International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-11 Issue-2, December 2021

Study of Homogeneous Chipboard Manufacturing using Betung Bamboo (Dendrocalamus Asper) Mixed with Polyethylene Addictive

Salman Salim, Mona Lena Abdul Aziz, Sufyan Abdullah, Mohamad Hairi Osman, Mastura Najiha Salman

Abstract**: *Bamboo is an evergreen plant native to Asia and America that grows at every altitude, even in unideal climate conditions. Betung bamboo or its scientific name Dendrocalamus Asper is one of the bamboo species that are easily found in peninsular Malaysia. This study examined the characteristics of Betung bamboo and its potential to manufacture chipboard. Several tests were conducted, namely modulus of elastic (MOE), modulus of rupture (MOR), thickness swelling (TS), and water absorption (WA) to evaluate the potential of Betung bamboo as the primary material in the manufacture of chipboard mixed with polyethylene as additive are the parameters considered. This study found that the composition of 70% bamboo and 30% polyethylene was produced optimum chipboard which met BS EN standards (British and European Standard). It was also found that the MOE and MOR values of the resulting chipboard exceeded the medium density board standards. For WA and TS values, the chipboard achieved the standard requirements. Thus, this study concludes that chipboard made of Betung bamboo with the addition of polyethylene is suitable to be applied for internal and external doors, and internal paneling for any commercial or domestic building and furniture.***

Keywords**: *Betung Bamboo, Chipboard, and Polyethylene***

I. INTRODUCTION

Bamboo is widely scattered on riverbanks and in open forest areas such as shifting cultivation areas and the fastest growing plant in the world due to its unique rhizome system rests. Currently, there are more than 121 bamboo genera encompassing about 1662 species in the world [1]. Bamboo has a long history of use as a building material, either in culm or as raw material for composite products [2]. *Dendrocalamus Asper* is a bamboo species that grows widely in tropical and subtropical regions, particularly in Southeast and South Asia.

This species is known by several names, including Betung, Petung, Batuang and Betho [3] as illustrated in Figure 1. It has been introduced in many parts of the world, including Latin and South America [5]. When mature at the age of 3 to 5 years, the bamboo is tall with large culms and is commonly known as giant or rough bamboo.

The culms can grow up to 20 to 30 m, with diameters ranging from 8 to 20 cm and an internode spacing of 40 cm [9]. The culm has a wall thickness of 6 to 22 mm and a density of 0.52 to 0.56 g/cm3 [7]-[9].

Fig. 1. Bentung Bamboo

The thick culms and strong shells of the *Dendrocalamus Asper* make it ideal for use as a building component and the manufacture of furniture, musical instruments and household appliances [3]. The use of bamboo is increasingly popular and even becoming a way of life, particularly in Asia and parts of South America [5]. In Malaysia, the use of bamboo in the construction sector is currently neglected and is restricted only to the traditional handicraft sector in China and India, bamboo is one of the most popular building materials in construction industry. One possibility is that bamboo resources are abundant in their countries, and aesthetics can be found in the bamboo content itself [6].

Furthermore, for its traditional use, bamboo culms have sparked interest in manufacturing various composite panels, including chipboard. Chipboard made of bamboo has an advantage in terms of raw material availability, which is renewable, fast-growing and environmentally friendly natural resource.

Manuscript received on November 24, 2021.
Revised Manuscript received on December 14, 2021.
Manuscript published on December 30, 2021.
* Correspondence Author
Salman Salim*, Centre for Diploma Studies, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Malaysia. E-mail: salman@uthm.edu.my
Mona Lena Abdul Aziz, Technical Division, Performance Audit Sector, National Audit Department, Precint 1, Federal Government Administrative Centre, 62000 Putrajaya, Kuala Lumpur, Malaysia. Email: mona.lena@audit.gov.my
Sufyan Abdullah, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Johor, Malaysia. Email: sufyan@uthm.edu.my
Mohamad Hairi Osman, Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia, Pagoh, Johor, Johor, Malaysia. Email: mhairi@uthm.edu.my
Mastura Najiha Salman, Faculty of Computer Science and Information Technology, Universiti Tun Hussein Onn Malaysia, Parit Raja, Batu Pahat, Johor, Malaysia. Email: mastura.salman00@gmail.com

In addition, bamboo particles can be used as raw material, allowing waste from the bamboo production process and bamboo waste from fields.

Since there is few information about bamboo used in chipboard manufacturing with the addition of other materials, this study evaluated the properties of bamboo chipboard as raw material to value-added products to better understand its characteristics.

II. MATERIAL AND METHOD

The raw material used in the manufacture of chipboard was from the Betung bamboo type.

The bamboo was cut into small pieces and soaked for 24 hours to remove dirt and oil. After that, the bamboo was dried in the sun before being crushed into particles and dust.

The bamboo particles were sifted according to the selected sizes (2.36 mm, 1.18 mm, 600 µm) as depicted in Figures 2 to 4. Hardening agent or wax was mixed with 1% by weight of the chip and 3% of the hardener depending on the type of adhesive used. All particle sizes were divided equally by a 1: 1: 1 ratio for each size.

In the mixing process, all the bamboo materials together with additives, namely formaldehyde urea glue and polyethylene, were mixed with a hand mixer for 5 minutes to ensure an even mixture. This was to stabilize the contents of the mixture so that the cavity contact gripped between the particles after compression. Then, this sample was placed in the oven at a temperature of 80°C to obtain a moisture content (MC) of around 3% to 5% as shown in Figure 5. The mold used was in the dimension of 30 cm x 30 cm x 1.2 cm.

Fig. 2. Particle size of 2.36 mm

Fig. 3. Particle size of 1.18 mm

Fig. 4. Particle size of 600 µm

Fig. 5. Bamboo particles in the oven

The chipboard should be compressed to a high and controlled temperature to produce the desired chipboard thickness in the hot press machine as shown in Figure 6. This process should be fully controlled to avoid defects on the sample board. The applied pressure was 1200 lb/in² with a temperature of 160°C. An aluminum iron plate was placed on the top of the sample to prevent damage to the board surface when pressed. The machine was pressurized for 10 minutes before the sample was removed from the mold and cooled. The detailed image of the compacted particles is shown in Figure 7.

Fig.6. Hot press machine

Fig.7. Detailed image of compacted particles

III. RESULTS AND DISCUSSION

A. Modulus of Elastic (MOE) and Modulus of Rupture (MOR)

The average strength values of the homogeneous chipboards for different percentages of polyethylene (PE) are summarized in Table-I.

Table- I: Average chipboard strength for different percentages of polyethylene

PE (%)	MOE (Mpa)	MOR (Mpa)	TS (%)	WA (%)
0	3651.5	42.86	30.24	53.00
10	2795	62.76	22.50	42.72
15	2905.5	66.56	18.00	32.88
20	3153.5	76.37	13.50	23.42
25	3875.5	88.25	13.00	16.81
30	4323	115.7	10.50	12.30
35	2693	80.29	7.76	9.33

a. PE – polyethylene. MOE – modulus of elastic, MOR – modulus of rupture, TS – thickness swelling, WA – water absorption

Figures 8 and 9 indicate the average values of MOE and MOR. It was found that the MOE and MOR values increased and exceeded the control value when 30% PE was added with maximum average values of 4323 MPa and 115.7 MPa, respectively. However, the values of MOE began to decrease when mixed with 35% PE. This was possibly due to the interaction between the bamboo particles with high plastic content, which resulted in poor bonding and thus the board to became soft and warped. Thus, it was evidenced that the optimum values for MOE and MOR were obtained with 30% PE in the chipboard. According to [10], the percentage polymer of used can considerably reduce the mechanical strength and water absorption of chipboard. The higher the MOE, the more rigid the material, while the lower the MOE, the easier it is to bend the material. At each percentage of PE, the overall modulus values exceeded the BS EN 310: 1993 standards, which were 1800 MPa for MOE and 14 MPa for MOR.

Retrieval Number: 100.1/ijeat.B32791211221
DOI: 10.35940/ijeat.B3279.1211221
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

International Journal of Engineering and Advanced Technology (IJEAT)
ISSN: 2249-8958 (Online), Volume-11 Issue-2, December 2021

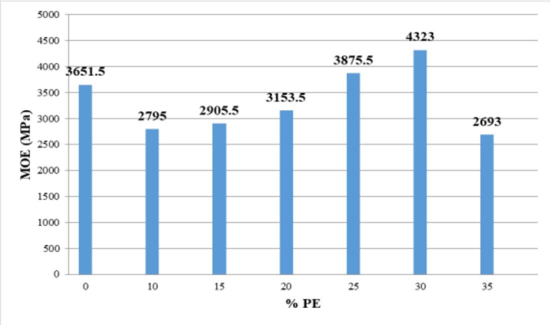

Fig. 8. Effect of PE percentage (%) on MOE average values

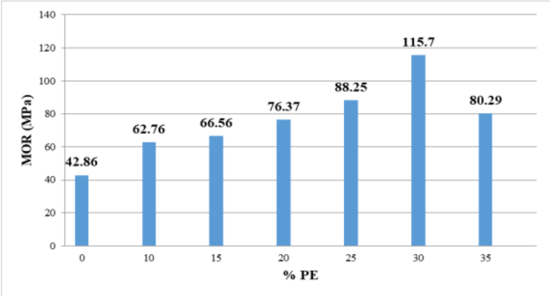

Fig. 9. Effect of PE percentage (%) on MOR average values

B. Thickness Swelling (TS) and Water Absorption (WA)

Meanwhile, Figures 10 and 11 depict the relationships between thickness swelling (TS), water absorption (WA) and the percentage of PE. The values of TS and WA decreased with increasing of PE. This may be attributed to the polymer polyethylene waterproofing that prevented moisture from absorbing into the particle cavity. In addition, there was a significant difference between the percentage of PE with thickness expansion rate and water absorption rate. It gives the impression that increasing the percentage of PE thickness will reduce the expansion rate and WA of a composite product. Therefore, the percentage of PE plays a role in reducing the rates WA and TS. According to [15] the minimum level for industrial TS requirement should be less than 15%, while the WA must be less than 16%. Therefore, chipboards manufactured with the addition of PE achieved industrial purposes. In this study, the PE percentages that achieved the desired standard were 30% and 35%. The addition of 20%, 25%, 30% and 35% PE in the chipboards produced acceptable TS values. The optimum values of WA and TS was 30% as they exceeded the standard levels for both tests.

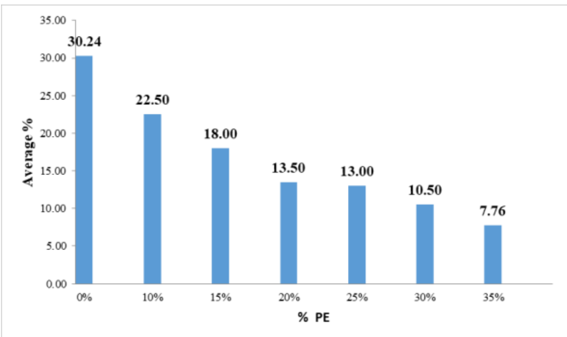

Fig. 10. Average values of thickness swelling for different polyethylene percentages

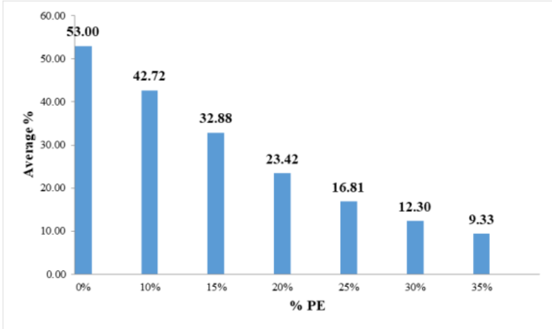

Fig. 11. Average values of water absorption for different polyethylene percentages

IV. CONCLUSION

Based on the findings of this study, it can be inferred that bamboo has a promising future as a building material [13]-[14]. The use of PE as an additive affected the characteristics of the chipboard. The increased percentage of PE on Betung bamboo particles fulfilled the criteria required in the end-use chipboard. This was evidenced in this study based on the optimal test values on different percentages of PE. From this study, a few conclusions can be drawn as follows:

1) Bamboo chipboard mixed with PE has better strength than standard wooden board (medium density category).
2) On the average values of MOR and MOE achieved and exceeded the standards. The board is suitable for industrial products, internal and external doors, internal paneling and furniture.
3) This study successfully identified that 70% bamboo and 30% PE was the optimum composition for manufacturing the chipboard.

ACKNOWLEDGMENT

The authors would like to thank the Research Management Centre (RMC), Universiti Tun Hussein Onn Malaysia, and the Ministry of Higher Education Malaysia forsupporting this research through the TIER 1 Grant (Vot. H820).

REFERENCES

1. Canavan, S., Richardson, D. M., Visser, V., Le Roux, J. J., Vorontsova, M. S., & Wilson, J. R. (2017). The global distribution of bamboos: assessing correlates of introduction and invasion. AoB Plants, 9(1).
2. Karlinasari, L. et al. (2021) ‘Some of the Physical and Mechanical Properties of Particleboard Made from Betung Bamboo (Dendrocalamus asper)’, MDPI Apploed Sciences, 3682(11), p. 13.
3. Dransfield, S.; Widjaja, E.A. Plant Resources of South-East Asia 7: Bamboos; Leiden Backhuys Publishers: San Francisco, CA, USA, 1995.
4. Dullah, H. et al. (2019) ‘Physical and Mechanical Properties of Empty Fruit Bunch Fibre-Cement Bonded Fibreboard for Sustainable Retrofit Building’, Journal of material science and engineering, 7(April), p. 9.
5. Gauss, C.; de Araujo, V.; Gava, M.; Barbosa, J.C.; Junior, H.S. Bambo particleboards: Recent developments. Pesqui. Agropecu. Trop. 2019, 49, 1–9.

Retrieval Number: 100.1/ijeat.B32791211221
DOI: 10.35940/ijeat.B3279.1211221
Journal Website: www.ijeat.org

Published By:
Blue Eyes Intelligence Engineering and Sciences Publication (BEIESP)

6. Zea Escamilla E., Habert G., Correal Daza J. F., Hector F. Archilla , Echeverry Fernández J. S., and Trujillo D. (2018). Industrial or Traditional Bamboo Construction? Comparative Life Cycle Assessment (LCA) of Bamboo-Based Buildings. Sustainability 2018, 10, 3096.
7. Javadian, A.; Smith, I.F.C.; Saeidi, N.; Hebel, D.E. Mechanical properties of bamboo through measurement of culm physical properties for composite fabrication of structural concrete reinforcement. Front. Mater. 2019, 6, 31–41.
8. De Lira, B.J.T.; Junior, G.B.; Brito, F.M.S. Effect of particle size on bamboo particleboard properties. Floresta Ambient. 2019, 26, 1–8, doi:10.1590/2179-8087.012517.
9. Park, S.H.; Jang, J.H.; Wistara, N.J.; Hidayat, W.; Lee, M.; Febrianto, F. Anatomical and physical properties of Indonesian bamboos carbonized at different temperatures. J. Korean Wood Sci. Technol. 2018, 46, 656–669.
10. Rao, A.N.; Rao, V.R.; Williams, J.T. Priority Species of Bamboo; IPGRI-APO: Serdang, Malaysia, 2015; ISBN 92-9043-491-5.
11. Jamaludin Kasim, Abd,Jalil Hj. Ahmad, Jalaludin Harun, Zaidon Ashraf Abd. Latif Mohmod dan Mohd Nor Yusof (2001). “Properties of Particleboard Manufactured from Commonly Utilized Malaysian Bamboo (Gigantochloa scortechinii)”. Universiti Putra Malaysia. ISSN: 1511-3701.
12. Rd Roro Altrista Yusrina Kharismi, Sutriyo, Herman Suryadi. (2018). Preparation and Characterization of Microcrystalline Cellulose Produced from Betung Bamboo (Dendrocalamus asper) through Acid Hydrolysis. Journal of Young Pharmacists. 2018; 10(2) Suppl: s79-s83.
13. Durai, J., & Long, T. T. (2019). Manual for Sustainable Management of Clumping Bamboo Forest.
14. Osman, M. H. B., Kai, O. S., Adnan, S. H., Salim, S., Rahman, M., Jaafar & Yahya, N. F. (2021, July). Mechanical properties of concrete containing expanded polystyrene (EPS) and palm oil fuel ash (POFA). In AIP Conference Proceedings (Vol. 2347, No. 1, p. 020093). AIP Publishing LLC.
15. Muhammad Ejaz Haziq Mahmood, Muhamad Fakhrur Razi Redzuan, Nor Hanani Hasan Nordin, Fara Izzati Jaafar, Salman Salim, Ahmad Hakimi Mat Nor (2017) Laminated Bamboo Panel Technology, Civil Engineering Technology, UTHM, 63, ISBN:9789672110316

AUTHORS PROFILE

Salman Salim, served as Industrial Fellow in the Department of Civil Engineering at Centre Diploma Studies (CeDS), University Tun Hussien Onn Malaysia (UTHM) with 16 years of experience teaching and writing in construction engineering also more than 10 years' experience in construction project from related industry. The academic qualification starting from Certificate Ungku Omar Polytechnic Ipoh Malaysia (Land Survey, 1988), Diploma in Civil Engineering University Technology Malaysia (1998), Bachelor with honors in Civil Engineering University Technology Malaysia (2001), and Master in Civil Engineering from UTHM (2012). He managed to get 11 research grants and produced 24 learning modules. He also managed to publish 15 book chapter, 9 proceeding paper, 4 book and 7 international journal papers. He is also registered as a member of the graduated engineer to the Board of Engineers Malaysia (BEM), Institute of Engineers Malaysia (IEM), Malaysia Board of Technology (MBOT), Concrete Association of Malaysia and Malaysia Bamboo Society (MBS). He is recognized as a Professional Technologist (Ts) from MBOT since 2017 under the field of Building Construction Technology.

Mona Lena Abdul Aziz, served as Civil Engineer in Building Information Modelling at Malaysian Public Works Department with 5 years and 8 months of held position of an Assistant Director experiences at National Audit Department and she also was involved in construction industry around 2 years. The academic qualification starting from Certificate in Engineering (Civil) Polytechnic Merlimau Melaka (2005) and Bachelor with honors in Civil Engineering (Construction) Universiti Tun Hussein Onn Malaysia (2015). She managed to get Top 15 of Award of Excellence Best Poster Competition Final Year Project (2014) and the Top 10 of The Best GEOFEST Presenter. She is also registered as a member of the graduated engineer to the Board of Engineers Malaysia (BEM) and Institute of Engineers Malaysia (IEM).

Sufyan Abdullah, served as Industrial Fellow in the Department of Civil Engineering Technology at Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM) with 11 years of teaching experiences and he also was involved in construction industry around 2 years. The academic qualification starting from Certificate in Civil Engineering (Construction) Polytechnic Malaysia (2002), Bachelor with honors in Civil Engineering (Construction) Universiti Tun Hussein Onn Malaysia (2007), and Master in Civil Engineering from the same university (2013). He managed to get 5 research grants and produced 5 learning modules. He also managed to publish 3 book chapters, 7 proceeding paper and 3 international journal papers. He is also registered as a member of the graduated engineer to the Board of Engineers Malaysia (BEM), Institute of Engineers Malaysia (IEM) and Malaysia Board of Technology (MBOT). He is recognized as a Professional Technologist (Ts) from MBOT since 2017 under the field of Building Construction Technology.

Mohamad Hairi Osman, served as Industrial Fellow in the Department of Civil Engineering Technology at Faculty of Engineering Technology, Universiti Tun Hussein Onn Malaysia (UTHM) with 13 years of teaching experiences and he also was involved in construction industry around 4 years. The academic qualification starting from Bachelor with honors in Civil Engineering (Construction) Universiti Tun Hussein Onn Malaysia (2006), and Master in Civil Engineering from the same university (2012). He managed to get 8 research grants and produced 6 learning modules. He also managed to publish 9 book chapter, 20 proceeding paper and 18 international journal papers. He is also registered as a member of the graduated engineer to the Board of Engineers Malaysia (BEM), Institute of Engineers Malaysia (IEM), Malaysia Board of Technology (MBOT), Concrete Association of Malaysia and Malaysia Bamboo Society (MBS). He is also registered as a Professional Technologist (Ts) qualified by MBOT since 2017 and registered as Professional Engineer (Ir) qualified by BEM since 2015.

Mastura Najiha Salman, is a student of Bachelor of Information Technology with Honours in Faculty of Computer Science and Information Technology at Universiti Tun Hussein Onn Malaysia (UTHM). The academic qualification starting from Diploma of Information Technology in Centre of Diploma Studies at Universiti Tun Hussein Onn Malaysia (UTHM). She also manages to get Gold place in 3rd International Innovation, Invention & Design Competition (ICON) 2020 with Internet of Things Based Smart Ventilation System for Home.