

# Ohio's Experiences With Treated Timber for Bridge Construction

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## ABSTRACT

Described in this paper are the various types of timber structures with which Ohio has had experience. It includes a discussion of the various timber bridges built in the 1930s, which normally were timber strip floors on steel beams on timber pile abutments and piers. Described also are some of the more modern types of timber structures used including glued-laminated transverse deck panels installed on existing steel beams; longitudinal laminated deck panels that are self supporting; and laminated, panelized timber box culverts. The specifics on these types include actual costs, ease of construction, and performance after installation. The panelized timber structures can be erected quickly with traditional construction equipment. Many treated timber structures, especially glued-laminated structures, have higher initial cost, but lower maintenance costs and a longer projected life.

Ohio has used treated timber in bridge construction for many years. The first bridges built in Ohio were of timber construction and the trend has continued through the years. The most common modern-day type of bridge that utilized timber was the steel beam on timber pile abutments and piers. Standard drawings dating from the early 1930s and most recently revised in 1965 are still being used although on a limited basis. The majority of these types of bridges still in use were built in the 1930s and 1940s. Ohio still has about 1,500 bridges with laminated strip floors in the state highway system. This does not include the hundreds of similar bridges on county and township roads.

Standard treated timber strip floors consisted of 3- x 6-in. dense, structural, southern yellow pine or select structural Douglas fir set on edge and fastened with steel clips to steel beams. The steel beams were generally spaced at from 3-ft to 3-ft and 4-in. centers. The specifications required nailing the individual boards together at 12-in. centers with 60d spikes. The fastening clips were spaced at 12-in. centers staggered on either side of the beams and fastened with 1/2-in. galvanized carriage bolts through the deck. These bridges, although not regularly being built today, lasted many years with minimum maintenance. It was not unusual for these timber strip floors, covered with 2 to 3 in. of asphalt concrete to last from 30 to 40 years with no maintenance except for an occasional overlay with more asphalt concrete.

By the mid 1950s, timber bridges were gradually being phased out by steel beam bridges with reinforced concrete decks. About the same time, road deicing salts were being used to a greater extent and this drastically shortened the life of these floor systems because the timber strip floors leaked, allowing the chlorides to attack the steel supporting beams. As was learned in the 1960s and 1970s, the deicing salts also attacked the new reinforced concrete decks and many started to spall badly after only 5 or 10 years of service. Unlike the reinforced concrete decks, the salts did not affect the treated

timber decks, but the effect of the salt leakage onto the beams below was a major problem.

The demise of nailed timber strip decks was also hastened by heavier loads and higher speeds. Timber decks tended to flex too much and loosen with age, at which time the asphalt-concrete wearing surface began to break up. Reinforced concrete decks had a higher resistance to impact caused by heavier loads and higher speeds.

Even with these drawbacks, it was obvious to many maintenance engineers that the treated timber decks properly constructed on steel beam superstructures would outlast the more modern reinforced concrete decks several times, with extremely low maintenance.

Because leakage through the strip floors was a considerable problem, as was keeping the floor clips tight, the Ohio Department of Transportation began to investigate the glued-laminated timber floors as a method of replacing the old strip floors. The glued-laminated floor looks similar to the strip floor just described, except that the individual boards are glued together at the factory and shipped to the site in manageable panel widths. This type of floor appeared to have several advantages, for example,

1. It was watertight (except at the joints);
2. It was panelized into 4-ft wide panels that could be placed much faster than the conventional strip floor; and
3. The individual boards, being glued together, could distribute the loads more efficiently than the individually nailed boards thus minimizing the possibility of loose floor clips.

In 1976, the Ohio Department of Transportation chose to specify a glued-laminated floor on two different types of bridges. One was a 3-span, steel beam bridge on timber piers and abutments built in 1932. This bridge is 120-ft long and 24-ft wide. The bridge is located in Jackson County on Ohio Route 124, which is a coal mining area and thus carries a considerable amount of coal truck traffic. The abutments and piers, even though they were 44 years old, were in excellent condition and required no work. It is interesting to note that the pH level of the stream

under this bridge is quite low; however, the timber piles are still in good condition. The existing steel beams were 21 WF 68 spaced at from 3 to 3.75 ft and were still in good enough condition to reuse with only minor repairs. The beams were originally discontinuous over the piers and as a part of this contract, were made continuous with the use of welded steel splice plates. The tops of the beams were sandblasted, primed, and topcoated before the floor was placed. The bridge is on a 25-degree skew and thus the floor was furnished with skewed ends. The floor specified was 5.125-in. thick with predrilled holes for the floor clips. The preservative was pentachlorophenol and was to be applied only after all gluing, cutting, and drilling of the panels was complete.

The panels were to be placed with no dowels between the joints. A mastic was applied to the mating faces of the panels in an effort to waterproof the joint and a small piece of aluminum flashing was placed over each beam directly under the panel joints. The intent of the flashing was to divert any drainage that might seep through the joints and to divert it away from the steel beams. The flashing was insulated from the beams by two heavy coats of paint, thus minimizing the possibility of bimetal corrosion. The 27 panels were placed in 2 days.

The only two problems that occurred with this project were: (a) the panels were oversaturated with the pentachlorophenol and were still dripping after being unloaded at the site; and (b) the top surface of the panels was too smooth, which resulted in some pushing and shoving of the new asphalt concrete overlay. It has since been learned that a vacuumed and slightly irregular surface is needed on which to place the asphalt concrete. The total cost of this project was \$78,366.70 and the cost per square foot of the glued-laminated flooring was \$8.30 in place. This route carries an average of 1,200 vehicles per day--100 of which are trucks. The deck is still in excellent condition; however, the wearing surface has some cracks in it.

The second bridge, which was reconstructed in 1976 using a glued-laminated timber deck, is in Lawrence County on Ohio Route 243. The bridge is a 129-ft-long through truss, 14.5-ft wide, built in 1884. The truss itself was in relatively good condition; however, the floor system, which consisted of steel stringers with a nailed timber strip floor, was badly deteriorated. The steel stringers were replaced with new continuous steel stringers and the new glued-laminated floor 5.250-in. thick was clipped to the stringers. The new stringers were spaced at 3 ft-4 in. The floor is still rated in good condition--no repairs needed although the wearing surface has some minor cracks. The total cost for this project was \$80,440.44, and the bid price per square foot for the glued-laminated timber decking was \$11.50 in place. The traffic count on this bridge is 900 vehicles per day, 40 of which are trucks.

There have been at least five other bridges reconstructed using glued-laminated timber decking since 1976 with the most recent being on Ohio Route 233 in Gallia County and Ohio Route 327 in Vinton County. These two bridges were sold as one project in July 1984. The bridge on Route 233 is 69-ft-and-8-in. long x 28-ft and 6-in. wide, and is a 3-span, steel beam bridge built in 1933. The existing timber strip floor and the existing steel beams were badly deteriorated and, as a result, were completely replaced. The existing steel H-pile abutments were encased in concrete. The new beams furnished were W 14 x 43 spaced at 2-ft and 7-in. centers. The floor specified was a 5.125-in. thick panel 4-ft wide and treated with pentachlorophenol. The bridge is on a

20-degree, 30-min skew and thus all panel ends were skewed.

The tops of all the beams were painted before placing the decking. All cutting and drilling of the flooring was to be done before treatment. The floor was fastened to the beams with galvanized steel floor clips and carriage bolts through the floor at 2-ft centers on each side. The second bridge on this project is 72-ft-and 2-in. long x 27-ft and 3-in. wide on a 43-degree, 30-min skew. The existing 20 WF 69 steel beams on 2-ft and 5.5-in. centers were reused.

The total cost of this project was \$310,657.18. The successful bidder on this project bid the 3,953 ft<sup>2</sup> of glued-laminated timber decking at \$18.00 per ft<sup>2</sup> in place. The average of the four bids for this item was \$17.90 per ft<sup>2</sup> in place.

The average daily traffic count on Ohio Route 233 is 360 vehicles per day, 40 of which are trucks. The average count on Ohio Route 327 is 430 vehicles per day, 30 of which are trucks.

The eventual cracking of the asphalt-concrete wearing surface over the panel joints was expected because it was decided not to specify the widely accepted steel dowelling between the panels. This process requires that steel dowels be partially embedded in the matching face of one panel and the adjacent panel be match-drilled to accept the protruding dowel ends. This would give better load transfer between the panels but was anticipated to be difficult to place in the field unless the holes were somewhat oversized, which would defeat the purpose.

In 1979, the Ohio Department of Transportation became aware of another type of timber bridge construction that appeared to have some advantages in spans up to 38 ft. Because treated timber was thought to outperform reinforced concrete and steel from a maintenance standpoint, the concept of longitudinal, laminated deck panels, which were self supporting without the need for structural steel underneath, was very appealing.

In 1979, a recently constructed longitudinal laminated bridge built by the County Engineer of Hancock County was examined. The bridge consisted of three spans of timber on reinforced concrete piers and abutments. The longitudinal, laminated deck slab consisted of 4-in. thick x 8- to 16-in. wide (depending on spans) boards set on edge and mechanically laminated together using 3/8-in. diameter x 15-in. long galvanized ring shank dowels. The decking was furnished in approximately 6 ft wide panels that were completely self supporting, eliminating the need for steel beams in spans up to 38 ft. The individual boards were cut to size, drilled, and pressure-treated before lamination.

A site had already been selected for using an all-timber bridge so that it would blend into the park-like setting in which it was located. (This location was on Ohio Route 551 in Pike County at Lake White State Park.) The existing bridge was a 147-ft long x 14-ft and 7-in. wide, 2-span pony truss. The bridge was badly deteriorated and beyond repair. It was also a 1-lane bridge on a relatively heavily traveled road during the summer months. The current traffic count on this road is 350 vehicles per day including 10 trucks. It was decided to specify an all-timber bridge for this location and to use longitudinal, laminated deck panels. The piers and abutments were also designed to be treated timber using capped pile abutments with timber backing and capped pile pier bents. The new bridge was designed to be 129-ft and 4-in. long x 28-ft wide and on a 45-degree skew. The four equal, 32-ft spans were designed to use 4-in. x 16-in. individually treated timbers set on edge and laminated into 6-ft wide

panels using .375-in. diameter x 15-in. long galvanized rink shank dowels. The type of treatment for this bridge was creosote.

Bids for this project were opened on July 7, 1981, and the successful bid was \$222,254. The cost for the 3,621.24 ft<sup>2</sup> of the Douglas fir deck panels was \$20.44 per ft<sup>2</sup> in place. The average of all six bids for this item was \$24.03 per ft<sup>2</sup> in place. This bridge is expected to last many years with minimal maintenance.

Because this bridge was built, several more longitudinal deck panels have been purchased to replace existing steel beam and timber strip floor bridges. A recent order was for an 18-ft long x 30-ft wide span bridge. The panels were to be panelized in 4- to 6-ft widths and be 10-in. thick. The specified timber to be used was Number 1 coastal region Douglas fir. This order was delivered to the Ohio Department of Transportation district yard at a cost of \$18.50 per ft<sup>2</sup>. The Ohio Department of Transportation current specifications require treatment with Number 1 creosote petroleum in accordance with American Wood Preservers' Association Standard C 14-84. The required retention is 12 lb per ft<sup>3</sup>. All members must be pre-cut and pre-bored before treatment. Unlike the glued-laminated transverse panels, which are treated after they are panelized, these longitudinal panels are panelized after the individual boards are treated. All panel sides, except the fascia panels, consist of one-half-height, 4-in. boards such that the individual panels can be ship-lapped together. The laps are predrilled to allow for 5/8-in. diameter drive pins. In all cases, the timber panels can be easily handled with the use of a backhoe or small crane.

Another type of timber structure that has been used in Ohio to a limited extent is the laminated timber box culvert. These structures are constructed of individually treated boards that are laminated together by drive spikes and/or through bolts. The individual panels are furnished in 4- to 6-ft lengths with a special finger-type interconnect where the panels join together in the corners. These units have been installed as either single-, double-, or triple-cell boxes. They have worked extremely well in streams with low pH levels. The oldest two such structures on a state highway in Ohio was installed in 1964. One is a triple cell (5 ft, 5 ft, 5-ft) and the other a double cell (5 ft, 5 ft). The current pH level of the streams going through these boxes is 4.0. Both structures are still functioning with no deterioration of the timber. The interior partitions

of the triple-cell structure at the inlet end are slightly distorted, which is apparently caused by debris in the stream. Several such box culverts have been installed in situations where the pH level of the latter is quite low. (Note: there are few types of materials that can be used in low-pH-level stream crossings.) Galvanized corrugated steel rusts through in a few months and concrete structures must be protected with a tile facing.

A recent installation in 1977 was a 7-ft span x 5-ft rise x 38-ft long, single-cell box. The pre-fabricated culvert cost \$5,600 and was installed by maintenance forces in 5 hr. A Gradall excavator was used to aid in the installation. It is important that these structures be installed on carefully prepared bedding and that the sidewall joints be staggered from the top and bottom panel joints. Care also must be taken to keep the units square until backfilling is complete. (Several of these units have also been built by Ohio Department of Transportation maintenance forces and used to extend existing narrow concrete box culverts.)

#### SUMMARY

It has been determined that the old, conventional, nail-laminated strip floors lasted an average of 30-40 years with minimal maintenance. Reinforced concrete decks have historically required considerable patching within 20 years and the average life before complete replacement has been 30-35 years. A typical reinforced concrete deck costs \$13.90 per ft<sup>2</sup> and the last glued-laminated timber deck cost \$18.00 per ft<sup>2</sup>. The longitudinal timber decking can be compared to a complete superstructure replacement using prestressed concrete box beams. A recent prestressed box beam project cost \$22.58 per ft<sup>2</sup>. (This compares favorably with the longitudinal deck project, which cost \$20.44 per ft<sup>2</sup>.)

In general, properly designed and treated timber can and should be seriously considered as an alternative to concrete and steel.

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