Properties of Scarf Joint with Different Angle Using Oil Palm Lumber and Kelempayan

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Abstract

The aim of this study was to determine the suitability and strength properties of scarf joint for the species oil palm (*Elaeis guineensis*) and kelempayan (*Neolamarckia cadamba*). It has been tested on different cutting angles such as 30, 45, 60 and uses a type of polyvinyl acetate adhesive for both species. The samples were tested using the method of bending and compression. The results of this study show an angle of 30 species of oil palm and Kelempayan is the strongest compared to an angle of 45 and 60 for the bending test. When comparing the two species of oil palm and Kelempayan, Oil palm is stronger than Kelempayan. For the compression test, the angle 60 is more resistant than an angle of 30 and 45 for both species. Therefore, the cutting angle 30 and 60 is suitable for used by industry because it is most resistant compared to the other angles. It can be concluded that species oil palm (*Elaeis guineensis*) and kelempayan (*Neolamarckia cadamba*) can be utilized for scarf joint in the production of furniture by using the appropriate angle and furniture that want to produce.

Keywords: strength, OPL

1. GENERAL REVIEW

Nowadays, the development of wood product is increasing. According to the Malaysian Timber Industries board (MTIB), Malaysian export of primary timber product from January until October 2011 has increased (Anon, 2011). This shows, the demand of wood that used as raw material is higher than another source in production making such as furniture product. The industries were trying to find the new sources or alternative material to replace or add the new method to balance the demand of products based on solid wood (Anon, 2011).

Other than that, joinery is an important in woodworking that consist two pieces of wood that jointing together, to produce a product that has a high strength. In woodworking process, wood can be jointing using adhesive, fastener, or binding. Other jointing that used in wood joint is dowel, butt joint and finger joint. The characteristics of wood joints are toughness, strength, appearance, and flexibility. Even though there is some progress in overcoming the problem of raw materials, one of the methods is using wood joint in an effort for maximizing the wood or raw material (Lee A, 2007). To fully understand the structural characteristic of furniture, it is necessary also understand the structural behaviour of the joint that are used in its construction in particular, how they carry load, how they deform under load, and how strong they are.

1.1. Oil Palm

Plantation of the oil palm in Malaysia has been an increment in one year to year. In the year 1920, Oil palm tree was planted 400 hectares in Malaysia. The hectares expanded to 4.3 million in 2007. Oil palms end up being the most principle item creates in Malaysia. The oil palm plantation was an increment in 2011, with 4.9 million hectares was planted in Malaysia (MPOB, 2011).

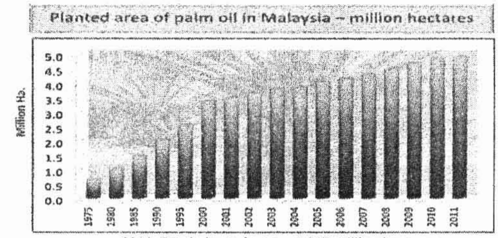

Table 1: The statistic of oil palm planted area in Malaysia

Sources: (MPOB, 2011)

1.1.1 Characteristic of oil palm lumber

The density in the peripheral region is over twist the value of the Centre region. At the top level, the density decreased toward the center of the trunk. The mean density for oil palm ranges from 485kg/m3 to 575kg/m3 at the peripheral and central regions respectively (Gan 2005). The oil palm tree has a height that ranges between 7 meters into 13 meters and the diameter average between 45cm into 65cm. The moisture content of the oil palm tree could range from 120% to more than 500%. The moisture content variation can be explained by the relative amount of vascular bundles and parenchyma tissue within the oil palm. The high moisture content gradient as found in the oil palm trunk is likely to cause a lot of problems in the drying process (Killman and Lim 1985).

1.2 Kelempayan (*Neolamarckia cadamba*)

Kelempayan (Neolamarckia cadamba) a fast-growing tree species is being invested in its physical and mechanical properties in order to assess its potential for future utilization. It grows very well and gregariously in exploiting the area, especially after logging. The growth characteristics of this tree suggest that under natural regeneration, a dense, even-age stand can be formed making it suitable for management of a plantation (Jusoh, 1993).

1.2.1 Properties of Kelempayan (*Neolamarckia cadamba*).

The properties of kelempayan that are the color of Heartwood is white with a yellow tinge and darkening to creamy yellow on exposure, and the sapwood is white turning to yellow on exposure. Texture is moderately fine and even. The grain is straight; vessels lines are present, low luster and have no characteristic odor or taste. Timber classification is light hardwood. The strength classified is in-group D that non-durable and easier to treat. The Kelempayan wood will be lighter with an air-dry at 15% moisture range of density of 370kg/m3 to 465 kg/m3 (Choo K. T, 1999).

1.3 Jointing system

A number of different jointing systems exist for large timber structures and those employing structural adhesives (Peter et al.,1998). Jointing is a part of woodworking that involves joining pieces of wood, to create furniture and structures. Some wood joint employs fastener or adhesive, while other used only wood elements.

To understand the strength design of furniture it is necessary to able to differentiate between the various structure elements and system that used in its jointing construction. Furniture appears to be constructed in an almost infinite variety of ways, and because of this often difficult to recognize the basic jointing system that gives it form, strength, and rigidity. Depending upon which type of joint predominates in the jointing system, a piece of furniture may accordingly be classified as frame, panel or shell type construction (Ecklelman, 2003).

1.4 Design of Furniture Jointing

The important step to determine the strength of jointing is should be designing the joint. This step is carried out after the final size of all the members had been determined so that the forces acting on each joint are accurately known. Normally, the joint is not stronger same like solid wood that gave low strength to part on a piece of furniture, and furniture was failed at the joint than any other single cause. It causes the lack information about the design of the joints at the furniture component. To get the joint that had a good strength we would like to be able to design a complete joint from a consideration of the load or forces that will be loading at the component used during its construction. (Eckelman, 2003).

1.5 Scarf Joint

Scarf joints rely on expanded, low angle cuts and glue for their holding power. This joint is much like a very low angle miter that is cut to expose an often lengthy grain as possible. It stretches out the idea of a butt joint until it almost disappears. A scarf joint will blends in far better than a simple butt joint. This seamless quality becomes important when a scarf joint is used for an area that's highly visible, such as in long runs of molding and trim work, which require some of the kind joinery (Rogowski, 2002).

Scarfing the joints together create longer length while maintaining the long grain throughout. Handrails and boat building are the two others area where the scarf joint is used. There is also a large variety of the scarf joint that used joinery designed to resist potential stresses (Rogowski, 2002).

1.5.1 Structure of scarf joint

This joint is the one of the method in jointing process where the two adherent that will join together using adhesive. This joint can be used if the material that wants is not in the specific length that required. The scarf joint method will be use (Greene, 2007).

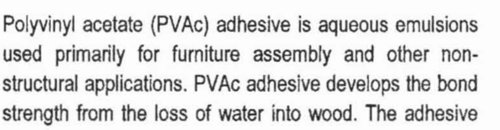

Figure 1: The structure of scarf joint.

1.6 Polyvinyl Acetate

Polyvinyl acetate (PVAc) adhesive is aqueous emulsions used primarily for furniture assembly and other non-structural applications. PVAc adhesive develops the bond strength from the loss of water into wood. The adhesive had excellent high dry adhesion strength and good gap-filling properties. High bond strength, fast setting, colourless glue lines combined with ease of application are the advantage of PVAc adhesive in wood bonding (Wing-Hing, 1991).

2. SAMPLES PREPARATION

Sources of the raw material used for this study were oil palm trunk and Kelempayan. The 25-year oil palm with the Diameter Breast High(DBH) 52 cm and 57 cm were used in this study that harvested at Felda Ulu Jempul Pahang. Kelempayan tree with age between 10 to 15 years old and DBH 37 cm harvested at Hutan Simpan Universiti Teknologi Mara Jengka.

3. METHODS

3.1 Preparation of Scarf Joint

The sample cut to accurate size of the width, thickness and length in the process made a scarf joint sample. The sample size that used was 30 mm x 30 mm x 300 m..The angel sizes that were used in this study are 30, 45, and 60. That was different cutting angle surface to show the distinctive strength between angels 30, 45, 60 for wood and non woody wood as a component that can be used in the furniture industry.

3.2 Bending test

Bending test was applied to all 60 samples for the both species oil palms and Kelempayan, which are 30 samples for the Oil palm and 30 for the Kelempayan of the scarf joint with three different angles such as 30, 45, and 60. The bending test was performed according to BS EN 408. Loads at break (N) of each sample were measured in this testing. The crosshead speed is about 2 mm/s distance between support spans is 280 mm and load span is 90 mm.

3.3 Compression test

The load crossheads speed that applied constant of 0.64 mm/s. The samples tested in this study were 30 for the Kelempayan and 30 for the Oil palm with different angles 30, 45, and 60. In compression test, maximum load (kN) and maximum stresses (MPa) calculated, and the results were analyzed to determine compressive strength using SPSS.

4. RESULTS AND DISCUSSIONS

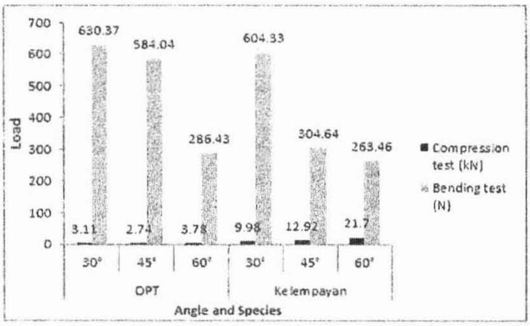

Figure 2: Strength properties of Species Oil palm and Kelempayan with different angles

Figure 2 shows the strength properties of the scarf joint with different angles using two species OPT and Kelempayan for compression test and bending test. The result show angle 60 has a highest strength compared with angles 30 and 45 for the compression test. The mean value was 21.7038 kN for species Kelempayan and 3.7775 kN for the OPT. For the angle 45 shows the mean value 12.9188 kN for the species Kelempayan and 2.7363 kN for species OPT. The results show for the species OPT, value angle 30 was higher than angle 45. Meanwhile, for the bending test, the angle 30 has more strength for the both species. In generally, the angle 60 showed the highest value on the both species (Oil Palm Trunk and Kelempayan) compared to other angles (45 and 30) for the compression test. For the Comparison on the species, strength of the species Kelempayan shows a better than the OPT species for the angles 30, 45, 60. That mean, the angle 60 for the both species had good strength properties and best performance compared to angles 30 and 45 for the compression test. In the bending test showed, the mean value of angle 30 was a higher strength than other angles. Value for the oil palm sample was 630.37 N and 604.33 N for kelempayan. For the angle 45 showed, species oil palm was higher value compared to kelempayan. It was also same to the angle 60. The results show the oil palm species has a better strength, and performance compares to the kelempayan for the angles in the bending test.

Table 2: Analysis of Variance on the test between subjects effect

Species	Sources	Dependent variable	Types sum of Squares	df	Mean Square	F	Significant
OPT	Angle size	Compression test	4.448	2	2.224	0.872	0.433
Kelempayan			595.357	2	297.678	81.050	0.000
OPT		Bending test	557357.52	2	278678.758	12.337	0.000
Kelempayan			553862.39	2	276931.195	78.066	0.000

From table 2, the result was shown the significant effect to both dependent variables on compression test and bending test. In compression test, the mean value of the oil palm species not has a comparison to angle 30, 45, and 60. While, the value of the kelempayan species was shown it has a comparison between that angles. Dependent variable for the bending test shown the species oil palm and kelempayan has a comparison value to each angle jointing. The comparison between that angle joint showed each angle joint had different strength properties. Each angle joint had an own purpose based on the user and function of the product.

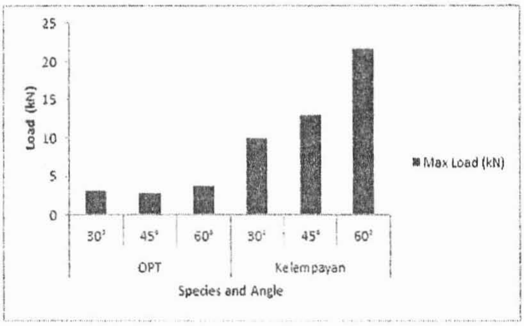

Figure 3: Comparison between Two Species with Different Angles in Compression Test

Figure 3 above represents the comparison result between different angles between two species in the compression test. The result show angle 60 has a highest strength of compression test compared with angles 30 and 45 which value was 21.7038 kN for species Kelempayan and 3.7775 kN for the OPT. For the angle 45 shows the value 12.9188 kN for the species Kelempayan and 2.7363 kN for species OPT. The results show for the species OPT, value angle 30 was higher than angle 45. That mean angle 45 was a lower strength compare to angles 30. This is because the sample for angle 45 has a little problem when the sample was taken such as the portion or layer in oil palm is mixed and difficult to get an accurate strength during testing. Generally, for this test use an adhesive (PVAc) as a medium to connect that joint. In case of compression test the angle 60 is the highest value for the both species because that angle has a small surface and slope that can be resistant to the stress or load that apply. Meanwhile, Kelempayan has a good strength and performance compared to the oil palm for the all angles. OPT has a lower strength compared to Kelempayan because opt is non woody wood that does not have cambium, secondary growth rings, ray cell, and knots to support it strength.

Table 3: ANOVA based on compression test

Sample species	Dependent variable	N	Angle size	Different	Significant (p-value<0.05)
OPT	Compression test	8	30	45	0.642
		8		60	0.414
		8	45	30	0.642
		8		60	0.206
		8	60	30	0.414
		8		45	0.206
Kelempayan	Compression test	8	30	45	0.006
		8		60	0.000
		8	45	30	0.006
		8		60	0.000
		8	60	30	0.000
		8		45	0.000

Based on the table above, the statistical analysis compression tested computing to ANOVA revealed to the three types of angular size on two species. The results showed for the OPT species with an angle 30 is not significant. That means, from this angle is not having a different strength between an angle 45 and 60 for the compression test. The angular size 45 and 60 also show not significant. The strength for this angle for oil palm species is not having different compared to other angles. This is because the influence of the properties of oil palm that gave effect to the strength of oil palm species. While the result in the kelempayan species shows the different result compared to the OPT species. For an angle 30, species kelempayan showed the significant between other angles. That means, the angle 30 had a different strength between angles 45 and 60 as shown in the table above. After that, the angle 45 also shows the distinct strength between angles 30 and 60. It was also same with an angle 60. This angle also shows the significant result. The strength of this angle is high compared to angles 30 and 45. It can be concluded, the result all angles to the species oil palm show no significant mean that not have different strength compared to the kelempayan species that angles 30, 45, 60 have a distinctive strength between each other.

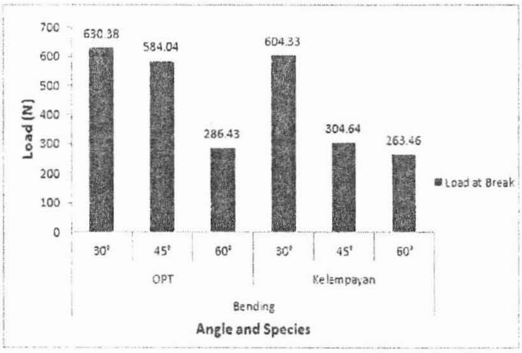

Figure 4: Comparison between Two Species with Different Angles in Bending Test

Figure 4 shows the comparison between two species with different angles for the bending test. The highest value for this test is angle 30 for the both species, which kelempayan 604.33 N and OPT 630.38 N and followed by the angle 45 with value 304.64 N for the Kelempayan and 584.04 N for the OPT. Then, the lowest values of bending test are the angle 60 for the both species. At this result, the angle 30 has more strength with the regard to strength properties and high mechanical bending moment resistant compared to other angles. It occurs because of glue line surface is broad and interaction between the PVAc adhesive on the fit of the joint. After that, the properties of oil palm that have high parenchyma cells that absorb the adhesive at bond glue line also can be given the sample of oil palm fix together and got a good strength. It as well supports by the vascular bundle that given the strength to oil palm. The both of species that have high strength caused by the adhesive that used, PVAc adhesive develop the bond strength from the loss of water into wood. Polyvinyl acetate had high dry adhesion strength, good gap-filling properties, high bond strength and fast setting were the cause the sample had an excellent strength.

Table 4: ANOVA based on bending test

Sample species	Dependent variable	N	Angle size	Different	Significant (p-value<0.05)
OPT	Bending test	8	30	45	0.544
		8		60	0.000
		8	45	30	0.544
		8		60	0.001
		8	60	30	0.000
		8		45	0.001
Kelempayan	Bending test	8	30	45	0.000
		8		60	0.000
		8	45	30	0.000
		8		60	0.181
		8	60	30	0.000
		8		45	0.181

Based on the table 4 above, the statistical analysis bending tests computing on ANOVA test revealed to the three types of angle size on two species. The results showed for the OPT species with an angle 30 is not significant when be compared with an angle 45 but if angle 30 be compared to the angle 60 there showed the significant result. That means, for the angle 30 is not having a different strength compare to an angle 45, but it has a different strength when compared with an angle 60. The angle sizes 45 also same with an angle 30. That was shown not a significant result for the angles 45 and 30 but when the angle 45 be compared to 60 the result showed significant.

That means, if the angle 30 compared with an angle 45 shows not had a different strength, but there had a different strength when angle 45 be compared with an angle 60. Then, the result of the angle 60 showed angles of 45 and 30 have a distinct strength if be compared with angle 60. While the result for the kelempayan species showed the angle 30 had a significant. That means, the strength for the angle 30 different between angles 45 and 60. After that, the angle 45 shows the distinct strength between angles 30 and 60. It was also same with an angle 60. This angle showed the significant result. The strength of this angle is high compared to angles 30 and 45. It can be concluded, the result all angles to the species oil palm show not a significant mean that not have different strength compared to the kelempayan species that angles 30, 45, 60 have a distinctive strength between each other.

5. CONCLUSIONS

This study has investigated potential changes to scarf joints in the industry in order to attempt to increase their structural efficiency. The species kelempayan and oil palm have their own characteristic that was given the strength to both of that species. The scarf joint at an angle 60 in compression test and 30 in bending test of the both species had a good strength, and the best performance jointing to compare to the scarf joint with an angle 45. This result was proving by the result on the compression test and bending test that was shown angles 60 and 30 got the highest value. The scarf joint with different angles can improve the requirement for the strength properties of jointing for uses in furniture manufacturing.

The uses of the scarf joint in furniture making can apply an angle of 30 and 60 in the industry depend on the furniture that wants to produce. The effect on the strength of jointing angle can be influent in many factors. Understanding the cause and characteristic of fracture in adhesive bonded joint and material are an influential to improving performance. After that, the choosing species that have good properties also is an important in the scarf joint to make sure the jointing have an excellent strength. The result showed species dicot and monocots such as oil palm and kelempayan had a valid strength when used on the scarf joint.

However, now the material kelempayan species is a decrease because the demand of this species for making furniture product is increased. So in this case the alternative resources such as oil palm should be used for make sure the raw material for making furniture still available. It can be concluded that species oil palm (Elaeis guineensis) and kelempayan (Neolamarckia cadamba) can be utilized for scarf joint in the production of furniture by using the appropriate angle.

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