Research Progress in Mechanical and Manufacturing Engineering Vol. 2 No. 2 (2021) 442-451
© Universiti Tun Hussein Onn Malaysia Publisher's Office

**RPMME**

Homepage: http://publisher.uthm.edu.my/periodicals/index.php/rpmme
e-ISSN : 2773-4765

# Identification of Malay Rattan Properties for Furniture Application

**Noraina Izzati[1], Shahruddin Mahzan[1*]**

[1]Faculty of Mechanical and Manufacturing Engineering,
Universiti Tun Hussein Onn Malaysia, Batu Pahat, 86400, MALAYSIA

*Corresponding Author Designation

DOI: https://doi.org/10.30880/rpmme.2021.02.02.050
Received 02 Aug. 2021; Accepted 27 Nov. 2021; Available online 25 December 2021

**Abstract:** Rattan cane is an important forest product, second only to lumber and bamboo in terms of economic worth and environmental advantages. Mechanical characteristics are more significant quality performance indicators that are highly associated with rattan cane processing and usage. Rattan is a form of natural fibre composite that is broadly employed in a variety of sectors, including architecture and furniture. As a result, it is critical to investigate the mechanical characteristics of rattan to ensure that it is suitable for specific applications. However, in order to tackle the issue of universal mechanical testing and standards on rattan, this present study will discuss the matter by compiling and reviewing researches on the testing methods and results of the mechanical properties of rattan. The testing methods involved are tensile test, bending test and flexural test. Charpy test that is usually used in impact test on rattan furniture is also reviewed in this paper. Conclusion can be drawn that rattan has higher flexural strength when compared with banana fibre, bamboo and steel as rattan is more ductile in nature. It is also exposed that weaving patterns have effects on the rattan seat towards the strength and durability of rattan chairs.

**Keywords:** Rattan, Mechanical, Rattan Properties, Mechanical Test

## 1. Introduction

Rattan is a multi-purpose plant resource with long tough slender stems found mostly in the tropical rainforests, and has a high economic value which can be considered as a material with high potential in the construction industry (Akpenpuun TD *et al.*, 2017). Rattan belongs to the family of Palmae or Arecaceae and classified in the largest group of the subfamily Calamoideae. There are 13 genera of rattan can be found in the world. Those genera are Calamus, Calospatha, Ceratolobus, Daemonorops, Eremospatha, Korthalsia, Laccosperma, Myrialepis, Oncocalamus, Plectocomia, Plectocomiopsis, Pogonotium and Retispatha. In peninsular Malaysia, there are about 107 species of rattan had been discovered. However, out of these 107 species, only 30 species that recognized to have market value. Meanwhile in Sabah and Sarawak, the rattan industry is still at the developmental phase.

Olorunnisola and Adefisan (2007) stated that rattan cane is an important forest product only second to timber and bamboo, and is extensively used as an excellent natural material for furniture, ropes,

---

**Corresponding author: sharudin@uthm.edu.my* decorative items, housing, craft products, and also as an innovative bone implant material. Rattan is one of the most popular demand in the world of creative hand-woven craft of Malaysia. The local plant parts from rattans are plaited and woven to produce exquisite bags, baskets, mats and even hats. It is also has been widely used in various household activities by the people that live in rural area. But nowadays, rattan has made its own way into the furniture industry in our country. This is a great opportunity for Malaysia to step up the game and increase the rattan furniture market value, locally and globally. However, the standard specification of rattan in our country is still in the development process, unlike the neighbouring country such as Indonesia and Philippine in which well-known for their rattan furniture industry.

Due to the absence of the rattan standard specification made for Malaysia, the aim of this study is to identify about the way to expand the quality of rattan furniture industry. So, as to achieve the goal, this study will be focusing on rattan mechanical specifications in order to bring improvements for the rattan furniture industry. Hence, this study will give the thoroughly estimation of the refinement and quality on the rattan furniture products for the country's future standard specification.

## 2. Materials and Methods

The flow of the experiments and methods used are by referring to the previous studies. The identification of mechanical properties may be categorized in several essential stages: Material preparation, experimental set up, and lastly is analysis of the rattan properties.

### 2.1 Material Preparation

From the studies by Yang *et al.* (2020), ten selected raw rattans were cleaned thoroughly and cut into desired length which was also done by Mahzuz *et al.* (2014). Both studies stated that the rattans were then air-dried approximately for 2 months (40 to 60 days) to obtain the universal moisture content – 9 to 15 percent. The universal moisture content was also reported in the sample preparation by Wan Tarmeze *et al.* (2007) which is between 12 to 15%.

For rattan fibres, Islam *et al.* (2019) explained that the rattans fibres need to be extracted first then immersed in water for 25 days. Hand lay-up process in fabrication process is used the most for experiments involving natural fibres which shown in the Figure 1.

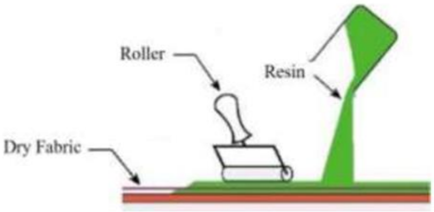

**Figure 1: Hand lay-up method used by Islam *et al.* (2019)**

### 2.2 Methods

#### 2.2.1 Tensile test

Gu and Zhang (2020) had conducted tensile tests on rattan strips to assess rattan-type impacts of bast, core, synthetic on main tensile characteristics such as tensile strengths of rattan strips. Fixed unit loading speed of 0.3 mm/min/mm on natural rattan strips (NRSs) and Unit loading speed of 0.4 mm/min/mm on synthetic rattan strips (SRSs). Constant rattan gauge length of 100 mm was also utilized as illustrated in Figure 2. For Islam *et al.* (2019), the loading rate was set to 2 mm/min on the Universal Testing machine (UTM) with the ASTM D3039 standard. Meanwhile Osoka *et al.* (2018), where Hounsfield Monsanto Universal Tensometer Machine was used to carry out tensile tests with moving grip of 5 mm.min-1 following ASTM D 638-99 standard. Compression test was carried out by Liu *et* *al.* (2014) in accordance with the National Standard of the People's Republic of China (GB 1935-2009) where Instron Testing Machine (5582, Instron Co., USA) was used with rate of 6 mm·min$^{-1}$ and it took 60s ± 30s.

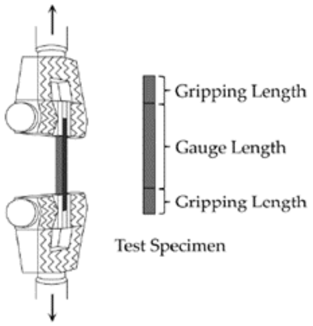

**Figure 2: Illustration of the defined gauge length of a rattan strip evaluated in the experiment by Gu and Zhang (2020)**

As demonstrated by previous works, the tensile test was a significant measurement to be conducted due to the responses of rattans to the stress by tensile force. By carry out this test, it reveals how strong the rattan is and how far it can stretch by doing so. This data is very important in order to improve the quality of rattan furniture production.

2.2.2 Bending Test

Shang *et al.* (2016) selected rattan species *P. kerrana*. In this study, mechanical properties of the specimens are determined by means of universal testing machine, UTM (Instron 5582, Instron Co., USA) as shown in Figure 3 and conducted in a 20°C setting with a relative humidity of 55 to 60%. As for Modulus of Elasticity (MOE) and Modulus of Rupture (MOR), Abasolo (2013) has conducted several tests on cultivated *Calamus merrillii* rattans that came with different age – 7, 8, 10, 11, 14, 15, 18 and 20 years old. Measurements were performed in green condition (> 30% moisture content). Using UTM, rate of 0.003 mm min-1, measure midspan deflections to the closest 0.025 mm. Zuraida *et al.* (2017) conducted three point bending tests, MOR of the rattan fibre-based binderless board and used UTM.

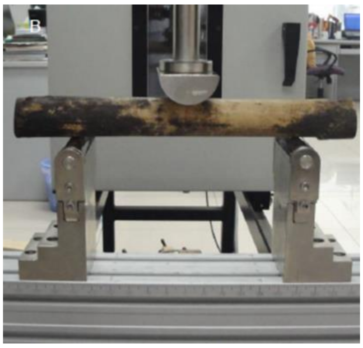

**Figure 3: Image of rattan undergoing bending test by Shang *et al.* (2016)**

2.2.3 Flexural Test

Islam *et al.* (2019) has conducted flexural tests on rattan and banana fibre reinforced epoxy composites. To assess the flexural characteristics of the composites, three-point bending tests in accordance to ASTM D7264 standard were performed on composite specimens that had undergone fabrication process. UTM is subjected to three-point bending tests after specimens are sliced parallel following the orientation of fibres in accordance with ASTM D7264. In the study by George *et al.* (2013), flexural testing was carried out on the three-point bending test machine.

### 2.3 Analysis

Based on past studies, statistical analysis will be carried out in order to obtain all the results and data from the tests conducted. Statistical analysis was conducted at the 5% ($\alpha = 0.05$) significance level. As for ANOVA (Analysis of Variance), Gu and Zhang (2020) carried out mean comparisons of each mechanical property for the factor examined for a 1-factor experiments. Both multiple comparisons procedures of least significant difference (LSD) and least-squares mean (LSMEAN) was considered to carry out if there were discovery of balanced rattan strip number and unbalanced rattan strip number, respectively. Lastly, Abasolo (2015) has linked between age and fundamental characteristics of plantation produced canes and investigated using regression analysis.

## 3. Results and Discussion

### 3.1 Mechanical Properties of Rattan

### 3.1.1 Tensile Properties

Yang *et al.* (2020) has conducted two types of tests which were tensile strength (TS) and tension modulus (TM) to obtain four different types of rattans' tensile property. It is shown in Table 1 that C. *yunnanensis* has the highest mean value of tensile strength, tension modulus and compressive strength with 57.91 MPa, 2514.2 MPa and 27.75 MPa, respectively. Table 2 shows the ANOVA on tensile and compression properties of four rattan species at different heights by Yang *et al.* (2020). Gu and Zhang (2020) were investigating the factors affecting rattans strips' tensile properties. From the study in Table 3, it shows that bast strips has much greater ultimate tensile strength than core strips. The natural rattan strips failed largely at two areas under tensile loads: strip breaks at the handle and length in strip gauges. Dissimilarity between bast and core strips in ultimate tensile strength is due to denser vascular bundles and fibres in bast compared to core strips as shown in Figure 4.

**Table 1: Tensile and compressive properties of four rattan species results by Yang *et al.* (2020)**

| Species | Tensile Strength, TS (MPa) | Tension Modulus, TM (MPa) | Compressive strength, CS (MPa) |
|---|---|---|---|
| C. *simplicifolius* | 41.99 | 1897.01 | 24.93 |
| C. *nambariensis var. yingjiangensis* | 44.74 | 2315.46 | 26.01 |
| C. *nambariensis var. xishuangbannaensis* | 43.94 | 2212.15 | 25.07 |
| C. *yunnanensis* | 57.91 | 2514.20 | 27.75 |

**Table 2: ANOVA on tensile and compression properties of four rattan species at different heights by Yang *et al.* (2020)**

| Source of variation | df | Statistical significance | | |
|---|---|---|---|---|
| | | TS | TM | CS |
| Species | 3 | 0.377 | 0.225 | 0.699 |
| Height | 4 | 0.773 | 0.879 | 0.879 |

TS tensile strength, TM modulus of tension, CS compressive strength
** Significant at the 0.01 level

**Table 3: Mean values of tensile strength for rattan strips by Gu and Zhang (2020)**

| Rattan type | Tensile strength at |
|---|---|

| | Proportional Limit, $\sigma_{pl}$ (MPa) | Yield Point, $\sigma_y$ (MPa) | Ultimate Point, $\sigma_u$ (MPa) |
|---|---|---|---|
| Bast | 17.57(16)(A) | 21.26(13)(A) | 35.00(18)(A) |
| Core | 16.22(19)(A) | 20.17(19)(A) | 30.13(17)(B) |
| Synthetic | 4.84(17)(B) | 5.87(15)(B) | 10.29(05)(C) |

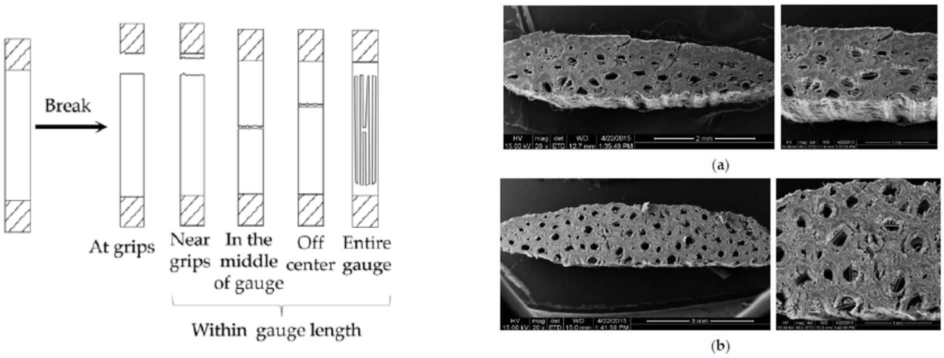

**Figure 4: Location of major failure for natural rattan strips after tensile loading test and SEM images of typical cross-sections of the bast and core rattan strip broken surfaces evaluated in tension by Gu and Zhang (2020)**

Rachchh *et. al* (2014) has study the mechanical characterization of rattan fibre polyester composite with six different fibre proportion laminates - 5%, 7.5%, 10%, 12.5%, 15% and 17.5%. Tensile stress was enhanced by increasing the fibre and decreased after some limits. From Table 4, the study showed that woven rattan reinforced composite grew rapidly to 12.5% following the tensile tension dropped, since resin contain will decreased when the fibre contains increased.

**Table 4: Mean values of tensile strength for rattan strips by Gu and Zhang (2020)**

| Plate No. | Contain of Fibre (%) | Tensile Stress (MPa) |
|---|---|---|
| 1 | 5.0 | 7.30 |
| 2 | 7.5 | 9.75 |
| 3 | 10.0 | 15.69 |
| 4 | 12.5 | 20.43 |
| 5 | 15.0 | 13.91 |
| 6 | 17.5 | 12.55 |

It is demonstrated that the tensile strength of rattan are depends on the anatomy of rattan plants. Different type of rattan plants has different internal structure such as the denseness and thickness of their vascular bundles and fibres, respectively.

The values recorded different numbers with the minimum tensile obtained was 5.87 MPa under synthetic conditions and this caused by severe plastic deformation but no apparent post-fracture collapse. The highest tensile strength recorded was 57 MPa for different setting. This shows that certain composition influencing the tensile strength. The values of tensile strength that have been tested on rattan parts are higher than the values tested on rattan strips.

### 3.1.2 Bending Properties

Yang *et al.* (2020) was investigating the factors affecting rattans strips' tensile properties. From the study, C. *yunnanensis* showed significantly higher MOR and MOE which is 72.32 MPa and 2150.29 MPa, respectively. In opposite, C. *simplicifolius* has the lowest MOR (54.13 MPa) and MOE (1303.36 MPa). In the study by Gu and Zhang (2020), MOE of bast strips was 1.2, 3.8 times that of core and synthetic strips due to the differences in vascular bundles and fibres' distribution. As for synthetic rattan strips, the strips above 0.2 mm/min/mm were approximately 1.1 times more than the unit loading speed of 0.2 mm/min/mm, followed by around 1.1 times less than the unit loading speed at 0.1 mm/min/mm. Table 5 shows the mean values of MOE of synthetic rattan strips by Gu and Zhang (2020).

**Table 5: Mean values of Module of Elasticity (MOE) of synthetic rattan strips with effect of unit loading speed conducted by Gu and Zhang (2020)**

| Unit Loading Speed (mm/min/mm) | Module of Elasticity, MOE (MPa) |
|---|---|
| 0.1 | 199 |
| 0.2 | 227 |
| 0.3 | 258 |
| 0.4 | 263 |
| 0.5 | 262 |
| LSD | 22 |

### 3.1.3 Flexural Test

Rachchh *et al.* (2014) has conducted flexural test on composite plate constructed of rattan fibre and GP-7150 unsaturated polyester resin. From the study, it was discovered that the load transferal between fibres is not adequate, therefore flexural strength is reduced by rising the fibre ratio beyond 12.5% as it was the maximum flexural strength gained as shown in the Table 6.

**Table 6: Flexural test result by Rachchh *et al.* (2014)**

| Plate No. | Contain of Fibre (%) | Flexural Strength (MPa) |
|---|---|---|
| 1 | 5.0 | 7.30 |
| 2 | 7.5 | 9.75 |
| 3 | 10.0 | 15.69 |
| 4 | 12.5 | 20.43 |
| 5 | 15.0 | 13.91 |
| 6 | 17.5 | 12.55 |

### 3.1.4 Comparisons with Other Materials

Islam *et al.* (2019) has conducted tensile and flexural test on rattan and banana fibres reinforced epoxy composites. From the study, it is found that tensile strength of banana fibre composites is found to be substantially 2.57 times greater than the composite rattan fibre. It is comparable for flexural strength of rattan fibre and banana fibre composite which is 131.56 Mpa and 128.47 MPa, respectively. As for study by Srujana *et al.* (2020) on rattan and bamboo, the mechanical properties gained were tensile, compressive, bending and MOE strength. From the study, rattan has lower tensile strength and compressive strength compared to bamboo. In terms of bending strength and elasticity, rattan shows an obvious difference in results compared to bamboo with 0.1 kN/mm2 and 3000 MPa, respectively. Zuraida *et al.* (2017) has conducted tests on binderless boards with hot press boards with natural fibre such as rattan, kenaf, cocoa husk and sugar cane bagasse to discover the MOR properties. It is concluded that minimum MOR requirement of 18 MPa suggested by JIS (2013) is achieved by kenaf and ratan binderless boards where the greatest MOR is a binderless board of kenaf followed closely by rattan 5,8 MPa and 48.8 MPa, respectively.

## 3.2 Testing Method

In this section, testing methods used along with the results obtained from the previous studies will be discussed. Several different tests had been carried out by researchers and some of them may or may not obtained the results within the same range from one another due to the differences in testing methods. Islam et al. (2019) and Rachchh *et al.* (2014) had conducted tensile tests on natural fibres such as rattan and other materials. Universal Testing machine (UTM) was used with different standards where Islam *et al.* (2019) using ASTM D7264 standard, while Rachchh *et al.* (2014) using the ASTM D-638 standards. Both used hand-lay process and the results obtained in both studies are in the same range. Islam *et al.* (2019) reported that the average tensile strength of 13.01±3.49 MPa, while tensile stress gained by Rachchh *et al.* (2014) were in the range of 7.3 MPa up to 20.43 MPa.

As for bending test, Yang *et al.* (2020) used Instron mechanical testing machine and Irawan et al. (2016) was also using Universal Testing machine in their respective studies. The results from Yang et al. (2020) showed that the range in between 24.93 MPa to 27.75 MPa for four types of rattans while Irawan *et al.* (2016) stated that the compressive strength simulation findings are still within the study range (28.2-33.6) MPa which are same as studies from Bhat and Thulasidas (1992) and Sebayang et al. (2004). Yang *et al.* (2020) and Irawan *et al.* (2016) had also conducted flexural tests on the specimens and Yang *et al.* (2020) obtained the results of MOE and MOR in the range of 54.13 MPa to 72.32 MPa and 1303.36 MPa to 2150.29 MPa, respectively while Irawan *et al.* (2016) achieved the average value of 54.1 MPa for natural rattan (NR) and 82.3 MPa for rattan laminated fiberglass epoxy resin materials (RLFERM).

## 3.3 Strength and Durability

Irawan *et al.* (2016) has conducted Charpy impact test on natural rattan (NR) and rattan laminated fiberglass epoxy resin materials (RLFERM). The study aimed to determine the comparison of strength between NR and RLFERM in rattan when the impact load is received. Figure 5 shows average impact strength of NR has increased by 39 kJ/m$^2$, while RLFERM has grown by 64% to 64 kJ/m$^2$. Thus, Irawan *et al.* (2016) concluded that the rattan lamination method with epoxy resin and fibreglass has been shown to increase the impact strength of rattan. Osoka *et al.* (2018) carried out Charpy impact test on natural fibre reinforced composites such as empty plantain bunch fibre, empty palm bunch fiber and rattan palm fibre with two types of thermosetting resins which is Polyester and Epoxy resins. Compared with steel and in accordance of ASTM D6110-02M standard. The results obtained show in Figure 6 that impact strength of all composites made of rattan palm or epoxy matrix is approximately nine times that of steel. George *et al.* (2013) also conducted Charpy test on natural fibre reinforced polymer composites. The study shows polypropylene-rattan has the second highest impact strength value which is 50 kJ/m$^2$.

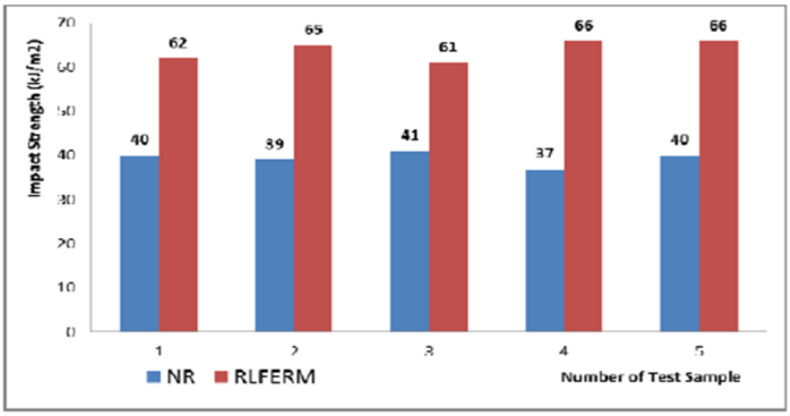

**Figure 5: Result of impact test on NR and RLFERM by Irawan *et al.* (2016)**

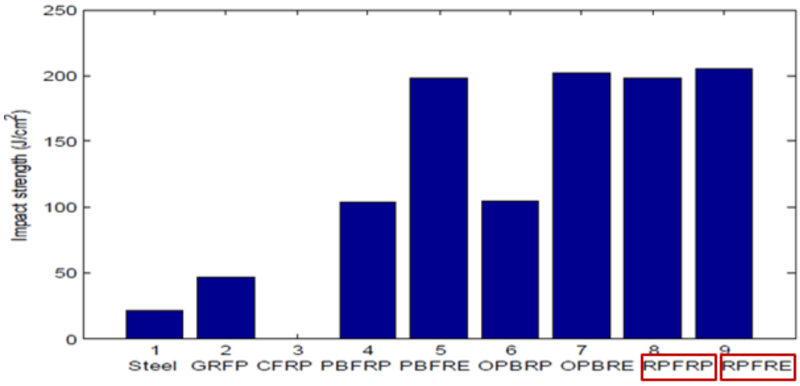

**Figure 6: Result of impact test by Osoka *et al.* (2018)**

Wan Arifin *et al.* (2007) conducted tests to evaluate the strength and stiffness characteristics of several types of joints of laterally loaded rattan furniture the joints were the nailed, nailed and bound with rattan rope, screwed and bound. From the study, it is found that the lateral stiffness and strength characteristics of the screwed joints generally were not substantially different than the nailed joints. Furthermore, it was discovered that utilizing denser rattan may generate stiffer and stronger rattan joints.

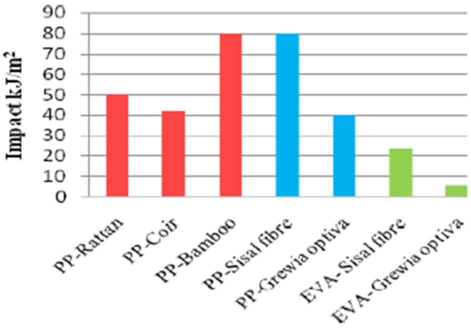

**Figure 7: Result of impact tests on natural fibre reinforced polymer composites by George et al. (2013)**

Gu *et al.* (2015) has conducted static and fatigue performances of natural rattan chair seat foundations exposed to vertical stresses. The study utilized three types weaving patterns of seat foundation specimens which are grid, herringbone, and square-corner that shown in the Figure 8. The vertical load-carrying capability of woven seat foundations with a herringbone or grid pattern was substantially higher than that of those with a square-corner design. Seat foundations with square corners provide a softer sitting surface than herringbone and grid designs. Seat foundations with herringbone and grid patterns offered a stronger sitting experience and greater deep-down support for heavier sitters.

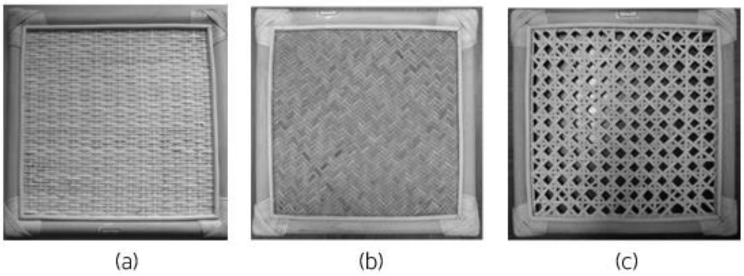
(a) (b) (c)

**Figure 8: Three weaving patterns of natural rattan seat foundation Three weaving patterns of natural rattan seat foundation specimens used in static tests: (a) grid, (b) herringbone, and (c) square-corner by Gu *et al.* (2015)**

It is demonstrated that Charpy test is the most influential test that have been conducted on rattans in order to obtain the data for impact tests. The values recorded different numbers with the minimum impact strength obtained was 37 kJ/m$^2$ on natural rattan while the maximum value of impact strength is 2049.7 kJ/m$^2$ when epoxy resin reinforced with rattan fibres. These past studies show that the reinforcement of rattans is proven to improve the impact strength of rattans. Furthermore, different type of weaving patterns influenced the capability of rattan chairs furniture.

## 4. Conclusion

In conclusion, tensile tests conducted on different species of rattan by past researchers concluded that tensile and compression tests on rattan will not be affected by rattan species, except for the MOE. The values of the tensile strength obtained from previous studies fall in the range between 30 MPa to 58 MPa for rattan. As for bending strength, rattans obtained the values that are in the range between 199 MPa to 4900 MPa for MOE while 25 MPa to 72 MPa for MOR. As for the mechanical tests on different parts of rattan, it can be concluded that the differences in results are causes by the differences in vascular bundles and fibres' distribution. It is discovered that the tensile stress of the woven rattan reinforced composite grew rapidly to 12.5% (20.43 MPa) following the tensile tension dropped, since resin contain will decreased when the fibre contains increased. The maximum flexural strength is 20.43 MPa with 12.5% laminate fibre. Besides, compared with the other properties, rattan is proved to have high average values for its bending or flexural properties. Rattan exhibited lower tensile strength of 13 MPa to 840 MPa compared to banana and bamboo. However, the flexural strength of rattan and banana is comparable with 131.56 MPa to 128.47 MPa. Different with rattan and bamboo, the MOE of rattan was significantly higher value with 3000 MPa to bamboo only obtained 15 MPa.

Furthermore, the testing methods using Universal Testing machine (UTM) or Instron mechanical testing machine with the desired parameters from 0.3 mm/min/mm to 2 mm/min and the analysis through ANOVA along with Charpy impact test by the previous researchers were successfully showed results for the observation of rattan properties. The tests showed that rattan has impact strength of 39 kJ/m2 to 2049.7 kJ/m2.

As a suggestion, research and development in rattan furniture should be directed toward increasing understanding in this sector in evaluating good rattan quality. More studies are needed to analyze the properties and to set the testing standard specifically for rattan as the universal international standard is still absent.

## Acknowledgement

The authors would like to thank the Faculty of Mechanical and Manufacturing Engineering, Universiti Tun Hussein Onn Malaysia for giving the opportunity to conduct this study.

## References

[1] Abasolo, W. P. (2015). Properties of rattan cane as basis for determining optimum cutting cycle of cultivated Calamus merrillii. Journal of Tropical Forest Science, 27(2), 176–188.

[2] George T.J., Jacob N., Francis F.K., Joseph M. (2013). Investigation on Mechanical Properties of Various Microwave Cured Natural Fibre Reinforced Polymer Composites. International journal of engineering research and technology, 2.

[3] Gu, Y., & Zhang, J. (2020). Tensile Properties of Natural and Synthetic Rattan Strips Used as Furniture Woven Materials. Forests, 11(12), 1299.

[4] Gu, Y., Wu Z., Zhang J. (2016). Load-deflection behavior of rattan chair seats. Wood and fiber science: journal of the Society of Wood Science and Technology. 48. 13-24.

[5] Irawan, A.P., Daywin, F., Fanando, F., & Agustino, T. (2016). Mechanical Characteristics of Rattan Reinforced Fiberglass and Epoxy Composites for Shank Prosthesis Application.

[6] Islam, Md Shariful & Azmy, Syed & Almamun, Abdullah. (2019). Comparative Study on Mechanical Properties of Banana and Rattan Fiber Reinforced Epoxy Composites.

[7] Liu, X.'., Tian, G., Shang, L., Yang, S., & Jiang, Z. (2014). Compression properties of vascular boundles and parenchyma of rattan (Plectocomia assamica Griff). Holzforschung, 68(8), 927–932. https://doi.org/10.1515/hf-2013-0194

[8] Mahzuz, H. M. A., Ahmed, M., Uddin, M. K., Hossain, M. M., & Saquib, N. (2014). Identification of some properties of a rattan (Daemonorops jenkinsiana). International Journal of Sustainable Materials and Structural Systems, 1(3), 232.

[9] Osoka E. & Onukwuli O. & Kamalu C. (2018). Mechanical Properties of Selected Natural Fiber Reinforced Composites for Automobile Application 1*. 7. 384-388.

[10] Rachchh, N. V., Ujeniya, P. S., & Misra, R. K. (2014). Mechanical Characterisation of Rattan Fibre Polyester Composite. Procedia Materials Science, 6, 1396–1404.

[11] Srujana N., Monesh G., Bhavani T. (2020) Identification of Rattan Cane in Structural Applications. In: Praveen Kumar A., Dirgantara T., Krishna P.V. (eds) Advances in Lightweight Materials and Structures. Springer Proceedings in Materials, vol 8. Springer, Singapore.

[12] Wan Arifin W.T., Husain H., Mustafa M.T., Azmi J. K. (2007). Stiffness and strength properties of rattan furniture joints subjected to lateral load. 6. 1-10.

[13] Yang, S., Xiang, E.'., Shang, L., Liu, X.'., Tian, G., & Ma, J. (2020). Comparison of physical and mechanical properties of four rattan species grown in China. Journal of Wood Science, 66(1), 2–3.

[14] Zuraida, A., Maisarah, T., WanShazlin-Maisarah, W.M.Y. (2017). Mechanical, Physical and Thermal Properties of Rattan Fibre-Based Binderless Board. Journal of Tropical Forest Science. 29(4). 485-492.