Opportunities for Timber Bridges in North America

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Outline

- Timber Bridges in North America
- Opportunities for Timber Bridges
- Codes and Standards
- Conclusions and Discussions

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Bridges in North America

– 70,000 in Canada and 710,000 in the U.S.

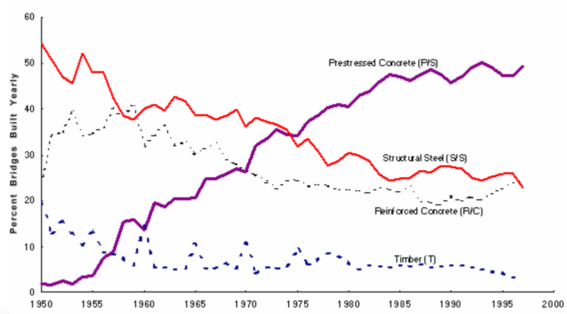

Figure 1 – U.S New Bridge Material Comparison, 1950-2000

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Timber Bridges in the U.S.

- Total number of U.S. bridges is 712,313
- Of which the number of timber bridges is 24,599 (3.4%)
- And the number of timber decked bridges is 45,985 (6.4%)

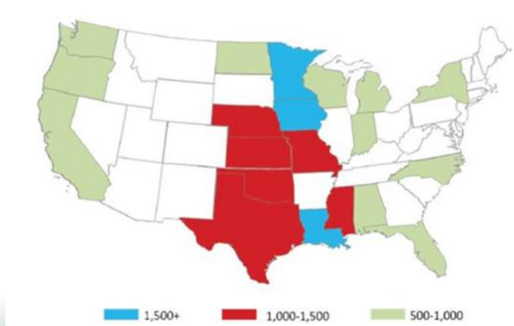

Figure 2 - U.S. States With More than 500 Timber Bridges, December 2010

Source: US Federal Highway Administration's National Bridge Inventory

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Table 1 – Top 10 U.S. State Timber Bridges, New & Reconstructed, 2001-2011

	New	Reconstructed	Total
Iowa	183	67	250
Texas	103	23	126
Indiana	83	14	97
New York	63	31	94
Florida	58	23	81
West Virginia	76	1	77
Michigan	48	27	75
North Carolina	70	5	75
Ohio	48	21	69
Louisiana	55	9	64

Figure - U.S. Timber Bridge Market Segments, 2001-2011

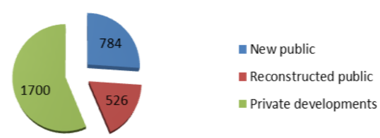

Table 2 - U.S. Timber Bridge Structural Evaluation

	Number	Percent
Bridge closed	1,098	4.5
Basically intolerable requiring high priority of replacement	4,930	20.0
Basically intolerable requiring high priority of corrective action	1,870	7.6
Meets minimum tolerable limits to be left in place as is	4,573	18.6
Somewhat better than minimum adequacy to tolerate being left in place as is	4,220	17.2
Equal to present minimum criteria	3,840	15.6
Better than present minimum criteria	2,272	9.2
Equal to present desirable criteria	822	3.3
Superior to present desirable criteria	71	.3
Total	23,696	96.3
Missing	903	3.7
TOTAL TIMBER BRIDGES	24,599	100.0

The Profile of New Timber Bridges

	Number	Percent
State Highway Agency	24	3.1
County Highway Agency	584	74.5
Town or Township Highway Agency	38	4.8
City or Municipal Highway Agency	45	5.7
State Park, Forest, or Reservation Agency	18	2.3
Other State Agencies	2	.3
Private (other than railroad)	1	.1
Railroad	1	.1
Bureau of Fish and Wildlife	1	.1
U.S. Forest Service	46	5.9
National Park Service	2	.3
Army	17	2.2
Total	779	99.4
Missing	5	.6
Total bridges	784	100.0

Table 3 – U.S. New Timber Bridge Ownership & Maintenance, 2001-2011

	Number	Percent
One	182	23.2
Two	596	76.0
Three or more	2	.3
Total	780	99.5
Missing	4	.5
Total bridges	784	100.0

Table 4 – U.S. New Timber Bridge Number of Lanes, 2001-2011

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The Profile of New Timber Bridges

	Number	Percent
Other or Unknown	252	32.1
M 9 / H 10	44	5.6
M 13.5 / H 15	41	5.2
MS 13.5 / HS 15	2	.3
M 18 / H 20	45	5.7
MS 18 / HS 20	306	39.0
MS 18+Mod / HS 20+Mod	20	2.6
MS 22.5 / HS 25	67	8.5
Total	777	99.1
Missing	7	.9
Total Bridges	784	100.0

Table 5 – U.S. New Timber Bridge Design Load, 2001-2011

	Number	Percent
Slab	311	39.7
Stringer/Multi-beam or girder	434	55.4
Truss - Thru	18	2.3
Other	21	2.7
Total bridges	784	100.0

Table 6 – U.S. New Timber Bridge Type of Design/Construction, 2001-2011

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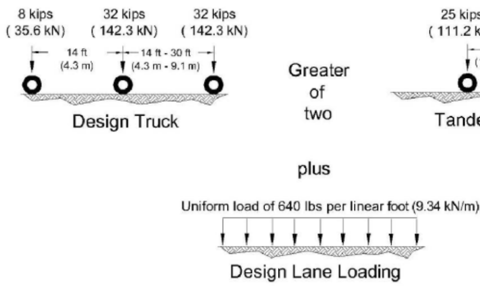
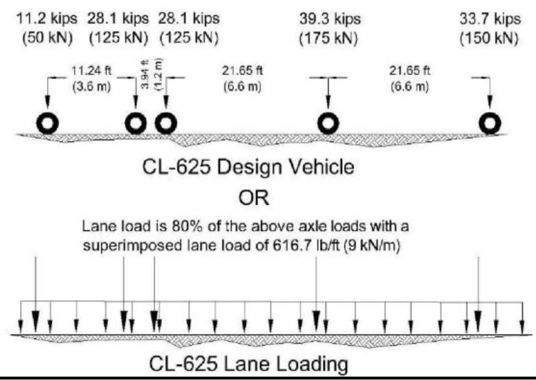


Truck/lane loading configuration in USA

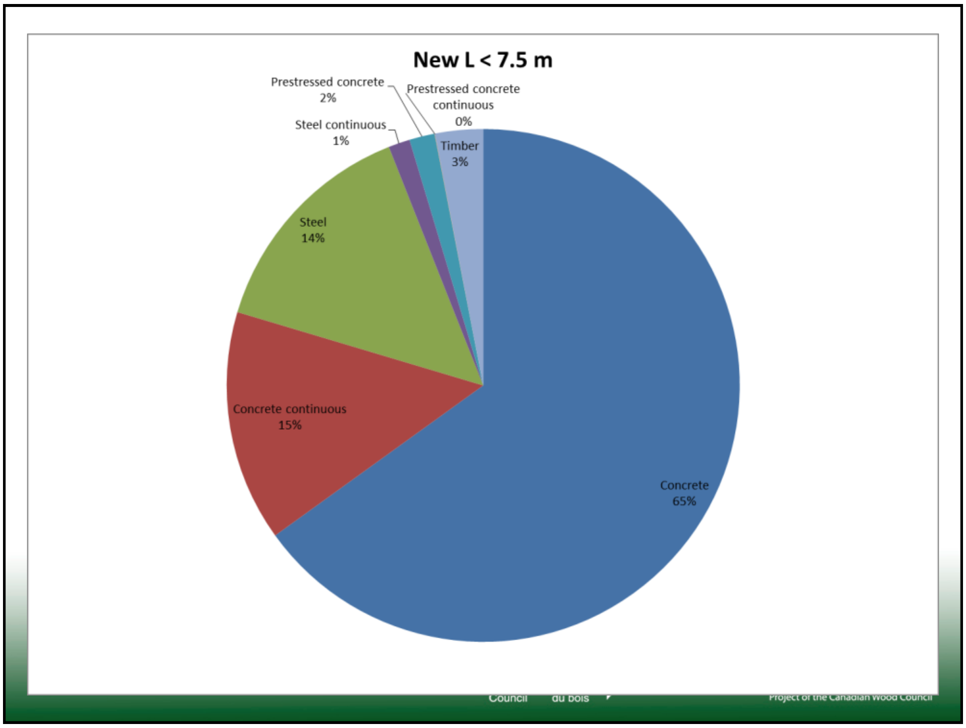
Truck/lane loading configuration in Canada

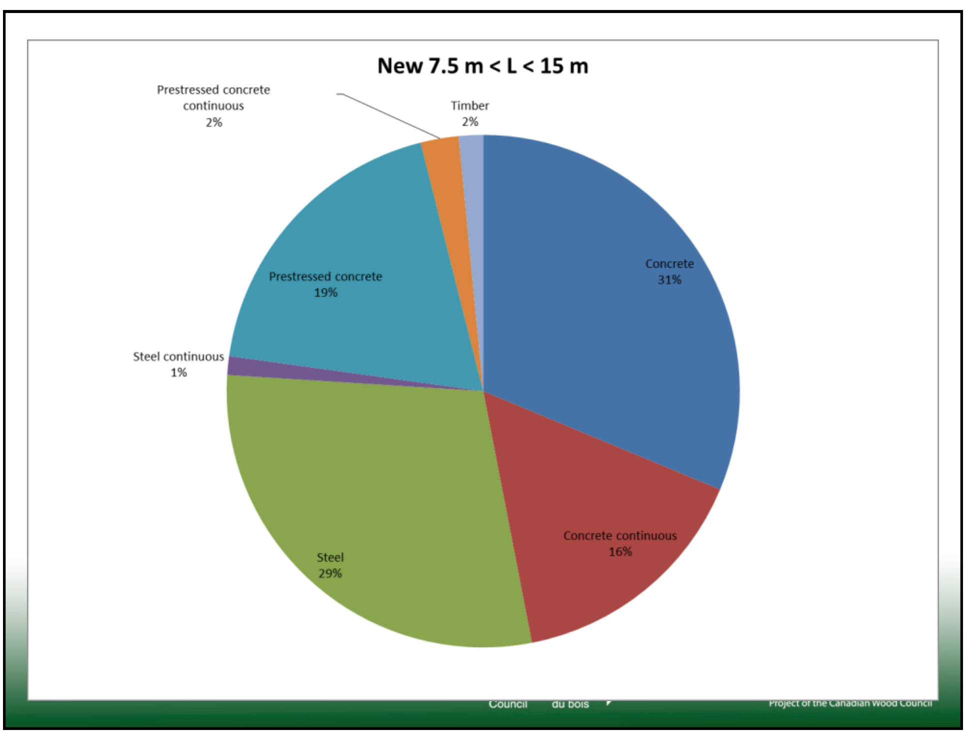


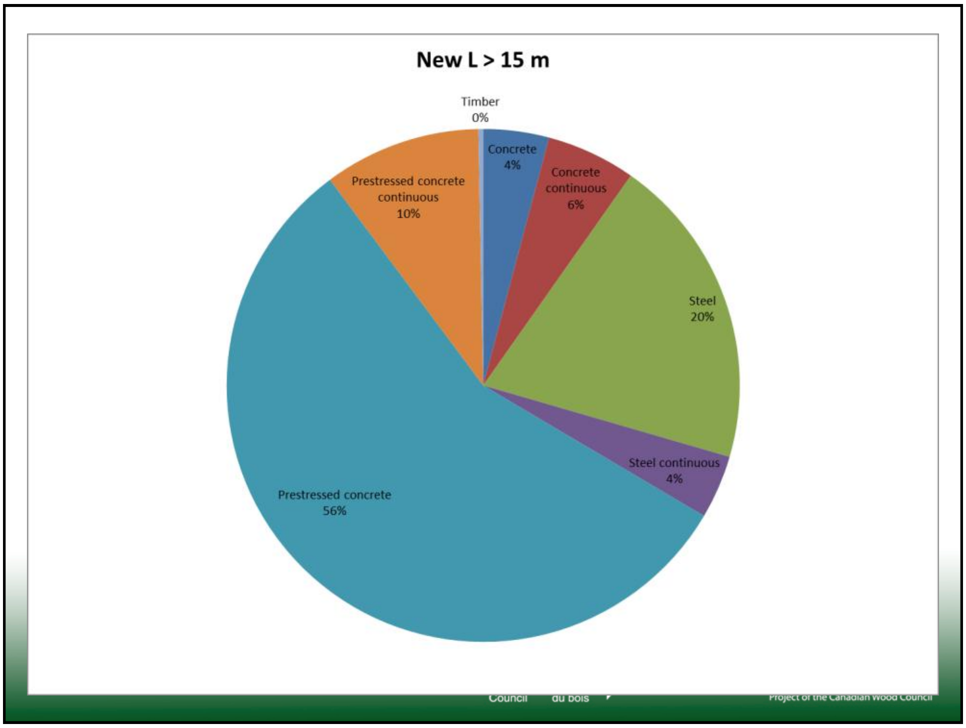
Source: Groenier & Wacker, 2008

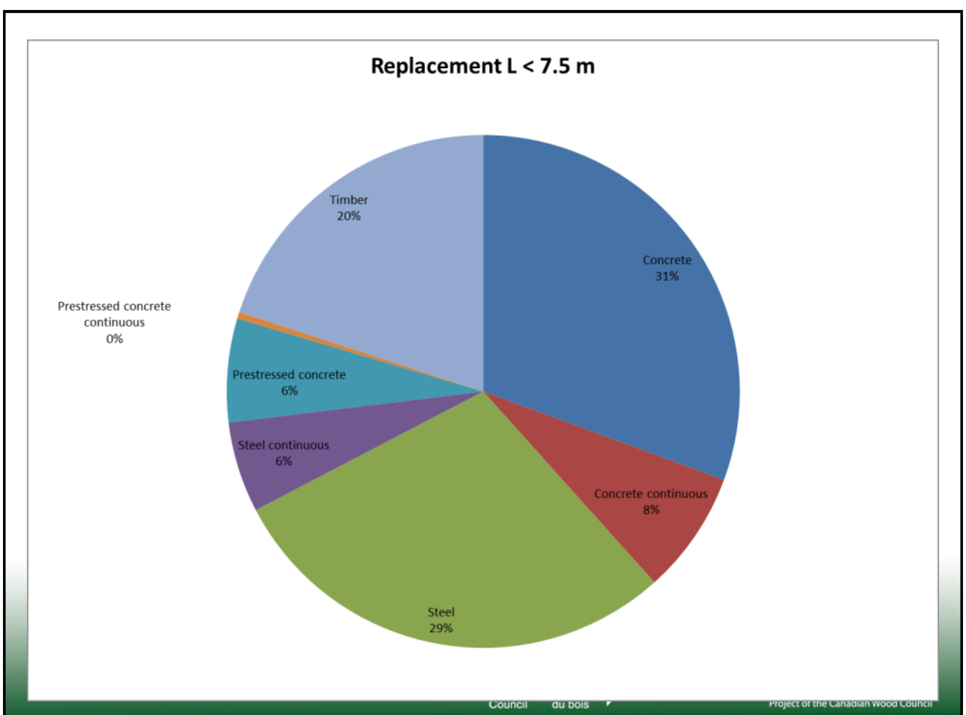
Table 7 – New U.S. County Bridges, Design Load MS18/HS20, Maximum Span Length & Material, 2001-2011

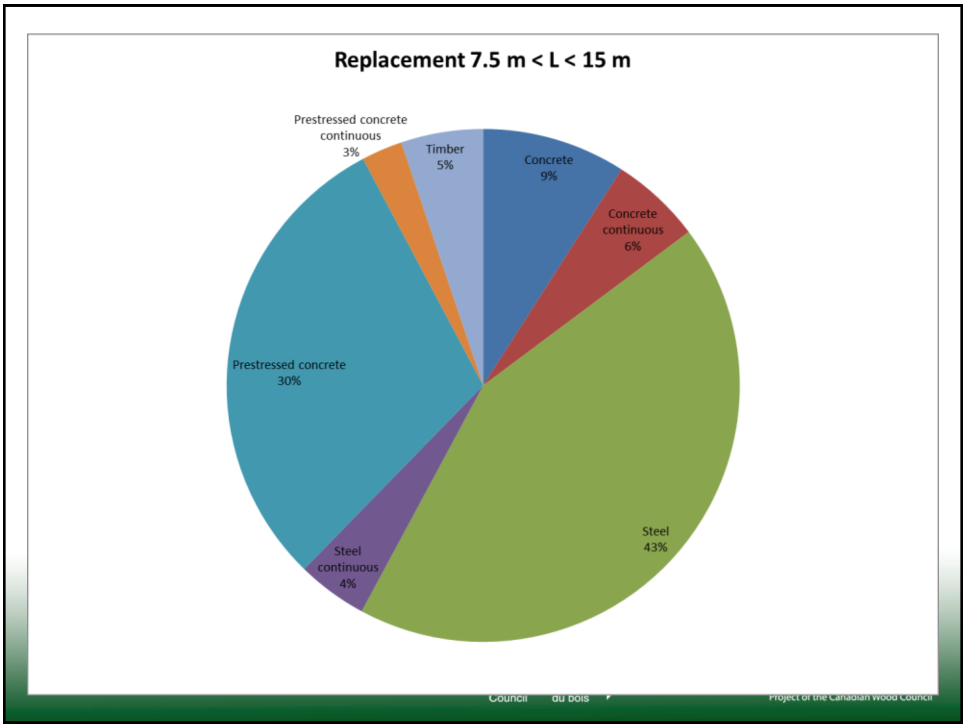
		Type of Material						
		Concrete	Concrete continuous	Steel	Steel continuous	Prestress-ed concrete	Prestressed concrete continuous	Timber
Length of maxim-um span	Less than 7.5	3211	719	710	67	79	1	149
	7.5 to less than 15	1825	915	1695	69	1102	140	89
	15 and greater	191	260	912	185	2602	457	14
Total bridges		5227	1894	3317	321	3783	598	252


New L < 7.5 m
Prestressed concrete 2%
Prestressed concrete continuous 0%
Steel continuous 1%
Timber 3%
Steel 14%
Concrete continuous 15%
Concrete 65%


New 7.5 m < L < 15 m
Prestressed concrete continuous 2%
Timber 2%
Concrete 31%
Prestressed concrete 19%
Steel continuous 1%
Concrete continuous 16%
Steel 29%


New L > 15 m
Timber
0%
Concrete
4%
Concrete
continuous
6%
Steel
20%
Steel continuous
4%
Prestressed concrete
56%
Prestressed concrete
continuous
10%


Replacement L < 7.5 m
Timber
20%
Concrete
31%
Concrete continuous
8%
Steel
29%
Steel continuous
6%
Prestressed concrete
6%
Prestressed concrete
continuous
0%


Replacement 7.5 m < L < 15 m
Prestressed concrete continuous 3%
Timber 5%
Concrete 9%
Concrete continuous 6%
Prestressed concrete 30%
Steel continuous 4%
Steel 43%

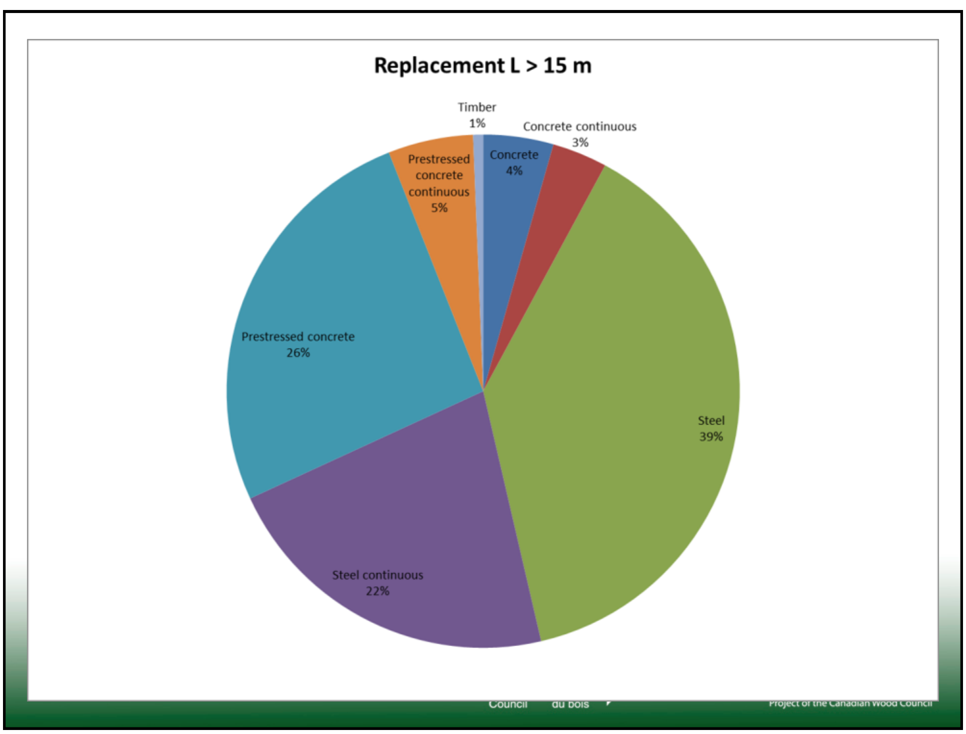

Replacement L > 15 m
Timber 1%
Concrete continuous 3%
Prestressed concrete continuous 5%
Concrete 4%
Prestressed concrete 26%
Steel 39%
Steel continuous 22%

Table 8 – U.S. Timber Deck Total, by Type of Bridge Material

	Number	Percent
Other	18	.0
Concrete	124	.3
Concrete continuous	33	.1
Steel	22,710	49.4
Steel continuous	1178	2.6
Prestressed concrete	120	.3
Prestressed concrete continuous	9	.0
Wood or timber	21,660	47.1
Masonry	1	.0
Aluminum, Wrought Iron or Cast Iron	132	.3
Total bridges	45,985	100.0

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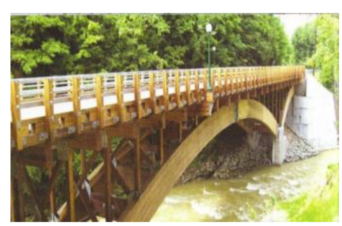
Opportunities for Timber Bridges

- A few facts
  - Maximum length of span
    - 60% of new timber bridges span < 7.5 m
    - 50% of replacement timber bridges span < 7.5 m
    - Bridges with longer spans are the target for engineered wood products
  - Roughly twice as many timber decks than bridges
    - Demand for timber deck materials
- Largest existing current market opportunity in the US
  - County bridges, HS20 design load, a maximum span over 7.5 m



Top: Alton Sylor Memorial Bridge, US, 52 m (170 ft)
Bottom: Hiroshima Airport Bridge, Japan, 145 m (476 ft)

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Timber Bridges in Canada

Kinsol Trestle

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Timber Bridges in Canada

- Past
  - Wood was a prominent structural material used in bridge construction up until the 1950s.
  - Due to abundance of forests

- Present
  - Fell out of use in favour of steel and concrete
    - In Ontario, 250 wood bridges out of Province's inventory of 3000 bridges
  - Why wood fell out of favour?
    - Spans associated with conventional wood bridges were relatively limited
    - Wood can decay; treatments can be both a bonus and a penalty.
    - Lack of wood design knowledge

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Timber Bridges in Canada

- Today and future
  - New technologies
    - High quality engineered wood products
    - Composite configuration: Carbon and glass fibre reinforced polymers (FRP), high performance concrete and epoxies
    - Major improvement in treatment methods
  - Resurgence of wood as a modern and yet sustainable bridge building material
  - Aesthetic and cultural considerations

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Engineered Wood Products

- Laminated veneer lumber (LVL) & Parallel strand lumber (PSL)
- Minimize the presence of inherent defects
- More effective preservative penetration
- Waterborne treatments are permitted for PSL by CSA S6

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PSL IN BRIDGES

Why PSL?

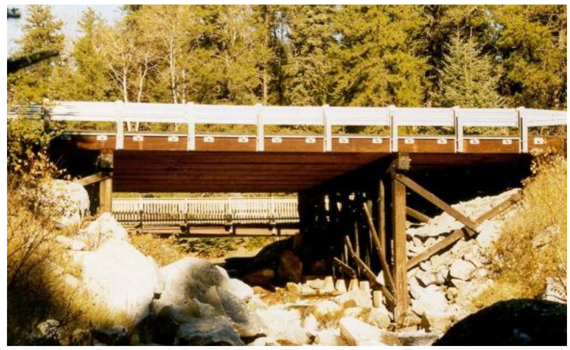
Domestic Product

Local Labour

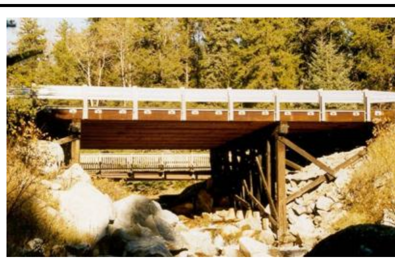
Durable/'Palatable'

Contemporary Material

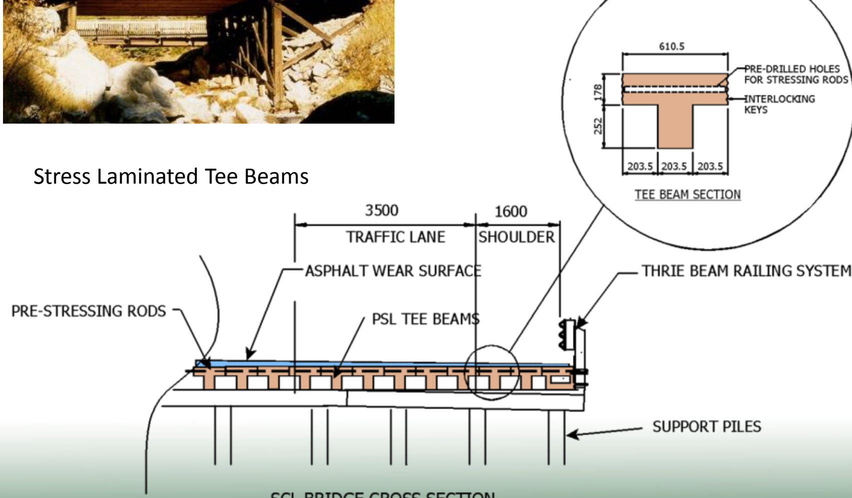
Sustainable Material



PSL IN BRIDGES



Stress Laminated Tee Beams



Source: Krisciunas, R., MTO

Rushing River Bridge 1996

Stress Laminated Tee Beams;
Penta Treated

Source: Krisciunas, R., MTO

Parallam in perfect condition >10 yrs later

Composite Concrete/Wood/Carbon Configuration

- Traditional composite wood/concrete bridge configuration
- Spans typically in the order of 6 m
- Many were built in 1950's and continue in operation today

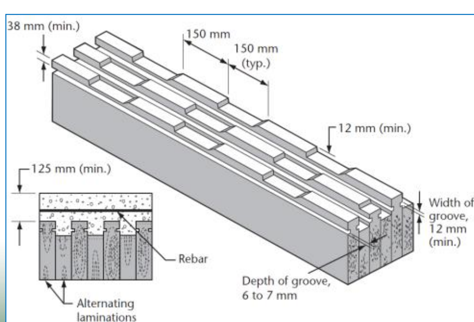


Figure 9.3
Details of wood-concrete interface

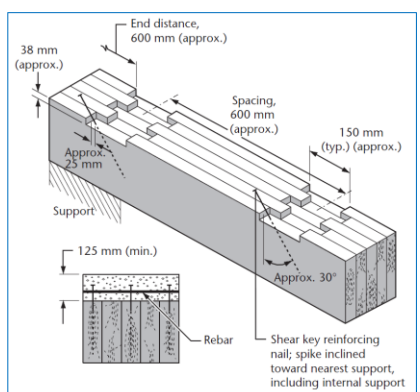


Figure 9.4
Alternative details of wood-concrete interface

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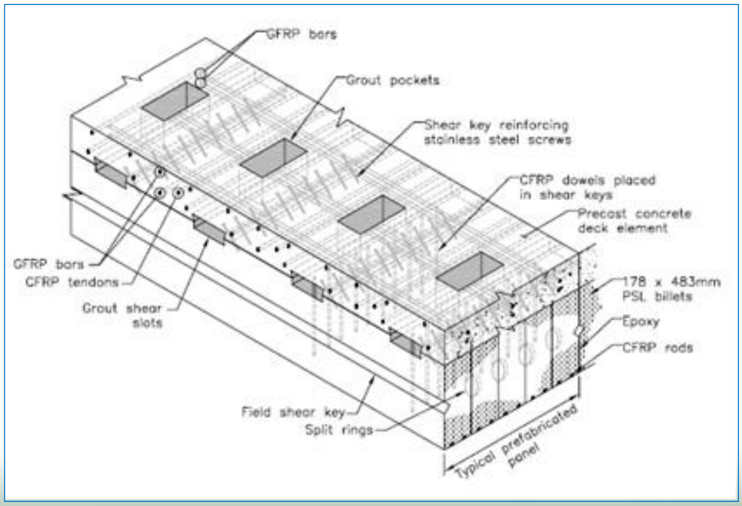
Composite Concrete/Wood/Carbon Configuration



CFRP reinforced PSL/precast concrete configuration

Source: Krisciunas et al, 2010

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Composite Concrete/Wood/Carbon Configuration

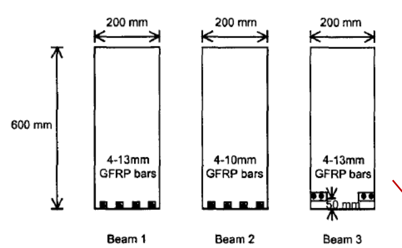


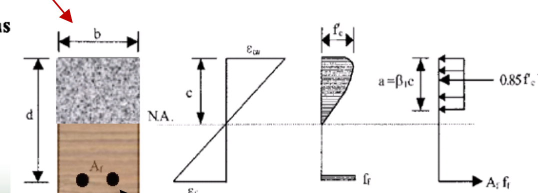
Figure 8 Full-scale specimen cross-sections

Combine High Performance Materials

Engineered Wood (PSL)

Precast Concrete

Carbon Fibre Reinforcing



Carbon Rods

MTO Concept

Wood Bridge Strengthening

Svekova et al, University of Manitoba

~2000

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Mather Cr Bridge

Source: Krisciunas et al, 2010

Eramosa-Garafraxa Townline Road Replacement Bridge
Location: near Fergus, Ontario

Span: 11.8m
Width: 10m; two lanes
Skew: 18 degrees

The provided bridge resulted in a structure 50mm thinner than the originally-proposed precast concrete structure and approximately 20% cheaper in price.

Source: Zurell, C., Blackwell

Minto Bridge West Deck Replacement
Location: Ottawa, Ontario

Total length: 52.2 m
Width: 5.8 m; one design lane

Source: Zurell, C., Blackwell

Codes and Standards

- Canada: Canadian Highway Bridge Design Code (CAN/CSA-S6)
  - One of the first to adopt limit states design
  - References CSA Standard O86 *Engineering Design in Wood*
  - References CSA Standard O80 Series for preservative treatment as well as AWPA Standards
  - Addresses sawn lumber, structural composite lumber (LVL & PSL) & Glulam
  - Section on Fibre-reinforced structures (Section 16)
- US: AASHTO-LRFD Design Specification
  - Recently adopted limit states design
  - References NDS & AITC 117
  - Follows AASHTO M133 for preservative treatment and references AWPA Standards
  - Only addresses sawn lumber & Glulam
- Comparison (Groenier, J. and Wacker, J. (2008) Designing Timber Bridge Superstructures: A Comparison of US and Canadian Bridges Codes. Structures Congress 2008.)

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Conclusions & Discussions

- A long history of wood bridges in North America
- Challenges and opportunities
- Resurgence of wood as a modern and yet sustainable bridge building material
- Suggested actions
  - Educating the design community
  - Development of design tools (publications & software)
  - Adoption of new products & technology
  - Development of market strategy
  - Awareness of sustainability of bridges

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Questions?

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