MEETING SUMMARY

SHRP2 PERFORMANCE SPECIFICATIONS FOR RAPID RENEWAL (R07) TECHNICAL EXCHANGE

TO:	Jennifer Balis, Richard Duval, Keith Platte, Pam Hutton
COPY:	Sam Rosenblum
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LOCATION:	Sheraton Burlington Hotel and Conference Center, Burlington, VT

Purpose

The SHRP2 Performance Specifications for Rapid Renewal (R07) Technical Exchange was intended to be an open exchange of current practices and lessons learned in performance specifications between states currently using the SHRP2 product in the Northwest. The goal was to present the latest techniques, discuss the benefits and challenges of using performance specifications and to provide suggestions to improve the AASHTO SHRP2 process and the performance specifications technology.

Attendees

- American Association of State Highway and Transportation Officials (AASHTO) – Keith Platte, Associate Program Manager; Pamela Hutton, SHRP2 Implementation Manager
- Federal Highway Administration (FHWA) – Jennifer Balis, Project Manager; Richard Duval, Construction Research Engineer; Lawrence Dwyer, Assistant Division Administrator, Vermont Division; Mark Richter, Construction & Maintenance Engineer, Vermont Division; Brad Neitzke, Materials Engineer, Western Federal Lands
- Alabama Department of Transportation (ALDOT) – Jeff Benefield; Lyndi Blackburn, Assistant State Materials and Tests Engineer
- Connecticut Department of Transportation (ConnDOT) –Jan Mazeau, Transportation Supervising Engineer
- Delaware Department of Transportation (DelDOT) – Larry Eliason, Engineer
- Maine Department of Transportation (MaineDOT) – Derek Nener-Plante, Pavement Design/Quality Engineer; Dale Peabody, Transportation Research Engineer, Richard Bradbury, State Materials Engineer
- Maryland Department of Transportation (MDDOT) - Nathan Moore, Assistant Division Chief Pavement;
- Massachusetts Department of Transportation (MassDOT) - Edmund Naras, State Pavement Management Engineer; John Grieco, Director of Research and Materials
- Missouri Department of Transportation (MoDOT) – Bill Stone, Research Administrator; Daniel Oesch, Field Materials Engineer
- New Hampshire Department of Transportation (NCDOT) – Charles Dusseault, Materials and Research Administrator; Denis Boisvert, Chief of Materials Technology
- New Jersey Department of Transportation (NJDOT) – Yashvi Patel, Engineer; Stevenson Ganthier, Principal Engineer

- New York Department of Transportation (NYDOT) – Tom Kane, PCC Pavements and Ride Quality Engineer
- Pennsylvania Department of Transportation(PennDOT) –Neal Fannin, Pavement Management Engineer
- Rhode Island Department of Transportation (RIDOT) – Mark Felag, Managing Pavement Engineer
- Vermont Agency of Transportation (VTrans) – Troy Lawson, HMA Materials Supervisor; Mladen Gagulic, Materials Engineer; Bill Ahern, Research Program Manager; Mark Woolavar, Construction Paving Engineer; Mike Fowler, Pavement Design Engineer; Jonathan Harrington, Project Manager; Kipp Brandon, Civil Engineer; Richard Ranaldo, Construction Services Engineer; Andrew Willette, HMA Manager; William Gray, Construction Paving Technology
- Applied Research Associates (ARA) – Bill Vavrik, Principal Engineer and Vice President; Dr. Shreenath Rao, Principal Engineer and Research Group Leader
- NCAT –Dr. Elton Brown
- CH2M HILL – Lee Gallivan, Consultant; Jen Smoker, Consultant

Invited Speakers:

- Shane Buchanan, Asphalt Performance Manager, Oldcastle Materials
- Ray Brown, Asphalt Research Engineer National Center for Asphalt Technology
- Cecil Jones, Diversified Engineering Services
- Steve Cross, Asphalt Recycling and Reclaiming Association
- Kevin Marshia, Chief Engineer, Vermont Department of Transportation
- Tom Bennert, Rutgers University

Executive Summary

The SHRP2 *Performance Specifications for Rapid Renewal* (R07) product was established to advance the development of performance specifications across the country. Through the Implementation Assistance Program (IAP), administered by FHWA and AASHTO, the States of Alabama, Maine, Missouri, Pennsylvania and Vermont receive support to implement this SHRP2 product. To help support the individual state activities, a two-day Peer-to-Peer Exchange was organized and held in Burlington, Vermont, September 20-21, 2016, to further the development of the program not only within the participating states, but nationally. As of the result of the 2015 Peer-to-Peer Exchange, the technical exchange was developed to expand the knowledge of the IAP States through the support of FHWA and AASHTO and the SHRP2 R07 Program on Rapid Renewal with the states from the Northeast.

It was reported during the Technical Exchange that most of the states were not aware of the SHRP2 guidance documents and/or the details contained within. These documents are the baseline of the information for the Technical Exchange.

The guidance documents referred to include:

- *Performance Specifications for Rapid Highway Renewal* (Report S2-R07-RR-1)
- *Strategies for Implementing Performance Specifications* (i.e. *Guide for Executives and Project Managers* Report S2-R07-RR-2)
- *Framework for Performance Specifications* (i.e. *Guide for Specifications Writers* Report S2-R07-RR-3)

The Technical Exchange was successful in creating opportunities for the transportation agencies and invited guests to openly discuss the experiences and challenges each were having regarding the development of

performance specifications within their respective states. Individual discussion sessions were effective at eliciting detailed feedback from participants on the R07 program, ranging from suggestions for improving the product to ideas of what transportation agencies really need to advance *Performance Specifications for Rapid Renewal* in their respective states. For example, participants said in order to advance performance specifications, they need documented examples of the benefits of shifting from method to performance specifications, and a simple, easy-to-read flow diagram illustrating the implementation of performance specifications. They also needed support and buy-in from agency management which is a duplicate finding from the Alabama Peer-to-Peer Exchange.

Each IAP states provided a summaries of their efforts including challenges to implement performance specifications. All participating agencies indicated the need for additional support from AASHTO to help advance *Performance Specifications for Rapid Renewal*, however, it was acknowledged that each state has their own institutional issues to address. AASHTO is limited in what they can do since the process to develop specifications varies by state. All of the presentations have been made available on the SHRP2 website for downloading.

CH2M continues to provide support for individual States. Additionally, participants recommended further marketing efforts such as the development of a webinars, and information on shadow specifications and state efforts in expanding *Performance Specifications for Rapid Renewal* beyond pavements. AASHTO has limited funding to support all state efforts but SME support continues to be provided. FHWA is providing support through additional work in the development of performance specifications for mix designs as a continuation of the work from NCHRP.

During the Peer Exchange, Dr. Thomas Bennert from Rutgers University was intending on providing information on Performance Specifications in the North East on what is needed to facilitate the development of Performance Specifications in other State programs. Unfortunately, Tom could not present the information due to a last minute illness but his information and presentation is available on the SHRP2 Website for viewing. His presentation emphasis asphalt pavement efforts but included other activities as well.

There were several presentations about the development of performance mixture design programs for asphalt materials and in-place recycling (full depth reclamation), which were very helpful in explaining the status of the *Performance Specifications for Rapid Renewal* product and the developing ideas for additional opportunities for states.

To further address the many issues from the Technical Exchange, FHWA and AASHTO is planning on extending the effort through a SHRP2 R07 product showcase to be held in a western state in the spring of 2017. The 2017 showcase is intended to focus on products as the SHRP2 R07 efforts are concluding.

The following discussions are based on the agenda from the IAP and participating states with the intended purpose of expanding the knowledge of SHRP2 R07 program in the Northeast.

Appendix A – Detailed Notes of Presentations and Comments

The following are detailed notes from the Vermont Performance Specifications for Rapid Renewal Peer Exchange.

Welcoming Remarks

Jennifer Balis, FHWA - Headquarters:

Our goals are to meet together, talk about what we've learned, what we've tried, and where we are going in regards to performance based specifications.

Mark Woolver: VTrans

Welcome to Vermont, Performance Based Specifications are certainly something Vermont is focused on. VTrans has developed a Performance Innovation and Excellence Unit (PIE). We've come a long way. In this state the

yearly snowfall is often predicted by the stripe on the back of the wooly bear caterpillar – the deeper the black stripe the deeper the snow expected that year. The deeper the snow the greater economic benefit for this tourism based state. Performance economists could use a wooly bear caterpillar to determine successful results.

Our agency is looking at measuring our performance mainly because what we don't measure doesn't get done. Education is also important to us.

Richard Duval, FHWA and Keith Platte, AASHTO
SHRP2 Overview and Performance Specifications for Rapid Renewal Product (R07)

FHWA wants to work with states, discuss need, define concepts and clarify how to take the first step to start this process.

- Conventional approaches to construction put the burden on the owner agencies. Performance Specification efforts is intended to share the risk between owner and contractor. Owner agencies have to understand that sharing risk is also directed related to sharing control of the activities.
- Conventional requirements hinder innovation. Performance Specifications are focused on the life of the project and accomplishing goals without assuming all control. A key is to target specifications on what an agency specifically needs from a particular contractor.
- Emphasize desired results and encourage innovation.

There is generally a lack of knowledge among states on how to take the first step regarding advancing Performance Specification. Questions include: what historical data to collect and analyze, how to work with industry, how to develop a specification, what terms or elements to include, etc.

- In general, these specification types represent a **progression** toward increased use of higher-level acceptance parameters that are more indicative of how the finished product will perform over time.
- To varying degrees, they all attempt to **shift performance risk to the contractor** in exchange for limiting prescriptive requirements related to the selection of materials, techniques, and procedures.
- By relaxing such requirements, performance specifications have the potential to **foster contractor innovation and improve the quality or economy**, or both, of the end product.

Application among the SHRP2 R07 IAP states includes:

- Alabama: Use of Intelligent Compaction as a basis for performance specification
- Maine: Performance specifications for asphalt pavement – Intelligent Compaction, concrete bridge deck steel cover and Performance Based Asphalt Mix Designs
- Missouri: Performance specifications for asphalt pavement – Intelligent Compaction, grading and geotechnical activities, and Performance Based Asphalt Mix Designs
- Vermont: Performance specifications for Full Depth Reclamation (reclaimed pavement and cement-stabilized base) with Intelligent Compaction
- Pennsylvania: Performance specifications for all elements of Bridge construction and maintenance as part of its P3 program

Performance Related Specifications are a tool that can be used to optimize performance of the roadway.

Lee Gallivan, AASHTO SME
Performance Specifications – *What are they, and how do they work?*

We want participants to ask the questions and we hope to generate more questions through the presentations. The questions seem simple but the answers are complex and difficult to answer. There are probably 20 different opinions present in this room alone on what is the definition of Performance Specifications. We want to start this discussion to bring us closer to being on the same page.

Performance Specifications must work between contractors and agencies as well as within each agency as different departments will have to work together as most have not done this before. Peer to Peer exercises works as well within a agency (different sections) as among multiple agencies.

The main purpose of an agency is to allocate money to address the transportation needs of the area, and to maintain the infrastructure in a safe and cost effective manner. There is always only so much money yet so many needs to optimize. How is this done? Method Specifications have been around for over a century and they will continue to be used for certain applications. Performance Specifications are not the answer to every situation. Agencies need to make sure they use the right level of specifications at the right time and on the right pavement. Sample questions that everyone needs to consider, includes:

- What is quality? Everyone has a different opinion?
- Done right the first time – what exactly is that?
- How do you put your specific desires into words?
- How do you convey to contractors in black and white (specifications) what the agency really wants?

We have identified the need to energize states to start talking because every state is different and Performance Specifications will look different for each as they articulate what they want to accomplish and how to describe to the contractor what is expected to be accomplished.

SHRP2 Performance Specifications document resources include:

1. Final SHRP2 Research Report (RR-1) -A guidance manual for implementing Performance Specifications (PS) (from the perspectives of project managers/decision makers)
2. *Strategies for Implementing Performance Specifications: A Guide for Executives and Project Managers (RR-2)* -A guide for and technical specification writers
3. Framework for Performance Specs: *Developing and Drafting Effective Performance Specifications: A Guide for Specification Writers (RR-3)* – A suite of guide performance specifications and the minimum of what you really need to have. This includes a definition of Performance Specifications.

Additionally the Transportation Research Board also has distributed the 6th Edition Glossary of Transportation Construction Quality Assurance Terms to standardize the definitions, which can be used as a tool to ensure we are talking on the same page. Both the SHRP and TRB documents include the same definitions for Performance Specifications.

Standardized Definitions Include:

- Materials and methods specifications. Also called method specifications, recipe specifications, or prescriptive specifications. Specifications that require the contractor to use specified materials in definite proportions and specific types of equipment and methods to place the material. Each step is directed by a representative of the transportation agency. [Experience has shown this tends to obligate the agency to accept the completed work regardless of quality.]– not when to apply but definitions of what to apply.
- End result specifications**.** Specifications that require the contractor to take the entire responsibility for supplying a product or an item of construction. The transportation agency's responsibility is to either accept or reject the final product or to apply a pay adjustment commensurate with the degree of compliance with the specifications. [End result specifications have the advantage of affording the contractor flexibility in exercising options for new materials, techniques, and procedures to improve the

quality or economy, or both, of the end product.] End results are not exactly Performance Specifications but the concept moves forward the process of getting the most out of performance specifications. End Results define what will be accomplished by date of completion while Performance Specifications assure how what was constructed will work from completion forward.

- Quality assurance specifications. Specifications that require contractor QC and agency acceptance activities throughout production and placement of a product. Final acceptance of the product is usually based on a statistical sampling of the measured quality level for key quality characteristics. [QA specifications typically are statistically based specifications that use methods such as random sampling and lot-by-lot testing, which let the contractor know if the operations are producing an acceptable product.]
- Performance specifications**.** Specifications that describe how the finished product should perform over time. [For highways, performance is typically described in terms of changes in physical condition of the surface and its response to load, or in terms of the cumulative traffic required to bring the pavement to a condition defined as "failure." Specifications containing warranty/guarantee clauses are a form of performance specifications. Other than the warranty/guarantee type, performance specifications have not been used for major highway pavement components (subgrades, bases, riding surfaces) because there have not been suitable nondestructive tests to measure long-term performance immediately after construction. They have been used for some products (e.g., highway lighting, electrical components, and joint sealant materials) for which there are suitable tests of performance.]
- Performance-based specifications. QA specifications that describe the desired levels of fundamental engineering properties (e.g., resilient modulus, creep properties, and fatigue properties) that are predictors of performance and appear in primary prediction relationships (i.e., models that can be used to predict pavement stress, distress, or performance from combinations of predictors that represent traffic, environmental, roadbed, and structural conditions). [Because most fundamental engineering properties associated with pavements are currently not amenable to timely acceptance testing, performance-based specifications have not found application in transportation construction.]
- Performance-related specifications**.** QA specifications that describe the desired levels of key materials and construction quality characteristics that have been found to correlate with fundamental engineering properties that predict performance. These characteristics [for example, air voids in asphalt concrete (AC) and compressive strength of PCC] are amenable to acceptance testing at the time of construction. [True performance-related specifications not only describe the desired levels of these quality characteristics but also employ the quantified relationships containing the characteristics to predict as-constructed pavement performance. They thus provide the basis for rational acceptance/pay adjustment decisions.]
- Warranty specifications. A type of performance specifications that guarantees the integrity of a product and assigns responsibility for the repair or replacement of defects to the contractor. [Warranty specifications can be written to guarantee either materials and workmanship or product performance.] Under R07 Specifications – warranties can be a part of performance standards. Maximum control can have maximum risk with warranties applied. PWL equations, it all depends on what project you are looking for.
    - 2-4 years – Material and Workmanship
    - 5-10 years- Short Term Performance
    - 11-20 years – Long Term Performance

Performance Related Specifications can include the elements of a warranty. Typically in existing specifications, contractors will walk away from the project at the completion of the work. Agencies need tools or mechanism is necessary to bring them back and keep them responsible for the quality of their work. Warranties have been successful in increasing the quality of the construction but administrative issues have tainted the results of using warranties.

Tools include the 5-7 year warranty – the bonding company ties the warranty to the contractor. Bonding costs and requirements can also undermine innovation and the performance of the project. The State of Florida includes a 3 year guarantees without a bond on all of their hot mix asphalt projects. If issues come up, the guarantee requires the contractor to come back to remedy the situation. If the contractor fails to come back, they would be restricted from future contract bidding with the Department for three years, time afterwards.

General History of Specification Development

1. Method Specifications, early in the 20th Century
2. End Result and Quality Assurance Specifications – (came out in the 1970's)
3. Statistical Specifications (1990's) – one thing we are all afraid of. Need to learn the power of statistics and how it can help them make more money. PADOT has end result spec and is currently promoting PWL for concrete and asphalt mixes. Approximately 35 States utilize PWL concepts to advance quality in their construction operations.
4. Warranty (1990's) – defining performance at a particular date in the future. (10-20 year point).

Understanding of Performance Specifications in the 21 Century, and what are they. The following is a little "visual" description that needs to be understood not only in the development of the Performance Specifications, but evaluating the benefits.

- .***Method Specifications describe what hammer to buy and how many times to hit the nail.***
- ***End Results describe what the agency wants nails, i.e. hammered into the wood.***
- ***Performance Specifications explain that the agency wants the wood held together for 20 years and allows for innovations if it will help accomplish this goal.***

Brad Neitzke, FHWA
Coordinated SHRP2 Efforts in Western Federal Lands Highway

HMA Progression of Specification at WFLH – natural progression of where things are going…

- 1961 Hot Mix Federal Specs – timeframe dealt with what was known. Proportionate measuring was important. Broadband graduation requirements; Asphalt content by weight during mixing; Asphalt cement by certification; Methods of manufacture
- 1971 – Gradation target value and tolerances, asphalt content target and tolerance, obtaining and measuring density, limited asphalt cement testing (primarily certification)
- 1980's add thickness, asphalt cement testing – limited certification looking at binders; statistical acceptance of hot mix, PWL specs came with measuring and providing pay lots and pay factors. Our contractors are not afraid of statistics but in 1985 they were.
- 1990's Performance graded binders added, smoothness measures – pay adjustments, incentives/disincentives. Next step was contractor testing on site – (previously agency tested).
- 2000's - looking at VMA, Air Voids and other asphalt mixture volumetrics, content with target value and tolerance to control HMA; minimum MVA; quality in regard to binder, inertial profiler tools,

Recognize that over the last 50 years we are still looking at proportion of mixtures and that the natural progress of next steps is to move to a performance specifications. Not sure what that next step is but want to learn more

Additional Mixture Empirical Tests including: Immersion – Compression, Tensile Strength Ratio, Hamburg Wheel Track Testing, Asphalt Pavement Analyzer, and TSRST are all relating to indicators on how it might perform.

These are the objectives for this project are to prove we can:

- Optimize and Improve Performance? Still have to define what performance is and how to measure.
- Determine how volumetric relate to performance and pavement life?
- Develop quality adjusted pay factors that reflect “as-constructed” pavement life?

The Project Outline is in 2 parts; a desktop study and construction

Perform desktop study: past data, test results, mix design data, field cores of existing pavement, advance lab testing, traffic data. It compare predicted life vs. “as-constructed” and compares against pay factors for completed work.

Past Projects include:

- Yellowstone National Park – East Entrance Road – WMA project with extensive testing.
- Grand Teton National Park: Eastside Highway – Outside Highway Paving

Performance Testing included:

- Cores obtained from existing pavement
- Advanced laboratory testing – fundamental AMPT
- In-service traffic data *(vehicle counts / traffic mix)*
- PMS / RIP data
- Performance relationships

Shadow Projects in Active Construction include:

- Skyliners Road, Bend, OR
- Norris to Golden Gate, Yellowstone National Park (currently under construction)

Additional sampling of current project materials included virgin materials testing, performance testing, use of calibrated performance models, predicted pavement life vs. volumetric properties, “As constructed” pavement life vs. pay factors, and AMPT and LVECD analysis.

Shadow Project Data included asphalt concrete mix design information (Contractor mix design, Agency verification, and TFHRC confirmation and comparison) as well as Acceptance Quality Characteristics *(AQCs)* (Asphalt content, VMA, Density, Asphalt binder, and Roughness *(IRI Evaluation).*

Deliverables: where are we going? The continuum of where we are from where we have been since the 60’s.

- Can we compare predicted pavement performance vs. Volumetrics?
- Can we determine as-constructed pavement life compared against PWL pay factors.
- Can we develop draft performance specifications? Don’t yet know what that looks like.
- Superpave Volumetrics relation to performance testing. How we approach payment/etc.

Federal Highway Lands is very excited about learning more – taking new steps to see what comes out of it.

Questions:

Are you using NEBDG design? Not for design structure but we can use that design in what we have. We want it in the construction phase as well as design phase. Looking at this model over time.

AS-Builds – how robust is the traffic data? Good but not excellent.

- Weigh-In-Motion sites help measure loads.
- RWIS – showing weather data for road surface.

- Need to know the conditions pavement is subject to in real time – need that data for solid performance specifications.

Richard Duval and Lee Gallivan
Framework for Developing *Performance Specifications* – SHRP2 RR-2 – and Group Discussion with States

Primary Objectives for Using Performance Specifications include:

- Transfer performance risk to the contractor
- Motivate contractors to be more quality conscious
- Improve long term durability
- Accelerate construction
- Encourage innovation
- Reduce agency inspection costs during construction

Accelerate construction, giving more risk to contractors…. How do we convince upper management? Contractors will push accelerated construction – not long term use.

Models are based on lots of projects – "related" it's not exact but improving over time. Tests will tell you. There is a balance.

In the tollway experience with concrete PMS – such a push to schedule and budget and quality. Quality seemed to regularly suffer. Many administrations in IL – on time and on budget – quality be damned. This helped us put a focus on quality where it had been missing.

Missouri – 2013 piloted quality management plan for 13 projects. Tried to push quality control to contractor and agency did quality assurance. Quality management scenario – contractor had to do 10 nuclear tests for compaction. We did quality assurance but optimized with better equipment from 10 tests – to 5. Quality management is a challenge for industry and internally in agency. Every project the contractor needs to put together a plan on how they will provide quality assurance. Hard to get past institutional issues – need tools to get past this – takes historical data to make people comfortable with tools.

- Is inspection cost identified in report? (People, equipment, data analysis etc…) In report "inspection costs" meant reduced staff – we are advocating optimal, efficient and specific inspection using innovative tools.
- What about overhead educating contractor, agency and tools… Upfront this is a huge burden in the short term. (Write education into specification). Overall letting PWL is coming – getting the word out involves a lot of people and upfront costs.
- Look to IL tollway and how PRS brought costs down.
- Reduce agency inspection is shifted to contractor costs – but not a huge cost necessarily to contractors.

Goals and Objectives:

- What do you need and what are your goals?

Idaho – decided maybe they needed to incentivize for the contractor gradually. How do you get the industry to buy into this? Money talks. If they see the risk they must also see the benefits.

The continuum of performance specifications looks like an umbrella of performance includes Quality Assurance Specifications thru Post- Construction Performance.

When moving on the continuum, you have to get to quality Assurance – if it's robust – then you are ahead of the game and able to move to performance related specifications easier. PRS use quality assurance characteristics.

Comparing as-design to as-construction. Give control to contractor to work within a box based on model data that will give you some predictability to high performance work.

Question regarding Density – is this an end result spec? We want X amount density and will measure. How will you accept it? Use a quality assurance spec for acceptance.

Florida, Mississippi, West Virginia – have had short term warranty success – but requires a huge maintenance agreement with a lot of post construction effort. We'd like to see high confidence due to parameters that you are going to get what you want to get.

MI or WI had mandated required warranty use – but not finding benefits. POI: Modified graphic is aligned with AASHTO SSC (currently being updated). Based on the SSC guide they are performance based.

Performance is design and construction aspects. – How you accept in the field is reflective of design.

Pyramid of Performance: Build Top Down not bottom up as we have done in the past. Helps develop focus of what materials come out in the end. Shift the emphasis from materials and methods to desired outcomes.

What goals do you need for asphalt pavements?

- Smooth, durable, long lasting, safe, drivable. – Not specific materials and mixes.
- Need tests in place to incentivize contractor's success. Too many holes in test procedures.
- Sunday afternoon TRB Workshop on pavement design issues – contrast stakeholders on building pavements with several different contracting methods – different goal/focus depending on procurement methods and specifications used for each. Design-bid-build run 10.8 on fines because they can.

  Base price – bonus is paid on 5 year, 10 year cycle depending on performance.

  Goals should be the same – contractors should be making money and will be more willing to listen if you have something innovative that will make things work better, faster, last longer. Performance specifications lend an atmosphere to being on the same goals. They will design on base mode but let's give them more incentive and trust.

User goals and needs – **Safety, Mobility, Comfort**. Needs to include in the development of the specifications. D

Simple steps regarding the development.

- ID user needs and goals of the agency. Define what you really want and determine if they are measurable?
- How do you plan to do this? Have to mold your needs and goals into your project and who is responsible for what? Level of responsibility of the contract, contractor vs. agency.
- Establish quantitative measurement strategies for each agencies goals.
- Money and levels of responsibility make a difference. Consider Agency and Contractor risk and roles.
- Gaps. What is missing in identifying user goals?

There is still confusion of what agencies should/shouldn't include in contract. If you have developed a form of performance specification you should be able to add it to your contracts.

Percent within limits is recommended by FHWA and 2014 report was heavy on quality assurance.

What works for you state?? Appropriate Measurements Strategies for Performance Specifications

- Finalize selection of performance parameters
- Rapid Renewal Considerations
- Establish a Sampling Plan
- Determine Measurement Frequency

- Decide what performance measure to use
- Set Performance Limits and Thresholds
- Assign Quality Management Responsibilities
- 23 CFR 637 (fall back)
- Construction inspection
- Consideration regarding Pay Adjustment Strategies

Have page estimates designed to discourage distortion? Discourage behavior in the industry. Incident paying incentive on binder type separate from mixture. Contractor's maximum deduct was 25% - he elected to give off-grade material and take the deduction as it was cheaper for him that way.

- Identification of Gaps. Need to know where you are and what you are missing.
- Technology Gap Considerations – tests available? Need to understand what is available and what is needed.
- Sampling and testing gaps – what do you want as part of the specifications, do they compare with other testing mechanisms, is sampling based on statistics or continuous coverage?
- Knowledge Gaps
- Examples and Ideas give you an idea of what you may want to write.

R07 State Experiences using *Performance Specifications*

Mark Woolaver, VTrans, Vermont Agency of Transportation –

VTrans is moving to utilize Performance Specifications on Full Depth Reclamation Projects.

Why PRS in Vermont

- In today's connected and information-rich world, customers are regularly introduced to new ways of using real-time information to save time and money; and DOTs are expected to take advantage of and use technology to improve efficiency and service.
- The DOT's customers – that is, the traveling public – expect that the products they use and the technologies they encounter will be "smart" and will ultimately improve their travel experience, They also expect that the information received will be accurate and reliable—regardless of who "owns" the road or the information.
- Moreover, technology will likely have an even greater impact on the transportation network in the future. We are watching a new era of transportation emerge through the Connected Vehicle program that that allows cars and infrastructure to communicate with one another. And a week doesn't pass without some news article on the future of autonomous vehicles. How these future technologies may impact how we manage and operate the transportation network is mind-boggling.
- We held an internal meeting with the Geotech team, materials, design, etc. and we all went thru our specification and did a redline version. Called in the contractors – brought them to the table. "This is untouchable" – the rest is negotiation. Blue line version was the contractor's version. This process eliminated the 'Us vs Them' mindset.
- One issue we recognize is nobody really reads the contracts or the specifications. – we tend to be complacent as a state.
- Contractors can and will research and design to issues if they know there are ramifications.
- End of life spec vs. End of project spec to walk away from.
- Construction causes of failure: Workmanship, Natural Disaster Material Failure, and Design Deficiency.
- Compaction effects pavement – it can be dramatic.

History of FDR in Vermont – Full Depth Reclamation w/Cement was Purely Method Spec; QC / QA Marginal at Best; No Borings / Test Pits (Rare); Contractor Mix Design Under Production; Field Cores @ 7 Days; Target (Spec) Strength = 175 – 350 psi; Field Breaks = >350 – 1200 psi

- Method specification was found to be insufficient.
- VTrans Identified Key Performance Indicators (KPI's) to Base Spec Improvement. ETC Findings.
- Developed Pseudo Performance measures.
- State took over the mix design. Specification Revisions (see slide)
- Any version material to add will be similar to what is in the road and match the mix design.
- FDR Split Mold – 3 day and 7 day breaks are pretty similar.
- Able to measure field reaction mode and make modifications
- Currently rewriting the book and not changing much. Emphasizing Inspection Requirements and training.
- Next Steps:
  - ETG Scanning Tour / Formed
  - Moratorium on Cement at Executive Level
- RSB Scanning Tour
  - Recommended Spec Revisions / Improvements
  - Primarily Construction (Workmanship) Based
  - Specification Revisions
  - Redline / Blueline Versions
  - Partial Implementation 2015 / Shadow 2016

  Continue to shadow current specifications for 2017

  Continue to monitor performance of projects

  Carry on the conversation.

Questions:

What about uniformity – percent by weight? The FDR spec is on the web, ref to section 900.675

Daniel Oesch, MODOT
Missouri Department of Transportation

MODOT is working with AASHTO on several fronts regarding performance specifications including"

- Test Trailer – Load Plate Testing
- IC Results from Route 141 – Results from Pilot Testing
- Intelligent Compaction – need to control amount of data.
- Own their own scanner – working on several projects – specifics on slides.
- Using TX report.
- Rte 24 project begins in about a week using Intelligent Compaction

- Performance Testing of Asphalt –
    - Some machines are unremarkable. Now using Hamburg Wheel Track Testing wheel tester.
    - Started with Louisiana method – wasn't confident. Illinois method works better for us.
    - Balancing Asphalt Mix Design – working on finding the sweet spot.
- Cracking Tests
    - "Let's work our way down the list and see what will work for us" (red at room temperature)
    - AASHTO Semicircular Bend Geometry SCB report –
- Asphalt Mixture Performance Testing –
- Cracking data is allowing us to begin to create a spec to address the issues.
- IR spots? We can do that.

Richard Bradbury, MEDOT, Maine Department of Transportation

- Lots of work as well regarding SHRP2 products
- Used hand held – GPR behind asphalt paver.
- Hasn't been a static process – change hot mix process yearly – tweak it.
- Can't rely on state agency testing – contractors must plan how they will comply.
- Take time to implement- pilot projects over time so that by 1998 everyone was on board to roll out. Takes time, education, working with industry. Cannot write in a vacuum and be effective. They musch have input on what is realistic and what can be implemented.
- Finding right measures is challenging good Pay factor can still have poor product. Quality doesn't always equate to Performance. Need to find missing pieces of uniform quality into actual performance.
- Exposure to tools and measuring techniques.
- Barriers to PS Implementation:
    - some overlays don't have a base system. Not all covered across the state. May have to pay for a base station.
- HMA industry is slow to buy-in.
- Maine's biggest problem is poor quality –not bad specifications. Contractors are slow to see benefits. One contractor is on board and purchasing equipment.
- Adding equipment purchase to specifications for contractors.
    - No national agreement on asphalt cracking tests – too many to choose. Would like something that works across the board.
- Concrete – internal and external resistance to change.

2017 Projects

Special Provision for IC w/base station and Pave-IRR

Shadow pay adjustment for thermal uniformity

Will also conduct GPR density scanning

Expanded use of Hamburg wheel tester for JMF approval/production

QC Plans

Library of LVECD data for future PB design criteria.

Special Provisions using GPR for rebar cover.

Collect more data using SR for in-place testing

Work with suppliers to implement Performance Engineered Concrete mixes.

Let's measure things that we really think will measure performance – move away from quality measures for measurement sake but better tests for mix design, other issues.

Lyndi Blackburn, ALDOT - Alabama Department of Transportation

- Wheel Track Testing for production monitoring – verification every 1000 tons.
- We have a lack of inspectors and a lack of experience. We need these tools to move forward.
- Utilize as many technologies as possible to get a complete picture of your roadway.
- Construction blames materials if any issues come up. Design will never admit issues.
- Alabama's approach is to incorporate IC, Infra-red technology – US 43 is our test site. Developed PS on intelligent compaction and hoping to use IC, IRI, IR for full quality control coverage of the pavement surface.
- Density is the single most important measurement for long term durability performance. If you put it down and you don't get the density you won't get performance. IC shows roller passes and a stiffness value. IR data shows you the temperature – help the contractor control details in the field.2-1882
- Goal to have a post-construction assessment of project and specifications. What worked and what doesn't.
- Expected Value – to supply new methods to control and evaluate the roadway map and placement practices.

Steve Cross – *Asphalt Recycling and Reclaiming Association*
Performance Specifications for In-Place Recycling (CP, CIR, FDR) Technologies and State Discussions

- Issues with Hot Mix?
- Issues with measuring density.
- Verification of Field Mix Properties –
- Testing delays can have impact on results.
- Resources available.

Shane Buchanan, Oldcastle Materials
Balanced Mix Designs for Asphalt Mixtures

- Need for Balanced Mix Design
    - Try to correct mixes that are too dry.
    - Solved rutting problem but added durability problems.

  - There is a specific asphalt mix for each purpose and need.
- Define BMD
  - Optimum binder content for mix is key. Not the case for all mixes.
  - History of mix Design (slide)
- Review FHWA Balanced Mix Design Task Force Efforts
  - History: states started performance testing.
  - Work Items, designing a mix based on intended application and service requirement.
  - Agency practices related to BMD:
- Performance testing tells you where you are on your measure
- Research Problem Statement – 3 year study 2 Phases. Very necessary testing. Want to create implementable tools for DOTs.
- 1 Million tons of HMA placed each day in the US (1.4) NY to Los Vegas every day. We need to make this more accurate for its needs.
- Research Problem Statement Update working its way up AASHTO.
- FHWA technical brief being developed by end of year.
  - If it works use it. If it doesn't work – stop using it. Be as simple as possible, be practical and be correct.
- Pretend you are a DOT rep – what test would you choose – Hamburg Wheel Track Testing supplemented with thermal DCT cracking test. Skip the rutted test – run fractured test till you get an acceptable number and chances are the pendulum will be in the middle.
- If we are low on asphalt why don't we add BMA requirement? Some states have…
- It's an aggregate issue. You have to determine aggregate balance.
- When do you over constraint? Il uses Hamburg Wheel Track Testing, I-fit (simple and works).

Ray Brown, National Center for Asphalt Technology
Improving In-Place Densities to Improve the Performance of Asphalt Pavements

- Compaction is one of the most important aspects of improved performance. Sometime we adjust mix design and convince ourselves we are changing compaction. Be very careful of this.
- Design the asphalt contact the right way – adjust if needed correctly. Don't just add to create low voids.
- 15 yrs. ago – study of 40 pavements in 15 states, state and contractors designed the mix. We sampled and tested and looked over time at compaction rates. Alarming results were the density numbers. Found 55% of projects had average density of less than 92%. 2-3 projects in one state would have the same density consistently in the state. Shocked to see these results. 93-94% now. Things haven't changed much and some have now gone lower.
- Need to improve compaction. Also had permeability issues. Few states have gone back to fine graded mixes different than the past (they used to have fil sand – or black dirt). Poor aggregates being used. Now we have better aggregates and fine mixes work better now. Fine Grad and Course Grade have about the same performance against rutting.

FHWA funded NCAT to report on increasing compaction and effects on pavement life. Also 10 state control sections with improvement to increase density. For each state Asphalt Institute came in and did best practices.

- Trying to improve efficiency didn't make a big difference.
- Adding roller increased compaction.
- Preconstruction meeting to go over plans.
- NCAT report showed 1% increase in density resulted in at least 10% increase in life.
- Items being used to improve density include: increase number of passes; apply more passes with vibrator on; Reduce speed of rollers; add additional rollers.
    - FL used static rollers – on control with vibrators the density did not improve.
- You can always calculate density on TMD.
- What density do we really want? 92-94-96?? You need enough – depends on grading, mixes, main thing is cutting down permeability.
    - Does everyone agree that permeability is the main thing? Durability – if you can keep air and water out you have significant durability.
- Need to know sizes of rollers – they vary in size and weight.
- Oscillating roller shows promise.
- Bond between layers is important for compaction. Starting point – can't pour it out of a pot to tack. Trackless tack was used in these projects.
- Roller Pattern – Rubber tire rollers can rough up the surface. Steel smooths out.
- Watch out for tender zones.
- Test locations is important – in direction of pavement? Works for some….
- Increased effort to obtain density can result in at least 1 to 2 percent higher density
- 1 to 2% higher density will provide a significant increase in pavement life – generally believed to be 10-20%

Questions and Comments:

- Reasonable to expect satisfactory compaction in – compaction with oscillating or rubber tire rollers.
- *How many states use rubber tire rollers?* Depends on what percent of work would use them? 20-100% Lots of people use oscilatories. Only bring rubber out when there is an issue.
- Tack Coat – controversial in New Hampshire – if tack is track less or harder grade which is harder than grade of the binder. Is this a clash? Would you be prone to horizontal cracking in lifts? Innapproprtiate application rates would be an issue. Seeing more and more insufficient tack with high recycle mixes who tend to be drier – tack can be captured by dry mix and not used for the intended purpose.
- Still grade tack might fracture – better results with a stiffer material. Biggest problem with tack is poor application – uneven. Many states use emulsion for tack –
- Low tracking tack – modifying with latex – haven't seen any problems yet. People moving to SBS from SBR, not seeing as much latex.
- Three general approaches to balanced mix design – can you expand on that for state looking for balanced mix design. If you were in a pool, unsure about your ability to swim – start in shallow – add value, use volumetrix and lastly performance measures. If you are experienced swimmer – let performance measures be more of a driver.

- Excellent performance test is the roadway – you know what you are getting and what your problems are. FAA designs 3.5% asphalt because of cracking not rutting. Most others use 4%. Lower air voids. You can forward out cracking easier than rutting. Make adjustments depending on how your pavement is performing. 20 year long performance test.
- Pick 5 quality characteristics of true performance metrics for asphalt during construction, related to long term life:
    1.) Uniformity of temp during placement.
    2.) Consistency of lift thickness you are placing.
    3.) Look at volumetrix and match what's produced to what's designed.
        a. When you calculate VMA – not just a number. Need to know if number is accurate.
        b. Don't use one number on all applications – not accurate. Need to monitor aggregates on gravities and location in pit.
    4.) Thermal and physical segregation – material transfer devices.
    5.) Proper plant calibration – account for moisture at plant (weather)
    6.) Air Voids
    7.) Make sure aggregates are quality before adding.
    8.) Visual observations are important.
        a. Longitudinal joints
        b. Transverse joints – from starting up.
- Recommendation of determining moisture?
    - A wet environment needs testing in the morning and several times a day. But don't check and then do nothing.
    - Out west once a week.
    - Some technologies monitor moisture in sand.
- Measuring real time – plant can't adapt – can't fix the moisture. Create miniature stock pile and use nuclear gauge.
- 12 5 mm mixes – coarse graded 1.5 inches – trouble getting density – management is looking at budget – adequate lift thickness mixes. Increase lift thickness – doing the public a favor.
- Placing over a sub grade or base layer that doesn't have the support you need.
- Longitudinal joints are the bulk of our problems – practical advice on improving? Core – measure density in core. Joint spec for coring.
- Where are your joint specifications – requirement is 91% - PennDOT is 92% and increasing joint density as we go.
- Notched wedge joint lends itself to low density – hard to roll that taper.
- What does the contractor think is a reasonable split of risk between contractor and agency? Contractors realize there is a certain amount of risk they need to take on. Well written spec seeks a balance of shared risk between the two.
- What are minimum requirements and acceptance of density? Differs per state. Reporting for requirements and results. Encouraging cutting cores for test results.

- Hope to complete a document that provides guidance to increase density by 1 – 2 %.
- There are frustrations in research – when you look at the whole picture you should come up with good results.
- It probably takes additional rollers. FHWA goal was to not add costs but with current equipment was less results.
- *What are you thinking about in choosing mix design?* Evaluate binders on the market, consistency is an issue and coming from many sources. Have to constantly monitor this. There are always things coming up.
- *Do you see us moving away from density and towards perm in 10 years*? If there was a better way to measure permeability.
- *If you take everything on as risk – how does the state not get risk if they don't get density and are back on the road multiple times?* If state gives contractor more risk – because of variabilities in the mix – better chance of them getting low density and more do-overs. Issue may be asking for testing but not loosening the handcuffs. Let contractors use innovation and prove to you that it works at a threshold and performance measure of your choice based on field data from your state. This is where we will end up years from now.
- Don't start with 10% RAZ, start with 3% RAZ – gradually is not a significant risk for anyone.
- Significant problem with politics and money when samples have to be shipped out of state. If it were a performance spec – the contractors should have the testing equipment.DOTs still haven't decided what they will require. Take baby steps – get more confidence as you go forward.
- Starting slowly, one issue on the East Coast are commercial labs that can test don't exist. Might need to gear up to run simpler tests at DOT lab.
- I'd like you to open the gates on a performance specification test = let me use what I want but pass your performance tests.

Day Two Introduction:

Performance Specifications aren't fancy – but an improved quality assurance specifications. It's a step toward improvement. Everyone has varied degrees of specifications but this is how we learn to run – walk first. Work with IAP states – nobody is 100% performance specifications but moving in that direction.

Cecil Jones, Diversified Engineering Services (DES)
Performance Engineered Concrete Pavement Mixtures

- These approaches can be applied to all concrete types. Want to adapt to structural concrete as well.
- MAP-21 – FHWA emphasized performance, linking investments to outcomes. Have been talking about this for years but not actually having any performance specifications written.
- Innovative new test methods related to performance - many in process. A lot are prescriptive 'do this not that' if the product doesn't work the agency has responsibility and risk. PS reallocate the risk. Not all are ready for 'prime time'. Hold industry accountable to meet PS. Key is to reliably measure criteria that assures performance needed.
- Specifications need strength, cracking (slide5)
- Task group was to expand on the task

- Specifications:
    - A “menu” – need options to choose
    - Not an off the shelf drop in
    - Intended to work for state and local agencies
    - Intended to respect organizational traditions while offering performance options. (won’t change your basic aggregate requirements)
    - 20 pages long – ballots such as table 3 –

Basics of Specifications

- Pick and choose what works for you. What your acceptance requirements are, quality control provisions.
- Appendices for new and emerging test methods (slide 16) occupy most of the spec – these are attachments with commentary and detailed discussion of each section – references for more detailed background.

Next Steps

SCOM balloting as provisional standard –

Lead states assisting in demos and shadowing on existing projects

This is a provisional standard – would appreciate editorial comments for improvement. Collecting info from agencies and industry. Want it to be dynamic and move toward applications in structural concrete as well.

FHWA mobile concrete trailer can be used to demonstrate new equipment and test methods (coop with American concrete institute).

Provisional standards can be modified as new methods are developed and as we learn from early adopters.

Why??

- What are your issues – how do you want to address them – customize.
- Research produced new test methods and approaches.
- Allows for better risk allocation
- Allows for innovation
- Shares responsibility for performance with industry.

Questions:

After SOM – read the commentary – incredible and this makes it easier to understand what is being suggested. Helps with what you don’t know and how to get smarter on it. HMA – if they did similar document would also be helpful and give us better understanding. We can explore and dig where you want to go with research.

Working to reduce schedule from 120 days – this is a beautiful piece to help.

May we have the document link? It’s about to be on an AASHTO ballet – your materials office should have the current version (August version). Tarantula curve – is a good predictor for me. MN did an incentivized tarantula curve – for workability it’s a good tool – why did you leave it out? (Discussion is in commentary) There are other aggregate packs – they are more prescriptive than performance. Also left out discussion on ternary blends to enhance performance but we don’t want to tell you what recipe you need to use. They aren’t really a performance test but things that will ultimately give you performance. (Plotting it tells you why). They won’t be in the spec doc but perhaps in other documents.

Midwest de-cracking – tripled cycles and eliminated a third of their pits? Is that in response to this document? Document references existing tests. Changing deicing materials – based on sodium chlorides and magnesium – doe it modify? Yes, in table three there are choices depending on what you are using.

Do you discuss pavement adjustments? No, decided to leave out. Other publications address this. Ultimately the plan is to bring the spec, QA, and administration aspect to bring the entire thing together.

Bill Vavrik, Illinois Tollway

Performance Related Specifications for Concrete Pavement Construction

- Concrete keeps the construction industry in Northern Illinois alive – 15 years, $12 billion capital program. Complete reconstruction of I-90
- 1.3 billion In construction on the tollway – 1.3 billion for the rest of IL.
- Tollway employees have less than 30 engineers. Use a lot of consultants to expand and contract as projects come and go.
- Performance Specifications and the road to get there (time frame)
    - 2013 – Shadow Implementation with FHWA
    - Mar 2014 – compared to other work – looked at all measurements to build a performance spec. Brought plan to tollway chief engineer – main driver of PRS – schedule and budget were driving all decisions of tollway. Many overlooked quality. Focus was on 'get it done'. Drivers = customers. Stay out of their way – but poor quality means you come back later…
    - June 2014 – Industry was invited every step of the way. Everyone sat at the table while we crafted the specification.
    - July – took draft to industry with concepts/ideas
    - Fall – winter 2014 – meetings to revising
    - April 2015 training
    - May 2015 – PS in effect.

Key to make this happen is partnership with FHWA in shadow projects that gave foundational understanding on how PS will work for joining concrete pavement – worked as if there was a full PS in place. "how we thought we would test under a PS" helped us to understand the PS tool – software.

Steps:

- Coordination was a huge aspect – all stakeholders had to be involved. All of industry, materials lab, construction, designers, dot, contractors,
- Collected data, looked at historical data
- Pave specification to develop evaluation
- Prepare for implementation – where will we use this? Random choosing / introduced lots and sub lots which were a change to the industry. Needed consistency in size of sub lots – drew them on the plan sheets for a baseline – a new step for designers.
- Special provisions – not from a spec book – but a special addition.
- Prepare for testing
- Evaluate PRS results.

Basis we do in the pay factor – is based on full 50 year life cycle cost analysis which originates in the initial pavement design report. Design vs As-Built

Develop Specifications:

- Start in pavement design – establish performance criteria through Pavement ME
- Identify AQC's
- Go thru Pave SPEC combinations come up with M&R plan that leads to the pay factor.

Trying to measure the things that matter and impact long term performance.

Really important to decide our Acceptance Quality Characteristics: Have to be measurable, correlate with performance, made sure it is under contractors' control. What are the things we CAN measure – segregation is difficult to measure – we found things we could measure that relate to performance. (We as an agency don't measure slump – contractor needs to know but we just want a smooth ride).

Lots and Sub lots:

- Lot: All mainline concrete (very different than past)
- Sub lot: one lane wide, 1,000 ft long. You have to be below the rejection level. Pass/Fail
- Sub lot limits marked on plans – pay factor was for the whole lot. Contract authority simplified…

Non-conforming Materials

- If material is rejected – go find a plan to fix it – if it works we'll accept it.
- Accepting or declining materials is on sub lot and based on results. If there were issues we would re test on the spot – multiple measuring tools.

Compressive Strength –

- 28 day for pay – cylinders were broken a lot but those tests didn't matter. You need to test to find the problems – owner will measure at the end to see how you did.

Made testing protocols – cylinders were made by contractors that would be broken for their pavement. They were responsible for first 24 hours till they arrived at lab for storage. Changes arguments since contractor is creating and transporting cylinders.

28 day compressive strength adjustment – strengths came up higher – lots of critique. Disincentive for strength were usually because the strength was too high.

PCC Thickness Quality Characteristic

- Thickness is important – MIT Scan 2 Marked 6 read 4 (to encourage consistency)
- Dowel Alignment – no bonus for proper alignment. But disincentive per diameter.
- Smoothness – added CA IRI Smoothness matters to customers – issue to contractors. You could grind into a bonus.

Collect more data than we ever have. Developed spreadsheet "Shreet" gathering new data and different data – can share blank with others. Calculates pay factors based on individual test results. Data distributed to all through Ebuilder.

Overall Pay Factor – created wintertime pavement – bowed to industry pavement.

2015 Results:

Overall we wanted to pay the bid price – year one we payed $100.2 year two 101.2 Should we consider raising the bar?

Benefits:

- Life cycle cost becomes the rational basis.
- Everyone was more focused on testing – "I get payed based on this test result"
- Clearer distinctions of who does what/when.
- More innovative environment – hostile to begin but now they love it.

Next: For CRC

- Need to determine what can be measured.

Questions and Comments:

- Required 15 ft. joints – aggregates are very consistent in Chicagoland. Designed using CTE worst case scenario. Didn't add to PRS because once mix is added – CTE doesn't. They weren't used to IRI. Old spec was CA profilograph day 2 or 3. PRS was call within 14 days of traffic – smoothness of product customer's drive on. Anticipated they would test but they didn't and we were doing too much testing after grinding. Ran into issues so now testing earlier.
- 2016 FHWA SHRP2 gave one contractor using streamlined vs. real time.
- Pay adjustment is on the lot: 4 values for each sub lot but standard deviation for entire lot goes into Pay Factor.
- PRS pay factors – based on quality of all factors leading to better quality of life. Our intent was to build the design life. We gave in a lot at the end – but the attention to quality went up 1000%. Historical data is the target so improvement raised the historical performance.
- Have you shadow tested sand meter? Small amount when trailer was out – one was purchased. Would like to go in this direction. Jason is going in lots of directions.
- Cecil – too strong? Depends on how you are getting strength – could cause more problems. Wisdom in having strength measures.
- *How was concrete cured?* 2 coats of curing compound – white pigment. PAMs material except in winter. Winter is done by temperature – looked at 10 day forecast, evaluating when consistently below 40 degrees it is "winter" and "spring" when 10 day forecast consistently above 40 degrees.
- *Any use of maturity meters?* No not specified, but contractor could run the test as an option. No one chose it.
- *What are missing pieces to translate to structural concrete*? We were focused on having a performance model that relates to long life performance.
- From specification point – it's easier to transition to structural than pay point.
- Did you reuse any material? 50% RAP in shoulder mix. Concrete got crushed for base aggregate. I-90 entire project is 60 miles long. In rural areas we did 2 lift concrete composite pavement. 12 inch think mainly. 8 inches of bottom concrete with RAP and recycled concrete/ durability issues passed but had some concerns. 3 inches on top and sides enveloped standard grade concrete – 2 pavers bottom mix/top mix. It worked in 30 rural miles – costs were lower even having another paver (and 8 finishers) Lot of issues but it went very well. In urban area there is no room for more materials.
- Base CT is aggregate issue – North Illinois is pretty consistent. Dolomite is solid for concrete.
- *Provisional specification is regarding concrete pavement but are you talking about transferring to bridge decks?* YES, working on logistics to relate.
- *Cold weather concrete – did you let them go with accelerators?* No, not at all but did change mix designs.

- Difficulty with smoothness – some built rough, warp and curling… what is the best time to test for smoothness? Still working these issues out. Multiple published papers conflict. Built in warp and curl has an effect on smoothness.
- Current "Northeast" State Performance Related Specifications
- Northeast Survey:

State Participant Discussion:

PennDOT: Sort of surprised FHWA didn't make R06, R07 Performance Specifications – we need a little push. On Asphalt side – early adopter stuff in SHRP2 you might have added that if you want to adopt these you could also add performance specifications. Or maybe it is not developed enough?

AASHTO: what was criteria for choosing R07 lead adopters?

FHWA: Round 2 had a lot of interest – chosen so long as there was a description of what would be done with the money. Round 5 did not get many applications – did not hear we wanted to explore applications of performance spec use.

Let's move this PS forward – "how am I going to get the test done?" No East Coast commercial entity except universities to do the test – 50K machine is in the realm of the grants from SHRP2. PennDOT was in Round 5 with P3 specifications. PennDOT has participated in every round – but haven't seen anything advancing performance testing. Wholesale effort balance design mix task force (Shane) full effort to standardize test methods. FHWA standardizing 3 fundamental tests. Academia is improving rugged testing. What we are asking from DOT's is to explore using the tests – simpler ones – to make it easier for DOTs to use testing. Turner Fairbanks will assist you with our research.

AASHTO: If state has any incentive money from P3 left over – they could request using to purchase equipment. Definitely. Or alternative would be to apply for an aid grant to purchase equipment.

FHWA: For all states interested in exploring testing but not convinced where we want to go – put together your thoughts – send to Richard and Jenny and ask for resources. Cc your FHWA division office please. A proposal of sorts – here is what we'd like to do, here is what we need, what is out there? Don't feel like the door is closed.

Anyone who wants to try these performance tests – states don't just go out and buy equipment without knowing where they are going with it.

Communicate goals to FHWA and let us know how you'd like us to help. Just make the first step. Incrementally learn and get help.

Ahern -VT: looks like all 6 states are looking at PRS. When contract community resists – where is the contracting community in this discussion? Non credited labs in NE is on point.

FHWA has a huge investment in PRS and always wanted to build it into a more robust system. Use models to predict performance. Want to continue process. Concerned contractors/consultants – they need to know where we are moving but we aren't at a place to give specifics. Things adapt to climate and region too. Over the next year things may be ironed out.

Can we include contractors in these meeting? YES. It would be very helpful. Cracking is an issue in NE, getting all NE states into a pooled fund and committing to a single technology to build a sound database.

Need to see more contractor quality management. Focus seems to be on acceptance side but the critical piece is the contractor quality management side. They have a huge role.

- We had to start someplace. A good QA program is a good start.

MEDOT: If we give contractor the risk and they produce low density and not grade and we have to take up that concrete and our customers are upset – who has the risk? If they improve what they do – it goes back to

education – specifications are not a panacea of everything. Misguided information leads to inaccurate expectations.

Agency has 100% of responsibility and risk, things vary per state and situation – you have to manage your own risk.

Risk allocation and defining what risk is: Workmanship – states struggling with "outliers/ stratified granulated sampling" If you find average all is well but intermittent failures – no different than a standard spec. Contractors say you can't break the randomness and pick out a spot to punish me. As you go forward with PRS will you look at how to highlight randomly chosen data, but a tool so you can see data and "calling into question the basis of materials acceptance".

You have to trust statistical tests. Statistical tests can be used as pay factor. If hot mix comes out encoded, we don't look away as it is visibly defective – you must remove this and replace it – if you challenge that we will test it but you still have to remove and replace it even if my test comes later for pay factor.

Interaction with contractor before time PRS or QA spec, assumes conforming materials – you have to deal with issues outside the conforming statistic. If you have an outlier you need to be able to get rid of it, not just on materials side – like test on cracking – want to know how to put PRS in terms of lay down. Have to consider quality control from contractor's side.

GPR Density scanner – entire lap of density tested and showing 100 feet of low density – whether or not a core falls there how are we going to handle that? Game changer with more data.

Objective – show pictures of what is acceptable/unacceptable, can test any space- any time, any spots that look like this is unacceptable. Infrared scanning – id's cold spot and segregation – we have concern with these and will deal with them on future contracts – unless you want to deal with this and we will listen.

Thank you. We have learned a lot – all this has taught us a lot.

Appendix B – Agenda

Preliminary Agenda
SHRP2 Performance Specifications for Rapid Renewal (R07)
Peer-to-Peer Technical Exchange
September 20-21, 2016

Sheraton Burlington Hotel & Conference Center
870 Williston Road
South Burlington, VT 05403

*AASHTO is sponsoring a 1 ½ day Peer-to-Peer Technical Exchange regarding the development and advancement of **Performance Specifications for Rapid Renewal (R07)**. Highlighted areas include the development of Performance Specification Programs, Performance Specification experiences with Asphalt and Concrete Pavements, Cold-Planing, Cold-in-Place Recycling, and Full Depth Reclamation projects with Emulsion or Cement Additives.*

Register Here to Participate

Tuesday, September 20, 2016

Time	Topic	Speakers
8:00 – 8:15 am	**Welcome**	*Jennifer Balis, Federal Highway Administration (FHWA)* *Kevin Marshia, Vermont Angency of Transportation (VTrans)* *Lawrence Dwyer, FHWA*
8:15 – 8:30 am	**Introduction to Vermont and Introduction of Attendees**	*Mark Woolaver, VTrans*
8:30 – 8:50 am	**SHRP2 Performance Specifications for Rapid Renewal**	*Richard Duval, FHWA*
8:50 – 9:10 am	**Performance Specifications – *What are they, and how do they work?***	*Lee Gallivan, Gallivan Consulting Inc.*
9:10 – 9:40 am	**FHWA- Western Federal Lands Coordinated Technology Implementation Plan (CTIP)**	*Brad Neitzke, FHWA*
9:40 – 10:00 am	**Break**	
10:00 – 12:00 pm	**Framework for Developing *Performance Specifications* – SHRP2 RR-2 – and Group Discussion with States**	*Richard Duval & Lee Gallivan*
12:00 – 1:00 pm	**Lunch on your own**	
1:15 – 2:30 pm	**R07 State Experiences using *Performance Specifications***	*Lee Gallivan, Facilitator*
	• Vermont Agency of Transportation – *Mark Woolaver, VTrans* • Missouri Department of Transportation – *Daniel Oesch, MODOT*	

	• Maine Department of Transportation – *Richard Bradbury, MEDOT* • Alabama Department of Transportation – *Lyndi Blackburn, ALDOT*	
2:30 – 3:00 pm	**Performance Specifications for In-Place Recycling (CP, CIR, FDR) Technologies and State Discussions**	*Steve Cross, Asphalt Recycling and Reclaiming Association*
3:00 – 3:15 pm	**Break**	
3:15 – 3:45 pm	**Balanced Mix Designs for Asphalt Mixtures**	*Shane Buchanan, Oldcastle Materials*
3:45 – 4:15 pm	**Improving In-Place Densities to Improve the Performance of Asphalt Pavements**	*Ray Brown, National Center for Asphalt Technology*
4:15 – 5:00 pm	**Group Discussion: State Experiences with Balanced Asphalt Mixtures Practices and Efforts to Improve In-place Densities for Asphalt Pavements**	*Ray Brown and Shane Buchanan, Facilitators*
5:00 pm	**Adjourn for the day. Optional dinner with participants.**	

Wednesday, September 21, 2016		
8:00 – 8:45 am	***Performance* Engineered Concrete Pavement Mixtures**	*Cecil Jones, Diversified Engineering Services (DES)*
8:45 – 9:30 am	***Performance Related Specifications* for Concrete Pavement Construction**	*Bill Vavrik, Applied Research Associates (ARA)*
9:30 – 10:00 am	**Group Discussion: Current Agency Practices for Concrete Mix Designs?**	*Bill Vavrik and Cecil Jones, Facilitators*
10:00 – 10:30 am	**Break**	
10:30 – 11:00 am	**Summary *Performance Specifications* in the North East**	*Tom Bennert, Rutgers University*
11:00 – 11:45 am	**Group Discussion: States Share What's Needed to Facilitate the Development of other *Performance Specifications* in the Northeast Region**	*Tom Bennert, Facilitator*
11:45– 12:00 pm	**Closeout Comments**	*Mark Woolaver* *Lee Gallivan*
12:00 pm	**Adjourn**	

Appendix C - Evaluations

Evaluation Form
Burlington, VT, SHRP2 Performance Specifications for Rapid Renewal (R07)
Peer-to-Peer Technical Exchange

Directions: *Please complete this evaluation form and return before you leave.*

1. What was your subject knowledge level of performance specifications *prior to* this workshop?

2-2 3-3 2-4 4-5 3-6 4-7 3-8 2-9 10
(no knowledge) (moderate knowledge) (extensive knowledge)

2. What was your subject knowledge level of the Performance Specifications *after to* this workshop?

1 2 3 4 5 2-6 6-7 8-8 7-9 10
(no knowledge) (moderate knowledge) (extensive knowledge)

3. How would you rate the effectiveness of the following elements of the workshop?

a. Overall workshop content

1 2 3 4 5 1-6 7-7 8-8 6-9 2-10
(low) (high)

b. Peer presentations on Performance Specifications, successes, and challenges

1 2 3 4 5 1-6 6-7 7-8 5-9 4-10
(low) (high)

4. Please indicate your level of agreement with the following statements:

a. This workshop provided me with a better understanding of Performance Specifications.

1 2 3 4 5 2-6 1-7 8-8 7-9 4-10
(strongly disagree) (strongly agree)

b. I understand how Performance Specifications can benefit my agency and program.

1 2 3 4 5 6 4-7 7-8 4-9 8-10
(strongly disagree) (strongly agree)

c. I found the format of the workshop encouraged active participation.

1 2 3 4 1-5 1-6 4-7 3-8 6-9 8-10
(strongly disagree) (strongly agree)

d. My participation in this workshop was worthwhile.

1 2 3 4 5 6 5-7 5-8 4-9 9-10
(strongly disagree) (strongly agree)

7. My expectations for what I would learn in the event were met.

1	2	3	4	2-5	6	8-7	2-8	6-9	5-10
(strongly disagree)									(strongly agree)

8. The presenters delivered clear information.

1	2	3	4	5	6	6-7	6-8	7-9	4-10
(strongly disagree)									(strongly agree)

9. What were the most important ideas you learned from the workshop?

Pay for what you want.
Things (change) takes time – the steps for developing a specification performance or other.
AASHTO Performance Specifications work well on or in the correct instance.
Difference between performance based and performance related specifications.
PRS implementation.
Performance specs are improved QA specs.
There are areas where Performance Specifications can benefit my state.
If the contractor is required to do QC, quality improves therefore performance can improve (workmanship).
Never thought of performance specs as an upgrade of QA. Implementable through balanced mix designs in HMA
The goal and concept of how performance specs could be applied in an introductory way to try their use.
The push for PRS is all new to me.
Primarily 1.) The definitions of PRS and PBS 2.) Other states' experiences using performance specs and 3.) Performance specs for CIR and CCPR asphalt.
Take steps to move toward PS. Resources that are available.
Try and do some pieces of performance related specs. An approach can be to start with QA spec and add performance criteria.
Incentivizing performance and using less prescriptive methods.
Development and concepts for Performance Specifications
Too many to mention. Especially enjoyed Bill Vavrick's presentation. Unfortunately my state does little to no concrete. However as discussed the process used should be replicated for asphalt.
Steps toward implementing PRS.
Tie performance specifications into actual performance service life of pavement to verify incentive/disincentive amounts.
Moving toward Performance Specifications is a process. Beginning and recognizing the process is important.
How some in the industry are approaching performance-based mix designs.

10. What obstacles or issues know of or perceive to be the greatest hurdle of implementing Performance Specifications in your jurisdiction?

Political, Inter-Division, Industry

Contractor buy-in.
Lack of support (by this I mean everyone is just trying to get the basics done and don't' have time or people for making change) within my agency and contractor opposition outside my agency.
Probably actually having a test or tests to be able to accurately predict performance.
We have had performance specs on some of our mixes for 10 years. We are looking into implementing performance specs on all our mixes.
Educating all staff (agency design staff, agency construction staff, contractors, consultants) on what a performance specification is and how to write one.
Many testing/verification methods to assure that performance will occur are difficult or complicated.
Low-bid process is disincentive to high quality = performance.
How does a given test relate to performance? This is important when considering the effects of loads, weather, and time has on performance.
Which tests?
Having reliable and ready to perform tests that correlate to long-term performance.
In my opinion, the cost of buying the needed testing equipment, convincing contractors to do the same, and the need to standardize the necessary testing for PRS and PBS.
Contractor/Industry buy-in. Education and training of all parties. Administrative procedures would need to change.
Educating everyone in your agency, upper management, industry – everyone needs to know the same goals and move together in stride.
Trying to account for changing variables that can change pavement performance and durability.
Correlation and understanding of performance measurements to HMA construction and mixture properties.
Buy-In and Culture.
Development and acceptance of new tests to support implementation, both by DOT and industry.
No real obstacles, agency needs to work slowly towards implementation, identify right testing measures, verifying testing can achieve goals, running pilot projects, gaining contractor buy-in.
Educating in-house staff and contractors, overcoming resistance to change, relinquishing of control.
Asphalt: Settling on tests/protocol by FHWA
Concrete: Better test for force transfer units, permeability, air system, durability.

11. Are there questions or issues you wished the workshop had addressed that it didn't?
More details on new/proposed asphalt test protocols.
No! (x4)
The differences between the different performance test, i.e. overlay, flex beam, Hamburg, Apa rut…
The need for visual inspection (in addition to testing) to address workmanship was briefly mentioned.
Visual inspection is critical part of quality measurement and should be addressed in performance specifications.
How does asset management interact with PRS?
What other subject areas would be potential performance specification trial area other than pavements.
[I'm fairly new to this – I don't know what I don't know!]
More specifics on tests and possible parameters.
Some discussion/presentation on HMA performance and modeling.
Would have benefitted from some real examples of the process to develop specifications… from concept to implementation. Illinois Tollway example was excellent!!
Stronger emphasis on contractor quality management systems related to Performance Specifications.

Availability of testing (Asphalt cracking tests) on East Coast.

12. What else could the Federal Highway Administration do to support you or your agency in learning more about Performance Specifications?

Research on Asphalt Cracking test Protocols beyond AMPT.
Without this workshop, there is very little help from FHWA on Specifications.
Keep in contact with all states and share other's success and failures.
Training for technicians.
Flexibility with program and allowing states to mold there available funds into the areas they now realize offer the most bang for the buck.
Publish a simple, short document that clearly defines/explains what a performance spec is and key elements to address in a performance spec.
FHWA should consider requiring qc, ton test for design and acceptance.
Pilot Specs for HMA
Encourage Demo Projects
As long as FHWA continues the ongoing research in performance specifications then I have no suggestions. Any further inquiries would come with and R07 proposal.
Keep offering these workshops and the (free!) resources.
Have half day training (maybe webinar) for agencies and have it geared to upper management.
Discussions/information on performance tests used in HMA and rational for selection.
Stay intimately involved in the discussion at both technical and management levels, also with industry as well.
Need real world examples!! Less on performance specification terminology. The goal is to improve quality/long term durability/balance risk/encourage contractor innovation – continue to support T2, peer to peer activities.
A historical review of where specifications started in the 50's and how they are evolving and why. Maybe this would help motivate change. A short video? This was touched on briefly but expanded content would be useful.
Identifying appropriate quality characteristics.
Offer early adopter funds for acquisition of equipment to do DCT, IRIT, Hamburg, Sam Meter, Resistivity Meter…

13. How might AASHTO further support you or your agency in learning more about Performance Specifications?

Establish standards for Asphalt Cracking Tests
Examples that target specific items of work.
Keep in contact with all states and share other's success and failures as well as education on new test methods.
Training for technicians.
Publish a simple, short document that clearly defines/explains what a performance spec is and key elements to address in a performance spec. – maybe a joint FHWA/AASHTO document.
PRS vs. Waste material Recycle/glass reob and Rass.
Pilot specs for HMA
Keep offering these workshops and the (free!) resources.
Email updates are good because it provides reminder and can be a resource.
Provide more examples of PRS or case studies of other projects, highlighting the successes and failures.
Assistance in the drafting and development of HMA performance type specs.

Stay intimately involved in the discussion at both technical and management levels, also with industry as well. – Same as FHWA but also with development of needed test standards.
Real world examples!! Continue to support T2 activities, work with state agencies that have implemented Performance Specifications to get the word out.
Peer to peer exchanges are awesome.
Guide specifications.
Guide documents as new technologies happen before ballots if possible.

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

These events are always well put together.
The event was worthwhile in introducing the idea of PRS, etc. however it was not clear that PRS would provide sufficient benefits to warrant their adoption considering the investment and risks involved.
Real World Examples!!! What is the though process from agency perspective, the state agency presentations were good.
Good Conference. Hotel could be closer to eating establishments.