Timber Bridges in the U.S – Past, Present and Future

Michael Ritter, Assistant Director
USDA Forest Service, Forest Products Laboratory
Madison, Wisconsin

Presentation Overview

- The Forest Resource
- Evolution of Materials and Designs
- The Timber Bridge Initiative
- Where We are Today
- An Opinion on the Future

The Forest Resource

It's all about the resource

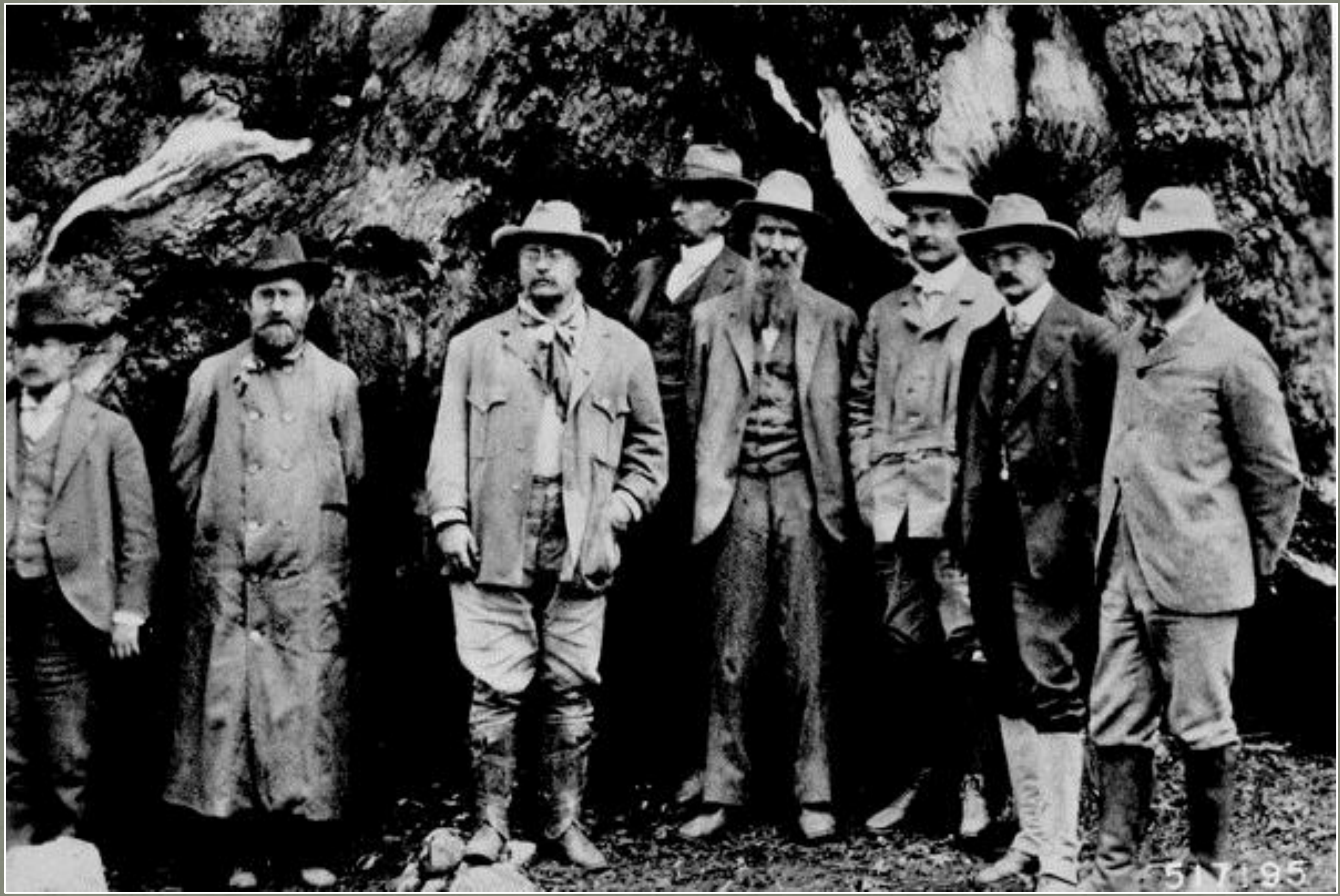
The Forest Resource

The Forest Resource

The Forest Resource

The Forest Resource

The Forest Resource



The Forest Resource

H.H.

U. S. DEPARTMENT OF AGRICULTURE,
DIVISION OF FORESTRY,
WASHINGTON, D. C.

GIFFORD PINCHOT, FORESTER.
HENRY S. GRAVES. SUPT. OF WORKING PLANS.
J. W. TOUMEY, SUPT. OF TREE PLANTING.
GEO. B. SUDWORTH, DENDROLOGIST.
OTTO J. J. LUEBKERT, HEAD CLERK.

February 2, 1900.

Mr. John Muir,

Martinez, Calif.

Dear Mr. Muir:

Many thanks for your telegram, which gives me exactly the information I was after. We are going to try to interest Congress in the preservation of the Calaveras Groves. I will keep you posted from time to time as the matter progresses.

Very sincerely yours,

Gifford Pinchot

Forester.

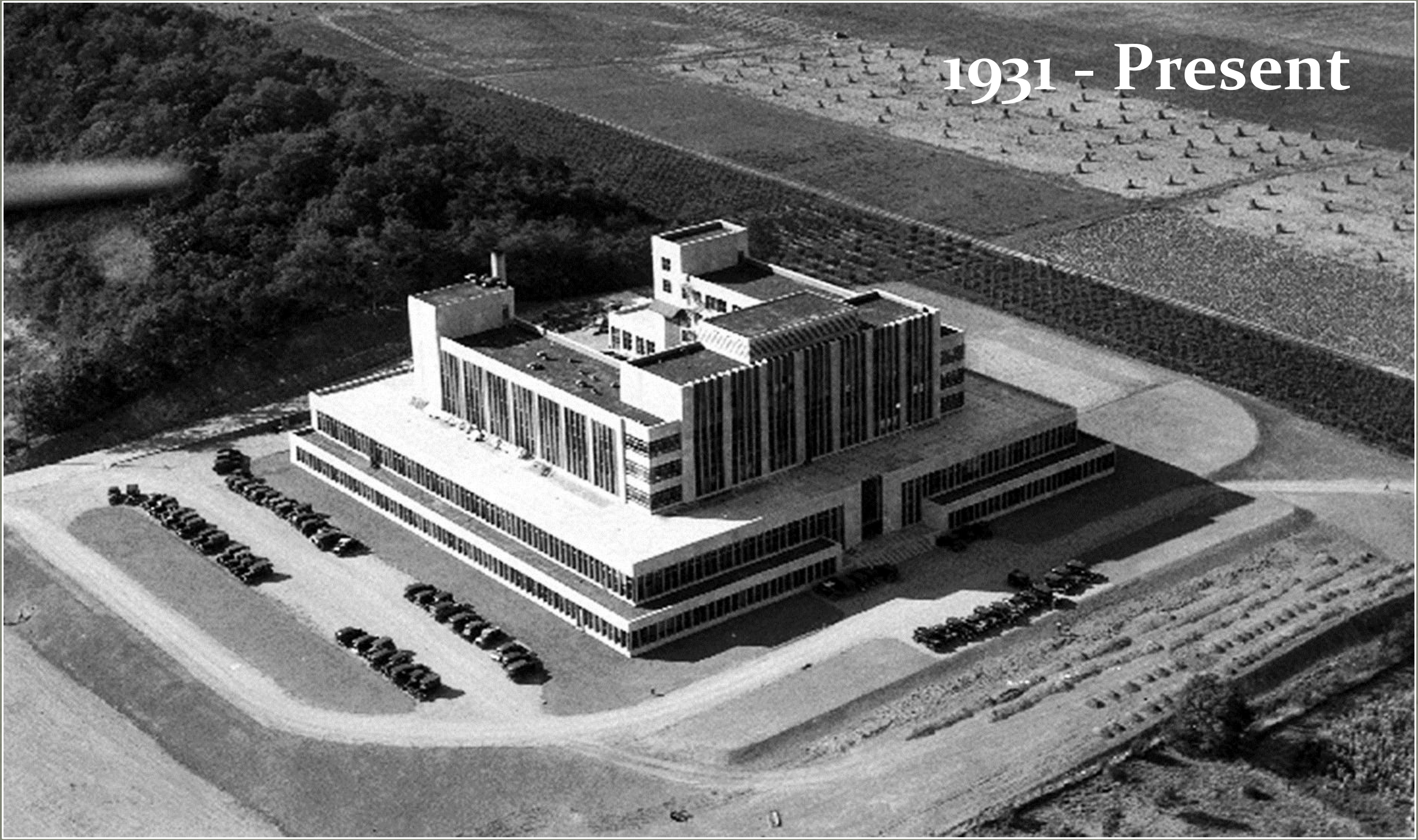
What is being done in California to save these trees?

COPIED

The Forest Resource

The Forest Resource

The Forest Resource



The Forest Resource

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The Forest Resource

Fire readiness and suppression has gone from 20% of the FS budget in 2001 (approximately $1 billion) to over 60% (approximately 3$ billion) in 2014. It is not uncommon to spend $1 million per hour fighting fires.

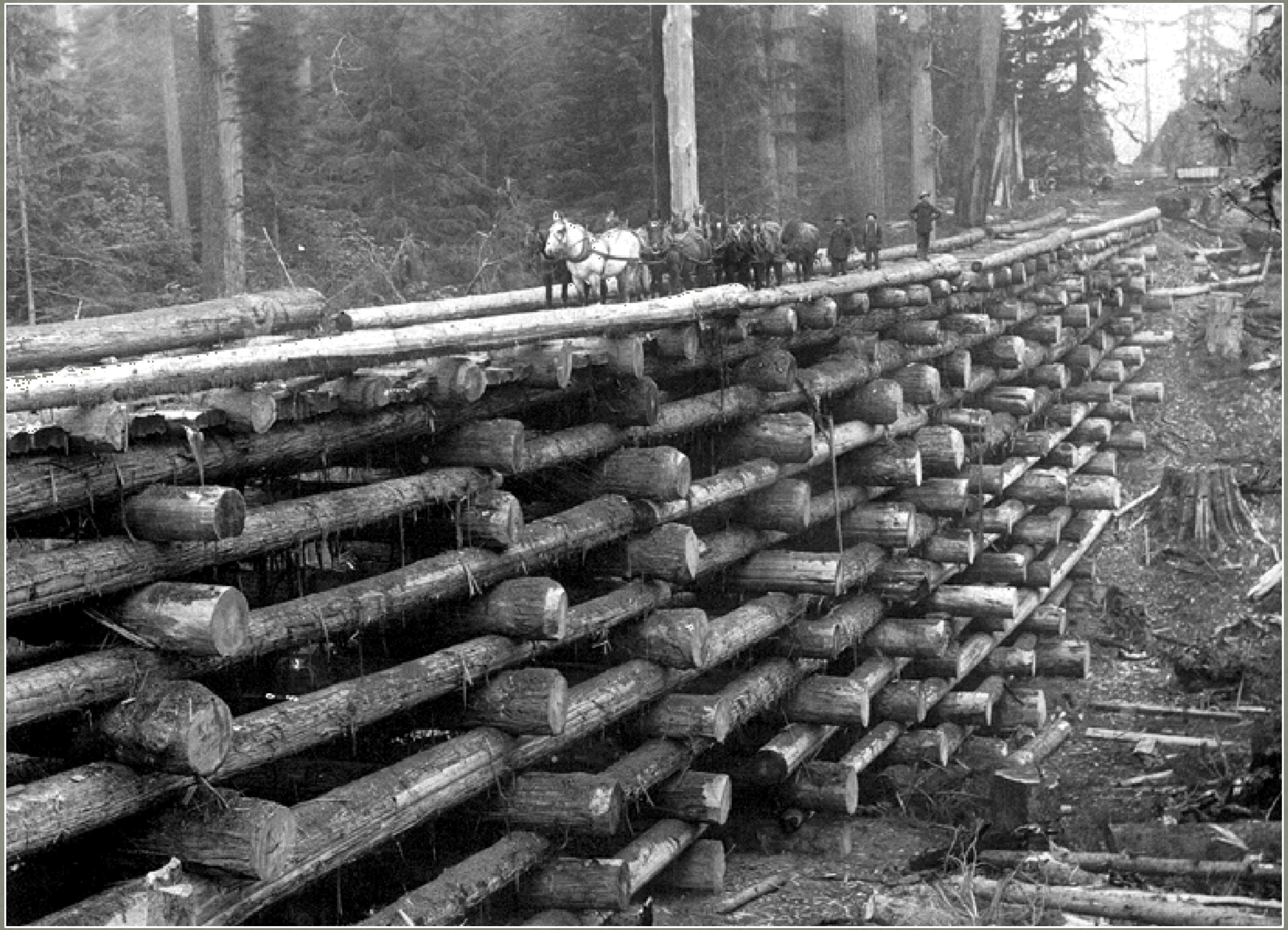
The Forest Resource

The Forest Resource

Material and Design Evolution

The last 150 years

Material and Design Evolution

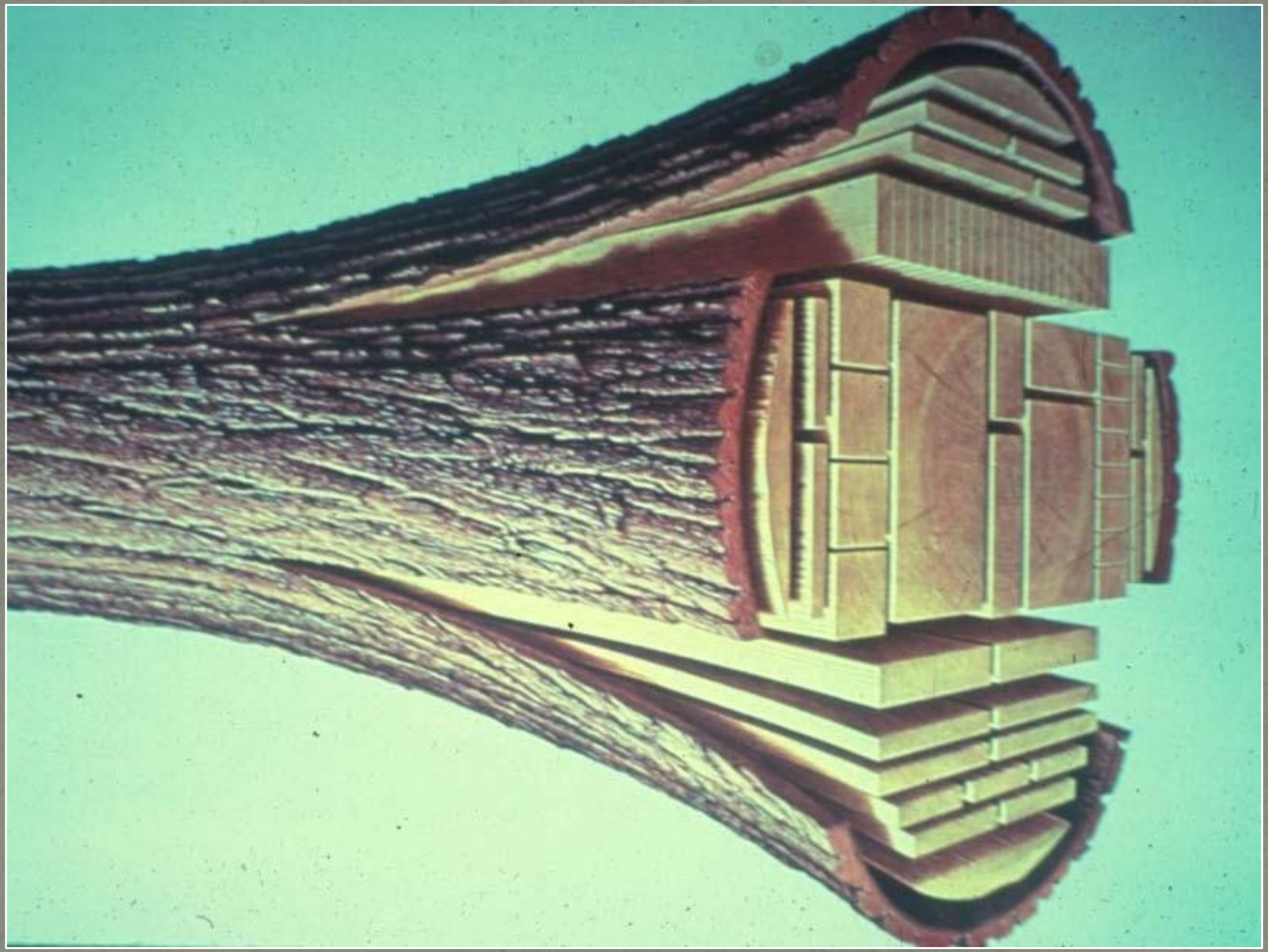


Material and Design Evolution

208' high x 843' long

Material and Design Evolution

Material and Design Evolution



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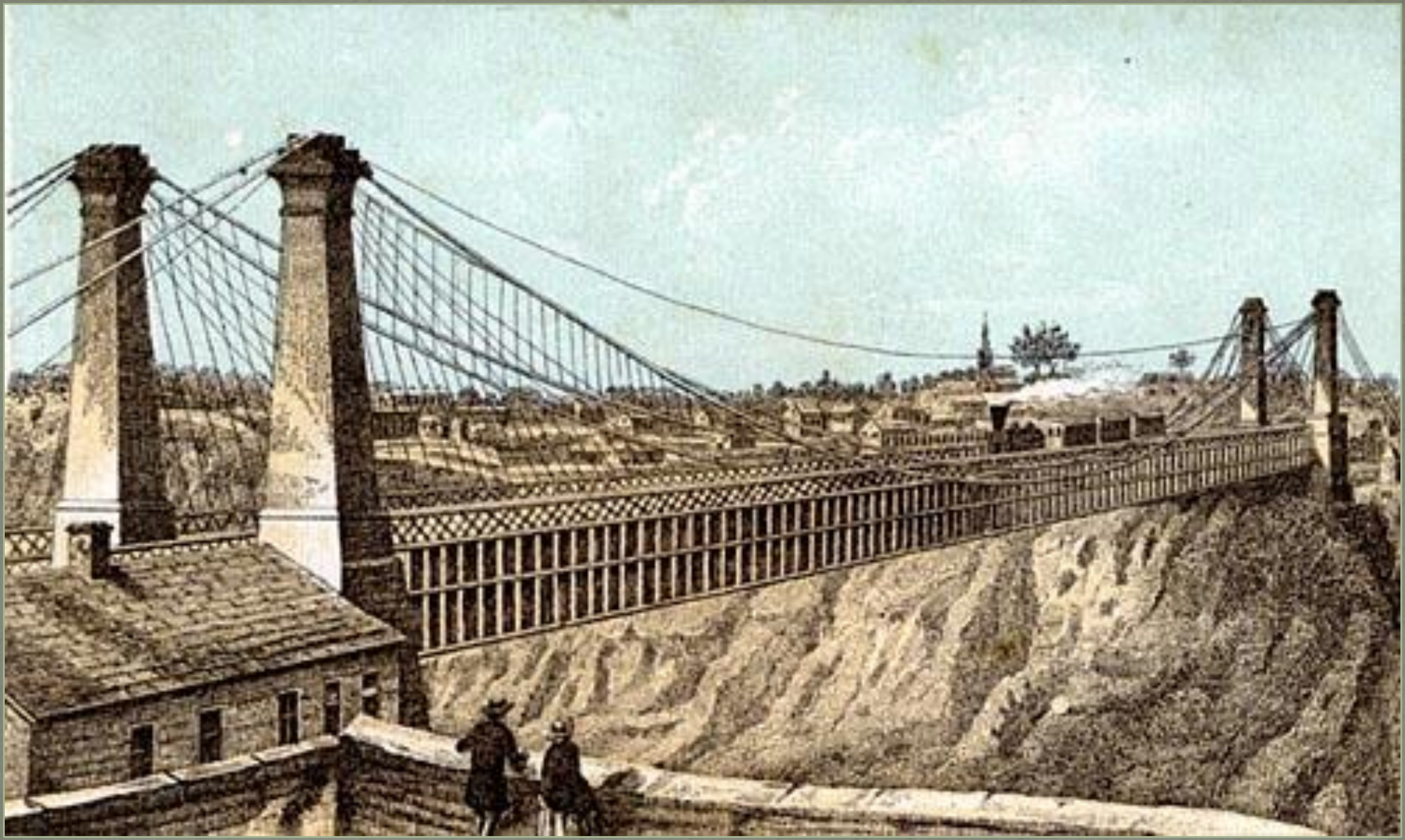

Material and Design Evolution

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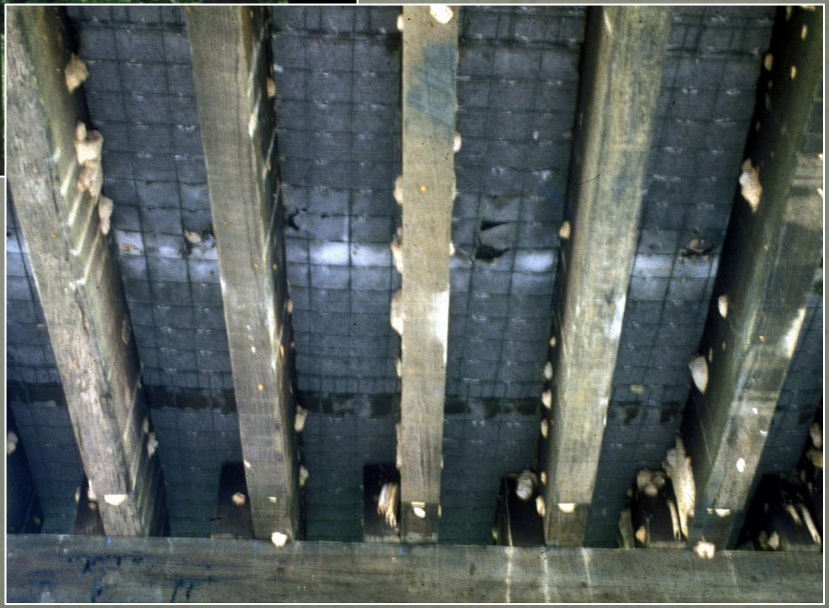

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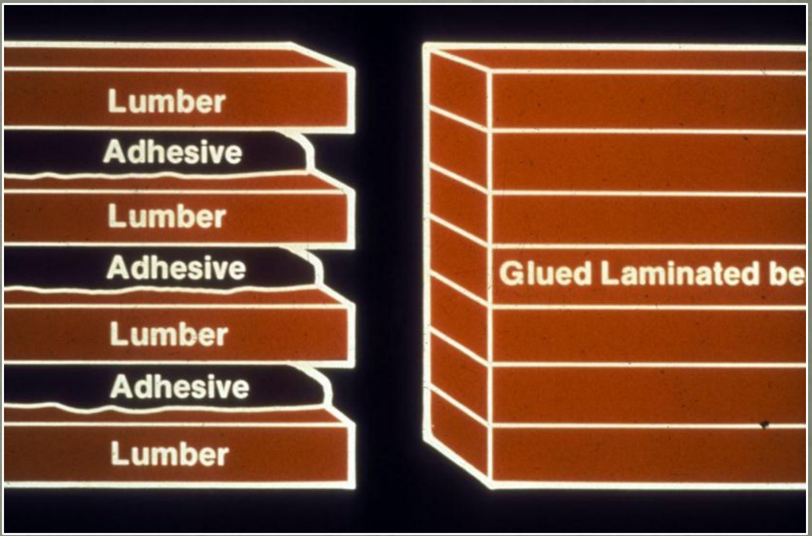

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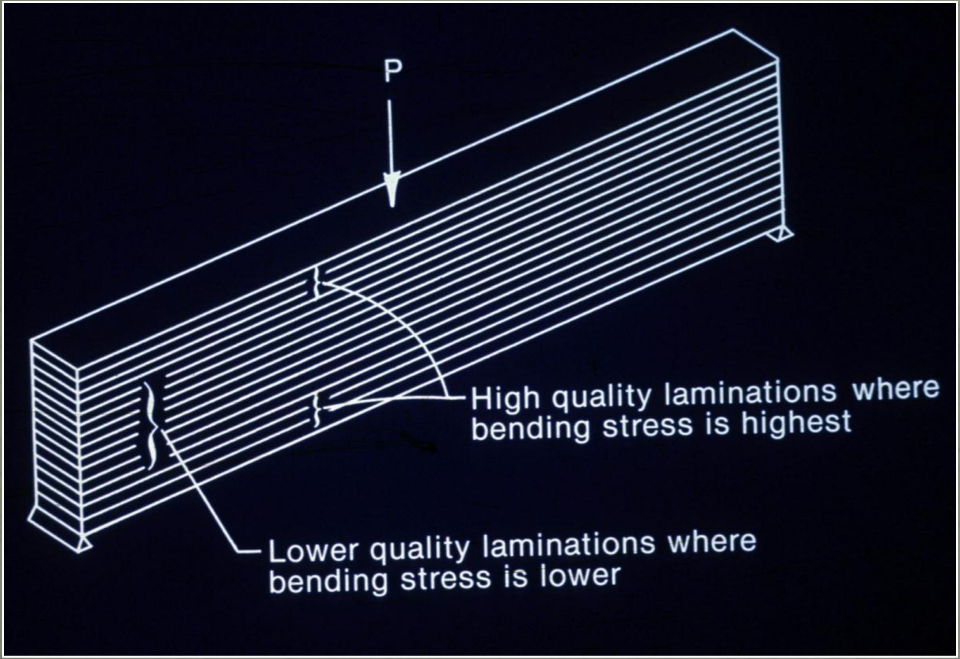

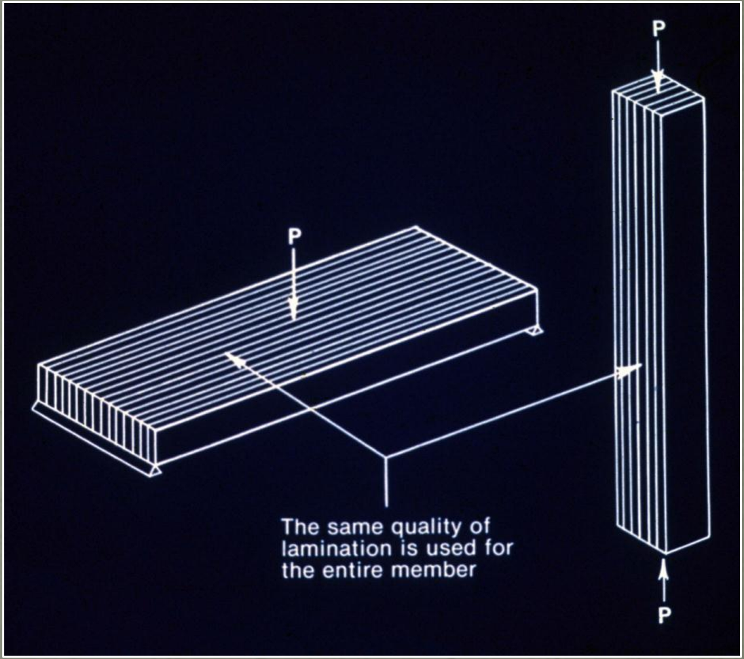

Material and Design Evolution

Material and Design Evolution

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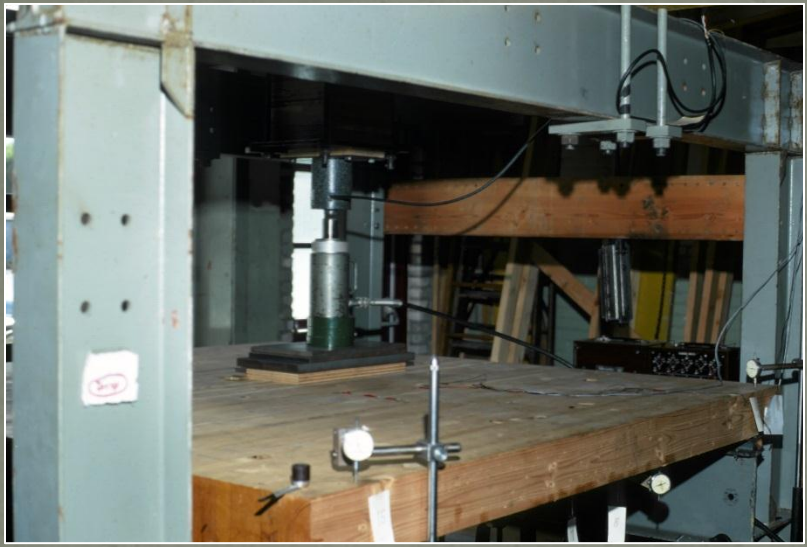

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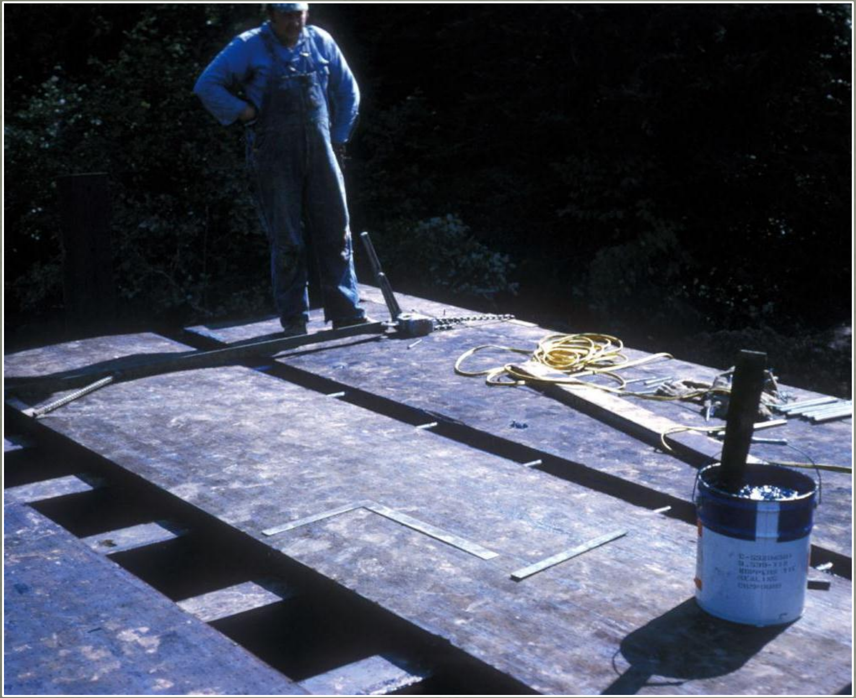

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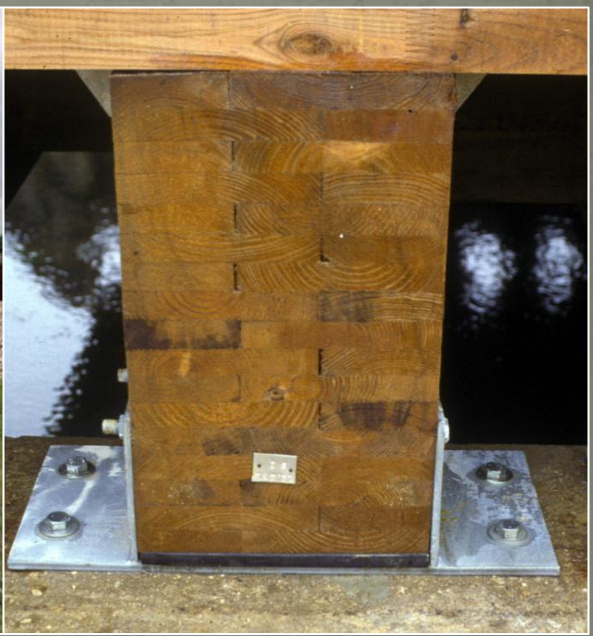
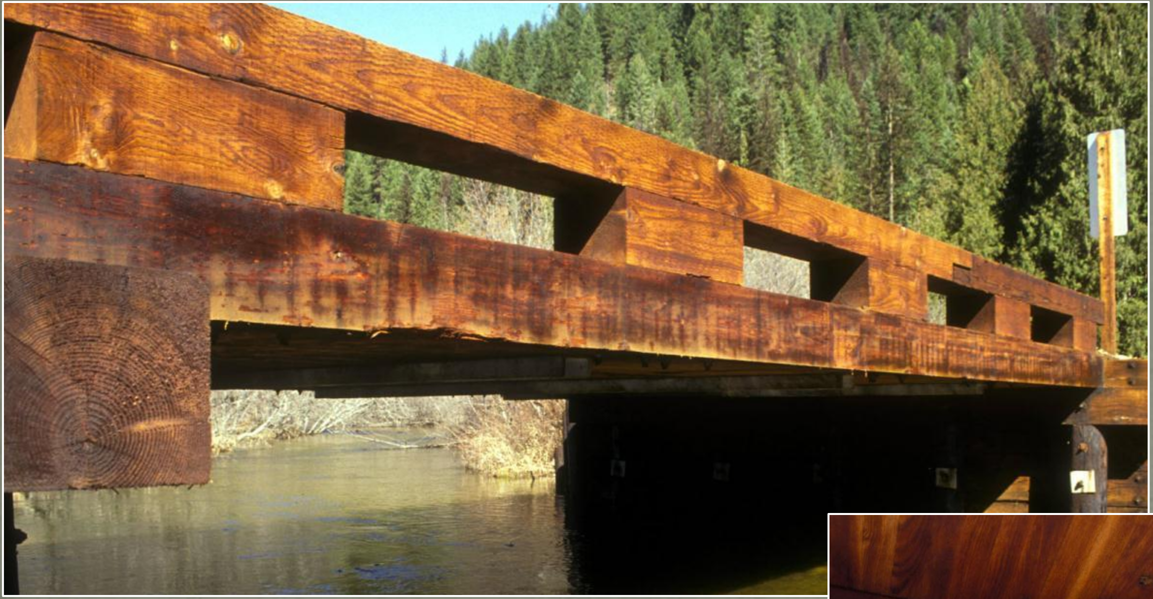
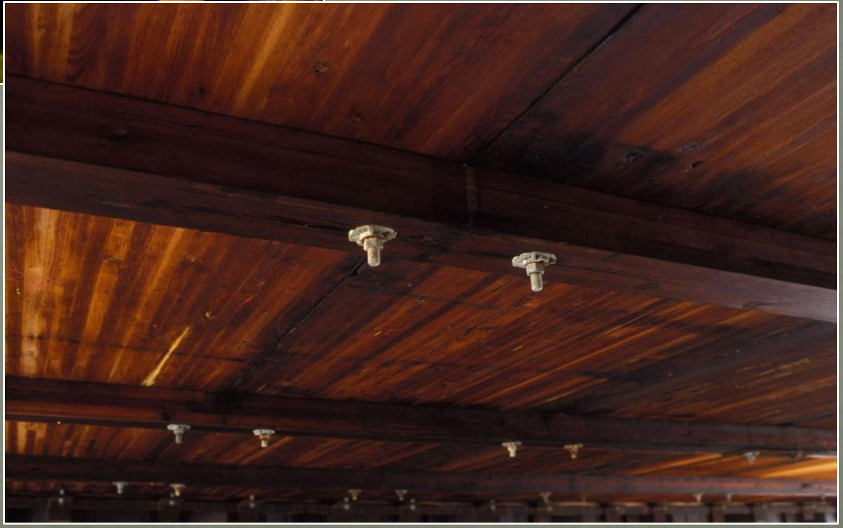


Material and Design Evolution

Material and Design Evolution





Material and Design Evolution

Material and Design Evolution

Open Deck Design

Material and Design Evolution

Ballast Deck Design

Timber Bridge Initiative

1989 – 2004
We must understand the past to grow in the future

Timber Bridge Initiative

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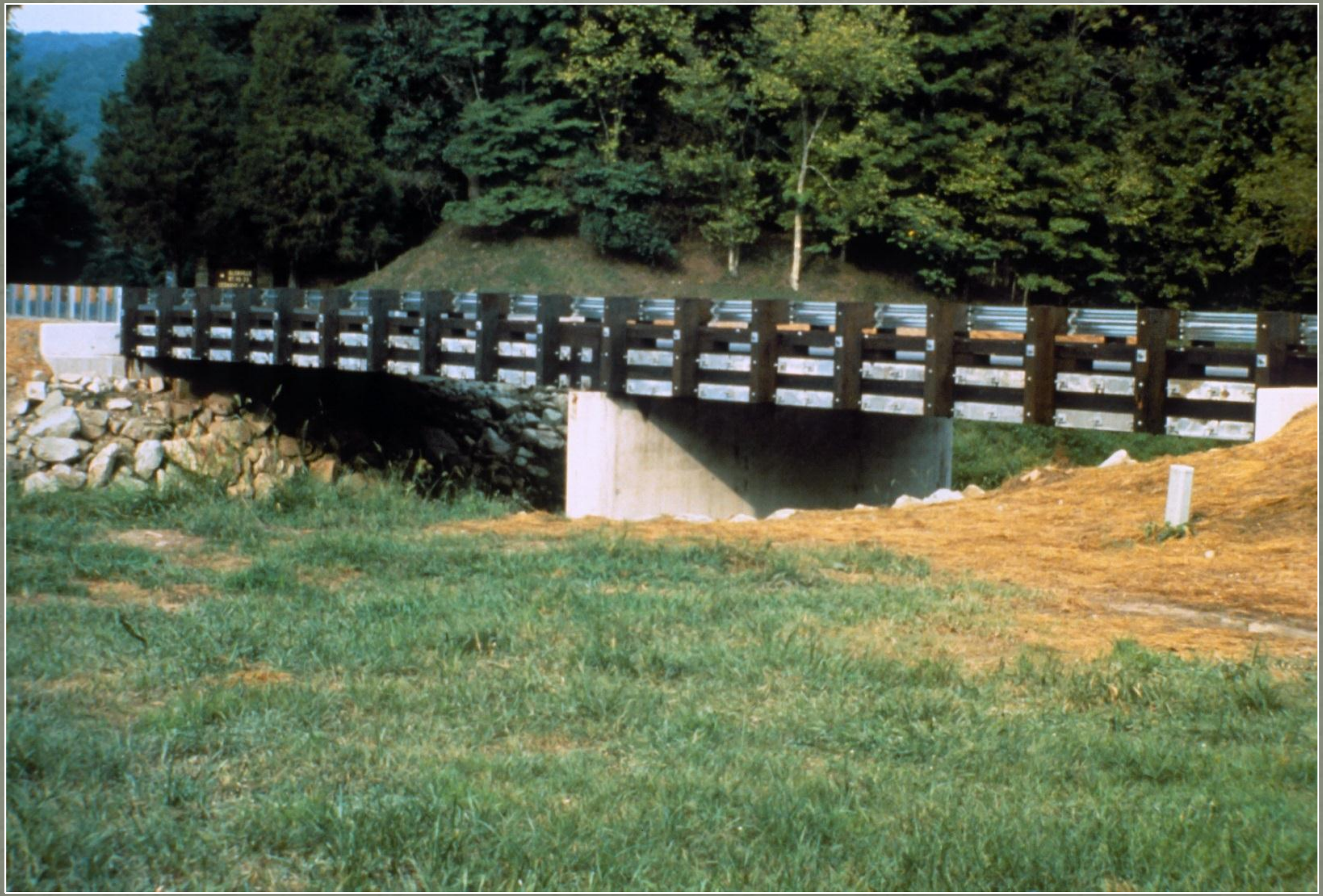

Timber Bridge Initiative

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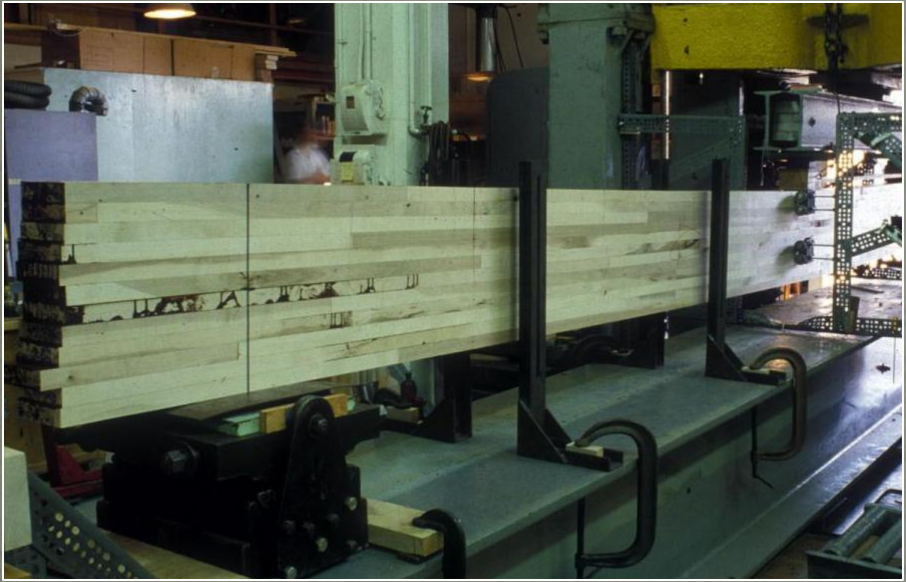

Timber Bridge Initiative

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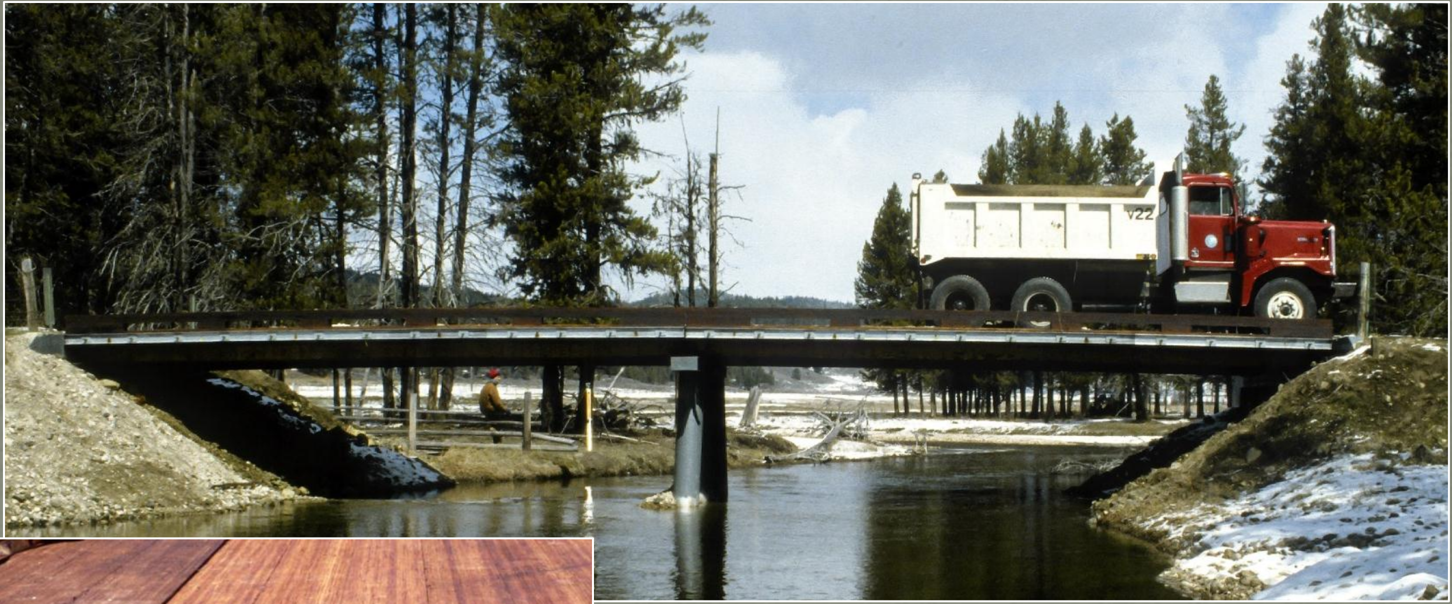

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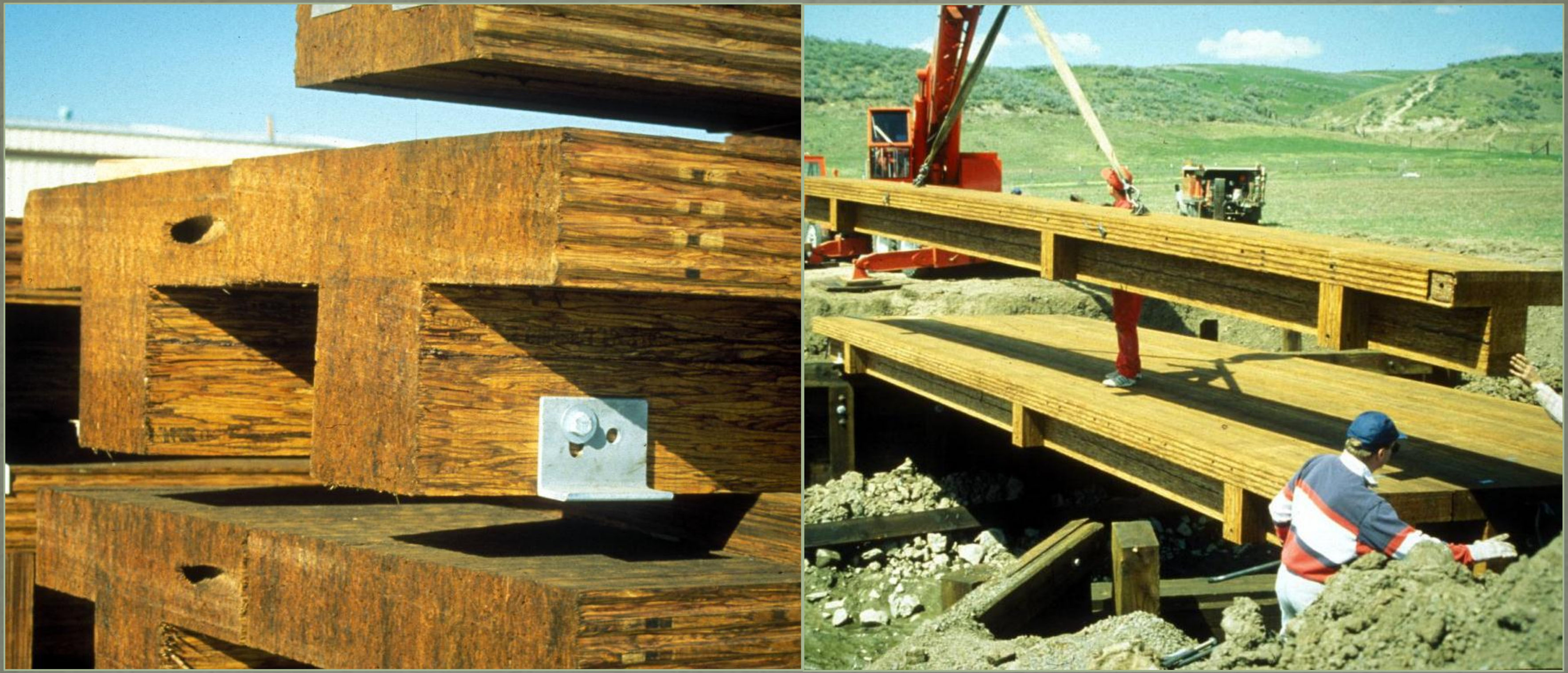


Timber Bridge Initiative

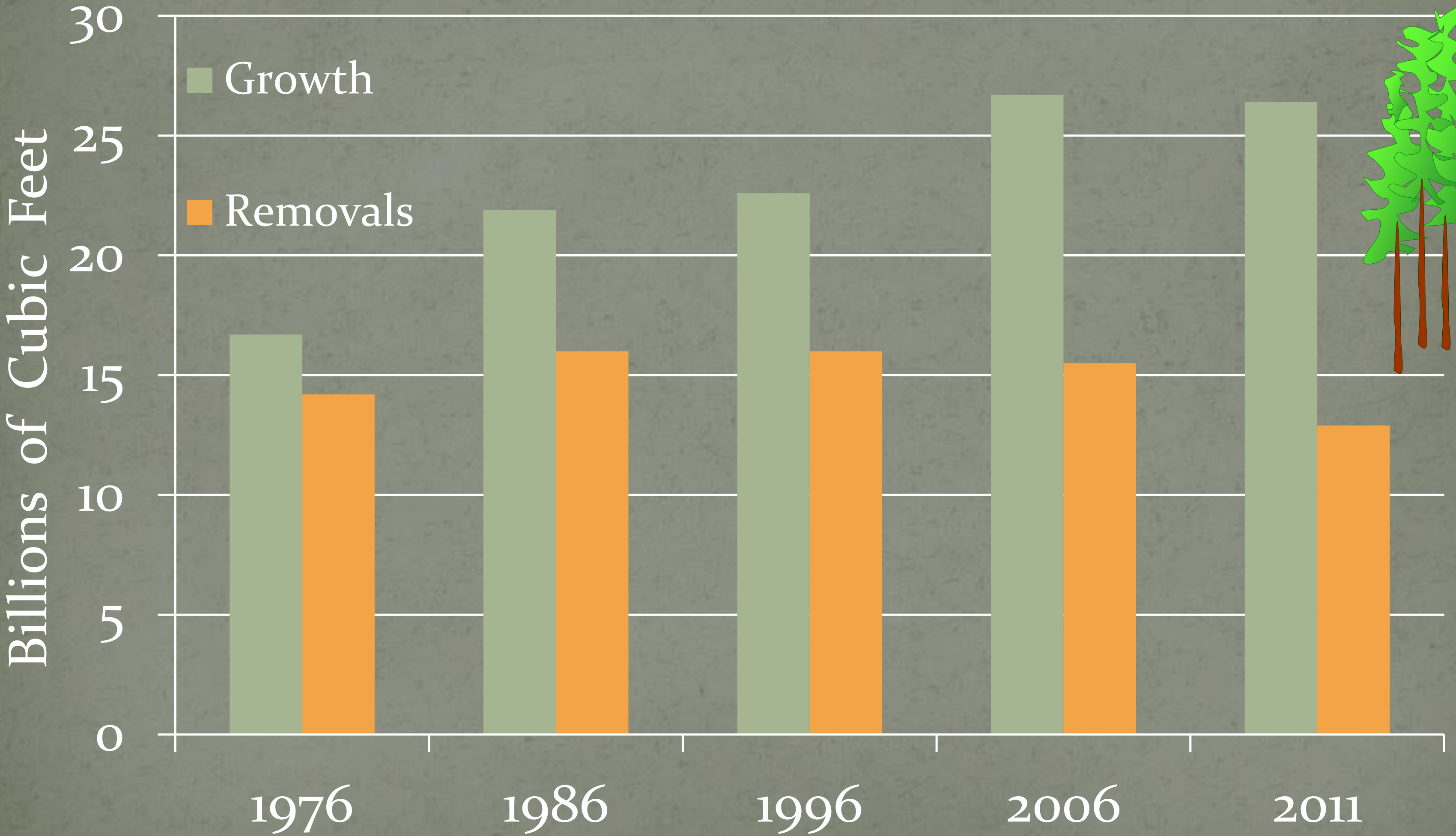
Timber Bridge Initiative

Timber Bridge Initiative

Where We are Today

What is the situation, what are the opportunities and challenges?

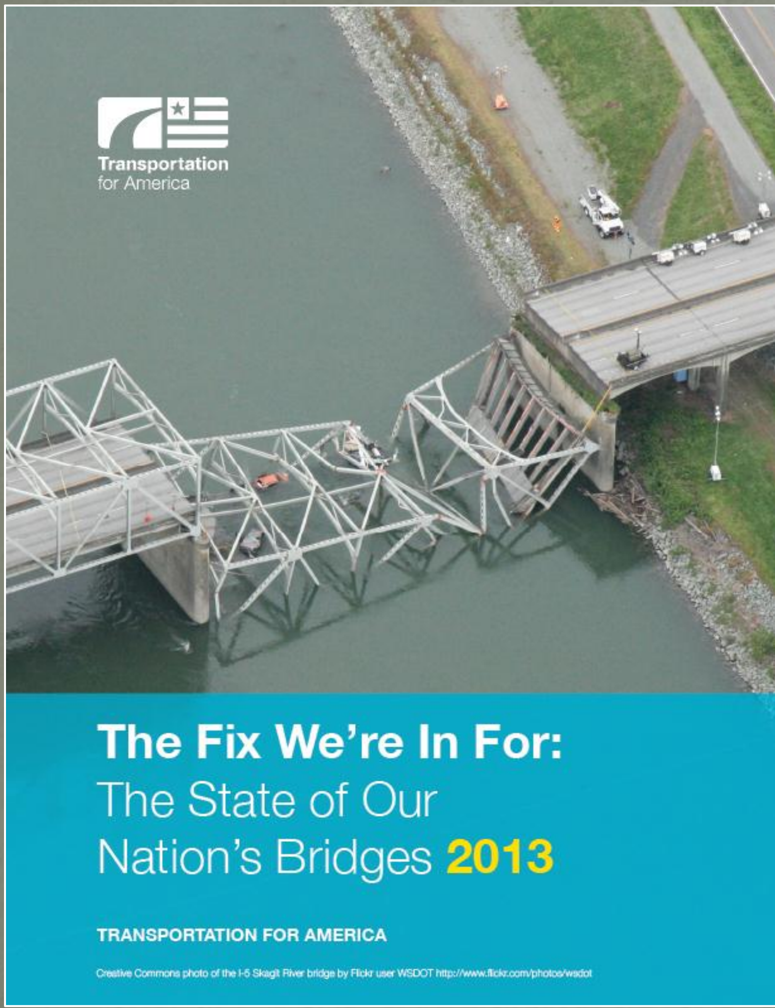
Annual Growth and Removal

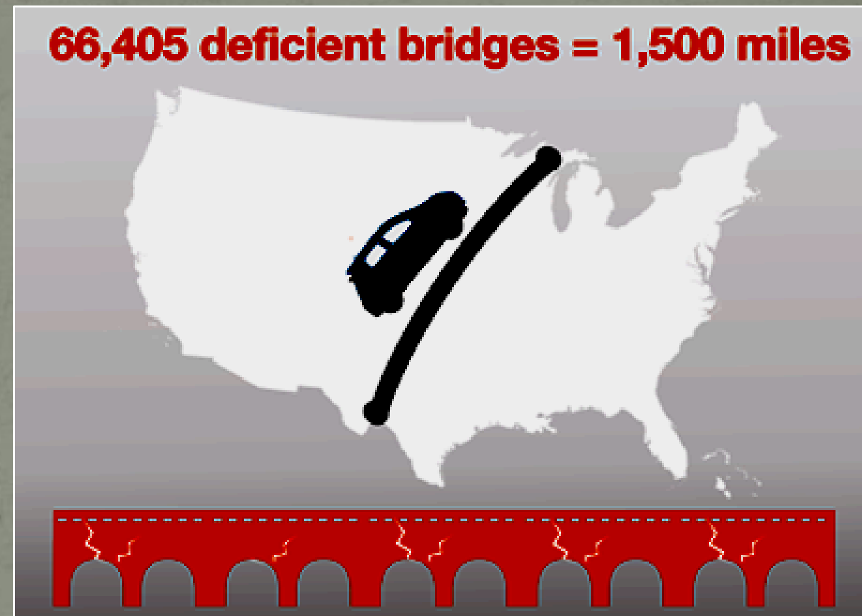


National Bridge Inventory – 12/2012

- 607,380 bridges (over 20' span)
- 22,724 bridges are wood bridges
- 151,497 bridges are deficient
  - 66,749 bridges are "Structurally Deficient"
  - 84,748 bridges are "Functionally Obsolete"
- Pennsylvania, Oklahoma and Iowa have the highest percentage of deficient bridges

Bridge Replacement is a Critical Need





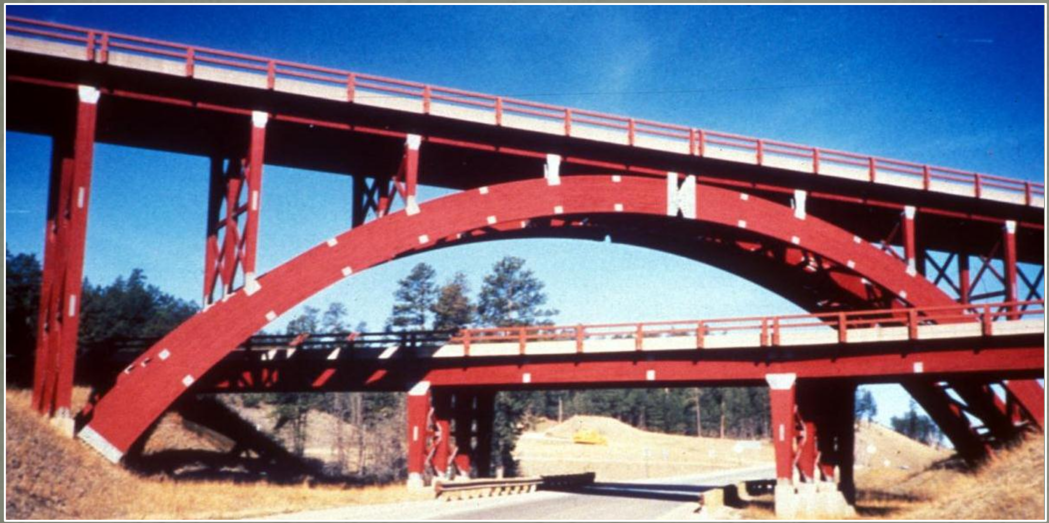
Transportation
for America

Where We are Today

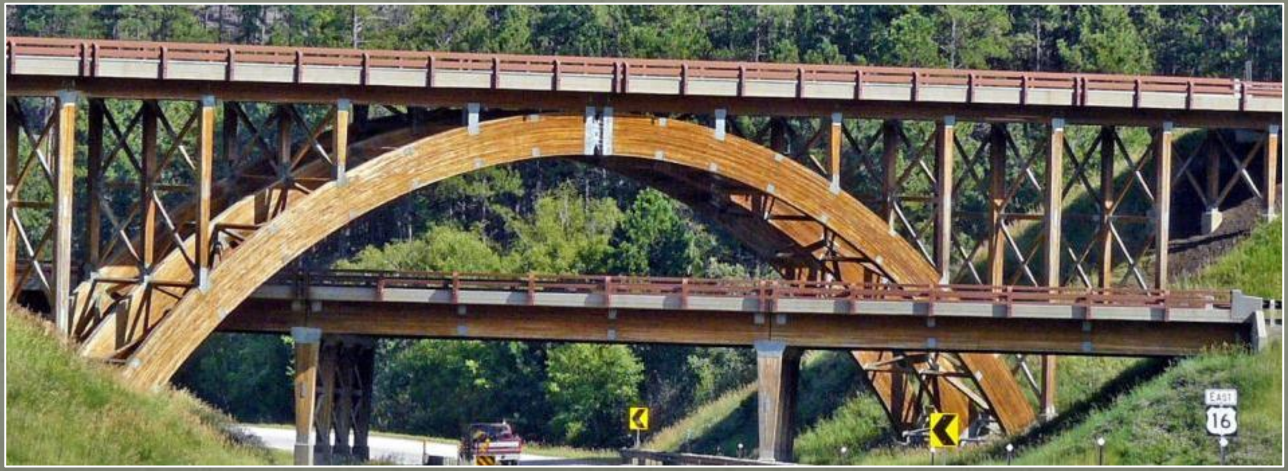
Challenge: Longevity Misconception

Where We are Today

Challenge: Longevity Misconception



1966



2010

Where We are Today

Challenge: Strength Misconception

Where We are Today

Challenge: Strength Misconception

Where We are Today

Challenge: Strength Misconception

Where We are Today

Challenge: Durability Misconception

Where We are Today

Challenge: Durability Misconception

Where We are Today

Challenge: Durability Misconception

Where We are Today

Challenge: Durability Misconception

Perception versus Reality: An Analysis of Timber Bridge Performance in the United States.

Robert L. Smith, Virginia Tech
Kim Stanfill-McMillan, Forest Products Laboratory, USDA Forest Service

Abstract

Bridge material selection is one of the most difficult decisions an engineer has to make. Many factors and individuals are often involved in choosing the proper bridge material for a given site and location. Not only physical factors such as strength or lifespan of material, but also site specific factors like roadway alignment and traffic count play important roles in material selection. It is not uncommon for state Department of Transportation engineers, private consulting engineers, and local highway officials all play roles in the material selection process. Each individual may have his/her own perception of bridge materials based upon past experience and education. And little is known how these perceptions influence the choice of materials. In this study perceptions of engineers and highway officials toward timber as a bridge material were compared to the actual performance of timber as reported in the National Bridge Inventory. To accomplish this case studies were conducted in four selected states. Highway officials and engineers in Mississippi, Virginia, Washington, and Wisconsin were surveyed by mail and personally interviewed to capture their perceptions toward timber as it compared to other major bridge materials (prestressed concrete, steel, and reinforced concrete). This information was compared with the actual performance data obtained from the National Bridge Inventory. The results indicate that there is a strong correlation between highway officials' perceptions towards bridge materials and the reported performance of these materials.

Keywords: Perceptions, National Bridge Inventory, timber, steel, concrete, performance.

Introduction

The need for bridge replacement has been well documented (Brungraber et al. 1987, Cheney 1986, USDA 1989). Over 40% of our Nation's bridges are in need of repair or replacement. According to the FHWA (1992) four major structural materials make up over 98% of all bridges in the United States. These include prestressed concrete (15%), steel (36%), reinforced concrete (40%), and timber (8%). However, since 1982 over seventy percent of the replacement bridges have been prestressed or reinforced concrete, while timber and steel were used in less than thirty percent of replacement structures. This suggests that perceptions toward prestressed and reinforced concrete by highway officials are better than that of competing materials.

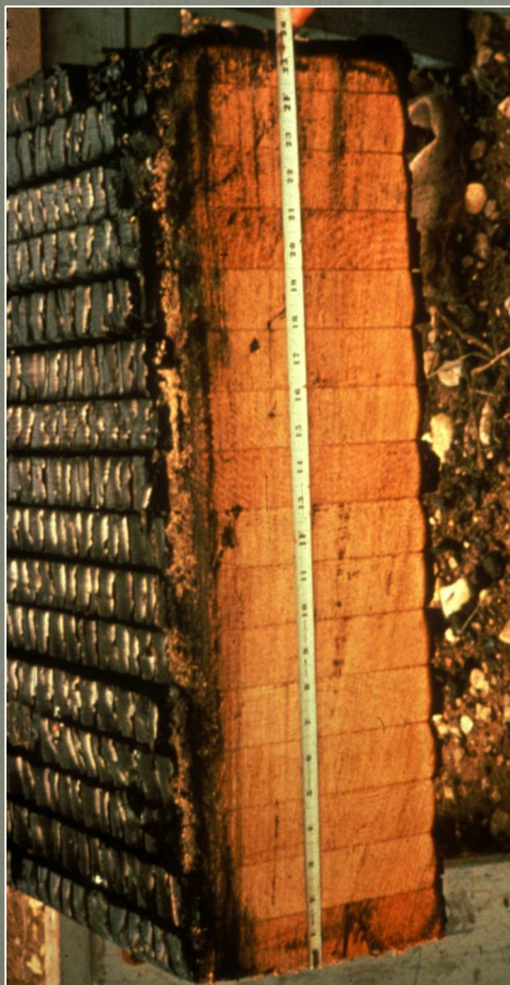
The United States has more than 3.9 million miles of roadway and 575,000 bridges. In 1967, in response to the collapse of the Silver River bridge over the Ohio River, Congress mandated the implementation of National bridge inspection standards. The individual bridge inspection records constitute the National Bridge Inventory (NBI). The purpose of the NBI is to provide a uniform base of bridge information that can be used to identify those bridges that are most in need of repair and to serve as a basis for allocating Federal Highway Administration (FHWA) funding for bridge replacement or rehabilitation. The NBI is administered by the FHWA in Washington, D.C. Data are updated continuously based on the latest bridge inspection, which are usually completed on a two year cycle.

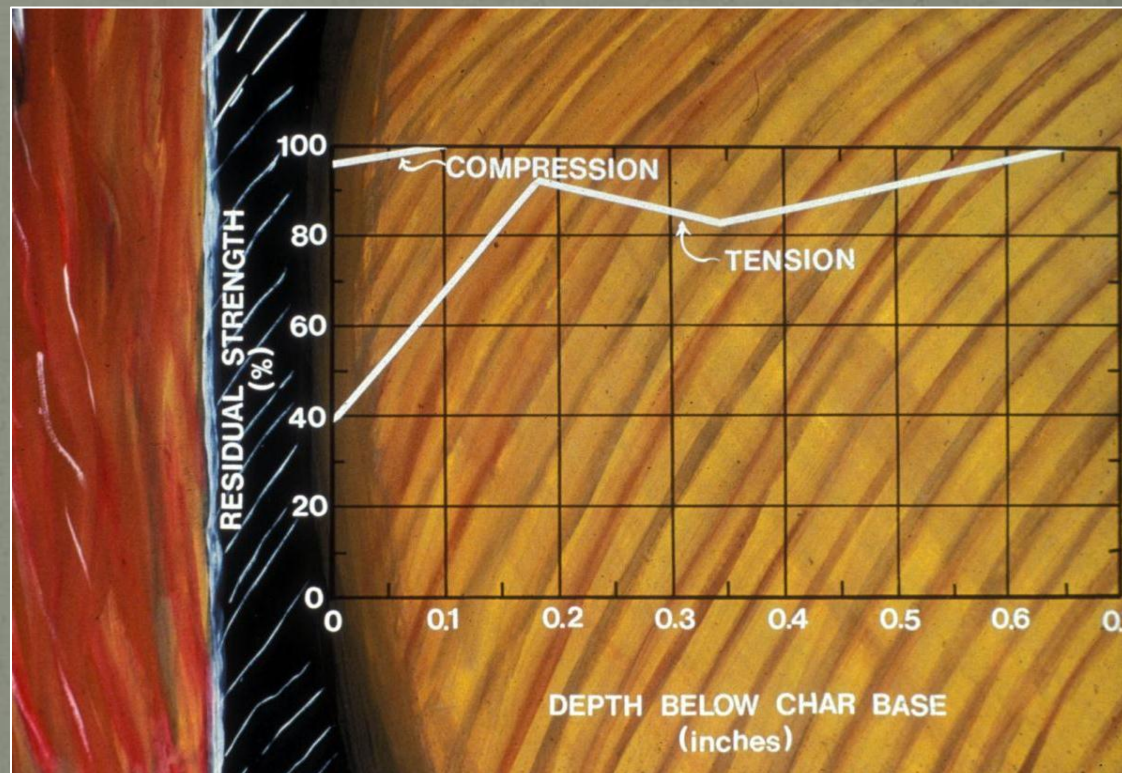
Where We are Today

Challenge: Fire Performance

Where We are Today

Challenge: Fire Performance





Where We are Today

Challenge: Fire Performance

Where We are Today

Challenge: Fire Performance

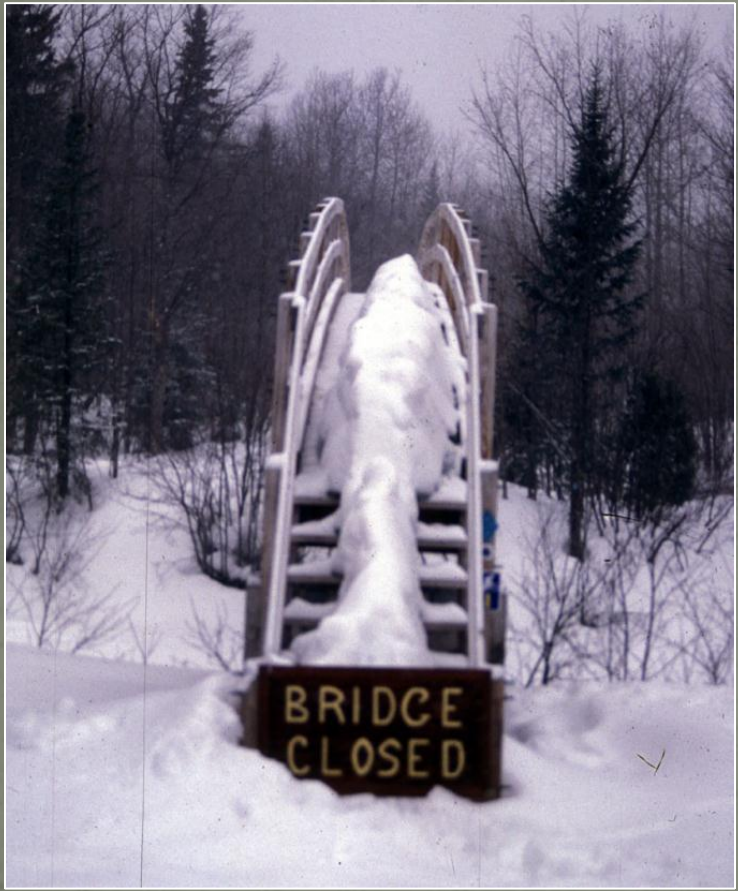
Where We are Today

Challenge: Engineering Education

The National Council of Structural Engineers Associations recommends one course in Timber Behavior and Design

Where We are Today

Challenge: Engineering Education



Where We are Today

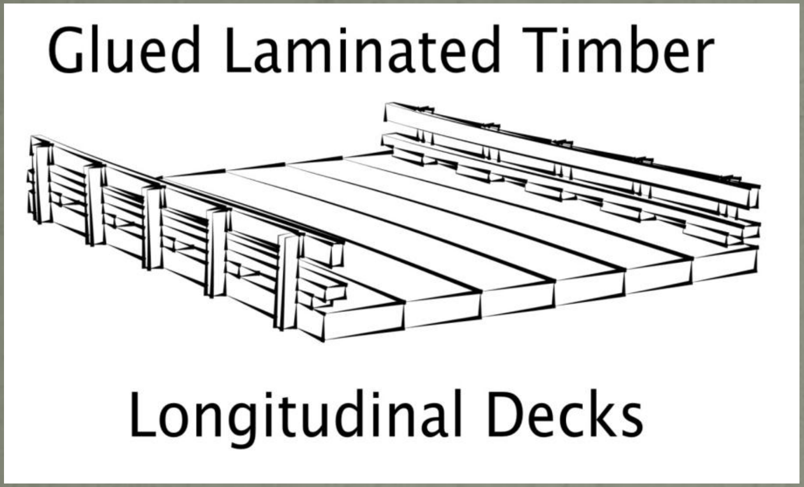
Challenge: Contractor Education

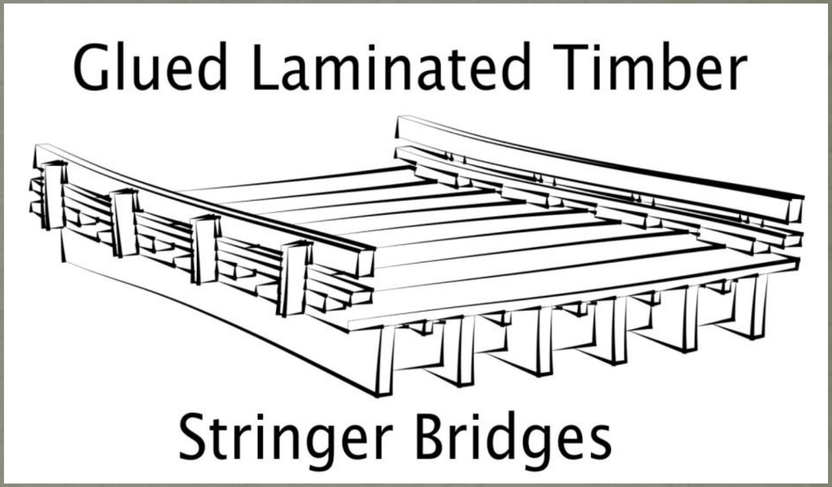
Where We are Today

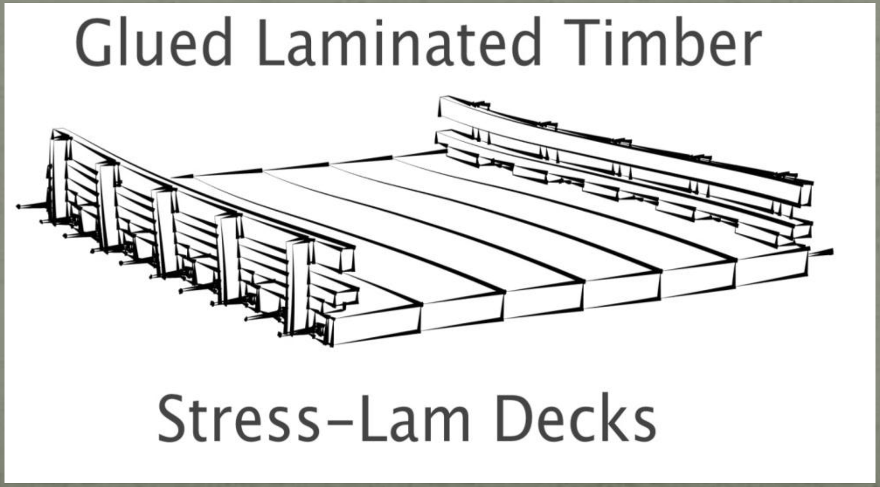
Challenge: Contractor Education

Where We are Today

Challenge: Contractor Education







Where We are Today

Challenge: Design Awareness

Where We are Today

Challenge: Design Awareness

Where We are Today

Challenge: Design Awareness

Where We are Today

Economics

USDA United States Department of Agriculture

Forest Service

Forest Products Laboratory

National Wood in Transportation Information Center

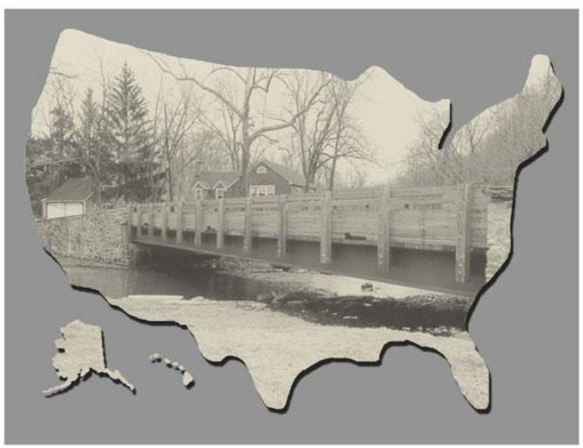
Research Paper FPL–RP–593

In cooperation with the

United States Department of Transportation

Federal Highway Administration

Timber Bridge Economics



National Cost Study of Timber Bridges

Glade M. Sowards, John Z. Wang, Blair Orr, Michigan Technological University

Kim Stanfill-McMillan, Forest Products Laboratory, USDA Forest Service

Abstract

A study is underway to determine the initial cost of timber bridges compared to those of steel, concrete, and prestressed concrete bridges. This report discusses the early results of the timber bridge portion of the data set. To this end, timber bridge owners, as identified in the June 1994 National Bridge Inventory (NBI), were sent a specially designed questionnaire to survey cost information on timber bridges under their ownership. In order to establish a comparative basis, timber bridges were selected under the requirements that they be built no earlier than 1980 and be load rated according to American Association of State Highway and Transportation Officials (AASHTO) specifications. No private or government demonstration bridges were included in this study, Given these requirements, 1604 timber bridges were identified as survey bridges. This paper summarizes the analysis of data collected on the cost of timber bridge superstructures throughout the country. The results of such analysis suggest that unit costs were highest for both the longest and shortest bridges considered and tend to increase with higher load ratings. Additionally, it was noted that questionnaire responses were lower than expected for shorter, narrower bridges that were designed to carry lighter loads.

Keywords: Timberbridge(s) superstructure cost.

Purpose And Background

According to Smith and Bush (1994), there are approximately 200,000 deficient bridges throughout the country with a projected replacement cost of $84 billion. As Wolchuk (1988) indicates, concrete decks account "for about two-thirds of the deficiency cases." In the face of such staggering figures, there has been a renewed interest in the prospect of timber bridge utilization.

Throughout much of the 19th century, timber structures accounted for the majority of the bridges and railroad trestles in the United States. These were simple structures constructed of sawn lumber. Many timber bridges of the period even lacked preservative treatments that would allow them to withstand exposure to moisture and decay. Additionally, the older timber bridges were often crudely designed with little or no input by engineers. For example, it was not until 1840 that a complete stress analysis of a timber bridge design was included with the bridge designer's patent. In the 20th century, timber bridges were first replaced by steel. Steel competed with timber as a bridge construction material on a first-cost basis by 1910 and came to dominate the bridge market by 1930 (Ritter 1990).

The failure of older, primitive timber bridges and their eventual replacement by newer steel and, later, concrete designs is the likely source of a general perception held by some today that timber bridges are of inferior quality. Over time, however, the limitations of steel, concrete, and prestressed concrete have become apparent and range from susceptibility to corrosion to costly maintenance and replacement.

Beginning in the mid-1940s engineers began to reconsider timber for bridge construction. The development of such techniques as glue- and, later, stress- lamination demonstrated the strength of timber as a construction material and led to a renewed interest in timber bridge utilization (Ritter 1990). The rationale for this interest is three-fold. First, timber offers a potentially low-cost

Where We are Today

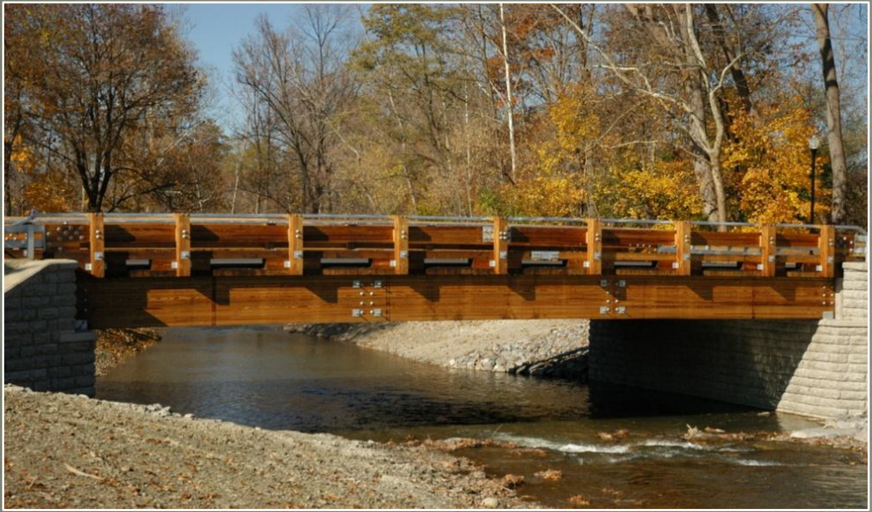
Opportunity: Versatility

Where We are Today

Opportunity: Versatility

Where We are Today

Opportunity: Versatility



LCI
LAMINATED CONCEPTS INC.

Where We are Today

Opportunity: Versatility

LAMINATED CONCEPTS INC.

Where We are Today

Opportunity: Versatility

WESTERN WOOD STRUCTURES

Where We are Today

Opportunity: Versatility

WESTERN
WOOD
STRUCTURES

Opinion on the Future

The Future

New Materials

1988 in Austria

The Future

New Materials

The Future

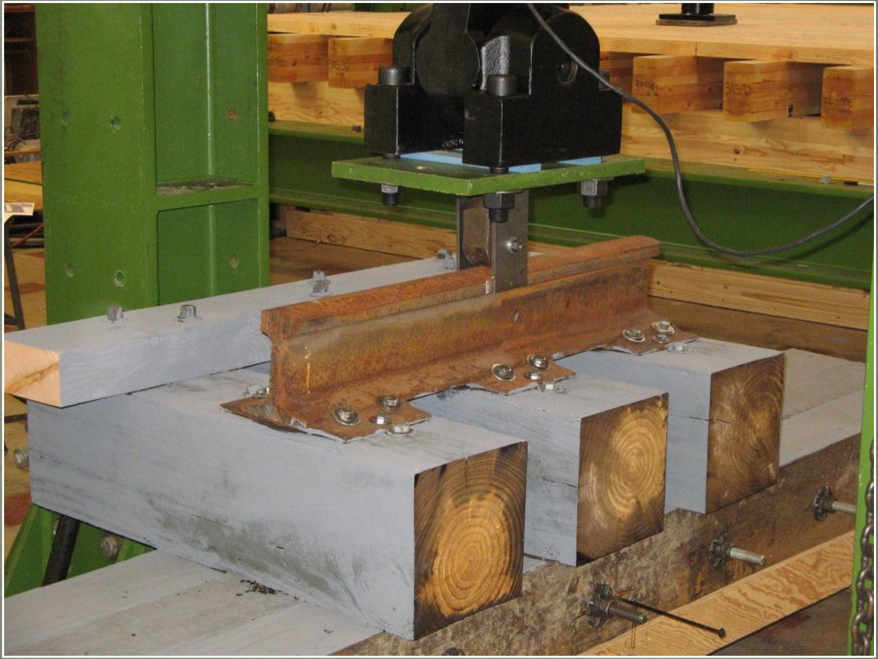
Composite Bridges

The Future

Smart Bridges and Remote Sensing

The Future

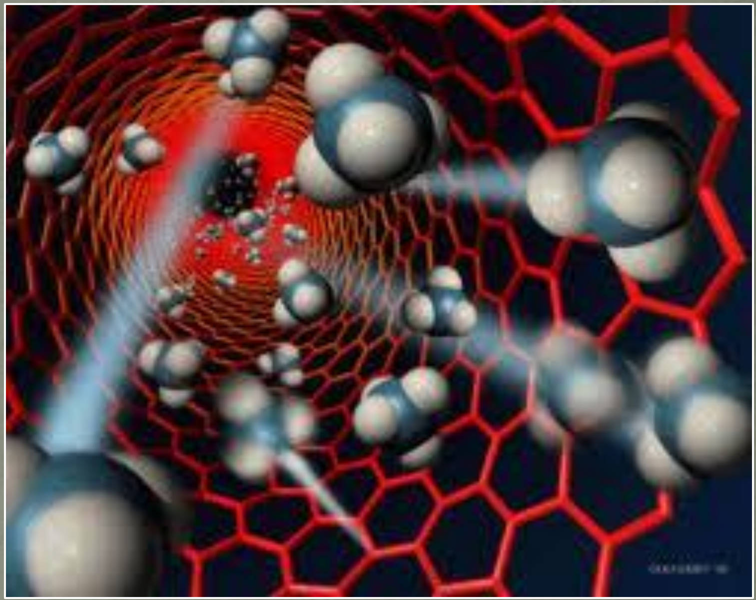
Fireproof Coatings



The Future

Nanotechnology

Nanotechnology is the understanding and control of matter at dimensions of 1 to 100 nanometers, where unique phenomena allow us to make new materials and devices with novel applications



1 nanometer = 1 billionth of a meter

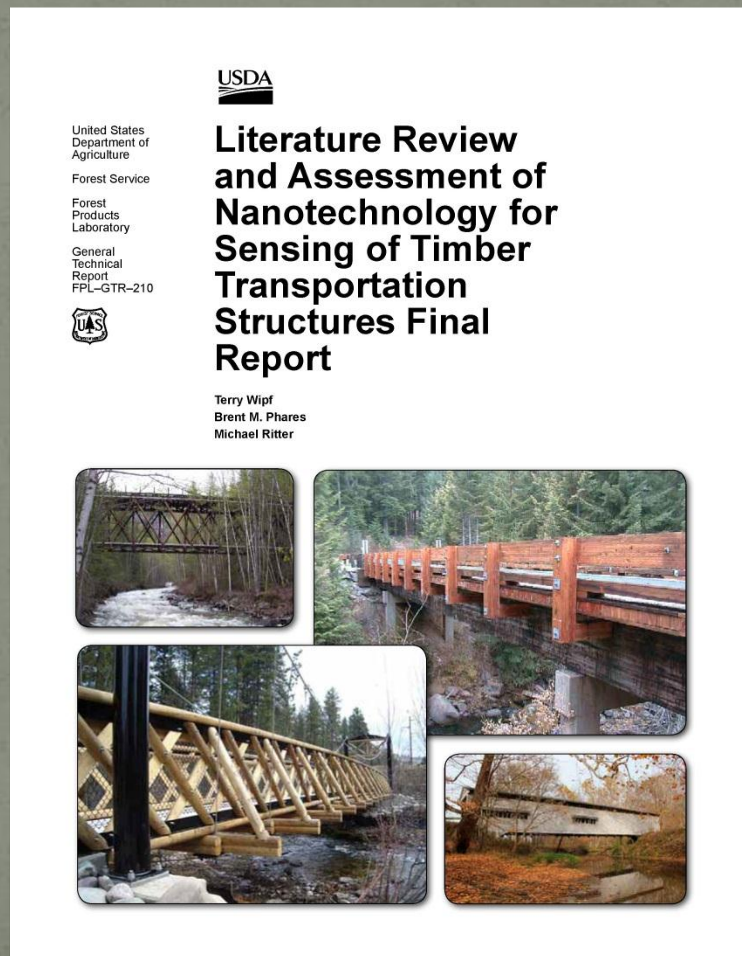
The Future

Nanotechnology

Nanoparticles of metals commonly used to preserve wood demonstrate unique properties compared to larger particles of the same material, including increased leach resistance, photostability and termite inhibition

The Future

Nanotechnology


USDA

United States
Department of
Agriculture

Forest Service

Forest
Products
Laboratory

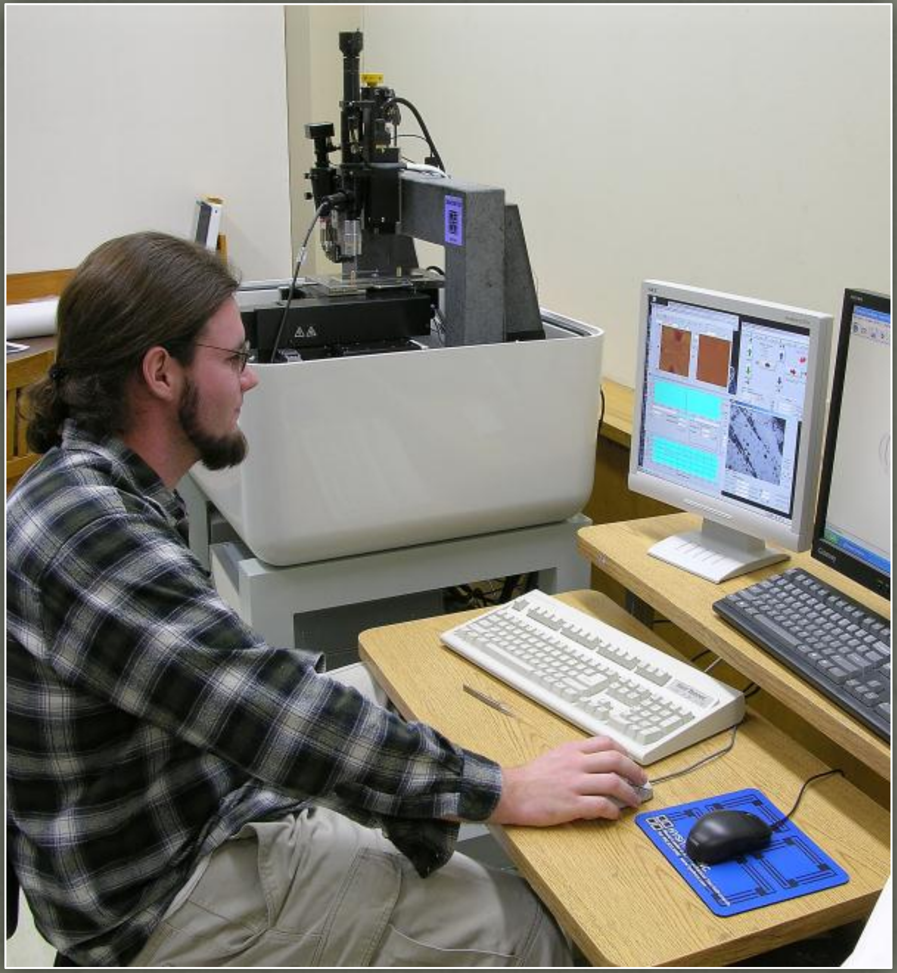
General
Technical
Report
FPL–GTR–210

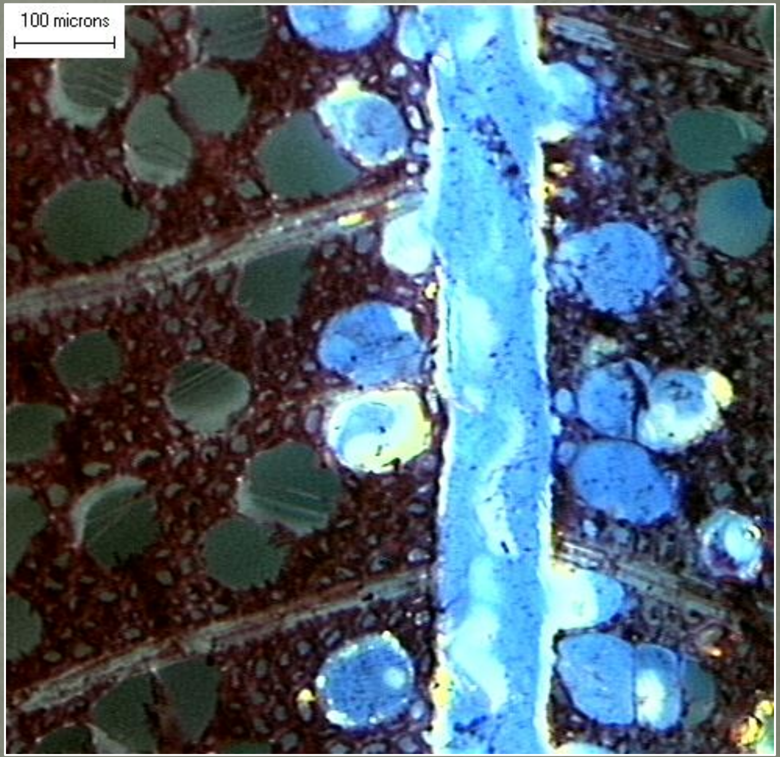
Literature Review and Assessment of Nanotechnology for Sensing of Timber Transportation Structures Final Report

Terry Wipf
Brent M. Phares
Michael Ritter

The Future

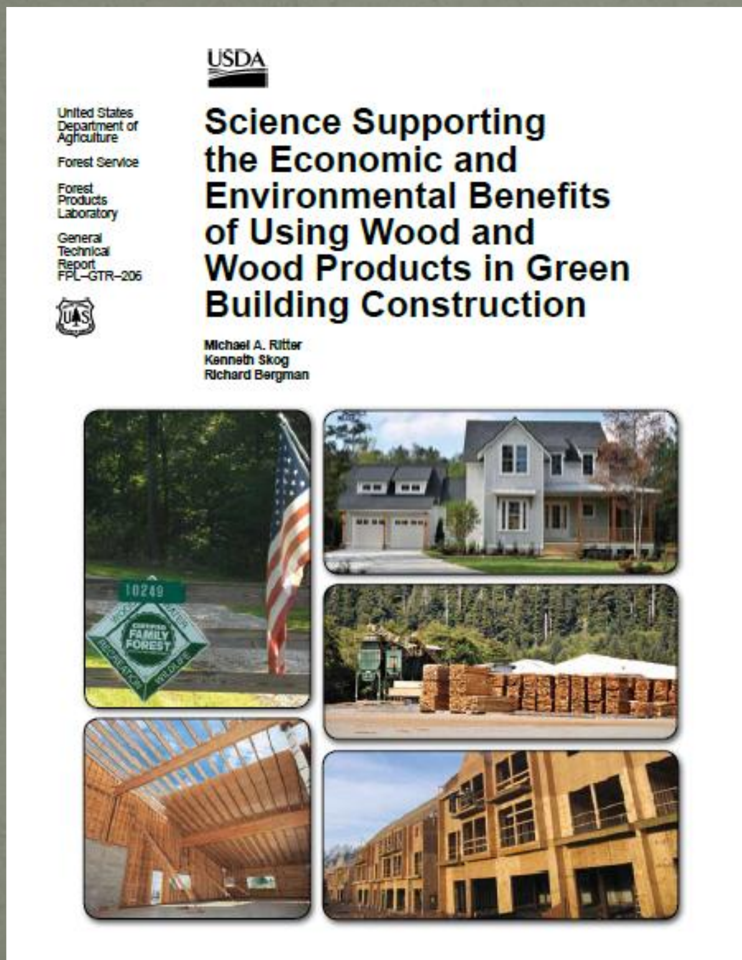
Adhesives





The Future

Sustainability and Green Building


USDA

United States Department of Agriculture

Forest Service

Forest Products Laboratory

General Technical Report FPL–GTR–206

Science Supporting the Economic and Environmental Benefits of Using Wood and Wood Products in Green Building Construction

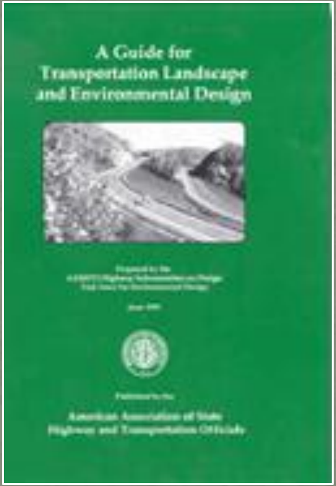
Michael A. Ritter
Kenneth Skog
Richard Bergman

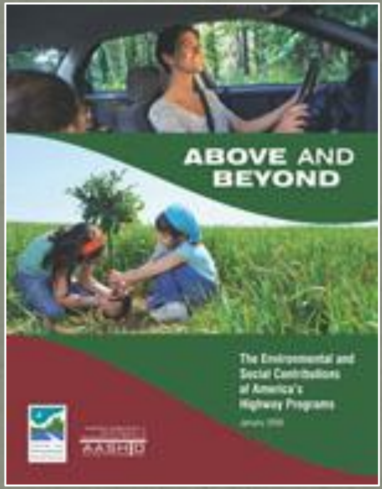
The Future

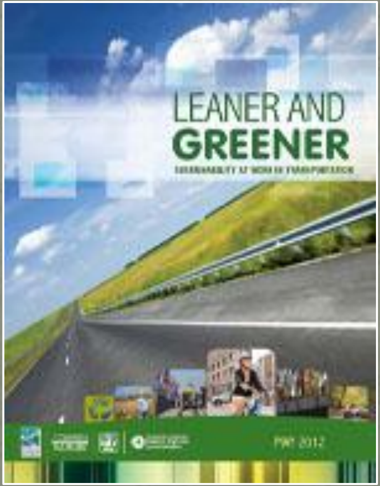
Sustainability and Green Building

Center for Environmental Excellence by AASHTO

One Stop Source of Environmental Information for Transportation Professionals

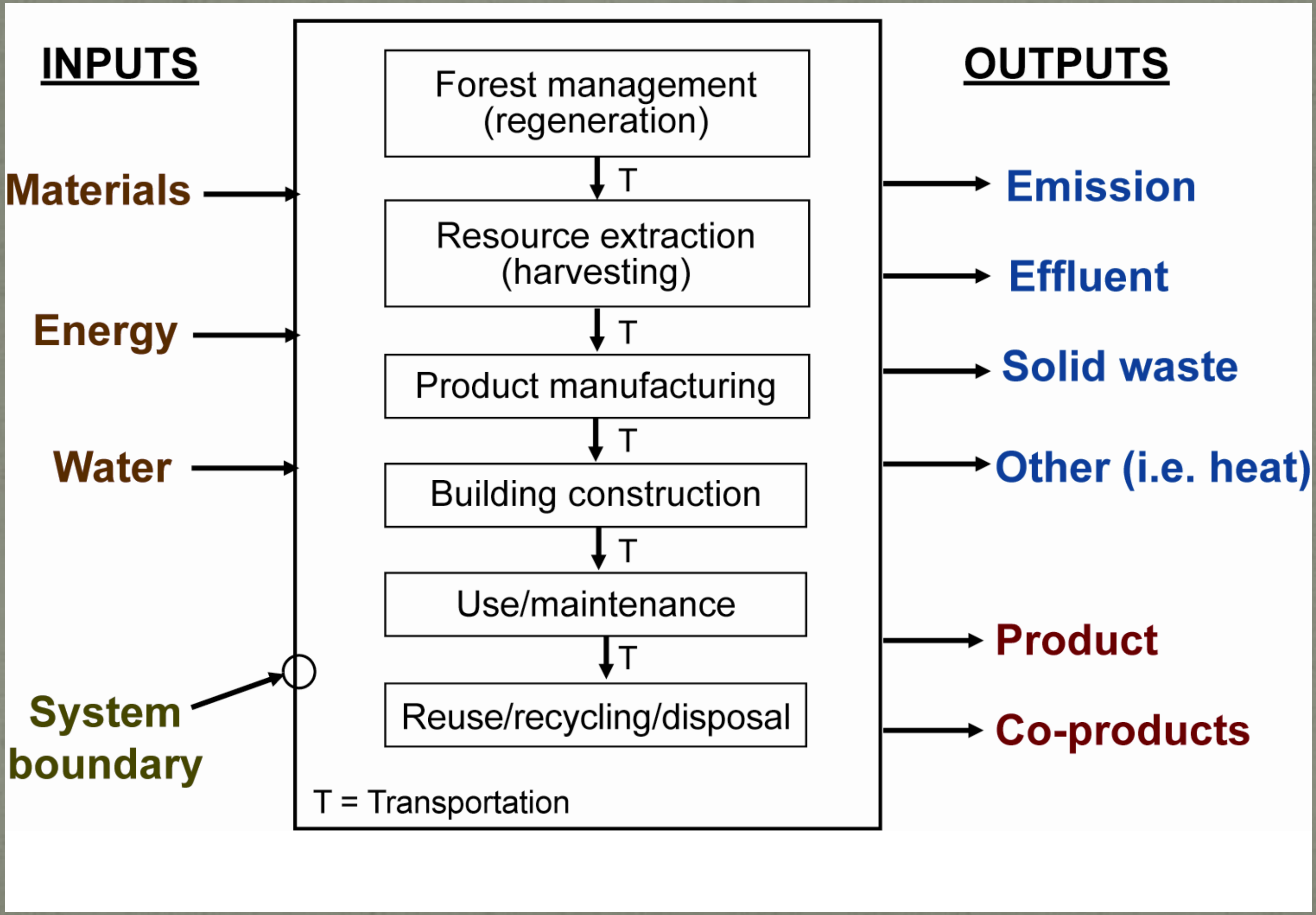






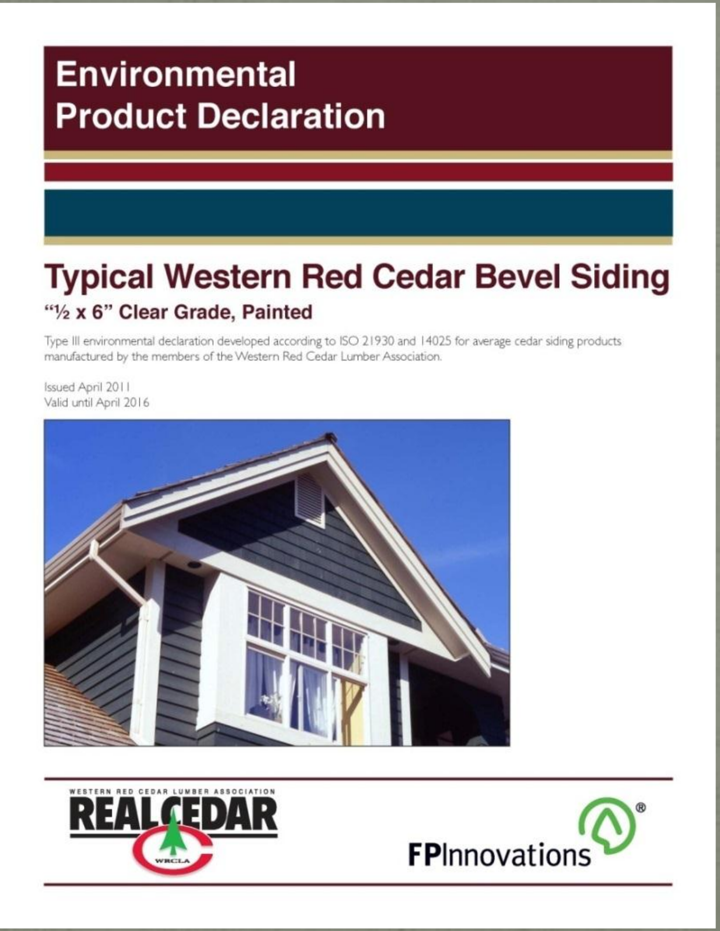
The Future

Sustainability and Green Building



The Future

Sustainability and Green Building


Environmental
Product Declaration

Typical Western Red Cedar Bevel Siding

"½ x 6" Clear Grade, Painted

Type III environmental declaration developed according to ISO 21930 and 14025 for average cedar siding products manufactured by the members of the Western Red Cedar Lumber Association.

Issued April 2011
Valid until April 2016

The Future

Research and Development

The Future

Education and Technology Transfer

NATIONAL CENTER FOR WOOD TRANSPORTATION STRUCTURES

www.woodcenter.org

WoodWorks

Conclusions

- Timber bridges are an excellent value-added option for a "growing" wood resource.
- Bridge replacement needs increase annually, especially on secondary road systems.
- There are numerous proven timber bridge designs.
- Acceptance of timber bridges can be further increased through education and technology transfer.
- Research must continue to develop and demonstrate new bridge systems, materials and technologies.
- The future is potentially bright!

Thank You