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PROPERTIES OF DIFFERENT SCARF JOINT ANGLE USING OIL PALM TRUNK AND KELEMPAYAN

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ABSTRACT

The aim of the study was to determine the suitability and properties of scarf joint for the species oil palm trunk (OPT) (Elaeisguineensis) and Kelempayan (Neolamarckiacadamba). It has been tested on different scarf cutting scarf joint angles such as 30°, 45° and 60° and uses a type of polyvinyl acetate adhesive of 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 OPT and Kelempayan is the strongest compared to an angle of 45° and 60° for the bending test. When comparing the two species of OPT and Kelempayan, OPT 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 scarf joint angle 30° and 60° is suitable for use by industry because it is more resistant compared to the other angles. It can be concluded that species OPT (Elaeisguineensis) and Kelempayan (Neolamarckiacadamba) can be utilized for scarf joint in the production of furniture by using the appropriate scarf joint angle and furniture that want to produce.

Keywords: strength, OPT, kelempayan, scarf joint, scarf joint angle.

INTRODUCTION

Nowadays, the development of wood product is increasing. According to Malaysian Timber Industries Board (MTIB), Malaysian export of primary timber product from January until October 2011 has increased. This indicates that the demand of wood uses as raw material is higher than other material especially in furniture production industries. The industries are trying to find the new, alternative material or to discover a new wood fabrication method to balance the demand of products based on solid wood.

Alternative materials can be achieved by considering the abundance of wood trunk available in Malaysia. The plantation of the oil palm in Malaysia has been increasing year to year. In the year 1920, oil palm tree was planted in 400 hectares and expanded to 4.3 million in 2007. Oil palm has become one of the major revenue to Malaysia. The oil palm plantation was an increment in 2011, with 4.9 million hectares was planted in Malaysia as shown in Figure-1.

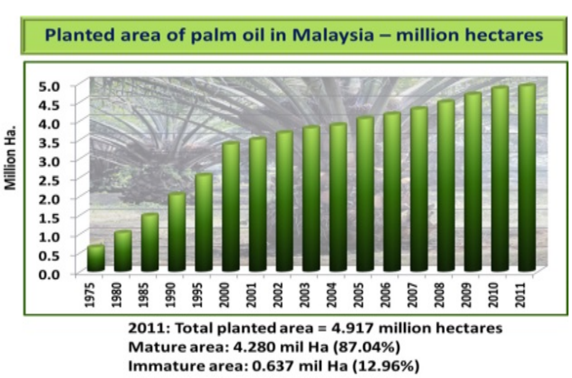

Figure-1. The statistic of oil palm planted area in Malaysia [1].

Characteristic of oil palm trunk is divided into the hard peripheral and softer inner core. The economic growing period is 25 to 40 years hence routing up of trees at this stage is uneconomical [2]. The density in the peripheral region is over twist the value of the center region. At the top level, the density decreased toward the center of the trunk. The mean density for oil palm trunk ranges from 485-575 kg/m3 at the peripheral and central regions respectively [3]. The oil palm tree has a height between 7-3 m and the average diameter between 45-65 cm.

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 [4].

On the other hand, Kelempayan (Neolamarckiacadamba) 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.

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

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Kelempayan wood will be lighter with an air-dry at 15% moisture range of density of 370kg/m3 to 465 kg/m3[5].

Joinery is an important feature in wood working where two pieces of wood jointing together in order to produce a product that has a high strength. In woodworking process, wood can be jointing using adhesive, fastener or binder.

Other than jointing; dowel, butt joint and finger joint are used as wood joint. The characteristics of wood joints are toughness, strength, appearance and flexibility. Even though there is some progress, one of the alternative methods in overcoming the problem of raw materials depletion supply is by using wood joint in an effort for maximizing the wood or raw material [6].In making these wood joints as useful furniture products, the joint structural behavior in terms of its ability to withstand loads, deform under load and its strength should be fully understood.

A number of different jointing systems exist for large timber structures and those employing structural adhesives7. Jointing is a part of woodworking that involves joining pieces of wood, to create furniture and structures. Some wood joint employs fastened or adhesive, while other only use wood elements.

In order to understand the strength design of furniture, it is necessary to be able to differentiate between the various structural elements and a 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.

The important step to determine the strength of jointing is by properly 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 as strong as solid wood which will cause low strength to part on a piece of furniture. The furniture will fail at the joint than any other single cause. It causes due to lack of information on the design of the joints in the furniture component. Good strength joint is designed by considering the load or forces used during its construction for the complete joint.

One of the good strength joint designs is the scarf joint. Scarf joints rely on expanded, low scarf joint angle 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 blend in far better than a simple butt joint. This seamless quality becomes important when a scarf joint is used in an area that is highly visible such as in long runs of molding and trim work, which require some of the kind joinery [7].

Scarfing joints together create longer lengths 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 [8].

This joint is the one of the methods in the jointing process where the two adherent that will joint 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 [9].

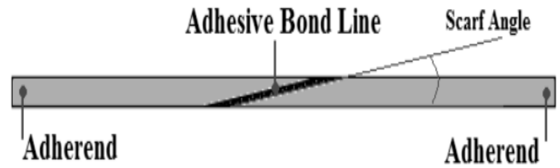

Figure-2. The structure of scarf joint [9].

Adhesive plays an important role in jointing process. 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 the wood. The adhesive had excellent high dry adhesion strength and good gap-filling properties. High bond strength, fast setting, colorless glue lines combined with ease of application are the advantage of PVAc adhesive in wood bonding.

METHODOLOGY

Sample preparation

The raw materials used for this study were oil palm trunk (OPT) (Elaeisguineensis) and Kelempayan. The 25 years OPT with the Diameter Breast High (DBH) 52cm and 57cm were used in this study that harvested at Felda Ulu Jempul Pahang. Kelempayan tree with age between 10 to 15 years old and DBH37cm harvested at Hutan Simpan Universiti Teknologi MARA Jengka.

Preparation of scarf joint

The samples were cut to accurate size in the process of making a scarf joint sample. The sample width, thickness and length is30mmx30mmx300mm respectively. The scarf joint angle which is investigated in this study are 30^o, 45^o and 60^o. That was different scarf joint angle surface to show the distinctive strength between angles 30^o, 45^o and 60^o for wood and non-woody wood as a component that can be used in the furniture industry.

Bending test

Bending test was applied to all 30 samples of each species OPT and Kelempayan at three different scarf joint angles 30^o, 45^o and 60^o. The bending test was performed according to British Standard408. Loads at break (N) of each sample were measured in this testing. The cross head speed is about 2mm/s distance between supports pansies 280mm and load spanis90 mm.

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Compression test

The load cross-head speed that applied constant of 0.64mm/s. The samples tested in this study were 30 for the Kelempayan and 30 for the OPT at different scarf joint angles 30º, 45º and 60º.Incompressiontest, the maximum load (kN) and maximum stresses (MPa) were calculated and the results were analyzed to determine compressive strength using Statistical Package for the Social Sciences (SPSS).

RESULTS AND DISCUSSION

The study obtained results for bending and compression tests on varying scarf joint angles samples for OPT and Kelempayan species.Figure-3 shows the comparison of bending strength between OPT and Kelempayan species at scarf joint angles. It was found that the highest bending strength is at angle 30º and the lowest at angle 60º for the both species. Bending strength values for OPT and Kelempayan are 630.38 N and 604.33 N at 30º, which followed by the angle 45º with values 584.04 N and 304.64 N respectively.

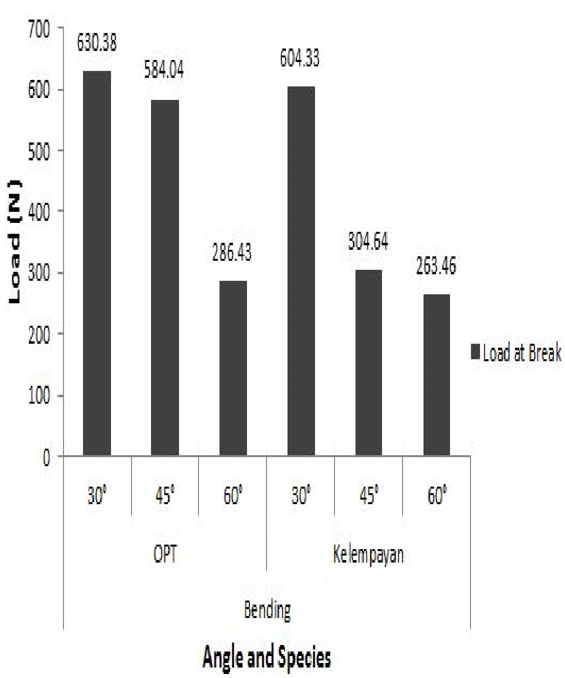

Figure-3. Bending strength of OPT and Kelempayan species at different scarf joint angles.

High values at angle 30º indicate that better performance in term of bending strength and high mechanical bending moment resistant compared to other angles. This is because of the broad glue line surface and interaction between the PVAc adhesive on the joint fit. Besides, OPT is known to have high parenchyma cells that absorb the adhesive at bond glue line which also enhance the sample of OPT bonding and have a good strength. It is well supported by the vascular bundle gives the strength to OPT.

In general, both species have high strength due to PVAc adhesive. PVAc adhesive develops the bond strength from the loss of water into the wood. PVA chad high dry adhesion strength, good gap-filling properties, high bond strength and fast setting which cause the sample to have an excellent strength.

The statistical analysis of variance (ANOVA) on bending tests for the two species at three scarf joint angles was tabulated in Table-1. The results show that bending strength for OPT species at angle 30oagainst angle 45ois not significant since the P-value obtained is greater than 0.05. On the other hand, the angle 30oagainst angle 60º the data is significant. Similarly to the angle 45º against 60o, the result is significant. That means, data at angle 30o is not varied significantly compared to angle 45o, but it has a significant variance when compared to data at angle 60o.

Table-1. 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

As for the Kelempayan species, the angle 30º against both angles at 45º and 60º give a significant value but the angle 45º against 60º has insignificant value. That means, the strength for the angle 30ovaries significantly between the two angles.

In conclusion, OPT species gives insignificant bending strength comparisons for angle 30º against 45º and otherwise. Kelempay species gives an insignificant bending strength comparison between angles 60º and 45º.

Figure-4 represents the compression strength between two species at different scarf joint angles. The result show angle 60º has the highest compression strength for both OPT and Kelempayan species at a value of 3.7775 kN and 21.7038 KN respectively. Compression strength at angle 45º is 12.9188 kN for Kelempayan and 2.7363 kN for OPT.

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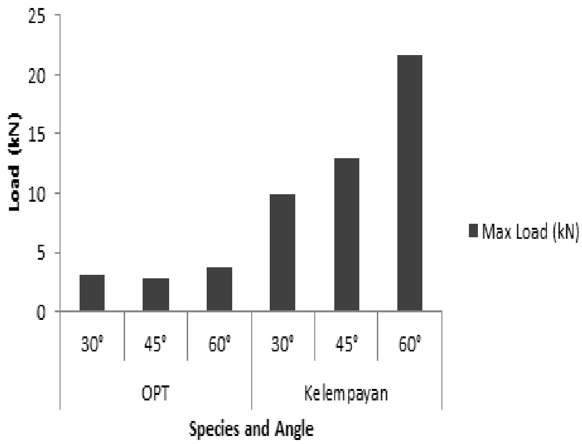

Figure-4. Compression strength between two species at different scarf joint angles.

The results show for the species OPT, value angle 30^o was higher than angle 45^o. This is because angle 45^o sample was difficult get an accurate strength during testing due to the sample was taken such as the portion or layers in OPT was mixed. The compression test for angle 60^o is the highest for both species because the angle has a small surface and slope that can be a resistant to the stress or load applied. Meanwhile, Kelempayan has a good compression strength compared to the OPT at all scarf joint angles. OPT has a lower strength because structural on woody wood that does not have cambium, secondary grow rings and knots to support it strength.

The statistical analysis ANOVA for compression test on two species at three different scarf joint angles is tabulated in Table-2. The ANOVA results showed for the OPT species the data varies between all scarf joint angle are insignificant as the P-values are greater than 0.05. The compression strength for OPT species at all scarf joint angles are not varied significantly compared to other scarf joint angles. This is because the influence of the properties of OPT that gave effect to the strength of OPT species.

Table-2. ANOVA based on a 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

On the other hand, all Kelempayan species ANOVA results are significant to all scarf joint angles. That means, the angle 30^o had a different strength between angles 45^o and 60^o as shown in the table above. It can be concluded, the result of all scarf joint angles in the species OPT show no significant mean that not have different strength compared to the Kelempayan species that angles 30^o, 45^o and 60^o which have a distinctive strength between each other.

Figure-5 shows the comparison between bending and compression strength of the scarf joint at varying scarf joint angles for OPT and Kelempayan species. The results show that the bending strength of both species is higher than compression strength. This is because upon bending the wood tends to be elastics. The woods have low resistance to compression as it has a low bulk modulus.

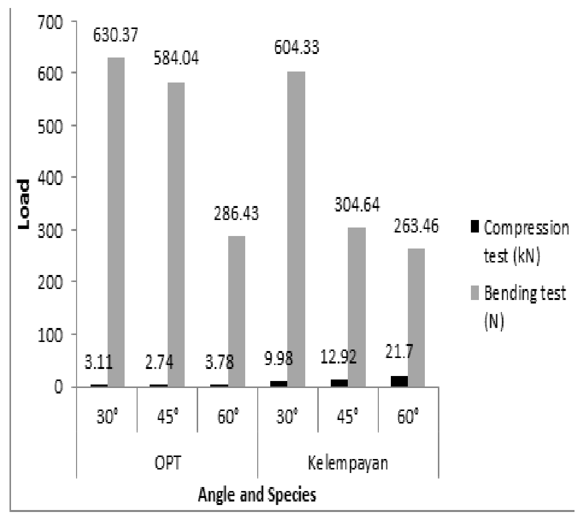

Figure-5. Strength of OPT and Kelempayan species at different scarf joint angles.

In terms of scarf joint angle, the best angle for compression is the largest angle at 60^o. Upon compression, the angle 60^o provides a small surface and slope that can be a resistant to the stress or load applied. In contrary, for bending, the best values obtained at the smallest angle 30^o. Upon bending, the angle 30^o provides a higher contact surface for the adhesive and woods which give better bonding and high strength.

The ANOVA result was shown in Table-3, the significant effect of both dependent variables on compression and bending tests. In compression test, the mean value of the OPT species has insignificant value in comparison to angle 30^o, 45^o and 60^o. While, the value of the Kelempayan species shows high comparison between that scarf joint angles. Dependent variables for the bending test shown both OPT and Kelempayan species have a significant comparison value to each scarf joint angle. The comparison between that scarf joint anglesshowedeachanglehasdifferentstrengthproperties.Eachanglehasa known purpose based on the user and function of the product.

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Table-3. ANOVA 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

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 OPT have their own characteristic that was given the strength to both of that species. The scarf joint at an angle 60^o in compression test and 30^o 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^o. This result was proved by the result of the compression test and bending test that was shown angles 60^o and 30^o 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^o and 60^o in the industry depend on the furniture that wants to produce. The effect on the strength of scarf joint can be influenced by many factors. Understanding the cause and characteristic of fracture in adhesive bonded joint and material area influential to improving performance. After that, the choosing species that have good properties also are an important in the scarf joint to make sure the jointing has an excellent strength. The results showed species dicotyled on and monocotyledon such as OPT and Kelempayan had a valid strength when used on the scarf joint.

However, now the material Kelempayan species are a decrease because the demand of this species for making furniture product is increased. So, in this case, the alternative resources such as OPT should be used for making sure the raw material for making furniture still available. It can be concluded that species OPT (Elaeisguineensis) and Kelempayan (Neolamarckiacadamba) can be utilized for scarf joint in the production of furniture by using the appropriate scarf joint angle.

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