# Properties of Mixed Species Lamination Product from *Khaya ivorensis* and Oil Palm Trunk

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**Abstract**

Mixed wood lamination is the combination of two or more layer from two or more different species to produce the furniture component. In this study, the species used are *Khaya ivorensis* and Oil Palm Trunk. The species are arranged alternately engaged for three and five layer using Poly Vinyl Acetate (PVAC) glue. The actual size for the both layer are 30mm x 30mm x 1000mm. The main purpose of this study is to determine the suitability mixed species lamination between *Khaya ivorensis* and oil palm trunk in different layer of lamination and the mechanical properties of *Khaya ivorensis* and oil palm trunk as a mixed species material. It is important to ensure either this two species suitable to be combined to become substitute material in furniture making. The sample was tested for mechanical properties which are bending and compression shear testing using British Standard (BS). According to the result of bending testing, three layer of lamination was more strength than the five layers for Modulus of Rupture (MOR). But it is become to vice versa for Modulus of Elasticity (MOE). Other than that, the result of compression shows slightly different between both layers but still the three layers has more strength than the five layers. The result was analysed using Statistical Package for the Social Sciences (SPSS).

Keywords: mixed species lamination, wood lamination, engineered wood

## 1. INTRODUCTION

Solid wood is depleting due to deforestation. The disappearance of natural forests has forced many countries to develop artificial forest re-plantation. The selected timber trees are mostly from fast growing species for light use timber (Killman and Choon, 1985). Wood lamination can be categorized as engineered wood product. Engineered wood product can be defined as reconstitute of wood (Smulski, 1997). Mixed species lamination is one of the alternative raw materials in furniture making. It is the bonding together of two or more layers of material or materials from two or more species.

Mixed species lamination commonly used unpopular, fast growing or plantation species. The material chose usually for the species which are less density compare than solid wood. The mixed species lamination can increase the strength of the materials due to the adhesive used for lamination. Sometimes, its strength is much better than the solid wood.

The used of mixed species lamination is depend on the adhesive used and it thickness. It can be used as flooring, furniture making like cabinet, table top and also for structural like beam and etc. Besides, while doing this mixed species lamination it is also can helps in utilize wood waste.

The main purpose of this study is to determine the mechanical properties of *Khaya ivorensis* and Oil Palm Trunk (OPT) as mixed species lamination material. Besides, it is also to compare the different mixed species lamination layer of the sample which 3 layer and 5 layer

## .2. MATERIALS AND METHODS

### 2.1 Raw Material Preparation

The raw materials used for this study are Khaya ivorensis and Oil Palm Trunk (OPT). Both are plantation species.

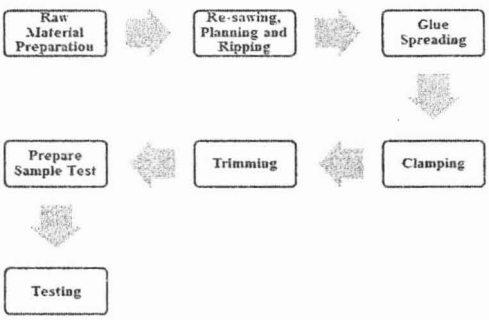


Figure 1: Flowchart of Mixed Species Lamination Process

Figure 1 shows the flowchart of mixed species lamination process. First the raw material from the both species was

chosen randomly from the different part and portion of the wood. The Khaya ivorensis is from 10 year old tree with the diameter breast height (DBH) 30 to 35cm. Moreover, the OPT used are from 25 year old tree. The selected materials were dried until its moisture content reach below 12%.

After that, it went to re-sawing, planning and ripping process. All the sawn timber will cut into the dimension of 70mm × 1000mm. Then, it proceeds to the ripping process to produced wood strips. For Khaya ivorensis, there are eight wood strips needed with the dimension 10mm × 70mm × 1000mm and another 12 strips was needed with the dimension of 5mm × 70mm × 1000mm.

But for OPT There are four strips needed for the size 10mm × 70mm × 1000mm and another eight strips needed for the size 8mm × 70mm × 1000mm. All of the strips size was cut with the tolerance of ±5mm.

After that, all wood strips was combined alternately between Khaya ivorensis and OPT for three and five layer. The adhesive used was Poly Vinyl Acetate (PVAC). It was applied by using roller. Then it goes to the clamping process for three days in a room temperature. After three days, the sample was goes through the planning and sanding processes to remove the excess glue. Besides it is also to straighten the edges of the sample and get the actual size of the sample which is 30mm × 70mm × 1000mm.

### 2.2 Testing

All the test method was done by using Universal Test Machine and the standard used are followed British Standard (BS). It is using In-House Test Method.

#### 2.2.1 Static Bending

The standard used for static bending testing was according to BS 373: 2008.

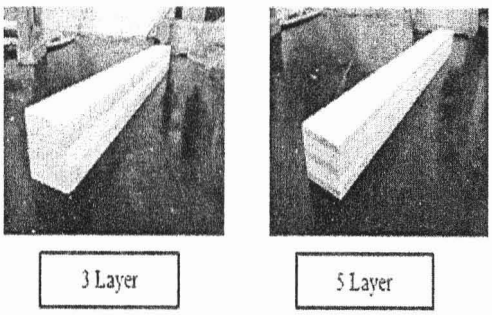


Figure 2: Bending Test Sample

Figure 2 shows the bending test sample for mixed species lamination. The size of the test sample was 30mm × 30mm × 360mm. The span used was 320mm with the speed 10mm/min.

#### 2.2.2 Compression Shear

The standard used for compression shear testing was according to BS 373: 1957 (reconfirm 2008).

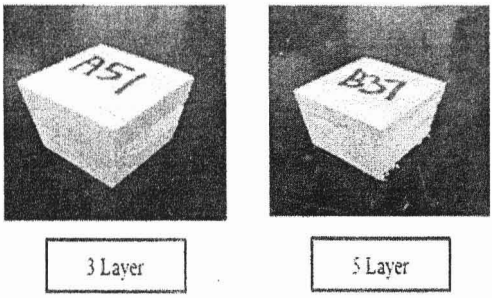


Figure 3: Compression Shear Test Sample

Figure 3 shows the compression shear test sample of mixed species lamination. The size of the test sample was 30mm × 30mm × 30mm. The speed of the testing was 10mm/min.

### 2.3 Experimental Design

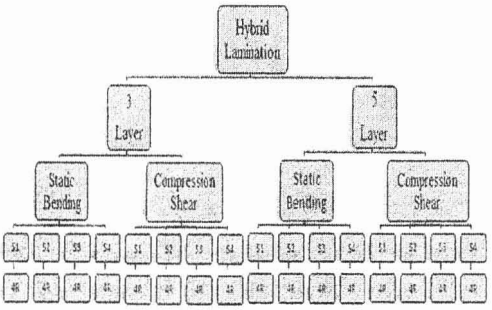


Figure 4: Experimental Design

Figure 4 shows the experimental design of the study.

## 3. RESULTS AND DISCUSSIONS

### 3.1 Properties of Mixed Species Lamination between Khaya ivorensis and OPT

Table 1: Mean Values

| *Layer* | *Density (Kg/m3)* | *MOR (MPa)* | *MOE (MPa)* | *CS (MPa)* |
|---|---|---|---|---|
| 3 | 601.03 | 22.9956 | 1034.751 | 3.8275 |
| 5 | 437.557 | 12.9238 | 1526.7130 | 2.4088 |

Notes: MOR- Modulus of Rupture, MOE- Modulus of Elasticity, CS- Compression Shear, MPa- Megapascal

Table 1 shows the means values of density, MOR, MOE and compression shear of the lamination. The density shows the mixed species lamination of 3 layers was 601.0300kg/m3 which higher than the 5 layer that only 437.5579kg/m3.

Other than that, for static bending testing, the MOR of mixed species lamination of 3 layers was not slightly difference than 5 layers which are 22.9956MPa for layer 3 and 12.9238MPa. But the MOR of 3 layers still higher than 5 layer.

However, it became vice versa for MOE. Mixed species lamination of 5 Layers recorded the higher reading of 1526.7130Mpa compared to 3 layers that only indicate 1526.7130MPa. It shows that 5 layers more flexible than 3 layers.

But for compression shear, there is no slightly different between mixed species lamination from 3 layers and 5 layers. It is simply differ by 1.417MPa where 3.8275MPa for 3 layers and 2.4088MPa for 5 layers. It shows that the shear strength of both layer are quite same.

### 3.2 Statistical Analysis

Table 2: Independent T-Test Analysis

| *SOV* | *dF* | *MOR* | *MOE* | *CS* |
|---|---|---|---|---|
| Layer | 1 | 15.605** | 0.42ns | 1.368ns |

Notes: SOV-Source of Varience, dF- Degree of Freedom, ns - not significant ($p>0.05$), x - significant at ($p<0.05$), xx - highly significant at ($p<0.01$)

Table 2 shows the summary of Independent T-Test Analysis for the both layers of lamination. The MOR result for the both 3 and 5 layers shows highly significant which is 15.605. Meanwhile, the MOE results indicate not significant which 0.42. Besides, for the compression shear, there is not significant shows on the result between the both 3 layers and 5 layers, which is 1.368.

### 3.3 The Effects of Layers on the Mechanical Properties

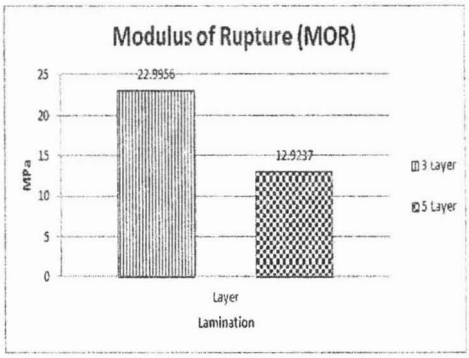


Figure 5: Modulus of Rupture

Figure 5 shows the effect of layer on mechanical properties of mixed species lamination. The layers consist of 3 and 5 layer. The MOR value of both layer was highly significant where the 3 layers shows the highest value, 22.9956MPa and 5 layers of lamination shows the lowest 12.9237MPa. The value of MOR expected decrease due to the decrease of the wood strips thickness for the lamination. The thickness of each layer of the lamination for 3 layers was 10mm for Khaya ivorensis and OPT but for 5 layers were 5mm for *Khaya ivorensis* and 7.5mm for OPT. According to Werren (1955), the MOR increase slightly with the increase of the thickness of each layer of lamination. Means by that, the more thickness of each layer, the more time taken for the lamination to break due to load applied.

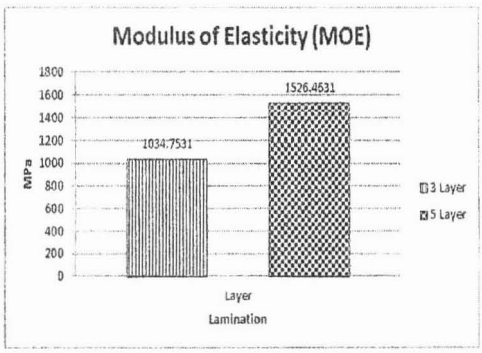


Figure 6: Modulus of Elasticity

Figure 6 shows the effect of layer on mechanical properties of mixed species lamination. The MOR value of both layer was not significant which did not show much difference. The values of MOE shows vice versa than MOR where 5 layers of mixed species lamination shows the highest 1526.4631MPa compare than 3 layers shows the lowest 1034.7531MPa. Usually, thinner material has high degree of flexibility compare than the thicker one. It is expected that the thickness of the strips on 5 layer of lamination gives more flexibility for the lamination

According to San and Paridah (2003), on their research of Bending Properties of Laminated Veneer Lumber (LVL), strongly suggest that by using thinner veneer of layer, the lamination will exhibit high values of MOE compare to those thicker veneer in production of LVL. Besides it also gives higher mechanical performance.

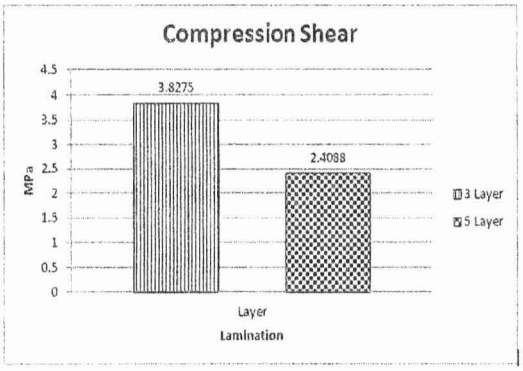


Figure 7: Compression Shear

Figure 7 shows the effect of layer on mechanical properties of mixed species lamination. The value of compression shear for both layer are not significant. It is shows that for 3 and 5 layer the values are not comparable and not have slightly different. The graph above show the highest was 3 layers, 3.8275MPa. Meanwhile, the 5 layers show the lowest, 2.4088MPa. Most of the failure occurs on the glue line. It is expected due to the amount of glue and clamp used. San and Paridah (2003) also said on their study of LVL that the thinner veneer the more glue will used to laminate the veneer together. So, the 5 layer of lamination required more amount of glue applied on it to ensure all the layer stick together completely, Other than that, the used of the manual clamp cannot ensure the uniform pressure applied to all part of the lamination. According to Sinha (2012), the glue selection and preparation was important that affect the strength of lamination.

## 4. CONCLUSIONS AND RECOMMENDATIONS

This study investigated the properties of the mixed species lamination from *Khaya ivorensis* and OPT in order to gain insight into the application in furniture industry. Based on the result the 3 layers of lamination performed very well strength wise when compared with the 5 layers of lamination. It is due to the thickness of the single layer of lamination and the total consumption of wood and OPT in the lamination. In addition, mixed species lamination actually can assist in enhance the value of wood that have defect. The beautiful surface only needed for the front and back of the lamination. Besides the strength of the wood that has defects will be increase in the present of adhesive.

As recommendation, this thesis should be taken as indicator on doing more research about mixed species lamination of others species especially plantation species in Malaysia. It is in order to substitute to the depleting of solid wood as raw material in furniture making. Further development work in this field of study is necessary. The determination of an improved method of extracting the right amount of wood from the OPT is very much needed. Besides, further research should be done to find the best ways to fully utilized the OPT to minimize the environmental burden to disposed all of the residual waste from the plantation sector.

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