

Relationship Between Timber Bridge  
Characteristics and Asphalt Pavement  
Wear Surface Performance

**SUMMARY**

CTS  
TG  
365  
.L36  
1997a



Minnesota Local Road  
Research Board

## Technical Report Documentation Page

1. Report No.  1998-07S	2.	3. Recipient's Accession No.	
4. Title and Subtitle  RELATIONSHIP BETWEEN TIMBER BRIDGE CHARACTERISTICS AND ASPHALT PAVEMENT WEAR SURFACE PERFORMANCE - <b>SUMMARY</b>		5. Report Date  June 1997	
		6.	
7. Author(s)  Douglas A. Lange Timothy D. Larson Robert Seavey		8. Performing Organization Report No.	
9. Performing Organization Name and Address  Wood & Paper Science Department University of Minnesota 2004 Folwell Avenue St. Paul, MN 55108		10. Project/Task/Work Unit No.	
		11. Contract (C) or Grant (G) No.  (C) 74708 TOC # 8	
12. Sponsoring Organization Name and Address  Minnesota Department of Transportation 395 John Ireland Boulevard Mail Stop 330 St. Paul, Minnesota 55155		13. Type of Report and Period Covered  Summary Report 1996-1997	
		14. Sponsoring Agency Code	
15. Supplementary Notes  To obtain a copy of the full report (Number 1998-07, same title), contact the Office of Research Services at 612/282-2274, or ora.research@dot.state.mn.us			
16. Abstract (Limit: 200 words)  This summary offers an overview of on a research study that assessed the magnitude of premature asphalt deterioration on timber bridges; identified the primary mechanisms responsible for wear surface deterioration; and suggested methods for improving asphalt pavement performance on timber bridges.  The study revealed that approximately 50 percent of counties experience some problems with premature reduced serviceability of the asphalt pavement wear surfaces that cover their timber bridges. The summary looks at possible pavement failure mechanisms and presents the following proposed solutions for controlling timber bridge asphalt pavement cracking: asphalt pavement saw & seal, asphalt pavement fabric or material underlay, removal of extruded oil-type preservative before surfacing, conditioning of bridge timbers to the expected equilibrium moisture content before bridge installation, and tightening of timber decks through maintenance practices.			
17. Document Analysis/Descriptors  timber bridge maintenance wood transportation structures asphalt pavement wear surfaces		18. Availability Statement  No restrictions. Document available from: National Technical Information Services, Springfield, Virginia 22161	
19. Security Class (this report)  Unclassified	20. Security Class (this page)  Unclassified	21. No. of Pages  6	22. Price

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

## **Summary Report**

Prepared by

Douglas A. Lange

Timothy D. Larson

Robert Seavey

Wood & Paper Science Department  
University of Minnesota

**June 1997**

Prepared for the

Minnesota Department of Transportation  
Office of Research Administration  
200 Ford Building Mail stop 330  
117 University Avenue  
St. Paul, MN 55155

The contents of this report reflect the views of the authors who are responsible for the facts and accuracy of the data presented herein. The contents do not necessarily reflect the views or policies of the Minnesota Department of Transportation at the time of publication. This report does not constitute a standard, specification, or regulation. The authors and the Minnesota Department of Transportation do not endorse products or manufacturers. Trade or manufacturers' names appear herein solely because they are considered essential to this report.

# Table Of Contents

<b>I.</b>	<b>INTRODUCTION .....</b>	<b>1</b>
<b>II.</b>	<b>EVALUATION OF TIMBER BRIDGE WEAR SURFACE PERFORMANCE.....</b>	<b>1</b>
<b>III.</b>	<b>INFLUENCE OF TIMBER BRIDGE MECHANICS ON WEAR SURFACE PERFORMANCE.....</b>	<b>1</b>
A.	BASIC BRIDGE DESIGN.....	1
B.	MECHANICALLY INDUCED ASPHALT CRACKING .....	2
1)	<i>Cracking Parallel to Deck Laminations</i> .....	2
2)	<i>Cracking Parallel to Deck Panel Joints</i> .....	2
3)	<i>Transverse Cracking Over Deck Supports</i> .....	3
C.	ADDITIVE WEAR SURFACE DETERIORATION .....	3
<b>IV.</b>	<b>MAINTENANCE AND PREVENTATIVE SOLUTIONS .....</b>	<b>3</b>
A.	REDUCTION OF INTER-LAMINATION MOVEMENT .....	3
B.	IMPROVED PAVING TECHNIQUES .....	4
1)	<i>Timber Deck Preparation</i> .....	4
2)	<i>Installation of Saw &amp; Seal Pavement Joints</i> .....	5
C.	ALTERNATIVE PAVEMENT DESIGN.....	5
1)	<i>Double Asphalt Chip-Seal</i> .....	5
2)	<i>Polymer Modified Lower Lift</i> .....	6
D.	BRIDGE REHABILITATION .....	6
<b>V.</b>	<b>CONCLUSION .....</b>	<b>6</b>
<b>VI.</b>	<b>REFERENCES .....</b>	<b>6</b>

## LIST OF FIGURES

<b>Figure 1</b>	- Panelized, Longitudinally Nail-Laminated Superstructure .....	2
<b>Figure 2</b>	- Pre-laminated, Transverse Nail-Laminated Deck on a Beam Superstructure.....	2
<b>Figure 3</b>	- Field Laminated, Longitudinally Nail-Laminated Superstructure .....	2
<b>Figure 4</b>	- Longitudinal and Transverse Pavement Cracking on a Field Laminated LNL Deck .....	3
<b>Figure 5</b>	- Proposed Steps Involved in Additive Wear Surface Deterioration .....	3
<b>Figure 6</b>	- Placement of Shims Between the Deck and the Transverse Stiffener Beam .....	4
<b>Figure 7</b>	- Decrease of Inter-Lamination Deflection After Tightening and Shimming the TSB.....	4
<b>Figure 8</b>	- Typical Saw and Seal Joint.....	5
<b>Figure 9</b>	- Retorfit Deck Rehabilitation of Longitudinal Superstructure Timber Bridge Decks .....	6

## **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**

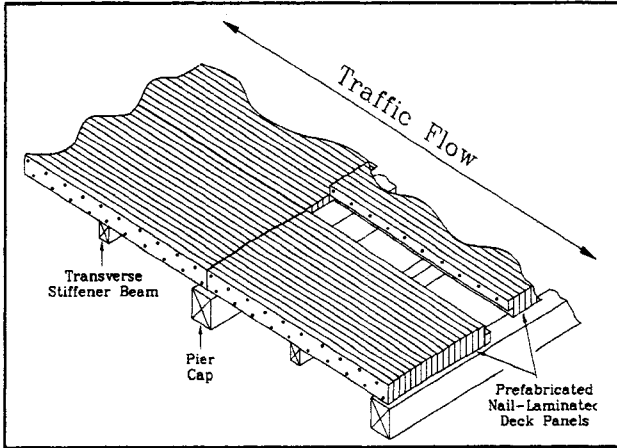
A look at the types of nail-laminated timber bridges found in Minnesota will help to identify some of the expected crack formations in asphalt wear surfaces.

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].

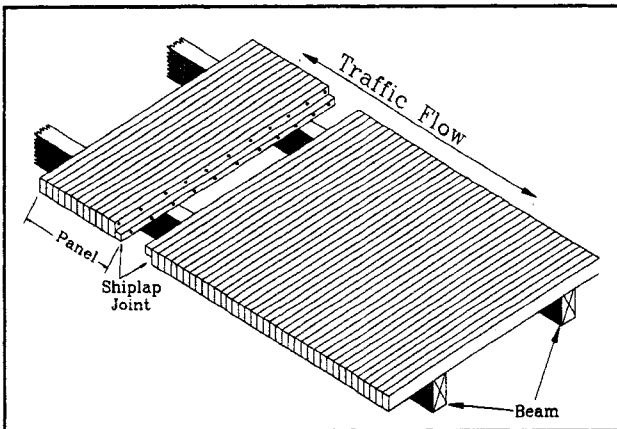
Since 1970, these bridge designs have incorporated prefabricated panelized deck systems. This systems utilizes factory laminated panels which are joined together by means of shiplap joints (Figure 1 & Figure 2). Nail-laminated bridge decks older than 1970 were laminated together entirely in the field. 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**

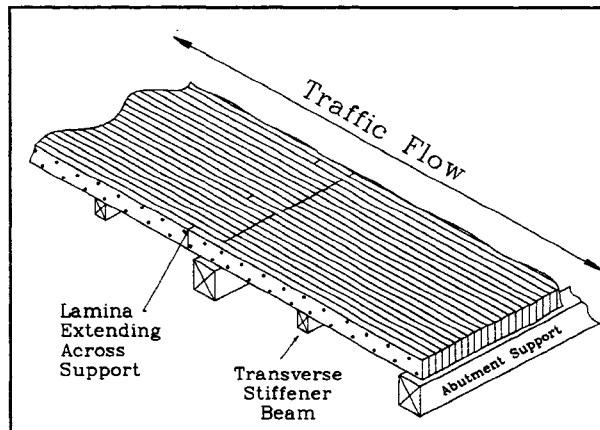
Often older field laminated bridge decks have existing gaps between the

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**

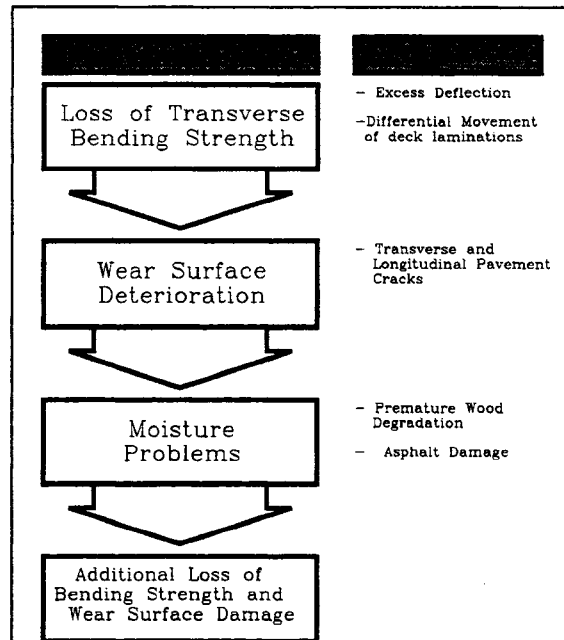
### 3) Transverse Cracking Over Deck Supports

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.

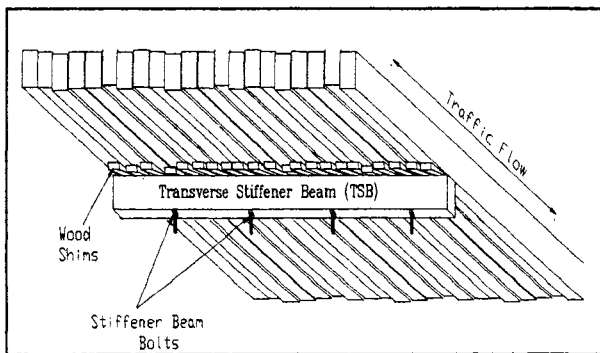


Figure 6 - Placement of Shims Between the Deck and the Transverse Stiffener Beam

## 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.

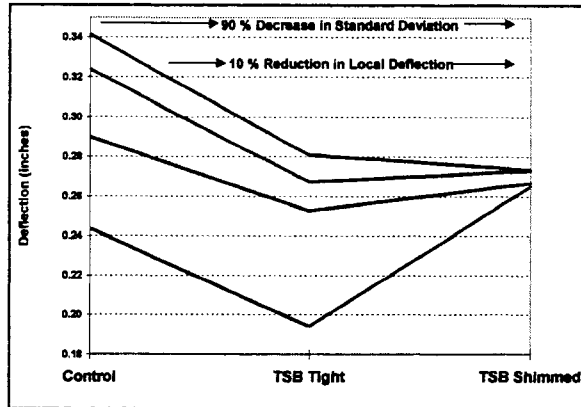


Figure 7 - Decrease of Inter-Lamination Deflection After Tightening and Shimming the TSB

### 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.





## 2) Polymer Modified Lower Lift

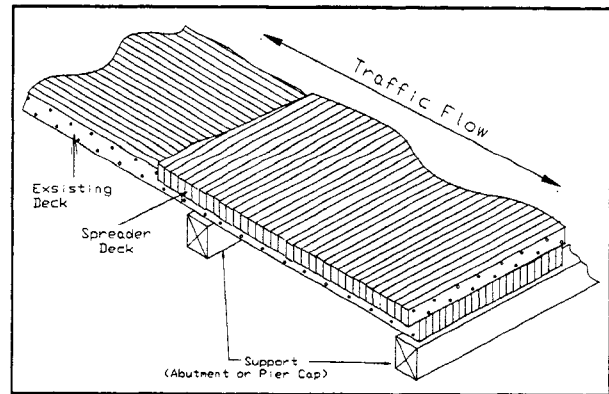
Currently a polymer modified asphalt underlay called sand anti-fracture (SAF) material is being tested as a means of preventing reflective cracking on both Minnesota state highways and timber bridges. The SAF material is produced by Koch Materials Company, and consists of a man-made/natural-sand mixture 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**

## VI. References

- 1) Johnson, K.A., Timber Bridge Design Manual, Wheeler Consolidated, Inc., St. Louis Park, MN, Fourth Edition, 1990.
- 2) Ritter, M.A., Timber Bridges: Design, Construction, Inspection, and Maintenance, United States Department of Agriculture, Forest Service, EM 7700-8, Aug., 1992.
- 3) Bruesch, L., "Surfacing Treated Decks with Bituminous Material," U.S.F.S. Eng. Tech. Information System, Field Notes, Vol. 8, Apr., 1976, pp. 1-3.
- 4) Janisch, D.W., and Turgeon, C., Sawing and Sealing Joints in Bituminous Pavements to Control Cracking, Minnesota Department of Transportation, Report No. MN DOT # 96-27, 1996.
- 5) Johnson, K.A. and Isakson, E., "Rehabilitation of Slab Span Timber Bridges," Proceedings of the 13th Structures Congress, Boston, Massachusetts, 1995, pp. 281-289.

