AASHTO T-9: Technical Committee on Bridge Preservation

Washington State DOT Preservation Program

Agenda

• Overview of WSDOT Bridge Network and Condition
• Bridge Preservation Challenges
  • Concrete Decks
  • Steel Bridges
  • Timber Bridges
• Floating Bridges
• Notable bridges

DeWayne Wilson: Bridge Asset Management Engineer
Bijan Khaleghi: State Bridge Design Engineer
Washington State’s Bridge System

- **Ave Age - 48**
- **3,120 bridges (53.5 M SF)**
- **Oldest - 1910**

Replacement value $58 Billion

- **80+ yrs old** – 251 bridges ($2.5B)
- **100+ yrs old** – 12 bridges ($55M)

% based on bridge deck area

Nearly 90% of WSDOT bridges built in the past 10 years are precast prestressed/post-tensioned concrete
State-owned bridges: 3,294
- 91.2% deck area in fair or better condition
- 223 bridges 80 years or older
- 6 are 100 years or older
- 126 bridges load restricted or posted
- **Replacement value: estimated $58.2 billion**
  - If all were new, based on 80-year replacement cycle: $727 million needed annually.
  - The 223 bridges over 80 years old have a replacement value of $2.5 billion
  - Asset management analysis shows an estimated need of $270 million per year over the next 10 years to preserve these assets
  - Current funding averages $118 million per year for stand-alone projects
WSDOT Concrete Decks

1910 - 78
Uncoated Rebar

1979 - 2007
Top Mat Coated

2007 - present
Both Mats Coated

792 Bridges
13.2 M SF
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%)
SR303 Manette Bridge
Bridge Deck Concrete Performance Mix Design

Mitigation Strategies for Early-Age Shrinkage Cracking in Bridge Decks

WA-RD 747.1
Pizhong Qiao
David McLean
Jianmin Zhuang

April 2010

WA-RD 747.1 WSDOT Research Report

Full-Depth Shrinkage Cracking on Prestressed Girder Bridge

Restrained Shrinkage Cracking Test

Brgs w/Performance Deck Conc
Built since 2013
88brgs – 2.5M SF

Evaluation of Performance Based Concrete for Bridge Decks

WA-RD 845.1
Eric Ferluga
Patrick Glassford

June 2015

WA-RD 845.1 WSDOT Research Report

- Research Report
- TRB Paper
- Webinar
# Performance Concrete - Mix Design Requirements

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<th>Traditional</th>
<th>Performance Based</th>
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<tbody>
<tr>
<td>Minimum 28-day Compressive</td>
<td>4,000 psi</td>
<td>4,000 psi</td>
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<tr>
<td>Strength</td>
<td></td>
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</tr>
<tr>
<td>Cement</td>
<td>Type I or II Portland</td>
<td>Type I or II Portland</td>
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<tr>
<td>Cementitious Content</td>
<td>735lbs minimum (660lbs cement &amp; 75lbs fly ash)</td>
<td>No set limits (565lbs – 610lbs)</td>
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<tr>
<td>Fly Ash</td>
<td>Required</td>
<td>Optional</td>
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<tr>
<td>Nominal Max. Size Aggregate</td>
<td>1-inch</td>
<td>1½-inch</td>
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<tr>
<td>Water Reducing Admixture</td>
<td>Required</td>
<td>Optional</td>
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<tr>
<td>Air Content</td>
<td>4.5% to 7.5%</td>
<td>4.5% to 7.5%</td>
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<td>Freeze-Thaw Durability</td>
<td>Not an option</td>
<td>3.0% min. air content 90% minimum durability factor after 300 cycles (AASHTO T 161)</td>
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<tr>
<td>(instead of above air content requirement)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Permeability</td>
<td>No requirement</td>
<td>Less than 2000 coulombs at 56 days (AASHTO T 277)</td>
</tr>
<tr>
<td>Length Change (shrinkage)</td>
<td>No requirement</td>
<td>Less than 0.032% at 28 days (AASHTO T 160)</td>
</tr>
<tr>
<td>Scaling</td>
<td>No requirement</td>
<td>Visual rating ≤ 2 after 50 cycles (ASTM C 672)</td>
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<tr>
<td>Shrink Reducing Admixture</td>
<td>Not Used</td>
<td>Optional (Typically used)</td>
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Concrete Bridge Deck issues:

- Deterioration / Rebar Corrosion
- Rutting

Typical Concrete Bridge Deck

3,038 WSDOT Bridges with Conc Deck

- Good: 2,124 brgs, 26.3M SF (57.7%)
- Fair: 807 brgs, 17.5M SF (38.4%)
- Poor: 107 brgs, 1.8M SF (3.9%)

NBI Deck Code Summary
WSDOT Concrete Bridge Decks (non-Integral)

Steel Girder

Prestress Girder

Steel Truss

Steel Arch

Steel Arch

Concrete Arch
Modified Concrete Overlays

- 44 Bridges, 0.6M SF (4.4%)
- 183 Bridges, 7.0M SF (49.6%)
- 357 Bridges, 6.5M SF (46%)
- 187 Bridges, 4.9M SF > 30 yrs
- 584 Bridges, 14.1M SF
- Ave Age – 26 yrs
- Oldest – 39 yrs
- I-5 Ship Canal, 0.7M SF (14%)

09/20/11
SR# 090-DEC
SRMP 86.26
DIR = NW
WSDOT Concrete Deck Rehab – 10 year Needs

2017 Planned Construction
12 bridges (366,924 SF)

2018 Planned Construction
14 bridges (143,234 SF)

2019 Planned Construction
5 bridges (55,665 SF)

Br Deck Rehab – 10 year Needs
13.6 million SF ($985M)
Need to do 1.36M SF per Year ($98.5M)
WSDOT Concrete Deck Deterioration Curve

- Good Deck @ 0% Deterioration
- Monitor FAIR Deck @ 1%
- Overlay @ 0%
- Good Deck @ 0% Overlay @ 0%
- Overlay between 2% and 5%
- Prioritize Overlay @ 2%
- Deck Deterioration Curve
- Deck Condition:
  - 0%
  - 2%
  - 4%
  - 6%
  - 8%
  - 10%
- Time - Years:
  - 10
  - 20
  - 30
  - 40
  - 50
Deadline to remove studded tires in Wash. March 31

WSDOT officials said they would like to see the use of tire studs phased out to improve safety and reduce pavement maintenance and preservation costs.

Studded-tire season is over, but the controversy never seems to end in the Northwest.

The state’s transportation agencies have been lobbying against studded tires for nearly three decades without much success.

The only states that explicitly prohibit studded tires for residents year round are Hawaii, Minnesota, Mississippi and Wisconsin.

Typical Concrete Bridge Deck

Rutting

US2 Geiger Blvd OC
Spokane, Wa

Prestress Conc Girder
Deck – 5.75”
Year Built – 1964 (54yrs)
Conc Overlay – 1987 (31yrs)

With constrained Funding for Deck Rehab
This is the new “Normal”
Bridge Deck Maintenance

- High risk for full depth repairs
- High risk for extended traffic closures
- Full depth repairs required formwork
WSDOT has 6 Segmental Box Girder bridges with a Modified Concrete Overlay
Plus the I-205 Col R bridge that is shared with Oregon
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
NBI Deck – 6
“Fair” Condition

Deck Patching / Spalls
1,871 SF (1.0%)
I-90 Denny Creek Bridge

52 Feet curb - curb

15’ cantilever

16 Feet

Transverse Post Tensioning
3.5” below top of deck
SR397 – Columbia R
Ed Hendler Bridge
Located near Pasco/Kennewick

Open – Sept 1978 (40 yrs)

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

1st Cable Stayed Bridge in USA

Original Cost - $30M
Replacement Cost - $120M+
8” Top Deck
2” Conc Cover
Standard Rebar

Each Segment is 27x 80 feet Weight-300 tons
Asphalt Removal - Scraping

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

SR397 – Columbia R
Ed Hendler Bridge

SR397 – Columbia R
Ed Hendler Bridge

SR397 – Columbia R
Ed Hendler Bridge

SR397 – Columbia R
Ed Hendler Bridge

SR397 – Columbia R
Ed Hendler Bridge
2nd Generation Concrete Overlays

4000D (Performance Mix)
I-90 Yakima R Bridges – 90/140N & S

1,112SF / 11,700SF = 9.5%

08/13/13
SR# 090-DEC
SRMP 86.26

I-90 Yakima R Bridges – 90/140N & S

90/140N
1,112SF / 11,700SF = 9.5%

08/13/13
SR# 090-DEC
SRMP 86.26

I-90 Yakima R Bridges – 90/140N & S

90/140S
524SF / 11,700SF = 4.5%

08/13/13
SR# 090-DEC
SRMP 86.26
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<th>Category</th>
<th>Number</th>
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<td>Painted Steel Bridges</td>
<td>297</td>
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<tr>
<td>WSDOT Owned Border Bridges</td>
<td>7</td>
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<td>Oregon Owned Border Bridges</td>
<td>6</td>
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<tr>
<td><strong>Bridges requiring Painting</strong></td>
<td><strong>310</strong></td>
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Steel Truss Bridges on Interstate 5

- I-5 Nooksack R
- I-5 Skagit R
- I-5 Stillaguamish R
- I-5 Ship Canal
- I-5 Nisqually River
- I-5 Lewis River
- I-5 Columbia River
Steel Bridges on Interstate 5

I-5 Columbia River

1916 – 3,538ft – “FAIR”
1958 – 3,538ft – “FAIR”
Seismic Resiliency and Retrofit

1971 San Fernando Earthquake

Modern Seismic Design Codes
- 500 yrs STD-83
- 500 yrs LRFD-94
- 1000 yrs SGS-09

Seismic Recover: SEE & FEE

Structural Vulnerability - Substructure

Crossbeam Bolsters

Other Column Retrofit Techniques
- Steel Jacketing
- Fiber Wrap
- Wire Wrap

Bolster Reinforcing Steel
Capacity Protection Requirement

Bridge Superstructure

Fiberglass & Epoxy Composite Jacket
Fabric & Polyester Resin Jacket
Carbon Fiber Composite Jacket
Steel Bridges on Interstate 5

Bridge Built – 1962
(56 yrs)

Center Spans
Steel Deck Truss
6 spans
2,293 feet

I-5 Ship Canal
“FAIR” Condition

I-5 Ship Canal Bridge

<table>
<thead>
<tr>
<th>Year</th>
<th>Patching [SF]</th>
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<td>2017</td>
<td>2,625</td>
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Future Deck Rehab cost - $35M
LMC (upper deck)
Applied 1985 (33 yrs)

I-5 Ship Canal Bridge – Express Lanes

<table>
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<th>Year</th>
<th>Patching [SF]</th>
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<td>2017</td>
<td>.436</td>
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Deck Rehab cost
$12-14M

Upper Deck Area
697,258 SF

Exp Lanes
Deck Area
189,480 SF
Steel Bridges on Interstate 5

I-5 Skagit R
WSDOT Steel Bridge Painting - 2018

SR99 Aurora Ave 99/560
Oct 2017 Ad

SR410 White R 410/101
Nov 2017 Ad

US12 Naches R 12/328N & S
Jan 2018 Ad

SR409 Col R Puget Island 409/10
April 2017 Ad

SR432 Cowlitz R 432/10S
May 2018 Ad

6 Bridges
SR141 – White Salmon River

Year Built – 1940
Yr Last Painted – 1988

| Action                     | Year   | Cost  $
<table>
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<tr>
<td>Planned Paint Year –</td>
<td>2014</td>
<td>$0.9 M</td>
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<tr>
<td>Do Nothing “Poor” Year –</td>
<td>2018</td>
<td>$3.0 M</td>
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<tr>
<td>Do Nothing Rehab Year -</td>
<td>2025</td>
<td>$3.0 M</td>
</tr>
<tr>
<td>Do Nothing Replace Year –</td>
<td>2035</td>
<td>$7.7 M</td>
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Unpainted Weathering Steel Bridges

19 bridges (0.87M SF)
Repl value $700 Million
Unpainted Weathering Steel Bridges

19 Bridges
0.87M SF

Ave Age – 33yrs
Oldest – 48yrs
Newest – 7 years

1 Bridge
0.02M SF
(2%)

12 Bridges
0.3M SF
(36%)

6 Bridges
0.5M SF
(61%)
WSDOT Timber Bridges

112 WSDOT Timber Bridges
Oldest – 1930 (87 years)
Newest – 1970 (47 years)
Ave Age = 68 years
Repl$ - $460 million
SR520 Albert D Rosellini Floating Bridge

Worlds Longest Floating Bridge

Floating section - 7,710 Feet
SR 104 Hood Canal Bridge

West Half – built in 1982

East Half – built in 2009
Hood Canal Approach Bridge
Accelerated Bridge Construction
Rolling Assembly
BMS Element 238 – Floating Bridge Anchor Cable

Cond State 1:
Like New – No Defects

Cond State 2:
Surface Corrosion / Galvanizing starting to deteriorate.

Cond State 3:
Corrosion with section loss / Single wire breaks

Cond State 4:
Multiple wire breaks / affects capacity
I-90 Floating Bridges
I-90 Floating Bridges

Lacey V. Murrow Bridge

- 17069 mm (56.0’)
- 2286 mm (7.5’)
- 2972 mm (9.75’)
- 18288 mm (60.0’)

Pontoon Cross Section

Bridge 90/25N Homer Hadley Bridge

Anchor Cable Replacement Plan

<table>
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<tr>
<th>Year</th>
<th># of Cables</th>
<th>$</th>
<th>Cables</th>
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<tr>
<td>2014</td>
<td>11</td>
<td>$2,300,000</td>
<td>Fn, Jn, L1n, L2n, L3n, L4n, L5n, L6n, Ms, Ns, Os</td>
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<tr>
<td>2016</td>
<td>10</td>
<td>$2,300,000</td>
<td>Ane, As, Bs, Pn, Ps, Qs, Rne, Rnw, Rs, Rse, Rsw</td>
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<tr>
<td>2018</td>
<td>11</td>
<td>$2,500,000</td>
<td>Cs, Hs, Is, Js, Ks, L1s, L2s, L3s, L5s, L6s, Ls</td>
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Totals 32 $7,100,000
Bridge 90/25N  Homer Hadley Bridge
NW Region’s Bridge Network

Ave Age - 48

1,150 bridges (24.5M SF)
Replace value $28.5 Billion

Oldest - 1920

80+ yrs old – 52 bridges (833K SF / $1B)
NW Region’s Bridge Network

- Ave Age - 46
- Oldest - 1920
- 1,156 bridges (26.8M SF)
- Repl value $26 Billion
- 80+ yrs old – 52 bridges ($982M)
Olympic Region’s Bridge Network

Ave Age - 48
583 bridges (9M SF)
Replace value $9.5 Billion

Oldest - 1916
80+ yrs old – 62 bridges (336K SF)
100+ yrs old – 3 bridges (4,529 SF)
Southwest Region’s Bridge Network

- **Ave Age - 49**
- **404 bridges (9M SF)**
  - **Repl value $4.4 Billion**
- **Oldest - 1915**

- **80+ yrs old** – 58 bridges ($375.6M)
- **100+ yrs old** – 5 bridges ($9.7M)
NC Region’s Bridge Network

Ave Age - 55

170 bridges (1.6M SF)
Repl value $1.4 Billion

Oldest - 1923

80+ yrs old – 10 bridges ($116M Repl)
South Central Region’s Bridge Network

Ave Age - 47

488 bridges (9M SF)
Repl value $5.6 Billion

Oldest - 1916

80+ yrs old – 42 bridges ($230.1M)
100+ yrs old – 3 bridges ($15.9M)
Eastern Region’s Bridge Network

- Ave Age: 49
- Oldest: 1910
- 319 bridges (9M SF)
  - Repl value: $3.3 Billion
- 80+ yrs old: 34 bridges ($146M)
- 100+ yrs old: 1 bridge ($20M)
EXISTING

PLANNED

Courtesy of Waterfront Seattle
QUESTIONS?

Demolition:

- Removes the Alaskan Way Viaduct.
- Closes and fills the Battery Street Tunnel.

Existing Conditions – Historic Piers, East Side

Existing

Planned