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THE BENDING OF TIMBER

The methods principally used for producing curved timber articles are bending, laminating and cutting from solid pieces. Of these methods, bending is the one most often used because it offers simplicity, economy and no reduction in strength due to cross grain. Although wood in its natural seasoned state cannot usually be bent to a small radius of curvature without fracturing, wood that has been rendered plastic by softening will usually bend with little or no degrade.

SELECTION AND PREPARATION

Careful selection of the timber to be bent is most important if the percentage of failures is to be kept to a minimum.

Species

The selection of timber species depends on the intended use, as well as the radius of the bend required. Factors such as weight, appearance, colour, and wearing qualities should all be considered, as well as the bending quality of the timber, before a choice of species can be made.

Availability of the various species must also be kept in mind. For a bend which is not too severe, many of the commonly available timbers will be satisfactory and there would be no advantage in paying more for difficult to get species simply because of their superior bending qualities.

At the conclusion of this publication, a list of the bending properties of various New South Wales species is given.

Selection of timber

Once you have decided on a species, it must be realised that not all timber of that species will be uniform and that the actual material to be bent must be carefully chosen, paying particular attention to several factors. Straightness of grain is essential for sharp bends and generally the timber chosen should be free from sloping or interlocked grain.

Knots should also be avoided, although experience will show that in some species the presence of small knots will be acceptable. If small knots are unavoidable they should be placed on the outside, or convex part of the bend, and efficient strapping must be used.

Backsawn rather than quatersawn material should generally be chosen, particularly in material with prominent medullary rays as they may cause wrinkling on the inner surface of quartersawn boards.

Moisture content

There is no complete answer to the question of optimum moisture content of timber to be bent. The higher the moisture content the more likely that crumpling will occur on the inner face of the bend. Alternatively, if timber is too dry it is likely failure will occur on the outside face of the bend where the timber is in tension. Most species seem to bend best at a moisture content of around 20-25 per cent and this range should be taken as a guide when selecting timber.

TIMBER PREPARATION

Any preparation that can be done prior to steaming is a great advantage. Time taken before steaming gives greater working time whilst the timber is still hot.

Holes for bolts and screws should be pre-bored at the end that will be attached to the job. This then provides an anchor point. Other fastening holes can be pre-bored, but care must be taken to retain strength where stress and strain occur.

In forming a bend, the degree to which the timber can be bent will depend largely on the thickness of the timber. Before bending, the timber should be dressed as closely as possible to the required thickness. Allowances for shrinkage and final dressing after bending should be kept to an absolute minimum.

Smooth finishing of the timber before bending is desirable because wherever there are any sawmarks or nicks in the timber there will be concentration of stresses from which cracks causing subsequent failure may spread.

SOFTENING OF TIMBER

Timber is most commonly softened by steaming, the significant part of the treatment being the heating of the timber to a temperature close to that of boiling water. Steaming is usually carried out at atmospheric pressure, about one hour of steaming timber being allowed per 25 mm of thickness. It is important that very long periods of steaming do not occur as they are liable to increase the moisture content considerably, thus accentuating difficulties such as shrinkage, checking, and warping during re-drying. Over-softening may also adversely affect the strength of the timber.

Steaming chambers are simply reasonably steam-tight boxes of sufficient size to accommodate the stock to be bent. If the chamber is made of wood it will have only a short service life unless lined with sheet metal, copper, or muntz metal - these being the most satisfactory. Zinc or galvanised iron should to be avoided because acids extracted from the wood attack these metals. Chambers can also be built from concrete, brick, or riveted or welded boiler plate. All these materials should be given several coats of a heavy bituminous paint to prevent corrosion. All condensed moisture should drain away rapidly.

Other methods of softening timbers have been suggested but these are generally not as satisfactory as steaming. A dry heat, as from hot air, will cause excessive drying of the timber and probably result in checking. Heating by immersion in boiling water is undesirable for several reasons: the moisture content will rise causing difficulties in re-drying, the water may cause staining of the timber and far more heat is required to boil a vat of water than to heat a steam chamber. Other methods of softening timber such as chemical soaking or impregnation have so far not given sufficiently good results to warrant recommendation.

PRINCIPLES OF WOOD BENDING

When a piece of timber is bent, the two faces of the bend will no longer be equal in length due to compressive forces causing fibres on the concave face to shorten and tensile forces causing fibres on the convex face to stretch. Only along the so-called "neutral axis" will there be no change in length and hence no stressing of the fibres. In its natural state, wood exhibits elastic properties over a limited stress range. If this limiting stress is not exceeded in a bend, the piece of timber will return to its original state; if the limiting stress value is exceeded, permanent deformation of the piece will occur, generally in the form of fractures that first appear on the stretched outer face.

Most common timbers in their natural state cannot be permanently bent to an appreciably small radius of curvature without either fracturing or requiring mechanical restraint. However, many timbers when subjected to softening processes, such as steaming, become semi-plastic, mainly due to their compressibility being greatly increased. Although the tensile properties of the timber are not greatly improved by this method, much sharper radii can be produced due to the larger amount of timber that is caused to undergo compression. In a bend made from treated wood, the "neutral axis" is forced to move towards the convex surface so that the amount of tension occurring in the piece is significantly reduced. In order to achieve the smallest possible radius of curvature in a bend, it is necessary to impose the maximum possible compression on the concave face without at the same time inducing sufficient tensile stress at the convex face to cause the fibres to fracture. This is the main principle underlying the method of bending timber by using a *restraining strap*.

With this method, the amount of stretch occurring in the convex face is mechanically limited by means of a supporting band placed along the face and attached to it in a manner that prevents stretching.

Normally, this band consists of a length of thin steel of the same width as the piece to be bent to which are fitted steel blocks or angles that fit closely to the ends of the piece of timber being bent. If the end-stops fit closely, no stretching of the fibres can take place during the bending of the timber due to the restraint imposed by the strap and the severity of the bend will be limited by the amount of compression that can take place.

In practice, a certain amount of stretch is allowed to take place and the steel restraining strap is often fitted with adjustable end-stops so that the amount of stretch can be regulated but still kept below the point at which fracture will occur. The end-stops are usually made adjustable by means of heavy screws passing through the end-fittings attached to pressure plates at their midpoint (see Figure 1). These adjustable plates also ensure that any discrepancies in length of the stock to be bent can be accommodated.

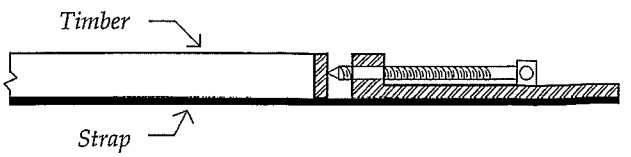

Figure 1.

The strap should be strong enough to take up any forces encountered in bending without stretching and yet should not increase to any great extent the effect required to make the bend. A common thickness for use in small bends is 0.8 mm.

Usually a lever is attached to the strap to facilitate bending. This may take the form of a simple or a reversed lever. The reversed lever is best as it enables the point of application of the force to vary as the bend proceeds (Figure 2).

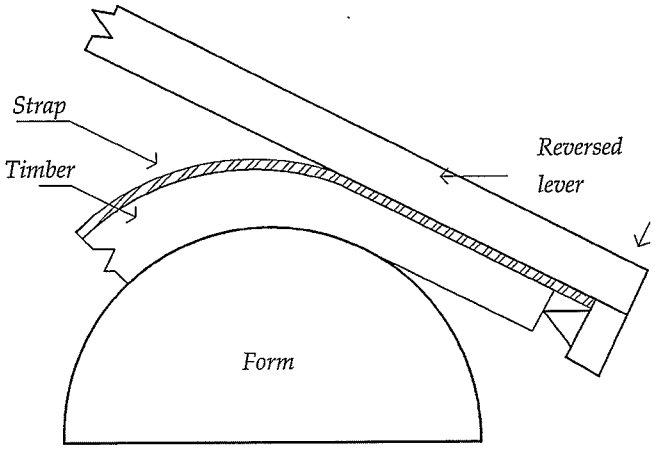

Figure 2.

With equipment such as this, failures due to tensile forces should be minimal. Failures due to compression can be reduced by careful selection of stock and the determination, by experience, of the maximum radial pressure able to be applied without causing fractures.

A form, or mould, is usually employed to ensure that the bend takes the required shape. Since bends usually straighten to some extent when they are released from restraint the form should be shaped to a slightly sharper radius than is finally required (Figure 3).

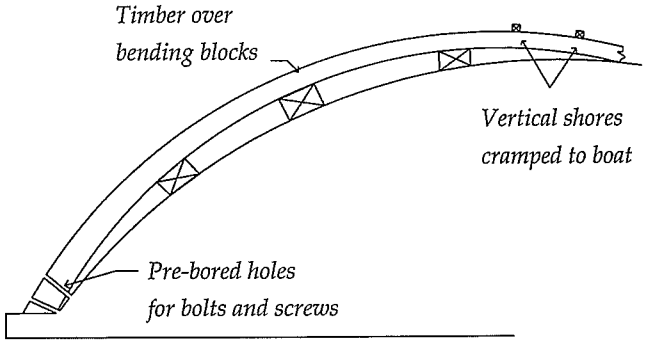

Figure 3. Typical method of bending timber sponsons around boats. Initial over-bending will be corrected when sponson is fastened to boat.

SETTING AND DRYING

Setting of a bend takes place as the timber cools and is usually complete by the time the timber returns to room temperature. During this time it is advisable that some provision be made for clamping the bend to the form, or alternatively some self-contained restraining system be devised so the restrained bend can be removed from the form to set.

Once setting has taken place the wood must be seasoned either in a kiln or drying-room, or under normal atmospheric conditions. If drying is carried out in a kiln care should be taken that no steam treatment for stress removal is given as this will cause the bend to open out. Once a bend has dried and set it will remain stable unless subjected to large fluctuations in temperature and humidity. In tropical climates this can be a problem and care should be taken to apply a suitable coating to the wood to protect it from excessive moisture changes.

LAMINATION

Since the thickness of a piece of timber affects the radius of curvature to which it can be bent, difficult bends are often manufactured by lamination. An example of this used to be tennis racquet frames where a number of thin laminated strips were used.

Strips can be bent simultaneously or individually. In the former case, glue is spread on the laminations which are then bent in the press and restrained until the glue is set. This method is only suitable for very thin strips. With thick laminations, pre-bending is necessary and the strips are glued after bending.

In both forms of lamination it is generally recommended that timber be dried to a moisture content of less than 15 per cent otherwise gluing may be ineffective and stresses due to shrinkage could occur during drying.

The successful lamination of bends is a job complicated by considerations such as the type of glue to be used and whether or not the timber requires softening before bending. Further advice should be sought before this type of bending is attempted.

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THE BENDING PROPERTIES OF TIMBER OBTAINABLE IN NEW SOUTH WALES

Classification		Common name	Botanical name
Very good	(ii)	Beech, myrtle	*Nothofagus cunninghamii*
	(iii)	Oak, northern silky	*Cardwellia sublimis*
	(ii)	Pine, celerytop	*Phyllocladus aspleniifolius*
	(ii)	Pine, huon	*Dacrydium franklinii*
	(ii)	Pine, King William	*Athrotaxis selaginoides*
	(i)	Pine, radiata	*Pinus radiata*
	(iii)	Quandong, silver	*Elaeocarpus grandis*
Good	(i)	Ash, alpine	*Eucalyptus delegatensis*
	(i)	Ash, mountain	*Eucalyptus regnans*
	(iii)	Ash, silver	*Flindersia bourjotiana*
	(i)	Ash, silvertop	*Eucalyptus sieberi*
	(iii)	Ash, southern silver	*Flindersia schottiana*
	(ii)	Blackwood	*Acacia melanoxylon*
	(ii)	Gum, manna	*Eucalyptus viminalis*
	(ii)	Gum, mountain grey	*Eucalyptus cypellocarpa*
	(i)	Gum, spotted	*Eucalyptus maculata*
	(iii)	Mahogany, rose	*Dysoxylum fraseranum*
	(i)	Messmate	*Eucalyptus obliqua*
	(ii)	Stringybark, red	*Eucalyptus macrorhyncha*
	(ii)	Wattle, Silver	*Acacia dealbata*
	(iii)	Yellowwood	*Flindersia oxleyana*
Fair	(iii)	Alder, rose	*Ackama australiensis*
	(i)	Blackbutt	*Eucalyptus pilularis*
	(iii)	Bollywood	*Litsea reticulata*
	(ii)	Gum, river red	*Eucalyptus camaldulensis*
	(i)	Karri	*Eucalyptus diversicolor*
	(ii)	Kauri, north Queensland	*Agathis palmerstoni*
	(iii)	Silkwood, red	*Lucuma galactoxylon*
	(ii)	Stringybark, white	*Eucalyptus eugenioides*
	(i)	Tallowwood	*Eucalyptus microcorys*
Poor	(iii)	Ash, crow's	*Flindersia australis*
	(ii)	Box, coast grey	*Eucalyptus bosistoana*
	(ii)	Box, yellow	*Eucalyptus melliodora*
	(iii)	Cheesewood, white	*Alstonia scholaris*
	(i)	Gum, rose	*Eucalyptus grandis*
	(ii)	Ironbark, red	*Eucalyptus sideroxylon*
	(ii)	Mahogany, southern	*Eucalytpus botryoides*
	(iii)	Maple, Queensland	*Flindersia brayleyana*
	(i)	Pine, hoop	*Araucaria cunninghamii*
	(iii)	Silkwood, bolly	*Crytocarya oblata*
	(ii)	Stringybark, yellow	*Eucalyptus muelleriana*
	(iii)	Walnut, yellow	*Beilschmiedia bancroftii*

(i) Commonly available in commercial quantities
(ii) Limited occurrence as single species
(iii) Rainforest - not usually obtainable

Note: Many of the above timbers listed as (ii) and (iii) may be available in small quantities from specialist suppliers while not all of those nominated as (i) will be available 'off the shelf' and may require ordering well ahead of time.