
SHRP2 Structures Solutions Retrospective Workshop Report

Report Overview

This report summarizes the Second Strategic Highway Research Program (SHRP2) Structures Solutions Retrospective Workshop, held on August 22, 2019 in Washington, D.C. The goals of the workshop were to engage agencies involved in SHRP2 implementation activities; discuss experiences and opinions regarding the SHRP2 Program, Structures products, and current disposition of the products; and identify potential next steps. This report summarizes the information shared at the meeting through presentations, group discussions, white papers, closeout reports, meeting materials, product resources, and meeting evaluation forms. While this report does not represent official guidance or recommendations, it captures feedback recorded from the workshop participants and is provided as a resource to the Federal Highway Administration (FHWA) and American Association of State Highway and Transportation Officials (AASHTO) to consider for similar programs in the future. The report is organized in the following sections:

- Overview of the SHRP2 Program
- Themes of the Overall SHRP2 Program (Research and Implementation Phases)
- Overview of the Structures Products
- Themes of the Structures Products
- Overview of Lessons Learned
- Roadmap for the Future
- Conclusion

Appendices include the following:

- Appendix A – Structures Solutions Retrospective Workshop Meeting Agenda and Meeting Materials
- Appendix B – Meeting Evaluation Report Results from Structures Retrospective Workshop Attendees
- Appendix C – Attendee List
- Appendix D – Group Discussion Notes
- Appendix E – Roadmap for the Future

Overview of the SHRP2 Program

SHRP2 is recognized as a complex program with \$232 million dedicated across a nine-year endeavor, involving over 100 research projects and more than 300 research contractors. Its inception was in the form of a congressional request from the Transportation Research Board (TRB), which via FHWA funding was ultimately responsible for research oversight. SHRP2 research produced 63 implementable solutions that help solve various transportation challenges identified by state Departments of Transportation (DOTs), in four focus areas of Safety, Reliability, Capacity, and Renewal. Beginning in 2013, the SHRP2 Implementation Assistance Program (IAP) provided implementation assistance through seven rounds. Transportation agencies have implemented the SHRP2 products on more than 430 projects across the country, in all four focus areas.

SHRP2 implementation was federally funded and state-supported with a total budget of just over \$170 million. A total of \$155 million has been allocated through the IAP, in the form of financial and technical assistance. States provided dedicated staff to implement the products, attended training and peer exchanges, participated in technical assistance visits, and developed reports. According to AASHTO and written in the 2018 SHRP2 End of

Year Report, it is estimated that for every \$1 invested by a state DOT in SHRP2 implementation, there is an average of a \$2 return on their investment in the form of project cost savings, direct funding, and technical assistance. Technical assistance included one-on-one subject matter expert training provided to DOT staff, classroom training, peer exchanges, workshops, webinars, summary reports, and other assistance in the application or implementation of a SHRP2 solution. Over 300,000 individuals have been engaged in the program. Through more than 12,000 outreach activities, SHRP2 showcased the benefits of implementing new and innovative solutions within the field of transportation. In addition to these outreach activities, over 16,000 hours of technical assistance was provided to transportation agencies, largely in the form of consultant support and subject matter expertise.

Themes of the Overall SHRP2 Program

At this workshop, the participants most familiar with the Structures products shared their experiences with the SHRP2 Program as a whole. They identified opportunities for continued improvement, collaboration, and support. Their responses are summarized below and in more detail in Appendix D's group discussion notes. Appendices A-C include the workshop agenda and materials, attendee list, and meeting evaluation responses.

- SHRP2 was a successful model of how to conduct and apply research.
- SHRP2 exposed people to new tools and methods.
- Participants noted that the length of the entire program, including the research and implementation, was unusually long.
- SHRP2 solutions provided a big picture perspective that undertook complex issues that are not easily addressed through NCHRP or state-sponsored research.
- Some of the issues addressed require additional follow up research to take full advantage of the ground work completed in SHRP2 (such as service life design of bridges and NDE), while others are well developed and being fully implemented in some agencies (accelerated bridge construction).
- SHRP2 opportunities for peer exchange allowed states to learn from each other about opportunities and project successes.
- Success would not have happened without the collective, collaborative effort of all the stakeholders.
- Participants noted that more could be done in messaging and marketing the SHRP2 program and products. They acknowledged the challenges among individual states, when information must trickle down from decision makers to implementors. Information presented by AASHTO to its committee members may not automatically transfer further to potential staff implementors.
- Internal champions are vital to the long-term success of SHRP2 products. Without leadership alignment to push implementation efforts it can be even more challenging to see SHRP2 products adopted as part of DOT day-to-day operations.

The SHRP2 program was successful in exposing state DOTs to new tools and methods, providing states opportunities to learn from other states' successes, and providing a big picture approach to transportation solutions. However, the length of the program made it challenging to account for emerging technologies, and the breadth of stakeholders on a variety of levels made reaching everyone a shared challenge. Nonetheless, SHRP2 was a successful model of how to conduct and apply transportation research solutions. Moving forward, internal champions will be vital to the long-term success of the program in order to incorporate SHRP2 products into day-to-day operations.

Themes of the SHRP2 Research Phase

The following summarized points were discussed among participants regarding the initial SHRP2 Research phase:

- The Technical Advisory Committee (TAC) consisted of participants from just four states who developed most of the research topics. While the topics chosen by the small group proved insightful and forward-thinking, in retrospect, broader input from a more diverse group may have added value. In addition, participants noted that there could have been more geotechnical products that fit the target of SHRP2 for long range research for solutions to complex issues.
- Broader outreach and participation during the research phase would have set the stage by preparing states for what was coming, could have built broader interest and investment, and thus would have made the products easier to implement.

The SHRP2 research introduced insightful and forward-thinking research topics. However, the beginning stages of research could have been more inclusive than the four states included in the TAC. Broader outreach and participation during the research phase were needed. Participation in the research phase was a significant time commitment, and it made it difficult to get out-of-state travel approved.

Themes of the SHRP2 Implementation Phase

The following summarized points were discussed among participants in regard to the overall SHRP2 implementation.

Knowledge Management

- States noted the benefit of information sharing with other states regarding lessons learned and project successes. However, discussions would have been more beneficial if other related disciplines were included such as maintenance, design, traffic, construction, procurement, and finance disciplines.
- States found that the peer exchanges, showcases, and workshops were beneficial, but more are needed.

Implementation Assistance Program

- SHRP2 was a good value for the money.
- Successful implementation was only possible through significant funding through the FHWA proof of concept, lead adopter, and user incentive awards.
- The application process for all three implementation assistance levels of engagement (proof of concept, lead adopter, and user incentive) was user-friendly. Compared to typical FHWA funding, this was much easier and faster.
- States appreciated the flexibility available in spending the funds and the flexibility working with FHWA to adapt the scopes in order to obtain practical results.
- States indicated that the time constraints of implementation were too strict. Availability of funding from FHWA for implementation was critical to state DOT adoption of the products but notice of that availability did not reach appropriate people in some states in time to prepare applications for funding awards.
- In some cases, the timing necessary for specific rounds of product implementation was unrealistic with active state project schedules, particularly in regard to state scheduled bridge projects.
- The procurement process to obtain consultant assistance can be time-consuming; one state expressed that consultant support should be provided upfront by AASHTO to save time.
- States felt that the reporting requirements helped solidify lessons learned.

Implementation of the Products with Technical Assistance

- The follow-up and reporting requirements of the implementation phase were useful and encouraged state DOTs to reflect on lessons learned, whereas they might not have done so otherwise.

- States appreciated technical support and found the Subject Matter Experts (SMEs) extremely beneficial.

Adoption as Routine Practice

- SHRP2 provided the additional motivation and necessary funds to apply solutions to known issues.
- Having FHWA, AASHTO, and TRB promoting this effort gave needed credibility to practitioners with leadership.
- Ultimately, successful implementation is dependent upon identifying an internal champion to ensure the product is used within the agency.

Marketing and Communication

- States felt that communication and outreach efforts could have been stronger. It is important to communicate the value of the SHRP2 products and tools.
- Better marketing and messaging to the states during the research phase could have improved implementation.

Overview of Structures Products

The nation's aging bridge inventory calls for new solutions for bridge maintenance, repair, and construction. The retrospective workshop focused on five SHRP2 tools to help transportation professionals build bridges more quickly, build on the proper foundation, use specifications that deliver the right project, design for longer-lasting bridges, generate new load and resistance factor design specifications, inspect concrete bridge decks with greater accuracy, and apply new portable technologies to map and inspect tunnel linings. These innovations can be used alone or in combination at every stage of the bridge design, construction, or preservation process to maximize impacts and save lives, money, and time. The purpose of these products is to provide better information to prolong the life of assets, showing what needs to be done and when it needs to be done. One outreach goal for the SHRP2 Solutions Program as a whole was to reach 10-15% of the states as a "tipping point" to give the products momentum in becoming mainstream solutions. Several of the Structures products more than achieved this goal, with the R04 Toolkit training reaching over 34 states.

Innovative Bridge Designs for Rapid Renewal (R04)

This SHRP2 product supported the application of multiple Accelerated Bridge Construction (ABC) technologies by providing training and technical assistance in the implementation of a design toolkit primarily focused on prefabricated bridge projects. The R04 toolkit provided the following:

- Standard design details, specifications, and concepts for foundation systems, substructure and superstructure systems, subsystems, and components.
- Recommended specification language for ABC systems that are suitable for future inclusion in the AASHTO Load and Resistance Factor Design (LRFD) Bridge Design and Construction Specifications.
- A guidebook with instruction for bridge owners to use prefabricated elements that allow for rapid, cost-effective bridge replacements.
- Design examples for complete prefabricated bridge systems.

The research for the toolkit was completed using two pilot projects and SHRP2 implementation enabled eight bridge projects to apply the toolkit. Six State DOTs, Eastern Federal Lands, and a tribal DOT in Arizona participated. Training and peer exchange on the technologies in the toolkit and the experiences of these implementations were provided to over 36 states.

Nondestructive Testing for Concrete Bridge Decks (R06A)

This product included a collection of geophysical technologies for evaluating and inspecting concrete bridge decks. The nondestructive testing (NDT) technologies include: Impact Echo (IE), Ultrasonic Surface Waves, Impulse Response, Ground-Penetrating Radar (GPR), Infrared Thermography Analysis, Electrical Resistivity, Galvanostatic Pulse, and Half-Cell Potential. A web-based evaluation tool helps transportation professionals select the appropriate NDT technologies for specific applications and identifies test procedures, protocols, available standards, and guidelines.

The goal was to encourage states to use the R06A product and other NDT methods as a means to improve the accuracy and speed of bridge deck condition rating and deterioration mapping while also increasing safety to workers and the travelling public. The NDT results from the use of these technologies can be utilized in asset management programs for long-term use, as well as in project-level evaluations to prepare repair/replacement scopes of work. The R06A product was made available to state DOTs in Round 4 and Round 7. A total of 20 states participated between the two rounds.

Nondestructive Testing for Tunnel Linings (R06G)

This product included a variety of mobile-scanning and hand-held technologies for mapping voids, debonding, delamination's, moisture, and other defects behind or within tunnel linings. The goal was to enable vehicles to drive through the tunnel and conduct the inspection without the need to close lanes. There is a user's manual and guide for evaluating the best NDT technologies for specific situations, as well as a [web-based evaluation tool](#) to select appropriate NDT technologies for specific applications. The implementation of the R06G product was expected to result in a number of states adopting NDT methods as a means to improve the accuracy and speed of tunnel liner condition rating and deterioration mapping, while also increasing safety to workers and the travelling public. The NDT results from the utilization of these technologies can be an aid to practitioners in asset management programs for long-term use, as well as in project-level evaluations to prepare repair/replacement scopes of work. The test results can also be fed into the new National Tunnel Inspection Standards (NTIS) system to improve the overall accuracy and usefulness of the evaluations. Throughout the course of the two IAP rounds, some additional research was conducted by State DOT practitioners to improve the results.

Service Life Design for Bridges (R19A)

Service Life Design is a scientific-based technology solution that identifies how bridges and their components deteriorate over time based on the environmental exposure they are subjected to. The R19A product includes comprehensive guidance to select and design durable bridge elements and components that are both easier to inspect and better-suited to their environments. It evolved into a series of procedures, reports, tools, and worked examples for bridge practitioners to use in developing engineering solutions that will produce bridges that remain in service longer and require fewer major repairs than in the past.

The objective of Service Life Design of Bridges is to complete a rational assessment of the potential deterioration mechanisms affecting bridges and their elements to achieve a target service life duration. The R19A IAP guides the Lead Adopter agencies on how to follow this process. Much of the process is contained in the *Model Code for Service Life Design*, Bulletin 34 published by the International Federation for Structural Concrete (*fib*). The *Service Life Design for Bridges Summary Guide* is a 50-page document supplemented by six appendices of useful data, Service Life Design reference examples, and sample specifications.

The SME team developed Service Life Design tools for evaluating chloride profiles on existing structures and performing full-probabilistic modeling of chloride ingress to assist in the selection of concrete mix designs and cover depth. Agencies were guided in the use of new durability testing procedures for determination of chloride migration properties (NordTest[NT] Build 492). The Academic Toolbox, complete with problem exercises, can be used by university professors to teach the basics of Service Life Design to students. Additionally, a Life Cycle Cost Analysis report, *A Briefing on Life-Cycle Cost Analysis of New Bridge Design Alternatives*, was developed to promote the concept of integrating the principles of Life Cycle Cost Analysis with Service Life Design of bridges to

demonstrate the importance of considering both the initial cost and cost of ownership. The document includes a worked Life Cycle Cost example for maintenance of a bridge and an example wherein Life Cycle Cost Analysis is used to evaluate two potential design features of a bridge.

Service Limit State Design for Bridges (R19B)

The *Service Limit State Design for Bridges* toolkit offers a quantitative framework to assess service limit states more accurately. The toolkit provides actual performance data, component-based distress models, and specific guidance for common bridge elements, as well as:

- A framework for calibrating service limit state specifications.
- Service limit state load and resistance factors.
- Bridge design procedures and model specifications for service limit states.
- Tools required for future service limit state improvements.
- Model specification changes that include designing for durability.

The toolkit contains databases, software tools used in the calibration (such as Monte Carlo spreadsheets), and instructions for developing new or revised spreadsheets and deterioration models.

The framework will calibrate the following AASHTO service limit state design elements:

- Live load deflections
- Bearing movements
- Settlement of foundations and retaining structures
- Permanent deformations of compact steel components
- Fatigue of structural steel and the steel reinforcement in concrete (complementary research being conducted through the National Cooperative Highway Research Program [NCHRP] 12-83)
- Slip-critical bolted connections
- Concrete approaches

Improved service limit state design can increase the service life of bridge components and give designers the option to select bridge components based on expected maintenance time and difficulty of replacement.

Themes of the Structures Products

In addition to providing feedback on the overall SHRP2 program, research, and implementation, the workshop participants shared their experiences with the specific Structures solution products. Their responses are summarized by product below.

Innovative Bridge Designs for Rapid Renewal (R04)

Assessment of Market Readiness

- Over the life of the SHRP2 program, several states, university technology centers, and industry organizations have developed materials and guidance that now surpass the toolkit in terms of completeness and state of the art technologies as they apply to the R04 product.
- ABC implementation continues to be advanced by transportation agencies and can be considered well past the tipping point of market saturation.
- The toolkit was useful to some states less familiar with the concepts of ABC. Positive feedback about the Toolkit was received from the 34 states that hosted the ABC Toolkit Training.

- A few states with more established ABC experience found that the toolkit covered material that was not as helpful to them.
- Messages in the toolkit could be misleading since the cost of utilizing the product concepts alone can give ABC a negative connotation. Participants felt focusing on the needs and benefits to apply ABC techniques in specific locations was a better emphasis than comparing costs.
- Designers want detailed examples the toolkit did not provide including, scoping, decision making frame work, cost estimate, design, specification, procurement method, and construction.

R04 Pilot Project Implementation as Part of the Research Phase

- States were not familiar with how to apply for the pilot project and it required a lot of effort. States had to dig into the application before deciding to pursue the research.
- Acquiring the funding for pilot projects was challenging for the states.
- Representatives involved in the research could have done more outreach and communication to established committees. Collaboration with AASHTO was not apparent until the late stages of the research phase. As an example, T-4 Technical Committee on Construction (Committee on Bridges & Structures) provided comments to the R04 research team, but the committee felt the comments were ignored by the research team.
- Participants also noted there was no involvement from the AASHTO Committee on Construction during the research phase.

Implementation of Product with Technical Assistance

- Outreach from the SME to states was beneficial.
- The SME took experiences from different states and incorporated examples into the state DOT workshops. As a result, the workshops became more valuable over time.
- The states appreciated that the SME interviewed them ahead of time and tailored each workshop agenda to their state specific needs.
- Better collaboration in general and outreach beyond state DOTs is needed. ABC is not just about bridge design.

Knowledge Management

- R04 exposed states to the ABC community. It was helpful to learn from other states and face-to-face peer exchanges, showcases, and site visits; in addition, the webinars were particularly beneficial.
- R04 implementation captured the attention of upper management, which helped drive the ABC program.
- Lessons learned and case studies from pilot projects (Iowa, New York) added value to the implementation phase of this product.
- The product branding was unclear at the start and there were mixed messages about whether to refer to R04 as a SHRP2 product or a toolkit.

Nondestructive Testing for Concrete Bridge Decks and Tunnel Linings (R06A/G)

Assessment of Market Readiness

- The equipment is easy to learn how to use as long as the implementers understand the limitations of the technology and the need to confirm with traditional inspection methods
- Even among NDT experts, the results interpreted from data are not standardized.

- There are still a limited number of applicable uses identified for NDT.
- Due to the complexity of this product, it appears holistically this product is not market ready.

Implementation of the Product with Technical Assistance

- The SME was easy to work with and knowledgeable about how to use the tools.
- The workshops were hands-on, which was beneficial. Participants toured tunnels and bridges and saw the technology being used in the field.
- Monthly phone calls facilitated learning about what other states were doing. Specifically, it helped the Oregon Department of Transportation (ODOT) frame its project.
- The test results are difficult to understand and interpret.
- The collected data can take a significant length of time to interpret.
- Traditional test methods are still required to verify the results.
- Pennsylvania found that the use of technology was more expensive than utilizing traditional test methods.
- North Dakota used Infrared (IR) solely because it is easier to interpret than Ground Penetrating Radar (GPR).

Knowledge Management

- Peer exchanges provided an opportunity to get feedback from other states.
- There is a misunderstanding among states regarding what type of information each test method provides and how best to use the data.
- GPR users do not always find it intuitive and new applications have had to overcome historical stigmas from past performance issues.
- The Nondestructive Evaluation (NDE) Web Manual is a useful resource for practitioners that is searchable and application-based; it can be found at the following FHWA website <https://fhwaapps.fhwa.dot.gov/ndep/>.

Service Life Design for Bridges (R19A)

Assessment of Market Readiness

R19A was straightforward and implementable and formed the basis for the new AASHTO Guide. The product provides a foundation for use and the concepts have been included in a new AASHTO Guide for Service Life Design that is fully implementable.

- DOTs have been considering service life for a long time but have been doing it subjectively. R19A provided an analytical method for quantifying service life.
- R19A is a data-driven approach. It is difficult to fully utilize if the appropriate data are unavailable or the staff lacks the skills to effectively implement it.
- Cracks in concrete are a reality, therefore a literature search and/or additional research on effects of cracks on concrete durability would be helpful to correlate with the service life design assumptions.
- The durability assessment, sometimes referred to as a birth certificate which documents bridge design and as-built conditions, is beneficial.
- State DOTs liked how the product was structured. If you want simple answers, it shows you the process and provides guidance on how to go through detailed formulas and design examples step by step.

- The worked examples are helpful and demonstrate how formulas are applied in practice.

Knowledge Management

- The explanation of service life design was satisfactory, but it can be better in terms of how cracks are considered once additional research on deterioration rates with cracking is conducted.
- State DOTs struggle with achieving durable bridge design and construction. Neither the construction nor materials committees were involved in the product research or implementation of the R19A product.
- It is important to stress that there is a need to understand the environment around the bridge before evaluating the service life design.

Service Limit State Design for Bridges (R19B)

Product Research Phase

- Initially, there were not enough data to properly calibrate the settlement of bridge footings. When WSDOT became involved during the research phase, they helped expand the database and calibration of the model.
- The lead researcher was very helpful and open to working with WSDOT to produce a successful product.
- The research accomplished predictions for the settlement of bridge footings on soil, but other aspects of bridge foundation (e.g., lateral deformations, retaining walls) were not addressed.
- The products from R19B provide a framework for calibration that can be used to improve the R19A service life design process after additional bridge performance data is collected.

Implementation of the Product with Technical Assistance

- To date, there have been no states implementing R19B, but the funding produced documentation and future training to instruct and inspire the use of the formulas and calibrations.

Knowledge Management

- This is a highly technical exercise and for most people it is difficult to understand; however, the reliability basis is transparent, and there is no additional knowledge needed to apply the code-based equations that were developed.
- The research was not inclusive of key stakeholders and implementers.

Overview of Lessons Learned

The workshop participants were asked to consider future efforts to implement a set of technical products coming out of research and what they might do the same or differently in terms of their SHRP2 experience.

Assessment of Market Readiness

- Capitalize on the value of pilot projects during the research phase to inform future implementation.
- Consider including supporting technologies and disciplines (e.g., geotechnical) in the research development process so product solutions are more widely applicable.
- Establish synergies between product technologies and data collected, to demonstrate to the states the economy of purchasing equipment with multiple uses.
- Involve more states in the research development process to establish invested interest and better prepare them for future implementation.

Knowledge Management

- Continue to encourage information sharing among states regarding lessons learned and project successes.
- Involve all disciplines in research and implementation discussions to better understand different perspectives and issues to be addressed.
- Facilitate more peer exchanges, showcases, and workshops to support greater knowledge transfer among state DOTs.
- Consider the best methods of information sharing in light of younger generations being more tech- and virtual-focused.

Implementation Assistance Program

- Maintain a simple application process and flexibility in how to use funds to encourage states to apply for the program.
- Continue to enable scope adaptations so states can obtain practical results.
- Establish more realistic implementation time periods to better align with project schedules.
- Consider allowing a third party (i.e. AASHTO) to provide state-selected consultant support upfront to save state DOTs time spent procuring a consultant.
- Maintain reporting requirements to help solidify lessons learned.

Implementation of the Product with Technical Assistance

- Continue to provide technical and SME support to assist states in implementation.
- Host more staff training, showcases, and peer exchanges to round out the technical assistance efforts.

Adoption as Routine Practice

- Encourage FHWA, AASHTO, and TRB to promote future programs to give needed credibility to practitioners with their leadership.
- Identify internal implementation champions to support institutionalization of products within agencies.

Marketing and Communication

- Conduct additional outreach to communicate the value of the SHRP2 products and tools.
- Increase marketing and messaging to state DOTs during research to establish invested interest and better prepare them for future implementation.
- Host additional peer exchanges, showcases, workshops, and trainings beyond state DOTs (i.e. contractors, consultants, technology vendors) to engage a wider audience in SHRP2 efforts.

Roadmap for the Future

This section identifies the recommended actions/next steps and lead agency in furthering each of the SHRP2 Structures products discussed during this workshop. Additional notes from the meeting are detailed in Appendix E.

Innovative Bridge Designs for Rapid Renewal (R04)

Participants recommended the following actions for R04 moving forward:

- Maintain responsibility for updating the toolkit

- Lead Agency: FHWA
- Market ABC at workshops and showcases
 - Lead Agencies: AASHTO, FHWA

Nondestructive Testing for Concrete Bridge Decks and Tunnel Linings (R06A/G)

Participants recommended the following actions and lead agencies for R06A/G moving forward:

- Develop protocols for the different NDT tools and their use with different materials
 - Lead Agency: Federal Highway Administration (FHWA)
- Establish standards for recording and collecting NDT data among the various tools
 - Lead Agencies: FHWA, American Association of State Highway and Transportation Officials (AASHTO)
- Develop a better understanding of interpreting NDT data in multiple environments
 - Lead Agency: FHWA
- Establish an NDT Pooled Fund and host an Expert Task Group (ETG) made up of FHWA, state DOTs, industry, and academia
 - Lead Agency: FHWA
- Develop a matrix of NDT technologies, types of NDT applications and specific uses that need to be addressed
 - Lead Agency: Expert Task Group (ETG)
- Identify gaps in NDT applications and technologies that need additional research
 - Lead Agency: ETG
- Lower costs by communicating state needs with industry providers
 - Lead Agency: ETG
- Maintain and further disseminate the FHWA NDE Web Manual
 - Lead Agency: FHWA
- Incorporate NDT data into bridge and tunnel condition ratings and/or state DOT asset management programs
 - Lead Agencies: AASHTO, NCHRP
- Create a Return on Investment (ROI) case study on which NDT methods generate the biggest return on investment
 - Lead Agencies: FHWA, ETG

Service Life Design for Bridges (R19A)

Participants recommended the following actions and lead agencies for R19A moving forward:

- Update the AASHTO Provisional Standard Measurement of Initial Asphalt Adsorption and Desorption in the Presence of Moisture (TP-6)
 - Lead Agencies: AASHTO Technical Committee on Bridge Preservation (T-9), AASHTO Committee on Materials and Pavements (COMP)
- Develop a training workshop on how to conduct a full-service life design
 - Lead Agency: FHWA
- Establish a national environmental exposure zone map
 - Lead Agencies: AASHTO T-9, NCHRP, TRB

Service Limit State Design for Bridges (R19B)

Participants recommended the following actions and lead agencies for R19B moving forward:

- Fund a calibrations study for tunnels
 - Lead Agencies: TRB, T-20 Technical Committee on Tunnels
- Encourage states to obtain more data, especially for lateral deformations
 - Lead Agency: Pooled Fund Study, with guidance from AASHTO and FHWA
- Establish a synergy between NCHRP 12-108 Guide Specifications for Service Life Design of Highway Bridges and R19B
 - Lead Agency: AASHTO T-9
- Increase or re-define the educational efforts to develop buy-in for this methodology
 - Lead Agency: FHWA

Conclusion

The workshop successfully engaged state DOTs involved in SHRP2 implementation activities and yielded key takeaways regarding the SHRP2 program, the SHRP2 Structures products, current disposition of the products, and next steps. While the process of implementing SHRP2 and its success varied across different locations and contexts, the SHRP2 program and Structures products were overall successful in helping state DOTs address important transportation related challenges.

The success of SHRP2 will in part be measured by the extent that the products, tools, and resources developed during the program continue to be utilized. Although SHRP2 funding is no longer available to support the implementation of the Structures products, the products with the greatest value to state DOTs and other agencies will continue to be supported and utilized. FHWA, AASHTO, and TRB successfully collaborated to support SHRP2, and the lessons learned, and recommended actions gathered from this workshop will be used to support and develop future initiatives.

Appendix A – Structures Solutions Retrospective Workshop Meeting Agenda and Meeting Materials



Photos courtesy: UDOT, MDOT, ADOT, MassDOT

Preliminary Agenda

SHRP2 Solutions: Structures Focus Area Workshop

Thursday, August 22, 2019

Hall of States, 444 North Capitol Street, NW, Room 233/235, Washington, DC

This workshop is intended to identify progress on SHRP2 structure products in terms of research, implementation, lessons learned and suggested next steps after the SHRP2 program concludes.

8:00 am	<p>WELCOME AND INTRODUCTIONS</p> <ul style="list-style-type: none"> • Round robin self-introductions: <ul style="list-style-type: none"> ○ Involvement with Products ○ Overall Involvement with SHRP2 	
	SHRP2 OVERVIEW	
	<ul style="list-style-type: none"> • High-level overview of all the SHRP2 Structures products including: <ul style="list-style-type: none"> ○ Background of why they were developed ○ Goals of the implementation research ○ Results of the pilot efforts and where we are today 	Patricia Bush, AASHTO Shay Burrows, Acting Director FHWA
8:30-10:40 am	STRUCTURES PRODUCT PANELS	
	<ul style="list-style-type: none"> • Innovative Bridge Designs for Rapid Renewal (R04) – 15 minutes <ul style="list-style-type: none"> ○ SME: Finn Hubbard, Fickett Inc. ○ R04 Specific Discussion (10 minutes) • Nondestructive Testing for Concrete Bridge Decks (R06A) – 15 minutes <ul style="list-style-type: none"> ○ SME: Dennis Sack, Olson Engineering • Nondestructive Testing for Tunnel Linings (R06G) – 15 minutes <ul style="list-style-type: none"> ○ SME: Dennis Sack, Olson Engineering ○ R06A/G Specific Discussion (10 minutes) • Service Life Design for Bridges (R19A) – 15 minutes <ul style="list-style-type: none"> ○ SME: Mike Bartholomew, Jacobs Engineering Group ○ R19A Specific Discussion (10 minutes) • Service Limit State Design for Bridges (R19B) – 15 minutes <ul style="list-style-type: none"> ○ SME: Naresh Samtani, NCS GeoResources ○ R19B Specific Discussion (10 minutes) • General Discussion on future FHWA work - 15 minutes 	
10:40-10:50 am	BREAK	

10:50-11:30 am	GROUP DISCUSSION – OVERALL FEEDBACK ON THE SHRP2 PROGRAM	
	<ul style="list-style-type: none"> • Focusing specifically on the SHRP2 Research phase: • Focusing specifically on the SHRP2 Implementation phase: • Key takeaways from the entire SHRP2 research program <ul style="list-style-type: none"> ○ What would you do differently? ○ How could communication regarding the SHRP2 been improved? 	Mara Campbell, Jacobs
11:30-12:30 pm	GROUP DISCUSSION – SPECIFIC FEEDBACK ON SHRP2 STRUCTURES PRODUCTS	
	<p>How successful was the implementation of the specific SHRP2 Structures products</p> <ul style="list-style-type: none"> • Innovative Bridge Design for Rapid Renewal (R04) (20 min) • Non-Destructive Testing for Concrete Bridge Decks and Tunnel Linings (R06A/R06G) (20 min) • Service Life Design for Bridges (R19/ R19B) (20 min) 	Mara Campbell, Jacobs
12:30-1:30 pm	LUNCH	
1:30-3:30 pm	GROUP DISCUSSION – NEXT STEPS FOR THE SHRP2 STRUCTURES PRODUCTS	
	<p>Next steps for these three topics are:</p> <ul style="list-style-type: none"> • Innovative Bridge Design for Rapid Renewal (R04) (30 min) • Non-Destructive Testing for Concrete Bridge Decks and Tunnel Linings (R06A/R06G) (50 min) <ul style="list-style-type: none"> ○ NDE Research Roadmap • Service Life Design for Bridges (R19A/R19B) (40 min) 	Mara Campbell, Jacobs
3:30-3:45 pm	BREAK	
3:45 pm	SUMMARY – What’s missing?	Mara Campbell, Jacobs
4:30 pm	WRAP UP	
	Final thoughts?	Mara Campbell, Jacobs
5:00 pm	ADJOURN	Patricia Bush, AASHTO

Flash Drive Contents

The flash drive provided the following documents:

- SHRP2 Implementation Assistance Plan Initial Reports (several from 2014)
 - R04 IPW Implementation Plan
 - R06AG Implementation Plan
 - R19A Implementation Plan
 - R19B Implementation Plan
- Structures Products Final Close Out Reports
 - R04 Implementation Summary Report
 - R04 Workshop Summary
 - R06A Final Report
 - R06G Final Report
 - R19A Final Report
 - R19B Final Report
- SME White Papers on Structures Products
- SHRP2 Service Life Design Guide and Appendices
 - Academic Toolbox Report
 - Appendix A – RFP Examples
 - Appendix B – NT Build Results
 - Appendix C -Chloride Threshold
 - Appendix D – Design Examples
 - Appendix E – Concrete Spec Update
 - Appendix F -Birth Certificate
 - Summary Guide – WIP Main Report
- SHRP2 Service Limit State Design for Bridges R19B Structures Toolbox
 - R19B Implementation Report
 - R19B Incorporation of Foundation Movements in AASHTO LRFD
- NDE Research Roadmap
- SHRP2 Bridge Brochure
- SHRP2 NDT Methods Brochure
- SHRP2 2018 End of Year Report
- SHRP2 IAP Brochure

In addition, you will find materials on the product web pages:

- AASHTO SHRP2 website: <http://shrp2.transportation.org>
- SHRP2 FHWA website: <https://www.fhwa.dot.gov/goshrp2/Solutions/Renewal/List>

Appendix B – Meeting Evaluation Report Results from Structures Retrospective Workshop Attendees

Rating	Overall Content Effective	Presentation Effectiveness	Expectations Met	Presenters delivered clear information
1	0	0	0	0
2	0	0	0	0
3	0	0	0	0
4	0	0	0	0
5	1	1	0	0
6	0	1	1	1
7	2	2	3	1
8	2	1	2	1
9	2	2	1	4
10	5	5	5	5
strongly disagree (1-2)	0	0	0	0
moderately disagree (3-5)	1	1	0	0
moderately agree (6-8)	4	4	6	3
strongly agree (9-10)	7	7	6	9
sum	12	12	12	12
% strongly disagree	0%	0%	0%	0%
% moderately disagree	8%	8%	0%	0%
% moderately agree	33%	33%	50%	25%
% strongly agree	58%	58%	50%	75%

What were the most important ideas you will take away from the workshop?

- SHRP2 resulted in a lot of useful products.
- How can I help in promoting products at my DOT?
- Communication and outreach regarding work for DOTs is still a challenge.
- The need for effective coordination.
- Had good discussion on lessons learned and benefits realized in research and implementation of renewal products and the way forward.
- In addition to our participation in R06A, I have learned about the other SHRP2 products, particularly ABC and Service Life of Bridges.
- Importance of deployable results
- Specification development is important for the successful deployment of products.

- Use of standards and development of templates and procedures for data collection.
- Enterprise software for utility conflict management

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

- None.
- I think it is hard, but there should be a mechanism for future follow-up that is the responsibility of workshop participants. I think the "next steps" content will get lost in just a report out by Jacobs.
- Should have focused on implementation process and future needs not technical details.
- No!

What else could the Federal Highway Administration do to support you or your agency in promoting SHRP2 Structures Products?

- Additional webinars and maintain web links for document downloads.
- Continual emphasis on NDE.
- Possible funding grants accompanied by concrete data.
- Fund ABC showcases.
- Fund/Facilitate contractor/DOT workshops.
- Coordinate w/AASHTO, T4 & Accelerated Bridge Construction-University Transportation Center (ABC-UTC).

How might AASHTO further support you or your agency in promoting SHRP2 Structures Products?

- Promote through AASHTO Webinars.
- Continued discussions with committees for service life considerations (R19A).
- Continue to support with guidance specs.
- Strong collaboration with other national ABC efforts.

Please provide us with additional comments, feedback, or ideas related to this event:

- Enjoyed the informative event. Well put together. Thanks.
- Event was coordinated and delivered very successfully.
- Awesome get together and learning opportunity.
- Great candid discussions.
- Great facilitating is important - well done Mara!

Appendix C – Attendee List

SHRP2 Structures Workshop R04 R06A/G R19A R19B AASHTO Hall of States, Washington DC – August 22, 2019			
Last	First	Agency	Email
Abu-Hawash	Ahmad	Iowa DOT	ahmad.abu-hawash@iowadot.us
Ailaney	Raj	FHWA	raj.ailaney@dot.gov
Azari	Hoda	FHWA	hoda.azari@dot.gov
Bartholomew	Mike	SME	mike.bartholomew@jacobs.com
Burrows	Shay	FHWA	shay.burrows@dot.gov
Bush	Patricia	AASHTO	pbush@ashto.org
Campbell	Mara	Jacobs	mara.campbell@jacobs.com
Conway	Joe	FHWA	joe.conway@dot.gov
Dutkiewicz	Carly	Jacobs	carly.dutkiewicz@jacobs.com
Elkaissi	Jamal	FHWA	jamal.elkaissi@dot.gov
Farrar	Matt	Idaho DOT	matt.farrar@itd.idaho.gov
Hersh Simmons	Cheryl	Utah DOT	cherylhersh@utah.gov
Hubbard	Finn	SME	fhubbard@fickettinc.com
Huether	Nancy	North Dakota DOT	nmhuether@nd.gov
Hutton	Pam	AASHTO	phutton@ashto.org
Johnson	Bruce	Oregon DOT (retired)	bruce.v.johnson@gmail.com
Luebke	James	Wisconsin DOT	james.luebke@dot.wi.gov
Macioce	Tom	Pennsylvania DOT	tmacioce@pa.gov
Mellon	Dorie	Caltrans	dorie.mellon@dot.ca.gov
Nallapaneni	Prasad	Virginia DOT	prasad.nallapaneni@vdot.virginia.gov
Nichols	Silas	FHWA	silas.nichols@dot.gov
Ruzzi	Lou	Pennsylvania DOT	lruzzi@pa.gov
Sack	Dennis	SME	dennis.sack@olsonengineering.com
Samtani	Naresh	SME	naresh@ncsgeoresources.com
Smoker	Jen	Jacobs	jennifer.smoker@jacobs.com
Swanwick	Carmen	Utah DOT	cswanwick@utah.gov

Appendix D – Group Discussion Notes

August 22, 2019

Group Discussion

1. Overall SHRP2 Program, Research, and Implementation

- North Dakota – tend to be conservative about trying new things. NDDOT participant was new and came in during implementation phase. Had heard internal conversations about looking at IR. It was great to have the opportunity to explore and learn, but she didn't know much about the SHRP2 program. When she reached out to people, they were great to work with once she found out about it.
- Wisconsin – helpful to reach out to key players to find out about opportunities and project successes. Asking the right folks.
- PennDOT – good part about it was it got a lot of people exposed to new tools and methods of how to do their job. Wasn't familiar with how to apply – fooled around for a few months. SME was helpful. It was just a lot of effort – 8 months before everything was set up, wrote report, and was ready to present it. Make process easier to navigate and clearly designed. Less effort on DOT side. Hire consultant to run the contract.
- ODOT – Implementation side there was a big effort to get the word out. Research side was more of a closed group – would've been good to broaden it out. 2006 – small group that brainstormed the topics. On one had need to applaud the topics that were developed. They were insightful and forward thinking but it was 4 people. Don't know if we would've come up with anything better if it were a bigger group but recommends having a bigger group next time around. Technical input from TCCs – on bridge side there were 4 people that represented the industry on guiding the research that went through. Ended up with some good projects and documents but there should be wider input. Have to have a manageable group.
- TAC that focused on carryout research project, which reported to the TCC.
- The qualifications were adequate but reaching out through AASHTO to a larger number of states would've helped let states know that the research was coming.
- Had to dig into application a bit to decide if you wanted to do it.
- With more outreach and participation during the research it would've been easier to implement.
- Within individual state, information needs to trickle down. AASHTO sends info to committee members but doesn't know what happens with it after that.
- Implementation based on a certain time period which seemed unrealistic to North Dakota – if had been involved earlier on would've had time to create projects. Takes months to just advertise projects. It only worked because they had a project that was already underway.
- Application process for the grant was very user friendly.
- Because of the timing once they had the grant – seven funding sources for project – the money had to be identified. 3 months trying to reestablish contact with AASHTO/FHWA.
- Beginning stages of research wasn't very inclusive.
- It was slow and needed more marketing and messaging to the states. That probably happened at some point but at DOT need to make sure you're talking to the right person.
- SHRP2 funding was a money source but there is not enough force and leadership alignment for these activities to become daily. Need a leader, implementation champion. Introduce information in

colleges. Once the research is done, it is done. Have to figure out a way to imbed it into the day-to-day operations of the DOT.

- Thinks SHRP2 is appropriate that it looks at the bigger picture. Original ideas put on table in 2006 and here we are in 2019 – took too long.
- Iowa – likes flexibility. Open to ideas on scope and work plan. Keep that. We're going to do a lot of the stuff anyways, but this provided additional motivation and funds.
- Caltrans – if we had done a project by ourselves, might have done it and looked away. Received money were required to submit reports and do all this other stuff.
- Can demonstrate to management the exposure that's worth the funds
- Compared to other FHWA funding this was much easier and faster.
- BIM – in the future would help accelerate the program
- Didn't go after 19B because it focused more on the specification side. The product they applied for they had need for.
- Can be implementable when a bridge is new but more difficult on an existing bridge.
- Difficult to start it because it is expensive.
- The research efforts were done within 4-5 years. Implementation took a decade, which is too long.
- The TCC started talking about implementation as soon as the products were underway. Attempt to frame the project for implementation.
- Too many soft products.

2. Product Specific Feedback - R04

- Acquiring the funding was a hassle.
- Collaboration with AASHTO did not happen.
- There were a few reps involved in research but did not reach out to established committees as well as they could have.
- Utah made comments on product that were completely ignored from AASHTO.
- Collaboration in general – didn't consider all of the disciplines involved.
- The toolbox wasn't original research – it compiled everything out there. It didn't go into areas that weren't already well developed.
- Messages in it were a little misleading – shouldn't discuss the cost of the product. Gave it a negative light.
- ABC isn't just about bridge design and there was no involvement from the committee on construction. Wasn't looked at holistically.
- It's hard to determine what kind of guidance to give designers. Need to have better alignment with AASHTO specifications. It's a process to become part of AASHTO's specifications.
- Iowa was involved in pilot early on – difficult because toolkit wasn't fully developed.
- Outside the scope of what the AASHTO specifications are supposed to address. They're not designed to go together. ABC guide document acts differently than the AASHTO specifications. Take a separate

subcommittee of AAHSTO people to design document that puts innovation out on the street and then determine how to codify it.

- Lots of different groups – funding to support collaboration. Establish an ETG. Clarify who’s doing what.
- When first applied for grant, it was called a toolkit, and then was told not to called it a toolkit but a product. What happened internally? Toolkit branding.
- Need to rethink how we train and share the information. Workshops don’t work for a lot of people – how often do they go back and share? Rethink websites, modules.
- The deliverables were good and helpful. The follow up and documentation of lessons learned was a plus.
- Penn- had never done ABC bridge. Consultant used toolkit to design bridge.
- ODOT – thought toolkit was elementary.
- Finn was able to take experiences from different states and incorporated examples into the workshops – because more valuable over time.
- We haven’t taken all of this learning and put it back into the toolkit.
- Finn asked what the states wanted to see in the workshop agenda.
- Vision that allowed products to be flexible.
- Captured attention of upper management and helped drive ABC program.
- Caltrans exposed to ABC community as a result – most powerful outcome.
- Knowing what other states had done and bringing in lessons learned was great. Face-to-face time is helpful.
- New generation wants to learn differently – need both online and face-to-face training.
- Designers want detailed examples of how to do something. Did not hit the mark with this.
- Document was useful – elements that you couldn’t just know by flipping through it.
- Need to find internal champion.
- Size of DOT can affect change culture.
- Outreach from SME was beneficial.
- Outreach beyond states.

3. Product Specific Feedback - R06A/G

- Easy to talk to people, get info, do the application, follow up (reporting) was good but minimal.
- Flexibility.
- Peer exchanges – opportunity to get feedback from other states, peer support.
- Hands-on. Workshop was beneficial. Went out to tunnel and used technology right there.
- Good learning curve. If it is usable it’s good to go.
- Monthly phone calls facilitated learning more about what the other states were doing. Helped ODOT frame project.

- Olson was a good SME, easy to work with, and knew how to use the tools.
- The report themselves weren't as helpful as talking to the SME.
- Reports outlined action items for CA, but the Caltrans participant wasn't aware.
- Give consultant help upfront. Could've saved three months if AASHTO/FHWA provided consultant.
- It is difficult to understand the results/end products.
- Non-standardization on results among NDT experts.
- Use of it is narrow.
- Still have to use traditional methods to verify the results.
- PennDOT – found it was more expensive.
- Part of the reason ND did IR because it is much easier to interpret than GPR.
- Bad stigma around GPR – not always intuitive. Have to have someone do for you and build trust that they're going to do it right.
- Takes a long time for data to be interpreted.
- Documentation that was released focused on the methods, limitations, pros and cons. Change the focus to applications. More user-friendly. NDE web manual is searchable and more application-based.

4. Product Specific Feedback - R19A/B

- Nobody understands it – A seemed straightforward but couldn't get information out of it which was necessary to do B.
- Data-driven approach. However, not helpful if data is unavailable or staff is lacking.
- Design ideas and recommendations were good but assume that bridge deck is in good condition. Reality is there are cracks – design assumptions are not accurate. Built around assumption that the concrete is not going to crack.
- How do you get them to build what they've designed? Didn't include construction committee or materials.
- Europe has been doing this for a long time.
- Didn't do as good of outreach. Make better known how cracks are considered.
- Created the Birth Certificate – good!
- DOTs have been considering service life forever but have been doing it subjectively – product provided analytical way to quantify service life.
- Foundation for future work.
- Like how it's structured – if you want a simple answer, this shows you the process.
- Provides guidance how to go through detailed formulas.
- Provides future vision.
- Struggling with good construction. How do you make that last?
- Focus on durability.
- Worked examples to see how formulas are applied in practice.

Appendix E – Roadmap for the Future

R04

- AASHTO is responsible for the guidance (Toolkit)
- Market ABC at workshops, showcases [AASHTO, T-4 to develop the material for the roadmap. In partnership with FHWA, who will sponsor the training]
- Contractor focused training?
- Leave it up to T-4 to decide what's next with the toolkit
- Lot of turnover with staff at the state level – toolkit provides guidance. Needs to be updated and add specifications.
- Make the toolkit web-based – easier to update
- Manual on bridge slide but need examples that are really helpful
- Duplication of effort if we decide to update it. The toolkit served its purpose. ABC is still utilizing the same design. Limited funding.
- What are the goals of the toolkit? What are the goals of the guide spec? Are they aligned, or do they bring something different? Are they both worth being updated?
- T-4 already working to update information. Work collaboratively with T-4/AASHTO and FHWA
- Contractor involvement – something we really lack. Difficult time interacting with contractors. AGC is meant to help with this but it's not working in CA.
- Consider ABC for every bridge
- Ways to justify cost of ABC

R06A

- Protocol for different NDT tools [FHWA] - Marketing of web manual. What is the limitation of each method – where it can be used. [FHWA]
- Establish standards – define the applications, gaps, standardization [collaboration between FHWA and AASHTO committee]
- You can get the data, it's how you can use it. Better understanding of the data [FHWA]
- Speed vs. accuracy
- One ETG for NDT efforts
- Create a support group/forum for states to communicate and exchange information. Structured conference call [ETG/FHWA]

R06G

- FHWA ETG made up of FHWA, states, industry, academia [FHWA]. Lead person that manages the group.
- Define types of applications that we want addressed by that industry/desired outcomes – actually technology has to be done by the industry. [ETG]
- Identify gaps that we want addressed. [ETG]
- Get costs down by working/communicating with industry. [ETG]
- Maintain NDE web manual. [FHWA]

- Incorporate NDT data into bridge and tunnel condition ratings/asset management program. Accurate quantities. [AASHTO/NCHRP] Long term: Should be in FHWA coding manual.
- Create an ROI case study or lessons learned on which methods create the biggest return. [FHWA, ETG]
- Develop a spec that DOTs can use. It would be a huge undertaking and there's so much variability. Long-term task for FHWA in collaboration with AASHTO. Leverage the work EDC-5 is doing and collaboration. Standardization of results.

R19A

- Update the AASHTO TP-6 [T-9, AASHTO Materials]
- A lot of effort to go through to make decisions. Not sure whether to move forward or not.
- Some states have design specifications that they've designed over time that seem to be working.
- NCHRP guide 12-108 is a simplified guide and might not go back to R19A unless the project requires detail.
- Products are developed. They're there, they're complete.
- Education, training of how to do a full-service life design of a bridge. [FHWA]
- Establish what exposure zone you're in through a site-specific study or national map. Environmental exposure map. [T-9, NCHRP, TRB]
- Epoxy steel and other materials - how to incorporate it into the life cycle costs. Use as one of examples.
- Vision is 10-15 years re-write 12-108 based on the partial factor method consistent with LRFD specs. Vision of where we want to go in the future. Not ready for this yet. Need a diverse group to agree with the direction.

R19B

- Re-calibration of factors and adding in new factors in LRFD
- Factors worked and did what they were supposed to do
- Framework for future calibrations of different features for LRFD. It should be a model for future calibrations and for states who want to do their own calibrations.
- R19A could benefit from R19B model
- Further work between the two products
- Improve messaging
- Load table is intended to inform bridge engineers
- If differential settlement is not calculated right, then there will be cracks.
- Targeted at bridge engineers, not geotechnical engineers
- Communicate to the right audience
- There was a huge structural component to R19B; it was not only geotechnical.
- PennDOT – looking to calibrate the factors for tunnels. Being told by NCHRP that nobody likes hearing about calibrations and they don't like to fund this stuff. Further conversations with tunnel folks on R19B. Fund calibrations study for tunnels. [TRB, NCHRP]
- Increase clarity of data

- Data problem on geotechnical side – how do you solve this on a national level? Need more data.
- Encourage states to get more data. [States with guidance from AASHTO and FHWA]
- Data standardization – FHWA data dictionary
- Synergy between NCHRP 12-108 and R19B [AASHTO T-9]
- The methodology for calibration in R19B should be the base document that we use from now on in calibrations.
- More educational efforts/resources [FHWA]
- 5-hour web-based training being launched through FHWA