集結時間이 合板接着强度에 미치는 影響

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The Effect of Variation of Assembly Time on Glue Bond Strength

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Resume

1. In order to investigate the effect of variation of assembly time on glue bond strength, and to determine the optimum range of assembly time with given glue, this experiment was made at the suggestion of the Wood Technology Laboratory, School of Forestry, Yale University.

2. For this investigation, three-ply-plywoods with 1/22 inch, birch veneer, phenolic resin, and soybean glue were made at the following variation of assembly time, that is, 1, 5, 10, 25, 35, 50, and 70 minutes, under both open and closed assembly manners, and the shear strength test at dry and wet were adoptted.

3. The shear strength and wood failure of each plywood panel constructed at the given assembly time have been illustrated in Tables 1, 2, 3 and 4. It has shown that there is a remarkable tendency, for increasing assembly time to give lower shear strength and wood failure throughout almost all cases. The effective range of assembly time of tested glues in this investigation for both open and closed assembly are summarized in the Table 7. Thus, allowable assembly time for Phenolic resin may be up to 10 minutes under open assembly and up to 50 minutes under closed assembly. For soybean glue, the permissible assembly time may be up to 5 minutes under open assembly and up to 15 minutes under closed assembly. The allowable assembly time for open assembly with the same glue is reduced by approximately one third or more than one third as compared with closed assembly time. This might mean that the closed asembly time for these glues is more practical than the open assembly.

I. Introduction

While glue of one kind or another has been widely used by wood-workers and others for many centuries, it still appears to have been considered a more or less mysterious products with many complicated characteristics. Among the complicated characteristics, the assembly time of any given glue may be a good example for discussion.

Assembly time usually refers to the elapsed time after the glue is spread and until the pressure becomes effective. Open assembly time refers to the elapsed time before parts are put together, allowing the solvent to evaporate. Closed assembly time refers to the elapsed time after parts are assembled and before pressure is applied. While assembly time of the given glue, being commercially used by many woodworkers, has been usually accompanied by

instructions of the manufacturer, woodworkers or users, however, do not fully understand about the possible range of the assembly time of the given glue, and possible changes of the characteristics due to the variation of the assembly time, except the very narrow range of the optimum assembly time of the given glue.

Only a little information on this matter has been made available by Forest Products Laboratory for glue manufacturers and users to obtain some ideas on the effect of the assembly time of given glue on the glue bond strength. However, further details on the effect of the variation of the assembly time on the glue bond strength have been requested so that users would be able to carry out a more flexible layout in their manufacturing.

Answering this request, this study has been made in order to investigate the effect of the variation of assembly time of the given glues e.i., resorcinol type, phenolic resin (U.S.P.), low temperature liquid, and Lauxen Glue No. 10B. cold press water-resistant soybean glue, at the Wood Technology Laboratory, Yale Forestry School.

Leading this study, the author is deeply grateful for the helpful suggestions, sincere criticisms and competent guidance made by Dr. F. F. Wangarrd, Yale Forestry School, and for the assistance of Mr. R. C. Clanch at the Laboratory.

2. Materials & Method

2.1 The following materials have been used. Veneer sheets: 1/22 inch in thickness, and 25 inch square of birch veneer were cut into 6 inches by 6 inches of small ply for the construction of 3-ply-plywood panels.

2-2 Adhesives: a) Resorcinol type, phenolic resin-U.S.P., low temperature liquid and U.S.P. catalyst powder for phenol, resorcinol resin liquid. b) Lauxen Glue No. 10B cold press water-resistant soybean glue (no-clamp type).

2.3 Chemicals : The following chemicals were mixed with soy bean Glue.

a. Hydrated calcium ($Ca(OH)_2$)
b. Caustic soda (NaOH)
c. Silicate of soda (Na_2OSiO_2)
d. Carbon disulfide (CS_2)
e. Tetra-sulphide mixture

Specifications of chemicals: Caustic soda (70 percent Na_2O); silicate of soda (water glass) 41 degree Baume and 8.9 percent sodium oxide, 29 percent silica; Hydrated lime -high calcium- at least 98 percent calcium hydrate, all pass through 200-mesh screen; Tetra sulphide mixture 6-4, (Carbon bisulphide 60 parts to carbon tetrachloride 40 parts mixture).

3. Procedures

3.1 Preparation of small ply.

Birch veneer sheets (1/22 inch in thickness and 25 inch sq.) were selected from among veneer piles. They were free from defects and air-seasoned. Each one of 24 sheets was dimensioned into 6 x 6 of small plies. From this cutting, 16 small plies were cut from one large veneer sheet. Among 16 small plies, 8 better plies were chosen for the construction of plywood panels to be tested. The following diagram (Fig. 1) shows the order of cutting of the small ply from the large veneer sheet.

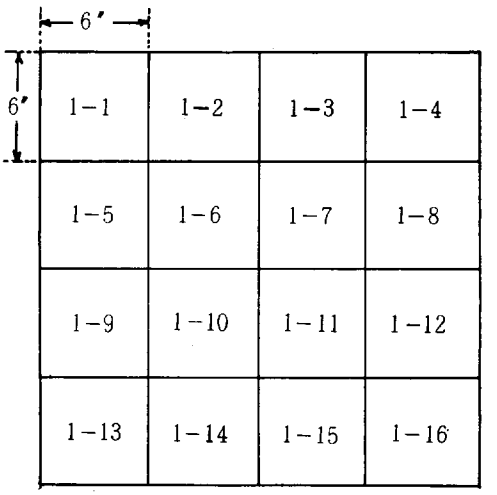


Fig. 1. The order of cutting of the small ply from the large veneer sheet.

At the marking, the left side number expresses

the large veneer sheet and the right side number expresses the small plies so that it is easy to identify the quality of each ply; where it comes from, and what it was before cut.

3.2 Moisture control of ply.

After being cut, the plies were stocked at the laboratory, until moisture content of ply reached the equilibrium condition at the laboratory. Prior to the gluing of each panel, then put into the oven to obtain zero moisture condition for the calculation of moisture content of each ply.

3.3 Matching: In order to eliminate the unexpected results which may come from the improper matching, the matching of ply for the 3-ply plywood construction was made in the following manners. At first, three large veneers which are very close in their quality were selected. After this selection, 8 small plies from one of three large veneer sheets, for the face veneer, were selected and 8 small plies from the other large veneer sheet, for the back veneer, were cut. From the remainder, also 8 small plies for the core were selected. Thus 8 different groups of plywood panel from 24 large veneer sheets were matched. The actual matching followed at this experiment is as the following tables show:

a) Closed assembly with phenolic resin, resorcinol type.

Group 1

Large veneer No.	Small plies to be matched							
1	11	12	10	9	6	5	2	1
2	1	5	7	8	6	3	2	4
5	14	13	9	5	4	3	2	1
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 1 for face; No. 2 for core; No. 5 for back.

Closed assembly with phenolic resin, resorcinol type.

Group 2

Large veneer No.	Small plies to be matched							
3	3	7	8	12	11	10	16	2
4	10	2	3	8	11	12	15	16
8	14	13	12	11	10	7	6	1
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 3 for face; No. 4 for core; No. 8 for back.

b) Open assembly with phenolic resin, resorcinol type.

Group 3

Large veneer No.	Small plies to be matched							
11	16	15	14	13	12	11	10	9
12	2	3	7	9	10	11	12	13
7	14	15	16	11	13	5	8	7
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 11 for face; No. 12 for core; No. 7 for back.

Group 4

Large veneer No.	Small plies to be matched							
10	9	10	11	12	13	14	15	16
6	12	2	1	9	11	14	15	10
9	1	2	3	4	5	6	7	8
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 10 for face: No. 6 for core; No. 9 for back.

c) Closed assembly with Lauxein 10 B soybean glue.

Group 5

Large veneer No.	Small plies to be matched							
17	14	15	13	12	10	9	7	6
21	14	12	11	10	8	4	3	2
13	8	7	6	5	2	3	4	13
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 17 for face; No. 21 for core; No. 13 for back.

Group 6

Large veneer No.	Small plies to be matched							
14	7	6	10	11	14	13	5	2
20	15	14	8	7	6	4	3	2
22	14	12	11	10	6	9	1	5
Assembly time to be allowed	0	5	10	14	25	35	60	70

Veneer No. 14 for face; No. 20 for core; No. 22 for back.

d) Open assembly with Lauxein 10-B soy bean glue.

Group 7

Large veneer No.	Small plies to be matched							
15	11	9	10	13	14	15	15	4
23	3	2	5	6	11	13	14	15
16	15	6	9	10	4	3	13	14
Assembly time to be allowed	0	5	10	15	25	35	50	70

Veneer No. 15 for face; No. 23 for core; No. 16 for back.

Group 8

Large veneer No.	Small plies to be matched							
18	14	9	10	12	6	7	4	2
24	1	16	3	4	5	13	14	15
19	16	15	14	13	12	11	10	9
Assembly time to to be allowed	5	10	15	25	35	50	70	

Veneer No. 18 for face; No. 24 for core; No. 19 for back.

3.4 Gluing Operation: a) Proportion of glue; 100 parts of phenolic resin and 20 parts of U.S.P. catalyst powder. b) Mixing of glue; Mixer, at first, was prepared and 100 parts of phenolic resin placed into the mixer. Following this, 29 parts of U.S.P. catalyst placed into the phenolic resin. Stirred until complete distribution of catalyst was obtained, about 5 minutes. c) Spreading of glue: Amount of glue per M. sq. ft. required was 50 to 55 pounds and single glue line per 1/4 sq. ft required was 6 grams. The spreading of glue was done with hand spreader. Temperature to be applied; It was applied cold setting at the room temperature. Next: Soy-bean glue. a) Proportion of glue; 200 parts of water at 70 degree Fahrenheit into the mixer. 100 parts of lauxein 10-B. 110 parts of water at 70 degrees Fahrenheit. 7 parts of lime in 20 parts of water. 8 parts of caustic soda in 20 parts of water. 25 parts of silicate of soda and 3 parts of tetra-sulphide mixture. b) Mixing of glue; At first, mixer and various chemicals above mentioned were prepared, then 200 parts of water (70 degrees Fahrenheit) placed into the mixer. Added 100 parts of Lauxen 10-B into the water. Stirred about three minutes until lump-free. Added 110 parts of water again. Mixed for two or three minutes. Added 7 parts of lime and mixed. Added 8 parts of caustic soda and mixed again. Following this, 25 parts of silicate of soda were added and mixed. At last, added 3 parts of tetra-sulplhide and stired for about 5 minutes. Thus glue was ready to be used. c) Spreading of glue; Amount of glue per M. sq. ft. required was 60 to 65 pounds, and single line per 1/4 sq. ft. required was 6 grams. Spreading of glue was done with hand spreader. Temperature; Cold setting at room temperature.

3.5 Pressing Operation: After gluing operation, keeping the required assembly time exact, pressing was accomplished, with the use of a handscrew press. Pressing period; For phenolic resin, it was kept over night under pressure. For the Soybean glue, 15 minutes was required. Pressing load; For the phenolic resin, 150 pounds per sq. in. was applied.

3.6 Shear testing; 2-days after plywood constructed, the shear test specimen was cut (Fig. 2) and tested both dry and wet. For the dry test, specimens were tested without any treatment before testing. However specimens for the wet test were soaked in cold water at room temperature for 24 hours. After cold water treatment, it was tested. Loading velocity was 800 pounds per minute.

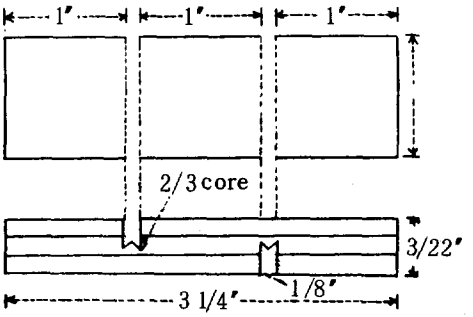


Fig. 2. Shear test specimen.

4. Result

Results obtained from this experiment were summarized as the following tables indicate.

4.1 Shear strength and wood failure of plywood panel constructed by open assembly with phenolic resin, U.S.P. resorcinol type, low temperature liquid.

Table 1

Assembly Time	Dry test		Wet test	
	P.S.I.	W.F.	P.S.I.	W.F.
1	440	24	401	63
5	368	26	336	32
10	232	18	224	22
15	139	13	150	11
25	150	8	85	3
35	96	1	39	0
50	76	2	24	0
70	74	0	00	0

P.S.I. means the strength pound per square inch. W.F. means wood failure.

4.2 Shear strength and wood failure of ply-wood panel constructed by closed assembly with phenolic resin U.S.P. resorcinel type, low temperature liquid.

Table 2

Assembly time	Dry test		Wet test	
	P.S.I.	W.F.	P.S.I.	W.F.
1	452	56	407	57
5	417	85	402	51
10	379	73	393	45
15	407	86	450	66
25	420	56	500	48
35	396	19	435	36
50	350	12	262	25
70	372	25	454	64

P.S.I. means the strength pound per square inch. W.F. means wood failure.

4.3 Shear strength and wood failure of plywood panel constructed by open assembly with soy-bean glue. Lauxein 10-B No-clam.

Table 3

Assembly time	Dry test		Wet test	
	P.S.I	W.F.	P.S.I.	W.F.
1	218	25	167	20
5	228	8	134	11
10	196	9	133	11
15	195	3	146	12
25	197	3	65	4
35	167	2	85	2
50	134	2	49	1
70	24	0	0	0

P.S.I. means the strength pound per square inch. W.F. means wood failure.

4.4 Shear strength and wood failure of plywood panel constructed by closed assembly soy-bean glue, Lauxein 10-B No-clamp.

Table 4

Assembly time	Dry test		Wet eest	
	P.S.I.	W.F.	P.S.I.	W.F.
1	329	15	182	22
5	323	19	180	14
10	301	17	192	24
15	309	16	199	19
25	260	20	137	18
35	282	6	152	8
50	238	1	137	25
70	227	13	142	10

P.S.I. means the strength pound per square inch. W.F. means wood failure.

5. Discussion

Unsatisfactory glue joints may be affected by many factors involved in the gluing operation. However, satisfactory glue joints in plywood manufacture are desirable, since they develop the full strength of the wood under all conditions of stress.

To produce this result, the conditions involved in the plywood manufacture, particulary in the glue operation, must be carefully controlled so as to obtain a continuous thin film of solid glue in the joint with adequate adhesion to both surfaces of the wood. These conditions involve:

1. Proper assembly time.
2. Proper moisture content of wood.
3. Properly prepared wood surfaces.
4. Glue of good quality.
5. Good gluing technique.
6. Proper amount of glue.

Assembly time ..... Among the above-mentioned many conditions, the assembly time may have great significance in the quality of plywood manufacture not only on the quality, but also on the coefficient of the plywood manufacture at the factory. This is why this investigation has been made to study the effect of assembly time on the glue bond strength.

As mentioned before, the time which elapses between the spreading of the glue of the wood and the application of pressure is called the assembly time. In gluing plywood and veneered panels the common practice is to build up a stack of panels 2 feet or more in height and to place them under pressure at one time. In this method of assembly, 20 minutes or more may elapse from the time the first panel of a stack is spread with glue before it is under pressure, whereas the last panel spread with glue may be pressed within two minutes.

After glue has been spread on dry wood, it thickens in some cases more rapidly than others. If too much time elapses after glue is spread, evaporation takes place resulting in dryness on the panel surface. It may result in unsatisfactory contact of glue and wood. If the time is too short to press the glued panels, it may result in too much of squeeze-out adding more water to the wood than necessary and may cause the wood to split out of position while being pressed. Therefore, to make a satisfactory joint it is important that the assembly time of a given glue be adequate. This has requested an investigation of the effect of assembly time of different glues due to the different assembly times, at both open and closed assembly. And for this investigation, 3 plies of plywood panel were constructed.

The proper moisture content: The moisture content of the veneer affects the results obtained in gluing and, in turn, is affected by the gluing process. It may be either increased or decreased, depending on

1. The gluing process used.
2. The form and composition of glue.
3. The amount of glue spread.
4. The dimensions of the veneer parts glued.

In general, hot press methods reduce the moisture content and cold processes increase it. Glues of high water content add more moisture to the wood than glue of low water content and heavy spread add more moisture than light spreads. More water is added by the glue to a construction made of thin plies than the one made of thick plies. The percentage increase in moisture content from a given amount of glue spread will be greater in woods of low specific gravity than in woods of high specific gravity.

Moisture content of veneer used at the time gluing is illustrated by the following table. The range of moisture content of veneer was minimum 6.50 percent to maximum 9.15 percent. However, the moisture content of each veneer among the same groups was much close of each other as illustrated in Table 5.

Table 5. Moisture content of veneer.

No. of Group	Veneer No.	Moisture Cont.	Remark
Group 1	1	8.75%	
	2	8.55	An average moisture
	5	9.15	content of these
Group 2	3	8.35	groups in 8.56%
	4	8.30	under closed assembly
	8	8.25	with phenolic resin
Group 3	7	6.60	
	11	6.80	An average moisture
	12	66.0	content of these
Group 4	6	6.60	groups is 6.65%
	9	6.80	uner open assembly
"	10	6.50	with phenolic resin.
Group 5	13	6.65	
	17	7.20	An average moisture
	21	7.30	content of these
Group 6	14	7.50	groups is 7.17%
	20	7.15	under closed assembly
	22	7.30	with soy-bean glue.
Group 7	15	7.05	
	16	7.20	An average moisture
	23	6.85	content of these
Group 8	18	8.05	groups is 7.55% under
	19	8.30	open assembly with
	24	7.85	soy-bean glue.

The average moisture content of veneers applying phenolic resin under closed assembly was 8.56 percent, ranging 8.25 percent to 9.15 percent of moisture content. And the average moisture content of veneers under open assembly with the same glue was 6.65 percent, ranging 6.50 percent to 6.80 percent. Veneers applying soy-bean glue under closed assembly had had an average 7.17 percent of moisture content ranging 6.65 percent to 7.50 percent and veneers applied open assembly with the same glue had an average 7.75 percent, ranging 6.85 percent to maximum 8.30 percent of moisture content.

According to previous study, it was learned that a range in moisture content of wood between about 7 to 12 percent give max. strength when tested both dry and wet for both the cold setting resin and casein glues. Since ply thickness, species, glues and gluing processes affected the percent of moisture added to wood, the optimum moisture content for maximum strength varies somewhat with different structures and processes. Considering all factors, however, it is recommended that, in cold press gluing, veneers and thin laminations up to 1/8 inch in thickness have, at the time of gluing, a moisture content of 5 percent to 8 percent, and that stock thicker than 1/8 inch have from 8 to approximate 12 percent. For the soy-bean glue, it is, however, recommended that the moisture content of veneer is permissible range 5 percent to 14 percent, and optimum range 9 to 12 percent.

In comparison with the foregoing recommendation, the moisture content of veneers used in this experiment was within quite a reasonable range, although the veneers applying Soy-bean glue had somewhat lower moisture content than the recommended optimum range of 9 to 12 percent.

Temperature: Temperature in the gluing operation should be controlled within recognized limits, which are governed largely by the characteristics of the glues. Temperature affects the working life of the glue solution, the permissible assembly time (or period), the rate of setting of the glue, and the conditioning of the glued stock. Temperature required for both phenolic resin and casein or soy-bean glue which were used in this investigation was low, and cold setting glue was used. However, it has been realized that the effect of temperature of gluing room and stock on the permisible assembly periods for casein and cold-setting synthetic resin glue is not critical. Now the actual temperature during use of both soy-bean and phenolic resin glue

was an average 79 degree Fahrenheit, ranging 78 to 81 degree Fahrenheit. Only small deflection of temperature, 3 degree Fahrenhelt, during the gluing between max. and min. temperature had been seen. Therefore the effect of temperature on the assembly period for this investigation may be negligible.

Other Factors Affecting: Except the moisture content of veneer and the temperature required, all other affecting factors to be taken into consideration during this experiment have been controlled just the same as in each case of the tested assembly time.

The effect of assembly time with phenolic resin: The effect of assembly time on the strength of phenolic resin glue joint under open assembly condition is illustrated in Fig. 3. The tests were made only-wood, glued with three plies of 1/22 in. Birch veneer of 6.5 percent to 6.8 percent moisture content under 150 pounds of pressure per square inch and at a room temperature (78 degree Fahrenheit). The dry strength tests were made on the ply-wood three days later, after glued, and wet strength test immediatly after soaking the specimens into water at room temperature for 24 hours. Maximum dry and wet strength of cold setting U.S.P phenolic resin under open assembly were obtained at assembly time one minute, then increasing assembly time, while decreasing strength gradually, minimum dry and wet strength at the assembly time of 70 minutes were obtained. Particulary a minimum wet strength at assembly time 70 min. was zero, that means all delamination during soaking specimens for 24 hours. Wood failures at both the dry and wet strength test have also shown almost same characteristics with the strength (that is, increasing assembly time meant decreasing wood failure). Data obtained has made a remarkable line in both dry and wet strength at assembly time between 15 and 10 minutes. In another words, both shear strength and wood failure at the assembly time 15 minutes were low or too low. According to previous study, it has been recommended that the allowable shear strength for the synthetic resin must be more than 350 P.I.S. or at least that. Therefore, following this recommendation, assembly time one to five minutes for U.S.P. phenolic resin under open assembly may be permissible.

However, the maximum dry and wet strengths with the same glue and materials under closed assembly were obtained at assembly time of one-minute at dry test, and at 70 minutes in wet test, as illustrated in Figure 4. At assembly times of 5, 15, 25, and 35 minutes, dry strength values were much closed in comparison with the strength values at assembly times 10, 50, and 70 minutes, which were also close to each other. Thus, it has not been shown that there is any clear markable line, grouping two with little different values between as above

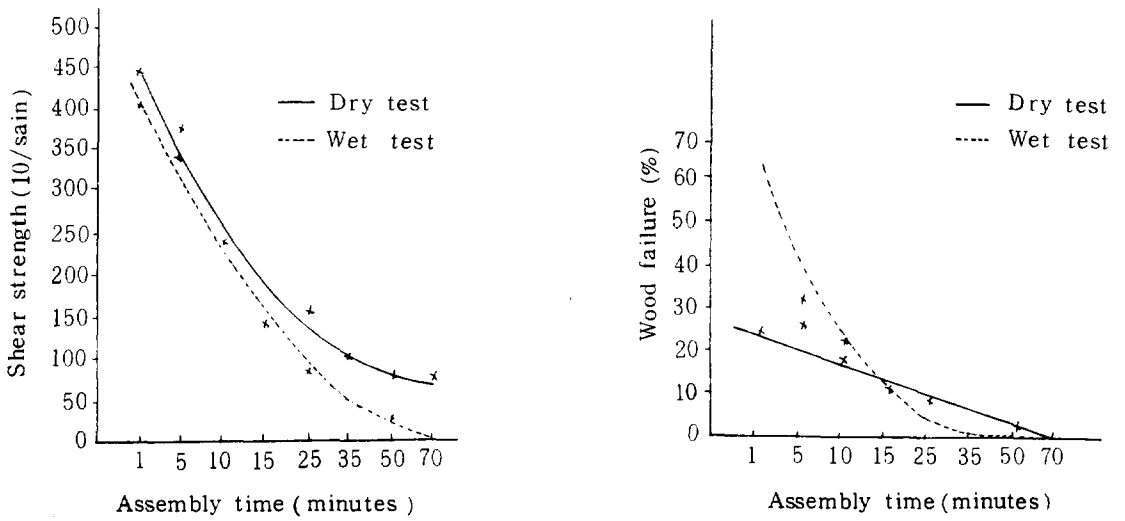


Fig. 3. Dry test (open assembly with P.H.R.) and Wet test.

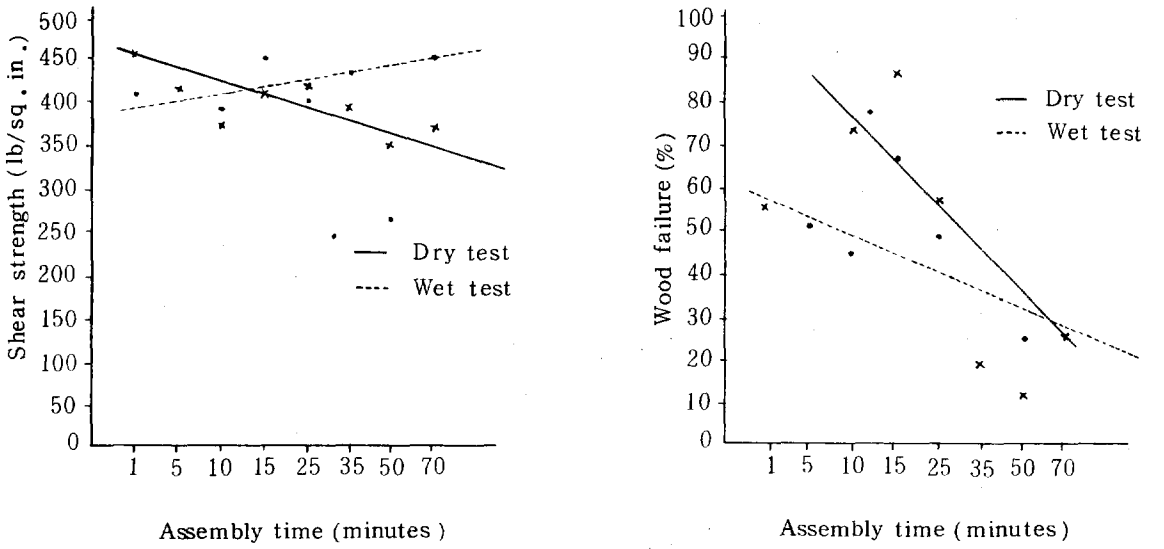


Fig. 4. Dry test (closed assembly with P H R)and wet test.

mentioned. However, dry strength in all cases of assembly period were the favorable strengths in practical purpose, compared with the recommendation, as shown at the Fig. 4. There is also seen a tendency in the dry strength test that increasing assembly time decreases strength gradually. Wet strength, but, has a different shape compared with dry strength, in other words, the increased assembly time increases strength, as shown by the same Fig. 4. This reversed result at the wet strength test, compared with dry strength, might result in an uneven and irregular film of solid glue, due to the different amount of glue squeezed out from glue line at the pressing, which might be the result, as the wet strength test. Strength and wood failure at wet test except the value at assembly time 50 min. are favorable. But longer assembly time, more than 50 minutes, may not be profitable for practical purpose. Therefore, the permissible assembly time for U.S.P. phenolic resin under closed assembly may be one or less than 50 minutes.

Soy-bean Glue: The effect of assembly time on the strength of soy-bean glue joint under open assembly conditiion is illustrated in Fig. 5. Maximum

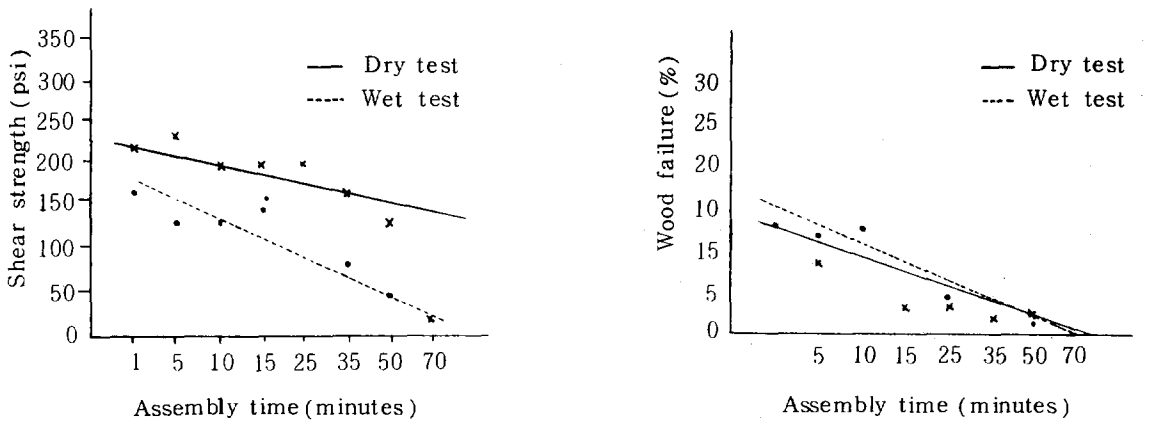


Fig. 5. Dry test (open assembly with soy bean) and wet test.

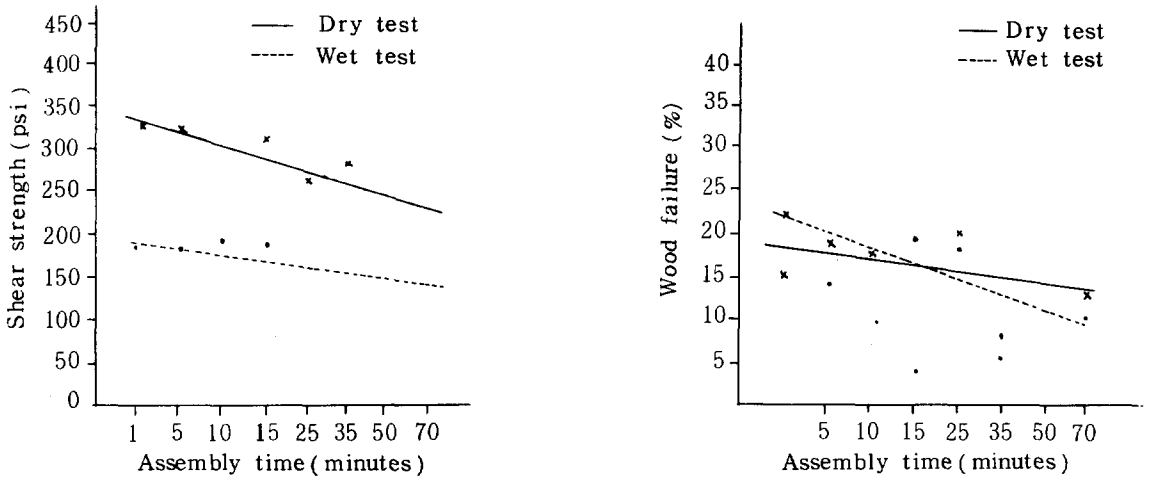


Fig. 6. Dry test (closed assembly with soy bean) and test.

dry and wet strengths of cold press soy-bean glue under open assembly were obtained at assembly time five minutes in dry test, and one minute in wet test. There has also been a remarkable tendency for increasing assembly time to have a correspondingly decreasing strength, showing minimum dry and wet strengths at assembly time 70 minutes. Zero strength means that glued veneer had been set before test in dry and delaminated during soaking in wet test. In other words, glue spread on the 'veneer was already set before pressing, then could not be satisfactorily stacked together. In this case, permissible assembly time for soy-bean glue under open assembly may be less than five minutes, wood failures of both dry and wet are low at assembly time 25 minutes . Also dry and wet strengths are low at assembly time over 35 minutes at dry test and 25 minutes at wet test.

With the same glue, maximum dry and wet strengths under closed assembly, however, were obtained at assembly time one minute at dry test and 10 minutes at wet test. Maximum wood failure of dry and wet test were obtained at assembly time 25 minutes at dry test and 50 minutes at wet test.

As illustrated in Fig. 6, there is a outstanding line, showing that increasing assembly time have been matched with decreasing strengths in both dry and wet tests, between assembly time 25 minutes and 35 minutes, that is, longer assembly time over 25 minutes have considerably decreased strength. These are low or too low. Therefore, under closed assembly, assembly time of less than 15 minutes may be permissible for the soy-bean glue.

Glue.

In the following table 6 are given approximate ranges in assembly times which are recommended as a guide in gluing cold setting glues under open and closed assemblies, and for given ranges of temperature and gluing pressure.

Table 6

Kind of glue	Temperature	Pressure	Manner of assembly	Allow. time
Urea resin	70–90°F.	100–200 PSI	Closed	Up to 20 min.
Urea resin	do	do	Open	Up to 10 min.
Casein glue	do	do	Closed	Up to 20 min.
Casein glue	do	do	Open	Up to100 min.

Where the cold-setting glues are coated on wood parts and left exposed to the atmosphere (open assembly), the allowable assembly time is reduced by approximatety one half, as compared with closed assembly periods. In the following Table 7 the permissible ranges of assembly time obtained from this experiment for both phenolic resin and soy-bean glue which are cold setting glues and tested both open and closed assembly have been shown.

Table 7

Kind of glue	Temperature	Pressure	Manner of Assembly	Allow. time
Phenolic resin	78–91°F.	150 PSI	Closed	Up to 50 min.
Phenolic resin	do	do	Open	Up to 10 min.
Soy-bean glue	do	200 PSI	Closed	Up to 15 min.
Soy-bean glue	do	do	Open	Up to 5 min.

In comparison with foregoing previous studies, the allowable assembly time of phenolic resin is more longer than that of urea resin at closed assembly. However, longer assembly time, even within permissible range of assembly time, may not be recommended for practical purposes. And the allowable assembly time of soy-bean glue is shorter than that of casein glue at open assembly. The shortest assembly time, like one minute, may not be also profitable since the amount of queezed out is seen more at the shortest assembly time than the longer. At this experiment, also the allowable assembly time for open assembly with the same glue is reduced by approximatly one third or more than one third as compared with closed assembly times. This might mean that the closed assembly for these glue is more practical than the open assembly.

Plate 1 and 2 have shown the amount of squeezed out, and Plates 3 and 4 have shown wood failures closey related to the different assembly time applied.

CONCLUSION:

With the data obtained from this experiment, the following conclusion has been made.

The shear strength and wood failure of each ply-wood panel constructed at the given assembly time have been illustrated in Tables 1, 2, 3 and 4. It has been shown that there is a remarkable tendency, for increasing assembly time to gives lower shear strength and wood failure throughout almost all cases.

The effective range of assembly time of tested glues in this investigation for both open and closed assembly are summarized in the following table.

Table 8

Kind of glue	Temperature	Pressure	Manner of Assembly	Allow. time
Pheonlic resin	78–81°F.	150 PIS	Closed	Up to 50 min.
Phenolic resin	do	do	Open	Up to 10 min.
Soy-bean glue	do	200 PIS	Closed	Up to 15 min.
Soy-bean glue	do	do	Open	Up to 5 min.

Thus, allowable assembly time for phenolic resin (U.S.P. Resorcinol type, low temperature liquid) may be up to 10 minutes under open assembly and up to 50 minutes under closed assembly.

For soy-bean glue (Lauxein 10-B, cold press water resistant, none clamp, made in Mosantos Chem. Co.), the permissible assembly time may be up to 5 minutes under open assembly and up to 15 min. under closed assembly. The allowable assembly time for open assembly with the same glue is reduced

by approximately one third or more than one third as compared with closed assembly times. This might mean that the closed assembly for these glues is more practical than the open assembly.

摘 要

1. 이 硏究는 Yale大學校 林科大學木材利學校室에서 最近 새로히 쓰기 始作한 phenolic resin의 一種과 soy-bean glue lauxein 10-B에 對하여 assembly time의 變動이 製作된 合板이 shear strength에 어떠한 영향을 주는가를 알고 또한 그의 比較的 適當한 實質的인 assembly time의 範囲를 決定하기 위하여 實施된 것이다.

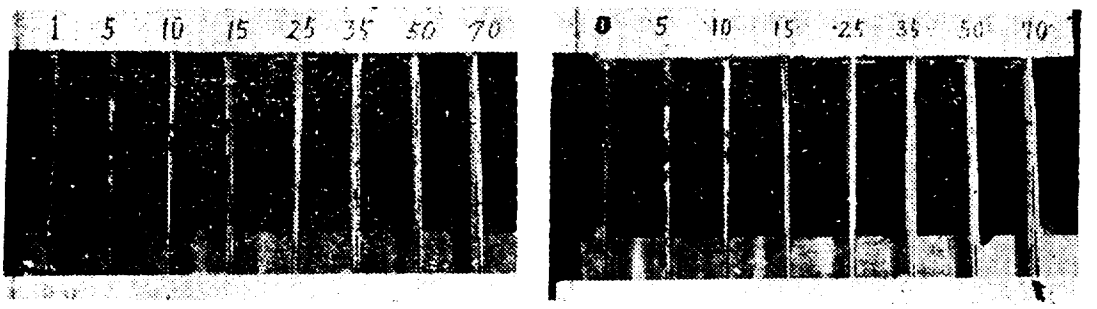
2. 이 硏究에서 쓴 단판은 同實驗室에 實驗用材料로 備置된 1/22 in. 너도 밤나무(beech) 단판을 使用하였으며 수지는 phenolic resin U.S.P. low temperature liguid resorcinol type와 Lauxein No. 10-B cold press water-resistant soy-gule 등으로 實驗用 sample을 購入하여 使用하였다.

3. 實驗用 ply-wood는 三合式으로 實驗을 하게된 assembly time의 variation은 一分에서 始作하여 5, 10, 15, 25, 35, 50, 70分 등으로 8個의 variation이 있게 하고 assembly 法으로는 open assembly와 closed assembly의 2法으로 하였으며 製作된 ply-wood의 性質比較는 dry test와 wet test의 shear strength test를 通하여 나타나는 shear strength와 목파율을 가지고 하였다.

4. assembly time의 variation에 따른 합판의 shear strength와 목파율은 Table 1. 2. 3. 4에 表示된 바와 같은 結果를 보였으며 phenolic resin을 갖이고 closed assembly 法으로 製作된 합판의 wet test를 제외하고는 모두 assembly time이 增加됨에 따라 shear strength와 목파율은 減少되여가는 傾向을 보이고 있다. 그리고 實質的으로 有效한 assembly time의 범위는 다음 表(8)과 같다.

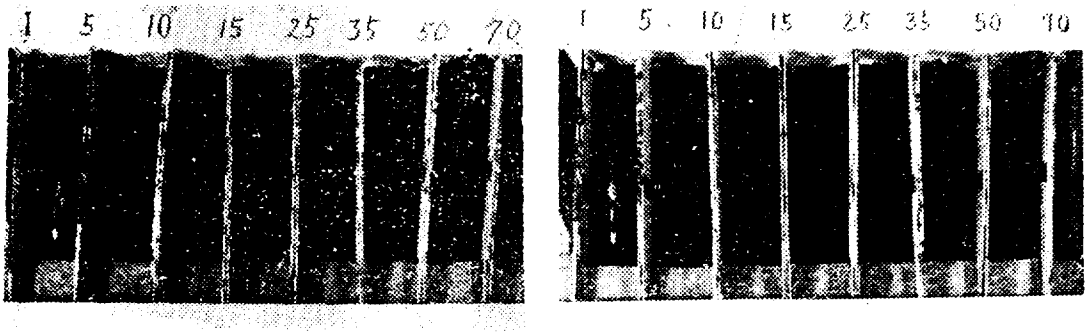
Kind of glue	Temp	Pressure	Manner of assembly	Allow time
Phenolic Resin	78-81°F	150 P. S.I	Closed	1-50分
〃	〃	〃	Open	1-10〃
Soy-bean Glue	〃	200 P. S. I	Closed	1-15〃
〃	〃	〃	Open	1-5〃

5. 이 實驗을 하는 동안 親切한 忠告와 指導鞭達를 애끼지 않고 도와주신 Yale大學校 木材利用學敎授 Dr. F. F. Wangaard 氏와 Prof. Hess 氏, 그리고 實驗室 擔任者인 Mr. Clanch 氏에게 衷心으로 謝意를 表示한다.



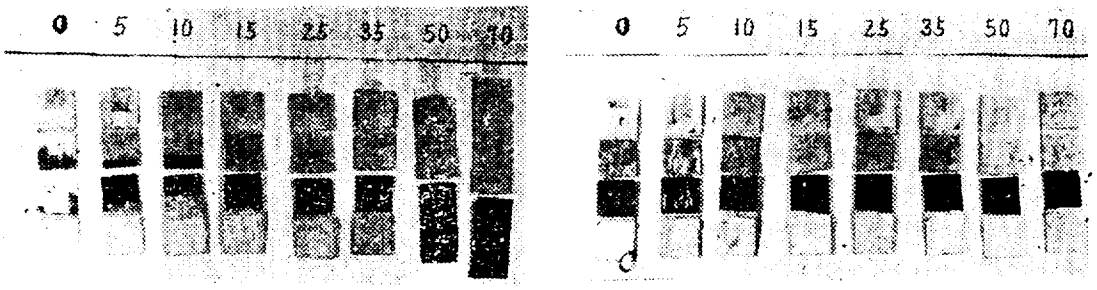
1 : A 1 : B

Plate 1: A: The amount of glue squeezed out due to the different assembly time at pressing, under closed assembly with Lauxein 10B soy-bean glue: Numbers shown at top express the different assembly time. B: The same under open assembly.



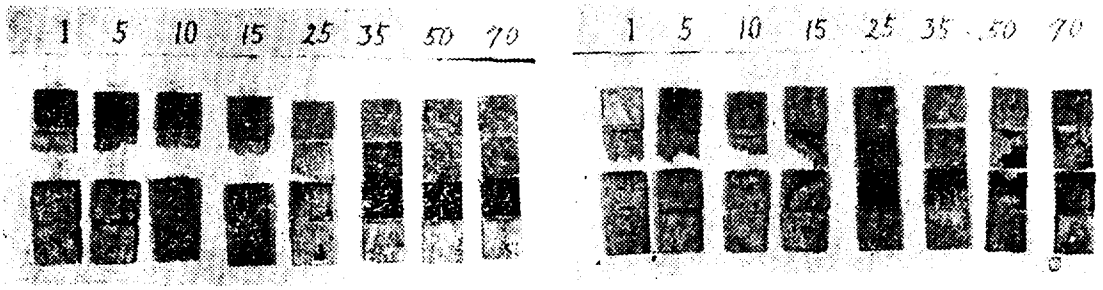
2 : A 2 : B

Plate 2 : A: The amount of glue squeezed out due to the different assembly time at pressing, under closed assembly with phenolic resin: num-beres shown at top express the different assembly time. B: The same under open assembly.



3 : A 3 : B

Plate 3 : A: The amount of wood failure at dry test, due to the different assembly time under open assembly with phenolic resin. B: The same at wet test.



4 : A 4 : B

Plate 4 : A: The amount of wood failure at dry test, due to the different assembly time under closed assembly with phenolic resin. B: The same at wet test.

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