The Durability Test on The Potential of Single Rattan Fibres

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Abstract-Currently, rattan yarns are used in the furniture business because they are widely accessible, economical, non-hazardous to health, and biodegradable to the environment; hence, by using it as a composite material scattering fibre, it will be able to solve the environmental problem in the future. The purpose of this study was to get a technical examination of the tensile strength of rattan single fibre composite reinforced unsaturated thermoset resin. The goal of this study is to determine the tensile strength composite of rattan single fibre with varied fibre diameter sizes ranging from 1 mm to 5 mm maximum. The specimen trial result is served in tensile strength when compared to the tensile strength authorised by ASTM as a theory of standardisation test. From the resulting study, we found the maximum of tensile strength and maximum impact has got by composite with 5 mm diameter. The morphology of surface composition was examined using optical microscopy (OM).

Index Terms- single fibre, fibre diameter, optical microscopy, mechanical properties, Young's modulus

I INTRODUCTION

Natural fibres have strong mechanical qualities, are renewable, are environmentally friendly, and are economically viable. As a result, they have received increased attention in recent time as underpinnings for matrix composites [1,2]. Nevertheless, natural fibres have disadvantages due to the local climate, conditions of growth and nature of the recovery process (prunning, enzyme treatment, etc) [3,4]. Furthermore, thermoset reinforcing plastic filler is lightweight, has improved mechanical properties, and is free of health dangers, whereas synthetics are expensive and need a lot of energy to produce. Natural fibres such as rattan are developing as cost-effective and seemingly environmentally better alternatives for synthetic polymers in composites, owing to the need for renewable fibre reinforced composites [5-7]. The ability to accurately and reliably quantify the tensile strength of natural fibres using a practical approach is thus critical for comparing different types of fibres and predicting the mechanical characteristic of their compounds. The single fibre tensile test is the most frequently used technique aimed at determining fibre tensile characteristics [8–10]. For synthetic and natural fibres, this technique offers adequate strength and modulus. In this study, we will discuss the problems and limits of single fibre test for rattan fibers. The rattan yarns supplied by AFR Craft Enterprise address Plot A, Mile 7, Bukit Gedong, Tg.Kling, Melaka while the resin supplied by Chemibond Enterprise Sdn. Bhd, Petaling Jaya, Selangor was utilised to authorize the procedure. This study emphasizes on the objectives to evaluate the strength of single rattan fibre for the purpose of turning into weive fabric. Although some progress has been made towards rattan fibre, further research is needed in the upgrading potential rattan fibre especially from the family of Calamus caesius. Customarily, Calamus caesius has been utilized by rural community for making baskets, mats, and crafted works. The circular cane, skin peel and hyperbolic shape give significantly critical high-quality materials for the very advanced rattan furniture fabrication. Commonly use for tide and reinforcement for bigger diameter rattan canes. The tone of the rattan influenced by components such as age, dampness substance and the light conditions during development [11-19]. The prototype sample for this study includes the original structure from the natural composite of rattan fibre. This study thus concurrent with the government policy to uphold handicraft as part of the national industry. The Malaysian Handicraft Development Corporation (PKKM), defines handicraft as the study of producing useful or decorative equipment with full hand or simple tools. According to the current state of the environment and the requirements of natural fibres for improvements in polymer composites, it was decided to examine the use of natural fibres as strengthening in polymer mixes as a strengthening method. Because natural resources are used in a variety of industrial applications and manufacturing operations, this also serves as a method of promoting economic growth in rural regions. According to the Malaysian government's concern for diversification of local woodland-based products, in addition to the craft and furniture sectors, this list has been compiled. According to the findings through this review [1], the characteristics of reinforced natural with synthetic fibers embedded with polymers are possible.

II SINGLE FIBRE TEST TOWARDS NATURAL FIBRES

A Confines of Single Fibre Test Carried on Natural Fibres

Single fibre test was initially used to evaluate the tensile characteristics of man-made fibres (ASTM D 3822-01). Herein approach, the fibre cross-section area is calculated supposing that the fibre is a rectangle, which is true for most man-made fibres. The tensile strength of a single fibre may be easily calculated from the force at which it fails in the tensile test. Most synthetic fibres are homogeneous and almost spherical because they are manufactured in a well-controlled and optimised process. The conservative single fibre test using Universal Tensile Test machine as shown in Figure 2 provides good and reliable tensile properties for synthetic fibers. Natural fibres, on the other hand, are not the same as synthetic fibres. Natural technical fibre is frequently composed of a bundle of primary fibres, resulting in an uneven form depending on the quantity of fundamental fibres and how they are packed together. Furthermore, the cross-section of elementary fibre is not completely round. As a result, the fibre diameter visible under microscope might vary greatly depending on the perspective. However, as illustrated in Figure 1, natural fibres can include as a hollow structure termed a lumen that seems as a tiny open conduit in the centre of the cell and may impair the real fibre area under mechanical loading [20,21]. The average diameter measurement is used to evaluate single fibre diameter due to its uneven shape and nonuniformity along the fibre axis. To address this issue, the average value of five or more apparent diameters recorded at different places along the fibre was recommended. The fibre, on the other hand, is designed to fail at the point of greatest stress concentration. If no other significant flaws occur, this site has the smallest cross-section. As a result, such a recommendation would be ineffective in resolving the issue. Furthermore, Natural and manufactured flaws or faults always exist on natural fibres; fibre failure at the smallest cross-sectional site may not be clear at all [22, 23], as failure might happen at the time of tensile testing where the failure is situated.

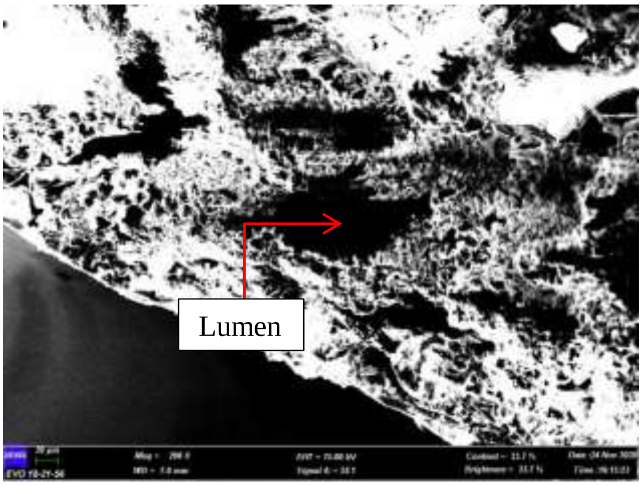

Figure 1: Lumen existence in rattan cross section on SEM

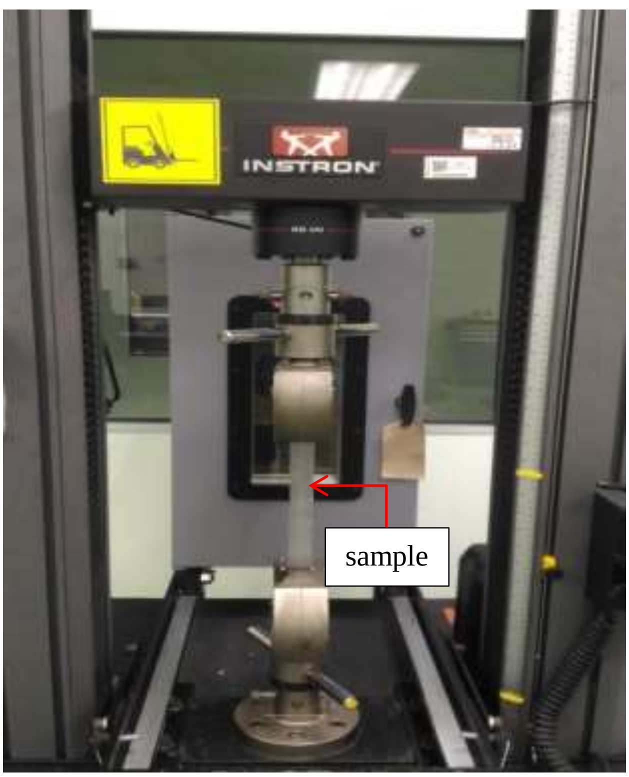

Figure 2: Tensile test for single fibre

Figure 3: Sample for tensile test of single fibre composite

Figure 4: Open mould for sample preparation

B Sample Selection for Testing

As previously mentioned, before and after testing the fibre breaking has enormous effects on performance, the results thus do not reflect the consistency of the fibre well. First, single technical rattan fibres with no splitting were handselected. In this step, if such defects are not reflective of fibre design even fibres with visible defects should be omitted. Furthermore, infected fibres would lead to an obscured cross-section picture that would result in a mistake in cross-sectional area assessment and removal. The rattan fibre was fitted to the mould, and the specimen was then fixed with epoxy resin in the ratio of 100:29 (weight/weight) of EpoxAmite resin and 102 Medium hardener, and dried at room temperature for 15 hours. Figure 4 shows Epoxy resin and Figure 5 shows the hardener. The resin mix is then poured into an open mould with a rectangular cavity as shown in Figure 6. These shapes are in accordance with ASTM D3822-01 standards. After around 15 hours of curing time, only the best samples peel out of the cavity and are ready for mechanical testing as shown in Figure 3. According to the supplier's specifications, the combined viscosity of this compound is 650 CPS by ASTM 2393.

C Fibre Tensile Testing Procedure

The pre-selected fibres are measured at desired temperature and condition in accordance with ASTM D3822-01. For fast handling and grasping, the two fibres ends were bound to a piece of tape respectively. During the test the strength-strain curve of the fibre is reported and the fibre properties are determined in its next step.

D Cross-section Area Determination

An exact cross-section area must be acquired by estimating the tensile strength and fibres modulus elastisity. To enhance the cross-section area accuracy, then a plane and clean cross-section of the fibre rupture need at the end. Consequently, the tested fiber was cautiously pinned on both end side of the long rattan fibre. Proper size of the rattan fibre could avoid the specimen moving in the epoxy liquid to elude a tilted cross-section. From the SEM image, the hollow structure (lumen) could be seen clearly in some elementary fibers as shown in Figure 1; nevertheless, this lumen could be discounted because it was at the most 1.5% of the whole part. This lumen is a normal existence for every natural fibre as it grown with hydrophilic characteristics.

III EXPERIMENTS

Six types of specimens including 100% epoxy without Rattan fibre (R0) and diameter 1 mm rattan retted by enzyme (R1) until 5 mm (R5). Epoxy was kindly supplied by Chemibond Enterprise Sdn. Bhd, Petaling Jaya, Selangor. The Rattan yarns were kindly supplied by AFR Craft Enterprise from Bukit Gedong, Tg.Kling, Melaka. Tensile testing were performed using an Instron 5548 Micro- tester. At room temperature, the following Single Fibre Test was performed in accordance with ASTM D 3822-01. Tensile tests were carried out on the carefully chosen rattan fibres (as described in previous section). Both rattan fibre ends were fastened with plastic cellotape for ease handling and gripping. A grip length of 9 mm and a gauge length of 50 mm were utilised for testing in this study. In all testing, a translation speed of 100 mm/min was used. The tensile characteristics of the fibre may be readily assessed using ASTM D 3822-01 because the cross-section area of the fibre is calculated and its corresponding force-elongation is acquired from the test. The diameter of 5 specimens for each type of fibers was determined before testing. The diameter-determination methods were examined by measure the average fiber diameter at five different random locations on the fiber. The obtained diameter, D, is utilized to calculate the cross-section area using equation of area $A = \pi r^2$ for the final mechanical data analysis.

IV RESULTS AND DISCUSSION

Figure 3 depicts usual stress–strain curves of rattan fibre from the tensile test. With the exception of slight slippage at the start of the experiment, the rattan fibres show a single linear elastic distortion until rupture without plastic deformation. Similar plot behaviour and form may be discovered for vegetable fibres described in other publications [24, 25]. Because the natural fibre is so weak, the little slippage at the start of the test was difficult to manage. Rattan fibres behave similarly to many organic fibres, which frequently exhibit plastic deformation following elastic deformation and have high ductility. By precisely defining the beginning of the curve, the zero-strain value was determined. All fibers show brittle failure with strain to failure of less than 2%. The average diameters, tensile strengths, modulus, and strains of the R0, R1, R2, R3, R4 and R5 fibers calculated from 30 specimens could be found in Table 1. It has been reported that the tensile strength and modulus of the rattan fibers are within the range of 10-30 MPa and 27.6–1000-2000 MPa, respectively [16-18]. The average tensile strength of rattan fiber composite is 13.01 MPa. The flexural strength of rattan fiber it is found to be 131.56 MPa [12].

In order to decrease the default property difference, the average diameter may be attempted to replace the lowest value because the fibre will probably fail in a smaller transverse section. The findings based on the minimal fibre diameter are likewise presented in Table 1. The standard deviations of these tests were still within acceptable bounds, perhaps due to the accuracy of the smallest cross section on the digital caliper. As mentioned above, in addition to the natural fibres' homogeneity, the significant standard diameter variance is largely attributable to the inaccuracy of the method employed in order to estimate their fibre diameter. As a result, the strength and modulus values for this specific fibre might be considerably varied as seen in Figure 5 through Figure 8. The growth area, climatic variables, and retting circumstances all contributed to the relatively lower tensile and specific strength values. Despite the fact that only five specimens were examined for each sample in this approach, it gives sufficiently reduced standard deviations, which are less than 11%. Furthermore, the approach of calculating the cross-section area by using the average diameter value of five random sites along the fibre is appropriate.

TABLE 1:
Rattan fibers parameters reinforced unsaturated thermoset obtained from single fiber test method.

Legend	Specimen name	Max Load [N]	Modulus Young's [MPa]	Ultimate Tensile Strength [MPa]	Extension at Break [mm]	specific strength (MPa.m^3/kg)
R0	100% EPOXY	1153.114	1508.772	16.158	7.229	724.665
R1	1mm	1508.687	1398.091	17.956	11.671	937.169
R2	2mm	1731.700	1654.205	23.279	9.310	1314.849
R3	3mm	1711.619	1420.181	20.633	9.669	1350.086
R4	4mm	1635.040	1378.460	20.492	11.679	1505.678
R5	5mm	1996.070	1761.444	26.972	9.164	2503.607

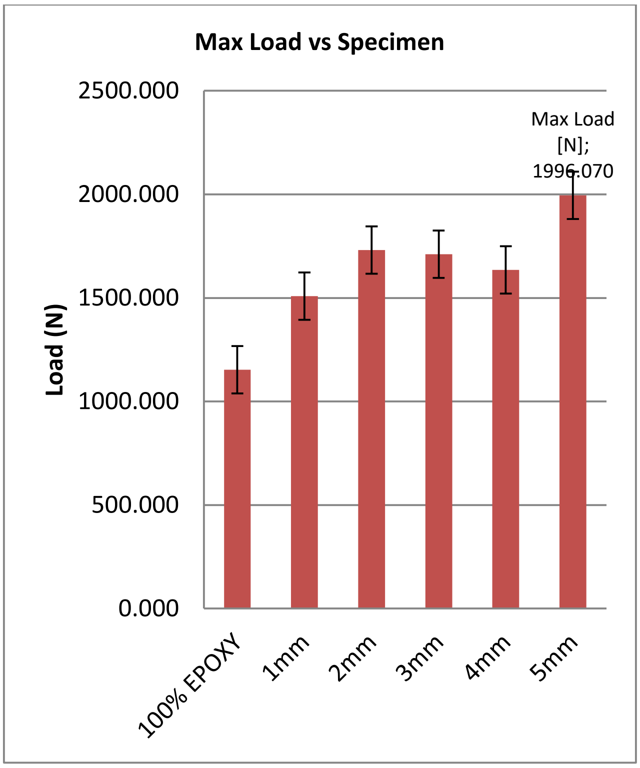

Figure 5: Maximum load for rattan fibers

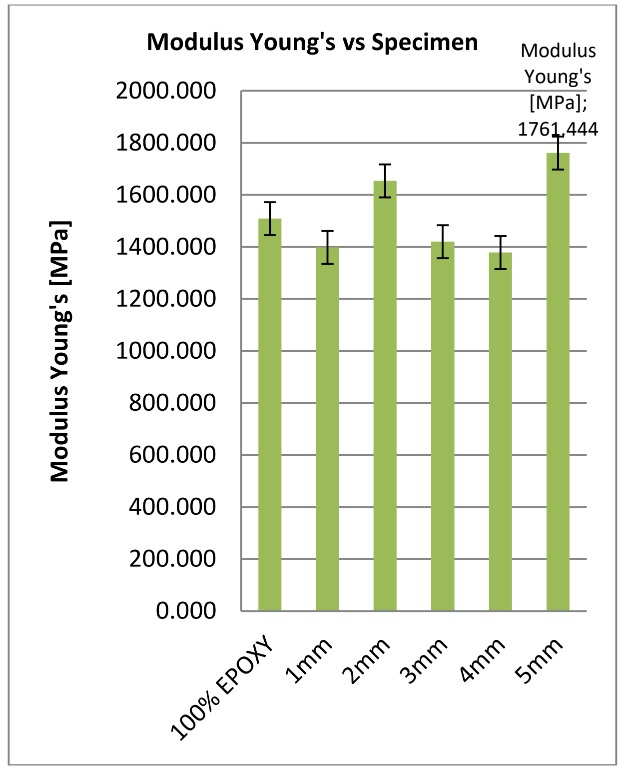

Figure 6: Modulus Young for rattan fibers

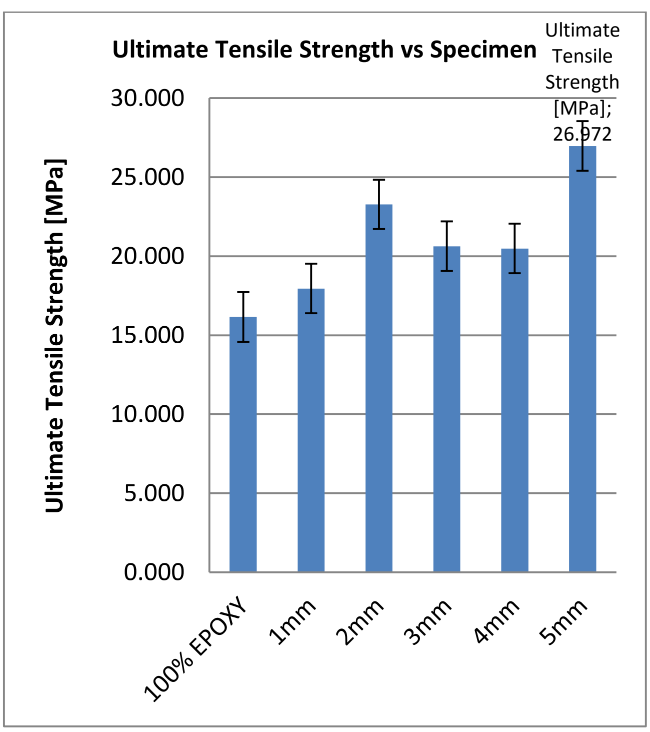

Figure 7: Ultimate tensile strength for rattan fibers

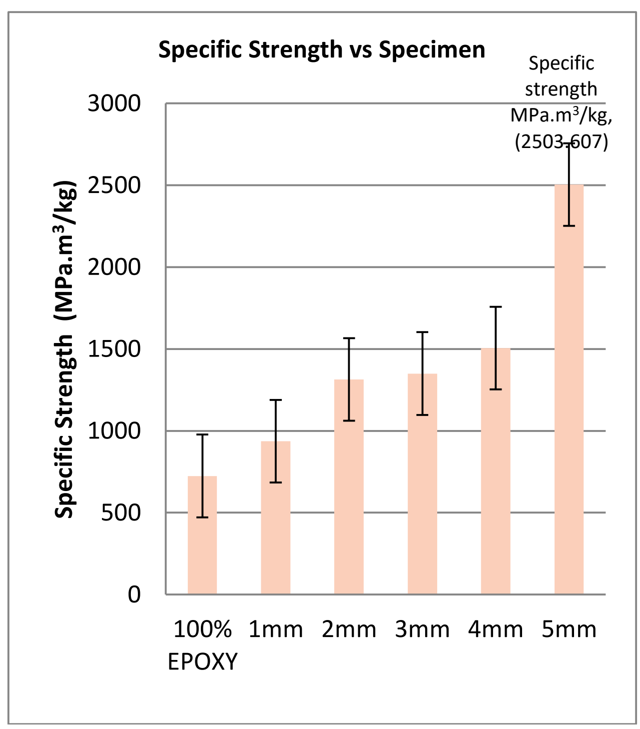

Figure 8: Specific strength for rattan fibers

V CONCLUSIONS

The diameter of this rattan single fibre is used to compute the surface area for the tensile characteristic's calculation with slightly different standard deviation for natural fibre based on the irregular shape, flaws and imperfections alongside the rattan fibres. In addition, the efforts to produce a sample of the cross-sectional area at the fault site were also concentrated on the rattan fibre assortment with a decent end of the fractures and on procedures. In this test, rattan yarn sliced into different diameter and pinned at both end. With this method, the maximum tensile strength, Modulus Young, maximum load, and specific strength of rattan yarn, was measured to be 26.972 MPa, 1761.444 MPa, 1996.07 N and 2503.607 Mpa.m3/kg respectively, with the low standard deviation of less than11%.

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