2.2 Factors in design

2.2.1 Structural application (load-bearing)

2.2.1.1 Loading conditions

Before embarking on the design of a construction or part of a construction the designer must be in possession of the following information:

- The actual load to be carried, which in turn will assign the construction to a load class as set out in *BS EN 1991-1-4 Eurocode 1. Actions on structures. General actions. Wind actions*[1] (*Eurocode 1*) in conjunction with *BS EN 1990 Eurocode. Basis of structural design*[2] (*Eurocode 0*). (If using *BS 5268* (now withdrawn) then loads should be taken from *BS 6399-2 Loading for buildings. Code of practice for wind loads* (withdrawn)[3].)
- The environmental conditions under which this load will be sustained, which will have a very significant effect on the performance of the wood-based panel. These conditions are defined in terms of Service Classes in *BS EN 1995-1-1 Eurocode 5: Design of timber structures. General. Common rules and rules for buildings*[4] (*Eurocode 5*), and were replicated in *BS 5268*.
- The duration of the principal load, which in turn will determine the long-term strength and deflection of the construction. In *Eurocode 5*, these parameters are quantified in terms of a duration of load factor (k_{mod}) and a creep factor (k_{def}).

There are three basic approaches, outlined below, to the design of structures using wood-based panels.

2.2.1.2 'Deemed to satisfy'

There are currently 'deemed to satisfy' tables for domestic floor and roof applications in *BS 8103-3 Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing*[5], for particleboard, OSB and a limited range of specific types of plywood, which are based on historical practice. Other plywood types are not precluded from use but the required thickness would need to be derived by design and/or testing in accordance with *BS EN 13986*.

There is no deemed to satisfy route for non-domestic floor applications.

In the case of wall sheathing and roof sarking with a bracing role, it is also possible to employ a deemed to satisfy approach, provided load-bearing panels complying with *BS EN 13986* are used and by using *BS 5268-6 Structural use of timber. Code of practice for timber frame walls*[6], where racking resistance figures can be obtained for various grades and thicknesses.

Those manufacturers that have carried out performance tests for floors, walls and roofs as described in *Section 2.2.1.3* will have done so to provide information on the panel thicknesses required to span various joist spacings and details for different fixing systems to those included in current guidance or any situation which is not covered by *BS 8103-3* or *BS 5268-6*.

2.2.1.3 Performance (prototype) testing of floors, walls and flat roofs

The actual testing of a prototype of the design offers the most efficient use of materials. However, the design cannot be modified from that tested, without further test work. Consequently, performance or prototype testing is generally applied only where a large number of identical units will be produced from the same design or where a calculation method (*Section 2.2.1.4*) cannot be used.

The prototype is tested using one of the new European performance tests, for example in the case of flooring, *BS EN 1195 Timber structures. Test methods. Performance of structural floor decking*[7]. The test results can then be converted into characteristic load and stiffness data for design use in accordance with *Eurocode 5*, using the requirements given in *BS EN 12871 Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls*[8].

2.2.1.4 Design by calculation

This is the generalised case in which a design of a structure is produced without the need for any prototype testing. Consequently, the design tends to be conservative, but there are no testing costs (provided the design data exists).

The actual design work may employ either limit state design (*Eurocode 5*) or permissible stress design (*BS 5268*). The Eurocode approach is now the method referred to in Approved Document A of the Building Regulations[9].

When the design is executed using limit state design according to *Eurocode 5*, the characteristic stress and moduli values used in the design analysis are to be found in *BS EN 12369-1 Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards*[10] and *BS EN 12369-2 Wood-based panels. Characteristic values for structural design. Plywood*[11] for all panel types except solid wood panels, and cement-bonded particleboard (CBPB).

Alternatively, characteristic values for all load-bearing panel types can be derived according to *BS EN 789 Timber structures. Test methods. Determination of mechanical properties of wood based panels*[12] and *BS EN 1058 Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values*[13] and may be obtained from the manufacturer.

The time modification factors to be incorporated in the design analysis are included in *Eurocode 5*, for all structural panel types except CBPB, or these can be derived from testing to *BS EN 1156 Wood-based panels. Determination of duration of load and creep factors*[14]. Design is carried out to *Eurocode 5* and in the UK this should be in conjunction with *PD 6693-1*

Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings[15].

When using the permissible stress design method, the working stresses and moduli used in the design calculation for plywood are provided in *BS 5268-2*. The material characteristic values should be converted into permissible stresses as described in *BS 5268*.

2.2.2 Non-structural applications

Perhaps the single most important parameter to be taken into account in non-structural (non-load-bearing) applications is moisture. Too often the ingress of moisture, either liquid or vapour, degrades the performance of wood-based panels used non-structurally in construction. Thus, window boards, skirting boards, claddings, fascias, door skins and floor overlays can and do suffer from the effects of moisture ingress. Consequently, in the tables on panel selection given in *Sections 2.4 to 2.14* of PanelGuide, different panel grades are given for:

- dry application with no risk of subsequent wetting
- wet application or where there is a high risk of the panel becoming wet.

Particular applications may necessitate consideration of more specialised properties such as sound absorption: this can be of great significance in the refurbishment and conversion of old properties into flats, especially so with the use of high density overlayment panels on the floors.

Water vapour permeability and abrasion resistance are other important factors that may need to be considered in specialised applications.

2.2.3 Fire performance

2.2.3.1 Fire classification systems

Over the last few years in the UK there have been two separate systems for quantifying and specifying the performance of materials in fire. This is due to the existence of a transitional period as the new CEN (the European Committee for Standardization) reaction to fire specifications begin to replace the previous set of British specifications (BS).

Although the two systems still co-exist, and both are referred to in UK Building Regulations, readers should appreciate that since 1 July 2013, when CE marking of wood-based panels for construction became mandatory, only the new CEN reaction to fire classifications can be used in the Declaration of Performance (DoP).

2.2.3.2 European standards (CEN)

All construction products are classified into one of seven Euroclasses (A to F) according to their reaction to fire performance in fire tests. Two of these tests will be used to classify the least combustible materials (Euroclasses A_1 and A_2). These two new tests are:

- A furnace test for non-combustibility, *BS EN ISO 1182 Reaction to fire tests for products. Non-combustibility test*[16] which is based on *ISO 1182*, but differing in small but significant detail.
- An oxygen bomb calorimeter test to measure the gross calorific potential, *BS EN ISO 1716 Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value)*[17] which is based on *ISO 1716*, but with modifications to improve consistency of operation.

At the lower end of the range of Euroclasses (classes E and F), construction products of appreciable combustibility can be assessed using a simple 'ignitability' test *BS EN ISO 11925-2 Reaction to fire tests. Ignitability of products subjected to direct impingement of flame. Single-flame source test*[18]. For products where no performance has been determined or where Euroclass E cannot be achieved, the products are assigned to Euroclass F.

Products that fall into Classes A_2, B, C and D (and D contains the wood-based panels except CBPB) are tested using the 'single burning item test' (SBI) to *BS EN 13823 Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item*[19] except where the products are used as floor coverings. The classification using test data from the reaction to fire tests is given in *BS EN 13501-1 Fire classification of construction products and building elements. Classification using test data from reaction to fire tests*[20].

For floor coverings such as wood-composite laminate flooring, a 'critical flux (radiant panel) test', *BS EN ISO 9239-1 Reaction to fire tests for floorings. Determination of the burning behaviour using a radiant heat source*[21] is used to determine performance in Euroclasses B to E.

When using wood-based panels in construction, the reaction to fire performance shall either be determined by test and classified according to *BS EN 13501-1* or the classes shall be taken from the appropriate table in *BS EN 13986* (Table 8 in the 2004 version). The Euroclasses given in this table refer to panels installed under specific conditions including:

- jointing
- fixing
- mounting, including any backing material or air spaces
- thickness
- density.

If the manufactured product does not satisfy any of these conditions, or the method of installation is different to that specified, then the product must be tested and classified according to *BS EN 13501-1*.

The reaction to fire tests cited above relate to the product. When that product is incorporated into a building element, the fire resistance of that element will be determined by a further series of fire resistance tests.

2.2.3.3 British Standards (BS)

The British Standard tests are still referred to in Part B of the UK Building Regulations and can therefore still be used to demonstrate compliance with the Regulations. (Only the EN test system can be used to demonstrate compliance with the Euroclass system, although attempts have been made to draw best fit parallels between the two rating systems.)

- Non-combustibility test. The first of the existing British Standard tests is the 'Non-combustibility test for materials' (*BS 476-4 Fire tests on building materials and structures. Non-combustibility test for materials*[22]) where a small sample of the wood-based panel is subjected to a temperature of 750°C. All wood-based panels, even when treated with fire retardants, are classified as 'combustible'.
- Ignitibility test. The second test is a measure of ignitability where a small pilot flame is used to determine whether the sample will ignite easily *BS 476-12: Fire tests on building materials and structures. Method of test for ignitability of products by direct flame impingement*[23]); this Standard replaced *BS 476-5:1979 Fire tests on building materials and structures. Method of test for ignitability*[24], which rated boards and wood-based panels as 'not easily ignitable'.
- Spread of flame. Following ignition, the development of a fire is dependent on a number of factors, one of the more important being the rate of spread of flame. Using *BS 476-7 Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products*[25] wood-based panels over 400 kg/m^3 are rated as Class 3 (except (CBPB)). Whereas panels with a lower density are rated as Class 4, CBPB is rated Class 1.

For many applications, when using the BS system, current regulations call for wall and ceiling linings to conform to Class 1; wood-based panels can be upgraded either by the application of intumescent paints to the surface, or by the incorporation of, or impregnation by, flame-retardant chemicals. These products can influence the method of combustion, lower the temperature of onset of decomposition and increase the thickness of the char layer.

The rate at which a combustible material contributes heat to a developing fire is a most important aspect. The fire propagation test (*BS 476-6 Fire tests on building materials and structures. Method of test for fire propagation for products*[26]) provides some measure of the rate of heat release. There are a few wood-based panel products that have a Class 1 spread of flame (*BS 476-7*) as well as having a satisfactory rating in the fire propagation test: these are then rated Class 0 under the BS system.

2.2.3.4 Guidance on fires in timber frame buildings during construction

In recent years, there have been a number of high-profile fires on timber frame construction sites. As a result, greater attention has been paid to the risk of fire during construction. Once completed, timber frame buildings comply with UK Building Regulations in relation to fire safety, but additional measures may be necessary during the construction phase. This has led to consideration of new products and changes to the specification of both timber frame and sheathing panels. Specifiers and constructors should refer to published guidance on this subject, such as:

- The Health and Safety Executive's *Fire safety in construction: Guidance for clients, designers and those managing and carrying out construction work involving significant fire risks*[27]
- *Fire Prevention on Construction Sites 8th edition Code and Checklist*[28]
- The Structural Timber Association (formerly UK Timber Frame Association) *Design guide to separating distances for timber frame buildings during construction*[29], for timber frame buildings and projects above 600m^2 total floor area.

2.2.4 References

1 BS EN 1991-1-4. Eurocode 1. Actions on structures. General actions. Wind actions, BSI

2 BS EN 1990. Eurocode. Basis of structural design, BSI

3 BS 6399-2. Loading for buildings. Code of practice for wind loads [WITHDRAWN], BSI

4 BS EN 1995-1-1. Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

5 BS 8103-3. Structural design of low-rise buildings. Code of practice for timber floors and roofs for housing, BSI

6 BS 5268-6 (Parts 1, 2 and 6.6.1). Structural use of timber. Code of practice for timber frame walls [WITHDRAWN], BSI

7 BS EN 1195. Timber structures. Test methods. Performance of structural floor decking, BSI

8 BS EN 12871. Wood-based panels. Determination of performance characteristics for load bearing panels for use in floors, roofs and walls, BSI

9 UK Building Regulations Approved Document A – Structure, available at www.planningportal.gov.uk

10 BS EN 12369-1. Wood-based panels. Characteristic values for structural design. OSB, particleboards and fireboards, BSI

11 BS EN 12369-2. Wood-based panels. Characteristic values for structural design. Plywood, BSI

12 BS EN 789. Timber structures. Test methods. Determination of mechanical properties of wood based panels, BSI

13 BS EN 1058. Wood-based panels. Determination of characteristic 5-percentile values and characteristic mean values, BSI

14 BS EN 1156. Wood-based panels. Determination of duration of load and creep factors, BSI

15 PD 6693-1. Recommendations for the design of timber structures to Eurocode 5: Design of timber structures. General. Common rules and rules for buildings, BSI

16 BS EN ISO 1182. Reaction to fire tests for products. Non-combustibility test, BSI

17 BS EN ISO 1716. Reaction to fire tests for products. Determination of the gross heat of combustion (calorific value), BSI

18 BS EN ISO 11925-2. Reaction to fire tests. Ignitability of products subjected to direct impingement of flame. Single-flame source test, BSI

19 BS EN 13823. Reaction to fire tests for building products. Building products excluding floorings exposed to the thermal attack by a single burning item, BSI

20 BS EN 13501-1. Fire classification of construction products and building elements. Classification using test data from reaction to fire tests, BSI

21 BS EN ISO 9239-1. Reaction to fire tests for floorings. Determination of the burning behaviour using a radiant heat source, BSI

22 BS 476-4. Fire tests on building materials and structures. Non-combustibility test for materials, BSI

23 BS 476-12:1991. Fire tests on building materials and structures. Method of test for ignitability of products by direct flame impingement, BSI

24 BS 476-5. Fire tests on building materials and structures. Method of test for ignitability, BSI [withdrawn]

25 BS 476-7. Fire tests on building materials and structures. Method of test to determine the classification of the surface spread of flame of products, BSI

26 BS 476-6. Fire tests on building materials and structures. Method of test for fire propagation for products, BSI

27 HSG168 Fire safety in construction: Guidance for clients, designers and those managing and carrying out construction work involving significant fire risks, ISBN 9780717663453, HSE, 2013, available at www.hse.gov.uk

28 Fire Prevention on Construction Sites 8th edition Code and Checklist (FSB9-8COMBO), ISBN 9781902790794, Fire Protection Association/Construction Information Publications, 2012

29 Design guide to separating distances for buildings during construction, UKTFA, Version 1, December 2011, available at www.uktfa.com

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