

Bending Strength Of Finger Joint From Kelempayan (*Neomalarkia cadamba*) and Ludai (*Sapium baccatum*)

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Abstract

*Finger jointing is a method to create long lengths of lumber from short pieces. Jointing system is the overcome steps that get into action by the manufacturing industry especially the furniture manufacturer and building construction. The aim of this study is to present results showing the comparative performance of the two different finger orientations and two different species. The main objectives of the study is to determine strength properties of different finger orientation and different species using kelempayan (*Neomalarkia cadamba*) and ludai (*Sapium baccatum*) strips either this finger specimen and species are suitable for jointing application. The average moisture content of wood materials used for the preparation of test samples was determined as 12%. Samples with dimensions of 320 x 20 x 20 mm were cut according to the procedure of BS EN 204 (1991). The load was applied at the centre of the span at the constant of 0.26 in/min (BS 373:1957). For bending strength test, the result MOE for mix species has a highest result while the highest for result MOR was kelempayan. The result bending strength at difference orientations show that the highest MOE was horizontal meanwhile the highest result for MOR was vertical.*

Keywords: *Finger joint, bending strength, kelempayan and ludai.*

INTRODUCTION

Jointing the end to end of two pieces of wood together has always been challenging and at times difficult. Wood in naturally has a great strength parallel to the grain. The problem is the wood cannot easily bond together at the end of the wood by using the adhesive. Therefore, the appropriate technique needs to joint it together. The finger joint is not a new type of end joint; it has been use for many years. Previous study on finger joint is mention as being use in the automotive industry in wood steering wheels and spokes of wood wheels. A large amount of wood waste was disposed in most of the wood base manufacturing factory in Malaysia. Kelempayan (*Neomalarkia cadamba*) is light hardwood with poor durability. It was categorized in Rubiaceae family and the density of this species is ranging at 0.44g/cm³ (oven dry weight). Ludai (*Sapium baccatum*) is one of the species under the Euphorbiaceae family. It is not durable under exposed condition as it under strength group D (weak) with light density more than 480kg/m³ air dry. PVAc has good stability to light and does not yellow. It remains soluble and does not cross-link and become irreversible. PVAc in strong concentrations, especially V25, may be used as a surface consolidant or as glue.

Finger joint is used in several wood product manufacturing processes including the horizontal joints for glulam manufacturing, the terms finger jointed lumber applies to dimension lumber (Boudreau P. Eng, n.d). The strength of the joints is controlled

by stipulating the quality of wood which must be present in the area of the joint (Boudreau P. Eng, n.d). Many wood related factors are also known to affect the strength of finger joints, such as species, density, and natural defects, while others are related to the gluing process. There are two types of finger joint namely vertical and horizontal. Horizontal finger joint is created by milling the finger joint pattern parallel to the wide face of the finger joint block. Vertical finger joint is created by milling the pattern perpendicular to the wide face of the blocks hence they are visible on the wide face of the resulting finger jointed lumber.

MATERIALS AND METHODS

Field procedure

The raw materials used in this study were Kelempayan and Ludai. This two species of wood were harvested from Forest Reserve UiTM Pahang and all of the wood processing was done at the Wood Industry workshop, UiTM Pahang. The logs were cut into one meter length using chain saw. After that, the logs had been cut into 2 x 1 inches size with the 4 inches trimmer. The timber was cut into 1 feet approximately 300 mm length using radial arm saw. In this project, the moisture content of the timber was measure. The MC of each raw material in this study is below than 12%.

Finger jointing profile preparation

The samples size was 1 x 2 x 12 inches length. The sample was cut into two parts with 150 mm in length by using the radial arm saw. After that, the samples were profiled by using the finger profiler machine. Next process was gluing process. Several approaches were available to apply adhesive to a surface of a joint. In this study the simplest and least precise method was used which is dipping a joint into the container of adhesive (BS EN 204, 1999). The stationary clamp grips at one side of the joint and holds it in place while the moveable clamp grips the piece on the opposite side of the joint and moves forward. This action forced the two halves together.

Testing

The specimens were tested using Universal Testing machine (INSTRON). The entire specimen which was 20mm x 20 mm x 300mm length was conditioned at a condition control room. All of the sample must be condition about 24 hour. The load that applied at the samples of the span at the constant of 0.26 in/min accordance to BS 373:1957 (British Standard Institution, 1957) until the testing specimen was broken.

Figure 2 indicates the bending strength determined the modulus of rupture (MOR) and the modulus of elasticity (MOE) of the finger jointed specimens. Test method examined according to ISO 10983 (1999). In this study, there are three combinations of wood species and in every combination of wood species have three samples. The test was done according to the combination of the samples. For example, the

kelempayan and kelempayan combination sample was finish in one series of test and the mean of the result was calculated. The same process also had done for the other two combination of ludai – ludai and kelempayan – ludai (DIN 52186, 1978).

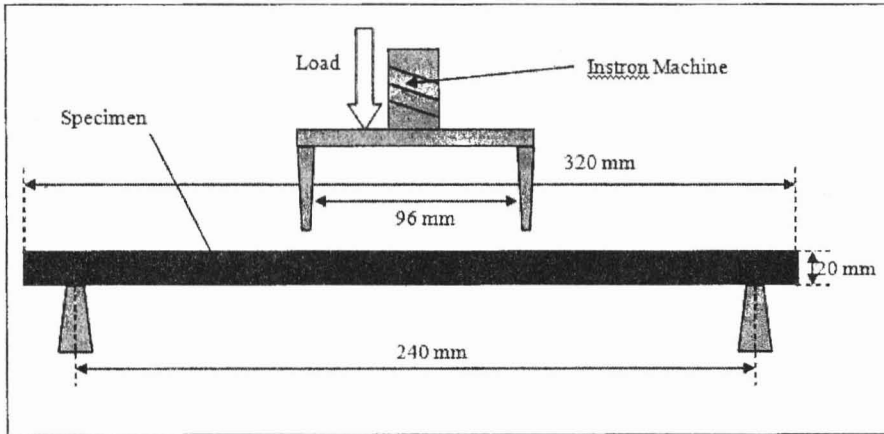


Figure 2: The testing specimen of the horizontal finger jointed

Modulus of Elasticity (MOE)

MOE is one type of measurement that resistance to bending related directly to the stiffness of a beam and it is a factor in strength of a long column. MOE are relate between stress and strain in a column, as the theory in Hooke laws said that, below the proportion limit the stress strain arrive was a straight line completely defines by its slope.

The MOE formula:

$$PL^3/48 I \Delta \text{ (Unit psi or MPa/ Nmm}^{-2}\text{)}$$

P = the load is pounds or kg (below the proportional limit)

Δ = the deflection at mid-span in inches/mm

L = the span in inches/mm

I = moment of inertia, a function of beam size

= (width x depth³)/12 for beams with a rectangular cross section.

Modulus of Rapture (MOR)

MOR was the value of point when the sample breaks, during bending test. According to the Shaler 1991, the requirement of structural applications is having the mechanical properties. The MOR is the stress obtained by the maximum load, instead of the load at the proportional limit. The MOR is calculating from the maximum load (load at failure in a bending test using the same testing procedure as to determine the MOE).

The MOR formula:

$$\text{MOR} = (1.5 \times P \text{ max } L) / bd^2 \text{ (Psi or MPa)}$$

P = the breaking (max) load

L = distance between supports and span

b = the width of the beam

d = depth of the beam

RESULTS AND DISCUSSIONS

The main objectives for this study were to determine the strength properties of different finger orientations and effect of different wood species on the fingerjoint strength properties. It was to identify which one of the species and the orientation of finger jointing had the good strength and best performance. These two finger orientations included the vertical finger orientation and the horizontal finger orientation using the polyvinyl acetate (PVAc) as the binder in this study. The discussion involves the mechanical properties analysis and the comparison on bending strength between the species and the two different finger orientations.

Table 1: Mean results of bending strength

Species	Orentation	MOR (MPa)	MOE (MPa)
Kelempayan	Vertical	24.87	3890.87
	Horizontal	20.09	5115.75
Ludai	Vertical	24.32	4753.32
	Horizontal	22.42	4610.44
Kelempayan-Ludai	Vertical	21.94	5032.48
	Horizontal	22.21	5780.05

Table 2 indicates the means bending strength of finger joint made from combinations kelempayan-kelempayan, ludai-ludai and kelempayan-ludai which fabricated in two orientations were vertical and horizontal. The vertical finger joint made from kelempayan wood shows the highest value in MOR which was 24.87 MPa while the lowest mean MOR obtained from finger joint made from mix kelempayan and ludai which was 21.94 MPa. The highest mean MOR value for horizontal finger joint was ludai wood (22.42 MPa) meanwhile the lowest was kelempayan (20.09 MPa). For the results MOE, it shows that the highest value for vertical finger joint was mix kelempayan and ludai (5032.48 MPa) whilst the lowest was kelempayan (3890.87 MPa). The mean MOE for horizontal finger joint made from mix kelempayan and ludai gave the highest value was 5780.05 MPa while the lowest MOE for horizontal finger joint was ludai (4610.44 MPa). Generally the maximum bending strength determined in finger joint made from mix kelempayan and ludai.

Table 3 shows the analysis of variance (ANOVA) of finger joint made from kelempayan, ludai and mix kelempayan and ludai. The analysis revealed that

comparison finger joint made from different species and different orientations were of no significance.

Table 3: Statistical analysis bending strength properties of finger joint

Source	Dependent Variable	Type III Sum of Squares	df	Mean Square	F	Sig.
species	moe	2423264.794	2	1211632.397	2.169	.157
	mor	5.192	2	2.596	.561	.585
orientation	moe	1979300.504	1	1979300.504	3.544	.084
	mor	15.162	1	15.162	3.275	.095

- a. R Squared = .479 (Adjusted R Squared = .262),
b. R Squared = .375 (Adjusted R Squared = .115)

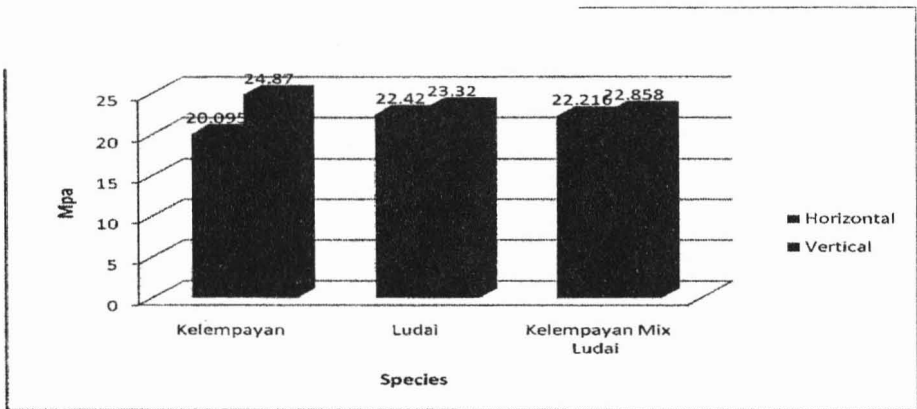


Figure 3: Bending strength of MOR based on species

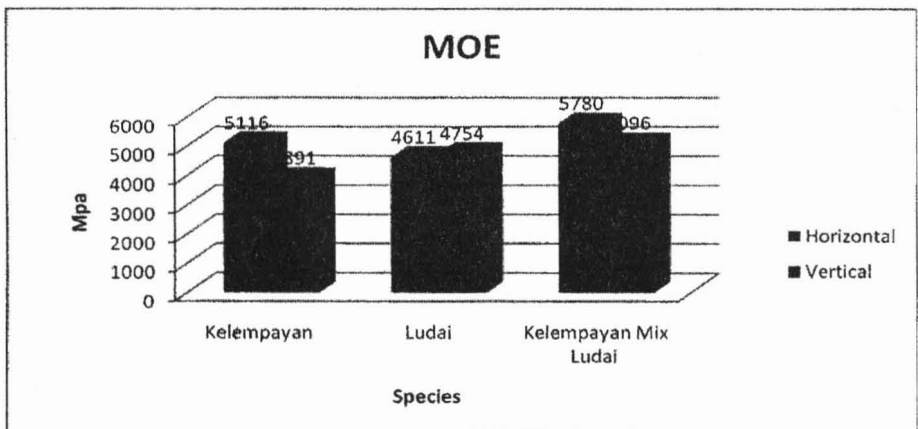


Figure 4: Bending strength of MOE based on species

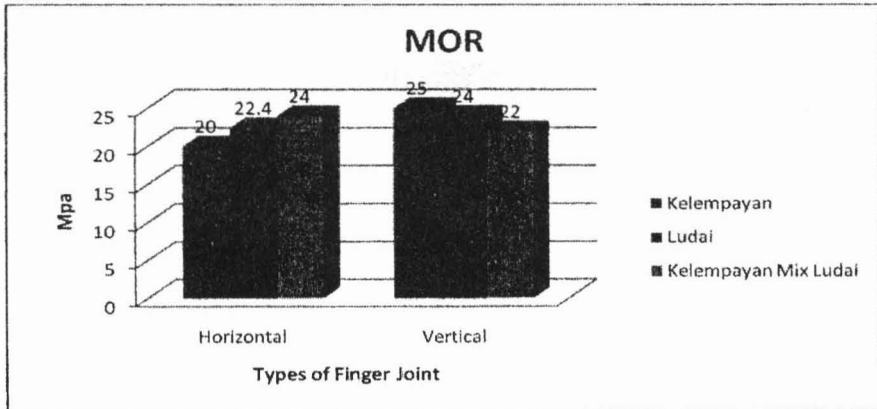


Figure 5: Bending strength of MOR based on orientation

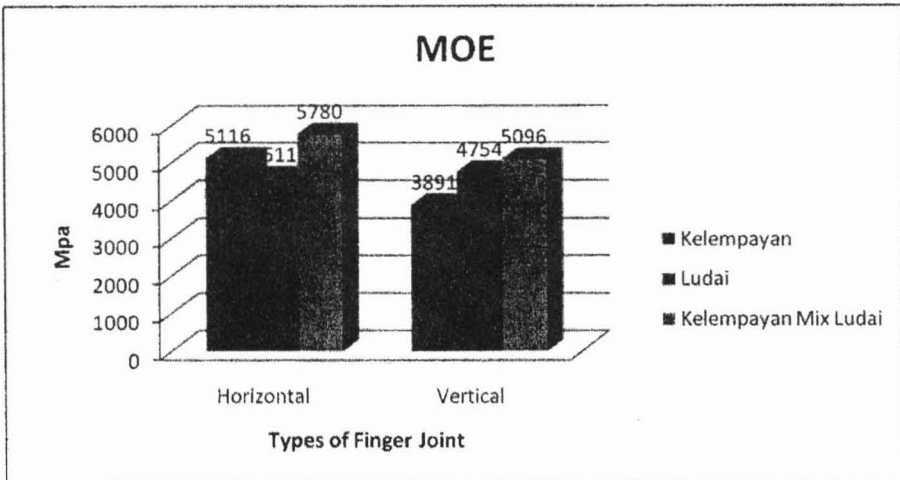


Figure 6: Bending strength of MOE based on orientation

Figure 3 summaries that most species and orientation have equaled result for MOR and MOE. For MOR species kelempayan with vertical orientation have a better strength that is 24.87 MPa. Otherwise, for MOE species mix kelempayan and ludai with horizontal orientation have a highest result was 5780.05Mpa (Figure 4). Figure 5 shows finger joint made from kelempayan has a highest result for MOR (24.87 Mpa). MOE finger joint mix species has a better result that was 5780 Mpa. MOR for vertical finger joint has a highest result was 24 Mpa. Figure 6 indicates MOE the highest result is horizontal with 5780 Mpa. Multivariate tests all species and orientations are not significant at all. There no different based on species or orientation.

CONCLUSIONS

From the results, it can be concluded that finger joint from kelempayan and ludai have a same strength based on MOR and MOE. Orientations are not affecting the strength of bending tests for all the samples. There are no relating both species and orientations of finger joints. Therefore, those species can be used together as finger joint material due to the comparable strength properties.

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