ASSESSMENT ON THE SAWING RECOVERY AND DRYING PERFORMANCE OF SALVAGED SOLID TIMBER THROUGH KILN DRYING PROCESS

Zahidah Zafhian,
Wood Drying Laboratory, Forest Product Division,
Forest Research Institute Malaysia, 52109, Kepong, Selangor
E-mail: zahidah@frim.gov.my

Sik Huei Shing
Wood Drying Laboratory, Forest Product Division,
Forest Research Institute Malaysia, 52109, Kepong, Selangor
E-mail: sik@frim.gov.my

Mohd Jamil Abdul Wahab
Forest Product Division,
Forest Research Institute Malaysia, 52109, Kepong, Selangor
E-mail: mohdjamil@frim.gov.my

Geetha A/P Ramasamy
Forest Product Division,
Forest Research Institute Malaysia, 52109, Kepong, Selangor
E-mail: geetha@frim.gov.my

Ramzul Iklas Ablah
Wood Drying Laboratory, Forest Product Division,
Forest Research Institute Malaysia, 52109, Kepong, Selangor
E-mail: ramzul@frim.gov.my

ABSTRACT

For the past one decade, approximately 200 dead and fallen trees were extracted around FRIM Campus each year due to lightning strike and pest attack. These damaged standing trees are potentially dangerous and would pose risk to public safety if left unattended. Most of these trees are lesser known species and less in demand compared to commercially known timber species, and they had to be discarded due to serious decay if stored over long period. However, these logs harvested from lesser known species could still be salvaged if were processed by using proper processing techniques and treatment procedures. The properties and performance of the salvaged timber could be enhanced for the production of value-added products such as furniture and wooden crafts. The aim of this study was to evaluate the sawing recovery of selected salvaged logs and to determine its drying performance through kiln drying process. The study was conducted by using readily available log resources, obtained from dead or fallen tress extracted by FRIM's Urban Forestry unit. Two species were selected which are Hopea odorata and Maesopsis eminii. These logs were converted into slabs of approximately 45 mm in thickness and 1.8 - 2.1 m in length. H. odorata and M. eminii slabs were tested for their physical properties before being dried at dry bulb temperature of 60°C in a 14 m3 capacity steam-heated drying system. The timber stacks were dried until a targeted moisture content of approximately 10%. The average sawing recovery of salvaged logs into slabs was evaluated based on their volume basis. The result shown that the average sawing recovery of H. odorata logs was 54.2% whereas M. eminii was 11.8%. The initial moisture content of H. odorata and M. eminii used in this study ranged from 34.9 - 36.84% and 79.3 - 105.21% respectively. The estimated basic density ranged from 671.84 - 698.15 kg/m3 for H. odorata and 415.53 - 453.61 kg/m3 for M. eminii. Meanwhile, the average volume shrinkage of H. odorata and M. eminii are 12.0% and 7.5% respectively. The drying time for H. odorata and M. eminii from fresh and partially air-dried condition to reach 8-10% moisture content was about 25 days. The result of the drying trial showed that both species were able to dry uniformly throughout the timber, although mixed species of different initial moisture content were dried in the same kiln charge.

Keywords: moisture content, drying, recovery

INTRODUCTION

Forest Research Institute Malaysia (FRIM) is a man-made tropical rainforest that sits on a 545-ha site adjacent to the Bukit Lagong Forest Reserve in the Kepong municipality, 16 km northwest of Kuala Lumpur. FRIM has been a natural habitat for thousands of species of flora and fauna including a large number of pioneer tree species. Apart from being a centre of research, development and commercialization in tropical forestry, FRIM has also become one of the attractions for eco-tourism, environmental education and recreational activities. For the past one decade, approximately 200 dead and fallen trees were extracted around FRIM Campus each year due to lightning strike and pest attack. These environmental and biological phenomena have caused failure to the tree structure with severely damaged trunk, rot and holes. These damaged standing trees are potentially dangerous and would pose risk to public safety if left unattended. The extraction of these dangerous tress is based on the complaints received as well as the results of periodic inspection and monitoring carried out on site.

Generally, the extracted trees were sent to FRIM sawmill for processing into sawn timber. According to recent FRIM Urban Forestry Unit's tree maintenance record, approximately an average of 200 logs with diameter between 30 to 113 cm and a length between 3 to 6 meters were sent to sawmill for 3 years consecutively between 2017 and 2019. Out of that amount, only 30% of the total logs have been processed and utilised while another 30% had to be disposed due to serious decay. Meanwhile, the remaining 40% of the logs could not be salvaged due to delay in processing time. Most of these trees are lesser known species and less in demand compared to commercially known timber species. When these less in demand log species are left unattended at open log yard for over a long period, they will begin to show sign of fungal and pest attacks. And eventually, these logs have to be discarded due to serious decay and make way for the newly extracted incoming logs.

An initiative has been taken to utilise these salvaged logs for the production of downstream value-added products. The project was conducted by using readily available log resources, obtained from dead or fallen tress extracted by FRIM's Urban Forestry Unit. In this study, two species were selected, namely *Hopea odorata* and *Maesopsis eminii*, based on their year-round availability. Using proper processing techniques and treatment procedures, the properties and performance of the salvaged timber could be enhanced for the production of value-added products such as furniture and wooden crafts.

Hopea odorata or locally known as Merawan Siput Jantan are mainly found in the Southeast Asia such as Peninsular Malaysia, Thailand, Indo-China and Myanmar. In Malaysia, *H. odorata* has been recommended for forest plantation due to its excellent growth, ease of management, potential uses and promising financial returns. *H. odorata* is classified as light hardwood with air-dry density of 785 kg/m^3 (Burgess 1979). The timber is strong and has been used for flooring for pedestrian traffic, light industrial floors and also high value-added products such as laminated timber and advanced composite (Nordahlia *et al.* 2020).

Maesopsis eminii is an exotic species originated from Africa. The tree was introduced in Forest Research Institute Malaysia (FRIM) in 1952 for reforestation trial (Sandrasegaran 1966). There are more than 4000 *M. eminii* trees planted from year 1952 to 1957 at various spacing in FRIM (Patrick & Muhammad 1980). *M. eminii* is a light hardwood timber with density ranging from 465 to 1,075 kg/m^3 (dry to green) (Lee *et al.* 1979). The timber has good physical and mechanical properties and suitable for manufacturing of furniture component such as parquet flooring and plywood.

An assessment on the potential use of the selected *H.odorata* and *M.eminii* salvaged trees for the production of solid sawn timber and wood-based products was carried out. The specific objective of this study is to evaluate their sawing recovery as well as to assess their drying performance through an appropriate kiln drying treatment. This paper provides the preliminary data on sawing recovery, physical properties and drying properties of salvaged *H.odorata* and *M.eminii* timber.

MATERIAL AND METHOD

The diameter of matured *Hopea odorata* and *Maesopsis eminii*. logs were measured at both end of each log. These logs were cross-cut into 1.8 to 2.1 m in length by using chain saw. Then, the logs were converted into slabs of approximately 45 mm in thickness by using breakdown saw. A total of 12 logs; 7 logs of *H. odorata* and 5 logs of *M. eminii* were processed into slabs of 45 mm in thickness, 1.8-2.1 m in length and various width rendering to the diameter of the logs. The volume of log was calculated based on the volumetric computation formula (Mohd-Jamil *et al*., 2020) as shown in Equation 1. Meanwhile, the total volume of slabs obtained was calculated by multiplying the dimension (length x thickness x width) of each slab.

$$\text{Equation 1:} \qquad V = \frac{L}{2}(A_b + A_t)$$

Where L = length of log (m), A_b = surface area of the bottom cut (m), A_t surface area of the top cut (m).

The sawing recovery of *H. odorata* and *M.eminii* logs was calculated based on the Equation 2:

$$\text{Recovery (\%)} = \frac{\text{Total volume of slabs (m}^3\text{)}}{\text{Volume of log (m}^3\text{)}} \times 100$$

Then, the *H. odorata* and *M. eminii* timber were tested for their physical properties. The specimen is obtained by cutting 45 mm-thick strips from randomly selected timber slabs of each species. The strips were further cut into cubes of 2 x 2 x 2 cm for the determination of initial moisture content (MC), density and shrinkage values. The weight and dimension of each specimen in the tangential, longitudinal and radial direction was measured before and after drying. The specimen was dried in convection oven at 103 ±2° until reach a constant weigh.

The *H. odorata* and *M. eminii* slabs were properly stacked in a box-shaped size with vertically aligned stickers at specific spacing before being loaded into the kiln for the commencement of the drying process. The timber stacks for the trial were made up of 1.8-2.1 m-long dimension slab measuring at approximately 45 mm in thickness and various in width. The timber stack was dried at dry bulb temperature of 60°C in a 14 m^3 capacity steam-heated drying system until reach a targeted moisture content of approximately 10%. The sample board from each species was randomly selected for periodical monitoring of drying performance study. After drying, the final MC and moisture gradient of the sample board were determined. Moisture gradient was determined by dividing the specimens into three pieces. The estimated current moisture content of the sample boards was normalised accordingly. The respective drying curves of both species was plotted based on set drying time interval (s).

RESULT AND DISCUSSION

Sawing Recovery

Hopea odorata and *Maesopsis eminii* logs were converted into slabs by using live sawing method. Live sawing, a method of cutting logs through and through on one plane, is selected in this study as it can help to improve the recovery and quality of the sawn timber as compared to conventional method using band saw. Furthermore, in live sawing, the bark is maintained in the thick flitches, and this help to restrain the warp development and relieves growth stress upon processing (Jegatheswaran *et al*, 2011).

The diameter of *H. odorata* and *M. eminii* logs measured at the bottom and top sections were 31.3 - 120 cm and 27.4 – 67 cm with length of 1.52 – 3.35 and 3.34 – 4.37 meters respectively. In total, approximately 60 and 11 pieces of flitches respectively were obtained from 7 *H. odorata* and 5 *M.eminii* logs. The recovery of *H. odorata* and *M. eminii* logs into flitches was evaluated on a volume basis.

The sawing recovery of each log varies from lowest value of 14% to the highest value of 89.9%. Based on the total volume of logs and flitches produced, the average sawing recovery for *H. odorata* was 54.2% while 11.8% for *M. eminii* (Table 1 and 2). *H. odorata* achieved a higher recovery as compared to *M. eminii* as it consists of large diameter logs of 80 cm and above. Furthermore, about 80% of *M. eminii* timber had to be rejected due to heart-rot, pest infestation, fungal attack, split and brittle heart and these circumstances had affected the volume recovery.

The result also shown that the sawing recovery varies with the diameter of logs. For *H. odorata*, log number 5 with diameter of 81.1-96.5 cm recorded the highest recovery of 89.9% whereas log number 4 with diameter of 80-95 has a recovery about 14% (Table 1). Although both logs are within the same diameter range, log number 4 experienced the lowest recovery because of high quantity of rejects due to serious decay. Thus, the recovery of *H. odorata and M.eminii* logs are highly influenced by the quality of both logs and sawn timber. Sim (1980) also found that the recovery of sawn timber is significantly affected by the dimension and quality of both logs and sawn timber.

Table 1: Sawing recovery of *Hopea odorata* logs

Species	Log No.	Diameter of log (top-bottom) (cm)	Length of log (m)	Volume of log (m3)	Volume of slabs obtained (m3)	Recovery (%)
H. odorata	1	60	3.352	0.95	0.15	15.64
	2	47.4-53	2.101	0.41	0.23	54.98
	3	31.3-53.9	1.878	0.32	0.28	87.78
	4	80-95	1.524	0.91	0.13	13.97
	5	81.1-96.5	2.184	1.33	1.19	89.90
	6	84.9-97.8	2.225	1.45	1.28	88.11
	7	110-120	2.16	2.24	0.87	38.88
Total				**7.60**	**4.12**	**54.18**

Table 2: Sawing recovery of *Maesopsis eminii* logs

Species	Log No.	Diameter of log (top-bottom) (cm)	Length of log (m)	Volume of log (m3)	Volume of slabs obtained (m3)	Recovery (%)
M. eminii	1	33-36.2	4.316	0.40	0.13	31.80
	2	34-50	3.338	0.38	0.11	29.90
	3	31.8-38.6	3.64	0.36	0.05	14.46
	4	27.4-35.7	4.37	0.33	n.a	n.a
	5	39.9-67	4.219	1.01	n.a	n.a
Total				**2.48**	**0.29**	**11.82**

Physical properties

The physical properties of *Hopea odorata* and *Maesopsis eminii* used in this study are shown in Table 3. Based on the randomly selected sample board, the initial moisture content of *H. odorata* and *M. eminii* are ranged from 34.9 - 36.84% and 79.3 - 105.21% respectively. Meanwhile, the green density for *H. odorata* is 906.71-951.82 and 813.30-856.35 for *M. eminii*. The estimated basic density for *H. odorata* used in this study ranged from 671.84 - 698.15 kg/m^3 and found to be within an acceptable range with the air-dry density of *H. odorata* reported by Choo *et al.* (2001) which is 495 to 980 kg/m^3. Meanwhile, the basic density of *M. eminii* used in this study ranged from 415.53 - 453.61 kg/m^3. According to Lee (1979), air dry density of *M. eminii* is 465 kg/m^3 which is comparable with the density of *M. eminii* used in this study. The average volume shrinkage of *H. odorata* and *M. eminii* used in this study are 12.0% and 7.5% respectively.

Table 3. Physical properties of *Hopea odorata* and *Maesopsis eminii*

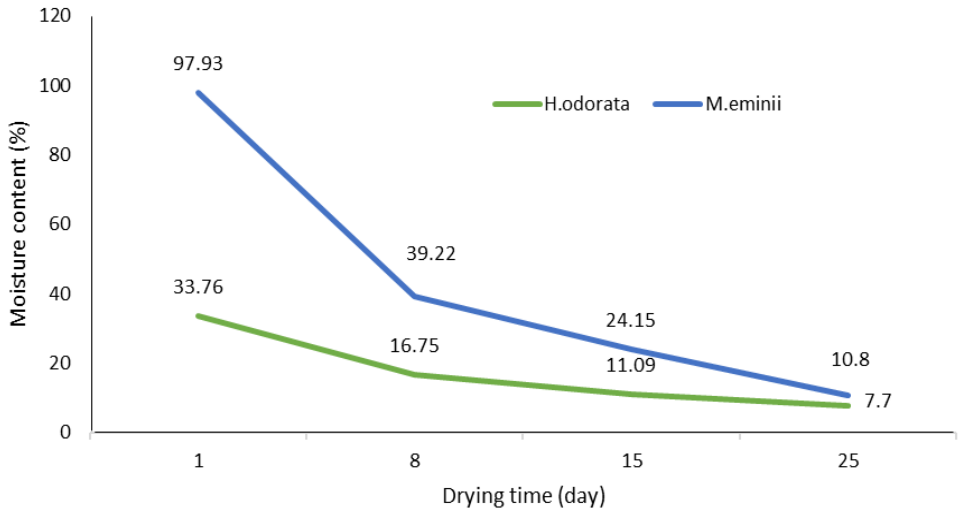
Species	Moisture content (%)	Green density (kg/m3)	Oven-dry density (kg/m3)	Basic density (kg/m3)	Shrinkage (%)			
					R	T	L	V
H. odorata	34.9 - 36.84%	906.71-951.82	775.99-793.70	671.84 - 698.15	5.8	5.0	0.2	12
M.eminii	79.3 - 105.21%	813.30-856.35	458.95-488.79	415.53 - 453.61	4.9	1.9	0.9	7.5

R=radial, T= tangential, L= longitudinal, V= volumetric

Drying performance study

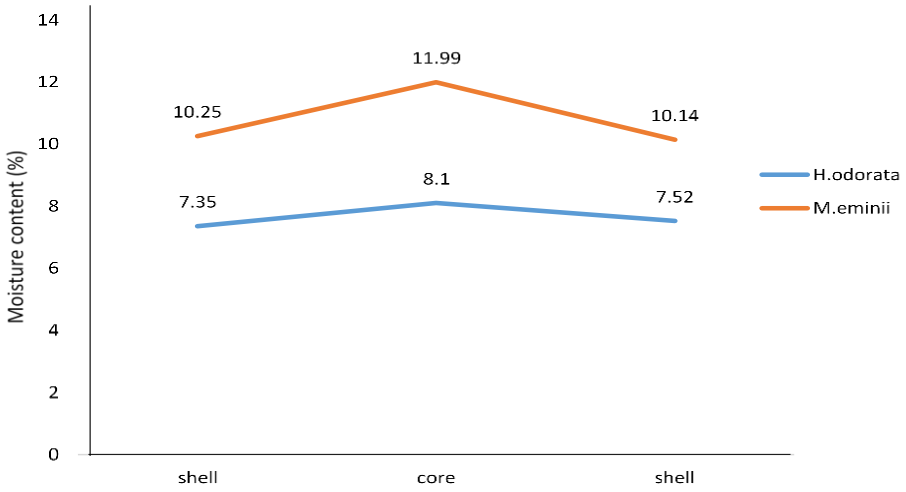
For drying performance study, only one control sample board was selected from each species. This is due to the constraints in handling large dimension slabs. The drying curve of *H. odorata* and *M. eminii* slab was illustrated in Figure 1. The initial moisture (MC) content of *H. odorata* control sample board is 33.76% whereas the initial MC of *M. eminii* control sample boards are 87.93%. Overall, the drying time for *H. odorata* and *M. eminii* from fresh and partially air-dried condition to reach 8-10% moisture content was about 25 days. Both species was discharged from the kiln at the same time so as not to disrupt the on-going drying process for the much wetter timber within the same kiln charge.

Figure 1. Drying curve of *Hopea odorata* and *Maesopsis eminii*



Dried *H. odorata* and *M. eminii* samples were sliced into shell and core sections across the transverse face to determine the distribution of moisture content within the individual sample. The moisture content (MC) distribution of selected control sample board after drying is shown in Figure 2. *H. odorata* and *M. eminii* samples were able to dry uniformly throughout the timber and the variation of MC between the inner and outer layers were within 1.85%. This showed that it is considered to be viable to dry mixed species of different initial moisture content in the same kiln charge. However, it is recommended that timber of different species should have the same sawn thickness and within the same density range. Gene (1992) also reported that by adopting a good drying regime, it is viable to dry timber of different moisture content in the same kiln charge.

Figure 2. Moisture content distribution of dried *Hopea odorata* and *Maesopsis eminii* sample board



CONCLUSION

The study has shown that the average sawing recovery of salvaged *Hopea odorata* logs was 54.2% whereas *Maesopsis eminii* was 11.8%. Meanwhile, the estimated basic density for *H. odorata* used in this study ranged from 671.84 - 698.15 kg/m^3 and 415.53 - 453.61 kg/m^3 for *M. eminii*. The average volume shrinkage of *H. odorata* and *M. eminii* are 12.0% and 7.5% respectively. The result of the drying trial showed that the drying time for *H. odorata* and *M. eminii* of fresh and partially air-dried condition took about 25 days to kiln-dry to 8-10% moisture content. Both species were able to dry uniformly throughout the timber, although mixed species of different initial moisture content were dried in the same kiln charge.

ACKNOWLEDGEMENT

The author would like to acknowledge Ministry of Water, Land and Natural Resources (KeTSA) for the funding of this study.

REFERENCE

Burgess HJ. 1979. *Malayan Timbers for Flooring*. Malaysian Forest Service Trade Leaflet No. 26. The Malaysian Timber Industry Board, Kuala Lumpur.

Gene Wengert. 1992. Techniques for equalizing and conditioning lumber. Forestry Facts. Department of Forest Ecology and Management. School of Natural Resources.

K.T. Choo, S.C. Lim & K.S. Gan. 2001. Timber Notes-Medium Hardwoods III (Mata ulat, Mempening, Mengkulang, Meransi, Merawan). *Timber Technology Bulletin* No.20, 2001. Forest Research Institute Malaysia, Kepong. 8pp.

Lee YH, Engku Abdul Rahman Cik & Chu YP. 1979. The Strength Properties of Some Malaysian Timbers. *Malaysian Forest Service Trade Leaflet* No. 34. 107pp.

Mohd-Jamil AW & Nor Marzuina FKN. 2020. Diameter and volumetric computation of plantation logs. *Timber Technology Bulletin* No.104, 2020. Forest Research Institute Malaysia, Kepong. 8pp.

Nordahlia AS, Roszaini K, Rafidah J, How SS & Wan Asma I. 2020. Wood properties and uses of planted *Hopea odorata* in Peninsular Malaysia. *FRIM Research Pamphlet No. 145*. ISBN 978-967-2149-71-2.

Patrick S & Muhammad AB. 1980. A checklist of plantation trials in Peninsular Malaysia. *Research Pamphlet No. 79.* FRI Kepong. 100pp.

Ratnasingam J, T'ng PM, Chong YY & Saied RF. 2011. An evaluation of the saw, dry and rip process for the conversion of rubberwood. *Journal of applied sciences*. 11 (14): 2657-2661.

Sandrasegaran K. 1966. Permanent sample plot information on stocking, growth and yield of *Maesopsis eminii Research Pamphlet No. 49*. Forest Research Institute Malaysia, Kepong.

Sim HC. 1980. Recovery of small diameter logs. *The Malaysian Forester*. Vol. 43 No.3.