Performance-Related Specifications: Integration of the Asphalt Mixture Performance Tester (AMPT)

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Acknowledgements

- Office of Preconstruction, Construction, and Pavements
- Office of Infrastructure Research and Development
- Office of Technical Services

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Agenda

- Overview of AMPT
- FHWA performance-related specification (PRS) framework
- Shadow performance-related specification (PRS) projects
- FHWA Asphalt Technology Guidance Program
- Questions

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Background

- Owner agencies short on funding
  - Need more pavement life
  - Less rehab
  - More "bang for buck"
- MAP-21 introduced performance-based administering of federal funds
  - FHWA established measures for States to set own targets

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Two Questions

- How can I extend pavement life?
  - Specification development/targets
  - Exceeding performance thresholds
  - Optimizing asset management plan
- How can I measure performance upfront?
  - Effect of RAP, WMA, etc., and pavement structure
  - Laboratory testing and conditioning
    - Fundamental
    - Index-based
    - Lots of tests

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AMPT – Addressing a Need

- Late 1980s-Early 1990s: Strategic Highway Research Program
  - Superpave mixture design approach
  - Performance grade binders
  - But no viable performance tests for mixture
- National Cooperative Highway Research Program
  - 9-19: Identify simple performance tests for Superpave (rutting, fatigue)
    - Dynamic modulus, flow number, flow time
  - 9-29: Produce prototype, conduct ruggedness and interlaboratory studies
    - Simple Performance Tester (now known as AMPT) was born!

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AMPT

- Temperature range from about 4° to 70°C
- Computer-controlled device
  - Software built-in for various test procedures
- Fundamental tests
  - Stress and strain modeling
  - "Bulk testing"
  - Pavement ME or FlexPAVE™
- Kits available for other tests

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AMPT Implementation

- Transportation Pooled Fund Study (TPF(5)-178)
  - Purchase, installation of 29 AMPTs
  - NHI Course (over 80 trainees)
  - Interlaboratory study on effect of air voids
  - National workshop
  - Equipment specification, and others!
- Test standard development, improvement, and revision
- Instructional videos, TechBriefs
- PRS shadow implementation (TFHRC-led)
- PRS workshops (2017, 2018, 2019)
- MATT projects/training
- User Groups at TRB and regional meetings

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AMPT Users Group

- National/International
  - TRB Annual Meeting
  - Discussion of issues, best practices, future efforts
  - 164 members
    - 28 DOTs represented
- Regional
  - User-Producer Groups
  - State Asphalt Paving Assoc. meetings

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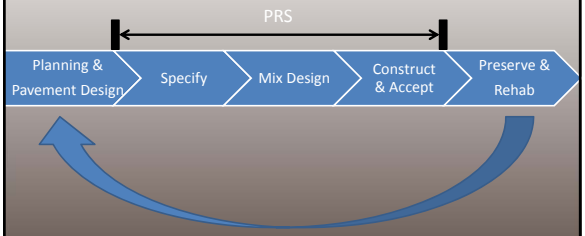
Continuum of Performance



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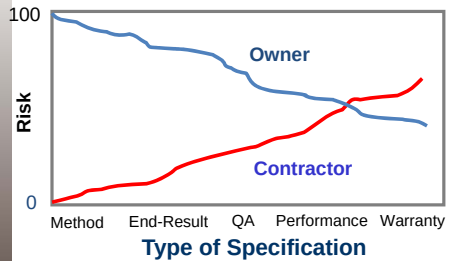
Continuum of Specifications



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Performance-Related Specifications (PRS)

"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****"*

Transportation Research Circular Number E-C137
Glossary of Highway Quality Assurance Terms

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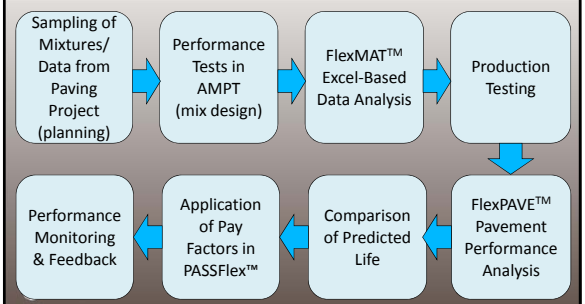
PRS Framework



FHWA PRS Initiative

- Use of fundamental tests to capture variance between as-designed and as-built AQCs
- Asphalt Mixture Performance Tester (AMPT) used in performance-engineered mixture design (PEMD)
- Performance volumetric relationships used in construction
- Structural response model (stresses and strains)

FHWA PRS Initiative

PERFORMANCE TESTING ONLY IN DESIGN PHASE!!!

Performance-engineered mixture design (balanced mixture design)

- Fundamental
  - How much distress? How much life?
  - Stresses and strains
  - Material properties (i.e., modulus)
  - Use with structural response model
  - Many temperature/loading conditions represented
- Index-Based
  - Go/no-go: correlation-based
  - Some engineering properties, some empirical
    - More tied to a material database
  - Not used with structural response model
  - Only a few temperature/loading conditions represented

Performance-engineered mixture design (balanced mixture design)

- Fundamental → FHWA PRS
  - How much distress? How much life gained/lost?
  - Stresses and strains
  - Material properties (i.e., modulus)
  - Use with structural response model
  - Many loading conditions represented
- Index-Based
  - Go/no-go: correlation-based
  - Some engineering properties, some empirical
    - More tied to a material database
  - Not used with structural response model
  - A few loading conditions represented
- Three distress types…one machine!

Benefits of PRS

- Long term pavement performance predicted from fundamental engineering properties
- Incentives and disincentives justified through reduction or increase in pavement life
- Allow contractors to be more innovative and more competitive

YES!

Challenges with PRS

- Testing efficiency and simplicity
  - Completed/Continuous
- Standardization of test methods
  - Ongoing
- Reliability of performance prediction models
  - Complete
- Performance volumetric relationships
  - Ongoing
- Same principles and methods between mix design and PRS
  - Ongoing

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Standardization of Test Methods

FULL SIZE SPECIMEN	SMALL SIZE SPECIMEN
Specimen Prep AASHTO R 83	Specimen Prep AASHTO PP XXX
Dynamic Modulus AASHTO T 378	Dynamic Modulus AASHTO TP XXX
Cyclic Fatigue AASHTO TP 107	Cyclic Fatigue AASHTO TP XXX
Stress Sweep Rutting AASHTO TP XXX	

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SMALL-SPECIMEN TRACK

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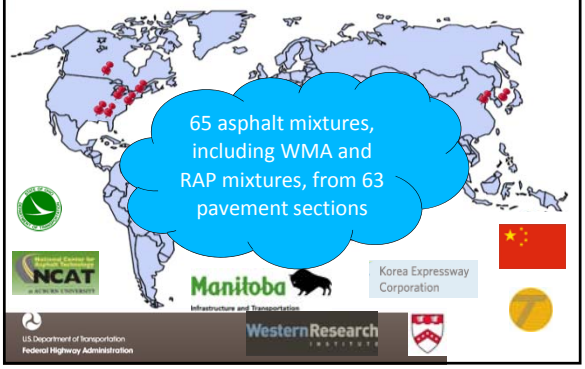
Reliability of Performance Prediction Models



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Performance Volumetric Relationships (PVR)

- Predict as-built performance
  - Without performance testing
- Database developed at TFHRC
- Expansion underway in shadow projects
  - Will use plant-produced variations
- Agency and contractor guidance for planning purposes

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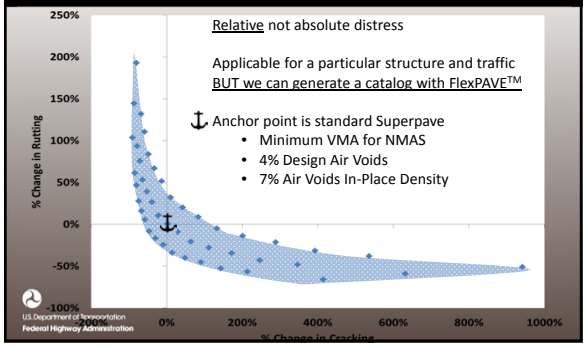
Initial PVR Database



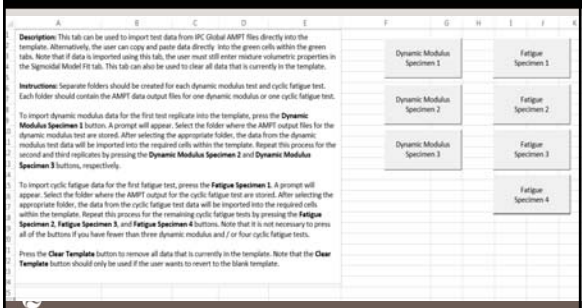
AASHTOWare Pavement ME-FlexPAVE™ Compatibility

- Graphical user interfaces similar
- Same climate, traffic inputs
- AASHTO TP 107 results proven to be compatible with K1, K2, K3 fatigue coefficients
- AASHTO T 378 (|E*|) remains critical input

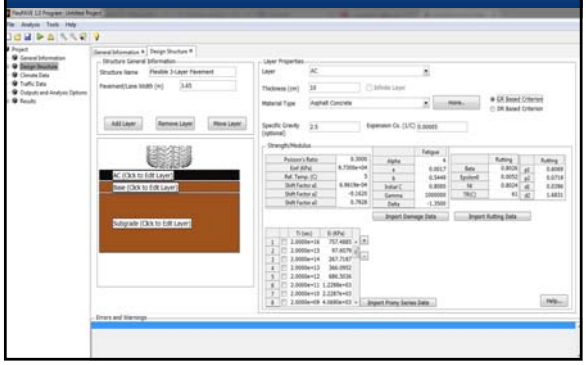
FlexMAT™ and FlexPAVE™ Available

- FlexMAT™ – Excel spreadsheet
  - Analyzes cyclic fatigue, |E*|, and SSR data
  - Import files directly
  - Output → FlexPAVE™
- FlexPAVE™ – performance prediction tool
  - PEMD through acceptance
  - Simulate as-design and as-built performance

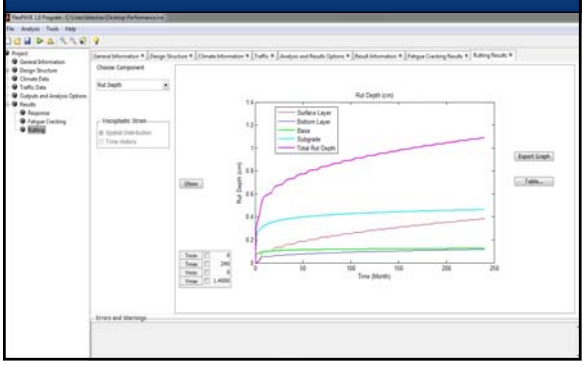
FlexMAT™



FlexPAVE™



Predicts Performance!



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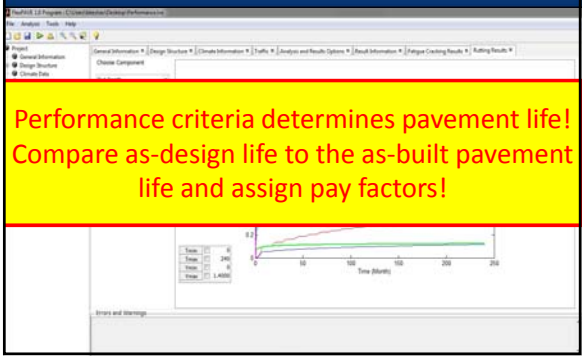

Performance criteria determines pavement life! Compare as-design life to the as-built pavement life and assign pay factors!

Material Behavior Across All Loading Conditions

- Time-temperature superposition
  - Major benefit
  - Reduces testing time/specimens
  - Enables robustness of models
- **Fundamental properties required to describe behavior across wide-range of conditions**
- **Allows for direct incorporation of pavement structure into predictions**

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Material Behavior Across All Loading Conditions

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- Fun
  describe
  conditions
- Allows for direct incor
  pavement structure into pre

THIS IS THE KEY DIFFERENCE BETWEEN OTHER AVAILABLE METHODS!

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FHWA Shadow PRS Program

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How Will This All Work?

- DOT determines project(s)
- Develop sampling plan with FHWA, NC St., ARA
  - 10 plant-produced samples (only in shadow)
  - Proficiency sample (1 project only)
  - Mix design replication sample
- Training before AMPT testing begins
- Volumetric testing as normally done
- AMPT testing whenever DOT has time

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Shadow PRS Status

- Maryland SHA – Underway (10 projects)
- Maine DOT – Sampled
- Missouri DOT – Sampled 3 projects
- Ontario MOT – Sampled
- Western Federal Lands – 1st project complete, 2nd ongoing
  - "Desktop study" also complete

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Office of Asset Management, Pavements, & Construction

Asphalt Technology Guidance Program (ATGP)

Long-Life Asphalt Pavement for the 21st Century

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Thank you!

- Questions?
- Contact information
  - 202.366.1286
  - david.mensching@dot.gov

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Same Principles and Methods in Design and PRS

- Testing is conducted at mix design phase
- Run predictions to establish as-design pavement life
- Same principles present
  - Prediction using cyclic fatigue and shift models
  - Pay factors assigned on a life difference

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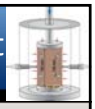
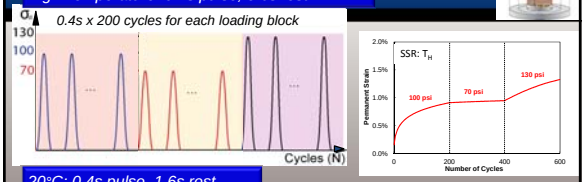
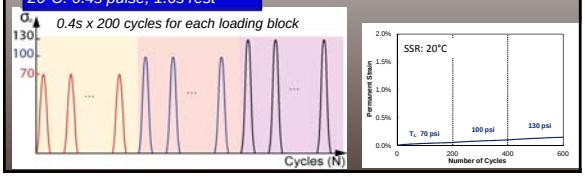
Stress Sweep Rutting (SSR) Test



High Temperature: 0.4s pulse, 3.6s rest



20°C: 0.4s pulse, 1.6s rest



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SSR Test

- Draft procedure ready for consideration by AASHTO
- FlexMAT™-Rutting available
  - Single tab spreadsheet
- Confined testing (10 psi)
- 1 day to complete all replicates
- **Model predicts permanent deformation at all loading conditions!**

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AMPT Cyclic Fatigue

- Fundamental, repeated loading test
- Direct tension (pull-pull)
- Small-specimen testing available (AASHTO TP xxx)
- AASHTO TP 107 – revisions out for ballot!
- **Material behavior across all possible loading conditions!**

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Field Validation of AMPT Cyclic Fatigue

- Pavement prediction software built from models
- Field validation
  - 59 mixtures
  - 55 different pavement structures
- Develop laboratory-to-field transfer functions
- **Volumetrics have a seat at the table!**

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Ruggedness, Precision, and Bias

- AASHTO T 378 |E*| – Complete!
- AASHTO TP 107 – Ruggedness and precision and bias underway
- Small-specimen cyclic fatigue – Ruggedness and precision and bias underway
- Small-specimen |E*| – coming soon

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Standard Sample Preparation

- Cylindrical specimens
  - AASHTO R 83 for full-size
  - Draft procedure ready for small-size
- Equipment required
  - Superpave gyratory compactor and molds
  - Core drill (bits depend on specimen size)
  - Wet saw
  - Water bath or other device (for Gmb)
  - Engineering square, piano wire

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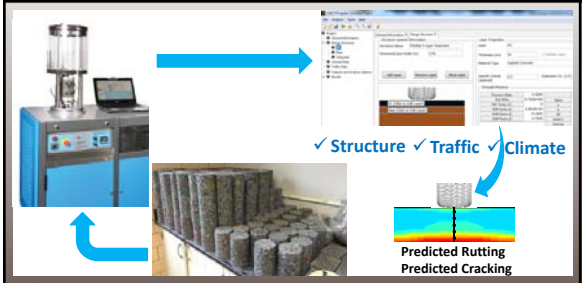
AMPT + Performance Prediction



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AMPT Cyclic Fatigue Process

Preparation
- Cylindrical specimen
- 100 mm x 130 mm
- Small-specimen:
38 mm x 110 mm
- End plate gluing, clamp system being explored
- **2-3 days for mix**

Testing
- Dynamic modulus fingerprint for specimen variability
- Pull-pull fatigue test
- Strain level based on TFHRC database
- Test temperature based on location of interest
- Load until crack forms
- **1-2 days for mix**

Analysis
- AMPT automatically captures data for analysis
- Calculate damage via FlexMAT or FlexPAVE
- Assign mixture rankings or use FlexPAVE
- **1-2 hours for mix**

About one week per mixture…worth it when considering the cost of premature failure?

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Advantages of AMPT Cyclic Fatigue

- Standard sample preparation
- AASHTOWare Pavement ME compatible
- Ruggedness, precision and bias underway
- FlexMAT™ & FlexPAVE™ available
- Predicts performance!
- **Material behavior across all possible loading/temperature conditions!**

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Two Major Tasks for DOT

- Accept 'shadow' mixtures based on the performance engineered mix design (PEMD) approach
- Collect volumetric-based acceptance quality characteristics (AQCs) during construction (PASSFlex™)
  - These would be used to determine hypothetical contractor pay

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Material Testing

- Proficiency Testing
  - Ensure repeatable results with separate laboratory AMPT
  - Only done on first shadow project
- PEMD Testing
  - Baseline for the as-designed condition
  - Needed in design phase of each project
- Production Testing with AMPT (Shadow only)
  - Establish PVR
- Production Testing with Volumetrics

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What Will a DOT Get Out of Shadow Project Participation?

- Understanding concept of PRS
  - Understanding pavement fatigue and rutting using fundamental test procedures
  - Pavement performance as function of AQCs
  - Construction Acceptance
- AMPT training
  - ARA, NCSU, & FHWA will work with State Agency to determine the best solution for training. The FHWA-MATT provides opportunities for DOTs to look over the shoulder of its personnel when testing for performance.
- PRS Software training and analysis support
- Potential for FHWA project funding support
- Potential for Mobile Asphalt Testing Trailer support

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