THE EFFECT OF SHORT PERIODS OF SIMULATED WEATHERING ON THE IMPACT PERFORMANCE OF PARTICLEBOARD[1]

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(Received 16 April 1975)

ABSTRACT

Eight commercial particleboards and two commercial plywoods manufactured for structural application were fabricated into 4′ × 4′ panel-joist systems and subjected to simulated on-site environmental conditions. Impact properties were determined by British impact and ASTM tests. The British impact test lacked sensitivity to establish differences between types of particleboard. Most particleboards exhibited about half the puncture resistance of plywood of equal thickness. Oriented particleboard had the greatest puncture resistance of any particleboards tested. Weathering without the influence of heat generally increased puncture resistance. ASTM sandbag testing of floor systems indicated that plywood and oriented particleboard had the greatest resistance to initial visible failure. Thicker boards or boards composed of larger-sized particles also had greater resistance to initial visible failure. All test weathering conditions generally caused a loss of resistance to initial visible failure of floor sections. The effects of the test weathering conditions upon strength to total failure were slight. It does not appear that loss of strength on the construction site is a significant problem as far as its effect on impact strength is concerned.

Additional keywords: Structural particleboard, particleboard, plywood, impact strength, sandbag drop test, puncture test, weathering, subfloor/underlayment, roof sheathing.

INTRODUCTION

This study was designed to compare and evaluate the impact properties of different types of commercial structural particleboard and plywood when used in applications such as roof sheathing or subfloor/underlayment and subjected to environmental conditions that might be encountered during on-site construction. Plywood was included in this study for comparative purposes, but it should not be inferred that we feel the ultimate goal of particleboard is to equal the performance of plywood.

Weather conditions that might be encountered during construction in the United States vary so widely that there are obvious difficulties in agreeing upon "average" exposure conditions. Personal judgment and the data of Hann et al. (1963) and Heyer (1963) led us to select a 48-h period of rain followed in some cases by 48 h of 150 F temperature as representative of "highly unfavorable" building conditions. Temperatures of this magnitude and duration have been measured experimentally between shingles and roof sheathing.

METHODS

Four conditions of use were evaluated in this study: (1) a dry condition that simulated the normal use situation in a home; (2) a wet condition that simulated an on-site construction situation immediately after rain; (3) a wet condition that involved wetted boards that redried at mild temperatures before being put into use; (4) a wet condition that was similar to the third but differed in that a temperature of 150 F was present during drying.

In order to evaluate the effects of these exposures on impact properties, two types of impact tests were performed. A 60-pound sandbag drop as specified in ASTM E-72 was used to test all boards for all ex-

[1] Presented at the Ninth Particleboard Symposium, Washington State University, Pullman, WA, 2 April 1975. Published as Sci. Jour. Ser. Paper No. 1575 of the Univ. of Minn. Agric. Exp. Sta.

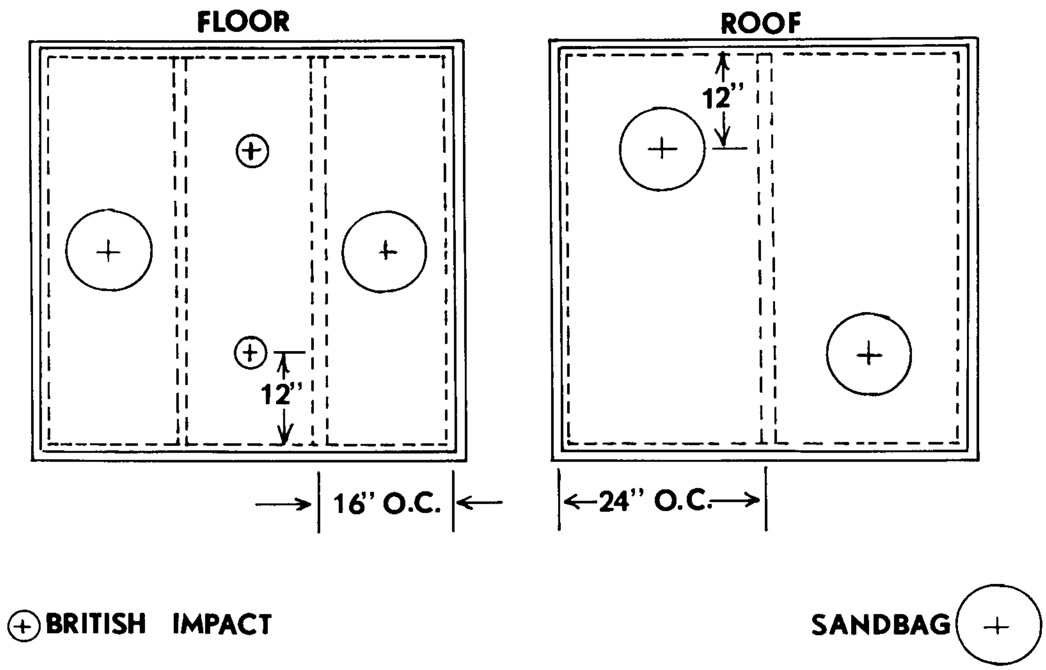

FIG. 1. Diagram of test locations on the four-foot square floor and roof panels.

posures. A British impact test complying with BS 1811 was used as a supplementary test on the boards tested as 16″ on-center floor units. This test is essentially a puncture or "spear" test.

A joist/sheathing system having a span of 12′ to 14′ would be ideal for testing if availability of materials and cost were not factors and if the objective was to simulate the impact behavior in actual systems. In this study, however, a 4′ × 4′ panel-joist system uniformly supported along the band joists was used. Information from this system should be valid for product comparison and for determining changes in properties due to weathering. The main difference between this joist system and one with a greater span is the amount of energy that is absorbed by the joists upon impact. The joists of this system deflect less; thus the sheathing material absorbs more of the impact energy resulting in a somewhat conservative measure of the impact performance of these materials.

Joist spacings of 16″ and 24″ on-center were used to simulate floor and roof sys-

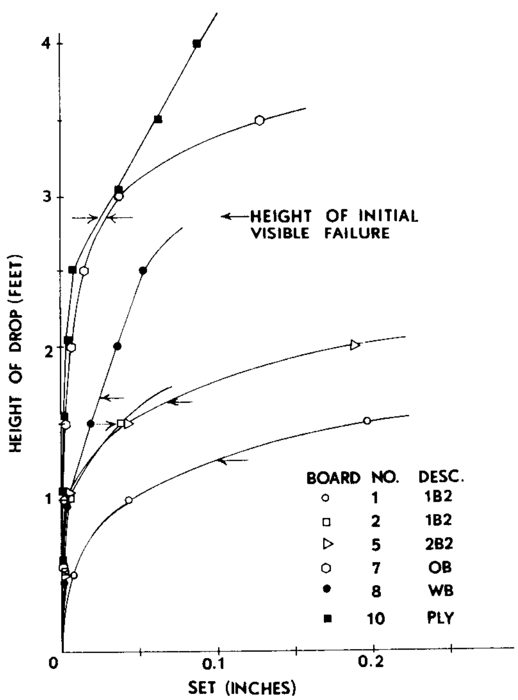

FIG. 2. Set in $\frac{5}{8}$-inch panels at 50% RH on 16-inch joist spacing.

TABLE 1. *Characteristics of commercial boards used in this study*

Board Number	Description	Type of Furnish	Type of Formation	Resin Type	Density (pcf) (OD wt. & vol. at 50% RH)
1	Mobile Home Decking (1B2)	Southern Yellow Pine (Shavings)	Graded Density	Urea	43.6
2	Mobile Home Decking (1B2)	West Coast Softwood (Shavings)	3 Layer	Urea	42.9
3	Mobile Home Decking (1B1)	West Coast Softwood (Shavings)	3 Layer	Urea	43.7
4	Mobile Home Decking (1B2)	West Coast Softwood (Shavings & Flakes)	3 Layer	Phenolic & Urea	41.6
5	Manufactured House Decking (2B2)	Southern Yellow Pine (Shavings)	Graded Density	Phenolic	44.8
6	Oriented Particleboard (OB)	West Coast Softwood (Flakes)	3 Layer Cross Laminated	Phenolic	40.4
7	Oriented Particleboard (OB)	West Coast Softwood (Flakes)	3 Layer Cross Laminated	Phenolic	38.8
8	Wafer Type Particleboard (WB)	Aspen (Wafers)	Homogenous	Phenolic	40.3
9	Interior Type Plywood-Exterior Glue	Group I Douglas-Fir Veneer	4 ply 32/16 Standard Grade	Phenolic	29.5
10	Interior Type Plywood-Exterior Glue	Group I Southern Yellow Pine Veneer	5 Ply Underlayment Grade	Phenolic	31.3

tems, respectively. As would be required by most building codes, the thickness of the sheet materials used in the floor systems was ⅝″ or thicker. Sheathing material ½″ and ⅝″ thick were used in the roof systems.

Eight commercial particleboards and two commercial plywoods comprising a range of species, thicknesses, board densities, particle geometries, and resin types were selected for this study (Table 1). Particleboards included planer shavings/residue boards such as urea-bonded mobile home decking and phenolic-bonded manufactured house decking, as well as larger flake-type oriented particleboard and wafer-type particleboard.

Two 4′ by 4′ test specimens for each panel type/span combination were randomly assigned to each of the weathering exposures described below:

Control: Equilibrated at 72 F and 50% RH and then tested.

Wet: Equilibrated at 72 F and 50% RH followed by a continuous 48-h room temperature wetting of the boards while positioned horizontally. The wetting was done with a garden soaker hose so that the top surface was covered with a film of water. Testing was at the end of the wetting period.

Wetted-Reconditioned: Equilibrated at 72 F and 50% RH, then wetted for 48 h as described above and allowed to again come to equilibrium at 72 F and 50% RH before being tested.

Wetted-Heated-Reconditioned: Equilibrated at 72 F and 50% RH, wetted in the same manner as described above, and then heated at 150 F and about 50% RH for 48 h. Testing was con-

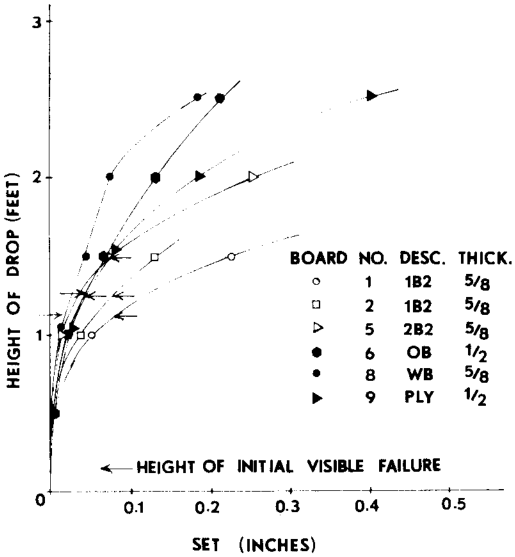

FIG. 3. Set at 50% RH on 24-inch joist spacing.

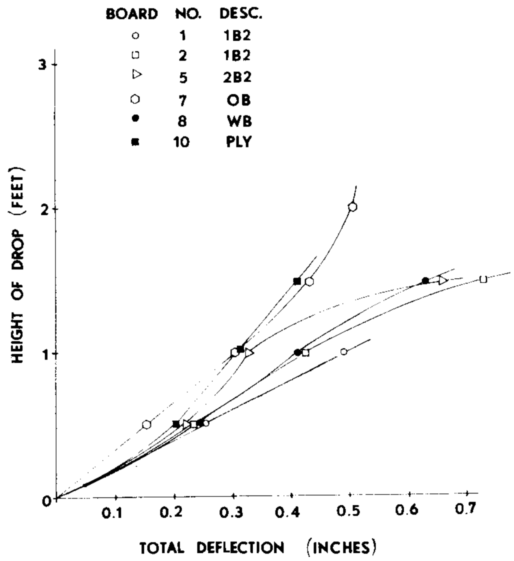

FIG. 4. Total deflection from 60-pound sandbag drop for ⅝-inch boards at 50% RH on 16-inch joist spacing.

ducted after re-equilibration at 72 F and 50% RH.

After wetting or reconditioning, the panels were nailed with 6d stiff stock screw shank nails spaced 6″ and 10″ apart on the outer and inner joists to 4′ by 4′ frames. The frames were fabricated from 2″ by 8″ Douglas-fir construction grade joists 16″ or 24″ on-center as shown in Fig. 1. Panels of ½″ thickness were tested only on 24″ centers, while ¾″ or thicker panels were tested only on 16″ centers. All of the ⅝″ panels were tested on 16″ centers and some were tested on 24″ centers.

All panels were subjected to successive 60-pound sandbag drops from an initial height of 6″ with increasing 6″ increments until total failure occurred. Two such drop sequences were made per panel to give 4 replications/panel-type/span-designation/weathering condition. The sandbag used and the testing procedures for the sandbag test adhered to ASTM E 72. Panel deflections were measured mechanically, and visual inspection was used to detect any failures. The height of drop necessary to cause bottom, top, and total failure was recorded. Top and bottom failure was determined when hairline cracks first became visible, and total failure was determined when the sandbag passed completely through the panel.

Set, the inelastic component of deflection, was measured from the top surface with the use of a rigid dial gauge jig. Total deflection, which is the sum of elastic and set deflection, was determined by measuring the vertical movement of a plunger placed beneath the center of impact on the panel with a cathetometer. The joist deflections during testing at mid-span under 12″ drop did not exceed 0.048 inches.

After the sandbag testing was completed, the British impact test, as specified in British Standard 1811, was conducted on all panels with joist spacing 16″ on-center. This test utilized an 8-kg rod with a hemispherical head 50 mm in diameter which was dropped vertically from an initial height of 25 mm with increasing 25 mm increments. The heights at which initial bottom failure and punch-through occurred were recorded. Bottom failure was determined when a hairline crack first became

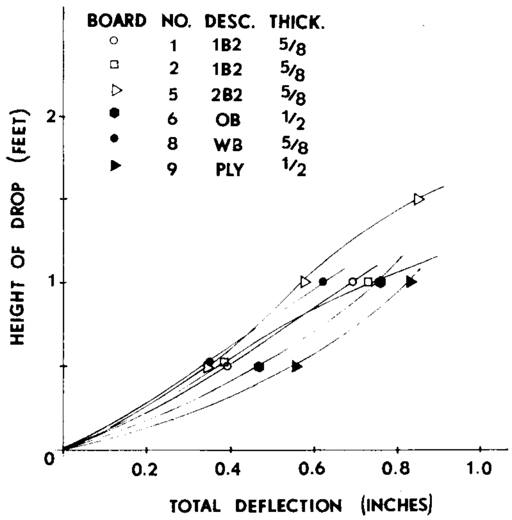

FIG. 5. Total deflection from 60-pound sandbag drop at 50% RH on 24-inch joist spacing.

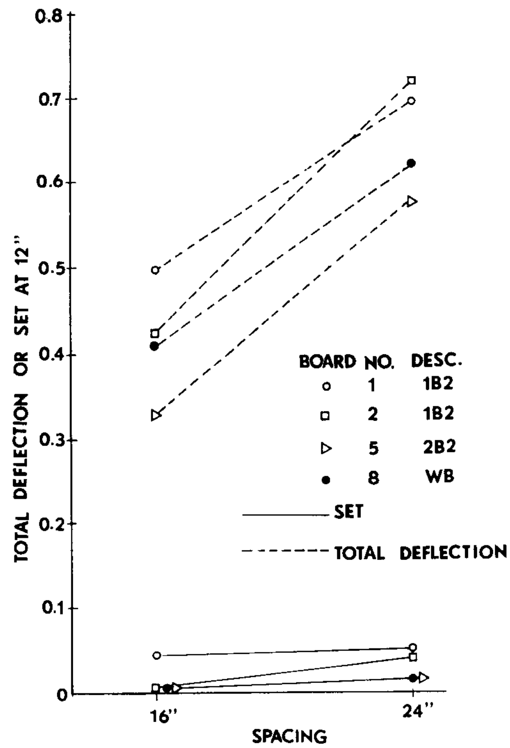

FIG. 6. Effect of span on total deflection and set from 12-inch drop at 50% RH for ⅝-inch boards.

visible. Punch-through was said to occur at the time the nose of the spear was completely imbedded in the board.

Although the main objective of this study was to determine how weathering affected impact properties, the effect on the basic mechanical properties was also determined. To do this 2′ by 2′ panels were subjected to the same weathering treatments as the 4′ by 4′ panels, and subsequently cut up into four 3″-wide static bending test strips. These strips were used in determining density, %MC, MOR, MOE, and IB. Static bending tests conformed to ASTM D 1037. Computation of MOR and MOE was based on the thickness of the samples at the time of test. Calculation of the MOE and MOR of plywood was based on the moment of inertia of the entire cross section so that a more direct comparison with particleboard could be made. Four torsional IB samples 1″ square were cut near the ends of each static bending strip after bending failure. Internal bond strength was estimated by a center line torsional shear test (Gertjejansen and Haygreen 1971).

RESULTS AND DISCUSSION

A visible difference in the surface wetting of the board types could be seen throughout the period of wetting. The entire surface of some particleboard types resisted wetting for considerable periods of time. Other board types appeared mottled with dry zones. Presumably these spots were due to high concentrations of size. Plywood panels wetted readily, and the water appeared to penetrate through the thickness of the panels.

Physical properties

The basic physical properties of the ten boards, at equilibrium with 50% RH and 72 F, are outlined in Table 2.

Table 3 shows the MOE, MOR, and IB values after exposure and reconditioning to 50% RH as a percent of the control values given in Table 2. From this table it can be seen that exposure to rain alone or to rain followed by heat did not have a consistent effect on either the MOE or MOR of all

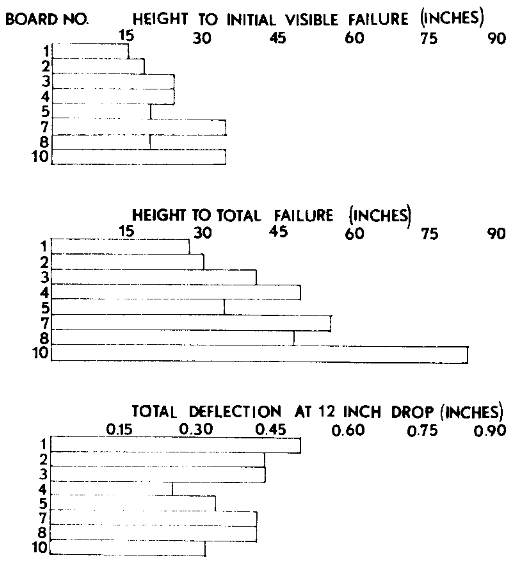

FIG. 7. Sandbag drop impact strength properties on 16-inch joist spacing at 50% RH.

board types. MOE and MOR of the urea-bonded shavings boards, 1, 2, 3, and 4 deteriorated under either of the wetting-drying conditions, while MOE and MOR of the 5/8″ phenolic-bonded shavings board 5 increased. This strength increase was probably due primarily to a higher initial density of the weathered samples.

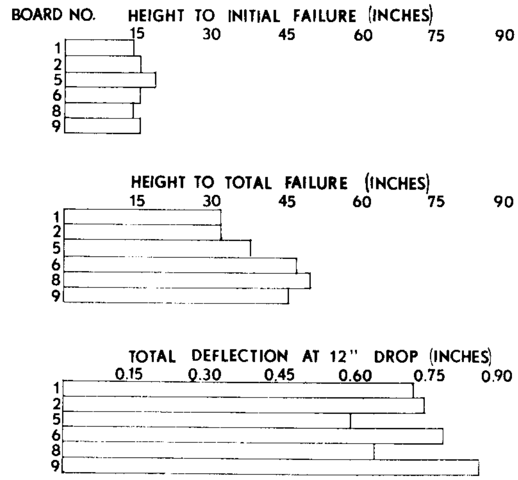

FIG. 8. Sandbag drop impact strength properties on 24-inch joist spacing at 50% RH.

British Impact Test

For this test eight board types, each having 2 replicates, were tested at 2 separate points. At each point initial visible failure and punch-through were noted. The results at the control condition are given in Table 4. Table 5 shows the percent change in British impact strength due to weathering.

The range in height-to-initial visible failure for various particleboards at the con-

TABLE 2. *Basic physical properties (conditioned at 50% relative humidity)*

Board Number	Description	Nominal Thickness (inches)	Ave Thickness (inches)	MOE (x1000 psi)	MOR (psi)	Torsional IB (psi)[a]
1	1B2	5/8	0.620	490	2820	136
2	1B2	5/8	0.633	439	2490	85
3	1B1	3/4	0.743	376	2310	70
4	1B2	13/16	0.830	572	2700	105
5	2B2	5/8	0.617	524	2980	109
6	OB	1/2	0.498	674	3850	111
7	OB	5/8	0.650	837	5330	135
8	WB	5/8	0.606	563	2530	97
9	Ply	1/2	0.472	1,440	7860	N/A
10	Ply	5/8	0.582	986	9260	N/A

[a]Values obtained from torsional centerline shear strengths of 16 one-inch square specimens using the formula: IB=11.3 x torque in foot pounds

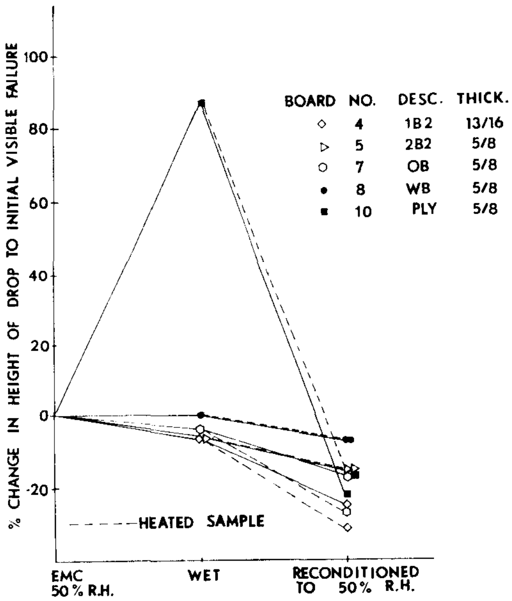

FIG. 9. Effect of various exposures on height of drop to initial failure on 16-inch joist spacing.

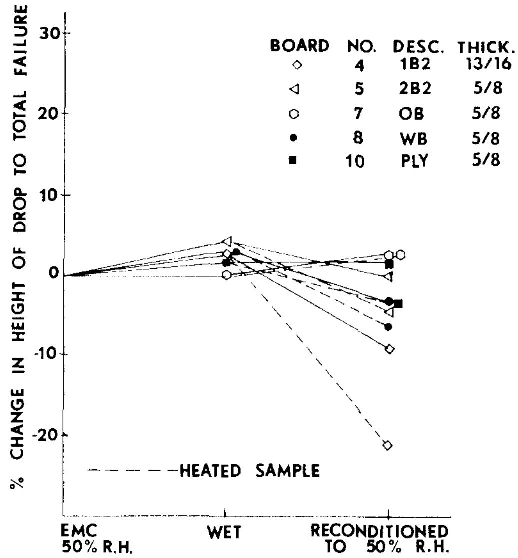

FIG. 10. Effect of various exposures on height of drop to total failure on 16-inch joist spacing.

trol condition was small, but widened somewhat as a result of weathering treatments. Plywood performed better than particleboard, and its closest overall competition was oriented particleboard. Impact strength of plywood increased when wet by 128%.

The range of values for height-to-punch-through of particleboard also was small and widened with severity of the weathering conditions. Overall, wetting or wetting-reconditioning without heat increased

TABLE 3. *Change in MOE, MOR and IB resulting from various exposures, expressed as percent change from controls shown in Table 2*

		48 Hr. Wetting and Reconditioned to 50% R.H.			48 Hr. Wetting, 48 Hr. Heating and Reconditioned to 50% R.H.		
Board Number	Description	% MOE[a] Change	% MOR[a] Change	% IB Change	% MOE[a] Change	% MOR[a] Change	% IB Change
1	1B2	-22.6	-25.5	-22.8	-14.1	-6.7	-2.9
2	1B2	-19.1	-4.4	-5.9	-19.4	-14.5	-8.2
3	1B1	-1.3	-3.5	17.1	-18.4	-12.6	5.7
4	1B2	-17.8	-27.8	-5.7	-17.3	-17.8	1.0
5	2B2	7.6	12.4	21.1	5.5	11.4	14.7
6	OB	-9.8	-2.3	-13.5	-22.1	-14.3	-13.5
7	OB	-12.3	-10.7	-19.3	-14.6	-11.3	-9.6
8	WB	-23.6	-13.8	0	-22.2	-23.3	-23.7
9	Ply	-15.5	9.4	N/A	-14.3	17.4	N/A
10	Ply	9.1	-17.5	N/A	2.1	-14.2	N/A

[a]Calculations based upon thickness of samples at time of test--not original thickness.

TABLE 4. *Results of the British Standard Impact Test utilizing an 8-kilogram rod on 16-inch on-center floor systems, conditioned to 50% relative humidity*

Board Number	Description	Nominal Thickness	Ht. to Initial Visible Failure (inches)[a]	Ht. to Punch Through (inches)
1	1B2	5/8	10.5	15.2
2	1B2	5/8	7.8	12.2
3	1B1	3/4	10.0	14.0
4	1B2	13/16	11.5	15.2
5	2B2	5/8	11.2	13.2
7	OB	5/8	10.5	17.5
8	WB	5/8	10.0	14.8
10	Ply	5/8	12.5	30.0

[a] Converted from metric units

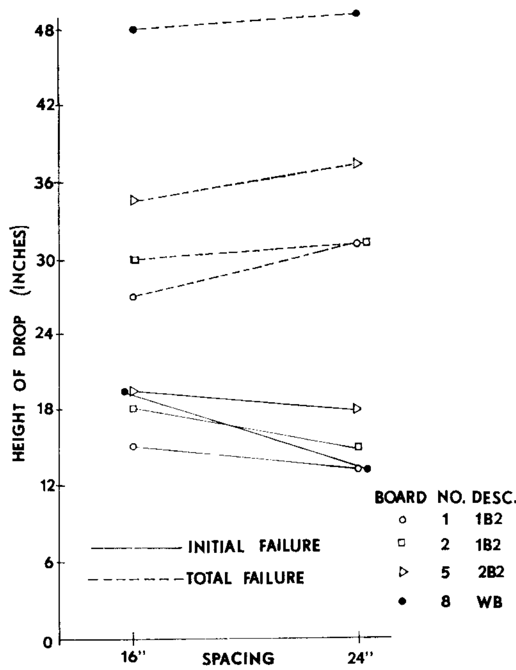

FIG. 11. Effect of span on height to initial visible failure and height to total failure at 50% RH for ⅝-inch boards.

puncture resistance while the effects of heat were positive and negative. Note that the strengths of oriented particleboard and plywood changed similarly and that both appeared to have better punch-through resistance after being exposed to weathering. No explanation is offered for this phenomenon. The punch-through resistance of the urea-bonded particleboards did not deteriorate to any great extent after they had been exposed to moisture and heat.

There seems to be no direct correlation between board thickness and resistance to

TABLE 5. *Change in British Standard Impact Test properties resulting from various exposures—expressed as a percent of the controls shown in Table 4*

			% Change from Strength @ 50% R.H.					
			Wet Condition		Wet & Recondition		Wet-Heat-Recondition	
Board Number	Description	Nominal Thickness	Initial Visible Failure	Punch Through	Initial Visible Failure	Punch Through	Initial Visible Failure	Punch Through
1	1B2	5/8	N/A	N/A	12.4	26.3	-9.5	41.4
2	1B2	5/8	5.1	13.1	2.6	-9.8	-10.3	-5.7
3	1B1	3/4	12.0	7.1	-10.0	3.6	-18.0	-7.1
4	1B2	13/16	-4.4	38.2	-30.4	5.3	-28.7	0
5	2B2	5/8	2.7	25.0	2.7	4.6	-8.9	0
7	OB	5/8	14.3	18.9	28.6	28.6	69.5	31.4
8	WB	5/8	5.0	14.9	-10.0	2.7	-12.0	2.7
10	Ply	5/8	128.0	(40)[a]	24.0	30.0	-2.4	(20)[a]

[a]Value is higher because some or all tests did not fail at the maximum (107 cm) drop.

TABLE 6. *Results of 60-lb. Sandbag Drop Test on 16-inch on-center floor systems tested at 50% relative humidity (controls)*

Board Number	Description	Nominal Thickness	Height to Failure (in.) Initial Visible	Total[a]	Total[b] Deflection from 12 inch drop (in.)	Set After 12" Drop (in.)
1	1B2	5/8	15.0	27.0	0.495	0.043
2	1B2	5/8	18.0	30.0	0.425	0.006
3	1B1	3/4	24.0	40.5	0.427	0.004
4	1B2	13/16	24.0	49.5	0.242	0.002
5	2B2	5/8	19.5	34.5	0.328	0.004
7	OB	5/8	34.5	55.5	0.301[c]	0.003
8	WB	5/8	19.5	48.0	0.408	0.006
10	Ply	5/8	34.5	82.5[d]	0.308	0.002

[a] The height of drop at which sandbag passes through the floor.
[b] The deflection including both elastic component and set.
[c] Due to an experimental error, value was extrapolated from curve in Figure 4.
[d] Failure of all samples did not occur at maximum drop height of 84 inches.

a puncture, but there does appear to be an interaction between IB and thickness that relates to puncture resistance.

The British spear test seems to lack the sensitivity to establish clear-cut differences between different types of particleboard products. This may mean that the puncture resistance of particleboard is basically the same, or that there is an inherent weakness in the test itself, which results in failure at a fairly uniform height. The cumulative effect of repetitive drops from heights increasing at 25-mm intervals may be the problem.

Sandbag Impact Test results

The major impact evaluation technique used in this study was the 60-pound sandbag drop. Selected impact strength and deflection results are listed in Tables 6, 7, 8, and 9 and in Figs. 2 through 10. A 12" drop was arbitrarily chosen for comparing set and deflection since this was the maxi-

TABLE 7. *Results of 60-lb. Sandbag Drop Test on 24-inch on-center roof systems tested at 50% relative humidity (controls)*

Board Number	Description	Nominal Thickness	Height to Failure (in.) Initial Visible	Total[a]	Total[b] Deflection from 12 inch drop (in.)	Set After 12" Drop (in.)
1	1B2	5/8	13.5	31.5	0.697	0.051
2	1B2	5/8	15.0	31.5	0.721	0.038
5	2B2	5/8	18.0	37.5	0.574	0.015
6	OB	1/2	15.0	46.5	0.760	0.026
8	WB	5/8	13.5	49.5	0.621	0.015
9	Ply	1/2	15.0	45.0	0.830	0.028

[a,b] Footnote Table 6

TABLE 8. *Change in impact properties of 16-inch on-center floor systems resulting from various exposures—expressed as a percent of the controls shown in Table 6*

	Percent Change from Board Conditioned @ 50% R.H.								
	Wet			Wet & Reconditioned			Wet-Heat-Reconditioned		
Board Number	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop
1	N/A	N/A	N/A	20.0	27.8	-20.0	-20.0	16.7	2.6
2	-8.3	10.0	2.1	-25.0	-5.0	37.6	-33.3	-15.0	24.2
3	-6.2	3.7	-26.9	-12.5	0	-5.4	-31.2	-18.5	-7.0
4	-6.2	3.0	23.1	-25.0	-9.1	19.8	-31.2	-21.2	2.1
5	-7.7	4.4	47.9	-15.4	0	23.2	-15.4	-4.3	32.9
7	-4.4	0	-5.9	-17.4	2.7	-9.8	-26.1	2.7	-28.8
8	0	3.1	5.1	-7.7	-3.1	-7.4	-7.7	-6.2	-7.4
10	87.0	1.8	-1.0	-21.7	1.8	-8.8	-17.4	(-3.6)[a]	2.8

[a] Footnote Table 6

mum height at which all test boards exhibited elastic properties.

Results at 50% RH and 72 F (control condition)

Results of the sandbag test at the control condition are given in Tables 6 and 7 for joists 16″ and 24″ on-center respectively. Figures 2 and 3 compare the development of set on some of the floor and roof panels. The point of visible failure is also indicated. In some cases considerable set developed before failure was observed. Note that some boards in Fig. 3 are of ½″ thickness. The 1B2 boards developed set most rapidly while the oriented particleboard performed nearly as well as plywood.

Figure 4 illustrates the total deflection as a function of height of drop for the ⅝″-thick boards used as floor panels. Figure 5 illustrates the same property for boards of ½″ and ⅝″ thickness tested as roof

TABLE 9. *Change in some impact properties of 24-inch on-center roof systems resulting from various exposures—expressed as a percent of the results of the controls shown in Table 7*

	Percent Change from Board Conditioned @ 50% R.H.								
	Wet			Wet & Reconditioned			Wet-Heat-Reconditioned		
Board Number	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop	Ht. to Initial Visible Failure	Ht. to Total Failure	Total Deflection @ 12" Drop
1	N/A	N/A	N/A	-11.0	0	5.6	-11.0	4.8	19.0
2	-10.0	0	26.4	10.0	4.8	2.8	-20.0	-4.8	6.7
5	8.3	-4.0	33.1	-8.3	-8.0	14.8	-8.3	-12.0	9.9
6	30.0	-3.2	13.4	0	-6.5	6.4	0	-3.2	-2.2
8	0	-12.1	25.0	11.0	-9.1	1.8	22.0	-9.1	4.5
9	40.0	33.0	16.0	20.0	60.0	6.5	20.0	40.0	0.6

panels. Figure 6 shows the effect of span on both set and total deflection. Set appears to develop only slightly more on 16″ centers than on 24″ centers (Fig. 6).

Note that ⅝″ plywood and ⅝″ oriented particleboard deflected the least and developed less set than the other products studied (Figs. 4 and 2). However, board thickness appeared to be the overriding factor when evaluating stiffness since ½″ plywood and ½″ oriented particleboard deflected more than the ⅝″ boards (Fig. 5). Increasing the span had a pronounced effect on total deflection as would be expected (Fig. 6).

Tables 6 and 7 indicate the average height of drop to cause initial visible and total failure. It can be seen that the average height to initial visible failure on the floor panels (Table 6 and Fig. 7) ranged from 15 inches for a ⅝″ shavings-type particleboard, board 1, to 34.5 inches for both ⅝″ plywood, board 10, and ⅝″ oriented particleboard, board 7. Thickness seemed to be an important factor. A noticeable improvement in height to initial visible failure was found with the ¾″, board 3, and 1³⁄₁₆″, board 4, particleboards. The wafer-type board, board 8, performed only slightly better than shavings-type boards in terms of initial visible failure but exhibited clearly superior properties in terms of resistance to total failure.

From Table 7 and Fig. 8, it can be seen that the height to initial visible failure on 24″ centers was similar for all boards, ranging from 13.5 to 18 inches. This, however, compares ½″ plywood, board 9, and oriented particleboard, board 6, with other boards that are ⅝″ thick. From Fig. 11 note that initial visible failure occurred slightly earlier on 24″ than on 16″ spans, but the height to total failure tended to increase slightly when going from the 16″ to 24″ span. The benefit obtained from large flake geometries or cross lamination in resistance to total failure can be seen from the results of the oriented and wafer-type particleboards and plywood (Tables 6 and 7).

The following summarizes the results of the sandbag test at the control condition. Shavings-type particleboard ⅝″ thick did not compare well with ⅝″ plywood in regards to impact strength and deflection properties when tested as subfloor/underlayment. Oriented particleboard on the other hand, was the equal of plywood as far as height to initial visible failure was concerned and was the best particleboard in respect to height to total failure. Changing the span from 16″ to 24″ had only a moderate effect on height to initial failure, total failure and set, but had a large effect on total deflection.

Results from Exposure to Weathering

Tables 8 and 9 and Figs. 9 and 10 show the change from the control condition as a result of the three types of weathering exposures. Figure 11 shows the effect of span on sandbag impact strength. In lieu of a detailed discussion, a few general observations regarding weathering are given below. These were generated from all tests, not just those illustrated in Figs. 9 and 10.

When boards were wetted as a result of 48 h of "rain," they generally lost little of their ultimate sandbag impact strength and sometimes became somewhat stronger in their resistance to ultimate failure. When deterioration occurred, it was on 24″ spans. Wetting resulted in much greater deflection and permanent deformation from a 12″ drop on both 16″ and 24″ spacings.

Weathering by wetting-reconditioning or wetting-heating-reconditioning generally produced the same results. The reconditioned strength values fell somewhat below control strengths, and the deflection after reconditioning was often but not always greater than that at the control condition. Deterioration of deflection performance tended to be slightly more pronounced when heating was present. Shavings-type particleboards, both urea- or phenolic-bonded, had lower sandbag impact strengths after weathering than did wafer-type particleboard, oriented particleboard, and plywood, in that order.

CONCLUSIONS

1. The British impact test generally lacked the sensitivity to establish differences between types of particleboard. When the British impact test was used, the height needed for punch-through was a more discriminating characteristic than the height to initial failure.
2. Most particleboards exhibited about half the punch-through or puncture resistance of plywood of equal thickness. Oriented particleboard had the greatest punch-through resistance of any of the particleboards tested.
3. Wetting or wetting-reconditioning increased the height of drop necessary for punch-through.
4. Height-to-initial failure from sandbag testing of boards 16″ on-center was highest in plywood and oriented-type particleboard at each of the 4 testing conditions.
5. The size of particles and board thickness were the characteristics that seemed to have the greatest influence on the initial visible sandbag failure. Thicker boards or boards composed of larger-sized particles had greater resistance to failure.
6. Wetting, wetting-reconditioning, or wetting-heating-reconditioning generally caused a slight loss in resistance to initial visible failure for boards over joists 16″ on-center, while the effect was variable for boards 24″ on-center.
7. Compared with phenolic-bonded boards, the urea-bonded boards incurred only slightly larger losses in sandbag impact strength due to heating. These losses might have been much larger, were it not for the effect of sizing, which appeared to retard a thorough wetting of the boards. The addition of a water repellent by a postmanufacturing treatment might limit the losses even further.
8. Under all test conditions, plywood had as good resistance or greater resistance to total sandbag failure than particleboard. One-half inch and ⅝″ plywood on 24″ and 16″ centers withstood a height of drop of 1.3 to 2.7 times the average height required to totally fail ⅝″ shavings-type particleboard, 1.7 times the height to totally fail wafer-type particleboard, and 1 to 1.5 times the height necessary to fail the oriented-type particleboards.
9. The effects of wetting or wetting-reconditioning with or without heat on the height-to-total-failure was slight.
10. In the case of floor systems, plywood and particleboard lost approximately equal percentages of their initial strength as a result of exposure and reconditioning with or without heat.
11. Plywood and oriented particleboard deflected less under impact than other types of particleboard of equal thickness.

FINAL COMMENTS

The results of this study are not intended to be used to establish impact criteria for particleboard at a level comparable to that of plywood. The impact performance of plywood is not the result of product engineering designed to meet use conditions but rather is due to the inherent properties of the cross lamination process. The development of design criteria for impact should be based on an analysis of impact loads actually encountered in structures.

Some of the particleboards evaluated in this study exceed the impact strength requirements of some Scandinavian countries that presently use particleboard for sheathing and subflooring material (Haygreen 1973). This suggests that particleboard can successfully be used in the United States for on-site building applications if the builders are educated to its limitations and proper application.

This study has shown that exposure to a period of short-term weathering has little effect, if any, on impact resistance. This and the fact that structural shavings-type particleboards have been used extensively and with good success by the U.S. manufactures of mobile homes and modular houses appear to provide justification for its consideration for on-site construction. However, the most important task would seem to be the determination of the magnitude of actual impact stresses, as well as the influence that combined loading and/or creep might have on reducing impact strength.

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