MEETING SUMMARY

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

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| **TO** | Raj Ailaney, Patricia Bush, Pam Hutton |
| **COPY** | Sam Rosenblum |
| **PREPARED BY** | Mike Bartholomew |
| **MEETING DATE** | September 25, 2018 |
| **LOCATION** | Embassy Suites- Des Moines, Iowa |

# 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 Iowa Department of Transportation (Iowa DOT) hosted—a peer exchange with the Michigan Department of Transportation, Ohio Department of Transportation, Indiana Department of Transportation, West Virginia Department of Transportation, Minnesota Department of Transportation, and the R19A Subject Matter Expert (SME) team in Des Moines, Iowa, on September 25, 2018. The peer exchange provided a forum for participants to discuss and exchange ideas on Service Life Design.

Twenty-six attendees participated in the peer exchange, including representatives from AASHTO, FHWA Headquarters, State representatives, and representatives from private engineering consulting firms. 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 Iowa 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 Iowa DOT, and was followed with the technical sessions and group discussions.

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# Service Life Design - Key Peer Exchange Findings

Iowa, as an IAP Lead Adopter agency has indicated a desire to implement policies on the use of overlays and various types of deck reinforcements to extend the Service Life of bridge decks. This will be supported by using life cycle cost analysis. Type of overlay and reinforcement to be used will be based on factors such as environmental exposure, road classification, age and condition of decks (for existing structures). Iowa also experimented with the use of ASTM A1010 High Chromium structural steel but felt that the current cost structure it is not conducive to its use on a regular basis.

For this Peer Exchange the participating states, Iowa, Indiana, Michigan, Minnesota, Ohio, and West Virginia were asked to respond to a survey questionnaire. Of the six responses received, four states replied that they had moderate knowledge of Service Life Design, while the other two had no prior knowledge of the topic. Minnesota indicated that they had started the process to look at how Service Life Design may be implemented but felt that it should be handled more on a programmatic basis than on a project basis. West Virginia has implemented a Service Life Design requirement for a major design/build bridge project.

Most of the states indicated that the philosophy of Service Life coordination between Design, Construction, and In-Service Operations would be a major challenge in their organizational structure. There is a lack of communication between the groups and implementing new concepts such as concrete material durability tests and hardened concrete cover measurements during construction will be a challenge. In-Service Monitoring of performance is also expected to be a challenge unless policies and organizational structure changes.

# 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.

Ahmad Abu-Hawash (Iowa DOT) – Gave an overview of Iowa DOT's participation as a Lead Adopter Agency in R19A, and a brief history on the development of the concept of Service Life Design of Bridges which was initiated around the year 2000. He introduced the goals of Iowa's R19A Participation and described the technologies Iowa has implemented from R19A including:

- UHPC overlay
- Structural health monitoring (I-74 Mississippi River Bridge)
- ABC

# Service Life Design Concepts

- Mike Bartholomew of Jacobs and the SME Team presented an "Introduction to Service Life Design", which included the following key issues:
  - Definition of Service Life Design (SLD)

- Goals of SLD
- Past research and historical development of SLD
- Introduced SLD design strategies
- Deterioration modeling methods for concrete structures
- Deterioration Limit States – depassivation (initiation of corrosion), cracking, spalling, loss of section (collapse)
- Typical structures that have been designed for extended life
- SHRP2 R19A program background and work focus areas, and
- Tools developed by SME team to assist in the design for durability and service life

- **Introduction to Service Life Design (SLD) & Implementing SLD for Concrete Structures**
  - Has there been calibration of full probabilistic models with actual structures?
    - Yes, fib Bulletin 34 has been calibrated using actual structures.
  - How to account for deck cracking?
    - Deck cracking is not a direct consideration in model (uncracked concrete assumed).
  - Is Average Daily Traffic (ADT) considered in parameters?
    - No.
  - What is the role of structure importance?
    - fib only takes importance into account directly at the Ultimate Limit State (ULS), which rarely controls. At the Service Limit State (SLS) the same target Reliability Index (RI) is used regardless of structure importance.
  - Are there any other equations than Fick's 2nd Law to evaluate/consider for Alkali Aggregate Reaction (AAR) or carbonation induced reinforcing corrosion?
    - AASHTO R80-17, Standard Practice for Determining the Reactivity of Concrete Aggregates and Selecting Appropriate Measures for Preventing Deleterious Expansion in New Concrete Construction is an excellent guide to designing for AAR. fib Bulletin 34, Model Code for Service Life Design also has equations for designing for carbonation.

- **Group Discussion – What does 100-year SLD mean?**
  - Need to get to 75-year life first!
  - Just considering SLD should have a big impact.
  - How to account for changes over the life of the structure? Such as:
    - Increases in AASHTO loading (especially live load) & code changes in general
    - Changes in bridge function or increases in traffic such that the bridge becomes functionally obsolete.
      - I-235 corridor in Iowa, for instance, replaced many bridges that were in good shape due to being functionally obsolete.
      - A study was referenced that found bridges were generally being replaced after about 50 years. If this is accurate, is designing for 100-year service life necessary/warranted for a typical bridge?
      - Better corridor planning and traffic projection needed.
      - CalTrans commonly designs substructures considering future widening to plan for the future and help mitigate bridges becoming functionally obsolete.

- Other things to consider as having an impact on SLD:
  - Inspection and maintenance access.
  - Certain components of the bridge have a much shorter life than 100-years and must be replaced on a regular basis (joints, bearings, etc.).
- NCHRP 12-108 - Guide Specification for Service Life Design will address different service life durations.

# R19A Implementation Updates

- **Overview of Material Testing for Service Life Design**
  - Do we need to do testing after construction?
    - Production testing should be considered, perhaps in a step-wise manner (more at first; less over time). Prequalification testing should be done at a bare minimum.
- **Group Discussion – Challenges of Durability Testing**
  - Iowa and Minnesota DOT noted they have done chloride testing in the past (generally ASTM C1202). Iowa DOT has essentially stopped doing it because the data wasn't being used.
  - NT Build 492 test not a lot more work than ASTM C1202. It's basically the same test, except the samples are split at the end of testing, sprayed with silver nitrate to measure chloride penetration.
  - Is there a chloride sensor that can be used or embedded in the concrete?
    - Corrosion "ladder" – multiple sensors at different depths embedded in the concrete. Wired as part of Structural Health Monitoring (SHM) system. One product is an "anode ladder" produced by Sensortech in Munich, Germany. See ACI special publication SP192-02 published in April 2000.
  - What are the 28-day tests used for?
    - Determination of appropriate remediation, if neccesary.
    - Some states may use test results to apply penalties for non-conformance.
    - Update SLD models with test results to see how as-built conditions will affect service life.
    - Asset Management.
  - How to measure as-built cover?
    - Proceq cover meters
    - FHWA RABIT – Ground Penetrating Radar (GPR)
    - Need to have acceptance criteria.
    - Iowa research project on deck cracking – perhaps collect cover data?
  - A structure "Birth Certificate" documenting what was built can be useful.
  - There are a limited number of construction inspectors to do testing. Convincing inspectors that extra data collection is necessary can be difficult, as they are already very busy.
  - Collaboration/sharing between departments (Design, Construction, Maintenance, etc.) and the different data systems they use can be difficult.
  - CONCLUSION: IT'S A CHALLENGE! Further research and input from State DOTs is necessary to identify what else needs to happen.

- **ASTM A1010 High Chromium Structural Steel Bridge**
  - Were the shear studs A1010?
    - It wasn't known for sure, but not likely.
    - If they weren't A1010, it was hypothesized that the difference in material between the studs and the A1010 girder could have contributed to the failure mechanism observed in the lab test specimen.
    - It was noted that the research team believed the shear stud design (modeled directly after the stud design in the actual bridge plans) to be lacking in general.
  - What weld material was used?
    - It wasn't known for sure, but special weld procedures are required for A1010. As such, the research team did not do any welding.
  - Are there other states using/experimenting with A1010?
    - Washington State, Oregon, and Virginia were noted.
  - Iowa DOT does not see much of a future for A1010 use, unless the costs come down significantly.
- **Group Discussion – Avoidance of Deterioration vs. Design Based on the Environment**
  - Avoidance is less involved with regard to design, and easier when it comes to construction inspection. There is a trade-off with cost though.
  - Construction quality control can be an issue.
  - fib method doesn't account for overlays.
  - Stainless steel rebar (multiple grades available, including MMFX all the way up to solid stainless) is a widely used avoidance method.
    - MMFX found to be ~2x as effective as black rebar.
    - Solid stainless found to be ~10x as effective as black rebar.
  - Iowa DOT typically uses epoxy coated reinforcing, as does Michigan DOT. Michigan DOT noted they have used stainless steel, but very rarely.
  - Minnesota DOT noted they have a formal policy on when the use of stainless steel rebar is warranted, and will share with the group.
  - Anyone using galvanized rebar?
    - The consensus was, not really. Not a lot of background study available.
    - The Tappan Zee bridge used galvanized steel rebar in the deck, but the SLD was actually done assuming black rebar.
  - It was suggested that life-cycle cost research comparing stainless steel rebar with lower quality concrete vs. black or epoxy coated rebar with higher quality concrete be done.
  - Is post-tensioning of deck considered an avoidance method?
    - While post-tensioning does reduce potential for cracking, the deck can still be subject to chloride infiltration, so it's not truly an avoidance method. Post-tensioning just ensures the assumption of uncracked concrete used in Fick's 2$^{nd}$ Law is more likely to be true.

# Group Discussion Topics

- **Design Issues – How is concrete cracking taken into account?**

- The corrosion products themselves tend to seal small, static cracks and prevent further corrosion. Large, open, or moving cracks tend to wash-out and don't seal in the same manner. This is a problem.
- Control of cracking and good, dense concrete (between cracks) will tend to control the corrosion process.
- If you had to choose between higher quality concrete with black reinforcing and lower quality concrete with stainless steel reinforcing, what would you pick?
  - Contractors will generally prefer higher quality concrete, as it is often the less-expensive option.
  - Brad Pease/COWI generally prefers to use higher quality concrete with black reinforcing and sufficient concrete cover, except in certain highly corrosive areas.
  - What about epoxy coated rebar? The cost premium vs. black rebar is minimal (~$0.05 in Iowa, for instance), so why wouldn't you use it rather than black rebar?
    - There was lengthy discussion regarding the philosophy of epoxy coated rebar usage. Some believe epoxy coating to be better than no coating, while some believe it's actually a hinderance and can lead to the opening of other avenues of corrosion should the coating be damaged.
- Are there benefits to two-course decks?
  - Iowa DOT noted that some of their longest lasting decks (30-40+ years) are two-course.

- **Construction – How can we verify the durability properties specified in design are achieved during construction?**
  - Quality control is always an issue.
  - More dedicated construction inspectors are needed.
  - More training for construction inspectors is needed. Construction staff sometimes doesn't recognize what's important in the specs, and why.
- **In-Service – How can a regular monitoring plan be implemented to verify that performance matches design intent?**
  - Construction inspectors need guidance and training.
  - Structure "Birth Certificate" or Statewide Plan?
    - A structure "Birth Certificate" can be useful for larger bridges.
    - Statewide plan for policies on recuring testing intervals (5 years? 10 years?)
    - Perhaps a step-wise or corridor-based testing policy is warranted.
  - Asset Management.
  - Bridge Information Modeling (BrIM).
  - Construction data needs to be integrated with inspection and maintenance data.
- **What organizational structures are required to successfully achieve longer lasting bridges?**
  - Challenges of programmatic vs. bridge-specific.
  - Doing anything cyclically can be difficult. Staffing issues often arise (workforce turnover, loss of knowledge, etc.).
  - Traffic control issues for maintenance and inspection.
  - Building relationships between departments (Design, Construction, Inspection, etc.).
  - Funding issues.
  - Develop policies, standards and details around SLD.

# Wrap Up and Adjourn

- **Additional Topics to Consider for Future Peer Exchanges**
  - Discuss upcoming NCHRP Guide Specification for Service Life Design in more detail.
  - Are you willing to consider trying implementation of SLD?
    - The consensus was “yes”.

# Appendix A – Agenda


**SHRP2 R19A Service Life Design for Bridges**
**Midwest Region Peer Exchange**

**Tuesday, September 25, 2018**
**Embassy Suites by Hilton**
**101 E. Locust St., Des Moines, Iowa 50309**

| Time | Topic | Speakers |
|---|---|---|
| 8:30 – 9:05 am | **Welcome and SHRP2 Introduction**<br>• FHWA, AASHTO, & State Introduction (25 min)<br>• Goals of Iowa's R19A Participation (15 min) | Pam Hutton, AASHTO<br>Raj Ailaney, FHWA<br>Jim Nelson, Iowa DOT<br>Ahmad Abu-Hawash, Iowa DOT |
| 9:10-10:30 | **Service Life Design Concepts**<br>• Introduction to Service Life Design (SLD) (30 min)<br>• Implementing Service Life Design for Concrete Structures (30 min)<br>• Group Discussion Topic – What does 100-yr SLD mean? (20 min) | Mike Bartholomew, Jacobs<br>Brad Pease, COWI<br>All participants |
| 10:30-10:45 am | **Break** | |
| 10:45-12:00 am | **R19A Implementation Updates**<br>• Overview of Material Testing for Service Life Design (25 min)<br>• Chloride Surface Loading on Iowa Bridge Decks (25 min)<br>• Group Discussion Topic – Challenges of Durability Testing (25 min) | Brad Pease, COWI<br>Mike Bartholomew, Jacobs<br>All participants |
| 12:00-1:00 pm | **Lunch** | |
| 1:00-2:40pm | **R19A Implementation Updates (continued)**<br>• ASTM A1010 High Chromium Structural Steel Bridge (20 min)<br>• South Skunk River Bridge – Service Life Comparison (25 min)<br>• Thin Polymer Overlays (25 min)<br>• Group Discussion Topic – Avoidance of Deterioration vs. Design Based on the Environment (30 min) | Brent Phares, Iowa State U.<br>Lily Yang, Iowa DOT<br>Ping Lu, Iowa DOT<br>All participants |
| 2:40-3:00 pm | **Break** | |
| 3:00-4:30 pm | **Group Discussion Topics**<br>• Design Issues – How is concrete cracking taken into account?<br>• Construction – How can we verify the durability properties specified in design are achieved during construction?<br>• In-Service – How can a regular monitoring plan be implemented to verify that performance matches design intent?<br>• What Organizational Structures Are Required to Successfully Achieve Longer Lasting Bridges? | Mike Bartholomew, Jacobs – Facilitator<br>All participants |
| 4:30-5:00 pm | **Wrap Up & Adjourn**<br>• Additional Topics to Consider for Future Peer Exchanges<br>• Fill Out Evaluation Forms | Mike Bartholomew, Jacobs |

# Appendix B – List of Attendees

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|---|---|---|---|
| Ahmad | Abu-Hawash | Iowa DOT | ahmad.abu-hawash@iowadot.us |
| Harold | Adcock | Iowa DOT | harold.adcock@iowadot.us |
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| Chad | Meyer | Jacobs | chad.meyer@jacobs.com |
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| Brad | Pease | COWI | brpe@cowi.com |
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| Billy | Varney | West Virginia DOT | william.h.varney@wv.gov |
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| Reza | Zandi | Ohio DOT | Reza.Zandi@dot.ohio.gov |

# Appendix C – Summary of Evaluations

**What were the most important ideas you learned from the workshop?**

- Group discussion was very informative
- Service Life modeling
- 4 Methods of Service Level Design/Practice
- Durability
- Cracked concrete contributions/effects
- Using Service Life Design to improve reliability of predicted strategies
- The advantage of implementing Service Life Design strategies

**Are there questions or issues you wished the workshop had addressed that it didn't?**

**Would you like to learn more about the SHRP2 *Service Life Design for Bridges* (R19A) product?**

- 2 Yes (from Iowa participants)

**Please provide us with additional comments, feedback, or ideas related to this event or future SHRP2 events:**

- Well done. Coverage excellent!

| Rating | Subject Knowledge level prior to workshop | Subject Knowledge level after workshop | Knowledge of SHRP2 prior | Knowledge of SHRP2 after | Overall 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 | Presented clear information |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 2 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 3 | 3 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 4 | 1 | 0 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 5 | 2 | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 6 | 5 | 1 | 3 | 2 | 3 | 3 | 2 | 1 | 0 | 1 | 1 | 1 |
| 7 | 2 | 1 | 1 | 1 | 3 | 3 | 2 | 3 | 0 | 4 | 3 | 2 |
| 8 | 0 | 6 | 1 | 5 | 5 | 5 | 7 | 7 | 7 | 3 | 3 | 4 |
| 9 | 0 | 4 | 0 | 4 | 4 | 4 | 4 | 3 | 5 | 5 | 5 | 5 |
| 10 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 |
| strongly disagree (1-2) | 2 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| moderately disagree (3-5) | 6 | 3 | 7 | 3 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| moderately agree (6-8) | 7 | 8 | 5 | 8 | 11 | 11 | 11 | 11 | 7 | 8 | 7 | 7 |
| strongly agree (9-10) | 0 | 4 | 0 | 4 | 4 | 4 | 4 | 3 | 6 | 6 | 6 | 6 |
| sum | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 15 | 14 | 14 | 14 | 14 |
| % strongly disagree | 13% | 0% | 20% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% | 0% |
| % moderately disagree | 40% | 20% | 47% | 20% | 0% | 0% | 0% | 7% | 7% | 0% | 7% | 7% |
| % moderately agree | 47% | 53% | 33% | 53% | 73% | 73% | 73% | 73% | 50% | 57% | 50% | 50% |
| % strongly agree | 0% | 27% | 0% | 27% | 27% | 27% | 27% | 20% | 43% | 43% | 43% | 43% |