Field Performance Validation of the Louisiana Balanced Mix Design Framework

An analysis of long-term pavement performance (8-18 years) to validate laboratory thresholds

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LOUISIANA DEPARTMENT OF TRANSPORTATION & DEVELOPMENT

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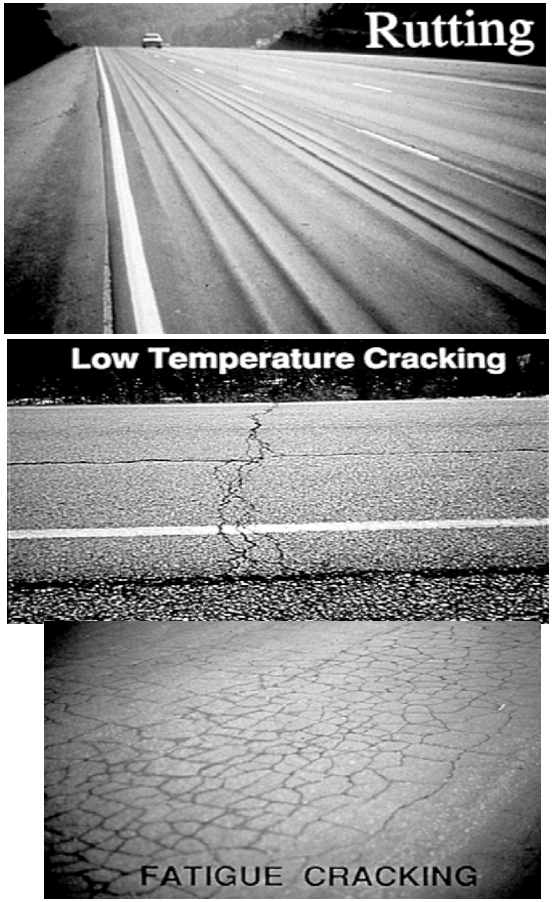
Presentation Outline

- **Introduction: The Evolution of Mix Design**
- **The Louisiana BMD Framework**
- **Study Objectives**
- **Methodology: Lab & Field Data**
- **The "Philosophy" of Validation**
- **Validation**
  - Rutting (HWT)
  - Cracking (SCB)
- **Summary and Conclusions**
- **Limitations and Questions**



The Evolution of Asphalt Mix Design

- **Method-Based Specifications (e.g., Marshall, Hveem)**
  - Prescriptive: Agencies specified exact materials and methods
  - Considered volumetric properties critical to mixture stability and durability
  - Contractor had minimal liability if the process was followed.
- **Performance-Based: Superpave (1990s)**
  - Shared responsibility between contractor and agency
  - Considered volumetric properties critical to mixture performance
  - Collaboration, innovation, and pavement quality improved with this change

Solving Rutting, Finding Cracking

New Problem: Cracking

The changes (less binder, stiffer mix) led to significant decrease in cracking resistance, durability, and workability.

New Complications

Widespread use of RAP, Crumb Rubber, and WMA additives limited the ability of a purely volumetric design to predict performance.

The Need for a New Approach

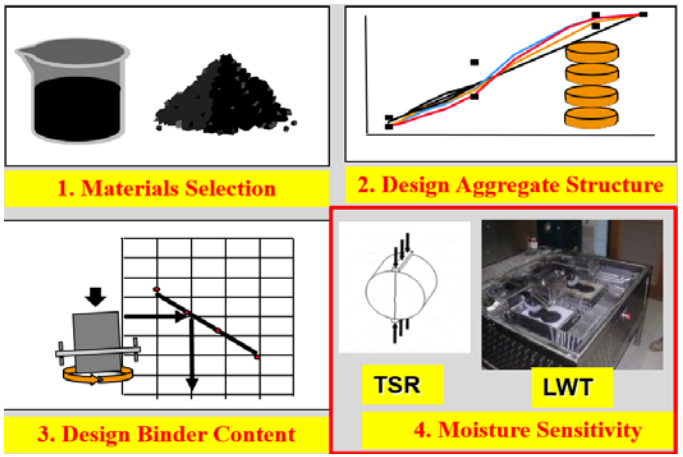
Agencies needed a way to complement volumetric design with mechanical tests that measure performance.

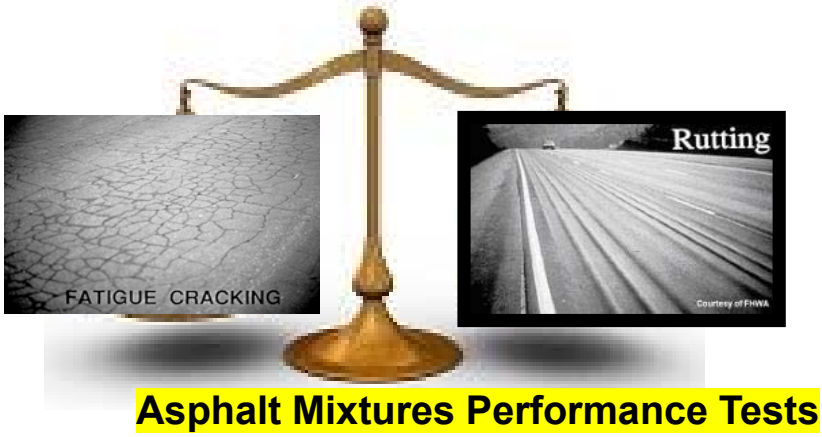
The Solution: Balanced Mix Design (BMD)

- Uses mechanical tests correlated to field performance
- Addresses multiple distresses simultaneously.
- **The Goal:** "Balance" the mix to resist rutting *and* cracking.

What is Balanced Mix Design (BMD)?

"An asphalt mix design using performance tests on appropriately conditioned specimens that address multiple modes of distress taking into consideration mix **aging**, **traffic**, **climate**, and **location** within the pavement structure."



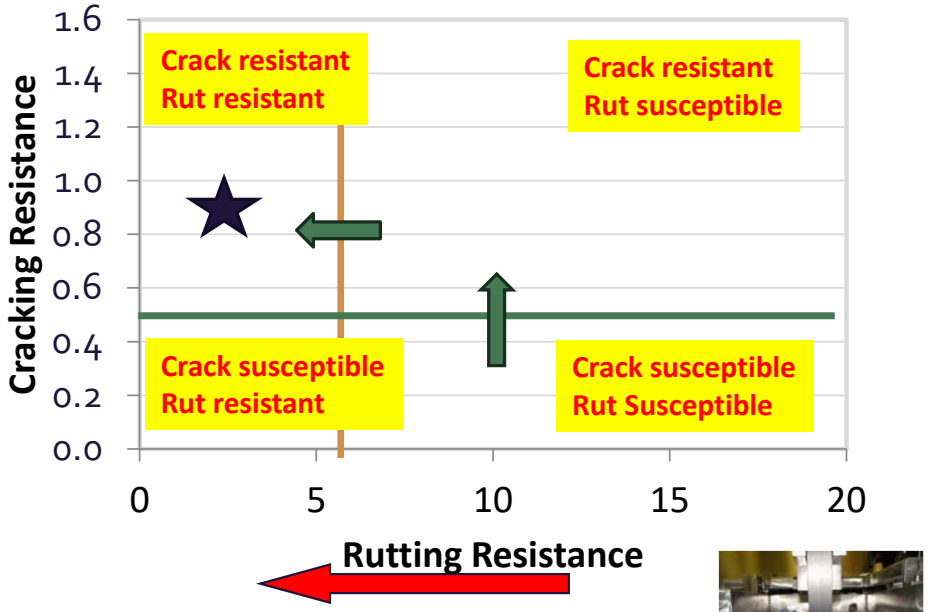


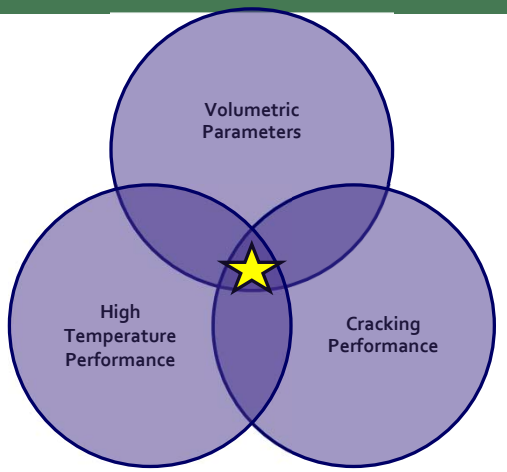
Asphalt Mixtures Performance Tests

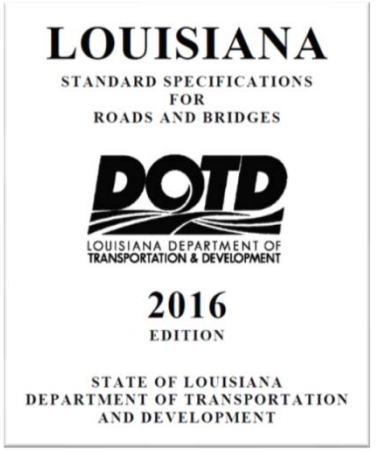
Tech Brief, Office of Preconstruction, Office of Preconstruction, Construction, and Pavements, FHWA-HIF-22-048, FHWA, US Department of Transportation, April 2022.

The "Louisiana Approach" (Implemented 2016)

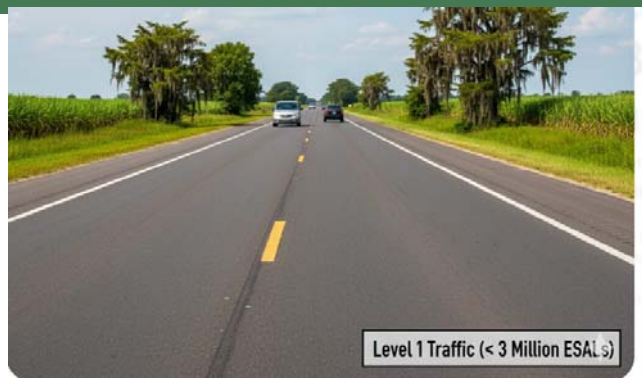
- *Volumetric and Mixture Performance Testing*
  - *Rutting (AASHTO T 324): LWT test (50°C, Wet)*
  - *Cracking (ASTM 8044): SCB test (25°C)*

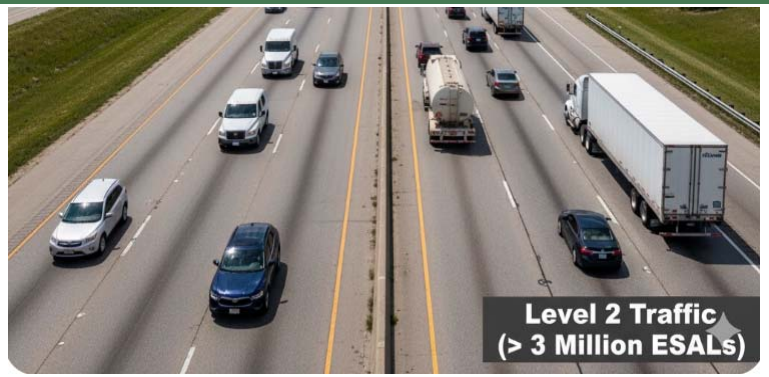






Louisiana's BMD Performance Criteria





Level 1 Traffic

(< 3 Million ESALs)

HWT Rut Depth: ≤ 10 mm

SCB Jc: ≥ 0.5 kJ/m²

Level 2 Traffic

(> 3 Million ESALs)

HWT Rut Depth: ≤ 6 mm

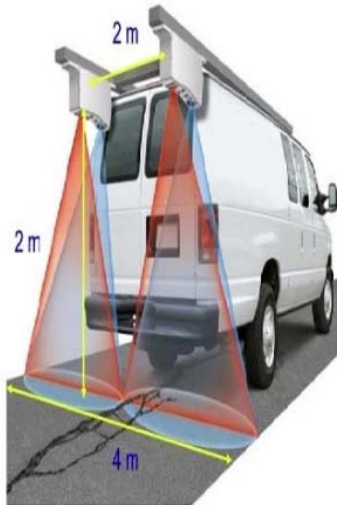
SCB Jc: ≥ 0.6 kJ/m²

Motivation

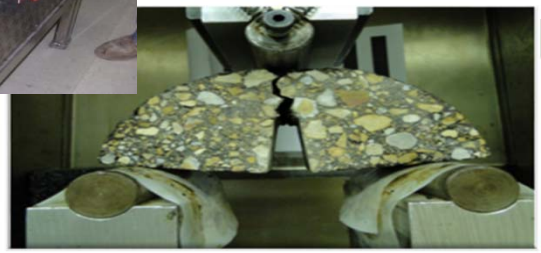
- Original BMD thresholds were established in 2016.
- Initial validation study (Mohammad et al., 2016) used pavement sections that were only **3 to 8 years old**.
- **The Question:** Are these thresholds still valid for predicting *long-term* performance?
- Pavements designed with these criteria are now reaching 8, 12, and even 18 years of service
- This Study: Re-evaluates and validates the BMD thresholds using data from these older, long-term pavement sections.

Research Objective

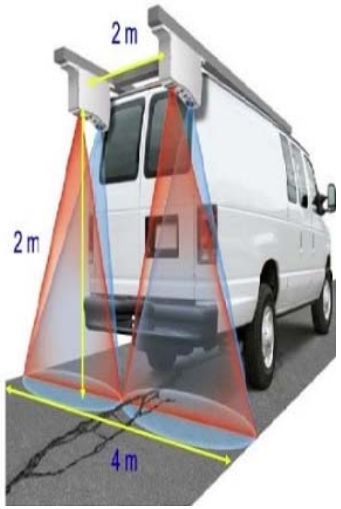
- **Validate BMD criteria** adopted by Louisiana DOTD
  - Hamburg Wheel Tracking (HWT), rut depth
  - Semi-Circular Bending (SCB), Jc
  - Comparing rutting and cracking data with acceptable performance values



Scope of Study

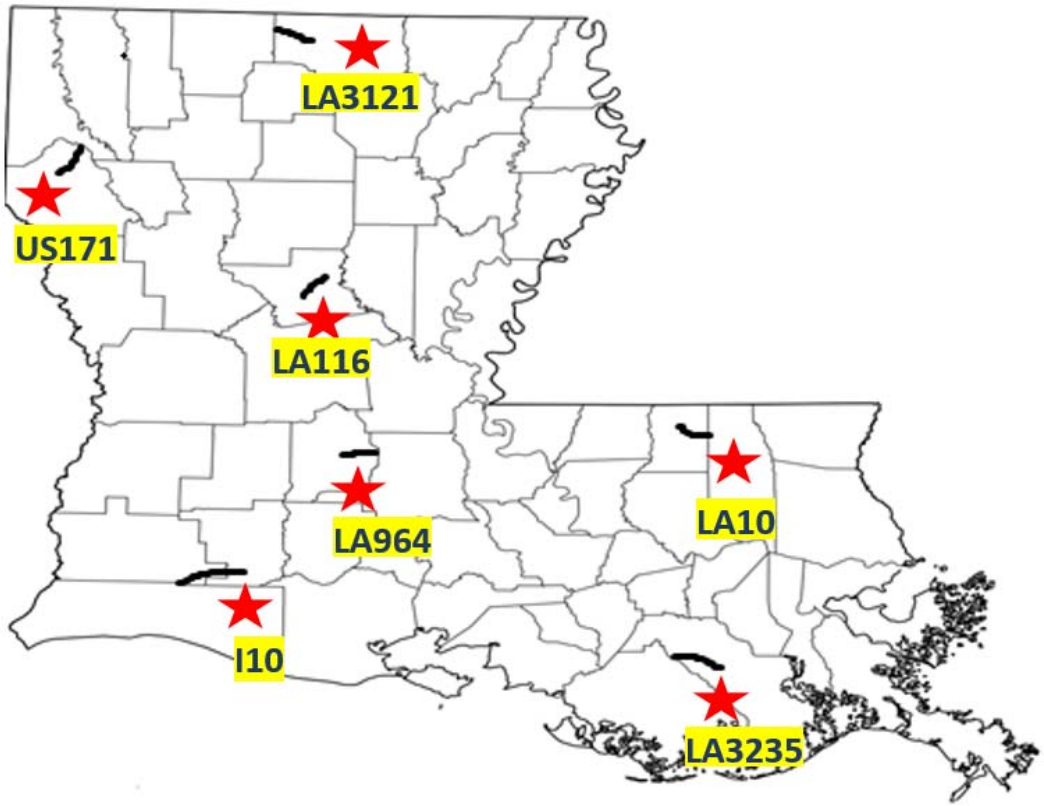


- **7** Field Rehabilitation Projects
- **13** Total Pavement Sections
  - **11** Level 1 Sections
  - **2** Level 2 Sections
- **Data Compared:**
  - Original lab HWT/SCB data (from construction)
  - Current field distress data (from LaDOTD PMS)



Project Locations

- Projects were selected to cover different geographical regions, mixture types, and traffic conditions.



Pavement Section Details

- **Level 1 Sections:** 11 Total
  - **Service Years**: 8 to 12 years
  - **Mix Types:** 6 Hot Mix Asphalt (HMA), 5 Warm Mix Asphalt (WMA)
  - **Asphalt Binders**: PG 70-22M, PG 70-22RM
- **Level 2 Sections**: 2 Total
  - **Service Years**: 16 to 18 years
  - **Mix Types**: Both HMA
  - **Asphalt Binders**: PG 76-22M

Construction Note: *All sections were 2-inch mill-and-replace overlays, providing a consistent basis for comparison.*

Performance Testing: Laboratory

HWT (AASHTO T 324)

Purpose: Measure rutting & moisture damage.

Method: A steel wheel (158 lb.) rolls over specimens submerged in 50°C water.

Duration: 20,000 passes.

Metric: Final Rut Depth (mm).

SCB (ASTM D8044)

Purpose: Measure cracking resistance.

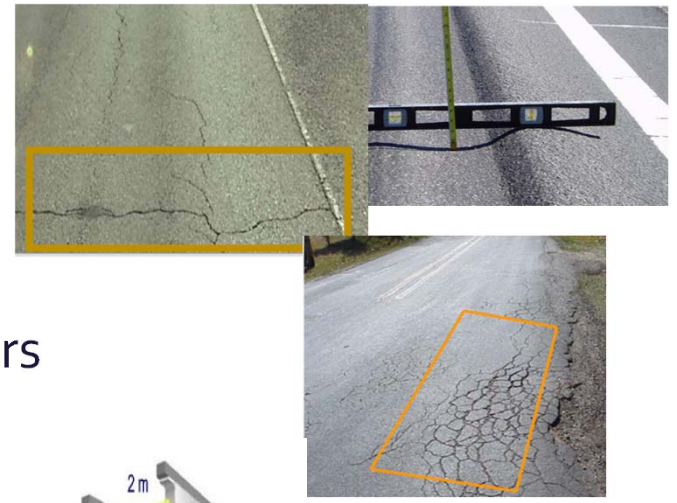
Method: A semi-circular specimen with a notch is loaded in a 3-point bend setup.

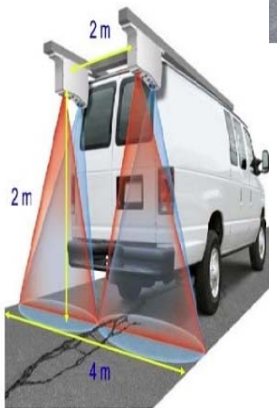
Replicates: Tested at 3 different notch depths.

Metric: Critical Strain Energy Release Rate (Jc) in kJ/m².

Performance Data: Field

- **Data Collection**
  - **Source**: Louisiana Pavement Management System (PMS).
  - **Vehicle**: Automatic Road Analyzer (ARAN).
  - **Frequency**: Every year for NHS roads and every 2 years for all other roads
  - **Data**: Rutting, Roughness, Patching, and Cracking (Alligator, Longitudinal, Transverse).
  - Data converted to index values (0 to 100) to trigger maintenance activities

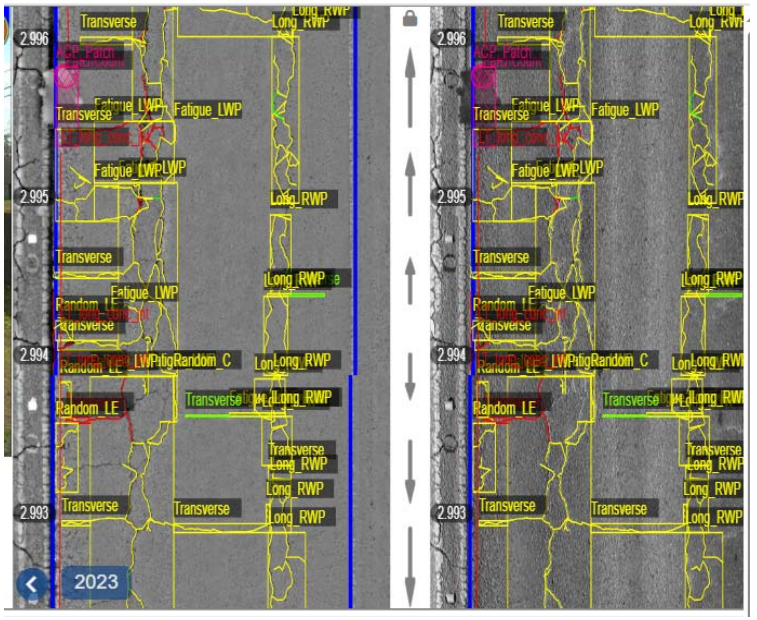




Performance Data: Field

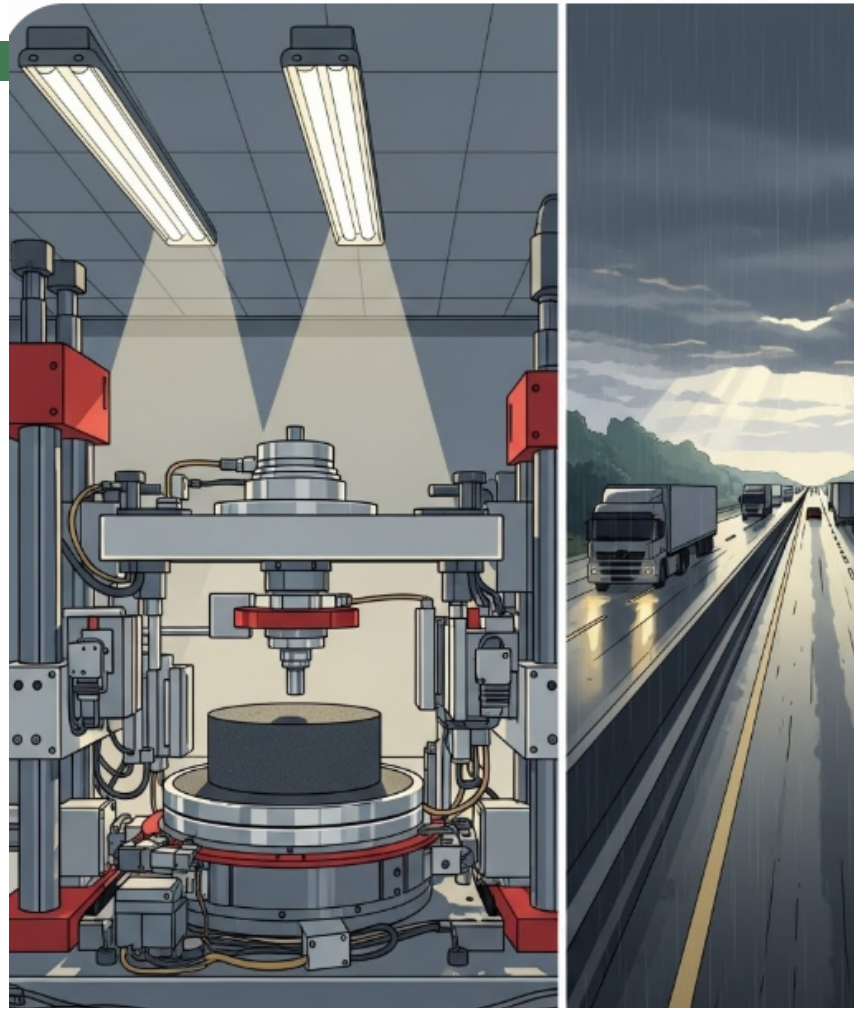
Field Failure Thresholds

- **LaDOTD maintenance triggers for overlay treatment**
  - ✓ Rutting: Field Rut Depth > 12.5 mm
  - ✓ Alligator Cracking (Flexible Pavement): Index between 90 and 60
  - ✓ Random Cracking (Transverse + Longitudinal): Index between 90 and 70



The Validation "Philosophy"

- **Burning Question: "Should we consider a direct 1-to-1 correlation?"**
  - **Plotting Lab Rut (mm) vs. Field Rut (mm) and looking for a good correlation is impractical and misleading**
  - **Initial Experimental did not consider confounding factors**



A More Robust Approach: The Pass/Fail Test

Instead of a direct correlation, this study validates the *thresholds* as a practical specification tool

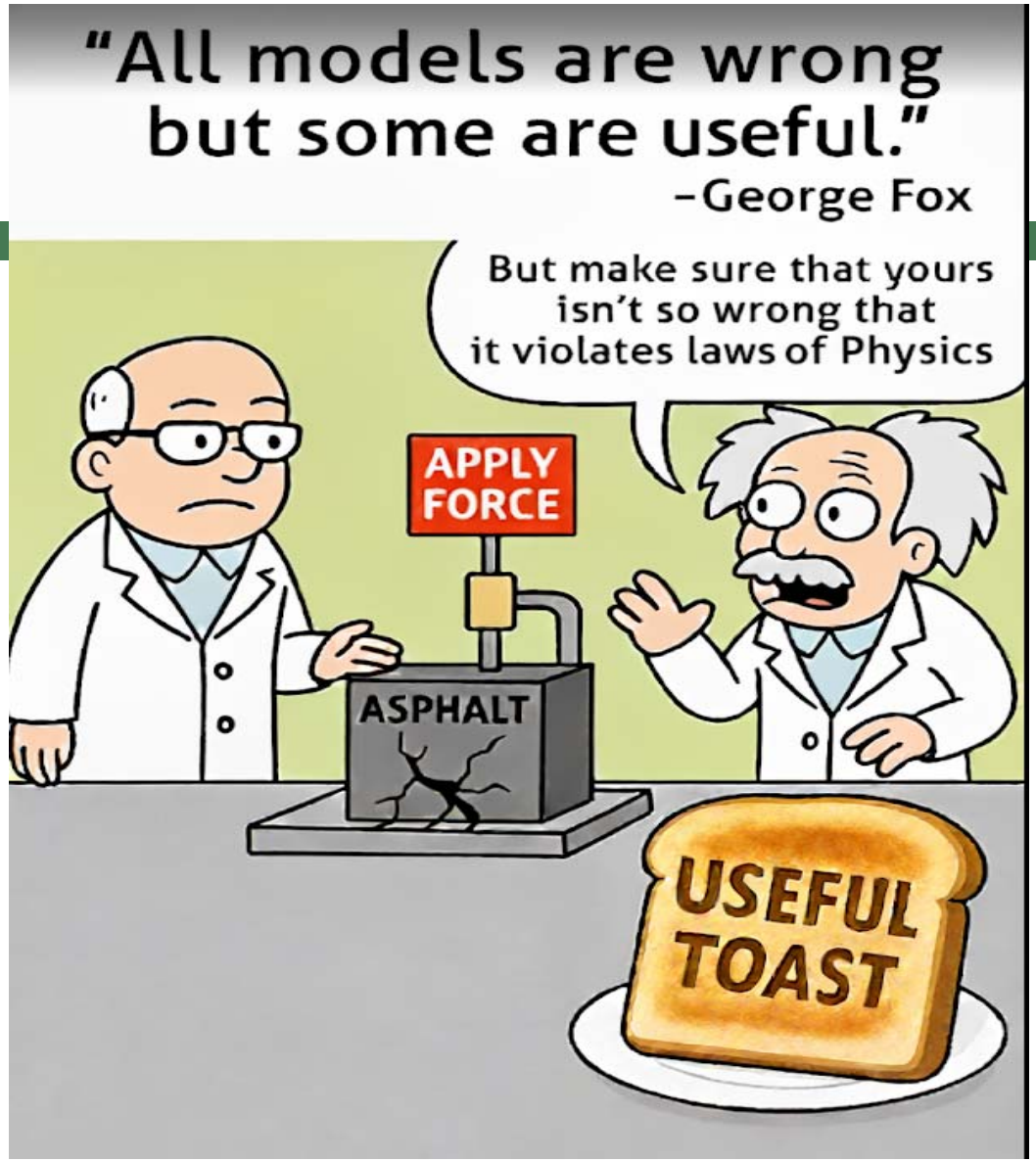
The logic is simple:

DOES...
Lab "Pass" = Field "Pass"?

For Level 1 Traffic
(Lab HWT < 10mm AND Field Rut < 12.5mm)

DOES...
Lab "Fail" = Field "Fail"?

For Level 2 Traffic
(Lab SCB < 0.6 AND Field Alligator cracking index <60


"All models are wrong but some are useful."
-George Fox
But make sure that yours isn't so wrong that it violates laws of Physics
APPLY FORCE
ASPHALT
USEFUL TOAST

Key Laboratory Findings (From Construction)

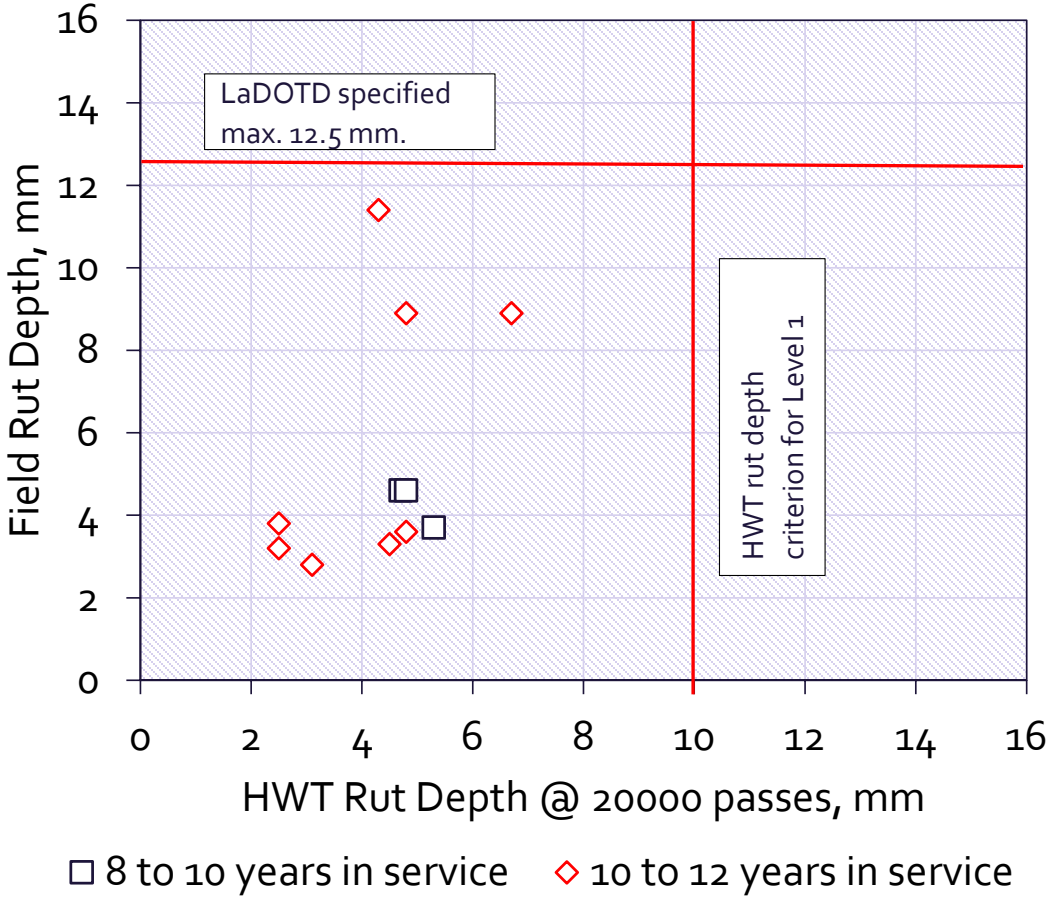
HWT Rutting Results

- **13 out of 13** sections **PASSED** the laboratory HWT rut depth criteria.
- All 13 mixes had good rutting resistance at the time of construction.

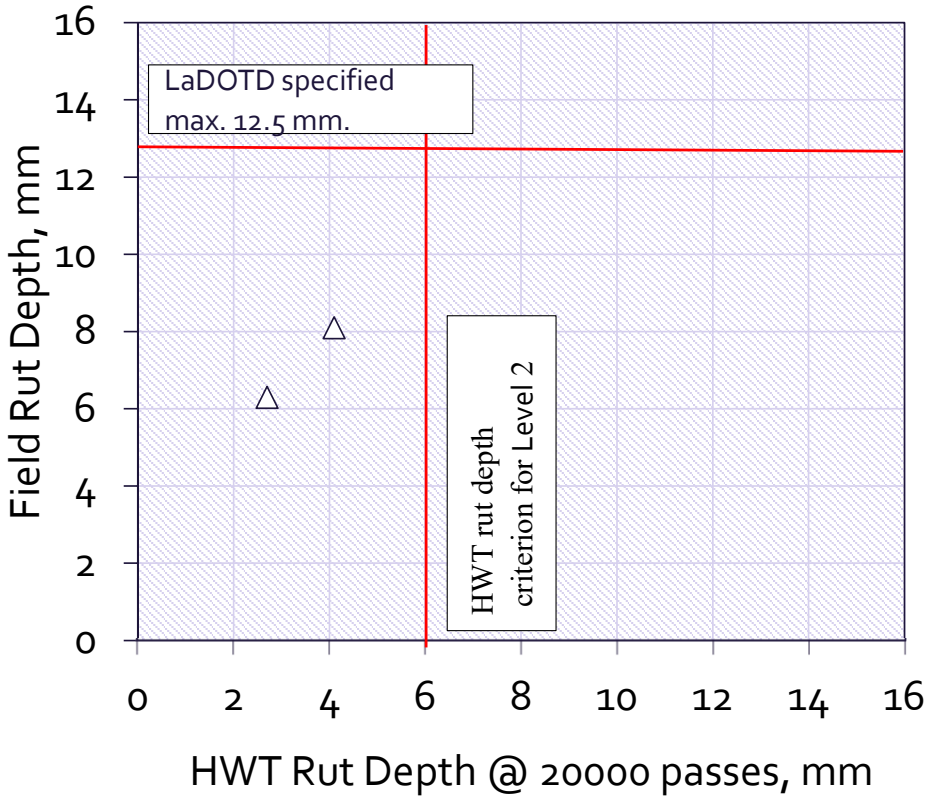
SCB Cracking Results

- **12 out of 13** sections **PASSED** the laboratory SCB Jc criteria.
- 1 section, **LA 964** (a Level 2 project), **FAILED** the lab test.
- Measured **Jc = 0.3 kJ/m²**, which is < 0.6 kJ/m² limit
- The most critical data point for validating the cracking threshold

Validation: Rutting (HWT)

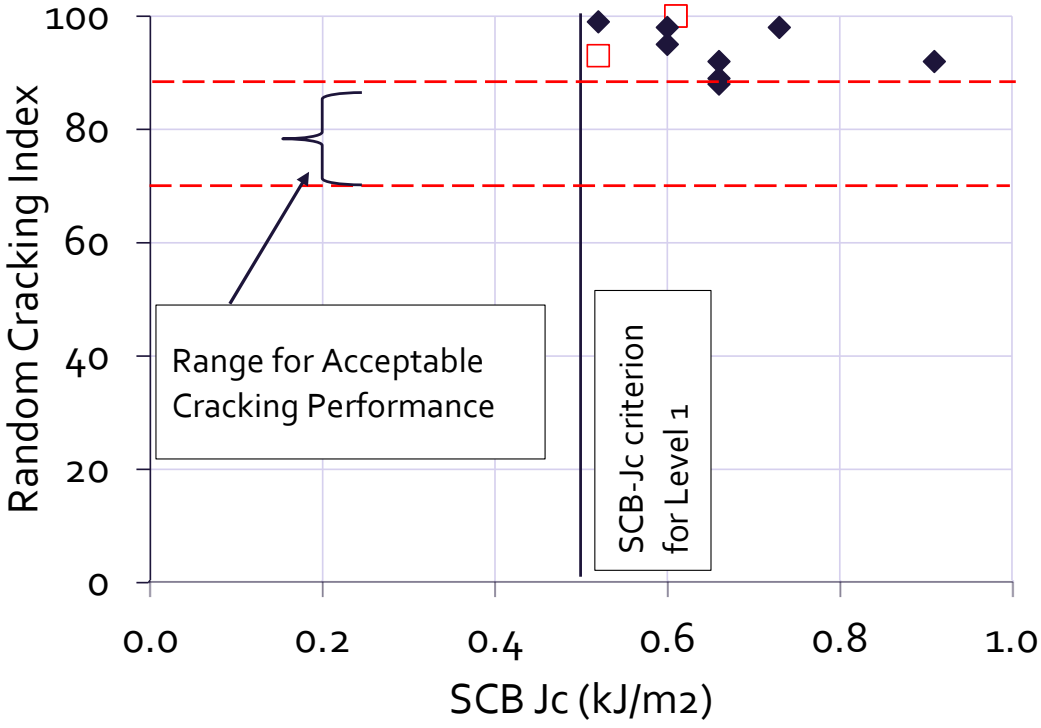


□ 8 to 10 years in service ◇ 10 to 12 years in service

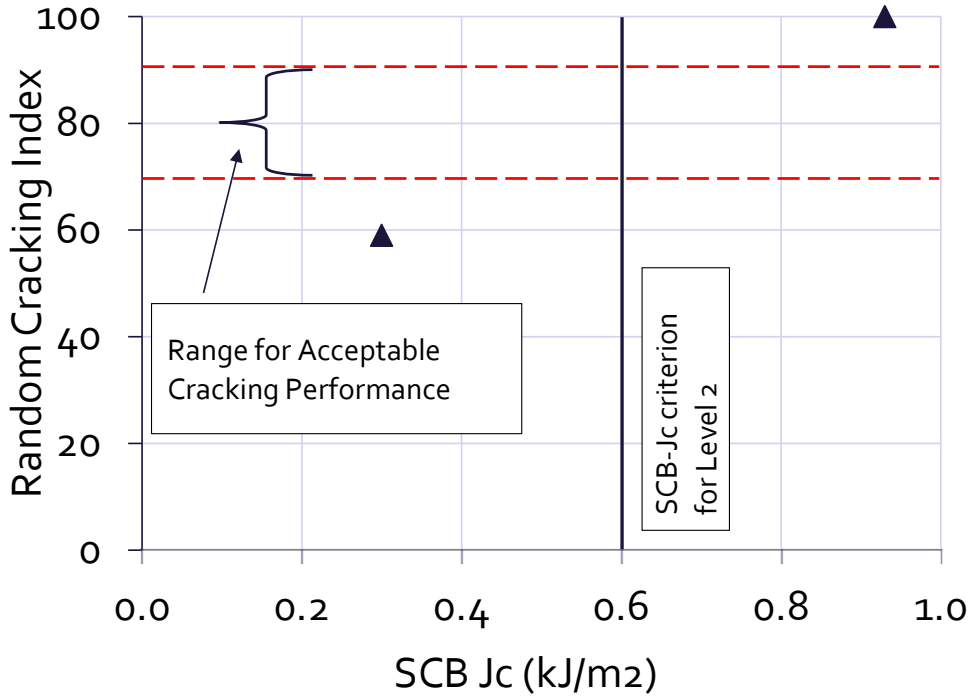


△ 16 to 18 years in service

Validation: Cracking (SCB) – Longitudinal + Transverse Cracking

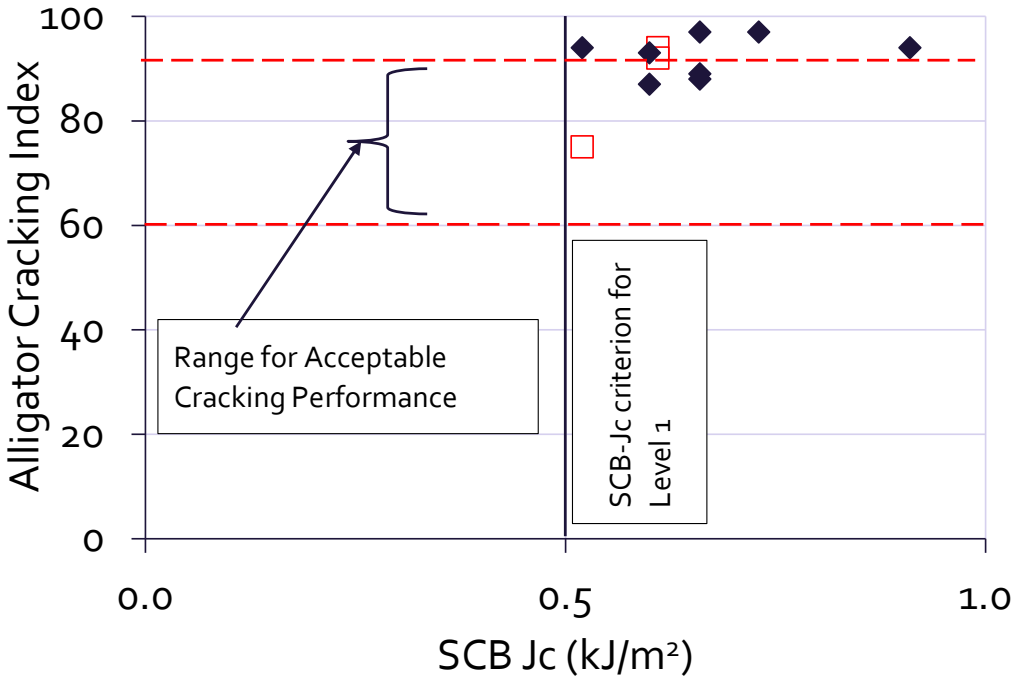


□ 8 to 10 years in service ◆ 10 to 12 years in service

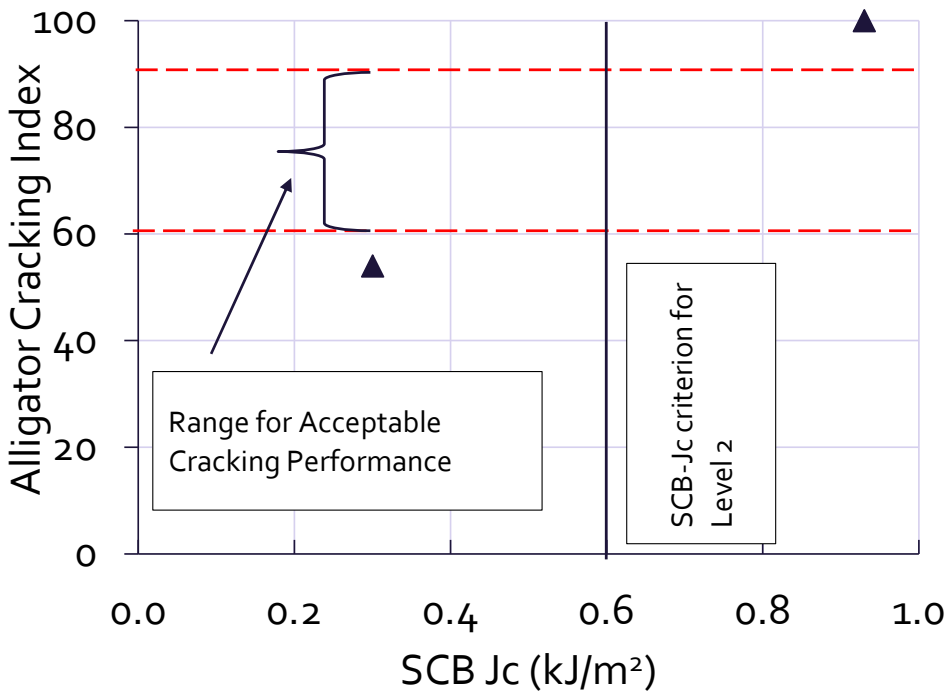


▲ 16 to 18 years in service

Validation: Cracking (SCB) – Alligator Cracking



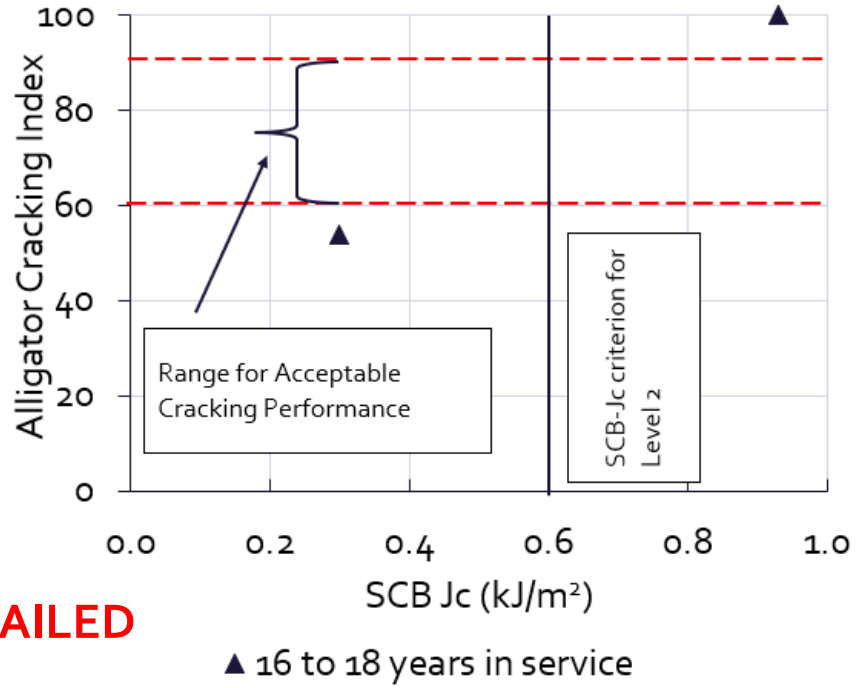
□ 8 to 10 years in service ◆ 10 to 12 years in service



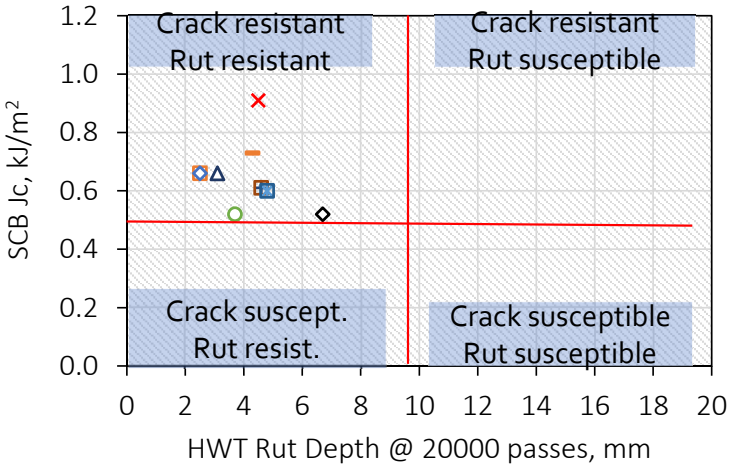
▲ 16 to 18 years in service

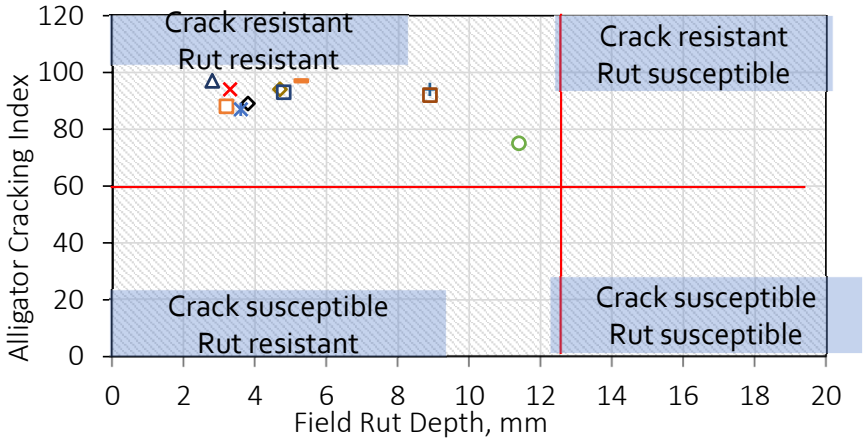
Validation: Cracking (SCB) - The "Fail"

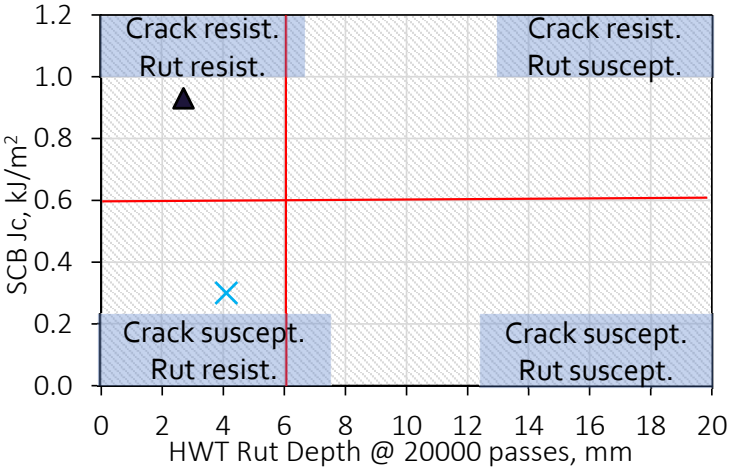
- **The Critical Data Point: LA 964**
  - **Lab Test (from 2005):**
    - This Level 2 section **FAILED** the lab test.
    - Measured SCB Jc = 0.3 kJ/m² (Threshold is ≥ 0.6)
  - **Field Performance (after 16 years):**
    - This section also **FAILED** in the field.
    - Random Cracking Index < 70
    - Alligator Cracking Index < 60
- **Conclusion (Part 2):**
  - The *only* mixture that **FAILED** the lab test also **FAILED** in the field.
  - This strongly validates that the 0.6 kJ/m² threshold is a meaningful minimum for preventing cracking.

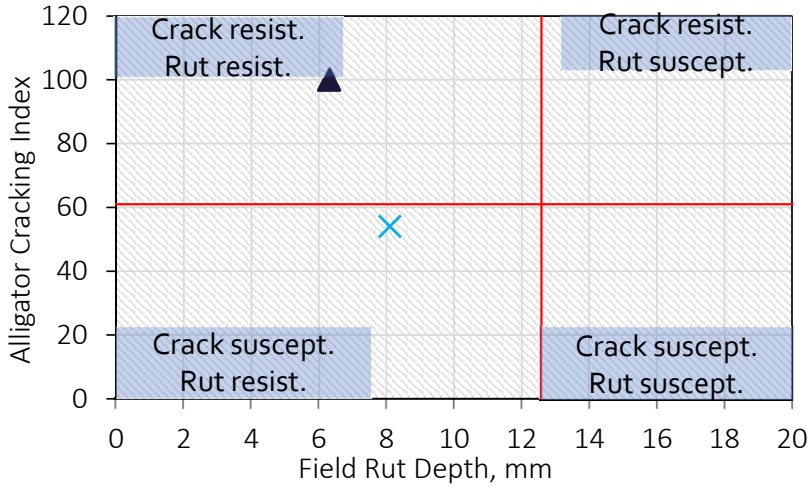


BMD Quadrant Plots



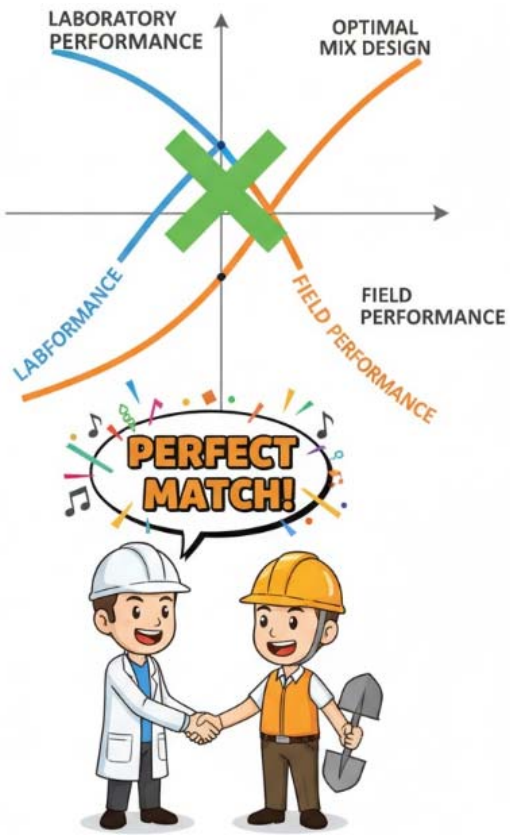






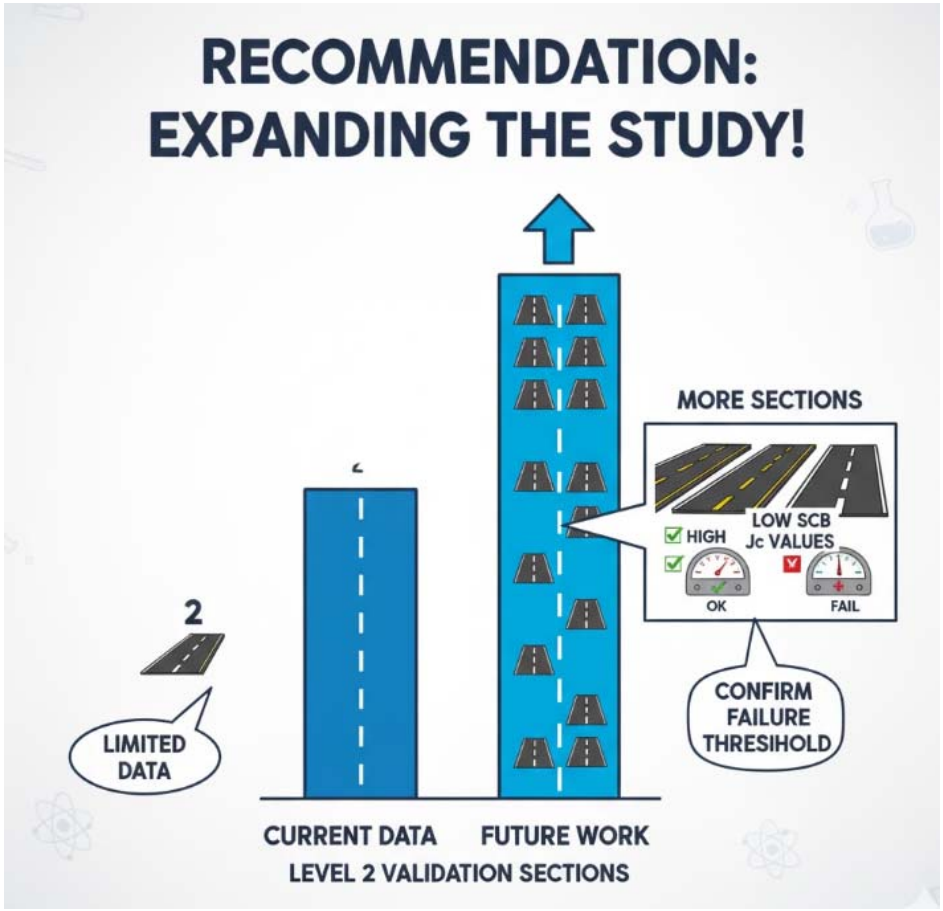
Summary & Conclusions

- **HWT Thresholds Validated:**
  - All 13 sections **PASSED** the lab HWT criteria (10mm/6mm) and all 13 showed acceptable field rut performance (<12.5mm) after 8-18 years.
- **SCB Jc Thresholds Validated:**
  - The 12 sections that **PASSED** the lab SCB Jc criteria (0.5/0.6 kJ/m²) also showed acceptable field cracking performance
  - The 1 section (**LA 964**) that **FAILED** the lab SCB Jc criterion also **FAILED** in the field for both random and alligator cracking.



Limitations and Future Research

- The Level 2 validation was based on limited data (2 sections).
- Future work should include more Level 2 sections and more sections with low SCB Jc values to further confirm the failure threshold.



Questions and Feedback?

The key to the German art of complaining is that if you look hard enough, you will always find something to complain about.