WSDOT’s Concrete Bridge Deck Preservation Program

DeWayne Wilson
WSDOT Bridge Asset Management Engineer
Washington State’s Bridge System

Ave Age - 47

3,120 bridges (53.5 M SF)

Repl value $51.2 Billion

Oldest - 1910

2.5B

80+ yrs old - 241 bridges (1.6 M SF)

100+ yrs old - 8 bridges (43,356 SF)
Nearly 90% of WSDOT bridges built in the past 10 years are precast prestressed/post-tensioned concrete.
3,038 WSDOT Bridges with Conc Deck

- **Good**: 2,124 brgs, 26.3M SF
- **Fair**: 807 brgs, 17.5M SF
- **Poor**: 107 brgs, 1.8M SF

*NBI Deck Code Summary*
WSDOT Concrete Bridge Decks

- Steel Girder
- Prestress Girder
- Precast Units
- Steel Truss
- Concrete Arch
- Precast Prestress Slab
- Steel Arch
- Segmental Post-Tension Box
- Post-Tension Box
Concrete Bridge Deck issues:

- Deterioration / Rebar Corrosion
- Rutting
- Rebar Cover
- Poor Quality Concrete
I-90 Franklin Falls Bridge

Weathering Steel Girder
Deck – 8”
Standard rebar in Deck
Year Built – 1980 (37yrs)
LMC Overlay – 1980 (37yrs)
Patching – 3,700SF (10%)
Typical Concrete Bridge Deck

Rutting

US2 Geiger Blvd OC
Spokane, Wa

Prestress Conc Girder
Deck – 5.75"
Year Built – 1964 (53yrs)
Conc Overlay – 1987 (30yrs)
Typical Concrete Bridge Deck

Rutting
Rutting

Oregon Trail
Guernsey State Park
Near Fort Laramie Wyoming
Typical Concrete Bridge Deck

Rebar Cover
SR10 Bristol Fill
Near Cle Elum
Built in 1937 – Deck Repl 2012

**Design Assumptions:**
Concrete in roadway slab:
Class "A" mix – Vibrated.
$f_c = 1200$ ksi per sq. inch
$f_y = 18,000$ ksi per "$t = 10$"

---

**Typical Concrete Bridge Deck**

**Poor Concrete**
WSDOT’s Deck Evaluation Process
Inspect / Rate Deck Condition
WSDOT Bridge Deck Inspection

**Condition State 1**

The deck surface has no spalls/delaminations or previous repairs. May have cracking or rutting.

**Condition State 2**

The deck surface has previous repairs.

**Condition State 3**

The deck surface has spalling.

**Condition State 4**

Delamination Test Results.

**Year Built – 1972 (45 yrs)**

**Deck Thickness – 7”**

<table>
<thead>
<tr>
<th>Elem</th>
<th>Description</th>
<th>Total</th>
<th>Unit</th>
<th>State 1</th>
<th>State 2</th>
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<tr>
<td>12</td>
<td>Conc. Deck</td>
<td>3,990</td>
<td>SF</td>
<td>2,774</td>
<td>1,053</td>
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<td>SF</td>
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<tr>
<td>376</td>
<td>Delam Testing</td>
<td>3,990</td>
<td>SF</td>
<td>3,827</td>
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<td>0</td>
<td>163</td>
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</table>

90/316N Paha Rd OC - milepost 215.24

Delam Test - October 2001

Year Built – 1972 (45 yrs)

Deck Thickness – 7”

Delamination Test Results.

<table>
<thead>
<tr>
<th>Elem</th>
<th>Description</th>
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<td>SF</td>
<td>3,827</td>
<td>0</td>
<td>0</td>
<td>163</td>
</tr>
</tbody>
</table>

Delam Test - October 2001
WSDOT Bridge Deck Inspection

Year Built – 1972 (45 yrs)
Deck Thickness – 7”

90/316N Paha Rd OC - milepost 215.24
Deck Rehab/Conc Overlay - 2013

Bridge Length – 105 FT
WSDOT Bridge Deck Inspection

90/316N Paha Rd OC - milepost 215.24
**WSDOT Bridge Deck Inspection**

**Condition State 1**
The deck surface has no spalls/delaminations or previous repairs. May have cracking or rutting.

**Condition State 2**
The deck surface has previous repairs.

**Condition State 3**
The deck surface has spalling.

**Condition State 4**
Delamination Test Results.

**Elem** | **Description** | **Total** | **Unit** | **State 1** | **State 2** | **State 3** | **State 4**
---|---|---|---|---|---|---|---
12 | Conc. Deck | 3,990 | SF | 3,990 | 0 | 0 | 0
35 | Soffit | 3,990 | SF | 3,990 | 0 | 0 | 0
803 | Conc Overlay | 3,990 | SF | 3,990 | 0 | 0 | 0

**90/316N Paha Rd OC - milepost 215.24**

**NBI Deck – 7**
“Good” Condition
### WSDOT Concrete Deck Evaluation/Rating

**BMS Condition (Top of Deck)**

<table>
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<tr>
<th>N/A</th>
<th>N/A</th>
<th>9</th>
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<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>8</td>
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<td>None</td>
<td>None</td>
<td>7</td>
</tr>
<tr>
<td>&lt; 1%</td>
<td>&lt; 1%</td>
<td>6</td>
</tr>
<tr>
<td>1% to 2%</td>
<td>1% to 2%</td>
<td>5</td>
</tr>
<tr>
<td>2% to 5%</td>
<td>2% to 5%</td>
<td>4</td>
</tr>
<tr>
<td>&gt; 5%</td>
<td>&gt; 5%</td>
<td>3</td>
</tr>
</tbody>
</table>

**BMS Condition (Bottom of Deck)**

**NBI Deck Code**

#### Table 4.1.6

**WSDOT Deck Condition to NBI Deck Overall**

- **Good**: 8
- **Fair**: 5
- **Poor**: 3
Thirty-eight bridge decks are past due for repair
As of June 2016; Dollars in millions

<table>
<thead>
<tr>
<th>Bridge deck needs</th>
<th>Number of bridges</th>
<th>Cost to repair</th>
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<tbody>
<tr>
<td>Past due for repair¹</td>
<td>38</td>
<td>$38.4</td>
</tr>
<tr>
<td>Due for repair²</td>
<td>47</td>
<td>$77.2</td>
</tr>
<tr>
<td>Due within the next 10 years</td>
<td>223</td>
<td>$726.5</td>
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<tr>
<td>Border bridge deck repairs</td>
<td>2</td>
<td>$22.3</td>
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<tr>
<td><strong>Total 10-year needs</strong></td>
<td><strong>310</strong></td>
<td><strong>$864.4</strong></td>
</tr>
</tbody>
</table>

Data source: WSDOT Bridge and Structures Office.
Notes: 1 Bridges with more than 5% of deck area patched or spalled are classified as “past due.” 2 Bridges with 2% to 5% of deck area patched or spalled are classified as “due.”

Should be funded for – $86M per year
2015-19 budget – $10M per year
With constrained Funding for Deck Rehab
This is the new “Normal”
Washington State’s Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks
45.8 million SF deck area

(2nd and 3rd Gen)

<table>
<thead>
<tr>
<th>Type</th>
<th>Count</th>
<th>SF</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare Conc</td>
<td>589</td>
<td>8.8M SF</td>
</tr>
<tr>
<td>Bare Conc-ECR</td>
<td>792</td>
<td>13.2M SF</td>
</tr>
<tr>
<td>Conc Overlays</td>
<td>564</td>
<td>14M SF</td>
</tr>
<tr>
<td>Asphalt</td>
<td>1030</td>
<td>8.5M SF</td>
</tr>
<tr>
<td>Polyester</td>
<td>23</td>
<td>21</td>
</tr>
<tr>
<td>Polymer</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(19.3%) (28.9%) (30.8%) (18.6%) (1.6%) (0.8%)
WSDOT Bare Concrete Decks

- 286 Bridges, 5.3 M SF (59.8%)
  - Ave Age – 52yrs
  - Oldest – 94yrs
  - 25 bridges > 75 yrs

- 259 Bridges, 2.5 M SF (28.3%)
- 43 Bridges, 1.0 M SF (11.9%)
- 589 Bridges, 8.8 M SF

- Total bridges: 589
- Total SF: 8.8 M
WSDOT Bare Concrete Decks

Year Built – 1923 (94 yrs)
Deck Thickness – 10”
Width 20 feet

SR155 – Okanogan River
Located in Omak

ADT – 6,884 / day

84th Omak Stampede
August 10-13 2017

NBI Deck – 6
“Fair” Condition
WSDOT Bare Concrete Decks

Year Built – 1952 (65 yrs)

SR99 – Alaskan Way Viaduct
Located in Seattle

ADT – 41,000 / day
WSDOT Bare Concrete Decks

Year Built – 1952 (65 yrs)

SR99 – Alaskan Way Viaduct
Located in Seattle

Damaged in 2001 Nisqually Earthquake
Demolition planned for 2019
WSDOT Bare Concrete Decks

Year Built – 1952 (65 yrs)

SR99 – Alaskan Way Viaduct
Located in Seattle

NBI Deck – 4
“Poor” Condition

Deck Patching / Spalls
5,419 SF (1.9%)

<table>
<thead>
<tr>
<th>Element</th>
<th>Element Description</th>
<th>Total</th>
<th>Units</th>
<th>CS 1</th>
<th>CS 2</th>
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<tbody>
<tr>
<td>12</td>
<td>Concrete Deck</td>
<td>288,446</td>
<td>SF</td>
<td>281,841</td>
<td>5,058</td>
<td>361</td>
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<td>35</td>
<td>Concrete Deck Soffit</td>
<td>288,446</td>
<td>SF</td>
<td>288,370</td>
<td>70</td>
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Washington State’s Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks
45.8 million SF deck area

(2nd and 3rd Gen)

Bare Conc (19.3%)
Bare Conc-ECR (28.9%)
Conc Overlays (30.8%)
Asphalt (18.6%)
Polyester (1.6%)
Polymer (0.8%)
Concrete Decks with Epoxy Coated Rebar

792 Bridges
13.2 M SF

1910 - 78
Uncoated Rebar

1979 - 2007
Top Mat Coated

2007 - present
Both Mats Coated
Concrete Decks with Epoxy Coated Rebar

- 792 Bridges
  - 13.2 M SF
  - Ave Age – 20yrs
  - Oldest – 38yrs

- 84 Bridges
  - 2.2 M SF
  - (16.6%)

- 709 Bridges
  - 11.0 M SF
  - (83.3%)
Concrete Decks with Epoxy Coated Rebar

**Prestress Girder Bridge**
- Year Built – 1979 (38 yrs)
- Deck Thickness – 7”
- 2” Cover – Top Mat

**SR22 – Yakima River Overflow**
- Located near Toppenish, Wa

**NBI Deck – 6**
- “Fair” Condition

**271 SF Patching and spalls**
- (0.9%)
Concrete Decks with Epoxy Coated Rebar

- Worlds Longest Floating Bridge
- Floating section - 7,710 Feet
- SR520 Albert D Rosellini Br
- Yr Open - 2016
WSDOT Concrete Deck Evaluation Study

Mitigation Strategies for Early-Age Shrinkage Cracking in Bridge Decks

WA-RD 747.1
Przhong Qiao
David McLean
Jianmin Zhuang

April 2010

Evaluation of Performance Based Concrete for Bridge Decks

WA-RD 845.1
Eric Fertuga
Patrick Glassford

June 2015

Brgs w/Performance Deck Conc
Built since 2013
69brgs – 2.2M SF

WSDOT Research Report

WA-RD 747.1

WSDOT Research Report

WA-RD 845.1
Washington State’s Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks
45.8 million SF deck area

- Bare Conc: 589 (8.8M SF) (19.3%)
- Bare Conc-ECR: 792 (13.2M SF) (28.9%)
- Conc Overlays: 564 (14M SF) (30.8%)
- Asphalt: 1030 (8.5M SF) (18.6%)
- Polyester: 23 (1.6%)
- Polymer: 21 (0.8%)
Bridges with a Modified Concrete Overlay

Total # Brgs = 584
Deck area = 14.1 mil SF

Deck Area

1979
1980
1981
1982
1983
1984
1985
1986
1987
1988
1989
1990
1991
1992
1993
1994
1995
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010

Latex
Microsilica
Fly-Ash

Low Slump

Rapid Set
LMC

1st Mod Conc Overlay
Low Slump Discontinued
1st Microsilica Conc Overlay
1st Fly-Ash Conc Overlay
Rapid Set Discontinued
1st Perf Mix Design Conc Overlay
2002-10
2016
6-09 Modified Concrete Overlays

6-09.1 Description

This Work consists of scarifying concrete bridge decks, preparing and repairing bridge deck surfaces designated and marked for further deck preparation, and placing, finishing, and curing modified concrete overlays.
Modified Concrete Overlays

- 44 Bridges 0.6M SF (4.4%)
- 183 Bridges 7.0M SF (49.6%)
- 357 Bridges 6.5M SF (46%)
- 584 Bridges 14.1M SF
- 187 Bridges 4.9M SF > 30 yrs
- Ave Age – 26 yrs
  Oldest – 38 yrs

09/20/11
SR# 090-DEC
SRMP 86.26
DIR ≡ NW
Modified Concrete Overlays

I-90 Denny Creek Bridge

Segmental Post-Tension Box
Standard rebar in Deck
Year Built – 1980 (37yrs)
LMC Overlay – 1980 (37yrs)
Deck – 10”

Length – 3,620 feet
Width – 52 feet
Repl Value - $200M
Modified Concrete Overlays

I-90 Denny Creek Bridge

Transverse Post Tensioning
3.5” below top of deck
Modified Concrete Overlays

I-90 Denny Creek Bridge

NBI Deck – 6
“Fair” Condition

Deck Patching / Spalls
1,871 SF (1.0%)
WSDOT has 6 Segmental Box Girder bridges with a Modified Concrete Overlay
Plus the I-205 Col R bridge that is shared with Oregon
WSDOT Concrete Deck Overlays – 2017

2017 Planned Construction
8 bridges (366,924 SF)

- I-90 Denny Cr WB 90/97.2N
- I-90 S Fk Snoqualmie 90/91S
- I-90 Franklin Falls WB 90/97.8N
- I-82 Thrall Rd OC EB 82/10S
- I-82 Canal OC WB 82/135N
- US97 Satus Creek 3rd 97/103
- SR432 Cowlitz R EB 432/10S
- Ad Date – May 2017
Washington State’s Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks
45.8 million SF deck area

<table>
<thead>
<tr>
<th>Treatment Type</th>
<th>SF Area</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Bare Conc</td>
<td>8.8M</td>
<td>(19.3%)</td>
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<tr>
<td>Bare Conc- ECR</td>
<td>13.2M</td>
<td>(28.9%)</td>
</tr>
<tr>
<td>Conc Overlays</td>
<td>14M</td>
<td>(30.8%)</td>
</tr>
<tr>
<td>Asphalt</td>
<td>8.5M</td>
<td>(18.6%)</td>
</tr>
<tr>
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<td>23</td>
<td>(1.6%)</td>
</tr>
<tr>
<td>Polymer</td>
<td>21</td>
<td>(0.8%)</td>
</tr>
</tbody>
</table>
Asphalt with membrane Bridge Deck Overlay
Asphalt Removal
Rotary milling has the risk of damaging the concrete deck.
Asphalt Removal - Scraping

Scraping to remove ACP Required when:
- Bridges over 100 feet in length
- Bridges with integral bridge decks
Asphalt with Membrane Overlay

1st Cable Stayed Bridge in USA

Open – Sept 1978 (39 yrs)

Length – 2,503 feet
Max Span – 981 feet
Deck Width – 60 feet

SR397 – Columbia R
Ed Hendler Bridge
Located near Pasco/Kennewick

Original Cost - $30M
Replacement Cost - $120M+
Asphalt with Membrane Overlay

**Asphalt History**
1978 - 1st ACP Overlay
1986 – Mill Fill 0.15’
1998 – New ACP w/Memb
2017 – New ACP w/Memb

**SR397 – Columbia R Ed Hendler Bridge**

**ADT – 16,129**
Asphalt with Membrane Overlay

8” Top Deck
2” Conc Cover
Standard Rebar

SR397 – Columbia R
Ed Hendler Bridge

Each Segment is
27 x 80 feet
Weight - 300 tons
Asphalt with Membrane Overlay

SR397 – Columbia R
Ed Hendler Bridge
Asphalt with Membrane Overlay

SR397 – Columbia R
Ed Hendler Bridge
Asphalt with Membrane Overlay

SR397 – Columbia R
Ed Hendler Bridge

Applying Membrane
Washington State’s Concrete Bridge Deck Program

3,039 Bridges with Concrete Decks
45.8 million SF deck area

(2nd and 3rd Gen)

<table>
<thead>
<tr>
<th>Type</th>
<th>589</th>
<th>792</th>
<th>564</th>
<th>1030</th>
<th>23</th>
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<td>8.8M SF</td>
<td>13.2M SF</td>
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<td>8.5M SF</td>
<td>1.6%</td>
<td>0.8%</td>
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<td>(28.9%)</td>
<td>(30.8%)</td>
<td>(18.6%)</td>
<td>(1.6%)</td>
<td>(0.8%)</td>
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<tr>
<td>Conc Overlays</td>
<td>20</td>
<td>23</td>
<td>21</td>
<td>21</td>
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<td>Polymer</td>
<td>23</td>
<td>21</td>
<td>21</td>
<td>21</td>
<td>1030</td>
<td>21</td>
</tr>
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</table>

Washington State Department of Transportation
Polyester Concrete Overlays

- 3 Bridges 26.5K SF (3.2%)
- 16 Bridges 278K SF (33.1%)
- 4 Bridges 533.5K SF (63.7%)
- 23 Bridges 837.8K SF

- Ave Age – 20yrs
- Oldest – 28yrs
- Range 4 - 28yrs (1989 – 2013)
- 8 bridges > 25 yrs

- 8 bridges

Polyester Concrete Overlays

Bridge Built – 1966
Polyester applied - 2007
ADT – 90,000

I-5 NB Viaduct
Located in Seattle

<table>
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<tr>
<th>Element</th>
<th>Element Description</th>
<th>Total</th>
<th>Units</th>
<th>CS 1</th>
<th>CS 2</th>
<th>CS 3</th>
<th>CS 4</th>
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<tr>
<td>804</td>
<td>Polyester Concrete Overlay</td>
<td>383,043</td>
<td>SF</td>
<td>382,743</td>
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<td>300</td>
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</table>
2017 Planned Polyester Overlays
4 bridges (366,924 SF)

- I-90 West Side Canal WB 90/152N Deck Area -
- I-90 Taneum Cr WB 90/150N Deck Area -
- I-90 Big Creek WB 90/126N Deck Area -
- I-90 Renslow Br EB 90/174S Deck Area -
WSDOT’s Concrete Bridge Deck Preservation Program

How do we Measure Success?
WSDOT Bridge Deck Replacements

16 bridges (588,536 sq ft) [1.5% of total Statewide Deck Area]

82/280S Col R Umatilla Under Contract 2017
### WSDOT Bridge Deck Replacements

**Bridge Built – 1955**
**Approaches Rebuilt - 1990**

**Bridge Length – 3,403 feet**
**Truss spans – 1,920 feet**

**ADT – 8,947**

**I-82 Col R Umatilla**
**Located near Umatilla Or**

**Patches and Spalls**
**3,884 SF (7.4%)**

#### BMS Elements

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<th>State 3</th>
</tr>
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<tbody>
<tr>
<td>20</td>
<td>Concrete Deck - Lightweight Aggregate</td>
<td>52,800</td>
<td>SF</td>
<td>48,916</td>
<td>3,020</td>
<td>864</td>
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<tr>
<td>26</td>
<td>Concrete Deck w/Coated Bars</td>
<td>40,600</td>
<td>SF</td>
<td>40,600</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>35</td>
<td>Concrete Deck Soffit</td>
<td>93,400</td>
<td>SF</td>
<td>92,561</td>
<td>282</td>
<td>557</td>
</tr>
</tbody>
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WSDOT Bridge Deck Replacements

I-82 Col R Umatilla
Located near Umatilla Or

Deck Replacement Contract
Awarded to Max J Kuney
$9.5 M
WSDOT Br Deck Preservation Savings

ECR - $1/SF
ACP w/membr - $20/SF
Conc Overlay - $80/SF
Polyester Overlay - $120/SF
Replace Deck - $250/SF
Replace Bridge - $800/SF

14M SF / 2 x $170/SF = $1.2 Billion Savings
Questions ?