भारतीय मानक

लकड़ी की सिझाई – रीति संहिता

(दूसरा पुनरीक्षण)

Indian Standard

SEASONING OF TIMBER — CODE OF PRACTICE

(Second Revision)

UDC 674·047·006·76

BUREAU OF INDIAN STANDARDS
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FOREWORD

This Indian Standard (Second Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Timber Sectional Committee had been approved by the Civil Engineering Division Council.

Seasoning is the first step in the efficient utilization of timber, especially in this country, where the climatic conditions are very trying for wood work, and where several commercially important species of wood are hard, heavy and liable to develop defects during drying and in use, unless carefully seasoned. It should be emphasized that all timbers, whether teak or other species, naturally durable or non-durable need proper seasoning in order to give satisfactory service. Seasoning should be regarded as an integral part of timber utilization. With the increased use of several secondary species that possess higher shrinkage than teak, padauk, deodar, rosewood, etc, it has become imperative that adequate attention should be paid to the process of seasoning of wood before use. This has been further necessitated also by the increasing availability of short rotation plantation wood of fast growing species under social/agro forestry programmes such as *Eucalyptus* hybrid, *Acacia nilotica*, *Populus deltoides*, *Grevillea robusta*, etc.

Freshly felled timber contains a large quantity of moisture, in many cases roughly 100 percent based on oven-dry weight of wood, though in some light timbers the quantity of water in green condition is twice as much as the weight of wood substance (that is, roughly 200 percent). A well seasoned piece of wood should on the other hand contain about 10 to 12 percent moisture on an average. This would be in equilibrium with the atmospheric humidity in several parts of the country. This degree of seasoning is necessary for proper retention of shape and size of component parts of high class articles, such as cabinet work, railway carriages, panelling, etc. For rough work, and for outdoor uses, drying of timber, say up to 15 to 25 percent moisture content, is considered enough. This also makes preservative treatment easy and effective.

The process of drying timber, under more or less controlled conditions is called seasoning. During the course of the drying process, timber may develop defects and this is avoided by providing adequate protection against unduly rapid drying conditions, care in stacking and top weighting of the stacked timber. Timber shrinks during drying; the main objective of seasoning is to eliminate this shrinkage and the associated drying defects before use. Other advantages are, increase in the strength and electrical resistance of timber, reduction in weight for transport purposes, improvement in wood-working qualities including gluing, painting and polishing, and a certain degree of protection from attack by insects and fungi depending upon the moisture content to which timber has been seasoned. Seasoned timber should be stored under cover protected from rain and other forms of precipitation.

Sawn timber for special purposes may be given an antishrink treatment and a recommended method is given in Annex A.

This standard was first published as tentative standard in 1958 and then revised in 1973. Apart from conventional seasoning processes, namely air and kiln seasoning, this second revision also details certain special seasoning processes and preseasoning treatments that may be adopted to reduce drying times, costs and defects, conserve energy or avoid pollution. This revision also incorporates guidelines on the technique of sawing of logs of certain species containing severe growth stresses to minimize warping on the saw and to minimize surface cracking during subsequent seasoning of the sawn timber.

The composition of the technical committee responsible for formulation of this standard is given in Annex E.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 1960 'Rules for rounding off numerical values (*revised*)'. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

Indian Standard

SEASONING OF TIMBER — CODE OF PRACTICE

(Second Revision)

1 SCOPE

This standard covers classification of timbers for seasoning purposes; preliminary treatment and storage; stacking practice; pre-seasoning treatment; seasoning methods; kiln schedules for seasoning different species of timbers; pre and post-treatment seasoning; kiln operation procedure; measures for control of warp; and inspection, transport and storage of seasoned timber. General guidelines are also included for seasoning of bamboo.

NOTE — The design and construction of seasoning kilns, recommended moisture contents for seasoned timber and methods of determination of moisture content are covered in separate Indian Standards, namely, IS 7315 : 1974, IS 287 : 1993 and IS 11215 : 1991 respectively.

2 REFERENCES

The following Indian Standards are necessary adjuncts to this standard:

IS No.	*Title*
287 : 1993	Recommendations for maximum permissible moisture content of timber used for different purposes (*third revision*)
401 : 1982	Code of practice for preservation of timber (*third revision*)
707 : 1976	Glossary of terms applicable to timber technology and utilization (*second revision*)
6313 (Part 2) : 1981	Code of practice for anti-termite measures in buildings: Part 2 Pre-constructional chemical treatment measures (*first revision*)
7315 : 1974	Guidelines for design, installation and testing of timber seasoning kilns
11215 : 1991	Methods for determination of moisture content of timber and timber products

3 TERMINOLOGY

For the purpose of this standard the definitions given in IS 707 : 1976 shall apply.

4 CLASSIFICATION OF TIMBERS FOR SEASONING PURPOSES

4.1 For the purpose of seasoning, timbers shall be classified into the following three classes depending upon their behaviour with respect to cracking and splitting, and drying rate:

a) Class A : Highly refractory
b) Class B : Moderately refractory, and
c) Class C : Non-refractory

4.2 Highly Refractory Woods

These are slow drying and difficult to season free from cracking and splitting. Examples are heavy structural timbers, such as sal (*Shorea robusta*) and laurel (*Terminalia alata*).

4.3 Moderately Refractory Woods

These may be seasoned free from surface and end cracking within reasonable short periods, given a little protection against rapid drying conditions. Examples are moderately heavy furniture class of timbers, such as sissoo (*Dalbergia sissoo*) and teak (*Tectona grandis*).

4.4 Non-refractory Woods

These may be rapidly seasoned free from surface and end cracking even in the 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 (*Boswellia serrata*), and all coniferous species.

4.5 Classification of commercially important Indian timbers into the above three classes is given in Annex B.

5 DEFECTS FOR SEASONING PURPOSES

5.1 For seasoning purposes, defects in timber shall be grouped as follows:

a) Drying defects, and
b) Defects not associated with drying.

5.2 Drying defects develop in timber as a result of drastic drying conditions, improper stacking, refractory nature of timber, irregular or non-

homogenous grain and properties or abnormal growth. Examples of drying defects are end splits, surface cracks, warping, internal cracks, case hardening and collapse. These may be minimized, if not prevented, in case of logs by proper storage and in case of sawn material by adopting proper methods of stacking and control over drying conditions during seasoning.

5.3 Defects not associated with drying are generally present in timber in the living tree while some like shakes may also develop on account of shocks sustained in felling. Examples of such defects are knots, heart and cup shakes, pith, brittle heart, pitch pockets, sloping, wavy or spiral grain, etc. Warping of green timber on the saw or splitting ahead of the saw in green planks containing the pitch, due to residual growth stresses present in the log, are also defects of this type. Such defects cannot be eliminated but further damage to wood may be prevented or minimized in many cases by adopting proper sawing and seasoning procedures.

6 PRELIMINARY TREATMENT AND STORAGE

6.1 The process of drying starts as soon as the tree is cut. Control over drying is, therefore, to be exercised immediately. It is desirable to protect the timber from the early green stage against rapid drying, caused by exposure to sun and hot winds.

6.2 Prevention of Drying of Logs

Seasoning of timber in the form of logs is not possible in practice. If the logs cannot immediately be cut into planks and scantlings, their drying should be restrained by storing under water which is popularly (but erroneously) known as water seasoning. During water storage, the logs should be completely submerged under water. If the water is stagnant as in the case of artificial log-ponds, it should be changed, say once a fortnight, to remove the fermenting material. The bark should be removed before the logs are stored under water. Logs may also be stored in sea water for comparatively shorter periods, but such storage exposes them to the risk of attack by marine borers. In case it is not possible to store logs under water they should be stored on land over raised foundations of masonry or durable or preservative treated timber under shade. In species liable to excessive surface cracking and end splitting, the bark may be left on during storage to retard rapid drying. The practice, however, increases the hazard of insect attack in some cases and should be adopted only where experience indicates that losses through cracking and splitting outweigh those through insect attack. Before stacking, suitable end coating (*see* **6.3**) and prophylactic preservative treatment conforming to IS 401 : 1982 should be given. Logs can also be stored on land under water sprays after debarking. For this, they shall be stacked on a raised cement-concrete platform under continuous or frequently intermittent water sprays. The platform shall be suitably prepared so as to enable collection of the water drained off from the logs into a reservoir which shall be fitted with necessary pipes, centrifugal pump and spray nozzles for lifting the water, its respraying and recirculation. Suitable preservatives or insecticides may, if required, be added to the water or it shall be replaced with fresh water at suitable intervals of time.

6.3 Thick sections of all timbers, and specially refractory timbers, are subject to end splitting. This can be prevented or minimized by coating the ends of logs and thick sections of all timbers with some kind of moisture-proof composition up to a distance of 80 mm from the ends. Costly half-wroughts for specialized wood products, for which special selection of timber is usually made, should also always be end-coated. Some of the effective compositions are mentioned below:

a) Thick coal tar,

b) Rosin and lamp black (10 : 1),

c) Hardened gloss oil,

d) Paraffin wax,

e) Anti splitting-cum-preservative compound of following composition:

H.S.P. bitumen Mex R 115/15	37·5	parts by mass
L.S.P. bitumen Mex R 10/20	12·5	
Creosote-fuel oil (50 : 50)	5·0	
Soap-stone	30·0	
Cinder (boiler ash)	15·0	
	100·0	

f) Bituminous solution in organic solvents,

g) Bituminous solutions in kerosene with boiler ash, having following composition:

H.S.P. bitumen	500 g
Kerosene	250 ml
Boiler ash	100 g

Sl No. (a), (b), (d) and (e) are melted and applied hot.

Sl No. (c), (f) and (g) are brush coated. Sl No. (f) can also be sprayed.

6.4 Timber Yard

The timber yard should be maintained under hygienic conditions. It should preferably be level, have a direct approach to the main road

and be away from residential areas. The land should be on a high level with proper drainage. It should be well-fenced to prevent cattle from straying inside (so as to avoid dung which is a source of serious infection). The layout of the yard should be such as to enable free movement of transport from one part to another. If the yard is big enough, trolley lines should be provided for easy movement of timber. The storage area for timber should be kept free of weeds and debris that restrict air movement along the ground surface, harbour fungi and insects, and create a fire hazard when dry. It should be surfaced with gravel in order to restrict weed growth. To protect the stack of timber from direct sun, there should be some big shady trees in the yard.

6.5 Methods of Stacking

6.5.1 *Logs (Awaiting Conversion)*

These should be stacked on foundation in closed stacks in one or more layers. The ends of logs should be coated with an antisplitting composition (*see* **6.3**). Top protection against direct sun should be provided by shade of trees or a covering of rejected odd-sized planks (wherever available) so arranged as to provide sufficient overhang at both log ends.

6.5.2 *Railway Sleepers*

In order to provide to a certain extent, the drying conditions suitable for the species of timber either the 'one and nine' (*see* Fig. 1) or the 'close crib' (*see* Fig. 2) method of stacking should be adopted. The 'one and nine' method is suitable for moderately heavy timbers, particularly coniferous sleepers in hot climate and for heavy timbers, in moist climate. All coniferous sleepers in northern India and non-coniferous sleepers in moist zones of southern India, West Bengal and Assam should be stacked by this method. The 'close crib' method gives slower seasoning as it reduces the air circulation. This is recommended for stacking sleepers of refractory timbers in hot and dry localities, such as sal in Uttar Pradesh and Bihar. The 'open crib' method (*see* Fig. 3) is a modification of 'close crib' method allowing more air circulation. The effect of drying of timber by this method is almost the same as in the 'one and nine' method. This is not a common method of stacking sleepers. Stacks, each containing about 100 sleepers are recommended. The centre-to-centre distance of crossers shall not exceed 1·5 m. These methods of stacking can also be used for short lengths of thick scantlings.

6.5.3 *Poles*

After debarking, poles should be stacked either in closed heaps or with crossers. In case of stacking in closed heaps, there should be alternate layers of butt ends and top ends at one end of the stack so as to keep the two ends of the stack level (*see* Fig. 4). In the case of stacking with crossers some of the poles themselves could be used as crossers. The centre-to-centre distance of crossers shall not exceed 3 m.

6.5.4 *Fence Posts*

These should be stacked in open crib fashion in which the alternate layers of posts are at right angles to each other leaving a space of about 80 mm between adjacent posts in the layer. A convenient height of 3 m is recommended for such stacks (*see* Fig. 5). The centre-to-centre distance of crossers shall not exceed 1·5 m.

6.5.5 *Bamboos*

These should be stacked in closed heaps on the foundations to any convenient height. There should be vertical pillars fixed into the ground about 2·5 m apart on the two sides of the stack running along the length. Bamboos may also be stacked on vertical wooden framework with horizontal partitions to divide up the stack for rapid seasoning.

6.5.6 *Horizontal Stacking of Sawn Timber (Other than Railway Sleepers)*

6.5.6.1 *Foundations*

Vertical pillars of treated timber or brickwork or concrete are integral parts of the foundation. They should be 3 000 mm^2 in cross-section and 300 to 450 mm in height and should be spaced about 1·2 m apart (centre-to-centre) along the length and width of a stacking unit. The length of the unit should depend upon the length of material to be stacked. Adjoining stacking units should be spaced at least 750 mm apart for ease of stacking and proper air circulation on all the sides of the stacks. The gulleys between adjoining rows of stacks should be aligned with the wind direction in localities where more or less a perennial wind direction obtains.

6.5.6.2 Long beams of suitable cross-sections, say 100 mm × 100 mm and above, should be placed above the foundation pillars to serve as a framework for the stacking of timber. These foundation beams should be prepared from strong timbers which should be treated with a suitable wood preservative conforming to IS 401 : 1982.

6.5.6.3 *Scantling and squares (baulks)*

These should be stacked with crossers 50 mm × 40 mm in cross section kept 2·5 m apart. The stacks should be raised to convenient heights, say up to 3 m. The ends shall be covered with a moisture-proof composition (*see* **6.3**). It is desirable that the width of individual stacks does not exceed 2·0 m.

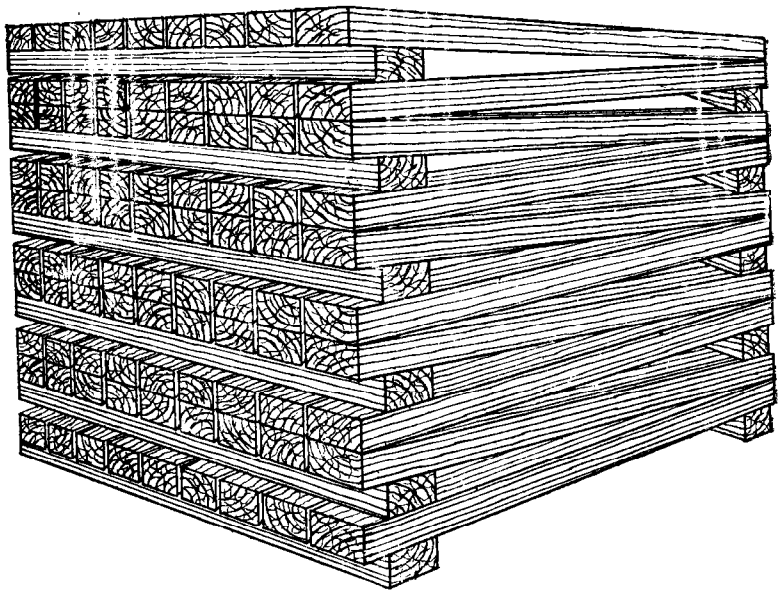


FIG. 1 ONE-AND-NINE STACKING

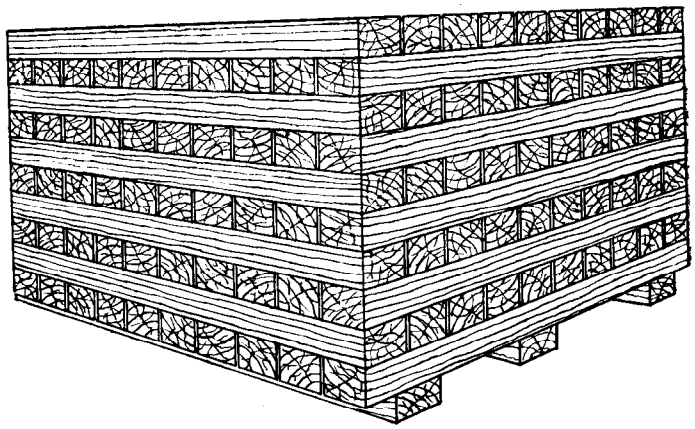


FIG. 2 CLOSE CRIB STACKING

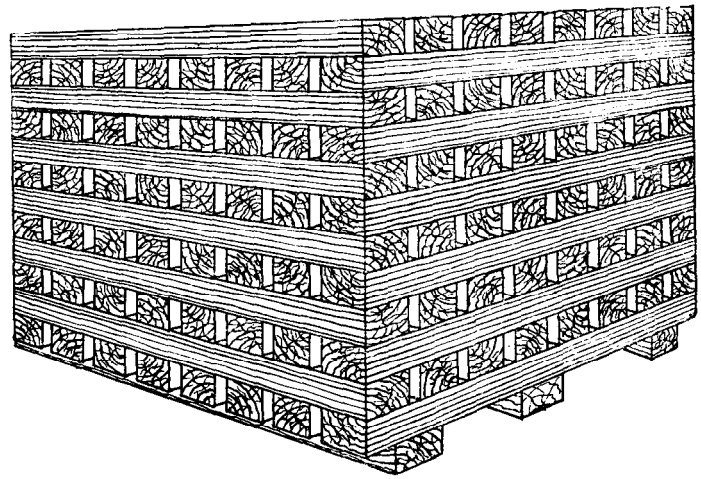


FIG. 3 OPEN CRIB STACKING

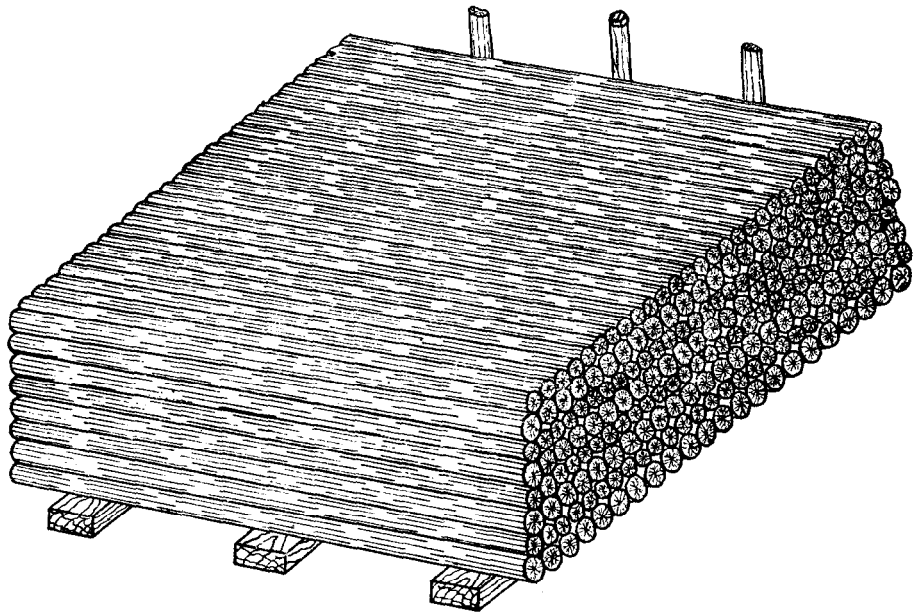


FIG. 4 STACK OF POLES

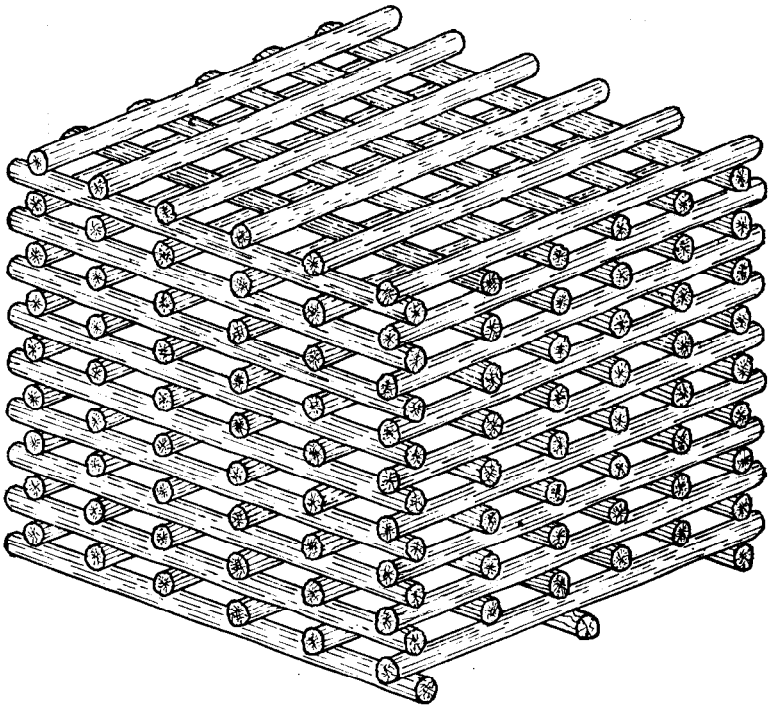


FIG. 5 STACK OF FENCE POSTS

6.5.6.4 *Planks* (*see* Fig. 6)

The stacking should be done on level foundations of skids. Crossers should be of uniform thickness and cross-section, say 40 mm × 25 mm for stacking planks up to 50 mm in thickness. The distance between the successive crossers in the layer should be about 600 mm for 25 mm thick planks. For thicker planks, the spacing may be increased to 750 mm. In case of very thin planks or species prone to warping, the spacing may be reduced to 450 mm. The crossers should be in vertical alignment in a stack. In the case of mixed lengths, the longest planks should be at the bottom and the shortest ones on the top. The stacking should be done under a shed to protect the timber against sun and rain. Heavy wooden beams, steel rails or concrete slabs should be placed at the top to minimize warping. It is desirable from the point of view of uniformity of drying that the width of the stacks should not exceed 1·5 m but if it does, an open space called flue or chimney about 250 mm wide should be left in the middle of the width from top to bottom to permit good air circulation in the centre of the stack. Gaps about 25 mm should also be left between adjoining planks in all the layers to allow free vertical movement of air.

6.5.6.5 Top weighting should be uniformly distributed over the stack and should act through a top layer of crossers and not directly over the top layer of planks. A minimum weighting of 380 kg/m² is recommended for control of warp and cup.

7 MOISTURE CONTENT OF SEASONED TIMBER FOR DIFFERENT USES

7.1 The final moisture content to which timber should be seasoned before use depends upon service requirements of the finished article and the climatic conditions of the locality where it is to be used, and should conform to IS 287 : 1973. The permissible limits of moisture content and the tolerances recommended in these limits for seasoned timber for different uses in the four climatic zones into which the country has been divided for this purpose is given in IS 287 : 1993 and methods of determination of moisture content have been laid down in IS 11215 : 1991.

8 SEASONING METHODS

8.1 Seasoning methods should be classified as follows:

a) Air seasoning; and

b) Kiln seasoning.

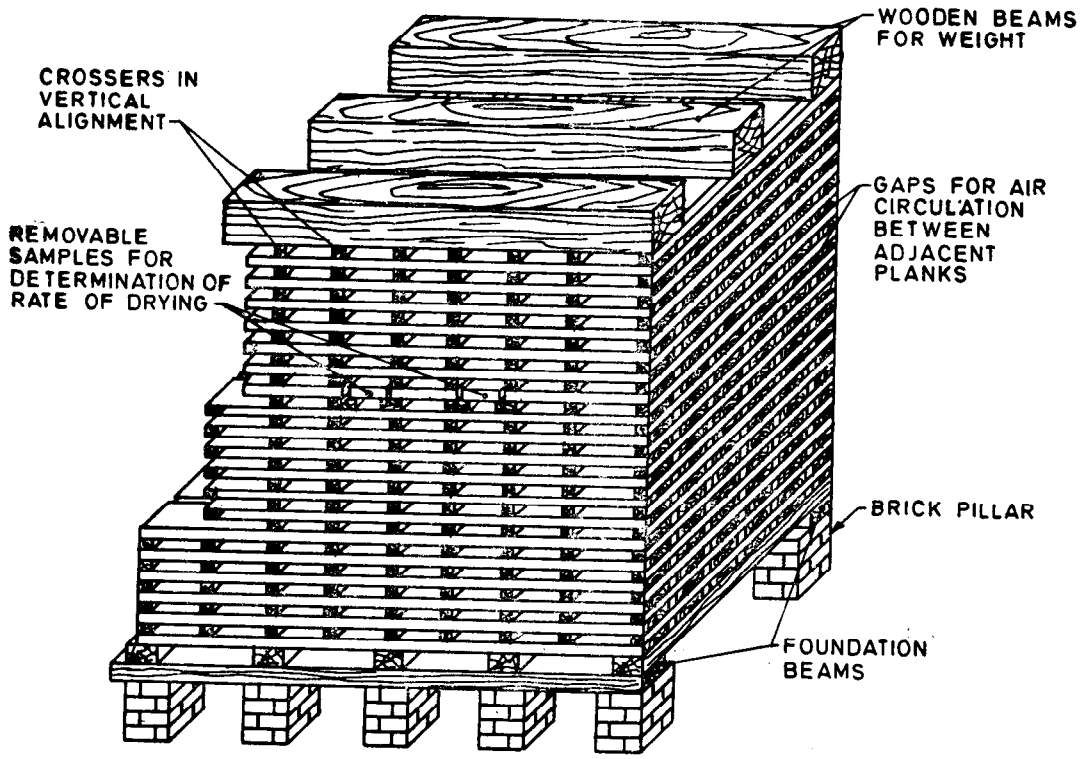


FIG. 6 HORIZONTAL STACKING OF PLANKS FOR AIR SEASONING

8.2 Air Seasoning

8.2.1 Sawn material for air seasoning should be stacked under shade, preferably in a shed. Three-recommended standard designs of sheds are described in **8.2.1.1** to **8.2.1.3**.

8.2.1.1 *Shed Type 1*

It consists of a roof with walls on all four sides, with gates at the two ends for the moment of timber. Adjustable shutter should be provided towards the top and bottom of the walls to control ventilation (*see* Fig. 7A). This type of shed is suitable for seasoning and storage of refractory timber in hot and dry climate such as sal (*Shorea robusta*) and laurel (*Terminalia alata*) in northern India.

8.2.1.2 *Shed Type 2*

It consists of a roof with walls on three sides, north side being open (*see* Fig. 7B). This is suitable for moderately refractory timbers like teak (*Tectona grandis*) and rosewood (*Dalbergia latifolia*) practically all over India, except in very moist climate.

8.2.1.3 *Shed Type 3*

It consists of a roof supported on pillars, all sides being open (*see* Fig. 7 C). This is suitable for refractory and moderately refractory timbers in very moist climate, and non-refractory timber in a dry climate.

8.2.2 The width of air seasoning sheds shall preferably be limited so to accommodate not more than two parallel rows of stacks plus the width of the intervening passage for movement of timber. The walls of the shed can be made of brick, durable or treated timber planks or asbestos cement sheets or treated bamboo reinforced lime and mud plaster walls. Timber can also be used for the columns. For the roof CGI sheets with or without a covering of treated wood shingles or corrugated asbestos cement sheets or compressed preservative and fire-retardant treated thatch boards can be used. CGI sheets, when used without covering, should be at least 2·4 m to 3·0 m above the top of the stacks to minimize heat radiation to the timber from the roof, or else, a ceiling should be installed below the sheet roofing to cut off radiation. A pucca floor should be provided. At the time of doing earthwork anti-termite measures shall be adopted [*see* IS 6313 (Part 2) : 1981]. The roof should have sufficient overhang on all sides to prevent direct spray of rain water. Proper drainage should be provided for the surrounding ground.

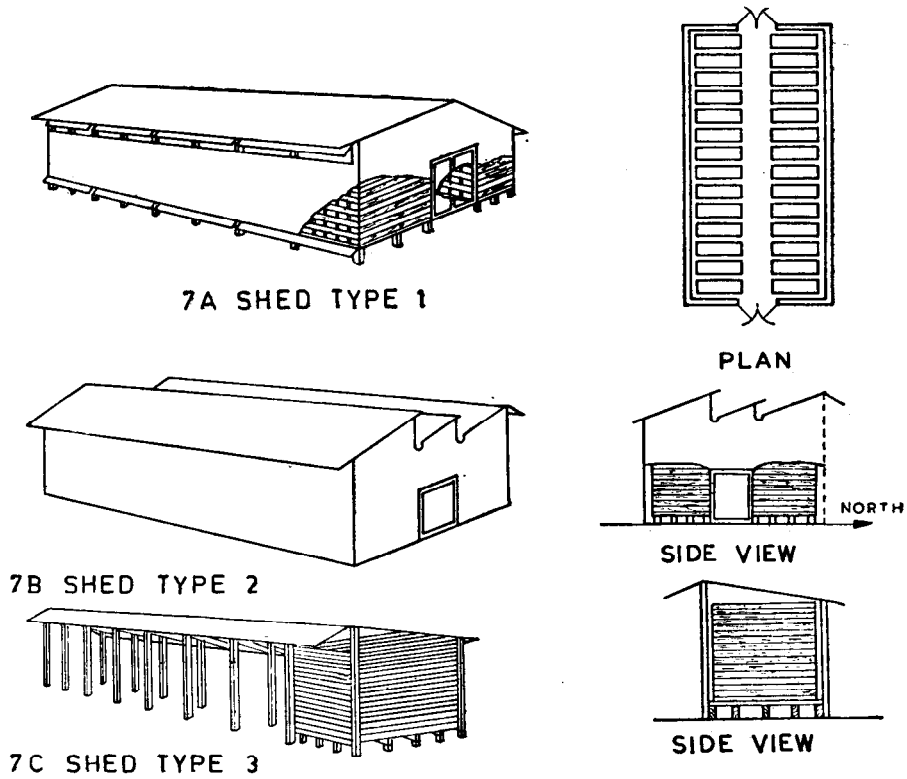


FIG. 7 AIR SEASONING SHEDS

8.2.3 For protecting timber from insect attack and decay during storage and seasoning a suitable prophylactic treatment conforming to IS 401 : 1982 should be given.

8.2.4 Air seasoning is usually a slow process. The actual period required will vary with the size and species of timber and the seasonal variations of climate. Ordinarily, timber should not be considered as fully air seasoned in less than six months. Planks of broad leaved species (hardwoods) 25 mm in thickness may take three to four months to season in a moderate climate. Scantling as used for door and window frames may take from 6 months to a year to attain reasonable degree of seasoning.

8.3 Kiln Seasoning

8.3.1 Kiln seasoning is a quick method of seasoning timber to the desired moisture content. Conditions best suited to each timber can be given, thus keeping the degrade within reasonable limits, while hastening the drying operation itself. For large scale production of seasoned timber, kilns have become almost an essential adjunct to many timber industries. Kilns are also indispensible for seasoning timber to low moisture contents for special uses, which cannot be attained in humid climates by air seasoning. Seasoning kilns are also used for sterilization of timber against insects and decay.

8.3.1.1 The seasoning kiln is a chamber equipped with arrangements for heating and humidifying the drying air to desired conditions of temperature and relative humidity and its circulation over the surfaces of timber stacked inside. Steam is generally used for heating and humidifying the air in seasoning kilns, though electrical heating and furnace gases are also sometimes used for supplying heat and for generation of the water-vapour necessary for humidification of the kiln air. In modern kilns fans are used for rapid circulation of air. In some older types of kilns, circulation is only thermal.

8.3.1.2 An efficient seasoning kiln for drying timber within the minimum possible time consistent with minimum of seasoning defects calls for certain minimum requirements with regard to relative humidities that can be attained and the uniformity of drying conditions within the kiln (IS 7315 : 1974). Lack of an efficient humidifying arrangement exposes the timber to increased degrade through cracking and splitting, as also makes case hardening

relief impossible particularly in refractory timbers. Non-uniform drying conditions lead to huge moisture content differences in the stock towards the conclusion of drying run, entailing time consuming and uneconomical equalizing treatments and making uniform relief of case hardening stresses extremely difficult, if not possible.

8.3.2 *Kiln Operation*

8.3.2.1 Crossers for stacking timber in kilns shall be 30 mm to 35 mm wide and 15 mm to 25 mm thick, except in thermal circulation kilns where crosser thickness shall not be less than 25 mm. They shall be made from sound, seasoned timber of moderately strong species. All crossers in any one charge shall be of uniform thickness.

8.3.2.2 Crossers shall be aligned in vertical rows directly over foundation beams (cross bearers) placed on the kiln floor across the stack of timber. They shall be spaced along the stack at intervals adequate to prevent warping of the timber in the kiln charge. However, the spacing shall not exceed 750 mm.

8.3.2.3 The sides of the stack shall be plane and vertical, with no projecting edges of planks, as far as possible. The stack shall be made to fill out the entire length and height of the stacking space. Any gaps in length and height shall be suitably blocked by baffles to prevent short-circuiting of air circulation via these gaps. The stack shall be sufficiently weighted on the top to prevent warping of the top layers (*see* **6.5.6.5**). Any gaps inevitably left between adjoining timbers in different layers shall also be randomly distributed within the stack to prevent short circuiting of air flow.

8.3.2.4 The composition of any one kiln charge shall be limited to timbers requiring the same drying schedule (*see* **8.4**) and having the same drying time.

8.3.2.5 Kiln samples shall be chosen from the thickest, wettest and slowest drying stock in the kiln charge or the combination thereof most difficult to dry in the light of data on refractoriness and drying schedules given in Annex B. In general, heartwood samples with slow drying characteristics shall be preferred to sapwood. Samples so chosen shall be used for selecting the drying schedule to be employed and for regulating the drying conditions at different stages during the run. However, where stock with widely differing initial moisture contents or drying times is mixed together in a kiln charge, it is sound practice also to keep extra samples of the driest and fastest drying pieces in the charge in order to follow their moisture content condition. These samples shall, however, not be used for regulating drying conditions in the kiln.

8.3.2.6 All kiln samples shall be selected free from knots and other natural defects. Samples shall be prepared in the manner set out in Annex C.

8.3.2.7 The number of kiln samples used per kiln charge shall be adequate to provide the kiln operator with sufficient data of the drying progress throughout the length and height of the charge, but as a minimum, there shall be one sample each on the entering and the leaving air sides of the timber stack to any 1·5 m of stack length and height. The samples shall be dried along with the stack of timber and shall be distributed evenly along its length and height as specified in Annex C.

8.3.2.8 To ensure minimum of drying defects consistent with a reasonably short drying period, it is necessary to ensure that the correct drying schedule be selected. When more than one species or thicknesses or material having widely different moisture contents are dried together in a charge, the drying conditions shall suit the stock needing the mildest drying schedule and shall be varied in accordance with the moisture content condition of the kiln samples prepared from such stock (*see* **8.3.2.5**). Drying schedules shall not be used which:

a) appreciably reduce the strength of timber, and

b) cause severe or uneven darkening which would not be removed from the timber by a normal planing operation.

8.3.2.9 When large variation in moisture contents between individual kiln samples placed together in a kiln charge is observed in the final stages of drying, a conditioning treatment at a suitably chosen relative humidity condition shall be given for an adequate period to minimize the moisture content difference between the kiln samples as also within their cross-section so as to be within specified limits (*see* **8.3.2.13**).

8.3.2.10 A check test shall be made at the conclusion of drying for average moisture content, moisture content distribution in the section and case hardening in all the kiln samples following the methods laid out in Annex D.

8.3.2.11 When necessary to prevent deterioration by checking, the kiln charge shall be allowed to cool inside the kiln to within 15 to 20°C of the outside temperature before removal.

8.3.2.12 During the drying time of each kiln charge, records shall be taken of the following details:

a) Dry and wet bulb temperatures of the entering air. These temperatures shall be preferably recorded continuously (if a recorder is available) or in any case at regular intervals not exceeding one hour. Recording shall also be made at every change of conditions in the kiln and at the time of stopping and starting for intermittent operation;

b) Any stoppage of fans or other kiln parts or the wet bulb water supply, the steam supply, or any other operation;

c) Details of weighings and calculations made in the preparation of kiln samples;

d) Details of periodic weighings and moisture content data of kiln samples to show progress in drying; and

e) Details of check test.

8.3.2.13 Unless otherwise specified, a kiln charge shall be deemed to have been seasoned satisfactorily if at the end of the kiln run (a) the average moisture content of all the kiln samples does not exceed 1 percent and the moisture contents of individual kiln samples does not exceed 3 percent of the desired final moisture content, (b) the difference of moisture content between the whole section and the core does not exceed 2 percent for timber, 40 mm or below the thickness and 4 percent for thicker timber, and (c) prongs prepared from the samples show no appreciable curvature after being allowed to room-dry for 24 hours, as determined by the procedure described in Annex D.

8.3.2.14 Start the conditioning treatment when the average moisture content of all the kiln samples has been reduced to the value 1 percent less than the desired final moisture content. At this stage, the RH in the kiln shall be suitably raised without altering the temperature that was being used in the last drying step of the schedule so that E. M. C. condition of the kiln air is 2 percent lower than the desired final moisture content[1]. The treatment should be continued till the moisture content requirements of **8.3.2.13** are attained.

8.4 Kiln Schedules

8.4.1 The kiln drying schedule gives the conditions of temperature and humidity to be maintained in a timber seasoning kiln for satisfactory drying of timber. The seasoning of timber is started at a comparatively lower temperature and higher humidity.

These conditions are gradually altered as the timber dries, until towards the end of seasoning the temperature of the air inside the kiln is fairly high and the humidity is low. The steaming treatments prescribed under each schedule are meant to initially heat up the kiln charge and inactivate mould growth at the start of the drying run, to partially relieve drying stresses in timber at the intermediate stages and to completely relieve case hardening stresses at the end of seasoning. For seasoning of Indian timbers, schedules I to VII (*see also* Annex B, and **8.4.5** to **8.4.11**) are recommended.

8.4.2 The temperature and humidity given in Schedules I to VII are meant for seasoning 25 mm thick timber. For timber more than 25 mm and up to 50 mm in thickness, the relative humidity should be kept 5 percent higher at each stage during seasoning. For timber 50 mm to 100 mm thick preliminary air seasoning to about 25 percent moisture content is recommended. This can be followed by kiln drying, if necessary, with the same humidity conditions as for 50 mm.

8.4.3 The average moisture content of the wettest half of the total number of samples on the side where air enters may be taken as a guide for making changes in the kiln schedule in preference to one single sample which happens to be the wettest. This refers to the study of rate of drying of timber and changes in kiln schedule to be made during kiln drying of timber.

8.4.4 The seasoning kiln can also be utilized for sterilization of timber, which is carried out by initial steaming of the charge at a temperature of 65°C to 70°C at 100 percent relative humidity for timber above 30 percent moisture content and 80 percent relative humidity for timber below 30 percent moisture content. The time for steaming should be 2 h for 25 mm thick timber. An additional period of heating at the rate of one hour for increase of thickness by every 12·5 mm over 25 mm is required.

8.4.5 Schedule I covers species marked I in col 4 of Annex B commonly used for packing case manufacture.

8.4.5.1 These timbers will take about 4 to 5 days to season. Initial steaming of the charge for about 2 h at 55°C and 100 percent relative humidity should be carried out to kill mould growth.

[1] Refer Table on page 85 of Timber Drying Manual by G. H. Pratt, Her Majestry's Stationary Office, London for EMC values under different temperature and RH conditions.

Schedule I for 25 mm Thick Planks of Species Marked 'I' in Annex B

Moisture Content of the Wettest Timber of Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	52	44	62·0
60	55	45	55·0
40	60	46	44 0
30	65	48	39·0
20	68	48	33·5

8.4.6 Schedule II covers timbers marked 'II' in col 4 of Annex B commonly used for light planking or for moderately heavy type of packing cases.

Schedule II for 25 mm Thick Planks of Species Marked 'II' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	45	40	72·0
60	47	40	64·0
40	49	40	56.0
30	53	40	44·0
20	58	40	32·5

8.4.6.1 These timbers will take about 5 to 7 days to season. Initial steaming of the charge for about 2 h at 55°C and 100 percent relative humidity should be carried out to kill mould growth.

8.4.7 Schedule III covers species marked 'III' in col 4 of Annex B which include most light furniture timber.

Schedule III for 25 mm Thick Planks of Species Marked 'III' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	42	38	76
60	45	40	72
40	47	40	64
35	49	40	56
30	51	40	50
25	53	40	44
20	55	40	39

8.4.7.1 These timbers will take about 8 to 10 days to season. In addition to the initial steaming, one intermediate steaming and one steaming towards the end for 2 to 3 h at 55°C and 100 percent relative humidity would be required.

8.4.8 Schedule IV covers species marked 'IV' in col 4 of Annex B which include common furniture timber.

Schedule IV for 25 mm Thick Planks of Species Marked 'IV' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	42	38·5	80
60	42	38	76
40	45	40	72
35	47	40	64
30	49	40	56
25	52	40	47
20	55	40	39

8.4.8.1 These timbers will take 12 to 15 days to season. One intermediate steaming and one steaming towards the end of drying at 55°C and 100 percent relative humidity for 2 to 4 h would be required. For precision drying for high class work conditioning treatment should be given.

8.4.9 Schedule V covers species marked 'V' in col 4 of Annex B used for furniture, constructional work or for certain special items, such as bobbins and other turnery articles.

Schedule V for 25 mm Thick Planks of Species Marked 'V' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	42	38·5	80
45	45	40	72
35	46	40	68
30	48	40	60
25	50	40	53
20	52	40	47
15	55	40	39

8.4.9.1 These timbers will take about 13 to 16 days to season. Some abnormal behaviour in seasoning need to be watched for and careful handling of the kiln would be necessary. In addition to the initial steaming; two intermediate and one final steaming at 55°C and 100 percent relative humidity for 2 to 4 h would be required for these timbers.

8.4.10 Schedule VI covers species marked 'VI' in col 4 of Annex B most of which are used for structural purposes and heavy planking.

Schedule VI for 25 mm Thick Planks of Species Marked 'VI' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	40	37	82
60	42	38	76
40	45	40	72
35	46	40	68
30	47	40	64
25	48	40	60
20	50	40	53
19	52	40	47

8.4.10.1 These timbers will take about 16 to 20 days to season. They need slow and careful drying. The charge will have to be steamed at least twice during the course of drying, in addition to the initial and final steaming at 55°C and 100 percent relative humidity for 2 to 4 h.

8.4.11 Schedule VII covers species marked 'VII' in col 4 of Annex B which include several heavy and highly refractory timbers.

Schedule VII for 25 mm Thick Planks of Species Marked 'VII' in Annex B

Moisture Content of the Wettest Timber on Air Inlet Side, Percent	Temperature		Relative Humidity Percent
	Dry Bulb °C	Wet Bulb °C	
(1)	(2)	(3)	(4)
Green	40	38	88
60	41	38	82
40	42	38	76
35	45	40	72
30	46	40	68
25	47	40	64
20	50	42	61
18	52	42	54
15	55	42	45

8.4.11.1 These timbers will take about 24 to 30 days to dry. The charge will need at least three intermediate steaming operations in addition to initial and final steamings at 55°C and 100 percent relative humidity for 2 to 4 h.

9 OTHER SEASONING METHODS

Apart from air and kiln seasoning, certain special seasoning methods have sometimes been adopted to reduce drying time, drying defects and/or seasoning costs, to conserve energy and avoid pollution.

9.1 High Temperature and Superheated Steam Drying

This technique essentially consists in kiln drying of timber at temperatures in the vicinity or in excess of the boiling point of water adopting suitable RH reduction schedules. Drying times are reduced several times compared to kiln drying under medium temperature schedules (*see* **8.4.5** to **8.4.11**). Hardwoods generally suffer severe warping, crook and collapse when dried green from the saw by this process. However, the process can be continuously used for quick drying without excessive degrade of hardwood timber after partial air drying or low temperature predrying (*see* **9.4**) to about 30 percent moisture content.

9.2 Solar Drying

9.2.1 Drying of timber can be appreciably accelerated compared to air seasoning and at appreciably reduced seasoning costs compared to conventional steam heated kiln of suitable design. Solar kilns based on the 'greenhouse' principle have been widely accepted in the country. Of the two designs of this type of kiln, namely, forced air circulation and thermal circulation designs, the former is better suited for rapid and uniform drying of timber without any degrade. This design is also provided with a water spray for additional humidification required while drying thick and refractory timber. It may be advantageously adopted for seasoning timber for end uses for which steam heated kilns are used. Solar kilns of capacity up to 50 m^3 of sawn timber per charge have been in commercial use in the country.

9.2.2 In the forced circulation solar heated kiln, the entire energy input required in the form of heat for evaporation of water is derived from solar energy. Electric energy is required only for driving the kiln fans. This results in considerable savings in overall process energy requirement. Besides, the kiln is a pollution-free system.

9.2.3 It is not possible to operate the schedules given under **8.4** in a solar kiln because of the inherent diurnal variation of kiln temperature. However, certain degree of regulation of kiln RH is possible by use of the water spray and adjustment of kiln vents to prevent cracking in the initial green stage of drying. The quality of timber dried in the solar kiln is generally better than air seasoned timber, because of better RH regulations possible in the solar kiln, and it approaches the quality of kiln dried timber. Case hardening stresses can be relieved by prolonged water spray humidification after the drying is completed.

9.2.4 The solar kiln is normally operated during daylight hours only. A single-pass forced air drying arrangement is incorporated making use of the dry air available on warm summer nights, which is effective during green stage drying. The solar drying periods are on the average double of those in steam heated kilns but considerably less than periods required for air seasoning.

9.2.5 Solar kiln temperatures have an inherent tendency to keep low during the green stage drying and to increase gradually as the drying progresses. Temperature differential over the ambient is around 7°C at the start of a green charge, gradually building up to 20°C or more at the completion of drying, on clear days. The solar kiln, therefore, needs much less skilled attendance than a steam heated kiln. The performance however suffers on continuously cloudy days.

9.3 Dehumidification Drying

9.3.1 This is essentially a kiln drying process in which the water vapour from the kiln is removed by condensing it as water on the evaporating (cooling) coil of a refrigerating system with both evaporating and condensing coils located within the kiln, rather than by venting it out as in the conventional steam heated kiln. The latent heat released on condensation of water vapour is picked up by the liquid refrigerant which evaporates inside the evaporating coil. This heat is finally re-delivered to the kiln air as heat of condensation of the refrigerant vapour via the condensing coil, in which the refrigerant vapour is compressed and re-condensed as liquid. The considerable venting heat loss that occurs during drying in a steam heated kiln is thus avoided.

9.3.2 This process, like solar drying, appreciably conserves the component of energy used as heat compared to that involved in drying in steam heated kilns. Its operation, however, requires the entire energy input to be in the form of electric energy. The process lends itself easily to automatic control of kiln conditions. This feature, together with the energy savings possible, is expected to make the running costs of this process economical compared to steam heated kilns.

9.3.3 The dehumidification equipment indigenously available at present limits kiln operating temperatures to 50°C. Drying times under this process are, therefore, liable to be slightly longer than in steam heated kilns.

9.3.4 The quality of drying is somewhat better as regards freedom from warping than in steam heated kilns, because of the lower temperatures adopted. Case hardening stress can be relieved by prolonged water spray humidification as in the solar kiln.

9.4 Predrying or Forced Air Drying

9.4.1 Predrying or forced air drying (*see also* **8.4.2** and **9.1**) may be adopted for accelerating the partial air drying of timber to about 25 percent moisture content preparatory to kiln seasoning in order to reduce kiln periods and increases kiln capacity, where climatic conditions are too humid or cold for air drying. The method consists in forcing unheated atmospheric air or air heated to low temperatures (not exceeding about 42°C) through the timber stack by means of fans in a single pass or by a recirculating system. Low temperature predrying by a recirculating system is generally carried out inside shed with lightly insulated walling. A solar kiln (*see* **9.2**) may also be very effectively used for partial predrying.

9.4.2 Predrying in conjunction with final drying in steam heated kilns offers overall economics in the drying operation compared to direct drying in steam heated kilns from the green condition. Gains are expected to be most if solar kilns are used for predrying. Predrying is also recommended for timbers that are susceptible to collapse and warping.

9.5 Baking Over Open Fire

This method is generally adopted for round bamboo used for tent poles fishing rods, etc, in case of species used for these purposes. The object of this treatment is primarily to sterilize the green bamboo to obtain benefit of slight formation of wood tar creosote and to reduce its surface moisture in order to provide primary protection against fungal discolouration and decay in storage. The treatment may, however, be effective in this respect only for short periods under adverse storage conditions, unless prophylactic preservative treatment conforming to IS 401 : 1982 is simultaneously given. The baking usually does not reduce the bamboo to the equilibrium moisture content level, and therefore suffices only for end-uses where subsequent change of cross-sectional shape and size to a certain extent can be tolerated without affecting serviceability. For more exact requirements, baked bamboo shall be further air seasoned (*see also* **6.5.5**).

10 PRESEASONING TREATMENTS

These treatments given to the green sawn timber prior to seasoning are aimed at reducing drying times, drying defects and overall drying costs.

10.1 Chemical Seasoning

10.1.1 This technique can be successfully applied to prevent cracking and splitting during seasoning of highly refractory hardwoods and thick sections for which these defects are found difficult to avoid under conventional air and kiln seasoning. Green sawn timber is first soaked in solution of an anti-shrink or anti-shrink-cum-hygroscopic chemical for an appropriate period, depending upon the species and thickness of section, so as to treat the outer layers of the section by diffusion. The treated timber is then air or kiln seasoned.

10.1.2 Any of the following chemicals or compositions may be used for chemical seasoning, depending, upon the cost considerations in relation to the end use:

a) Polyethylene glycol — 1 000 or 1 500, 25 to 40% (*m/m*) solution at room temperature. Temperatures up to 45°C may be maintained to accelerate the treatment.

b) Commercial fertilizer grade urea, 60% (*m/m*) solution maintained at 45°C.

c) Urea-sorbitol solution, 16 : 24 : 5 (water-urea-sorbitol) by mass, maintained at 45°C.

10.1.3 For kiln drying of timber pre-treated with compositions given in **10.1.2**(b) and (c), the appropriate schedule shall be selected as per **8.4** except that the RH used in the first drying step of the schedule shall not exceed 80 percent; for kiln drying of timber treated with composition **10.1.2**(a), it may be safely possible to adopt accelerated RH reduction schedules compared to those prescribed in **8.4**.

10.1.4 Chemical seasoning can be advantageously adopted for half wroughts of rifle, furniture, shoe lasts, shuttles, handicrafts like fruit bowls and statues, tool handles, tent mallets and also for door and window frames made from refractory species such as *Eucalyptus* hybrid (*E. tereticornis*), *Terminalia alata*, etc.

10.2 Presteaming

10.2.1 Steaming of green sawn timber at atmospheric pressure at temperature in the vicinity of 100°C for 2 to 4 h can accelerate subsequent air or kiln drying of some timber species of the moderately and highly refractory classes (*see* **4.3** and **4.2**) such as *Gmelina arborea, Schima, wallichii, Lannea coromandelica, Dipterocarpus* spp., *Shorea robusta*, etc. Impermeable and moderately permeable wood responds better to this treatment than permeable wood, and the radial planks better than the tangential. Steaming followed by quenching in cold water and hot water treatment near 100°C have also been found to be effective.

10.2.2 Adoption of this pretreatment in commercial seasoning practice however needs careful preliminary trials, since it has been found to enhance warping and collapse in subsequent kiln drying of some species.

10.3 Special Sawing Procedures

10.3.1 The broad faces of tangentially sawn planks of most species suffer more surface cracking than the broad faces of radially sawn planks. Radial or quarter sawing may therefore be adopted to advantage in case of larger-girth logs of highly refractory hardwoods such as *Eucalyptus* hybrid (*E. tereticornis*) Quercus spp., *Terminalia alata*, etc, to reduce surface cracking during seasoning. This sawing method however appreciably reduces the width of planks available from logs of a given girth, besides slightly reducing the volume yield and increasing sawing labour and time compared to conventional plain sawing.

10.3.2 A balanced tangential sawing scheme for logs, in which a discrete sawing sequence is adopted for successive planks (*see* Fig. 8), has been found most successful in obtaining planks of uniform thickness with minimum bowing and crook on the saw, in the case of species containing severe growth stresses in the log such as *Eucalyptus* hybrid (*E.* tereticornis), *Populus deltoides* and *Acacia auriculaeformis*. This procedure may be useful to minimize growth stress induced bow and crook during sawing of logs of such species.

10.3.3 A saw-dry-rip procedure, found effective in obtaining final cut sizes free from bow and crook in some species containing severe growth stresses, such as *Populus deltiodes, Hevea braziliensis* and *Eucalyptus grandis*, consists in flat sawing of the log into full-width thick flitches which are then seasoned. The seasoned flitches are finally converted into the cut sizes required. The larger width and thickness in which the flitches are seasoned are believed to assist in accommodation and ultimate reduction of the stresses. In some species like *Populus deltoides* rapid seasoning of the flitches at high temperatures has been found practical and effective without any increase of degrade, while in some others the flitches may be air or kiln seasoned.

11 PRETREATMENT AND POST TREATMENT SEASONING

11.1 Timber intended to be treated with oil-

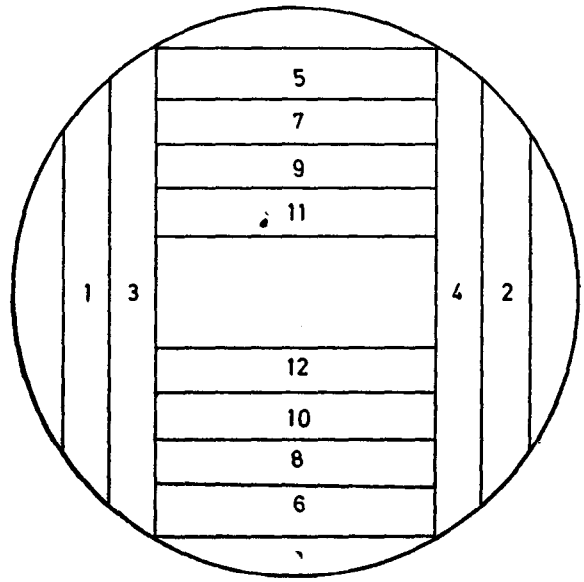


FIG. 8 BALANCED TANGENTIAL SAWING

type preservatives may be seasoned to the final moisture content levels (*see* IS 287 : 1993) before treatment.

11.1.1 Timber intended to be treated with water soluble preservatives needs both pre- and post-treatment drying, first to dry it to the moisture content levels specified in IS 401 : 1982 for ensuring proper absorption and penetration and subsequently again to reduce the moisture content to the final required levels. Air seasoning is preferable for the pre-drying preparatory to preservative treatment, and the final drying (after treatment) may then be effected in air or in a kiln before the timber is manufactured or fashioned to the desired shape and size. In any case, the seasoning should not be carried out under drastic conditions causing serious lateral movement of the preservative outward from inside. Post-treatment seasoning of timber treated with water-soluble borax-boric acid composition shall be done in air, as kiln seasoning tends to result in partial loss of these chemicals under high temperatures.

11.1.2 Where timber is partially pre-air dried and roughly fashioned to required shape and size preparatory to treatment with water soluble preservatives, the following precautions are recommended:

a) Sufficient oversize should be left at the rough fashioning stage to allow for shrinkage during post-treatment seasoning and for moulding and machining operations during subsequent manufacture.

b) Post treatment seasoning shall be carried out slowly to avoid cracks and end splits in the fashioned timber. Besides, for end coating of individual fashioned timber pieces immediately after treatment, sufficiently high RH may be adopted for the initial steps in kiln drying.

This procedure must be adopted only after making preliminary trials on the timber species to be used, particularly if refractory species are used.

12 INSPECTION OF SEASONED TIMBER

12.1 Seasoned timber should be inspected for conformity to specifications of moisture content, residual case hardening stresses, wherever necessary, and natural as well as seasoning defects.

12.2 For inspection of a given lot of timber with regard to moisture content and residual case hardening stresses, test samples shall be drawn which are representative of the lot in dimensions, quality and moisture content. The number of samples to be tested depends upon the size of the lot, the permissible range of moisture contents (which depends upon the end-use), the composition of the lot and the

likely variation in moisture content between the individual pieces. However, as a minimum, not less than 5 percent samples shall be selected for tests from any lot.

12.3 Conformity to moisture content requirements shall be determined in accordance with the maximum permissible limits of moisture content and the tolerances recommended in these limits for seasoned timber for various end-uses, as laid down in IS 287 : 1993 and following the testing procedure prescribed in IS 11215 : 1991.

12.4 Seasoned timber shall be inspected for residual case hardening stresses, wherever it is intended to be resawn or planed asymmetrically on opposite faces for precision jobs or turned or carved to produce intricate shapes and designs. It shall be deemed to be free from objectionable stresses if prongs prepared from the test samples according to the procedure in Annex D have no appreciable curvature after room-drying for 24 h.

12.5 Seasoned timber shall be inspected for defects (both natural and seasoning defects) in accordance with specifications laid down for sawn timber or quality of timber for various end-uses.

13 STORAGE AND TRANSPORT OF SEASONED TIMBER

13.1 As far as possible, seasoned timber should be promptly used before its moisture content has had time to alter due to climatic changes. However, when storage becomes unavoidable, it should be stored in close stacks under a shed maintained under dry conditions to retard moisture content change. Stacks may be further protected by polythene covers enclosing each stack from all sides and the top. Planks and scantlings may be stored after strapping with metal bands in small lots. Where seasoned timber is required to be maintained within close tolerances of moisture content pending use for regular, large scale production work, such as for aircraft construction, railway coach shutters, rifle, furniture, pattern making, etc, storage should be done in conditioning sheds maintained at proper equilibrium moisture content conditions.

13.2 Seasoned timber should be transported in close stacks in covered wagons or under tarpaulin covers to protect it against rain. Seasoned half-wroughts of timber for special use should preferably be packed in gunny bags for transport.

ANNEX A

(Foreword)

ANTI-SHRINK TREATMENT FOR WOOD

A-1 DETAILS OF TREATMENT

A-1.1 Timber for high class jobs requiring precision of shape and size in use, such as for rifle fore-ends, dies for automobile bodies and pattern making may be given an anti-shrink treatment with polyethylene glyocol (PEG)-1 000, to which sodium pentachlorophenoxide has been added for protection against insects and fungi, provided that the treated timber shall be used indoors or shall be painted over with polyurethane or other effectively water-resistant paint.

A-1.2 The treatment shall be given to wood with moisture content not less than 30 percent (preferably green freshly sawn wood) and preferably after shaping it roughly to the final form and size to minimize treatment time. Treatment shall be given for an adequate period to allow the chemical to penetrate through and through for effective dimensional stabilization.

A-1.3 The minimum concentration of water solution of PEG-1 000 needed for imparting near complete dimensional stabilization to timber depends upon the specific gravity of the wood and may be roughly estimated by the following formula:

$$C = \frac{\frac{30}{1{\cdot}1} \times 1{\cdot}125}{\frac{1}{S} - \frac{1}{1{\cdot}53}} \times 10$$

where

C = concentration of solution, grams of PEG-1 000 per litre of solution (in the formula fibre saturation moisture content of wood expressed as percentage of the oven-dry weight is 30; mean specific gravity of bound water in wood is 1·1; specific gravity of PEG-1 000 is 1·125; and specific gravity of wood substance determined by water displacement method is 1·53).

S = basic specific gravity of the wood species, green volume-oven-dry weight basis.

A-1.4 The treated timber shall be close-stacked under a polythene sheet cover for a few days after treatment, to promote diffusion of the chemical into the cell walls. It shall then be air dried or kiln dried in the normal manner before manufacture.

ANNEX B

(*Clauses* 4.5, 8.3.2.5, 8.4.1 *and* 8.4.5)

CLASSIFICATION OF SOME OF THE IMPORTANT INDIAN TIMBERS BASED ON THEIR SEASONING BEHAVIOUR AND REFRACTORINESS

SPECIES	TRADE NAME	REFRACTORINESS	KILN SCHEDULE
(1)	(2)	(3)	(4)
Abies densa	red fir	C	—
Abies spp. (other than *Abies densa*)	fir	C	I
Acacia catechu	khair	A	—
Acacia chundra	lal-khair	A	—
Acacia leucophloea	hiwar	A	—
Acacia nilotica	babul	B	VI
Acacia tortilis	Israel babul	A	VII
Acer spp.	maple	B	V
Acrocarpus fraxinifolius	mundani	B	III
Adina cordifolia (*Haldina cordifolia*)	haldu	B	V
Aesculus indica	horse-chestnut	B	IV
Aglaia spp.	aglaia	A	VI
Ailanthus spp.	maharukh and gokul	C	I
Albizia chinensis	siris	B	—
Albizia lebbeck	kokko	B	IV
Albizia odoratissima	kala-siris	B	IV
Albizia procera	safed-siris	B	IV
Alnus spp.	alder	C	I
Alstonia scholaris	chatian	C	I
Altingia excelsa	jutili	A	V
Amoora wallichii	amari	B	IV
Anogeissus acuminata	yon	A	—
Anogeissus latifolia	axle wood (bakli)	A	VII
Anogeissum pendule	kardahi	A	—
Anthocephalus chinensis	kadam	C	II
Aphanamixis polystachya	pitraj	B	V
Artocarpus chaplasha	chapalsh	B	III
Artocarpus heterophyllus	kathal	B	III
Artocarpus hirsutus	aini	B	IV
Artocarpus lokoocha	lakooch	B	V
Avicennia officinalis	baen	A	—
Bauhinia spp.	kanchan	B	—
Betula spp.	birch	B	V
Bischofia javanica	uriam	A	VI
Bombax spp.	semul and didu	C	I
Boswellia serrata	salai	C	II
Bridelia spp.	kasi	B	—
Broussonetia papyrifera	paper mulberry	C	—

Species	Trade Name	Refractoriness	Kiln Schedule
(1)	(2)	(3)	(4)
Buchanania spp.	charoli	B or C	II
Buxus sempervirens	boxwood	B	V
Calophyllum spp.	poon	B	IV
Canarium spp. (other than *Canarium strictum*)	white dhup	C	I
Canarium strictum	white dhup	C	—
Canthium spp.	balasu	B	—
Carapa moluccensis	pussur	B	VI
Careya arborea	kumbi	A	VI
Cassia fistula	amaltas	A	VII
Cassia roxburghii	vakai	A	—
Castanopis spp.	chestnut	B	IV
Casurina equisetifolia	casuarina	A	—
Cedrus deodara	deodar	C	III
Celtis australis	celtis	B	IV
Chloroxylon swietenia	satinwood	A	VI
Chukrasia velutina	chickrassy	B	IV
Cinnamomum spp.	cinnamon	B	V
Cleistanthus collinus	karada	A	—
Crypotomeria japonica	suji	C	—
Cullenia rosayroana	karani	C	—
Cupressus torulosa	cypress	C	III
Dalbergia latifolia	rosewood	B	IV
Dalbergia sericea	saras	B	II
Dalbergia sissoo	sissoo	B	IV
Daphniphyllum himalyense	verm-ratendu	B	II
Dillenia spp.	dillenia	B	—
Diospyros spp.	ebony and marblewood	A	VI
Dipterocarpus spp.	gurjan and hollong	B	V
Duabanga grandiflora	lampati	C	I
Dysoxylum binectariferum	devdam	B	—
Dysoxylum malabaricum	while cedar	B	IV
Elaeocarpus tuberculatus	rudrak	C	II
Emblica officinalis	amla	A	—
Endospermum spp.	bakota	C	II
Erythrina spp.	pangara	C	I
Eucalyptus globulus	blue gum	A	VI
Eucalyptus tereticornis	Mysore gum	A	IV
Evodia spp.	Kambli	B	—
Exbucklandia populnea	piple	C	—
Excoecaria agallocha	geon	C	I
Ficus spp.	figs	C	I & II
Fraxinus spp.	ash	B	V
Gardenia spp.	gardenia	B	V

Species	Trade Name	Refractoriness	Kiln Schedule
(1)	(2)	(3)	(4)
Garuga pinnata	gargua	B	III
Gluta travancorica	gluta	A	—
Gmelina arborea	gamari	B	III
Grevillea robusta	silver oak	B	VI
Grewia tiliifolia	dhaman	B	VI
Gyrocarpus jackquini	tanaku	C	I
Hevea braziliensis	rubber wood	B	V
Heritiera spp.	sundri	A	VII
Holarrhena antidysenterica	kurchi	B	III
Holoptelea integrifolia	kanju	B	III
Hopea spp. (other than *Hopea odorata*)	hopea	A	VII
Hopea odorata	thingan	A	—
Hymendictyon excelsum	kuthan	C	III
Juglans spp.	walnut	B	V
Kingiodendron pinnatum	piney	B	V
Knema attenuata	jathikai	C	II
Kydia calycina	pula	C	II
Lagerstroemia hypoleuca	pyinma	B	IV
Lagerstroemia lanceolata	benteak	B	IV
Lagerstroemia parviflora	lendi	A	—
Lagerstroemia specioca	jarul	B	VI
Lannea coromandelica	jhingan	B	III
Lophopetalum weightianum	banati	C	I
Machilus spp.	machilus	B and C	III
Madhuca spp.	mahua	A	—
Mallotus philippensis	raini	B	III
Mangifera indica	mango	C	II
Manilkara spp.	bullet wood	A	—
Maniltoa polyandra	ping	A	—
Melia azedarach	persial lilac	B	—
Melia composita	malaber neem	B	—
Mesua ferrea	mesua	A	—
Michelia spp.	champ	B	III
Miliusa tomentosa	hoom	B	V
Millingtonia hortensis	nimichambeli	B	III
Mitragyna parvifolia	kaim	B	V
Morus spp.	mulberry and bola	B	IV
Olea glandulifera	vern-gair	A	VI
Olea spp.	olive	B	—
Ougeinia oojeinensis	sandan	B	VI
Palaquium spp.	pali and tali	B	IV
Parishia insignis	red dhup	B	I
Parrotiopsis jacqemontiana	parrotia	B	V
Picea smithiana	spruce	C	I

Species	Trade Name	Refractoriness	Kiln Schedule
(1)	(2)	(3)	(4)
Phoebe spp.	bonsum	B	III
Pinus kesiya	khasi pine	B	—
Pinus roxburghii	chir	C	II
Pinus wallichiana	kail	C	II
Planchonella longipetiolata	lambapatti	C	I
Poeciloneuron indicum	ballagi	A	—
Polyalthia spp.	debdaru	B	V
Populus spp.	poplar	C	II
Prosopis juliflora	mesquite wood	A	VII
Prosopis specegera	jhand	A	VI
Protium serratum	murtenga	B	—
Pterocarpus dalbergioides	padauk	B	IV
Pterocarpus marsupium	bijasal	B	VI
Pterocarpus santalinus	red sanders	A	—
Pterocymbium tinctorium	papita	C	I
Pterospermum acerifolium	hathipaila	B	V
Pterygota alata	narikel	C	I
Quercus spp.	Indian oak	A	VI
Robinia pseudacacia	black locust	B	—
Sageraea elliptica	chooi	A	VI
Salix spp.	willow	B	III
Samadera indica	karimgotta	C	–
Santalum album	sandalwood	B	—
Sapium baccatum	seleng	C	II
Schima wallichii	chilauni	B	IV
Schleichera oleosa	kusum	A	—
Schrebera swietenioides	mokha	B	VI
Shorea assamica	makai	B	—
Shorea robusta	sal	A	VII
Sonneratia apetala	keora	B	III
Soymida febrifuga	rohini	A	VII
Spondias spp.	amra	C	I
Sterculia urens	karar	C	—
Sterculia villosa	udal	C	I
Stereospermum spp.	padri	B	—
Swintonia floribunda	civit	B	III
Strychnos nux-vomica	kuchla	A	—
Strychnos potatorum	chilla	A	—
Swietenia spp.	mahogany	B	VI
Syzygium spp.	jaman	A	VII
Tamarindus indica	imli	B	—
Tamarix aphylla	frash	B	—
Tectona grandis	teak	B	V
Terminalia arjuna	arjun	B	VI

Species	Trade Name	Refractoriness	Kiln Schedule
(1)	(2)	(3)	(4)
Terminalia bellirica	bahera	B	IV
Terminalia bialata	white chunglum	B	IV
Terminalia chebula	myrabolan	A	—
Terminalia manii	black chuglam	B	—
Terminalia myriocarpa	hollock	B	III
Terminalia paniculata	kindal	A	VI
Terminalia procera	white bombwe	B	IV
Terminalia alata (*Terminalia crenulata* Syn. *Terminalia alata* pro parte. *Terminalia coriacea* Syn. *Terminalia alata* pro parte. *Terminalia alata* Syn. *Terminalia alata* pro parte)	laurel	A	VI
Tetrameles nudiflora	maina	C	I
Thespesia populnea	bhendi	B	—
Toona ciliata	toon	B	V
Trewia nudiflora	gutel	C	I
Tsuga dumosa	hemlock	C	III
Ulmus wallichiana	elm	C	—
Vateria indica	vellapine	C	II
Vitex spp.	milla	A	VII
Wrightia spp.	dudhi	C	IV
Xylia xylocarpa	irul	A	—
Xanthoxylum limonella	mullilam	B	V
Ziziphus spp.	ber	B	VI

ANNEX C

(*Clauses* 8.3.2.6 *and* 8.3.2.7)

PREPARATION OF KILN SAMPLES AND THEIR LOCATION

C-1 PREPARATION OF KILN SAMPLES

C-1.1 Full length planks or scantlings selected as representative of the kiln charge shall be set aside as the charge is being stacked. A 750 mm sample shall be cut from a distance of at least 450 mm from one end of each plank or scantling or from its centre as illustrated in Fig. 9. At the same time as this sample is cross cut from the plank or scantling a full cross-section measuring 12 to 20 mm along the grain shall also be cross cut from near both ends of the sample. The sample and the two sections so obtained shall be suitably marked for later identification of the set, for example as *A*, *B* and *C* respectively.

C-1.2 Immediately after cutting, the respective weights of the sample and the two sections shall be recorded. The sample shall be end-coated and then placed in the kiln charge. The sections shall be oven-dried and their oven-dry weights determined. The moisture contents of the sections shall be calculated from the following formula:

$$\text{Moisture content, percent} = \frac{\text{Wet weight} - \text{Oven-dry weight}}{\text{Oven-dry weight}} \times 100$$

The mean of the moisture contents of the two sections *B* and *C* shall be taken as the moisture content of sample A and shall be used for calculating the oven-dry weight of the sample.

This calculated oven-dry weight together with the periodic weighings during kiln drying of the sample A will give the current moisture content and progress of drying, by use of the formula.

C-1.3 One half of the kiln samples prepared in accordance with **C-1.1** and **C-1.2** shall be placed in pockets in the right-hand side of the kiln charge. They shall be evenly distributed over this face of the charge both as to length and height. The remaining half of the samples shall be placed identically on the left-hand side of the charge.

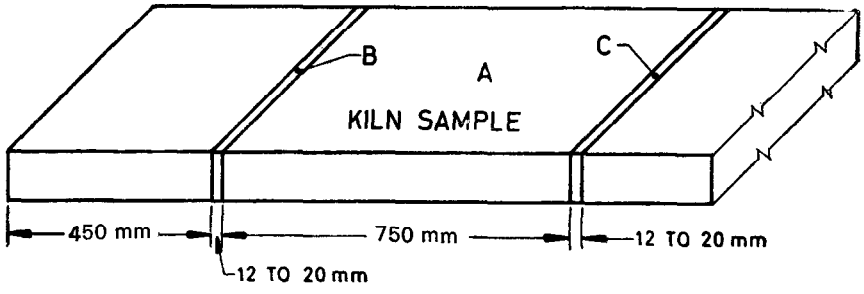


FIG. 9 METHOD OF CUTTING ORIGINAL MOISTURE CONTENT SECTIONS AND KILN SAMPLE FROM TIMBER TO BE KILN DRIED

ANNEX D

(*Clauses* 8.3.2.10, 8.3.2.13 *and* 12.4)

FINAL CHECK TESTS ON KILN SAMPLES IN A KILN CHARGE

D-1 CUTTING OF TEST SECTIONS

D-1.1 Three complete test cross-sections, 12 mm to 20 mm long in the direction of the grain, shall be cross-cut from a point at least 150 mm from the ends of each kiln sample included in the kiln charge (*see* Fig. 10).

D-2 TEST FOR MOISTURE CONTENT IN THE WHOLE SECTION

D-2.1 One of the three test sections obtained in accordance with **D-1.1** shall be weighed immediately after cutting on a balance, the sensitivity of which is not less than 10 mg. The section shall then be dried in a ventilated (and preferably thermostatically controlled) oven at temperature of 100°C to 105°C until the weight is constant. It shall then be weighed immediately after removal from the oven.

D-2.2 The percentage moisture content in the whole section shall be calculated as follows:

$$\text{Moisture content (percent)} = \frac{W_1 - W_0}{W_0} \times 100$$

where

W_1 = initial weights of test section, and

W_0 = oven-dry weight of test section.

D-3 TEST FOR MOISTURE CONTENT DISTRIBUTION IN CROSS SECTION

D-3.1 The second test section out of the three cut in accordance with **D-1.1** shall be marked on the freshly cut surface immediately after cutting, so as to subdivide it into shell and core zones in case of timber 40 mm or below in thickness or shell, intermediate and core zones in case of thicker timber, in the manner illustrated in Fig. 11. The section shall be quickly sawn to separate out the different zones. The two outside portions of the shell shall be weighed together, oven-dried and then weighed together again to calculate their moisture content in the manner of **D-2** above. In like manner, the two intermediately portions shall be weighed together but the core shall be weighed as a single piece for determination of their respective moisture contents.

D-3.2 Core moisture content determined according to the procedure **D-3.1** in conjunction with the moisture content in the whole section determined as per procedure of **D-2** shall be used to judge conformity of the kiln seasoned charge to the requirements of **8.3.2.13**.

D-4 TEST FOR RESIDUAL CASE HARDENING STRESSES

D-4.1 The third test section out of the three cut in accordance with **D-1.1** shall be marked and sawn so as to produce three prongs of equal thickness in case of timber 40 mm or below and six prongs in case of thicker as illustrated in Fig. 12. The middle prong in the former case and prongs 2 and 5 in the latter shall be broken out. The prong shall be room dried for 24 h and its curvature shall then be recorded to judge conformity of the seasoned timber to the requirements of **8.3.2.13.**

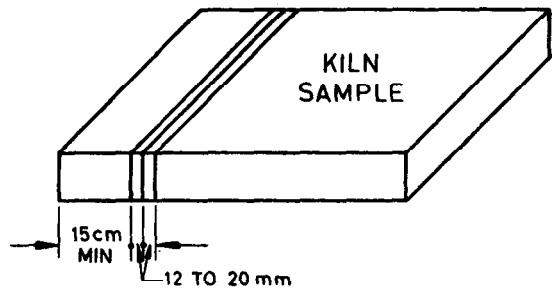
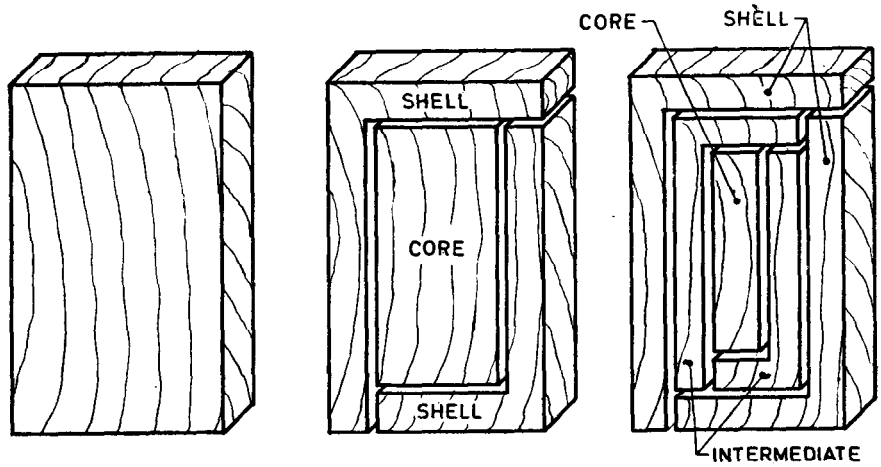


FIG. 10 TEST SECTIONS FOR FINAL CHECK

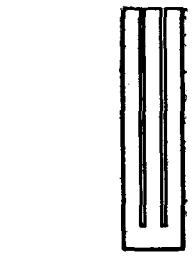


11 A WHOLE MOISTURE SECTION

11 B MOISTURE DISTRIBUTION SECTION FOR STOCK 40 MM OR BELOW IN THICKNESS

11 C MOISTURE DISTRIBUTION SECTION FOR STOCK THICKER THAN 40 MM

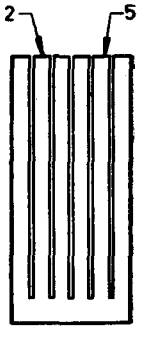
FIG. 11 FINAL MOISTURE SECTIONS



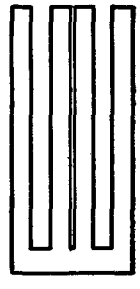
STOCK LESS THAN 40 mm THICK SHALL BE SAWN AS SHOWN SO AS TO PRODUCE THREE PRONGS OF EQUAL THICKNESS FOR CASE HARDENING TEST . THE CENTRE PRONG SHALL BE BROKEN OUT

NO CASE HARDENING

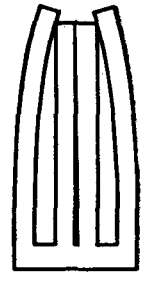
SEVERE CASE HARDENING



STOCK THICKER THAN 40 mm SHALL BE SAWN AS SHOWN TO PRODUCE SIX PRONGS OF EQUAL THICKNESS FOR CASE HARDENING TEST. PRONGS TWO AND FIVE SHALL BE BROKEN OUT



NO CASE HARDENING



SEVERE CASE HARDENING

FIG. 12 CASE HARDENING SECTION : SECTION TO BE ROOM DRIED BEFORE CONCLUSION IS MADE AS TO CASE HARDENING

ANNEX E

(*Foreword*)

COMMITTEE COMPOSITION

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(*Continued on page 26*)

(*Continued from page 25*)

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