Strength Properties Of T-Shaped Joint Memebers From Kelempayan Wood

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Abstract

The T-shaped joint members commonly in furniture component structure such as rail and stretcher on chair or table leg. In this study, the jointing system that use on T-shaped joint members were dowel joint, mortise and tenon joint, and JCBC screw with cross dowel joint. The main objective of this study was to determine the strength properties of T-shaped joint members using each jointing system. The testing method of study the strength properties were tensile and compression tests. The study consist of two phase's investigation: i) to study strength properties of T-shaped joint members from kelempayan; and ii) to compare the strength properties of jointing system using dowel, mortise and tenon, and JCBC screw with cross dowel joints. The average moisture content of wood material used for the preparation of test sample was below 12%. The results were analyzed using analysis of variance (ANOVA). The results of the tensile tests and compression test show the significant effect. It can be concluded that the mortise and tenon joints offered the best performances and high strength properties compare to dowel joint and JCBC screw with cross dowel joint.

***Keywords**: Strength properties, T-shaped joint members, kelempayan.*

INTRODUCTION

To fully understand the structural characteristic of furniture, it is necessary to also understand the structural behavior of the joints that are used in its contraction in particular, how they carry load, how they deform under load, and how strong they are. By definition, a joint is simply a place or location where two or more members come together and unite a joint. Therefore, actually has the dimension of a point. In practice, however, a joint must necessary have finite dimensions it can never actually be a point. In trying to visualize the structural behavior of a joint, it is also helpful to think of it really as a finite body rather than a point. A furniture joint consisting of short lengths of the ends of the members joined together and fasteners which are used to hold them together. The strength of a furniture joints related to its design. It is important that the joint is scientifically designed, so that the furniture can safely carry and support the force imposed while in service. The jointing systems that apply on furniture component should in high performance and has the potential to achieve substantial reductions in the volume of timber used in conventional structure.

In furniture manufacturing, before the product can be produce into the market, the quality control department should test their strength performance of the product. For testing the furniture, they have many variation of testing method can be apply, one of the testing is jointing test. This testing method can determine how the strength properties perform for each jointing system that use. In determine jointing strength, they also many test method can be apply like tensile test method, compression test method, shear test method, and bending test method. Each test has a standard and requirement that we choose. The jointing performance is the important factor to understanding the ability and feasibility of joint to carries the maximum stress before it assemble as a furniture product.

T-shaped consists two pieces of wood that connecting together at right angles to form 'T' shape. The T-shaped joint members commonly in furniture component structure such as rail and stretcher on chair or table leg. T-type and L-type members are commonly used in strength test (Wang and Juang (1988) in Abdul Hamid et al., 2004). The jointing systems that apply on furniture component should in high performance and has the potential to achieve substantial reductions in the volume of timber used in conventional structure. In this study, the jointing system that use on T-shaped joint members are wood dowel joint, mortise and tenon joint, and screw JCBC with cross dowel joint.

Recently, the main raw of material for furniture manufacturing in Malaysia usually are made from tropical wood like hardwood species, medium hardwood species, and others some from rubberwood (Malaysian oak). The huge usages of those materials cause the depleting or reduce of the resource in the future. However, other material should be research and investigated to be a new alternative to those materials to support the furniture manufacturing. Thus, a timber from kelempayan (*Neolamarkia cadamba)* wood could be a feasibility raw material for furniture industries in the future. The growth of kelempayan is usually fast for the first 6 to 8 years and the age of 10 to 15 years, the trees can be felled (Wyatt-Smith, 1999). The wood is categorized in light hardwood (Choo et al., 1999), however those species has own value to be commercially as a material for furniture through this research and could be a new material to making furniture component. Further research can be identifying the suitable jointing system that can apply for the application on furniture component joint based on lightwood species especially.

MATERIALS AND METHODS

Forest Reserved of Universiti Teknologi MARA Pahang have been supplied the samples of raw material. The average age of the kelempayan (*Neolamarkia cadamba)* tree is 10 to 15 years old and the diameter breast high (DBH) ranging from 30cm to 45cm at the midpoint. The logs were sawn along the fiber grains. The average moisture content of wood material used for the preparation of test sample was determined as below 12%.

For the strength test, the specimens were cut into size to make T-shaped member joint samples. Two samples of wood that use, wood A (300 x 50 x 25mm) and for wood B (200 x 50 x 25mm) with three types of jointing system: dowel joint, mortise and tenon joint and JCBC screw with cross dowel. The dowel dimension size used in this study was 10 x 50mm (Figure 1) which cut followed the standard requirement in furniture industry. The dowel and the hole were contacted together by using the polyvinyl acetate (PVAc) as adhesive, then the members clamped by using manual clamping. The mortises were machined into the posts with 30mm hollow chisel bit mounted in a drill press. The tenons were machined using table saw with a special jig to ensure all cutting were made parallel to the sides of the rail and perpendicular to the surface of the table saw. The dimension of sample is shown in Figure 2. The PVAc was applied to all faces of the tenons and to the slides and bottom of the mortises. Then, they were clamped by using manual clamping to make the connection on joint more fit and give the strength to the joint. The dimensional size of JCBC screw was 100 x 9mm and for the dimensional size of cross dowel was 12x10x7mm (Figure 3). This screw was selected because not only it has standard low-cost fasteners that are readily available to furniture industry, but also it has excellent holding strength in wood and wood-based materials. The standard dimension of JCBC screw and cross dowel followed the requirement based on the joint and fastener for school chair.

Twenty-four units of jointing were fabricated. The experiment was conducted with special jig that design during this study. Two type method of strength test were carried out, namely tensile test and compression test (Figure 4). The load crosshead speed was applied constant of 3.00mm/min for tensile test and 100mm length of the span with the crosshead speed 15.00mm/min for compression test and full-scale load range was 10000 N. The results were analyzed by using analysis of variance (ANOVA).

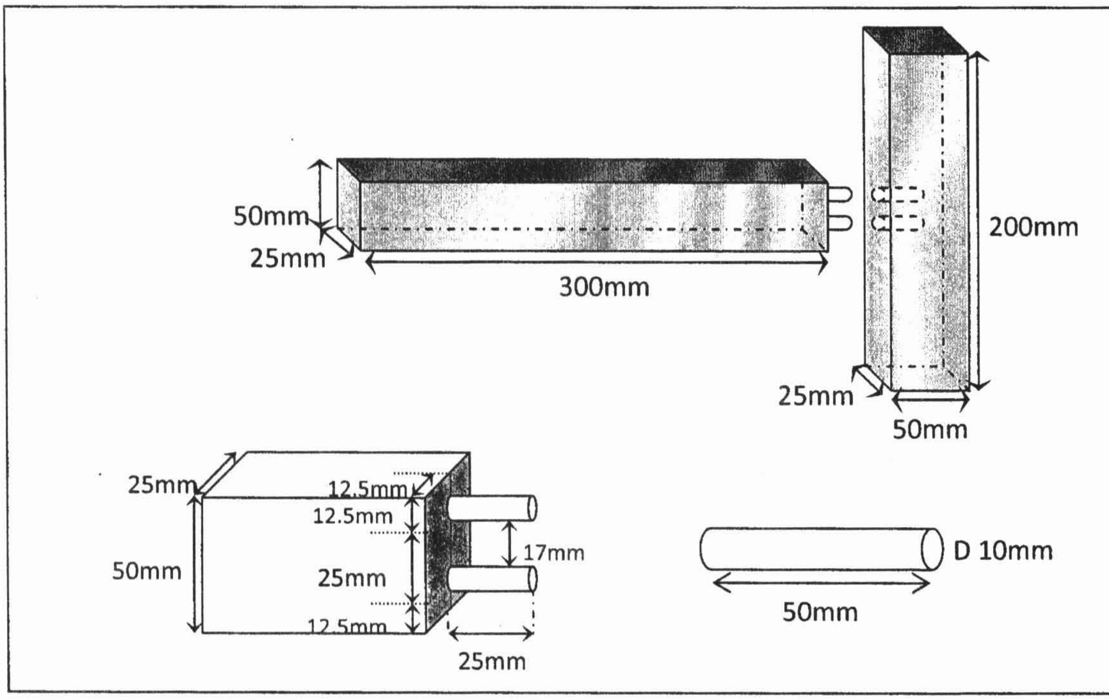


Figure 1: The dimensional of dowel joint

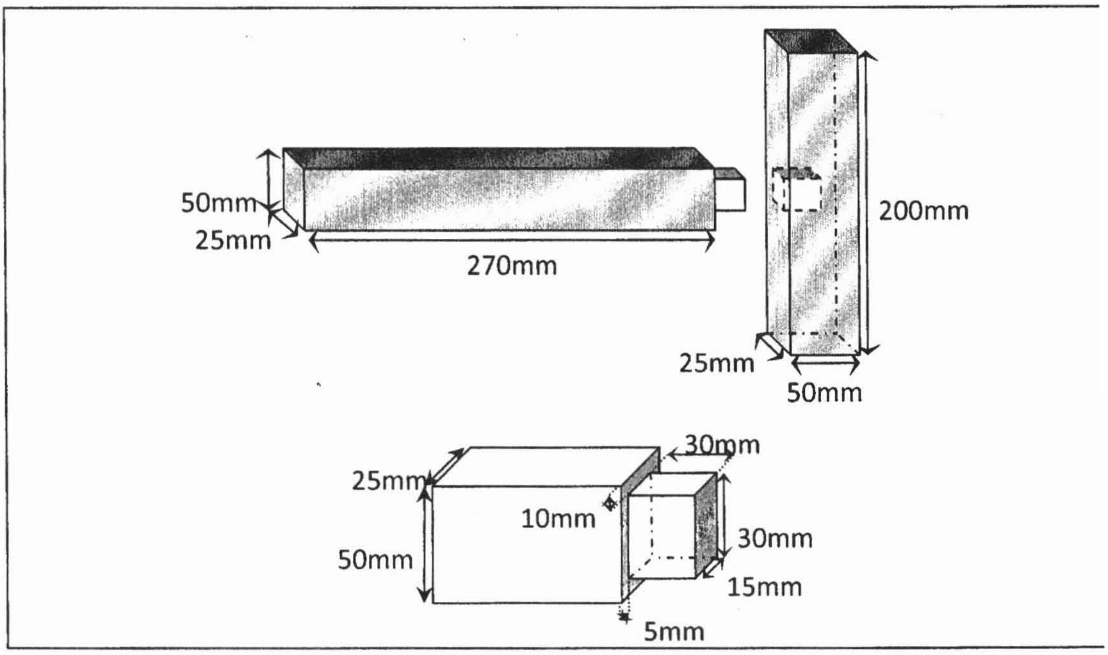


Figure 2: The dimensional of mortise and tenon joint

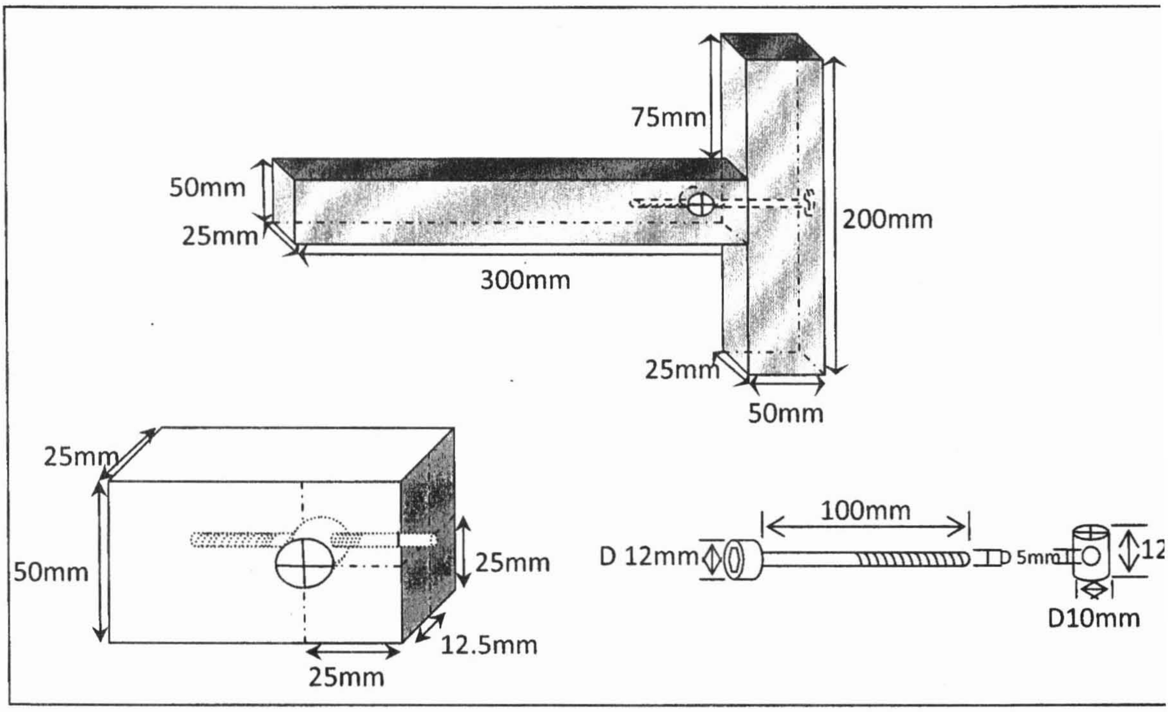
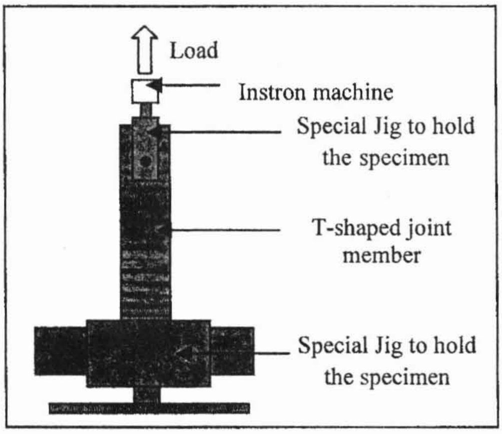
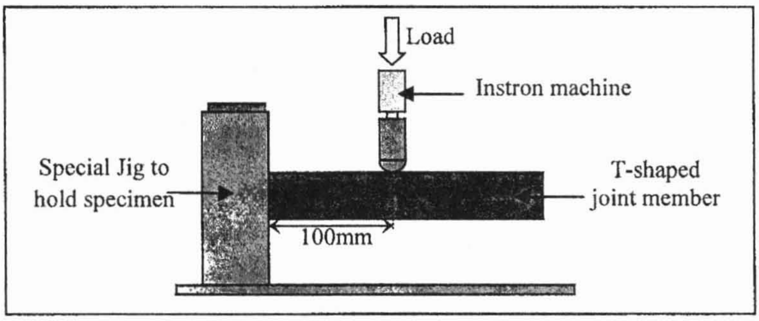


Figure 3: The dimensional of JCBC screw with cross dowel joint



(a) Tensile test



(b) Compression test

Figure 4: Type of testing method

RESULTS AND DISCUSSIONS

The data obtained in this study provide needed information concerning the strength properties of jointing system. The mean ultimate moment capacities of the joints assembled with different jointing system (Table 1). A standard analysis of variance (ANOVA) method was applied to the data, the factor had significant effect on both testing method (Table 2). The mortise and tenon joint was show the higest value on both testing method compared to other jointing system. The mean stregth test of the mortise and tenon joint was the good strength properties and best performance properties compare to the dowel joint and JCBC screw with cross dowel joint. Previous study has defined some of the factors that effect their strength. For example, the strongests joints obtained when a close tolerance is maintained between the mortise and tenon (Milham, 1949). Haviarova et al., (2001) have designed and tested school desks and chairs for developing and underdeveloped countries and they used mortise and tenon joints for the construction. Their results show that mortise and tenon joints were efficient load carries and highly resistant to cycling loading. When properly made, this type of construction produced a strong and durable joint (Eckelman, 1999).

Table 1: The mean ultimate moment capacities of the joints assembled with different jointing system

Jointing System	Tensile Test (N)	Compression Test (N)
Dowel Joint	2715.5	472.5
Mortise and Tenon Joint	2765.25	755.75
JCBC Screw with Cross Dowel Joint	1843.75	634.25

Table 2: Analysis of variance (ANOVA) on the test of between subject effect

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
Jointing System	Tensile test	2148780.500	2	1074390.250	6.689	.017
	Compression test	161541.167	2	80770.583	7.667	.011

Notes: *F-values are significant at $p< 0.05$, ns at $p <0.10$ and ns – not significant

The tensile strength test has a similar trend to the withdrawal strength test (Figure 5). The highest value of tensile test obtained in mortise and tenon joint was 2765.25 N and followed by dowel joint was 2549.4 N. For the lowerst value of tensile test was a JCBC screw with cross dowel joint by 1843.75 N. Generally, for dowel joint and mortise and tenon joint used a adhesive (PVAc) as medium to connect that joint. In case of tensile test, the mortise and tenon joint is the highest value follow by the dowel joint. Those joint were stronger compare to the JCBC screw with cross dowel joint. This is because the joints have glue support on the both joint. Therefore they increase the flesibility of the strength properties on that joint. Adhesive strength is a mechanical property that have ability to hold two material together under a given set of conditions. Meanwhile for the JCBC screw with cross dowel joint, the connection only depends on the strength of cross dowel to hold the JCBC screw without any support. According to Dupont (1963), that optimum joint strength was obtained when glue was applied to both the tenon and sides of the mortise.

The compression strength test has a similar trend to bending (Figure 6). The highest value of compression test was mortise and tenon joint by 755.75 N and follow by the JCBC screw with cross dowel joint by 614.8 N. While, for the lowest value of compression test was the dowel joint by 445.8 N. At this result, the mortise and tenon joint has more strength with the regard to strength properties and high mechanical bending moment resistance compare to the dowel joint and the JCBC screw with cross dowel joint. This occurs because of the strong interaction between the PVAc adhesive on the fit of the mortise and tenon joint and the effect on flexibility than tenon dimension. Flexibility and bending strength of rectangular mortise and tenon was investigated by Hill and Eckelmen (1973), they concluded that bending strength of mortise and tenon joints are the function of wood species and mortise and tenon dimension. For the dowel joint, double dowel pins as a connected on that joint. The flexibility to hold the load in compression test is lowers even combination with strength adhesive, this happened because the dimensions of dowel pins were small and the ability to hold as a joint is less. According to Eckelman (1971), the bending strength of a dowel is proportional to its diameter.

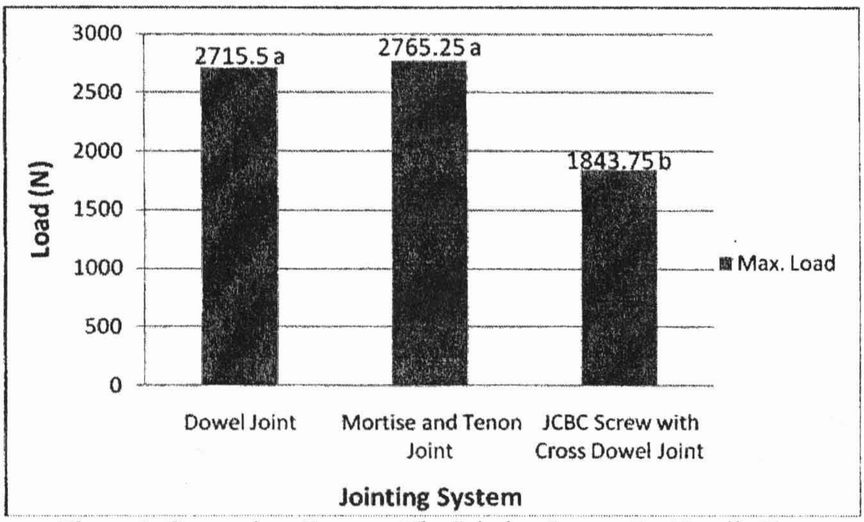


Figure 5: Comparison Between The Jointing System For Tensile Test

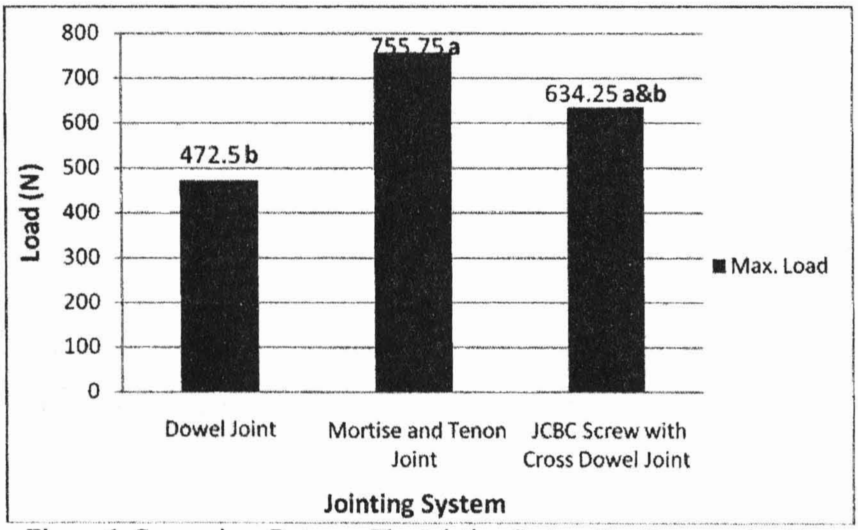


Figure 6: Comparison Between The Jointing System For Compression Test

Failures

Plat 1 shows the failures occur due to the kelempayan wood that being used to join the T-shaped member sample. Wood cracking and split occur in both test, tensile and compression test. The maximum loads that apply on each testing give the effect on strength properties of wood.

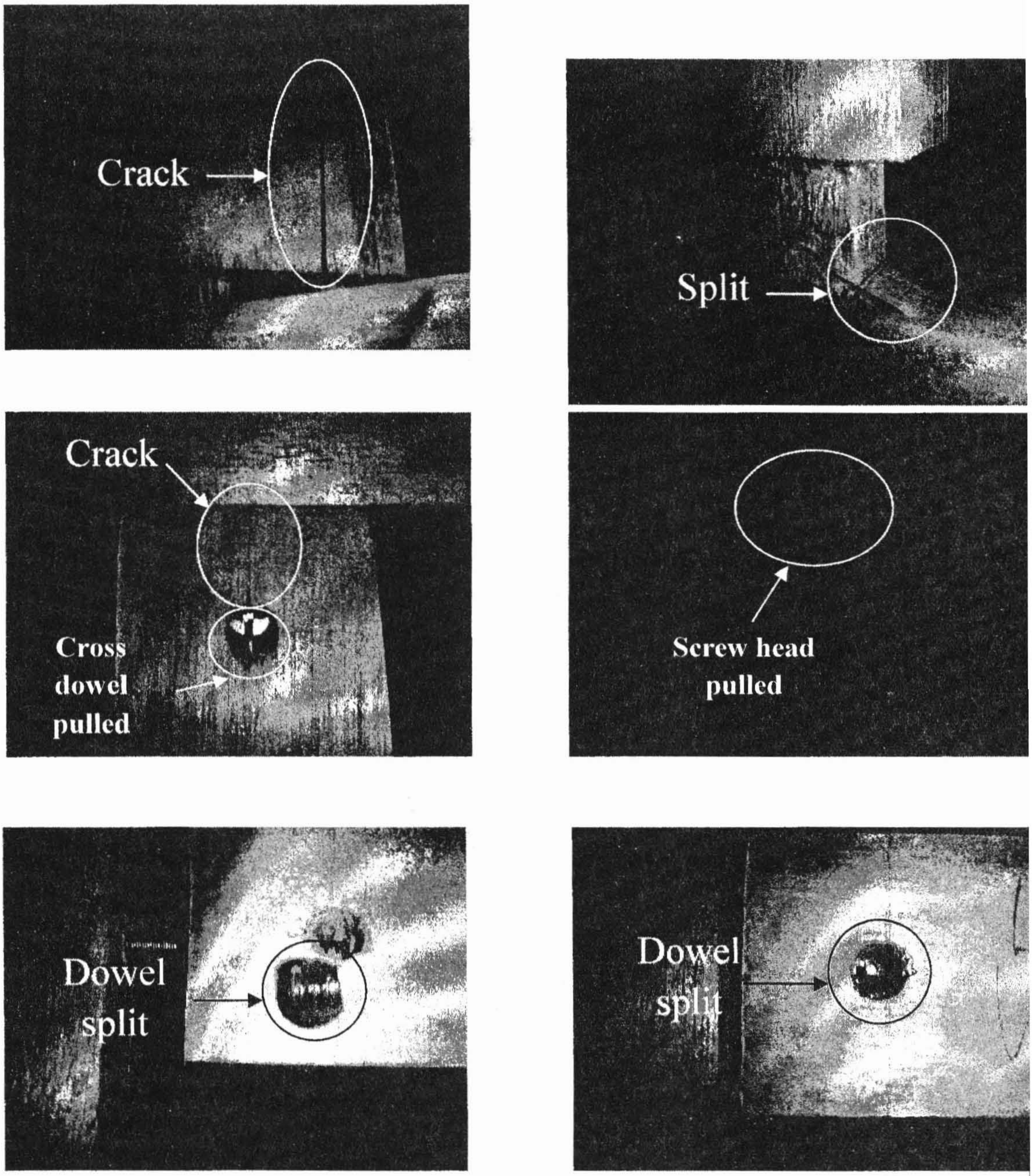


Plate 1: Failures that occurred at the joint and wood

In tensile test, two forces are acting along the same axis trying to pull the jointing system until failures. The behavior of structural elements T-shaped joint member to an external load applies makes the jointing hold that maximum stress and the ability of wood cannot carries and this factor make the wood cracking and split. For the compression test, the forces are acting along the perpendicular to the axis of the wood. This gives deflection on the jointing system to hold the stress. Wood crack while the joint in the maximum ability to carries the load. As load is increased, the crack opens and interlocking of the aggregate reduces quickly. Cross dowel made from metal and high strength to hold the JCBC screw as a joint. In case of cross dowel made failures on some sample of testing. This happen because the ability of cross dowel is over the limit and makes the cross dowel split. The failures in wood as crack and split depend on the strength of woods species. Based on Choo et al. (1999), "Kelempayan is lightwood species, the strength classified is in group D that non-durable and easier to treat. The timber is light and soft with range from density of 370 to 465 kg m^3."

CONCLUSIONS

The mortise and tenon joint was the best performance properties and stronger jointing system compare to the dowel joint and JCBC screw with cross dowel joint. That fact can be proving by the result on tensile and compression tests, for the both tests method show that the mortise and tenon joint got the highest value. Based on this study, the result can improved the requirement for strength properties of jointing system for general uses especially in furniture manufacturing.

The effect for the strength properties of jointing system can be influent in many factors. Understanding the cause and characteristic of fracture in adhesive bonded joints, and material is important to improving their performance, developing products based on new combination of material and adhesive, predicting the performance of new material, and developing design methods for structural joints. To increase the performance of joint, adhesive is one of the medium can be use. By adding the suitable adhesive based on the characteristic of anatomical wood as material using, it can gave mechanical properties supported on the strength joint.

Besides that, by choosing wood species that have good properties is an important factor in furniture component. Wood in category medium to light hardwood species with density approximately 500 kg/mm^3 could give the standard requirement for furniture industry using those materials to be a product. Otherwise, some of lightwood species also can be utilized as a raw material as well as kelempayan wood. The texture and appearance of kelempayan wood is very good and high of esthetic value. These elements make the kelempayan wood suitable as an interior product like furniture display and not to hardcore uses. Thus, it recommended that the mortise and tenon joint is the suitable jointing system for application on kelempayan wood.

References

Choo K. T, S. Gan and S. C. Lim. 1999. Timber notes-light hardwoods VI (dedali, kedondong, kelempayan, kelumpang, kembang semangkok).

Dupont and Werner. 1963. Rationalization of Glued Joints in the Woodworking Industry. Modern Holzverarbeitung, No. 30.

Eckelman, C. A. 1971. Bending Moment Strength and Moment-Rotation Characteristics of Two-Pin Moment Resisting Dowel Joints. J; 21, No. 3.

Eckelman, C. A. 1999. Bending Strength of Plate Joints in Table Construction. Holz als Roh-und Werkstoff 57:171-177.
Haviarova E, Eckelman C. A and Erdil Y. 2001. Design and testing of wood school desk frames suitable for production by low technology methods from waste wood residues. J; 51:79–88.

Haviarova E, Eckelman C. A and Erdil Y. 2001. Design and testing of environmentally friendly wood school chairs for developing countries. J; 51:58–64.

Hill M. D and Eckelman C. A. 1973. Mortise and tenon joints: flexibility and bending strength of mortise and tenon joints. Furniture Des Manuf; 45:54–62.

Wyatt-Smith, J. 1999. Pockets check List of Timber Tree. Third revision by K. M. Kochummen. 300-316

Milham R. M. 1949. A comparison of strength characteristics of the mortise and tenon joint and dowel joint. Unpublished master thesis. University of Michigan, USA.

Abdul Hamid, S., J. Zaihan, W. S. Hashim, E. Puad, A. Zulhazmi, A. Z. Noor Azmiza and M. Siti Zalifah. 2004. A preliminary study on the strength properties of common joints and the physical performance of chair made from solid oil palm trunk. Lee. S. S, Aminah H, Norini H, Lim S. C, and Lim H. F (Eds) in *Proceedings of The Conference on Forest Products Research.* Kuala Lumpur, Malaysia. 280-287.

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