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Packaging code

Part 8: Guidance on wooden boxes, cases and crates

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Contents

Foreword *vi*

1 Scope *1*
2 Normative references *1*
3 Terms and definitions *2*
4 Wood for packaging *5*
5 Wood-based sheet materials *17*
6 Other wood-based products used in packaging *19*
7 Moisture in wood and the avoidance of problems in storage and use *23*
8 Fastenings *31*
9 Package design *48*
10 International pictorial marking symbols for the handling of goods *57*
11 Dangerous goods *58*
12 Wooden case, crate and box styles *59*
13 Dock pallets *73*
14 Skid and rail design *75*
15 Crates *79*
16 Sawn wood boxes *82*
17 Boxes and cases of plywood and other sheet materials *86*
18 Metal edged plywood boxes and cases *88*
19 Wirebound cases and crates *93*
20 Legality of timber products on the market – EU Directive *102*
21 Wood packaging recycling *102*
22 Phytosanitary requirements for imported and exported wood packaging *102*

Annexes
Annex A (informative) Health and safety *103*
Annex B (informative) Table sizes for skids sills and rails *104*

Bibliography *113*

List of figures
Figure 1 – Exaggerated effect of drying shrinkage *30*
Figure 2 – Common packaging fasteners *32*
Figure 3 – Nail head types *33*
Figure 4 – Nail plate *35*
Figure 5 – Ring nail after ISO test *36*
Figure 6 – Types of staples *40*
Figure 7 – Nail and staple patters, boards to battens, minimum edge distance *42*
Figure 8 – Fastenings of sawn boards (good and bad practice) *43*
Figure 9 – Reinforcing straps on a sill base *44*
Figure 10 – Tensional strapping used on a small plywood case *45*
Figure 11 – Reusable spring steel fastener *46*
Figure 12 – Reusable spring wire fastener *47*
Figure 13 – Coach screw *47*
Figure 14 – Coach bolt *47*
Figure 15 – Rope handle *56*
Figure 16 – Webbing handle *56*
Figure 17 – International ‘sling here’ symbol *57*
Figure 18 – Steel lifting plate for slings *57*
Figure 19 – International handling symbols relevant to wooden packages *58*
Figure 20 – Style 1 – Girth battened case *60*
Figure 21 – Style 1 – Girth battened case with panelled ends *61*
Figure 22 – Style 1 – Girth battened case, battened ends, with single diagonal braces to sides and ends *62*
Figure 23 – Style 1 – 1/R, girth battened case, battened ends, reinforced base *62*

Figure 24 – Style 2 – Horizontally battened case, vertically battened ends *63*
Figure 25 – Style 3 – Horizontally battened case, diagonally braced *63*
Figure 26 – Style 4 – Vertically boarded case, internally battened *64*
Figure 27 – Style 1 – Typical case sides *64*
Figure 28 – Styles 2 and 3 – Typical case sides *66*
Figure 29 – Style 4 – Typical case side *67*
Figure 30 – Styles 1 and 2 – Typical case ends *68*
Figure 31 – Style 3 – Typical case ends *69*
Figure 32 – Style 4 – Typical case end *70*
Figure 33 – Typical case base styles *71*
Figure 34 – Typical case lids *72*
Figure 35 – Stevedore dock pallet *74*
Figure 36 – Pallet bridle *74*
Figure 37 – Length of subspan *76*
Figure 38 – Spliced skid *78*
Figure 39 – Style 11 – Light-braced crate *80*
Figure 40 – Style 12 – Horizontally semi-sheathed crate, externally battened *80*
Figure 41 – Style 13 – Braced crate with vertical and horizontal sheathing *81*
Figure 42 – Style 14 – Light crate with continuous bracing *81*
Figure 43 – Style 21 – Basic boxes *82*
Figure 44 – Style 22 – Combed tenon box *83*
Figure 45 – Style 23 – Internally battened box *84*
Figure 46 – Style 24 – Battened end box *84*
Figure 47 – Style 25 – Panelled end box *85*
Figure 48 – Style 26 – Battened top and base box *85*
Figure 49 – Plywood box styles *87*
Figure 50 – Style of metal edged boxes and cases *89*
Figure 51 – Application of the tenterhook *91*
Figure 52 – Relevant dimensions for the two stock styles of metal edging *91*
Figure 53 – Foldable metal edging in use *92*
Figure 54 – Dimensions of bifurcated rivets *93*
Figure 55 – Allbound wrap before assembly *94*
Figure 56 – Styles of allbound cases showing construction details *95*
Figure 57 – End styles for allbound boxes *96*
Figure 58 – Corner styles for allbound cases and crates *97*
Figure 59 – Recessed pallet designs used with wirebound pallet cases and crates *98*
Figure 60 – Style 53, wirebound pallet crate with horizontal binding wires *98*
Figure 61 – Alternative styles of wraps (sides) *99*
Figure 62 – Alternative lid styles for wirebound pallet cases and crates *101*

List of tables

Table 1 – British grown softwoods and hardwoods suitable for packaging *7*
Table 2 – Imported species suitable for packaging *10*
Table 3 – Strength properties of clear softwoods *14*
Table 4 – Strength properties of clear hardwoods *15*
Table 5 – Equivalent appearance grades of wood for packaging *16*
Table 6 – Types of wood-based sheet materials *21*
Table 7 – Wood equilibrium moisture content (emc) in humid air *28*
Table 8 – Moisture-related movement/distortion characteristics of timbers *30*
Table 9 – Types of nail used in packaging *33*
Table 10 – Acceptable loading modes for the different nail types *34*
Table 11 – Safe working loads (withdrawal and shear) for single nail joints [A)] in pine species, using nails 2.65 mm diameter × 50 mm long with 35 mm pointside penetration *37*

Table 12 – Conversion factors for alternative nail shank diameters *37*
Table 13 – Approximate count (number of nails) per kg for nails *39*
Table 14 – Staple sizes *41*
Table 15 – Summary of journey hazards *49*
Table 16 – Acid timber species *53*
Table 17 – Degree of susceptibility to attack *54*
Table 18 – Results of corrosion of four metals *54*
Table 19 – Style number allocation covering the main styles of boxes, cases and crates *59*
Table 20 – Plywood boxes *86*
Table 21 – Bifurcated rivets for metal edged cases *93*
Table 22 – Size limits for metal edged cases *93*
Table 23 – Binding wire characteristics *101*
Table 24 – Staple wire characteristics *101*
Table A.1 – Adverse effects in softwoods and hardwoods *103*
Table B.1 – Skid, sill and rail working loads *105*
Table B.2 – Spliced skid, sill and rail working loads *109*

Summary of pages

This document comprises a front cover, an inside front cover, pages i to viii, pages 1 to 114, an inside back cover and a back cover.

Foreword

Publishing information

This British Standard is published by BSI and came into effect on 31 December 2011. It was prepared by Subcommittee PKW/0/-/11, *Packaging – Wood*, under the authority of Technical Committee PKW/0, *Packaging*. A list of organizations represented on this committee can be obtained on request to its secretary.

Supersession

This part of BS 1133 supersedes BS 1133-8:1991, which is withdrawn.

Information about this document

This is a full revision of the standard, and introduces the following principal changes:

- a change of status from code of practice to guidance document;
- the introduction of a new Annex A on health and safety issues;
- the introduction of a new Annex B on tables of sizes for skids sills and rails.

Relationship with other publications

The packaging code now consists of the following parts:

- *Part 7.6: Paper and board wrappers, bags and containers – Moulded pulp packaging*;
- *Part 10.1: Mental containers – Tins and cans*;
- *Part 10.2: Metal containers – Metal drums*;
- *Part 15: Tensional strapping*;
- *Part 18: Packaging in glass*;
- *Part 19: Use of dessicants in packaging*;
- *Part 22: Packaging in plastics containers*.

Entry and dimensional requirements for pallet bases in cases and crates are covered worldwide by BS ISO 6780 and for Europe by BS EN 13382. The two do not conflict with each other but BS ISO 6780 allows additional pallet sizes which are used across Europe since there are few compatibility issues. However, individual local commercial contracts might not permit certain pallet types, materials or sizes.

Use of this document

As a guide, this part of BS 1133 takes the form of guidance and recommendations. It should not be quoted as if it were a specification or a code of practice and claims of compliance cannot be made to it.

Presentational conventions

The guidance in this standard is presented in roman (i.e. upright) type. Its recommendations are expressed in sentences in which the principal auxiliary verb is “should”.

Commentary, explanation and general informative material is presented in smaller italic type, and does not constitute a normative element.

Contractual and legal considerations

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

Compliance with a British Standard cannot confer immunity from legal obligations.

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1 Scope

This part of BS 1133 provides guidance for manufacturers, users and specifiers of wooden boxes, cases and crates for industrial, defence and other commercial applications.

This document contains guidance on wood species, sheet materials and fastenings likely to be encountered by UK manufacturers or export packers and gives guidance on the design of:

a) industrial, defence and commercial cases and crates;

b) ranges of smaller sawn wood boxes for general use;

c) ranges of plywood and wood-based sheet boxes and cases;

d) plywood cases of metal edge construction;

e) wirebound boxes, crates and cases;

f) warehouse storage containers.

This British Standard also gives brief guidance on sustainability and recycling.

Annex A contains health and safety information.

Annex B contains tables of sizes for skids sills and rails.

NOTE 1 Knowledge of engineering principles is needed to produce a design specification from the information given in certain tables, particularly in relation to large cases and crates.

NOTE 2 Much of the information in this British Standard might also be of value in other areas where wood is used in packaging and distribution, e.g. agricultural boxes and pallets.

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.

BS EN 12246, *Quality classification of timber used in pallets and packaging*

BS EN 13183-2, *Moisture content of a piece of sawn timber – Part 2: Estimation by electrical resistance method*

BS EN 13246, *Packaging – Specification for tensional steel strapping*

BS EN 13427, *Packaging – Requirements for the use of European standards in the field of packaging and packaging waste*

BS EN 22872, *Complete, filled transport packages – Method for determination of resistance to compression*

BS EN 22874, *Complete, filled transport packages – Method of test for stacking using compression tester*

BS EN ISO 2234, *Packaging – Complete, filled transport packages and unit loads – Stacking tests using a static load*

BS EN ISO 4180, *Packaging – Complete, filled transport packages – General rules for the compilation of performance test schedules*

BS EN ISO 15867, *Intermediate bulk containers (IBCs) for non-dangerous goods – Terminology*

BS ISO 6780, *Flat pallets for intercontinental materials handling – Principal dimensions and tolerances*

3 Terms and definitions

For the purposes of this part of BS 1133, the following terms and definitions apply.

3.1 batten
length of wood added to a wooden case or crate to hold the boards together and to strengthen and protect it

NOTE Girth battens are fitted externally and run fully top to bottom and across the case top.

3.2 blocking
any block, strip, packing or distance piece, usually of wood, fastened to the inside of a case to mount or hold the contents in position against vertical or horizontal movement

3.3 box
lightweight case, of close-boarded or sheet material, not normally fitted with girth battens, sometimes with open-top bulk storage

NOTE Specialist boxes such as open-top potato boxes may hold up to 1 t.

3.4 case
assembly of skids, headers and cross members, fully covered with sheathing so that goods cannot be viewed and are therefore protected from pilferage, weather and impact damage

3.5 corner post
vertical batten forming all or half of a single case corner on to which sheathing is nailed

3.6 crate
assembly of skids, posts, headers and cross members with skeletonized outer sheathing which permit goods to be viewed

3.7 cripple
failure by bending, while only partly driven, of a nail or staple during insertion into timber

3.8 cross member
connecting, horizontal structural member of the base perpendicular to skids, positioned between the headers

NOTE Heavy goods are often fixed by bolting to these.

3.9 crush batten
structural member fitted horizontally inside the top of the shorter case dimension running parallel with the headers with the function of preventing slings from crush-damaging the goods

3.10 diagonal braces
multiple components of a case or crate nailed internally or externally between 30° and 60° and positioned between frame members to prevent distortion of the structure

3.11 dunnage
loose wood members of varying size that are part of stevedores' moving, slinging and stacking equipment for distributing load, levelling, holding sling gaps and reducing stress in critical members

3.12 duration of transport
period of time from delivery of the package to the carrier to its arrival with the recipient

3.13 export packaging
packaging sufficient to protect goods for shipment, allowing for multiple transhipment, specific climatic conditions in transit and duration of transport

3.14 freight container
standardized modular international system of shipping containers for export and import of large volume of goods

NOTE Freight containers are covered for BS ISO 1496 (all parts).

3.15 goods for packing
merchandise to be rendered transportable and storable by packaging

3.16 header
connecting horizontal structural member perpendicular to skids or sills, placed at the two ends of each skid or sill and held by nailing or bolting

3.17 heavy good
item requiring special packaging due to its bulk and/or construction and measurements

3.18 kiln drying (KD)
use of controlled airflow, heat and humidity in a large drive-in insulated oven for a period varying from hours to days, to quickly and safely remove water from wood without degrade

NOTE Kiln drying is also used to sterilize timber, e.g. in international export phytosanitary treatment under ISPM 15 [1].

3.19 load-bearing package
package constructed in such a way that it can bear the full weight of the packed goods in the process of loading and unloading whatever equipment is used for lifting

NOTE The loading gear (ship's tackle) is applied to the package.

3.20 means of packaging
system and type of packing material used to contain goods to be packaged in order to make them fit for transport and storage

3.21 multiple-use package
package intended for multiple use, possibly collapsible or folding

3.22 package
packed goods ready for transport

3.23 packaging
material used to pack goods and also the process of using it

3.24 packing
generic terms for all means and auxiliary means of packaging

3.25 rail
wood member, at right angles to sawn boarded sheathing, which both supports and acts as assembly jig during the construction of sheathing panels

NOTE For plywood sheathing panels rails are fitted to stiffen and aid nailed connection to adjacent components.

3.26 rubbing strip
strip applied to the bottom of a large case under the skids to permit slings to enter from the ends and then stop at a pre-determined point

NOTE Rubbing strips only need compressive strength to withstand stacking.

3.27 sheathing
weatherproof covering of plywood, waferboard, MDF or water-resistant tri-wall

3.28 sill
longitudinal timber beam placed internally as an alternative to skids when a machine's mounting points are not its lowest part, i.e. if it has projections below its base

3.29 sill-based case
case built with sills running lengthwise and boards running across the width of the base

3.30 skid
longest structural member of a case or crate placed horizontally below flooring boards and running from end to end of the base

3.31 skid-base case
case built with skids running lengthwise and flooring boards running across and above the width of the base

3.32 sling point
essential strengthened lifting position and clear marking for slings to be placed to assist lifting

3.33 sling spreader base
part of stevedores' sling lifting equipment to separate slings and hold clear of a crate or case to serve the same purpose as crush battens, but fitted externally and temporarily

3.34 spliced
joining of multiple shorter pieces of timber by means of overlapping sections to achieve a strong full-length component

3.35 vertically built case
case built with a substantial base and vertically boarded sides and ends

NOTE Such a design is commonly used for shipping heavy machinery.

3.36 warehouse storage container
stackable storage container from sawn or wood sheet material used in storage and shipping

3.37 wirebound
case or crate or entirely very largely held together and fastened with thin ductile steel wire, enabling flat packing after use for storage or return to sender

3.38 wooden packaging
item (e.g. boxes, punnets, trays, cases, crates, pallets, stillages, collars and bins) made exclusively or primarily of wood

4 Wood for packaging

4.1 Sawn wood – Species suitable for packaging uses

Wood is a natural material and it is not possible to control its quality by methods appropriate for manufactured packaging materials such as plastics or metal. BS EN 12246 lists two packaging grades. The species and grade of wood should be selected to suit the particular end use.

Wood is classified as "softwood" (the conventional term for both the timber and the trees belonging to the botanical group gymnosperms) or "hardwood" (from deciduous trees), irrespective of whether it is actually physically hard or soft. As far as commercial timbers are concerned, softwoods are all conifers. Most wood used for packaging applications is softwood, but hardwood can also be used.

The heaviest (denser) species of timber are usually stronger, although they are often more difficult to work and fasten.

Where the properties of a timber species are not known, the strength and the ease with which nails can be driven into the wood (commonly referred to as "nailability") should be checked before use.

Nailability is particularly relevant when improved nails, such as annularly threaded nails, are used because these are more difficult to drive and might bend on entry into very dense species. See **8.2.4** for more information about nails with poor resistance to bending.

Some timbers are also particularly liable to cause acidic corrosion of metallic objects with which they are in contact and this hazard should also be considered.

NOTE BS 7195 deals with metal goods packed within proximity of corrosive wood species.

Sapwood (the outer layer of the tree trunk which, in the growing tree, contains living cells and reserve materials, e.g. starch) is often lighter in colour than the inner heartwood, but might not be distinguishable. Sapwood contains starches and is more susceptible to insect and fungal attack than heartwood, but it is not practicable to specify heartwood for wooden box, case or crate construction nor is it necessary for the short life of the average wooden container.

4.2 British grown species

4.2.1 Softwoods

4.2.1.1 Pines

Pines are among the strongest of the softwoods used for packaging. The heartwood of the timber is often a reddish brown in colour and is usually resinous. Knots are large and scattered, with a tendency to loosen on drying.

Pines have a greater susceptibility to sapstain (bluestain) than other species and close piling after sawmill conversion should be avoided while still at a high moisture content.

NOTE Sapstain is a stain in softwood sapwood resulting from the growth of certain fungi which derive their nourishment from wood cell contents, but do not cause decomposition of the wood cells themselves. The stain is greyish blue in colour and hence is also referred to as bluestain.

The following pines are used for packaging purposes.

a) Corsican pine, one of the strongest species.

b) Lodgepole pine, similar in strength to European redwood.

c) Maritime pine, imported from France and Portugal. This has the highest bending strength of any commercially available softwood packaging species.

d) Scots pine, known as European redwood when grown and imported from Scandinavia, Baltic countries and Russia. The different geographical origins cause a variation in the texture, density and size of knots, resulting in separate listings in reference tables.

4.2.1.2 Spruces

Spruces are the lightest of the main packaging timbers listed, lighter in colour and less resinous than the pines, the knots tend to be small, tight and concentrated in nodes.

Norway spruce is widely planted throughout the UK and has the advantage of a good stiffness to weight ratio.

The British-grown wood is generally lower in strength properties than the same species imported from Scandinavia, which is known as whitewood.

Sitka spruce is the most widely planted species in the UK, and should be used where light weight is essential, having a good strength to weight ratio.

NOTE The knots of the sitka spruce tend to be small.

4.2.1.3 Other conifers

This group includes the strongest softwoods which should be used for specialist purposes rather than for general use. Examples of other conifers are:

a) douglas fir, widely planted in the British Isles and the strongest and stiffest of the UK softwoods listed;

   NOTE 1 Some splitting might be experienced when Douglas fir is nailed but increasing the distances of the nail from the edge, or the use of a blunt nail, can reduce this to acceptable levels.

b) larch; three varieties are available throughout Britain (see Table 1), although European larch is less likely to be encountered. The larches are stronger in bending, and harder and tougher than most softwoods.

NOTE 2 Splitting could be troublesome where nails are driven near the edge of boards, but this can be reduced by the same means indicated for Douglas fir.

Table 1 **British grown softwoods and hardwoods suitable for packaging**

Standard name	Other names	Botanical name	Density [A)] kg/m³
fir, Douglas [B)]	Columbian pine	*pseudotsuga menziesii*	530
larch, Dunkeld [B)]	hybrid larch	*larix eurolepis*	530
larch, European [B)]	—	*larix decidua*	590
larch, Japanese [B)]	—	*larix kaempferi*	560
pine, Corsican [B)]	—	*pinus nigra maritima*	520
pine, lodgepole [B)]	contorta pine	*pinus contorta*	470
pine, maritime [B)]	—	*pinus pinaster*	530
pine, Scots [B)]	Redwood	*pinus sylvestris*	520
spruce, Norway [B)]	European whitewood	*picea abies*	420
spruce, Sitka [B)]	silver spruce	*picea sitchensis*	400
ash, European	English ash	*fraxinus excelsior*	710
aspen, European	English aspen	*populus tremula*	450
beech, European	English beech	*fagus sylvatica*	690
alder	—	*alnus glutinosa*	530
birch, European	English or silver birch	*betula spp.*	670
chestnut, European	horse chestnut	*aesculus hippocastanum*	520
elm, Dutch	—	*ulmus hollandica*	580
elm, English	—	*ulmus procera*	560
oak, European	English oak	*quercus spp.*	720
plane, European	English plane	*platanus spp.*	640
poplar, black	robusta, European blackpoplar	*populus spp.*	450
poplar grey	—	*populus canescens*	480
poplar, white	abele	*populus alba*	450
willow, white	crack willow	*salix spp.*	450
lime	—	*tilia spp.*	610

[A)] Density values are averages for the species air dried to 15% to 18% moisture content.

[B)] Denotes a softwood.

4.2.2 Hardwoods

Hardwoods vary in colour, strength, weight and other properties and include the strongest UK timbers. There is only a low volume of hardwoods used in packaging, except for specialized functions, largely due to limited availability, higher cost, and the fact that some species are difficult to nail.

In general, UK hardwoods should be used in distance blocking and heavy-duty skids where high compression or scuffing strength are required.

Hardwoods are frequently supplied in an undried, and therefore weaker, state.

The following are some examples of hardwoods and their associated features.

a) Aspen. [See item h).]

b) Ash and beech. Possessing excellent strength properties, these species are well suited to top-quality box and case members. Care should be taken as longer nails can bend on entry when hand-driving is undertaken. The difference between radial and tangential shrinkage is greater than in most other species and this can lead to greater distortion after drying.

c) Birch, a species with high strength properties very similar to oak, although availability is limited and dependent on locality. Some difficulties might arise due to splitting, therefore persons should consider pre-boring or the use of pointless or reduced diameter nails to avoid this.

d) Elm, a difficult timber to work, but with exceptional nail-holding properties. When available, this timber should be used for distance blocking or for short lengths. Elms are typically around 30% weaker than oak in bending but considerably better than softwoods with regard to nail holding.

e) Horse-chestnut, a soft, easily worked timber with strength characteristics similar to those of softwoods. This species is not to be confused with sweet chestnut, which is an acidic timber, liable to corrode steel fastenings, and not recommended for packaging.

f) Oak. This species occurs throughout Britain and Europe. It is difficult to nail, and pre-boring or the use of pointless nails might be necessary. This timber is acidic and likely to promote corrosion of steel fastenings in damp conditions. Oak is often thought of as being much stronger than softwoods, but the difference in bending strength is quite small.

g) Plane. Of limited availability, this should be used for decorative work. It has high resistance to cleavage and indentation; other strength properties are similar to those of pines.

h) Poplar, both UK and European. With this species, the effects of shrinkage and distortion on drying can be excessive.

NOTE Aspen is from the same botanic species group as poplar.

i) Willow, whose strength properties in general are similar to poplar, but is suitable for blocks where bending strength is unimportant. Crack willow can suffer from splitting during conversion and nailing, white willow being superior in this respect.

4.2.3 European grown species

4.2.3.1 General

This category includes those species grown in Russia which are widely imported into Europe. The most important species are described in **4.2.3.2** and **4.2.3.3**.

4.2.3.2 Softwoods

The following softwoods can be used for packaging purposes.

a) Whitewood, widely imported from Scandinavia, Baltic area and Russia for the construction, joinery and packaging industries. It has good working properties and a high stiffness to weight ratio. One of the lightest of the species used in packaging, the timber can vary in strength according to its geographic origin, the more northerly grown timber tending to be stronger due to its slower growth.

NOTE 1 This is commonly known as European whitewood/European or Norway spruce.

b) Maritime pine. An important UK packaging species imported from France and Portugal where the plantation grown timber tends to be heavier and generally stronger than that grown in Britain, although strength can vary widely with plantation location. It has a tendency towards large knots and knot clusters which can reduce strength. The species has outstanding nail-holding properties.

c) Redwood, widely distributed in Europe and Northern Asia and an important packaging species in the UK. The sapwood band is creamy white to yellow in colour, narrow in northern growing areas, but becoming wider in southerly areas. The heartwood is pale yellowish brown to red brown, resinous and usually distinct from the sapwood. The timber is easily worked and takes nails well, although resin can be a problem. When grown in the UK, it is customary to refer to this species as Scots pine.

NOTE 2 This is commonly known as European redwood.

d) Douglas fir. [See **4.2.1.3**a)]

e) Larch. [See **4.2.1.3**b)]

f) Norway spruce. (See **4.2.1.2**)

NOTE 3 Table 2 shows European-grown softwoods and hardwoods suitable for packaging.

4.2.3.3 Hardwoods

The following hardwoods can be used for packaging purposes.

a) Poplar. Six main types including aspen are found in Europe, but the most common commercial species are the black Italian poplar and, when plantation grown, the hybrid *Populus* × *euramericana*. Density or specific gravity are a good measure of strength and poplar from Turkey, as generally imported for packaging, has the lowest density of all the species likely to be used in British case making.

NOTE 1 For their low weight, poplar timbers are relatively strong and tough, but while the species traditionally seen in the UK, the black Italian poplar, falls between maritime pine and spruce in strength, the faster-grown Southern European hybrids are weaker than spruce.

NOTE 2 Poplars of the Populus × euramericana hybrids imported from Turkey could be up to 35% weaker than Portuguese maritime pine, or up to 20% weaker than sitka spruce. These values are based upon breaking strength in the well-dried condition. Turkish poplar takes nails well and is less likely to splinter than the spruces.

NOTE 3 The poplar hybrids dry and shrink rapidly, but tend to retain moisture in pockets. There is also a tendency for some knots to split.

b) Elm and horse-chestnut. [See **4.2.2**d) and e)]

c) Beech. Southern and Mid-European beech is a very strong timber with properties similar to UK grown beech. There might be a slight reduction in density, reducing strength by a small amount.

Table 2 **Imported species suitable for packaging** *(1 of 2)*

Standard name	Origin	Other names	Botanical name	Density [A)] kg/m^3
Alder	Europe, Baltic	—	*Populus canescens*	390
Aspen, European	Europe	poplar, balsam	*Populus tremula*	450
Beech, European	Europe	Slavonian beech	*Fagus sylvatica*	690
Birch	Canada, USA, Baltic, Russia	American birch, white birch, yellow birch	*Betula spp.*	610–710
elm, Dutch	Europe	—	*Ulmus hollandica*	580
fir, balsam [B)]	widely distributed	balsam	*Abies balsamea*	400
fir, Douglas [B)]	Canada, Europe	Columbian pine	*Pseudotsuga menziesii*	530
fir, silver [B)]	Central and Southern Europe	European silver pine	*Abies alba*	480
hemlock, eastern [B)]	East Canada, East USA	white hemlock	*Tsuga Canadensis*	470
hemlock, western [B)]	North-western USA	Pacific hemlock	*Tsuga heterophylla*	500
larch, Dunkeld [B)]	widely distributed	hybrid larch	*Larix × eurolepis*	530
larch, European [B)]	widely distributed	—	*Larix decidua*	590
larch, Japanese [B)]	widely distributed	—	*Larix kaempferi*	560
larch, tamarack [B)]	Canada and Northern USA	eastern larch	*Larix laricina*	580
pine, elliotis [B)]	Brazil	—	*Pinus elliottii*	490
pine, Austrian	Central Europe	Bosnian pitch pine	*Pinus nigra* var *nigra*	800
pine, Corsican [B)]	UK and Southern Europe	Bosnian pitch pine	*Pinus nigra maritime*	520
pine, jack [B)]	Canada	princess pine	*Pinus banksiana*	500
pine, lodgepole [B)]	Europe, Western Canada	contorta pine	*Pinus contorta*	470
pine, maritime	SW France	—	*Pinus pinaster*	520
pine, maritime [B)]	Portugal	Portuguese pine	*Pinus pinaster*	530
pine, radiata [B)]	Chile, New Zealand South Africa	Insignis pine, Monterey pine	*Pinus radiata*	480
pine, southern [B)]	Southern USA	loblolly pine, shortleaf, longleaf pine, slash pine	*Pinus taeda, Pinus echinata, Pinus palustris, Pinus elliottii*	670–490
pine, yellow [B)]	Eastern Canada, Eastern USA	eastern white pine, northern pine	*Pinus strobus*	420
poplar, black	France, Belgium, Turkey	robusta, black Italian poplar	*Populus nigra, Populus eur 'serotina'*	450
poplar, grey	Europe	—	*Populus canescens*	480
poplar, hybrid [C)]	Southern Europe	Turkish poplar	*Populus euramericana*	370

Table 2 **Imported species suitable for packaging** *(2 of 2)*

Standard name	**Origin**	**Other names**	**Botanical name**	**Density** A) kg/m^3
redwood, European B)	Russia, Finland, Sweden, Poland	Baltic redwood	*Pinus sylvestris*	520
rubberwood	Malaysia	—	*hevea brasilliesis*	610
spruce, black B)	Eastern Canada	water spruce	*Picea mariana*	480
spruce, Engelmann B)	Canada/USA mountains	mountain spruce	*Picea engelmannii*	450
spruce, red B)	Canada	yellow spruce	*Picea rubens*	450
spruce, Sitka B)	Western coastal areas	silver spruce	*Picea sitchensis*	450
spruce, white B)	widely distributed	eastern Canadian spruce	*Picea glauca*	420
whitewood, European B)	Russia, Finland, Sweden, Poland	Baltic whitewood	*Picea abies*	450

A) Density values are averages for the species air dried to 15% to 18% moisture content.

B) Denotes a softwood.

C) Not given as a standard name in BS 7359.

4.2.4 North American grown species

4.2.4.1 General

Timber from Canada and the USA is used for packaging in the UK. The timber in Canada and Alaska is predominantly coniferous, with approximately 90% softwood and 10% temperate hardwood, while that in the USA is approximately 70% softwood and 30% temperate hardwood.

The main softwood species imported into the UK for packaging are described in **4.2.4.2**.

NOTE Table 2 includes other species for reference purposes, although they are not as widely used.

4.2.4.2 North American softwoods

The following softwoods can be used for packaging purposes.

a) Balsam fir. The timber is very similar to spruce in colour and general appearance, but is coarser and less lustrous. There is practically no difference in colour between sapwood and heartwood, but the ends of logs usually show a wide sapwood band and a darker core, although this is not really noticeable once the log is converted. The wood is fairly light in weight, softer than spruce and the timber is easily worked and takes nails well.

b) Jack pine. A timber of the hard-pine class, with a sapwood about 40 mm wide, yellowish in colour and a heartwood varying in colour from pale to reddish brown. It is not unlike European redwood (*pinus sylvestris*) in appearance, but is more resinous and coarser in texture. It has similar strength to European redwood and Portuguese maritime pine.

c) Black spruce. A slow-growing tree, also known as swamp or water spruce, comparatively small, sometimes no more than 12 m high. It is similar to white spruce in appearance, but heavier, harder and stronger.

d) Douglas fir. A strong timber with similar properties to the same species grown in the UK.

e) Hemlock. Western hemlock is similar to European redwood in strength, but can suffer from splitting when nailed. Eastern hemlock has a tendency to warp and twist during drying and is considerably less strong then western hemlock.

f) White spruce. The wood is almost white to pale yellowish brown in colour, closely resembling a European whitewood. It is straight-grained, lustrous and slightly resinous. The wood weighs approximately 420 kg/m^3 when dried, but, since a proportion of other species might be included in shipments, this weight is conservative and the average weight could be a little higher. It takes nails well. The timber is generally marketed as Canadian spruce and, while the bulk of shipments contain mostly timber of *picea glauca*, they might contain some red spruce, black spruce and balsam fir.

g) Red spruce. Similar to white spruce in appearance, but the prominent late wood bands give a more sharply defined annual growth ring and greater density.

h) Southern pine. A commercial mixture of four species from the southern states of the USA as listed in Table 2, also called southern yellow pine. Each species varies individually from a medium to a high strength.

NOTE Table 2 lists the density values of North American softwoods.

4.2.4.3 Hardwoods

Imported hardwoods are often used for shorter lengths and blocking.

The main species of hardwood are:

a) ash – black ash is the primary packaging species among the ashes and has good all-round strength properties;

b) birch – its characteristics are not dissimilar to ash, but paper birch (as packaging grades commonly are) is somewhat weaker; it takes nails well;

c) maple – for packaging, the variety exported is usually soft or silver maple; its strength is similar to that of many average softwoods. It is easily worked, but slow drying;

d) poplar – it has low strength properties but is easily nailed. It is of low density and might distort during drying.

Other overseas grown species suitable for packaging are:

a) kapur/keruing – imported from South-east Asia, these are among the strongest of the species included in this standard. Their availability might be limited because of competition from other end uses. Some resin exudation might occur with keruing, while kapur could promote corrosion of fastenings due to its slightly acidic nature;

b) radiata pine – the backbone of the southern hemisphere softwood industry in Chile, South Africa and New Zealand, although it is not native to those parts. It is indigenous to only a small area around Monterey in the state of California, USA, where it is also known as insignis or Monterey pine and where it is a relatively unimportant species;

c) elliottis pine – one of the heavier and stronger of the four species comprising southern yellow pine as commercially grouped and exported by the USA. It is commonly known as slash pine or longleaf pine in the USA. It is included in this section to cover Brazilian elliottis pine. When grown in Brazil, the species is normally plantation grown and, since it grows faster in Brazil than in the USA, it would be expected to be weaker and the existing USA strength data would probably not be relevant.

4.2.5 Special considerations – Nasal or skin irritants

Although dust problems are particularly associated with certain species, it should be noted that airborne wood dust can cause irritation due to its physical characteristics. This is a basic problem which should be dealt with in the same way as dust arising from any material.

Where irritation occurs due to a particular species, it has been shown that, in many instances, it is related to specific chemical constituents in the wood. The response of an individual to a particular irritant species depends entirely on that individual.

NOTE A list of irritant softwood and hardwood species in shown in Annex A.

4.3 Strength of sawn wood and factors affecting strength

4.3.1 General

Manufacturers and specifiers of wood packaging should refer to BS EN 12246 for their sawn timber purchases. Both the aesthetics and the strength of wood play a part in producing acceptable packaging.

There are three factors that should be taken into account at the time of purchase:

- basic strength of a species;
- visual appearance grading; and
- effects of moisture.

4.3.2 Basic strength

4.3.2.1 General

Unlike timber for building purposes, typical sizes of packaging timber cannot be purchased in guaranteed minimum strengths. Relevant mean strengths are listed in Table 3 and Table 4.

The values of bending strength in Table 3 and Table 4 are not working stresses but the mean breaking strengths, which means that, at best, 50% of a given species is likely to be weaker than the listed values, at worst (and in fact in almost every practical usage of the timber), the average strength is likely to be substantially less than given values as the tests are on perfect, defect-free wood specimens. Table 3 and Table 4 are primarily intended for comparison between species and should not be used for design purposes. Table 3 and Table 4 should not be used for basic case and crate design unless safety factors are introduced; such factors typically allow for the weakening incidence of knots, wane and slope of grain.

The main use of Table 3 and Table 4 should be to make valid comparisons between species so that a case manufacturer or specifier can evaluate a species and determine whether special allowances or extra thicknesses should be taken due to it possibly being weaker than a tried-and-tested species.

Table 3 **Strength properties of clear A) softwoods**

Standard name	Origin	Botanical name	Moisture content		
			green	20%	12%
			Mean bending strength (N/mm²)		
fir, balsam	Canada	*Abies balsamea*	43	53.1	74.5
fir, Douglas	Canada	*Pseudotsuga menziesii*	54	66.6	93
fir, Douglas	UK	*Pseudotsuga menziesii*	53.1	65.3	91
fir, silver	Central and Southern Europe	*Abies alba*	41	52.2	77
fir, silver	UK	*Abies alba*	43	54.3	79
hemlock, western	Alaska to North-western USA	*Tsuga heterophylia*	52	66.1	97
larch, Dunkeld	UK	*Larix × eurolepis*	43	55.3	82.6
larch, European	UK	*Laris decidua*	53	66.7	96.3
larch, Japanese	UK	*Laris kaempferi*	48	60	85.6
pine, Corsican	UK	*Pinus nigra maritima*	41	53.3	81
pine, jack	Eastern Canada	*Pinus banksiana*	45	57.4	84.7
pine, lodgepole	UK	*Pinus contorta*	41	54.3	85
pine, maritime	Portugal	*Pinus pinaster*	47.4	59.8	86.8
pine, maritime	UK	*Pinus pinaster*	36	48.2	77
pine, radiata	Chile	*Pinus radiata*	38.1	49	73.2
pine, radiata	Kenya	*Pinus radiata*	41	54.3	85
pine, radiata	New Zealand	*Pinus radiata*	38	53.3	91.6
pine, Scots	UK	*Pinus sylvestris*	46.2	59.4	88.9
pine, yellow	Canada	*Pinus strobus*	42	53.8	80
redwood	Russia, Finland, Sweden, Poland	*Pinus sylvestris*	44	57.1	86.5
spruce, black	Eastern Canada	*Picea marina*	38	48.1	70
spruce, Norway	UK, Republic of Ireland	*Picea abies*	36	46.7	71
spruce, sitka	Canada	*Picea sitchensis*	39	49.9	74
spruce, sitka	UK, Republic of Ireland	*Picea sitchensis*	35	44.9	67
spruce, white	Eastern Canada	*Picea glauca*	36	40.8	49.7
whitewood	Russia, Finland, Sweden, Poland	*Picea abies*	39	51.3	79.5

A) Clear means that data are obtained from small specimens of knot-free, straight-grained timber tested in accordance with BS 373. Commercial timber is not likely to be clear and therefore is weaker than the values given.

Table 4 **Strength properties of clear [A] hardwoods**

Standard name	Origin	Botanical name	Mean bending strength (N/mm²)			Compression strength
			Moisture content			
			green	**20%**	**12%**	**green**
ash, European	UK	*Fraxinus excelsior*	66	82	—	27
beech, European	UK, Northern and Central Europe	*Fagus sylvatica*	65	81.8	118	28
birch	Europe	*Betula spp.*	63	81	123	
elm, Dutch	UK, Europe	*Ulmus × hollandica*	44	53.7	—	19
elm, English	UK	*Ulmus procera*	40	49.1	—	19
kapur	Sabah	*Dryobalanops spp.*	81	92.4	—	41
keruing	Malaysia, Sabah	*Dipterocarpus spp.*	70	83.3	—	35
mengkulang	Malaysia, Sabah	*Heritiera spp.*	81	91.8	—	40
oak, European	UK	*Quercus petraea*	59	71.4	126	28
plane, European	UK	*Platanus × hybrida*	54	—	—	24
poplar, Italian black	UK, Europe	*Platanus × euramericana*	41	50.9	—	19
poplar, grey	Europe	*Populus canescens*	44	54.3	—	20
poplar, Turkish	Southern Europe	*Polulus euramericana*	32	39	—	—
willow, white	UK	*Salix alba*	36	44.6	—	15

A) Clear means that data is obtained from small specimens of knot-free, straight-grained timber tested in accordance with BS 373. Commercial timber is not likely to be clear and therefore is weaker than the values given.

4.3.2.2 Softwoods

Two sets of bending strength values are given in Tables 3 and 4: the green or fresh cut strength, which applies to most softwood upon assembly, and the 20% strength, which applies to some imported species, such as European redwood or Canadian white spruce, because of their drier state upon import to the UK.

Green moisture content should normally be taken as a level above 28% (fibre saturation point), the point at which a further increase of moisture does not affect wood strength.

After a period in use, most packing case softwood dries to 20% moisture level and strength comparisons should be made at this level.

NOTE Where values for timber tested to BS 373 are not available, species have not been included in Tables 4 and 5.

4.3.2.3 Hardwoods

Hardwoods are used in UK packaging, where compression strength, abrasion resistance and nail-holding strength are of greater importance (blocks, short bearers etc.). The bending strength of packaging grades of hardwoods is far less than given in Table 4, since the wood qualities sold into the packaging market have a large proportion of grain slope, knots and wane.

NOTE 1 Details of the effects these naturally occurring features have upon sawn wood strength are given in BS 4978.

Hardwoods dry more slowly than softwoods and should be used in thicker sections. They remain nearer to the green strength values for much of the lifetime of a typical case and only these values are relevant (see Table 4).

NOTE 2 This might not apply to Far Eastern hardwoods which are imported in a drier state.

4.3.3 Appearance grading

Appearance grading is important in the sale of commercial timber today. This system is not concerned with strength but with outward appearance. For the selection of packaging grades of timber, with the exception of very large cases and crates, there is no alternative, since the stress grading system does not extend down to small sizes (the minimum is 35 mm thick).

Appearance grades are not necessarily inferior to stress grades, e.g. redwood sold as "Scandinavian 5th appearance grade" might be both stronger and more attractive in appearance than redwood sold as "SC1 stress grade".

NOTE Table 5 lists the equivalent appearance grades of wood for packaging.

Table 5 **Equivalent appearance grades of wood for packaging**

Name	Country of origin	Acceptable packaging grade	Higher packaging grade
Douglas fir-larch	Canada	No. 3 common	No. 2
hem fir	Canada	No. 3 common	No. 2
redwood	Russia, Sweden, Finland, Poland	Russian 5th, Scandinavian 6th	Russian 4th, Scandinavian 5th
spruce-pine-fir [A)]	Canada	No. 3 common	No. 2
whitewood	Russia, Sweden, Finland, Poland	Russian 5th, Scandinavian 6th	Russian 4th, Scandinavian 5th

[A)] Spruce-pine-fir imported from Canada comprises the four major species mixed at random (balsam, fir, jack pine, black and white spruce).

4.4 Basic sizes of sawn softwoods and hardwoods

4.4.1 General

The UK imports timber from many parts of the world in addition to producing its own, which results in a wide choice of species available to the user but, since there is as yet no effective international standardization of sizing, it also results in a relatively wide range of basic sizes.

NOTE BS EN 1313-1 covers the sizes of softwoods available from supplying countries with details of acceptable tolerances and further machining which might be carried out for particular end uses.

Although some logs are still available "in the round", most hardwoods are now imported as sawn sections, cut to specific thicknesses. Parcels of hardwood consist of three product groups:

a) specified widths, square edged;

b) random widths, square edged;

c) random widths, waney edged.

4.4.2 Softwood and hardwood

The methods of measurement of hardwoods are more complex than the measurement of softwood.

Surfaced (planed) softwoods are imported from Canada and the USA known as CLS (Canadian Lumber Standards) or ALS (American Lumber Standards) respectively.

Most hardwoods are imported in specific thicknesses but random widths which are within an agreed and accepted range. They might also be imported as cut-to-size dimension stock or as logs sawn through and through and cut to size on order.

NOTE Through-and-through sawing results in planks of uniform thickness which can be tapered along their length with waney edges.

5 Wood-based sheet materials

5.1 Plywood

Plywood is an ideal packaging material, limited only by its higher cost than sawn wood of the same thickness. It has superior performance under arduous conditions while retaining comparatively high strength/low weight properties.

Plywood for packaging can have three, four, five or seven plies; the larger the number of plies, the higher the quality and the lower the chance of distortion due to moisture, or high load (see **5.3**) which can occur in packaging applications.

During manufacture, synthetic resin adhesive should be applied to plywood by roller spreaders, sprayers or coaters and the veneers should be assembled with the grain of each at 90° to the adjacent veneer.

In certain circumstances this practice of bonding at right angles may be varied in order to produce plywood with special characteristics. The resultant assembly is known as a "lay-up", and is then subjected to pressure and heat.

After cooling, the panels should be trimmed, usually to 2 400 mm × 1 200 mm, although other sizes such as 2 440 mm × 1 220 mm and 1 525 mm × 1 525 mm are available from certain countries.

The international harmonization of plywood specifications has made extremely slow progress over the years and even now a comprehensive international standard does not exist. This is largely due to plywood's complex mixture of variables including:

a) adhesive type;

b) veneer type;

c) thickness and grade of veneer;

d) veneer lay-up;

e) surface finish;

f) overall panel thickness.

For packaging applications this lack of standardization has had less effect than in industries such as the building industry where requirements can be more specialized.

The critical three variables in packaging are:

- adhesive type (moisture resistance);
- veneer species (avoidance of surface decay);
- overall panel thickness (strength).

5.2 Plywood adhesives

5.2.1 General

The export packer should be aware of the type of adhesive that has been used in plywood manufacture in order to avoid problems with the finished package and because incorrect adhesive can lead to problems with delamination and loss of integrity.

The purchaser should be aware that the selection of an interior grade of adhesive when cases are to be stored externally can lead to delamination.

The purchase of plywood from a source which has not been subject to quality controls should be avoided, since it could result in an inadequate quantity of adhesive or the use of an interior grade of adhesive with no warning of lack of moisture resistance.

5.2.2 Adhesive classification

5.2.2.1 General

The two main types of plywood available are urea formaldehyde bonded and phenol formaldehyde bonded. Phenol formaldehyde bonded should be selected for packaging purposes where enhanced moisture resistance is required.

5.2.2.2 Urea formaldehyde (UF) bonded

This type of bond should be used in moisture resistant (MR) or interior type (INT) plywood.

Moisture-resistant plywoods survive full exposure to weather for limited periods only. They can withstand cold water and hot water for a limited time, but fail when exposed to boiling water.

Interior plywood is strong and durable in dry conditions and resistant to cold water.

5.2.2.3 Phenol formaldehyde (PF) bonded

This type of bond is used in weather- and boil-proof (WBP), Exterior or Exposure 1 type plywoods. PF bonds are highly resistant to weather, micro-organisms, cold and boiling water and both wet and dry heat.

5.2.2.4 Melamine urea formaldehyde (MUF) bonded

A third type of adhesive, urea formaldehyde fortified with melamine and known as MUF, is used in some types of plywood manufactured in the Far East. MUF bonds are more resistant to moisture and weather than UF bonds, but not as resistant as PF ones. MUF is sometimes designated CBR or cyclic boil resistant, which is a grade slightly below WBP.

NOTE Different countries have different designations for the adhesive classes and these might be marked on the face of the plywood.

5.3 Plywood grade and thickness

Short-term strength and water resistance should be the main criteria for design due to the typically short life and lack of need for aesthetics in packing case design.

For most plywoods the visual quality of plywood veneers are characterized by letter designations, e.g. CD Exterior has one side veneer of a higher quality (C) than the other side (D). For wood packaging applications, veneer appearance of C or D should be deemed adequate for most purchasers.

The type of adhesive used (see **5.2.2.2**), and whether the veneer characteristics restrict external exposure to weather, should be important considerations for export packers.

The timber veneers of plywood should be durable, and bonded according to the guidance given in **5.2.2.2**, **5.2.2.3** and **5.2.2.4**. With thinner grades of plywood, the imbalance caused when the outer veneer becomes saturated (thereby expanding) and the inner veneer remains dry can cause an outward bowing of sheathing if not tied at sufficient centres to maintain rigidity.

5.4 Veneer species

There are certain types of degradation which look unattractive, e.g. surface moulds and stains, and certain hardwood plywoods might be particularly badly affected, with moulds occurring within a few weeks in adverse conditions of high humidity.

6 Other wood-based products used in packaging

6.1 General

A growing interest in using timber waste as economically as possible has led to the development of sheet materials of a lower cost than plywood such as fibreboard and wood chipboard. Although these products use wood as the raw material, unlike sawn wood, their quality can be controlled.

NOTE Table 6 lists types of wood-based sheet materials.

6.2 Wood chipboard

Wood chipboard is particle board made exclusively from small particles of wood together with a binder, the particles being larger than in fibreboard and the binder normally being synthetic resin. Boards are available from 3 mm to 50 mm thick and can be of uniform construction through their thickness, of graded density, or of distinct three- or five-layer construction to give enhanced bending strength properties without excessive weight.

Wood chipboard has progressively superseded blockboard and laminboard and uses wood wastes, including forest thinnings, planer shavings and other joinery shop residue.

Wood chipboard in sheet form has a low strength to weight ratio and is difficult to nail due to a combination of high density (500 kg/m^3 to 700 kg/m^3) and thickness (12 mm to 20 mm) in excess of most fibreboard or plywood.

NOTE 1 The thinner boards are easier to work, but have low impact resistance.

Processed wood should be used for moulded blocks since its performance equals that of most sawn softwoods in terms of fastener retention but exceeds it in terms of dimensional stability under changing humidity.

The wood chips and cutter shavings should be mixed with a glue-wax suspension during manufacture and this mixture should be placed in a mould which is then pressed under high pressure and heated to cure.

NOTE 2 Moulded chipboard distance blocks provide pallet-based case manufacturers with an alternative method of production with more uniform quality. The extremely small dimensional variations facilitate automatic feeding of blocks where this operation is important.

6.3 Flakeboard

6.3.1 General

There are two types of flakeboard: waferboard and orientated strandboard.

6.3.2 Waferboard

Waferboard is a flakeboard made of specially prepared flakes, predominantly from small particles of wood, and a binder. It is normally made from wood wafers or flakes at least 32 mm in length, randomly orientated.

6.3.3 Orientated strandboard (OSB)

OSB is a three-layer flakeboard in which the grain of the flakes in each of the layers is aligned, the orientation in the centre layer being across the board, while the grain of the flakes in the surface layers lies parallel to the long axis of the board. The description orientated structural board is also used for this material.

The method of producing waferboard and orientated strandboard is that used to produce wood chipboard but with some differences, for example only small roundwood logs are used, and wood waste is not.

For this method, the logs should have their bark removed, be cut to length and then should be put into a waferizer which reduces them to wafers (waferboard) or strands (OSB), after which the wafers or strands should be dried. After drying to a moisture content of between 3% and 8%, the majority of fine particles should be removed from the finish. The dry wafers or strands should be stored to await further processing and blended with phenol formaldehyde (PF) adhesive with a proportion of either paraffin slack wax or wax emulsion. A waferboard mat is then formed by random distribution of wafers.

NOTE 1 The mat-forming section of an OSB production line orients the strands of the first layer mainly in one direction. The second layer is then oriented at right angles to the first, and so on. It is the orientation process which gives the panel properties more akin to plywood.

Flakeboards are comparable with, or replacements for, plywood, since their properties and handling qualities are more akin to those of plywood rather than fibreboard or wood chipboard.

NOTE 2 Waferboards are of greater interest to the packing case maker because they tend to be light and easier to nail.

6.4 Fibreboard (fibre building board)

Fibreboard, more correctly termed fibre building board, is defined as sheet material, usually over 1.5 mm thick, made from fibres of ligno-cellulosic material. It is sold as hardboard, medium board and softboard (insulating board). The wet process is the most common technique for manufacturing hardboard, medium board and softboard. Certain packaging applications make use of fibreboard where moisture resistance is not critical. Particular applications are fruit and vegetable trays strengthened by wood battens.

Hardboard and medium board, which are produced between 3.2 mm and 12 mm thick, should be used for packaging applications.

NOTE In packaging, the term "fibreboard" is also used to refer to cases made of solid or corrugated fibreboard.

Solid fibreboard is made from recycled paper and typically is less than 2.5 mm in thickness, while corrugated fibreboard consists of one or more sheets of fluted paper ("fluting") glued to two or more liners. Both solid and corrugated fibreboard can be used in conjunction with wood in some packaging applications and the actual material required should be specified.

Table 6 **Types of wood-based sheet materials** *(1 of 3)*

Type	Use	Class and condition	Relevant standards
OSB (orientated strand board)			
EN OSB/1	General purpose boards for interior for use in dry conditions or low relative humidity	Dry conditions or up to 65% RH	BS EN 300
EN OSB/2	Load bearing packing case sheathing and smaller boxes in dry conditions	Load bearing for use in dry conditions or up to 65% RH	BS EN 300
EN OSB/3	Load-bearing Packing case sheathing and smaller boxes for use in short term humid conditions	Exposed with occasional wetting	BS EN 300
EN OSB/4	Heavy duty load-bearing packing case sheathing for use in short-term humid conditions and flat top packing case lids liable to occasional wetting	Heavy duty, exposed with occasional wetting	BS EN 300
Chipboard			
EN Type P1	Standard grade, low strength to weight ratio, general purpose small packaging, poor structurally, for dry interior use	Moisture Class 1	BS EN 312

Table 6 **Types of wood-based sheet materials** *(2 of 3)*

Type	Use	Class and condition	Relevant standards
EN Type P2	Furniture grade with finer surface, still a low strength-weight ratio, dry interior use, not structural	Moisture Class 1	BS EN 312
EN Type P3	Same as P1 and P2 but moisture resistant, uses similar to above low strength-weight ratio, for occasional short term wetting	Moisture Class 2	BS EN 312
EN Type P4	Higher strength–weight ratio, domestic flooring applications so can be used for packing case flooring, shelving and dry interior use	Moisture Class 1	BS EN 312
EN Type P5	Moisture resistant, higher strength-weight ratio, resists short-term wetting as case flooring, for use in more humid structural conditions but not long term wetting.	Moisture Class 2	BS EN 312
Plywood			
EN 636 Class 1	General purpose plywood, non-durable large packing case sheathing and smaller boxes	Class 1 – internal – dry conditions	BS EN 636
EN 636 Class 2	Short-term exposure weather resistant plywood for packing case sheathing and smaller boxes	Class 2 – humid conditions with risk of wetting	BS EN 636
EN 636 Class 3	Long-term exposure packing case sheathing, pallet collars, flat-top packing case lids, waterproof glue line but take into account durability of surface veneer species	Class 3 – exterior plywood – moisture level frequently above 20% emc	BS EN 636 and BS EN 314-2:1993, Class 3 for glueline
MDF (medium density fibreboard)			
Type MDF	General purpose sheathing small cases, interior dry use, not structural	EN 622-5 Class 1	BS EN 622-5

Table 6 **Types of wood-based sheet materials** *(3 of 3)*

Type	Use	Class and condition	Relevant standards
Type MDF H	General purpose sheathing small cases, limited humid conditions, not structural	EN 622-5 Very limited wetting Class 1 and 2	BS EN 622-5
Type MDF Exterior	General purpose sheathing small cases, limited exterior conditions but not fully exposed	EN 622-5 Occasional wetting Class 1, 2 and 3	BS EN 622-5
Hardboard			
EN 622-2 Service grade	Thinnest material, limited to lightest duty smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2
EN 622-2 Standard grade	Slightly stronger duty thin material smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2
EN 622-2 Tempered grade	Strongest hardboard for smaller box sheathing for use in dry conditions	Use in dry conditions	BS EN 622-2
Blockboard and laminboard			
EN 636 Class 2	Short-term exposure weather resistant for packing case sheathing and smaller boxes, often veneered, can also be good structurally if grain direction is allowed for	Class 2	Glueline to BS EN 314-2:1993 Class 2 or 3

7 Moisture in wood and the avoidance of problems in storage and use

7.1 Sawn wood

Before wood is stored or used to construct boxes or cases, a percentage of the water it contains should be removed. The target should be for wood to have 20% moisture content or less. Timber should be dried prior to storage because it can decay if kept at a high moisture content for long periods, and certain species cannot safely be stored even for a few days in the close piling that is normal in packaging timber yards.

The development of unsightly moulds (light surface growths which can be brushed off) or sapstain/bluestain, which penetrates throughout the sapwood causing permanent staining, should be avoided by the following actions.

a) Stacking with thin spacers between each board or batten to allow free passage of air and dispersal of humidity until the timber is at, or below, 20% moisture content when close piling under cover creates less risk.

b) Kiln drying to 20% moisture content and storing under cover.

Immersion in fungicidal solutions (which provide short-term protection from sapstain and mould) should not be carried out.

Below 20% moisture content, known as the decay safety line, timber is generally safe from discoloration or damage.

NOTE 1 Placing wood packaging in freight containers can present special problems due to high humidity and high temperature. Substantially lower wood moisture contents are needed in such cases.

Timber should be dried to a level appropriate to its end use and all sheet materials should be stored in such a way that moisture ingress is minimal.

NOTE 2 Wood, provided that it is at 20% moisture content or below, can be close piled, but only if protection from rain is available in order to avoid damage caused by increased changes in moisture content.

Softwoods and permeable hardwoods of very low moisture content take up moisture more quickly than the less permeable hardwoods so that storage and temporary exposure to weather should be adjusted accordingly.

NOTE 3 The abbreviation "emc", which stands for equilibrium moisture content, occurs frequently in relation to timber being dried and timber in service.

Wood is hygroscopic, that is, its moisture can change to levels which are related to the temperature and humidity of the surrounding air. An emc value is the moisture content which a piece of timber achieves when exposed for a long period to air at a particular relative humidity (RH) and temperature (although temperature has the lesser effect).

NOTE 4 The approximate relationship between the RH and emc of sawn wood is given in Table 7.

Much packaging timber is machined and assembled at a high moisture content, often at 30% to 40%, but, although this timber is easier to nail and easier to machine at these high moisture contents, shrinkage is more marked than if assembly had taken place at 20%.

When the cell cavities are empty of water, but their walls are still holding water to their maximum capacity, the wood is said to be at fibre saturation point. Water over and above the fibre saturation point level fills, or partially fills, the cavities of the wood fibres. Its removal during the drying of the wet wood reduces only the mass of the wood, not its dimensions. For most common timbers, this fibre saturation point falls between 25% and 30% moisture content. Further drying below fibre saturation point can result in shrinkage as the fibre walls contract. This process happens in reverse if dried wood is put into a wet environment and absorbs water.

7.2 Degradation of wood by corroding metal

7.2.1 General

Wood can corrode metals, but corroding steel also degrades wood. Alkalis produced in the localities of cathodic reactions and iron salts at local anodic areas both cause degradation of wood and loss of wood strength. Iron stains on wood around steel fasteners are produced by interaction between iron salts and tannins and related substances in the wood; they indicate that corrosion and degradation are starting. Iron stains are not always associated with fastenings and new corrosion; they can be caused by traces of iron salts left behind from woodworking and machining operations.

If the wood is always wet, the acid in it, aided by salt if immersion is in seawater, acts as a bulk electrolyte in which various electrochemical cells can be formed, which can be more vigorous than the micro-cells set up in atmospheric corrosion; in particular, the wood can be degraded by alkalis formed at a cathode as well as by iron salts formed at a rusting iron anode.

7.2.2 Oxygen concentration cells

The shank of a fastener inserted into wood becomes starved of oxygen and anodic, and the exposed head becomes cathodic. The cathodic alkali gives negligible protection to the head as it is soon washed away, but could cause alkaline degradation of the wood at the area of emergence.

7.2.3 Other concentration cells

A cell might be set up when a single piece of metal passes through two different woods, caused by differences between the contents of acid, salt and oxygen in the two woods.

7.2.4 Bimetallic corrosion cells

Wet wood, especially salty wood, is an electrolyte, and bimetallic cells are set up between two different metals in contact with one another and embedded in wood.

NOTE A common case is where copper-base fasteners are used to attach wooden planking to a steel framework, where the corrosion of the steel can occur.

The new copper preservative solutions can have this effect too.

7.3 Plywood

Plywood uses identical species to sawn wood, yet, when subjected to moisture changes, plywood’s cross-spliced construction provides superior dimensional stability in the plane of the panel. The swelling or shrinkage of wood along the grain with changes in moisture content is small, being only about 1% of that across the grain. In plywood, therefore, the tendency of individual veneers to swell or shrink crosswise is greatly restricted by the relative longitudinal stability of the adjacent plies (veneers). The vastly superior strength of wood along its grain can easily counteract the small forces set up by the wood across its grain due to moisture movement.

Moisture expansion of a plywood panel that is free to move consists of a uniform restrained swelling across the full width or length, and a less restrained swelling at the edges. Edge swelling is independent of panel size, varies with the thickness of veneers having grain perpendicular to the direction of expansion and, for the same veneer thickness, is about twice as great for face plies as for inner plies.

In package assembly, under UK conditions, relative humidity might vary between 30% and 70%, with corresponding moisture contents ranging from 6% to 13%. Total dimensional changes of a 1 200 mm × 2 400 mm standard plywood panel exposed to this change in conditions could be expected to average about 1 mm across the width and 2 mm along the length, showing substantial improvement upon the performance of sawn woods.

7.4 Measurement of moisture content

There are two methods of measuring moisture content in general use. The most common method, using an electrical moisture meter, consists of a non-destructive reading surface which is based upon the fact that the electrical properties of timber vary with its moisture content. This method, covered in BS EN 13183-2, should be used for packaging work. The electric moisture meter gives an instant reading which can be repeated many times with little effort to give an overall picture of moisture content and its distribution.

NOTE 1 A skilled user of a resistive type meter can obtain results within 2% of the true moisture content.

The most common and accurate moisture meters are of the electrical resistance type. These work on the principle that, as the moisture content of a piece of timber increases, its electrical resistance decreases; conversely, timber with a low moisture content has a high resistance.

Conductivity should be measured between two pin-like electrodes which are pushed or hammered into the timber to be tested. Corrections should be applied with varying species to improve the accuracy of the results.

NOTE 2 The portability of these battery-powered instruments is also a major advantage and moisture meters have gained wide acceptance in determining moisture content during the processing, storage, transportation, installation and in-service checking of timber and timber products.

The range over which the better meters are accurate is 9% to 28%, but the meter should be periodically calibrated to traceable standards.

It should be noted that the readings given by moisture meters are sometimes influenced by the presence of salts such as those from waterborne preservatives, e.g. the very common copper-based preservatives, and from contamination by sea water. Such salts increase the conductivity of the wood, particularly at higher moisture contents, and give falsely high readings of moisture content. The magnitude of this effect is variable and it is not possible to correct the readings, but when the presence of salts is suspected, higher than expected moisture readings should be examined further, e.g. by the use of a hammer electrode with insulated pin shanks.

NOTE 3 The alternative method of measuring moisture content, the oven drying method, is destructive in that it involves taking the piece of timber (or a sample of it), weighing it to determine the mass of wood plus the water it contains, drying it to obtain the dry mass and using the formula given in BS 373 to calculate the moisture content.

When measuring plywood with an electric meter, it should be regarded as a separate material and not treated merely as the timber species from which it is made. The moisture content readings obtained with a resistance-type meter on plywood are often misleading and they should not be regarded with confidence, since the presence of soluble chemicals in the gluelines of certain types of plywood affects the reading obtained.

Resistance-type meters might, in extreme cases, indicate moisture values of approximately double those obtained by the more accurate oven drying methods.

NOTE 4 BS EN 13183-3 covers a third method of measurement. However, tests against the most accurate oven-drying method show that this is the less accurate the resistive meters covered in BS EN 13183-2.

7.5 Kiln-dried timber – Problems with development of moulds after drying

Kiln-dried softwood pallet boards occasionally present problems because after a few weeks in stock or in use they can develop a white/grey mould. The moisture content they were dried to is critical to prevent this from happening, e.g. 20% moisture content is known as the "decay safety limit" and any timber above this level should be considered at risk.

The purchaser should specify that timber should be kilned to 20% or less and users should check the wood with a moisture meter on arrival.

Freshly felled softwood straight from the sawmill might have from 35% up to 60% moisture content. The amount of water in the wood depends on time of year, species, time at the sawmill, etc. Pallet and box makers accept timber with 25% to 30% moisture on delivery.

Kiln-dried pallet wood from suppliers can have a moisture content of 24% (still quite wet) down to a very dry 12% for pallets for the paper industry. To kiln dry thin pallet boards to a low level takes between 15 h and 60 h in a drying kiln, depending on their wetness, thickness of the boards, their species and the drying temperature and humidity in the kiln.

NOTE 1 "Kiln dried" does not automatically mean that wood is very dry, for example fencing makers routinely ask sawmills to kiln their wood down to 27–28% because it is ideal for chemical pressure treatment.

Any commercial order for kiln-dried wood should always state the required moisture content.

NOTE 2 A range of 15–18% contains a good margin of error in order to stay below the "decay safety limit"

On delivery, a few boards should be measured for moisture content using a moisture meter.

There are several reasons why white or grey moulds or bluestain can start on clean and apparently dry boards.

a) The moisture content in some of the timber might be above the decay safety limit of 20%.

b) There might be lack of air movement in a closed, unheated store.

   NOTE 3 A lower store temperature at night or over the weekend without good ventilation can automatically raise RH. Normal indoor RH values are between 30% and 55%. Values above 70% RH could be the cause of the problem.

c) Airborne spores settling on apparently dry boards.

NOTE 4 A high relative humidity can be measured with a battery-operated hygrometer. The right type can measure in seconds, though some models take several minutes to obtain an accurate reading.

7.6 The causes of bluestain in packaging timber

7.6.1 General

Bluestain (also called sapstain) is a discolouration of timber caused by deeply penetrating fungi that have dark coloured threads (hyphae). Bluestain varies in colour but is usually greyish blue in appearance. Bluestain is permanent and, due to its depth of penetration, cannot be cleaned off, thus giving rise to customer complaints.

Staining does not only affect the surface but can also penetrate throughout the entire depth of sapwood, showing up as staining on the side or as end grain.

In certain species, sapstain can also invade the heartwood.

7.6.2 Free or restricted ventilation

Timber should be dried to 20% moisture content using either air or kiln drying to prevent discolouration damage and it should then stored under well-ventilated cover to protect it from rain. If not freely ventilated, the timber needs to be dried to the levels given in Table 7 in order to protect from mould and stain.

Table 7 **Wood equilibrium moisture content (emc) in humid air**

Degrees C	0°	5°	10°	15°	20°	25°	30°	35°	40°	45°
RH%										
30%	6.3	6.3	6.3	6.3	6.2	6.1	6.0	5.9	5.7	5.6
35%	7.1	7.1	7.1	7.0	7.0	6.9	6.7	6.6	6.4	6.3
40%	7.9	7.9	7.9	7.8	7.7	7.6	7.5	7.3	7.2	7.0
45%	8.7	8.7	8.7	8.6	8.5	8.4	8.2	8.0	7.9	7.7
50%	9.5	9.5	9.5	9.4	9.3	9.1	9.0	8.8	8.6	8.4
55%	10.4	10.4	10.3	10.2	10.1	10.0	9.8	9.6	9.4	9.1
60%	11.3	11.3	11.2	11.1	11.0	10.8	10.6	10.4	10.2	10.0
62%	11.7	11.7	11.6	11.5	11.4	11.2	11.0	10.8	10.6	10.3
65%	12.4	12.3	12.3	12.2	12.0	11.8	11.6	11.4	11.1	10.9
67%	12.8	12.8	12.7	12.6	12.4	12.2	12.0	11.8	11.5	11.3
70%	13.6	13.5	13.4	13.3	13.1	12.9	12.7	12.5	12.2	11.9
72%	14.1	14.0	13.9	13.8	13.6	13.4	13.2	12.9	12.7	12.4
75%	14.9	14.9	14.8	14.6	14.5	14.2	14.0	13.7	13.4	13.1
77%	15.5	15.5	15.4	15.2	15.1	14.8	14.6	14.3	14.0	13.7
80%	16.5	16.5	16.4	16.2	16.0	15.8	15.6	15.3	15.0	14.6
85%	18.5	18.5	18.4	18.2	18.0	17.8	17.5	17.2	16.9	16.5
90%	21.0	21.0	20.9	20.7	20.5	20.3	20.0	19.7	19.3	19.0
95%	24.4	24.4	24.3	21.1	24.0	23.7	23.4	23.1	22.7	22.3
98%	26.9	27.0	26.9	26.8	26.7	26.4	26.1	25.8	25.5	25.1

NOTE 1 Units: relative humidity percentage (RH%) versus Degrees Centigrade (°C) yielding wood equilibrium moisture content percentage (emc%).

NOTE 2 Example: a relative humidity of 60% at 20 °C results in an emc in wood of 11%.

7.6.3 Wet timber

While the fungi responsible for bluestain are not the same as those which produce fungal decay, the conditions which favour development of bluestain also favour the eventual onset of more serious fungal decay, although this takes longer to occur depending on species and conditions. Most species of wood used for pallets and packing cases in Europe are classed as perishable or non-durable.

Timber should not be left wet in poorly drained or ventilated storage or to gain water outdoors. It should not rise to a moisture level above 20% for more than a month or two or else, in addition to sapstain, irreversible decay is likely to start.

NOTE 1 This period depends on ambient temperature and the durability of the species.

NOTE 2 In the early stages bluestain does not affect timber strength.

Decay progressively reduces wood strength and should be avoided.

All the wood components for pallet and boxes should be structurally sound in order to remain safe in use.

7.7 Shrinkage and distortion of sawn timber

7.7.1 General

There are two interrelated problems associated with putting sawn timber into service at a higher moisture content than its eventual emc: shrinkage and distortion.

7.7.2 Shrinkage

If a piece of timber at 25% moisture content is put into a 13% emc environment, it can be expected to shrink at least 3% tangentially and 1.5% radially, or 2.25% on average. Although this is not much on a 25 mm × 25 mm batten, it represents a 3 mm gap on a 150 mm sheathing board.

It is unrealistic to apply high precision to matters involving moisture content and shrinkage, but a severe mismatch between the moisture content at the supply, manufacturing and end use stages can lead to serious problems.

7.7.3 Distortion

Radial shrinkage is only half tangential shrinkage and, since the grain of a piece of timber rarely runs parallel to its edge, this means that, in practice, large changes of moisture content can be accompanied by distortion. This could result in the bowing or twisting of battens or cupping of cladding boards.

NOTE 1 Figure 1 shows characteristic (though exaggerated) shrinkage even when the grain runs perfectly parallel.

Distortion should only be removed by machining, prior to assembly, but this involves considerable cost.

If in a particular design of case no shrinkage gaps should appear during transportation or end user storage, the moisture content of the timber sheathing should be reduced to a few percentage points above the expected emc.

NOTE 2 For example, drying from 40% to 18% would satisfy the most rigorous requirement.

Although the effect of drying is to increase the strength of the timber itself, the effect on nailed joints is often the reverse. This is because the initial high friction between the members of a joint created by the high-speed application of nails is gradually lost as the member components shrink away from each other during drying.

The strongest joints are those made when the timber is dried to, or very near to, the emc before assembly. The effect of drying is to increase the withdrawal resistance of individual nails, which, of course, is the reverse of the effect on the total joint.

The following single rule can be applied in relation to the effect of drying on joint strength.

a) For joints in shear, a lowering of strength could result.

b) For joints in tension, a raising of strength could result.

NOTE 3 Species vary considerably in their tendency to distort.

NOTE 4 Table 8 gives some examples of large and small movement timbers.

NOTE 5 A number of species have not been evaluated yet.

Figure 1 **Exaggerated effect of drying shrinkage**

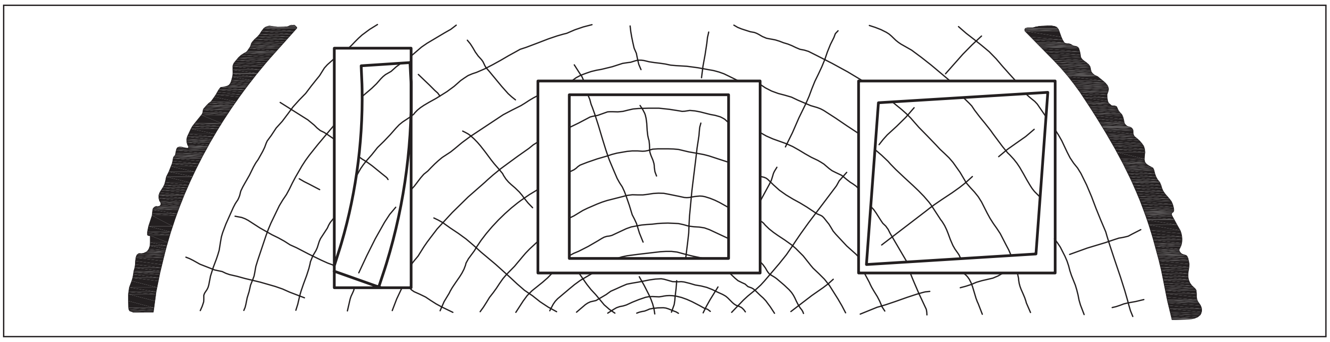


Table 8 **Moisture-related movement/distortion characteristics of timbers**

Timbers with small movement values	Douglas fir, hemlock, western white spruce, sitka spruce, larch, western red cedar
Timbers with medium movement values	ash, Scots pine, birch, Euopean whitewood, elm, European redwood
Timbers with large movement values	beech, radiata pine, poplar

7.8 Shrinkage and distortion of sheet materials

As distinct from sawn wood, but both shrinkage and expansion can occur with plywoods and other processed sheet material through the effects of moisture.

Normally plywood is at a very low moisture content when supplied (this is a by-product of conditioning to 4% to 6% for gluing) and can then rise to its emc as dictated by storage conditions. The effects of this on plywood sheathed cases stored outdoors might be that the outer veneer takes up moisture more quickly than the inner plies (which are protected by their gluelines) and a strong force is set up, producing convex curvature (viewed from outside the case).

NOTE This problem is more likely to occur with 3-ply or 4-ply panels rather than the thicker 5-ply or 7-ply sheets.

7.9 Air and kiln drying

Some cases need pre-dried timber in the equilibrium range of 17% to 20% and possible reasons for such usage include:

a) avoidance of corrosion damage to goods;

b) easier machining of some species;

c) an increase in strength properties;

d) the avoidance of gaps between boards on drying;

e) the need to save weight for transit.

7.10 Effect of moisture on contents

7.10.1 Relative humidity (RH)

The action of sealing a case against the weather, particularly if the contents are not enveloped in a moisture vapour-resistance sheet, can create entrapped moisture.

If goods are packed into a case with no protection, wood can affect the immediate environment of metal items even though the two materials are not in direct contact.

The RH of the air in the interior of a sealed wooden case is determined by the initial moisture content of the wood itself. When the relative humidity exceeds 50%, corrosion of metals, especially ferrous metals, is rapid. In the interior of a wooden packaging case an RH of 80% can be quite common.

7.10.2 Surface contact

When direct contact between wood and metal is involved, serious corrosion does not occur under dry conditions with most species. Apart from ferrous metals, improper selection of species or inadequate drying of wood intended for packing cases might result in corrosion of lead and some of its alloys, aluminium and magnesium (and alloys thereof) and zinc.

NOTE 1 Brass and copper are not ordinarily corroded by wood, but examples of such corrosion are known.

Where direct contact between wood and metal occurs, a barrier such as waxed paper should be positioned at the contact point to avoid acid induced corrosion.

Occasionally, corrosion still occurs despite reasonable precautions being taken. This is due to the fact that wood itself is acidic and some species particularly so, e.g. kapur, oak and sweet chestnut. Heat treatment of the timber, such as during kiln drying, might make the situation worse because, although any acid vapours present could be driven off, the rate of formation of further vapour is greatly accelerated, giving higher concentrations in the short term.

While the significance of such corrosive damage should not be exaggerated, it is a possibility to be borne in mind where susceptible products are to be stored in the long term, especially where high humidities and temperatures are encountered.

Methods of totally preventing corrosion are not easy to find. Polyethylene sheet is not impervious to vapour and more effective lining materials are barrier foils or aluminium/kraft laminates. Even with these materials problems might occur through ineffective sealing, puncture from fastenings, splinters, etc. or from in-transit inspection.

NOTE 2 Advice on the temporary protection of metal surfaces against corrosion, on the use of desiccants in conjunction with barrier materials and on prevention of corrosion caused by vapour from organic materials is given respectively in BS 1133-19 and BS 7195.

8 Fastenings

8.1 Fastenings for wooden boxes, cases and crates

Wooden packaging, unlike many other timber products, is frequently subjected to dynamic loads as well as long-term static loads due to the rigours of transportation, storage and exposure to the elements.

The short design life required (often much less than a year) means that the construction should be lightweight so as to avoid unnecessary weight and costs. These factors combine to make the loads imposed on the fastenings used in the packaging industry closer to their ultimate strength than in other applications such as building and construction. It is for these reasons that in some sections of the wood packaging industry annularly threaded nails should be used. For board to board joints, clinched nails or heavy duty staples should be used.

NOTE A wide range of other fastenings is used, including screws, bolts and wire stitching. Some use is also made of adhesives.

8.2 Nailed joints

8.2.1 General

The methods of jointing described in this subclause are widely used, strong and efficient. The tables of strengths and working loads shown in Tables 9, 10 and 11 are not based on manufacturers' data, but on independent tests undertaken on the wood species of Europe and North America. The tests were carried out on sawn woods in both dry and wet conditions and, as a result, the information is specific to the UK box, case and crate industries. Certain data do not support all the (often theoretical) results accepted in the past. An example of this is the evidence that coated nails are not the major improvement on plain bright steel nails once thought, since the improvement that coated nails demonstrate in timber with a low moisture content is not paralleled in timber with a high moisture content.

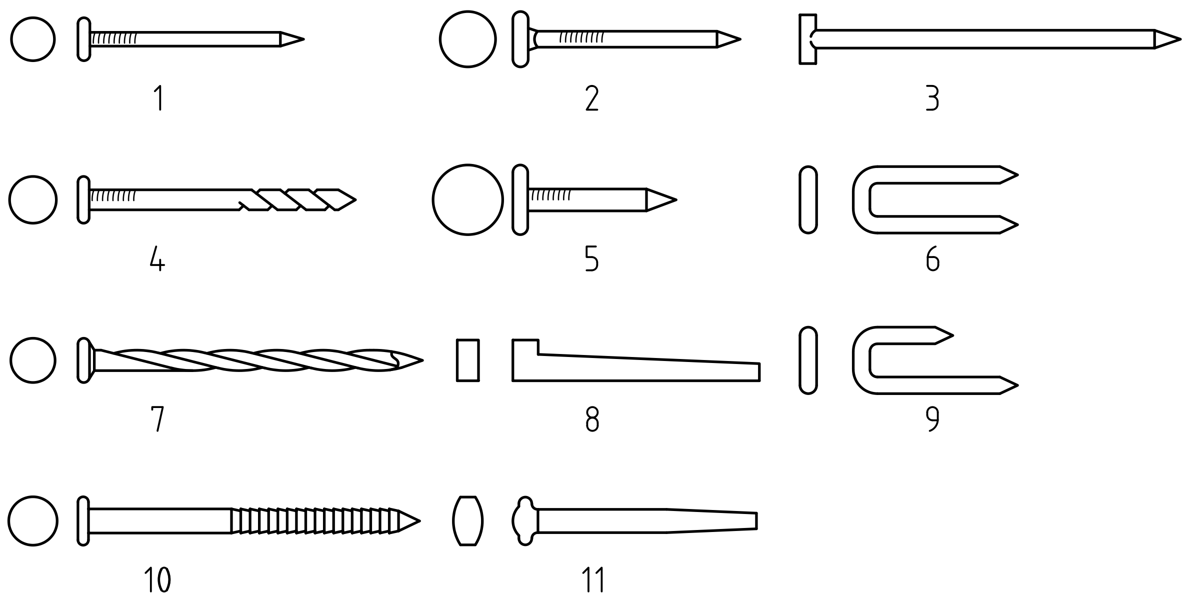
8.2.2 Types of nails used in packaging

Nails are the main type of fastening used and are available with a range of shank and head profiles (see Figure 2 and Figure 3, as well as Table 9), surface finishes and proprietary coatings. The basic nail from which all these variations are derived is the bright plain shank nail made from mild steel with a flat round head, round plain shank and diamond point. All these features can be, and have been, modified both to improve aspects of performance, particularly increasing withdrawal strength, and to allow the fastener to be driven by an air-operated hand tool, or hopper feed nailing machine.

NOTE 1 The various types of nails used in packaging are listed in Table 9.

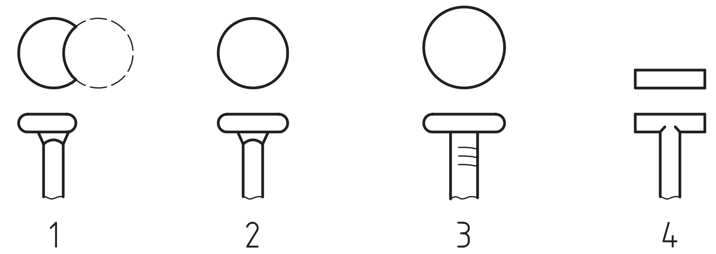
NOTE 2 Nail types and their suitability for different loading modes are listed in Table 10.

Figure 2 **Common packaging fasteners**



Key

1	Common or bright	5	Extra large head clout	9	Tenterhook
2	Clout	6	Staple	10	Annular ringed
3	T nail	7	Square twisted	11	Cut clasp
4	Helical thread	8	Cut		



Key

1 Notched or "D"
2 Round
3 Large
4 "T"

Figure 3 **Nail head types**

Table 9 **Types of nail used in packaging**

Nail type	Description
Annularly threaded nail, screw nail, threaded nail	A nail having part of its shank ring threaded to improve withdrawal strength
Bright mild steel nail	A nail made from bright drawn steel wire and supplied without further surface treatment [A)]
Common nail	A nail having a large flat head used for fixing thin or soft material
Clout nail	Obtainable in steel, copper and aluminium
Coated nail, resin coated nail	A nail that has been treated with a proprietary coating [B)] to increase its grip in wood
Collated nail	Any type of nail supplied in compact flat or coiled sets for pneumatic tools
Helically threaded nail	A round wire nail having part of its shank spirally threaded
Improved nail	A nail whose shank has been deformed, machined or coated in order to improve withdrawal strength, e.g. annularly threaded, square twisted or helically threaded nail
Plain head nail	A wire nail with the standard round flat head which has a specific size relationship to the shank diameter
Round wire nail	A nail made from round section wire
Square twisted nail	A square shank nail having all of its shank spirally threaded through a twisting motion during manufacture

[A)] Material or treatment applied to a bright mild steel nail, primarily to provide corrosion resistance.

[B)] A compound such as plastic polymer resin applied to the shank of a nail by the manufacturer.

Table 10 **Acceptable loading modes for the different nail types**

Type	Shank	Head	Acceptable loading modes
Common or bright	Plain	Round	Shear loads and withdrawal if clinched A)
Common or bright	Plain	Notched	Lower head loads only or shear loads
Common galvanized	Hot dip galvanized	Round	Shear or medium withdrawal loads
Common	Plastic polymer coated	Round	Shear loads and withdrawal if clinched A)
Helically threaded	Twisted (round)	Round	Shear and medium withdrawal loads
Twisted	Twisted (square)	Round	Shear and medium withdrawal loads
Annularly threaded	Concentric grooves	Round	Highest shear B) and withdrawal loads
Clout	Normally hot dip galvanized	Large diameter	Fastening lining papers, thin plywood
Cut	Square taper	Rectangular	Shear loads only
"T" nail	Plain	Rectangular	Low loading only

A) Clinched nails might be subjected to medium to high density withdrawal loads provided a 6 mm to 9 mm clinch is achieved.

B) High shear loads are only permissible if the nails are of adequate bending strength when determined by an approved method of measuring nail bending torque (Nm).

NOTE BS EN 409 and BS EN ISO 12777 (all parts) specify a method of test for nails.

A joint's separation strength is dependent upon a combination of nail withdrawal resistance and nail-head pull-through resistance. A joint's shear strength is dependent upon both these factors, but also upon the bending strength of the nail. The degree to which each of these three parameters individually affects the shear strength is dependent upon both the nature of the joint and the quality of its accompanying two parameters, e.g. in a shear joint, a high nail-bending strength reduces the need for a high nail-head pull-through resistance since head loading is much reduced. At present, insufficient research has been conducted in relation to wooden packaging to be able to be precise as to joint working loads.

To improve the withdrawal resistance of a nail, the shank profile should be changed or "deformed", as in the square twisted, helically or annularly threaded types shown in Figure 2.

Helically threaded and square twisted nails improve withdrawal strength by a factor of 1.5 to 2.0 compared with plain shank nails, and annularly threaded nails can improve performance by a factor of 2.5 to 3.5. The variation in performance is due to differences in the efficiency with which the wood fibres reform around the shank of the nail after driving and whether the wood shrinks or swells during changes in the moisture content.

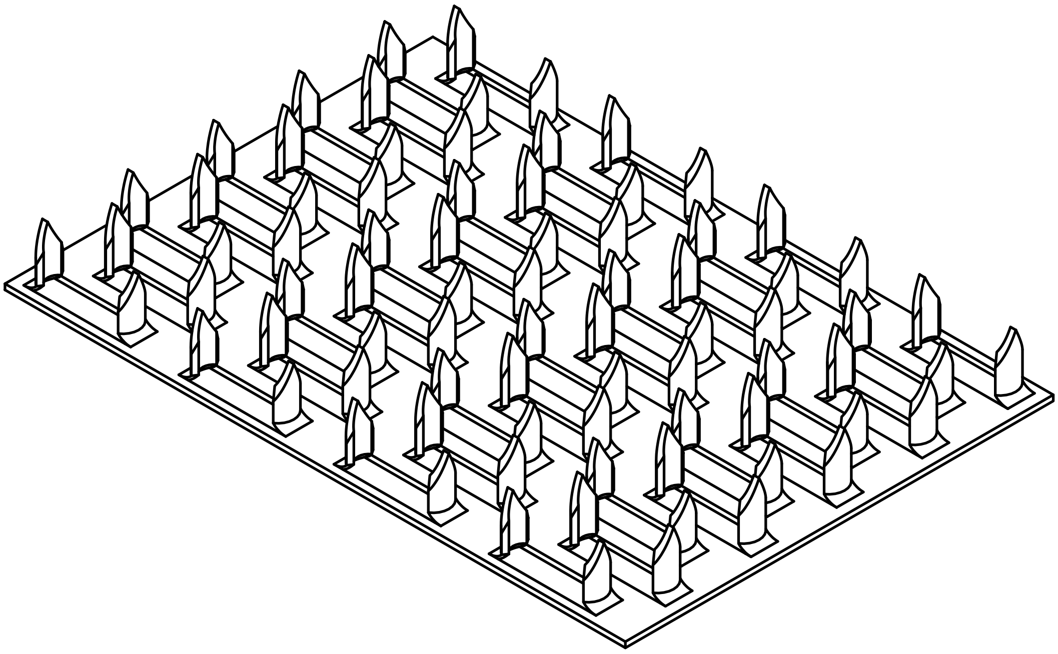
NOTE 3 As a class, these nails are often referred to as deformed shank nails.

NOTE 4 BS EN 10230-1 specifies requirements for steel nails, but not collated nails.

8.2.3 Using punched steel nailplates

Nailplates (see Figure 4) are made from one-piece steel sheet with a large number of short nails formed during a pressing-forming operation. They are widely used in timber house building and construction and more recently have been used in packaging. Plates have now largely replaced diagonal wood cross bracing in high-performance boxes, since they give a similar level of racking resistance to box sides and ends but, unlike wood cross bracing, they can cope with wood drying shrinkage without box strength loss when part dried sawn timber is used in assembly.

Figure 4 **Nail plate**



To be able to resist the large lateral load applied in practice and when in use at the bottom of a stack, plates of an adequate size and type should be applied with a rotary or hydraulic press under factory conditions and not using hand tools or a press of inadequate capacity. Plates should not be hammered into place. A hydraulic or flywheel type press system should be used.

Unlike trussed rafters or I-beams used for housing, in boxes a pair of nailplates should not be applied to each side of a timber panel joint and a typical specification should be based on a single plate on each side and end.

Each nailplate should be fully embedded to achieve complete penetration of the nails without pressing the plate into the timber more than about 0.3 mm and there should be no gap between plate and timber.

Corrosion protection of plates should be via electroplated zinc and of a thickness intended for internal woodwork. This means that nailplate corrosion should be avoided, and crates and cases should be under cover for most of the year to assist in maintaining low moisture content and avoiding wood decay. Customers should be informed of these steps, or wood decay and plate corrosion can lead to weakened crates and cases and, eventually, failure.

8.2.4 International strength quality levels for pallet and case nails

BS ISO 15629 contains internationally accepted levels for the bending strength of wood packaging nails (see Figure 5).

There are three levels for heavy duty annular ring shank, twisted nails, helical thread and plain) nails and three lower levels for light duty plain nails.

Above 6.0 Nm	BS ISO 15629, high bending strength
Above 5.4 Nm	BS ISO 15629, medium bending strength
Above 4.5 Nm	BS ISO 15629, low bending strength
4.5 Nm and below	Unclassified

NOTE 1 The unit used for nail bending strength in BS EN ISO 15629 is Newton-metres (shortened to Nm).

These values do not relate directly to nail diameter or type; they apply to whatever nail diameter can achieve the required bending strength. Therefore poor-quality steel might need a 3.5 mm diameter to achieve high strength and a better quality steel might only need a 3.3 mm nail to achieve high strength.

For plain clinched *pallet mat* nails the three levels should be:

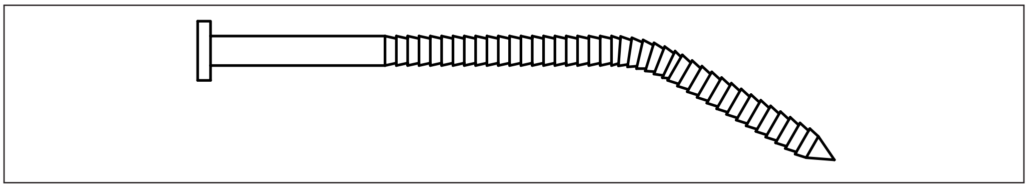
Above 2.5 Nm	BS ISO 15629, high-clench strength
Above 2.2 Nm	BS ISO 15629, medium-clench strength
Above 1.9 Nm	BS ISO 15629, low-clench strength

This information has been produced to give a comparison between the main types of nail and is intended:

- to compare shank types in order to evaluate performance differences;
- to give the safe working load (SWL) values for design purposes.

NOTE 2 For more detailed information see BS ISO 15629.

Figure 5 **Ring nail after ISO test**



8.2.5 Safe working loads

Manufacturers' literature is of little use when comparing the wide variety of fastenings available because of competing claims for performance or non-quantitative methods of stating performance.

The values in Table 11 are for a softwood of 500 kg/m^3 density and, therefore, wood of lower density should have a correction factor applied to reduce the safe working load. Greater nail penetration than 35 mm allows a proportional increase in withdrawal SWL, but no increase should be allowed for shear safe working loads if penetration is increased.

NOTE 1 Many case designs put unbalanced loads on fasteners and the total number of nails required cannot be determined by simply dividing content mass by the values given in Table 11.

Table 11 **Safe working loads (withdrawal and shear) for single nail joints A) in pine species, using nails 2.65 mm diameter × 50 mm long with 35 mm pointside penetration**

Type of nail	Withdrawal SWL	Shear SWL
	kg	kg
Common: plain shank	9	26
Common: slanted entry	14	26
Common: hot dip galvanized B)	23	26
Helically threaded	21	26
Square twisted	21	26
Annularly threaded	34	26

A) Single nail joint values are given for ease of calculation in multiple nail joints. Single nail joints are not recommended in practice.

B) The rough surface of hot dip galvanized nails results in higher withdrawal resistance than that of electro-galvanized nails.

NOTE Shear load values assume that nails have adequate bend resistance conforming to BS ISO 15629.

Table 12 **Conversion factors for alternative nail shank diameters**

Nail diameter	Withdrawal	Shear		
	For working withdrawal resistance multiply by factor:	Minimum thickness of component head side	Minimum point side penetration	For working load multiply by factor:
mm		mm	mm	
2.0	0.57	17	17	0.57
2.2	0.69	17	20	0.69
2.36	0.79	17	23	0.79
2.5	0.89	18	24	0.89
2.65	1.00	19	25	1.0
3.0	1.28	22	29	1.13
3.35	1.60	25	32	1.26
3.75	2.00	29	38	1.41
4.0	2.28	32	44	1.51

The package designer should use a wide range of nail lengths and diameters.

NOTE 2 Table 12 gives percentage corrections to apply to the values in Table 11 to enable changes in safe working load with different diameters of nail to be estimated.

8.3 Surface finishes and coatings

The vast majority of packing case fastenings are of unprotected steel, since the short-term life of such items requires no more. It is unusual for boxes or cases to have a life longer than 1 year or to be sold on appearance.

Where protection against corrosion is required, fasteners should be coated with a corrosion-resistant surface finish. The choice of finish should depend upon specialist requirements and the length of life required. Zinc protection by means of galvanizing or sherardizing should be the finish selected. Hot-dip galvanizing, due to the rough surface finish, also improves the withdrawal strength of the nails, in addition to providing anti-corrosion properties.

Coatings, such as plastic polymer resin, are also available, mainly from manufacturers of collated nails. These might ease the entry of the nail into the timber and yet still increase the withdrawal resistance of the nail. However, in UK laboratory tests, these coatings have demonstrated withdrawal resistance below that of untreated nails when driven into timber with a high moisture content and tested after long periods of exposure, because the wood surrounding the nail shank shrinks away from the nail shank.

High moisture contents can be expected in a significant quantity of cases at some stage in their life cycle.

NOTE Chromate passification gives improved resistance to corrosion in damp conditions.

The high moisture content in timber, at the manufacturing stage, results in lower strength properties, but the effect on overall long-term joint strength in cases is the reverse, which is due to two factors.

a) The mildly corroded surfaces of the common bright nail have a greater coefficient of friction and have greater withdrawal resistance,

b) The wood fibres reform and maintain a tighter grip around the shank of the nail. Deformed shank nails also improve withdrawal resistance.

This increase in strength reverses for bright unprotected nails, as time passes, as there is a chemical/physical deterioration at the steel/wood contact surfaces.

8.4 Effect of density on joint strength

8.4.1 Nail bending on insertion

Nail bending on insertion (cripple) refers to bending failure due to the axial driving creating stress exceeding the bending strength of the nail.

The density of the timber into which the nail is driven has a substantial effect on joint strength. While low density reduces pull-out resistance, too high a density creates problems either of inability to drive in nails through seizure at the half-way point, or else cripple of the nail before full entry.

Nail manufacturers have developed a shank diameter:length ratio which, in softwoods, usually avoids cripple. This is a minimum of 0.035 (3.5%) and the general acceptance of such a ratio is shown by the non-availability of nails outside this range.

Table 13 lists lengths and diameters meeting the relevant ratio and gives the approximate number of nails per kilogram that should be used when calculating the design mass of finished cases, etc.

For denser species such as maritime pine the bending strength of nails should meet or exceed the regular grade nail performance requirements.

The diameter:length ratio at which nail bending on insertion is likely, is lower for power/air-driven nails than for hammer-applied nails because hand-driven nails are normally driven by three or four sharp blows, each blow imparting more energy at the same point of driving than a corresponding power system (which is inherently smooth). This means in practice that a nail that would constantly cripple in hand application can be satisfactorily driven home by a power system.

Table 13 **Approximate count (number of nails) per kg for nails**

Length (mm)	Diameter (mm)											
	2.0	2.1	2.2	2.36	2.5	2.65	2.8	2.9	3.0	3.35	3.75	4.0
20	1 428	—	1 594	—	—	—	—	—	—	—	—	—
25	1 557	—	1 287	—	—	—	—	—	—	—	—	—
27	1 446	1 312	1 195	—	—	—	—	—	—	—	—	—
30	1 306	1 185	1 080	938	—	—	—	—	—	—	—	—
32	—	1 113	1 014	881	785	—	—	—	—	—	—	—
35	—	1 020	930	808	720	—	—	—	—	—	—	—
38	—	942	858	746	664	—	—	—	—	—	—	—
40	—	896	816	709	632	563	—	—	—	—	—	—
45	—	798	727	632	563	501	—	—	—	—	—	—
50	—	720	656	570	508	452	405	378	353	283	—	—
55	—	656	—	—	463	412	369	344	321	258	—	—
60	—	—	—	—	425	378	339	316	295	237	—	—
65	—	—	—	—	393	349	313	292	273	219	175	—
70	—	—	—	—	—	325	291	271	253	203	162	—
75	—	—	—	—	—	303	—	253	237	190	152	133
80	—	—	—	—	—	—	—	—	—	178	—	—
90	—	—	—	—	—	—	—	—	—	159	127	111
100	—	—	—	—	—	—	—	—	—	—	114	100

8.4.2 Holding power

In general, timbers with greater density give increased holding power and the hardwoods usually rank above softwoods in terms of fastening retention, however, this does not necessarily mean a stronger joint.

As nail shank profiles have been developed over the years, the head has remained constant or even reduced in size. This means that stresses in loaded cases tending to pull the joint apart are more likely to cause failure by nail pull-through when softwood is nailed to dense wood. This is even more likely when using nails with modified heads (see Figure 3) if the head loadbearing area is reduced.

8.4.3 Clinching of nails

To improve the strength of joints where thin materials are joined, a nail longer than the members being joined should be driven through and clinched against a steel plate. This technique should normally only be carried out horizontally on the bench, and results in a higher impact withdrawal resistance.

Appropriate allowances for clinching should be:

a) approximately 6 mm for 2.65 mm diameter nails;

b) approximately 9 mm for 3.35 mm diameter nails.

Excessive clinch allowances can weaken joints through offering a long lever against which pressure can act and loosen joints by bending the elbow of the clinch. Weakness in clinched joints should be avoided by ensuring that nails are at least regular grade (see **8.2.4**).

8.5 Stapled joints

8.5.1 Types of staples used in packaging

8.5.1.1 General

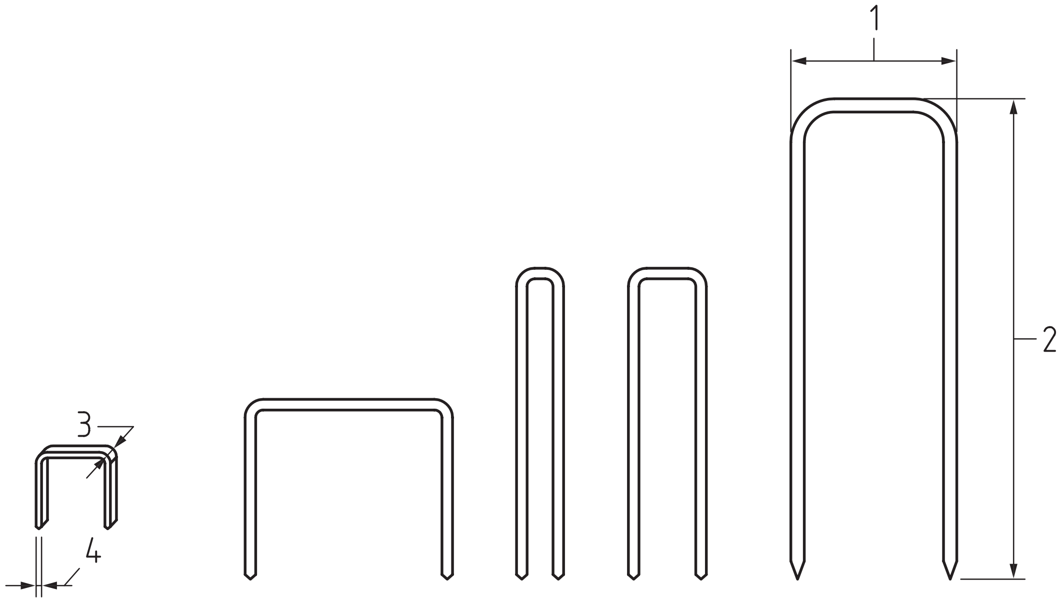
Staples can be used in structural and non-structural applications, and should be driven with a hand- or power-operated tool.

Medium- and heavy-duty staple tools are normally air operated, the tool being connected to a regulated compressed air supply.

NOTE 1 An example of structural use is the fastening of sawn sheathing boards and a non-structural use is the fixing of waterproof linings or cushioning material to the inside of a case.

NOTE 2 See Figure 6.

Figure 6 **Types of staples**



Key
1 Crown
2 Length
3 Stock width
4 Stock thickness

8.5.1.2 Varieties of staples

Staples might vary in length from a few millimetres to 65 mm, as given in Table 14. They are normally made from mild steel wire and can be produced with various points, chisel, divergent and self-clinch being the most common.

Self-clinch staples should only be used when the members to be joined are placed on a metal work surface. For all stapling applications the tool should be held at 90° to the members being joined.

When a tool is driving self-clinch staples, the resulting clinch gives a higher withdrawal strength and produces no hazard to the packed product.

Selection of the correct length of the fastener should be made by adding a maximum of 6 mm to the total thickness of the members to be joined.

Collated staples should be supplied as bright mild steel, galvanized or galvanized with proprietary coating in strips.

Table 14 **Staple sizes**

Type	Purpose	Thickness mm	Crown width mm	Length mm
Light/medium duty	Linings Light assembly	0.5 to 1.4	5 to 13	up to 40
Heavy duty	Assembly	1.1 to 1.9	8 to 25	up to 75
Heavy duty non-proprietary	Assembly	3.35	10 to 25	up to 65

8.5.1.3 Other staples

Although convenient and widely used, staples do not have to be purchased as proprietary types.

Round steel wire can be machine formed into a staple shape at the box manufacturer's premises, allowing great design variation. Wire-bound cases use this technique for the very large number of staples used in each and every case. This on-site system should be used when much heavier gauges of staple, up to 3.35 mm, is needed. A disadvantage is that heavy specialized machinery should be used both to manufacture and to apply the factory formed staple.

8.5.2 Safe working loads for staples

The main uses for heavy duty staples are in the fastening of battens and ties to boards and in assembly. Heavy duty staples with a minimum stock thickness and stock width of 1.57 mm × 1.40 mm, respectively, should be used for these applications.

NOTE 1 Another popular usage is in fixing sheet materials to solid timber frameworks.

Medium and heavy duty staples should also be used for attaching the binding wires in wirebound constructions; in such applications they are particularly valuable where a lighter, but more frequent fastener is needed, i.e. at reduced pitch.

Where the use of staples is being considered, manufacturers should be consulted for specific design strength information. Any permissible load values should be based on evidence from test reports; alternatively, calculations should be made using the formula for a permissible lateral load per fastener where a staple could be assumed to have a value equal to that of a nail 1.5 times its diameter.

NOTE 2 Example: assuming 50 mm × 1.6 mm two-leg wire staples:

1.5 times staple diameter = 1.6 mm × 1.5 mm = 2.4 mm nail diameter.

This diameter of 2.4 mm is still less than the diameter of the smallest diameter of loose nail given in BS EN 1995-1-1-2 (2.64 mm), so the permissible load for a 2.4 mm staple should be reduced.

Resistance to corrosion and fatigue should be considered in comparison with that of the larger diameter nail of equivalent length. Also, for staples driven into dense timbers, the tensile strength of the staple should be the limiting factor since bending can occur and the method given in Note 2 might not be appropriate.

The advantages of staples are their ease of application and a reduced tendency to split timber. The disadvantages are lower joint strength and the need to compensate for this by reducing pitch (i.e. increasing staple density).

Crown pull-through can be a problem and the staple head should be oriented at 45° to the top face grain in all constructions.

8.6 Nailing and stapling techniques for joints

8.6.1 Nailing and stapling patterns

Nailing and stapling patterns and the density of fastness per unit area of joints are considerations when joint strength is to be maximized (see Figure 7). Particular attention should be paid to certain designs of case, particularly light crates where there are fewer fasteners, if adequate strength is to be achieved.

Where sheathing is positioned over battens of adequate depth, plain, twisted, annularly threaded nails or heavy duty staples can be used, but where thin boards are tied, clinched plain shank nails or self-clinching staples only should be used, otherwise adequate pull-out resistance is not developed.

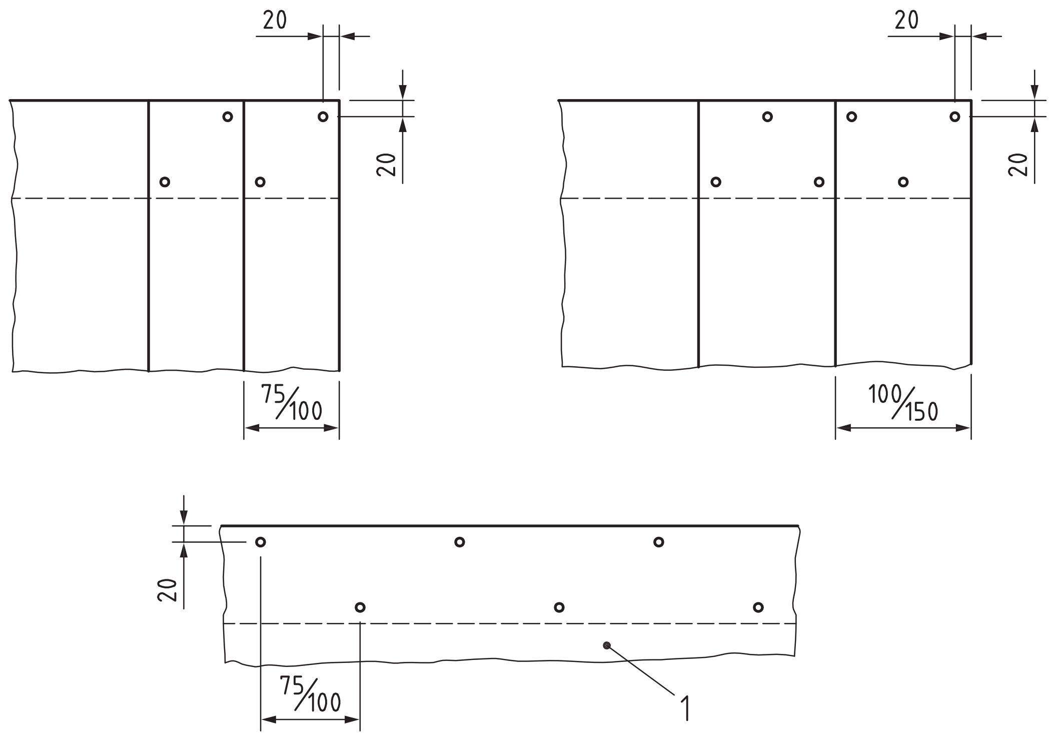
When clinched nails or staples cannot be used, annularly threaded nails should be used. A generally used guideline with regard to the length of fastener to be used in a given non-clinched construction is that it should be three times the thickness of the outer member, e.g. 19 mm sheathing requires a 60 mm fastener.

Standard patterns are designed to impart good resistance to various types of applied load including those which can result in withdrawal, shear and rotational racking movement. For plywood and sheet materials rotational stress in joints is minimal, but for boarded constructions, particularly those without bracing, large rotational stresses can develop due to racking movement caused by impacts, movement and compressive loads while stacked.

The rule to observe in deciding on a nailing or stapling pattern is that fasteners should be placed as far away as possible from the geometric centre of the joint, yet not so near the edge of the board that breaking away of wood edges or end splitting occurs.

NOTE 2 Figure 8 gives examples of good and bad patterns.

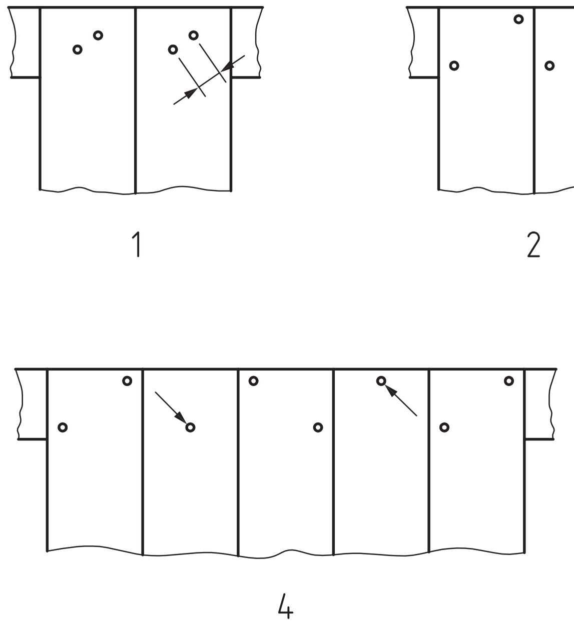
Figure 7 **Nail and staple patters, boards to battens, minimum edge distance**



Key

1 Plywood fastener pattern

Figure 8 **Fastenings of sawn boards (good and bad practice)**



Key

1 Poor racking resistance due to close proximity of fasteners
2 Spacing develops maximum strength
3 Slight increase in racking and 50% increase in shear
4 50% of boards are ineffective in racking
5 Probability of end splitting when loaded, owing to inadequate end clearance

8.6.2 Other factors affecting joint strength

8.6.2.1 General

In addition to fastener type (see **8.2.2** and **8.3**) and wood density (see **8.4**) the factors described in **8.6.2.2** to **8.6.2.5** affect joint strength.

8.6.2.2 Species

Spruces and poplars are of lower than average density and generally produce joints around 20% weaker in tension than the denser pines.

Some hardwoods fail to achieve the strength that their high density would suggest, either because of splitting, or because a shorter nail should be used in order to avoid cripple.

8.6.2.3 Steel strength of the nail

A particularly high-strength steel should be used in highly shear-stressed or rotationally stressed joints or where tough hardwoods are being penetrated. Almost all UK boarded designs have joints subject to rotational stress (plywood and sheet material cases excepted) and a higher strength nail should be used to give good racking performance.

8.6.2.4 Nail diameter

Nail diameter is expressed in millimetres. The term gauge, used in connection with nail thickness, is now deprecated as related to imperial units of measurement.

The bearing surface of nail against the wood fibres has a direct relationship to joint strength and strength is derived from:

a) the bearing area;

b) the surface characteristics;

c) the ability of the nail to resist bending stress (many failed joints demonstrate bent nails as well as pull-out symptoms).

8.6.2.5 Nail length

Nail length affects the degree of withdrawal strength.

8.6.2.6 Acidic timbers encouraging corrosion

Care should be taken since contact between metal fastenings (particularly steel) and certain species is likely to encourage early corrosion even in the absence of excessive moisture.

NOTE See BS 7195 for more information on the prevention of corrosion.

8.7 Other fastening systems

8.7.1 Strapping

8.7.1.1 General

There are two distinctly different types of strapping which should be used in wood packaging.

a) Short reinforcing straps as shown in Figure 9; these should be made of steel and attached with nails.

b) Fully encircling straps (or tensional strapping) as shown in Figure 10; these can be made of steel, or non-metallic materials but should not be held in place with nails or staples since they develop their reinforcing function by means of tension. Many packaging applications provide for the use of tensional strapping as an integral part of the container or package.

NOTE Sill bases (Figure 9) have flooring attached to their underside to allow for projection below the base mounting points. These are not normally used in UK industrial packaging.

Figure 9 **Reinforcing straps on a sill base**

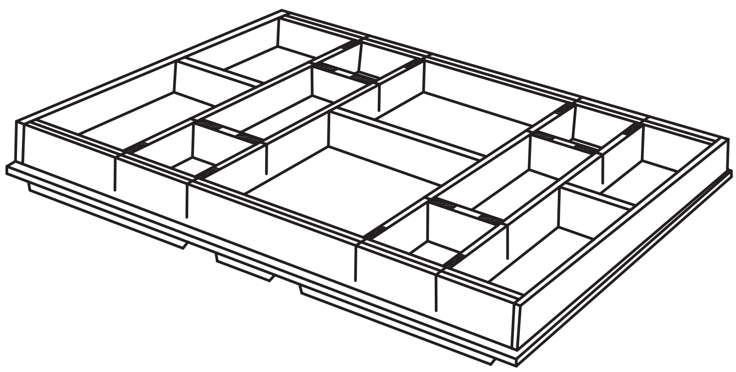
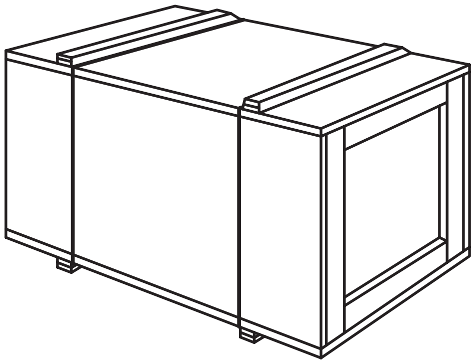


Figure 10 **Tensional strapping used on a small plywood case**



8.7.1.2 Reinforcing straps

Reinforcing straps are available drilled or undrilled, in thin steel, and should be applied to members requiring additional security. Improved nails should be used to avoid possible detachment en route.

NOTE Reinforcing straps have only tensional strength.

8.7.1.3 Tensional strapping

8.7.1.3.1 General

Tensional strapping should be applied to packages by semi-automatic or fully automatic equipment and tied, crimped or sealed under tension.

NOTE 1 For more guidance refer to BS EN 13246, BS EN 13247, BS EN 13394.

NOTE 2 Tensional strapping might be applied to wooden boxes, crates, cases, palletized and unitized loads.

Tensional strapping should not to be used for lifting purposes. Some reasons for the use of tensional strapping are:

a) to reinforce and strengthen packages, and to protect them against some hazards of transportation, thus assisting in ensuring safe arrival;

b) to allow economies to be effected in package construction (e.g. thinner materials);

c) to render the contents of the package less liable to pilferage (e.g. opening en route is immediately obvious).

In determining the size, number and type of straps to be used, consideration should be given to the shape, size and mass of the package, the material of which it is made and the handling, storage and transport conditions likely to be encountered.

There are three classes of tensional strapping.

- Steel, which could be flat, round or oval with a tensile strength about twice that of weftless or thermoplastic strappings. The surface finish could be natural, blued, painted, waxed, galvanized or copper coated.
- Weftless, which consists of continuous strands of high tensile textile laid in parallel and bonded with adhesive. The width could be 6 mm to 25 mm.
- Thermoplastic, which is extruded in a rectangular cross section in which high strength has been developed by orientation. The width is typically 5 mm to 25 mm.

8.7.1.3.2 Moisture and temperature resistance

Steel strapping is unaffected by moisture in the short term, but corrosion of certain finishes might result from prolonged exposure. Weftless viscose tape decreases in tensile strength when wet, but the effect of dampness is to tighten the strapping round the container. The performance of thermoplastic and polyester weftless strapping is not normally affected by moisture. Non-metallic strapping is not significantly affected by temperatures between – 40 °C and + 40 °C.

8.7.1.3.3 Application

Straps should be applied at right angles to the edges of packages in order to prevent loosening. Strapping should be applied sufficiently tightly to ensure that it performs its function efficiently, but not applied so tightly or positioned in a way that causes damage to the contents or lead to the breakage of the strapping.

NOTE 1 BS EN 13246 and BS EN 13394 contain details of the strength, selection and use of tensional strapping.

Edge protectors, pads, cleats, etc., should be interposed between the strapping and the package to protect edges, finishes, and the strapping itself where risk of damage is involved. Non-metallic strapping should be applied with an initial tension sufficient to develop the elasticity which is the feature of this type of material. Where practicable, bridging (leaving a portion of wire or strapping not in contact with the package) should be avoided.

Whenever possible, steel strapping should be applied to wooden cases and crates immediately before despatch, particularly if the timber has a high moisture content and is therefore liable to shrinkage. Tensional wire should not be applied along the grain of the timber without edge protectors.

NOTE 2 Jointing under tension can depend upon the material and the proprietary tool used. Methods include clipping, cut and interlock, welding or mechanical twisting.

8.7.2 Proprietary connectors

While styles come and go, the reusable spring steel case fastener should be used as a standard connector of KD boxes (finished ends, sides, etc., which are shipped to customers in a form which is rapidly and readily assembled) and some intermediate bulk containers (IBCs).

NOTE They are strong and reusable and two types are shown in Figure 11 and Figure 12.

Figure 11 **Reusable spring steel fastener**

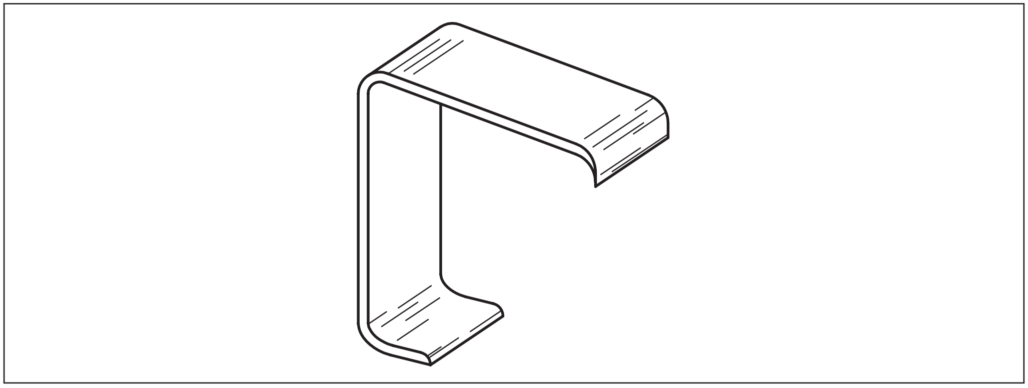
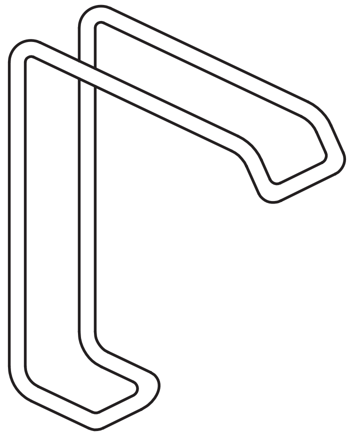


Figure 12 **Reusable spring wire fastener**



8.7.3 Coach screws

Used for heavier or demountable cases, these square-headed screws (see Figure 13) should be initially hammer-driven into prepared holes drilled to a size just below the root diameter of the thread, and given their final turns with a spanner. Flat washers below the screw head should be used to ensure maximum load carrying ability.

NOTE Tests in timber at high moisture content have shown that the difference in load-carrying ability between a coach screw initially hammered to 3/4 depth and a fully spanner applied screw is insignificant.

8.7.4 Coach bolts

Coach bolts (see Figure 14) have a square shank section just below the cup head which beds into the timber in order to prevent turning while the nut is tightened. Loads carried are higher than coach screws and the method should be used to connect skids to cross skids, load to skid, etc. Both sides of the joined members should be easily accessed.

Figure 13 **Coach screw**

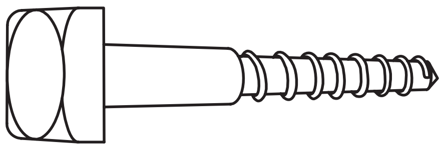
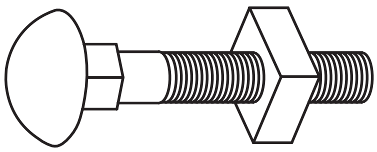


Figure 14 **Coach bolt**



9 Package design

9.1 Journey hazards and modes of handling

The level of protective packaging that should be used for domestic and export goods is not only dependent upon the nature of the product, but also upon the type of handling, storage and transit to which both the case and the goods are likely to be subjected. From the moment of manufacture most goods are liable to damage and, whenever possible, protection should be afforded to them. Short-term anti-rust treatments to bright parts or unprotected surfaces, the removal of projections, glass, handwheels, control knobs, etc. should be carried out.

Manufacturers should take these precautions or the export goods might become damaged before or during transport to the export packer.

9.2 Product to be packed

When using a wooden container, the factors detailed in the following list should be given due consideration.

a) Should the product be partially dismantled to reduce the cubage?

b) Should a number of products be packed into one case to improve handling, or should each product be packed separately?

c) Does the product give the case added strength?

d) Is the product an "easy" or "difficult" one to pack?

NOTE 1 Products considered easy to pack would comprise articles of moderate density, evenly distributed, being in full contact with sides and base of the case and not exerting undue pressure at any one point.

NOTE 2 A difficult product would be one of high density where a large proportion of the weight is placed on a small proportion of the case sides or base thereby creating concentrated load points. The term "difficult" can also be applied to light loads that are fragile, of awkward shape or difficult to protect.

It is not easy to standardize case sizes, except where long production runs of similar size products are envisaged. Nevertheless, the use of one type and size of case for products that vary only slightly in size might prove to be more economical than manufacturing a case for each individual size.

9.3 Mode of transport

9.3.1 Journey hazards

All articles, whether packaged or not, are likely to encounter certain hazards during distribution to customers. Before any steps are taken to design a case for a given article, consideration should be given to these hazards. When long production runs are anticipated for particularly valuable fragile goods, methods of test for complete, filled transport packages should be as given in BS EN ISO 4180.

NOTE 1 In the absence of specific data with regard to over-stacking en route, many designers assume a superimposed load level of 800 kg/m².

With careful handling once packed, and provided that the case is adequate, no damage is likely to occur during handling, transport, storage and shipment. The packer should make provision in the design of the case by marking which parts should be removed first in order to avoid damage during unpacking.

NOTE 2 Table 15 summarizes possible hazards and precautions at each stage of the journey.

9.3.2 Weight and size limits

All forms of transport, whether road, sea or air, have limitations and penalties for exceeding the maximum weight and size limits. Excessively wide cases do not allow for the use of lifting grabs and 500 kg should be considered the upper weight limit for their use.

NOTE Very small or light cases are often manhandled, which might be more hazardous than mechanical handling.

Table 15 **Summary of journey hazards**

Journey stage	Possible hazards	Precautions
Finished product, awaiting packaging	Pilferage; damage to finish or bearing surfaces; bright parts finger marked causing local corrosion; glass instruments damaged; ingress of moisture or dust	Adequate waterproof or dustproof coverage; anti-corrosion treatments; removal of projecting parts; drainage of fluids in case the product is inverted en route
Journey to export packer	Braking and acceleration forces; mishandling during loading/unloading; vibration and resonances from road vehicle; impact from other packages; superimposed load	Ensure that handling equipment and vehicle are adequate for the job; remove projecting parts; protect against weather and dust; secure by ropes using cushioning to protect finish; ensure ropes will not impose loads onto parts liable to damage by imposed shocks
During packaging	Damage during hoisting and fixing to mountings; permanent set in slender parts; damage to finish and bearing surfaces	Always use lifting lugs when provided; follow designer's instructions as to mounting points
Journey to docks by road	Braking and acceleration forces; although these are normally less than 2 g on roads	If case and dunnage are designed to absorb known shocks, no damage should occur
Journey to docks by rail	Accelerating and shunting; accelerations up to 1 g for freightliner trains, up to 5 g for loose coupled wagons; vibrations from track	If case and dunnage are designed to absorb known shocks, no damage should occur
Docks handling at loading port	Mishandling during unloading; careless stacking often in the open on the dockside; exposure to rain, salt spray; changes in humidity; heavy cases placed on unsupported lids without dunnage; sheathing puncture by fork lift truck. In general, docks handling would seem to be the most hazardous operation, and instances of puncture and drop impact damage are common	Adequate waterproofing is essential; marking of all cases with the centre of gravity, sling points; provision of fork lift bearers; crush battens are advisable; tall cases should be provided with very adequate bases to ensure that they remain upright; sheathing material should have high resistance to impact
Loading, stowing	Mishandling; crushing by lifting nets or slings; impact; movement with aid of pinch bars; superimposed load whilst stowed	Be aware of dock handling procedures; make adequate warning markings for fragile contents
Voyage	Sea movement can damage cases by a constant racking movement; sea water; condensation; vibration causing resonance in sensitive goods	Adequate construction for known hazards; waterproofing; desiccant/inhibitor; cushioning; drain holes
Handling at destination	The majority of developed countries now have adequate port facilities. Developing countries may rely on the use of ship's gear overside and lighters or rafts. After a prolonged voyage cases may show signs of wear and tear, joints may have loosened, blocking may have become displaced and, in extreme instances, goods may be loose within the case	Although facilities are outside the control of the packer, a knowledge of the likely destination facilities will determine the design of the case, e.g. extra bracing or strong sheathing

9.3.3 Road transport

Manufacturers of machinery and plant for export normally arrange for packing to be carried out either in their own despatch department, where the manufacturer is responsible for packing, or on the premises of a specialist export packer. After packing very little damage is normally experienced during transport by road to the docks or airport, as lateral braking and acceleration forces are not high and a maximum of 2 g is expected. The vehicles used are normally designed specially for the loads to be carried and the packaged goods remain in good condition.

Lifting on and off the transport vehicle is the most hazardous part of the road journey, and fork lift truck drivers should take precautions when handling cases. For example, loads should not be lifted before the full length of the tine is under the case, because this can result in toppling and cause added stress in the case. Moreover, fork lift truck drivers should not try to force the tines under a case without battens of suitable thickness as that can result in damage, although the omission of fork lift battens is unlikely to occur with a competent case manufacturer.

9.3.4 Rail transport

The carriage of export goods by rail can be split into two distinct categories, both of which can involve the handling of wooden cases.

a) Homogenous loads where the goods are loaded into a freight container or large wooden packing case at the manufacturer's or freight forwarder's premises and transported by road or rail to the freightliner terminal or rail depot. Freight containers are forwarded to the docks by freightliner train, while the large packing case will be loaded into a covered or flat wagon, depending upon size, for transportation by goods train to the docks. Goods carried by freight container on freightliner trains are subjected to less impact shock than those in loose coupled wagons.

b) Groupage traffic where wooden cases may be loaded into wagons with packages of all sizes, weights and shapes. Where possible, fork lift trucks should be used, but during final stowage into covered ferry wagons, manhandling and the use of pinch bars should be considered.

9.3.5 Sea transport

9.3.5.1 Dock handling

It is after the arrival at the transit sheds that most instances of mishandling take place. Falls from fork lift trucks in motion and impact fractures of the sheathing by the fork lift trucks in motion and impact fractures of the sheathing by the fork lift tines are not uncommon.

During storage awaiting shipment, cases might be subjected to high superimposed loads resulting from stacking without dunnage to spread the load.

The package should have sufficient strength to withstand normal handling hazards and superimposed loads, otherwise partial case failure at this early point could increase vulnerability to dirt and moisture and provide ready access to a pilferer.

Movement from the transit shed to the dock should be by fork lift truck, powered platform truck, or mobile crane. Lifting from the dock into the ship's hold should be by slings, grabs, C-hooks, nets or dock pallets. Slinging points should be very clearly marked as, during high-speed lowering and braking of hoists, for example, the final lowering can produce considerable flexing in longer cases.

Although heavier cases are usually placed at the bottom of the hold to aid ship stability, a case can be stowed on its side to level up a layer. If a case is in the bottom layer, heavier cases should be placed on top with or without dunnage.

9.3.5.2 Sea crossing

While at sea, the packing case should be able to resist prolonged compression and racking loads and possible movement of the cargo as they can cause loosening of the fastenings, dislocation of interior dunnage and even fracture of the sheathing. The resultant damage might allow the ingress of moisture or other contaminants present in the hold from previous voyages, or water might enter the cargo hold.

Extremes of temperature and humidity are common during sea voyages, and inhibitors and desiccants should be used for many goods.

NOTE It is unlikely (although possible) that timber used in export packaging might have been so dry and tightly assembled at manufacture that expansion due to the rise of moisture content creates problems of distortion during the voyage.

9.3.5.3 Discharge at destination port

Discharge at the port of destination is the real test of a packing case, since many overseas ports do not have the necessary lifting equipment. In the extreme, cargo can be lifted overside onto rafts and floated to open beaches, then manhandled to the nearest track or road.

NOTE Many insurance claims are due to inadequate facilities at the destination port.

Even if the dock facilities are excellent, many areas still rely on primitive methods of transport from the docks to the customer.

Lorries should not be used on rough tracks, animal-drawn wagons and river boats as these create extra hazards.

Heavy rain and intense temperatures should also be taken into consideration during case design.

9.4 Long-term storage

9.4.1 Avoidance of vapour corrosion inside wooden boxes

Vast numbers of metal objects are transported in wooden boxes without loss by corrosion. This could be because the metals are protected, the wood is of the less corrosive sort, is dry to begin with and does not become wet for any length of time, or the packs are opened promptly. When one or more of these conditions does not apply, vapour corrosion can then become a hazard.

9.4.2 Condition of wood

Fresh wood, kiln-dried wood and damp wood should be avoided. Wood should be kept in a dry atmosphere for as long as possible before use.

9.4.3 Ventilation

Acid vapours do not corrode if they blow away, but a small amount of ventilation is not enough to ensure this does not happen, especially if venting is blocked when boxes are piled.

9.4.4 Impervious linings

Boxes should be lined with aluminium or zinc foil, since if the lining is complete and remains intact, no vapours can pass it. Glues should not be allowed to spill inside, as many of them emit corrosive vapours.

9.4.5 Inner packs

Valuable goods should be packed in a vapour-proof wrapping, heat-sealed or zipped, and preferably desiccated inside, with a transparent window, behind which a cobalt chloride humidity indicator should be lodged. Polyethylene of thicker gauges is a fairly good barrier, but the preference should be given to a sandwich containing a centre layer of aluminium foil. With a first-class barrier, wood shavings should be used as an outer cushioning material, though care should be taken to avoid the barrier becoming torn.

9.4.6 Protective coatings on steel

Corrosion by acetic acid vapour resembles that by sulphur dioxide in an industrial atmosphere, though in the most severe cases it is more rapid than anything caused by an atmosphere that is still breathable.

Protective treatments effective against industrial atmospheric corrosion have an equal order of effectiveness against vapour corrosion and nickel plus chromium coatings give the same order of protection.

9.4.7 Protective coatings on other metals

Zinc should be treated. Magnesium alloy, being highly susceptible, should never be crated in other than the fully protected condition.

NOTE 1 Aluminium and its alloys with their normal protective treatments, as well as stainless steel, are safe.

Copper and its alloys should be by lacquering or painting.

NOTE 2 Plating with tin, silver or gold gives good protection.

9.5 Temporary protection

9.5.1 General

Conditions inside a wooden box are less predictable and can be worse than any natural atmosphere, e.g. a box made of freshly felled oak stored out of doors in the tropics would corrode even a highly resistant metal in time.

9.5.2 Precautions during storage

Boxes should be stored under ventilated top covers. If storage in the open is unavoidable, white plastic drapes should be used for protection against rain and sunshine, though a box which is already damp should not be enclosed. The drape should be white, to prevent the box becoming too warm in the sun, since the relative humidity inside a wooden box rises with a rise in temperature.

9.6 Moisture protection in export packing

With machinery, steel goods and many other products being shipped, climatic protection should be considered an important consideration, particularly when crossing geographical areas with extreme temperatures. The humidity inside a case stored on a voyage with warm daytime temperatures followed by cold nights encourages condensation to form, with potentially disastrous results for moisture-sensitive equipment. Even in cool conditions condensation might form and any timber used within the protection envelope is also a source of moisture.

A number of methods and proprietary products with different efficiencies should be used to prevent corrosion, some of which are:

a) hermetically sealing the equipment with polythene (polythene admits a very small amount of water) and introducing a desiccant such as silica gel crystals to absorb moisture produced. Advice should be sought from desiccant suppliers on the amount of desiccant needed for the water volumes/temperatures expected, the polythene surface area, and the storage period;

b) hermetically sealing equipment with a bituminized craft paper (almost totally vapour proof) and introducing a smaller amount of desiccant into the pack;

c) simple overhead protection (e.g. internal plastic roof cover in a case to stop direct water) plus corrosion preventative sprays or brush-on compounds for less sensitive equipment such as steel castings.

The choice of methods should depend upon product water sensitivity.

To add to the effectiveness of the choices a), b) and c) vapour corrosion inhibitor (VCI) paper should be added.

The use of protection methods should be dictated by the customer's needs and the available budget.

9.7 Corrosive effects of wood in packing cases

Wood is a corrosive substance by nature, and can be made more corrosive by treatment given to it such as certain preservative solutions. Unlike most other corrosive substances, one of the corrosive chemicals occurring naturally in it, acetic acid, is volatile, and in an ill-ventilated space, can cause corrosion of metal nearby even without being in contact with it.

Corrosion problems caused by wood can therefore arise in two ways.

a) Inside wooden containers, by vapour corrosion without contact.

b) Through contact in wood structures, through attack by wood acids or wood treatment chemicals.

NOTE Table 16 lists the acidities of a number of woods reasonably representative of the acidities of the wood stored at temperate temperatures and humidities.

Under extreme storage conditions, much greater acidity can develop, e.g. birch becomes as corrosive as sweet chestnut after 3 months at tropical temperature. Other woods can develop much greater acidity in this way if stored under extreme conditions.

Table 16 **Acid timber species**

Wood	Vapour corrosion
Oak	High
Sweet chestnut	High
Steamed European beech	Fairly high
Birch	Fairly high
Douglas fir	Fairly high
Gaboon	Fairly high
Teak	Fairly high
Western red cedar	Fairly high
Parana pine	Moderate
Spruce	Moderate
Elm	Moderate
African mahogany	Moderate
Walnut	Moderate
Iroko	Moderate
Ramin	Moderate
Obeche	Moderate

9.8 Metal corrosion inside wooden containers – Acid woods

The corrosive agent emitted by the wood is acetic acid, and the metals most susceptible are those readily attacked by it.

NOTE Table 17 shows the degree of susceptibility to attack.

Table 17 **Degree of susceptibility to attack**

Susceptibility to attack	Metals
Group 1 – Severe attack	cadmium, carbon steels, low alloy steels, lead and lead alloys, magnesium and its alloys, zinc and zinc alloys
Group 2 – Moderate attack	copper and its alloys
Group 3 – Very slight attack	aluminium and its low-strength alloys, nickel
Group 4 – Insignificant attack	austenitic stainless steel, chromium, gold, molybdenum, silver, tin, titanium and its alloys

9.9 Effect of humidity

Table 18 gives the typical results of the corrosion in an enclosed vessel of four metals by a 1% acetic acid solution dissolved in various solutions chosen to maintain the relative humidity within the vessel at the levels stated. The vessels were kept at 30 °C. These figures show the influence of RH on vapour corrosion by acetic acid. Even steel, which is particularly heavily attacked at high humidities, is attacked only very slowly at 72% RH (and below). This threshold figure is the same as for the corrosion of steel by the sulphur dioxide in an industrial atmosphere. Copper, on the other hand, has a threshold above 85% RH, and a not too high rate of corrosion at 96% and 100% RH, hence its classification as a Group 2 metal. Some other evidence puts the threshold for magnesium alloy at 63% RH.

Although no figures are available, water is known to promote the formation of acetic acid in wood. High humidity has a twofold effect, in that it both promotes the formation of acid and the subsequent corrosion by that acid.

Table 18 **Results of corrosion of four metals**

Metal	Corrosion g/dm^2 after 40 days		
	72% RH	85% RH	96% RH
Cadmium	0.12	1.4	1.6
Zinc	0.12	0.75	1.5
Steel	trace	0.9	> 0.9
Copper	trace	trace	0.65

9.10 Special factors

9.10.1 Drying shrinkage

Care should be taken when storing sawn wood sheathed packing case for a period of months under ventilated cover as it can dry and gaps appear between boards. To avoid this, the wood should be kiln dried prior to assembly. Alternatively, plywood should be used to eliminate such problems without special treatment and this is a frequently employed alternative.

9.10.2 Corrosion and appearance

Acid wood species (see **9.7**) should be avoided to reduce the chance of unsightly corrosion of fastenings. Wood moisture content should be reduced by kilning or air drying, and zinc-protected fastenings should be used to eliminate the risk entirely.

In order to keep a box or case aesthetically attractive over a period of a year or more the timber should be dried to 20% moisture content or below and zinc-protected nails, bolts, etc. should be used.

NOTE There are no storage problem with sawn wood species even if classed as perishable.

Birch-faced plywoods could suffer surface mould and should be avoided for long-term exposure or uncertain storage conditions.

9.11 Cases for external storage

Plywoods with a waterproof glueline should be used for cases for external storage, and bowing through differential moisture uptake should be prevented by closer spacing of framing members. Bitumenized felt or a kraft paper sandwich in the case top should be used, and provision should be made for drainage in the base.

9.12 Built-in handling aids

9.12.1 Manual aids

When required, cases can be fitted with rope or webbing handles secured with wood or metal brackets (see Figure 15 and Figure 16). Such handles are suitable for cases filled to a maximum of 50 kg but fragile goods should be grouped to make manual handling impossible, and proper provision should be made for fork lift truck handling.

9.12.2 Provision for handling by fork lift and pallet trucks

As packages become larger, they should be designed both to encourage the use of appropriate mechanical handling equipment and to prevent the use of unsuitable equipment.

NOTE 1 An example of encouragement of fork lift truck use is nailing 50 mm battens across the short dimension of a case. An example of prevention is the placing of 50 mm battens 2.5 m apart and the filling in of the gap between with 50 mm battens.

If fork lift trucks are to be used, the base of a case should have battens of at least 50 mm in height. If pallet trucks are to be used, a batten height of 95 mm to 110 mm should be provided to ensure that both European and North American pallet trucks can be used.

NOTE 2 Many North American pedestrian pallet trucks only require 65 mm, but there is an upper limit of about 110 mm above which some cannot elevate.

Figure 15 **Rope handle**

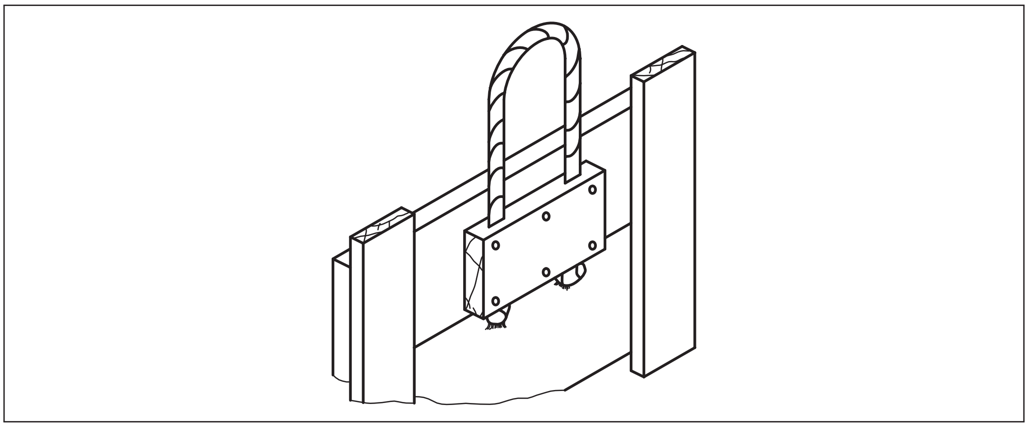
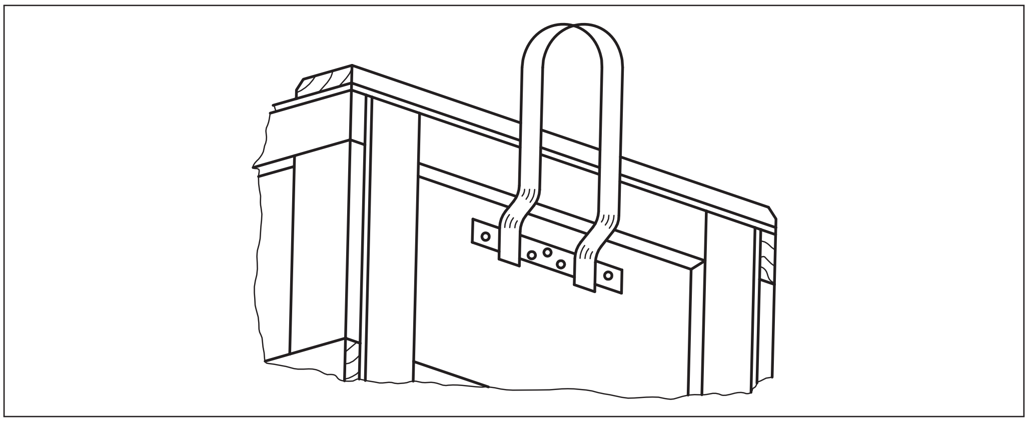


Figure 16 **Webbing handle**



9.13 Slings and grabs

9.13.1 General

Slings and grabs should be used for the stowage of heavy items into a ship's hold but special features such as those described in Figure 18 should be designed into the case.

9.13.2 Slings

Many failures of large cases in transit are due to the incorrect positioning of slings and, in order to limit stresses developed in a large case or crate to the minimum, the case should be supported at specific points in relation to its length. For the majority of situations where the contents are uniformly distributed, slings should be placed at points one-quarter in from the case ends, although if the contents have mounting feet near this point then the sling points should coincide exactly.

The position of slings should be marked by using both international "sling here" symbols (Figure 17) at four points around the case and base battens and/or steel lifting plates at appropriate points.

NOTE 1 See Figure 18 for an example of a steel lifting plates for slings.

NOTE 2 See Figure 19 for a list of international symbols.

Figure 17 **International 'sling here' symbol**

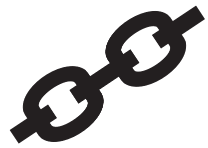
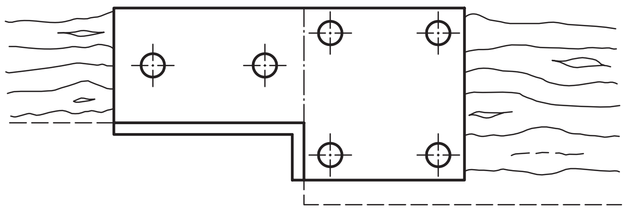


Figure 18 **Steel lifting plate for slings**



9.13.3 Grabs

There is a physical case width limit above and below which scissor grabs do not work. They are a faster method of handling cases, and a designer should always assume that they are likely to be used. The case should be strong enough to withstand the loads, possibly severe, induced during lifting. An inadequately sized grab can double the load in a crush batten that a correctly sized grab would induce.

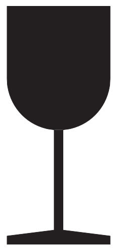
Grabs induce the following loads in cases.

- Transverse load at a single horizontal point across the top, often in excess of the gross case weight.
- Tensile load in the case sides shared unequally, therefore creating high local stresses in fastenings and sheathing directly below the attachment points.
- Sometimes a more severe load to the base than that applied by slings, often in reverse loading to that of slings.

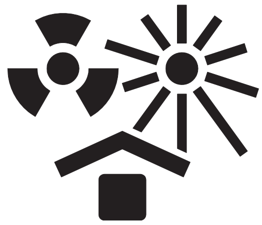
10 International pictorial marking symbols for the handling of goods

The symbols in Figure 19 apply to packages of all kinds, but do not include instructions/symbols specific to the handling of dangerous goods. They should be stencilled in black directly on to the wood sheathing of wooden cases, which, in the case of rough sawn timber, should be planned prior to stencilling. The use of red or orange should be avoided, since these colours are used in the labelling of dangerous goods.

Figure 19 **International handling symbols relevant to wooden packages**



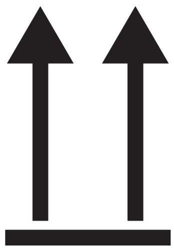
a) FRAGILE, HANDLE WITH CARE



b) PROTECT FROM HEAT AND RADIOACTIVE SOURCES

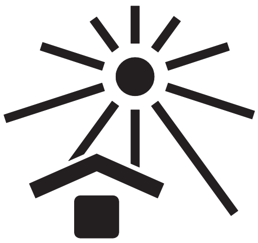
c) NO HOOKS A)

d) KEEP DRY B)

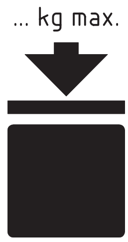


e) THIS WAY UP C)

f) CENTRE OF GRAVITY D)



g) KEEP AWAY FROM HEAT



h) STACKING LIMITATION E)

A) The design of heavy goods packages cannot always resist top lifting by grabhooks.

B) Not all cases have waterproof internal liners. Plywood used in the construction might not have a waterproof glueline.

C) Certain designs of small cases make it difficult to distinguish top from bottom.

D) This ought to be stencilled as a minimum on the two longest case sides (this information is normally supplied by the manufacturer of the items packed).

E) The maximum load in kilograms ought to be marked above the arrow.

11 Dangerous goods

For transport of dangerous goods the guidelines in BS EN ISO 15867 should be consulted.

12 Wooden case, crate and box styles

12.1 Styles

Although diagrams and drawings are the most effective way of communicating designs of boxes, cases and crates, in practice, the written or spoken word often has to suffice, though can lead to ambiguity, particularly where the specifier has limited experience.

This British Standard gives a method of designating main styles through a simple numerical system covering all categories of boxes, cases and crates.

NOTE 1 Table 19 gives the outline of the overall sequence.

NOTE 2 There is no internationally agreed designation system.

Table 19 **Style number allocation covering the main styles of boxes, cases and crates**

Type	Style number
Industrial cases	1 to 4
Crates	11 to 14
Sawn wood boxes	21 to 26
Plywood (and other sheet material) boxes	31 to 38
Metal edge boxes	41 to 45
Wirebound cases and crates	51 to 53

12.2 Main industrial case styles

12.2.1 Storage containers

Amongst a range of export shipping containers are included the popular category of storage containers. These comprise any of the following export shipping containers as ordered/required by customers.

12.2.2 Primary styles

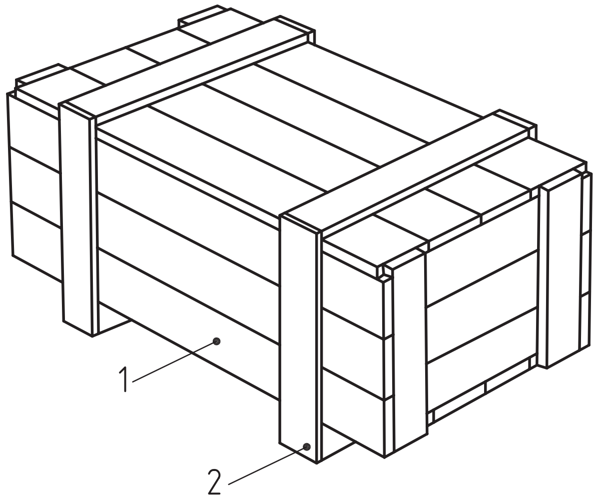
12.2.2.1 General

In mainstream industrial/commercial packaging in the UK, there are four predominant styles of medium/large size cases which form the basis for the majority of export packaging activity. Within the main four styles, there are a number of options for sheathing, ends, bases, etc. and these are illustrated and described in **12.4**.

12.2.2.2 Style 1 – Girth battened case

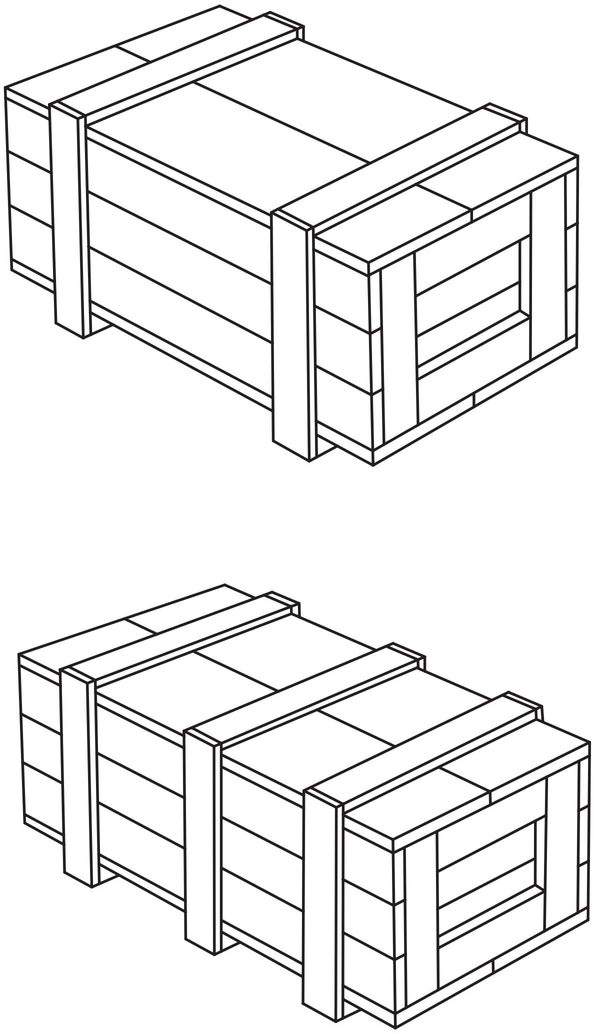
Figures 20, 21, 22 and 23 show the properties of Style 1 girth battened cases.

Figure 20 **Style 1 – Girth battened case**



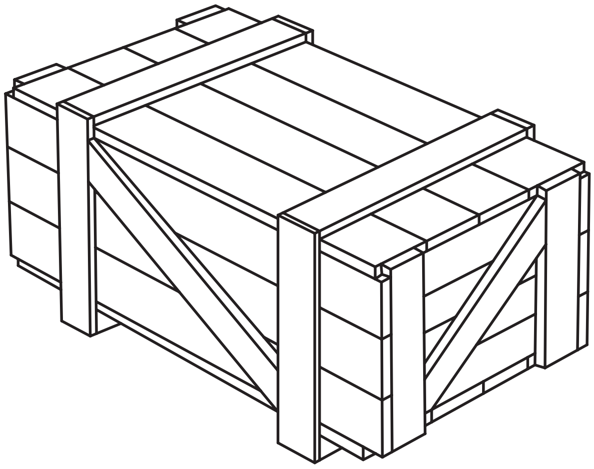
Key	1 Board		2 Batten
Characteristics	Excellent compression and burst strength if clinched and/or annularly threaded nails are used		
Battens	Girth: two clinched to sheathing		
	Ends: two vertical		
	Base: two (min. 50 mm for fork lift truck handling)		
Sheating	Softwood, sawn or planed, tongued and grooved (PTG), 16 mm to 32 mm thick		
Bracing	None		

Figure 21 **Style 1 – Girth battened case with panelled ends**



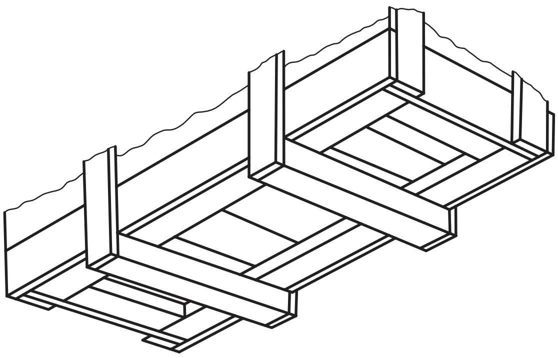
Characteristics	Similar to Figure 18 but parallel end gives excellent resistance to internal and external forces
Battens	Girth: two or three clinched to sheathing
	Ends: not applicable
	Base: two (min. 50 mm for fork lift truck handling)
Sheathing	As Figure 18
Bracing	None
Nailing	Annularly threaded nails and clinching for higher loads

Figure 22 **Style 1 – Girth battened case, battened ends, with single diagonal braces to sides and ends**



Characteristics	Greater resistance to distortion (racking) loads, i.e. greater ability to maintain squareness when subjected to applied loads of various types
	Suited to manufactured products with little space between product and case. May be fitted with diagonal braces at the top
Battens	Girth: two clinched to sheathing
	Ends: two vertical
	Base: two (min. 50 mm for fork lift truck handling)
Sheathing	As Figure 18
Bracing	Diagonal at ends and sides
Nailing	Annularly threaded nails and clinching for higher loadings

Figure 23 **Style 1 – 1/R, girth battened case, battened ends, reinforced base**

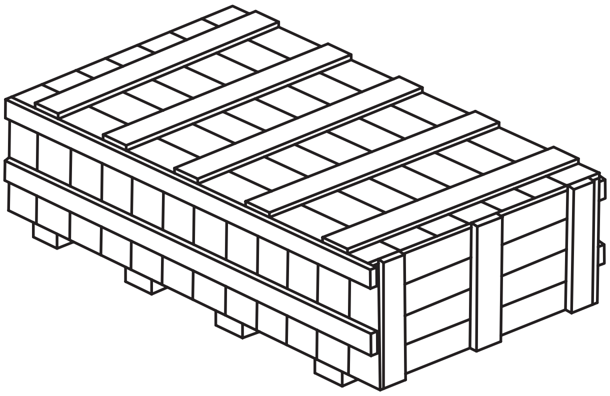


Characteristics	Extension of style 1 with fully framed base and denser nailing. Other details as Figure 24

12.2.2.3 Style 2 – Horizontally battened case

Figure 24 shows the properties of Style 2 horizontally battened cases.

Figure 24 **Style 2 – Horizontally battened case, vertically battened ends**

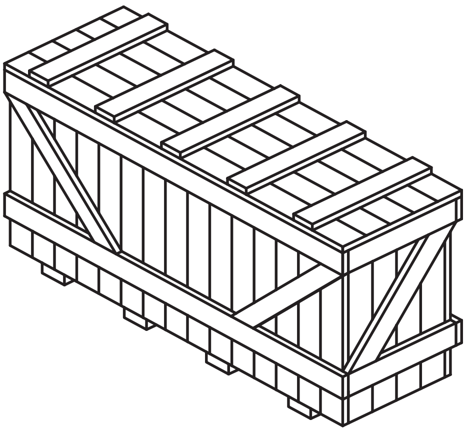


Characteristics	Vertical side sheathing, horizontal non-encircling battens
Battens	Sides: two horizontal, clinched to sheathing
	Ends: three vertical
	Base: four (appropriately spaced and min. 50 mm for fork lift truck handling)
	Top: five girth battens
Sheathing	Softwood, sawn or planed, tongued and grooved (PTG), 16 mm to 32 mm thick
Bracing	None
Nailing	Annularly threaded nails and clinching for higher loadings

12.2.2.4 Style 3 – Horizontally battened case, diagonally braced

Figure 25 shows the properties of Style 3 horizontally battened cases, diagonally braced.

Figure 25 **Style 3 – Horizontally battened case, diagonally braced**

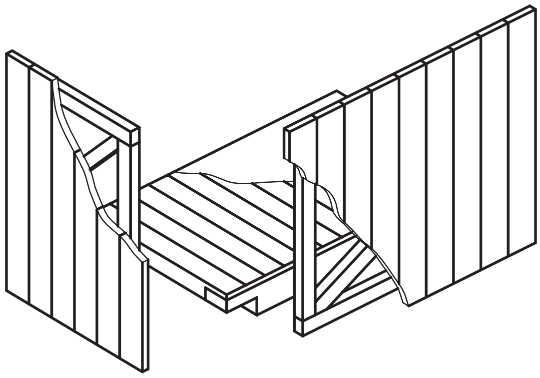


Characteristics	Increased resistance to racking loads through diagonal braces to sides and ends
Battens	Sides: two horizontal, clinched to sheathing
	Ends: two horizontal, clinched to sheathing
	Base: four (appropriately spaced and min. 50 mm for fork lift truck handling)
	Top: five girth battens
Sheathing	Softwood, sawn or planed, tongued and grooved (PTG), 16 mm to 32 mm thick. Vertical on sides and ends
Bracing	Single diagonal at ends. Two diagonal at sides

12.2.2.5 Style 4 – Vertically boarded case, internally battened

Figure 26 shows the properties of Style 4 vertically boarded cases.

Figure 26 **Style 4 – Vertically boarded case, internally battened**



Characteristics	Designed for tight stowage to prevent external battens being torn off or interfering with stowage. The use of lifting grabs should be discouraged with this style
Battens	Sides: diagonally braced frame
	Ends: diagonally braced frame
Sheathing	Softwood, sawn or planed, tongued and grooved (PTG), 16 mm to 32 mm thick. Vertical on sides and ends
Bracing	Single diagonal (internal)

12.3 Typical components for main styles

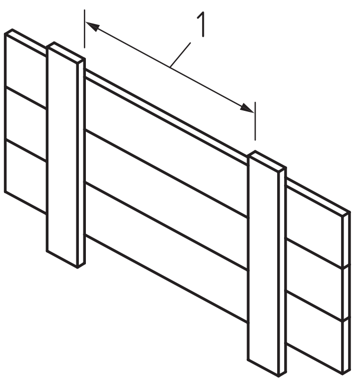
12.3.1 General

The range of case components in Figure 27 to Figure 34, taken in conjunction with the styles described in Table 19, gives the user greater flexibility in packaging a wide range of items and sizes.

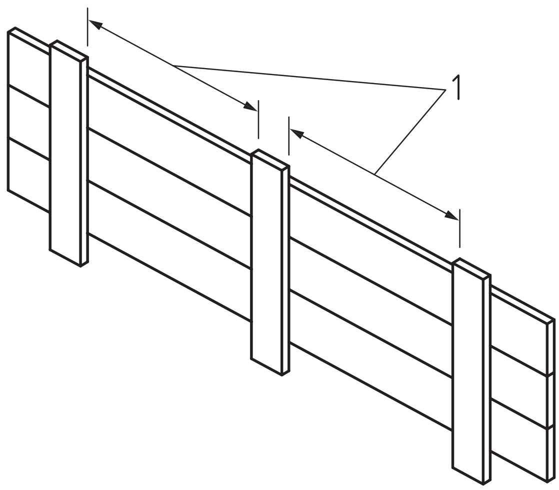
12.3.2 Typical case sides – Style 1

Figure 27 shows the properties of the case sides for Style 1.

Figure 27 **Style 1 – Typical case sides**

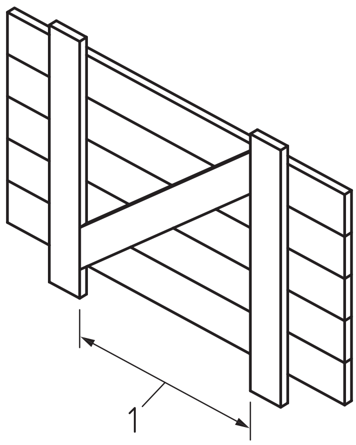


a) Two-batten horizontally boarded side A)

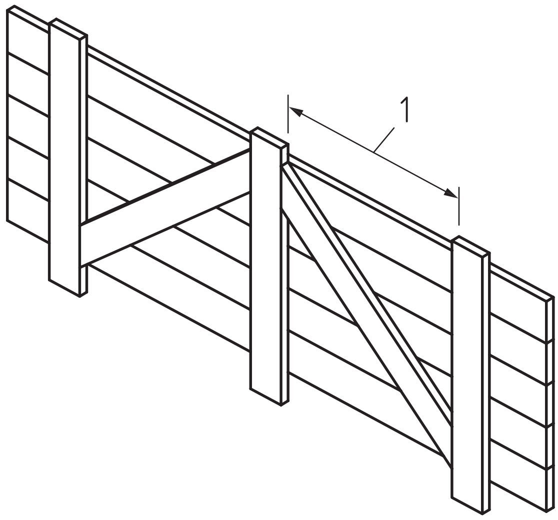


b) Two-batten, horizontally boarded side B)

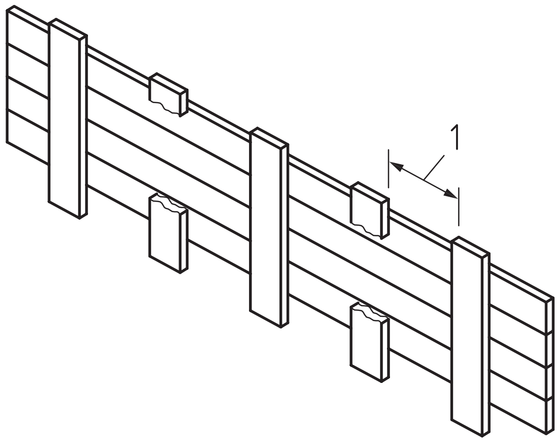
Figure 27 **Style 1 – Typical case sides**



c) Two-batten, braced, horizontally boarded side C)



d) Three-batten, jointed boards, horizontally boarded side D)



e) Five-batten, jointed boards, horizontally boarded side E)

Key

a 1)	Maximum spacing 1 m
b 1)	Maximum spacing 1 m
c 1)	Maximum spacing 1.2 m
d 1)	Maximum spacing 1.2 m
e 1)	Maximum spacing 1m

A) This example has two or more vertical battens, depending upon length of case.

B) This example has three vertical battens.

C) This example is illustrated with a single diagonal brace. The number of vertical battens of diagonal braces depends upon the length of the case.

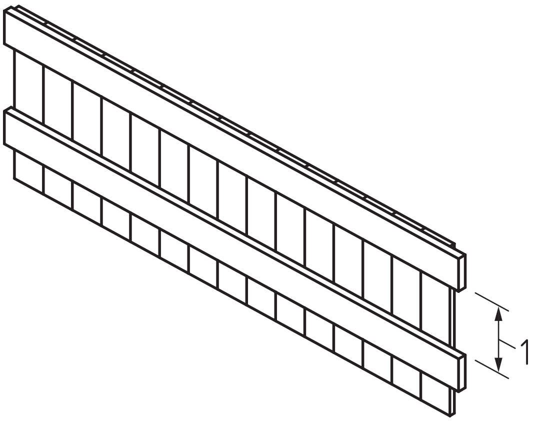
D) This example has three vertical battens and double or continuous diagonal braces.

E) This example has five vertical battens and jointed boards. The joints need to be covered by battens and staggered to avoid weakness.

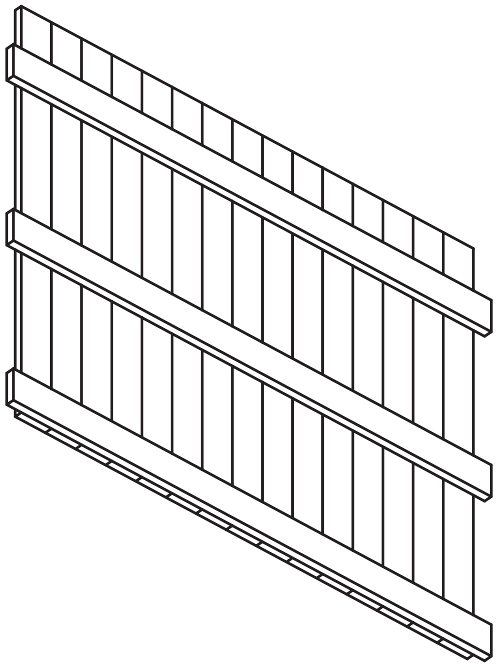
12.3.3 Typical case sides – Styles 2 and 3

Figure 28 shows the properties of the case sides for Styles 2 and 3.

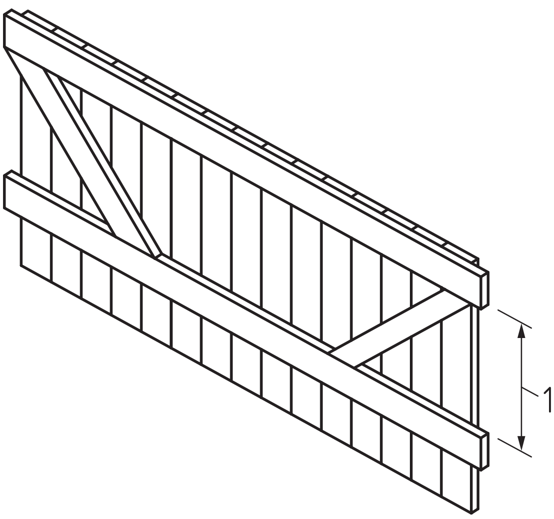
Figure 28 **Styles 2 and 3 – Typical case sides**



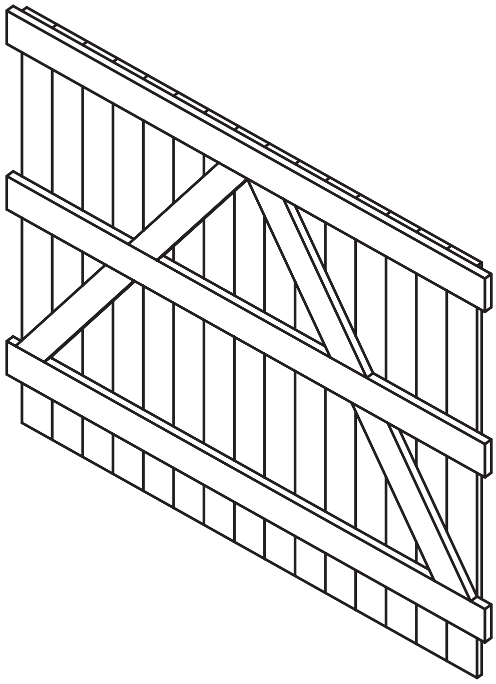
a) Vertically boarded side, two horizontal battens



b) Vertically boarded side, three horizontal battens



c) Vertically boarded side, two horizontal battens, diagonally braced



d) Vertically boarded side, three horizontal battens, continuously braced

Key

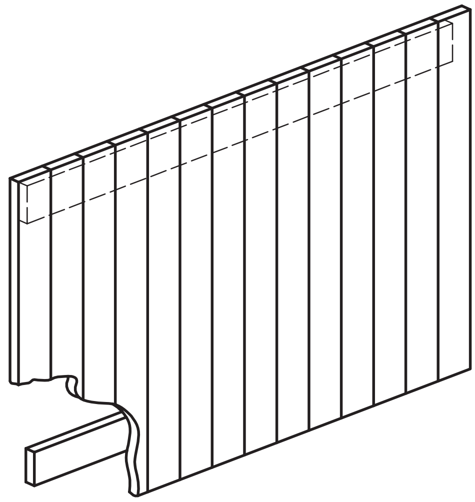
a 1) Maximum spacing height 1.4 m

c 1) Maximum spacing height 1.4 m

12.3.4 Typical case side, style 4

Figure 29 shows the properties of the case sides for Style 4.

Figure 29 **Style 4 – Typical case side**

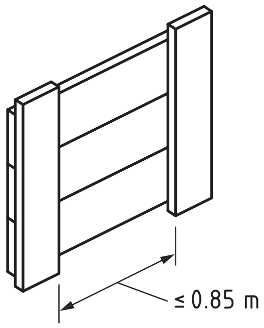


NOTE This example shows a vertically boarded side without internal bracing. An alternative, which gives greater horizontal rigidity, is either to use the timber method shown in Figure 28 c), where both ends of an internal brace butt both battens, or to use a centrally placed horizontal steel nailplate running either side of the boarding around 60 mm to 100 mm wide, and covering at least five boards. See ***8.2.3****.*

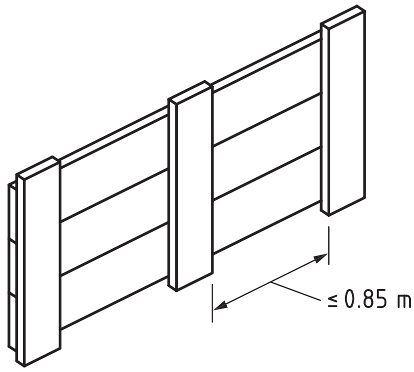
12.3.5 Typical case ends – Styles 1 and 2

Figure 30 shows the properties of the case ends for Styles 1 and 2.

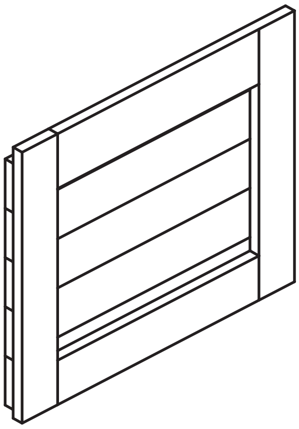
Figure 30 **Styles 1 and 2 – Typical case ends**



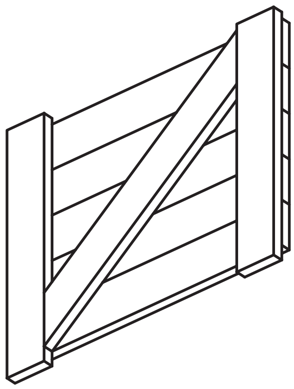
a) Horizontally boarded end, two vertical battens A)



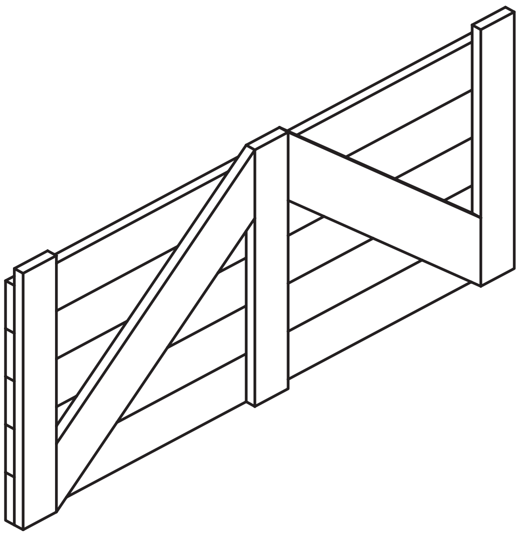
b) Horizontally boarded end, three vertical battens



c) Horizontally boarded, panelled end



d) Horizontally boarded end, two vertical battens, diagonally braced A)



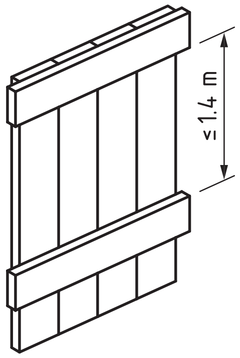
e) Horizontally boarded end, three vertical battens, diagonally braced

A) This example is for use with standard base only.

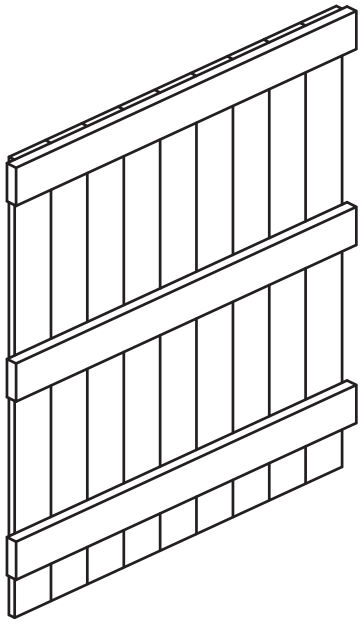
12.3.6 Typical case ends – Style 3

Figure 31 shows the properties of the case ends for Style 3.

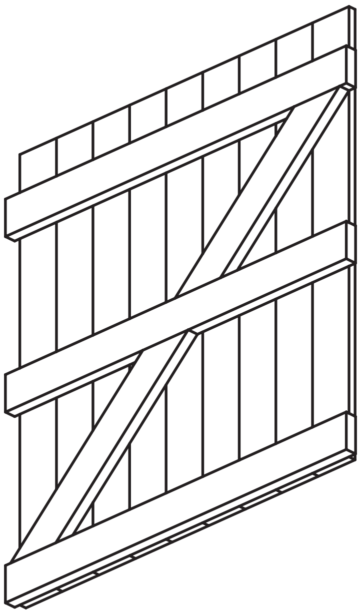
Figure 31 **Style 3 – Typical case ends**



a) Vertically boarded end, two horizontal battens



b) Vertically boarded end, three horizontal battens

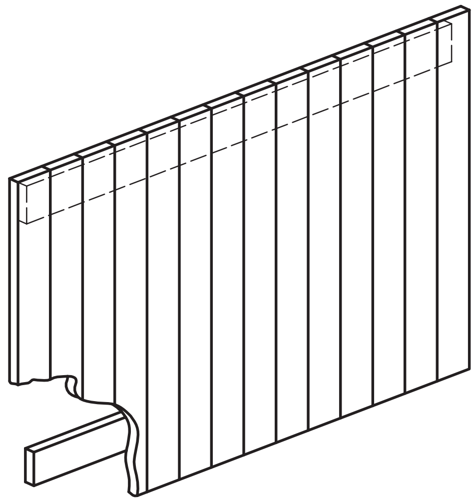


c) Vertically boarded end, three horizontal battens, diagonally braced

12.3.7 Typical case end – Style 4

Figure 32 shows the properties of the case ends for Style 4.

Figure 32 **Style 4 – Typical case end**



NOTE This example shows a vertically boarded end with two horizontal internal battens.

12.3.8 Typical case bases

12.3.8.1 General

Heavier styles of case base should be designed to ensure that their strength is adequate for the load. The major factor is the bending strength of the base in both horizontal planes while stiffness should be carefully assessed if the contents are fragile.

The size of the timber sections and the number of parallel members depends upon:

a) the item packed: its length, fragility and strength;

b) the type of load: easy, average or difficult;

c) the position of mounting points;

d) the grade of timber used;

e) the method of handling to be employed en route;

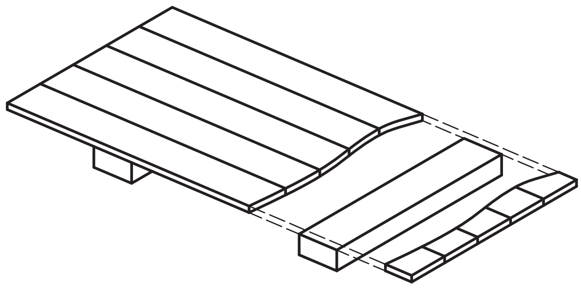
f) the contribution of the case sides to base strength.

12.3.8.2 Typical case base styles

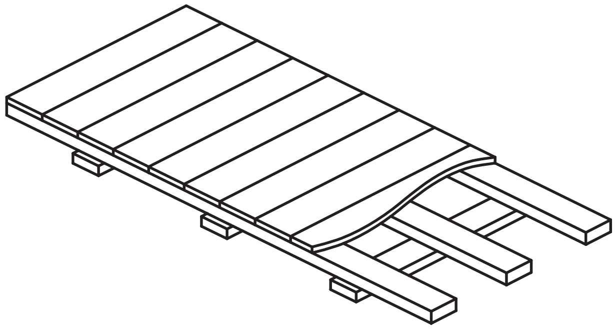
Typical case bases are illustrated in Figure 33.

NOTE All the styles permit handling by fork lift truck and/or slings.

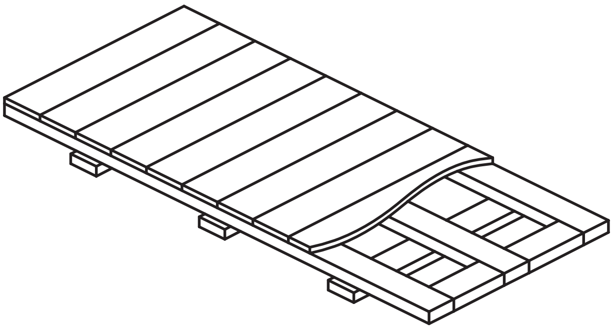
Figure 33 **Typical case base styles**



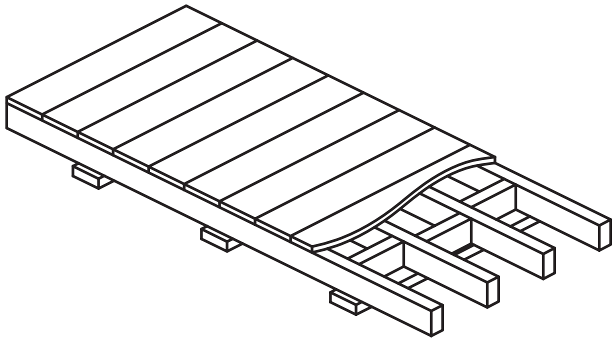
a) Standard base



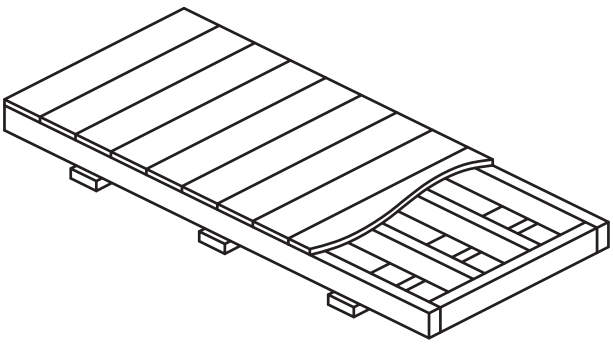
b) Cross batten base with flat runners without fillers A)



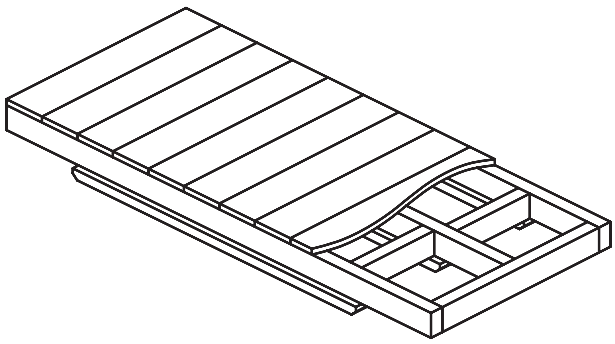
c) Cross batten base with flat runners with end fillers



d) Cross batten base, runners on edge, with fillers over cross battens B)



e) Cross batten base, runners on edge, with end batten providing a complete frame



f) Skid base C)

A) Flat runners for reduction of cube.

B) Runners on edge give greater strength and stiffness.

C) Deep skids for increased strength and stiffness. Rubbing strips allow fork lift truck/sling access.

12.3.8.3 Skid or sled base

The skid or sled base is a heavy timbered platform with runners to move large goods from ship to shore or onto road transport.

NOTE 1 It is called a sled pallet by NATO and the US military and known as a skid base in Europe.

Supplies and equipment should be secured to the pallet with tensional strapping which passes through slots between the skid and the platform. The platform should be made from softwood boards running across the short direction or strong plywood.

The sizes of a sled base should be 3 m to 12 m. Slings should be held from inward movement along the skid by a positive location due to notches or rubbing strips shorter than the skid and nailed to it.

The base should be strong enough in both horizontal directions not to stress the items shipped so as to cause damage. If the shorter direction needs additional strength when the goods merit this through weight or fragility, then headers (short battens) the full width should be fitted just above the platform base.

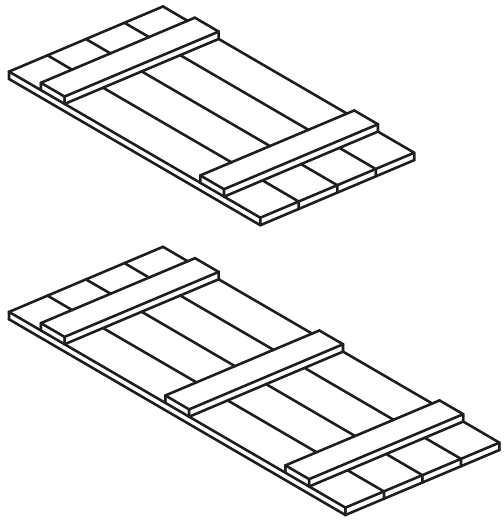
Longer skids with greater tendency to flex cause a greater design problem. Nailing should not be used in such a design; the usual fasteners are coach bolts or coach screws.

NOTE 2 A pallet bridle can be used to prevent slings causing crush damage.

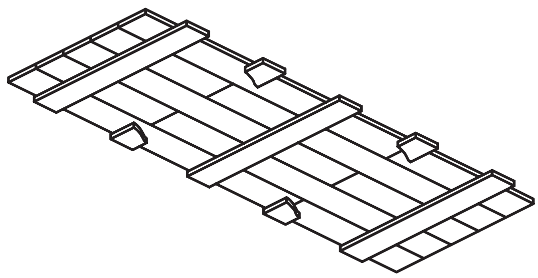
12.4 Typical case lids

Typical case lids are shown in Figure 34.

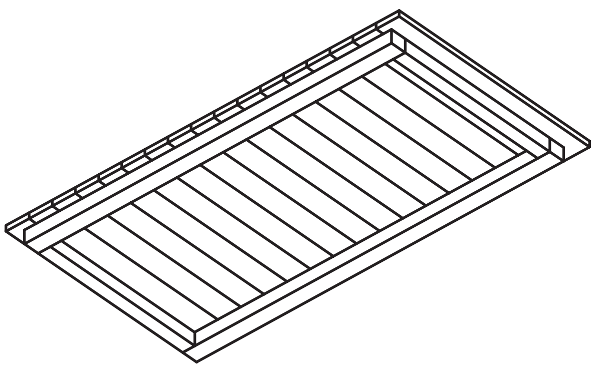
Figure 34 **Typical case lids**



a) Typical case lids Style 1, typically battened, battens flush with edges



b) Typical case lid, Styles 2 and 3, multi-battened, battens overlapping edges



c) Typical case lid, Style 4, internally battened

12.5 Plywood and wood-based sheet for large cases

The stiffness of the sheet is an important consideration in the use of plywood for the sheathing, bases and lids of cases. With regard to vertical loads applied to tall cases, special attention should be paid to vertical compression strength (because of boxes that might be over-stacked while stored) and lids should have adequate stiffness between their supporting battens.

The cross-spliced construction and near equalization of strength along length and width of plywood (compared with sawn boarding) can often be used to advantage and the designer should always be aware of the direction of the face grain (the stiffer direction) and its effects on the strength of the component. Small cases using light battens or metal edged plywood should be built with the face grain vertical on at least two sides, if not all four, to increase stacking strength.

When building large cases a general rule, in lieu of special calculations, should be that if horizontal face grain in plywood is unavoidable in side and end sheathing, then the frequency of placement of vertical battens should be doubled. This is particularly the case when using 3-, 4- and 5-ply grades, which have very pronounced differences in strength in the two flat planes.

NOTE 1 The full benefit of cross-lamination is only exhibited by panels with seven or more plies.

NOTE 2 Plywoods with three, four and five plies typically exhibit double the bending and compression strength and stiffness in one direction than the other.

NOTE 3 When the term compression strength is used for sheet material in relation to packaging, this means the in-plane buckling strength, i.e. the sheet on edge in a vertical plane with load applied to the top edge.

13 Dock pallets

13.1 Stevedore dock pallet

A stevedore pallet (see Figure 35) is larger than a normal pallet (as defined by BS ISO 6780 and BS EN 13382). It is typically 1200 mm × 1800 mm, and designed like a two-way entry timber double-wing pallet. It can be used with fork lift trucks or bar slings. Stevedore pallets are often used to load/unload loose cargo where goods arrive unpalletized.

When used as a slave pallet, this pallet size can lift two loaded 800 mm × 1200 mm pallets alongside each other. Since an 800 mm × 1200 pallet can often carry 1500 kg the stevedore should be design to be able to withstand a weight of 3000 kg.

A stevedore pallet can have three, four or five bearers but they should always be of double-wing, reversible construction. The stringers should not be notched and should measure 75 mm × 100 mm × 1200 mm, or even 100 mm × 100 mm × 1200 mm. The deckboards should be 45 mm to 50 mm thick and the overall pallet height 200 mm.

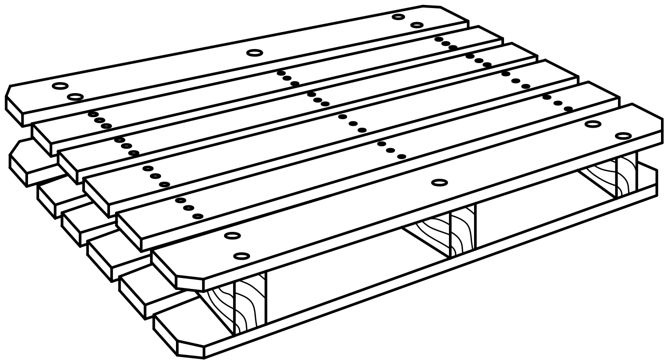
The outside stringers should be set in by 100 mm to 150 mm from the deckboard ends so the wings comfortably permit the use of bar slings.

Neither annular ring nor twist nails should be considered suitable for this type of pallet. Coach screw or a recessed coach bolt construction should be used. The four outer deckboard coach screws would be under very high load if non-recommended loose slings are used at the dockside in a developing country, so great care should be taken with counterbored recessed coach bolt constructions.

NOTE Counterboring or drilling at the four outer deckboard ends can reduce the pallet strength.

The exact specification of this kind of pallet should be agreed with the customer before supply.

Figure 35 **Stevedore dock pallet**



13.2 Non-compatible loading devices – Pallet bridle

Bridles (see Figure 36) are lifting devices designed to hoist special types of cargo and should only be used on pallets with wings.

Flat pallets conforming to BS ISO 6780 permit the use of pedestrian pallet trucks, which a common pallet used with the bridle (i.e. stevedore pallet; see **13.1**) does not.

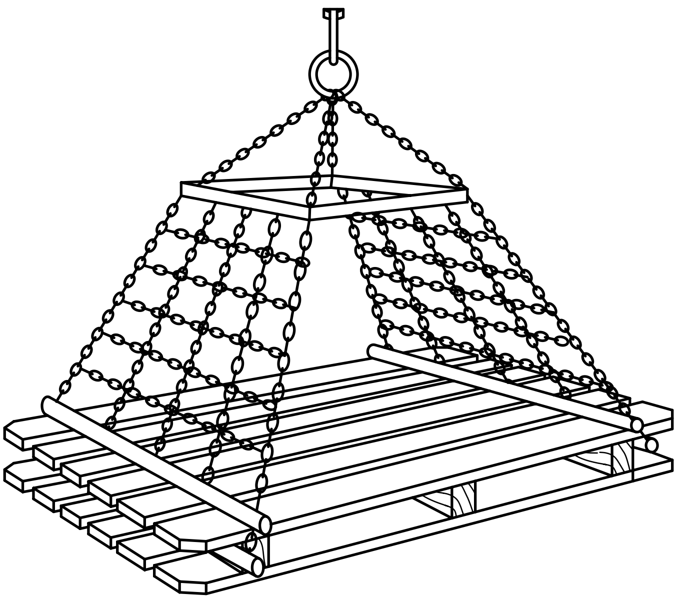
Nets should be used to assist the safer handling of loose cargo on wing pallets and should also be used with above-average pallet sizes such as dock pallets. Cargo handlers should insert the lifting bars integral with the bottom of the nets into the ends of the pallet under the pallet wings. The sling nets should be spread around the cargo as far as they can reach and the assembly should be over the cargo hook.

NOTE 1 The square steel bar assembly serves as a load spreading device.

If a pallet bridle is used in conjunction with a load spreader it can often reduce the compression load on the lifted goods.

NOTE 2 There is no international standard to assist with the design of pallet bridles.

Figure 36 **Pallet bridle**



14 Skid and rail design

14.1 Solid timber skids and rails

The major design criterion of these members is bending strength. The size of a section of timber depends upon:

a) the severity of handling; severity of being either the position of support (e.g. fork-lift truck, sling) or the rapidity of application of the lifting load (e.g. long slender cases rapidly accelerated by means of hoisting);

b) content load;

c) grade of timber.

In order to do so effectively they should be solid, continuous and connected to the skid by adequate nailing.

Two methods for calculating skid sizes are described in **14.2**. That for deep skids (see **14.2.2**) is most efficient in terms of timber usage and that for shallow skids (see **14.2.3**) is more efficient in terms of minimizing case shipping cubage. Each method yields a skid of equivalent strength.

14.2 Method of calculation of sizes

14.2.1 General

Methods for calculating the sizes of deep and shallow skids are given in **14.2.2** and in Annex B (Table B.1) and the following points should be considered when using either method.

a) Headers and cross skids are transverse skids that can carry the load between main skids (e.g. fork-lift truck tines can only pass under three out of four skids and the headers then carry the load into the "unloaded" skid). The sizes of headers and cross skids can be found using the method for deep skids and shallow skids given in Annex B.

b) The maximum subspan is the distance between any load attachment point and a handling point.

c) A better quality of timber can reduce skid size.

NOTE 1 Table B.1 is computed for the most common long timber in the UK, i.e. European redwood/whitewood.

d) The maximum deflection resulting from the use of Tables B.1 and B.2 is 3% of span, e.g. 60 mm in a 3 m skid. This percentage can be reduced if the contents and sheathing add stiffness.

Subspans are distances from lifting points to payload attachment points (shown in Figure 37 as up-arrows and down-arrows respectively). In Figure 37 subspans are 1 and 4 for slings and 2 and 3 for a lift truck. Good design can also be achieved through the batten *a* in Figure 37, which prevents entry of truck forks at worst-stress points x and y.

A subspan less than 1/6 L (see Figure 37) should not be used for computation less than 0.5 m. If the subspan is determined at less than 0.5 m, then 0.5 m should be used to allow a margin of safety.

NOTE 2 The sizes and sections given by this method take no account of the increase in strength afforded either by the use of X bracing in the sheathing or by the use of panel materials such as plywood. The use of these means that large reductions in the skid sections might be possible, but the safe use of such reduction methods depends upon the use of proper structural analysis or standard designs, where these are available.

If a skid is cut away to allow for fork tines or slings, the skid should be assumed to be of this thinner reduced section throughout for design purposes.

14.2.2 Deep skids

Deep skids are used when the aim is to use the least timber. The size of the skid should be determined as follows.

a) Determine the length of the maximum subspan (see Figure 37).

b) Decide on a convenient cross-sectional dimension for the rails.

c) Add all these rail breadths together (see Figure 38).

d) Find the load carried for the total breadth, depth and subspan of rails.

e) Subtract this portion of the load from the total weight of the contents.

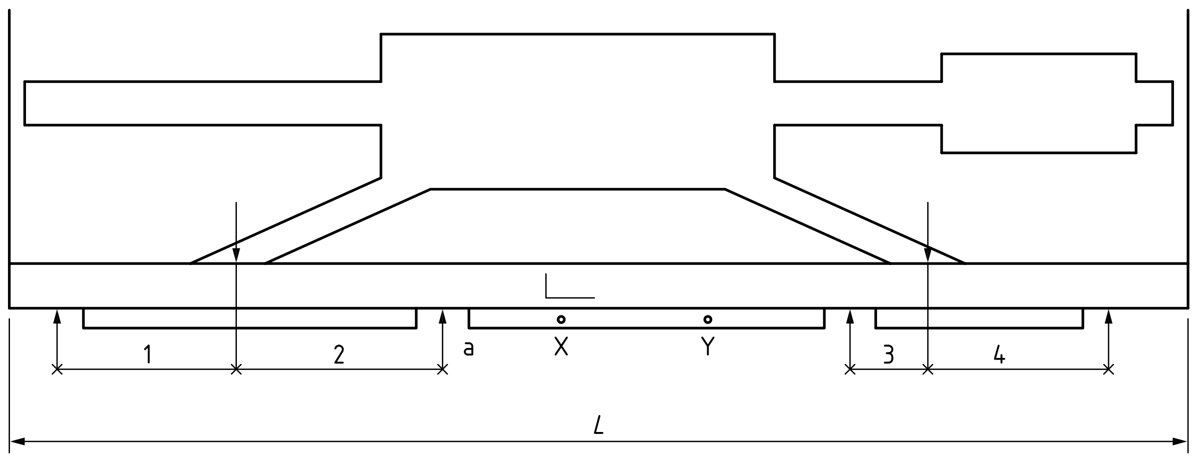
f) Use the remaining load and the maximum subspan to find the total breadth and depth required for the skid.

g) Divide the breadth figure only by the number of skids required, e.g. quarter the breadth for four skids, but do not quarter the depth.

h) Use these sizes for skid manufacturers.

NOTE If not allowing for lengthwise rails to take a portion of the load, steps b) to e) can be ignored.

Figure 37 **Length of subspan**



Key

1 Subspan 1
2 Subspan 2
3 Subspan 3
4 Subspan 4

14.2.3 Shallow skids

Shallow skids use more timber than the method described for deep skids but have the advantage of using smaller timbers and reducing the shipping cubage. The size of skid should be determined according to the following points.

a) Determine the length of the maximum subspan (see Figure 37).

b) Decide on a convenient cross-sectional dimension for the rails (if substantial size rails are to be used).

c) Add all these rail breadths together.

d) Find the load carried for the total breadth, depth and subspan.

e) Subtract this portion of the load from the total weight of the contents and call the new reduced load L.

f) Find the load L carried against the subspan, add depth of skid you chose and read off the total skid breadth from Table B.1.

g) Decide on a convenient number of skids and apportion the load carried to each skid, in proportion, e.g. four skids each carry 25% of the load L.

h) Use these skids for skid manufacture.

NOTE Example: Subspan = 0.67 m; depth chosen = 100 mm; L = 1000 kg; total skid breadth from Table B.1 needed is 163 mm. If this is less than is needed, increase the total skid breadth in proportion to the load, so if L = 2000 kg, the skid breadth needed is 326 mm.

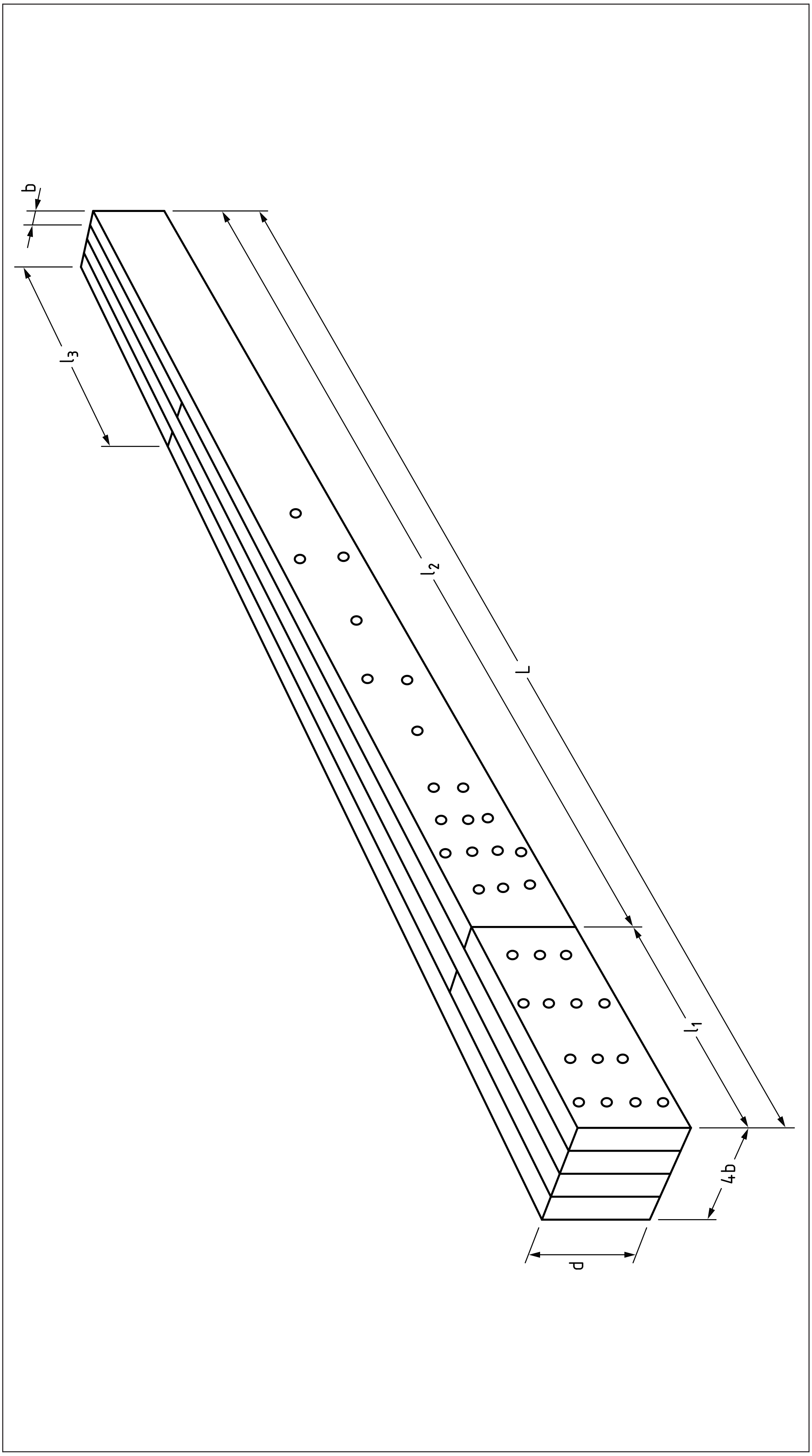
14.3 Spliced skids

Spliced skids need fabrication and the most efficient nailed fabrication is vertically laminating and splicing to make the longest lengths needed (see Figure 38). Annular ringed shank nails give greater strength and laminated skids should not have joints on adjacent lamina closer than 1 m in plan.

Figure 38 shows that a break should be avoided in adjacent laminates which can coincide to create weak points or occur in the centre third of length L.

NOTE Table B.2 in Annex B gives suitable wood laminate thickness (b in Figure 38) and depth thickness (d in Figure 38), allowing for one-third strength reduction from solid wood skids.

Figure 38 **Spliced skid**



15 Crates

15.1 General

A wooden crate is a framework used as a package for the transportation of goods which do not require the complete protection of a case.

Having less sheathing components, crates should be braced with diagonal members to impart racking (anti-deformation) strength. The top and base should be fully or partly clad with sheathing boards, using the styles described in Clause **12**.

On all crate styles, between 30% and 70% savings on timber can be made compared with boxes and cases.

A braced crate should be able to carry the same loads as a sawn wood case or plywood case, though it does not offer equal protection to the contents.

The advantages of crates as opposed to cases are:

a) a saving on wood and fastenings;

b) a saving on mass;

c) easy inspection of contents without dismantling.

The disadvantages are:

- increased damage might occur;
- the possibility of pilferage, if the contents are small;
- weather protection is negligible.

Crates are particularly vulnerable to racking because they have fewer members to resist such thrust.

15.2 Styles of crate

15.2.1 Style 11 – Light braced crate

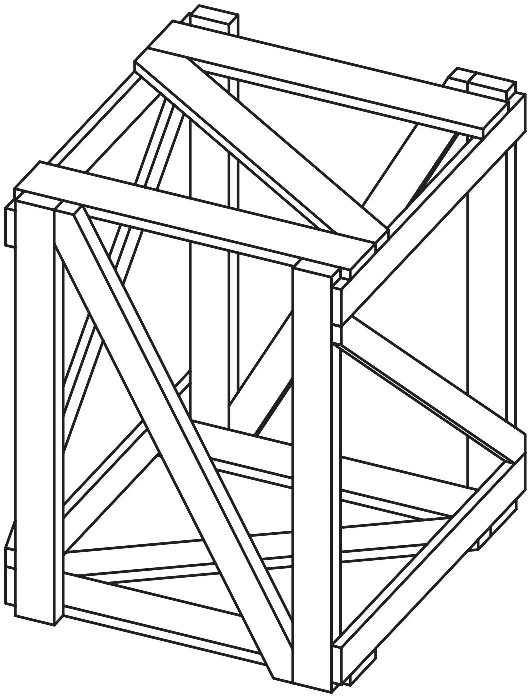
Style 11 should have the absolute minimum of components but should still enable stacking.

This style has no physical protection of contents and can be fitted with fork lift truck battens.

The construction for this style uses minimum timber volume, yet retains considerable racking and stacking strength. Style 11 uses the lock-corner principle (where all end grain nailing is avoided to maximize nail withdrawal resistance).

NOTE An example of Style 11 is given in Figure 39.

Figure 39 **Style 11 – Light-braced crate**



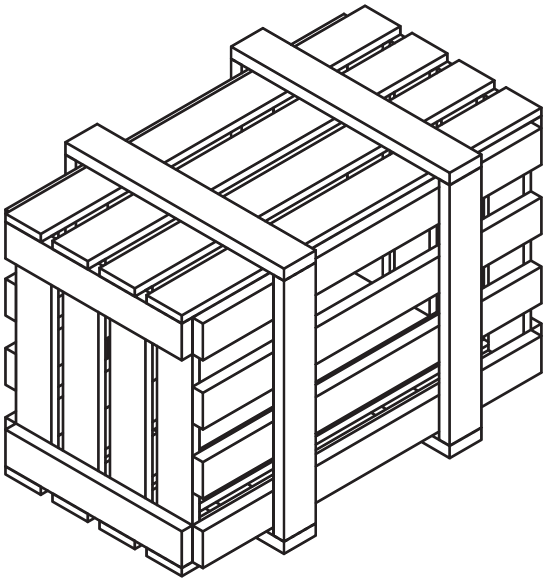
15.2.2 Style 12 – Horizontally semi-sheathed crate, externally battened

Style 12 is built in a similar way to a case but with reduced sheathing members.

This style provides similar protection to a case except for resistance to fork tine damage and weather. It could be fitted with fork lift truck battens, or external diagonal braces of the type shown in Figure 22.

NOTE 2 An example of Style 12 is shown in Figure 40.

Figure 40 **Style 12 – Horizontally semi-sheathed crate, externally battened**



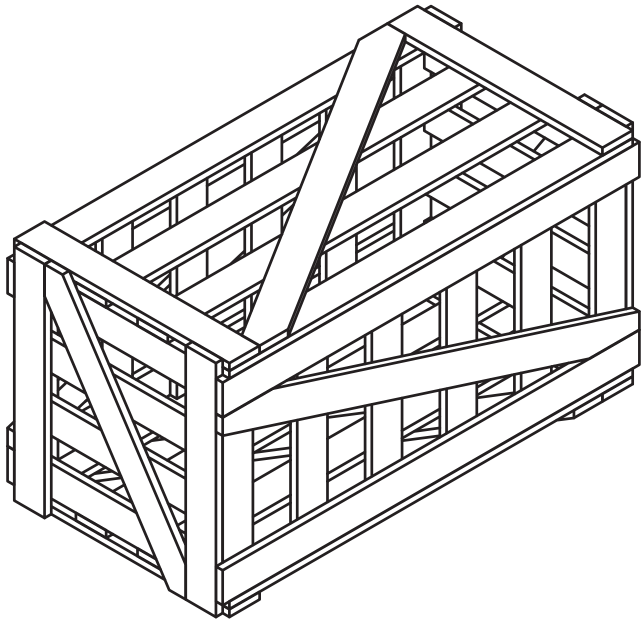
15.2.3 Style 13 – Braced crate with vertical and horizontal sheathing

This style is based upon Style 11 but provides greater protection for the contents.

Style 13 style should not be used with to fork lift truck battens, except at the ends or unless the base brace is omitted or fitted internally. Style 13 uses the lock-corner method.

NOTE An example of Style 13 is shown in Figure 41.

Figure 41 **Style 13 – Braced crate with vertical and horizontal sheathing**

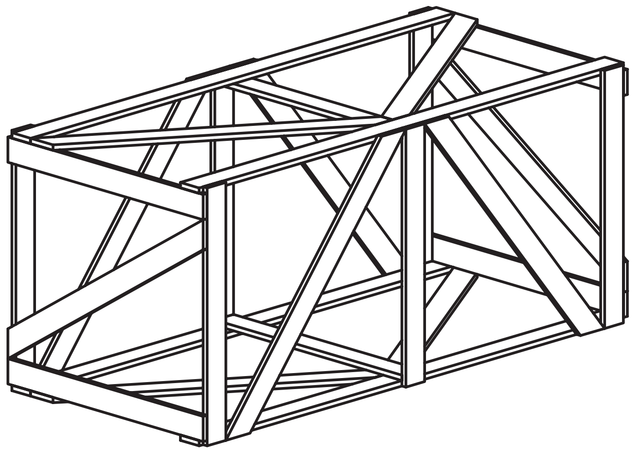


15.2.4 Style 14 – Light crate with continuous bracing

This style is similar to Style 11 but fitted with a stronger base in order to be suited to fork lift truck or sling handling.

NOTE An example of Style 14 is shown in Figure 42.

Figure 42 **Style 14 – Light crate with continuous bracing**



16 Sawn wood boxes

16.1 General

The convention used is that a box is a container intended for lightweight goods, and should not be fitted with fully encircling girth battens, while a case is a larger container for heavier goods, which should be fitted with girth battens, usually externally.

16.2 Lightweight boxes for manual handling

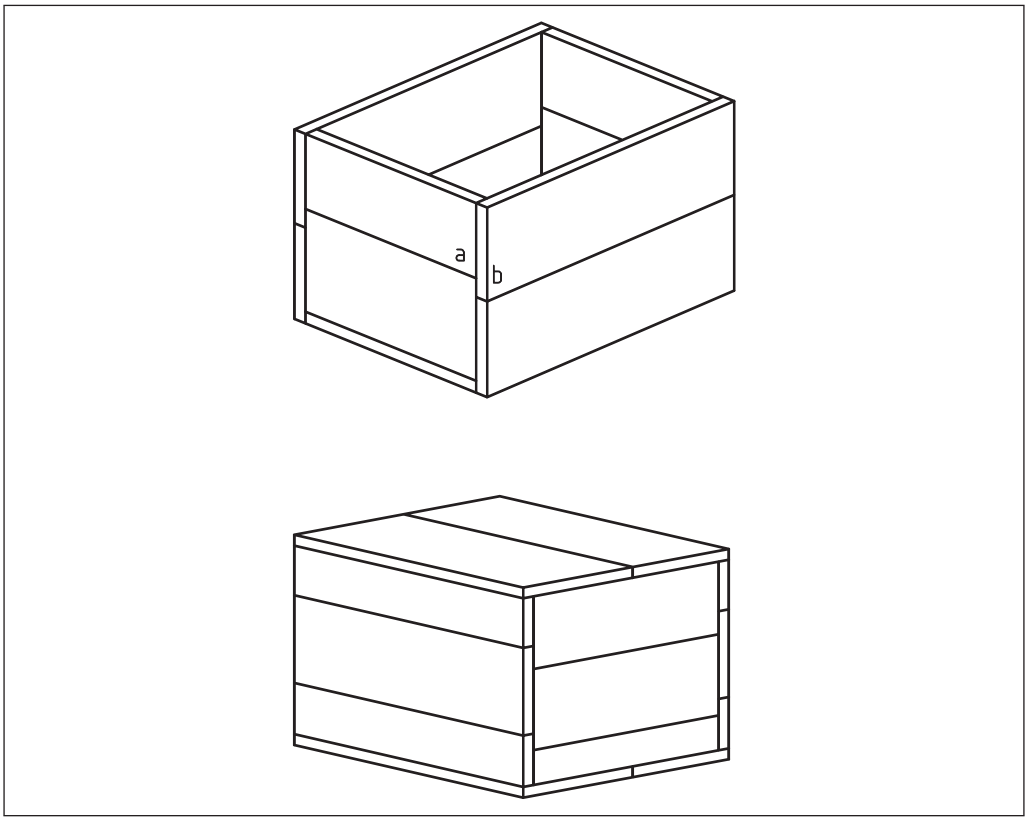
16.2.1 Style 21 – Basic boxes

The sides in Style 21 are fixed by nails driven into the end grain of the two ends, which makes the construction relatively weak.

Joints a) and b) (see Figure 43) should be staggered by at least 50 mm when the box depth necessitates that two or more side or end members are used. The nails fixing the base should be driven into the side grain of the ends and those fixing the sides should be nailed into the base side grain. For balanced strength, the ends should be thicker than the other components, primarily to ensure adequate nail retention

The recommended maximum sizes should be: 500 mm × 300 mm × 200 mm (length × width × height). Wood thickness should be: 8 mm to 16 mm, and 16 mm at the ends.

Figure 43 **Style 21 – Basic boxes**



16.2.2 Style 22 – Combed tenon box

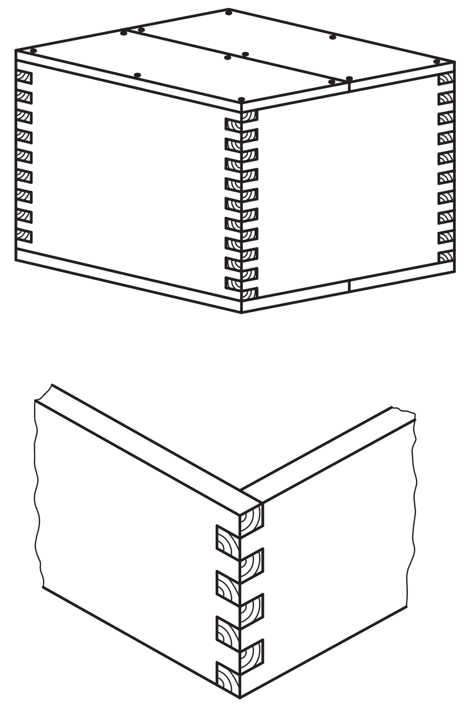
The sides in this style should be fixed to the ends by combing (machining tenons) and should glued with adhesive. The sides and ends should each be in one piece, or, if in separate pieces, joined by “tongue and groove” or a similar method.

NOTE 1 Often fitted with handles, this style finds applications as a returnable box for beverages, or as a field box for fruit and vegetables

The recommended maximum sizes for Style 22 should be 600 mm × 400 mm× 300 mm (length × width × height). Wood thickness should be: 16 mm to 19 mm all round.

NOTE 2 See Figure 44 for an example of Style 22.

Figure 44 **Style 22 – Combed tenon box**



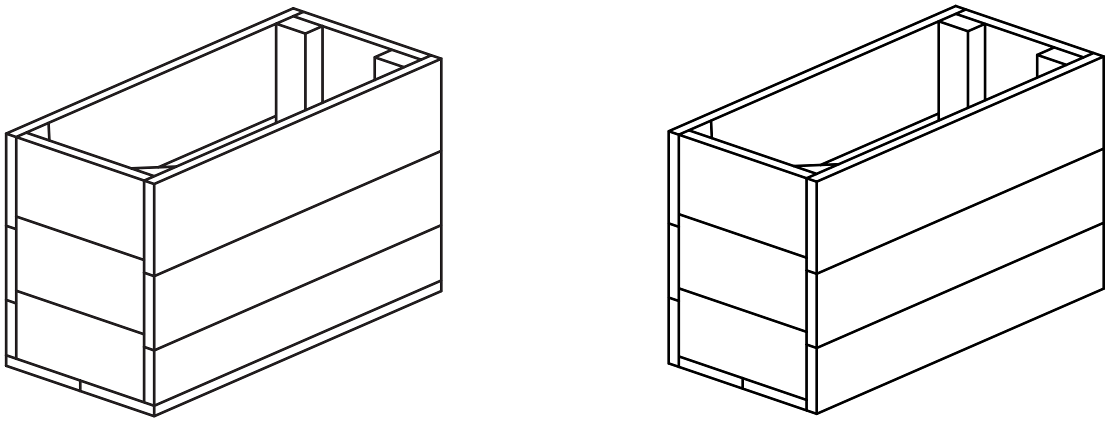
16.2.3 Style 23 – Internally battened box

This style derived from Style 21, but with triangular or rectangular battens fitted inside the corners, which make space saving possible if the battens do not interfere with the contents. Reduction or elimination of end grain nailing improves strength and the shipping cube is less than externally battened styles. There is no need for ends to be of greater thickness than sides. Higher loads can be carried if the base is set into the sides and nails are loaded in shear mode.

The recommended maximum sizes for Style 23 should be: 600 mm × 400 mm × 300 mm (length × width × height). Wood thickness should be 12 mm to 16 mm, while battens should be 35 mm× 35 mm.

NOTE Figure 45 shows two examples of Style 23 boxes.

Figure 45 **Style 23 – Internally battened box**



a) Internally battened box b) Internally battened box with inset base

16.3 Battened boxes for mechanical handling

16.3.1 Style 24 – Battened end box

Style 24 should have externally battened ends and should comprise two vertical battens at each end (longer than end panel height), but without girth battens.

NOTE 1 Corner strength is considerably increased and end grain nailing reduced.

In this style, 50 mm battens should be used to aid fork lift truck or sling movement. For higher load limits, the base should be nailed to the sides/end with annular threaded or twisted nails.

Style 24 is more labour intensive to produce than Style 21 since there are four different lengths to cross-cut, as opposed to only two in the basic box style.

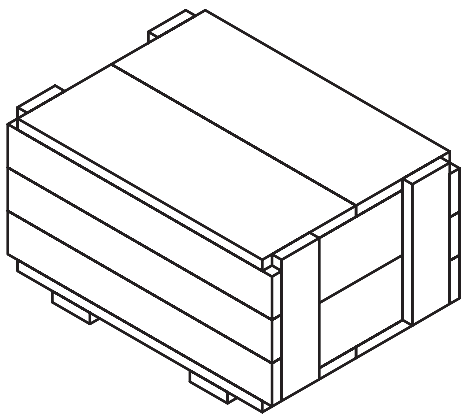
The measurements for Style 24 should be:

- wood thickness: 16 mm to 32 mm;
- battens: 19 mm × 75 mm;

Improved nails should be used for higher loadings.

NOTE 2 Figure 46 shows an example of style 24.

Figure 46 **Style 24 – Battened end box**



16.3.2 Style 25 – Panelled end box

Style 25 should have vertical and horizontal battens at the ends, but no top or bottom battens except when fitted as shown in Figure 47 with 50 mm base battens to aid fork lift truck or sling movement.

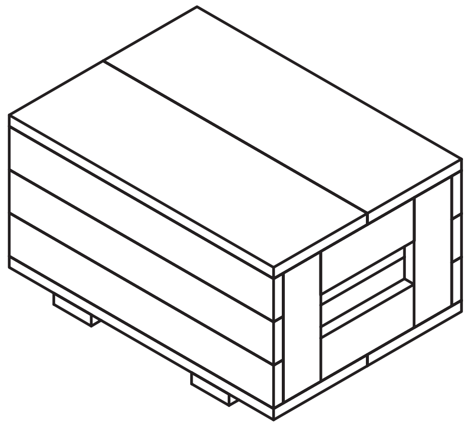
NOTE This also works to reinforce board ends against splitting and to strengthen sides by the greater holding power of nails driven into the side grain of vertical battens.

For higher load limits the base should be attached using annularly threaded nails and low density timber species should be avoided to ensure good fastening.

The measurements for style 25 should be:

- wood thickness: 16 mm to 32 mm;
- battens: 19 mm × 60 mm.

Figure 47 **Style 25 – Panelled end box**

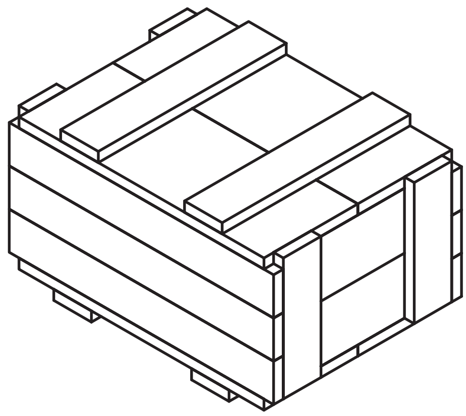


16.3.3 Style 26 – Battened top and base box

Similar to Style 24, but the battens should be positioned on the lid to aid removal of the lid in one piece and 50 mm base battens should be employed to aid fork lift truck or sling movement. Battens should be clinched to the top and nailed through the base using improved nails. Wood thickness for style 26 should be 16 mm to 32 mm. Improved nails should be used for higher loadings.

NOTE Figure 48 shows an example of Style 26.

Figure 48 **Style 26 – Battened top and base box**



17 Boxes and cases of plywood and other sheet materials

17.1 General

In addition to plywood, a number of wood-based sheet materials, such as waferboard, could be used for the construction of boxes and crates. However, the range of potential sheet materials is so wide that it is not possible to substitute on a 1:1 basis. Each material should be assessed on its merits in relation to strength, nailability, etc.

17.2 Industrial styles using sheet materials

Plywood and most wood-based sheet materials have exceptional strength in racking. Plywood and flakeboard have good strength in bending in at least one transverse plane. Their drawback is that, because of the thinness of the material, they should be anchored to something such as a heavier, easily nailed, member, hence why plywood boxes are constructed with softwood battens and frames.

The coupling of softwood, sheet materials and improved fastenings offers great strength, a strength which can, in many cases, exceed the all-softwood design.

Sheet materials are particularly suited for use with tool-driven staples, since they are usually fixed at more frequent points than all-sawn wood constructions.

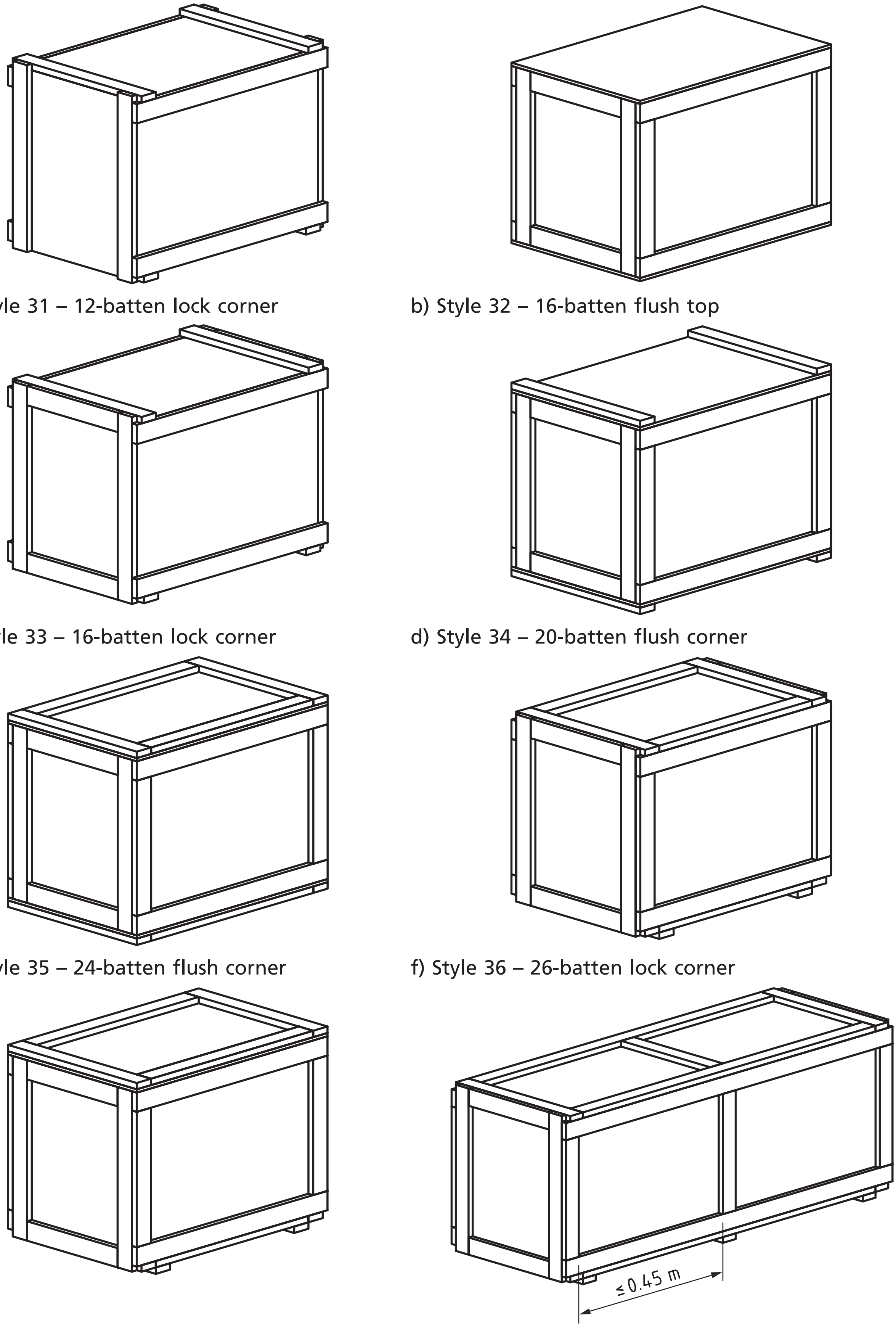
NOTE 1 Most users find it worthwhile to start from a standard proven design and Table 20 and Figure 49 cover a range of common basic styles to which a user might add special features.

NOTE 2 Style 22 described under sawn wood boxes (see Clause ***16****) can also be produced in hardwood plywood 12 mm to 19 mm thick.*

Table 20 **Plywood boxes**

Style no.	**Plywood thickness** mm	**Battens** mm
31	6.8	32 × 16
32	6.8	32 × 16
33	6.8	38 × 19
34	8	38 × 19
35	8	38 × 19
36	9.5; 8	50 × 22
37	9.5; 12	50 × 22
38	9.5; 12	75/100 × 22

Figure 49 **Plywood box styles**



a) Style 31 – 12-batten lock corner

b) Style 32 – 16-batten flush top

c) Style 33 – 16-batten lock corner

d) Style 34 – 20-batten flush corner

e) Style 35 – 24-batten flush corner

f) Style 36 – 26-batten lock corner

g) Style 37 – 26-batten flush corner

h) Style 38 – 26-batten lock corner, extended

18 Metal edged plywood boxes and cases

18.1 General

The main feature of this type of case is the replacement of the wood battens used in normal plywood cases by thin pliable metal edging as the means of connecting the sheets.

There are three broad classifications of metal edged box:

a) rigid non-returnable [see Figure 50a) and Figure 50b)];

b) semi-collapsible [see Figure 50c) and Figure 50d)];

c) collapsible [see Figure 50e)].

Any of these types can be fitted with a pallet base.

The body members, usually thin plywood sheets, should be joined together along all external angles with metal edging strip fixed with bifurcated rivets.

Certain styles use a combination of sawn wood battens together with metal edging to achieve maximum strength while retaining demountability. The benefits of metal-edged boxes include the fact that many types can be delivered flat so they provide minimum cubage in transit when packed. They are also water resistant.

18.2 Styles of metal edged boxes and cases

18.2.1 Rigid non-returnable

Cases which are delivered to the user assembled, referred to as "rigids", should have their body panels joined along all external angles by metal edging fixed with bifurcated rivets. Flat metal strips should be fixed in a similar manner along the top edges, projecting above the body to receive and retain the lid. The lid can be supplied with battens fixed to locate the unfolded body component [see Figure 50a)].

After assembly, the lid and base should be fixed to the body using:

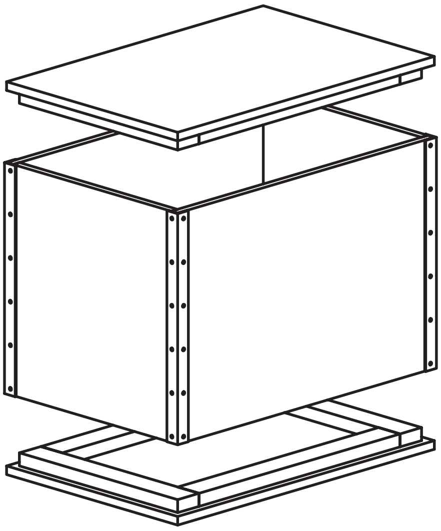
a) staples, usually applied by pneumatic tool;

b) clout or other suitable nails;

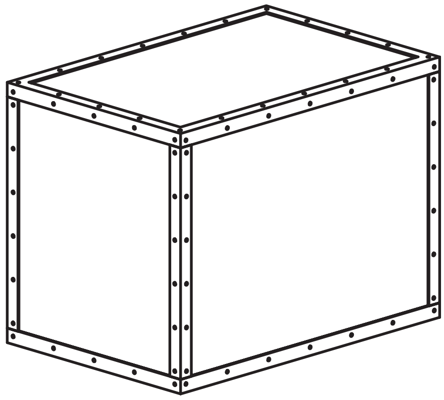
c) tenterhooks, where the long leg should be driven into the deeper member and the shorter leg into the body or the shallower member.

NOTE Variations include the internally battened lid/base, Style 41 [see Figure 50a)], which once assembled becomes a rigid non-returnable and the box, and Style 42 [see Figure 50b)], which is an entirely metal edged box with an externally fitted lid.

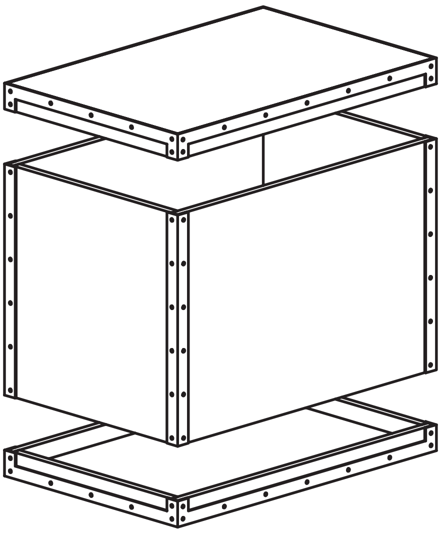
Figure 50 **Style of metal edged boxes and cases**



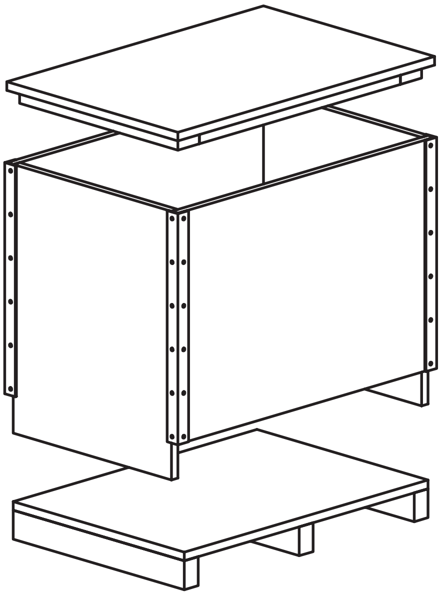
a) Style 41 – Internally battened lid/base



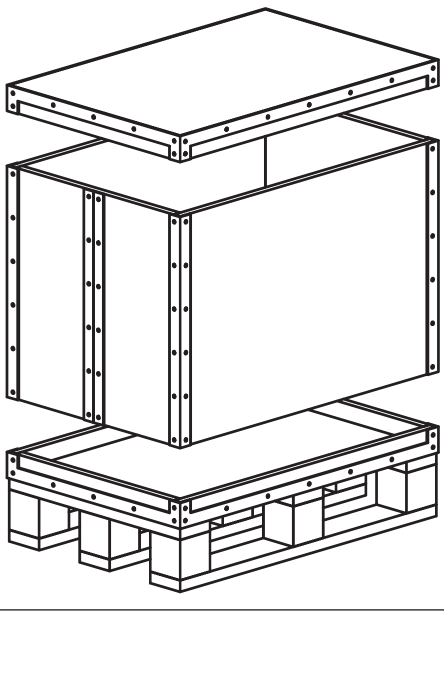
b) Style 42 – Rigid box



c) Style 43 – Flanged (semi-collapsible)



d) Style 44 – Pallet based (semi-collapsible)



e) Style 45 – Collapsible, pallet based

18.2.2 Semi-collapsible

This type of box cannot be stored or transported as compactly as collapsibles (**18.2.3**) and has fewer riveted joint folds, usually just four, but, as a consequence, has added strength.

NOTE Variations include the plywood flanged, Style 43 [see Figure 50c)], with lid and base of identical size, reducing the volume for transport when empty and the pallet based, Style 44 [see Figure 50d)] which is suitable for mechanical handling but can be dismantled.

18.2.3 Collapsibles

Cases which are delivered in the flat (collapsibles) should have their body panels joined with the flexible metal edging. Softwood battens should be fixed along the edges of the plywood lids and bases which are normally additional folding edges to assist in compact storage.

NOTE Figure 50(e) shows the collapsible, pallet based, Style 45.

18.3 Construction and materials

18.3.1 Construction

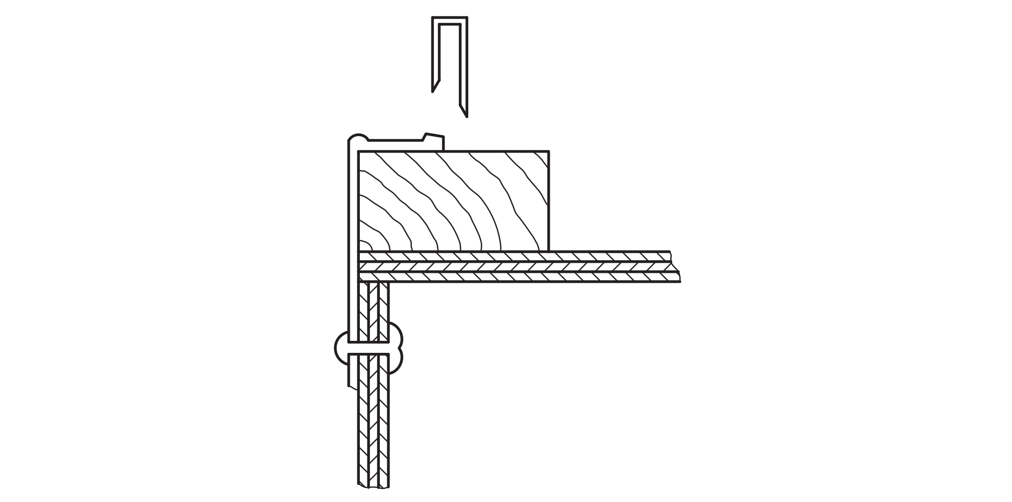
Where practicable, the joints in the metal edging should be positioned towards the centre of the side or the end of the case. Vertical metal edging on the long edges of the panels should be in one piece. Where metal edging is carried around a corner, the horizontal flange should be notched so that the mitre formed on bending overlaps slightly. Metal edging around the top of a case should be fixed so as to allow a fold of at least 15 mm on to the battens of the lid.

Where the dimensions of a case demand the use of more than one piece of metal edging, the pieces used should be of unequal length, the ends overlapped and the joints at each vertical edge staggered. Very short pieces should not be used. A rivet should be placed at all corners where the metal overlaps and also where the edging overlaps at joints, so that the head engages the overlap.

Tenterhooks (see Figure 51), staples and clout nails for closing should be spaced at not more than 70 mm centres. Lid battens should be fixed with 2 mm diameter wire nails (with a minimum clinch of 3 mm) or with 0.9 mm diameter wire staples (with a minimum clinch of 6 mm) driven from the plywood into the batten.

Bases should be fitted with battens and pallet-style constructions to allow fork tine entry for mechanical handling. For details of pallet dimensions, styles and the minimum clearances to facilitate mechanical handling, reference should be made to BS ISO 6780.

Figure 51 **Application of the tenterhook**



18.3.2 Materials

18.3.2.1 Sheet materials

Hardwood plywoods between 3 mm and 6 mm in thickness and softwood plywoods of 8 mm and above should be used.

NOTE Waferboards and oil tempered hardboards can also be suitable.

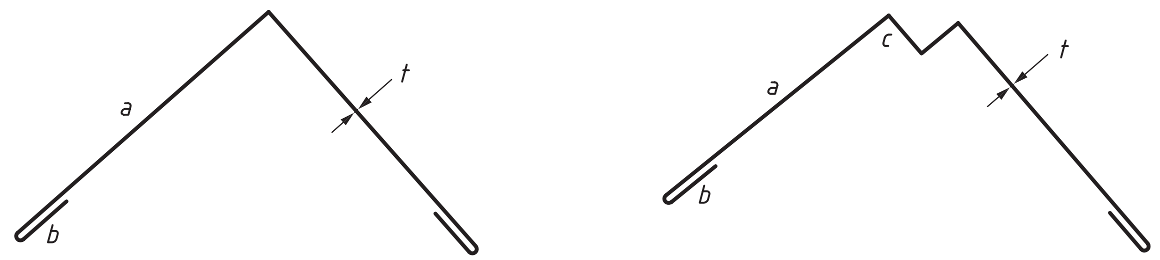
Softwood or low density hardwood battens should be used.

18.3.2.2 Metal edging

Metal edging should be of suitable tinplate and each edge should be folded over a minimum of 3 mm. Hinges should be sufficiently thin to allow for easy collapsing of the case and clearance should be allowed for flat folding. Plastics edging can also be used in place of steel. This is normally thicker.

NOTE 1 Dimensions of the two stock sizes are shown in Figure 52 and the method of use is illustrated in Figure 53.

Figure 52 **Relevant dimensions for the two stock styles of metal edging**



a) fixed metal edging

Key a)

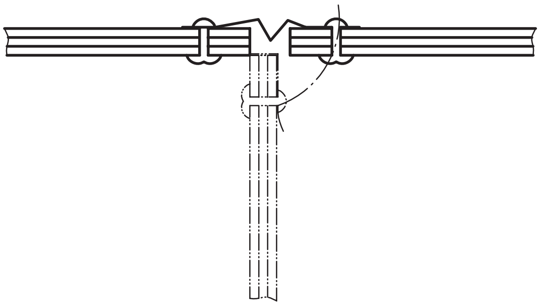
a Size
b Lap
t Thickness

b) foldable metal edging

Key b)

a Size
b Lap
c Fold
t Thickness

Figure 53 **Foldable metal edging in use**



18.3.2.3 Rivets

Steel bifurcated rivets of various diameters are commonly used and should be rust-proofed.

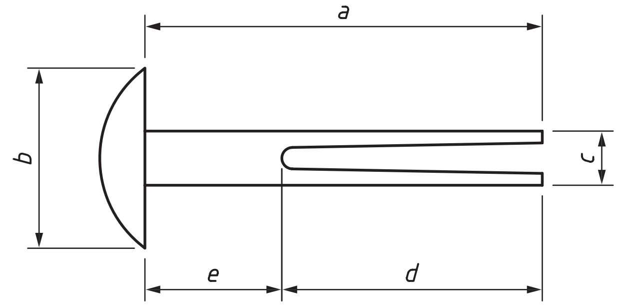
The bifurcated rivet should be manufactured from steel with a pan-head, and should be rust-proofed by a zinc or nickel process if required. To allow for various thicknesses of plywood (or other sheet material) the appropriate length should be chosen, as given in Table 22. The larger diameters of bifurcated rivets should be produced with a longer slot length in order to allow use over a wider range of thickness. The letters a to e in Figure 54 relate to the dimensions in Table 21.

NOTE BS 4894 is the British Standard specification for bifurcated rivets.

Table 21 **Bifurcated rivets for metal edged cases**

Shank length *a* mm	Diameter		Bifurcated slot length *d* mm	Solid shank length *e* mm	Rivet count per kg
	Head *b* mm	Shank *c* mm			
8	7.8	3.8	5	3 to 5	1 110
11	7.8	3.8	6	4 to 8	1 000
16	7.8	3.8	6	8 to 12	770
19	9.6	5.0	13	7 to 15	526

Figure 54 **Dimensions of bifurcated rivets**



18.4 Size limits

The size limits applicable to metal edged cases are given in Table 22.

Table 22 **Size limits for metal edged cases**

Plywood thickness mm	Maximum case volume m^3	Equivalent cube side mm
3.2	0.027	300
4.2	0.064	400
6.3	0.216	600
8.0	1.0	1 000
9.5	2.0	1 260

19 Wirebound cases and crates

19.1 General

The wirebound case- and crate-making system is an assembly system where traditional materials (sawn wood, plywood, etc.) are entirely, or very largely, assembled with a fastening system using various diameters and strengths of wire. Its main advantage is that most designs of wirebound case can be delivered flat and then assembled when required. With many wirebound designs the cases can be collapsed after use and returned to the sender occupying the minimum transport volume. Simple hand tools are supplied to the user for assembly and closure. Sizes vary from very small to medium size, the medium size crates and cases are usually pallet based.

19.2 Construction

A wirebound case is a wooden container of which the sides, top and bottom are stapled or stitched together by several binding wires to form an interlocking framework. There are two categories of wirebound container:

a) allbound (for loads typically under 100 kg);

b) pallet case or crate (for unit loads where mechanical handling is necessary).

The fundamental principle should be to use wire, wood cleats and relatively thin-face materials in order to approach the strength of solid nailed wooden cases, yet maintain lightness and demountability. The strength of the box should be determined primarily by the size of the cleats in the frame, the thickness of the face materials and the number, diameter and method of closure of the binding wires.

NOTE Racking and stacking strength are also affected by whether sheet material (such as plywood) or narrow sawn boards are used.

19.3 Allbound cases and crates

19.3.1 Construction

The allbound case or crate should consist of an interlocking wrap (see Figure 55) to which separate ends should be fixed to form a box. Closure should be effected by folding down the section fitted with wide loops through which the narrow loops are then passed to close the case (see Figure 56).

Binding wires are normally uniformly spaced and each wire should be continuous round the box. For cases of the styles shown in Figure 56, the ends of the wires should be looped to permit passing the loop of the wire on the front of the box through that of the lid and in sufficient length to allow a good downward bend for security. The length of the loop on the downward bend should be not less than 30 mm.

Figure 55 **Allbound wrap before assembly**

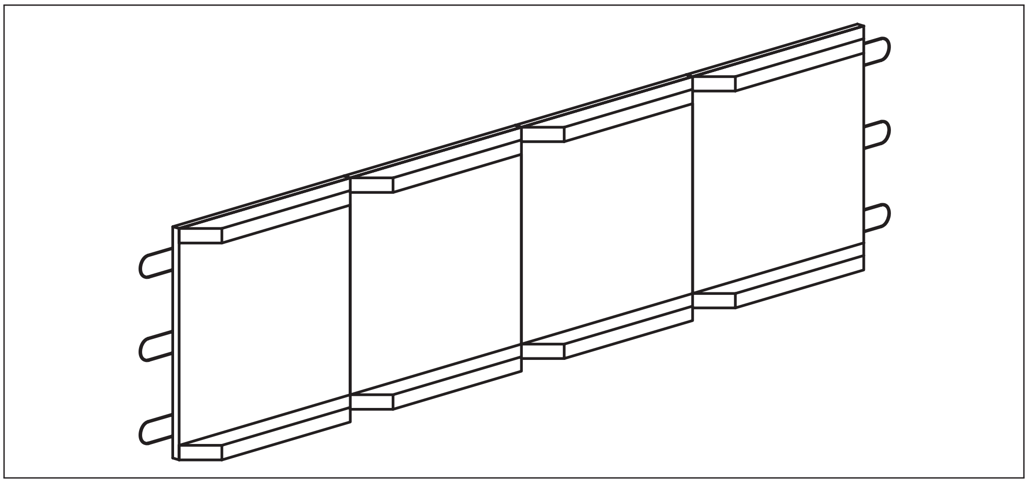
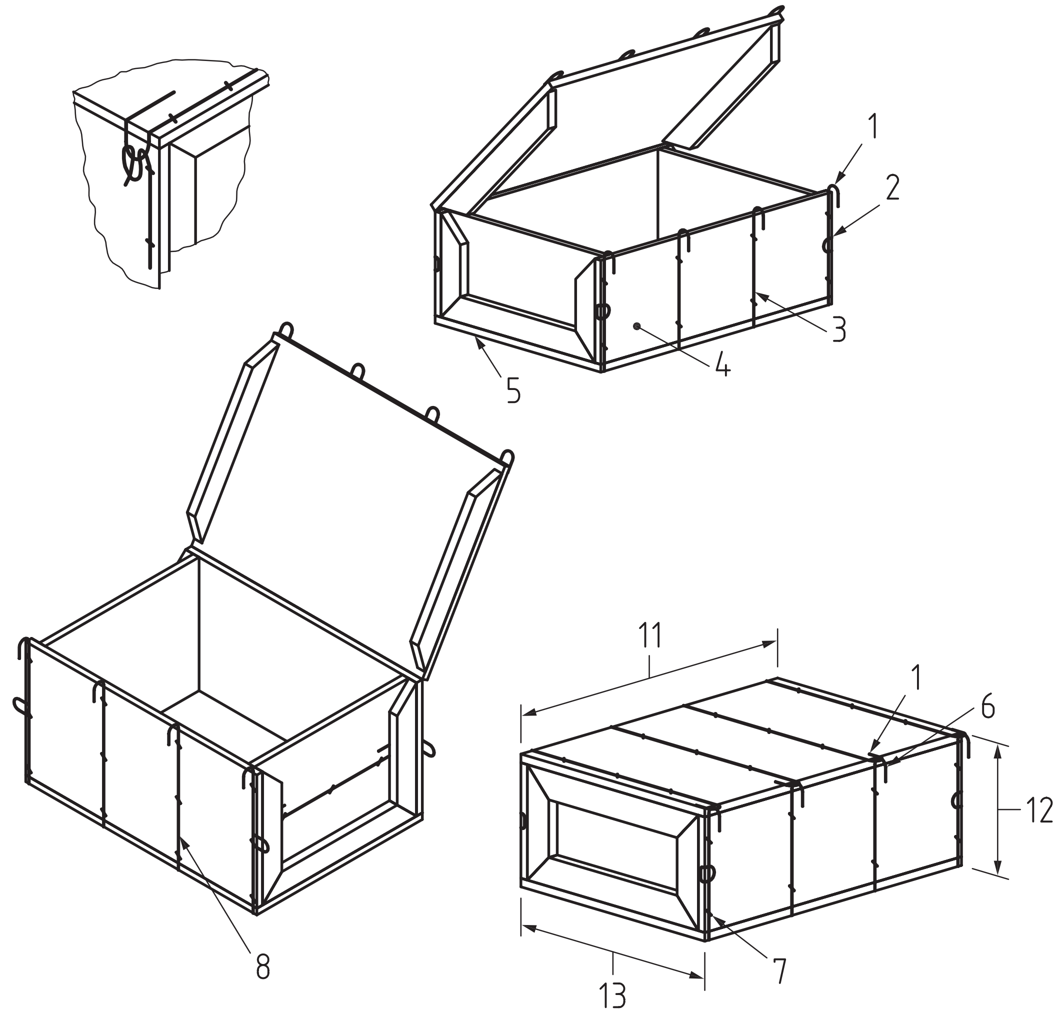
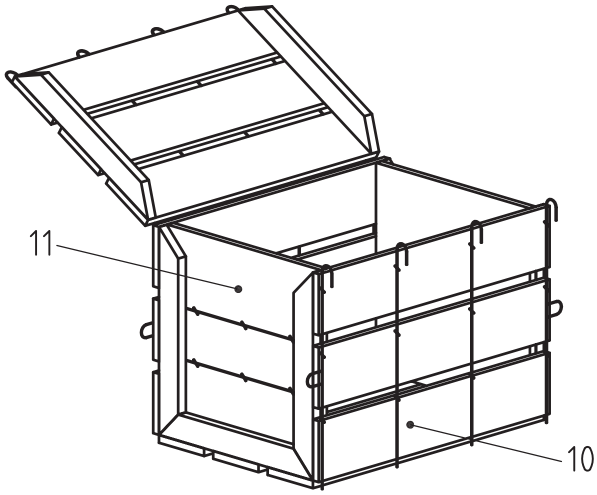


Figure 56 **Styles of allbound cases showing construction details** *(1 of 2)*



a) Style 51 – Plywood case (dimensions are in millimetres)



b) Style 52 – Softwood crate (dimensions are in millimetres)

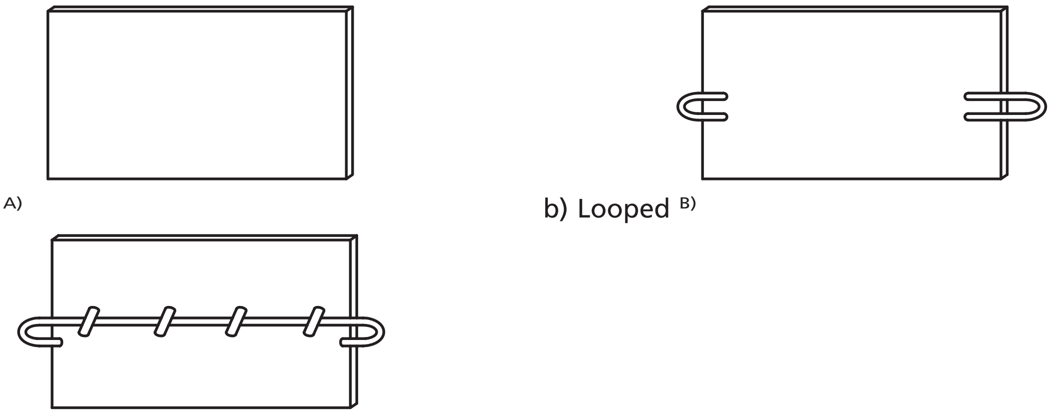
Figure 56 **Styles of allbound cases showing construction details** *(2 of 2)*

Key a)		**Key b)**	
1	Narrow loop	1	Face material, 5.7 mm or 9 mm softwood
2	Cleat and wire	2	Plywood wired end with two wires
3	Wire only		
4	Face material, 4 mm, 5 mm, 6 mm or 9 mm plywood		
5	Cleat (usually) 22 mm × 22 mm		
6	Wide loop		
7	Staple		
8	Binding wire		
9	Length		
10	Height		
11	Width		

19.3.2 Ends

Ends are usually of plywood and various designs should be as shown in Figure 57.

Figure 57 **End styles for allbound boxes**



a) Loose [A)]

b) Looped [B)]

c) Wired [C)]

A) Simplest style but can only be used if a solid object is being packed, e.g. ammunition case.

B) Useful for small quantities where loose items are being packed.

C) The strongest design. It is made on wirebound machinery and can have more than one wore if required.

19.3.3 Corner styles

Corner styles are shown in Figure 58.

Figure 58 **Corner styles for allbound cases and crates**

a) Standard A)

b) Follow-on overlap B)

c) Top and bottom overlap C)

A) Widely used, mainly for open crates and close-boarded boxes.

B) Used to give a neater finish to corners.

C) Used mainly on 9 mm plywood boxes, gives a neater finish and improves stacking strength.

19.3.4 Performance and size restrictions

Allbounds to the minimum specification (i.e. 4 mm hardwood plywood or 5 mm sawn softwood face material) should normally be used to carry anything that two people can comfortably lift between them, typically up to 50 kg. Extra strength should only be added if the product is very dense, or if it is to be subjected to rough handling.

Strength can be achieved by increasing the thickness of the face and end material, increasing the number of cleats and/or increasing the diameter of the wire.

Length restrictions should be 225 mm to 2 300 mm; if either width or height are over 500 mm then a pallet case or pallet crate should be used.

19.4 Wirebound pallet cases and crates

19.4.1 General

In this category the sides should wrap horizontally around a pallet base. The bottom cleat on the wrap should lock into a recess below the pallet top deck boards (see Figure 59). When fastened onto the pallet base, wraps (sides) cannot be moved vertically or horizontally since they become one integral unit.

NOTE 1 A typical wirebound pallet crate (style 53) is shown in Figure 60 and alternative wrap styles are illustrated in Figure 61.

Pallet bases for wirebounds should be designed to provide adequate strength when used as an integral unit with the wrap. They should not be used as separate flat pallets for materials handling.

NOTE 2 Wraps can be made with a follow-on-overlap (see Figure 59). This makes a neater corner, although normally it is only used in conjunction with plywood wirebound cases.

19.4.2 Styles of lids

Alternative lids for wirebound pallet cases and crates are shown in Figure 61.

Figure 59 **Recessed pallet designs used with wirebound pallet cases and crates**

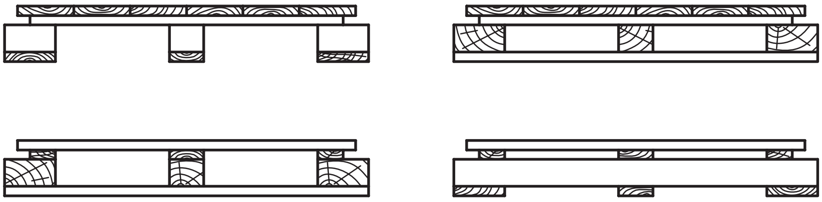
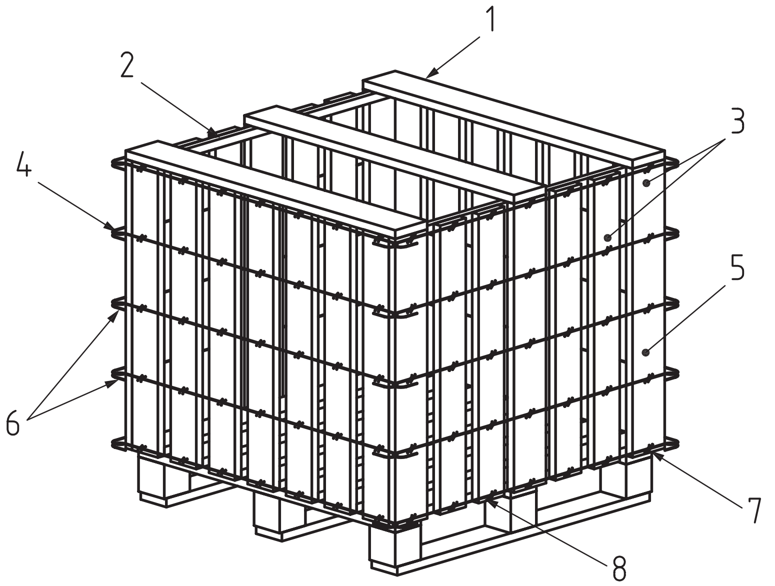


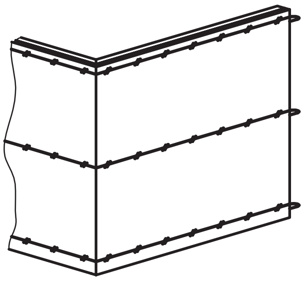
Figure 60 **Style 53, wirebound pallet crate with horizontal binding wires**



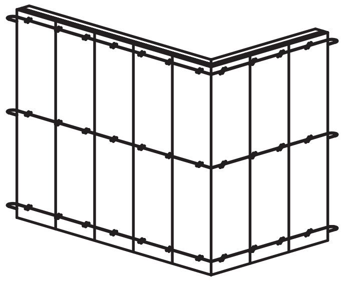
Key

1	Top board	5	Face material
2	Cleat	6	Cleat and wire assembly
3	Wrap	7	Staple
4	Wire only	8	Binding wire

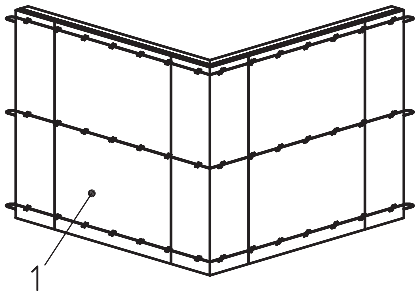
Figure 61 **Alternative styles of wraps (sides)**



a) Plywood or OSB



b) Close-boarded softwood



c) Composite

Key

1 Infill, typically double-wall corrugated fibreboard

NOTE 1 Face material is 4 mm, 5 mm, 6 mm, 9 mm or 12 mm.

NOTE 2 Corner boards are 150 mm × 9 mm softwood.

19.4.3 Performance and size restrictions

For the most common size of 1 200 mm× 1 000 mm× 1 000 mm (length × width × height), examples of maximum stacking capabilities are as follows.

a) Slatted crate: 7 mm softwood face material (see Figure 62):
- three high static;
- two high in transit.

b) Plywood: 4 mm face material [see Figure 62a)]:
- three high static;
- two high in transit.

c) Close-boarded: 9 mm softwood face material [see Figure 62b)]:
- four high static;
- two high in transit.

d) Corrugated composite: 150 mm × 9 mm softwood corner boards [see Figure 62c)]:
- two high static;
- two in transit.

The load carrying and stacking capability of the above designs can be improved by one or more of the following:

- increased face board thickness;
- increased wire diameter, and/or additional wires;

- increased width or number of cleats;
- introduction of corner posts;
- strengthening of the pallet base.

If stack heights in excess of the values given above are required, tests to BS ISO 2234, BS EN 22872 or BS EN 22874 should be carried out.

NOTE Wirebound pallet cases and crates are available up to a maximum length of 6.5 m and a maximum height of 2.3 m.

19.5 Binding wire and staple wire

The characteristics of the binding wires and staple wires, used in the manufacture of wirebound cases and crates, are set out in Table 23 and Table 24 respectively.

Table 23 **Binding wire characteristics**

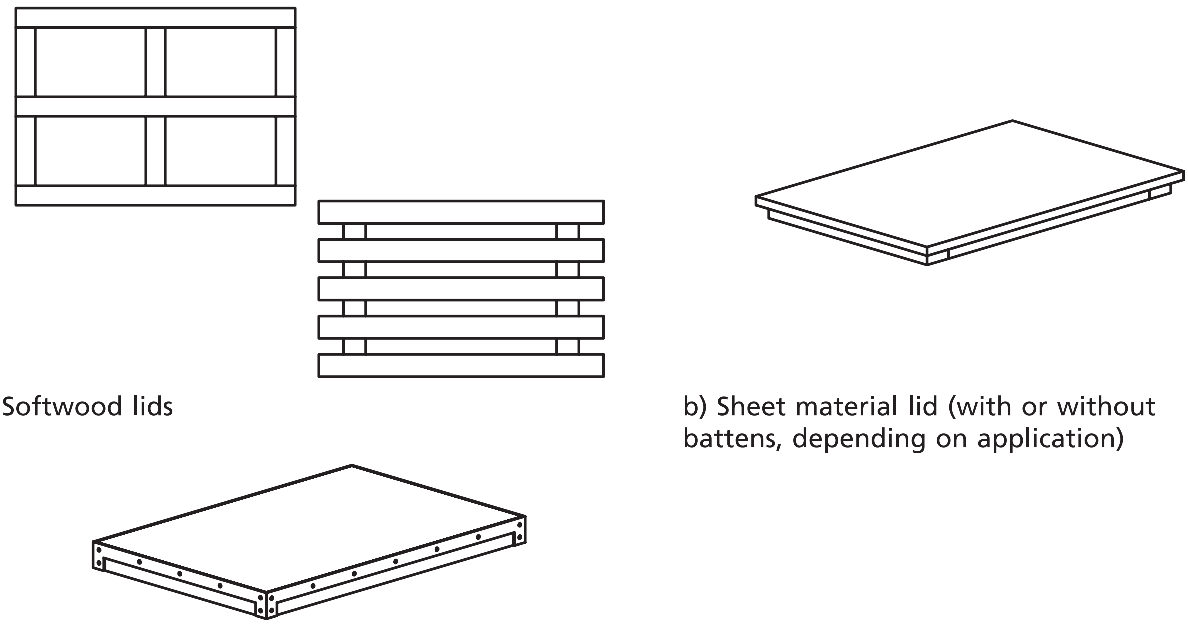
Wire diameter mm	Tensile strength N/mm²	Length per unit mass m/kg	Wire coating
2.00	750 to 900	40	medium galvanized
2.30	700 to 850	30	medium galvanized
2.60	550 to 700	23	medium galvanized

The staple length in Table 24 should be equal to the sum of the binding wire diameter, the staple wire diameter, the face material thickness and the cleat depth (in the case of cleat and wire assembly) plus a minimum clinch of 1.5 mm.

Table 24 **Staple wire characteristics**

Staple length mm	Wire diameter mm	Tensile strength N/mm²	Angle to binding wire degrees	Length per unit mass m/kg	Wire coating
10 to 15	1.00	850 to 1 005	30 to 50	143	heavy galvanized
16 to 35	1.60	850 to 1 005	30 to 50	67	medium galvanized
36 to 48	2.00	850 to 1 005	50	40	medium galvanized

Figure 62 **Alternative lid styles for wirebound pallet cases and crates**



a) Softwood lids

b) Sheet material lid (with or without battens, depending on application)

c) Flanged lid (e.g. riveted plywood or corrugated)

20 Legality of timber products on the market – EU Directive

There is an increasing demand for timber to be purchased from independently certified legal and sustainable sources, meaning that all timber supplied should come from legal and sustainable forests. Local authorities and commercial companies should ensure that timber supplied to them is from sustainable sources and should have proof that the wood in the end product is guaranteed to come from the source claimed. The forest from which the wood comes should be certified as a sustainable source, as well as all those along the wood supply chain to the end product.

NOTE 1 This procedure has now been published as Directive 995/2010 [2], also known as FLEGT (Forest Law Enforcement Governance and Trade compliance). This is not a UK statutory instrument yet but is expected to become so during 2013 and is then going to encompass all sawn and manufactured wood used in export packing as described in this British Standard.

21 Wood packaging recycling

Attention is drawn to the UK Packaging (Essential Requirements) Regulations 2003 [3] on all aspects of wood packaging recycling. The Regulations are derived from European Directive 94/62/EC [4] and assisted by BS EN 13427. Both are concerned with minimizing the impact of packaging and packaging waste on the environment.

NOTE BS EN 13427 covers waste from timber packing (including steel nails and plastic moisture protection), recycling and packaging recovery and lists the set of European standards which give guidance, rules, methods of measurement and threshold limits required to meet 94/62/EC [4].

22 Phytosanitary requirements for imported and exported wood packaging

Phytosanitary requirements are protective measures which should be taken against the introduction into countries of organisms harmful to plants or plant products such as timber and wood sheet materials.

In 2002 the UN Food and Agriculture Organization published ISPM (International Standard for Phytosanitary Measures) No 15, "Guidelines for regulating wood packaging material in international trade" [1], and this document has been implemented by an increasing number of countries since then.

In 2004 the European Union recognized ISPM15 in Directive 2004/102/EC [5]. This Directive relates to phytosanitary control for incoming non-EU wood pallets and packaging (not traffic between EU and Switzerland).

In 2006 the requirements for ISPM15 [1] were published by the Forestry Commission as three statutory instruments:

- the Plant Health (Fees) (Forestry) Regulations 2006 [6];
- the Plant Health (Forestry) (Amendment) Order 2006 [7];
- the Plant Health (Forestry) (Wood Packaging Material Marking) Order 2006 [8].

Annex A (informative) Health and safety

A.1 Irritants

Table A.1 gives a list of adverse health effects in softwood and hardwood irritant species.

Table A.1 **Adverse effects in softwoods and hardwoods** *(1 of 2)*

Timber name	Adverse health effect
Abura/bahia	vomiting
Afrormosia	skin irritation, splinters go septic, nervous system effects
Afzelia/doussie	dermatitis, sneezing
Agba/tola	skin irritation
Alder	dermatitis, rhinitis, bronchial effects
Andiroba/crabwood	sneezing, eye irritation
Ash	decrease in lung function
Avodire	dermatitis, nose bleeds
Ayan/movingui	dermatitis
Basralocus/Angelique	unspecific effects
Beech [A)]	dermatitis, decrease in lung function, eye irritation (possibly from bark lichens)
Birch [A)]	dermatitis on sawing lumber
Bubinga	dermatitis, skin lesions possible
Cedar of Lebanon [B)]	respiratory disorders, rhinitis
Cedar (central/s America) [A)]	allergic contact dermatitis
Cedar (western red) [B)]	shingles, asthma, rhinitis, dermatitis, mucous membrane irritation, central nervous system effects
Chestnut (sweet)	dermatitis (possibly from bark lichens)
Douglas fir [A)] [B)]	dermatitis, splinters go septic, rhinitis, bronchial effects
Ebony	mucous membrane irritation, dermatitis, possibly a skin sensitizer
Freijo/cordial	possibly a skin sensitizer
Gaboon/okoume [A)]	asthma, cough, eye irritation, dermal effects (hands, eyelids)
Gedu nohor/edinam	dermatitis (rare)
Greenheart	splinters go septic, cardiac and intestinal disorders, severe sports goods throat irritation
Guarea	skin and mucous membrane irritation
Gum (southern blue)	dermatitis
Hemlock (western) [B)]	bronchial effects, rhinitis
Idigbo [A)]	possible irritant
Iroko	asthma, dermatitis, nettle rash
Larch [B)]	nettle rash, dermatitis (possibly from bark lichens)
Limba [A)]	splinters go septic, nettle rash, nose and gum bleeding, decrease in lung function
Mahogany	dermatitis, respiratory disorders, mucous membrane irritation
Makore [A)]	dermatitis, mucous membrane and respiratory tract irritation, central nervous system and blood effects
Mansonia	splinters go septic, skin sensitisation, irritation, respiratory disorders, nose bleeds, headache, cardiac disorders
Maple	decrease in lung function
Meranti/lauan (various)	skin irritation
Oak (various)	asthma, sneezing, eye irritation

Table A.1 **Adverse effects in softwoods and hardwoods** *(2 of 2)*

Obeche [A)]	skin and respiratory tract irritation, nettle rash, dermatitis and rails (handling articles), feverish, sneezing, wheezing
Opepe	dermatitis, mucous membrane irritation, central nervous system effects, e.g. giddiness, visual effects, nose bleeds and blood spitting
Padauk	itching, eye irritation, vomiting, swelling (e.g. of eyelids)
Peroba	turnery skin and mucous membrane irritation, systemic effects, e.g. headache, nausea, stomach cramps, weakness, blisters
Pine (many species) [A)] [B)]	skin irritation (e.g. photosensitization); decrease in lung function
Poplar [A)]	sneezing, eye irritation, blisters
Ramin	dermatitis (possibly from bark)
Rosewood (many species)	dermatitis, respiratory disorders.
Sapele [A)]	skin irritation
Spruce (several species) [A)] [B)]	respiratory disorders, possible photosensitization
Teak	dermatitis (potent, even after seasoning) nettle rash, respiratory disorders
Utile	skin irritation
Walnut (not African)	sneezing, rhinitis, dermatitis from nut shells and roots
Wenge	septic splinters, dermatitis, central nervous system effects, e.g. giddiness, drowsiness, abdominal cramps
Whitewood (American) [A)]	dermatitis
Yew [B)]	dermatitis, systemic effects, e.g. headache, blood pressure drop, cardiac effects

[A)] Used for plywood manufacture.

[B)] Softwood

Annex B (informative) Table sizes for skids sills and rails

B.1 Skid, sill and rail working loads

The methods for calculating skid sizes are given in Clause **14** and tables of sizes are shown in Tables B.1 and B.2. Each method yields a skid of equivalent strength.

NOTE 1 In Table B.1 the following values for the moduli of elasticity and rupture are assumed, allowing for short term load-sharing factors.

- *Modulus of rupture = 12 N/mm².*

The values given in Table B.1 are computed to give the safe working load with a maximum deflection not exceeding 3% of the total span. Suitable timbers will normally be of any sound grade (excluding rot and decay) meeting GS or MGS.

Table B.2 gives safe working loads for spliced skids and rails.

NOTE 2 In Table B.2 the following values for the moduli of elasticity and rupture are assumed, allowing for short term.load-sharing factors.

- *Modulus of rupture = 8 N/mm².*

The values given in Table B.2 are computed to give the safe working load in skids spliced with not less than four laminations, with a maximum deflection not exceeding 3% of the total span when using nailing that meets BS ISO 15629 "medium strength" and with sufficient nail density at splice ends. Since packaging manufacturers usually make their own spliced skids, suitable timbers will normally be of any sound grade (excluding rot and decay), even though they might not meet the working strengths given in Table 3, due to the minimizing defect effect by laminating.

Table B.1 **Skid, sill and rail working loads** *(1 of 5)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
0.5	200	75	43
0.5	500	75	109
0.5	600	75	130
0.5	700	100	86
0.5	1 000	100	122
0.5	1 300	100	159
0.5	1 600	100	196
0.5	2 000	125	157
0.5	2 400	125	188
0.5	2 800	125	219
0.5	3 000	125	235
0.5	3 100	125	243
0.5	3 200	150	174
0.5	4 000	150	218
0.5	5 000	150	272
0.5	5 500	150	299
0.5	5 600	175	224
0.5	6 000	175	240
0.5	7 000	175	280
0.5	8 000	175	320
0.67	300	75	87
0.67	500	75	145
0.67	600	100	98
0.67	900	100	146
0.67	1 000	100	163
0.67	1 200	100	196
0.67	1 300	125	136
0.67	2 000	125	209
0.67	2 300	125	240
0.67	2 400	150	174
0.67	3 000	150	218
0.67	3 500	150	254
0.67	4 000	150	290
0.67	4 100	150	298
0.67	4 200	175	224
0.67	5 000	175	266
0.67	6 000	175	320

Table B.1 **Skid, sill and rail working loads** *(2 of 5)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
0.67	6 500	175	346
0.67	6 600	200	270
0.67	7 000	200	286
0.67	8 000	200	326
0.67	9 000	200	367
0.67	9 700	200	396
0.67	9 800	225	316
0.67	10 000	225	322
0.83	400	75	145
0.83	500	100	102
0.83	900	100	239
0.83	1 000	125	130
0.83	1 500	125	196
0.83	1 900	125	248
0.83	2 000	150	182
0.83	3 000	150	272
0.83	3 000	150	299
0.83	3 400	175	226
0.83	4 000	175	266
0.83	5 000	175	334
0.83	5 200	175	346
0.83	5 300	200	270
0.83	6 000	200	306
0.83	7 000	200	358
0.83	7 800	200	398
0.83	7 900	225	317
0.83	8 000	225	322
0.83	9 000	225	363
0.83	10 000	225	403
1	300	75	130
1	400	100	98
1	600	100	146
1	800	100	196
1	900	125	141
1	1 000	125	157
1	1 200	125	188
1	1 500	125	235
1	1 600	150	174
1	2 000	150	218
1	2 700	150	294
1	2 800	175	224
1	3 000	175	240
1	4 000	175	320
1	4 300	175	344

Table B.1 **Skid, sill and rail working loads** *(3 of 5)*

Subspan	Total load of contents	Depth of skids	Total breadth of skids
m	kg	mm	mm
1	4 400	200	270
1	5 000	200	306
1	6 000	200	367
1	6 500	200	398
1	6 600	225	319
1	7 000	225	338
1	8 000	225	387
1	9 000	225	436
1	9 200	225	446
1	9 300	250	365
1	10 000	250	392
1.17	600	100	171
1.17	700	125	128
1.17	1 000	125	182
1.17	1 300	125	238
1.17	1 400	150	178
1.17	2 000	150	254
1.17	2 300	150	292
1.17	2 400	175	224
1.17	3 000	175	280
1.17	3 700	175	346
1.17	3 800	200	271
1.17	4 000	200	286
1.17	5 000	200	358
1.17	5 500	200	393
1.17	5 600	225	316
1.17	6 000	225	338
1.17	7 000	225	395
1.17	7 900	225	446
1.17	8 000	250	366
1.17	9 000	250	412
1.17	10 000	250	458
1.33	700	125	146
1.33	1 000	125	209
1.33	1 100	125	230
1.33	1 200	150	174
1.33	2 000	150	290
1.33	2 100	175	224
1.33	3 000	175	320
1.33	3 200	175	342
1.33	3 300	200	270
1.33	4 000	200	326
1.33	4 800	200	392
1.33	4 900	225	316

Table B.1 **Skid, sill and rail working loads** *(4 of 5)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
1.33	5 000	225	322
1.33	6 000	225	387
1.33	6 900	225	446
1.33	7 000	250	366
1.33	8 000	250	418
1.33	9 000	250	470
1.33	9 500	250	497
1.67	1 000	150	182
1.67	1 600	150	290
1.67	1 700	175	226
1.67	2 000	175	266
1.67	2 600	175	346
1.67	2 700	200	275
1.67	3 000	200	306
1.67	3 900	200	398
1.67	4 000	225	322
1.67	5 000	225	403
1.67	5 500	225	444
1.67	5 600	250	366
1.67	6 000	250	392
1.67	7 000	250	458
1.67	7 600	250	497
1.83	1 500	150	299
1.83	1 600	175	234
1.83	2 000	175	294
1.83	2 300	175	338
1.83	2 400	200	270
1.83	3 000	200	337
1.83	3 500	200	393
1.83	3 600	225	319
1.83	4 000	225	355
1.83	5 000	225	444
1.83	5 100	250	366
1.83	6 000	250	431
1.83	6 900	250	496
2	2 000	175	320
2	2 100	175	336
2	2 200	200	270
2	3 000	200	367
2	3 200	200	392
2	3 300	225	319
2	4 000	225	387
2	4 600	225	446

Table B.1 **Skid, sill and rail working loads** *(5 of 5)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
2	4 700	250	369
2	5 000	250	392
2	6 000	250	470
2	6 300	250	494
2.17	2 100	200	278
2.17	3 000	200	398
2.17	3 100	225	325
2.17	4 000	225	419
2.17	4 200	225	441
2.17	4 300	250	365
2.17	5 000	250	425
2.17	5 800	250	493
2.33	1 900	200	271
2.33	2 000	200	286
2.33	2 700	200	386
2.33	2 800	225	316
2.33	3 000	225	338
2.33	3 900	225	441
2.33	4 000	250	380
2.33	5 000	250	458
2.33	5 400	250	494

Table B.2 **Spliced skid, sill and rail working loads** *(1 of 4)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
0.5	200	75	65
0.5	300	100	55
0.5	600	100	110
0.5	700	125	82
0.5	1 000	125	118
0.5	1 300	125	153
0.5	1 400	150	114
0.5	2 000	150	164
0.5	2 200	150	180
0.5	2 300	175	138
0.5	3 000	175	180
0.5	3 600	175	216
0.5	3 700	200	170
0.5	4 000	200	184
0.67	300	100	74
0.67	500	100	123

Table B.2 **Spliced skid, sill and rail working loads** *(2 of 4)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
0.67	600	125	94
0.67	900	125	141
0.67	1 000	150	109
0.67	1 700	150	185
0.67	1 800	175	134
0.67	2 000	175	160
0.67	2 700	175	216
0.67	2 800	200	172
0.67	3 000	200	184
0.67	4 000	200	245
0.67	4 100	225	199
0.67	5 000	225	242
0.83	400	100	123
0.83	500	125	99
0.83	700	125	137
0.83	800	150	109
0.83	1 000	150	136
0.83	1 300	150	177
0.83	1 400	175	140
0.83	2 000	175	200
0.83	2 100	175	210
0.83	2 200	200	169
0.83	3 000	200	230
0.83	3 200	200	245
0.83	3 300	225	200
0.83	4 000	225	242
0.83	4 600	225	279
0.83	4 700	250	231
0.83	5 000	250	245
0.83	6 000	250	294
0.83	6 300	250	309
1	400	125	94
1	600	125	141
1	700	150	114
1	1 000	150	164
1	1 200	175	144
1	1 800	175	216
1	1 900	200	175
1	2 000	200	184
1	2 700	200	248
1	2 800	225	203
1	3 000	225	218
1	3 800	225	276
1	3 900	250	230

Table B.2 **Spliced skid, sill and rail working loads** *(3 of 4)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
1	4 000	250	235
1	5 000	250	294
1	5 300	250	312
1.17	600	150	114
1.17	900	150	172
1.17	1 000	175	140
1.17	1 500	175	210
1.17	1 600	200	172
1.17	2 000	200	215
1.17	2 300	200	247
1.17	2 400	225	203
1.17	3 000	225	254
1.17	3 300	225	280
1.17	3 400	250	233
1.17	4 000	250	275
1.17	4 500	250	309
1.33	800	150	174
1.33	900	175	144
1.33	1 000	175	160
1.33	1 300	175	208
1.33	1 400	200	172
1.33	2 000	200	245
1.33	2 100	225	203
1.33	3 000	250	235
1.33	3 900	250	306
1.5	800	175	144
1.5	1 000	175	180
1.5	1 200	175	216
1.5	1 300	200	179
1.5	1 800	200	248
1.5	1 900	225	207
1.5	2 000	225	218
1.5	2 500	225	273
1.5	2 600	250	230
1.5	3 000	250	265
1.5	3 500	250	309
1.67	1 100	200	169
1.67	1 600	200	245
1.67	1 700	225	206
1.67	2 000	225	242
1.67	2 300	225	279
1.67	2 400	250	235

Table B.2 **Spliced skid, sill and rail working loads** *(4 of 4)*

Subspan m	Total load of contents kg	Depth of skids mm	Total breadth of skids mm
1.67	3 000	250	294
1.67	3 100	250	304
1.83	1 400	200	236
1.83	1 500	225	200
1.83	2 000	225	266
1.83	2 100	225	280
1.83	2 200	250	237
1.83	2 800	250	302
2	100	100	74
2	200	125	94
2	300	125	141
2	400	150	131
2	500	150	164
2	600	175	144
2	900	175	216
2	1 900	225	276
2	2 000	250	235
2	2 600	250	306
2.17	1 700	225	268
2.17	1 800	250	230
2.17	2 000	250	255
2.17	2 400	250	306
2.33	2 000	250	275
2.33	2 200	250	302

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