation in accordance with BS EN 1058:2009. Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values [22].

The properties listed in BS EN 12369 include characteristic values for bending, tension, compression and shear. In the case of floors

and roofs, this enables the behaviour under uniform loads to be assessed, but there is no agreed method of calculating behaviour under concentrated or impact loads. Where required, these criteria should be tested in accordance with BS EN 12871 and the data provided by the manufacturer.

Like all wood-based products, panels are affected by the duration of the load applied, both in relation to deflection (creep) and to failure. Eurocode 5 gives factors to account for these effects.

In the case of floor and roof decking, the soft body impact test has to demonstrate that the requirements of BS EN 12871 can be met. The concentrated load test results are used to check the capacity of the panel against the design concentrated load, specified in BS EN 1991-1-1 Eurocode 1. Actions on structures. General actions. Densities, self-weight, imposed loads for buildings [23]. Design checks may also need to be carried out for any uniform load specified.

In wall sheathing, design for racking resistance can be carried out by test in accordance with BS EN 594. But there is no codified method for using this data with Eurocode 5. Guidance on design for racking by calculation using Eurocode 5 is given in PD 6693-1 Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings [24]. For most panel types this calculation only requires a knowledge of thickness, but for plywood the density is also required.

The above refers principally to design for structural criteria but the design may also need to take account of other factors such as fire, acoustics and durability.

Variations when using BS 5268 (withdrawn, 2009)

BS 5268-2 gives grade stresses for a range of plywoods from Scandinavia and North America. These materials must also demonstrate compliance with the CPR, by compliance with BS EN 13986 and by affixing a CE mark. For other materials, characteristic values (from BS EN 12369 or via the BS EN 789/BS EN 1058 route, see Eurocode design) may be used and BS 5268-2 gives conversion factors to modify these into grade stresses.

Loads are specified in BS 6399-1 Loading for buildings. Code of practice for dead and imposed loads (withdrawn by BSI in 2010) [25].

In wall sheathing, design for racking resistance can be carried out using basic racking resistance values given in BS 5268-6 Structural use of timber. Code of practice for timber frame walls. Part 1: Dwellings not exceeding seven storeys [26] or Part 2: Buildings other than dwellings not exceeding four storeys [27]. Both Parts 1 and 2 were, however, withdrawn by BSI in 2009. Testing in accordance with BS EN 594 is also possible.

Specification

The simplest and most effective way of specifying a panel product for structural use is to require compliance with *BS EN 13986* and a technical class, for example *OSB/3*. The specification should consider at least the following factors:

- Panel type – this may be generic, such as plywood, or a more specific technical class such as *BS EN 300 OSB/3*.
- Thickness
- Fire performance rating
- Durability requirement – in *BS EN 13986* durability relates to factors for thickness swelling and moisture resistance. If high moisture contents are anticipated panels may also require preservative treatment (see *BS EN 335* for guidance) to reduce the risk of fungal decay
- Formaldehyde class.

The panel specification selected should:

- be a load-bearing type complying with *BS EN 13986*. Refer to the appropriate product Standard, such as *BS EN 312*
- be suitable for the prevailing service class. For example, Service Class 2 requires a panel suitable for use in humid conditions
- have adequate minimum strength and stiffness properties – specify minimum characteristic values.

Take care when specifying plywood in an exterior environment. Both the glue bond and biological durability of the wood plies contribute to the overall durability of the panel. Most plywoods will require preservative treatment or other form of protection if a prolonged life in an exterior environment is desired.

The specification may need to cover other criteria, such as acoustics.

If a specific brand of product has been found to be suitable and to comply with the CPR, then it may be specified directly. However, specifiers and suppliers should remember that substitution with a similar material will not automatically ensure compliance with the CPR and all performance requirements.

Variations when using BS 5268

For minimum strength and stiffness properties, specify permissible stresses.

Maintaining fitness for purpose

Compliance with the CPR and CE marking requires that anyone who handles or distributes a panel must be in a position to demonstrate its 'fitness for purpose'. Under the terms of the CPR, distributors and merchants have a legal obligation to supply a

product that is suitable for the communicated intended end-use, as well as the technical data needed to verify its performance.

Fitness for purpose can also be affected by the way that panels are handled, transported and stored at all stages through the supply chain, including construction sites. As a natural material, wood is hygroscopic; it can take up and release moisture from the atmosphere and its physical and mechanical properties can change as a result. Wood-based panels behave in a similar way to solid wood, swelling if they absorb moisture and shrinking if moisture is lost. Panels should be installed into a building at a moisture content as close as possible to that which they will achieve in service. Correct storage, transportation, handling and conditioning are also vital to the correct performance of the panel in the finished building.

The PanelGuide [28] and *DD CEN/TR 12872:2014 Wood-based panels. Guidance on the use of load-bearing boards in floors, walls and roofs* [29] offer further guidance.

Example specifications

These examples illustrate the specification of typical applications of wood-based panels. 'Real life' specifications will vary depending on the governing factors of a particular design, and must be considered on a case-by-case basis.

In these examples, 'x' denotes a value or grade which must be determined by the designer/specifier and included in the specification. The design follows *Eurocode 5*.

BS ENs are the official English language version of European Standards ENs. Other versions may be designated, for example NF EN, France; SS EN, Sweden; DIN EN, Germany. These may appear in documentation and CE marks on panels manufactured outside the UK and, providing the EN number is the same, are equally acceptable.

To comply with CPR Article 9, the CE mark should include:

- the last two digits of the year in which the mark was first affixed
- the name and address of the manufacturer or an unambiguous identification mark allowing the name and address to be identified
- the unique code identifying the product type
- a reference to the DoP
- the level or class of performance declared (this is unclear since it could refer to any number of properties)
- a reference to the harmonised technical specification (*BS EN 13986* in this case)
- the identification number of the Notified Body responsible for certifying the FPC
- the intended use of the product.

Table 2: Wall panel with OSB wall sheathing – service class 2

Component	Specification	Purchasing	Notes
Sheathing	Oriented strand board compliant with <i>BS EN 13986</i> for load bearing applications in humid conditions, ie OSB/3 compliant with <i>BS EN 300</i> , with additional impact testing carried out to <i>BS EN 596</i> for wall sheathing.	Look for a CE mark which includes <i>BS EN 13986</i> and states that the panel is OSB/3 (a structural panel will also show the notified body number, the regulation (CPR) and the manufacturer’s number). The mark may also include ‘Wall Sheathing’ if the <i>BS EN 594</i> and/or <i>BS EN 596</i> tests have been carried out. This should also be stated on the Declaration of Performance.	For a material to be CE marked for load bearing humid conditions it has to comply with <i>BS EN 300</i> requirements. OSB/3 is a load bearing board for use in humid conditions (service class 2). The <i>BS EN 596</i> test is a pass/fail test.
	Thickness: x mm.		Required to achieve the required racking resistance according to Eurocode 5.
	Formaldehyde Class: Ex .	The CE mark will state whether the board is E1 or E2.	A formaldehyde class has to be stated.

The specification for the complete wall element will also address:

- substrate
- fixing type
- setting out
- fixing centres
- fixing distance from edges.

Table 3: Plywood floor – service class 1
(Consider service class 2, depending upon the risk of wetting)

Component	Specification	Purchasing	Notes
Flooring	Plywood compliant with <i>BS EN 13986</i> , suitable for internal use as structural floor decking on joists, ie compliant with <i>BS EN 636</i> grade <i>BS EN 636-1 S</i> , (or grade <i>BS EN 636-2 S</i>) with additional performance testing to conform to load category x on x mm span as per Eurocode 1. Characteristic strength and stiffness values as follows.	Look for a CE mark which includes <i>BS EN 13986</i> and states that the panel is <i>BS EN 636-1 S</i> (or <i>BS EN 636-2 S</i>). A structural panel will show the notified body number, the regulation (CPR) and the manufacturer’s number. The mark may also include “Flooring” to indicate that <i>BS EN 12871</i> point load and impact tests have been carried out. The load category for a specific span can be found from the manufacturer or it may be stated on the CE mark. Characteristic strength and stiffness values can be obtained from the manufacturer or agent – they may be based on <i>BS EN 12369-2</i> or derived from test data to <i>BS EN 789</i> . This information should also be stated on the Declaration of Performance.	For a plywood to be CE marked for service class 1 conditions it must comply with <i>BS EN 636</i> grade <i>BS EN 636-1 S</i> . For service class 2 conditions it must comply with grade <i>BS EN 636-2 S</i> . (In both cases, ‘S’ indicates ‘structural’.) To be used as flooring the board must be categorised as load bearing with additional <i>BS EN 12871</i> performance testing carried out.
	Thickness: x mm.	Manufacturer’s technical information should state this.	Required to meet design requirements.
	Formaldehyde Class: Ex .	The CE mark will state whether the board is E1 or E2.	A formaldehyde class has to be stated.

The specification for the complete floor element will also address:

- substrate
- setting out of panels
- expansion provision
- support of joints between panels
- fixing to joists.

Acknowledgement

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References

1. BS EN 13986:2004+A1:2015. Wood-based panels for use in construction. Characteristics, evaluation of conformity and marking, BSI
2. BS EN 1995-1-1:2004+A2:2014 Eurocode 5. Design of timber structures. General. Common rules and rules for buildings, BSI
3. BS 5268-2:2002+A1:2007 Structural use of timber. Code of practice for permissible stress design, materials and workmanship, BSI
4. WIS 2/3-56: CE marking: implications for timber products, TRADA, 2016
5. BS EN 634-2:2007. Cement-bonded particleboards. Specifications. Requirements for OPC bonded particleboards for use in dry, humid and external conditions, BSI
6. BS EN 622-2:2004. Fibreboards. Specifications. Requirements for hardboards, BSI
7. BS EN 622-3:2004. Fibreboards. Specifications. Requirements for medium boards, BSI
8. BS EN 622-4:2009. Fibreboards. Specifications. Requirements for softboards, BSI
9. BS EN 622-5:2009. Fibreboards. Specifications. Requirements for dry process boards (MDF), BSI
10. BS EN 300:2006. Oriented strand boards (OSB). Definitions, classification and specifications, BSI
11. BS EN 312:2010. Particleboards. Specifications, BSI
12. BS EN 636:2012+A1:2015. Plywood. Specifications, BSI
13. BS EN 13353:2008+A1:2011. Solid wood panels (SWP). Requirements, BSI
14. BS EN 335:2013. Durability of wood and wood-based products. Use classes: definitions, application to solid wood and wood-based products, BSI
15. BS EN 12871:2013. Wood-based panels. Performance specifications and requirements for load bearing boards for use in floors, walls and roofs, BSI
16. BS EN 596:1995. Timber structures. Test methods. Soft body impact test of timber framed walls, BSI
17. BS EN 594:2011 Timber structures. Test methods. Racking strength and stiffness of timber frame wall panels, BSI
18. BS EN 12369-1:2001. Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards, BSI
19. BS EN 12369-2:2011. Wood-based panels. Characteristic values for structural design. Plywood, BSI
20. BS EN 12369-3:2008. Wood-based panels. Characteristic values for structural design. Solid-wood panels, BSI
21. BS EN 789:2004. Timber structures. Test methods. Determination of mechanical properties of wood based panels, BSI
22. BS EN 1058:2009. Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values, BSI
23. BS EN 1991-1-1:2002 Eurocode 1. Actions on structures. General actions. Densities, self-weight, imposed loads for buildings, BSI
24. PD 6693-1:2012. Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI
25. BS 6399-1:1996. Loading for buildings. Code of practice for dead and imposed loads, BSI
26. BS 5268-6.1:1996 Structural use of timber. Code of practice for timber frame walls. Dwellings not exceeding seven storeys, BSI
27. BS 5268-6.2:2001 Structural use of timber. Code of practice for timber frame walls. Buildings other than dwellings not exceeding four storeys, BSI
28. PanelGuide, V4, Wood Panel Industries Federation and others, available at www.trada.co.uk
29. DD CEN/TR 12872:2014 Wood-based panels. Guidance on the use of load-bearing boards in floors, walls and roofs, BSI

About TRADA

The Timber Research and Development Association (TRADA) is an internationally recognised centre of excellence on the specification and use of timber and wood products.

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