Using *Performance Specifications for Rapid Renewal* in Missouri
SHRP2 CASE STUDY

Accelerating Innovation in Missouri through the SHRP2 Solution: *Performance Specifications for Rapid Renewal (R07)*

Efforts to Enhance MoDOT's Construction Program

The Missouri Department of Transportation (MoDOT) is one of five transportation agencies currently implementing *Performance Specifications for Rapid Renewal* (R07) through the SHRP2 Implementation Assistance Program (IAP), administered by the Federal Highway Administration (FHWA) and the American Association of State Highway and Transportation Officials (AASHTO). MoDOT was awarded implementation assistance in 2013 through the SHRP2 Implementation Assistance Program (IAP) in the Lead Adopter Incentive category, providing funds to help offset costs associated with product implementation and risk mitigation. This case study briefly describes the MoDOT project, goals, and activities to implement *Performance Specifications*.

By developing a performance specification for asphalt pavements, MoDOT intends to further advance the quality and application of the agency's asphalt mixtures and extend the service life of its pavements. MoDOT initially upgraded its asphalt pavement materials and procedures as part of the original SHRP research conducted under the auspices of the Transportation Research Board. These changes included using performance-graded asphalt binders and Superpave Gyratory Compactors (SGC) to optimize roadway mixtures for various traffic and temperature conditions. The initial work concentrated on the materials and mix designs and did not address the constructability of the mixtures, which left the state and contractors to use their existing methods to place and compact the mixtures.

To address this void, in its SHRP2 implementation project MoDOT included assessing the value of using performance specifications for Intelligent Compaction (IC) and thermal profiling (IR) as part of construction operations to address two critical elements related to

What are *Performance Specifications for Rapid Renewal (R07)*?

To help transportation agencies develop and implement performance specifications, SHRP2 created *Performance Specifications for Rapid Renewal* (R07). These model performance specifications address various project types (such as for pavements, geotechnical, and bridges) and project delivery methods (such as design-bid-build, design-build, design-build-warranty, and design-build-operate-maintain).

The conventional approach to highway construction places the burden on the owners of the facilities to design, specify, and control the work. Performance specifications, on the other hand, shift some of the agencies responsibilities to contractors and empowers them to look for new solutions to save time, minimize disruptions, and enhance safety and quality while meeting the specific goals of the project.

Included in the *Performance Specifications* product are:

- Model performance specifications;
- Ranking grids;
- Step-by-step instructions for developing performance specifications

the compaction of asphalt pavements—namely, optimizing compaction operations to ensure complete coverage, and generating compaction at the optimal temperatures. (For more information on the relationship between Performance Specifications and Intelligent Compaction, go here.)

Challenges Facing MoDOT

MoDOT recognized that various issues currently exist with its asphalt pavement construction program, and therefore, targeted improving construction specifications as the first step in their IAP implementation. MoDOT has considered using a combination of specifications consisting of performance-related specifications for its construction program and performance-based specifications for mixture designs that includes resilient modulus, creep properties, and fatigue properties. Performance specifications are considered the next generation of quality assurance specifications, since they are more quality based and can use predictive models to assign rational pay adjustments to various quality characteristics when fully developed.

MoDOT Specifications and Project Goals

MoDOT has been involved with the SHRP2 *Performance Specifications* program since June 2009, beginning with geotechnical efforts as a precursor to the current IAP effort. In August 2010, MoDOT advanced a pilot project on US 141 in Chesterfield to evaluate new concepts for geotechnical performance involving embankment and pavement foundation construction, with a prescribed goal of eliminating the nuclear density gauge testing equipment. The project introduced various grading and base construction technologies to MoDOT, which included IC. As part of the renewal element of the SHRP2 *Performance Specifications* program, MoDOT initially wanted to continue with the advancement of IC on soils and asphalt materials, but chose instead to limit its involvement to asphalt material due to the lack of grading projects by the department in the foreseeable future.

MoDOT's current specifications include procedures for various categories of projects, such as quality assurance (statistical) type specifications for high-type asphalt (multiple layers of mixtures). These specifications are considered to be quality assurance type specifications based on percent-within-limits procedures utilizing the mean standard deviation and quality limits determined for various quality characteristics. For single-layer projects with a thickness less than two inches (50 mm), the acceptance program is basically a method-type specification that depends on the number of passes of the rollers for acceptance of the construction operations.

MoDOT has created specifications that contain requirements for both IC (partially based on AASHTO PP 81-14) for assurances related to roller coverages and IR (partially based on AASHTO PP 80-14) to be used for materials immediately behind the paver for determining temperature differentials in the hot mat . Roller coverages and uniform temperatures of the hot mat are critical elements needed for good compaction of asphalt materials. Advancing IC and IR is a step towards performance specifications and provides opportunities for the department to advance the performance and life of the state's asphalt pavements.

MoDOT's Goals in Using Performance-Related-Specifications:

- Allow for innovation and greater flexibility in mixture designs of asphalt materials.
- Determine performance criteria for the desired end-product.
- Determine the best value for the end-product.
- Reward exceptional performance by contractors.
- Continue to expand the use of recycled materials.
- Supply MoDOT with new methods to accurately and completely evaluate the roadway mat and placement practices of the contractor.
- Encourage contractors to apply greater control and ingenuity.
- Improve project quality.
- Accelerate construction.

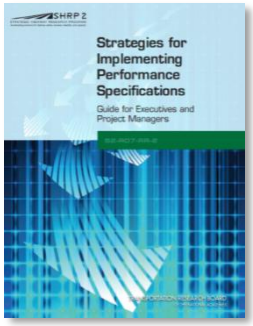
- Minimize costly construction oversight.
- Reduce claims and inspection.

MoDOT Implementation Activities

Overall, MoDOT's implementation process includes:

- Evaluation of test methods against actual field performance.
- Experimenting with performance test methods for use with value engineering (VE) proposals.
- Proposing trial incentive and disincentive limits based on the testing from each mixture type.
- Shadow implementation of the technologies to develop knowledge of the processes and design consideration.
- Construction of pilot projects.

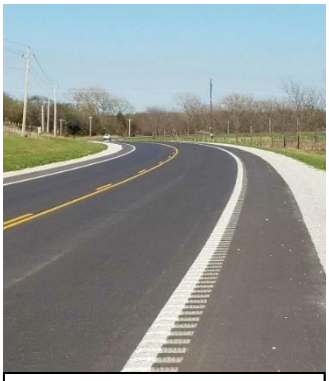
In March 2014, MoDOT hosted an Intelligent Compaction (IC) training course (Intelligent Compaction Data Management Training and Equipment Demonstration) funded by FHWA for state personnel and contractors that provided an introduction to the technology and the related data management system program. There were nearly 60 participants in attendance for the the day and a half event.



Guidance document developed through the Transportation Research Board's research on SHRP2.

The IC workshop was successful in:

- Familiarizing participants with fundamentals of Intelligent Compaction.
- Demonstrating the route to successful IC implementation.
- Demonstrating the operations of the data management system program "Veta".
- Developing participants into technology champions of IC for their organizations or companies.



MoDOT Rte. 24, Randolph County
Photo Courtesy James Gillespie, MoDOT Resident Engineer

During summer of 2015, the SHRP2 subject matter expert (SME) began working with MoDOT construction/materials and research offices to advance their development of performance specifications. MoDOT made the decision to develop its specifications with direct assistance from the SME using the AASHTO specifications for Intelligent Compaction and Thermal Profiling, along with examples from other states.

MoDOT included IC and IR as part of its construction operations to address two critical elements related to the compaction of asphalt pavements: optimizing compaction operations to ensure complete coverage, and compaction at the optimal temperatures. (IR is part of a separate SHRP2 product [*Technologies to Enhance Quality Control on Asphalt Pavements*, R06C]) and is not addressed in this case study. MoDOT has also decided to expand its development of performance – based specifications for asphalt materials mix designs.

In October of 2016, MoDOT authorized the first IAP pilot project that contains both the IC and IR requirements. MoDOT Project No. FAF-24-2(31), J2P3051, Randolph County on RT-24 from Chariton/Randolph County line east to 1.5 miles west of Route "C" near Huntsville, for 7.637 miles. The project consisted of the reconstruction of the shoulders and resurfacing of the 2-lane facility and has been completed.

The project's specifications included IC-IR training to be provided by MoDOT and use of its infrared scanning equipment procured through an R06A SHRP2 Implementation Assistance award. Quality assurance assessments were applied based on the results of the "Veta" analysis for IC and the MOBA IR scanning report for IR. In addition, the specifications included improved definitions of the technology equipment (rollers and rovers), Global Positioning Systems (GPS), and data management requirements via the "Veta" program. Incentive/disincentive adjustments were included for individual IC segment coverages, as well as for low, moderate, and severe segregation for IR operations.

MoDOT representatives acknowledged the value of training by including a section titled "On-Site IC and IR Training" that must be completed by both the contractors and agency personnel prior to the initiation of the paving operations. The training was designed to be four-to-eight hours in length and consists of hands-on activities using the data management program as well the introduction of the technologies. Personnel from the contractor included the paving superintendent, quality control manager, and the roller operator(s). MoDOT project engineer and field inspector(s) also were required to attend to represent the state transportation agency. The project training efforts were completed, and it was determined that the training content needed to be revised.

MoDOT has subsequently applied for and received approval for an extension of its IAP project in order to address mixture designs using advanced testing protocols, including the Flexibility Index Test (I-FIT) for cracking, Hamburg Test for rutting, and the Asphalt Mixture Performance Tester (AMPT) for Dynamic Modulus, Tri-Axial Stresses, and Cyclic Fatigue testing for asphalt materials mixture designs. The SHRP2 extension includes MoDOT laboratory testing of asphalt materials with all the technologies to develop internal experience on using the equipment and to establish performance thresholds based on mixture types for inclusion in future shadow projects.

Hamburg Rutting Tester

Asphalt Mixture Performance Tester

Illinois Flexibility Index Tester

Photos Courtesy
Dan Oesch, MoDOT Field Materials Engineer

Other MoDOT Implementation Activities

In November of 2015, MoDOT participated in a SHRP2 *Performance Specifications* Peer-to-Peer Exchange in Montgomery, Alabama, with representatives from the other SHRP2 programs participating. In September of 2016, MoDOT participated in a SHRP2 technical exchange in Burlington, Vermont, to discuss the details of performance specifications, and in March 2017, MoDOT again joined the other states in a SHRP2 product showcase in Salt Lake City, Utah. Participating in the various efforts provided MoDOT with the opportunity to advance its program while sharing experiences with other states. The state technical exchanges were sponsored by AASHTO and FHWA and offered states the opportunity to hear how their peers are developing and using performance specifications. Meeting summary notes from all the meetings are available and located on the AASHTO SHRP2 Website.

As MoDOT advances towards the use of performance specifications for construction, the agency has been approved by the FHWA for a 2016 Construction Accelerated Implementation Deployment (AID) grant to advance Intelligent Compaction and Thermal Profiling technologies. Originally ten projects for the AID award projects were selected by the department for construction in 2017, using revised performance specifications based on the experiences and findings from the 2016 project. Due to cost savings from the initial projects, three additional projects were identified to use the IC-IR specifications bringing the total to 13 for the 2017 program.

The 2017 expanded program includes a "required" full day IC-IR training for both the Contractor and the Department field representatives prior to initiating asphalt paving operations. The training has been modified to address:

- Familiarizing participants with fundamentals of intelligent compaction.
- Demonstrating successful implementation of both IC and IR operations.
- Understanding the IC-IR MoDOT demonstration project Protocols, file naming conventions, and SharePoint submissions for MoDOT and Contractor representatives.
- Demonstrating the operation of the data management system program "Veta" and analysis of the data.

Lessons Learned from MoDOT

Overall, the Rte. 24 project was successful in identifying the benefits of using these technologies along with performance specifications. During the project planning and evaluation process, MoDOT recognized that the development of performance specifications requires collaboration and support between multiple divisions within the Department and the Districts in order to implement new technologies and achieve the real benefit of the training.

Other lessons learned from the MoDOT pilot project included:

- Project training on IC-IR operations and data management need to be further emphasized.
- Better coordination is needed with IC and IR representatives to ensure proper operation of the equipment.
- Better coordination is needed with GPS representatives.
- Improved training is needed for both the contractor and MoDOT personnel on data management using the data management software "Veta".
- New construction practices need to be identified by the Department and the contractor to optimize the use of these new technologies.

Several key "lessons" have been noted as a result of the IAP projects being implemented across the country. They include the following.

- The SHRP2 program has developed three documents (see the Appendix) that provide a baseline understanding of performance specifications. At a minimum, these guidelines need to be shared within any department considering the development of performance specifications.
- It is recommended that agencies need to have a better understanding of the basic definition of Method, End Result, and Quality Assurance specifications.
- State agencies need to develop realistic goals and expectations for incorporating performance specifications. Short and long-term goals and objectives are recommended and the appropriate staff should be dedicated to their development.
- The National Highway Institute has developed training courses on writing specifications. Multiple representatives from the agencies, including management, should participate in the training.
- The development of new or updated specifications is a challenge for most agencies. Through SHRP2, technical assistance can be provided to assist states interested in advancing these new technologies.

Benefits and Value of Moving Towards Performance Specifications

MoDOT efforts in the asphalt area are anticipated to demonstrate the power and adaptability of the new technologies to achieve project-specific goals and satisfy the overall agency needs. Short and long-term benefits to the agencies will differ, but moving towards performance specifications will demonstrate that these new technologies will help extend the life of rapid-renewal projects. The results of the project confirmed that the use of performance specifications provided the contractor with the necessary tools to optimize compaction operations. The technologies resulted in an

improvement of the overall construction quality. MoDOT SHRP2 performance specifications are expected to be extended into a number of other agency operations.

Next Steps

Due to the successes of the initial projects, MoDOT is considering an additional ±20 projects for 2018 and an expansion of the project types to include high-type statistical acceptance projects. The specifications are being evaluated to determine if adjustments are needed to the incentive/disincentives as part of the construction program and additional training requirements.

For More Information:

To learn more about MoDOT's use of *Performance Specifications for Rapid Renewal* (R07), contact *William (Bill) Stone, P.E.* at William.Stone@modot.mo.gov. To learn more about SHRP2 and the *R07* product, contact Jennifer Balis, FHWA, at jennifer.balis@dot.gov or Keith Platte, AASHTO, at kplatte@aashto.org.

FHWA GoSHRP2 Performance Specifications (R07) Website:
http://www.fhwa.dot.gov/goshrp2/Solutions/Renewal/R07/Performance_Specifications_for_Rapid_Renewal FHWA's product page includes presentations from various workshops, links to source documents, and a map showing which states are participating in the IAP program to implement *Performance Specifications* (R07).

AASHTO SHRP2 Performance Specifications (R07) Website:
http://shrp2.transportation.org/Pages/R07_PerformanceSpecificationsforRapidRenewal.aspx

References

AASHTO PP80 "Standard Practice for Continuous Thermal Profile of Asphalt Mixture Construction," AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Washington, D.C., (2014).

AASHTO PP81 "Standard Practice for Intelligent Compaction Technology for Embankment and Asphalt Pavement Applications," AASHTO Standard Specifications for Transportation Materials and Methods of Sampling and Testing, Washington, D.C., (2014).

Chang, G, Xu, Q, Rutledge, J, etc., *Accelerated Implementation of Intelligent Compaction Technology for Embankment Subgrade Soils, Aggregate Base, and Asphalt Pavement Materials*, FHWA-IF-12-002, Federal Highway Administration, Washington, D.C., (2011).

Chang G, Intelligent Compaction website: www.intelligentcompaction.com, last visited, (2017).

Federal Highway Administration (FHWA). Performance Specifications – Strategic Road Map, http://www.fhwa.dot.gov/construction/pssr04.pdf, Washington, D.C., (2004).

Gallivan, V, Horan R, Chang G, *Validation of Intelligent Compaction Measurement Systems for Practical Implementation*, Transportation Research Board 90th Annual Meeting, Washington, D.C., USA, (2011).

Gallivan V, Chang G, Horan R, *Practical Implementation of Intelligent Compaction Technology in Hot Mix Asphalt Pavements*, *Asphalt Paving Technology*, Journal of the Association of Asphalt Paving Technologists, Volume 80, pp. 1-32 , Lino Lakes, Minnesota, (2011).

Gallivan, V, Horan, R, D'Angelo, J, *Intelligent Compaction – Improved Construction Technologies for Hot Mix Asphalt That Benefits Agencies and Contractors*, International Society of Asphalt Pavements (ISAP) 11th International Conference on Asphalt Pavements, Nagoya, Japan, (2010).

Gallivan, V, Chang G, Horan R, *Intelligent Compaction For Improving Roadway Construction*, GeoHunan International Conference, Changsha, Hunan Province, China, (2011).

Horan R, Xu Q, Chang G, Gallivan V, *Improving Quality Control Of Hot Mix Asphalt Paving Using Intelligent Compaction Technology*, Transportation Research Board 90th Annual Meeting, Washington, D.C., USA, (2012).

Missouri Standard Specifications for Highway Construction, Section 400 Flexible Pavements, Section 413.0 Asphaltic Concrete Pavements, 403.13 Spreading and Finishing, 403.15 Compaction, 403.23.7 Percent Within Limits, Jefferson City, Missouri, (2016).

Missouri Project Specifications J2P3051, Section Q -- Infrared Scanning, and Section R – Intelligent Compaction Requirements, Federal Aid Project No. FAF-24-2(31), RT 24, Randolph County, Missouri (2016).

Title 23, Code of Federal Regulations, Part 635, Subpart D, Section 413, *Guaranty and Warranty Clauses*, August 25, 1995, as amended on December 10, 2002 and August 14, 2007, Washington, D.C.

Transportation Research Board, *Transportation Research Circular, Glossary of Transportation Construction Quality Assurance Terms – Sixth Edition*, No. E-C173, Washington, D.C., (2013).

Transportation Research Board, National Cooperative Highway Research Program, NCHRP Synthesis No. 492, Performance Specifications for Asphalt Mixtures, Washington, D.C., (2016)

Transportation Research Board, (SHRP2), *Performance Specifications for Rapid Highway Renewal,* Report S2-R07-RR-1, Washington, D.C., (2014).

Transportation Research Board, (SHRP2), *Strategies for Implementing Performance Specifications*, i.e. *Guide for Executives and Project Manager,* Report S2-R07-RR-2, Washington, D.C., (2014).

Transportation Research Board, (SHRP2), *Framework for Performance Specifications*, i.e. *Guide for Specifications Writers,* Report S2-R07-RR-3, Washington, D.C., (2014).

Xu Q, Chang G, Gallivan V, Horan R, *Data Analysis for Hot Mix Asphalt Intelligent Compaction*, Transportation Research Board 90th Annual Meeting, Washington, D.C., (2011).

Appendix

The following definitions from various TRB documents should be considered when developing new specifications.

Understanding Performance Specifications

Performance specifications are part of a development continuum process by the states to make improvements in construction operations to meet or exceed the design and performance goals of the projects. Over a hundred years ago, most states were developing prescriptive or recipe/method type specifications with the intent to provide a stable level of understanding between the agencies and the contractors on what was expected. Nearly fifty years ago significant changes to the standard project delivery methods began to take form with the movement towards quality where End-Results-type specifications were and still are used today across the country. Forty years ago, Quality-Assurance-type specifications were developed to better communicate the project's criteria and requirements with contractors, making significant changes on how the "quality" of the project was measured and accepted by the introduction of statistics in the processes to highway agencies. Performance-Type-Warranty specifications were first introduced in 1995 through changes in federal legislation that allowed warranties on Federal Aid Projects, this enabled responsibilities for the construction of pavements to be shared with the contractors. Highway agencies have now moved towards the use of performance specifications. In 2014, the Transportation Research Board in partnership with the FHWA and AASHTO developed the SHRP2 R07 guidance documents.

The SHRP2 guidance documents provide recommended approaches towards the development of performance specifications and strategies to accelerate construction, minimize disruption of traffic and communities and produce long-life facilities on our national roadways.

The conventional approach to highway construction places the burden on the owners of the facilities to design, specify, and control the work. Over the decades, construction processes have advanced beyond the control of traditional prescriptive specifications. Furthermore, most agencies have been experiencing reduction of personnel in the design and construction fields and at the same time, an expansion in the projects and new requirements due to high-speed construction, night-time construction and/or extensive rehabilitation.

The traditional way of doing business is no longer meeting the quality demands of today's projects. Performance specifications, on the other hand, shift some of the agencies' responsibilities to contractors and empowers them to look for new solutions to save time, minimize disruptions, and enhance safety and quality in the interest of rapid renewal while meeting the project-specific goals of the project.

Performance Specifications Definitions

Performance specifications vary; generally they describe how the finished product should perform over time. For highways, performance is typically described in terms of changes in the 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 been used on major highway pavement components (e.g., subgrades, bases, surfaces, etc.) but use has been limited due to a lack of suitable nondestructive tests to measure long-term performance during or after construction. They have been used for some products (e.g., highway lighting, electrical components, joint sealant materials, etc.) for which there are suitable tests of performance.

Performance-Related Specifications

These type of specifications 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 quality characteristics but also employ the quantified relationships containing the characteristics to predict as-constructed pavement performance. They provide the basis for rational acceptance/pay adjustment decisions.

Performance-Based Specifications

Performance-based specifications 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.

Intelligent Compaction Technology

Intelligent Compaction (IC) is an equipment-based technology that has been developed to improve the contractor's quality control operations and improve the performance of the pavements. IC is defined as using single or double-drum vibratory rollers with accelerometers mounted on the axel of a drum, global positioning systems and on-board computers that can display various roller operating settings on color-coded maps in real-time. Roller outputs include roller locations and passes, stiffness of the compacted materials, the roller operation (amplitude and vibrations) and the speed of the rollers. For asphalt mixtures, infrared temperature sensors are mounted on the rollers for real-time surface pavement temperature monitoring. The history of development and usage of IC can be found in the FHWA Transportation Pooled Fund (TPF) IC final report and the Intelligent Compaction website. Intelligent Compaction technology is applicable to soils (embankments), roadway foundations (bases), and asphalt materials (Hot Mixture Asphalt (HMA), Warm Mix Asphalt (WMA), Stone Mastic Asphalt (SMA), etc.) and multiple in-place recycling technologies (Cold-In Place Recycling (CIR), Cold Central Plant Recycling (CCPR), Hot In-Place Recycling (HIR) and Full Depth Reclamation (FDR)).

Infrared Scanning Technology

Infrared (IR) is an equipment-based technology that has been developed to improve the contractor's quality control operations and improve the performance of the pavements. IR technology is placed on the asphalt paver to monitor the temperature of the mixture on the mat for temperature uniformity. More information on Infrared technology can be found under the SHRP2 R06(C) program.

SHRP2 Guidance Documents

- *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)