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# Relationship Between Timber Bridge Characteristics and Asphalt Pavement Wear Surface Performance

## SUMMARY

REPRODUCED BY:  
U.S. Department of Commerce  
National Technical Information Service  
Springfield, Virginia 22161



Minnesota Local Road  
Research Board

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## **Summary Report**

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**June 1997**

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## **I. Introduction**

The proper function of an asphalt pavement wear surface on a timber bridge is important for providing both a safe and durable road surface, as well as to protect the timber structure against premature wear and decay. There are currently approximately 1400 asphalt covered nail-laminated timber bridges in Minnesota. Given the importance which timber bridges serve in our states' infrastructure, an evaluation of asphalt wear surface performance on Minnesota timber bridges was completed, and methods for reducing or controlling timber bridge wear surface degradation were analyzed. Several basic bridge maintenance and paving techniques were identified as probable solutions for solving common timber bridge wear surface problems. This article summarizes these findings. A full length version of this study is also available.

## **II. Evaluation of Timber Bridge Wear Surface Performance**

According to results from a qualitative survey distributed to Minnesota's county engineers, approximately fifty percent of the responding engineers believe a portion of the timber bridge wear surfaces in their counties suffer from some form of premature distress. While the criteria each county used to assess their bridge wear surfaces may have been somewhat subjective, these results nevertheless do indicate additional attention is required for maintaining some timber bridge wear surfaces.

Information from the survey and visual inspection of timber bridge wear surfaces throughout the state indicates wear surface deterioration rate is influenced by the following factors:

- 1) Timber bridge mechanics.
- 2) Paving practices.
- 3) Asphalt pavement design.

In the following sections these factors are addressed by first describing the basic mechanisms associated with asphalt wear surface failure, and then proposing simple solutions for preventing premature asphalt deterioration.

## **III. Influence of Timber Bridge Mechanics on Wear Surface Performance**

### **A. Basic Bridge Design**

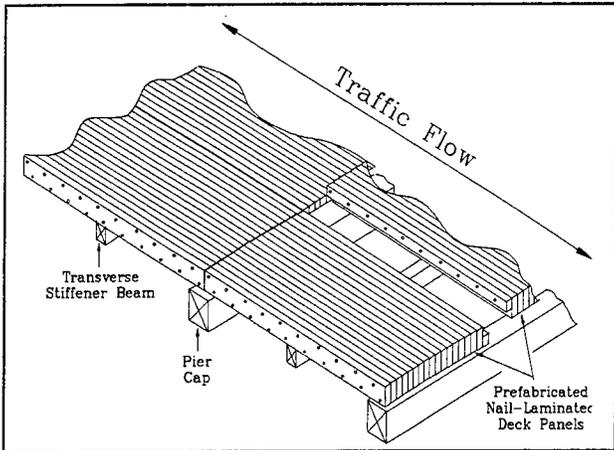
A look at the types of nail-laminated timber bridges found in Minnesota will help to identify some of the expected crack formations in asphalt wear surfaces.

Currently two basic bridge designs comprise the majority of timber bridges found in Minnesota, these are the longitudinally nail-laminated superstructures (LNL)(Figure 1), and transverse nail-laminated decks supported by beam superstructures (TNL) (Figure 2) [1,2].

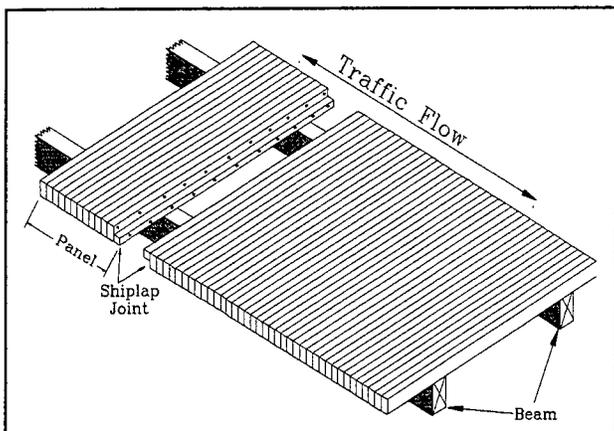
Since 1970, these bridge designs have incorporated prefabricated panelized deck systems. This systems utilizes factory laminated panels which are joined together by means of shiplap joints (Figure 1 & Figure 2). Nail-laminated bridge decks older than 1970 were laminated together entirely in the field. Field laminated LNL have every tenth lamination extending across the pier-cap support, and thus can be easily distinguished from panelized systems (Figure 3).

The LNL timber bridge also incorporates a transverse stiffener beam

(TSB) as a lateral load-transferring device for the superstructure. The TSB is attached to the mid-span locations of the bridge (Figure 1 & Figure 3).



**Figure 1 - Panelized, Longitudinally Nail-Laminated Superstructure**



**Figure 2 - Pre-laminated, Transverse Nail-Laminated Deck on a Beam Superstructure**

**B. Mechanically Induced Asphalt Cracking**

Several common forms of mechanically induced pavement cracking occur in timber bridge wear surfaces, they are:

**1) Cracking Parallel to Deck Laminations**

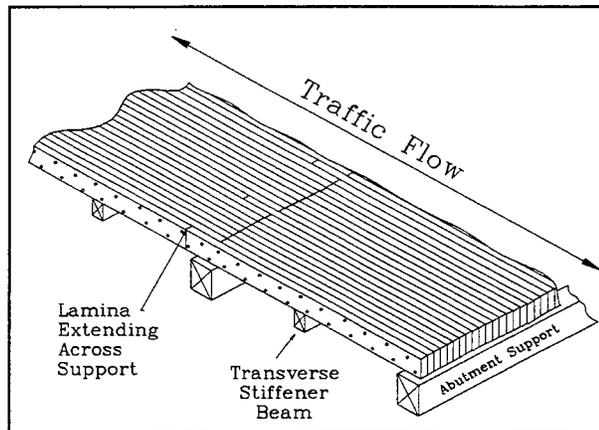
Often older field laminated bridge decks have existing gaps between the

laminations due to the field nailing method and/or lamination shrinkage from wood moisture loss. Because of these gaps individual laminations may move independently of one another, which effectively decreases the load transfer capability of the deck and increases the bridge deflection. In addition, the load transfer capacity of a LNL bridge may be reduced if the TSB loses firm contact with the bridge deck. This will occur as the TSB and deck laminations shrink from moisture loss, and as connecting bolts loosen from vehicle induced vibration.

Both asphalt cracking and fatigue can occur as a result of differential lamination movement and loss of transverse load transfer capability. For example, severe longitudinal pavement cracking can be seen in the pavement overlay covering a Minnesota LNL bridge due to both of these factors (Figure 4).

**2) Cracking Parallel to Deck Panel Joints.**

Similar to pavement cracking in response to lamination gaps, cracks may also form over panel joints due to differential movement of the panels.



**Figure 3 - Field Laminated, Longitudinally Nail-Laminated Superstructure**



**Figure 4 - Longitudinal and Transverse Pavement Cracking on a Field Laminated LNL Deck**

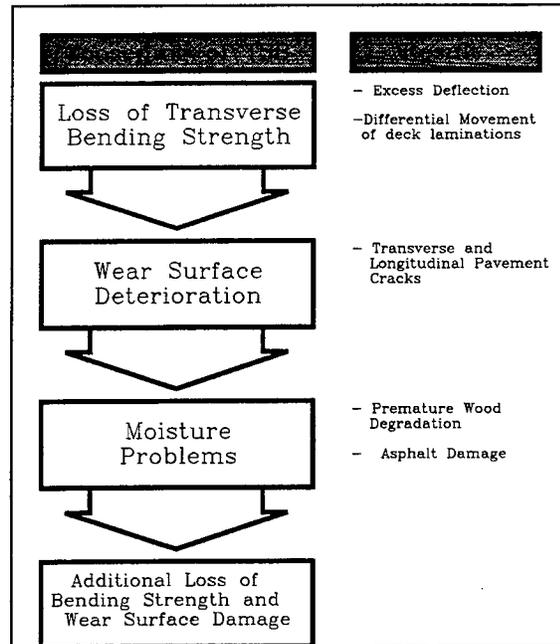
### 3) **Transverse Cracking Over Deck Supports**

Transverse pavement cracks over the pier-caps and abutment-caps are about the most common form of pavement cracking observed in timber bridge wear surfaces (Figure 4). Both bridge deflection and differential movement between laminations over the abutment caps and pier caps will focus stress in the asphalt overlay producing a well defined transverse pavement crack.

#### C. **Additive Wear Surface Deterioration**

As cracks project through the depth of an asphalt overlay, water and other material begin to infiltrate into and through the wear surface, and down to the timber members. Freeze-thaw cycles expand the wet material causing the pavement to buckle and further deteriorate. The timber members can also suffer from the moisture with a loss of strength, and increased susceptible to fungal attack if the optimal conditions prevail. This additive form of

deterioration is shown in a flow chart form (Figure 5).



**Figure 5 - Proposed Steps Involved in Additive Wear Surface Deterioration**

## IV. Maintenance and Preventative Solutions

### A. **Reduction of Inter-lamination Movement**

A simple maintenance procedure, developed in Sibley County for restoring transverse load transfer in LNL bridges, has effectively demonstrated the reduction in cracking parallel to deck laminations. The procedure involves two simple steps:

- 1) Tightening of all bolts connecting the TSB to the bridge deck, and adding lock nuts.
- 2) Hammering wood shims into the remaining gaps between deck laminations and the TSB (Figure 6). The shims should be made from a species at least as dense

as Douglas fir, white oak is a good alternative.

This procedure was recently implemented and analyzed on several LNL timber bridges in Freeborn County. The experiment involved recording inter-lamination deflection on four consecutive lamination before and after tightening and shimming the TSB. The standard deviation of inter-lamination deflection decreased by 90%, and the mean local deflection was reduced by 10% (Figure 7). These results help to explain the improved performance of asphalt wear surfaces on timber bridges in Sibley County where all LNL bridges have had TSBs tightened and shimmed.

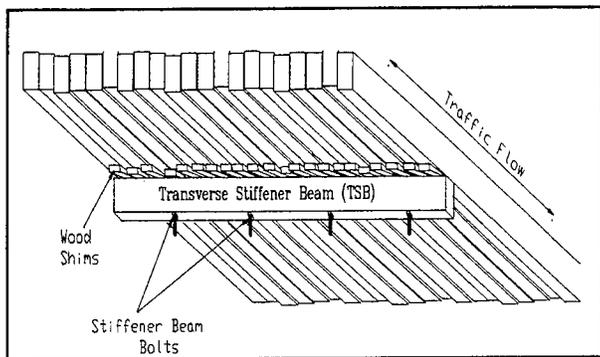


Figure 6 - Placement of Shims Between the Deck and the Transverse Stiffener Beam

## B. Improved Paving Techniques

### 1) Timber Deck Preparation

New and re-paved timber bridge decks should receive a small amount of special attention prior to paving with asphalt. The following deck preparation procedures are suggestions for improving asphalt pavement adhesion to the timber surface. Asphalt, which is not adequately bonded to the deck, may be vulnerable to displacement and cracking from bridge deflection.

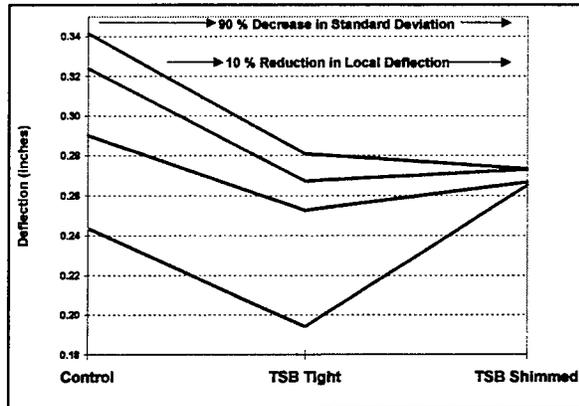


Figure 7 - Decrease of Inter-Lamination Deflection After Tightening and Shimming the TSB

### a) Removal of Excess Creosote

New timber bridges occasionally have problems with creosote preservative extruding out of the wood to form a liquid layer on the deck surface. Under these conditions the creosote preservative has been reported to inhibit proper bonding of asphalt to the wood deck surface. This bonding problem likely occurs because creosote is a coal-tar distillate, and is therefore a solvent of asphalt. If excess creosote is present on the deck, then the deck surface should be cleaned with a blotting agent prior to paving.

Excess or extruded creosote can be removed from the deck by applying a fine material to the deck to work as a blotting agent. By this method a mixture of dust and 10% -20 % crushed material passing the No. 8 sieve can be spread on the deck at a rate of 10-15 lbs/yd<sup>2</sup>. The blotting material should be left in place for one week, or until the creosote is fully adsorbed. The bridge should then be swept of all loose material [3].

**Note:** Disposal of creosote contaminated material may pose a problem and should therefore be investigated prior to application.

## b) Sweeping and Washing Prior to Paving

The nail-laminated timber deck typically has an uneven surface, adjacent laminations can sometimes vary in height up to an inch. Sand, soil and other fines can easily be trapped in crevices on these surfaces. A thorough sweeping and washing of the deck prior to paving can effectively remove these fines and help to maximize bonding the pavement to the deck.

Washing the deck should easily be accomplished with any portable water spray system. Washing should probably be performed the day before paving to allow thorough drying time.

## c) Asphalt Tack Coat

A standard asphalt tack coat should be evenly spread and allowed to set on the dry timber deck prior to paving

Omission of a tack coat application should however be considered if extruded creosote has posed a problem on a timber deck. In this situation a tack coat might only worsen pavement adhesion because it could be dissolved by the creosote, leaving a thick liquid layer preventing a bond from developing between the asphalt pavement and the timber deck.

## 2) Installation of Saw & Seal Pavement Joints

The saw & seal joint procedure is a crack prevention method which has proven to be a highly effective means of reducing reflective cracking on Minnesota highways [4]. This method may be an ideal way of controlling the adverse effects of pavement cracking over bridge piers and abutments.

The saw & seal joint consists of a reservoir-cut and a relief-cut. With the proper set-up, both cuts can be produced in a single pass (Figure 8). The deep relief-cut insures the weakest region of the asphalt will be located at the joint. The joint is protected with the flexible sealant used to fill the reservoir-cut.

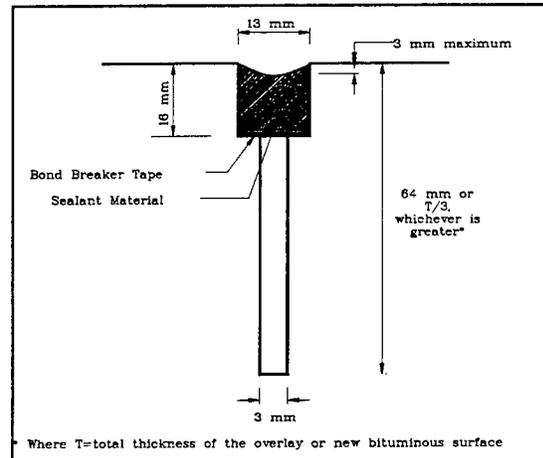


Figure 8 -Typical Saw and Seal Joint

## C. Alternative Pavement Design

Asphalt pavement experts from the University of Minnesota and Mn/DOT Road Research site poor pavement design as a common factor in pavement deterioration. In adequate pavement design may allow a surface to be more susceptible to raveling, fatigue and cracking. A more flexible wear surface design is suggested to help reduce both mechanically induced and temperature related wear surface cracking.

### 1) Double Asphalt Chip-Seal

A double asphalt chip-seal may be a good alternative to the standard pavement overlay because the high asphalt content of the chip-seal will produce a more flexible system. In addition the chip-seal can be easily maintained with additional applications.

## 2) Polymer Modified Lower Lift

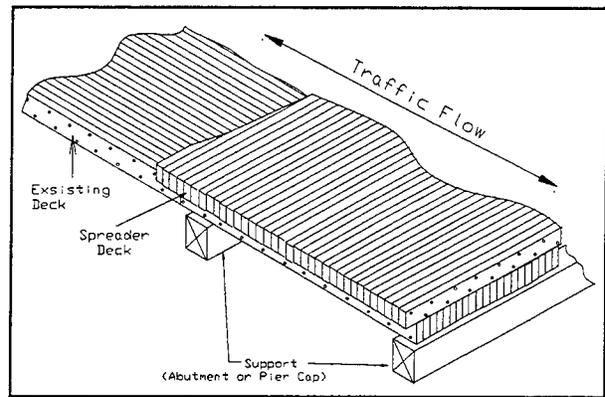
Currently a polymer modified asphalt underlay called sand anti-fracture (SAF) material is being tested as a means of preventing reflective cracking on both Minnesota state highways and timber bridges. The SAF material is produced by Koch Materials Company, and consists of a man-made/natural-sand mixture combined with a polymer modified binder. The SAF should help prevent pavement cracking by retarding the effects of lamination and deck panel movement.

### D. Bridge Rehabilitation

Deck rehabilitation is also an option for improving the bridge load transfer capability and/or widening an existing bridge to meet new road width specifications [5]. Installation of a retrofit nail-laminated deck over the existing deck is an option worth considering for accomplishing both of these needs (Figure 9).

### V. Conclusion

The nail-laminated timber bridge is a valuable resource to Minnesota's rural road system. With little additional maintenance, the performance of these bridges can be increased bringing savings to the county and state through decreased pavement and bridge repair costs.



**Figure 9 - Retrofit Deck Rehabilitation of Longitudinal Superstructure Timber Bridge Decks**

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- 2) Ritter, M.A., Timber Bridges: Design, Construction, Inspection, and Maintenance, United States Department of Agriculture, Forest Service, EM 7700-8, Aug., 1992.
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