Applying Balanced Mix Design to SMA

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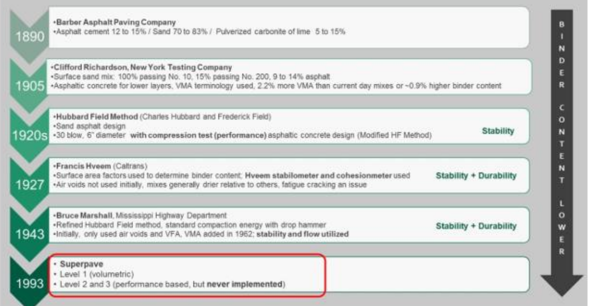
History of Mix Design



The most common performance tests for Balanced Mix Design are rutting and cracking tests.

Problems with the Current Approach

Volumetrics alone cannot adequately evaluate mix variables such as recycle, warm mix additives, polymers, rejuvenators, and fibers.

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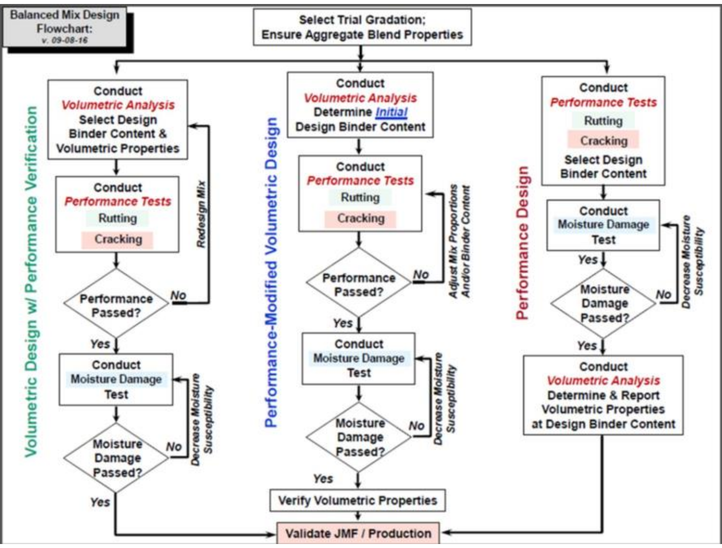
What are some BMD upsides?

- Increase understanding of the factors that drive mix performance.
- Design for performance and not just to "the spec."
- Start thinking outside of long-held rules and constraints.
- Innovate!

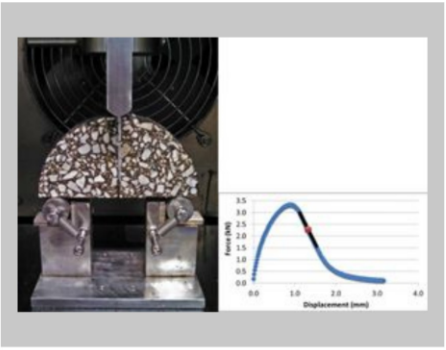


Performance Testing

Hamburg Wheel Tracking Test

This test evaluates the mixture for permanent deformation due to rutting as well as moisture susceptibility.

Illinois Flexibility Index Test (SCB I-FIT)

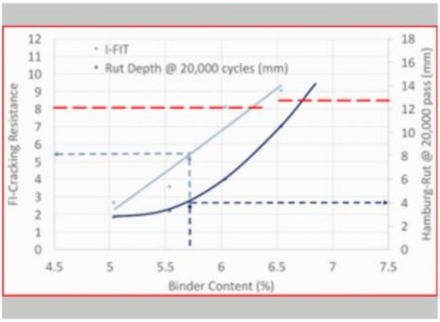


This test is designed to evaluate the mixture's resistance to fatigue cracking.

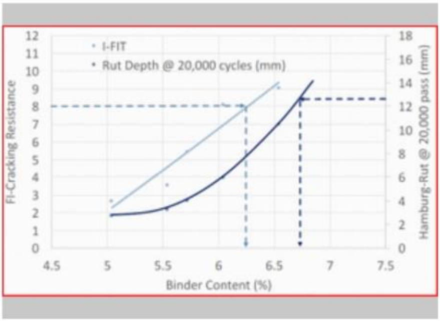
Disc-Shaped Compact Tension Test (DCT)

This test is designed to evaluate the mixture's resistance to low temperature/thermal cracking.

Volumetric Mix Design vs. Balanced Mix Design

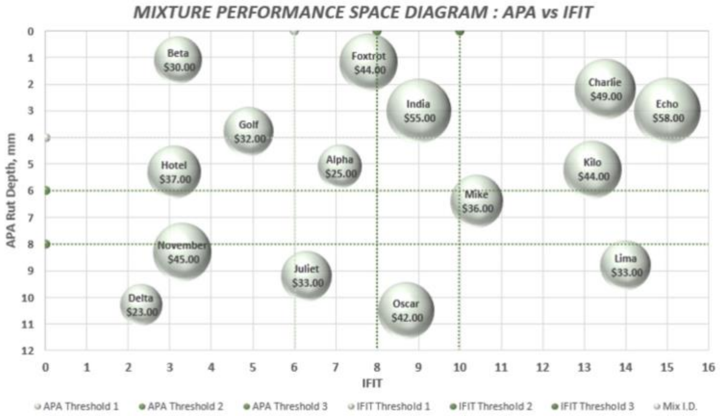


Volumetric Mix Design



Balanced Mix Design

The following information is for illustrative purposes only.



Objectives

1 **Information**

How do the current designs perform?

Can we better evaluate and compare new mixes?

How do different conditions impact performance?

Are material performance assumptions valid?

2 **Life Cycle Cost Analysis**

3 **What are we trying to balance?**

Can we balance it?

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	Mix Type				
	190 C	125 SMA I-435	095 SMA I-435	T5 City Overlay 40R	T5 City Overlay 60R
Virgin AC PG	64-22	64V-22 GTR	64V-22 GTR	52-34	58-28
Virgin AC %	3.50%	6.50%	6.00%	2.60%	1.50%
Additive %	0.00%	0.00%	0.00%	0.00%	0.20%
Recycle AC %	1.50%	0.00%	0.00%	2.00%	2.90%
Total AC %	5.00%	6.50%	6.00%	4.60%	4.60%
Air Voids	3.00%	4.80%	4.80%	2.70%	2.00%
Rut Depth (mm)	3.19	4.13	6.88	12	10
Stripping Inflection	NA	17,761	11,271	10,211	9,086
Passes	20,000	20,000	20,000	12,662	16,112
Flexibility Index	< 1	10	3	3	3
DCT (J/m2)	320	714	626	347	446
Continuous Grade	NA	NA	NA	72.1-26.1	70.8-27.3

	190 C	095 SMA I-435	125 SMA I-435	T5 City Overlay 40R	T5 City Overlay 60R
Hamburg	1	3	2	5	4
DCT	5	1	2	4	3
IFIT	3	2	1	2	2
Average	**3**	**2**	**1.7**	**3.6**	**3**
Price	**3**	**5**	**4**	**2**	**1**

	Mix	**T5 40 -1**	**T5 40 -2**	**T5 60 -1**	**T5 60 -2**
Design	Virgin AC Grade	PG 52-34	PG 52-34	PG 58-28	PG 58-28
	FRAP, %	40	40	60	60
Volumetrics	Targeted Total AC, %	4.8	4.8	4.8	4.8
	As Measured Total AC, %	4.6	4.7	4.6	4.4
	Added AC, %	2.7	2.7	1.7	1.7
	Recycle AC, %	2.1	2.1	3.1	3.1
	Binder Replacement, %	44%	44%	65%	65%
	Additive, %	0.0	0.0	0.2	0.2
	Air Voids, %	2.7	4.4	2.0	2.4
	VMA, %	12.9	14.1	12.9	13.4
Performance Testing	TSR	N/A	91.3	N/A	99.2
	SIP, # passes	11,691	19,894	11,840	9,321
	Rut depth @10,000 passes, mm	7.1	3.3	6.0	7.6
	SCB FI	4.4	1.6	2.7	3.2
	DCT Energy, J/m^2	347	324	446	386
	Continuous PG	72.1-26.1	69.2-28.0	70.8-27.3	70.8-29.3
	(T_{cont}, S), °C	-32.7	-33.3	-30.1	-31.3
	(T_{cont}, m), °C	-26.1	-28.0	-27.3	-29.3
	Delta Tc, °C	-6.6	-5.3	-2.8	-2.0

Real Life Benchmarking - Designing Comparisons

DCT

Control: 375.5 J/m2

High RAP: 442.5 J/m2

Regressed Air: 609.0 J/m2

Trend follows expectations

IFIT

Control: 0.2

High RAP: 2.1

Regressed Air: 4.6

Trend follows expectations

Hamburg

Control: 10.66mm @ 10,108 - SIP: 6,882

High RAP: 14.36mm @ 20,000 - SIP: 15,752

Regressed Air: 3.33mm @ 20,000 - SIP: n/a

Looking at our 2018 SMA

DCT

Project 1: 745J/m2

Project 2: 583 J/m2

Project 3: 631 J/m2

IFIT

Project 1: 0.8

Project 2: 5.2

Project 3: 2.3

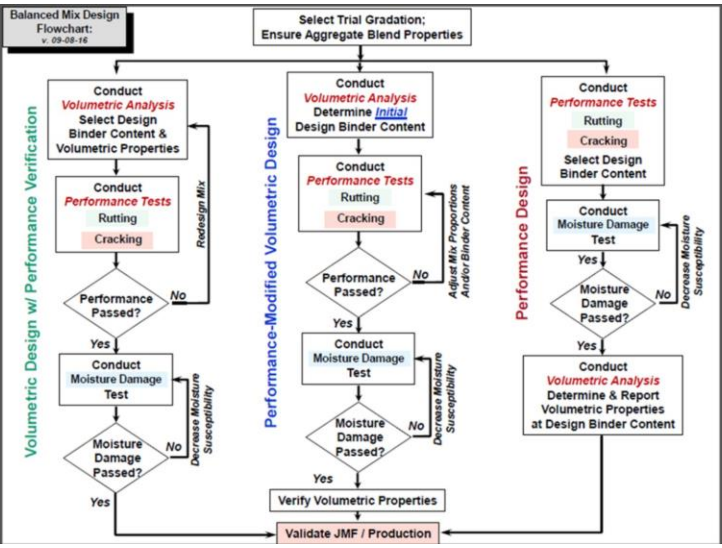
Hamburg

Project 1: 2.7mm @ 10,108 - SIP: N/A

Project 2: 4.5mm @ 20,000 - SIP: N/A

Project 3: 5.1mm @ 16,506 - SIP: n/a

Where does this leave us?



Resources

1. Association of Asphalt Paving Technologists (AAPT)
2. National Center for Asphalt Technology (NCAT)
3. National Asphalt Pavement Association (NAPA)
4. Asphalt Pavement Alliance (APA)
5. Construction Materials Testing Group, Kansas City
6. Manchester Pavement Solutions, Kansas City

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