BALANCED MIX DESIGN APPROACH

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<table>
<thead>
<tr>
<th></th>
<th>1. I’m going to share some thoughts with you that you already know</th>
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<tbody>
<tr>
<td></td>
<td>2. I will tell you that we are not alone in these thoughts</td>
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<td></td>
<td>3. I’ll share a little history with you</td>
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<td>4. I’m going to ask you some questions - I don’t expect you to answer</td>
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<td>5. I’m going to state the obvious</td>
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<td>6. I’ll share some ideas and some examples to go with them</td>
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<td>7. Hopefully we can start to build on these ideas</td>
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Initial Thoughts

Dry mixes are prevalent in our industry.

Lowering N-design and raising lab molded densities will only help so much.

Restrictive specifications and general notes are not long term solutions.

Continuing to increase binder replacement without addressing mix performance is not sustainable.

We need to increase our understanding of the factors which drive mix performance to help us better optimize our mixes.
It’s a Nationwide Problem

Several tests sections on NCAT test track are dedicated to investigating long term pavement performance.

Researchers across the country are looking at better ways to design longer lasting pavements.

NAPA recently created the Pavement Performance Task Group in response to concerns over states issues with pavement performance.
Gyration levels vary widely

Levels are being reduced with the intent of increasing binder content in mixes

The Problem: Mixes that are designed to meet specifications while minimizing cost @ lower gyrations don’t always equate to more binder
## Evolution of Mix Designs

<table>
<thead>
<tr>
<th>Year</th>
<th>Company/Method</th>
<th>Mix Design Details</th>
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<tbody>
<tr>
<td>1890</td>
<td>Barber Asphalt Paving Company</td>
<td>Asphalt cement 12 to 15%, Sand 70 to 83%, Pulverized carbonite of lime 5 to 15%</td>
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<tr>
<td>1905</td>
<td>Clifford Richardson, New York Testing Company</td>
<td>Surface sand mix: 100% passing No. 10, 15% passing No. 200, 9 to 14% asphalt. Asphaltic concrete for lower layers, VMA terminology used, 2.2% more VMA than current day mixes or ~0.9% higher binder content</td>
</tr>
<tr>
<td>1920s</td>
<td>Hubbard Field Method (Charles Hubbard and Frederick Field)</td>
<td>Sand asphalt design. 30 blow, 6” diameter with compression test (performance) asphaltic concrete design (Modified HF Method)</td>
</tr>
<tr>
<td>1927</td>
<td>Francis Hveem (Caltrans)</td>
<td>Surface area factors used to determine binder content; Hveem stabilometer and cohesionmeter used. Air voids not used initially, mixes generally drier relative to others, fatigue cracking an issue</td>
</tr>
<tr>
<td>1943</td>
<td>Bruce Marshall, Mississippi Highway Department</td>
<td>Refined Hubbard Field method, standard compaction energy with drop hammer. Initially, only used air voids and VFA, VMA added in 1962; stability and flow utilized</td>
</tr>
<tr>
<td>1993</td>
<td>Superpave</td>
<td>Level 1 (volumetric). Level 2 and 3 (performance based, but never implemented)</td>
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Some Questions We Need to Ask Ourselves

Is going to SP the answer?

Is getting rid of RAP and RAS the answer?

Is disallowing modifiers like REOB and PPA the answer?

IS DOING THINGS THE WAY WE’VE ALWAYS DONE THEM THE ANSWER?

What about traffic and climate? Are universal volumetrics (e.g., VMA and air voids) controlling designs without regard to traffic and climate?
Following The Recipe

“Recipe” driven volumetric designs are based on history and what we think works.

The Problem . . . .

Recipe specifications have become convoluted and confounded over time with specified items and general notes competing against each other to achieve the desired goals:

- New requirements get added, but nothing gets removed.
- Innovation has become stifled by our own specifications.

Eliminate the restrictions and focus on PERFORMANCE.
A Better Approach

LET’S STOP USING THE RECIPE TO DETERMINE IF THE CAKE IS GOOD

We need to define our expectations and open up the recipe to meet the end result

• What defines a good cake?  It Tastes Good
• What defines a good mix?  Lasting Performance

Optimized Mix Design Approach Foundational Points

• “Use what works”
• “Eliminate what doesn’t”
• “Be simple and practical”

“Good doesn’t have to be complicated and complicated isn’t always good.”
What We Need And What They Want

Design For Performance, Not Economics

CONTRACTORS WANT A LEVEL PLAYING FIELD
What is a Balanced Mix Design?

**Optimize**
- Make the best or most effective use of (a situation, opportunity, or resource)

**Balance**
- Being in proper arrangement or adjustment, proportion

**Balanced Mix Design**
- Optimize the mix to provide needed performance and balance between stability and durability.
Optimized Mix Design Approach – Framework

Material Selection  Optimize JMF  Mix Performance Evaluation  Workability
Optimized Mix Design Approach – Framework

THE WEAK LINK IN PERFORMANCE TESTING

Indicator of cracking resistance

Mix Performance Evaluation

Stability

Durability

Indicator of rutting resistance
Optimized Mix Design Approach – Framework

Material Selection
- Aggregates
- Binder, Modifiers & Additives
- Recycled Materials

Optimize JMF
- Gradation
- Binder Content
- Volumetrics

Mix Performance Evaluation
- Stability
- Durability
- Adjustments

Workability
- Mixing
- Compaction
- Segregation
Optimized Mix Design Approach – Framework

Material Selection
- Aggregates
- Binder, Modifiers & Additives
- Recycled Materials

Binder Source; REOB, PPA
Polymer Modified; Latex
Warm Mix Additive
Antistrip Agent, Lime

Compatibility

RAP, RAS, GTR Properties
Rejuvenator

Binder from recycle is never 100%
Significant findings: Laboratory Evaluation - SMA

![Graph showing rut depth and overlay cycles for different treatments: Control, 20% RAP, 5% RAS (MW), 5% RAS (TO). The graph illustrates the decrease in rut depth as the overlay cycles increase.]

- Control: High rut depth with low overlay cycles.
- 20% RAP: Moderate rut depth with moderate overlay cycles.
- 5% RAS (MW): Lower rut depth than Control with higher overlay cycles.
- 5% RAS (TO): Lowest rut depth with highest overlay cycles.

Legend:
- Hamburg
- Overlay
Significant findings: **Laboratory Evaluation - Superpave**

**Graph:**
- **Y-axis:** Rut Depth (mm)
- **X-axis:** Overlay Cycles

**Legend:**
- Hamburg
- Overlay

**Samples:**
- Control PG 58-28
- PG 58-34
- PG 58-28 w/0.6% HG
- PG 58-28 w/0.75% HG

**Overlay Cycles:**
- Hamburg: 25% RAP 2% RAS
Optimized Mix Design Approach – Framework

IS MORE ALWAYS BETTER?

Optimize JMF

Gradation

Binder Content

Volumetrics

Dense Graded Stone on Stone Contact
Gap or Open Graded

WHAT DRIVES PERFORMANCE?

VMA
Vbe
Film Thickness
Influence of AC%
Optimized Mix Design Approach – Framework

Mix Performance Evaluation
- Stability
- Durability
- Adjustments

BALANCE
Mix Performance Space Diagram

STIFF MIX
(bottom layers of full depth pavements)

POOR MIX
(non-surface, low traffic or temporary use only)

SOFT MIX
(reflective crack control)

SUPER MIX
(SMA, high traffic surface mixes)

From: Dr. Bill Buttlar, University of Illinois
Balanced Mix Design Approach – Limestone Rock Asphalt

![Graph showing the relationship between Cantabro Loss and Hveem Stability](image)

- **Cantabro Loss, %**
- **Hveem Stability**

- **Type I D Fine**
Optimized Mix Design Approach – Framework

- Mix Performance Evaluation
  - Stability
  - Durability
  - Adjustments

- Binder Content
- Binder Grade or Source
- Gradation (P200)
- Aggregate Source
- Recycle Content
- Additives
Is the mix easy or difficult to design? Does it mix well through the HMA plant? Is production consistent?

Is the mix easy or difficult to compact?

Is the mix prone to segregate?
Final Thoughts

Some form of a balanced mix design framework is probably in our future.

There is a lot of work at the national level already in progress towards utilizing this type of approach.

Constraints:
- Large ships turn slow
- A change in our thought process
- Durability - Overlay
- Gsb - Aggregate bulk gravities
QUESTIONS?