RIGIDITY AND STRENGTH OF FRAME WALLS SHEATHED WITH FIBERBOARD

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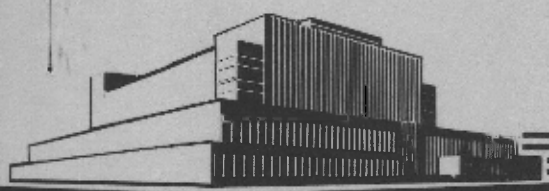

FOREST PRODUCTS LABORATORY
MADISON 5, WISCONSIN

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE
In Cooperation with the University of Wisconsin

RIGIDITY AND STRENGTH OF FRAME WALLS SHEATHED WITH FIBERBOARD

By

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Introduction

Because of the extensive use of fiberboard for sheathing, there is an increasing desire on the part of prospective home builders, engineers, architects, loan agencies, and housing authorities for authentic information on the rigidity and strength of the various fiberboards. At the Forest Products Laboratory a series of tests was made on room-size wall panels sheathed with fiberboard to determine their rigidity and strength. The effects of nailing, storage in high humidity, wetting, openings in wall panels, and vibration on these panels were also investigated. This report gives the results of those tests and, for comparative purposes, includes test data on walls sheathed with horizontal and diagonal wood sheathing.

Test Material

Most of the panels tested were 9 by 14 feet; some were approximately 7 by 12 feet, and others were 8 by 8 feet. All results were adjusted so that direct comparison with 9- by 14-foot panels could be made.

Framing

The framing for the 9- by 14- and 7- by 12-foot panels was nominal 2- by 4-inch southern yellow pine of No. 1 Common grade. It was selected from seasoned stock at a local yard and stored on stickers in a heated building for several weeks before use. The average moisture content of this framing when the frames were built was about 13 percent.

The framing for the 8- by 8-foot panels was Douglas-fir No. 2 or Better grade. Its moisture content was about 17 percent.

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[1] Maintained at Madison, Wis., in cooperation with the University of Wisconsin.

Sheathing

The fiberboard sheathing for the 9- by 14-foot and 7- by 12-foot panels, designated fiberboard No. 1, consisted of 4- by 9-foot or 4- by 7-1/3-foot sheets approximately 25/32 inch thick and weighing about 19.4 pounds per cubic foot based on weight when oven-dry and volume when air-dry. It was dark brown because of an asphaltic treatment during manufacture. This material was obtained from the stock of a local dealer. With the exception of eight sheets required for the vibration-test panels, it was stored in a humidity room maintained at 72° F. and a relative humidity of 52 percent until nailed to the frames. The equilibrium moisture content of the fiberboard stored in this room was about 6-1/2 percent. The eight sheets for the vibration test were kept in a heated testing laboratory until applied to the frames and tested. The fiberboard kept in this laboratory reached a moisture content of about 3 percent.

The fiberboard for the 8- by 8-foot panels was designated as fiberboard No. 2 and was 25/32 inch thick and 24 by 96 inches in area. It was asphalt coated and had a V-type tongued-and-grooved horizontal joint.

Construction of Test Panels

All panel frames consisted of 2- by 4-inch upper and lower plates and 2- by 4-inch studs spaced 16 inches, except that at the ends of the 14-foot panels the spacing was 12 inches and in the 7- by 12-foot and 8- by 8-foot panels the spacing was 16 inches from the outside edge of the end post to the center of the first stud. The end posts for test panels consisted of two 2- by 4-inch pieces spaced about 1 inch apart, to which a third 2 by 4 was nailed with its 4-inch side perpendicular to the 4-inch sides of the other two and its outside edge flush with the outside edge of the outer 2 by 4. This is common practice in order to leave a nailing ledge for lath, although none of the panels were lathed. The frames were put together with sixteenpenny common nails, and the studs were fastened to the plates by two nails through the plates into the ends of the studs.

Width of Sheets

Panels Without Openings

The 9- by 14-foot panels required four sheets 44, 48, 48, and 28 inches wide; the 7- by 12-foot panels, three sheets 48 inches wide; and the 8- by 8-foot panels four sheets 2 by 8 feet. The 9- by 14- and 7- by 12-foot panels had the sheets placed with the long dimension vertical and permitted perimeter nailing. The 8- by 8-foot panels had the sheets placed horizontally, and two of the sheets were cut at the center of the length.

Panels With Openings

Certain panels with openings had full-length pieces between and adjacent to door and window openings with small pieces placed above the door opening and above and below window openings. Other panels had full-width boards with cut-outs for door and window openings, as shown in the sketches in tables 1 and 2.

Nailing

The recommended nailing for fiberboard No. 1 is eightpenny common nails spaced 3 inches on center at all vertical edges, 6 inches on center on intermediate frame members, and approximately 5-1/3 inches on center along the upper and lower plates. Some panels had double the recommended nailing, as shown in table 2.

The nailing for fiberboard No. 2, which was used in 2- by 8-foot sheets placed horizontally, was 11-gage galvanized nails 2 inches long, with 7/16-inch heads, and spaced 4 inches on center vertically and at least 3/8 inch from all edges. No nails were placed along horizontal edges.

Test Procedure

Racking Test

Racking tests were made to determine the resistance of the various panels to a static load applied horizontally to the upper plate and acting in the plane of the panel. The lower plate was bolted to a heavy 6- by 8-inch timber, which in turn was fastened to the base of a million-pound-capacity testing machine. The upper plate was securely bolted to a 5- by 6-inch timber, which was held against lateral movement and therefore furnished the resistance that is supplied to walls in service by the upper floor or ceiling system. Two vertical hold-down rods, one on either side of the test panel, were fastened at one end to the base of the testing machine and at the other end to a bearing plate on top of the 5- by 6-inch timber to which the upper plate was bolted. The horizontal movement of the upper plate with respect to the lower plate was measured for various increments of load. A diagrammatic sketch and a photograph of a panel set up in the testing machine are given in figures 1 and 2.

Vibration Test

Vibrating of specimens was accomplished by bolting the wall panels to a vibrating machine having a horizontal throw. The lower, or sole plate, of each panel was bolted to a heavy timber that in turn was fastened to the table of the vibrating machine (fig. 3). The upper plate was also securely bolted to a heavy box loaded to a weight of 800 pounds, which furnished the resistance to lateral and longitudinal movement that is always supplied to

walls by the upper floor system. The alining action of cross walls was simulated by 2 blocks equipped with rollers placed approximately 18 inches from each end of the panel. The blocks were anchored to a framework provided for that purpose and positioned so that only the rollers came into contact with the sides of the heavy box attached to the upper plate. The wall panels, both fiberboard- and lumber-sheathed, were vibrated at an approximate rate of 112 cycles per minute and a horizontal throw of the bottom plate of about 1.4 inches. This produced a deflection of 0.1 inch in the top plate of panels having let-in diagonal bracing and horizontal wood sheathing.

Effect of Various Factors on Strength and Rigidity of Panels

The results of the tests have been placed in four tables so that the effects of the various factors investigated on the strength and rigidity of the panels could be more easily presented. In all four tables the strength and rigidity of a panel with horizontal sheathing and no bracing has been taken as a control. Although the panels as tested varied in size, the test results were adjusted to a panel 9 by 14 feet in size so that the values in the table can be compared directly.

Effect of Sheathing and Method of Attachment

The strength and rigidity of panels with various sheathing materials attached by various methods are shown in table 1. The panels with wood sheathing placed horizontally (item 1, table 1) are given a ratio of 1 for relative rigidity and relative strength.

Fiberboard No. 1 in 4- by 8-foot sheets nailed according to the manufacturer's recommendation (item 2, table 1) had 3 times the rigidity and nearly 4 times the strength (maximum load) of the base panels. Figure 4 shows how the fiberboard pulled away from nails in the racking test. If 2- by 8-foot sheets are used, as is commonly done today, and the sheets are nailed only on vertical edges (item 3, table 1), the rigidity is no greater and the strength is about 1.4 times as great as compared to panels with horizontal wood sheathing and no bracing. (See fig. 5.)

The addition of 1- by 4-inch let-in bracing to horizontal wood sheathing (item 4, table 1) greatly increases the rigidity and strength to over 4 times the rigidity and 3.5 times the strength of horizontal sheathing alone.

Diagonal wood sheathing, which is also very effective (item 5, table 1), has a relative rigidity of 3.8 and a relative strength of over 8.

When door and window openings are in the wall, the strength and rigidity are greatly decreased. For panels with fiberboard sheets extending from top to bottom plate between and adjacent to door and window openings and additional small pieces placed above the door and above and below the window opening

(item 6, table 1), the relative rigidity is only 1.6 and the relative strength 2.1. Window and door openings also greatly reduce the rigidity and strength of panels with horizontal sheathing and let-in bracing (item 7, table 1) and panels with diagonal wood sheathing (items 8 and 9, table 1). (See fig. 6.)

The addition of wood siding to panels with diagonal wood sheathing helps counteract the lowering of the rigidity and strength by window and door openings (items 10 and 11, table 1).

Effect of Nailing

When eightpenny common nails are spaced 3 inches along all vertical edges, 6 inches on intermediate studs, and 5-1/3 inches on plates, as recommended by fiberboard manufacturers, the rigidity and strength of panels with 4- by 8-foot sheets are about 3 and 4 times greater, respectively, than those of panels with horizontal sheathing without bracing (items 2 and 4, table 2). These results compare favorably with those for panels with horizontal sheathing and let-in bracing (item 4, table 1). Doubling the number of nails increases the rigidity and strength about 50 percent, which is less than the increase in number of nails would indicate (items 3 and 5, table 2). A similar effect of increased number of nails occurred in panels subjected to high humidity before test (items 6 and 7, table 2). Figure 7 shows nails bent from shearing forces on the panels.

Doubling the number of nails is less effective in panels with door and window openings than in panels with no openings. The increase was about 0.1 to 0.2 for rigidity and 0.2 to 0.4 for strength (items 8, 9, 10, and 11, table 2).

Effect of Moisture

The addition of moisture reduces both the rigidity and strength of a panel sheathed with fiberboard. For a panel stored for 1 month in a room held at 94 percent relative humidity and 40° F. the reduction was about 15 percent in both rigidity and strength, as compared to values for a dry panel (items 2 and 3, table 3). A reduction of about 20 percent in rigidity and strength occurred in panels sprayed with water for three 24-hour periods alternated with two 24-hour drying periods (items 4 and 5, table 3). These panels showed less change in moisture content than those exposed to high humidity but still had greater reductions in rigidity and stiffness. Whether the different type of fiberboard, the different size of the sheets, or the method of attachment affected the results is not known. Figure 8 shows the method used to wet the panels.

Effect of Vibration

The 9- by 14-foot panels with full-length fiberboard sheets attached with eightpenny common nails showed little reduction in rigidity and strength after being vibrated (table 4). The panel vibrated 1,000,000 cycles (item 3, table 4) was slightly higher in rigidity and strength than the panel vibrated

50,000 cycles (item 4, table 4). This result indicates that any probable reduction occurred within the 50,000 cycles.

When 2- by 8-foot sheets were attached by 11-gage nails 2 inches long with 7/16-inch heads, the vibrating caused a shearing of all the nails in each fiberboard sheet except the center row. One panel received 150,000 vibrations, but the other two panels received only 19,000 and 28,000 cycles. The rigidity of these partially failed panels was obtained but no maximum load was recorded. The remaining relative rigidity was only about 0.4 as compared to unvibrated panels (items 5 and 6, table 4).

Table 1.--Comparison of strength and rigidity of panels with different types of sheathing attached by different methods

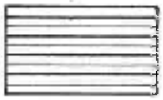
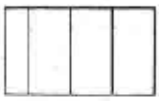
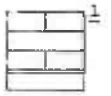
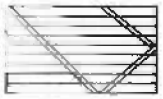
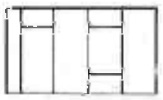
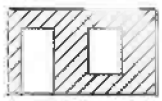
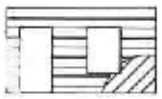
Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard (Percent)	Relative rigidity	Relative strength	Reference panel No.
1	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing	None			1.0	1.0	2A, 19, 20, 33
2	Fiberboard No. 1	 9 by 14 feet	Eightpenny nails spaced 3 inches on vertical edges, 6 inches on intermediate studs, 5-1/3 inches on plates	do	0.52	4.6	3.0	3.8	3a, 4a
3	Fiberboard No. 2	 8 by 8 feet	Galvanized nails (11 gage, 2 inches long, with 7/16-inch heads) spaced 4 inches vertically, 3/8 inch from edge; no horizontal nailing	do		7.0	1.0	1.4	10, 11, 12
4	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing; 1- by 4-inch let-in bracing	do			4.2	3.5	34
5	do	 9 by 14 feet Sheathing in tension	2 eightpenny nails per stud crossing	do			3.8	8+	5, 26, 31
6	Fiberboard No. 1	 9 by 14 feet Reinforcing stubs	Eightpenny nails spaced 3 inches on vertical edges, 6 inches on intermediate studs, 5-1/3 inches on plates	do	.52	5.2	1.6	2.1	7a

Table 1.--Comparison of strength and rigidity of panels with different types of sheathing attached by different methods (Continued)

Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard	Relative rigidity	Relative strength	Reference panel No.
						Percent			
7	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing; 1- by 4-inch let-in bracing	None			1.5	2.2	7B
8	do	 9 by 14 feet Sheathing in tension	2 eightpenny nails per stud crossing	do			1.4	3.9	8B, 9C
9	do	 9 by 14 feet Sheathing in compression	2 eightpenny nails per stud crossing	do			1.0	1.3	8C, 9B
10	Wood sheathing and siding	 9 by 14 feet Sheathing in tension	Sheathing -- 2 eightpenny nails per stud crossing; siding -- sevenpenny box	do			3.3	5.4	29
11	do	 9 by 14 feet Sheathing in compression	Sheathing -- 2 eightpenny nails per stud crossing; siding -- sevenpenny box	do			2.0	3.3	10C

[1] Values for this panel adjusted for size.

Table 2.--Comparison of effect of nailing on strength and rigidity of panels with different types of sheathing

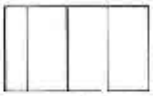
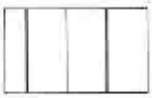
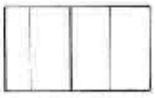
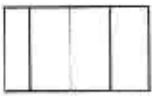
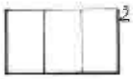
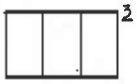
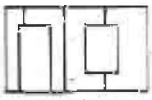
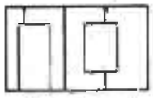
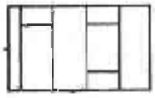
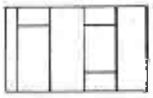
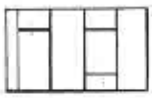
Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard	Relative rigidity	Relative strength	Reference panel No.
						Percent			
1	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing	None			1.0	1.0	2A, 19, 20, 33
2	Fiberboard No. 1	 9 by 14 feet	Recommended nailing[1]	do	[2]0.52	4.6	3.0	3.8	3a, 4a
3	do	 9 by 14 feet	Double recommended nailing	do	.52	4.9	4.6	6.2	3b, 4b
4	do	 9 by 14 feet	Recommended nailing (nailed between nailing marks)	do	.53	5.6	3.0	3.6	5a
5	do	 9 by 14 feet	Double recommended nailing (nailed between nailing marks)	do	.53	5.6	4.3	5.3	5b
6	do	 7 feet, 4 inches by 12 feet, 1-5/8 inches	Recommended nailing	Stored in room at 94 percent relative humidity and 40° F. for 1 month before test	.53	16.7	2.6	3.3	1

Table 2.--Comparison of effect of nailing on strength and rigidity of panels with different types of sheathing (Continued)

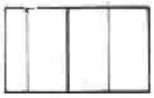
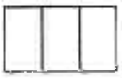
Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard	Relative rigidity	Relative strength	Reference panel No.
						Percent			
7	Fiberboard No. 1	 7 feet, 4 inches by 12 feet, 1-5/8 inches	Double recommended nailing	Stored in room at 94 percent relative humidity and 40° F. for 1 month before test	0.50	17.7	3.9	4.9	2
8	do.	 9 by 14 feet	Recommended nailing	None	.53	4.8	1.5	1.6	6a
9	do.	 9 by 14 feet	Double recommended nailing	do.	.53	4.6	1.8	2.2	6b
10	do.	 9 by 14 feet Reinforcing stubs	Recommended nailing	do.	.52	5.2	1.6	2.1	7a
11	do.	 9 by 14 feet Reinforcing stubs	Double recommended nailing	do.	.52	5.5	1.7	2.6	7b
12	do.	 9 by 14 feet	Recommended nailing	do.	.53	5.6	1.2	1.7	8a

[1] Eightpenny common nails spaced 3 inches on centers at all vertical edges, 6 inches on intermediate studs, 5-1/3 inchs on plates.

[2] Specific gravity based on weight and volume when material was ovendry.

[3] Values for this panel adjusted for size.

Table 3.--Comparison of effect of moisture on strength and rigidity of panels with different types of sheathing

Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard	Relative rigidity	Relative strength	Reference panel No.
						Percent			
1	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing	None	.....	.....	1.0	1.0	2A, 19, 20, 33
2	Fiberboard No. 1	 9 by 14 feet	Eightpenny nails spaced 3 inches on vertical edges, 6 inches on intermediate studs, 5-1/3 inches on plates	.....do.....	0.52	4.6	3.0	3.8	3a, 4a
3	.....do.....	 7 feet, 4 inches by 12 feet, 1-5/8 inches	.....do.....	Stored in room at 94 percent relative humidity and 40° F. for 1 month before test	.53	16.7	2.6	3.3	1
4	Fiberboard No. 2	 [1] 8 by 8 feet	Galvanized nails (11 gage, 2 inches long, with 7/16-inch heads) spaced 4 inches vertically, 3/8 inch from edge; no horizontal nailing	None	.....	7.0	1.0	1.4	10, 11, 12
5	.....do.....	 [1] 8 by 8 feet	.....do.....	Sprayed with water for three 24-hour periods alternated with two 24-hour drying periods and tested while wet	.....	12.0	.8	1.1	10, 11, 12

[1] Values for this panel adjusted for size.

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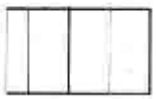
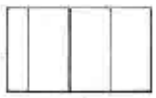
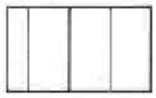
Table 4.--Comparison of effect of vibration on strength and rigidity of panels with different types of sheathing

Item No.	Cover	Panel	Nailing	Conditioning before test	Average specific gravity of frame	Moisture content of fiberboard	Relative rigidity	Relative strength	Reference panel No.
						Percent			
1	Wood sheathing	 9 by 14 feet	2 eightpenny nails per stud crossing	None			1.0	1.0	2A, 19, 20, 33
2	Fiberboard No. 1	 9 by 14 feet	Eightpenny nails spaced 3 inches on vertical edges, 6 inches on intermediate studs, 5-1/3 inches on plates	do	0.52	4.6	3.0	3.8	3a, 4a
3	do	 9 by 14 feet	do	Vibrated 1,000,000 cycles before test	.51	2.3	2.8	3.7	9
4	do	 9 by 14 feet	do	Vibrated 50,000 cycles before test	.52	3.4	2.6	3.0	10
5	Fiberboard No. 2	 [1] 8 by 8 feet	Galvanized nails (11 gage, 2 inches long, with 7/16-inch heads) spaced 4 inches vertically, 3/8 inch from edge; no horizontal nailing	None		7.0	1.0	1.4	10, 11, 12
6	do	 [1] 8 by 8 feet	do	Panel 10 had 150,000 cycles; panel 11, 19,000 cycles; panel 12, 28,000 cycles [2]		6.0	.4		10, 11, 12

[1] Values for this panel adjusted for size.

[2] All except center row of nails in each sheet sheared off.

Report No. 1151

ZM 94254 F

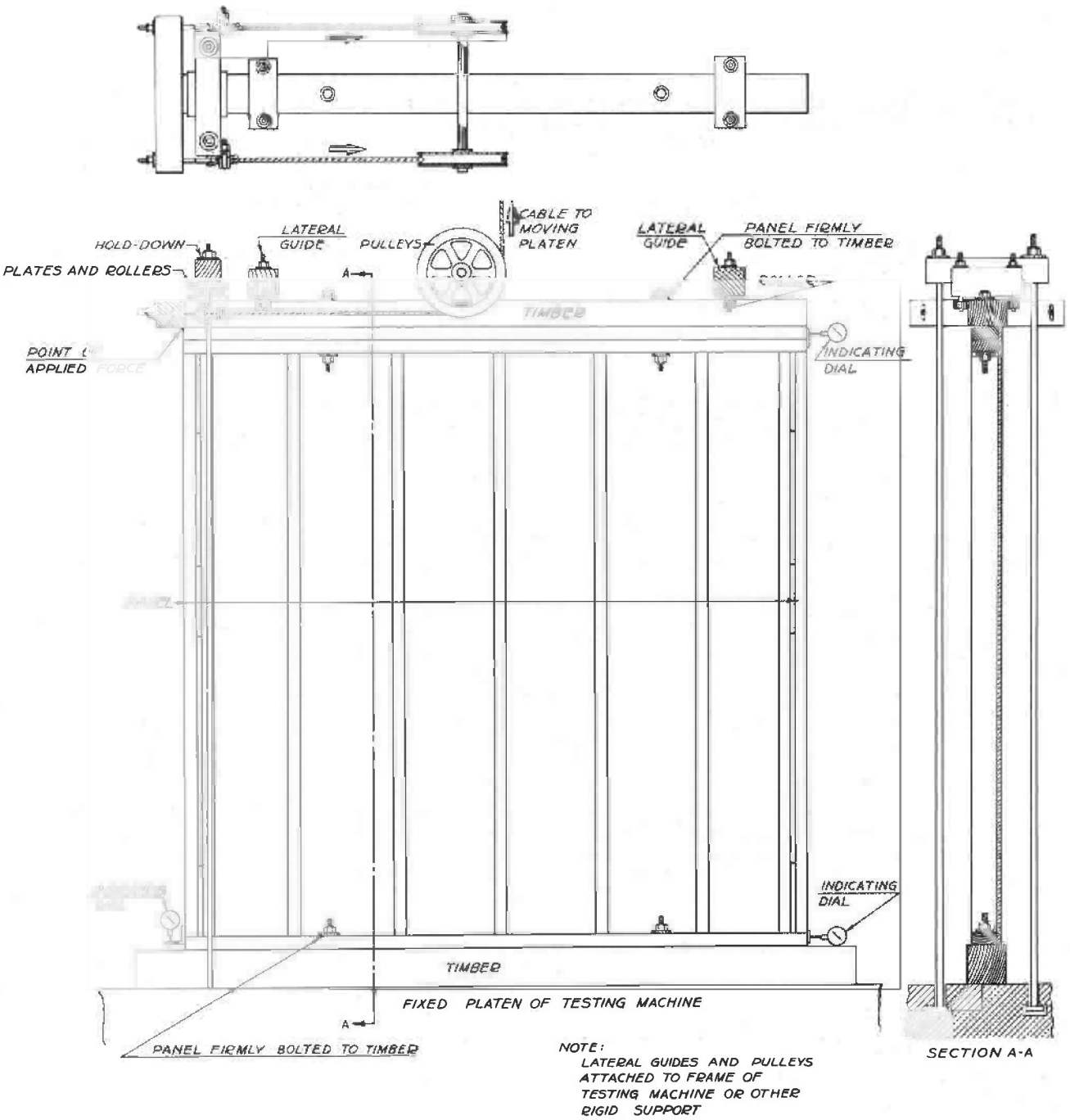


Figure 1. --Sketch of apparatus for testing racking resistance of wall panels.

Z M 91084 F

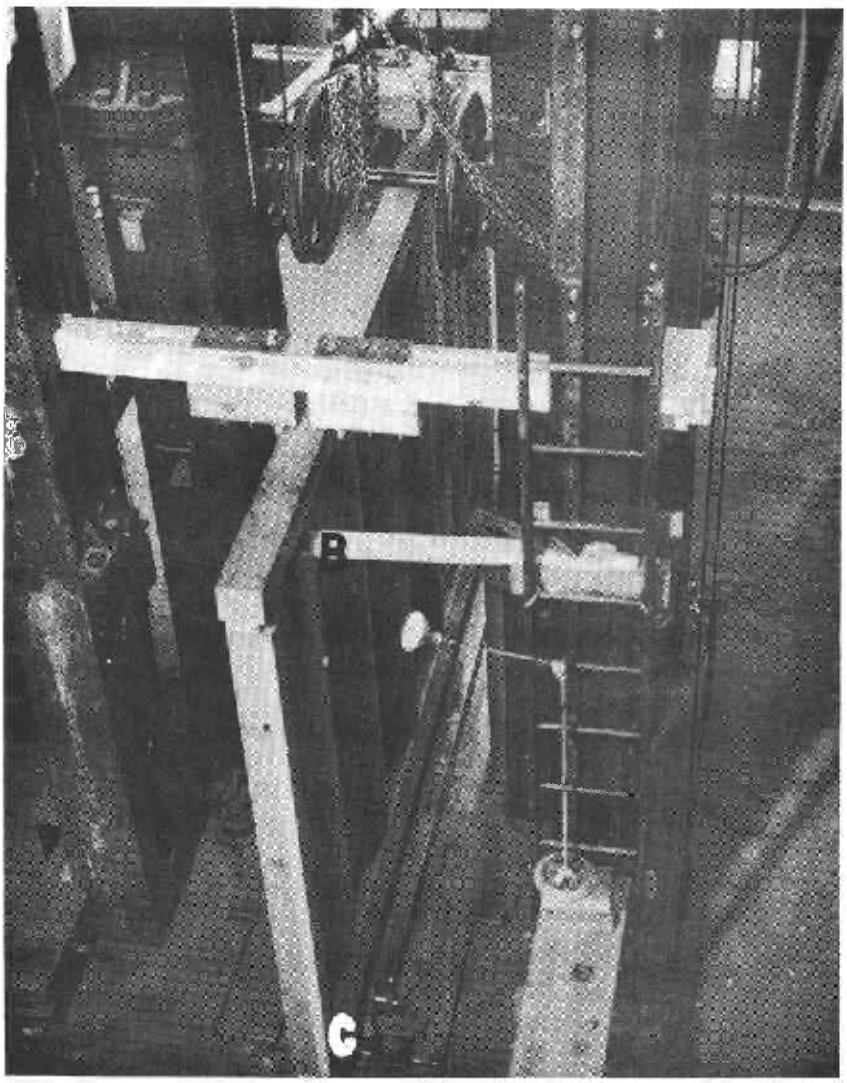


Figure 2. --Set-up for racking test of panels showing the timbers attached to the upper and lower plates, dial indicators B and C, and the method used to keep the panel in a vertical plane simulating the action of cross walls.

Z M 76464 F

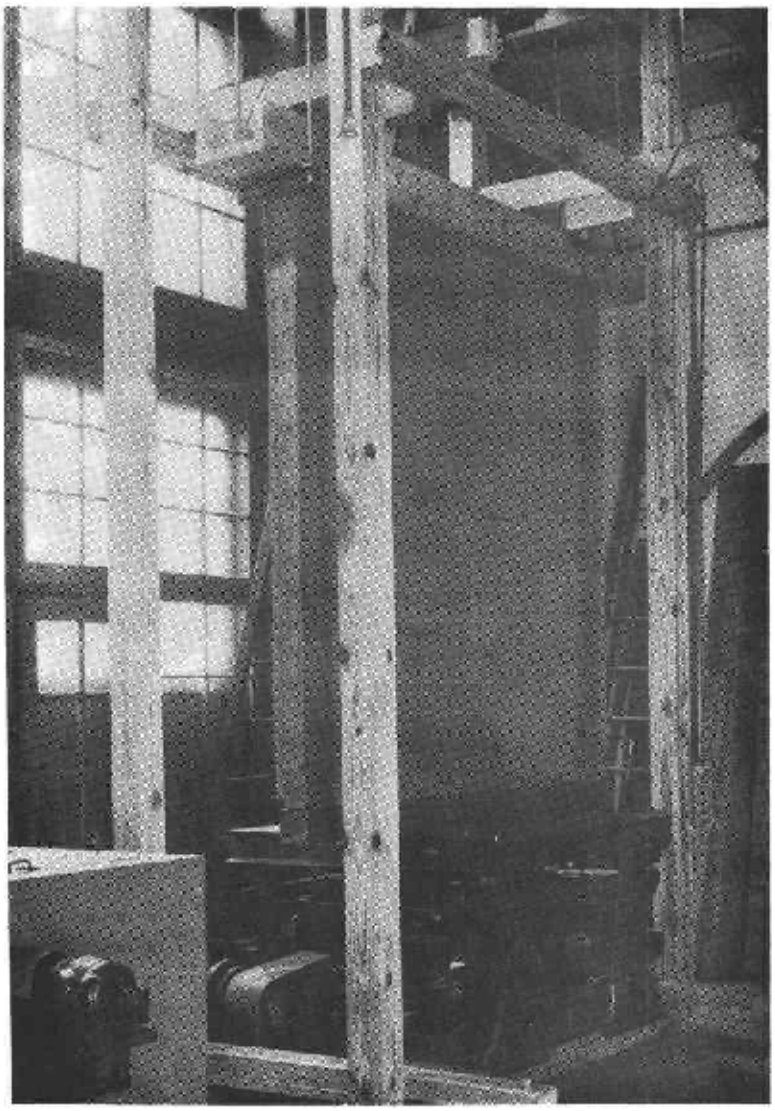


Figure 3. --Set-up for vibration test of panels.

Z M 80827 F

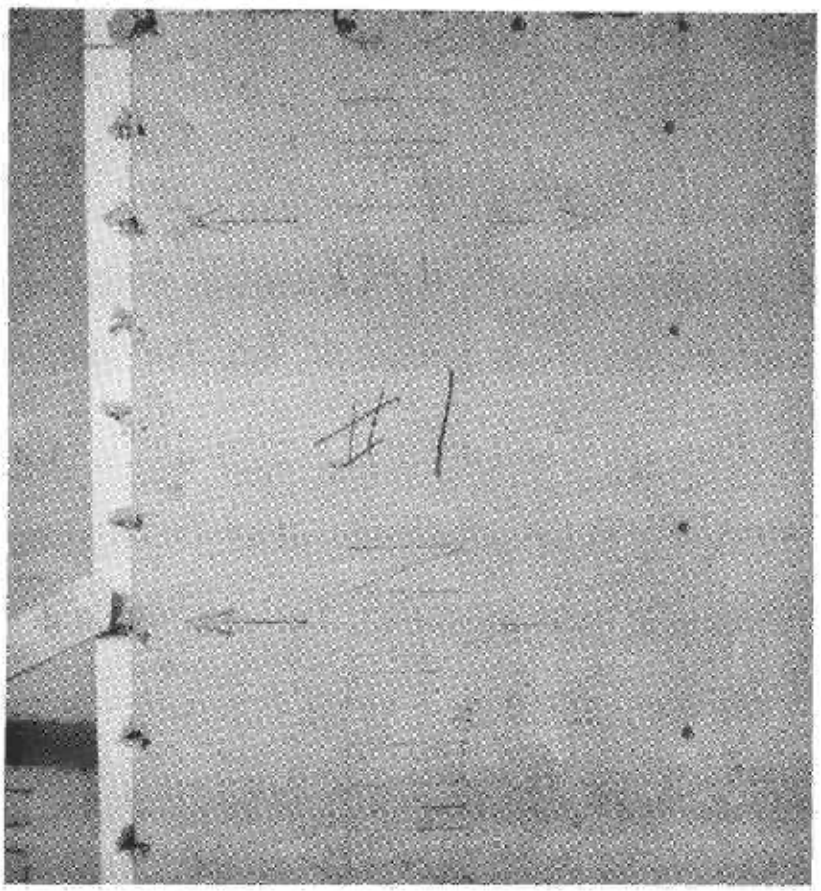


Figure 4. --Fiberboards torn from nails -- typical failure during racking test of panels without openings and panels with openings when fiberboard was applied in full-length sheets.

Z M 30153 F

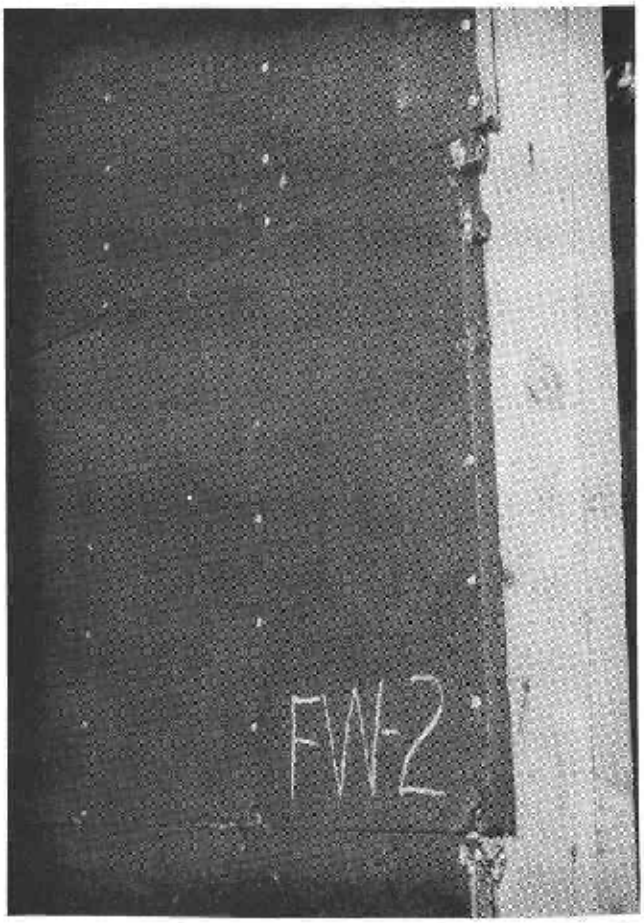


Figure 5. --Typical failure of 2- by 8-foot sheets of fiberboard in racking tests.

Z M 80820 F

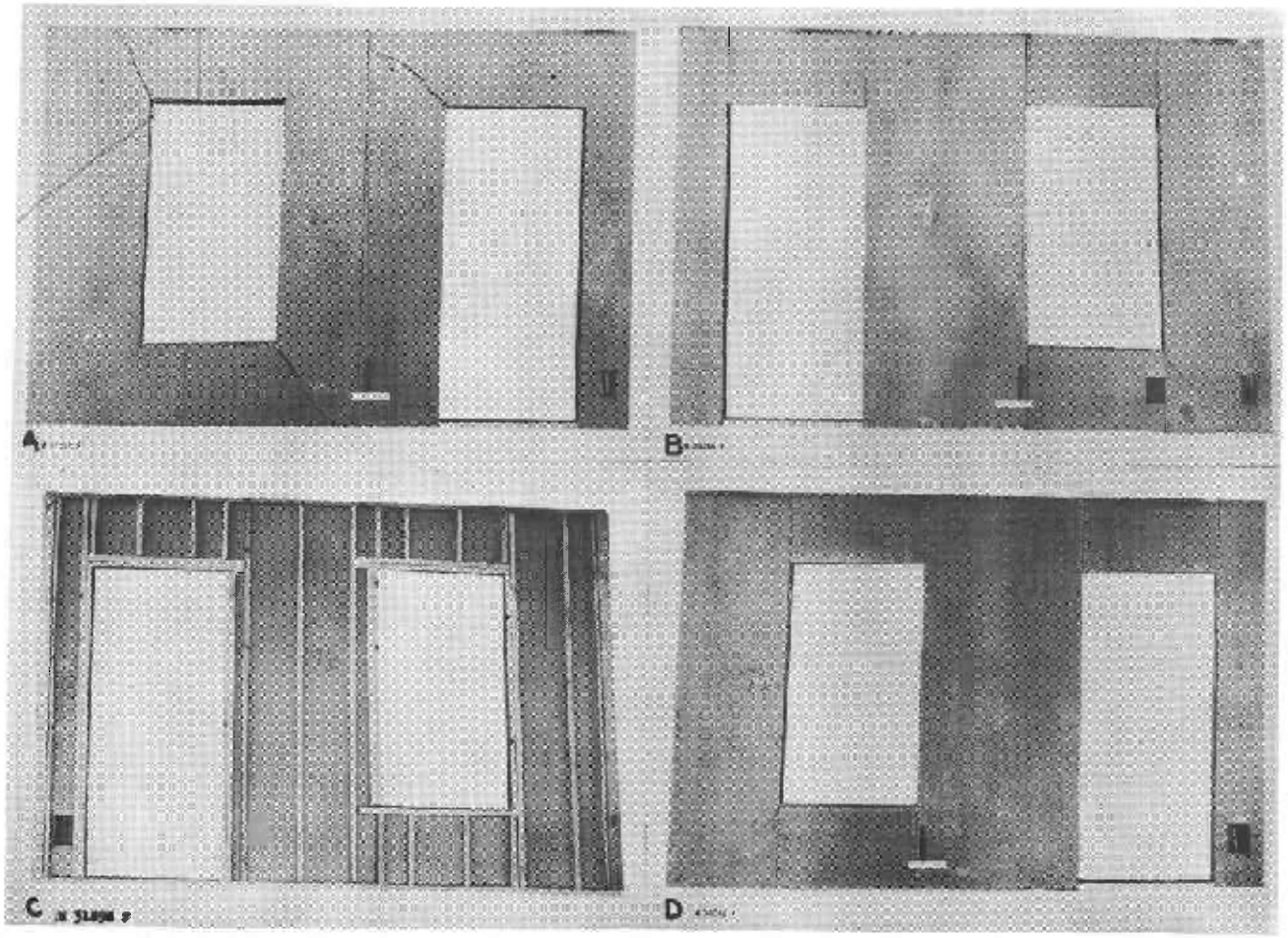


Figure 6.--Fiberboard-sheathed panels after racking tests. A, Typical failure in panels with sheathing sawed to fit openings. Test load applied at left end of upper plate. B, Sheathing applied in full-length sheets without reentrant angles. Objectionable failures shown in A eliminated. C, Fiberboard applied as in B, but 2- by 4-inch stubs inserted above door and window openings and below windows to provide additional nailing for sheathing. D, Opposite face of panel C showing nailing of sheathing to short reinforcing stubs. (Plumb bob shows distortion of panels after test.)

Z M 31898 F

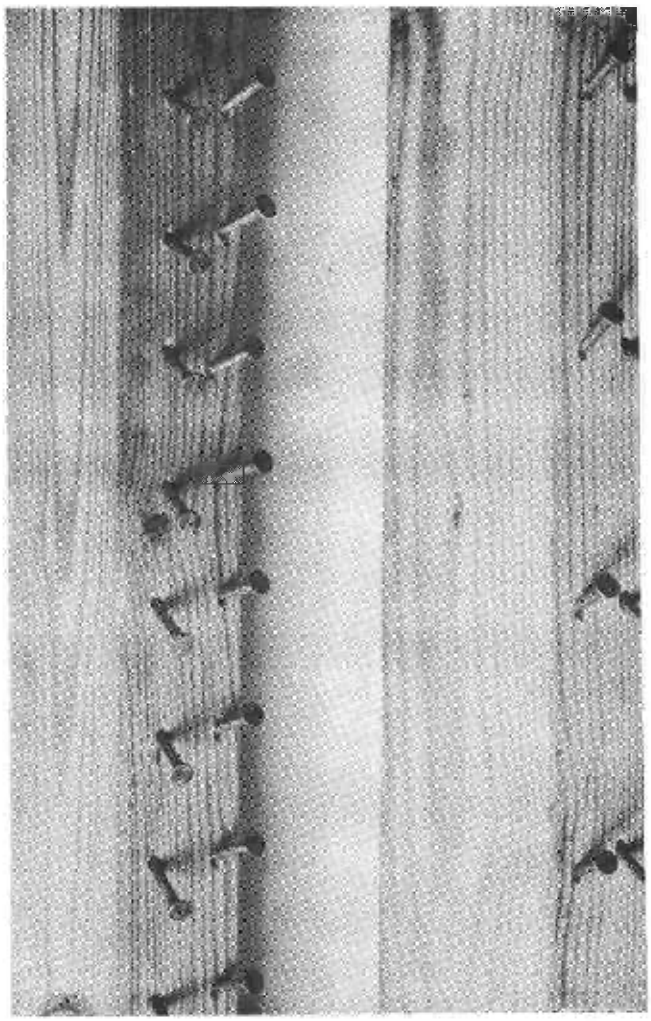


Figure 7. --Bending of nails caused by shearing forces acting in opposite directions along studs. Right, recommended nailing on intermediate studs; left, double recommended nailing.

Z M 30240 F

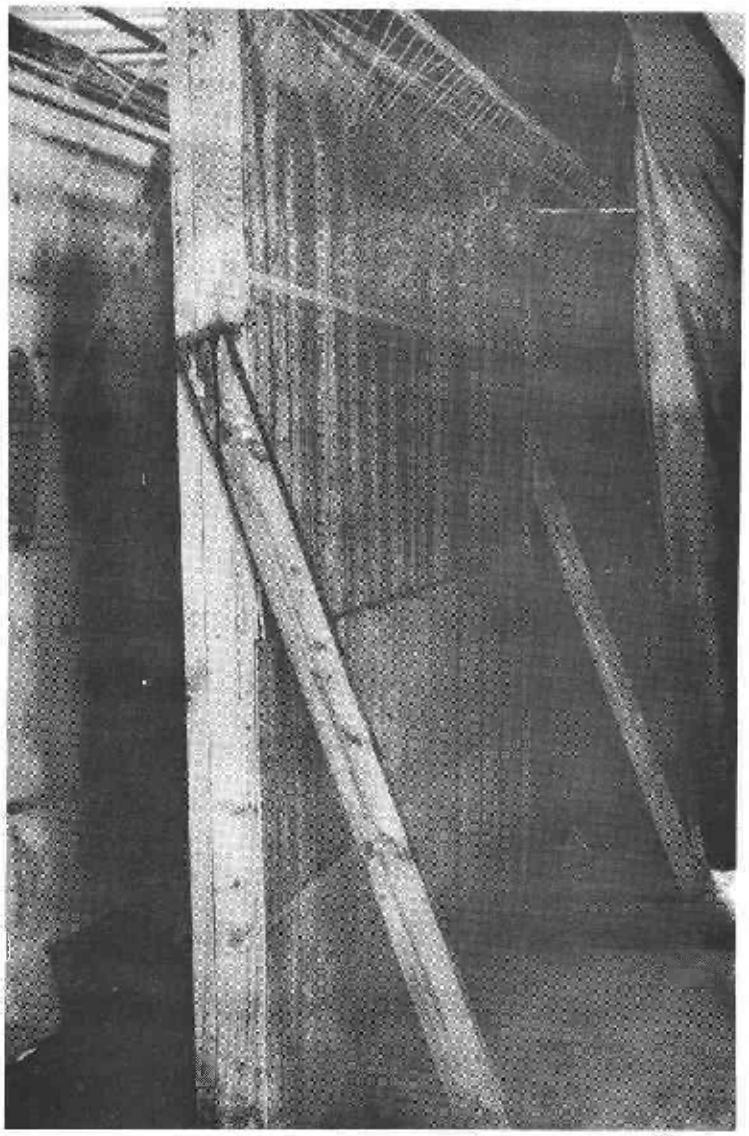


Figure 8. --Spray chamber for water-spray treatment of racking panels.

Z M 80893 F

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