Scholars Journal of Engineering and Technology (SJET) **ISSN 2321-435X**
Sch. J. Eng. Tech., 2013; 1(1):39-43

(An International Publisher for Academic and Scientific Resources)
www.saspublisher.com

Research Article

Determination of Tensile Stress and Bond Stress with Concrete of a Rattan (*Calamus guruba*)

H.M.A.Mahzuz[1], M. Ahmed[2], M.K.Uddin[3], M.M. Hossain[3], N. Saquib[3]
[1]PhD Student, [2]Professor, [3]Research Associates
Department of Civil and Environmental Engineering, Shahjalal University of Science & Technology, Sylhet-3114, Bangladesh,

***Corresponding author**
H.M.A.Mahzuz
Email: mahzuz_211@yahoo.com

Abstract: Bangladesh is a region where abundant amount of rattan (or cane) is available of different types. This paper attempts to understand several properties of Zali bet (Calamus guruba). It is easily available in many parts of Bangladesh. All the rattan samples used in this study were collected from minimum three years old trees. These samples were used to find the Ultimate Tensile Strength (UTS), Yield Strength (YS), Modulus of Elasticity (MoE) and Bond Strength (BS) with concrete. Pull-out test was done to have an idea about the Bond Strength of rattan with concrete. Here three types of specimens were prepared to investigate the relative performance. Each type includes two specimens. Pull out test of steel was also made to report comparison. From the result of laboratory work Zali bet offered some prospective data which can be utilized as the preliminary reference for the future works related to it.
Keywords: Rattan**,** Strain, Steel, Tension test, Modulus of Elasticity

INTRODUCTION

Rattan is very important forest products of Bangladesh and they have been traditionally used by the rural people in various household activities. A large part of the demand in construction, thatching, household articles and fuel-wood of the rural populace are being met by rattan. Rattan products chiefly serve the rural economy, the bulk of the national population. Nevertheless, these plants are important since they provide basic and useful materials to the rural housing, particularly the poor sections of the population. Rattan provides inexpensive furniture, utensils and agricultural implements. These materials are important in the handicraft and small cottage industry sector. Rattan is comparatively cheaper than wood and has tremendous a growth potential in rural areas. Rattan is one of the important natural resources of Bangladesh forests and homestead. In Bangladesh, only two rattan genera are reportedly occurring, *Daemonorops* and *Calamus.* The former is represented by a single species only, *D. jenkinsianus.* The latter, on the other hand, has 10 species [1]. Generally in the forests of Bangladesh rattans occur in the north-eastern hill forests of Chittagong, Cox's Bazar, Hill Tracts and Sylhet. In hill forests rattans are found to grow well in well-drained, moist, sandy-loam soils on the slopes. For handicrafts and for tying material in house construction and in furniture making. *C. guruba* (jali bet or sundi bet) is commonly used. No actual inventory has been conducted regarding the total growing stock of rattans both in the villages and in the forests of Bangladesh.

Whereas the mechanical properties and behaviour of steel have been thoroughly studied and well documented. There exist researches on the behaviour of bamboo as well [2, 4, 5, 6]. While there exists very few comprehensive data like [3] describing the characteristics of rattan. Therefore, unquestionable there lies a great scope of research in this field. The aim of this study is to provide a preliminary contribution toward the collection a mechanical property of one rattan in Bangladesh. The study was conducted to understand the stress-strain relationship of Zali bet. Tests also have been performed to have an idea about the bond strength with concrete.

SAMPLE PREPARATION AND TESTING METHOD

Three years old, any type of fault-free canes (that is Zali bet) were selected from careful visual inspection for tension test. After cutting the rattan it was kept in open air for two months to be removed from moisture. Eleven specimens were prepared for tension test at the Universal Testing Machine (UTM) (Figure 1). Five specimens of Zali bet were tested to find out the Modulus of Elasticity (MoE) and the yield strength. Offset method was taken to find out the Yield strength. 0.5% offset value was taken for calculation.

Figure 1: Tension Testing of Rattan in UTM

For Pull-out test the concrete was prepared by Ordinary Portland Cement of ASTM-type-1. The mixing ratio 1:2:3 (by volume) was used having the same water-cement (w/c) ratio (0.485). The fineness modulus (FM) was kept constant (2.79). All the steps of the study confirmed the standard procedural methods of ASTM. As the surface of rattan is too smooth therefore specimens were prepared in three categories as shown in Figure-2 to investigate the relative performance with concrete. Each type includes two specimens. Galvanized Iron (GI) weir (1.75 mm diameter) was used in two forms (ring and spiral) with rattan. Therefore a total six samples were prepared. They can be categorized as a) Normal Rattan sample (termed as N1 and N2), b) Rattan sample with spiral of GI weir having 25mm pitch (termed as R1 and R2), c) Rattan sample with ring of GI weir having 25mm spacing (termed as S1 and S2). Pull out test of two steel bars (Yield strength of 414 MPa) was also made to report comparison. In this paper they are termed as ST1 and ST2. All the steel and rattan samples were poured in concrete cylinder of 300 mm height and 150 mm diameter. Curing was done for 28 days. After this period they were tested in UTM to find the bond strength. A visible idea about test of the samples at UTM is shown at Figure 3.

Figure 2: Prepared Rattan samples for Pull-out test

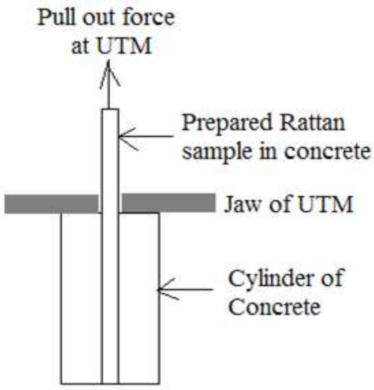

Figure 3: Pull-out test of samples at UTM

RESULT AND DISCUSSION

Proper gripping is the most important factor for tensile test of rattan. Any slippage at joint or damage of sample due to excessive compression at the grip of UTM may harm the exact strength of rattan. In this study these possibilities were carefully avoided. The failure pattern of rattan specimen was typical splitting without any slip at the grip locations. All the splits are parallel to the grain and in maximum cases failure occurred more than one location. From these results it can be concluded that the tensile strength is nearly uniform and failure pattern is very similar for rattan specimens where failure at grip was avoided.

The tensile tests were conducted at 12.7±2% moisture content. Table 1 shows detailed information about the size of rattan samples, maximum load and maximum stress taken by each rattan specimen. It is seen form the table that the average ultimate stress is 73 MPa having a variation from 61- 113 MPa. But the maximum numbers of five samples are found in the range between 61-65 MPa. Among the samples the Stress-strain curves of five samples are shown from Figure 4-8. Each of the Figures of stress-strain is unique in shape. No exact or regular shape is got observing them. Therefore it can be concluded that the shape of stress-strain diagram of a rattan sample can not be predicted out of the available information of this research. More samples are needed to be tested to find an acceptable typical shape of stress-strain diagram of the rattan- Zali. The gage length varied from 60 mm to 63 mm for all the samples. From the Stress-strain curves of all the five samples the yield strength has been calculated by offset method taking 0.5% Offset. It can be easily mentioned observing the pattern of the stress-strain curves that the Yield Strength from 0.5% offset can be taken because the ultimate is much higher than this. The detailed information about the outcome of Figure 4-8 is presented at Table 2. The average of Yield strength is 51 MPa, average of Ultimate Tensile Strength is 79 MPa and the average of MoE is 6542 MPa. The strain at Ultimate Tensile Strength rages from 0.025 to 0.08. It is also found from the test that the

Ultimate Tensile Strength is about 1.55 times higher than that of Yield strength.

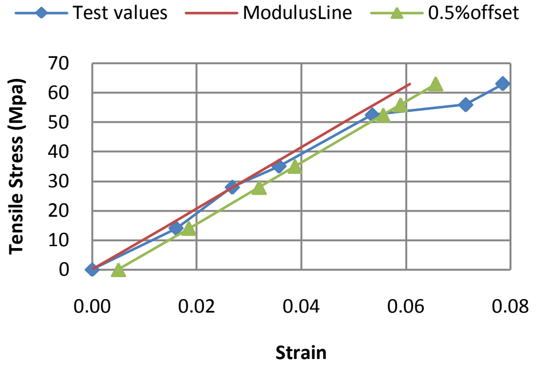

Figure 4: Stress-strain diagram of Sample 1

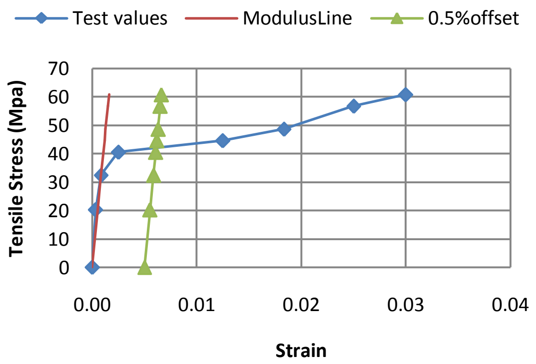

Figure 5: Stress-strain diagram of Sample 2

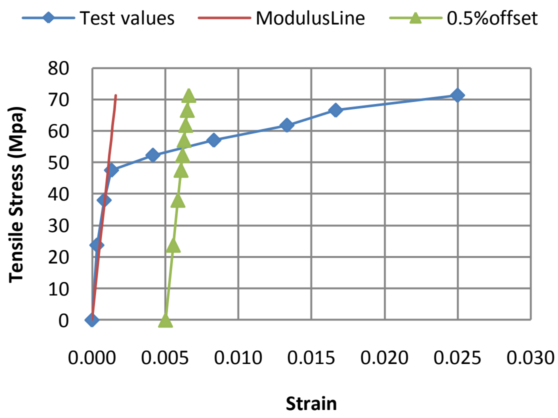

Figure 6: Stress-strain diagram of Sample-3

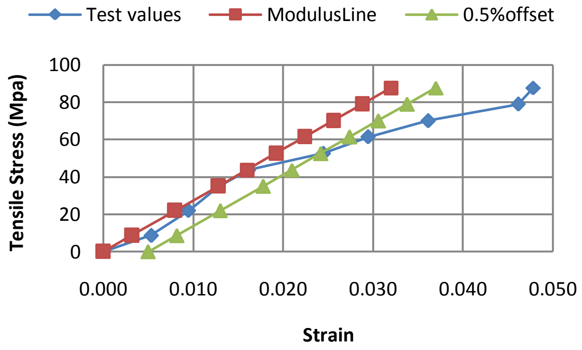

Figure 7: Stress-strain diagram of Sample-4

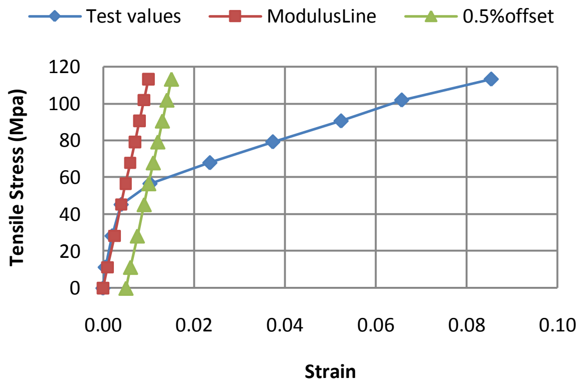

Figure 8: Stress-strain diagram of Sample-5

For Pull-out test concrete 27.5 MPa (28 days strength) was used. The several properties related properties of the concrete are shown at Table 3. The description of each type sample for Pull-out test is reported in the previous section. It was observed from the study that steel bars offered much more bond strength than each of the rattan samples. This is because of the deformed shape steel. No steel bar was seen to be fractured during test. It was concrete that cracked in this case.

For rattan samples no crack was visible during failure. Even no fracture was reported in the rattan samples. They were just pulled out from the concrete portion without any physical damage. Among the samples better bond strength (0.46 MPa) was shown by Ring type rattan samples that is about two times than the others. Yet comparing to steel the value is much less. Therefore expected result may not be ensured if rattan is used at concrete as reinforcement in load bearing structures like beam or any type of tension member.

Table 1: Tensile Test Result of Rattan Specimen

Sample Name	Sample No	Dia mm	Area mm^2	Load KN	Stress Mpa	Average Ultimate Stress, MPa	Stress Range MPa	No of Samples
Zali Bet	1	14	153.86	12	77	73	Below 60	0
	2	13.5	143.07	9	60		61-65	5
	3	14	153.86	10	63		66-70	0
	4	13	132.67	8	61		71-75	3
	5	13	132.67	9	65		76-80	1
	6	13	132.67	8	61		81-85	0
	7	12	113.04	8	71		86-90	1
	8	11.5	103.82	8	72		Over 90	1
	9	12.5	122.66	11	88			
	10	13	132.67	10	73			
	11	11	94.99	11	113			

Table 2: Modulus of Elasticity of rattan (Zali bet)

Sample No	Yield Strength (Mpa)	Average Yield Strength (Mpa)	Ultimate Strength (Mpa)	Average Ultimate Strength (Mpa)	Ratio of Ultimate to Yield Strength	Modulus of Elasticity (MPa)	Average Modulus of Elasticity (MPa)
1	53	51	63	79	1.55	10600	6542
2	42		61			7000	
3	52		71			7429	
4	52		88			2080	
5	56		113			5600	

Table 3: Specifications of the concrete used for Pull-out test

Cement	FM of Sand	Water Cement Ratio	Unit weight of stone (Kg/m^3)	Mix ratio	28 days Compressive strength (Mpa)	Unit weight of Concrete (Kg/m^3)
OPC-ASTM Type-1	2.79	0.485	1600	1:2:3	27.5	2557

Table: 4: Bond Strength (BS) from Pull out test of Rattan (Zali bet)

Name	Dia mm	Height mm	Surface area mm^2	Actual Load KN	Bond Stress MPa	Average Bond Stress MPa	Failure Type	Comment
ST1	16	300	15079.64	79.70	5.28	6.04	Concrete was crushed	BS was ensured
ST2	20	300	18849.56	128.07	6.79			
N1	11.5	300	10838.49	2.83	0.26	0.22	Rattan pulled out from concrete	BS was ensured. Since R shows higher values so it can be concluded that R is better than N and S.
N2	13	300	12252.21	2.30	0.19			
R1	12.75	300	12016.59	4.45	0.37	0.46	Rattan pulled out from concrete	
R2	10.75	300	10131.64	5.52	0.54			
S1	11.75	300	11074.11	2.30	0.21	0.28	Rattan pulled out from concrete	
S2	10	300	9424.78	3.37	0.36			

CONCLUSION

The tensile tests were performed taking the natural state of rattan. Except air drying (for 60 days) no other chemical and physical treatments were performed. Further study can be made keeping them in mind. Research can also be done taking other available canes. Being a natural material rattan offers much less tensile strength than that of steel. The bond strength is also reported to be much less comparing steel. Yet for the rattan –Zali, some basic idea about the tensile strength and bond strength with concrete is provided by this research. The overall scenario of the study certainly can be utilized as the preliminary reference for the future works related to it.

ACKNOWLEDGEMENT

The authors are grateful to the Seven Circle (Bangladesh) Ltd. for providing all the OPC, ASTM Type-1 needed for the research. The authors also express their gratitude to the Department of Civil and Environmental Engineering, Shahjalal University of Science & Technology, Sylhet, Bangladesh for providing all the necessary laboratory supports.

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