2.2 Factors in Design

2.2.1 Structural application (load-bearing)

Before embarking on the actual 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 6399: Parts 1 to 3 or Eurocode 1: Parts 0, 1 and 2-1 (ENV 1991-1; 1991-2-1);
- 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 both BS 5268: Part 2 and Eurocode 5 (ENV 1995-1-1);
- 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}), though this approach to time dependence may change in a future revision of Eurocode 5.

There are three basic approaches, outlined below, to the design of structures using wood-based panels: these are also presented in the tables in Sections 2.4 to 2.14 of PanelGuide and, in particular, in Table 2.1 which contains all three approaches, though one of these, as explained below, is no longer applicable, with the exception of sheathing (Table 2-9) and pitched roofing (Table 2-6).

2.2.1.1 "Deemed to satisfy"

For many decades it has been possible to design structural components on a deemed to satisfy basis. Thus, for a particular set of conditions, defined in terms of design, load and environmental conditions, initial testing and long-term experience has demonstrated compliance of the design with specified requirements. However, in the case of floors and flat roof decking, because of a change in the test methodology with the adoption of CEN standardisation and a consequential lack of test evidence to demonstrate compliance with the performance requirements of BS EN 13986, BS 7916 has been withdrawn. This means that for flooring and flat roof decking the prescriptive specification linking panel thickness to joist/batten spacing in Table 4 of BS 7916 is no longer valid and must not be used. The means of demonstrating structural compliance with the CPD is now limited to one of the two methods described in 2.2.1.2 and 2.2.1.3. Those manufacturers that have carried out the new performance tests for floors described in 2.2.1.2 will be able to provide information on the panel thicknesses required to span various joist spacings.

However in the case of sheathing and sarking with a bracing role, it is still possible to employ a deemed to satisfy approach, provided load-bearing boards complying with BS EN 13986 are used.

2.2.1.2 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 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 the calculation method (see below) cannot be used.

The prototype is tested using one of the new European performance tests, eg, in the case of flooring, BS EN 1195 (Test methods: performance of structural floor decking); the test results can then be converted into design load using BS 5268: Part 2.

The results of the prototype testing can also be used to design the elements in accordance with EC5 using the requirements given in BS EN 12871 (wood-based panels – performance specifications and requirements for load-bearing boards for use in floors, walls and roofs).

2.2.1.3 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 permissible stress design or limit state design. When using the former method, the working stresses and moduli used in the design calculation for plywood are provided in BS 5268: Part 2 (revised 2001). For particleboard, OSB and fibreboard the characteristic values (5 percentile values) in EN 12369: Part 1 are taken and are converted to working stresses as set out in BS 5268: Part 2 (revised 2001). Alternatively, the characteristic values for all load-bearing panel types can be derived according to BS EN 789 and BS EN 1058 and may be obtained from the manufacturers; these values must again be converted to working stresses as set out in BS 5268: Pt 2 (revised 2001) if using permissible design data. The time modification factors to be incorporated in the design analyses are included in BS 5268 Pt 2 (revised 2001) for all structural panel types except cement bonded particleboard.

When the design is executed using limit state design according to Eurocode 5 (ENV 1995-1-1), the characteristic stress and moduli values used in the design analysis are to be found in EN 12369 Parts 1 and 2 for all panel types except solid wood panels, and cement bonded particleboard. Alternatively, characteristic values for all load-bearing panel types can be derived according to BS EN 789 and BS EN 1058 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 cement bonded particleboard, or can be derived from testing to ENV 1156.

2.2.2 Non-structural applications

Perhaps the single most important parameter to be taken into account in the 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 board 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, and for wet application or where there is a high risk of the board becoming wet.

Particular applications may necessitate consideration of more specialised properties such as sound adsorption: 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

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

Although the two systems still co-exist, readers should appreciate that since 1st April 2004, when CE marking of wood-based panels for construction became mandatory in the majority of European countries (excepting the UK and a few others), only the new CEN **reaction to fire** specifications can be used to achieve compliance with the Harmonised Standard BS EN 13986 whether or not the actual CE mark is used .

2.2.3.1 British Standards (BS)

The first of the existing British Standard tests is the *Non-combustibility Test for Materials* (BS 476 Part 4 (1970) where a small sample of the wood-based panel is subjected to a temperature of 750ºC; all wood-based panels, even when treated with fire retardants, are classified as *combustible*. The second test is a measure of ignitability where a small pilot flame is used to determine whether the sample will ignite easily (pr ISO 11925-2 (1997)); this standard recently replaced BS 476 Part 5 (1979), which rated boards and wood based panels as *not easily ignitable*.

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 Part 7 (1987) wood-based panels over 400 kg/m^3 are rated as Class 3 (except cement-bonded particleboard), whereas panels with a lower density are rated as Class 4; cement-bonded particleboard is rated Class 1.

For many applications, 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 influence the mechanism of decomposition, 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 and one in which wood-based panels do not show up very well, especially so when compared with alternative materials such as plasterboard. The *fire propagation test* (BS 476 Part 6 (1989) 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 Part 7 (1987)) as well as having a satisfactory rating in the fire propagation test: these are then rated Class O in accordance with UK building regulations.

2.2.3.2 European standards (CEN)

All construction products are classified into one of seven Euroclasses (A-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 which is based on ISO 1182, but differing in small but significant detail, and an *oxygen bomb calorimeter test* to measure the gross calorific

potential, BS EN ISO 1716 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 will be assessed using a simple *ignitability* test BS EN ISO 11925-2. 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) BS EN 13823 except where the products are used as floor coverings. The classification using test data from the reaction to fire tests is given in prEN 13501-1.

For floor coverings such as a wood-composite laminate flooring, a *critical flux (radiant panel) test,* BS EN ISO 9239-1 is used to determine performance in Euro classes B-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 Table 8 in the Harmonised Standard BS EN 13986. The Euroclasses given in this table refer to un-jointed panels, T&G jointed panels installed according to ENV 12872 and fully supported joints installed according to ENV 12872 provided the panels comply with the minimum thicknesses and minimum densities given in Table 8 of BS EN 13986 and are used in real applications where they are **fixed without an air gap behind**, against class A1 or A2-s1, d0 products with minimum density 10 kg/m^3, or at least class D-s2, d0 products with minimum density 400 kg/m^3**. If the manufactured product does not satisfy any of these minimum requirements or is used with an air gap behind, then it must be tested and classified according to BS EN 13501-1.**

The above reaction-to fire tests relate to the product. When that product is incorporated into a building element, the **fire resistance** of that element will be determined by a whole series of other tests. It is anticipated that there will be at least 60 European standards (or part-standards) relating to fire resistance of parts of a building.