Wood Seasoning

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Wood Seasoning Discipline

The process of seasoning is essentially one of removing moisture from timber.

Seasoning as applied to wood is primarily a drying process.

Freshly felled timber contains a large quantity of moisture, the major portion of which has to be removed before the timber is fit for use for most purposes

Advantages of Seasoning

- Seasoning reduces the likelihood of mould, stain, or decay.
- Seasoning reduces weight and thereby reduces transportation and handling costs.
- As wood dries, most of its strength properties also improve.
- The shrinkage that accompanies drying takes place before the wood is used as a product.

- Strength of joints made with nails and screws is greater in dried wood than in green.
- Wood must be relatively dry before it can be glued or treated with preservatives and fire retardant chemicals.
- Drying improves finishing characteristics of wood.

How moisture is calculated ?

$$\% MC = \frac{(\text{initial weight} - \text{oven dry weight})}{\text{oven dry weight}} \times 100$$

A laboratory oven used for determining moisture content in wood samples

Maximum permissible moisture content of timber for different end uses

Use	Moisture content percent (Max).			
	Zone I	Zone II	Zone III	Zone IV
	Average Relative Humidity of the zone			
	40%	40-50%	50-67%	>67%
Aircraft	12	12	14	15
Agriculture implements	12	14	16	16
Ammunition boxes	10	12	14	15
Beams and rafters	12	14	17	20
Boot lasts	10	12	14	16

Doors and windows **(a) 50 mm and above in thickness** **(b) thinner than 50 mm**	**10** **08**	**12** **10**	**14** **12**	**16** **14**
Electrical industry	**10**	**12**	**14**	**15**
Flooring strips for general purpose	**08**	**10**	**10**	**12**
Furniture and cabinet making	**10**	**12**	**14**	**15**
Handles	**12**	**12**	**114**	**15**
Rifle parts and gun stocks	**08**	**10**	**12**	**12**
Shuttles and bobbins	**08**	**10**	**12**	**12**

Sports goods, umbrellas and sticks	**10**	**12**	**14**	**16**
Ship and boat building: **Deck** **Frame** **Planking**	 **10** **12** **12**	 **12** **14** **14**	 **12** **16** **14**	 **14** **18** **16**
Toys, turnery, carving, clocks, brushes, picture frames, brooms, cigar boxes, pens, pencils, mathematical and musical instruments and household goods	**08**	**10**	**12**	**12**

Factors which affect drying rate of timber

The rate of drying of wood is governed by an interaction of the external drying conditions, viz., temperature, relative humidity, rate of air circulation, and the rate of moisture diffusion within the wood, as detailed below-

Temperature: If relative humidity is kept constant, the higher is temperature the higher is drying rate. Temperature influences the drying rate by increasing the moisture-holding capacity of air, as well as by accelerating the rate of diffusion of moisture through the wood.

Relative Humidity: If temperature is kept constant, lower relative humidity result in higher drying rates. This is affected by increased moisture gradient in wood, resulting from the reduction of moisture content of surface layers when the relative humidity of air is reduced.

Air circulation: With constant temperature and relative humidity, the higher possible drying rate is obtained by rapid circulation of air across the surface of the wood. This is brought about by the rapid removal of moisture evaporating from the wood, so that the relative humidity of air in contact with wood is not allowed to rise beyond the relative humidity being maintained in the body of the drying air.

Species: Some species dry much faster than others. This is mainly related to the resistance which wood offers to moisture diffusion, which is governed by the dimensions, alignment and structure of capillary system of wood, and the nature and extent of plugging of this structure by gums, extractives, organic growth like tyloses, pit aspiration, etc.

Initial moisture content: The amount of moisture contained in wood affects the time required to bring it to given moisture content. As a general rule, wood dries at a faster rate when green. The rate decreases with decrease of moisture content under constant drying conditions.

Grain direction: Wood dries much more rapidly in the longitudinal direction than in transverse direction. The rate of drying from end-grain is 10 to 15 times faster than from the radial or tangential surfaces. In practice, however, timber is mostly sawn with its length conforming to the general direction of grain and with the width and thickness transverse to the grain. Because of the large difference between longitudinal and transverse dimensions, drying of timber in common commercial size occurs mostly from its lateral faces by transverse movement rather than from the end-grain faces by longitudinal movement of moisture

How wood dries ?
What is free water ?
What is bound water ?
What is FSP ?

Moisture in Wood

Fresh timber contains an appreciable amount of water, as much as two to three times its oven-dry weight.

The larger part of this moisture is in the cell cavity (known as lumen) as free water and the rest in the cell walls as bound water chemically bonded with wood substance.

Freshly cut green timber begins to lose moisture as soon as it is exposed to atmosphere. The free water is the first to leave and after it the bound water follows.

The point at which the cell cavities no longer contain free water is called the fibre saturation point (FSP). Shrinkage of wood starts on drying only below this point and is proportional to the loss in bound water. For most of the Indian woods the FSP lies between 25 – 30 % moisture content.

Wood is a hygroscopic material, and at any given combination of temperature and relative humidity, it attains a corresponding moisture content termed as equilibrium moisture content. Higher equilibrium moisture contents are associated with higher humidity.

Below the FSP, the shrinkage in wood is not equal in all directions because of the anisotropic nature of wood. The shrinkage along the grain is negligible. Across the grain it is considerable and about twice as much in the tangential direction as in the radial direction. The inequality in shrinkage in the three directions, at right angles to each other, set up strains, which, if excessive, cause cracking and warping of the wood. These can be minimised by drying the wood with care. The table below gives an idea regarding shrinkage of some of the Indian wood species –

Drying of timber sections is largely a diffusion-controlled phenomenon, involving the considerable resistance of the capillary structure of the wood to the passage of moisture. Drying time is also prolonged due to the necessity of humidity control for avoiding cracking and splitting, and permissible temperatures (especially for hardwoods) have to be limited to 40^0C – 75^0C for control of collapse and warping.

For the purpose of seasoning, timbers are classified into three classes depending upon their behaviour with respect to cracking and splitting, and drying rate (IS 1141:1993)

Class A (highly refractory woods): these are slow drying timbers and difficult to season free from cracking and splitting. Examples are heavy structural; Timbers, such as sal (*Shorea robusta*) and laurel (*Terminalia alata*)

Class B (moderately refractory woods): these timbers may be seasoned free from surface and end cracking within reasonable short period periods, given a little protection against rapid drying conditions. Examples are moderately heavy furniture class of timbers, such as shesam (*Delbergia sissoo*) and teak (*Tectona grandis*).

Class C (non-refractory woods): these timbers may be rapidly seasoned free from surface and end cracking even in open air and sun. If not rapidly dried, they develop blue stain and mould on the surface. Examples are light broad leaved (hardwood) species for packing cases, such as semul (*Bombax spp*.) And salai (*Bosewellia serrata*) , and all coniferous species.

Storage of timber before seasoning

The drying and biological degradation of logs is checked for long periods by keeping them submerged under fresh water.

Wherever it is not possible to do so, they should be stored on land over raised foundations of masonry preferably under shade.

Before stacking, suitable end coatings (eg. Bitumin paint) should be applied and prophylactic treatments given as and when necessary.

Air Seasoning

There are two commercially important methods of seasoning wood practiced in this country, viz., Air seasoning (natural seasoning) and kiln drying (artificial seasoning). In the process of air seasoning the timber to be dried is properly stacked and left to nature for drying. Certain precautions to protect the wood from hot winds and sun should be taken while seasoning refractory hardwoods.

Stacking of timber

Kiln Seasoning

The process of kiln drying is carried out in a seasoning kiln which is a chamber, usually made of masonry and heated by means of steam or smoke gases, and in which the desired conditions of temperature and humidity of the air can be maintained. A rapid circulation of air may also be maintained around the timber being seasoned with the help of fans. Kiln seasoning is a method of quick drying of timber to any desired moisture content under controlled conditions of temperature and humidity. For this reason many timbers which are likely to get damaged in air seasoning can be dried satisfactorily in a seasoning kiln.

Seasoning Schedules

Based on the above classification seven seasoning schedules have been developed for different types of timbers in the country (please refer IS 1141: 1993).

Schedule I covers species used for packing case manufacture.

Schedule II covers species used for light planking or moderately heavy type of packing cases.

The kiln drying schedule is a guide chart with respect to the temperature and humidity conditions to be maintained in the kiln when the moisture content of the wettest samples of wood on the entering air side in the kiln has reached the stage specified in the schedule.

Schedule III covers species used for most light furniture.

Schedule IV covers species used for common furniture.

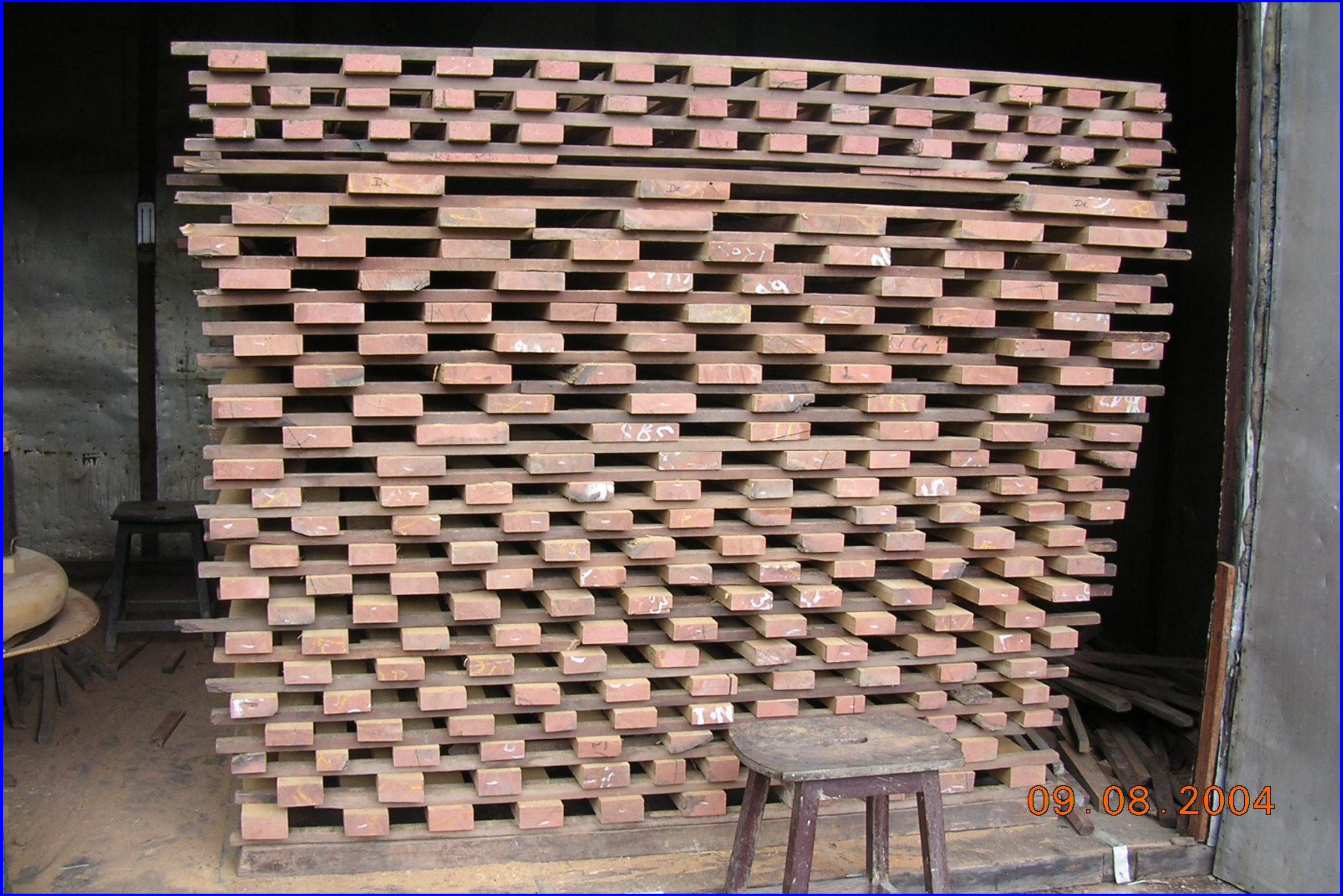
Schedule V covers species used for furniture, constructional work , bobbins and other turnery articles.

Schedule VI covers species used for structural purposes and heavy planking.

Schedule VII includes several heavy and highly refractory timbers.

Steam heated kiln, solar drying kiln, dehumidifier kiln, high temperature drying kiln are different types of kiln being used by the industry. Chemical drying, vacuum drying, radio frequency drying, microwave drying of timber are techniques of research interest and yet to commercialise in the country.

The degree of seasoning to be given to wood depends upon the service requirements and the climatic conditions of the locality where the wood is to be used. For high class work such as cabinet making, panelling, and other indoor uses, the wood should be thoroughly seasoned to a moisture which is in equilibrium with the atmospheric humidity of the locality (10 % to 12 % moisture content suits the greater part of this country). For outdoor uses such as poles, bridges, railway sleepers, etc., partial drying of timber to about 25 % moisture content is considered reasonable.



Wood Stack ready inside a kiln

Two chambers of a steam-heated kiln

Fan pulleys outside a steam-heated kiln

Inside floor showing air ducts

False ceiling inside a kiln

Outside opening of a air-duct

Valves inside a control room for controlling heat and RH inside stack room

Over-head fans above false ceiling inside stack room

Heat Exchangers

Dampeners

Wood stack loaded inside an Electrical Kiln

Fans and electrical heaters

A dehumidifier kiln

Solar kiln – A cost effective technique for timber drying

A solar timber-drying kiln mainly works on the principle of greenhouse effect. Solar heat is used for drying timber. Drying cost is less here as compared to a steam-heated kiln. Drying degrades are also comparatively less but drying time is usually longer. Solar kiln is most effective when it is used as a pre-drier to bring down moisture content of timber to a lower level before keeping the timber stack inside a steam heated kiln for final drying. FRI, DeharaDun has developed solar kiln and installed at many places of the country. The IWST, Bangalore has also installed two solar kilns – one at KSFIC, Bangalore and another at Shimoga.

Side view of a Solar Kiln

FRI Solar Kiln

Advanced Drying techniques

Vacuum drying, radio frequency drying, microwave drying of timber are techniques of research interest and yet to commercialise in the country. Tunnel drying is also being used off late for specific purposes.

Radio frequency drying

Under powerful high frequency field of one-mega cycles per sec. wet wood is heated quickly through out the section. Very quick drying thus can be obtained by these means in permeable woods.

Vacuum drying

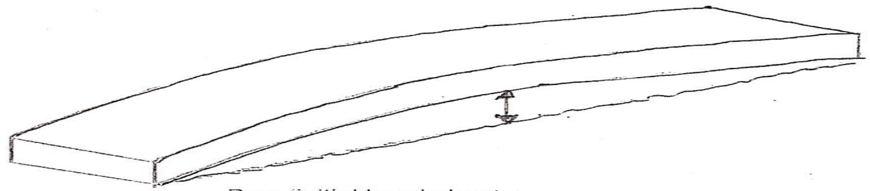
Wet wood enclosed in the chamber in which arrangement for infrared heating or convective heating is provided. A vacuum is applied to remove water vapour from the chamber. Very rapid drying at low temperature occurs with permeable woods.

Drying Defects

Drying defects develop in timber as a result of uncontrolled drying conditions, improper stacking, refractory nature of timber, irregular or non-homogeneous grain and properties or abnormal growth. Examples of drying defects are end splits, surface cracks, twisting, cupping , internal cracks, case hardening and collapse. These may be minimized in case of logs by proper storage and in case of sawn timber by adopting proper methods of stacking and control over drying conditions during seasoning.

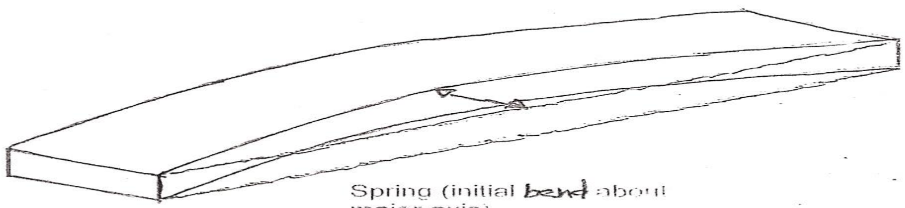
Defects	Definition
Case hardening	The condition existing in wood in which the outer layers have undergone rapid drying and become set without corresponding shrinkage, causing stress between the inner and outer layers. It causes warping of the wood when further converted.
Check	A separation of fibres along the grain forming a crack or fissure in the wood not extending through the piece from one surface to another. It occurs across the rings of annual growth.
Collapse	Flattening or buckling of the wood elements during drying due to irregular and excessive shrinkage.
Honey-combing	Separation of the fibres (checks) in the interior of the wood induced by drying stresses when the outer layers have become casehardened.

Split	**A separation of fibre along the grain forming a crack or fissure that extends through the piece from one surface to another. A split at the end of a piece of wood is an end split.**
Surface stain	**A brownish discolouration of wood caused either by oxidation or by accumulation of extractives during drying.**
Warp	**Distortion (bow, cup, spring or twist) in converted wood causing departure from its original plane, usually developed during drying**
Bow	**A curvature of a piece of wood in the direction of its length**



Bow (initial bend about minor axis)

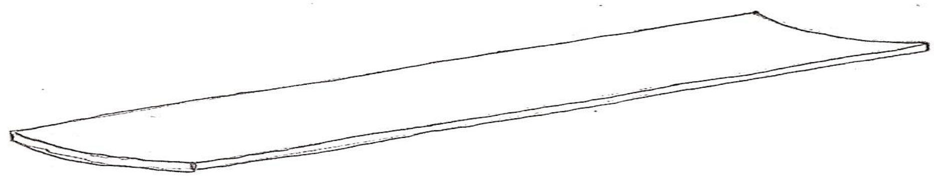
(a) <u>Bow</u> : It is identified as a flatwise deviation and is measured by the chord which the curvature make between the extreme ends and by the depth at the middle portion. It is evaluated by the ratio of the max. deviation (d) to the length of the chord (l).



Spring (initial bend about major axis)

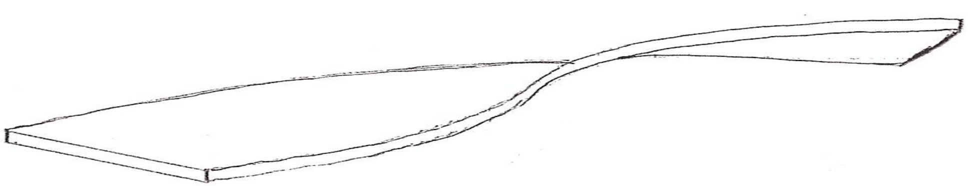
(a) <u>Spring</u> : It is identified as an edgewise deviation and is measured in the same manner as bow.

Cup	**A curvature occurring in the cross section of a piece of wood**
Diamonding	**The changing of the cross section of square sawn wood from square shaped to diamond shaped**
Dish	**Curvature of a piece such that one of the faces is concave. A combination of bow and cup. The term is commonly applied to manufactured boards such as plywood, block board, and particle board.**
Spring	**A curvature of a piece in the plane of its edge**



Cupping

(c) <u>Cup</u> : It is identified as a deviation of a piece of timber in which the face becomes concave or convex across the grain or the width of the piece. It is measured by the chord, which the curvature makes between the extreme edges, and by the depth at the middle portion. It is evaluated by the ratio of maximum deviation (*d*) to the length of the chord (*l*).



Twist

(d) <u>Twist</u> : It is identified as the spiral distortion of the edges of a piece of timber so that the four corners of any face are not in the same plane. It is measured by the degree of twist and is generally expressed qualitatively as slight, moderate and heavy, depending on whether the twist is less than 10° or between 10° and 25° and more than 25°, as estimated on the basis of relative rotation between the two ends.

Twist	Spiral distortion along the grain of a piece of a wood
Shrinkage	Reduction in dimensions due to decrease in moisture content
Swelling	Increase in dimensions due to increase in moisture content.

Defects	Causes	Prevention or reduction to minimum	Possible remedy
Case-hardening	Too rapid surface drying owing to use of too low humidity in early stage and/or too high temperature in later stages	Use higher humidity in early stages and limit temperature in final stages.	At the end of the kiln run: Long conditioning period or a relief treatment viz., raise temperature and humidity for 2 to 6 hours according to severity of stresses.
Surface checking	Too rapid drying of surface in relation to the core.	Use higher humidity in early stages.	No cure. Checks will tend to close when wood fully dried to uniform moisture content.
End splitting	Ends drying more rapidly than the rest owing to: End grain drying	Paint ends with bituminous paint.	None

Defects	Causes	Prevention or reduction to minimum	Possible remedy
	Overhanging ends Too much circulation over ends too little through stack.	Pile properly with stickers at or very near ends of rows. Baffle off ends and make all air go through stack.	
Honeycombing	Severe case hardening in early stages followed by internal checking from excessive stressing in centre. Too high temperature in final stages.	Use higher humidity in early stages. Periodic steaming and limit final temperatures	None
Distortion: Cup	Differential shrinkage across grain in tangential and radial directions.	Cannot be prevented but all forms of distortion can be minimised by the following: Pile very carefully, viz., place stickers at frequent intervals and in perfect alignment: place stickers at ends of all boards.	Apply reconditioning treatment as for collapse but if piling is bad dismantle stack and re-pile properly before steaming

Defects	Causes	Prevention or reduction to minimum	Possible remedy
Spring and bow	Differential shrinkage along the grain owing to irregular or curved grain or reaction wood		
Twist	Spiral grain or interlocked or irregular grain	Use lower temperature schedule Place heavy weights on top of stack	Condition to the correct moisture content
All forms of distortions	Improper piling of timber, eg. Uneven stickers at too great intervals or placed out of vertical alignment	Leave out low-grade material with very irregular grain.	Steam for three hours at 70^0C

Defects	Causes	Prevention or reduction to minimum	Possible remedy
	unsupported ends of boards. High temperatures causing greater shrinkage and hence increased distortion. Over drying		
Mould growth	Poor circulation Very slow drying at moderate temperatures	Speed up circulation Use higher temperature if species not one liable to warp or collapse badly	

Species	Refractoriness	FSP %	Kiln Schedule	Shrinkage % green to oven dry		
Acacia nilotica (babul)	B	21.0	VI	2.6	6.0	9.1
Cedrus deodara (deodar)	C	21.5	III	3.6	5.2	8.4
Dalbergia latifolia (rosewood)	B	19.0	IV	2.7	5.8	8.5
Dalbergia sissoo (shisham)	B	20.9	IV	2.8	4.9	7.9
Eucalyptus globulus	A	-	VI	7.8	15.4	24.2

Species	Refractoriness	FSP %	Kiln Schedule	Shrinkage % green to oven dry		
Grevillea robusta (silver oak)	B	-	III	-	-	-
Mangifera indica (mango)	C	22.0	II	3.0	4.9	7.3
Pinus roxburghii (chir pine)	B	26.2	II	4.3	5.6	11.2
Populus spp. (poplar)	C	-	II	-	-	-
Pterocarpus marsupium (bijasal)	B	23.5	VI	4.3	6.1	10.2

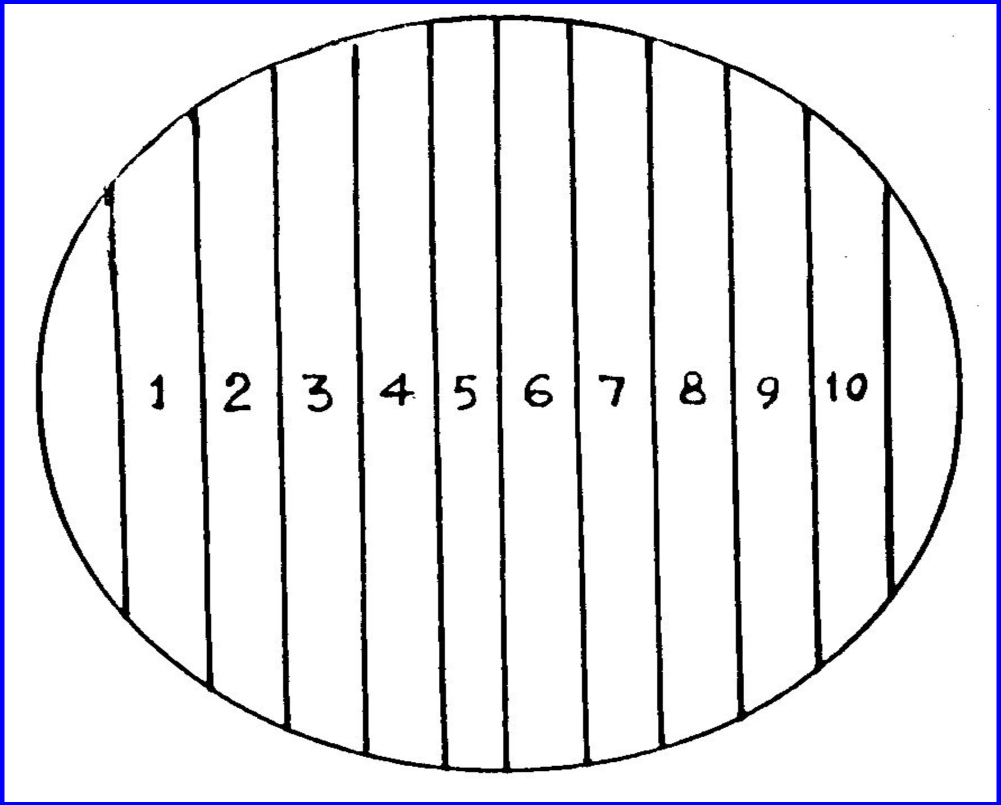
Species	Refractoriness	FSP %	Kiln Schedule	Shrinkage % green to oven dry		
Salix spp. (willow)	B	25.7	III	3.1	8.7	10.8
Shorea robusta (sal)	A	23.7	VII	4.2	8.8	11.8
Tectona grandis (teak)	B	-	V	2.2	3.9	5.5
Terminalia tomentosa (laurel)	A	24.7	VI	4.8	7.1	12.2
Toona ciliata (toon)	B	28.4	V	3.4	6.5	10.1

Special sawing techniques for Eucalypts

To minimize the problems during sawing, Radial Sawing, Balanced Tangential Sawing and Quarter sawing are used. These various sawing techniques along with plain sawing are detailed below.

(1) Plain sawing (P)

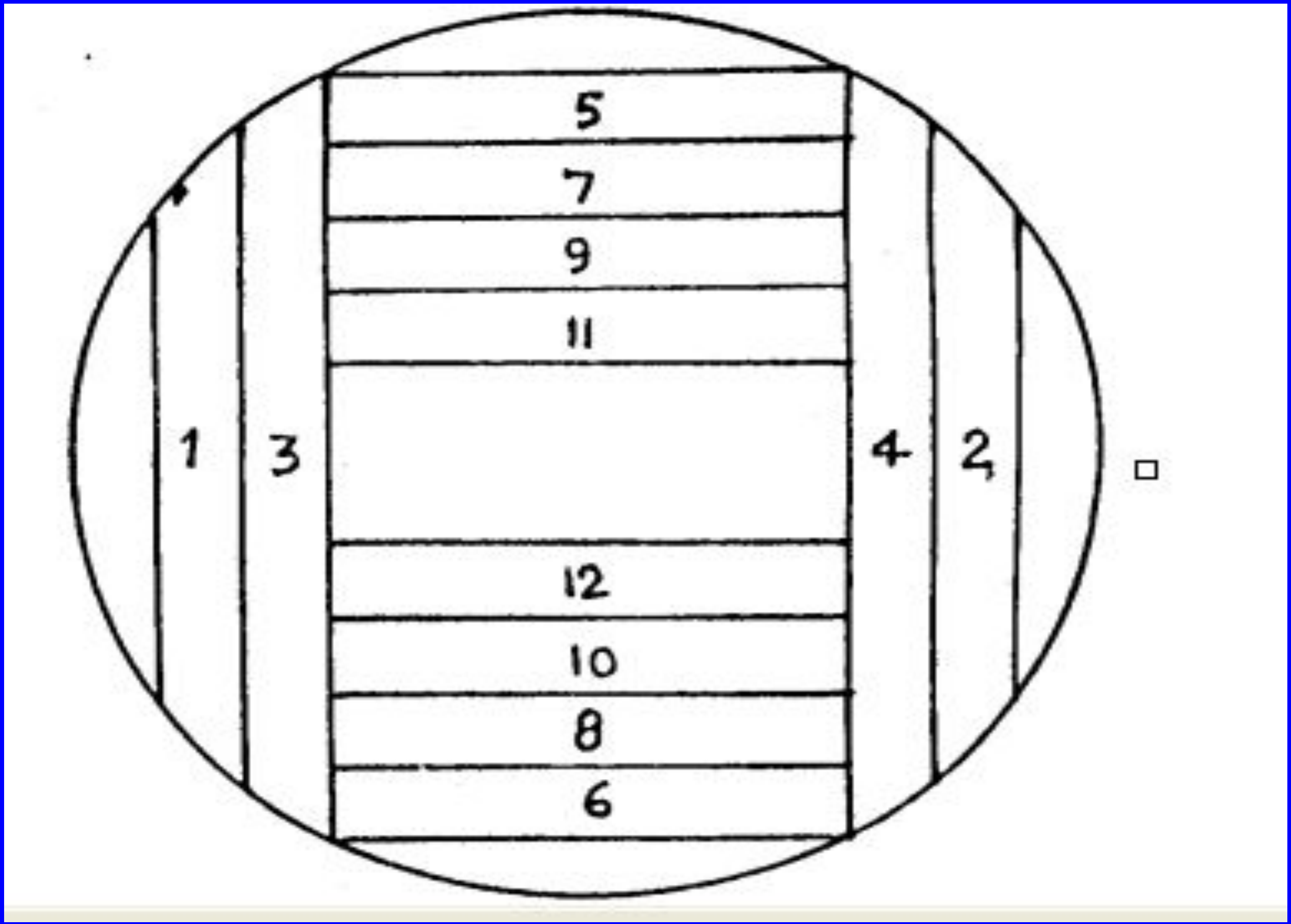
Also known as live sawing, this is the most common sawing pattern adopted by saw millers. This is the easiest and basic of all sawing patterns. Unfortunately the problems related to growth stresses are more manifested in this sawing pattern and hence modifications were introduced later on. Fig. below gives the representation of the live sawing pattern of a log.



Plain sawing

(2) Balanced Tangential Sawing (BTS)

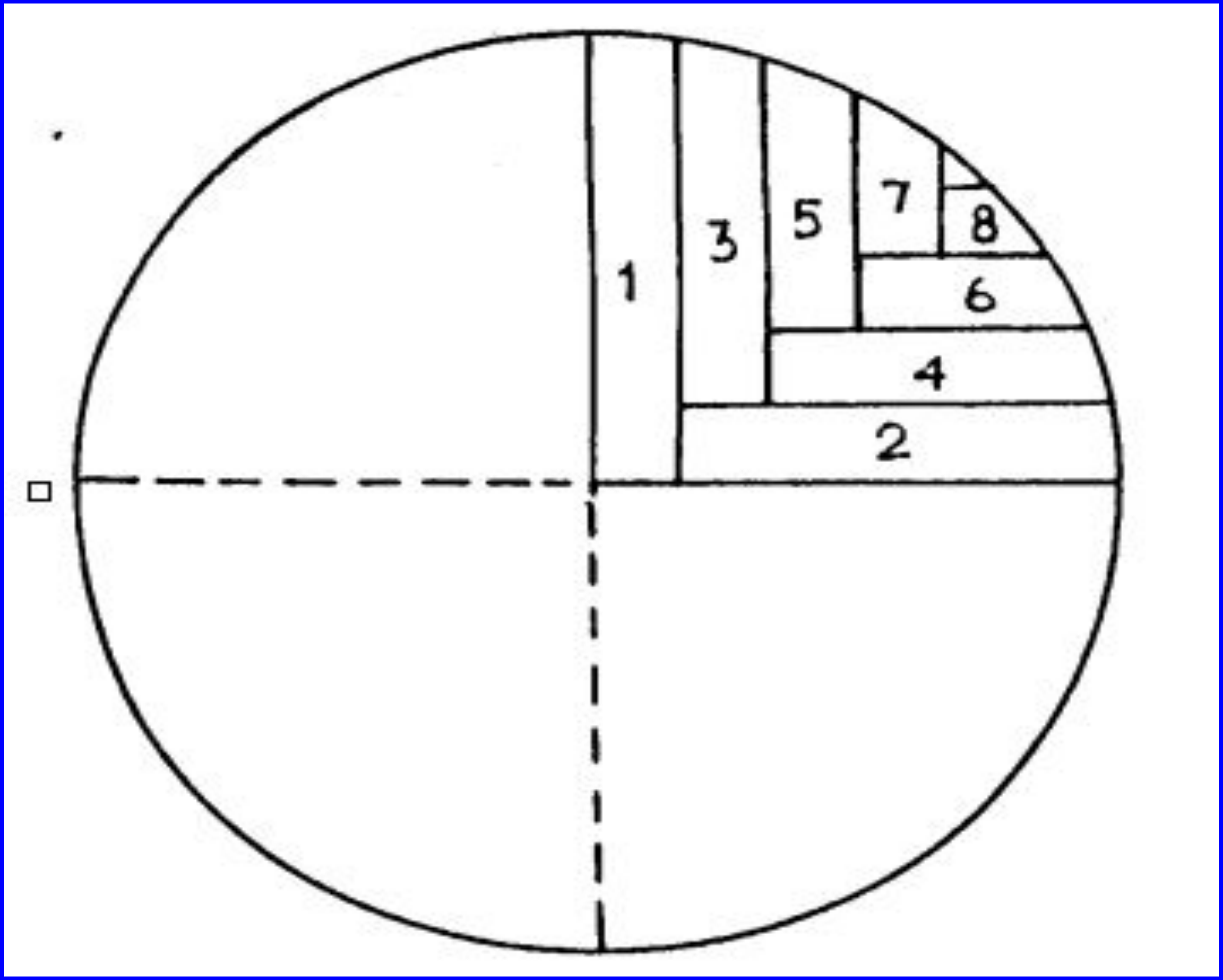
Planks obtained by quarter sawing, particularly from small girth logs (below 1 m girth) are rather narrow in width, not exceeding the radius of the log. To obtain wide enough planks from smaller girth logs and to minimize the appreciable warping and non-uniformity in thickness of the sawn planks during sawing operation, a symmetrical sawing sequence called BTS has been developed. This is also known as cant sawing. In this method planks are sawn sequentially from symmetrically located positions on either side of a diameter till a central slab of width equal to the minimum width of planks desired remains. Thereafter this slab is again sequentially sawn from either side of the diameter. Sawing is stopped about 50 mm short of the pith on either side leaving a flitch with centrally located pith.



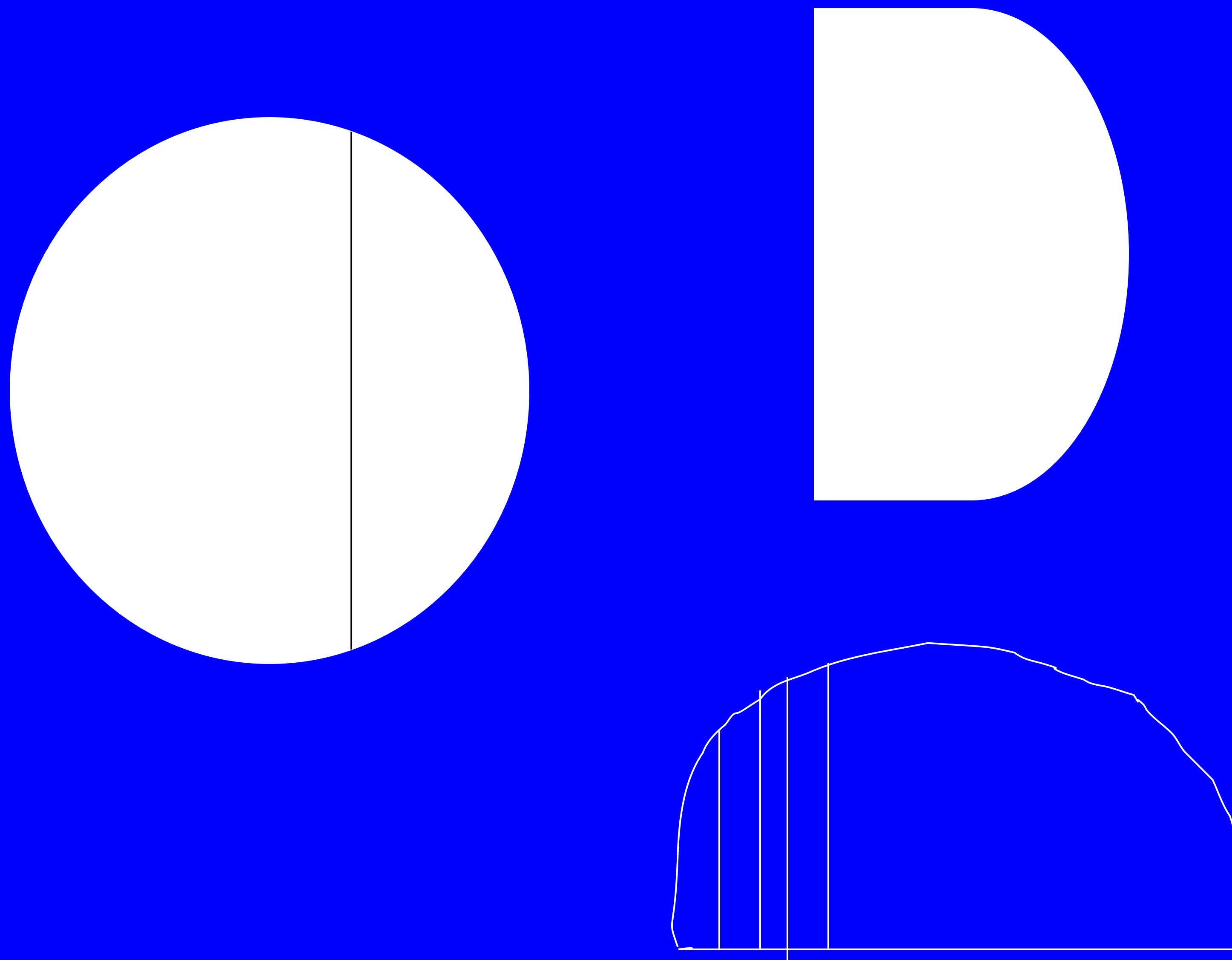
Balanced Tangential Sawing (BTS)

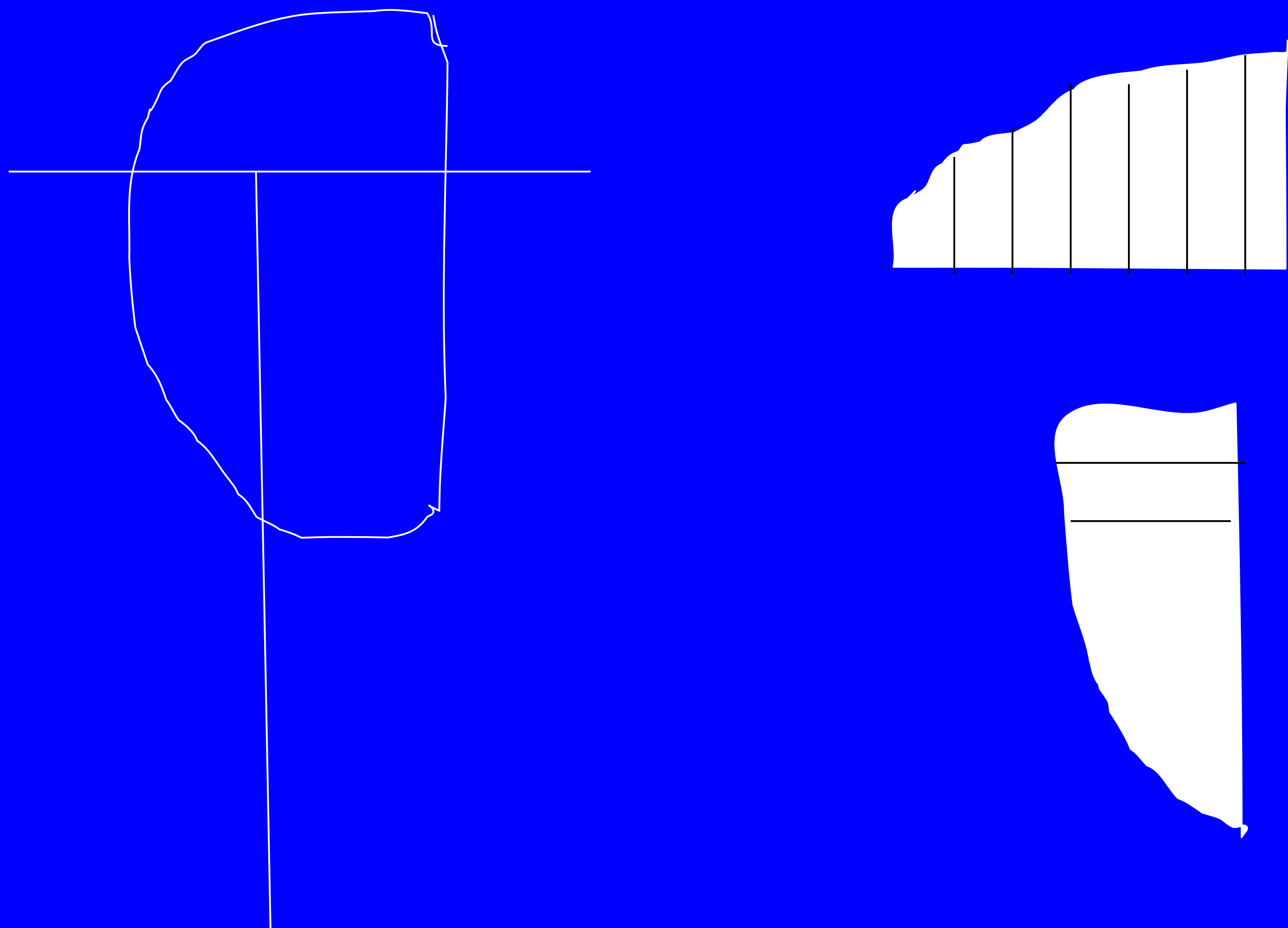
(3) Quarter or Radial Sawing (QS)

This method has been evolved to avail of the significant advantage of the fact that quarter sawn planks suffer almost no cracking or splitting and cupping in subsequent air or kiln drying. This is of great advantage for small units which have to depend upon air seasoning for their timber. This method of sawing consists in quartering the log, followed by sawing of planks for each quadrant in the sequence indicated. There is chance of a certain amount of two-plain warping in the quadrants during quartering of the logs. The planks also may show a certain amount of spring (longitudinal bending of the edge in the plane of the flat faces) during sawing. The spring and non-uniformity of thickness have to be corrected by subsequent edging and plaining of the planks after seasoning has been completed. It is important to remove centre heart portions appearing on the edges of the quarter sawn planks, which are prone to splitting in subsequent seasoning. A representation of this sawing pattern is given in Fig. Below-



Quarter Sawing or Radial Sawing





SCHEDULE FOR KILN DRYING OF 2.5 cm. THICK PLANKS OF EUCALYPTUS

Moisture content percent	Temperature °C		Relative Humidity Percent
	Dry bulb	Wet bulb	
Green	43	40	82
50	45	40	77
35	49	43	69
25	55	45	55
20 to final	60	45	42

Warping on sawing has been found to be appreciably minimized by this sawing procedure due to balanced sequence of cuts. The small amount of bowing still obtained is not a drawback for end uses where the planks are to be finally fixed in position such as in case of table tops, as planks can be flattened by a small force before fixing. Planks show some non-uniformity in thickness that is however, considerably less than in plain sawing or quarter sawing. Since all planks obtained by this technique are tangential in cut, they need greater care as regards humidity control in air or kiln drying than quarter-sawn planks. While planks obtained from outer positions in the log do not suffer cracking or objectionable cupping, those obtained closer than 50 mm distance from the pith split in the centre heart portions and cup along their width.

In addition to an initial and final steaming for 3 hours, an intermediate steaming is given (at 25-30 % m.c.) for nearly 4 hours at 55^0C.

For seasoning of timber more than 25 mm and up to 50 mm in thickness, the relative humidity should be kept 5% higher at each stage in the above schedule. For timber thicker than 50 mm, seasoning can be carried out economically and with less degrade by combining a preliminary period of 60 to 90 days air seasoning to a moisture content of about 25% with final kiln seasoning with the same humidity conditions as for 50 mm thick timber. For timber, that has been partially air dried to a moisture content of about 25%, 6-8 days are required for final kiln drying to a moisture content of 12% in a steam heated kiln.

Eucalyptus with end cracks

End coating for controlling end cracking in Eucalyptus

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THANK YOU !