

MEETING SUMMARY

SHRP2 PERFORMANCE SPECIFICATIONS FOR RAPID RENEWAL (R07) SHOWCASE

TO: Jennifer Balis, Richard Duval, Keith Platte, Pam Hutton, Kate Kurgan

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MEETING DATE: March 14-15, 2017

LOCATION: Holiday Inn Express, Salt Lake City, Utah

Purpose

The SHRP2 Performance Specifications for Rapid Renewal (R07) Showcase was to facilitate an open exchange through conversation among participants of current practices and lessons learned using the SHRP2 guidance on performance specifications. Several of the lead adopter states facilitated these discussions. The goal was to engage participants on the benefits and challenges of using performance specifications and to provide suggestions to encourage states and contractors to implement them.

Attendees

- American Association of State Highway and Transportation Officials (AASHTO) – Keith Platte, Associate Program Director; Pamela Hutton, SHRP2 Implementation Manager; and Kate Kurgan, SHRP2 Implementation Associate Program Manager
- Federal Highway Administration (FHWA) – Jennifer Balis, Project Manager; Richard Duval, Construction Research Engineer; Paul Ziman, Pavement and Materials Engineer, FHWA Utah Division, Assistant Division Administrator, Vermont Division; and Brad Neitzke, Materials Engineer, Western Federal Lands
- Alabama Department of Transportation (ALDOT) – Lyndi Blackburn, Assistant State Materials and Tests Engineer
- Arizona Department of Transportation (AZDOT) – Todd Emery, Deputy State Engineer and Julie Kliewer, State Construction and Materials Engineer
- California Department of Transportation (Caltrans) – Srikanth Balasubramanian, Chief, Office of Asphalt Pavements; Charles Susko, Chief, Office of Contract Administration
- Colorado Department of Transportation (CDOT) – Amanullah Mommandi, Research Engineer

- Idaho Transportation Department (IADOT) – John Bilderback, Construction and Materials Engineer and Jake Legler, Technical Engineer
- Maine Department of Transportation (Maine DOT) –Richard Bradbury, State Materials Engineer
- Missouri Department of Transportation (MoDOT) – Bill Stone, Research Administrator and Daniel Oesch, Field Materials Engineer
- Montana Department of Transportation – Matt Needham, Testing Operations Supervisor and Chad Richards, Engineering Cost Analyst
- North Carolina Department of Transportation (NCDOT) – Jess Earley, Research and Investigations Engineer and Kevin Lacy, State Traffic Engineer
- Nevada Department of Transportation (NVDOT) – Steven Hale, Quality Assurance Engineer and Charlie Pan, Assistant Chief Materials Engineer
- North Dakota Department of Transportation – Kevin Gorder, Assistant District Engineer and Justin Ramsey, Transportation Engineer Manager
- Hawaii Department of Transportation – Brian Ikehara, Materials Engineer and James Kephart Materials Testing and Research Engineer
- Utah Department of Transportation – Seven Anderson, State Pavement Design Engineer; Howard Anderson, State Asphalt Materials Engineer; Scott Andrus, State Materials Engineer; Amy Poloni, Quality Systems Engineer; Glen Clark, Quality Assurance Engineer; Jeff Saddler, Materials Engineer; Scott Strader, Concrete Inspection Manager; and Brian Lea, Concrete Engineer
- Vermont Agency of Transportation (VTrans) – Mark Woolavar, Construction Paving Engineer and Aaron Schwartz, Bituminous Civil Engineer
- Washington State Department of Transportation – Jolena Missildine, Design-Build Engineer and Denys Tak, Assistant State Construction Engineer
- Wyoming Department of Transportation – Ryan Steinbrenner, Materials Engineer and Charlie Bauer, Construction Staff Engineer
- Applied Research Associates (ARA) – Kevin Chesnik, Consultant
- CH2M HILL, Inc. – Jen Smoker, Consultant

Invited Speakers:

- Paul Ziman, FHWA Division (for Ivan Marrero)
- Dr. Pedro Romero, Researcher, University of Utah
- Christopher Robinette, Granite Construction
- Jerry Reese, CEO, Plote Construction

Executive Summary

Despite the large spring snow storm occurring in the Midwest and East Coast, all but one of the participants safely arrived in Salt Lake City (while over 6,000 other travelers' flights were canceled and more delayed). The facilitators introduced the participants and the purpose and plan of the event, but quickly determined that the room needed adjustments to encourage optimum participation. As the states shared their status and questions regarding performance specifications, it also became clear that the contractor presentations should proceed some of the other breakout sessions so the agenda was shifted to advance the contractor perspectives. Christopher Robinette, Granite Construction, and Jerry Reese, CEO, of Plote Construction gave clear presentations with specific examples of adopting performance measures.

The Showcase continued as outlined in the agenda with each panel briefly introducing an aspect of an issue and allowing participant states to make comments, ask questions, and provide information about their own experiences.

There were a variety of responses when asked what participants felt they learned from the Showcase. Participants gained a broader overview and understanding of performance specifications, which included the following:

- Making new contacts and exchanging knowledge and implementation ideas with other states.
- Hearing what the important issues and strategies were to the different DOTs.
- Understanding where other states are in the process of performance specification development.
- Engaging in good group discussion to learn what specific ideas states are focusing on, challenges facing industry, and gaps in specifications.
- Recognizing performance goals that would fit in within their particular agency's current QA program.

As one participant wrote, "the performance specification process is the next logical step after having a good quality assurance program." Knowledge transfer included new awareness of methods to test for Performance Metrics; what 'baby steps' are needed to implement performance specifications; other's experiences with infrared testing and intelligent compaction; and cement stabilized Full Deck Reclamation (FDR) Performance Specifications.

Outcomes and Recommended Activities

One participant shared that the showcase was a, "Great introduction for us with a long way to go!" Other participants left asking for clarification and more specifics in the following areas: more information on how to implement performance specifications (such as user buy-in and management acceptance); more examples of method specifications, performance related specifications, specific asphalt and concrete specifications, and performance based specifications to compare when creating performance specifications; and more on why infrared (IR) testing and intelligent compaction (IC) techniques can actually predict future performance.

Participants wanted to hear more about the following: different materials (such as, concrete and aggregate) other than asphalt; technologies that can be used; states telling what they are doing (surveys before meeting); discussion on specific performance testing methods; details in regard to specifications that states have implemented and/or planning; presentations from industry; and options on pavement preservation specifications and specifically requested a database of performance specifications already implemented by state. There is a real need to define and market products to contractors (what products? And market to whom?).

The issue of warranties brought up more questions including: how does a DOT match the length of a warranty to the actual design period; how can warranties tell you anything with 5-year warranty; and should not warranties need a Performance Specification with a way to test it in a field test?

One state had expected good examples of Performance Specifications that were in practice and was hoping for a database of specifications to look at. They have some questions that prevent their agency from moving forward but would they would be happy to follow someone who has already done the work. This state is still assessing what is the right performance specification and what their contractors can comply with based on size and resources. They requested other examples of what other states have done.

Summary of State Comments

Utah

Utah recognizes Performance Specifications can be in any bid item, so their goal is to use research with the University of Utah to begin to apply them. Utah is looking for a performance test such as the Semi-circular Bending (SCB) Test to give more balance or higher binder contents in their hot mix asphalt (HMA). Utah rewrote their concrete specification for Portland concrete and self-leveling cement. They were focused on target values and extra durability and they were looking to see how that fell in line with other states' experiences.

Utah has looked into intelligent compaction on hot mix and like the value on mapping and thermal testing. Industry was concerned about cost. They have tried some projects but are looking at it as a Quality Control (QC) tool. Utah contractors seem to have a good idea of where their materials are located. In disputes, they seem to know where they are at and looking back at where we are at. The DOT believes contractors should be innovative and do the best they can. Twenty-eight years ago, Utah used to pay for asphalt binder as a separate pay item from hot mix asphalt but . when they put penalties on the binder if they were out of specification, Utah would receive unbalanced bids. Bids would be placed as low as one cent per ton for the asphalt binder, so if it was penalized not much would be taken away. By doing this, bidders did not care if the binder was penalized.

Because of this bidding practice, Utah took away the separate pay item for the asphalt binder and hot mix asphalt as one bid item. Over time, this gave contractors the incentive to engineer mixes with less asphalt binder in them for cost saving purposes. This mix would produce unbalanced mixes that were too dry. Since then, the contractors have corrected the mix so the mixes are not as dry and continue . working on

correcting some dry mix issues to move this issue forward. The contractors have recently adopted the Illinois procedure and are waiting to see if they will have Reclaimed Asphalt Pavement (RAP) in the mix.

North Dakota

North Dakota is dealing with dry mix issues such as gyrations and do not have different counts for different roadways. Their concern for rutting has made North Dakota hesitant to fix gyrations. Regarding pavement markings, they are looking for effective and affordable solutions including epoxies, paint, and plastics because they have miles of roads with low traffic. In dealing with concrete repairs, they need preventative maintenance and want their concrete to last 50 years, even though North Dakota does not use much concrete pavement.

When North Dakota requires innovation, it is a cost additive. Their techniques vary but they recognize innovations in traffic management are a rich source of time savings.

Wyoming

Wyoming is intrigued by the possibility of tracking performance measures particularly with thermal cracking. They would like a specification on cracking because they are not as concerned about rutting. Wyoming is looking to stabilize FDRs and create parameters for performance specifications versus method specifications. They have never combined asphalt payment, although they saw one unbalanced bid. Their mixes are not too dry but can be richer.

Contractors drive technology in this state and they noted a need to market products to contractors: “When Wyoming went to warm mix the contractors pushed it and the agency played catch up. We are pushing infrared but if our contractors don’t bite, we second guess.”

Idaho

Idaho is dealing with bridge section issues including early shrinkage on decks, with 1.5-year-old decks falling to the road below; they are looking for tests that predict long-term durability. They use polymer overlay warranties, have chip seal under warranty, and have done a few pilots on overlay warranties.

Idaho is interested in how to provide incentives to contractors (overcoming dry mixes – dust amounts) to fix this system. The incentive process to facilitate contractors have changed contractors’ behavior. They are focused on moving forward on their second version of quality incentives, including incentivizing for joint-density specifications. . While waiting for this test, Idaho sees warrantees as a big push of the agency. Idaho has warranties on everything as they are work to get meaner and leaner.

California

California asked how to teach staff about risk so they are not out there inspecting all the time. In California, there is no inspector available through most night work, so IR tools are key. They want contractors to be ready to take on the risk since . California will not be out there to tell contractors to stop. Contractors need to stop on their own. Their contractors want to take on the innovation but they do not want to take on the risk. They are interested in how industry is reacting in other states regarding risk and innovation. California has developed specifications with the industry but while half of the state are on board, the other

half are trying to stop the use the specifications. They requested that SHRP2 come to California and talk to the industry.

Washington

Washington is looking for balance between using institutional knowledge and leaning on contractors. They commented that with the room filled with subject matter experts (SMEs) in materials and their collective experience, the expectation cannot be to ignore agency institutional knowledge and rely solely on contractors. Washington's method specifications arose from poor performances. In regards to warranty and long-term performance, they want to hear how to address failures after completed work has been accepted. Traditionally, if something goes wrong 'the state fixes it,' but if the contractor has to fix it, one challenge is the length of time.

Washington has an industry work group team that meets monthly outside of construction season and includes a concrete and asphalt team, a design-build team, and others. When issues with specifications come up, they take it to these groups, not asking for approval but for input on what is right to do, looking for fatal flaws, and what would work best. This has been very helpful. The participants commented that if all contractors are happy, we are not doing our job. Washington has some contractors under prequalification (only bid one at a time until you perform otherwise). Sometime subcontractors can cause problems. The challenge is how to address bad contractors among subcontractors and material suppliers.

Hawaii

Hawaii asked about how performance specifications could help in accelerated use of polymers on bridge decks, new construction, raised highways, and maintenance. They are interested in limiting liability but also continuing some review of methods. They shared that with only two quarries on one island, their resources are limited.

Nevada

Nevada uses dry mix on asphalt but not SuperPave and their mix design is 100-percent in-house. They recognize performance-based tests are available to create performance specification but their questions included: are test procedures repeatable; when you go into the field for acceptance, is your test criteria still good in the field; and how can we make sure the final product is equal to what the mix requires? There is often no correlation between mix design and final product.

Nevada has a few big contractors with established QC programs. (*There used to be a 6-week NHI course on materials with a week-long QA/QC session.*) They were accepted based on workforce issues and perhaps QC is improving. Nevada's preference is using their results as acceptance. They would like every contractor to have QC but the only time it is specified is for big pours but then they dictate what is expected and what QCs should be done. Contractors are expected to have best practices to benefit their work.

Arizona

Arizona is starting a significantly large performance project with a 30-year warranty. They see the need for a mindset change within the DOT, "We can't tell the contractor what to do if we want the risk carried

by the one who can manage it.” They are looking for ideas, small steps for the rest of the program to leverage limited resources (people and money) throughout the program. They want to reduce construction inspection workforce and change it to something else but asked: how to leverage limited resources and how to limit inspection?

Arizona is at various levels of specifications. Their method specification with a performance specification on stripes does not work and they recognize sometimes it can be cheaper to replace a sign with a new one than to test the quality of the old sign. Industry knows what to do right now if they are penalized, namely to fix it. But, if the state switched to a performance test that they are not passing, doesn't the state need to understand and give them the information to know how to fix it? There is a huge gap between designing the perfect mix and executing it. Should states tell contractors how to fix it? They need to know where the resources and tools are to make change. Contractor mix producers only have certain things they can control at their plants, including flow of aggregates and amount of liquid. Switching to performance measures is a whole new education point for them and they are very slow to change. They are curious to see progress and examples 5 years from now.

Montana

Montana is looking at low temperature cracking related to plant mix and finds they have similar issues as Idaho with delamination on bridge decks. They wanted to hear about chip seal warranty – putting down thin overlays, mill and fill and 3/8 mixes as they are having issues with the Hamburg Wheel Test. They requested information regarding delaminating bridge decks, but no specifications on concrete; asphalt specifically CTV pulverizing; performance and warranty on back fill compaction (culverts and such); road base aggregate materials; and how other states are meeting specifications. Montana requires volumetrics during construction and contractors complain this hampers their production rates so they wanted to know how other states spec volumetrics.

Montana is in a good spot with plant mix, good QA, good incentives, gap is good performance test in low temperature cracking but do not have great relationships with industry. When they tried peer exchanges in concrete association for QA and performance tests, the contractors stopped doing business with the state.

Montana is very interested in IR Paving to help show the best contractors. They deal with problems because of trucks not being big enough for the job. They have looked to Missouri's example for insight. The first question from construction will be, “Are we getting any money from this?” Contractors will be a mixed bag.

Missouri

Missouri is using intelligent compaction, and infrared scanning on the back of a paver for thermal profiles. They have paid incentive/disincentives for ability to control segregation. Activities include: plot compaction curve for each count; assess optimum pass count. Missouri started with the Louisiana method and Fit test (Illinois version), and have rated all mixed types. They put forward a specification on each mix type to put on any project the state chooses with an opportunity to add RAP if meeting performance criteria. The asphalt meeting has a pre-meeting technical committee and Missouri can take issues to them.

IC and IR funding helped them put a pay factor on items and incentive and disincentives as well, and seen as 'they are paying us to do this.' One project used performance criteria for mixed designs. (When this was announced everyone appeared to accept it but there were issues from contractors such as, "I took deductions on some areas but it's managed just as well as the other parts").

Stripe and testing experience in the past entailed that the contractor put down stripe and DOT tested, but there was subjectivity with a hand-held gauge (such as, sun and number of tests). Later, contractors were brought in to test and found more was failing than initially thought. Consultant's testing is useful. Based on data, generally stripers need to slow down. Contractors wanted to figure out what effects the tests so Missouri worked with them to test their stuff and determine where they fit in the process.

Innovations include using R06C where the contractor was adjusting speed of trucks and paver based on IR scanner. "Sending feed of temps to plant manager and that was purely QC to plant manager. They could make adjustments in the field at 2 am based on what they could see."

Maine

Maine had shortcomings in QA, good QA specifications but not relating to good performance. Maine is a 100-percent asphalt pavement state. Incentives were to push the envelope on SuperPave designs and then oil prices went up. They were seeing more pavement rejected for segregation, cracking, tenderness (workmanship), and needed characteristics to measure material properties and uniformity to define, "what makes good asphalt". They are doing work on the bridge side including rapid renewal Bridge Deck permeability measurements, and specking rebar cover after construction. They are hoping for a performance-based mix design.

Maine was doing a form of performance specification in the 1960s, but did not educate contractors and they balked. In the 1990s, Maine began a more robust educational approach to make contractors more comfortable and aware of what was being required. Maine was impressed that contractors expected they had good QC. Maine contractor's test quality but may really not have a good process in control.

In terms of innovation, the state was not specific regarding automated machines but contractors saw profitability. They have not seen a cost benefit of other innovations (IC or IR testing) so they are not using them. Contractor and agency should want to use IR scanner because densities are more accurate and much can be learned with that data. They are wondering if the states can incentivize contractors through the pilot projects. On one particular SHRP2 pilot, night paving was expected to be smooth but did not turn out that way. Tools showed that operators, trainers, and inspectors were not as trained as in the past. PaveIR is a great QC tool and inspection tool. If contractors are not adopting it on their own, they can be incentivized through these pilot project. *One grind out will pay for a 30K piece of equipment.*

Vermont

Vermont explained that performance specifications have to be cooperative between industry and agencies. " *We can't do this in a box – remove 'us vs. them;' mentality.*" They explained that End of Project = Performance Specifications while End of Life = Performance Related Specifications. These are key quality

characteristics because no one has yet to correlate failures to what it means for the life of the project. They described the need for a predictive model for end of life performance.

Vermont is trying to change culture, getting input from contractors. It has been a 6-month process and a good experience but they fear they are writing specifications for the lowest common denominator contractor. Contractors are trying to get out of doing things – inspecting, ways to pay, did not want to change as far as Vermont wanted. The conclusion being an open dialogue as the key.

Vermont is holding annual meetings in various parts of the states – challenging contractors in annual meetings to step forward. They also holding regional contractor meetings. They see QC is overlooked. Contractors know their business much better than the DOTs do. Then as the owners they know if something has gone wrong without testing. *“We can’t use the QC results because contractors know their business way better than we do although we may think we do. They know when things go awry even before testing. We are a small state and we know them all by name – we know who the bad apples are.”*

New Mexico

New Mexico has a contractor performance qualifier on award process, factor grading that can change their rankings, and an annual report is available. New Mexico used the draft performance-based qualifications from the research project and pursued it. They used a tiered approach on how to do this but now need to do it in a partnership with associations.

Alabama

Alabama was having trouble using the product because their project was delayed. They explained that Performance Related is defined by what you get when you specify the life cycle costs relationships correlated to quality performance. Performance Based is defined by what you get when you let the contractor chose (performance oriented). It must meet general criteria using certain tests; specifications have to have repeatability and have to be done quickly; it focuses on material attributes, based on mathematical models and it focuses on the outcomes and not the process. Alabama wants to improve their specifications to performance related so contractors will utilize current technologies that cover the entire roadway mat to give the state a clear understanding of what’s in place after construction is complete.

With Performance Based Specifications, expect the same construction schedule but measure different aspects of the performance. This allows contractors to take the books, find the best, and use it as a living document. Should they know if their process for quality management is in control or not? They can keep control charts which are a minimum requirement of a QC plan, although they would like to get rid of this. The fastest way to know your quality is to look on a chart and should not be an . exercise but a reason.

Alabama’s expected value using Performance Specifications includes creating new methods to evaluate what roadways look like after work, to encourage contractors to use new technology, to improve efficiency and accuracy, and to reduce costs and claims.

Suggested Activities to Support State Efforts

- Share examples of other states – standard prescriptive specifications – what do they look like.
- Put more documents on the AASHTO website.
- Provide help updating software – company went bankrupt. Steering Committee of AASHTO software to merge PavEME with FlexPave software. (Harold Von Quintas)
- Provide support for Asphalt Mixture Pavement Tester (AMPT) performance specifications that never received technical support from the company for calibration, use, or tips. AMPT is supposed to be the simplified.
 - The software does not have float numbers.
 - FHWA had a meeting with the providers at Transportation Research Board (TRB). It lacked robustness.
 - Empirical tests can still tell the future when there is enough data.
 - AMPT has wonderful mechanisms behind it, but right now it is not there.
- Create a test that can go to the field where we are accepting the material. Look for field tests. Fifteen to sixteen states asked Turner Fairbanks for a field test that work. FTIR and XFR are available for polymers – if not from the mechanical side, perhaps by the chemical side.
- Provide workshops focused on one project and one solution. Caltrans, Missouri, and Vermont would be interested in state training.
- Interact with AASHTO committees making decisions about pavements. What is the relationship while they are the ones doing guidance documents? How do we funnel our research and work back to AASHTO rather than it being done one state at a time.
- Address big challenges rising to the surface. There were originally three levels of design in SuperPave (Levels 2 and 3 were supposed to get into performance measures but it was not practical).
- Identify Performance Specifications on fundamental properties of the pavement. To get from basic QA – the best thing moving forward is to recognize current acceptance has holes, not getting best performance, what can we do that gets empirical data and help us look forward – focus our acceptance criteria to the things that show us performance will be better. Just because we cannot get a formula that will work for 20 years, does not mean the data are useless.
- Encourage vendors to respond appropriately. Need to move forward together. The power of the tools of the test AMPT will rise to a higher level. FHWA wants to equip states with as many tools as they can.
- Supply missing Performance/Volumetric relationship. Working on our volumetric state testing – we get to the point that we want to get to a performance specification, but designers would push back.

Future challenges will include discussions where people still want to tell contractors how to do the job. Releasing control to contractors to balance risk is a cultural shift.

- Promote changing culture in DOTs – SHRP2 has targeted state training sessions – to help work within a specific agency to introduce them to the product and benefits.
- Promote the guide specifications (available on the flash drive and website) that have a lot of questions to help guide thinking on what your state will want to do. They are not totally prescriptive, but help identify gaps and items to solve. There are 21 prototype guide specifications.
- Provide SME Lee Gallivan (SHRP2 R07) for assessment to help states move forward.
 - Missouri – intelligent compaction - PP81 – commentary – what worked what didn't work. Example specs for states to see. The implementation is really important. Need to take it beyond research.
 - Montana – Interested in IR paving. Should we pay for more IR scanners?
 - Arizona – Challenge with industry – know what to do what to fix it now if they get penalized. If we go to a performance test what do you change to fix what is not right. Have to provide information on how to change what is failing.

Appendix A—Chart of State Use of Incentives and Disincentives

State	Asphalt						Concrete				
	Density	Joint Density	Volumetrics	Liquid Asphalt	Smoothness	Percent w/Limits	Mix Gradations	TSR	Strength	Thickness	Smoothness
Maine	Inc/Dec	Inc/Dec	Inc/Dec	Inc/Dec	Inc/Dec	Inc/Dec	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis
Alabama	Inc/Dis		Inc/Dis	Inc/Dis	Inc/Dis		Inc/Dis	Pass/Fail	Inc/Dis	Inc/Dis	Inc/Dis
California	Dis	Pass/Fail	Pass/Fail	Pass/Fail	Inc/Dis		Pass/Fail	Pass/Fail	RSC Dis	Dec	Pilot In/Dis
Federal Lands	Inc/Dis		Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis			Dis		
Indiana	Inc/Dis		Inc/Dis		Inc/Dis	Inc/Dis			Inc/Dis	Dis	Inc/Dis
Missouri	Inc/Dis	dis	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Pass/Fail	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis
Montana	Inc/Dis	inc	Inc/Dis		Inc/Dis			Pass/Fail	Dis	Dis	Dis
Nevada	Inc/Dis	Pass/Fail	Pass/Fail	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Dis	Dis	Dis	Inc/Dis
North Dakota	Dis		Pass/Fail	Dis	Inc/Dis		Dis		Reject	Dis	Inc/Dis
Vermont	Inc/Dis	Inc/Dec	Inc/Dis	Pass/Fail	Inc/Dis		Pass/Fail	Pass/Fail			
Washington	Inc/Dis			Inc/Dis	Inc/Dis	Inc/Dis				Dis	Inc/Dis
Wyoming	Inc/Dis	Inc/Dec	Inc/Dis	Dis	Inc/Dis	Inc/Dis	Inc/Dis	Pass/Fail	Inc/Dis	Dis	Inc/Dis
Arizona	Inc/Dis		Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Dis		Inc/Dis	Inc/Dis	Inc/Dis
Utah	Inc/Dis	Inc/Dic	Pass/Fail	Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Dis	Dis	Pass/fial	Inc/Dis
Hawaii	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail	Pass/Fail
Idaho	Inc/Dis		Inc/Dis	Inc/Dis	Inc/Dis	Inc/Dis	Dis		Dis	Inc/Dis	Inc/Dis
North Carolina	Dis	n/a	Dis	Dis	Inc/Dis	n/a	Dis	Dis	Dis	Dis	Inc/Dis

Yellow boxes indicate there is no policy for that item for that State.

Appendix B—Evaluation Results (Individual evaluation sheets are posted on the Share Point Site.)

Rating	Overall workshop content	SHRP2 Overview and Performance Specifications	Performance Specifications Panel Discussion	Benefits of Developing and Deploying Performance Specifications Discussion	Contractor Experiences in Using Performance Specifications	Resources for Developing Projects with Performance Specification	Advancing Performance Specifications	Challenges of Developing and Deploying Performance Specifications	This showcase provided me with a better understanding of Performance Specifications	I understand how performance specifications can benefit my agency and program.	I found the format of the workshop encouraged active participation.	My participation in this showcase was worthwhile	My expectations for what I would learn in the event were met.	The presenters delivered clear information
strongly disagree (1-2)	0	0	0	0	0	0	0	0	0	0	0	0	0	0
moderately disagree (3-5)	0	1	0	1	1	1	1	1	1	0	0	1	2	1
moderately agree (6-8)	18	20	14	16	12	17	18	13	13	16	16	12	16	15
strongly agree (9-10)	12	10	17	13	18	12	9	17	17	15	15	15	13	15
sum	30	31	31	30	31	30	28	31	31	31	31	28	31	31
% strongly disagree	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%	0%
% moderately disagree	0%	3%	0%	3%	3%	3%	4%	3%	3%	0%	0%	4%	6%	3%
% moderately agree	60%	65%	45%	53%	39%	57%	64%	42%	42%	52%	52%	43%	52%	48%
% strongly agree	40%	32%	55%	43%	58%	40%	32%	55%	55%	48%	48%	54%	42%	48%

Appendix C—Detailed Notes of Presentations and Comments

The following are detailed notes from the Utah Performance Specifications for Rapid Renewal Showcase.

Welcome

- The purpose of this meeting is facilitated conversations and breakout conversations.
- There will be some speakers and moderators but not a lot of formal presentations.
- The expectation is to learn about what is happening in the western states in Performance Specifications as well as to provide those states with current state of the practice from the lead states in Performance Specification use.
- Jennifer Balis, FHWA
 - We appreciate the lead adopters who are facilitating the discussions.
 - We appreciate the time everyone took to be here with us.
- Pam Hutton, AASHTO
 - There are some hard copies of the research reports available to take home.
 - This conversation has to do with the research. Please ask questions and share comments.
 - This Showcase is piloting an agenda aimed at providing opportunity to engage in conversation.
 - This is not a class – this is your time to talk with each other.
- Paul Ziman, FHWA
 - Thank you for coming.

Introduction to Utah and Introduction of Attendees

- Self-introductions of all Utah attendees and some interesting Utah facts:
 - Utah is the cross roads of the west.
 - 5 national parks
 - 5 national forest
 - 7 national monuments
 - 85,000 square miles with 5,884 miles of pavement and \$240 million (M) budget for pavement preservation and rehabilitation.
 - State of Utah’s population is 3 million.
- Utah did a design-build project on I-15 in the middle of the city for the Olympics. (UDOT slide – shows Performance Based Specifications for Asphalt, Concrete and Warranties.)

Introduction of Showcase - Keith Platte

- We want you to:
 - Share
 - Listen
 - Learn
- Engage – be an active listener
- Start a take away list
- Take what you have learned back to your agency where the process starts again but in your agency among your staff.
- Goals and outcomes
 - Cheaper
 - Stronger
 - Faster
- Who will create the longest list of take a ways for their agency?

Project Overview - Richard Duval and Keith Platte

- Overview of agenda
- The whole point of this gathering is to have a conversation with your peers.
- The challenge is that we still use end results, and QA specifications but are not moving towards Performance Specifications. These specifications do not tell us how our investments are performing. Innovation is hindered by conventional approaches.
- High-level SHRP2 overview and this product has been offered in rounds 2 and 5 (AL, ME, MO, VT, PA)
- IAP states include:
 - Alabama
 - Maine
 - Missouri
 - Vermont
 - Pennsylvania
- Performance Specifications represent progression towards parameters that will perform over time. We need to hear from more contractors to get feedback on how they view the use of Performance Specifications.
- There is a difference between performance-related and performance-based specifications (and we are not really there yet).

- Many people are moving toward QA (could be pavement, traffic, paint striping and many other things) to measure performance results. This is the progression we are trying to help move people toward.
- Moving toward performance based specifications means the owner and contractor share more of the risk. “I want it to perform for 20 years,” means giving more control to the contractor to complete the work using their solutions. As long as the end result provides the expectations being looked for by the State DOT.
- Working down the pyramid of Performance from top to bottom – where we used to start at the bottom and worked our way to the top.
 - Share risk with contractor by giving him more control, but make sure DOT will get what they pay for.
 - Accelerate delivery and use lean principles – use some inspections but realize there are ways the specifications will help eliminate some inspection by holding the contractor to more risk.
- How and why do we need to use Performance Specifications?

State Expectations for the Showcase Kevin Chesnik

Utah

- Utah rewrote concrete specification for Portland concrete and self-leveling cement.
 - Going with target values and extra durability.
 - Looking to see how that falls in line with other states.
- Performance Specifications can be in any bid item.
- Goal to get to Performance Specifications through research with University of Utah.
- Believe contractors should be innovative and doing the best they can.
- Still remembers 28 years ago paying for asphalt mix and binder separately.
- Implemented SuperPave – Hamburg Wheel test, dealt with stripping problem, hydrated lime in all mixes corrected stripping 1% by total weight.
- Dealt with Rutting – SuperPave and asphalt by the ton (dried the mixes up – 4.7 to 4.3; drier made distresses change)
- Now have cracking and dry mix issues along with delaminating layers and tack coat issues.
- Utah used to pay for asphalt binder as a separate pay item with our hot mix asphalt. When they put penalties on the binder if they were out of specification it started to get unbalanced bids. They would put as low a one cent a ton for the asphalt binder on their bid so if it was penalized there would not be much to take away. By doing that they did not care if the binder was in penalty.
- Because of this, Utah took away the separate pay item for the asphalt binder and bid the hot mix asphalt as one bid item. Over time this gave the contractor the incentive to engineer mixes with less

asphalt binder in them because of the cost savings. That produced unbalanced mixes that are too dry. They have corrected some of that and the mixes are not as dry now.

- Utah is looking for a performance test such as the SCB Test to further give more balance or higher binder contents in their HMA.
- Working on correcting some dry mix issues but wanting to move this forward. Have a professor coming to speak about field performance and test. There is a lot of preparation for the test.
- Recently adopted the Illinois procedure. Waiting to see if they will have RAP in the mix. Preparation in cutting beam slivers is an issue. Semi-circular bending beam, I-fit IL method that indicates more binder. Looking to detect RAP.

North Dakota

- Dealing with dry mix issues – gyrations. They do not have different counts for different roadways. Scared of rutting so hesitant to fix gyrations.
- Pavement markings –looking for effective and affordable. Epoxies, paint, plastics – lots of miles with low traffic.
- Concrete repairs - need preventative maintenance – want them to last 50 years even though North Dakota does not use much concrete pavement.

Wyoming

- Looking to stabilize FDRs, create parameters for performance specifications vs method specifications.
- Have never combined asphalt payment –saw one unbalanced bid
- Mixes are not so dry but can be richer.
- Tracking performance measures – intrigued by this possibility.
- Thermal cracking – would like a spec on cracking – not as concerned about rutting.

Idaho

- Dealing with bridge section issues: early shrinkage on decks is a problem 1.5-year old decks falling to the road bellow. Looking for tests that predict long-term durability.
- Polymer overlay warranties – chip seal under warranty and a few pilots on overlay warranties.
- How to provide incentives to contractors (overcoming dry mixes – dust amounts) to fix this system.
- Incentive process to facilitate contractors changed behavior.

California

- How we teach staff about risk and so they are not out there all the time?

- Contractors need to be ready to take on the risk. California is not going to be out there to tell contractors to stop. Contractors need to stop on their own. How are contractors in various states taking the risk? They want to take on the innovation but they do not want to take on the risk.
- How is industry reacting in different states – risk and innovation? They want to have ability to use innovation but not take risk on themselves alone.

Washington

- Struggling with the balance of using institutional knowledge and leaning on contractors. The room is filled with SMEs in materials so with all this experience, are we now expecting institutional knowledge to pause and just throw this back on the contractors?
- Method specifications arose from poor performances
- Warranty and long-term performance –
 - How do we address failures after we accept completed work?
 - Traditionally if something goes wrong ‘the state fixes it’ – but if the contractor has to fix it, the challenge is the length of time.

Hawaii

- How will this help us in accelerated use of polymers on bridge decks, new construction, raised highways, and in maintenance? Want to limit liability but also continue some review of methods.
- With only two quarries on one island our resources are limited.

Nevada

- Dry mix on asphalt – we do not use SuperPave. Mix design 100-percent in-house.
- Performance based tests are available to create performance specifications.
 - Are test procedures repeatable?
 - When you go into the field for acceptance, is your test criteria still good in the field?
 - How can we make sure the final product is equal to what the mix requires? There is often no correlation between mix design and final product.

Arizona

- Starting a significantly large performance project with 30-year warranty.
- Need a mindset change within our DOT, “We can’t tell the contractor what to do if we want the risk carried by the one who can manage it.”
- Ideas, small steps for the rest of the program to leverage our limited resources (people and money) throughout our program.
 - Reduce construction inspection work force and change it to something else.

- How do we leverage limited resources?
- How do we limit inspection?
- We have a method spec with a performance spec on stripes that does not work.
- Sometimes it can be cheaper to replace a sign with a new one, then to test the quality of the sign.

Montana

- Looking at low temperature cracking related to plant mix.
- Similar issues as Idaho with delamination on bridge decks.
- Want to hear about chip seal warranty – putting down thin overlays, mill and fill and 3/8 mixes are having issues with the Hamburg Wheel Test.
- Delaminating bridge decks, no specifications on concrete.
- Asphalt – want to hear about CTV pulverizing.
- Performance, warranty on back fill compaction (culverts and such)
- Road base aggregate materials – meeting specifications around the states. Many varied sources.

Contractor Experiences in Using Performance Specifications

SR 202 South Mountain Freeway Project Chris Robinette – Granite Construction

- Design, Build, and Maintain – P3 Project.
- Connect 202 Partner with ADOT
- 1 year into project.
- Construction Joint Venture between Fleur-Granite-Ames, PB, 202 Maintenance LOC (see slide)
- ADOT retains ownership – with 30 years of maintenance by Granite.
- Need to make sure we develop a project maintainable for 30 years at budget developed at bid time. Incentivized to build quality upfront – don't want frequent maintenance if possible. Trying to minimize impacts to traffic for inevitable rehab and maintenance.
- Specific metrics for pavement and others on the project with continual inspection thru 30 years.
- Located in heart of Phoenix metro area – loop roads run throughout.
- Planning to replace existing Pecos Road (A long cul-de-sac of 4 miles with a dead end).
- Lengthy, involved project: 22 miles of roadway to connect loop, 11 miles of sound wall, 4.5 miles of improvement on I-10. 40 bridges to build ranging from 110-2,600 feet long. – counting bridges is not straight forward, 6 miles of shared-use asphalt for bike and pedestrians, 1 system interchange, and 1 pedestrian bridge.

- 13 interchanges (see slide on Scope) including 1 double roundabout and 2 half diverging diamond interchanges. Provides potential for Gila River DOT to build into it.
- Ultimate build-out – 8 lanes total with 3 general purpose and 1 HOV in each direction, median barrier and \$900M price tag.
- Inter-relationship of members is key. ADOT sets the tone.
- Maintenance – provided hot button issues before design was started.
 - Landscaping 7,000 trees 23,000 shrubs and accents – need water allocations for 30 years, compatible plant selection to water requirements and desert environment, communication with irrigation controllers and resources for water.
 - Drainage – 26,000 liner feet of culverts and off site drainage in addition to 136,000 linear feet of on-site drainage. Need to have clearance for maintenance equipment.
 - Pavement – very important 900,000 tons of hot mix; spent a lot of time with life cycle analysis – HMA vs. Portland Cement Concrete Pavement (PCCP)
- Design team
 - Historical Performance analysis on PCCP and HMA regarding timing, rehab, specifications
 - Material selection – asphalt binder grade selection – hot temps in region so risk of rutting
 - HMA vs PCCP – ribbons of concrete in roads are for bus lanes.
 - Timing and scope of rehabs – typical scope and timing
- Construction – looking at how we build it
 - Do we have expertise? Self-perform vs. Subcontractors. Need set independent of us performing the scope of work.
 - Quality Metrics
 - Constructability – looking at plan sets, specifications for reality check.
 - Optimization for post award. Finding best solution to the project.
- Owner Influence
 - Technical provisions
 - Long-term performance – additional service life of 10 years added
 - Local stakeholders (pedestrian bridge)
 - Aesthetic corridor – landscaping and development
- Created one combined spec book – “C20P Specifications” from all the Specification Sources (too many books to go to the field with)
 - ADOT Blue Book

- Technical provisions
- Stored Specifications ADOT
- City of Phoenix
- How we bid the project
- Other Stakeholders
- Key Specification Components
 - Self-performed vs. subcontractor wrote specifications were doable to local contractors but would provide required quality.
 - Known performance – moving away from the method specifications and more toward what performance specifications were – wanted more flexibility.
 - Maintain ADOT incentive/disincentive.
 - Bid as a lump sum – no incentives built in. Needed to determine how to create specifications based on how we bid it, but with subcontractor flexibility to even out with incentive and disincentives.
 - Lot by lot perspective. Allow contractor to go lot by lot to even out.
 - Wanted to maintain ADOT work with Percent Within Limits
 - PCCP – ride quality, compressive strength, thickness
 - HMA – ride quality, quality attributes, thickness, wanted to make sure pavement performance was what we want. Went off cores – applied rigid pavement percent within limits (PWL) for pavement to hot mix.
 - Needed to make sure we gave them the pavement accurately.
 - Pavement Section
 - Overall thickness
 - Pavement lifts
 - PWL application
 - Project commitments
 - High Density Polyethylene Pipe
 - Updated 1990 specification – looked at old specifications and update project specifications to allow deeper into fills – upwards of 24 feet for 24-inch pipe. Major update.
 - Irrigation System
 - Reviewed by maintenance (was currently line of sight standard)
 - Use fiber optic line

- Specification developed for controllers. Tied to Intelligent Transportation Systems.

I-90 Tollway Performance Related Specifications - Jerry Reese, Plote Construction

- \$2 Billion worth of work on I-90.
- 2 years ago we had never build a process under PRS specifications.
- First company in Illinois to build a project with PRS Specifications: Smoothness, Thickness, Joints, Strength, and Air Content.
- Company resources happen to sit on the project location itself so it was the right place, right time.
- Tollway project highlights
 - 12 miles in length
 - 7 interchanges
 - 11 bridges
 - 44 walls
 - 3 giant box culverts
 - 400,000 tons of concrete
 - Zero Slabs removed – not a single random crack.
- Project challenges
 - Right-of-Way Issues with High Pressure Gas Lines
 - Company did not want us on their property.
 - Had to get over high pressure gas lines.
 - Limited construction season.
 - JAWA Waterline issues – Work stoppage May to October
 - Villages all along were creating a new waterline.
 - Wettest June in IL History 11 inches of rain.
 - Aggregate, Cement, Fly Ash and Lime Shortages (unable to stabilize wet materials).
 - No contiguous Area of Work – constant jumping around and moving dirt.
 - Constant rebalancing of dirt cut/fill
 - Limited available labor force (Union environment)
 - Unexpected soil conditions.
- Overcame challenges with partnering!

- Went to agency with issues. Proactive to work things out. Consultants did not recognize gas lines, decided on a dollar value to complete the project. Reached agreement over 3 months.
- Completed 7 months of work in 4 months. Finished paving in December.
- 14 consecutive, 7-day work weeks in a row.
- Hired other subs to assist with miscellaneous work.
- Shut down other projects to free up resources.
- Cross-trained paving crews (They actually trained asphalt guys to place concrete.)
- Reallocating aggregate supply locations – bid all aggregate out of one source so we had to figure out how to supplement from other sources. Wrote a computer program to predict inventories – married inventory to customers. Worked 24 hours per day at all five facilities.
- Redesigned concrete mixes to have a backup plan if supplies go low.
- Completed pavement on Christmas Eve.
- How did we enhance our success?
 - Extensive QC planning for aggregates and material production.
 - Weekly corridor wide planning (9 projects total).
 - Heavy use of global positioning system (GPS) and computer aided technology.
 - Widen pavement track lines with asphalt layers to enhance smoothness.
 - Trained on profilers.
 - GSI device used for real time smoothness reading of plastic concrete.
 - Used central mix concrete plant with full time QC Oversight – tested every 50 yards.
 - Extremely well maintained equipment and very experienced staff.
 - Cohesive planning and execution strategy between project managers and field crews to determine who is in charge. Had to change perspective because we needed answers and the dirt coordinator does not always know it all.
 - Did it all using the latest GPS technology – thickness requires adhesive control – seeking absolute grade. Asphalt and concrete off the same controls. Cultural change – survey crews controlling – that was new.
- Air Quality – 101-percent pay factor average.
- Thickness Quality Pay Factor – in excess of 101 percent pay factor.
- Smoothness – averaged 98.72 percent or 65 International Roughness Index (IRI) pre-grind.

Discussion with Contractors

- In the Arizona project how did you allocate risk of material escalation? Not sure. Contract time? October 2019
- What trench width did you use? AASHTO or State specification? If you write a specification with a trench width the contractor has to find a way.
- As you move to performance specifications – what changes do you need to make in sourcing materials, plant production, etc. to improve consistency and reduce variability? Jerry is a material producer so it is part of their business. Meeting PRS specifications is more a project level issue than a materials issue. (Plote)
- Arizona project was looking at material sources (granite in West) hot plants – look at our resources and compare with request of owner.
- How important is the QC? QC technicians are responsible per plant.
- When you notice strength inconsistent – how did toll way allow you to make changes? Stopped using cement source that was determined as the problem and used back up sources. Pound for pound replacement – Contractor accepted risk with using new cement source.
- How did you know pavement design was going to give you 20-year life? Design team included specialty contractor and designed per AASHTO with ADOT technology. ADOT gave full gamut of what could be chosen for pavement. Mainline was flexible pavement, cross streets – rigid pavement. Full flexibility from ADOT to select the appropriate pavement as most optimal. Have to ask “what is the best for the individual project?”.
- How do you set up your own performance measures internally with a P3? To meet the client and get a low bid – what internal measures did you set up to meet the criteria? Did not want a pavement that we would have to conduct a full depth rehabilitation. Historical performance was 8 to 10 years for intervention. Flex pavement would need this. Rigid pavement – friction course rehabilitation compared to initial construction cost. Reflective cracking quality and raveling.
- Plote 3-year warranty. Little will happen to concrete in 3 years – initial saw cuts needed to get slurry removed from slab – contributes to spalling. Made sure saw joint was re-coated – often they are not. Construction only.
- Did you extend 30-year performance requirements on subcontractors? They are not responsible for maintenance, may be shorter-term warranty for subcontractors. May contract with them to perform maintenance though.
- As we move toward Performance Specifications – what should agencies be aware of from your perspective? Alternative procurement – balance risk between contractor and risk. We can price for the risk but in a low-bid situation there may be a balance of what you get. There seems to be a reluctance to adopt new technology – agencies get flack for going out on a limb; careers can be threatened. Design build – great ideas can be kicked out because “we don’t do it that way”. Technology

does not get transferred into the agencies. Add-mixture people are the most up-to-date on technology.

- Agency people have to get out of their own way – not feel threatened by new ideas.
- Scarcity or variability of materials – did you always use owners specifications or did you use mix design and show it works? Who took on the extra costs? The Illinois project could not vary from requirements. Arizona had the option to make changes to gradations and mix designs but they opted not to. Backfill and embankments had some changes. Agency has to be comfortable with changes. Changes to specification came post-award.
 - Discussed videotaping pipes and laser profiling, but the inspections would offset savings.
- Six Specifications into one – Distributed Electronically. Specifications book created at beginning of project but changes and revisions will be made through execution phases. Not sure how it will transfer to maintenance phase.
- How do you see performance specifications impacting smaller contractors – through specifications we pass them along to sub-contractors? Need to produce and meet requirements we are looking for. They get our specifications book as part of their subcontract – an open let for a lot of the work packages.
- Smaller contractors should not have any problems qualifying these specifications.
- Work according to schedule and cash flow.

R07 IAP States- Performance Specifications Panel Discussion (Experiences of Alabama, Maine, Missouri, and Vermont) Lindy Blackburn

- Almost 11,000 center lane miles
- Heavy on the asphalt side
- \$3M pavement budget
- Three-fourths of all expenses are in pavements
- Lifecycle costs on pavements is killing us
- How is R07 helping Alabama?
 - Can help in intelligent compaction
 - IR scanner
 - Initial profile
 - Bring all things together to encourage contractor to look at total mat
- Alabama's approach
 - Having trouble using the product because project delayed
- Performance related – this is what you get when you specify.

- LCC relationships correlated to quality performance.
- Performance based – this is what you get when you let them chose (performance oriented).
 - It must meet general criteria using certain tests.
 - Specs have to have repeatability and have to be done quickly.
 - Focuses on material attributes, based on mathematical models.
 - Focuses on the outcomes and not the process.
- End up with same construction schedule but measuring different aspect of the performance.
- Contractors – can take the books, find the best, and use it as a living document
- Expected value using R07
 - New methods to evaluate what roadways look like after work.
 - Encourage contractors to use new technology.
 - Improve efficiency and accuracy.
 - Reduce cost and claims.

Missouri - Dan Oesch

- We are using intelligent compaction, infrared scanning on back of a paver for thermal profile. Paid incentive/disincentives for ability to control segregation. Intelligent Compaction 6-page specification to obtain the optimal pass count. Plot compaction curve each count. Looked for optimum pass count.
- Started with Louisiana method, and Fit test (IL version), and have rated all mixed types. Put forward a specification on each mix type to put on any project we choose. Opportunity to add recycling, in meeting performance criteria.
- AMPT, Dynamic Modulist, Stress Cyclic Fatigue, Planning shadow implementation this summer – air voids, etc. Rate SuperPave parameters based on battery of tests that effect the performance.

Maine – Richard Bradbury

- We had shortcomings in QA, good QA specifications but not relating to good performance. We are a 100-percent asphalt pavement state. Incentives were to push the envelope on SuperPave designs – oil prices went up.
- We were seeing more pavement rejected for segregation, cracking, tenderness (workmanship) needed characteristics to measure material properties and uniformity – “what makes good asphalt?” Doing work on bridge side including rapid renewal Bridge Deck permeability measurements.
- Specking rebar cover after construction. Hope for a performance-based mix design.

Vermont – Mark Woolaver

- We cannot do this in a box – remove “us vs. them” mentality. Has to be cooperative between industry and agency.
- End of Project – Performance Specifications.
- End of Life – Performance Related Specifications. Key Quality Characteristics. We have yet to correlate failures to what it means for the life of the project.
- Need a predictive model for end of life performance.

State DOT Discussion

- Do you have contractor meetings where you can discussed revising specs? Washington State has industry workgroup meetings. Outside of construction season they meet on a monthly basis
- Who is doing Performance Specifications?
 - Bridge Deck, Test panel – evaluate patterns, measure core samples on Shot Creek.
 - What are key component – strength
 - Concrete bridge deck, shrinkage, permeability, and mix design
- How do you know you are getting what you want?
 - Strength, air content, and permeability
 - When something new comes along – do not throw everything we know out. Don’t throw away the basics.
 - Need repeatable, reproducible, test methods, have to find what the key characteristics are.
- What about Bridge decks?
 - Testing for long term to guarantee bridge deck performance.
 - Need to test while contractor is under contract for reliability going forward.
- Early indicators – how do you put these into a performance specifications that you can determine problems short term?
- What predicts performance? Advance knowledge of the materials. Air in concrete or entrained air?
 - Resistivity – developing resistivity meter to measure bridge deck and how it relates to sealers and when they need to be reapplied. OK did research on permeability but we want to do this based on age of bridge – need a base line on older bridges. Trying to look forward.
 - Super Air Meter - Air bubble test – liked. Physical materials laboratory is focused on it.
 - Trial batches and running tests in the field.
 - There is an effort for performance engineered mixes for concrete. Using box test, super air meter, TRS and Pooled Fund to further develop Resistivity – 4F factor. High, medium and low volume based on resistivity for long term performance. PEM allows you to pick and choose.

- Allowance of bridges for dead load? Is this applying to measuring permeability of hot mix overlay on bridge decks? Usually rely on membranes with manufacturer’s testing of permeability. When does it stop working?
- Traffic stripes for reflectivity requirements: Alabama does not use snowplows. Thermo plastic is 25K per mile. Performance Specification that tries to measure a property today that tries to predict results for tomorrow.
- Ownership makes you more protective of your work.
- Will contractors be more inclined because of incentive/disincentives? Consider giving them options.
- North Carolina Thermos: have degradation curve over time. Mostly thickness of what goes down and the 30 day reading as predictive qualities. Have to have good material and good adhesion. Seems to hold up well.
- Quality of ride is a good indicator of future performance. Public notices too.
- **Missouri** – stripe and testing.
 - In the old days the contractor put down stripe, we tested, there was subjectivity with hand held gauge (sun, number of tests). Later on we brought in a contractor to test, found later more was failing than initially. Consultant’s testing is useful. Stripe and DBs requirement – strippers need to slow down.
 - Warranties, behind on bridge program, legislature approved design bridge on 800 bridges. Bonded over the period of time but the cost of the banks holding money and risk over time was substantial. Ended up bidding many bridges on our own. Having tests in place without extra risk saves substantial money over time.
- **Vermont** was told they could not afford warranties.
 - Keep QC and QA as separate entities.
 - Quality Characteristics – we all struggle with, consider who is picking them – the engineer? You may have to look at FHWA’s pyramid and move up further – quality of ride, comfort, rutting, cracking... this is what the public is concerned with.
 - Do not completely throw out volumetric but think differently. It took 2 years of head butting for restriping 2 miles but after the back and forth it is going smoother.
 - Development of a specification is important. Our specification has performance related measures but is not true performance related specification. We took the draft and invited industry in for a review of the red line and created a blue line draft – then hashed it out over months to identify key performance indicators.
- **Vermont** is trying to change culture, getting input from contractors, it’s about a 6-month process and it has been a good experience for all of us – although we fear we are writing specifications for the lowest common denominator contractor.

- We are trying to get out of doing things – inspecting, ways to pay, some of them the contractors didn't want to change as far as we wanted – open dialogue was the key.
- This is confirming that we will continue to do this.
- Holding annual meetings in various parts of the states – we are challenging contractors in our annual meetings to step forward. Also holding regional contractor meetings.
- **Washington** has industry work group team – outside of construction season we met monthly. Concrete asphalt team, design build team, and others.
 - When we have issues with specifications we take it back to these groups – not asking for approval but their input on what is right to do, looking for fatal flaws, what works best, - it's been very helpful.
 - If all contractors are happy we are not doing our job.
 - When rewriting specifications in this formula – what are the changes? Concrete deck is a good example.
 - Washington designed templates – looked for feedback from contractors. Performance based is design build. They hire third parties to do evaluations.
- **Missouri** – The asphalt meeting has a pre-meeting technical committee and we take issues to them.
 - ICIR funding helped us put a pay factor on items and incentive/disincentives as well. Seen as "they are paying us to do this."
 - AEID, using performance criteria for mixed designs (when announced everyone was on board but they are also saying "I took deductions on some areas but it's managed just as well as the other parts).
 - Contractors wanted to figure out what effects the tests. Work with them to test their stuff and where they fit in the process.
- **Maine** was doing this in the 1960s but did not educate contractors and they balked. In the 1990s began a more robust educational approach to make contractors more comfortable and aware of what is being required.
- Are incentive and disincentive formulas based on contractor bid price?
 - Yes in **Alabama**.
 - Intelligent Compaction in **Missouri**, started low \$5, per 150 feet on IR, \$10 per 1000 feet on IC (based on lane length) but most was based on physical cost of mix.
 - **Maine** uses bid price for hot mix – capturing in-place quality of mixture. Concrete we have set unit price in special provision book so not based on bid price.

- **Alabama** introduced IRI we did pilots throughout the state – will require contractor to get certified. Nobody bought the equipment till it was written in contracts – gave them some confidence in seeing that their work wasn't that bad.
- **Nevada** – PLI – started as a university project. There was a lot of give and take, did three pilot projects. Specifications in Phase 1 were easy to meet, but tightening through Phase 2 and 3. IRI did not have a committee but several meetings to develop. Contractors are getting used to this.
- **Arizona** - We have a long history of working with industry for specifications – vetted through AGC and other associations for comments.
- **Washington** – In 2020 our DOT will move from QA/QC to QA role.
 - Capping engineers, gaining experience with design build.
 - If your contractors are used to this testing they may want verification immediately. It takes them a while to realize they are in control of this.
- **Missouri** – In every other manufacturing realm, the owner does not do their own inspection. Contractors are good at testing but physical inspection had some conflict of interest. State continues inspection but leaves most of the testing to contractors.
- **Maine** – We did some pilots with contractors testing but the extra work to go to a contractor test result mode wasn't worth the effort at the time. Need good validation process, laboratory qualification, dispute resolution process well defined, good business rules in place.

Benefits of Developing and Deploying Performance Specifications Discussions (State Experiences) Bill Stone

- Quality Assurance/ Quality Management Pilots –
 - It is the responsibility of QA put on contractor, needed quality management plan (how will you share this to Missouri DOT and agreed upon inspection from us). Final acceptance of product is usually based on statistical sampling of the measured quality level for key quality characteristics.
 - We want to eliminate nuclear density testing.
- Performance specifications – looking to predict long term performance. What can we do to measure long-term performance immediately after construction?
- AID Grant for Intelligent Compaction – incorporated into 13 let projects.
 - One project is finished – full disincentive. \$750K in grant funding with 20-percent match. Will train contractors as well.
 - Intelligent Compaction – Optimum Pass Count
 - Used R06C procured MOBA scanner.
 - Looking for complete mapping vs. single core. There is opportunity for 100-percent coverage.

- Investigating use of LiDAR for Boundary Limits of projects with IC and IR – percent coverage on pilot did not go well.
- Moving forward – want to evaluate findings per project. Report Findings and Job Special Provisions.

States Conversation:

- Acceptance on Incentive vs. Disincentives
 - **Vermont** – summarize them at the end of the year. Do not want to continuously punish or reward. Want to get to a net gain of zero.
 - **Alabama** – gives us more confidence in what we are getting. This is how we evaluate.
 - **Maine** – sometimes you will under estimate, other times you will over estimate. Want to have it even out. What is the incentive there and how does it apply?
 - **Arizona** – have been doing it for at least 20 years. Originally it was only disincentives. Compaction data shows reduced density lowered significantly when incentives were added. Enables them to be more proactive. Allows them to lower bid prices but assumes what you are getting is a higher quality. We pay for it no matter what. We are just ensuring quality.
 - **California** – Central office sees benefits – field personnel is left with more work, more opportunity for arguing with contractor, field workers will limit this as it puts a big burden on them. The contractors that are good at it put it in their bids. What else should we be measuring?
 - **Montana** – have had a few bit changes in the last few years. Long experience in MT I/D used historically for compaction, ride, and volumetric. They all had their own incentive/disincentives, so now there are plant mix ties (2014) no longer separate so you cannot sacrifice quality and still come out ahead. Has to be quality in all three. Contractors took it pretty well. Pavement meetings held 2 times a year – we are very balanced right now.
 - A good QA spec is set up that at a good quality they get 100-percent pay.
 - Disincentives without incentives – could create same quality but taking a cut in pay.
 - Contractors IRI Specifications/smoothness – asking why we are paying them for smoothness work – it's sometimes their competitive edge.
 - Whatever you do, you pay for it.
- Barriers to Adoption
 - It's new, no one likes change.
 - Timely calculation and accuracy of results.
 - Huge amount of data behind it. Paving miles per day we can't wait till the next day for data.
 - Are you getting the performance you want? Small sample size has risk to agency.
 - Be bold – **Missouri** is willing to try anything.
- How has reporting changed with Performance Based Specifications?

- Internal QA/QC testing – chunk thru lots. Contractor has a big lift to gather information and do testing. Do our results matter at the end of the day? Bid-Build too – at the end of the day it's the owner's results that count. What is the significance of the contractor's QC results?
- Unknown. If you want to identify key quality characteristics – it's unknown how to get there. Hard to agree on what to do. Unknown on implementation.
- Are you going to continue this or is it a onetime thing (considering cost to implement) is this something for the future? Missouri DOT plans to ramp it up in 2018.
- What are the key quality characteristics?
 - Models are out there – they know key characteristics.
 - Fundamental vs. Empirical tests. Right now focused on empirical tests. Fundamental engineering tests need to come to play. Empirical results don't tell how materials are going to perform in future.
 - The specifications today 12 Bayesian model averaging (BMA) may work better than 13 BMA.
- Financial impacts to projects
- FHWA Division Office reaction and acceptance
- Public reaction to incentives/disincentives
- Chart

Discussion on State Application of Performance Specifications Rick Bradbury

- 3-year program - \$3 billion
- 23,000 centerline miles
- All asphalt pavements
- Want to encourage contractors to innovate
- Want to meet customer needs
- Properly applied specs can be applied to any projects
- Need to balance the benefits with the risks
- Looking at Performance based mix designs
- Need independent assurance
- Need to have a good dispute process
- Quality control – where should the contractors be focusing
- Takes this very seriously
- Contractor are focusing on the final mix
- Need to think about resources and what goes into it

Why Performance Specifications?

- Current QA not always resulting in performance
- Desire to promote innovation
- Move closer to user needs

Project Selection Considerations

- Scope?
 - Complexity
 - Opportunity to innovate
 - Existing conditions
- Can performance be defined?
 - Desired outcomes
 - User needs
- Can criteria be measured timely and cost effective?
- Delivery Method? Design, method
- Project Selection Considerations – balance benefits with risks. Use the appropriate tier and applies to more than New Pavement construction.
 - Bridges and structures
 - Recycling
 - Pavement Preservation – IR thermal profiling for uniformity.
 - Performance Based Mix Designs – criteria for longer lasting pavement. Predicting rutting and cracking.
- **New Jersey** is doing some procedures for mix design identifying user needs and measuring performance instead of means and methods. Particularly interested in getting rid of RAP – minimum amount must be used. Not telling contractor what to use but what the end product has to be.
- Need to get fundamentals in place before going to higher level testing.
- Quality Control – has been overlooked, we work with industry a lot.
 - Conversation rarely talks about Quality Control and where the contractor should be focused on to get the result we need.
 - Do we need to rethink QC requirements?
 - The auto industry relies on process controls.
- Are we hindering QC by using data for acceptance?

- Agency acceptance is important but just to confirm we are getting what we want.
- Some contractors spend more time testing mix going into truck – much less time on stock pile care, good equipment. Basic processes that don't promote good quality.
- Need to rethink Process Control – so the processes are tuned to produce good results. Statistical acceptance will always be subpar quality because people only rise to the lowest common denominator.
- Need to determine which technologies apply where.
- Goal: A pavement specification less than 5 pages. (The US Constitution is 4 pages)
- Much of today's specification language move to QC Plan or Quality Management Plan. They should tell us how they are going to meet it.

State Discussion:

- What is the state of quality management?
 - **Maine** was impressed that contractors expected they had good QC. Maine contractor's test quality but may really not have a good process in control.
 - **Alabama** – Do they know if their process is in control or not? Keep control charts. Minimum requirement of QC plan; they would like to get rid of this – fastest way to know your quality is to look on a chart. It should not be an exercise but a reason.
 - **Utah** contractors seem to have a pretty good idea of where their materials are at. In disputes, they seem to know where they are at and looking back at where we are at.
 - **Vermont** – QC is overlooked. Contractors know their business much better than the DOTs do. Them as the owners they know if something has gone wrong without testing. *"We can't use the QC results because contractors know their business way better than we do although we may think we do. They know when things go awry even before testing. We are a small state and we know them all by name – we know who the bad apples are."*
 - **Nevada** – They have a few bigger contractors that have an established QC program. There used to be a 6-week NHI course on materials – QA/QC session is week-long. We accepted them based on workforce issues. Seems like we are going in circles – now QC is not so bad. Our preference is using our results as acceptance. We would like every contractor to have QC but the only time we spec it out is when we have big pours, what we expect, what QC's they should do – all dictated. We expect them to have best practices to benefit their work.
- Low bid process presents barriers to high quality.
 - **North Dakota** - Seems like states are reluctant to have bad apples bid on projects in their state but they are the low bid. No policing to get them out of the business. Why is it a secret that they are performing poor? We need to find a way to take the bad apples out of the basket.

- There are safety issues that come out in quality. Can safety be tied to performance? Low bid projects, develop pre-qualifications, elements, and performance specifications. Hash it out in the industry. QBS as well as low bid ideas – minimum performance standards. It could weed out those that undercut the process by doing bad work.
- Best value procurement.
- A third bid quality related to safety. Worth trying but may not work.
- Flagship or pilot project – where is the approach for quality on all bids.
- **New Mexico** has a contractor performance qualifier on award process. Factor grading that can change their rankings – annual report is available.
- Research project – performance based qualifications NM took the draft and pursued it. Tiered approach on how to do this. Need to do it in a partnership with associations.
- **Washington** has some contractors under pre-qualification (only bid one at a time until you perform otherwise). Sometime subcontractors can cause problems. The challenge is how to address bad apples among subcontractors and material suppliers.
- Smaller work is where you have the most issues. Low bid process presents barriers to good quality.
- Is this a way to start addressing these kinds of problems?
- Opportunities for innovation? How are you incentivizing innovation?
 - **Maine** – did not specific that they used automated machines. Contractors saw the profitability of that. They have not seen a cost benefit of other innovations (intelligent compaction or infrared testing) so they are not using it.
 - When **North Dakota** requires innovation – it’s a cost additive. Seems to be all over the board with techniques. Innovation in traffic management are a rich source of time savings.
 - **Vermont** – found the easiest thing to do is to pay for it. Once the DOT introduces it then contractors can start phasing it out.
 - **Wyoming** - Contractors drove technology in state. *Note – need to market products to contractors. “When Wyoming went to warm mix the contractors pushed it and the agency played catch up. We are pushing infrared but if our contractors don’t bite we second guess.”*
- Tools and technologies as part of R07? QC tools versus acceptance tools?
 - **Utah** – looked into intelligent compaction on Hot Mix and really like value on mapping and thermal. Industry was concerned about cost. We tried some projects but looking at it as a QC tool.
 - **Missouri** – R06C contractor was adjusting speed of trucks and paver based on IR scanner. *“Sending feed of temps to plant manager and that was purely QC to plant manager. They could make adjustments in the field at 2 am based on what they could see.”*

- **Maine** – Contractor and agency should want to us IR scanner. Densities are more accurate. Using the information and learning. Can the states incentivize them through the pilot projects?
- California – There is no way we can have an inspector in most of our night work. IR tools are the key.
- **Maine** – One particular pilot on SHRP2 – night pavement expected to be smooth but it was a horrific night. Tools showed us that operators, trainers and inspectors are not as trained as in the past. PaveIR is a great QC tool as well as inspection tool. They are using the info and learning – if they aren't adopting on their own we can incentivize thru these pilot project. *One grind out will pay for a 30K piece of equipment.*
- R07 Report or guide specifications?
 - A few have read
 - There is great information in the guide specification
 - Gives different tiers of disincentives

Recap of Day 1

Resources for Developing Projects with Performance Specifications Richard Duval

- Need shadow projects
 - Maine
 - Missouri
 - Western Federal Lands
- What will help get this implemented in your agency? What tools or resource would actually help?
 - Performance Specifications is a new way of doing business.
 - **Washington** - Share examples of other states – standard prescriptive specifications – what do they look like.
 - Put more documents on the AASHTO website.
 - Need help with updating software – company went bankrupt and was dead in the water. Steering Committee of AASHTO were to merge PaveME with FlexPave software. (Harold Von Quintas)
 - **Alabama** – need robustness. Need to be working with this day in and day out.
 - AMPT performance specifications are exciting – (got ours thru Pooled Fund) never received technical support from company for calibration, use, tips, or anything. AMPT is supposed to be the simplified.
 - We can't seem to get them to respond – software does not have float numbers. FHWA had a meeting with the providers at TRB. Lack robustness. Empirical tests can still tell the future when there is enough data. AMPT has wonderful mechanisms behind it, but right now it's not there.

- We need a test that can go to the field where we are accepting the material. Looking for field tests. Fifteen to sixteen states told Turner Fairbanks and asked for a field test that works. FTIR and XFR are available for polymers – if not from the mechanical side, perhaps by the chemical side.
- Workshops - Vermont had a 1-day workshop – focused on one project and one solution. **Caltrans**, **Missouri**, and **Vermont** would be interested in state training.
- How are we interacting with AASHTO committees who are making decisions about pavements? What is the relationship while they are the ones doing guidance documents? How do we funnel our research and work back to AASHTO rather than it being done one state at a time.
- Some big challenges are rising to the surface. There were originally three levels of design in SuperPave (Levels 2 and 3 were supposed to get into performance measures but it was not practical).
- Performance Specifications on fundamental properties of the pavement. To get from basic QA – the best thing moving forward is to recognize current acceptance has holes, not getting best performance, what can we do that gets empirical data and help us look forward – focus our acceptance criteria to the things that show us performance will be better. Just because we can't get a formula that will work for 20 years doesn't mean the data is useless.
- FHWA is still working on getting vendors to respond appropriately. Need to move forward together. The power of the tools of the test AMPT will rise to a higher level. FHWA wants to equip states with as many tools as they can.
- Performance/Volumetric relationship is missing. Working on our volumetric state testing – we get to the point that we want to get to a performance specification, but designers would push back. Future challenges will include discussions where people still want to tell contractors how to do the job. Releasing control to contractors to balance risk is definitely a cultural shift.
- Changing culture in DOTs – SHRP2 has targeted state training sessions – to help work within a specific agency to introduce them to the product and benefits.
- The guide specifications (available on the flash drive and website) have a lot of questions to help guide thinking on what your state will want to do. They aren't totally prescriptive, but help identify gaps and things to solve. 21 prototype guide specifications.
- What do you need?
 - **Arizona** – not sure yet. Need to sit back and look and talk to staff.
 - Should Lee Gallivan (SHRP2 R07) review your program and provide a path forward? Probably would not be bad to do this assessment.
 - **Missouri** – intelligent compaction - PP81 – commentary – what worked what did not work. Example specs for states to see. The implementation is really important. Need to take it beyond research.
 - **Montana** – Interested in IR paving. Should we pay for more IR scanners?

- **Arizona** – Challenge with industry – know what to do what to fix it now if they get penalized. If we go to a performance test what do you change to fix what is not right. Have to provide information on how to change what is failing.
- This was not structured to give you examples but to answer your questions.
- Please give us your questions.
- Concrete bridge decks – break it down, give examples,
- **Missouri** – Intelligent Compaction – 26 pages of IC spec came from AASHTO – used it to add 5 pages to our spec that worked for us. Intelligent Compaction.com (15-20 states have their examples online)
- Example specifications on line.
- SME time – Ongoing research at FHWA
- Went through all the resources available.
 - Decision support guide can be promoted.
 - Peer-to peer technical support within your state
 - Maintain a library of applied specifications
 - Seek standardization of testing parameters, procedures and reporting practices for equipment.
- Training and Education via FHWA
 - Reconfiguring QA course
 - Continued efforts of SHRP2, Turner Fairbanks, DOT Partners
 - Education Videos
 - Whiteboards
 - FHWA Tech Briefs
 - FHWA Training on PRS Testing – OK, NC, ME, MO
 - Shadow Projects – ‘jump into the shallow end’ FHWA is focused on EMPT machine for fundamental testing. Support balance mix design approach but not emphasized.
- Where do we go from here?
 - FHWA Contract: Develop and Deploy Performance-Related Specifications for Pavement Construction (ARA, NC State, Advanced Asphalt Technologies, FHWA)

Discussion

- Rutting, Fatigue, Durability, Permeability, RAP (UT up to 25 percent) – need a test for all of this. Some tests are sensitive to RAP and binders. Looking to mix a perpetual pavement that only needs top layer rehabilitation. Arizona design is a model.

- FHWA – simplifying testing thru software modifications but they are still dealing with gaps and volumetrics. Shadow projects will provide better data to help us make relationship between volumetrics and other issues.
- Our research funding has to have a match and we fight for the match vs. budget to work on roads. Research isn't always practical and able to implement. Implementation was impossible without SHRP2 funding to help make our budget actually useful to us 'boots on the ground'. Reviews and technical assistance were a great package for SHRP2.
- R07 is Conceptual – examples aren't far from where you are now – we want to give you space to try it in other ways and get away from materials focus and on to performance.
- We are not as far along as some of the other states – just struggling to get our agency all on the same page about values of asphalt. Bringing it to industry is yet another struggle.
- Is there anything we can do to help you work with industry?
 - **California** developed specifications with Industry – but half are on board and the other half are trying to stop this.
 - SHRP2 should come out and talk to the industry – such as stripers
 - **Washington** - impacts to local agencies – do not forget the smaller jobs where locals use state specifications (likely same contractors). Lots of education needs to take place with local agencies.
- In **Federal Lands** – work is across multiple states – isolated from political pressure within State DOTs. IRI specification – brought it in, showcase within our agency with contractors from multiple states, rolled out proposed IRI spec. As an industry, there is research, data, and we had to demonstrate to them smooth roads have added benefits, last longer, better for public, affordable. This happened 10 years ago.
 - We help one another fill the gaps. How do I best fill these gaps to stand before contractors and say 'this is what we are implementing and this is how and this is why?'
- **Idaho** - moving forward on quality incentive version 2. Incentivizing for joint density specification. This is what they are focusing on. Waiting for the magical test. Warrantee is a big push of our agency – warranty everything. Trying to get meaner and leaner.
- What is it going to take to change culture? Retirements? Trying to encourage contractor culture change; we have more questions than answers. This kind of forum allows you to see what other states have tried or are thinking.
- **Montana** – in a good spot with plant mix, good QA, good incentives, gap is good performance test in low temperature cracking. Not a great relationship with industry. Peer exchanges in concrete association – QA, performance tests, did it all and the contractors stopped doing business with the state.

- Really interested in IR Paving in Montana would help bring best contractors to the top. We have problem with not big enough trucks on the job. Looking to Missouri for how they did this. First question from construction will be: “Are we getting any money from this?” Contractors will be a mixed bag.
- **Arizona** – we are at various levels of specifications. Industry knows what to do right now if they are penalized – to fix it. But if now we go to a performance test that they aren’t passing – we need to know ourselves and give them the info to know how to fix it. Huge gap – we can design the perfect mix but it isn’t executed right its trash.
 - Why should states tell contractors how to fix it? They need to know where the resources and tools to make change.
 - Contractor mix producers only have certain things they can control at their plants, flow of aggregates, and amount of liquid is about it. Some know exactly what they needed to do but now that they are in SuperPave volumetrics. Going to performance measures is a whole new education point for them – very slow to change. Contractors in Maine are not sending people to TRB.
 - It would be nice to be here 5 years from now to see progress and examples.
- **Montana** requires volumetrics during construction and they complain we hamper their production rates... how do other states spec volumetrics?
- Do not lose expertise in the department – because we have to be able to step in and show them just how much contractors CAN do?
- Contractors may not have staff to do the production.

Advancing Performance Specifications - Howard Anderson

- Performance Tests for Stripping, Rutting, and Cracking.
- Had to take inspectors out of plants – now use QMP audits for lime and moisture.
- Rutting: used Georgia Loaded Wheel Test, Asphalt Pavement Analyzer, Hamburg Rut Test, PMW, All contractors now run the Hamburg test.
- Hamburg Equipment – experimenting higher polymer mixes – added 20-pound load to Hamburg.
- UDOT Performance, Research, Asphalt Pavement and Cracking.

Bending Beam Rheometer (BBR) for Asphalt Mixtures - Pedro Romero

Looked for a low temperature load bearing test AASHTO TP125

- Used for 15 to 20 years in asphalt for binder testing. But we have shown it is also valid for asphalt mixtures. Equipment is tested and verified over long time.
- Challenges include:
 - Where do you get your specimens? Can do slabs but also like pucks or cores,

- Are the beams too small to test for mixtures?
- Is the teste repeatable?
- Does it relate to field performance?
- Sample preparation – need masonry saw. Modified a commercial tile saw with an asphalt blade.
- Is beam size adequate? Use composite theory – consider gauge length, ratio is not an issue. Large aggregates do not create outliers within data sets.
- Created a ruggedness study and a precision – bias statement.
- Experiment of 40 random beams showed favorable results.
- Looked at relation to field performance – 7 state roads, all had same binder grade, took cores in fall. Results were very different for each core. If you are targeting low temperature properties with binder only – you are missing out on important data. You need to look at the mix. Plotted on black space diagram because of large variations. Performance predictions worked within 1 year.
- Binder testing alone is not sufficient to determine mixture performance.
- BBR testing is practical.
- BBR testing on mixtures is repeatable across labs.
- BBR test results can be used to predict sections with potential for low temperature cracking
- Performance-related specification will allow for innovation.
 - Contractors know their product – I do not need to tell you how to put your mixture together but I need to tell you what I want.

Developing and Deploying Performance Specifications – Mark Woolaver

- FDR
- Everything worked until we added cement. We threw our spec at cement “the way we always did it”
- What is Construction?
 - Causes of Failure – 66-percent workmanship, 21-percent design deficiency, 9-percent material failure, natural disasters
 - Vermont Construction - 79-percent workmanship and 21-percent material failure
- Crew change caused 100K deduction due to poor workmanship.
- Specification Revisions (list of characteristics measured by contractors – on slide)
- Did we get what we wanted? Chief engineer smooth ride home, plows not breaking; so far a success. Found problem, brain stormed, brought in outside folks, involved industry, simple changes and came back in line to where we wanted to be.
- PRS Order of Importance in **Vermont**

- Lost “us/them” mindset
 - Balance “done it that way before” with open to new ideas.
 - Exec support
 - Engage all internal parties
 - Engage available external parties through IAP or other efforts
 - Improve Training/Communication
 - Believe “design” is achievable and above a “recipe”
 - Repeat
- Contractor has more QA to do but we pay for it.

Questions/Thoughts

- **Wyoming**- When your first mix failed – used micro cracking. Doing our first one this summer – no performance built in. Speed makes a big difference to get 2-percent cement all the way down. Baseline PH test. PH needs to be consistent all the way down.
- Speed and moisture content are QC and critically important.

Close Out

- Chart will go in report – What chart?
- This research results in a process not a product. Performance Specifications will not be in EDC 4 coming up.
- Ask questions – we can help you find experts to help. You do not have to go at this alone.
- Watch for Case Studies from IAP states.
- There is still SHRP2 R07 money available. It is your money. We want to know what more we can do to help you.
 - Ask the question – be open in your thinking. There are lots of opportunities and may be ways to say “yes”.
 - Let us know how the format of this workshop worked.
 - Let us know if your expectations were not met – what did we miss?