TechBrief

The Performance Engineered Pavements (PEP) incorporate long term performance into the structural pavement design, mixture design, construction, and materials acceptance of our nation's asphalt and concrete pavement infrastructure. The concept of PEP is to optimize the pavement structure and materials to meet climate, and traffic requirements while allowing for contractor innovation with properly assigned risk and reward. This technical brief highlights several initiatives that comprise the PEP program.

Office Name: Office of Infrastructure
FHWA-HIF-20-005
Date: November 2019

U.S. Department of Transportation
Federal Highway Administration

Performance Engineered Pavements

This Technical Brief provides an overview of the several initiatives that encompass the concept of Performance Engineered Pavements (PEP). This document serves as the first in a series of PEP technical briefs on designing and accepting our nation's pavements for performance. Future technical briefs will focus on Asphalt Performance Testing (APT), Concrete Performance Testing (CPT), and Performance Related Specifications (PRS). Additionally, FHWA software and informational guidance for PRS are in development.

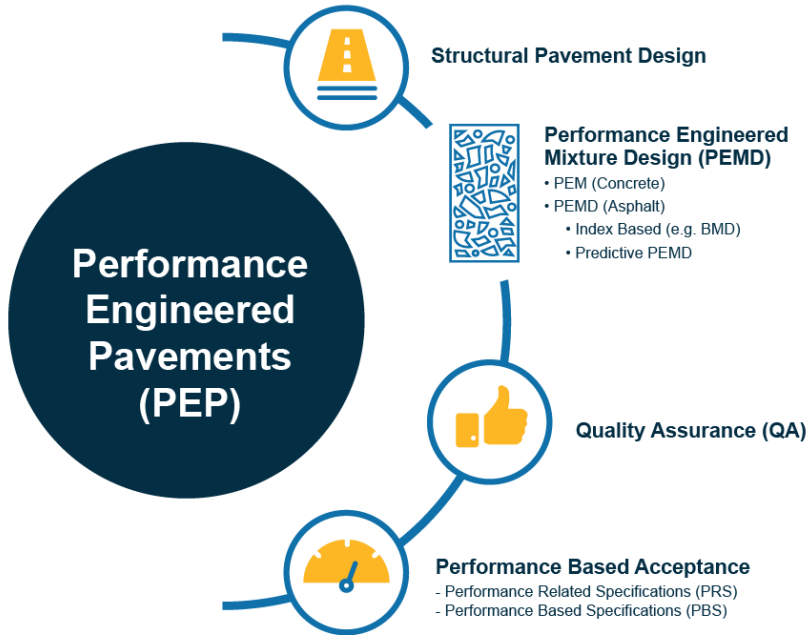

Figure 1: Performance Engineered Pavements

Introduction

Starting with several regional road tests and the American Association of State Highway Officials (AASHTO) Road Test in the 1950s and 1960s, there has been a focus on improving performance of asphalt and concrete pavements. More recently, the Moving Ahead for Progress in the 21st Century Act (MAP-21) and the Fixing America's Surface Transportation (FAST) Act legislations increases the emphasis on performance and accountability for taxpayer funds. The Transportation Performance Management (TPM) and performance measures were also established for our nation's highways and bridges with the result that federally funded agencies are working to meet performance goals. Furthermore, the pavements' community desires to incorporate performance into design and acceptance. By incorporating performance into materials selection, mixture design, and the acceptance process; agencies are addressing

the various failure mechanisms that can lead to early deterioration of pavements. Performance testing during the mixture design process allows industry to optimize mixtures for the available materials and the intended traffic, climate, and service environment. Performance tests can also lead to more sustainable pavements by assessing and optimizing the use of reclaimed and recycled materials and new products in materials mixture design. A focus on performance during construction ensures that the elements incorporated in the mixture design are properly constructed and perform as intended. Integrating this performance focus into an agency's QA program will confirm and achieve design expectations.

Performance Engineered Pavements Goal

The primary goal of this PEP initiative is to increase the long-term durability and performance of our nation's pavements. Performance engineering and testing can increase accountability for the public's funding. This initiative also encourages agencies to identify the prevalent failure mechanisms within their network and assess the available performance tests to address the causes of premature deterioration. Incorporating performance testing into the mixture design process can provide contractors more flexibility in their material selection and mixture design. It will also allow agencies to consider the incorporation of reclaimed, recycled, and innovative products into pavements while minimizing their risk of premature deterioration. Performance testing during construction allows agencies to assess the design performance during production by integrating quality characteristics that relate to performance into the agency's QA Program. These PEP goals also reduce the occurrence of major pavement repairs and the frequency of work zones that incur user delays and safety exposure to construction professionals and the traveling public.

Performance Engineered Mixture Design

The Performance-Engineered Mixture Design (PEMD) is a comprehensive engineering analysis and testing of concrete or asphalt mixtures on constituent materials and/or mixtures to meet or exceed the pavement design requirements and performance lifecycle.

Performance Engineered Mixture Design for Asphalt

PEMD in asphalt includes a predictive and index-based approach. These approaches use performance test(s) to indicate mixture quality and long-term performance. The predictive approach uses performance test(s) with Mechanistic-Empirical (ME) prediction models. The index-based approach is independent of ME modeling.

For asphalt pavements, PEMD seeks to achieve the combination of binder, aggregate, and mixture proportions that will meet performance criteria for a diverse number of pavement distresses and a specified level of traffic, climate, and pavement. PEMD supplements volumetric mixture design by using performance tests to address multiple distresses while considering mixture aging, traffic, climate, and location within the pavement structure as a part of the asphalt mixture design and approval process. Performance tests are necessary to supplement volumetric mixture design.

Volumetric requirements alone do not adequately capture the performance characteristics of asphalt mixtures containing reclaimed binder, recycling agents, polymers, and other additives common in modern asphalt pavement. An example of an index-based PEMD procedure is Balanced Mixture Design (BMD) that many state Department of Transportations (DOT) are currently exploring. As agencies consider investments for performance tests, it is important to recognize that some devices or approaches have the flexibility to conduct both index-based and predictive PEDM, whereas others are limited to index-based PEDM.

Performance Engineered Mixtures for Concrete

The Performance Engineered Mixtures (PEM) addresses concrete pavements durability issues rather than designing and accepting concrete primarily on strength. This effort will address the various failure mechanisms leading to early deterioration of concrete pavements through changes in mixture design. Significant improvements and the development of new concrete tests offer a complete assessment of concrete quality and enhancement to performance than many traditional tests. Concrete pavement performance will improve when mixture design and acceptance incorporates durability tests that address those failure mechanisms. These adjustments will enable concrete pavements to better withstand environment influences. The AASHTO PP 84, the Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures, includes the following critical durability parameters: strength, cracking, freeze-thaw resistance, aggregate durability, and permeability.

Quality Assurance

PEP focuses on the incorporation of performance tests into the mixture design and its approval process. Moving to implementation of PEP requires that the performance required is achieved both in the design phase, the production of asphalt and concrete materials through the paving operations and construction of the pavement. Incorporation of performance tests into an agency's QA program, including agency acceptance and the producer's QC testing, is necessary to verify that the designed and specified performance requirements are met. The incorporation of incentives along with disincentives associated with performance testing during production as a part of the QA program will also reward higher quality and performance.

As agencies move toward implementation of PEMD and PEM concepts for asphalt and concrete, incorporation of the appropriate performance tests into the agency's formal mixture design and QA program will be necessary. During development of acceptance specifications that incorporate performance tests it is necessary to:

1. Define the project type and scope that warrant performance testing specifications;
2. Determine if the performance tests will be used in an indexed based (go – no go system) or in a performance predictive approach with incentive or disincentive pay adjustments;
3. Define the roles and responsibilities of the agency and contractor, and;
4. Establish performance testing frequencies, production controls, and acceptance limits.

Performance Related Specifications

Performance Related Specifications (PRS) is a step along the QA continuum toward performance based acceptance. PRS are QA specifications that describe the desired levels of key materials and construction quality characteristics which correlate with fundamental engineering properties that predict performance. These characteristics (e.g., air voids in asphalt concrete and permeability of Portland Cement Concrete (PCC)) are amenable to acceptance testing at the time of construction (*Transportation Research Board's E-Circular 235 (TRB E-C235)*). As a QA specification, PRS uses calibrated predictive ME performance models to assign rational pay adjustments based on the ME model predicted difference between the as-designed and as-constructed expected service life of the pavement.

Next Steps

For both asphalt and concrete, FHWA encourages agencies to incorporate performance engineering into their mixture designs and durability testing into the mixture design evaluation, verification, and acceptance process. The performance engineering and durability testing should be tailored to the expected traffic and environment that pavement will be exposed to over the service life.

The following broad criteria can be used in the implementation of performance engineered pavements:

- Conduct a robust evaluation of performance tests that address local failure mechanisms, local materials, climate, and traffic (e.g., example criteria can be found in the National Cooperative Highway Research Program (NCHRP) 20-07/Task 406 Final Report);
- Conduct performance testing on pilot projects to obtain field data and educate industry and state field personnel;
- Refine specifications based on results of pilot projects;
- Develop project selection guidelines that define the appropriate use of a performance test(s) specification;
- Incorporate performance tests that increase pavement performance and durability into mixture design development and approval;
- Incorporate performance testing within their QA Program at the start of production such as during the construction of a test strip and on a fixed frequency for verification or acceptance during full production; and
- Develop shadow projects to evaluate QA programs that include performance testing.

References

- National Cooperative Highway Research Program. "NCHRP 20-07/Task 406 Final Report for Development of a Framework for Balanced Asphalt Mixture Design," 2018.
- American Association of State and Highway Transportation Officials. "AASHTO PP 84-19 Standard Practice for Developing Performance Engineered Concrete Pavement Mixtures," 2019.
- Transportation Research Circular. "TRB's E-C235, Glossary of Transportation Construction Quality Assurance Terms: Seventh Edition," 2018.

Performance Engineered Pavements

Contact — For more information, contact:

Richard Duval, Asphalt Materials & Pavement Performance Engineer Lead
FHWA Office of Preconstruction, Construction, and Pavements
Richard.Duval@dot.gov
Matthew Corrigan, Construction Research Engineer
FHWA Office of Infrastructure Research & Development
Matthew.Corrigan@dot.gov
Bob Conway, Sr. Pavement and Materials Engineer
FHWA Resource Center
Robert.Conway@dot.gov

Distribution — This Technical Brief is being distributed according to a standard distribution. Direct distribution is being made to the Divisions and Resource Center.

Key Words — performance engineered pavements (PEP); asphalt performance testing (APT); concrete performance testing (CPT); performance engineered mixture design (PEMD); balance mixture design (BMD); performance engineered mixtures (PEM); performance related specifications (PRS).

FHWA-HIF-20-005

November 2019