


SHRP2 SOLUTIONS
STRATEGIC HIGHWAY RESEARCH PROGRAM

Overview of SHRP2 R19A and Activities Done by Other States

Oregon DOT Workshop – Portland, OR

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CH2M

January 17, 2018

U.S. Department of Transportation
Federal Highway Administration

American Association of State Highway and Transportation Officials
AASHTO

Presentation Overview

- Need for Service Life Design

- SHRP2 R19A Implementation Action Program
  - Program Goals
  - Work Focus Areas
  - Participating Agency (Lead Adopter) Projects
  - Lessons Learned

- Summary

Need for Service Life Design

- Growing interest by the industry to make bridges more durable with longer expected lives

- Influenced by political motivation – popular to state that a new bridge will last 100+ years…

- Evident by requirements in recent Owner's RFPs – particularly on Design Build projects

Service Life Designed Structures

- Ohio River Bridge, KY – 2016 (100 years)

Service Life Designed Structures

- Tappan Zee Bridge, NY – 2018 (100 years)

courtesy of New York State Thruway Authority

Need More Focus on These

- Representing the majority of the 600,000+ bridges in the US

Need for Service Life Design

- Expectations of SLD requirements often unclear
- A more robust definition was needed for SLD
- FHWA in conjunction with AASHTO and TRB through the 2nd Strategic Highway Research Program (SHRP2) initiated project R19A
  - Bridges for Service Life Beyond 100 Years: Innovative Systems, Subsystems and Components

SHRP2 Project R19A

SHRP2 R19A Team

RESEARCH – **TRB**

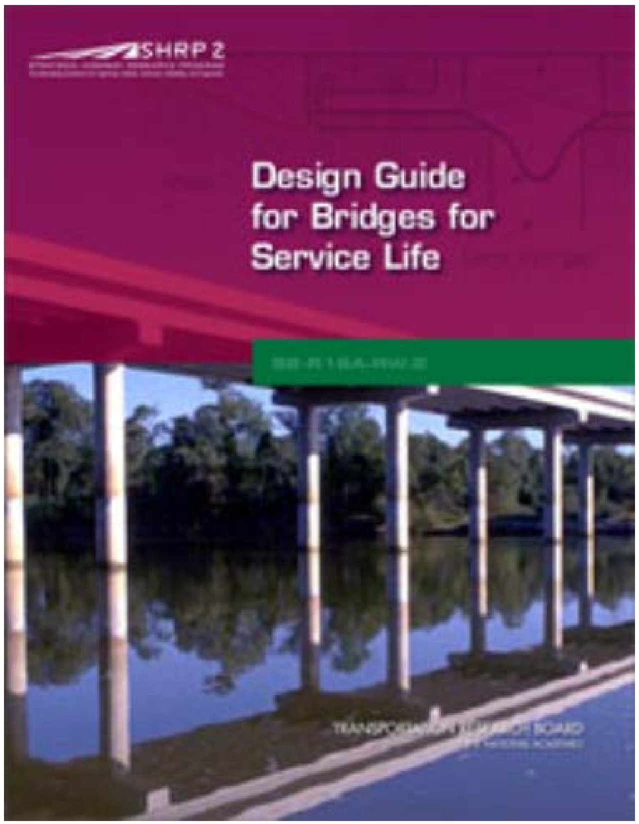
IMPLEMENTATION – **FHWA/AASHTO**

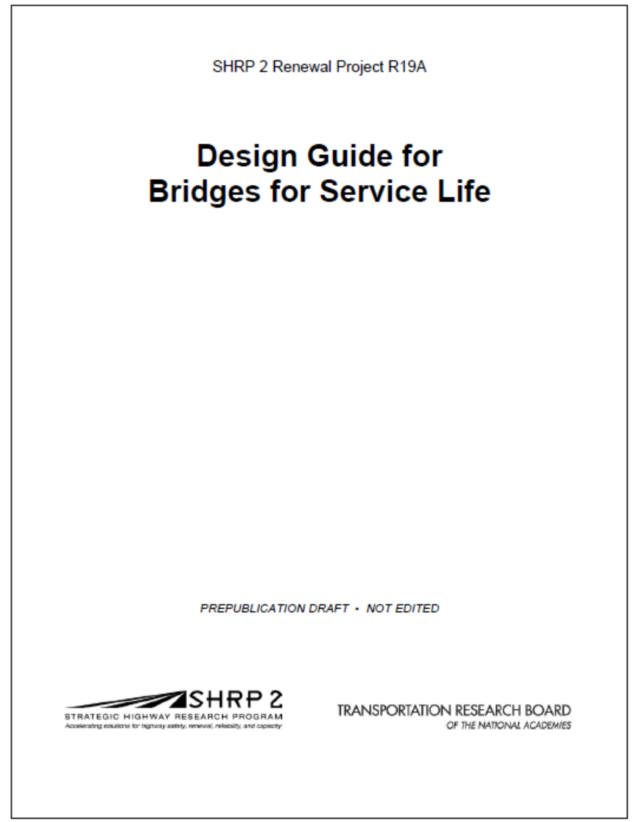
SUBJECT MATTER EXPERTS / LOGISTICS SME LEAD – **CH2M (Jacobs)**
TECHNICAL SMEs – **COWI**

LEAD ADOPTER AGENCIES

Research Work Completed

- Project R19A – Service Life Design Guide




SHRP 2 Renewal Project R19A

Design Guide for Bridges for Service Life

PREPUBLICATION DRAFT • NOT EDITED

SHRP 2 STRATEGIC HIGHWAY RESEARCH PROGRAM

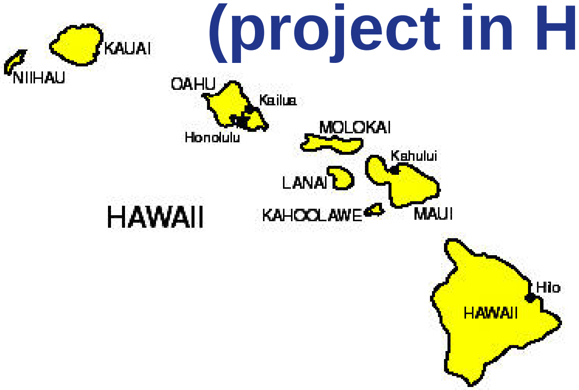
TRANSPORTATION RESEARCH BOARD OF THE NATIONAL ACADEMIES

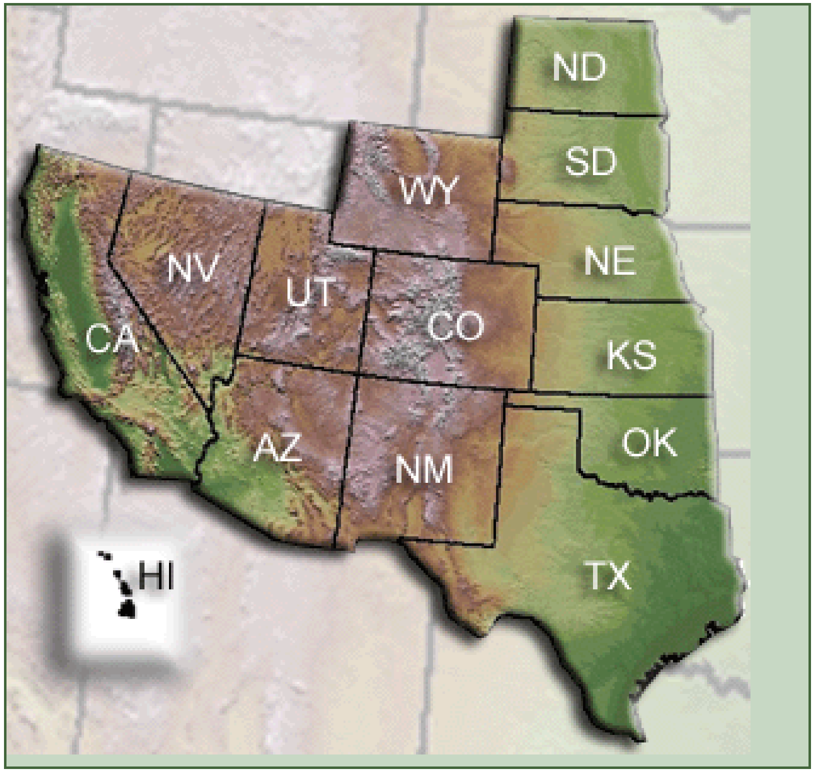
  - http://www.trb.org/Main/Blurbs/168760.aspx

IAP Lead Adopter Agencies

Oregon

Central Federal Lands (project in Hawaii)





IAP Lead Adopter Agencies

Iowa

Maine

Pennsylvania

Virginia

IAP Goals

- Promote SLD concepts through:
  - Marketing, outreach & training
  - Workshops & Peer Exchanges
- Assist Lead Adopter agencies in developing in-house SLD skills
- Build a strong technical foundation
  - Develop training & reference materials
  - Develop “Academic Toolbox”
  - Lessons learned summaries

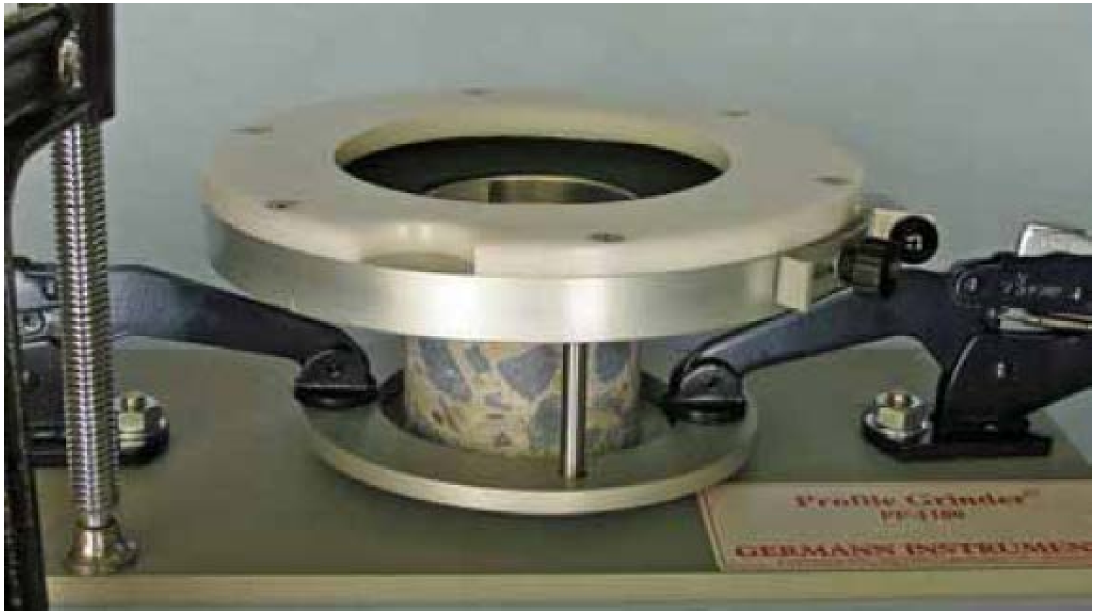
Current Work Focus Areas

- Performing tests on material durability properties of concrete mix designs
  - Concrete chloride diffusion coefficients (NT Build 492)
  - Measurement of as-constructed concrete cover

Elcometer

Current Work Focus Areas

- Tests on existing bridges to assess environmental loading and material behavior
  - Taking concrete cores to measure chloride loading from de-icing chemicals or sea water



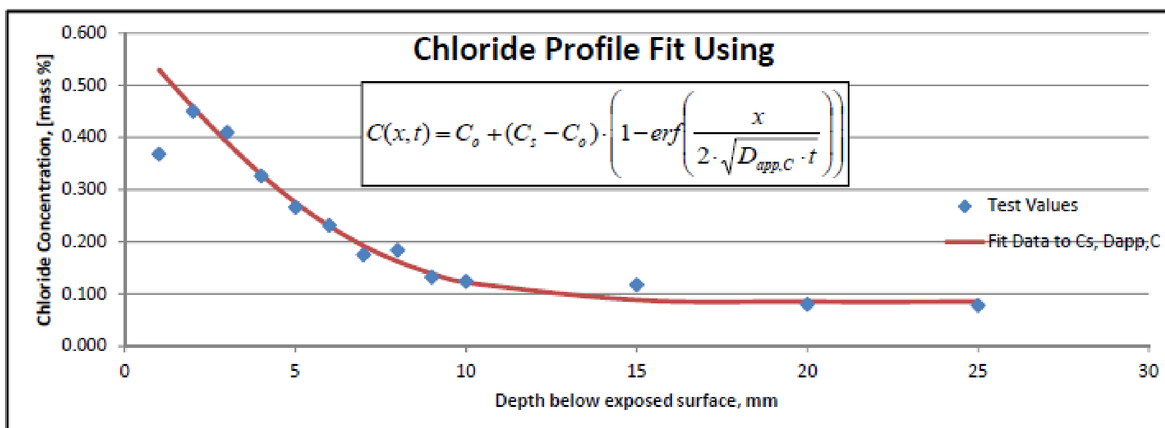
Source: Germann Instruments

Current Work Focus Areas

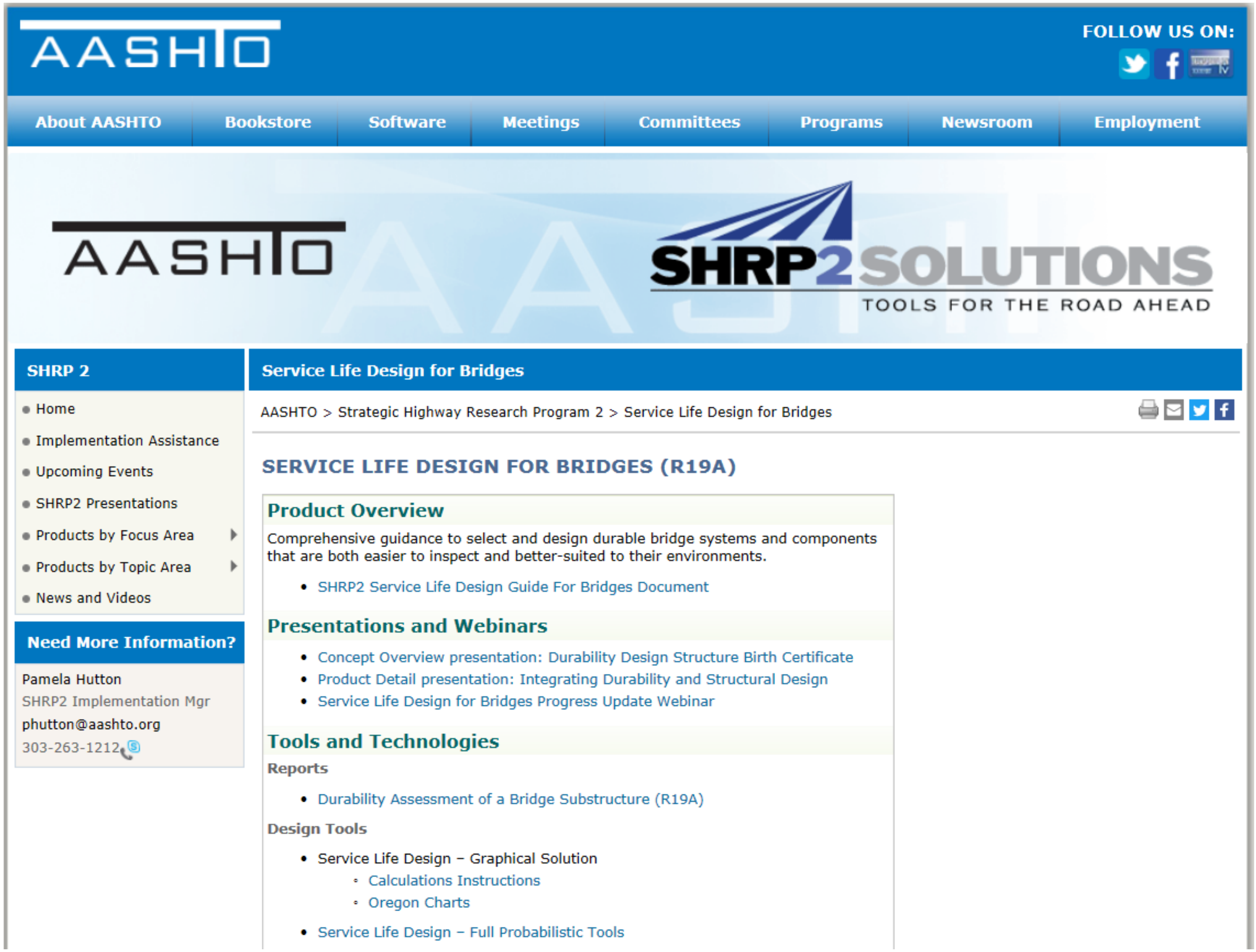
- Developing design tools and processes to aid in SLD
  - Excel spreadsheet for chloride profiling

d	depth from surface	[mm]	1	2	3	4	5	6	7	8	9	10	15	20	25	
C_m	Test Values	[mass %]	0.368	0.450	0.410	0.326	0.266	0.231	0.175	0.183	0.132	0.124	0.117	0.080	0.078	
C_c	Fit Data to C_s, $D_{app,C}$	[mass %]	0.530	0.458	0.391	0.329	0.275	0.230	0.192	0.162	0.139	0.122	0.089	0.085	0.085	$\sum (C_m - C_s)^2$
$(C_m - C_s)^2$	Sum of least squares			6.72E-05	3.76E-04	1.10E-05	9.01E-05	1.55E-06	2.93E-04	4.34E-04	5.00E-05	4.66E-06	8.12E-04	2.66E-05	4.90E-05	2.22E-03

C_o	Initial chloride content (measured)	[mass %]	0.085
t	Exposure time	[yr]	1
C_s	Chloride content at exposed face	[mass %]	0.605
$D_{app,C}$	Apparent coefficient of chloride diffusion	[mm²/yr]	15.324



Implementation Products – Dedicated Webpage



- http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx

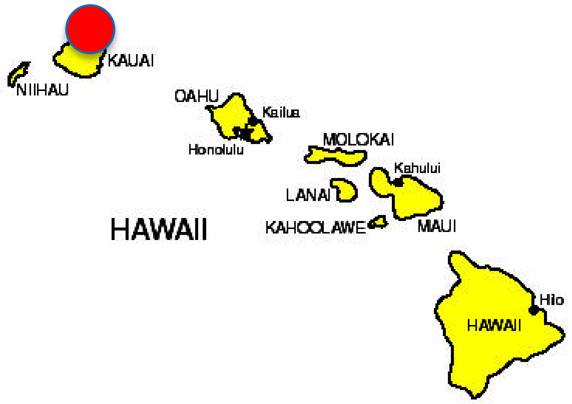
IAP Projects - Round 4
Initiated Fall 2014

IAP Team Leaders

- FHWA Central Federal Lands
  - Bonnie Klamerus, Mike Voth
- Iowa DOT
  - Ahmad Abu-Hawash, Norm McDonald
- Oregon DOT
  - Bruce Johnson, Paul Strauser, Zach Beget, Ray Bottenberg, Andrew Blower, Craig Shike
- Pennsylvania DOT
  - Tom Macioce
- Virginia DOT
  - Prasad Nallapaneni, Soundar Balakumaran

FHWA Central Federal Lands

- **Tropical Coastal Exposure on North Shore, Island of Kauai, HI**
  - 3 bridge replacements - 500’ to 1,000’ from the coastline



FHWA Central Federal Lands

- Testing brackish water salinity
- Coring of existing abutments at water line / splash zone for surface chloride concentration
- NT Build 492 tests performed on baseline concrete mix designs

Iowa DOT

- **New Bridge at Site with Extreme De-Icing Spray Exposure**

  - Using A1010 High Chromium Structural Steel
  - Lab and field testing A1010 for steel corrosion resistance performance
  - Recommendations from ODOT experience - Hormoz Seradj

Iowa DOT

- **Replacement of Twin Structures on I-35 over South Skunk River near Ames**

  - Chloride profile testing on existing structures
  - NT Build 492 tests on concrete mix designs
  - SB Bridge – Designed to current Iowa DOT policies
  - NB Bridge – Will be designed using SLD
  - Final Product – Side-by-side comparison report between the two structures

Pennsylvania DOT

- **Statewide Evaluation of Chloride Resistance of Concrete**
  - Performed NT Build 492 tests on 105 samples from 7 ready mix and 2 precast concrete suppliers

Figure 1: Company location map relative to PennDOT districts

Pennsylvania DOT

- **PennDOT Concrete Classifications tested**
  - Class A – Structures & Misc., 3000 psi (31 samples)
  - Class AA – Structures & Misc., 3500 psi (36 samples)
  - Class AAAP – Bridge Decks, 4000 psi (30 samples)
  - Class HES – High Early Strength, 3500 psi (3 samples)
  - SCC – Self-Consolidating, must meet requirements of above classifications (6 samples)

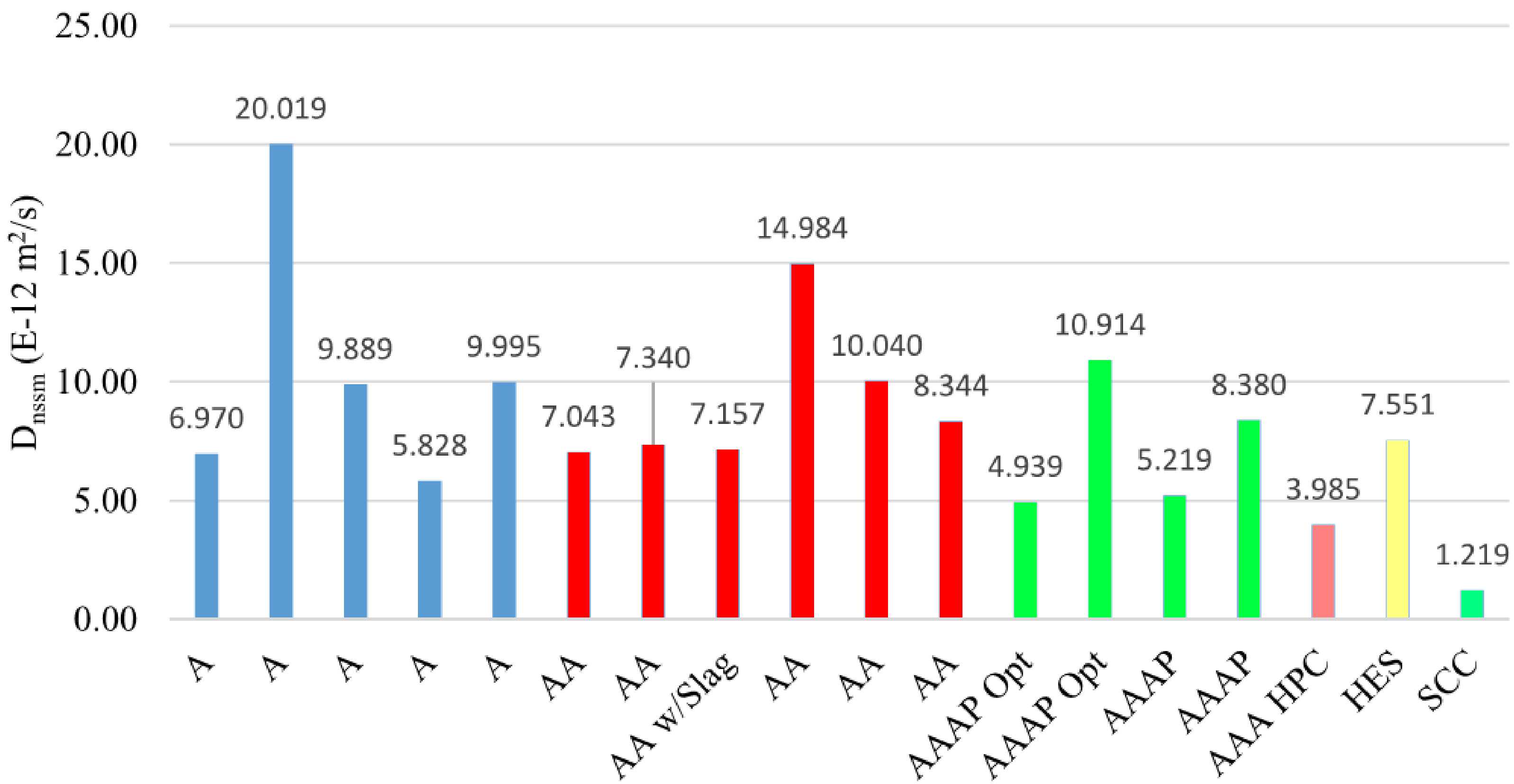
Pennsylvania DOT

TABLE A
Cement Concrete Criteria

Class of Concrete	Use	Cement Factor(3)(5) (lbs/cu. yd.)		Maximum Water Cement Ratio(6) (lbs/lbs)	Minimum Mix(2,9) Design Compressive Strength (psi) Days			Proportions Coarse(1) Aggregate Solid Volume (cu. ft./cu. yd.)	28-Day Structural Design Compressive Strength (psi)
		Min.	Max.		3	7	28		
AAAP	Bridge Deck	560	690	0.45	—	3,000	4,000	—	4,000
HPC	Bridge Deck	560	690	0.45	—	3,000	4,000	—	4,000
AAA(4)	Other	634.5	752	0.43	—	3,600	4,500	—	4,000
AA	Slip Form Paving(7)	587.5	752	0.47	—	3,000	3,750	11.00-13.10	3,500
AA	Paving	587.5	752	0.47	—	3,000	3,750	9.93-13.10	3,500
AA	Accelerated Patching(8)	587.5	800	0.47	—	—	3,750	9.93-13.10	3,500
AA	Structures and Misc.	587.5	752	0.47	—	3,000	3,750	9.93-13.10	3,500
A	Structures and Misc.	564	752	0.50	—	2,750	3,300	10.18-13.43	3,000
C	Structures and Misc.	394.8	658	0.66	—	1,500	2,000	11.45-15.10	2,000
HES	Structures and Misc.	752	846	0.40	3,000	—	3,750	9.10-12.00	3,500

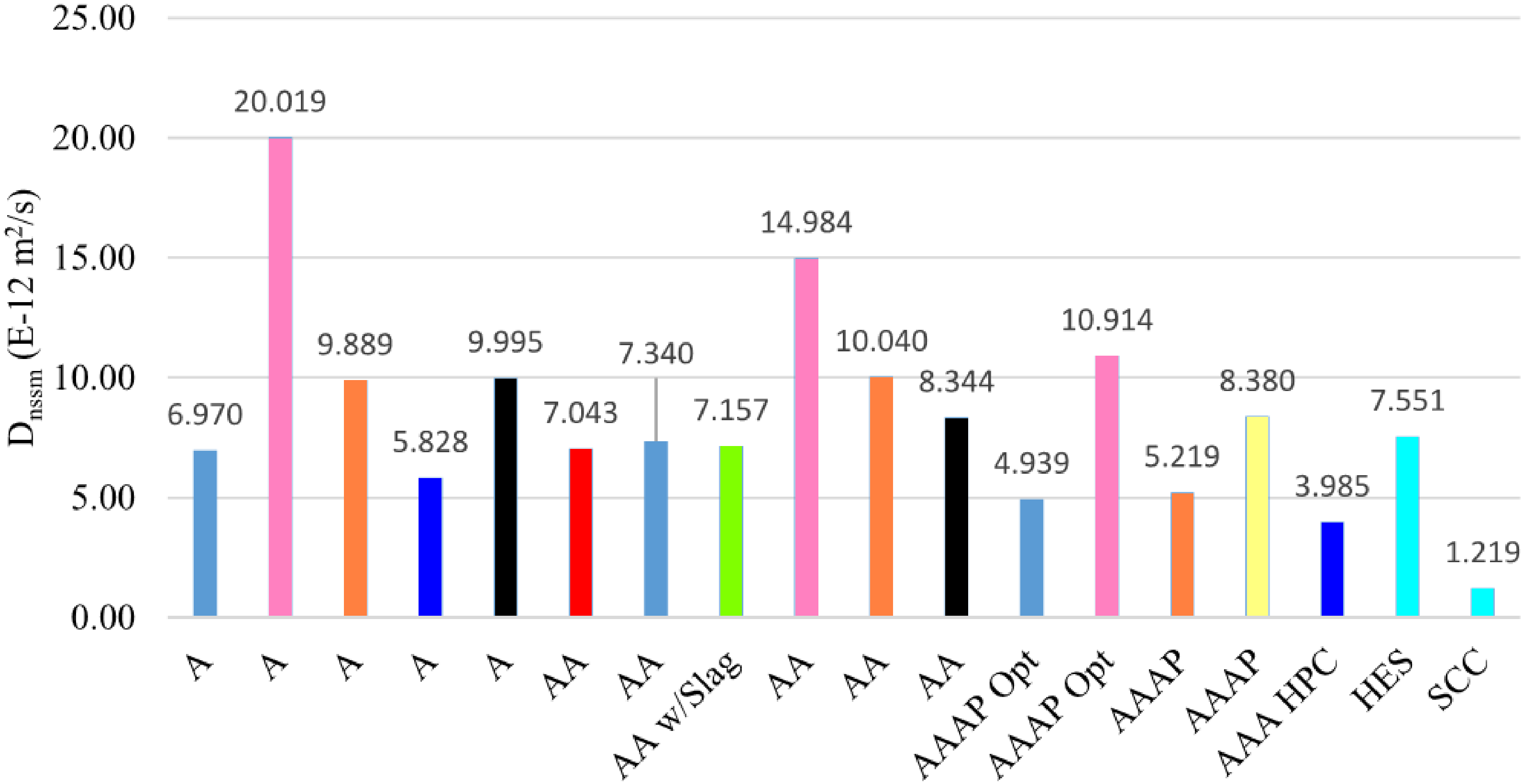
Pennsylvania DOT

Chloride Migration Coefficient by Concrete Class



Pennsylvania DOT

Chloride Migration Coefficient by Concrete Supplier



Pennsylvania DOT

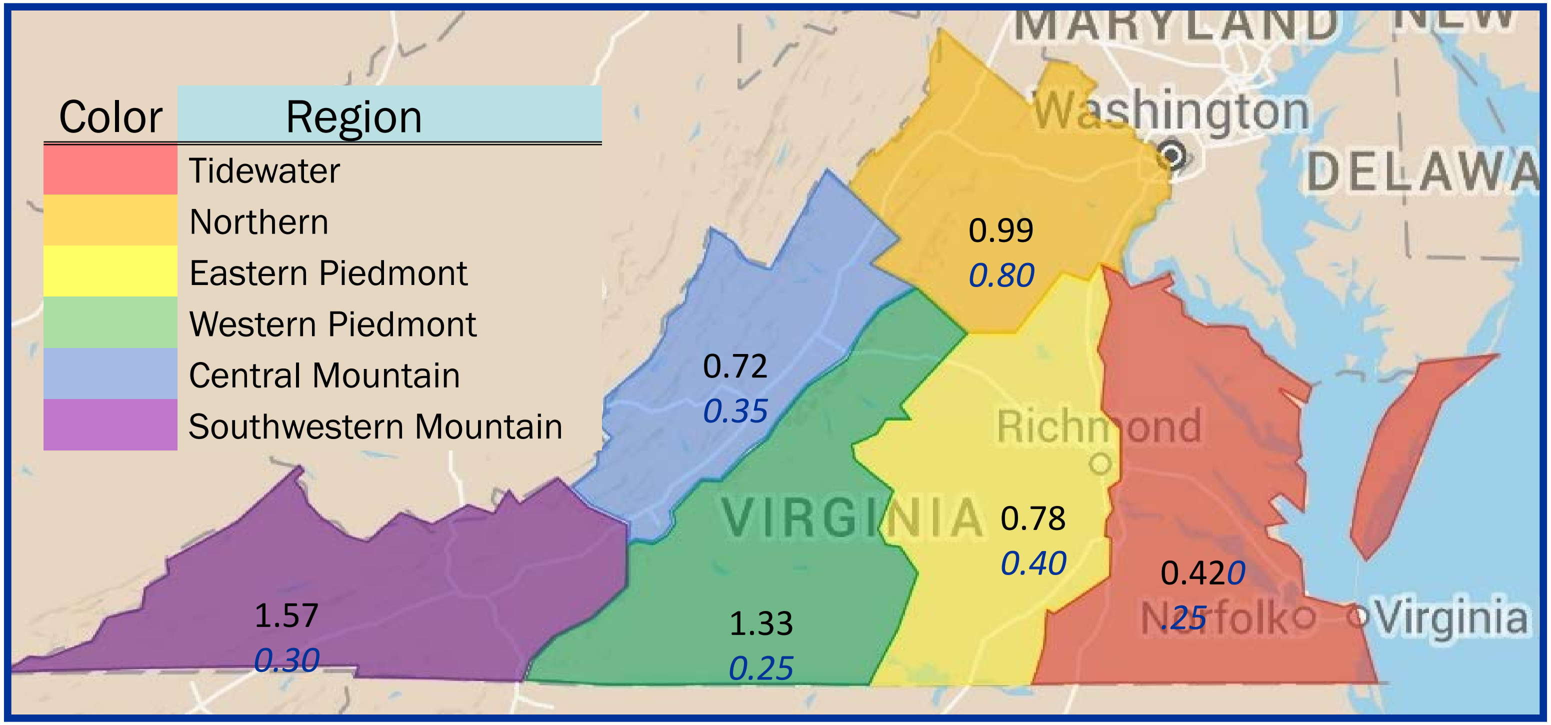
- **Final Service Life Design Workshop held August 16, 2016 in Harrisburg, PA**
  - Overview of Service Life Design for Bridges
  - Chloride Induced Corrosion Modeling
  - Concrete Deterioration Mechanisms
  - Implications of Cracks in Concrete on Service Life
  - Service Life Design Requirements for RFPs
  - Service Life Design for Steel Structures

Virginia DOT

- **Statewide Evaluation of Chloride Surface Loading and Resistance of Concrete**
  - Compared historic chloride surface loading to fib-34 methods
  - Performed NT Build 492 tests on over 20 ongoing bridge construction projects around the state
  - Developing a database of reference values specific to Virginia for use in modeling

Virginia DOT

- **Categorization of chloride loading by zones**



– Historical data (Williamson, 2007)

$$\left(\% \frac{mass\ Cl^-}{mass\ binder}\right)$$

– *fib 34-predicted*

Virginia DOT

- **Final Service Life Design Workshop held October 4, 2017 in Charlottesville, VA**
  - Overview of SLD – SME Team
  - Concrete Material Testing Program – Virginia Tech
  - Chloride Profiling of Existing Bridges – Virginia Tech
  - Specifications on Corrosion Resistant Reinforcing – VDOT
  - SLD Tools developed – SME Team
  - SLD for Alternative Delivery Projects – SME Team
  - R19A work done by other agencies – SME Team

IAP Projects - Round 7
Selected Summer 2016

IAP Team Leaders

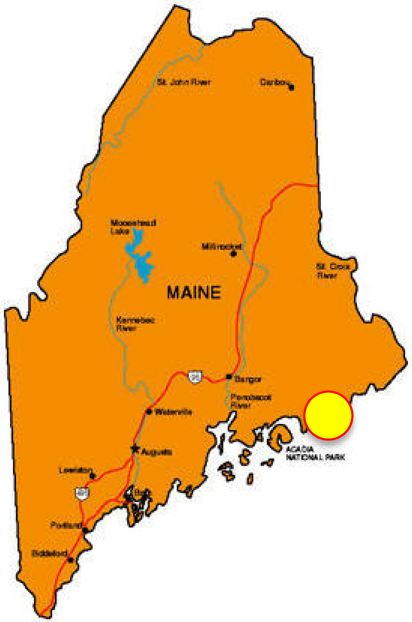
- Iowa DOT
  - Ahmad Abu-Hawash, Norm McDonald
- Maine DOT
  - Dale Peabody

Iowa DOT

- **Thin Deck Overlays as a Bridge Preservation Action**
  - Evaluation of structures on US-18 corridor
  - Kick-off Meeting to take place on June 20, 2017

Maine DOT

- **Replacement of Beals Island Bridge in cold weather coastal environment**
  - Chloride profiling on existing bridge
  - NT Build 492 tests on proposed concrete specifications



Lessons Learned

Lessons Learned

- Chloride profiling on core samples produce much better results than powder samples from rotary drilling
- Deicing application is low enough in some parts of Oregon to disregard corrosion from chlorides
- Need to develop contour maps of chloride loading
- Chloride migration tests (NT Build 492) are relatively easy to implement
  - Virginia and Iowa performing in-house testing

Lessons Learned

- Most state concrete classifications are flexible in w/c ratio, and % flyash or slag replacing cement
- Mix design flexibility ≠ Consistent durability properties
  - Chloride migration test values (NT Build 492)
  - Aging coefficients (need ≥ 20% flyash to benefit)
- Need to develop guidelines for more consistent concrete specifications for SLD

IAP Next Steps

- Conduct Agency Final Training Workshops for CFL, IA, ME
- Develop Reference Material Documentation / add to AASHTO/SHRP2 web page
  - Academic Toolbox
  - Life Cycle Cost Example
  - Lessons Learned Summaries
- Develop 5 FHWA Peer Exchanges in non-IAP states

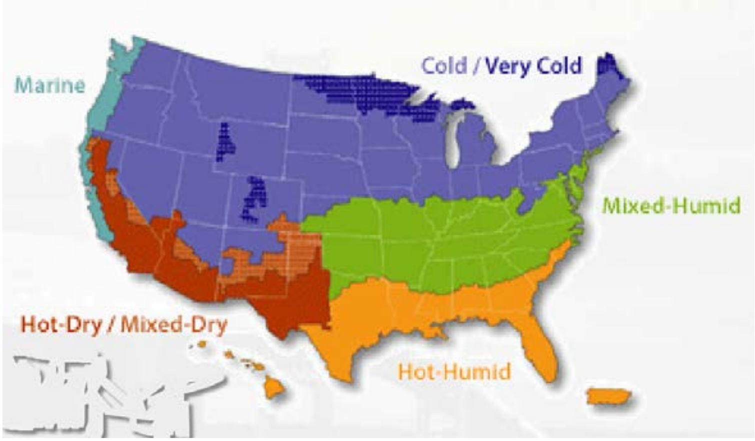
Current Research - NCHRP 12-108

- Uniform Service Life Design Guide Specification
  - Sponsored by AASHTO T-9 – Bridge Preservation Technical Committee
  - Modjeski & Masters / John Kulicki / Rutgers University / COWI / NCS GeoResources

- Project Goals
  - Develop AASHTO Guide Specification for Service Life Design of Highway Bridges
  - Develop Case Studies to Demonstrate the Application of the Proposed Guide

Current Research - NCHRP 12-108

- Deemed-to-Satisfy and Avoidance of Deterioration Strategies to form the majority of the Guide Specification
  - Calibrated by more rigorous approaches
- Full Probabilistic and Partial Factor Methods
  - Included as an Appendix
- Environmental Classification
- Recommended Service Life
  - Main Structure Components
  - Replaceable Components
    - Bearings, Joints, etc.



Current Research – NCHRP 12-108

- Work Plan / Schedule
  - Tasks 1 & 2 – Literature Review and Synthesis
  - Task 3 – Develop Proposed Methodology
  - Tasks 4a & b – Propose Annotated ToC & Case Studies
  - Task 5 – Interim Report #1

    (all completed 03/10/17)

  - Tasks 6, 7 & 8 – Develop & Execute Methodology & Sample Section & Interim Report #2 (scheduled 10/01/17)
  - Tasks 9 & 10 – Develop Guide and Case Studies (scheduled 07/01/18)
  - Tasks 11 & 12 – Revisions & Final Deliverables (scheduled 12/01/18)
  - End of Project (scheduled 02/28/19)

Summary

- Service Life Design is necessary to promote more durable, longer lasting structures
- Current implementation
  - SHRP2 R19A projects (FHWA CFL, IA(2), ME, OR, PA, VA)
- Tools being developed to assist designers
  - http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx
- AASHTO T-9 Initiated Research
  - NCHRP 12-108 Uniform Service Life Design Guide

Questions?

Implementation Leads:

- Patricia Bush, *AASHTO Program Manager for Engineering,* pbush@aashto.org
- Raj Ailaney, *FHWA Senior Bridge Engineer,* Raj.Ailaney@dot.gov

Subject Matter Expert Team:

- Mike Bartholomew, *CH2M,* mike.bartholomew@ch2m.com
- Anne-Marie Langlois, *COWI North America,* amln@cowi.com

Resource: AASHTO's R19A Product Page

- http://shrp2.transportation.org/Pages/ServiceLifeDesignforBridges.aspx