UNIVERSITI PUTRA MALAYSIA

GLUING PERFORMANCE OF MIXED HARDWOOD TABLETOP

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APPROVAL SHEET

Name of Candidate : **SRI SUTOPO**

Title of Project : **GLUING PERFORMANCE OF MIXED HARDWOOD TABLE-TOP**

Approved by :

.....
Assoc. Prof. MOHD. ZIN JUSOH
(Supervisor)

.....
MR. MOHD. HAMAMI SAHRI
(Supervisor)

.....
Assoc. Prof. DR. RAZALI ABDUL KADER
(Coordinator, M.S. Wood Industries Technology Programme)

.....
Assoc. Prof. DR. YUSOF HADI
(Dean, Faculty of Forestry)

Date :

For my wife Yuli, my son Daru and my daughters Putri and Ira

GLUING PERFORMANCE OF MIXED HARDWOOD TABLETOP

By :

S r i S u t o p o

A Project Report is submitted in partial fulfilment of the requirements for the degree of **Master of Science (Wood Industries Technology)**

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A B S T R A C T

Information of gluing properties suitability on tropical wood species is lacking. This study was conducted to provide important information on the possible use of certain species and types of adhesives.

Gluing performance of three hardwood species i.e. Kelempayan (*Anthocephalus chinensis*), Yellow meranti (*Shorea* spp.) and Rubberwood (*Hevea brasiliensis*) with Urea formaldehyde (UF) and Polyvinyl acetate (PVAc) was carried out.

The differences between species as well as types of adhesives used showed a very significant effect on the gluing performance of the assembled material. Species combination glued with UF resulted in shear strength exceeded the minimum industrial requirements of 5.5 MPa and 4.1 MPa under dry and wet conditions respectively. Yellow meranti single species and Kelempayan-Rubberwood combination under wet condition did not meet the requirement. PVAc glued materials did not meet the minimum industrial requirement.

Rubberwood-Rubberwood combinations glued with UF produced boards with highest shear strength of 10.8 MPa and average wood failure of 93.0 per cent. Performance of mixed-species Rubberwood-Kelempayan combination glued with UF produced boards with highest shear strength of 9.4 MPa and the average wood failure of 96.0 per cent.

Generally, mixed-species combinations resulted in comparable strength properties with single species combination except that of Rubberwood glued with UF. Nevertheless, gluing performance of Rubberwood with PVAc improved when combined with Kelempayan or Yellow meranti. Surface quality of adherend had a major effect in gluing performance especially when PVAc adhesive was used. This means adherend with smoother surface produce worse gluing performance.

CHAPTER ONE

I N T R O D U C T I O N

Furniture demand is increasing continuously parallel with population growth ; because new family normally requires a new set of furniture. In the 80's, furniture export from ASEAN countries has increased at very fast rate. This is due to the pressure of increasingly large and sophisticated domestic furniture market in ASEAN countries (Anon., 1990).

In furniture manufacturing, solid wood is commonly used for table-top, even though the other materials such as plywood, MDF, plastic, even some metals and glasses are also used. The use of solid wood as table-top usually based on the natural properties and characteristics such as textures, surface features, and their versatility. etc. Robinson (1965) stated that wood has been adapted for furniture design and has provided furniture manufacturers with greater flexibility in production changes than other materials.

ASEAN countries in particular Malaysia and Indonesia are the major producer of tropical hardwood species.

One of disadvantage of solid wood is that they are rarely available in big sizes suitable for table-tops. This has posed a challenge for furniture manufactures designer to create a new technology to produce the best of table-tops with reasonable price. Through currently available technology particularly gluing and jointing, the possibility of making a larger size of timber suitable for the production of table-tops is good.

Single species is ideal for the production of table-top because of the homogenous nature. However, the supply of preferred species such as Ramin, Teak, Mahogany, and Rosewood, is becoming scarce and not sufficient for future industrial uses. Therefore, attempt to use mixed-hardwood products should be encouraged to supplement the future shortage.

Gluing is a process of uniting two or more pieces of single species as well as mixed species of wood using adhesives. Some hardwood species have similar characteristics such as natural colour, textures and grain, even some physical properties such as shrinkage and strength. Those similarities is important in uniting and gluing mixed species particularly for table-top manufacturing. Light coloured wood is preferred in furniture market demand in recent years. Some species such as Ramin (Gonystylus bancanus), Rubberwood (Hevea brasiliensis), and Damar (Agathis sp.),

are popular species for furniture and interior decoration of wood materials.

Other potential species such as Kelempayan (Anthocephalus chinensis), Yellow meranti (Shorea spp.), are not intensively used in furniture production especially for table-top.

Information on gluing properties of tropical hardwood species and suitability of adhesives for table-top fabrication is still lacking. More research work need to be conducted to provide important basic information for the proper use of potential wood species and types of glue for special purpose.

Three species namely Rubberwood, Yellow meranti and Kelempayan are the potential species for table top production. However, the performance in relation to gluing has yet to be proven. Therefore it is necessary to conduct a laboratory study to assess the suitability of wood-adhesive combination. The present study was conducted with the following objectives :

1. To evaluate the glueline shear strength of single and mixed species hardwoods table-top using Polyvinyl acetate (PVAc) and Urea formaldehyde (UF) adhesives.

2. To determine the factors affecting gluability of mixed hardwoods table-top.

CHAPTER TWO

LITERATURE REVIEW

Table-top have sizes which are usually wider than widths of natural timber. Good adhesives and latest gluing technology could be used to achieve size requirement of table-top. All factors as species of wood, type of adhesive, and technical preparation of substrate, have to be considered in order to produce a satisfactory product and achieve a certain quality standard. Finally the product has to be tested according to certain standard.

2.1 Wood species

Three species of wood namely Yellow meranti (Shorea spp.), Kelempayan (Anthocephalus chinensis) and Rubberwood (Hevea brasiliensis) were used for the study :

2.1.1 Yellow meranti

Yellow meranti (Shorea spp.) is a popular wood species in ASEAN countries particularly in Indonesia and Malaysia. In The United State (U.S.A) and in The United Kingdom (U.K) these species is recognised as yellow seraya. These species is commonly used in the

plywood manufacture. The height of the tree can reach up to 60 m with 150 cm in diameter.

The heartwood is pale-yellow to yellow-brown, sometimes with a slight green tinge. The sapwood is easily distinguisable when dry as it is lighter colour. The specific gravity of Yellow meranti varies from 0.37-0.86 and shrinkage 2.5 per cent of radial and 7.5 per cent of tangential.(Martawijaya et.al, 1981).

This wood can be sawn without difficulty and may be planed and moulded to a good finish. This wood is excellent for joinery works and also suitable for all forms of light construction provided it is not used in contact with the ground. (Anon.,1968). Yellow meranti is satisfactory for plywood, floor construction and cheap furniture.

2.1.2 Rubberwood

Rubberwood (Hevea brasiliensis) is the famous species particularly in Indonesia and Peninsular Malaysia. This species has been planted in Peninsular Malaysia in the past hundred years mainly for its latex. Rubberwood trees are normally replanted after attaining the age 25 - 30 years. Diameter (DBH) of tree can reach up to 50 cm.(Anon.,1988).

The wood is whithish-yellow when freshly cut and season to pale colour, within a pinkish tinge. The sapwood is not differentiated from the heartwood (Paul Ng.1990). Its grain is generally straight and its texture moderately coarse.(Tan et.al.,1981). Air dry density ranging between 560 - 650 kg per cubic meter averaging 640 kg per cubic meter. Shrinkage 0.8 per cent in radial and 1.2 per cent of tangential from green to air dry at 17 per cent moisture content.(Anon.,1988).

Rubberwood has traditionally been used as firewood and for charcoal manufacture in Peninsular Malaysia. However, since the early 70's, it has been processed into blockboard cover and also converted into chips for pulp and paper making. More recently it has been put to more sophisticated uses in furniture making and moulding (Salleh and Sim, 1979 in Hoo et.al.,1982). It is being used as a mixture of rubberwood and other timber species for the manufacture of knock-down furniture (Tan et.al.,1981).

Rubberwood is easily available in Malaysia and commonly used in the furniture industry (Mohd. Shukari et.al.,1985). Rubberwood give a good finish after planing (S4S) and suitable for table-top.

2.1.3 Kelempayan

Kelempayan or Jabon is common name of Anthocephalus chinensis (Lamk.) A. Rich. ex Walp. In The United State (USA) and in The United Kingdom (UK) this species is recognised as Kadam. The tree usually grown in the alluvial swampy soil at the river bank, or at the clay podzolic particularly at the open logged over areas. The height of the tree
with diameter at breast height of 160 cm.

The wood is white-yellowish and very difficult to distinguish between sapwood and heartwood. Wood texture is moderately smooth to moderately coarse, and the grain usually straight. The specific gravity of 0.29 - 0.56 with an average of 0.42. Radial shrinkage of 3 per cent and tangential of 6.9 per cent.

Kelempayan is commonly used for match sticks, box cover, pulp, and light construction materials. It is also very easy to be shaped and processed by machine and give smooth surface (Martawijaya et.al.1989).

2.2 Wood adhesives

Wood adhesives is the material commonly used in wood bonding or jointing to produce wider or longer pieces.

Shield (1970) stated that basic function of adhesive is to fasten the components of an assembly together and maintained the jointed parts under the services conditions specified by the design requirements. According to Blomquist (1983) adhesive as a substance capable of holding materials together by surface attachment. Gent et.al.(1983) defined the adhesion as the state in which two surfaces are held together by interfacial forces which may consist of valence force or interlocking action, or both. The forces of attraction are due to the interaction of molecules, atoms and ions of the two adjacent surfaces.

Wellons (1983) stated that wood has two characteristics that greatly influence its use in bonded assemblies i.e. heterogeneity and variability. Thus, wood adhesives must be capable of bonding adherends that are both heterogeneous and variable.

2.2.1 Adhesives classification

Basically the adhesives can be classified into various groups based on its characteristics and system. Kollmann (1975) classified adhesives into two groups based on chemical constituents of their main composition i.e. (1) Natural glues, and (2) Synthetic glues.

Blomquist (1983) gave the same classification of adhesives with Kollmann (1975) i.e. natural and synthetic glues, however he added synthetic elastomers : neoprene, nitrile, polysulfide. Anon.(1990) described the adhesives based on capability in its utilization :

1. Weather and boil proof type (WBP)

This adhesives have been proved to make joints highly resistant to weather, micro organisms, cold and boiling water, steam and dry heat, such as phenol and resorcinol formaldehyde resins.

2. Boil resistant type (BR)

These adhesives have good resistant to weather and to the boiling water test, but fail under the very prolonged exposure to weather. This type is also resistant to micro organisms attack. Example of this adhesives is urea - melamine formaldehyde resin.

3. Moisture resistant and moderately weather resistant type (MR)

These adhesives providing a high bonding strength in the dry state, and capable withstanding prolonged soaking in water at normal temperature. Also resistant to micro organisms attack. This adhesive as urea-formaldehyde resin.

4. Interior type (INT)

These adhesives should only be used in dry condition, not resistant to moisture or micro organisms. These adhesive may be composed of animal glues, blood albumin, casein and soya.

2.2.2 Adhesive composition

Wood adhesives consist of three components namely base material, solvent and additive materials. Blomquist (1983) specified the component of adhesive as follow :

1. Base

This component may be either of natural or synthetic origin. These material is usually a solid substance become the "back bone" of the adhesive film and which the adhesive usually takes its name, such as phenolic resin or epoxy resin.

2. Solvent

   These liquid materials are required to dissolve or disperse the base material and additives in order to provide a liquid system of all components for application to the adherends.

3. Additive materials

   Additive could be a thinner to produce low viscosity, catalyst to increase the rate of reaction, hardeners, fillers, extenders, preservatives, fortifiers and carriers.

2.2.3 Adhesives selection

Many factors have to be considered based on both of characteristics, adherends and adhesive itself.

According to Marra (1983) two main consideration in the selection of adhesives namely: durability and ease of use. These consideration can be specified into four factors where the adhesive have to resist : Stress, Heat, Moisture and Organism. This factor commonly known as SHMO - factors. Other important consideration is price of the adhesive.

Blomquist (1983) stated that there are three important factors namely the adherends, mechanical properties and cost has to be considered during adhesive selection.

2.2.4 Adhesive used

Based on the requirement of the study two types of adhesives have been chosen namely (1) Urea formaldehyde (UF) and Polyvinyl acetate (PVAc).

2.2.4.1 Urea formaldehyde (UF)

Urea formaldehyde is a thermosetting resin which has been used widely, particularly in hardwood gluing and jointing. Stainer and Warren (1987) stated that thermosetting adhesives such as UF and PF (Phenol formaldehyde), have been used to bond wood products for many decades. Cagle (1973) noted that urea-formaldehyde adhesives are widely used in making hardwood plywood and in various furniture gluing operation.

Selbo (1964) stated that urea resin glue bonds are highly resistant to cold water, and this supported by Clark (1965) noted that urea resin is moderately to highly water resistant and low cost.

Seller et.al. (1991) said that UF resin are the cheapest synthetic thermosetting binder for wood, and the particle board industry. Low costs and emission characteristics of UF resins has generated interest in finding new way of stabilizing it and make it more acceptable to the environment.

Shield (1970) classified that UF adhesives belongs to "moisture resistant and moderately weather resistant joints", can survive full exposure to weather for a few years. They will withstand cold water for a long period and hot water for a limited time, but fail under a boiling water test. Urea formaldehyde normally applied on wood and related materials such as thin veneer and plywood furniture assembly and joineries and in the manufacture of small wood particles at moisture content level between 7 - 15 per cent.

2.2.4.2 Polyvinyl acetate (PVAc)

Polyvinyl acetate is commonly used in furniture and joinery. Clark (1965) said that polyvinyl acetate has poor water resistant properties and suitable only in dry and interior used type. Shield (1970) supported that PVAc adhesive is suitable only for furniture and joinery industries but not suitable for timber structures. According to Cagle (1973), polyvinyl acetate glue was formulated and available since the end of World-War II, and found immediate application in the furniture industry, largerly replace animal glues for edge gluing lumber and for assembly operation. For instances in fastening chair ring to legs, and in dowel and mortise-and-tenon joints.