

## DENSITY OF PLYWOOD PRODUCED IN MALAYSIA

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### INTRODUCTION

Plywood is one of Malaysia's most important timber products, with a production of 1,562,329 million m<sup>3</sup> in 2021 (MPC 2022). The export value of plywood was 1,492,110 million m<sup>3</sup> in 2021. The three largest importers are Japan (703,750 m<sup>3</sup>), United States of America (174,950 m<sup>3</sup>) and Republic of Korea (134,870 m<sup>3</sup>).

The primary components of plywood are wood veneer and adhesives. The veneer is extracted from logs, predominantly obtained from forests and plantations. Commonly used adhesives are urea formaldehyde, melamine urea formaldehyde and phenol formaldehyde. Other materials usually incorporated with the adhesive are hardeners, industrial flour, insecticides and fungicides.

Plywood is produced in various sizes, with the most commonly made size being 1220 mm × 2440 mm (4 feet × 8 feet) and 914 mm × 1829 mm (3 feet × 6 feet), with a thickness of about 12 mm. The type of wood used to produce the veneer has a great influence on the density of plywood. The density affects its physical, mechanical, and other properties. Higher density is associated with higher strength and increased difficulty in machining (Moslemi 1974).

Besides that, the density of plywood can be used to estimate the amount of carbon stored in a given volume. Carbon constitutes about 50% of wood weight on an oven-dried basis (Negro & Bergman 2019). Carbon dioxide is absorbed from the atmosphere through photosynthesis and converted into carbon organic compound, mainly composed of cellulose, hemicellulose and lignin. When trees are harvested and processed into plywood, the carbon remains stored in the plywood.

Plywood is typically used in construction and various applications. Carbon storage is affected by the durability and longevity of plywood products. The carbon remains stored in plywood when this intermediate product is further used in applications with long service life and also with fewer replacements or repairs.

The objective of this study is to determine the density of plywood produced in Malaysia. The evaluation of density value for plywood can later be used for the estimation of carbon stock and annual carbon change on the volume basis of plywood production, import and export. It is vital for the country to have its own activity data for the calculation of carbon stock and annual carbon change in harvested wood products (HWP). The estimation of carbon stock and annual carbon change in HWP will improve with the use of country-specific data.

## METHODOLOGY

Plywood samples were obtained from twelve manufacturers in Peninsular Malaysia (3), Sabah (4) and Sarawak (5). Given that plywood with a thickness of 12 mm is most commonly produced, therefore, this thickness was chosen for the study. During sampling, at least two sheets of plywood from the same production series were randomly selected during sampling. The plywood was kept in a dry environment to ensure stability.

The density of plywood was determined from air-dried samples. Specimens were randomly selected and cut to 50 mm × 50 mm size from each plywood sheet. The weight, thickness, length and width of the specimens were measured using balance, micrometer, and caliper. The moisture content of the specimens was determined according to the oven-dried method based on BS EN 322 (BSI 1993). The moisture content of the specimens was maintained below 14%. The density of the specimens was calculated using the formula below.

$$\text{Density} \left( \frac{\text{kg}}{\text{m}^3} \right) = \frac{\text{Weight of specimen}}{\text{Volume of specimen}}$$

## RESULTS AND DISCUSSION

A total of fifteen plywood samples were obtained from the plywood manufacturers, with five samples from each region. The plywood samples had 5 or 7 veneer layers, with the majority having 5 layers (Table 1). Their moisture content ranged from 8 to 13%. All samples had moisture content below 14% as specified in the Japanese Agricultural Standard (JAS 2018).

The density of the plywood ranged from 407 to 795 kg/m<sup>3</sup> with an average density of 461 to 721 kg/m<sup>3</sup> and an overall average of 608 kg/m<sup>3</sup>. The difference in the number of veneer layers did not affect the plywood density, as reported by Muhammad-Fitri et al. (2018).

**Table 1** Density of Malaysian plywood

No.	Number of veneer layer	Average Density (kg/m <sup>3</sup> )	Density range (kg/m <sup>3</sup> )
1	5	658	572–771
2	7	543	535–550
3	5	654	643–668
4	7	721	591–795
5	7	648	572–782
6	5	611	407–684
7	5	566	437–744
8	5	461	411–548
9	5	550	504–590
10	5	637	582–742
11	5	615	526–688
12	5	594	563–632
13	5	656	536–722
14	5	629	503–692
15	5	574	438–707
	Average	608	

High moisture levels can attract biodegradation agents such as fungi and insects that view wood as a food source (Eaton & Hale 1993). Additionally, it can influence adhesion and, consequently, the characteristics of the plywood (Aydin et al. 2006). Plywood needs to maintain low moisture content, as specified in standards, to deter biodegradation agents attack and preserve the bonding quality and properties of the board.

More than 440,000 m<sup>3</sup> of timbers are used for veneer and plywood production annually in Peninsular Malaysia (JPSM 2022). Of this total, the majority of the timber consists of light hardwood (90%), followed by medium hardwood (8%), and a small proportion of other wood types. Light hardwood has a density range of 400 to 720 kg/m<sup>3</sup> according to the Malaysian Grading Rules (MTIB 1984), so it is expected that the density of plywood is lower or around 700 kg/m<sup>3</sup>. Rubberwood is the most used timber for veneer or plywood, accounting for nearly 192,000 m<sup>3</sup> followed by kedondong at 30,000 m<sup>3</sup>. Other wood types used include medang, red meranti, mahang, rengas, mersawa, pelong, gerutu and sesenduk. Kelat (8,000 m<sup>3</sup>) and keruing (6,000 m<sup>3</sup>) are two popular medium hardwood timbers (720–880 kg/m<sup>3</sup>). Some timbers are categorised as ‘others’ because their types could not be identified but are widely used, amounting to 138,000 m<sup>3</sup> for light hardwood and 16,000 m<sup>3</sup> for medium hardwood. Additionally, oil palm trunks are also used for veneer or plywood, with a total of nearly 10,000 m<sup>3</sup>. This study solely used plywood containing hardwood.

The density of plywood is generally higher than that of the wood used since, in addition to veneer, it contains adhesives and additives such as industrial flour and anti-biodegradation chemicals. Depending on the amount of adhesive and additives used, studies by Bier (1986) and Suffian & Rafeadah (2020) showed differences in plywood density between 16% and 30% compared to the wood used. Assuming the plywood has a density of 608 kg/m<sup>3</sup> and 16% density difference, the density of the wood used for plywood is 511 kg/m<sup>3</sup>, which falls into the category of light hardwood.

## CONCLUSION

Plywood produced in Malaysia has an average density of 608 kg/m<sup>3</sup>. The majority of it is 12 mm thick and made up of 5 veneer layers. Seven-layer plywood is also produced. The number of veneer layers does not affect the plywood’s density. The most commonly used wood type for plywood production is light hardwood group. The plywood has a moisture content of less than 14% to ensure good bonding and plywood properties, while also preventing attacks from biodegradation agents. The density data can later be used for the estimation of carbon stock and annual carbon change on the volume basis of plywood production, imports and exports.

## ACKNOWLEDGEMENTS

The authors would like to express their gratitude to the staff of Biocomposite Branch, FRIM who involved in the sample collection and testing for this study.

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Plywood is an important product in the timber industry. In addition to providing a discussion on plywood density, this article offers an explanation of the typical specifications for plywood, including thickness, number of layers and moisture content. The effects of number of layers and moisture content on the plywood properties are also elaborated. The density data can later be used to estimate the carbon stock and carbon changes in plywood.

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Series Editor : Latifah J  
Managing Editor : Vimala S  
Typesetter : Rohayu Y

Set in Times New Roman 12



Printed by Publications Branch, Forest Research Institute Malaysia  
52109 Kepong, Selangor