# SUITABILITY OF SHORT LUMBER FOR PALLETS

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# SUITABILITY OF SHORT LUMBER FOR PALLETS

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## Introduction

During the past 10 years, pallets have become increasingly popular and their use has spread throughout the country. It was suggested that pallets, because of their rather simple design, might offer opportunities for enlarging the utilization of short length lumber that otherwise might become waste. Since the top deck of a pallet appeared to be the most logical place to attempt such utilization, the Forest Products Laboratory tested both two-way and four-way entry pallets made with top deck boards that butted at their midlength. These were compared with similar pallets made with the conventional full length deck boards.

## Description of Material

The lumber for the test pallets was received from the Gurdon Lumber Sales Company, Gurdon, Ark., through the cooperation of the Morgan Lumber Sales Company, Columbus, Ohio. The species of lumber consisted mostly of sweetgum with some white elm. It was received with all pieces cut to size and ready for assembly.

To assemble the pallets, two kinds of nails were used as follows:

2-1/4- by 0.113-inch diameter, regular steel, diamond point, annular grooved.

1-1/4- by 0.080-inch diameter, regular steel, bright, common.

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

## Construction of Pallets

### Two-Way Entry

Two-way entry, 48- by 48-inch, double-faced (top and bottom decks alike), reusable pallets were assembled at the Forest Products Laboratory. Each top and bottom deck consisted of two 3/4-inch end deck boards and five 3/4-inch intermediate deck boards fastened to three 2- by 4-inch stringers with sevenpenny annular-grooved nails (fig. 1).

Two styles of deck construction were tested. In one, all the intermediate deck boards were butt-jointed at their midlength, and the end deck boards were single pieces. In the other, all the deck boards were single pieces.

In both styles, all the deck boards were fastened to the stringers with three sevenpenny annular-grooved nails per nail joint. All the nails were staggered to prevent splitting.

The component parts of the two-way entry pallet are listed in table 1.

The average moisture content of the deck boards, as determined by a moisture meter, was 17 percent and that of the stringers was 40 percent.

### Four-Way Entry

The four-way entry, 40- by 48-inch, single-faced (top deck only), expendable pallets were also assembled at the Forest Products Laboratory. The top deck consisted of two end deck boards and four intermediate deck boards fastened to three subdeck boards with clinched threepenny common nails (fig. 2). All boards were 3/8 inch thick.

The same two styles of deck board construction were tested as in the two-way entry design.

In both styles, the top deck boards were fastened to the subdeck boards with two threepenny common nails, clinched, per nail joint. The top deck assembly and bottom deck boards were fastened to the posts with two sevenpenny annular-grooved nails per nail joint. All nails were staggered to prevent splitting.

The component parts of the four-way entry pallet are listed in table 2.

As determined by a moisture meter the average moisture content was 17 percent for all deck boards and 40 percent for the posts.

## Test Methods

In studying the performance of the two styles of deck board construction, five different kinds of tests were conducted. Unloaded pallets were subjected to these tests according to the following schedule:

| Type of pallet | Style of deck board construction | Number of pallets in each test | | | | |
|---|---|---|---|---|---|---|
| | | Cornerwise drop | Revolving drum | Corner-to-corner diagonal compression | Concentrated load | |
| | | | | | Point | Bar |
| Two-way entry | Butt-jointed | 3 | 3 | 3 | 0 | 3 |
| | Unjointed | 3 | 3 | 3 | 0 | 3 |
| Four-way entry | Butt-jointed | 3 | 3 | 0 | 3 | 3 |
| | Unjointed | 3 | 3 | 0 | 3 | 3 |

### Cornerwise-Drop Test

In the cornerwise-drop test, which was made to determine the resistance offered to diagonal distortion, the pallets were dropped onto a cast-iron plate embedded in a concrete floor so as to strike on each of the four corners in the clockwise sequence shown by the letters A, B, C, and D in figures 1 and 2. The pallets were dropped 4 times from each height of 2, 3, and 4 feet successively. If no failure occurred after these drops, the pallets were dropped continuously from a height of 4 feet until 2 pallet members separated, which was judged as failure. The distance between diagonally opposite corners was measured before and after each drop. After each drop onto a corner, the pallet was caught so that it would not fall flatwise.

### Revolving-Drum Test

Rough-handling tests to determine the overall ruggedness of the pallet material and construction were made by use of a 14-foot revolving hexagonal drum. As the drum revolved, the pallet slid, tumbled, and fell in varying positions against the hazards and guides fixed on the faces of the drum.

The pallets were subjected to 6 falls from heights of 4 to 6 feet for each revolution of the drum. The drum was stopped at frequent intervals in the test to examine and record the degree of damage.

The test was continued until any two pallet members separated, which denoted failure, as shown in figure 3.

## Corner-to-Corner Diagonal Compression Test

In the corner-to-corner diagonal compression test, which was made to determine the resistance to diagonal distortion, the pallets were placed in a universal testing machine with two diagonally opposite corners in line with the direction of the machine-head movement. The load was applied by a movable head traveling at a uniform rate of about 0.25 inch per minute. Load readings were taken at 1/2-inch increments. This test was applied only to the two-way entry pallet.

## Point-Load Test

A pallet was placed in a normal stacking or storage position in a universal testing machine. The load was applied at the center of the two intermediate deck boards nearest the end deck boards, as shown in figure 4. The head movement was about 0.25 inch per minute, and load readings were taken at every 1/4-inch increment of deflection.

This test was applied only to the four-way entry pallets to determine the stiffness of the pallets at two nonsupported points.

## Bar-Load Tests

The bar-load test was applied to determine the stiffness of the two styles of deck board construction. A pallet was placed in a normal stacking or storage position in a universal testing machine. The load was applied at the two midpoints between the center and end stringers or posts and across all the intermediate deck boards, as shown in figure 5. The head movement was about 0.25 inch per minute, and load readings were taken at every 1/4-inch increment of deflection.

## Test Results

### Cornerwise-Drop Test

The two-way entry pallets with butt-jointed deck board construction required on the average more drops to cause failure than did the pallets with unjointed deck board construction. Based on the average change in diagonal dimensions as an indication of rigidity, the pallets with butt-jointed deck board provided the more rigid construction. The reason for this may be the additional nailing at the center stringer. Failure was usually caused by the nails breaking between the deck boards and the stringers. This resulted in loosening of a deck board.

In the four-way entry pallets there did not appear to be any significant difference in the performance of either style of deck board construction. Failure was usually caused by the common nails breaking or pulling out, and thus loosening a top deck board.

Results of the cornerwise-drop test are shown in table 3.

### Revolving-Drum Test

In the two-way entry pallets there appeared to be little difference in the performance of either style of deck board construction, as judged by the average number of falls to cause failure in the revolving drum.

In the four-way entry pallets the butt-jointed deck board construction withstood, on the average, more falls to cause failure than the unjointed deck board construction. The four-way entry pallets with butt-jointed deck boards failed in 123, 202, and 212 falls in the drum. The four-way entry pallets with unjointed deck boards failed in 81, 110, and 239 falls in the drum. Such variations may be expected in tests of such a complex structure in which there was no attempt at matching material among the specimens and in tests where the cycle of falls may not be the same for each specimen. Although the tests are too few for definite conclusions, it is believed that the results at least indicate that there was little difference in performance between the two deck board constructions.

Results of the drum tests are shown in table 4.

Corner-to-Corner Diagonal Compression Test -- Two-Way Entry Pallets

The pallets with butt-jointed deck board construction offered more resistance to diagonal deformation than pallets with unjointed deck board construction. This was probably due to the additional nailing at the center stringers. Failure was caused by withdrawal of the nails due to the lateral movement of the pallet members.

Results of this test are shown in table 5.

Point-Load Test -- Four-Way Entry Pallets

The unjointed deck board construction appeared to be stiffer than the butt-jointed deck board construction at the nonsupported points as shown in table 6. Since deck board deflections of 1/2 to 1 inch might hinder the entrance of handling devices, and since the load differential required in both constructions to cause these deflections was relatively small, there appears to be little significant difference in the performance of either style of deck board construction. Furthermore, this difference does not appear to be too significant since pallet loads are generally more evenly distributed over the full area of the deck and are not concentrated at two points as was done in these tests.

Bar-Load Test

In the two-way entry pallets the unjointed deck board construction sustained slightly higher loads for given increments of deflection than pallets with the butt-jointed deck board construction. This might be expected because each half of the single-piece deck board spanning the three stringers received some support from that portion extending beyond the center stringer, as in a continuous beam. The butt-jointed deck boards, which met at the center stringer, did not receive any support from the portion beyond the midpoint or center stringer. Each portion was similar to a simple beam.

In the four-way entry pallets, there appeared to be little significant difference between either style of deck board construction.

The results of the bar-load tests are shown in table 7.

## Conclusions

In general, pallets with the butt-jointed intermediate deck boards compared favorably with those made with unjointed intermediate deck boards. Thus, it appears that short length lumber could be utilized for intermediate deck boards in pallet construction.

It is recommended that the Laboratory's results be checked by actual trial use of pallets employing butt-jointed deck board construction, since some of the distortion and stresses involved in these tests may be greater than those at which a pallet may be judged unserviceable.

Table 1.--Component parts of two-way entry pallet

| Part | Number of pieces | Length | Width | Thickness | Board measure |
|---|---|---|---|---|---|
| | | Inches | Inches | Inches | Board feet |
| | | Butt-Jointed | | | |
| End deck boards | 4 | 48 | 5-5/8 | 3/4 | 8.0 |
| Intermediate deck boards | 20 | 24 | 5-5/8 | 3/4 | 20.0 |
| Stringers | 3 | 48 | 3-5/8 | 1-5/8 | 8.0 |
| | | Unjointed | | | |
| End deck boards | 4 | 48 | 5-5/8 | 3/4 | 8.0 |
| Intermediate deck boards | 10 | 48 | 5-5/8 | 3/4 | 20.0 |
| Stringers | 3 | 48 | 3-5/8 | 1-5/8 | 8.0 |

Table 2.--Component parts of four-way entry pallet

| Part | Number of pieces | Length | Width | Thickness | Board measure |
|---|---|---|---|---|---|
| | | Inches | Inches | Inches | Board feet |
| **Butt-Jointed** | | | | | |
| End deck boards | 2 | 40 | 3-5/8 | 3/8 | 1.1 |
| Intermediate deck boards | 8 | 20 | 3-5/8 | 3/8 | 2.2 |
| Subdeck boards | 3 | 48 | 3-5/8 | 3/8 | 2.0 |
| Bottom deck boards | 3 | 40 | 3-5/8 | 3/8 | 1.7 |
| Post | 9 | 3-5/8 | 3-5/8 | 2-5/8 | 3.0 |
| **Unjointed** | | | | | |
| End deck boards | 2 | 40 | 3-5/8 | 3/8 | 1.1 |
| Intermediate deck boards | 4 | 40 | 3-5/8 | 3/8 | 2.2 |
| Subdeck boards | 3 | 48 | 3-5/8 | 3/8 | 2.0 |
| Bottom deck boards | 3 | 40 | 3-5/8 | 3/8 | 1.7 |
| Post | 9 | 3-5/8 | 3-5/8 | 2-5/8 | 3.0 |

Table 3.--Results of cornerwise-drop tests

| Type of pallet | Style of deck board construction | Number of pallets tested | Average change in diagonal dimensions[1] after the following number of drops | | | | | Average number of drops to failure | Remarks |
|---|---|---|---|---|---|---|---|---|---|
| | | | 4 | 8 | 12 | 16 | 20 | | |
| | | | Inch | Inches | Inches | Inches | Inches | | |
| Two-way entry | Butt joints | 3 | 0.55 | 1.05 | 1.63 | 2.19 | 2.81 | 28 | Nails broke between boards and stringers, causing end deck board to loosen. Not much splitting. |
| Two-way entry | Unjointed | 3 | .75 | 1.30 | 2.46 | 2.82 | 4.09 | 20 | Same as above. |
| Four-way entry | Butt joints | 3 | .48 | 1.02 | 1.60 | 2.35 | 2.80 | 20 | Breaking or pulling out of clinched nail caused the top deck boards to loosen. Great amount of splitting of the deck boards. |
| Four-way entry | Unjointed | 3 | .55 | 1.13 | 1.72 | 2.57 | ..... | 18 | Same as above. |

[1] The average of the two top deck diagonal measurements.

Table 4.--Results of the drum tests

| Type of pallet | Style of deck board construction | Number of pallets tested | Average number of falls to failure | Remarks |
|---|---|---|---|---|
| Two-way entry | Butt-jointed | 3 | 167 | End deck boards loosened from stringers by nail breakage. One stringer split. |
| Two-way entry | Unjointed | 3 | 155 | End deck boards loosened from nail breakage. One end board had cross grain splitting in two places. |
| Four-way entry | Butt-jointed | 3 | 179 | Posts loosened from top deck due to nail breakage. Bottom deck board split. End top deck board split off from pallet. |
| Four-way entry | Unjointed | 3 | 143 | Bottom deck board loosened from post due to nail breakage. Posts loosened from top deck. End deck board had cross grain splitting. |

Table 5.--Results of corner-to-corner diagonal compression tests on two-way entry pallets

| Style of deck board construction | Number of pallets tested | Average load in pounds at 1/2-inch increments of diagonal compression | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | 1/2 | 1 | 1-1/2 | 2 | 2-1/2 | 3 | 3-1/2 | 4 |
| Butt-jointed | 3 | 667 | 928 | 1,132 | 1,292 | 1,437 | 1,555 | 1,663 | 1,760 |
| Unjointed | 3 | 543 | 750 | 868 | 982 | 1,100 | 1,212 | 1,310 | 1,427 |

Table 6.--Results of point-load test on four-way entry pallets

| Style of deck board construction | Number of pallets tested | Average load in pounds at 1/4-inch increments of deflection | | | | | |
|---|---|---|---|---|---|---|---|
| | | 1/4 | 1/2 | 3/4 | 1 | 1-1/4 | 1-1/2 |
| Butt-jointed | 3 | 338 | 495 | 635 | 780 | 897 | 979 |
| Unjointed | 3 | 317 | 562 | 838 | 1,017 | 1,207 | 1,321 |

Table 7.--Results of bar-load test on intermediate deck boards

| Type of pallet | Type of construction | Number of pallets tested | Average load in pounds at 1/4-inch increments of deflection | | | |
|---|---|---|---|---|---|---|
| | | | 1/4 | 1/2 | 3/4 | 1 |
| Two-way entry | Butt-jointed | 3 | 3,364 | 6,667 | 9,059 | 9,765 |
| Two-way entry | Unjointed | 3 | 6,406 | 9,843 | 10,859 | 12,100 |
| Four-way entry | Butt-jointed | 3 | 719 | 1,293 | 1,733 | ..... |
| Four-way entry | Unjointed | 3 | 725 | 1,338 | 1,996 | ..... |

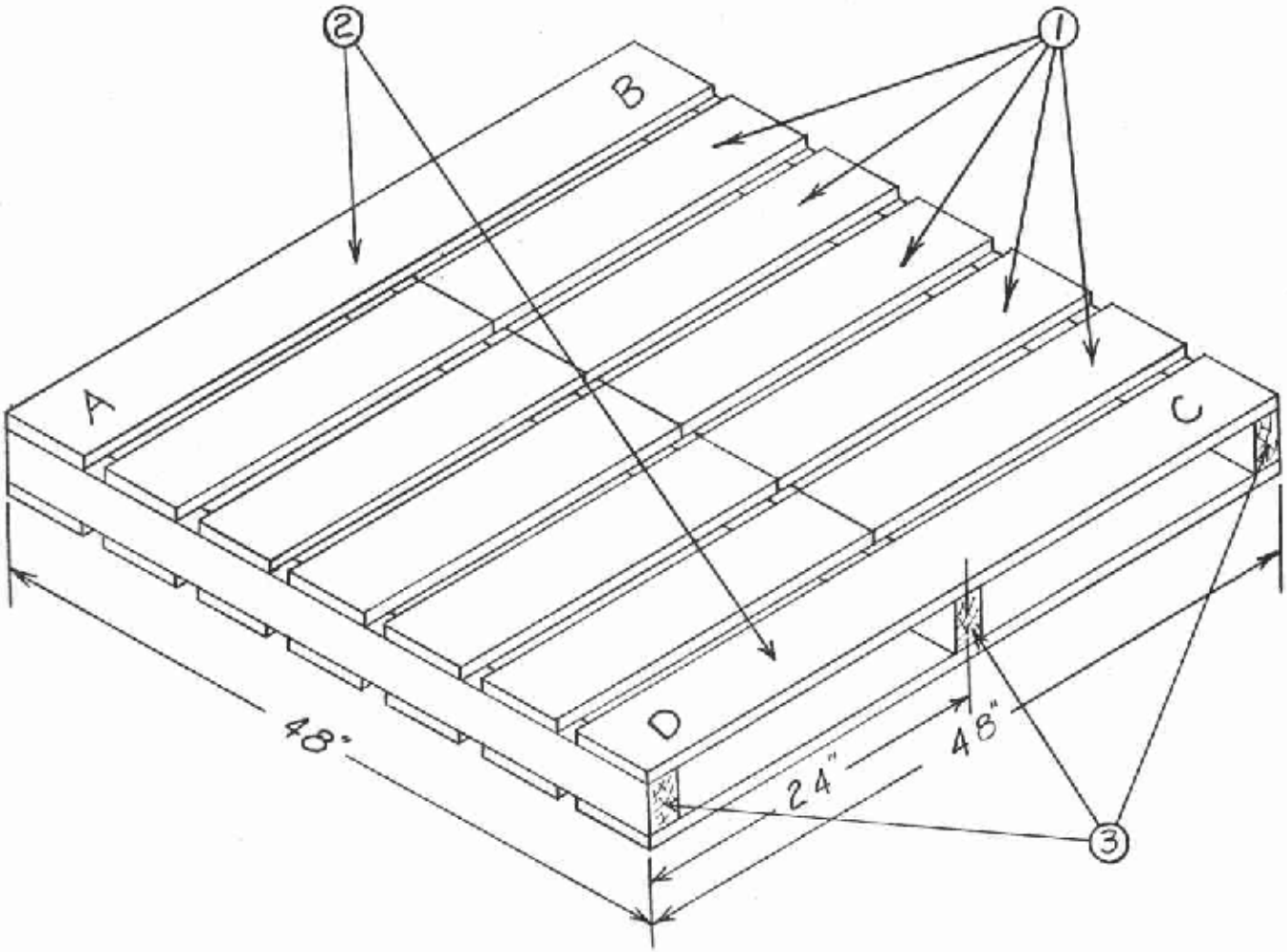


Figure 1. --Component parts of the two-way entry pallet: (1) intermediate deck boards; (2) end deck boards; and (3) stringers. Boards were nailed to the stringers with three annular-grooved nails per nail joint.

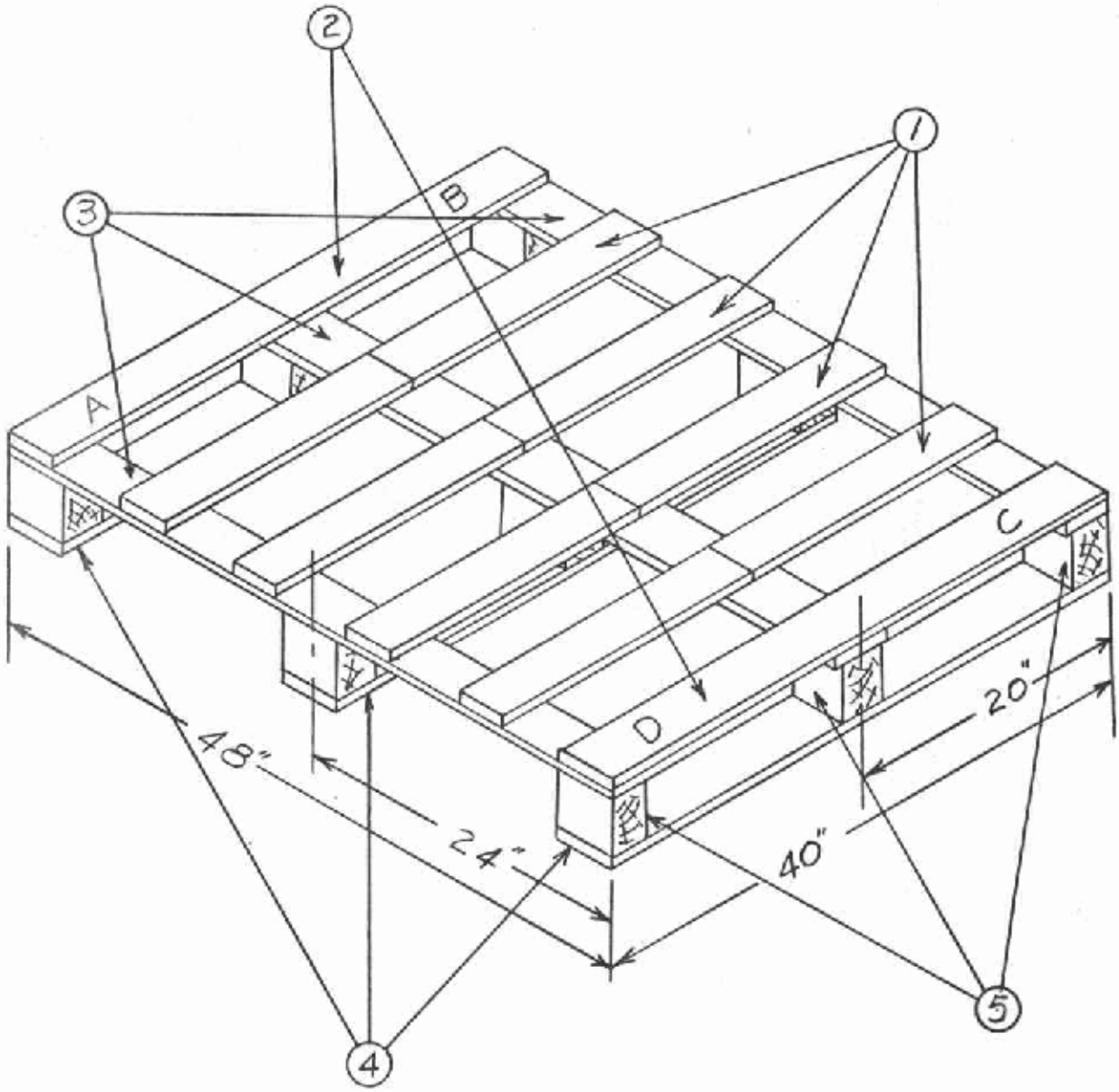


Figure 2. --Component parts of four-way entry pallet: (1) intermediate deck boards; (2) end deck boards; (3) subdeck boards; (4) bottom deck boards; and (5) posts. Two clinched common nails per joint were used on the subdeck boards; two annular-grooved nails per joint were used to fasten top deck to posts.

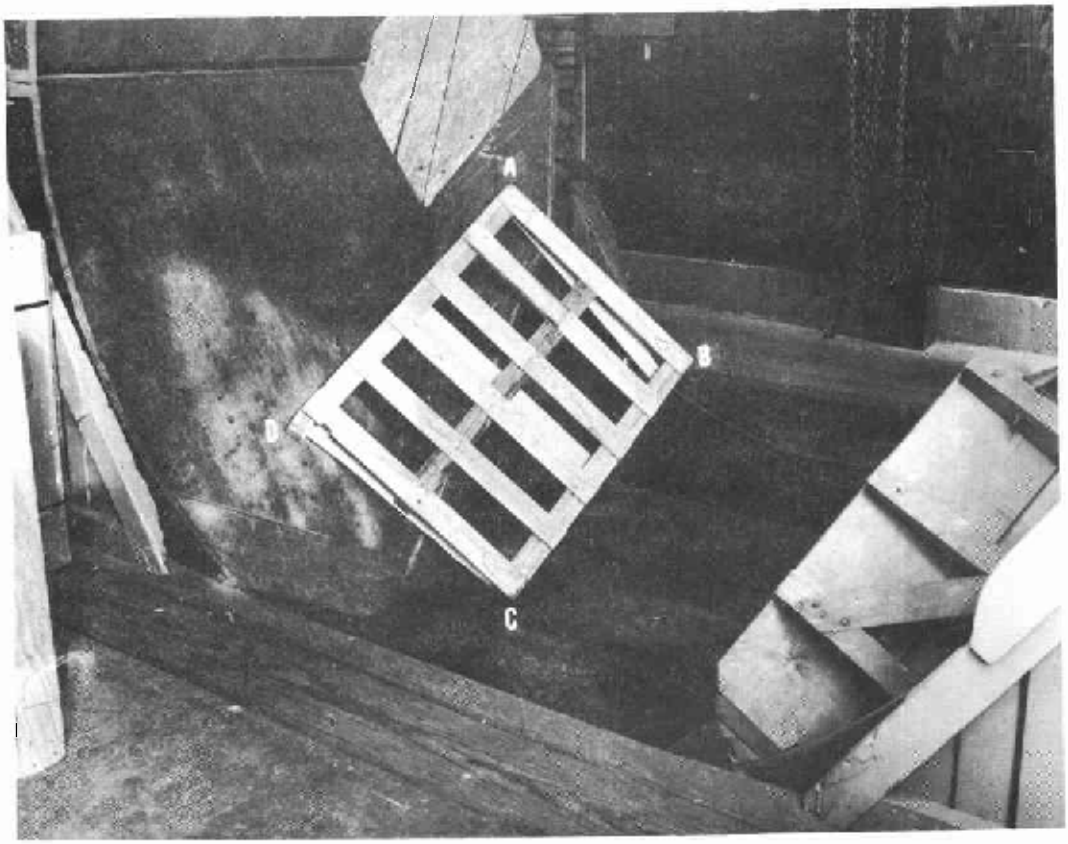


Figure 3. --Typical failure of a four-way entry pallet in the revolving drum; the corner post (D) separated from the top deck.

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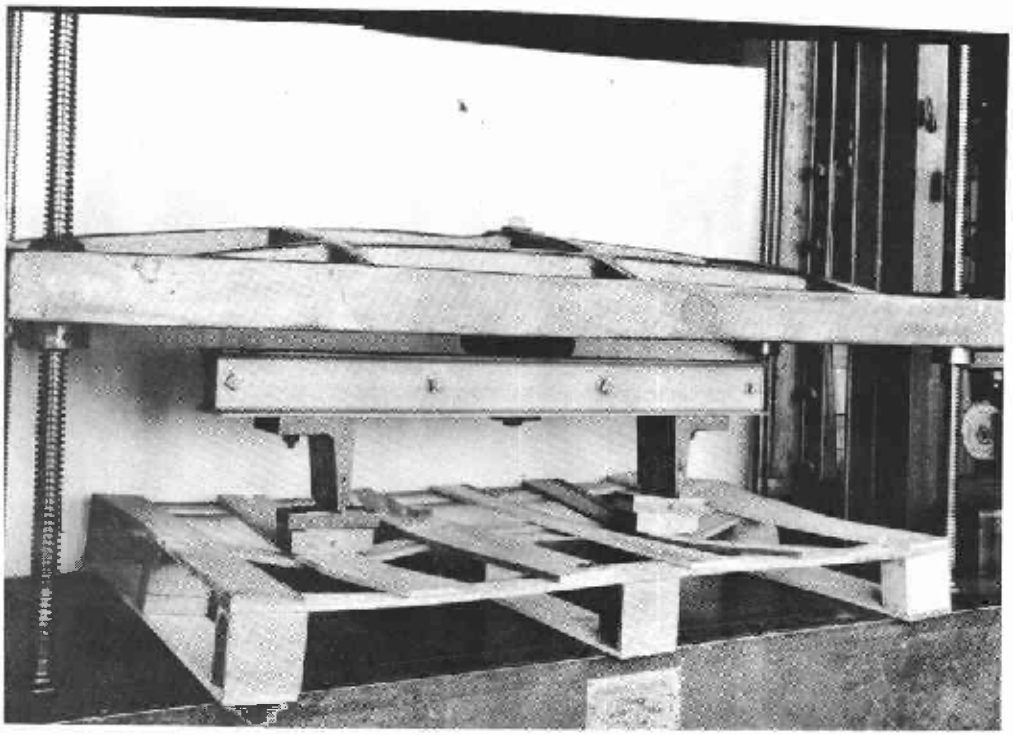

Figure 4. --Four-way entry pallet subjected to point-load test.

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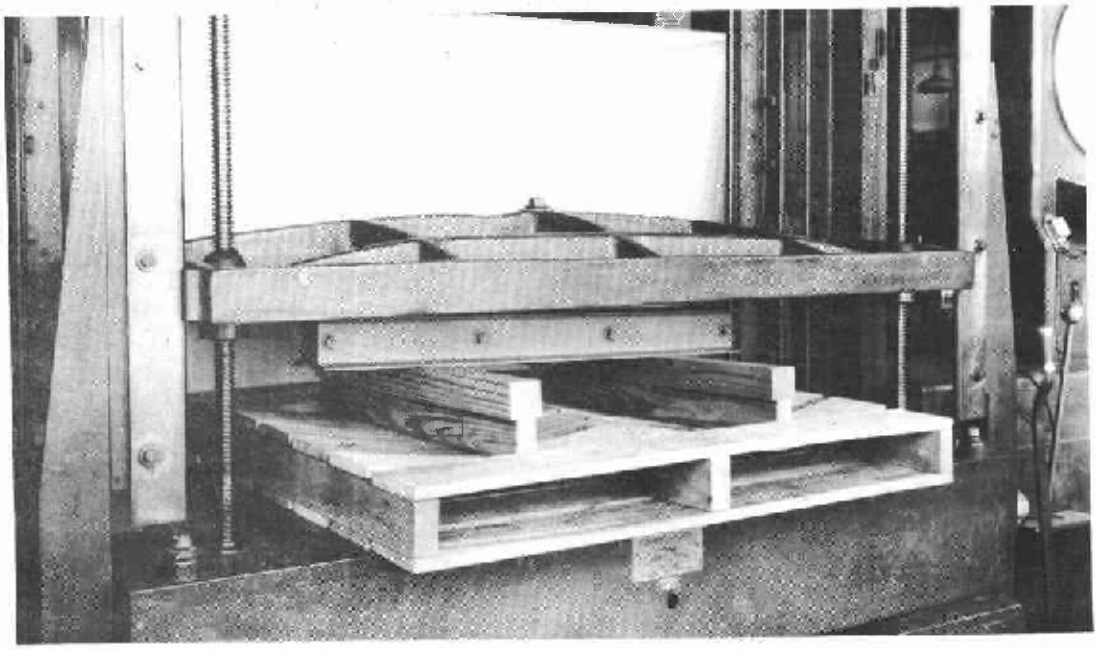

Figure 5. --Two-way entry pallet subjected to the bar-load test.

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