MEETING SUMMARY

SHRP2 SERVICE LIFE DESIGN FOR BRIDGES (R19A) NORTHEAST REGION PEER EXCHANGE

TO	Raj Ailaney, Patricia Bush, Pam Hutton
COPY	Sam Rosenblum
PREPARED BY	Mike Bartholomew
MEETING DATE	March 12, 2019
LOCATION	Hampton Inn & Suites Denver Downtown – Denver, Colorado

Background

The Federal Highway Administration (FHWA) in conjunction with the American Association of State Highway Transportation Officials (AASHTO) and the Transportation Research Board (TRB) have established the 2nd Strategic Highway Research Program (SHRP2) to address four focus areas – Safety, Renewal, Capacity, and Reliability. Project R19A – Service Life Design of Bridges, one of the Renewal projects, is an innovative technology approach being promoted to ensure that new more durable bridges are designed to remain operational for 100 years or more.

To assist agencies with advancing the implementation of Service Life Design, FHWA sponsored—and the Central Federal Lands Highway Division (CFL) hosted—a peer exchange with the Colorado Department of Transportation (CDOT), Montana Department of Transportation, Utah Department of Transportation (UDOT), Idaho Transportation Department (ITD), Texas Department of Transportation (TxDOT), Arizona Department of Transportation (ADOT), New Mexico Department of Transportation (NMDOT) and the R19A Subject Matter Expert (SME) team in Denver, Colorado, on March 12, 2019. The peer exchange provided a forum for participants to discuss and exchange ideas on Service Life Design.

Twenty-one attendees participated in the peer exchange, including representatives from AASHTO, FHWA Headquarters, State representatives, and academia. The peer exchange was formatted to provide a mix of presentations and facilitated roundtable discussions, as shown on the agenda in Appendix A. This structure provided attendees with several opportunities to collect information from their peers and examine different ways to implement Service Life Design. Representatives from Maine and Pennsylvania shared their noteworthy practices and strategies as wells as the challenges and barriers they experienced in applying Service Life Design. The event began with opening remarks from AASHTO, FHWA, and CFL, and was followed with the technical sessions and group discussions.

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Service Life Design - Key Peer Exchange Findings

FHWA Central Federal Lands, as the host state and an IAP Lead Adopter agency has indicated a desire to implement Service Life Design concepts, including documentation of the durability properties specified during design and achieved during construction, as discussed about the Birth Certificate for new bridges.

Testing of standard concrete mix designs for chloride migration coefficient performed on CFL's project in Hawaii showed less favorable results than in other states that have performed the testing. One theory is that results may be affected by a more porous aggregate available on the islands. Also, there is no source for fly ash on the islands. These issues indicate that as part of a Service Life Design it is important to know the local material availability.

The three bridges in the CFL project cross freshwater streams but are located within 500 to 1,000 feet of the coastline. The initial assumption was that there would be brackish water from tidal variations near the bridges and this would be considered a highly aggressive chloride environment. Salinity tests were performed on the streams and cores were taken from the existing bridge abutments to measure chloride surface content. Results of the tests showed that the water had very low amounts chlorides, less than that of the local drinking water. Both of these results were unexpected and show the importance of performing tests to classify the environmental loading.

For this Peer Exchange the participating states, Colorado, Montana, Utah, Idaho, Texas, Arizona, and New Mexico were asked to respond to a survey questionnaire. Four responses were received, two from CFL, one from Colorado, and one from the University of Hawaii, indicating that they had moderate knowledge of Service Life Design.

Peer Exchange Discussion Notes

Introduction

Pam Hutton (AASHTO) – Gave overview of the SHRP2 Program as documented in handout documents provided to participants. From publication *2017 Implementation Highlights - Advancing the State of the Practice*, identified $155 million in funding assistance, 340+ projects implemented, 300,000+ participants engaged, 12,300+ outreach activities, and 16,600+ hours of technical assistance rendered. Also discussed publication on *FHWA/AASHTO Implementation Assistance Program State Participation in Rounds 1-7*, which identified the 430 projects by product name and participating agency.

Raj Ailaney (FHWA) – Gave an overview of the SHRP2 Solutions for Bridges, which included the participating agencies for project R19A – Service Life Design of Bridges. Also discussed the deliverables being produced for R19A.

Bonnie Klamerus (CFL) – Gave an overview of Central Federal Lands participation as a Lead Adopter Agency in R19A.

Service Life Design Concepts

- **Introduction to Service Life Design (SLD) –** presentation by Mike Bartholomew/Jacobs
  - No questions or discussion.
- **Implementing SLD for Concrete Structures –** presentation by Neil Cumming/COWI
  - CDOT - Material covered addresses the concrete properties, did not get into details of design?
    - Neil – that is correct, will get into more later along with concrete cover
    - Bonnie – important to note later in the day lead adopter states have their own specific process

    - Mike B.– most lead adopter states have a plan moving forward
    - Bonnie – helpful to see how state who have the money plan to use it
  - Comment from participant - Future AASHTO guide on SLD would be “bible” for SLD for engineers.
  - Neil – weakness of fib model is not ideal for North America while AAHSTO guide would be.
  - Participant - How does concrete coaters or sealers factor in?
    - Neil - Inhibit the chloride from entering. It depends on how long the membrane lasts. It will extend length of time, but how much is unknown.
  - ITD - Challenge from studded tires and chains. Does this project deal with that?
  - Not specifically, however wearing can be accounted for.
  - Raj – mentioned how previous webinar has short presentation on future AASHTO Guide.

R19A Implementation Updates

- **Goals of Central Federal Land’s R19A Participation –** presentation by Mike Voth/CFL
  - CDOT Question – HDOT doesn’t use epoxy?
    - Mike V - Don’t believe it works. No consistent evidence
    - CDOT response – Find epoxy has worked really well in CO especially with de-icing materials
    - Neil – Findings have been inconsistent
  - Bonnie – points out how model includes epoxy
    - Neil – this model adds arbitrary factor
    - CDOT – is the model incorrect?
    - Neil – variance in results across jurisdictions
  - Steve – Where is this concrete located?
    - Bonnie and Mike – One mix for the entire project
  - What type of corrosion inhibitor do they use?
    - Mike V - Calcium nitrate, but there are various
- **Overview of Material Testing for Service Life Design –** presentation by Neil Cumming/COWI
  - Bonnie – tests would vary based on location?
    - Neil – Yes, Hawaii would not need freeze-thaw test
  - Mike V. – where is industry at in U.S. in testing chloride migration coefficient
    - Neil – They are very resistant to testing. However, testing of coefficient is new and there are not many labs set up to test
  - Bonnie – As someone who has to write specs and owner asks for 100-year service life there is no basis to achieve their request, i.e. no provisions in AASHTO to base procedure off of.
    - Neil – Will address more during discussion period
  - ITD – does surface chloride coefficient change overtime?
    - Neil – intuitively you are correct. It builds over a period of time and then levels out. Maxes out at 20-30 years. Model assumes it starts at that value.

- **University of Hawaii Testing Program –** presentation by Guar Johnson/ University of Hawaii
  - Bonnie – Since water is basically stagnant the thought was the brackish water would reach up the river to slightly inland bridges. This surprisingly was not the case.
    - Gaur – only 2' tide differential. Could vary for other locations.
  - Did you include light weight concrete in your testing?
    - No
- **Coastal Bridge Replacements on Kauai North Shore –** presentation by Bonnie Klamerus/CFL
  - HDOT requirements do not allow steel or timber main components
    - CDOT – why?
    - Bonnie – fear of corrosion
  - Increased cover requirements compared to AASHTO
    - Stephanie (MnDOT) - Is this related to a service life design guide?
      - Bonnie – No SLD guide, found in HDOT bridge design manual
  - Jamal – Black rebar seems to be working for HDOT?
    - Bonnie – It does. Mild, temperate climate
    - Gaur – True, area of high chloride however is more corrosive. Overall, black rebar is in great shape. Concrete mix plays a big role in corrosiveness. This is concluded based off how it was found older structures at Pearl Harbor performed better than newer structures.
    - Neil – found the same thing in Vancouver
- **Service Life Comparison using fib 34, Life 365 and Stadium –** presentation by Guar Johnson/University of Hawaii
  - Stephanie – How were the corrosion rates determined?
    - Gaur - Corrosion rate is a pull-down option that determines concentration at level of rebar
  - Steve (FHWA-CFL) - Do we know if we are out of bounds of data on corrosion inhibitors, half gallon doubled service life?
    - Gaur – This is a way to do relative comparison.
    - Neil – Life365 was originally set up 15 years ago. Database in program is largely empirical.
    - Gaur – use both SHRP2 and Life365 to compare
    - Neil – Different models all produce various results including Stadium model
  - Mike B – CI sometimes affects test results. Recommend not using CI when performing the testing.
    - Neil – Alters resistivity of concrete and can skew results
  - Mike B – SHRP2 is more effective when running more than 5,000 iterations. New version will allow for more variability, such as range of slag.

- **R19A Participation from Other Agencies –** presentation by Mike Bartholomew/Jacobs
  - No questions or discussion

Group Discussion Topics

- **Design Issues – How is concrete cracking taken into account?**
  - Neil – service life is typically defined as length of time before you need to update/improve/replace structure. Service life also depends on amount of maintenance you are willing to provide. How is this affected by cracking? Look at areas of construction joints or low cover. Cracking affects the amount of maintenance that will be required. Other approach is to understand the concrete will be cracking no matter what. None of the aforementioned models account for cracking. Design for crack control and attempt to keep it in "normal" range. "Normal" range should not affect cracking
  - CDOT – Maintenance does not look for cracks to seal them off. Only time they address is when they see spalling or large widening of cracks. Lack of modeling cracked concrete appears to be a shortcoming
  - Neil – difficult to model. There have been attempts. Would affect chloride mitigation value. Another issue is cracking is not uniform. For example, silica fume limits cracks beyond surface.
  - CDOT – Wish they took samples at cracked location
  - Gaur – limits in cracks have not been found to prevent corrosion
  - CDOT – CI is good but at crack locations their effects are limited. Freeze thaw is a big factor. CDOT designs bridges as composite
  - Neil – silica fume limits permeability but has more propensity for cracking. Suggests no silica fume in decks and reducing restraint conditions. In terms of maintenance. Easier to seal cracks prior to corrosion. Most states
  - Participant - Does deck washing affect SLD?
  - Neil – helps clean out drains and remove chloride, but overall minimal effect.
- **Construction – How can we verify the durability properties specified in design are achieved during construction?**
  - Jamal – we find if we don't have good QC performance, there will be issues. Believes contractors do not have enough supervision to warrant valid test results.
  - Neil – Agrees that QC by contractor does not often meet standards. Thinks QA should be a means to verify QC was done correctly. Hard to provide QC people authority to take action.
  - Jamal – Experience has shown that many issues arise in this process.
  - Neil – Owners need to take responsibility to enforce stringent QC process, especially on the contractor side. This needs to happen early in the process to be effective.
  - Jamal – Entity needs to be separate from production
  - Neil – independent QC process has been effective
  - Mike V. – How is chloride mitigation coefficient verified during construction?
  - Neil – Values reported need to be lower than the specified value by at least the range of variability.
  - Mike V. – what happens when chloride mitigation coefficient fails?
  - Neil – Should be testing and recording test results often. Should follow trends of results to see that criteria are being met. A few failures can be acceptable.
  - Mike V. – 28-day test. With compressive stress there is a limit and a procedure for when removing and replacing as required. How is this similar?
  - Neil – Highlights the importance of pre-qualification. Can still take action if criteria are not met.

- Participant – could add provision in contract if criteria is not met to put burden on contractor?
- Participant – Would a warranty work?
- Neil – warranty is only as good as the contractor stays in business
- Stephanie – Are there any handback requirements?
- Neil – handback requirements are vague. Biggest benefactor would be lawyers.
- Neil – Believes concrete cover is much more important than chloride mitigation coefficient. Tolerances for cover is rarely met. In order for owners to build in protection they should specify a larger concrete cover value. Design should be about 10 mm less.
- Participant – Colorado uses concrete maturation device (??) and has had a lot of success.
- Neil – Agreed. There has been a focus on curing which is appropriate but believes there should be more attention paid to temperature differential in the first 48 hours
- IDT – contractor want to place concrete cover in morning. Peak of hydration takes place at peak heat in the afternoon.
- Neil – suggests pushing for nighttime pour.

- **In-Service – How can a regular monitoring plan be implemented to verify that performance matches design intent?**
  - Mike B. - Recommends testing every 10-20 years to determine where you are and compare to what you anticipated. Is cover better or worse?
  - Neil – plot chloride profile with age of bridge. If you find chloride is diffusing at a faster rate, can take actions.
  - Gaur – in this case okay to be reactive because these samples will improve future SLD
  - Neil – Can cast test block next to structure. This allows for “unlimited” testing
  - Neil – Haven’t talked much about carbonation depth. Approach we take is if you do everything you need to prevent chloride exposure, you will prevent carbonation depth effects.
  - Mike B. – Some states won’t have issues with Chloride. Would be good to have something specific for carbonation.
  - Neil – monitor results over five-year periods. This would be proactive. Owner agencies need to be in preventive mind frame.
  - Participants - finds health monitoring systems can capture this info
  - Steve – what about CMGC?
  - Neil – don’t have much experience with that?
  - Mike B. – Found that contractor typically gets their way over the consultant. Somewhat similar to DB.
  - Participant – DB requires good contract.
  - Mike B. – Owner has more control when putting together contract and put more stringent control on contractor.
  - Bonnie – Need to define what service life means and have criteria.
  - Neil – Agree. Has seen many very vague definitions of what service life is.
  - Bonnie – Is there an invite to the upcoming webinar?
  - Raj – emails have been sent. Takes place on March 20.

  - Participant – Are presentations posted online?
  - Pam – Yes. Go to SHRP2 to webpage, renewal focus area, there is a link to R19

- **What organizational structures are required to successfully achieve longer lasting bridges?**
  - Neil – is D-B approach working?
  - Half group – No
  - Neil – giving projects to lowest bidder results in lower product
  - Jamal – Have seen this in CO.
  - Neil – collaboration between designer and builder is good, but owner has restricted control.
  - Jamal – Owner wants project within budget and on time
  - Neil – but have to build what is specified
  - Participant – Talked a lot about concrete. How to incorporate structural steel.
  - Neil – steel components need to be addressed in future. So do structure health monitoring systems. Concrete is focus because that is where modeling is. Steel has various types of coating systems and types of steel. No numerical methodology really exists. Steel typically has more maintenance issues than concrete
  - TxDOT Participant – I agree to some degree. Weathering steel has been successful but to a limit.
  - Mike B. – In upcoming webinar, a steel example will be worked through. We will talk about service life of steel and the protective coating.

Appendix A – Agenda

SHRP2 R19A Service Life Design for Bridges
Southwest Region Peer Exchange

March 12, 2019 – Denver, CO
Hampton Inn & Suites Denver-Downtown
1845 Sherman Street, Denver, Colorado 80203

Time	Topic	Speakers
8:30 – 8:50 am	**Welcome and SHRP2 Introduction** • FHWA, AASHTO, & Agency Introduction (20 min)	Raj Ailaney, FHWA Patricia Bush, AASHTO Bonnie Klamerus, FHWA CFL
8:50-10:15	**Service Life Design Concepts** • Introduction to Service Life Design (SLD) (30 min) • Implementing Service Life Design for Concrete Structures (35 min) • Group Discussion Topic – What does 100-yr SLD mean? (20 min)	Mike Bartholomew, Jacobs Neil Cumming, COWI All participants
10:15-10:30 am	**Break**	
10:30-12:00 am	**R19A Implementation Updates** • Goals of Central Federal Land's R19A Participation (10 min) • Overview of Material Testing for Service Life Design (25 min) • University of Hawaii Testing Program (30 min) • Group Discussion Topic – Challenges of Durability Testing (25 min)	Mike Voth, FHWA CFL Neil Cumming, COWI Gaur Johnson, U. of Hawaii All participants
12:00-1:00 pm	**Lunch**	
1:00-2:20pm	**R19A Implementation Updates (continued)** • Coastal Bridge Replacements on Kauai North Shore (30 min) • Service Life Comparison using *fib* 34, Life365, and Stadium (30 min) • R19A Participation from Other Agencies (20 min) • Group Discussion Topic – (20 min)	Bonnie Klamerus, FHWA CFL Gaur Johnson, U. of Hawaii Mke Bartholomew, Jacobs All participants
2:20-2:40 pm	**Break**	
2:40-4:30 pm	**Group Discussion Topics** • Design Issues – How is concrete cracking taken into account? • Construction – How can we verify the durability properties specified in design are achieved during construction? • In-Service – How can a regular monitoring plan be implemented to verify that performance matches design intent? • What organizational structures are required to successfully achieve longer lasting bridges?	Mike Bartholomew, Jacobs – Facilitator All participants
4:30-5:00 pm	**Wrap Up & Adjourn** • Future Service Life Design Research Needs • Complete Evaluation Forms	

Appendix B – List of Attendees

SHRP2 R19A Service Life Design for Bridges
Southwest Region Peer Exchange
March 12, 2019 – Denver, CO
Hampton Inn & Suites Denver-Downtown
1845 Sherman Street, Denver, Colorado 80203

	First Name	Last Name	Job Title	Agency	Email Address	Sign In
X	Raj	Ailaney	Sr. Bridge Engineer	FHWA	raj.ailaney@dot.gov	
X	Mike	Bartholomew	Senior Principal Bridge Engineer	Jacobs	mike.bartholomew@jacobs.com	
	Steve	Belcher	ADA	FHWA-CFL	steven.belcher@dot.gov	
X	Stephanie	Brandenberger	Bridge Engineer	Montana Dept of Transportation	stbrandenberger@mt.gov	
X	Troy	Branigan	Structural Engineer	Jacobs	troy.branigan@jacobs.com	
X	James	Corney	Structures Project Engineer -	Utah Department of Transportation	JCorney@utah.gov	
X	Neil	Cumming	Consultant/Presenter	COWI	ncgx@cowi.com	
X	Karl	Eikermann	Bridge Design Team Leader	DOT/FHWA/CFLHD	karl.eikermann@dot.gov	
X	Jamal	Elkaissl	Structural Engineer	FHWA/ Resource Center	jamal.elkaissi@dot.gov	
X	Danielle	Germani	Structural Engineer	FHWA - CFL	danielle.germani@dot.gov	
X	Matthew	Greer	Bridge Engineer	FHWA CO Div	matt.greer@dot.gov	
X	Michael	Hyzak	Bridge Engineer	TxDOT Bridge Division	michael.hyzak@txdot.gov	
X	Rick	Jensen	EM-1, Bridge Design	Idaho Transportation Department	rick.jensen@itd.idaho.gov	
X	Bonnie	Klamerus	Supervisory Structural Engineer	CFLHD/FHWA	bonnie.klamerus@dot.gov	
X	Shane	Kuhlman	State Bridge Engineer	NMDOT	shane.kuhlman@state.nm.us	
X	Nathan	Marshall	Civil Engineer (Structural)	FHWA - CFL	nathan.marshall@dot.gov	
X	Ryan	Owen	Bridge Engineer	FHWA - CFLHD	ryan.owen@dot.gov	
	John	Rohner	Sr. Bridge Engineer	Jacobs	john.rohner@jacobs.com	
	SAMIR	SIDHOM	BRIDGE DESIGN TEAM LEADER	FHWA- FLHD	samir.sidhom@dot.gov	
X	Pe-Shen	Yang	Assistant State Bridge Engineer	Arizona Department of Transportation	pyang@azdot.gov	
X	Mike	Voth	Materials Part't Engineer	FHWA-CFLHD	michael.voth@dot.gov	
X	Man	Yip	Bridge Engineer	CDOT	Man.yip@state.co.us	
X	Gaur	Johnson	Str Engr	UH	gaur@hawaii.edu	
X	JAMAL	ELKAISSI	Sr.ENGR	FHWA	jamal.Elkaiss@dot.gov	
X	Pam	Hutton		AASHTO		

Appendix C – Summary of Evaluations

What were the most important ideas you learned from the workshop?
Clarification of concepts read in the reports.
Quantitative models and test methods
Methods for calculating and designing for service life.
Chlorides and corrosion inhibitors
How to protect rebar, get a life longer bridge
Spreadsheets, knowledge
Definitions of service life. What my agency can do to get the service life.
The general concept and the challenges of service design (material challenges).

Are there questions or issues you wished the workshop had addressed that it didn't?
Costs; what are other states doing in detail?
Cost increase for projects designed for service life extension
More design methodologies
Steel info
Other service issues other than concrete.
Looking for more info on AASHTO Guide Spec due to come out and similarity to Bulletin 34.
Better understanding of service life design concepts. Tools effective for evaluating options but targeting "design life". In years is still subjective. Testing methodologies and differences in results.

Would you like to learn more about the SHRP2 R19A product?
Yes, but we actively do reservation measures to counteract chloride intrusion.
Would like more info on Oregon and Iowa projects.
I like to see the design examples of bridges with service life design method.
Construction practices, maintenance practices, inspection, steel coatings vs. sacrificial rolled plate girder cross-sections.

Additional comments:
This was a good educational event. Discussing the costs associated with service life design would be beneficial.
Good information provided.
States may have difficulties to conduct the required tests to establish the design parameters for regular bridges.

Rating	Subject knowledge level prior to workshop	Subject knowledge level after workshop	Knowledge of SHRP2 prior	Knowledge of SHRP2 after	Overal Content Effective	Presentation Effectiveness	Provided a better understanding of implementing	I understand how Service Life Design can benefit my agency	Encouraged Active Participation	Was worthwhile	Expectations Met
1	0	0	1	0	0	0	0	0	0	0	0
2	2	0	4	0	0	0	0	0	0	0	0
3	3	0	2	1	0	0	0	0	0	0	0
4	2	0	1	0	0	0	0	0	0	0	0
5	1	0	2	0	0	0	0	0	0	1	0
6	2	3	1	3	1	0	0	1	1	1	0
7	3	1	4	5	4	5	4	4	6	6	3
8	2	7	0	2	8	7	6	4	3	2	5
9	0	2	0	3	0	1	3	4	2	2	3
10	0	1	0	1	2	2	2	2	2	2	3
strongly disagree (1-2)	2	0	5	0	0	0	0	0	0	0	0
moderately disagree (3-5)	6	0	5	1	0	0	0	0	0	1	0
moderately agree (6-8)	7	11	5	10	13	12	10	9	10	9	8
strongly agree (9-10)	0	3	0	4	2	3	5	6	4	4	6
sum	15	14	15	15	15	15	15	15	14	14	14
% strongly disagree	13%	0%	33%	0%	0%	0%	0%	0%	0%	0%	0%
% moderately disagree	40%	0%	33%	7%	0%	0%	0%	0%	0%	7%	0%
% moderately agree	47%	79%	33%	67%	87%	80%	67%	60%	71%	64%	57%
% strongly agree	0%	21%	0%	27%	13%	20%	33%	40%	29%	29%	43%