Validation Techniques for Setting BMD Test Criteria

CAPRI
CONSORTIUM FOR ASPHALT PAVEMENT RESEARCH AND IMPLEMENTATION

Case Study: *MassDOT* with Modeling

Assessment
Setting Initial Criteria

Objectives

Massachusetts (MassDOT) is advancing balanced mix design (BMD) to address bottom-up fatigue cracking at intermediate temperatures while maintaining rutting resistance. This case study documents how mechanistic-empirical (ME) modeling (AASHTOware® PMED) was used to support setting laboratory screening criteria—specifically, to assess the reasonableness of candidate test bounds derived from benchmarking and to confirm that proposed criteria align with predicted performance for Massachusetts climate and traffic conditions.

Benefit

This validation strategy provides a pathway for agencies with limited historical field data, where benchmarking is used in assessment, and setting initial criteria and models (PMED) are employed to check that the thresholds are consistent with predicted distress.

Background

A 2019 MassDOT survey identified bottom-up fatigue cracking at intermediate temperatures as a primary distress, with rutting addressed via existing Hamburg Wheel Tracking Test (HWTT, AASHTO T 324) criteria. UMass Dartmouth's Highway Sustainability Research Center with the Texas A&M Transportation Institute (TTI), developed a BMD protocol tailored to Massachusetts' climate, traffic, and material conditions, using laboratory testing, benchmarking, and mechanistic-empirical modeling.

Methodology

BMD Approach: Selected Approach A for volumetric design with performance verification.

1. ***BMD Approach:*** MassDOT selected Approach A. Approaches B & C require a separate study to determine new allowable volumetrics. Since there was not enough data to verify the reliability of the performance tests for MassDOT mixtures.
2. ***Performance Tests:*** MassDOT has been utilizing a rutting test (HWTT) to ensure that its VMA requirement (1% above AASHTO M 323 recommended minimum) would not lead to rutting and shoving in the field. Indirect Tensile Asphalt Cracking Test (IDEAL-CT, ASTM D8225) was selected for cracking due to its cost-effectiveness and speed.
3. ***Aging Protocols:*** The agency adopted short-term aging (STA) per AASHTO R 30 (2 hours at compaction temperature for volumetric properties, and for HWTT, loose mix conditioned for 4 hours at 135°C then brought to compaction temperature) and long-term aging (LTA) of 20 hours at 110°C for cracking evaluation with IDEAL-CT. LTA is based on NCHRP and subsequent TTI research findings.
4. ***Robustness of Production Tolerances:*** Building on a 2019 study, mixes were evaluated for rutting resistance at the upper production tolerance limit for the optimal binder content (OBC), and for cracking resistance under the following conditions:
    a. At the lower OBC production tolerance limit.
    b. At the lower OBC limit, combined with the upper aggregate gradation production tolerance.
    c. At the lower OBC limit, combined with the lower aggregate gradation production tolerance.

5. ***Setting Initial Criteria with Modeling Support:*** A benchmarking experiment was conducted with 21 plant-produced 12.5-mm Superpave mixes (PG 64S-28 binder) using IDEAL-CT at 25°C. Statistical analysis set a preliminary CT_{Index} criterion of 90 or greater as passing. Dynamic modulus (|*E**|)and flexural beam fatigue were conducted on the mixes, with CT_{Index} above and below 90, as inputs into the PMED. The ME models predicted longer service life from passing mixes ($CT_{Index} \geq 90$) – validating the preliminary criterion.

Results *(To Date)*

- ***IDEAL-CT criterion****:* $CT_{Index} \geq 90$ for STA-conditioned 12.5-mm mixtures, **validated by PMED** for fatigue cracking resistance.
- ***HWTT criteria:*** HWTT criteria: ≤ 12.5 mm rut depth after 20,000 passes, no stripping inflection point (SIP) before 15,000 passes at 45°C, established prior based on a field-lab study without modeling.
- ***Production QA considerations:*** Mixes at lower OBC tolerances showed increased cracking susceptibility, and ***binder source changes*** impacted performance. MassDOT includes low-temperature cracking susceptibility checks based on ΔTc of the binder to ensure balance across production tolerances and binder variations.

Note. *Modeling was used to support the preliminary cracking criterion. Rutting and ΔTc criteria were based on separate studies that were not validated with ME modeling.*

Recommendations

- Implement the protocol for 12.5-mm mixtures with PG 64S-28 binders, using IDEAL-CT ($CT_{Index} \geq 90$) and HWTT for design and QA phases.
- Conduct additional benchmarking for LTA-conditioned mixtures, as the $CT_{Index} \geq 90$ may be too stringent post-LTA.
- Use **PMED to validate criteria** for agencies with limited field data.
- Monitor binder source changes with ΔTc during production QA to maintain performance.

Challenges

- Limited historical field performance data required reliance on **PMED for validation**.
- Variability in binder sources and production tolerances risks unbalancing mixtures.
- LTA protocols need further validation to establish appropriate cracking criteria.

Level of Effort / Cost

The study required moderate effort, involving laboratory testing of 21 mixtures, statistical analysis, and PMED modeling. Costs included personnel time, equipment for IDEAL-CT and HWTT, and collaboration with industry partners (e.g., Aggregate Industries, Brox Industries). The approach is scalable for other DOTs with access to similar testing facilities.

References

- UMass Dartmouth Highway Sustainability Research Center Reports
- NAPA BMD Resource Guide

Agency and Research Entities

massDOT Massachusetts Department of Transportation

UMass | Dartmouth

Texas A&M Transportation Institute

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