HOW PALLETS WITH LAMINATED RED OAK DECKBOARDS PERFORMED IN USE

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ABSTRACT

In-use tests in a combination brick and cement block yard and subsequent laboratory tests indicated that laminated pallet deckboards made from knife-cut, low-grade red oak logs can perform as well as deckboards of solid red oak. Performance was not significantly different between laminated oak deckboard pallets assembled with 2-l/2-in.-long by 15-gage staples and pallets assembled with conventional helically threaded pallet nails if approximately five staples were used for every three nails based on total fasteners per pallet. In a severe handling environment, a synthetic elastomeric adhesive for assembling pallets did not perform as well as nails or staples.

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INTRODUCTION

In 1971, the U.S. Forest Products Laboratory reported that low-grade red oak logs could be made into satisfactory pallet deckboards by rotary knife-cutting, press-drying, and gluing into the final product.[2] Laboratory evaluations of pallet corners, deckboards, and full-size pallets helped answer questions such as: How do the laminated deckboards perform in the finished assembly? Can they be machined and fastened? Is there any marked difference between two-ply and three-ply deckboards? How do the laminated deckboards compare with similar solid deckboards? The results indicated that both two-ply and three-ply laminated oak deckboards produce reusable pallets with a high level of performance.

The objective here was to obtain some results of in-use performance, consequently the U.S. Forest Products Laboratory arranged with a brick and cement block factory to place a number of pallets with laminated red oak deckboards as well as with solid oak deckboards (control) in service. How these pallets performed is reported here.

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

[2] Hann, R. A., Jokerst, R. W., Kurtenacker, R. S., Peters, C. C., and Tschernitz, J. L. Rapid Production of Pallet Deckboards from Low-Grade Logs. USDA Forest Serv. Res. Pap. FPL 154. Forest Prod. Lab., Madison, Wis. 53705. 1971.

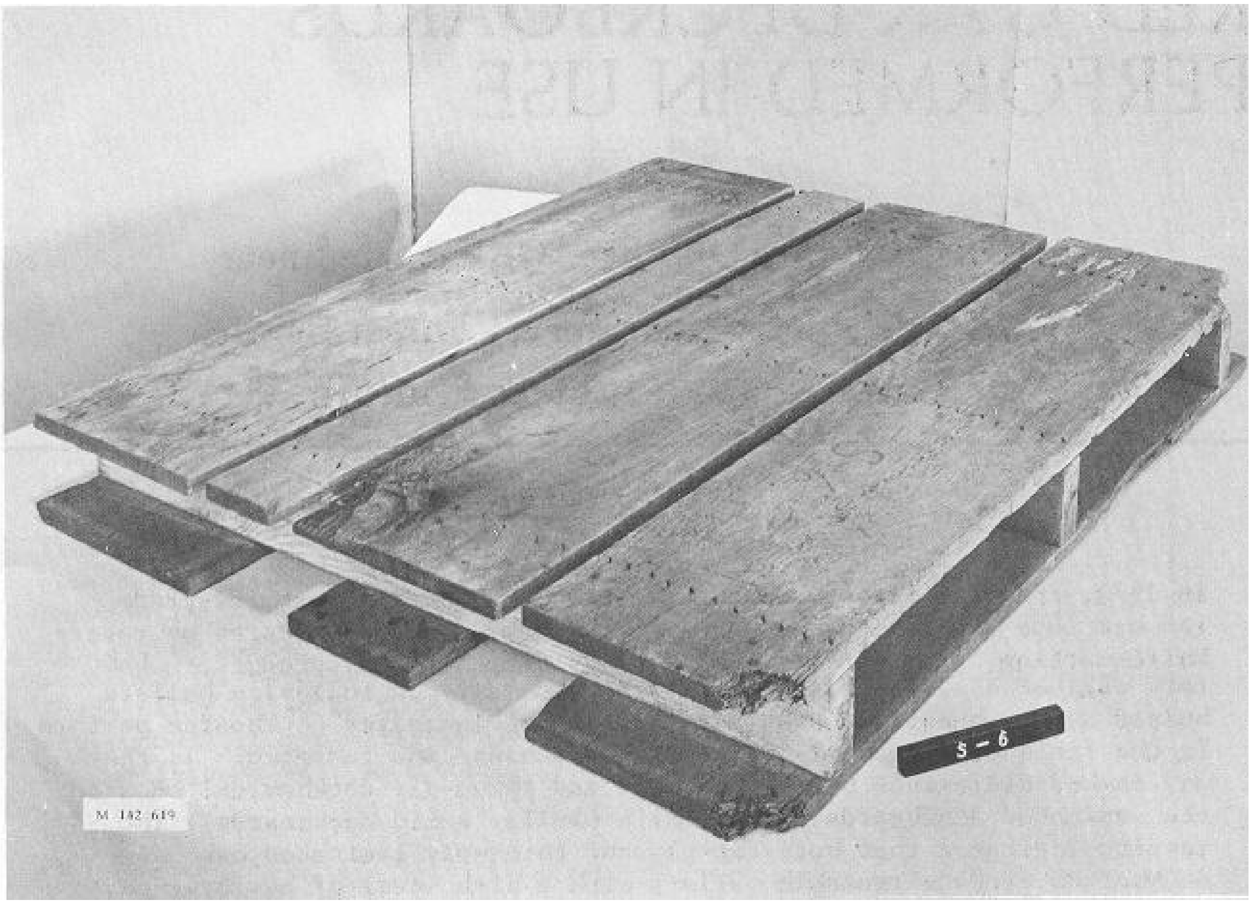

Figure 1.--The serviceable condition shown is typical of laminated deckboard pallets assembled with either staples or nails after 18 months' use in a cement block and brick yard followed by a free-fall-on-corner drop test. (Note crushed deckboard corners from the free-fall-on-corner test.)

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PALLET CONSTRUCTION

Forty test pallets were made of red oak, 40 by 48 in., reusable, two-way entry, double-deck, nonreversible, and winged with three stringers.

For all pallets, the green solid oak stringers were 40 in, long, 3-5/8 in. high, and 1-3/4 in, thick. The outside stringers were 41 in. apart; this resulted in a 3-1/2-in. wing on each side,

The laminated deckboards were fabricated from knife-cut red oak veneer 7/16 in. thick. These two-ply laminated deckboards were 48 in, long and either 11, 7, or 4 in. wide. They were produced by combining rotary knife-cutting, press-drying, and gluing;[2] the deckboards were about 3/4 in, thick,

For the pallets made with laminated deckboards, there were four boards, three 11 in. wide (two were used as edge deckboards) and one board 4 in. wide, equally spaced for the top deck and three boards, two 11-in.-wide edge deckboards and one 7-in.-wide board, equally spaced for the bottom deck.

The ten control pallets had 3/4-in.-thick green solid oak deckboards. The top deck was composed of seven boards, six 5-3/8 in. wide and one 3-5/8 in. wide. These were arranged so that the 5-3/8-in.-wide leading edge deckboard and the adjacent 5-3/8-in.-wide deckboard were butted together with the balance being equally spaced. The bottom deck consisted of five 5-3/8-in.-wide boards, one at each end and a group of three slightly spaced and centrally located.

The pallets were assembled with hammer-driven nails, with pneumatically driven staples, or with a synthetic elastomeric adhesive. The nails were conventional helically threaded pallet nails, 2-1/2 in. long with a wire diameter of 0.120 in. The staples were formed from 15-gage galvanized steel wire, had 2-1/2-in.-long chisel-pointed legs with a 7/16-in. crown, and the lower 1-1/8 in. of the staple legs were coated with a plastic material. Staples were driven so that the crowns made an angle of about 45° with the grain of the deckboards.

The adhesive was a synthetic elastomer formulated without any organic solvent vehicle. It was easy to apply and use, but had a long cure time. Small wood shims, 1/32 in. thick, were used in the joints to control the glueline thickness. Additional details of the pallet assembly are given in Table 1.

Of the 30 pallets with laminated deckboards, 10 were assembled with nails, 10 with staples, and 10 with adhesive.

Table 1.--Pallet assembly

Deckboards			Fastener		
Type	Width (in.)	Position	Number of nails per joint	Number of staples per joint	Adhesive thickness (in.)
Laminated	11	Leading edge	6	11	1/32
Laminated	11	Interior	6	8	1/32
Laminated	7	Interior	4	5	1/32
Laminated	4	Interior	2	3	1/32
Solid	5-3/8	Leading edge	3	--	--
Solid	5-3/8	Interior	3	--	--
Solid	3-5/8	Interior	2	--	--

IN - SERVICE TESTS

To obtain firsthand information on the performance of the laminated deckboard pallets, the 40 test pallets were placed in service in a combination brick and cement block yard. Initially it was planned to keep the pallets in service until they required repair or were no longer serviceable.

After about 18 months, the brickyard underwent a policy change, and converted to expendable pallets. At this time, 15 of the original 40 test pallets were salvaged and returned to the Forest Products Laboratory where they were visually inspected. During the in-service period, the cooperator kept a record of the movement of the test pallets.

LABORATORY EVALUATION

After 18 months of service, 13 of the 15 pallets that were returned to the Laboratory were still serviceable. These pallets were further subjected to a laboratory test, a free-fall-on-corner drop from a height of 40 in. This test provides a measure of the pallet's resistance to dynamic racking stresses in the plane of the pallet deck. After 12 drops on the same corner, the average amount of racking was calculated from "before" and "after" measurements of each diagonal of both top and bottom decks.

RESULTS

In-Service Tests

The cooperator's records indicated that within 1 month all of the experimental pallets were sent out with loads of cement block. Subsequently, as pallets were returned, they were again sent out with either cement blocks or bricks. A pallet load of cement block weighed about 3,000 lb and a load of brick, about 4,000 lb.

All pallets were subjected to at least one trip, whereas the maximum number of trips for a pallet was six. The average was just under three trips per pallet.

Visual observations indicate that brickyard handling is severe, but this type of use may not involve numerous handlings per pallet. When pallet loads of bricks or cement blocks or of both are moved to the job site, pallets are not immediately unloaded and returned to the supplier. Instead, the masons use the materials directly from the pallets. Thus the pallets may remain at the job site for several months. Although not being handled during this period, the pallets are subjected to the deleterious effects of outdoor storage.

Inspection of the 15 pallets revealed that two, both with laminated deckboards, were no longer serviceable. One was assembled with synthetic elastomeric adhesive; the other, with staples. The adhesive-assembled pallet had lost all of its top deckboards; one outside stringer was split half its length, and was wired together. A bottom deckboard was split for most of its length, whereas another had a piece (1 by 2 in.) of the corner broken away.

One of the top leading edge deckboards of the unserviceable stapled pallet was frayed on the underside--apparently by the forks. The other top leading edge deckboard had a number of splits from the ends towards the center. One interior top deckboard was severely damaged in the area overhanging the stringer. One end of all three stringers was split. The opposite end of an outside stringer had an 18-in.-long piece broken off the bottom.

The typical condition of the remaining 13 pallets after being in use is given in Table 2. Only one laminated deckboard had a slight visible delamination--about 4 in. long.

Table 2.--Condition typical of brickyard pallets when returned to U.S. Forest Products Laboratory

Number of pallets	Fastener method	Type of deckboard	Condition typical of pallets: Top deckboards	Condition typical of pallets: Bottom deckboards	Condition typical of pallets: Stringers
4	Staple	Laminated	15 small splits not exceeding 7 in., many 4 in. or less; generally between staples. Occasionally small pieces broken out at corners.	8 small splits not exceeding 5 in.; generally between staples. Occasionally small pieces broken out at corners	Occasional splits up to 14 in. long. Some evidence of fork-tine impact damage.
2	Nail	Laminated	3 small splits, not necessarily at nails. Two small pieces broken out at corners. One piece 27 in. long broken out at corner through nail.	9 splits; some originating where end of deckboard has been gouged or damaged.	Occasional splits up to 13 in. long. Some evidence of fork-tine impact damage.
3	Adhesive	Laminated	13 splits not exceeding 11 in.; majority 5 in. or less. One deckboard slightly delaminated about 4 in. At least one deckboard each pallet severely mangled or damaged.	22 splits; 5 exceeding 9 in., leading edges frayed. Some pieces of deckboards broken off.	Occasional splits; one 30 in. long through center of stringer. Evidence of fork-tine impact damage.
4	Nail	Solid[1]	36 splits; 4 over 14 in. long. Most splits between nails. Splintering, fraying, and breaking at leading edges.	21 splits; 2-7 in. or more; most splits between nails. Some splintering, fraying, and breaking. Generally at leading edges.	Some splitting up to 4 in. long. Some evidence of fork-tine impact damage.

[1]Control pallets.

Table 3.--Average racking in free-fall-on-corner drop test expressed as percentage of original diagonal measurement of pallets after service in brickyard

Deckboard Fastener	Deckboard Type	Number of replicates	Average pallet weight (lb)	Average racking (pct)
Staple	Laminated	4	81	1.1
Nail	Laminated	2	81	2.1
Synthetic elastomeric adhesive	Laminated	[1]1	78	.2
Nail	Solid[2]	4	75	5.5

[1] 2 pallets failed when the top leading edge deckboards came off; 1 at 3 drops, the other at 6 drops.

[2] Control pallets.

Laboratory Evaluation

The average racking in the plane of the pallet deck caused by the free-fall-on-corner drop test expressed as a percentage of the original diagonal measurement is given in Table 3. All pallets except two performed well and survived all 12 corner drops. Those with laminated deckboards were well within the proposed acceptable 5 pct maximum allowable racking limitation, whereas the solid deckboard (control) pallets exceeded the maximum allowable by only 0.5 pct. It should be remembered that these values were obtained with pallets after approximately 18 months use in a cement block and brick yard.

The two pallets that did not survive the 12 free-fall-on-corner drops from 40 in. were laminated deckboard pallets assembled with a synthetic elastomeric adhesive. Both of these pallets lost one of the top leading edge deckboards; one at three falls, the other at six. In both, the deckboard was intact and failure occurred at or in the synthetic elastomeric glue bond. Further, it was obvious that a synthetic elastomeric adhesive did not resist the hazards of severe handling as effectively as did either nails or staples.

After the drop test, all pallets had crushing of the corners of the top and bottom edge deckboard that received the impact, With laminated deckboards, crushing averaged 1 to 1-1/2 in.; with solid deckboards, crushing averaged less than 1 in. Figure 1 shows the average condition of a laminated deckboard pallet assembled with staples after approximately 18 months of service and after the free-fall-on-corner drop test from 40 in.

Table 3 indicates that pallets with stapled or nailed-laminated deckboards are more resistant to racking in the plane of the pallet deck than pallets with nailed solid oak deckboards. Most of this difference no doubt is attributable to the fact that most of the laminated deckboards were wider than those of solid oak. The wider deckboards provide for larger nail couples that offer more resistance to racking.

Previous laboratory tests[3] indicate little permanent deformation when pallets assembled with synthetic elastomeric adhesive are subjected to the free-fall-on-corner drop test from 40 in. However, these tests show that exposure to the severe in-use conditions weakened the joints of deckboards on two of the pallets and caused failure of the joints.

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[3]Kurtenacker, R. S. Appalachian Hardwoods for Pallets: Effect of Fabrication Variables and Lumber Characteristics on Performance. USDA Forest Serv. Res. Pap. FPL 112. Forest Prod. Lab., Madison, Wis. 53705. 1969.

CONCLUSIONS

In-use tests and subsequent laboratory evaluation of pallets indicate that laminated pallet deckboards from low-grade red oak logs produced by rotary knife-cutting, press-drying, and gluing can be substituted for solid red oak deckboards in reusable pallets.

No significant difference was found between laminated deckboard pallets assembled with staples and those assembled with standard helically threaded pallet nails. Thus, satisfactory performance may be expected from staple-assembled pallets if about five staples are used for every three nails based on total fasteners in the pallet.

Synthetic elastomeric adhesive-assembled pallets with laminated deckboards performed less satisfactorily than those assembled with either staples or nails in resisting rough handling when the in-use environment and handling were severe.

The wide, laminated deckboards provided more resistance to racking in the plane of the pallet deck than did similar-sized pallets that had a greater number of narrower solid wood deckboards.

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