BONDING STRENGTH OF LOCAL COMMERCIAL WOOD ADHESIVES–(I)

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Summary

Bonding strength of several commercial adhesives was determined through the shear strength of wood joints of walnut (*Juglans regia*), *Eucalyptus camaldulensis* and Juniper (*Juniperus excelse*) wood species. The durability of these adhesives was also estimated after conditioning the wood joints to 65%, 80% and 95% RH at 35°C. In addition the optinum pressing time for each adhesive was determined.

Taking shear strength of walnut wood as a standard for comparison of bonding strength it was observed that different commercial adhesives exhibited highly variable bonding and durability qualities. Rubber based adhesives exhibited very poor bond strength whereas, polyvinyl acetate adhesives provided acceptable bond strength. All adhesives showed loss of strength with an increase in humidity. The gluibility of woods also varied in different species tested in this study. In general, for developing strength the adhesives took lesser time than that prescribed by the manufacturers.

Introduction

A large number of commercial adhesives are available in the local market for use in the wood working and building industry. These adhesives are of different brands and it is not easy to select a proper adhesive for a particular application. Although the adhesive manufacturers supply information to help the user but this infromation is not sufficient for efficient use of the binders. It is recognized that the selection of adhesives depends upon their known performance. However, data regarding performance of the local adhesives is not available in the country.

In order to provide information about the performance of local commercial adhesives to the local adhesive using industries, five commercial wood adhesives were tested for their bonding strength under different humidities. The optimum cramping/pressing time for developing maximum bond strength was also determined.

Materials and Methods

The materials for this study consisted of three wood species and five brands of commercial adhesives. Since all adhesives were in liquid form, their solid contents were determined by

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2. Mention of commercial products does not imply endorsement by Forest Products Research Division, Pak. Forest Institute, Peshawar.

oven drying method. On the basis of solid glue content in each adhesive, the weight of liquid glue for a joint was determined. The infirmation about wood adhesives used in this study is given in the Appendix.

The wood joints were made from one inch thick, air dried flat sawn wooden planks of walnut, juniper and eucalypt wood according to the procedures outlined in ASTM D 905–49 (1). The wood adhesives were spread @75.2 gms/m^2 (oven dry content basis). Wooden jigs were used for pressing the joints. The glued assembly was placed during pressing in the oven at 35 ± 2°C.

The wood joints were tested for their bond strength according to ASTM D 905-49. Prior to testing, the wood joints were conditioned at 35±2°C in the humidity oven at 65% RH for seven days. The standard temperature and humidity conditions as described in ASTM D 905-49 were not applied because the temperature lower than 35°C could not be maintained in the humidity oven.

The durability of wood joints was determined by testing their bond strength after subjecting them to 65%, 80% and 95% RH.

Results and Discussions

Effect of cramping/pressing time on the bonding strength of adhesives

In order to determine optimum cramping/pressing time for developing maximum bond strength in a wood joint, walnut wood joints were made by using different adhesives with variable pressing time i.e. 15 minutes, 30 minutes, 1 hour and 4 hours. The joints were tested for their shear strength after conditioning them at 65±2% RH and 35±2°C temperature. The results (Fig. 1 and Table 1) indicate that an increase in pressing time does not produce improvement in shear strength in a wood joint in case of Mowilith 270 and Calatac WD adhesives. In case of crown wood adhesive increase in pressing time results into the increase in the strength of the joint and 98% of the strength is developed between 30 to 60 minutes of pressing. Aica Aibon-601 and Samad Bond-101 Adhesives, produce joints of varying strength, however, maximum bond strength is developed in them after 15 minutes.

The wood failure results (Fig. 1) indicate that wood failure in Aica Aibon 601 and Samad Bond-101 joints is zero and their shear strength ranges between 6–12 kg/cm^2. This means that the wood joints made by using these adhesives cannot resist shear stresses considerably and delaminate if shear stress in the range of 6-12 kg/cm^2 is applied. The poor shear strength of these adhesives indicates that these can be used for laminating the overlays on to wood surfaces where no shear stresses are applied on a joint.

The Mowilith-270 adhesive which is basically a plyvinyl acetate base adhesive (2), produces maximum bond strength after 15 minutes of pressing at 35°C. The Calatac WD adhesive resembles Mowilith-270 adhesive in physical properties. The joints made by Mowilith and

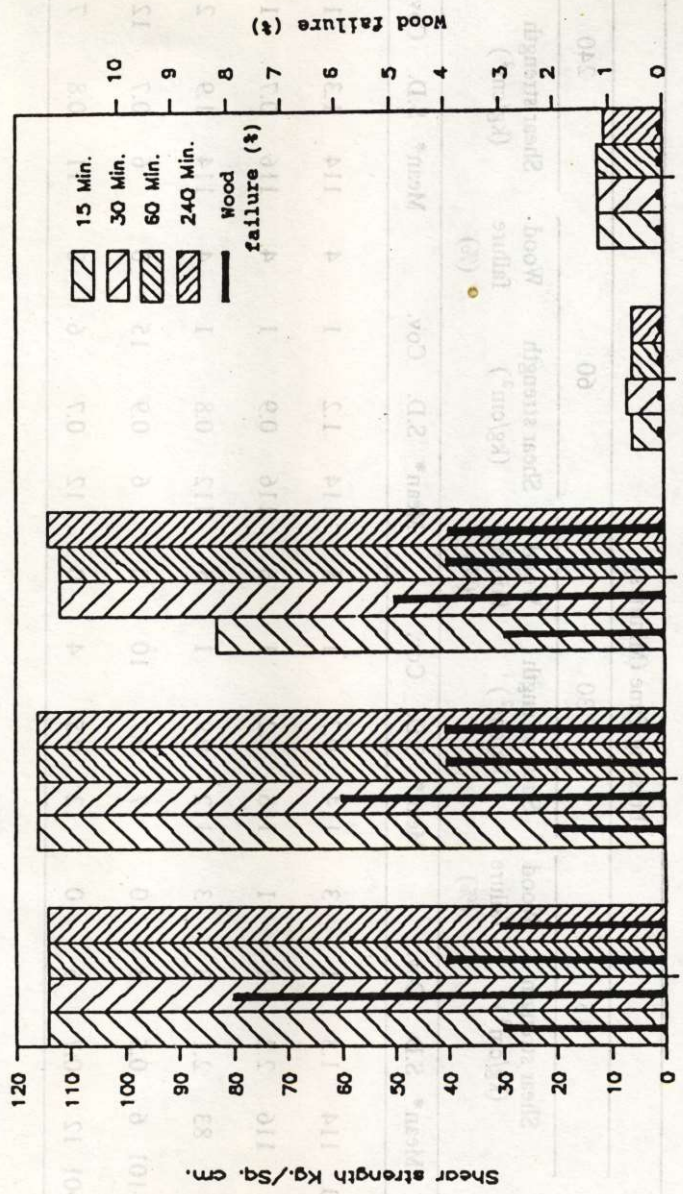


Fig 1: Effect of cramping/pressing time on the bonding strength of adhesives

Table 1. Pressing time and the bonding strength of different adhesives in Walnut wood joints.

Adhesives	Pressing Time (Minutes)															
	15				30				60				240			
	Shear strength (kg/cm^2)			Wood failure (%)	Shear strength (kg/cm^2)			Wood failure (%)	Shear strength (kg/cm^2)			Wood failure (%)	Shear strength (kg/cm^2)			Wood failure (%)
	Mean*	S.D.	Cov.		Mean*	S.D.	Cov.		Mean*	S.D.	Cov.		Mean*	S.D.	Cov.	
Mowilith-270	114	1.3	1	3	114	0.7	1	8	114	1.2	1	4	114	1.3	1	3
Calatac W.D.	116	2.2	2	1	116	1.2	1	6	116	0.9	1	4	116	0.7	1	4
Crown	83	2.1	3	3	112	0.9	1	5	112	0.8	1	4	114	1.9	2	4
Samad Bond-101	6	0.5	8	0	7	0.7	10	0	6	0.9	15	0	6	0.7	12	0
Aica Aibon-601	12	0.7	6	0	12	0.5	4	0	12	0.7	6	0	11	0.8	7	0

* Each figure is a mean of 20 values

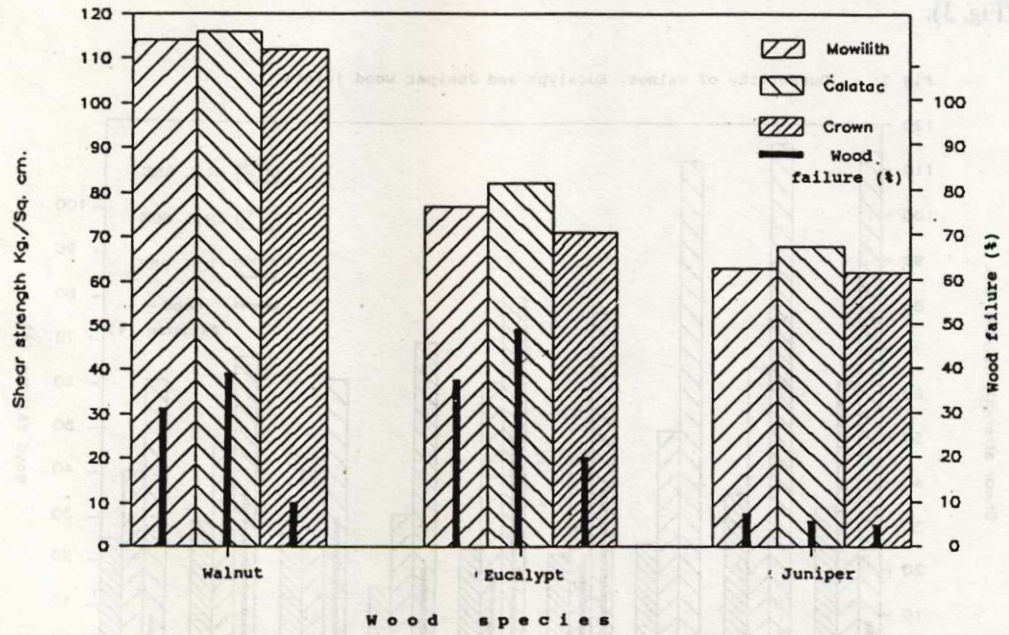
Calatac adhesives develop maximum bond strength after 15 minutes of pressing. On the other hand, the crown wood adhesive develops 98% of maximum strength in 30 mintues. These findings agree with the recommendations of Knight (3).

The greater strength of Calatac WD adhesive joints appears to be due to its higher viscosity than that of others. Conversely the lower strength of the crown wood adhesive joints can also be attributed to the lower solid content of the adhesive. When the quantity of solids in an adhesive syrup are higher, it requres low quantity of the adhesive to be spread on the surface. When small quantity of adhesive is applied, the glue line is thin as compared to that formed by Crown and Mowilith 270 adhesives. It is recognized that thinner glue lines are stronger than thicker glue lines (4).

Gluibility of Walnut, Eucalypt and Juniper wood species.

The results of shear strength of wood joints made from Walnut, Eucalypt and Juniper woods show that walnut has better gluiability for Mowilith 270, Calatac WD and Crown as compared to other woods (Fig. 2). These species can be graded as walnut > eucalypt > juniper

Fig 2: Gluiability of Walnut, Eucalypt and Juniper wood species

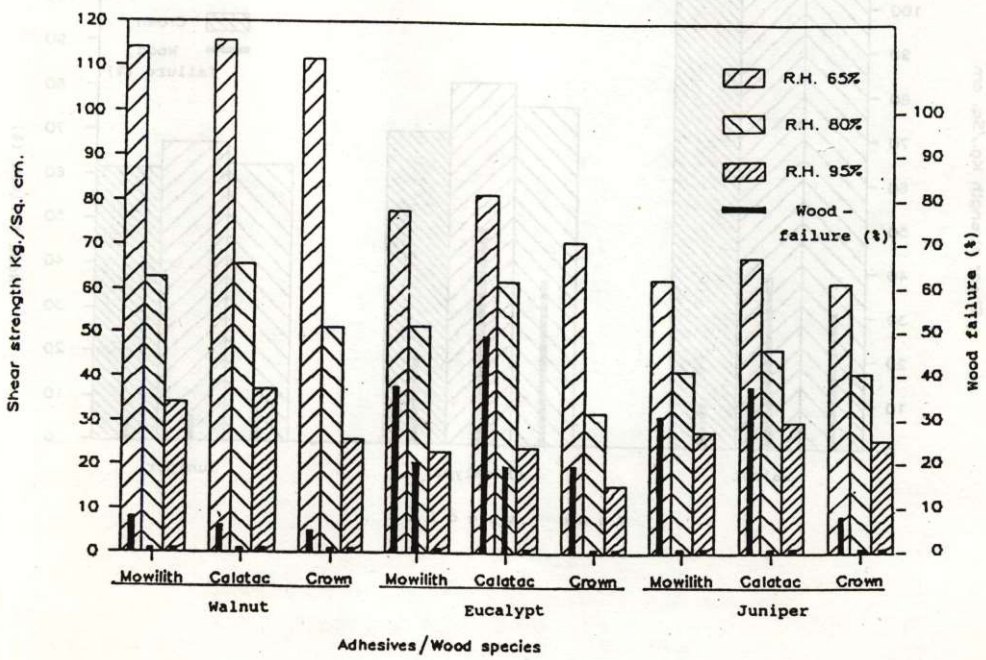


as far as their gluiability is concerned. The shear strength of walnut wood joints is about 41% higher than eucalypt wood joints and about 70% higher than juniper wood joints. The eucalypt wood joints are about 21% stronger than the juniper wood joints. The greater wood failure in case of juniper wood joints as compared to walnut wood joints is because of comparatively poor shear strength of juniper wood. Wood failure in case of Eucalypt wood joints is higher than in walnut wood joints but the strength in latter joints is comparatively lower. This deficiency in strength can be attributed to the presence of loose fibers and seasoning defects like surface checks. Other reasons include the chemical effect of the adhesive at the interface which causes damage. The chemical action within a glue line causes shrinkage and inability to deal with very high tensile stresses developed by shrinkage of timber adjacent to the glue line (5). However, it is very difficult to determine the true reason for the failure of a glued timber joint (3).

Durability of walnut, eucalypt and juniper wood joints

Durability of walnut, eucalypt and juniper wood joints was estimated by determining their shear strength after subjecting them to 65%, 80% and 95% ± 2% RH at 35 ± 2°C for seven days. From the results (Table 2) it appears that in walnut wood joints Mowilith 270 bonds loose about 43-45% of their strength at 80% RH and 67 to 70% of their strength at 95% RH. The Crown bonds lose about 54% strength at 80% RH and 77% strength at 95% RH (Fig. 3).

Fig 3: Durability of Walnut, Eucalypt and Juniper wood joints



In eucalypt wood joints Mowilith 270 and Calatac WD bonds lose about 33% and 24% of their strength at 80% RH respectively. At 95% RH both these adhesives lose about 70% of their strength. The rate of strength loss in crown bonds is 54% and 79% at 80% and 95% RH respectively (Fig. 3).

In case of juniper wood joints, the Mowilith 270 and Calatac WD and crown bonds lose about 31 to 34% of their strength at 80% and 56 to 58% strength at 95% RH (Fig. 3).

Wood failure results (Fig. 3) at 80% and 95% RH indicate that all these three wood adhesives i.e. Mowilith 270, Calatac WD and Crown cannot withstand humid atmosphere. These findings agree with the findings of Knight and Gillespie. They found that these are thermoplastic adhesives and provide excellent dry strength below 43°C but only limited water resistance. Under long exposures to humidity the polyvinyl adhesives are inefficient (6, 7, 8).

Conclusions

Samad bond 101, Aica Aibon 601, Mowilith 270, Calatac WD and Crown wood adhesives are cold setting adhesives and, therefore, cannot be used in manufacturing products involving high temperature. Samad bond 101 and Aica Aibon 601 wood joints cannot withstand shear stress, therefore, these adhesives should be used for laminating the overlays onto wood or wood based panels. Calatac WD bonds are stronger than Mowilith and Crown bonds but they also cannot withstand longer exposures to the relative humidities greater than 65%. These adhesives are useful in furniture and joinery work. Their use for structural purposes is not advised because they give high joint strength at normal temperature.

Table 2. Bonding strength of different adhesives subjected to humidity changes

Adhesives	Relative himidity (%)											
	65				80				95			
	Shear strength (Kg/cm^2)			Wood failure (%)	Shear strength ($Kg//cm^2$)			Wood failure (%)	Shear strength (Kg/cm^2)			Wood failure (%)
	Mean*	S.D.	Cov.		Mean*	S.D.	Cov.		Mean*	S.D.	Cov.	
					Juniper (*Juniperus macropoda*)							
Mowilith-270	63	2.2	5	31	42	1.6	4	0	28	1.5	5	0
Calatac W.D.	68	1.2	2	39	47	1.0	2	0	30	1.0	3	0
Crown	62	1.4	2	10	41	1.1	3	0	26	0.7	3	0
					Eucalyptus camaldulensis							
Mowilith-270	77	1.8	2	38	52	0.8	2	21	23	1.8	8	0
Calatac W.D.	82	1.1	1	50	62	1.1	2	20	24	1.3	5	0
Crown	71	1.7	2	20	32	1.2	4	0	15	0.9	6	0
					Walnut (*Juglans regia*)							
Mowilith-270	114	0.7	1	8	63	0.8	1	0	34	1.7	5	0
Calatac W.D.	116	1.3	1	6	66	1.2	2	0	38	2.1	6	0
Crown	112	0.9	1	5	52	0.9	2	0	26	1.5	6	0

* Each figure is a mean of 20 values.

Calatac WD, Mowilith 270 and Crown wood adhesive require 15 to 30 minutes cramping period for producing maximum bond strength if 75.2 gm/m^2 (oven dry content) of glue spread is used. If glue quantity greater than 75.2 gm/m^2 is used it will require longer cramping periods and the excess glue will also be wasted through leakage from the glue lines.

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Appendix: Information on different adhesives

Adhesives Brand	Marufacturer/ suppliers	Cramping/Pressing time (Minutes) Hours	Glue spread* (g/m^2) 1	2	Solid content of adhesive**
Calatac W.D. Synthetic Glue	ICI Pakistan Ltd. Karachi	3–4	160–185	115.07	64.23
Mowilith-270	Hoechst Pakistan Ltd. Karachi	"	160–185	160.00	47.00
Aica-Aibon-601	Aica Kogyo Co. Ltd. Japan	–	430–645	153.04	49.25
Crown	Malik Traders Mandi Bahuddin Pakistan	3–4	160–185	202.02	37.20
Samad Bond-101	Samad Rubber Works Limited Lahore Pakistan	–	–	202.15	53.58

* Not specified by the manufacturer whether O.D basis or A.D basis.

1. Glue spread recommended by the manufacturer.

2. Actual quantity of glue syrup used in the study. The quantitites mentioned are equivalent to 75.2 gms oven dry glue content.

** Solid content determined by oven drying method.