Cottonseed and Peanut Meal Glues: Permanence of Plywood Glue Joints as Determined by Interior and Exterior Accelerated Cyclic Service Tests

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THE preparation and strength properties of cottonseed and peanut meal glues for use in bonding plywood have been described in previous reports from this laboratory (2, 3). It was indicated that cottonseed and peanut meal glues prepared from solvent-extracted meals compare favorably with commercial casein glues in static strength properties.

In order to evaluate these meal glues for potential industrial uses, dynamic tests, simulating actual use conditions and indicating the resistance of the plywood adhesive bond to deteriorating influences, were made. The purpose of this report is to present data on the strength properties of cottonseed and peanut meal glues in plywood bonds as they are affected by dynamic tests, i.e., accelerated interior and exterior cyclic service tests, and to suggest potential industrial uses for these meal glues.

Experimental

Glue formulation. Cottonseed meal glue, consisting of 100 parts of hexane-extracted meal, 4 parts of sodium hydroxide, 15 parts of sodium silicate, 15 parts of calcium hydroxide, and 3 parts of carbon disulphide-carbon tetrachloride, was prepared as previously described (3). Peanut meal glue was prepared from solvent-extracted peanut meal in a similar manner (2). The casein glue was a commercially available glue mix which required only the addition of water.

Plywood preparation. Each glue mix was prepared and applied to birch veneer to form three-ply panels as recommended to give maximum shear strengths. These recommended conditions were selected in order that each glue could be compared under its optimum utilization. The cottonseed meal glue was applied at a rate of 21 pounds of glue (dry basis) per 1,000 square feet of glue line, cold pressed at 80°F. and 200 p.s.i. for 1,440 minutes, and followed by hot pressing at 237°F. and 200 p.s.i. for 10 minutes. The peanut meal glue was applied at a rate of 28 pounds of glue (dry basis) per 1,000 square feet of glue line and cold pressed at 80°F. and 200 p.s.i. for 1,440 minutes. The commercial casein glue was applied at a rate of 26 pounds of glue (dry basis) per 1,000 square feet of glue line, cold pressed at 80°F. and 200 p.s.i. for 1,440 minutes, and followed by hot pressing at 237°F. and 200 p.s.i. for 10 minutes. The press opening during these operations was five 3⁄16-inch panels. Test pieces, 3⁄16 inch, 3¼ inches by 1 inch, cross-slotted to give a center section of 1 square inch, were cut from the plywood panels; then they were conditioned at 77°F. and 32% relative humidity for 6 days (1).

Method of testing. The interior accelerated service test consisted of subjecting the conditioned test pieces to exposure in an atmosphere having 85-90% relative humidity at 77°F. for 48 hours and on removing the pieces from this atmosphere immediately determining the tensile shear strengths of 20 test pieces. This constituted one test cycle. Then the remaining unbroken test pieces which had been subjected to the first test cycle were reconditioned at 77°F. and 32% relative humidity for six days, followed by resubjecting them to exposure in an atmosphere having 85-90% relative humidity at 77°F. for 48 hours, and then on removing them from this atmosphere immediately determining the tensile shear strengths of 20 test pieces. This constituted two test cycles. Subsequent test cycles were made in a similar manner.

The exterior accelerated service test consisted of immersing the conditioned test pieces in water at 77°F. for 48 hours and on removing the pieces from the water immediately determining the tensile shear strengths of 20 test pieces. This constituted one test cycle. Then the remaining unbroken test pieces which

TABLE I

Effects of Accelerated Service Tests on Tensile Shear Strengths of Bonded Wood Materials [1]

Accelerated service test	Number of cycles	Tensile Shear Strengths[2] Average	Range	Standard deviation	Standard error	Coefficient of Variation	Wood Failure
		(lbs./in.²)	(lbs./in.²)	(lbs./in.²)	(lbs./in.²)	%	%
Cottonseed Meal Glue[3]							
Interior	0	375	306-388	41	9	11	85
	1	368	300-384	56	12	15	75
	3	284	255-314	47	11	17	60
	5	264	221-291	40	9	15	45
	7	202	161-268	38	9	17	25
	9	127	87-145	33	7	26	5
Exterior	1	135	122-154	15	3	11	40
	3	76	47-101	9	2	12	0
	5	36	0-66	5	1	14	0
Peanut Meal Glue[4]							
Interior	0	368	302-390	44	10	12	70
	1	358	301-387	32	7	9	65
	3	289	259-320	58	13	20	50
	5	231	205-259	37	8	16	45
	7	149	106-215	19	4	12	25
	9	92	71-123	25	6	30	10
Exterior	1	133	115-147	18	4	14	20
	3	56	41-74	7	2	13	0
	5	27	0-53	5	1	19	0
Commercial Casein Glue							
Interior	0	384	358-405	34	8	9	100
	1	378	354-400	42	9	11	90
	3	292	256-321	44	10	15	60
	5	283	231-315	45	10	16	50
	7	256	215-291	41	9	16	45
	9	193	144-223	37	8	20	20
Exterior	1	173	151-188	21	5	12	75
	3	116	68-138	17	4	15	15
	5	72	44-93	11	3	14	5
	7	57	0-81	11	3	19	0

[1] Each glue mix and glue line prepared as recommended to give maximum tensile shear strengths.
[2] Average of 20 values determined for 3-ply test pieces by tensile shear tests.
[3] See Hogan, J. T., and Arthur, J. C. Jr., J. Am. Oil Chem. Soc., *28*, 20-23 (1951).
[4] See Burnett, R. S., and Parker, E. D., Trans. Am. Soc. Mech. Eng., *68*, 751-6 (1946).

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had been subjected to the first test cycle were reconditioned at 77°F. and 32% relative humidity for six days, followed by reimmersing them in water at 77° F. for 48 hours, and then on removing them from the water immediately determining the tensile strengths of 20 test pieces. This constituted two test cycles. Subsequent test cycles were made in a similar manner. Both of the above methods are similar to accelerated service tests A.S.T.M. Designation D906-47T (1).

Shear strengths reported are averages of at least 20 values. Wood failure was evaluated by visual observation. Any failure in the wood was reported, and the percentage of the total number of pieces tested showing wood failure was calculated.

Results and Discussion

The effects of the accelerated service tests on the strength properties of the plywood glue joints are shown in Tables I and II and Figures 1 and 2. It is seen that the commercial casein glue is most resistant to both the interior and exterior tests, cottonseed meal glue is second, and peanut meal glue is least resistant. On an absolute strength basis cottonseed meal glue is superior to peanut meal glue on the interior test. However on the exterior test cottonseed and peanut meal glues are about equal in performance with the cottonseed meal glue, having higher wood failure than peanut meal glue at the end of the first exterior test cycle.

TABLE II

Percentage Changes in Shear Strengths of Bonded Wood Materials as a Result of Exposure to Accelerated Service Tests

Accelerated service test	Number of cycles	Percentage changes from original shear strengths		
		Cottonseed meal glue	Peanut meal glue	Commercial casein glue
Interior	1	−2	−3	−2
	3	−24	−22	−24
	5	−30	−37	−26
	7	−46	−59	−32
	9	−65	−75	−47
Exterior	1	−64	−64	−55
	3	−80	−85	−70
	5	−90	−93	−81
	7	....	....	−85

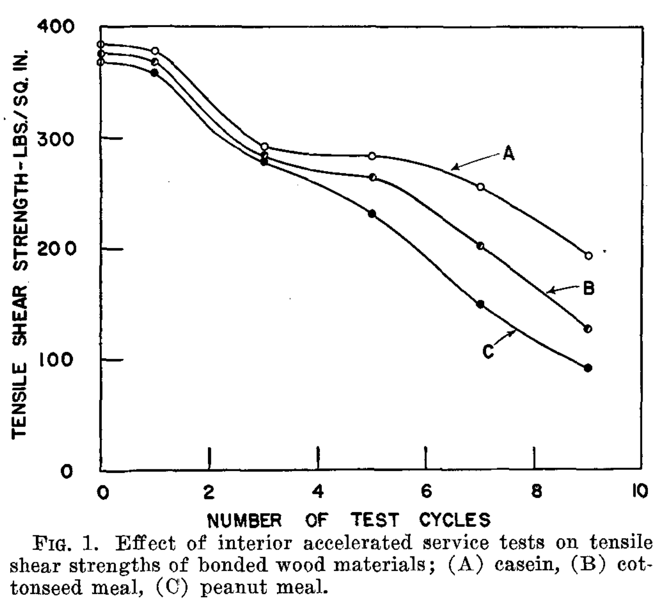

FIG. 1. Effect of interior accelerated service tests on tensile shear strengths of bonded wood materials; (A) casein, (B) cottonseed meal, (C) peanut meal.

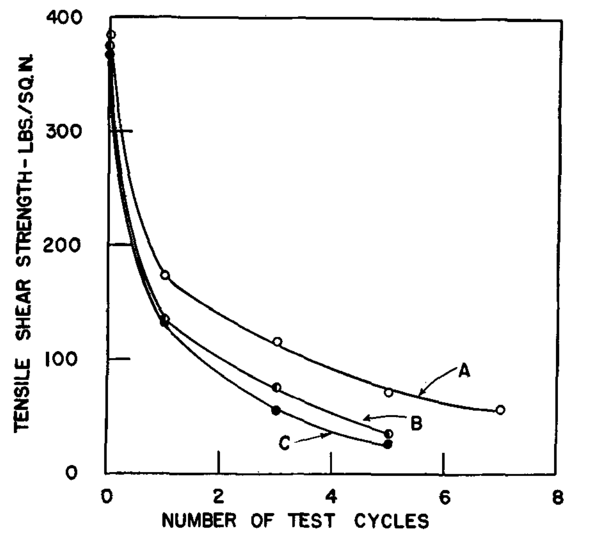

FIG. 2. Effect of exterior accelerated service tests on tensile shear strengths of bonded wood materials; (A) casein, (B) cottonseed meal. (C) peanut meal.

From these data it can be concluded that cottonseed meal glue compares favorably on an interior accelerated service test basis with commercial casein glue for five test cycles. After five cycles the cottonseed meal glue deteriorates more rapidly than the commercial casein glue. The peanut meal glue compares favorably on an interior test basis with commercial casein and cottonseed meal glues for three test cycles. After three cycles the peanut meal glue deteriorates more rapidly than either of the other glues.

From the results of these dynamic tests it would appear that cottonseed meal glues can be utilized for bonding plywood designed primarily for interior uses and for bonding plywood which may be used in building forms which may be discarded after several times of use. In regions where the average relative humidity is comparatively high, cottonseed meal glue bonds will be short-lived and will not be as permanent as casein glue bonds.

From economic considerations the amount of glue used per 1,000 square feet of glue line in cottonseed meal and casein glue bonds in these investigations is about equal. However the relative raw material costs of the basic glue components are that casein (16% nitrogen) is about five times as expensive as cottonseed meal (9% nitrogen). Considering the costs of compounding the glues, cottonseed meal glue (6.7% nitrogen) should be much cheaper than casein glue (8.4% nitrogen) on both a pound and a glue line basis, while having almost equal interior test strength properties.

Summary

It has been shown that of the three protein glues tested, commercial casein glue is most resistant to both interior and exterior accelerated service tests and that cottonseed meal glue is superior to peanut meal glue and compares favorably with commercial casein glue on an interior test basis for five cycles, the strength of the casein bond changing from 384 to 283 lbs./sq. in. and of the cottonseed meal bond changing from 375 to 264 lbs./sq. in. Cottonseed meal glue can probably be used for bonding plywood

designed primarily for interior uses, for regions of comparatively low relative humidity, and for bonding plywood which may be used in building forms which may be discarded after several times of use.

Acknowledgment

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A New Continuous Solvent Extractor for Oleaginous Substances

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IT has long been recognized that the most efficient method of removing the oil from oleaginous materials, on the basis of oil recovery alone, is by extraction with solvents (1). That this method is not applied more widely today is due, in part, to design problems associated with the physical characteristics of some of the most common materials, e.g., the "fines" problem found in the extraction of vegetable seeds and nuts.

The complications that the "fines" problem has introduced into the design of the extraction plant, particularly the extractor, are well known. Also it is well known that this problem has been most difficult to solve for the so-called "high oil" seeds, which comprise the bulk of the world's production of oil seeds. Recent advances in preparing such materials for extraction, both the whole seed and forepressed seed cake, have reduced the "fines" problem to a matter of materials preparation and have made possible the development of an extractor which will operate efficiently in those installations where, by reason of economics, two or more seeds must be processed in the one unit (in sequence).

For this purpose a continuous percolation extractor was conceived in which the solids would be deposited upon a porous belt conveyor running horizontally. Extraction would be carried out by percolating the solvent through the solids in stagewise, countercurrent fashion. The extractor would be constructed as simple as possible and, above all, would be easily controllable.

Continuous, countercurrent operation was considered necessary from the standpoint of operating efficiency. Stagewise operation was considered advantageous for reasons which will be pointed out later. Extraction by percolation was decided upon because advantage could be taken of the self-filtering property of a bed of solids to reduce the fines content of the strong solution. And lastly, since the bed of solids would not be disturbed in passing through the extractor, it was believed that "fines" production within the unit could be minimized.

Certain engineering data are necessary, of course, for the design of any extractor. For a percolation extractor of the type visualized, a knowledge of extraction rates, the amount of solution retained by the solids in passing from stage to stage and in leaving the extractor, the rate at which solutions will percolate through the solids, the rate at which the solids are wetted by the solution, and bulk densities of the solids are of most importance. Each must be determined for the materials the extractor will be expected to process, taking into consideration a suitable range of bed depths and the various solvents which may be used.

Extraction rates and the amount of solution retained by the solids enter into the determination of the number of stages and have a direct bearing upon the size of the extractor. Also the latter must be known before the solvent-to-solids ratio can be determined. Wetting rates determine the minimum time required for a solution thoroughly to wet the solids. The amount of percolating solution per stage and the size of the stage pumps are determined by the rate at which solution will percolate through the solids. The relationship of bulk density and bed depth to capacity is apparent.

SINCE little of the data were available at the time and since all had an effect upon design, a research program for the purpose was sponsored at Armour Research Foundation, Chicago. The present continuous extractor, illustrated in Figure 1, is the result. Although six stages are shown, the actual number of stages will vary with conditions. For simplicity, details of mechanical construction have been omitted.

Briefly, the extractor consists of a continuous porous belt installed horizontally within a vapor-tight housing. The upper half of the belt acts as the carrier for the solids, the whole being driven by a variable speed, high reduction drive. The space above the belt is divided into a series of chambers by vertical partitions which extend to within a short distance of the solids, the clearance varying with bed depth. Solution is sprayed over the solids through manifolds installed in alternate chambers. The intermediate chambers are equivalent to short, free drainage periods between periods of active spraying and act to separate the stages. Nozzles in the manifolds direct the solution upward against a distributor, which breaks the force of the liquid spray and distributes the solution evenly over the solids. The porous construction of the belt allows free drainage of the solution into pans situated between the belt halves. The pans serve as reservoirs from which the solution may be withdrawn by stage pumps and re-