Study on specimens shapes for tensile test of Malaysia bamboo

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Study on specimens shapes for tensile test of Malaysia bamboo

Y Ahmad[1] and S F Hamzah[2]

[1] Forensic Engineering Center, School of Civil Engineering, UniversitiTeknologi Malaysia, 81310 Johor Bahru, Johor, Malaysia

[2] School of Civil Engineering, Universiti Teknolohi Malaysia, 81310 Johor Bahru, Johor, Malaysia

Abstract. In Malaysia, the bamboo is rarely used in structural elements due to the lacks of understanding on the feasibility and potential of bamboo and its behavior when subject to load. The strength should be fully understood as the structure is intended to take higher loads. Till now, the strength data for Malaysia bamboo is unavailable. Thus, testing on bamboo should be done to get the correct data. However, the tensile procedure on specimen preparation suggested by many codes lead to incorrect failure modes where most of the tensile test end-up with failure at the grip rather than at the gauge length or between the grips. Therefore, thorough investigation on the specimen shape is needed to ensure that the correct failure modes is obtained. Bambusa Vittata was prepared and cut into strips with average size of 200 mm long, 15 mm wide and 9 mm thick. The specimens were then trimmed to the required shape. A total of 20 specimens were divided into four groups with different shapes, namely S (strip cut), SS (strip cut- side curve), DC (double curve) and SC (single curve). Tensile strength tests were carried out on these four groups with average dry moisture content between 9 % - 16 % after air-dried. Based on the testing, the results show that the appropriate cutting pattern for tensile test was SS, followed by DC, S and SC. The failure pattern of bamboo occurred for SS was exactly at the gauge length area as compared to the other specimens with maximum average stress and strain of 201.9 kN/mm^2 and 1.227 % respectively.

1. Introduction

In recent years, the use of steel bar as reinforcement was limited heavily and difficult to obtain because of its expensive prices. Furthermore, the production of steel bar has high energy consumption and can cause to global warming. Bamboo is one of the alternative materials that can replace steel bar in concrete beam due to the low cost, fast growing, environmental friendly and most importantly its strong in tension as stated in [3-8, 12], the strength of bamboo is greater than many timber products, but it is quite less than the tensile strength of steel. Experimentally it has been found that the ultimate tensile stregth of some species of bamboo is comparable to that of mild steel and it varies from 140 N/mm^2 – 280 N/mm^2 as reported in [2] and it can reach up to 370 N/mm^2 [1]. A study which reported by [8] has shown that the ultimate tensile strength of moso type bamboo species is half of the ultimate tensile strength of mild steel where the behavior of bamboo, is similar to steel when subjected to tensile and compressive strength. In Malaysia, the bamboo is rarely used as reinforcement in structural elements like column, beam and foundation due to the lacks of understanding the feasibility and potential of bamboo use in structures and its behavior when subject to load. Therefore, it is important to deeply study the parameters affecting the strength of bamboo and it should be fully understood as the structure beam is intended to take higher loads. Till now, the strength data for Malaysia bamboo is not available. Thus, testing on bamboo should be done to get the correct data. However, the tensile procedure on specimen preparation suggested by many codes lead to incorrect failure modes where most of the tensile test end-up with failure at the grip rather than at the gauge length or between the grips. Therefore, thorough investigation on the specimen shape is needed to ensure that the correct failure modes is obtained and the appropriate shapes for tensile test was proposed as guidelines to be used.

2. Methodology

Series of tensile test was conducted for Bambusa Vittata which commonly known as Buluh Gading Besar. The specimes were prepared and cut into strips with average size of 180 mm long, 15 mm wide and 7.5 mm thick. The specimens were then trimmed to the required shape as shows in Figure 1. Some of the specimens was trimed accoding to IS 6874. The bamboo was cut based on the following criteria which should be considered in the selection of bamboo culms (whole plants) for use in construction:

a) At least three years old plant should be used showing a pronounred brown color.
b) The longest larger diameter culms available should be selected. Whole culms of green, unseasoned bamboo should not be used.

A total of 20 unnode specimens were divided into four groups with different shapes, namely S (strip cut), SS (strip cut- side curve), DC (double curve) and SC (single curve). Thus, there are 5 specimens in each group as shown in Table 1. Tensile strength tests were carried out on these four groups with dry moisture content with average between 9 % - 16 % after 28 days air-dried similar to [11,13]. All specimens were without bulk and untreated.

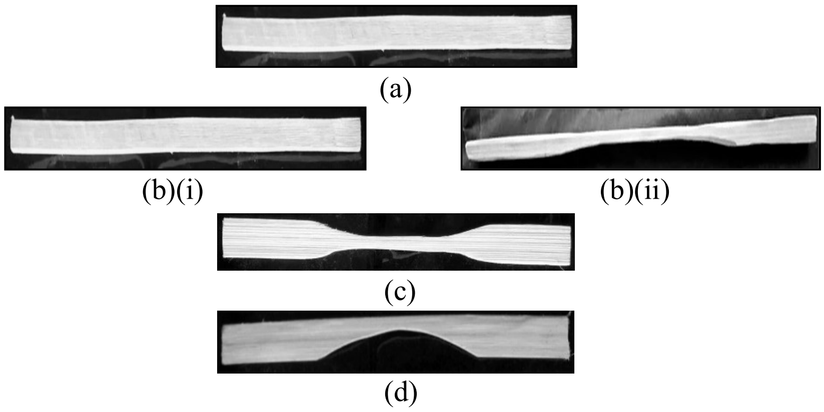


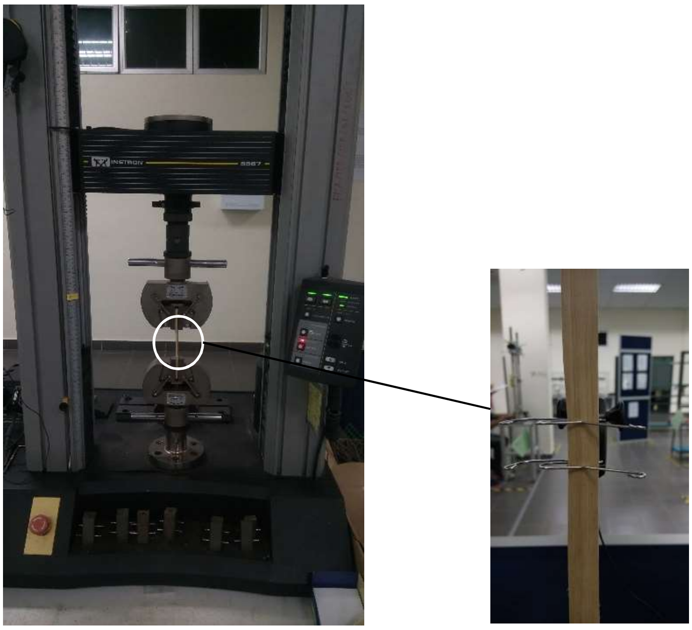
Figure 1. Different types of cutting shapes and its view from top and side (a) Top view – S shape (b)(i)Top view – SS shape (b)(ii) Side view – SS shape (c) Top view – DC shape (d) Top view – SC shape.

Table 1. Number of specimens according to it shapes.

Notation	**No. of specimens**
S	5
SS	5
DC	5
SC	5
Total	20

2.1 Experimental Procedure

Universal Testing Machine with capacity up to 600 kN and extensometer (50 mm length gauge) were used for tensile testing of bamboo according to ISO/CD 22157-1 standards (International Organization for Standardization). Figure 2 shows the experimental setup for the test.



(a) (b)

Figure 2. Experimental setup: Universal Testing Machine: (a), and position of extensometer during the test (b).

All the specimen cross-sectional dimensions of the gauge portion of the specimens was measured at three places in the gauge portion, and the mean value was calculated. Both end of the specimens were clamped at the grips of the testing machine in order to ensure a fixed position. Extensometer was placed at the middle gauge portion of the specimen. The tensile load was applied to all specimens continuously throughout the test at rate of 0.0254 mm/s as stated in [10] which is more practical. Failure mode of the specimens was observed during and after the test to ensure that the failure occured at the gauge portion. Then, the failure mode was recorded as required.

3. Results and Discussion

3.1 Stress-Strain curve

The tensile tests were conducted on different cutting shapes of bamboo to find an appropriate shape where the failure mode should occur at the gauge length or between the grips rather than at the grips. The stress - strain curve was produced based on the data obtained from the testing, as shown in Figure 3 to Figure 6. Table 2 provides an overview of the summary for maximum stress and strain of all specimens from each cutting shapes. From the table, it can be noted that SS shape have the highest maximum stress compared to DC, S and SC with average stress 201.9 MPa. However, S shape produced the lower maximum strain with 0.961 % followed by SC, SS and DC.

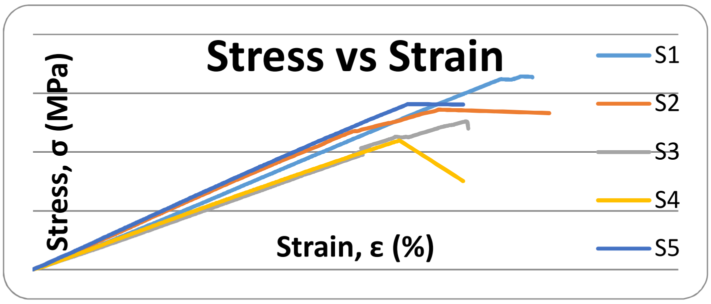


Figure 3. Stress – strain curve for cutting shape, S with five number of specimens.

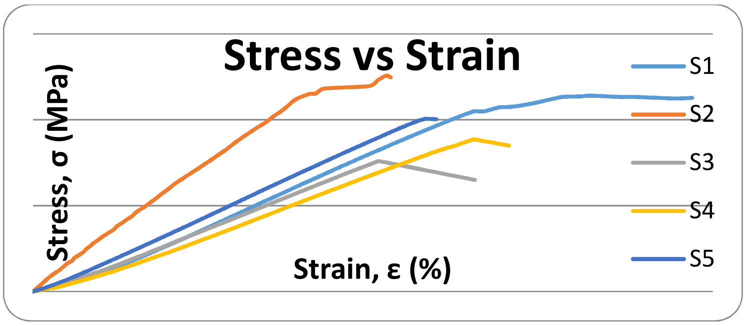


Figure 4. Stress – strain curve for cutting shape, SS with five number of specimens.

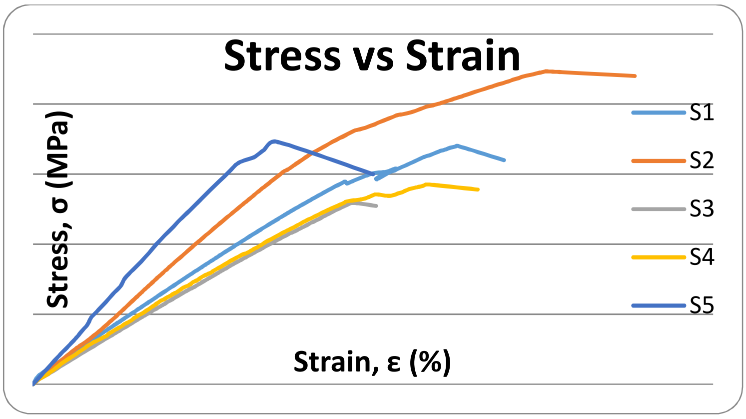


Figure 5. Stress – strain curve for cutting shape, DC with five number of specimens.

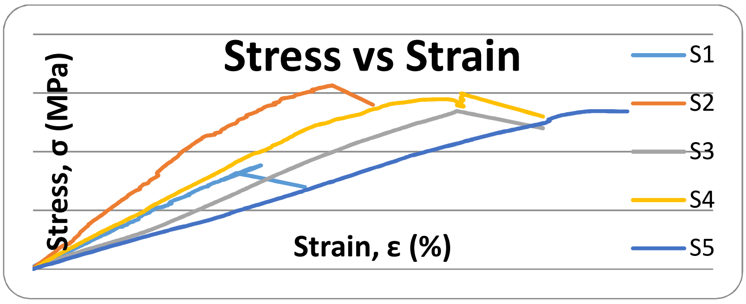


Figure 6. Stress – strain curve for cutting shape, SC with five number of specimens.

Table 2. Summary of maximum stress and strain for all specimens.

No. of specimens	S		SS		DC		SC	
	Max Stress, σ (MPa)	Max Strain, ε (%)	Max Stress, σ (MPa)	Max Strain, ε (%)	Max Stress, σ (MPa)	Max Strain, ε (%)	Max Stress, σ (MPa)	Max Strain, ε (%)
1	164.3	1.134	228.0	1.631	170.2	1.623	88.3	0.670
2	136.1	0.943	251.3	1.039	223.4	1.961	156.5	0.880
3	126.1	1.006	152.0	1.017	129.4	1.218	134.6	1.247
4	109.8	0.852	177.2	1.296	142.7	1.508	149.5	1.260
5	140.8	0.872	201.1	1.153	173.2	0.930	134.6	1.649
Total	135.4	0.961	201.9	1.227	167.8	1.448	132.7	1.141

3.2 Modes of Failure

The bamboo tensile test specimens exhibited a few categories of specimen failure and it depends on the shapes of the specimen itself. Figure 7 to Figure 10 indicate the test specimens after failure. Based on the observation, the time required for the testing is around 3 – 6 minutes per specimens and the failure for each group specimen was different during and after the test end.

Figure 7. Failure modes of S shape.

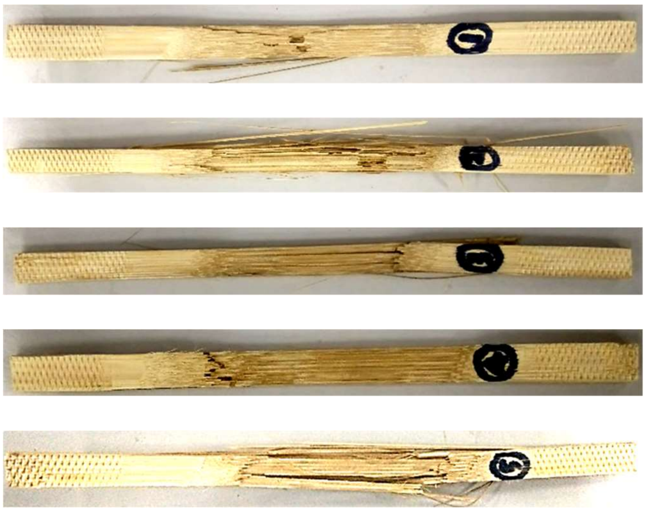


Figure 8. Failure modes of SS shape.

Figure 9. Failure modes of DC shape.

Figure 10. Failure modes of SC shape.

Based on the figure presented above, generally the bamboo failure often occur at the grips rather than gauge length area which is in between the grips. This cases is similar to the study conducted by [9]. For S shape, its clearly can be seen the failure was exactly appear at the grips compared to SS, DC and SC. Whereas, for the mode failure of SS and DC shape were considered as 'preferred' failures in the sense of being mostly unaffected by the gripping process. SC and S shapes failure occured at the grips, but however the way of the specimens to breaks was totally different. From the observation, all these failure modes may effected by three major factors which cannot be avoided when testing bamboo. Uneven grip pressure, cutting shapes and the position of specimens when gripping are the most important sources which can lead to the failure of specimens.

4. Conclusion

Based on the result obtained, it can be concluded that, the appropriate specimen shape for tensile test is SS cutting shape with the average maximum strength stress 201.9 MPa. It is because the splitting failure occured at the middle of specimen where it suppose to fail instead of at the grip ends.

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