Using *Performance Specifications for Rapid Renewal* Western Federal Lands SHRP2 CASE STUDY

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

Western Federal Lands Efforts to Enhance Its Construction Program

The Federal Highway Administration (FHWA) - Office of Federal Lands was established to promote effective, efficient, and reliable administration of federal lands including public roads and bridges. The Western Federal Lands Highway Division (WFLHD) is headquartered in Vancouver, Washington, and covers the states of Alaska, Idaho, Montana, Oregon, and Washington for the Office of Federal Lands.

The WFLHD understands the value of performance specifications in the administration of the highway program and directly participated in the FHWA/AASHTO Assistance program SHRP2 R07 program to share their knowledge through the Rapid Renewal (R07) efforts of the SHRP2 Implementation Assistance Program (IAP).

This case study describes the WFLHD project to implement Performance-Related Specifications within their division. This case study is based on a post-construction evaluation of asphalt materials utilized on the project to establish a baseline for future modification of mix design procedures.

Challenges Facing WFLHD

By developing a performance specifications for asphalt pavements, WFLHD intends to further advance the quality and application of the agency's asphalt mixtures and extend the service life of its pavements. Like state DOTs, WFLHD initially upgraded their asphalt pavement materials and procedures as part of the original SHRP research conducted under the auspices of the Transportation Research Board, which is now included in the Federal Lands specifications. 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 SHRP project focused on materials and not the

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 agencies' responsibilities to contractors and empower them to apply 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; and,
- Step-by-step instructions for developing performance specifications

constructability, resulting in the use of existing procedures to design and construct the mixtures. To address mixture design, the WFLHD is utilizing new technologies that relate the value of the materials to the expected pavement performance/service life of pavements by developing performance-based mixture designs.

Performance-related or performance-based 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. WFLHD intends to advance these technologies by developing performance-**based** mixture designs that includes resilient modulus, creep properties, and fatigue properties.

Current pavement design procedures are mechanistic-empirical in nature and have received significant attention regarding the design of asphalt pavements. Currently available software for mechanistic-empirical pavement design includes the AASHTOWare Pavement ME Design Software program. Pavement ME allows users to predict pavement distresses by applying layered elastic theory for mechanical responses and using empirical models for distress predictions.

The Layered Viscoelastic Pavement design for Critical Distresses (LVECD) program, which employs three-dimensional viscoelastic finite element analysis with moving loads, can also be used to predict the fatigue and rutting performance of pavements. The LVECD program employs the simplified viscoelastic continuum damage (S-VECD) model as the material model for the fatigue performance predictions of asphalt mixtures under complex loading and environmental conditions. WFLHD is shadow testing mixtures in accordance with the LVECD program to advance the agency's knowledge of this technology.

WFLHD Specifications and Project Goals

WFLHD has been using statistical acceptance processes/percent within limits (PWL) procedures to accept asphalt pavements for more than 25 years, but the current acceptance process does not directly measure pavement performance and the determination of pavement life. Instead, empirically derived PWL limits for the Acceptable Quality Characteristics (AQC) of Asphalt Binder content, Voids in Mineral Aggregates (VMA), and In-place Density are used to adjust pay factors based on statistical variances between the as-constructed asphalt pavement and the approved mix design that targets asphalt content and mixture specifications. Payment adjustments currently only emphasize process control in the production and placement of the pavement as related to the approved mix design, but not on pavement performance. Performance-based criteria are needed to relate the value of the materials provided to the expected pavement performance.

Past research has led to the development of relationships that predict pavement performance based on the volumetric properties measured by agencies' current construction practice. When combined with proven laboratory test methods that measure pavement performance, these performance predictive relationships can be further enhanced to provide a more accurate determination of the expected pavement life. These predictive relationships and advanced testing provide a valuable piece of information that can be used to:

- Optimize and improve pavement performance.
- Determine how volumetric property variations affect pavement life.
- Provide information needed to determine performance-based pay factors that reflect the as-constructed pavement life.

WFLHD Goals For Performance-Related Specifications For Asphalt Mixtures Include:

- 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.
- Moving beyond (long-term) volumetrics.
- Defining performance criteria.

WFLHD Implementation Activities

The development of performance-based mix design procedures requires as-designed/constructed data from multiple projects to establish reasonable limits. The results from testing from the initial project will be used as a starting point in the development of draft performance-based mixture design procedures to be used on future WFLHD shadow projects.

During construction of the project, WFLHD decided to include the project in the AASHTO SHRP2 R07 Rapid Renewal Program (PRS) evaluation project. Loose hot mix asphalt (HMA), asphalt binder, stockpile materials and Quality Assurance (QA) data were collected and delivered to FHWA Turner-Fairbanks Highway Research Center (TFHRC) for further testing and analysis. Project: WFLHD Skyliners Road Improvements, OR-PFH 247(1), Deschutes County, west of Bend, Oregon. The roadway was constructed in two phases in 2015 and 2016. During the summer of 2016, WFLHD and TFHRC conducted laboratory testing of the materials.

Specific testing by the FHWA TFHRC included Asphalt Mixture Performance Testing (AMPT) using AASHTO TP 79 for dynamic modulus, AASHTO TP 107 for Cyclic Fatigue Testing for cracking, and tri-axial stress sweep testing procedures included in AASHTO TP 116 for rutting. The results of the testing will be used to conduct a post-evaluation of the project pavement performance. This testing, along with Superpave volumetric testing data, will then be used to determine the initial performance and service life of the pavement.

Testing of the materials by TFHRC was completed in June 2017; a draft report summarizing the testing and preliminary analysis has been prepared and used as the basis of this case study. Final analysis of the testing has not been completed and will be published by the TFHRC.

WFLHD/TFHRC Testing Protocols

TFHRC produced and verified the mix design with the stockpiled aggregates, Reclaimed Asphalt Pavement (RAP), plant produced materials, liquid binder materials, and prepared gyratory samples at three air voids content (densities) to represent the as-constructed materials represented by the in-place cores provided by WFLHD. Fifty-one field cores represented 2015 and 2016 operations and were evaluated in accordance with AASHTO T166.

The TFHRC testing plan included testing the plant-produced loose mix, laboratory batched mix, and the in-place field cores. Plant-produced and laboratory batched mixtures were tested at the three air voids levels to determine the Dynamic Modulus in the Asphalt Mixture Performance Tester (AMPT). Direct Tension Cyclic Fatigue Testing in accordance with AASHTO TP107 was conducted at four actuator displacements at a single temperature. The Stress Sweep Rutting Test was conducted at two testing temperatures at one confining pressure at three deviator stress to classify the quality of materials and to evaluate the relationship between plant produced, laboratory produced, and in-place cores.

WFLHD has been working with TFHRC and representatives from the North Carolina State University (NCSU) to refine the development of performance-based asphalt materials mix designs through the SHRP2 R07 effort. The evaluation/analysis portion of the program will be conducted using the new software FlexMAT™ and FlexPAVE™.

Other Implementation Activities

In September 2016, WFLHD participated in a technical exchange in Burlington, Vermont, to discuss the details of their performance specifications program, and in March 2017, WFLHD joined the other participating states in Salt Lake City, Utah, in a R07 product showcase. These efforts provided WFLHD with numerous opportunities in which to advance its program and share experiences with other states. The state events were sponsored by AASHTO and FHWA. Summary notes from the Vermont, and Utah meetings are available on the AASHTO SHRP2 R07 product page. WFHLD also participated in an AMPT workshop held on the NCSU Campus in Raleigh, N.C. in January, 2017.

Lessons Learned from WFLHD

WFLHD recognized that the development of performance-based criteria requires collaboration and support between the agency and the contractors. Training for agency and contractor representatives on testing procedures and data analysis will need to be emphasized as part of any future projects to ensure that full benefits are achieved.

Benefits and Value of Moving Towards Performance Specifications

Although no specific benefit analysis has been completed, WFLHD efforts in the asphalt area are anticipated to demonstrate the power and adaptability of new technologies to achieve project-specific goals and satisfy overall agency needs. As with the other IAP states, short- and long-term benefits to the agency will differ, but moving towards performance specifications will demonstrate that these new technologies help extend the life of rapid-renewal projects.

Next Steps

WFLHD intends to complete the initial project analysis to advance these technologies and plans to continue its efforts to expand performance-related specifications into 2018 and beyond.

For more Information

To learn more about WFLHD's use of *Performance Specifications for Rapid Renewal* (R07), contact *Brad Neitzke, P.E. (WFLHD)* at Brad.neitzke@dot.gov or *Richard Duval, P.E. (TFHRC)* at Richard.duval@dot.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
AASHTO's product page offers case studies, training modules, presentations, factsheets, guidance documents, and a list of other states implementing the R07 product.

References

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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 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 traffic disruption for 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 agency 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 these specifications 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 which has 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 also been used for some products (e.g., highway lighting, electrical components, joint sealant materials, etc.) which there are suitable tests available.

Performance-Related Specifications

These types 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 [AV] 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.

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)