COMPARISON OF FIBER BOARD AND PLYWOOD FOR USE IN ROADSIDE SIGN PANELS

J. E. Simonsen

Research Laboratory Division
Office of Testing and Research
Research Project 65 NM-142
Research Report No. R-565

State of Michigan
Department of State Highways
Lansing, February 1966

COMPARISON OF FIBER BOARD AND PLYWOOD FOR USE IN ROADSIDE SIGN PANELS

A proposal for the use of "Super Phenol-Black" fiber board as a substitute for plywood panels, submitted by the Building Board Division, West Virginia Pulp and Paper, Tyrone, Pa., was considered by the Committee for the Investigation of New Materials at its May 18, 1965 meeting. It was agreed by the Committee that the Research Laboratory Division should evaluate this material. The evaluation consisted of the following items:

1. Static bending tests on samples of fiber board and plywood to determine their comparative strength and stiffness properties.

2. Theoretical analysis of stresses in sign panels subjected to wind loads as specified in the 1961 AASHO "Specifications for the Design and Construction of Structural Supports for Highway Signs."

3. Comparison of the impact toughness and fracture appearance of the two materials.

4. Cost analysis to determine the amount of saving through use of fiber board instead of plywood.

Samples and technical information on the "Super Phenol-Black" fiber board were obtained through C. L. Whitfield, Detroit Area Sales. This material consists of a homogeneous flake core overlaid with a black, high-density, phenolic-impregnated paper weighing 30 lb per M sq ft. Currently, the fiber board is available only in 5/8-in. thick, 48 by 97 in. panels.

Plywood samples (edge-marked "GPX HIGH DEN. 60/60 EXT.-DRPR B-B8 CS 45-60") were selected from stock at the Department's Sign Shop in Lansing. The edge marking is the Douglas Fir Plywood Association's grade trademark, and denotes an exterior-type Douglas fir plywood with solid face and core veneers, each face overlaid with a 60 lb per M sq ft, high-density phenolic impregnated paper. It is manufactured by Georgia-Pacific Corp. and conforms to U.S. Commercial Standard CS 45-60. The most frequently used plywood panel is 48 by 96 in. and 5/8-in. thick.

Static Bending Tests

Methods. The fiber board was tested in accordance with ASTM Designation D 1037 ("Evaluating the Properties of Wood-Base Fiber and Particle Panel Materials"). The plywood was tested in accordance with ASTM Designation D 805 ("Standard Methods of Testing Veneer, Plywood, and Other Glued Veneer Constructions").

Equipment. A hydraulic load cylinder with an attached round head loading block, connected to a Riehle compression testing machine, was used to apply the load. The supports were round-edged and adjustable to accommodate prescribed span lengths of 15 in. for the fiber board and 30 in. for the plywood. A 0.001-in. indicating dial with a 3-in. range was used to obtain deflection measurements. The test assembly set-up for fiber board is shown in Fig. 1.

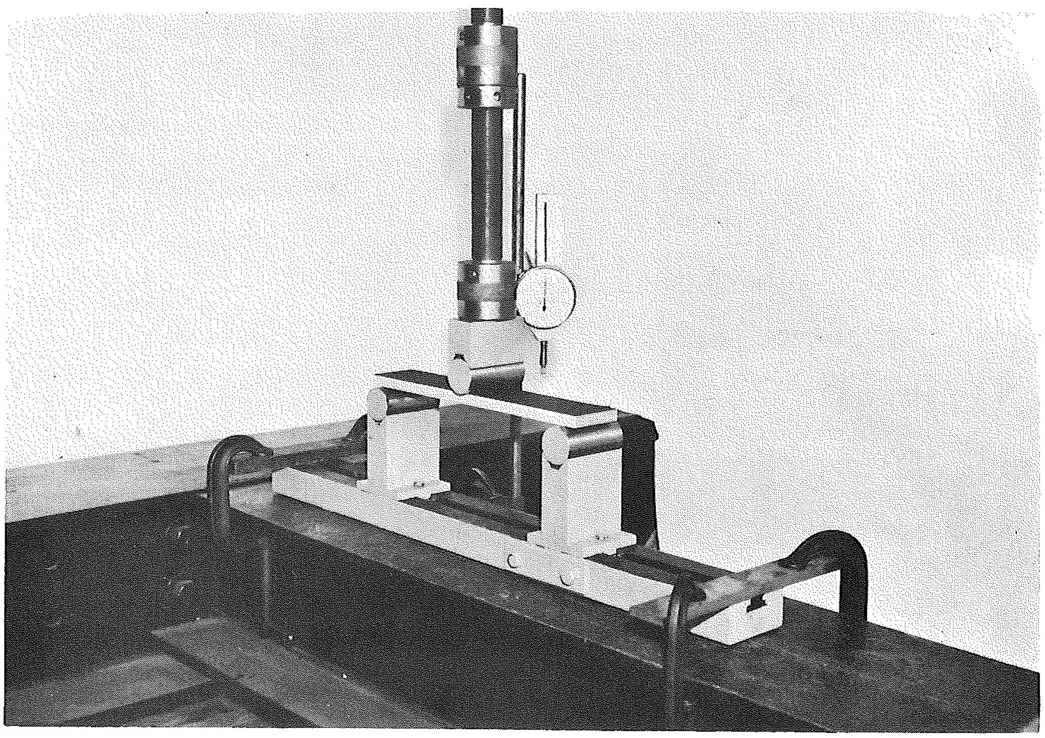

Figure 1. Laboratory set-up for static bending test.

Samples. Sample sizes were 17 by 3 by 5/8-in. and 32 by 2 by 5/8 in. for fiber board and plywood, respectively. The grain direction of the face plies of the plywood samples was parallel to the length of the sample.

Six samples of each type of material were tested, three in a dry condition and three in a soaked condition. Because the Laboratory is not equipped with a conditioning chamber, the samples tested in the dry condition were not conditioned to constant weight and moisture content at a relative humidity of 65 $\pm$ 1 percent and a temperature of 68 $\pm$ 6 F as prescribed. Instead, these samples were stored and tested under room conditions. The samples tested in the soaked condition were submerged in water at 72 F for 24 hr before test and tested immediately upon removal from the water. Before the samples were conditioned in water the edges were sealed. The fiber board samples received two brush coat applications of a clear polyurethane sealer, supplied with the samples, following the manufacturer's recommendations for the method of application and number of coats. The plywood samples received one brush coat of the sealer type currently used by the MDSH Sign Shop.

<u>Procedure</u>. After the sample was positioned on the supports, the load was applied continuously throughout the test and the motion of the load block conformed to the specified loading rates (0.30 in. per min $\pm$ 50 percent for fiber board, and 0.30 in. per min $\pm$ 25 percent for plywood). Load and deflection readings were taken at predetermined intervals until the maximum load was reached. The character of failure for each sample was recorded. Moisture content and specific gravity of each sample at the time of test were determined from a moisture coupon 1-in. by the width of sample. This coupon was cut from the body of the sample near the point of failure just after the test was completed. Each coupon was measured and weighed in its moist condition, and then oven dried at a temperature of 100 C until approximately constant weight was attained.

<u>Results</u>. The test data are presented graphically in the form of average load-deflection curves in Figs. 2 and 3, and the nature of failure of each type of material in the dry condition is illustrated in Fig. 4. In the case of fiber board, both dry and moist, and for dry plywood, the ultimate failure was characterized by tension failure in the bottom fibers. For moist plywood, an initial compression failure in the top veneer occurred directly above a joint in the adjacent veneer layer, but ultimate failure resulted from a tensile fracture in the bottom veneer layer.

Based on the test data, certain physical properties of the two materials were computed and are summarized in Table 1. In calculating strength and stiffness properties of the plywood, a homogeneous material was assumed.

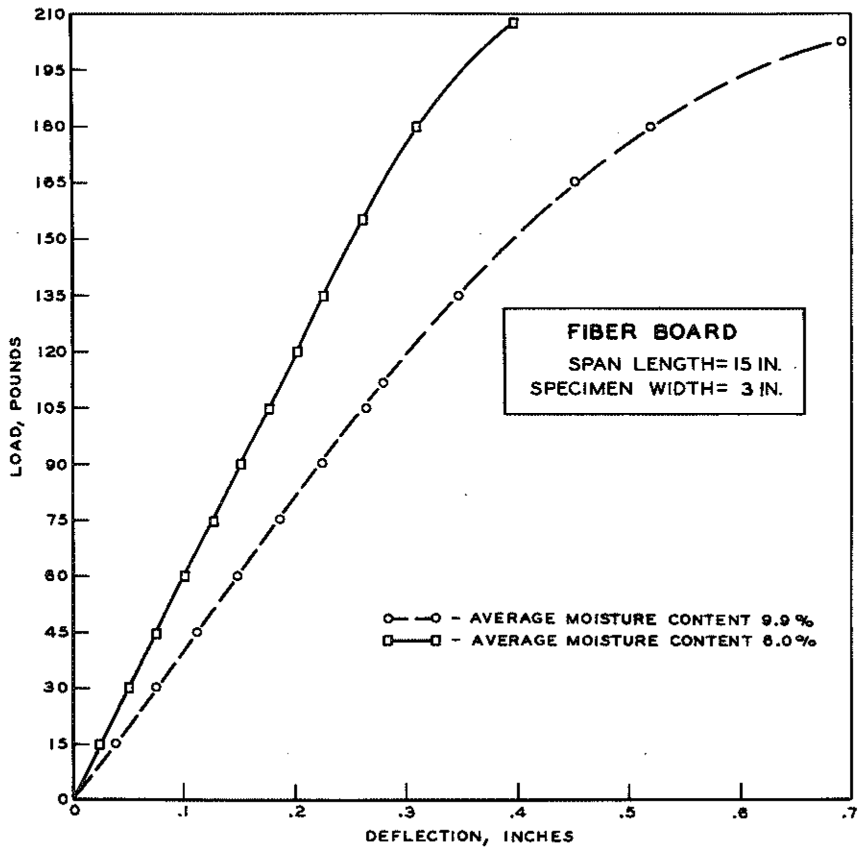

Figure 2. Average load-deflection curves for tested fiber board specimens

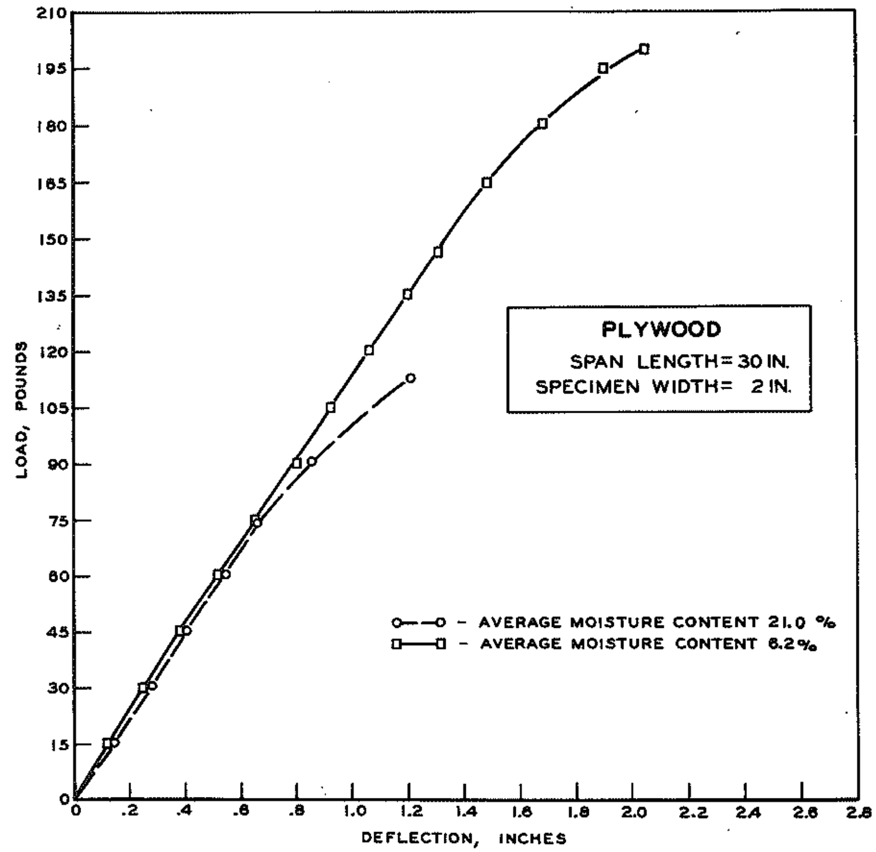

Figure 3. Average load-deflection curves for tested plywood specimens

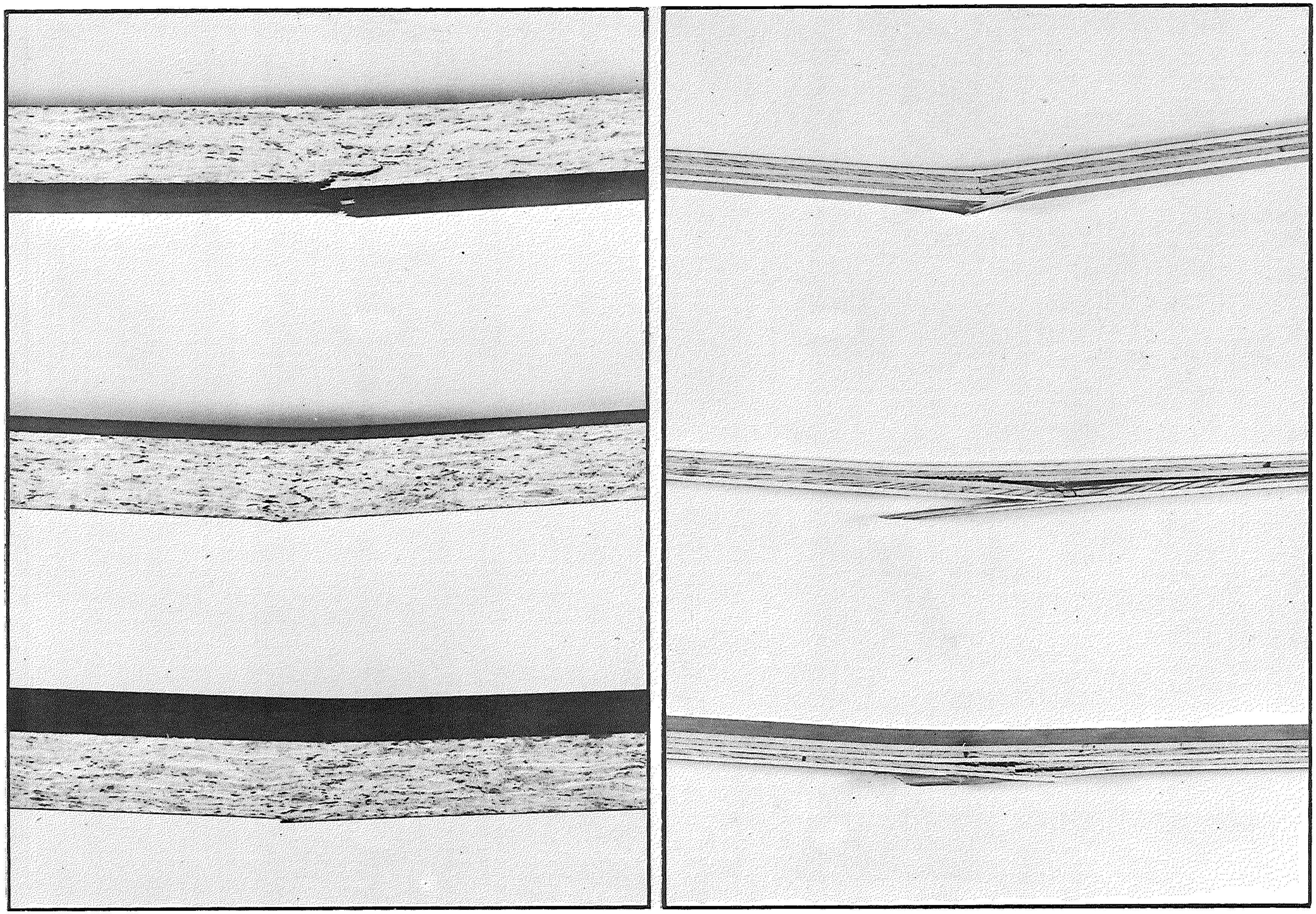

Figure 4. Typical static bending test failures of dry-condition specimens, with fiber board at left, and plywood at right.

It should be noted that because plywood is a laminated material, its physical properties depend on the moisture content of each layer and the bond strength between layers. For this reason the plywood data presented may vary substantially from test data on plywood specimens of the same size sampled from different lots.

Soaking the specimens as described resulted in a 3.9-percent average increase in moisture content for the fiber board, whereas plywood moisture content increased an average of 14.8 percent. The stress at the proportional limit of the wet specimens was reduced 30 and 51 percent for fiber board and plywood, respectively. A reduction of 9 percent in the modulus of rupture occurred for fiber board and 46 percent for plywood, and the percent reductions in modulus of elasticity for fiber board and plywood were 39 and 8, respectively.

TABLE 1
PHYSICAL PROPERTIES OF FIBER BOARD AND PLYWOOD

Type of Material and Test Condition	Sample No.	Moisture Content, percent	Specific Gravity*	Stress At Proportional Limit, psi	Modulus of Rupture, psi	Modulus of Elasticity, psi
Fiber Board (Room Conditioned)	1	6.0	0.74	2,550	4,100	600,000
	2	6.0	0.74	3,100	3,460	608,000
	3	6.1	0.74	2,480	3,840	713,000
	Avg. Value	6.0	0.74	2,830	3,800	640,000
Fiber Board (Soak Conditioned)	4	8.7	0.69	1,790	3,500	395,000
	5	11.8	0.71	1,920	3,140	400,000
	6	9.4	0.75	1,970	3,680	369,000
	Avg. Value	9.9	0.72	1,890	3,440	388,000
Plywood (Room Conditioned)	1	6.7	0.57	9,560	12,900	1,925,000
	2	5.8	0.57	9,000	12,400	1,739,000
	3	6.2	0.57	9,550	12,960	1,796,000
	Avg. Value	6.2	0.57	9,370	12,750	1,820,000
Plywood (Soak Conditioned)	4	22.2	0.63	5,470	7,720	1,670,000
	5	20.6	0.53	4,800	7,020	1,700,000
	6	20.3	0.62	3,400	5,960	1,662,000
	Avg. Value	21.0	0.59	4,560	6,900	1,677,000

* Based on volume at time of test and weight when over dry.

Theoretical Stress Analysis

The analysis included roadside signs mounted on one, two, and three supports. Based on a prescribed wind load of 35 psf as per AASHO specifications and assuming non-yielding supports, the maximum fiber stress in a sign panel 5/8-in. thick was computed for each of the three mounting conditions. The panel width, spacing of supports, and overhang were obtained from "Signing Standards for Interstate and Arterial Freeways" prepared by the Traffic Division. Computed stresses and safety factors are given in Table 2.

Impact Toughness

At the December 16, 1965 meeting of the Committee for Investigation of New Materials, it was requested that the Research Laboratory investi-

TABLE 2
STRESSES IN SIGN PANELS

Sign Type	Panel Width, in.	Support Spacing, in.	End Overhang, in.	Max. Fiber Stress, psi	Safety Factor*	
					Fiber Board	Plywood
One Support	36	--	--	605	3.1	7.5
Two Supports	72	48	12	805	2.3	5.7
Three Supports	96	32	16	480	3.9	9.5

* Based on average stress at proportional limit in specimens in soaked condition, as obtained in the static bending tests (Table 1).

gate the impact toughness properties of fiber board and plywood. In compliance with this request, impact tests were performed on unnotched 5/8 by 7/8 by 3 in. samples of the two materials. The plywood specimens included samples with the grain of the outside veneer layer either parallel or perpendicular to the cross-sectional plane.

Test results are given in Table 3. The samples, prepared from material stored at room conditions, had earlier been determined to have an average moisture content of 6 percent. As the table indicates, the grain direction of the outside veneer layers in the plywood had little effect on impact toughness. Based on the test results, the plywood absorbed slightly over 50 percent more energy to fracture than the fiber board. The mode and appearance of failure are illustrated in Fig. 5. As can be seen, the fiber board fractures were in the form of a fairly clean break with damage confined to the immediate area of the failure. The impact splintered the plywood samples and damaged them much more extensively than the fiber board specimens.

Although the results show that for the sample sizes tested, plywood absorbs about 1-1/2 times more energy than fiber board, the data cannot be used to predict the salvage value of accident damaged sign panels of these materials. This is because the damage inflicted by a vehicle depends on the manner in which the sign is hit. Because there are no records available pertaining to the salvage value of traffic damaged plywood sign panels, and since the fiber board has not been used for this purpose, there are no data on which to base an estimate of the salvage value of the respective materials.

TABLE 3
IMPACT TOUGHNESS

Type of Material	Sample No.	Cross-Sectional Area, sq in.	Absorbed Energy, ft-lb
Fiber Board	1	0.53	4.25
	2	0.56	6.75
	3	0.55	6.00
	Average	0.55	5.67
Plywood[1]	1	0.52	9.75
	2	0.52	7.50
	3	0.51	9.00
	Average	0.52	8.75
Plywood[2]	1	0.48	6.25
	2	0.48	10.25
	3	0.48	9.00
	Average	0.48	8.50

1 Grain of outside veneer layers perpendicular to cross-sectional plane.

2 Grain of outside veneer layers parallel to cross-sectional plane.

Cost Analysis

The analysis was confined to comparing central purchase prices, because it appears that storing, handling, fabrication, and mounting costs would be the same for both materials.

The cost of plywood, based on an order of 1000 sheets of 48 by 96 by 5/8 in. material from Georgia-Pacific Corp. in Grand Rapids, is $0.304 per sq ft. Cost quotations on "Super Phenol-Black" fiber board submitted by C. L. Whitfield and based on 500 sheets 48 by 97 by 5/8 in.

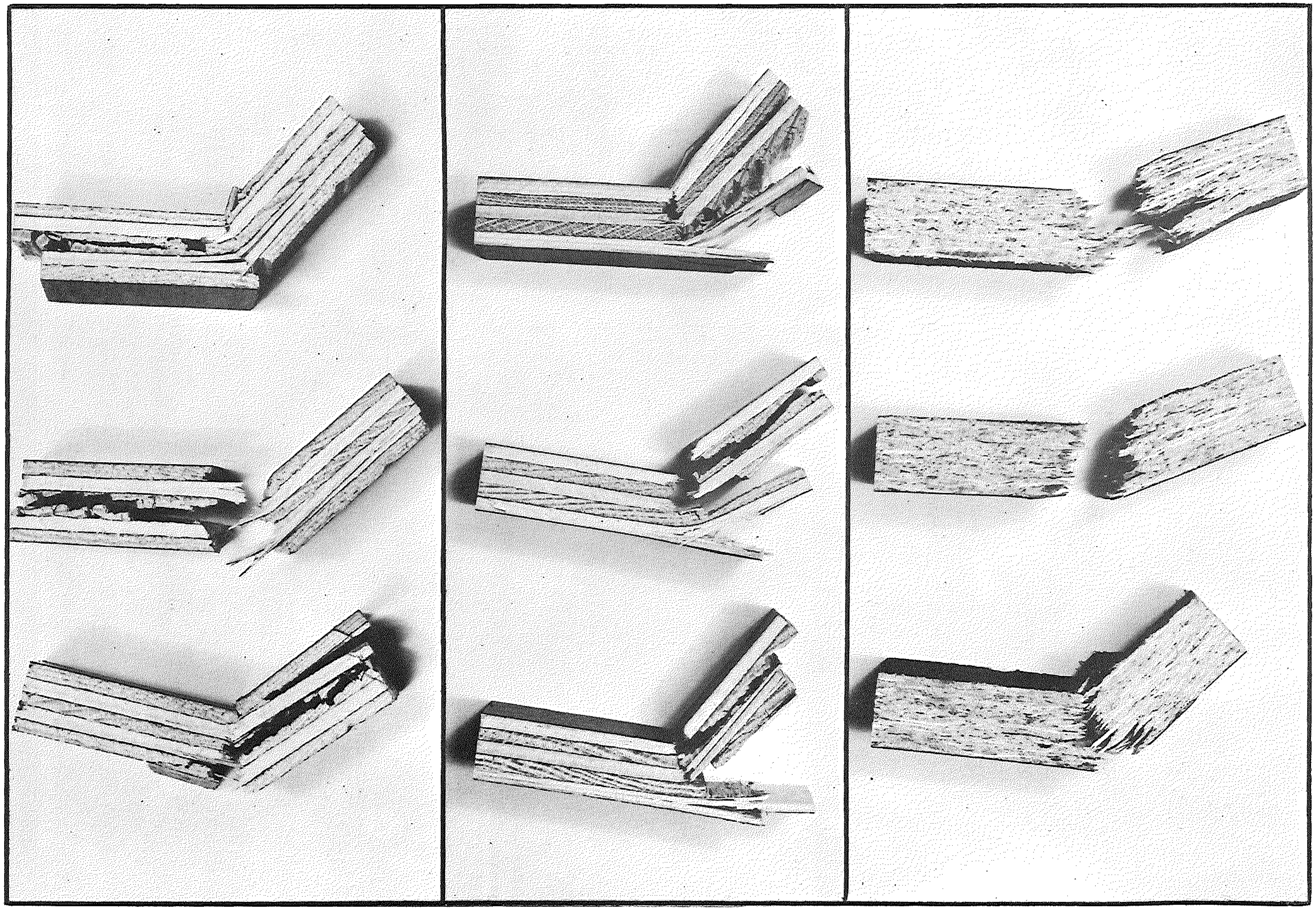

Figure 5. Mode of failure of impact test samples: plywood with grain of outside veneer layers parallel to cross-sectional plane of the sample (left), plywood with grain of outside veneer layers perpendicular to cross-sectional plane (center), and fiber board (right).

delivered in Lansing were $0.244 per sq ft. Thus, a saving of $0.06 per sq ft is possible with the use of the fiber board material.

Conclusions

1. Based on test results for specimens having an average moisture content of 6 percent, the plywood is 3.4 times stronger and 2.8 times stiffer than the tested fiber board. Thus, on the basis of strength and stiffness, the fiber board is not equivalent to the plywood.

2. Safety factors, based on computed maximum fiber stress in sign panels and on proportional limit stresses in specimens tested in the soaked condition, are 2.1, 2.3, and 3.9 for panels mounted on one, two, and three supports, respectively. The tested fiber board, therefore, is sufficiently strong to be used for roadside sign panels.

Recommendations

Because no information is available on the effects of weathering on the tested fiber board, it is recommended that before acceptance of the fiber board panel as an alternate sign panel material, a limited experimental installation should be made. In this connection, it is suggested that 10 to 20 experimental signs be installed, preferably in the Lansing vicinity, with fabrication and installation observed by the Research Laboratory which would then carry out periodic inspections to obtain information on weathering properties of this material. When sufficient data have been collected to warrant conclusions on this important aspect, recommendations with respect to final acceptance of this material would be made.