CENTRAL BUILDING RESEARCH INSTITUTE, INDIA.

BUILDING RESEARCH NOTE 71

SOLAR TIMBER SEASONING KILN

Seasoning Process

A newly felled tree contains relatively higher moisture mainly due to the free-water contained in the cell-cavities. Removal of this water leaves only the bound moisture which is held in the wood tissues. This condition is known as fibre saturation point and moisture content at this point ranges between 24–30 per cent. When the bound moisture commences to dry out of the wood tissues, the plasticity of the cellular content of the wood is lessened, shrinkage commences, internal stressing of the wood structure occurs and the material exhibits a general improvement in strength.

The removal of moisture is controlled by the vapour pressure gradient that develops across the timber due to the difference in moisture contents inside and outside the timber. The vapour pressure gradient is given by :

$$\Delta p = \frac{2U_l - U_h}{s} \qquad \ldots\ldots (1)$$

Where, U_l and U_h are the moisture contents inside and outside the wood respectively. The condition for successful seasoning can be achieved by controlling three factors namely : (1) temperature, (2) humidity and (3) circulation of air. A brief description of main seasoning methods is given below :

Air Seasoning

Moisture is removed with the help of air and sun while protecting the timber from the rains. Air inside

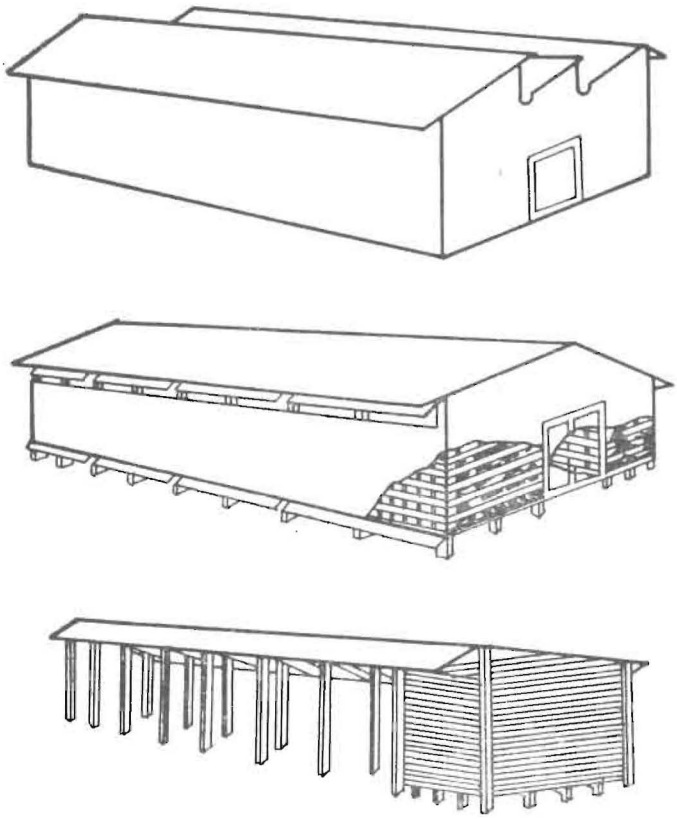

Fig. 1 Air Seasoning Sheds

the seasoning shed gets saturated with the moisture removed from the timber and is continuously replaced by fresh air due to natural circulation. A few designs of air seasoning sheds are given in Fig. 1.

In its simplest form a seasoning shed can be a large dutch barn having a roof. But the best shed to meet the necessary requirements is a long narrow building. It should have openings in the walls at the top and the bottom for free circulation of air through the piles of timber.

The platform used for stacking the timber is made of concrete or brick work. The platforms should offer protection to rhe timber against infestation from soil organisms, fungi and other insects. However, in order to protect the timber from termites some anti-termite treatment has to be given. However, the normal practice in air-seasoning is to keep timber without proper stacking on an uneven platform in the field or under a shed. In these situations, the material could not be protected properly from sun rays and rain showers. Moreover, the direction of air flow can also not be regulated. Thus, no proper air seasoning can be achieved in this manner.

Kiln Seasoning

In steam-heated kilns the humidity is controlled by regulating the temperature of fresh air having admitted to replace the moisture saturated air. The kilns may be maintained at 54° to 82°C and are known for rapidity, adaptability and precision. In a properly operated kiln each piece of wood is seasoned to desired moisture content in the reasonable time. The humidity and temperature at which wood is seasoned are injurious to the insects or fungus present in it. However such kilns require much skill to operate and their installation also require several lakhs of rupees.

Some timbers are difficult to season as they are liable to surface splits and checks due to large tension stresses on outer layers. Such wastages can be reduced by adopting 'chemical seasoning' before kiln seasoning. The process of chemical seasoning consists of treatment to the surface layers of timber with hygroscopic chemicals. The chemicals keep the moisture content of the surface layers high and the timber do not shrink during drying. Sodium chloride and urea have been used for this purpose.

Solar Seasoning

Solar energy is also used in air seasoning of timber. Effective use of solar energy is achieved by designing a proper solar kiln. Research during past two decades led the developments of two major types of solar kilns. Their brief description is as follows :

1. Solar kilns consisting of enclosed heavily insulated seasoning chambers and external solar energy collectors.
2. 'Green house' type, consisting basically of framed structures with transparent walls and black painted solar energy collectors.

Both the above types of kilns are based on solar heated air as seasoning medium. However, two different systems are employed to transfer the heat energy from the place where it was collected to where it was used.

The different systems are either hot air or water for transfer of heat. Liquid transfer systems are generally used with kilns having external collectors. They are very costly and complex to install. But they are designed with the device for shortage of heat for use during periods when the solar energy is not available.

Hot air tranfer systems are used in the green house type of kilns where the solar energy collector forms an integral part of the kiln. They are relatively cheap and show more acceptability by the users in comparison to the solar kilns based on liquid transfer systems. There is no transfer system provision of storing heat in these kilns during cloudy days and nights.

Solar Kiln Developed In CBRI

In India the solar kiln having forced drying system could not become popular due to their high cost and maintenance. Keeping in view of Indian economic and climatic conditions, a solar timber seasoning kiln is developed in the Central Building Research

Institute, Roorkee. It consists of three main parts namely (i) Solar Energy Collectors, (2) Seasoning Chamber, and (3) Chimney. Fig. 2 shows a schematic diagrame of a CBRI solar kiln.

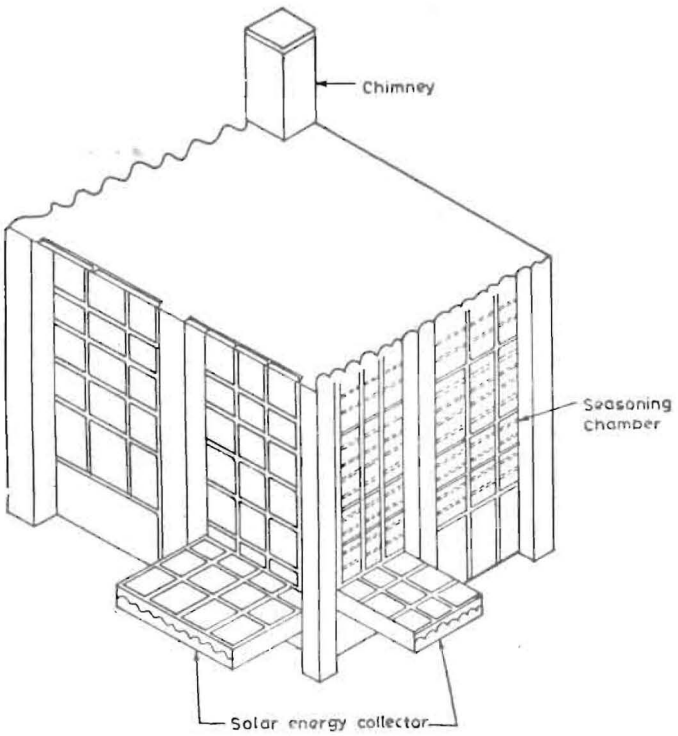

Fig. 2 Solar Timber Seasoning Kiln

Black painted G.1. sheets are used as solar energy collectors. With the help of wooden frames, transparent glass sheets are fitted around the collector leaving air gaps for the movement of fresh air. They are attached to the bottom of south and/or west walls of the seasoning chambers at an angle of 30° with the horizon.

Double wall seasoning chamber is constructed with glass except the north wall which is of brick masonry. Black painted aluminium fins are fitted in the east and south walls at an angle of 45° with the horizon. The roof is made of black painted corrugated G.I. sheets and has a slope of 1 in 3. To provide stack effect and circulation of fresh air inside the seasoning chamber (Fig. 3) a small chimney is fitted vertically over an opening in the corner of the roof in the seasoning chamber.

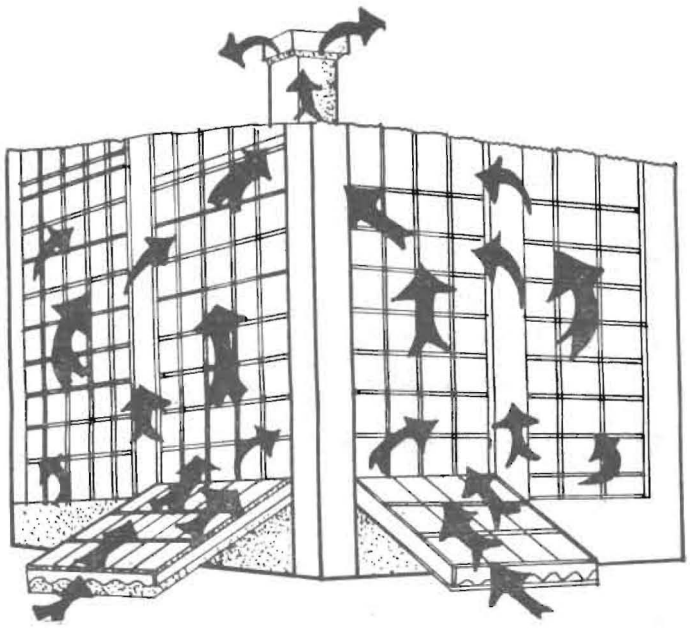

Fig. 3 Schematic Diagram Showing Flow of air in the Solar Kiln

Energy Requirements

Removal of free water from the green wood, in order to make it suitable for structural purposes, requires heat. The amount of heat required depends upon the presence of moisture content in the wood. Seasoned timber is the one in which moisture content is reduced to around 10 percent. The removal of moisture should be slow, so that the wood may not warp or crack and the seasoning is permanent. The amount of heat required to evaporate water may be calculated by :

$$Q = 596.73 - 0.601\ T_c \text{ K Cals/Kg} \quad \ldots\ldots (2)$$

Where, T_c is the temperature of the kiln. Experiments showed that a kiln temperature of 50°C is an ideal condition. So, the amount of heat required is :

$$Q = 566.68 \text{ Kcal/kg.} \quad \ldots\ldots (3)$$

Assuming that the effective time of seasoning is 240 hours, we have :

$$Q = 0.60 \text{ kW/m}^3 \quad \ldots\ldots (4)$$

Equation (4) gives the amount of heat required for seasoning of one cubic metre of wood. This requirement of heat is met by the following means :

(i) Solar heat collector,

(ii) Incidence energy through walls and ceiling, and

(iii) Radiant heat through aluminium fins.

Heat through solar collector

The amount of energy obtained in these kilns through solar energy collectors having an efficiency factor as 50 per cent is given as :

$q_c = 0.224\ A_c$ kW per collector/m².

For a set of two collectors, it becomes.

$$q_c = 0.448\ A_c \text{ kW/m}^2 \quad \ldots\ldots (5)$$

Where, A_c is the area of the solar collector.

Heat through walls and ceiling

The incidence energy I_t is given by :

$$I_t = I_{DN} \cos\theta + I_{ds} + I_{dg} \quad \ldots\ldots (6)$$

Where,

I_{DN} = direct component of solar radiation.

I_{ds} = diffused solar radiations.

I_{dg} = ground reflected radiations.

θ = angle of incidence.

The incidence energy for the month of January, 32° North latitude are taken from 'ASHRAE Hand Book of Fundamentals', Section IV.

1. **Ceiling :** The ceiling is made of corrugated G.I. sheet and have a slope of 1 in 3. In this case,

   $\cos\theta = \sin\beta$

   Where, β is the solar altitude and is equal to 38°.

   The amount of heat entering through the ceiling is therefore, given by :

   $$I_{tR} = 0.4 \text{ kW/m}^2. \quad \ldots\ldots (7)$$

2. **East Wall :** The walls are made of transparent glass having air gap of about 5 cm. For vertical components $\theta = 0°$, so $\cos\theta = 1$. Thus,

   $$I_{tE} = 0.089 \text{ kW/m}^2 \quad \ldots\ldots (8)$$

3. **West Wall :** Heat entering through west wall is the same as from the east wall. Thus,

   $$I_{tW} = 0.089 \text{ kW/m}^2 \quad \ldots\ldots (9)$$

4. **South Wall :** The maximum amount of heat enters through the south wall and is calculated as :

   $$I_{tS} = 0.875 \text{ kW/m}^2 \quad \ldots\ldots (10)$$

Heat through aluminium fins : The amount of heat radiated by aluminium fins has been calculated as follows :

$$q_a = 0.455 \text{ kW/m}^2 \quad \ldots\ldots (11)$$

Loss of heat through air changes : The amount of heat entering in the kiln is partly consumed in evaporating water from the wood. A fraction of heat is also lost due to air changes. Assuming two air changes per hour, we have the amount of heat lost due to air changes as follows :

$q_l = 0.04$ kW/m³

Heat balence :

Total heat gain $= I_{tR} + I_{tE} + I_{tW} + I_{tS} + q_a + q_c$

Loss of heat $= Q + q_l$

Heat lost through walls, ceiling and roof may be taken as 50 per cent of that total heat gained.

Performance of the kiln

Performance of the kiln was studied by seasoning of various species of woods, e.g., from non-refractory to highly refractory species. Among the non-refractory species of woods that were studied are Mango *(Magnifera Indica)*, Haldu *(Aldina Cardifolia)* and Deodar (Cedrus Deodara) while medium refractory wood is Teak *(Tectona Grandis)*. Jamun *(Eugenia Jambolana)* and Shisham *(Dalbergia Sissoo)* are among the highly refractory species.

The time taken in seasoning in the kiln was compared with air seasoning which was carried out simultaneously under a nearby shed. The results are shown in Table 1.

TABLE 1—COMPARATIVE TIME FOR SEASONING

Type of wood	Size of Sample cms.	Initial Moisture Content (%)	Time taken to reach at 10% m.c.	
			Solar Kiln (days)	Shed (days)
1. Mango	300×15×3.75	57	17	35
2. Jamun	300×15×3.75	67	27	62
3. Haldu	300×15×3.75	73	18	40
4. Sal	300×7.5×15	32	67	4 Months
5. Teak	300×5×15	18	20	42
6. Deodar	300×5×15	15	14	25
7. Shisham	300×5×15	25	28	60

During the course of seasoning, it was found that the removal of moisture was very quick above fibre saturation point but below the fibre saturation point, it was slow. In case of mango wood, the initial moisture content of the wood was 57%. The planks which were kept in the solar kiln were seasoned to 18% moisture content in 14 days while in the shed it could reach upto 28% moisture content during the same period. In the solar kiln, 10% moisture content was attained after 17 days while in the shed, the blanks took 35 days to attain this value.

In case of jamun wood which is considered a refractory species from seasoning point of view, the time taken in seasoning upto 10% moisture content in the solar kiln was 27 days, against 62 days under the shed.

Figures 4 and 5 show the rate of seasoning of mango and jamun woods in the solar kilns as well as in a shed.

On an average it could be concluded that the time taken in seasoning in the solar kiln is about half of that taken in the air seasoning.

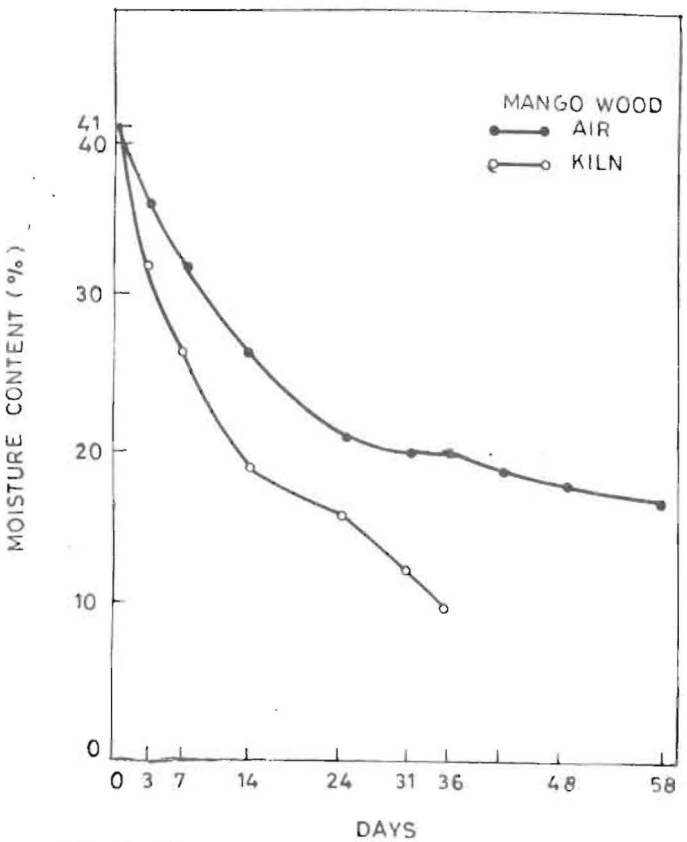

Fig. 4 Rate of Seasoning of Mango Wood

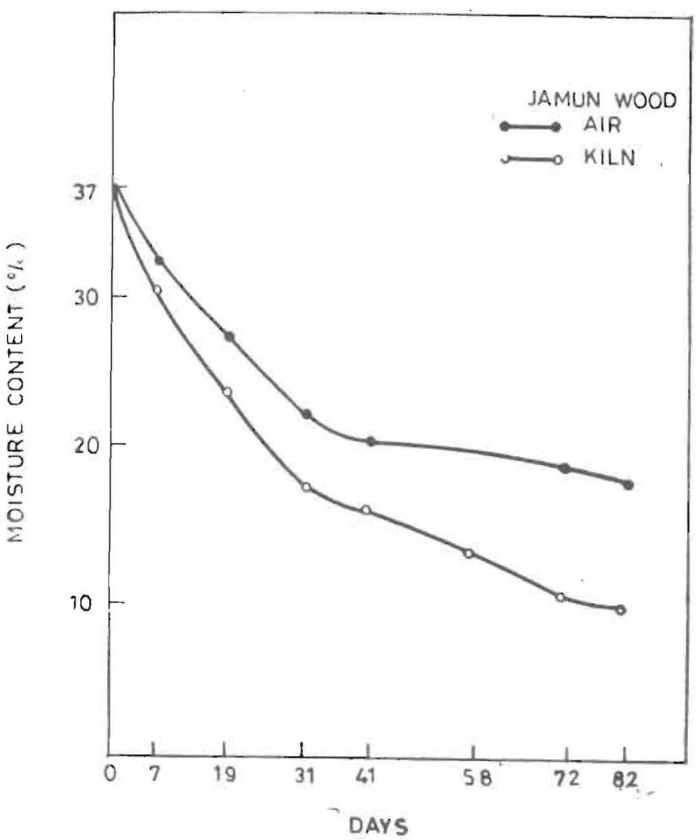

Fig. 5 Rate of Seasoning of Jamun Wood

Stacking Pattern

Fig. 6 shows the stacking pattern of the wooden planks inside the kiln. The planks or scantlings of the woods are kept from east to west direction in the solar kiln. The space between two planks is kept about 5 cm. The dimensions of the battens which are used as crossers are 5.0 × 5.0 cm. Precautions are taken during stacking that there should not be any obstruction in the air flow between planks.

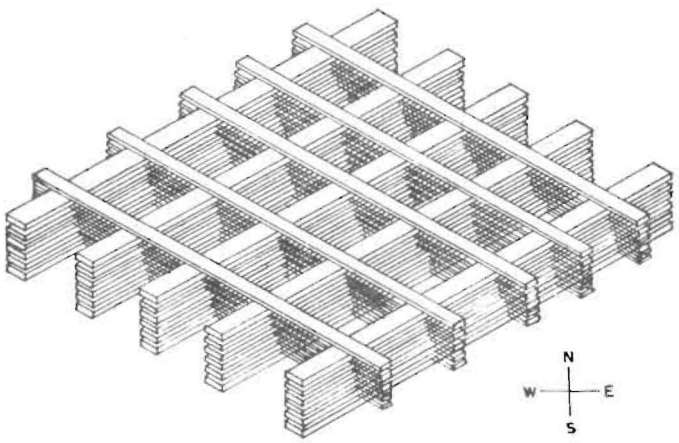

Fig. 6 Stacking Pattern of Planks in Solar Timber Seasoning Kiln

Conclusions

Studies have shown that the solar timber seasoning kiln developed at CBRI performs much better than air seasoning. The time taken in seasoning in the kiln is half to that in air seasoning.

The high temperature inside the kiln helped in lowering relative humidity. However, in the initial stages it was somewhat more than the prevailing atmospheric relative humidity due to quick release of moisture from wood. This high humidity was helpful in controlling a few seasoning losses such as, end cracking and surface bending. During rainfall, the moisture content of the planks kept inside the shed increases due to high relative humidity of the atmosphere. However, in the kiln there was no appreciable chage as the entry of fresh moist air is prevented. The maximum temperature of the kiln recorded in Roorkee was 56°C.

Capacity of the kiln

The kiln is designed in three different capacities viz. 3, 15 and 50 Cu.m. of wood. Till now about 20 licences of the kiln have been given in India and Bhutan. Various energy conservation agencies are providing subsidy for the construction of the kiln.

APPENDIX

Extract from the Performance Report on Solar Timber Seasoning Kiln Received from a Few Entrepreneurs who Constructed the Same Kiln as per CBRI Design

1. West Bengal Forest Development Corporation Ltd., Special Division No. 1, Siliguri

   (i) Performance of the timber seasoning kiln set up at Madarihat is very satisfactory. Miscellaneous timbers like Gammar, Sissoo, Panisaj, Chikrasj, Toon, Champ, etc. are being seasoned in this kiln. Normally planks and battens containing 30 per cent moisture are seasoned down to 13 per cent to 14 per cent inside the kiln within a period of 15 to 20 days during summer and winter and, within 25–30 days during rainy season.

   (ii) Capacity and approximate estimated cost of the plant being set up at Sarugarh, near Siliguri : The average capacity of the chamber for sawn timber using 50 per cent space for separators and providing for wastage of space around 20 per cent on account of odd sizes of timbers is 11.52 cu.m. The cost of installation of the kiln at Sarugarh, already incurred is Rs. 60,000.00.

2. Institute of Engineering & Rural Technology, Civil Lines, Allahabad

Solar timber seasoning kiln has air temperature inside the seasoning chamber ranging between 60°C to 65°C. The seasoning time for 3 cu.m. soft timber is 20 days on an average. The kiln can satisfactorily season timbers like Salwood, Cheer and Mango. The moisture content is reduced to 9 to 11 per cent. Only one skilled worker with a little training can operate, monitor and maintain the kiln.

3. International Tools and Patterns, Industrial Area, Hardwar

(i) There is sufficient saving in time in seasoning of various woods in the solar kiln in comparison to air seasoning.

(ii) In comparison to conventional steam heated kilns, the cost of construction of the solar kiln is much lower. Further, as the kiln operates on natural draft system, use of the energy generated to drive out moisture is eliminated. Thus, there is good scope for large scale use of solar timber seasoning kilns of this design.

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