quality assurance procedure ensures the continued high standard of production. Quality assurance tests are conducted on behalf of the mill during which the following properties may be checked:

- **Mechanical:** panel stiffness and strength in flexure
- **Lay-up and Dimensional:** grade of veneers, veneer and panel thickness tolerance, length, width and squareness
- **Durability:** adhesive bond in shear

In addition to sampling for quality assurance testing, random auditing of mill quality control records is conducted by an independent auditor.

Table 4 American plywood types to be considered for selection

Panel type	Standard manufactured to	Bond durability class of adhesive	Equivalent European bond class
C-D grade (grade C group 1 face veneer, grade D group 1 back veneer: unsanded)	PS1-95	Exposure 1 *	2 (humid conditions)
C-C grade (grade C group 1 veneers throughout: unsanded)	PS1-95	Exterior	3 (unprotected exterior conditions)
A-C and B-C grade (grade A or grade B face veneer, grade C group 1 veneers throughout: sanded)	PS1-95	Exterior	3 (unprotected exterior conditions)
Underlayment (grade C plugged face veneer, grade C and D inner veneer, grade D back veneer: touch sanded)	PS1-95	Exposure 1 *	2 (humid conditions)

* Exposure 1 boards are manufactured with the same phenolic adhesives used for Exterior boards, but owing to other compositional factors Exposure 1 boards should only be used in applications where their ability to resist moisture and weather during long construction delays is required prior to protection.

3 Design

3.1 Different roof types

As with other aspects of architectural design, trends in roof design have produced a variety of construction types throughout the years. These may be classified into three main categories of pitched, flat and domed. The majority of housing stock utilises pitched roof construction with recent trends for framing based on prefabricated trussed rafters. A trussed roof structure produces a solution with very efficient use of material, and can be constructed at very low cost to the client. Furthermore, specialist trussed rafter manufacturers generally produce a full set of design calculations that comply with and satisfy local authorities' requirements, building regulations and relevant standards such as BS 5268-3.

Around the 1920s, the modernist movement greatly influenced architectural roof design, turning fashion away from pitched roof construction towards flat roof construction. Different designs of flat roof have been developed over the years to two generic types that are termed 'cold deck' and 'warm deck' construction. Both types require a flat deck placed on top of the structural roofing members for which plywood is ideally suited. The progressive decline in popularity of other decking materials such as asbestos cement sheet, and the virtual elimination of compressed strawboard, has placed more traditional panel products at the forefront of the decking industry.

BRE found from the English House Condition Survey[2] that the largest proportion of flat roof construction has been designed as cold deck. A cold deck roof (Figure 1(a)) has the roof insulation placed between roof joists and below the timber decking, thereby reducing the overall depth of the roofing system but placing the timber decking in a relatively cold environment, hence the generic term 'cold deck'. To avoid moist air migrating from the building and causing condensation to form in the roof void, a vapour check should be installed immediately below the roofing members. This should be installed with weatherproof joints including overlaps. Moisture that penetrates into the roof void needs to be dissipated by adequate ventilation. This is usually achieved by allowing for a sufficiently large unobstructed void between the decking and insulation in each cavity and ventilating this void to the outside air. Openings at the eaves are usually sufficient for small roof areas whilst larger flat roofs may require roof vents placed at select distances. Services, if required in the roof void, should preferably be accommodated below the vapour check membrane by battening out below joists. This avoids penetrations through the vapour check. If, however, penetrations are unavoidable, any holes should be tightly sealed.

There are two types of warm deck commonly used for flat roof construction that do not require ventilating. These are termed 'sandwich' and 'inverted'. The sandwich roof carries that description because thermal insulation is sandwiched between the vapour control layer laid on the deck and the weatherproof membrane laid above it, as shown in Figure 1(b). The