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SEASONING

OF

WESTERN AUSTRALIAN HARDWOODS,

WITH NOTES ON THE TESTING OF SEASONED TIMBER.

Prepared under the direction of S. L. KESSELL, Conservator of Forests.

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SEASONING OF WESTERN AUSTRALIAN HARDWOODS.

BEFORE entering into any discussion on the merits and demerits of any method of seasoning, it is as well to study the structure of wood, and the part moisture plays in its composition.

Under high magnification, wood is seen to consist of a number of cells, like honeycomb, the cells, however, being much longer in proportion, and in hardwoods, very irregular in size and shape. Of these cells the larger ones are called "pores" and the smaller ones "fibres." Interspersed between these vertical cells are horizontal ones (the medullary rays) which are thin-walled and flat. It is thought that the cell walls consist of small particles closely packed, the interstices, in green timber, being filled with moisture. These particles are composed of a foundation material, cellulose, and lignin, a binding material giving strength to the cell walls, and also giving them colour. As mentioned, wood consists of fibres and pores. The ends of the fibres are closed but the pores, which conduct sap in a vertical direction to the branches and leaves, are open at either end. Similarly the medullary rays transmit moisture in a horizontal direction from the bark to the heart and *vice versa*.

EFFECT OF MOISTURE.

Moisture is present in green timber in two ways; as free water filling the cell cavities, and as fibre moisture absorbed in the cell walls. Fibre moisture usually weighs about 30 per cent. of the dry weight of the timber, the free moisture accounting for another 30 to 150 per cent. of the dry weight. From any individual cell the free water is always evaporated before the drying has any effect on the moisture in the cell walls. As the moisture in a cell dries, water is transmitted through the cell walls to it from adjacent cells, until the balance of moisture throughout the wood is re-established. If dry air is passed over a green board the free moisture in the outside cells is dried out and a transmission of moisture through the cell walls is set up. After the free water has been dried out, the water saturating the walls is removed. For ideal drying, the outside must not dry at a greater rate than the moisture can be transmitted to it from the centre. Heat raises this rate of transmission. If drying is allowed to proceed on the surface at a rate greater than the rate of transmission, all the free water is dried from the external cells and a start is made on the evaporation of the fibre moisture. Beyond a small amount of shrinkage and a resulting increase in the strength intensity, the drying out of the free water has little effect on the properties of the timber, but, on removing the fibre moisture, there is a much greater shrinkage and increase in the strength properties. In addition, the ability of the cell walls to transmit moisture is reduced. Thus, with too fast drying, fibre moisture is dried out of the surface layers, the even transmission of free water from the centre is arrested, and the internal part of the wood becomes enclosed in a hard case. This is known as "case-hardening." After reaching this stage if drying is continued, the tendency is for the case to become denser and thicker with still less ability to transmit moisture from the centre. It will be noticed also that the wood is in a state of strain; the outside, being drier than the centre, tends to shrink more, so that the centre is in compression and the surface in tension. If this state of strain continues to rupture point, there will be surface checking of the timber. On the other hand, if no checking takes place, the wood surface accommodates itself to the tensile stress and sets itself in a stretched position. Further drying tends to make the internal portion of the timber shrink also, but, in this, it is prevented by the hard case. As a result internal cracks (honeycombing) appear. No extraction of the moisture from the surface of the wood at a greater rate than it can be transmitted from the centre must be allowed ; or in other words, for successful drying, the fibre saturation moisture must be retained in the surface cells until the interior cells have given up their free water. It will be understood, of course, that for any transmission of moisture to take place, there must be a slight downward gradient from the centre of the board to the surface.

It has been shown that the rate of drying of a piece of wood depends solely on the rate of transmission of moisture. Therefore, as the rate of transmission increases with the temperature, the higher the temperature the greater the possible drying rate. Care must be taken that the temperatures are not so high as to injure the wood in any way. Wood, especially when green, subjected to high temperatures, is liable to collapse, due to weakening of the cell walls. The two conditions for the maximum rate of drying without injury must be a surface drying at a rate not great enough to cause case-hardening, and a temperature as high as the wood will stand without injury.

DRYING MEDIUMS.

Unsaturated air and superheated steam are the two most important driers. Superheated steam, except at pressures below atmospheric, when cost becomes exhorbitant, is, because of the high temperatures necessary, unsuitable for use with hardwoods. Air is the medium in general use. The drying value of air depends on the two factors, temperature and humidity. The drying value increases with the temperature. But air as a drying agent acts by removing moisture from the wood to increase its own humidity ; or, in other words, drying takes place when air has a greater affinity for water than the wood. As would be expected, the nearer air is to saturation point, that is, the higher the humidity, the smaller is the affinity for moisture. Hence the rate of drying of the wood surface can be regulated by the humidity of the air. It will be noticed that in drying the wood, the air tends to destroy its ability to do further drying, because of its resulting increased humidity. Hence for drying to be continuous the air in contact with the surface of the wood must be changed continually. There are, then, three essentials for successful drying—control of temperature, control of humidity, and control of circulation.

METHODS OF SEASONING.

In the forest the cycle of life is practically self contained. Seeds are sown, they spring up, grow to trees, shed unnecessary branches which help to form the humus, reach maturity, age, and die. The dead trees shed their bark, split, dry, rot, fall down, and go also to form the humus from which the existing forest gets its food. Hence it will be seen that Nature's practice with timber is to destroy, not to preserve. "Natural" seasoning does not exist ; *all seasoning must be artificial.* Seasoning can be considered as a process to circumvent the destructive action of Nature. The commonest method of drying in use at present is that known as air seasoning. The boards are stacked in layers with spacing strips between them to allow free circulation of the air.

It will readily be realised that in air drying not one of the three essentials, temperature, humidity and circulation, is under control. In the day time, the temperature is generally fairly high, while the humidity is low, but in the night the temperature is lower and the humidity is higher. It is obvious, therefore, that most of the drying takes place during the hottest part of the day, and that, for the rest of the time the timber is practically lying idle. If, therefore, the rate of drying of the timber is to be reasonably fast, the drying rate in the hottest part of the day must be severe, and there is always the possibility, on a very hot dry day, that an excessive rate will do serious damage to the timber. If the climate is so moderate that destructive conditions are never encountered, the drying rate is usually so slow that the interest on the capital bound up in the seasoning stacks makes the cost of air seasoning excessive. In Western Australia, 1in. Jarrah, providing it is not in the form of wide boards for highest grade work, can readily be dried by the air-seasoning process. If, however, it is required to season thicker sizes without blemish, the high cost of drying due to the degrade, and to the time required, will make this method far from practicable. In this State, therefore, as in other timber-producing countries, the need has been felt for some means of bringing the drying conditions under control and of making the drying process continuous, and it is this need that was responsible for the timber dry kiln.

HISTORY OF KILN-DRYING IN WESTERN AUSTRALIA.

Early kilns were mere instruments for driving water out of wood. Attempts at temperature, humidity and circulation control were rare and where existing were extremely crude. One is not surprised to find that these early attempts ended in failure. In this State, as in others, the need was felt for improvement on the air-seasoning method, and as a consequence various elemental types of kilns were tested, but with no positive results. Because of this there sprang up amongst local men a prejudice against rapid seasoning methods, and after these early attempts no kiln-drying was done in the State for an extended period. But, in America, with a view to eliminating some of the causes of the failures, further experiments were carried out. Gradually drying came to be regarded as a science and it was then treated from a scientific standpoint. Now it takes a prominent place amongst the engineering arts. No longer is the control mere guesswork, but scientific accuracy applied to a process, the fundamentals of which are thoroughly understood, has resulted in the evolution of the modern dry kiln.

A few years ago, it being realised that in Western Australia there was vast room for improvement, an attempt was made to introduce modern drying methods. This met with a certain amount of opposition from the timber men of the State as some of them, remembering their early failures, did not doubt that kiln-drying was impossible, at least with Australian woods. In spite of this, a modern kiln of small dimensions was erected, and preliminary experiments were carried out. From its inception the plant proved a success. It was demonstrated beyond a doubt that the local hardwoods could be dried thoroughly in it, still yielding a product of first-class quality. In order to place drying on a sound basis, a kiln of commercial cross section, but only 8 feet in length, was erected. The kiln was of the Tiemann type, which affords extreme delicacy of control.

Charges of 4in., 3in., 1in. and ½in. Jarrah, 1in. Karri and 1½in. Tuart were dried out, and the value of the product was amply demonstrated by the competition amongst local furniture makers for it. 1in. and ½in. kiln-dried Jarrah from these charges was selected for the exhibits at the British Empire Exhibition at Wembley. Realising that kiln-drying was more than a commercial proposition, that it was in fact a necessity, a local firm built two kilns, and within twelve months they doubled their plant.

SOME ADVANTAGES OF KILN-DRYING TIMBER.

In Western Australia, with 1in. jarrah boards, it is necessary, in order to obtain the best results, to stack out only in the winter. The high temperatures and low humidities of the summer months, because of too rapid surface drying, cause a large amount of warping and cracking. Severe case-hardening is also present. For the highest grades, boards cut in summer must be block-stacked until the cool weather, and then be re-stacked with spacing strips. 1in. jarrah takes two years to air-season thoroughly. Karri is much more difficult to dry successfully than jarrah. When green a single day of low humidity is sufficient to ruin boards. With dry kilns, 1in. jarrah, taken green from the saw, can be thoroughly dried in 25–28 days, while 1in. karri, which cannot be air-seasoned for the higher grades of work, can be turned out, a first-class product, in 35-40 days.

As mentioned before, both wood and warm dry air have an affinity for moisture. If the wood is dry and the air has a high humidity, the wood has the greater affinity, and will absorb moisture from the air, until a balance is reached. This happens in air-seasoning. The wood is dried down to a balance point in summer, but, in winter, during the low temperatures and high humidities, re-absorption takes place. The moisture content of wood in outdoor stacks rises to 17 or 18 per cent. or even higher. Naturally if air-seasoned timber is taken from outdoor stacks in the damp season and made up, then when the dry weather comes there will be a large amount of shrinkage. This explains why much of the timber described as thoroughly air-dried so often fails to give satisfaction. With kiln-drying a constant output can be maintained, the wood being dried as it is required, and being forwarded immediately to be made up. Thus wood can be dried with equal ease in both summer and winter and also the reserve stock, being small, can be kept under cover, and can be prevented from re-absorbing too much moisture during the damp months.

Case-hardening occurs, of course, in air-dried stacks, particularly those stacked for a period insufficiently long to allow thorough seasoning, and, as a result, there is usually to be found a large variation in moisture content between the inside and outside of boards. Whenever such boards are re-sawn or planed, the dry surface is removed, exposing the comparatively green interior ; further drying, accompanied by shrinkage takes place. With rapid seasoning methods, the timber is dried until the inside is down to the requisite moisture percentage, the timber being then subjected to a period of medium temperature and high humidity. This has the effect of bringing the moisture content of the outside up to that of the centre, and also it relieves the case-hardening stress. A variation between the centre and surface of more than 1 per cent. rarely occurs in the local kiln-dried product.

In America, prior to the war, all timber used for airplanes was air-seasoned. The exigencies of the war and the scarcity of dried material, however, necessitated the kiln-drying immediately from the green condition of practically all wood used in the United States for this purpose. It was established that many species of wood could be dried from the green state with better results than could be obtained by the irregular and unscientific method of air-seasoning. Exhaustive strength tests made showed beyond question that properly kiln-dried wood is just as strong, tough and stiff as the best air-dried material. It is interesting to note that England and France specified against kiln-drying airplane woods. The British allowed a moisture content of 15 per cent. for most woods, rising to 18 per cent. for ash. The maximum percentage moisture content allowable in the United States was 11. In the latter stages of the war England followed the American practice and adopted kiln-drying.

By far the greatest percentage of timber seasoned in this State consists of flooring, chiefly in sizes 1 inch thick, by 4, 5 and 6 inches wide. This class of timber can readily be dried by air-seasoning to a good product, but for a number of years past the supply has so exceeded the demand that it has, of necessity become a practice not to leave the timber in the stack for a sufficient period to season thoroughly. At the present time a comprehensive investigation into the time required for air-seasoning and the methods employed, is being carried out with a view to collecting data on this important matter. There is every indication that it will be possible, in the case of this material, to develop a system of combining air and kiln seasoning, with a view to reducing costs and to producing a better product of standard moisture content, irrespective of whether it is summer or winter.

The question of cost of kiln-drying will not be studied here, but it is sufficient to state that the saving of interest on the capital bound up in the requisite large air-drying stacks, the small percentage of waste due to discard, the superiority of the resulting product, as against the extra cost in kiln operation, have proved the modern dry kiln to be a commercial success. In the older timber countries within the last few years the expansion of this portion of the timber trade has been so great that in the near future kiln-drying will not be a novelty, looked on with suspicion, but the generally accepted practice.

THE TESTING OF TIMBER.

Considering the small amount of trouble necessary to conduct scientific tests, and considering also the great advantages of having an accurate knowledge of the true condition of timber, it is very surprising that owners of stocks of wood are not more enterprising in this direction. Not only is it possible to determine the actual state of the timber, but also its future behaviour, when in use, can be predicted with a fair degree of certainty. Unfortunately, it is not an uncommon occurrence to see a beautiful piece of wood-work spoilt by subsequent warping or shrinkage of the wood. As the timber used was apparently thoroughly dried before making up, the tendency is to class such a wood as unfit for the higher grades of work. Such a condemnation of the timber is, in many cases, entirely erroneous. The trouble lies in the fact that neither the time of drying, nor the appearance of the timber, can be taken as a criterion of its condition. The only reliable evidence is that of a properly conducted test.

There are three main faults for which tests should be made—

(*a*.) Too high a moisture content. This, of course, means further shrinkage in the made-up article.

(*b*.) Uneven distribution of moisture. Where drying has been too severe in the early stages, there is a tendency for only the outside fibres of a piece of wood to dry. These outside fibres, when dry, act as a shield, and tend to prevent the removal of moisture from the central portion of the wood. It is not unusual to find, therefore, that while a piece of wood is thoroughly dry on the outside, the middle part has not yet reached that state. Since nearly dry wood loses moisture very slowly at ordinary temperatures, it takes a considerable time for the whole of the timber to drop to a uniform degree of dryness. It is for this reason that the moisture distribution test is of such great importance. Consider the results obtained by making up a board which is insufficiently dry internally. The rough surface is planed off, and thus, the greener central portion is made more accessible to drying influences. Further drying takes place and the wood commences to shrink. Again, if more wood is planed off one side than the other, or if one side is polished (polishing tends to prevent drying), different amounts of drying, and consequently unequal shrinkages occur on the two faces, and dishing and distortion of the wood follow. Hence, for good results, the centre of the wood must be as dry as the outside.

(*c.*) Stresses in the timber due to shrinkage in drying. These stresses, as the timber stands in the rough state, balance one another, and so long as the timber is left in this condition, no movement need be expected. If, however, the wood is planed or sawed to a smaller thickness one set of the balancing forces is removed, and the wood immediately commences to shift.

TESTS :—

(*a.*) *Moisture content :*

Select a piece of wood from the material to be tested, and cut from it a section about ¾in. in length along the grain. This section should be cut at least 2ft. from the end of the piece, as otherwise it might be affected by end drying. Clean off all loose splinters and saw-dust from the section, and then weigh it on a balance to an accuracy of 1 per cent. Place the section on hot steam pipes, or in a dry oven heated to 212 degrees F., and leave until it ceases losing weight. Weigh again to an accuracy of 1 per cent. The difference between the first and second weights gives the amount of water present in the section, and this amount, divided by the second weight and multiplied by 100 represents the moisture content of the wood expressed, as a percentage of dry weight. For the timber to be classed as well dried, this moisture content should be from 10 to 12 per cent.

(*b.*) *Moisture distribution :*

Where tests are being made for moisture distribution it is not necessary to make an independent test for moisture content.

To carry out the test a section ¾in. long is cut, as in the moisture content test. Lay this section on the bench so that the end grain is upwards and with two vertical saw cuts divide it into three strips, each ¾in. in length along the grain, of widths equal to the width of the original board, and of thicknesses roughly ⅓ that of the original board from which the section was cut. (*Note.*—The final two saw cuts are rip cuts). Clean each strip, weigh, dry out, re-weigh and calculate the moisture content of each as in test (*a*). The moisture content of the central strip should not be greater than 12 per cent. and should also not be more than 2 per cent. greater than the moisture content of the outside strips.

It is worthy of note that the variation in moisture content in kiln-dried wood is extremely low. In the kiln the timber is usually dried slightly below the figure required, moisture being afterwards added to bring the wood to a normal state. Because of this, in good kiln-dried material the central portion has rarely a moisture content 1 per cent. greater than the outside.

(*c.*) *Stresses due to drying :*

The most common stress present is that due to case hardening. This is tested for as follows :—

As in the above two tests, cut a section ¾in. long. Two saw cuts are made as in the test (*b*) but with the difference that the cuts are not the full width of the section, about ½in. being left to bind the strips together. The section now resembles the end of a three-pronged fork with the prongs flattened. The central prong is broken out. If the two outer prongs bend in and nip, the timber is badly case-hardened. Such timber should only be used in positions where it can be held tightly in place. If planed, cut, or slotted, and placed where it can not be secured tightly, distortion will occur. If the prongs incline in or out only a small amount, or if they remain parallel, the wood is practically free from strain and can be used without fear of trouble from this source. It is of the utmost importance, when taking this test, to note the behaviour of the timber *immediately* after the saw cuts have been made, and the central prong has been broken out. The subsequent behaviour of the prongs does not enter into this test. Boards which are warmer than ordinary room temperature, or which have damp surfaces, should not be taken as specimens for case-hardening tests.

Where the pieces tested are above 2in. in thickness, five saw-cuts instead of two should be made. This divides the section into six prongs, the second and fifth being broken out, and the first, third, fourth and sixth being retained to indicate the condition of the timber. It will be found convenient and sufficiently accurate to use for the moisture distribution test, the strips made in the prong test for case-hardening.

The method of testing completely a quantity of timber, therefore, is as follows :—

Select several representative pieces from the pile to be tested. Taking each piece in turn treat it thus :—

Cut a section at least 2ft. from an end, and slit it into three prongs for the case-hardening test. Break out the middle prong ; note the behaviour of the two outside prongs ; break them off also ; clean and weigh the three prongs. These prongs are then dried out and re-weighed, their moisture contents being calculated. Care should be taken that the prongs are weighed as soon as possible after the cutting of the original section.

Where timber is known to be fairly dry, an indication of moisture distribution can often be obtained without weighing. A prong test is cut, and without breaking out the centre prong, it is placed in some warm dry place where the prongs will dry evenly. If the moisture distribution is uneven, it will be found that there is a difference in the lengths of the three prongs due to uneven shrinkage. It should be remembered that this test does not necessarily indicate that timber is thoroughly dry. For example, a board taken from a stack in winter might be at 18 per cent. moisture content, but of the same moisture content throughout. Under these circumstances, it would pass this test but would still be unfit for use on account of its high moisture content. The test, therefore, should be used with care, but it may be used safely where the outside of the timber is known to be thoroughly dry.

TESTING EQUIPMENT.

It is essential that every yard producing seasoned timber, and every factory with seasoned wood as a raw product should have the nucleus of a testing equipment. As this equipment is not expensive and the actual time required for testing is small, the very desirable knowledge of the condition of the timber can be gained at small cost.

While the cutting of moisture content and prong sections can most readily be done with a band saw, this is by no means essential. Good results can be obtained with an ordinary hand saw, and the difficulty attendant upon making the two final or rip cuts in the prong section can be overcome by placing the section on a piece of thin board, and ripping both section and board at the same time. For the weighing of moisture content sections a cheap chemical balance weighing to 100 gms. or even photography scales of the letter scale type can be used. It is advisable to have weights graded on the decimal system, as this reduces calculation to a minimum. Where steam is continuously available, the drying oven need consist simply of a sheet-metal box, preferably lagged, with a steam heated coil in the bottom, and provision for ventilation. The temperature should be maintained between 212 deg. F., and 240 deg. F. With temperatures below the lower limit, drying will not be complete, while above the upper limit inaccuracies will occur due to charring.

Where electricity is available a simple oven can be made by using carbon filament globes as heating elements. Such an oven consists of a 26 gge. galvanised iron box 13in. long by 8 inches wide and 7 inches deep, external dimensions. The box has a lining of similar material, and the half-inch space between the outside and the lining is filled with pulverized asbestos or other moderately fireproof insulating material. The top of the box is of double thickness asbestos packed, and is hinged to give access to the interior. The box has four ⅜in. ventilation holes extending from the outside to the inside, in each side, about ½in. from the bottom. Nine similar holes are provided in the hinged lid. Four 32 C.P. (90 watt) carbon filament globes are wired into the box below the centre line, two at each end of the box, the lamp sockets being secured to the lining by means of the shade nut usually provided with sockets. The two lamps at an end are in series and the two pairs of lamps are in parallel. Series lamps are not used, so that each lamp when burning is under a pressure of only half the normal voltage and so emits a dull glow. The consumption of each lamp is thus 22½ watts, or a total for the oven of 90 watts. The oven is completed with a length of flexible wire and an adaptor, and may be connected to any electric lamp socket. Samples ¾in. in length along the grain of the timber are thoroughly dry after 48 hours, but, if quicker results are required, the error after 24 hours' drying is not likely to be greater than ½ per cent. of moisture content. The temperature attained by the ovens should be in the neighbourhood of 212 deg. F. They should be tested with a thermometer and, if found to be too low, the temperature may be increased by keeping the oven in a loose fitting box such as a petrol case with a cover.

With this simple equipment, it is thus possible to determine whether timber is ready for use when in the stack, or whether, if being prepared for manufacture, it is likely to prove suitable for the purpose intended. The small premium paid in the cost of tests is amply repaid in the insurance against failure due to the knowledge of the condition of the timber being used.

CARE OF SEASONED TIMBER.

Once wood has been thoroughly dried, it is often thought that there is no longer any need to be careful of its moisture condition. On the contrary, however, just as much care should be exercised in the storing as in the drying of timber.

In the winter months, dry timber stacked out of doors absorbs moisture and swells. This absorption, towards the end of the winter with 1 inch material, often raises the moisture content to a percentage of 18 or higher. It will readily be conceded that to use such timber for indoor work is inviting trouble. In order, therefore, that satisfactory results may be obtained in winter, it is advisable to stack indoors in late autumn a sufficient supply to last till the end of the following spring. Timber stacked indoors should be placed in a well ventilated, dry room or shed, and should be kept at least a foot off the floor. If the timber absorbs moisture, this can be prevented by the use of a fire or radiator in the room, for a short time, at intervals.

At present there is a much too great tendency towards irrational methods, and until timber users realise that it is only by application of scientific principles to the treatment of wood that satisfactory results can be obtained, there will continue to be a great and needless waste in material and money throughout the industry.

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