Balanced HMAC Designs

IHEEP

Conference

San Antonio, Tx.

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TxDOT Construction Division

Flexible Pavements Branch

Background

- Stability and durability are arguably the two most important factors related to HMA performance
- The goal is to have a mix that is both resistant to rutting (stability) and resistant to cracking (durability)
- Over the past 10 years, rutting has diminished significantly due to the use of polymers and the Hamburg Wheel Test (HWT)
- Reflective cracking is arguably the most common distress associated with flexible pavements in Texas
- No state’s currently evaluate HMA mixtures for cracking resistance at the mixture design stage
- Generally speaking “we test for rutting resistance with the HWT and hope for cracking resistance”

Background (continued)

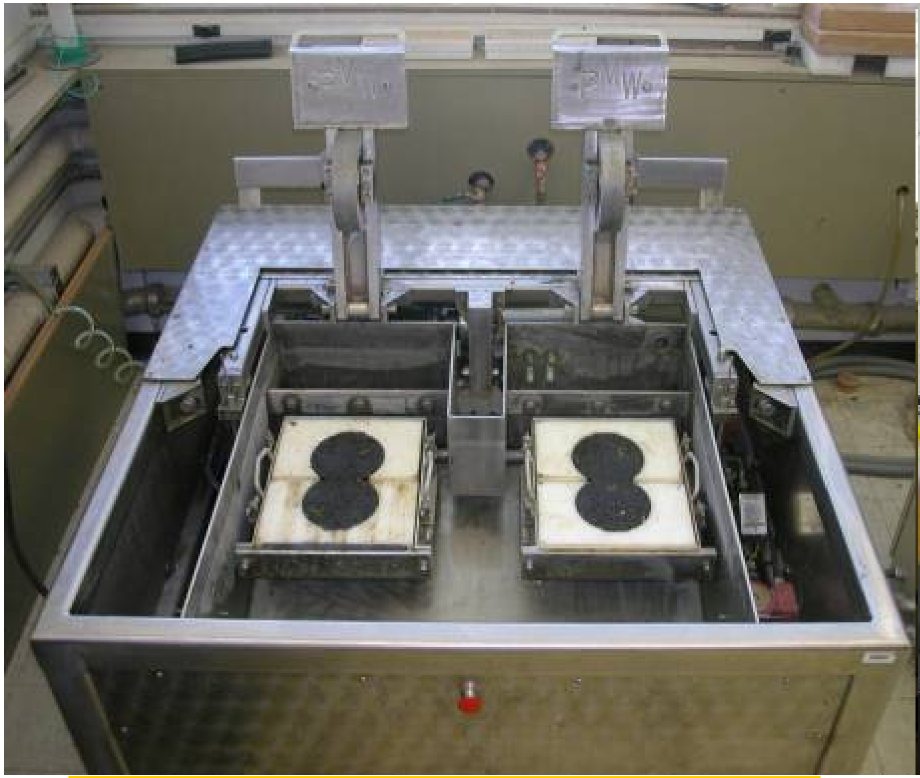
- The Overlay Tester appears to be a good predictor of reflective cracking
- The overlay tester has revealed that most TxDOT mixes are relatively susceptible to cracking
- There is a lot of potential for using the Overlay Tester to improve the way we design our mixes
- TxDOT is currently working with TTI on project 0-5123 to develop HMA mixes that are both stable (rut resistant) and durable (crack resistant)

Project 0-5123: Advanced overlay design system incorporating both rutting and reflection cracking requirements

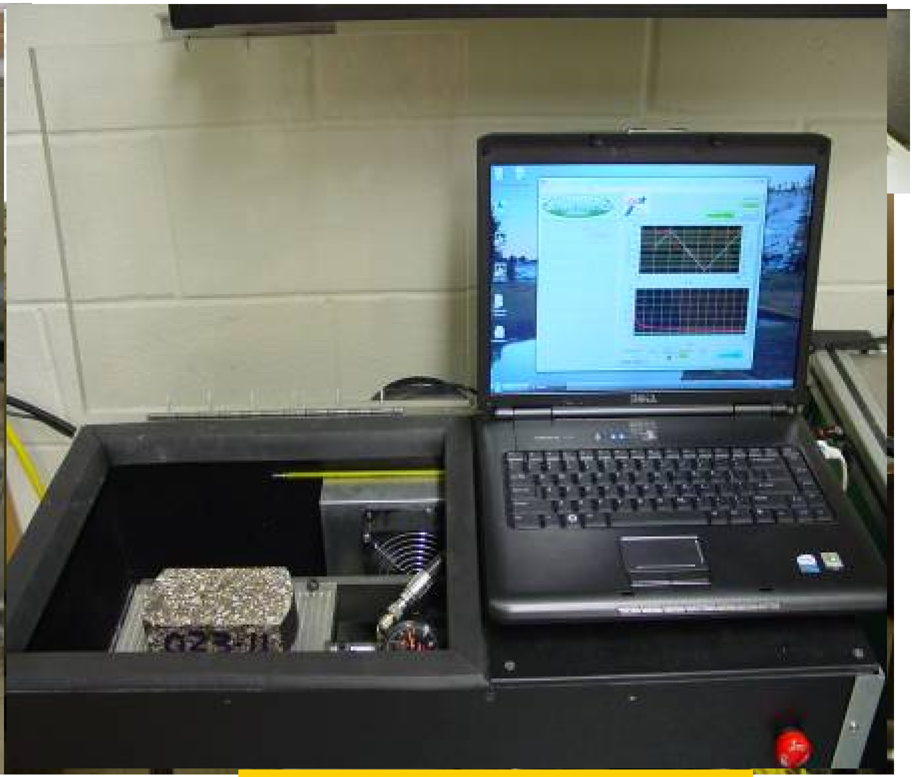
Feb. 27, 2006, Austin, Texas

Fujie Zhou, Tom Scullion, and Sheng Hu
Texas Transportation Institute

Lab testing: performance evaluation

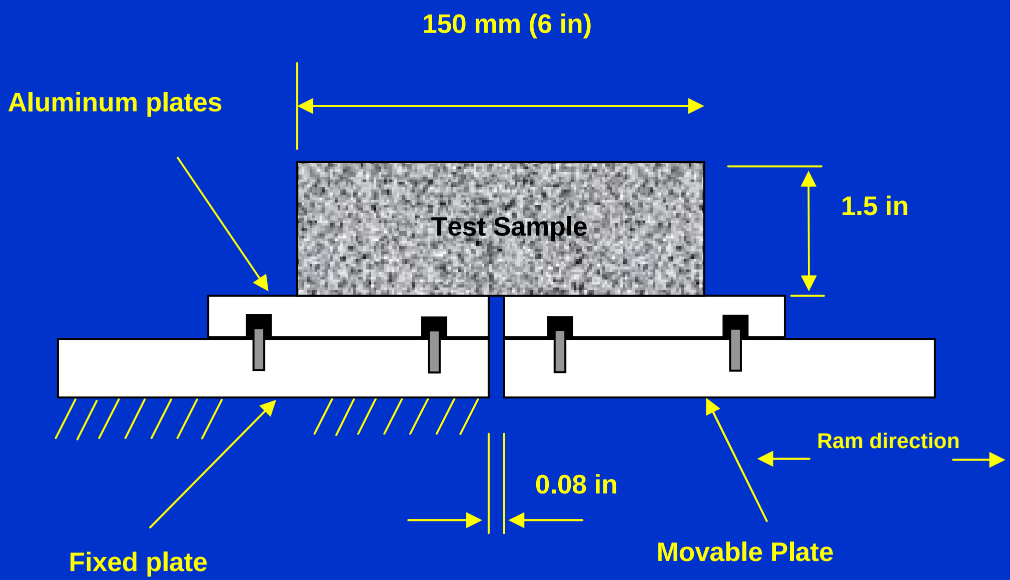


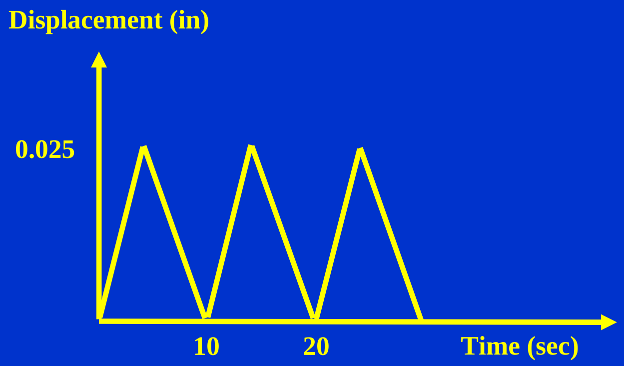
Hamburg Wheel Tracking Device



Overlay Tester

Loading Configuration





- Sample - 6'' length, 3'' width, 1.5'' height
- Loading - Continuously triangular displacement, 5 sec loading & 5 sec unloading
- Standard Test Conditions
  - ✓ Opening displacement - 0.025 in.
  - ✓ Room temperature - 77 ± 3 F
- Definition of failure
  - ✓ 93% Load Reduction
  - ✓ Visible crack on surface

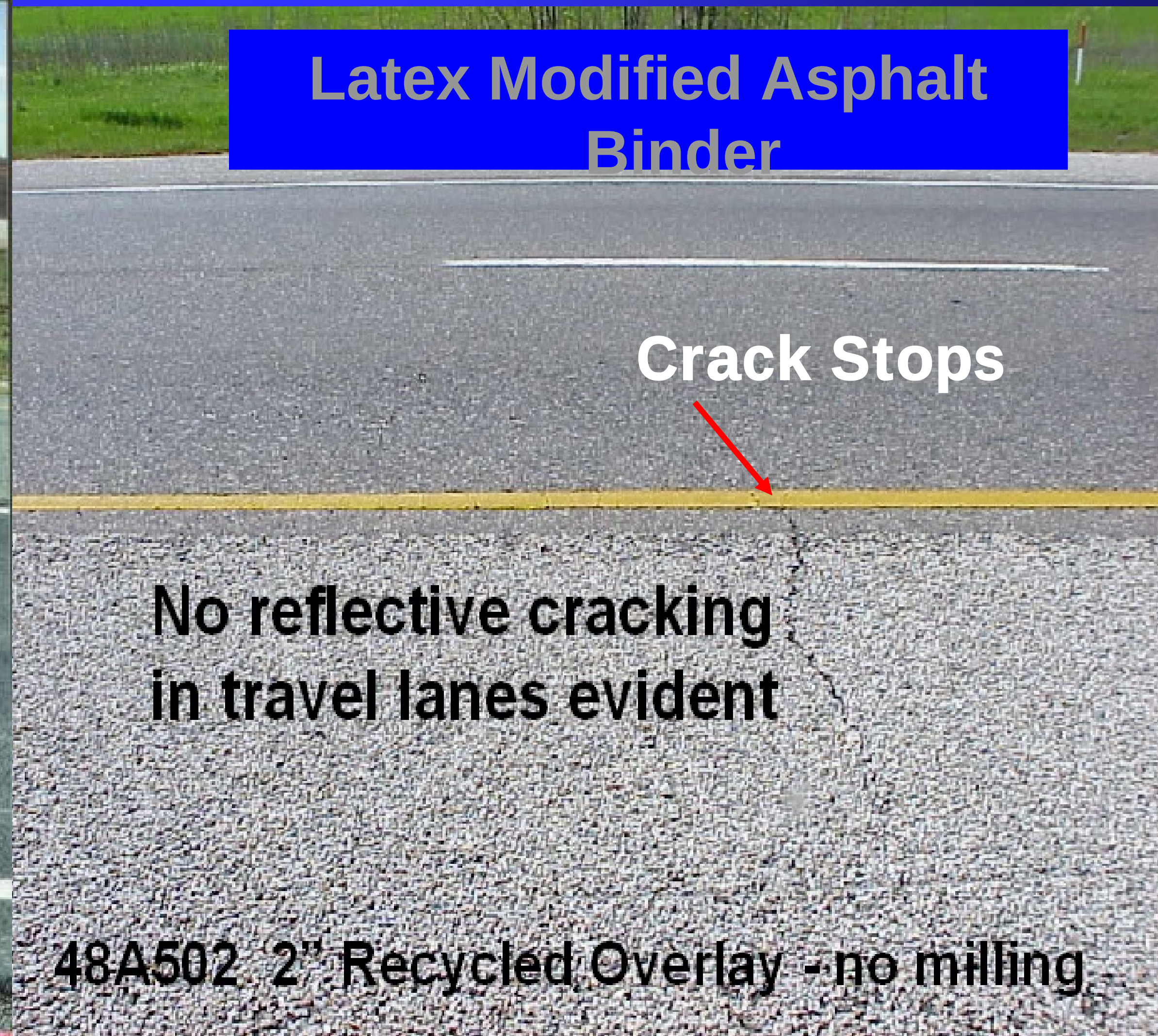
Statewide Evaluation of Good/Bad reflection cracking projects

US 84 Abilene (6 mo old)

Inplace Recycling

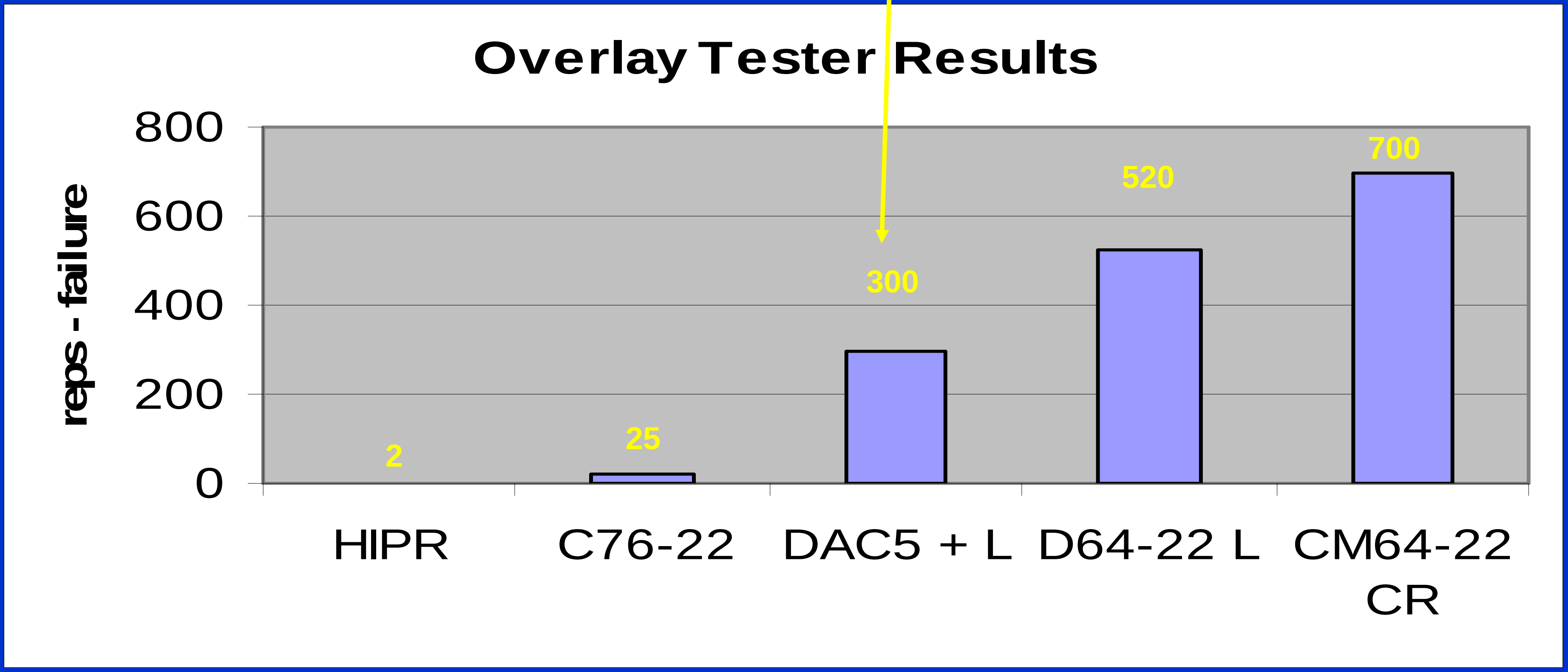
US 175 Dallas

10 year old section

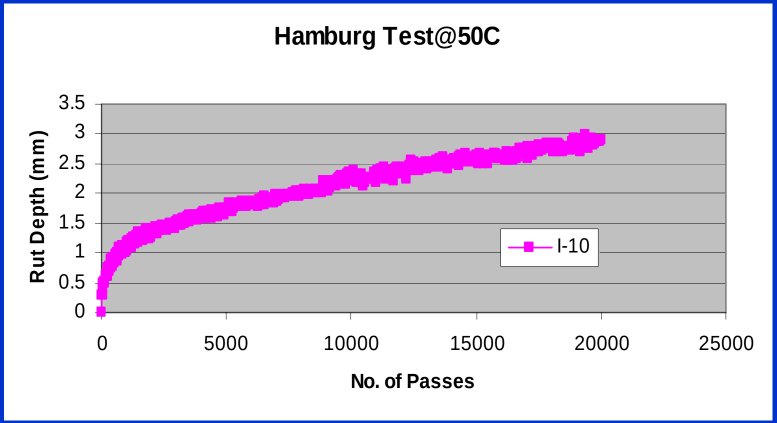


Field Validation Studies

1) Does the test rank materials correctly ?
2) What are acceptable criteria ?



IH-10 Type C (PG76-22L), 4.4%AC



Properties	Result	Target
Cracking (overlay tester cycles to failure)	**2**	>200
Rutting (APA rutting after 8000 cycles)	**2.6 mm**	<6mm
Rutting Hamburg (Hamburg cycles to 0.5 inch rut)	**>20K**	>20K

Rut resistance mix (4 in thick) placed on IH 10 in 2002 heavy traffic

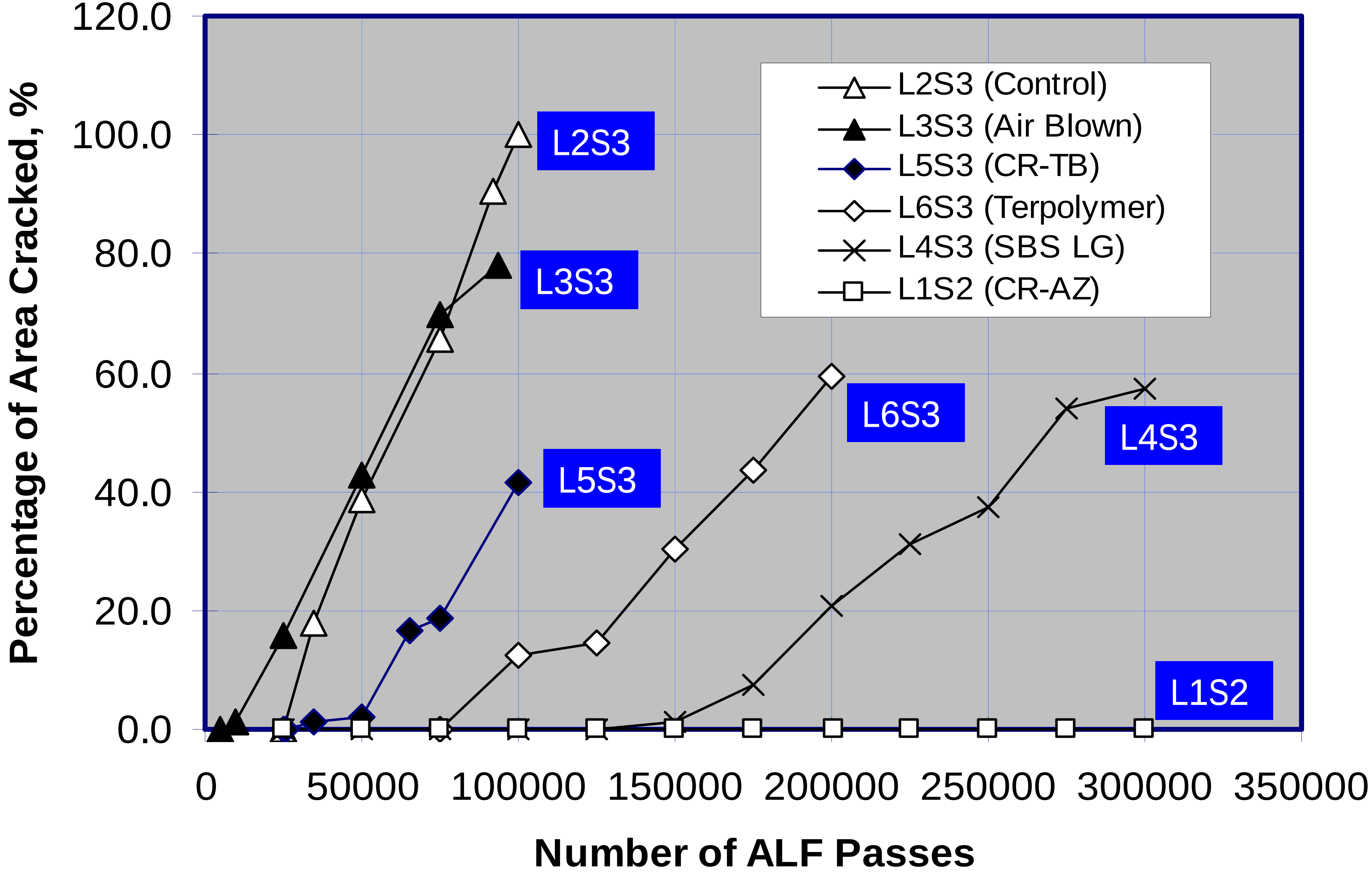
Reflection cracking in 2004


Two FHWA ALFs with
12 Pavement Lanes Constructed in
the Summer and Fall of 2002

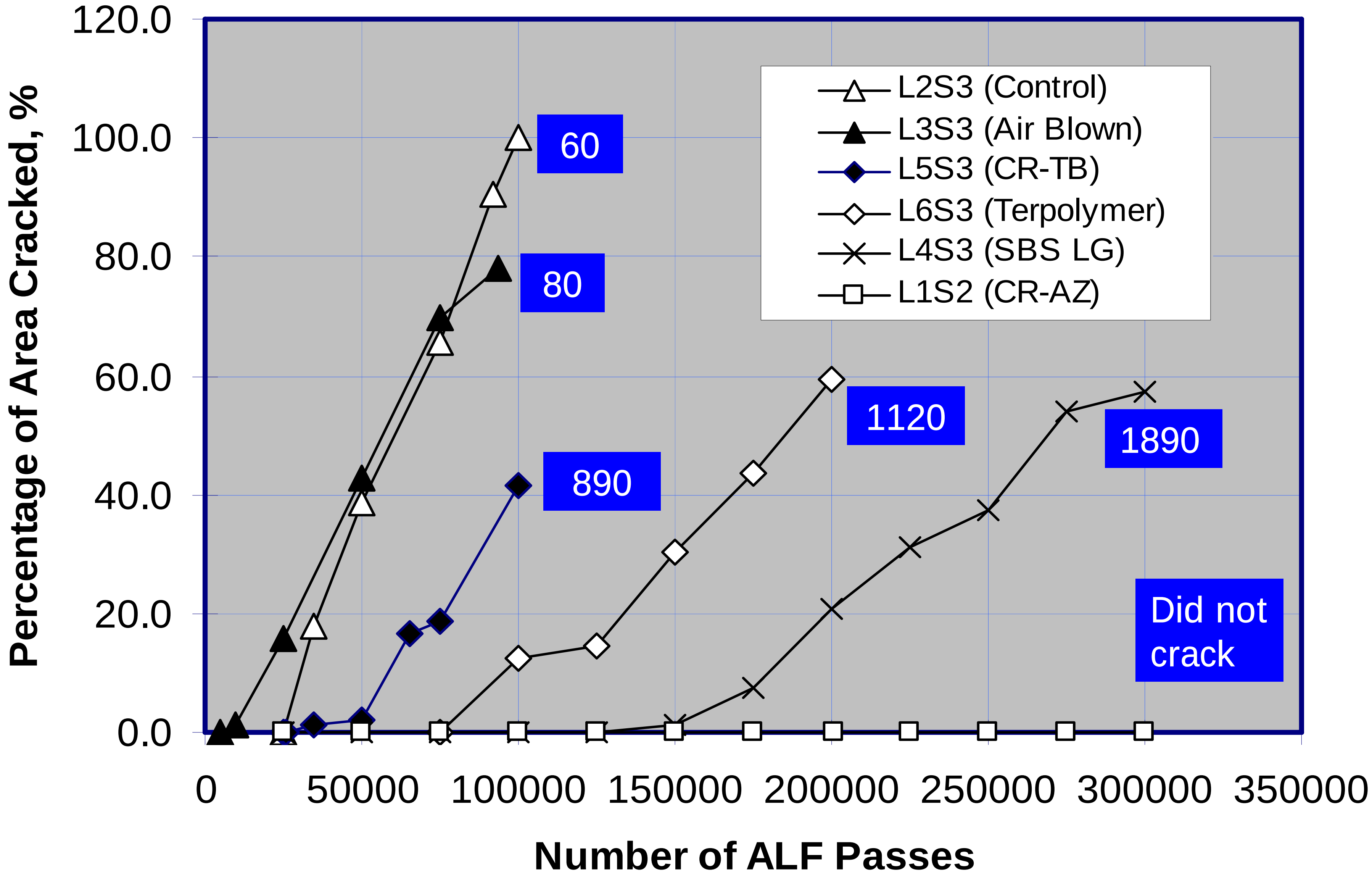
As-Built Pavement Lanes

CR-AZ ---- 70-22	PG 70-22 Control	Air Blown	SBS LG	CR-TB	TP	PG 70-22 + Fibers	PG 70-22	SBS 64-40	Air Blown	SBS LG	TP
1	2	3	4	5	6	7	8	9	10	11	12

Lane 1	Lane 2	Lane 3	Lane 4	Lane 5	Lane 6
CR-AZ	Control	Air Blown	SBS LG	CR-TB	TP
300,000	100,000	100,000	300,000	100,000	200,000

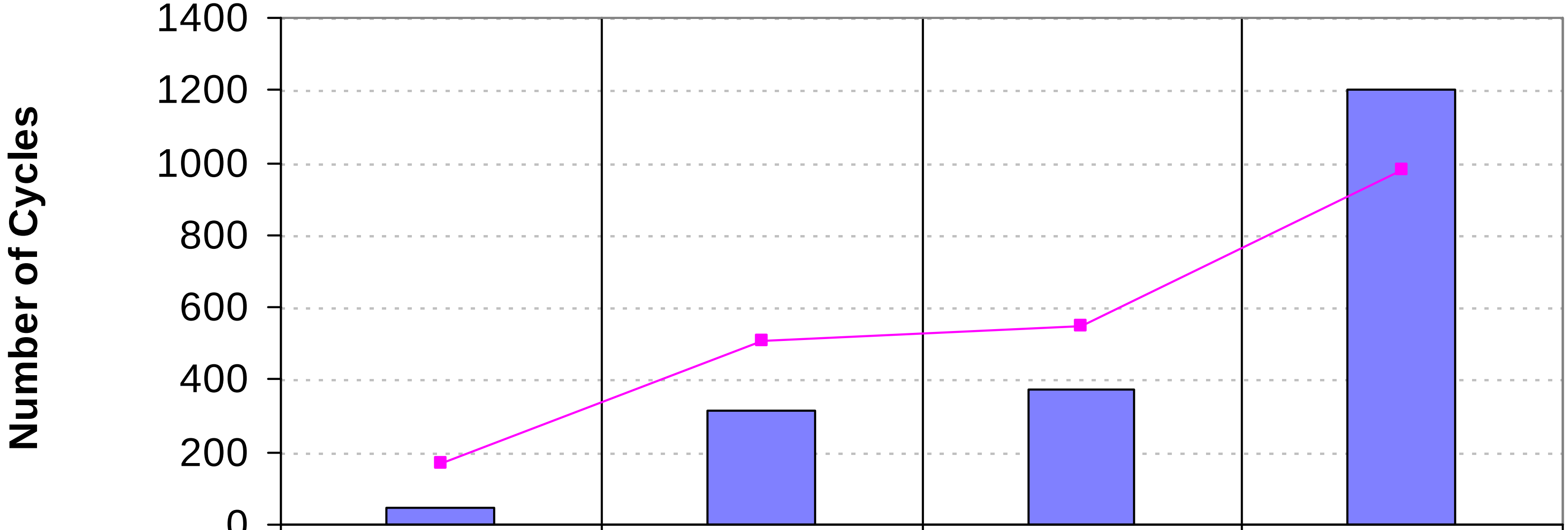


Percentage of Area Cracked vs. ALF Wheel Load Passes



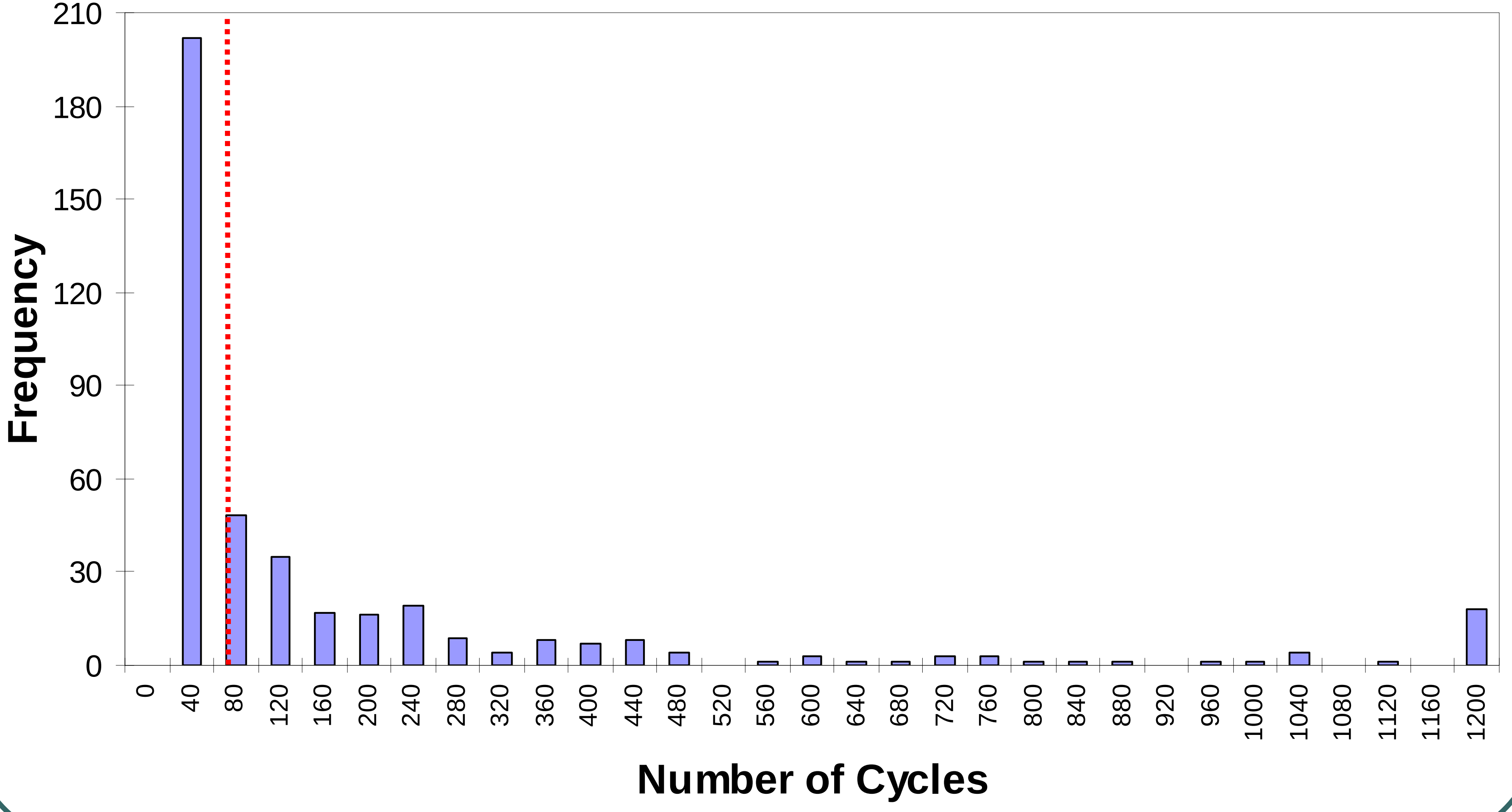
OT vs. FHWA-ALF Fatigue Test Results

Influence of Mix Type

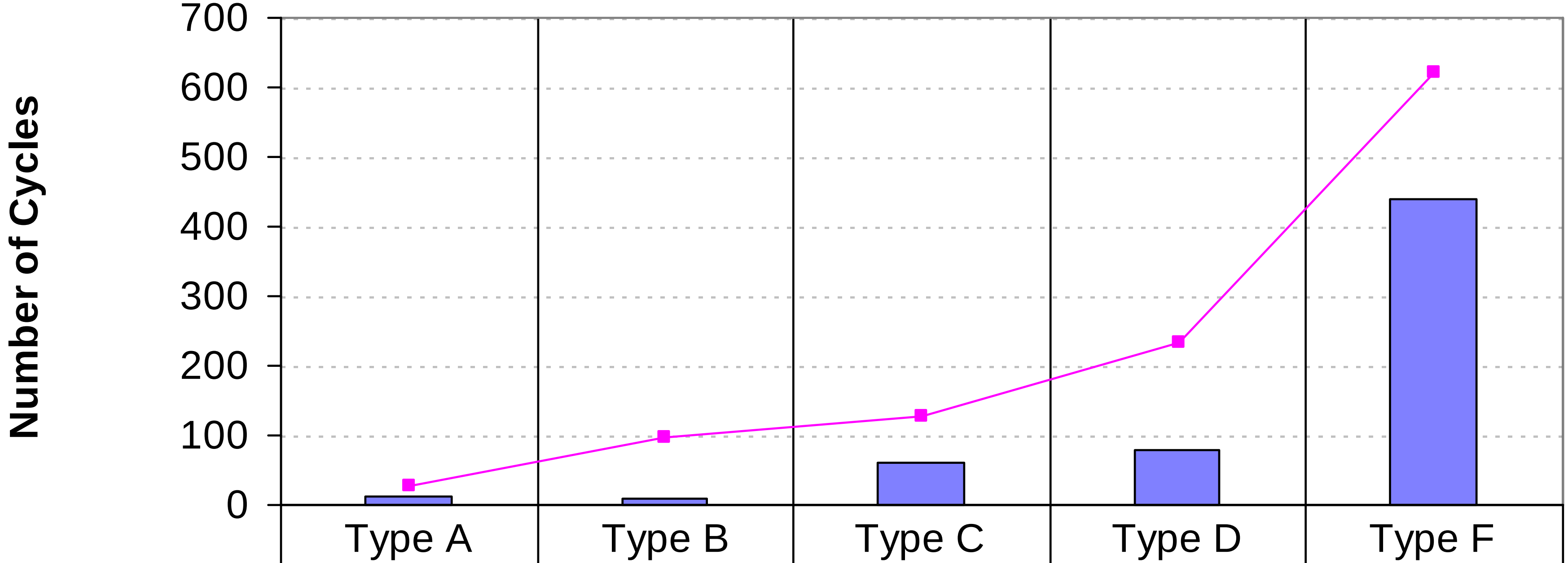


	Dense Graded	Performance Designed	Stone-Matrix Asphalt	RBL/CAM
Median	47	317	374	1200
Count	417	76	39	58
Minimum	1	3	24	83
Maximum	1200	1200	1200	1200
Average	172	507	548	978

Frequency Distribution
Dense-Graded Hot Mix Asphalt

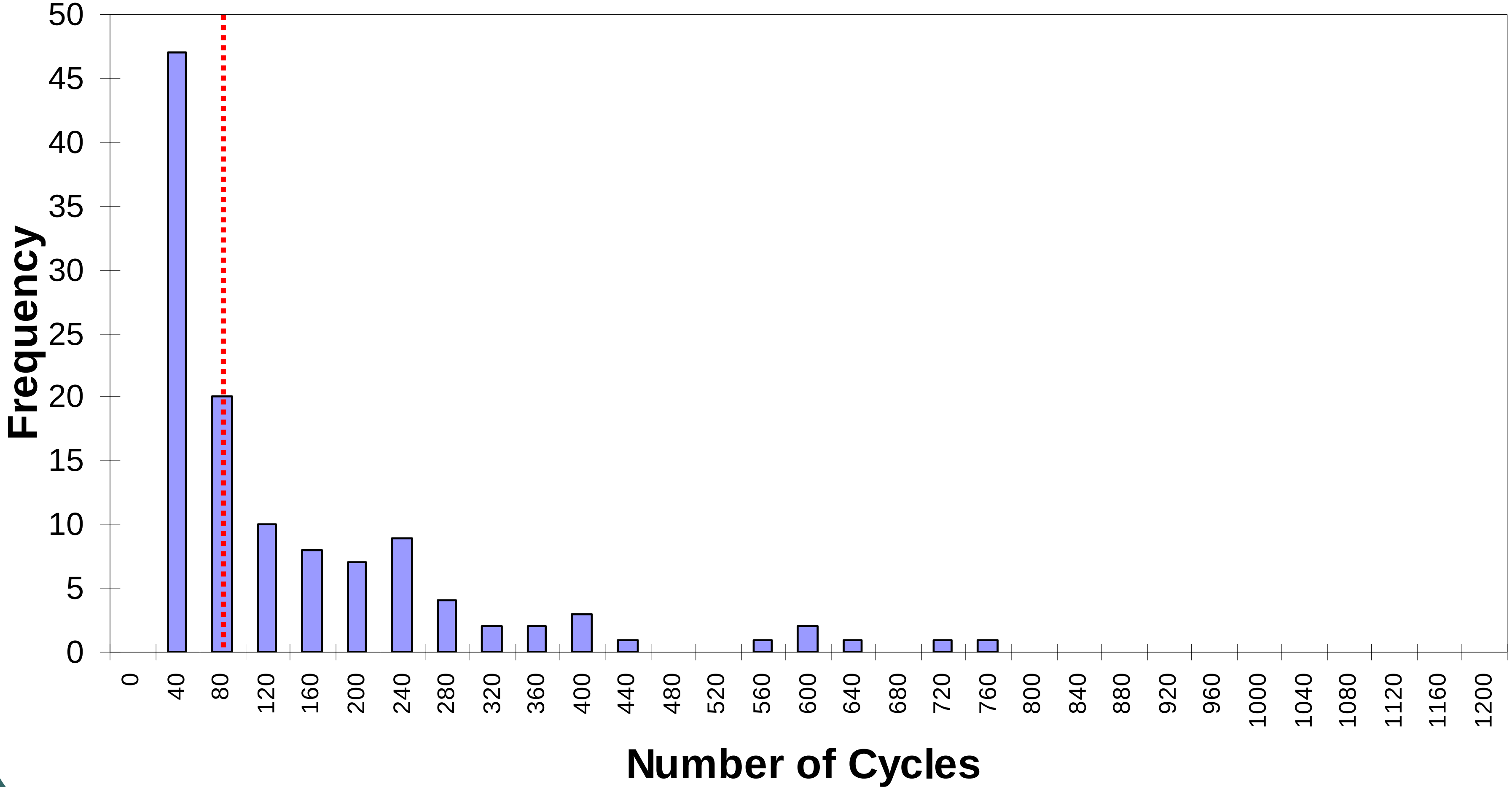


Influence of Mix Type
Dense-Graded Hot Mix Asphalt



	Type A	Type B	Type C	Type D	Type F
Median	13	10	61	78	438
Count	15	108	119	162	13
Minimum	2	1	2	2	43
Maximum	98	1200	752	1200	1200
Average	28	97	127	232	621

Frequency Distribution
Dense-Graded Type C

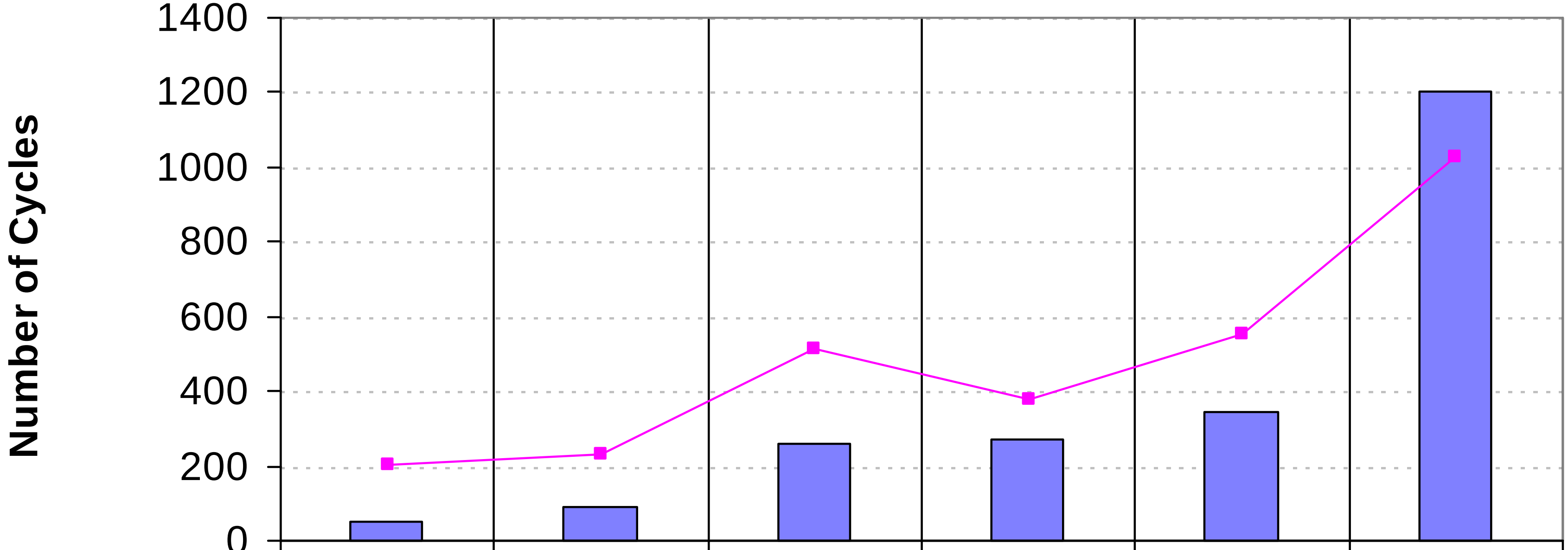


Lab testing: Performance evaluation-SMA Mixtures

- Houston: SMA-C (¾")---AC=6%
  - HWTT: 4.9 mm @20,000 passes
  - OT: 450 cycles
- Dallas (IH635): SMA-D (½")---AC=6%
  - HWTT: 4.2 mm @20,000 passes
  - OT: 410 cycles
- Beaumont (US96): SMA-D (½")---AC=6.3%
  - HWTT: 7.2 mm @20,000 passes
  - OT: >1500 cycles

Influence of Aggregate Type

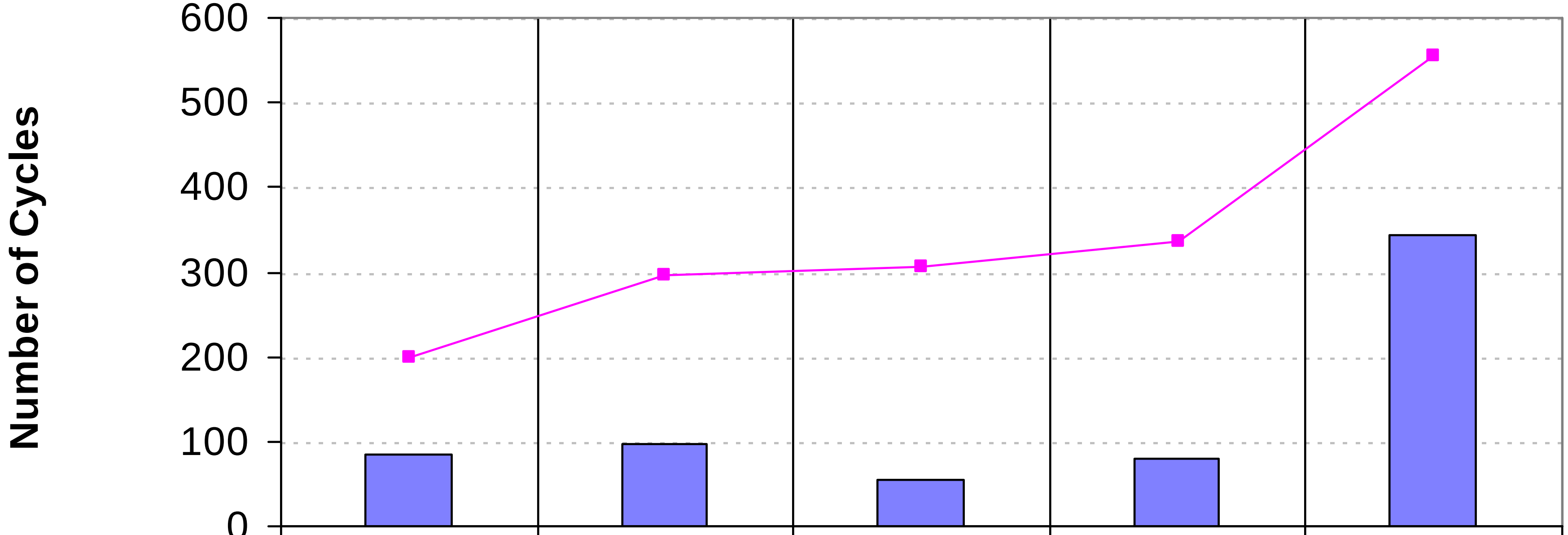
All mixtures



	Limestone	Gravel	Granite	Rhyolite	Sandstone	Quartzite
Median	53	90	262	271	344	1200
Count	147	62	80	15	25	14
Minimum	2	2	2	80	10	457
Maximum	1200	1200	1200	1200	1200	1200
Average	204	232	512	378	555	1030

Influence of Asphalt

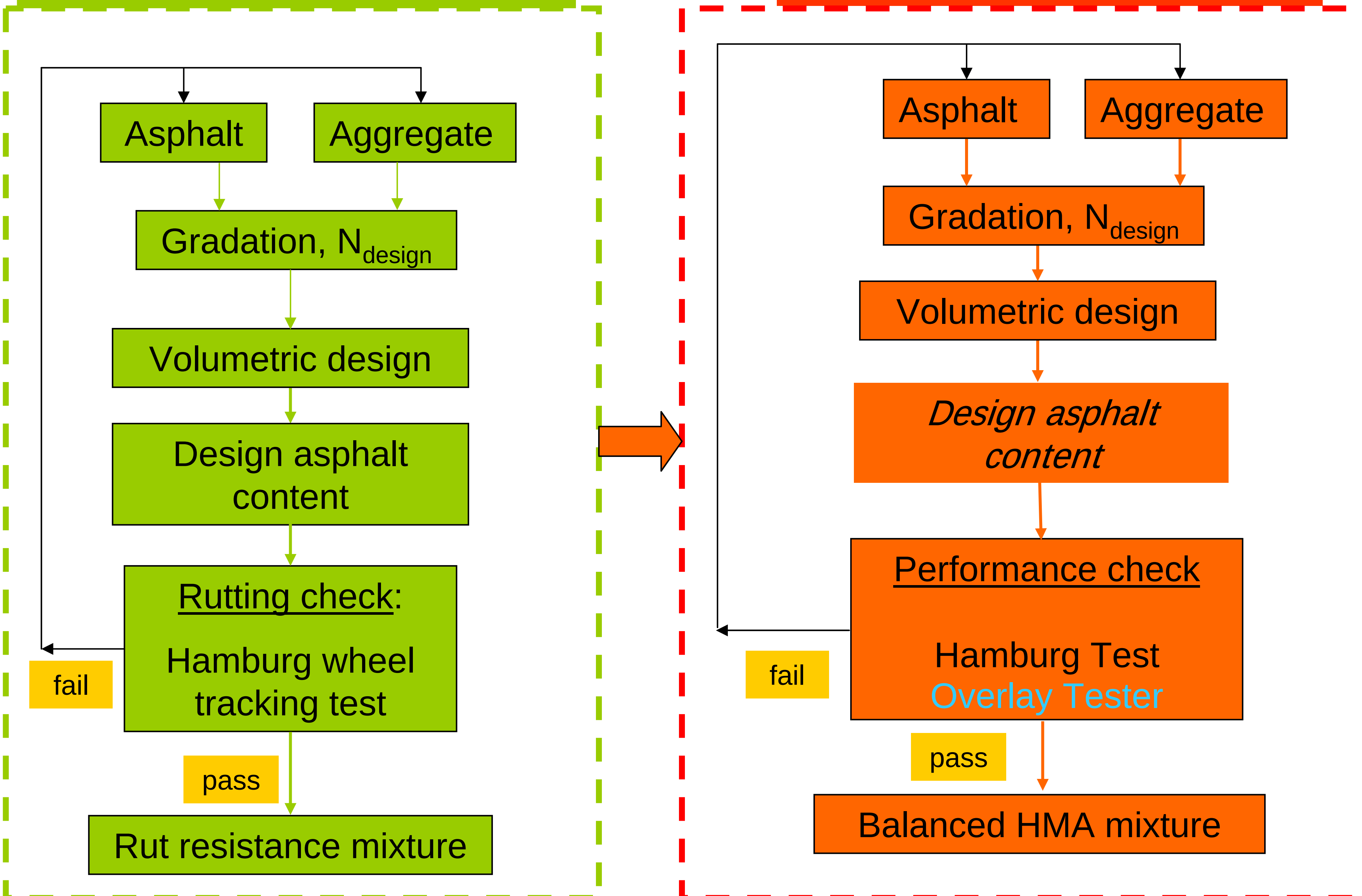
All mixtures

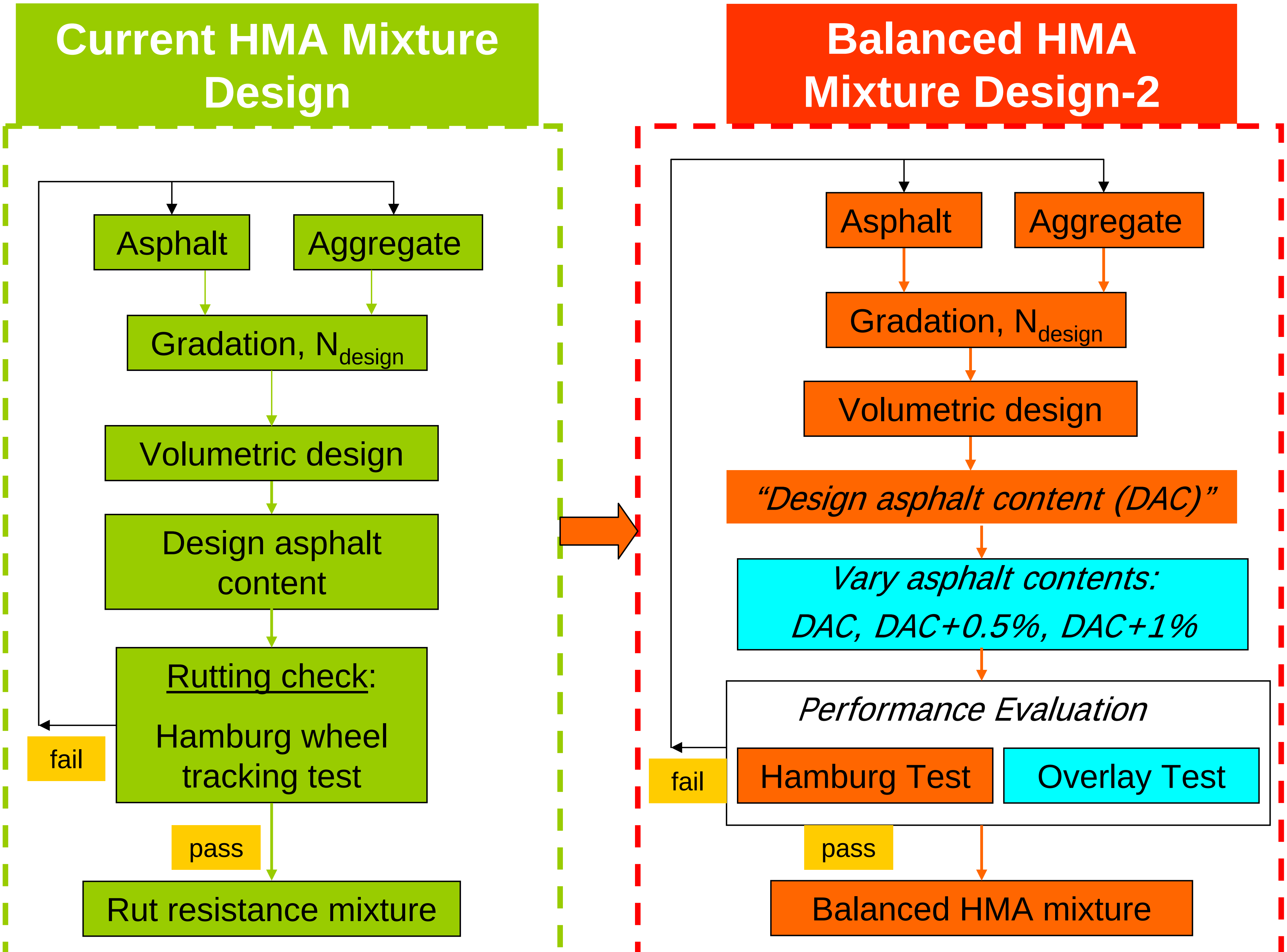


	64-22	70-22	70-28	76-22	CRM
Median	84	96	55	80	344
Count	119	156	69	172	21
Minimum	2	1	2	2	14
Maximum	1200	1200	1200	1200	1200
Average	199	297	306	336	555

Current HMA Mixture Design

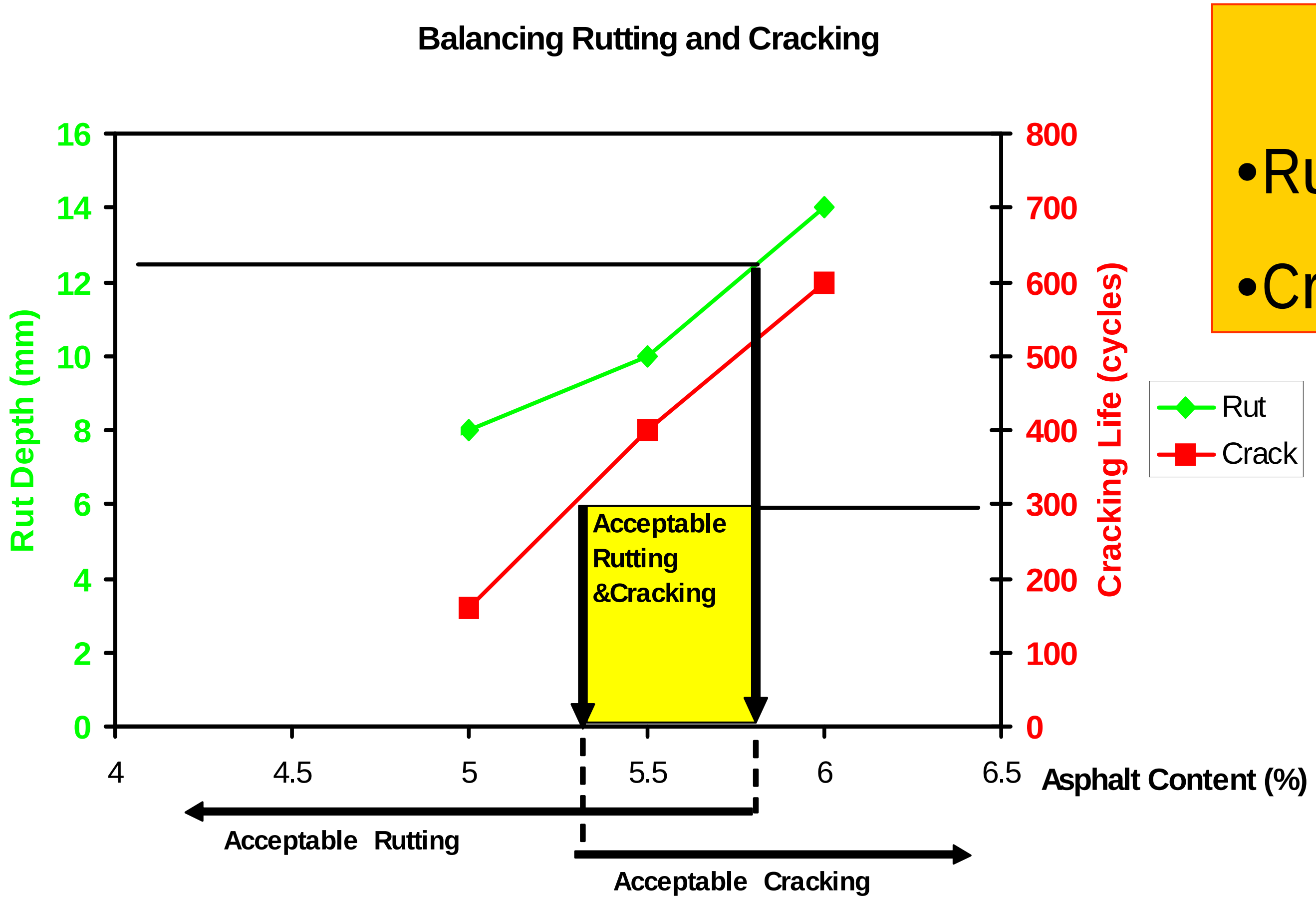
Balanced HMA Mixture Design-1





Current HMA Mixture Design
Asphalt
Aggregate
Gradation, N_{design}
Volumetric design
Design asphalt content
Rutting check:
Hamburg wheel tracking test
fail
pass
Rut resistance mixture
Balanced HMA Mixture Design-2
Asphalt
Aggregate
Gradation, N_{design}
Volumetric design
"Design asphalt content (DAC)"
Vary asphalt contents:
DAC, DAC+0.5%, DAC+1%
Performance Evaluation
Hamburg Test
Overlay Test
fail
pass
Balanced HMA mixture

Methodology for Balancing Rutting and Cracking Requirements



Criteria

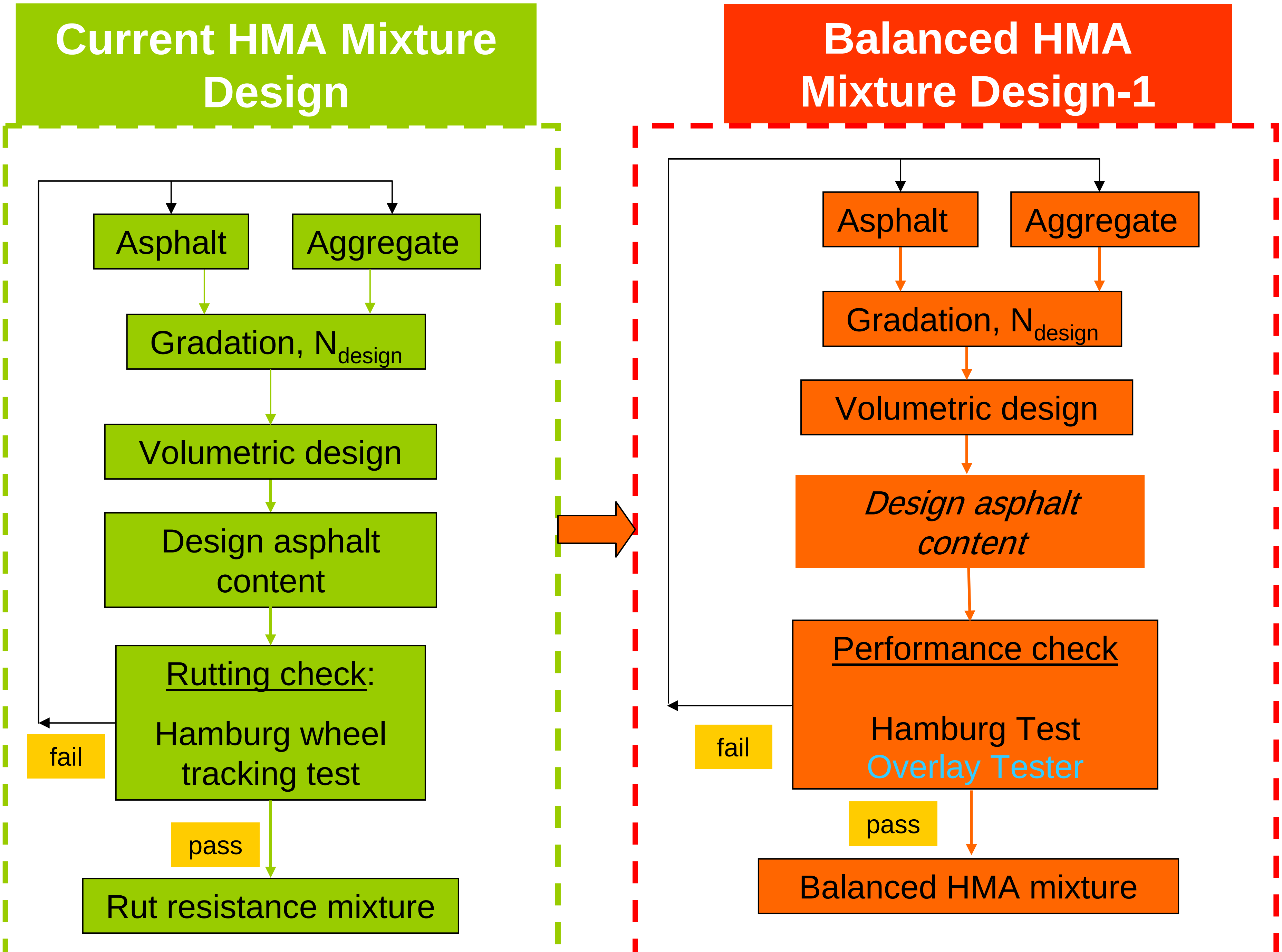
- Rutting: 12.5 mm
- Cracking: 300* cycles

Currently used in Houston, originally based on field experience.

Lab testing: performance evaluation

- Hamburg wheel tracking test: 12.5 mm
  - PG64-22: Rut depth @10000 passes
  - PG70-22: Rut depth @15000 passes
  - PG76-22: Rut depth @20000 passes

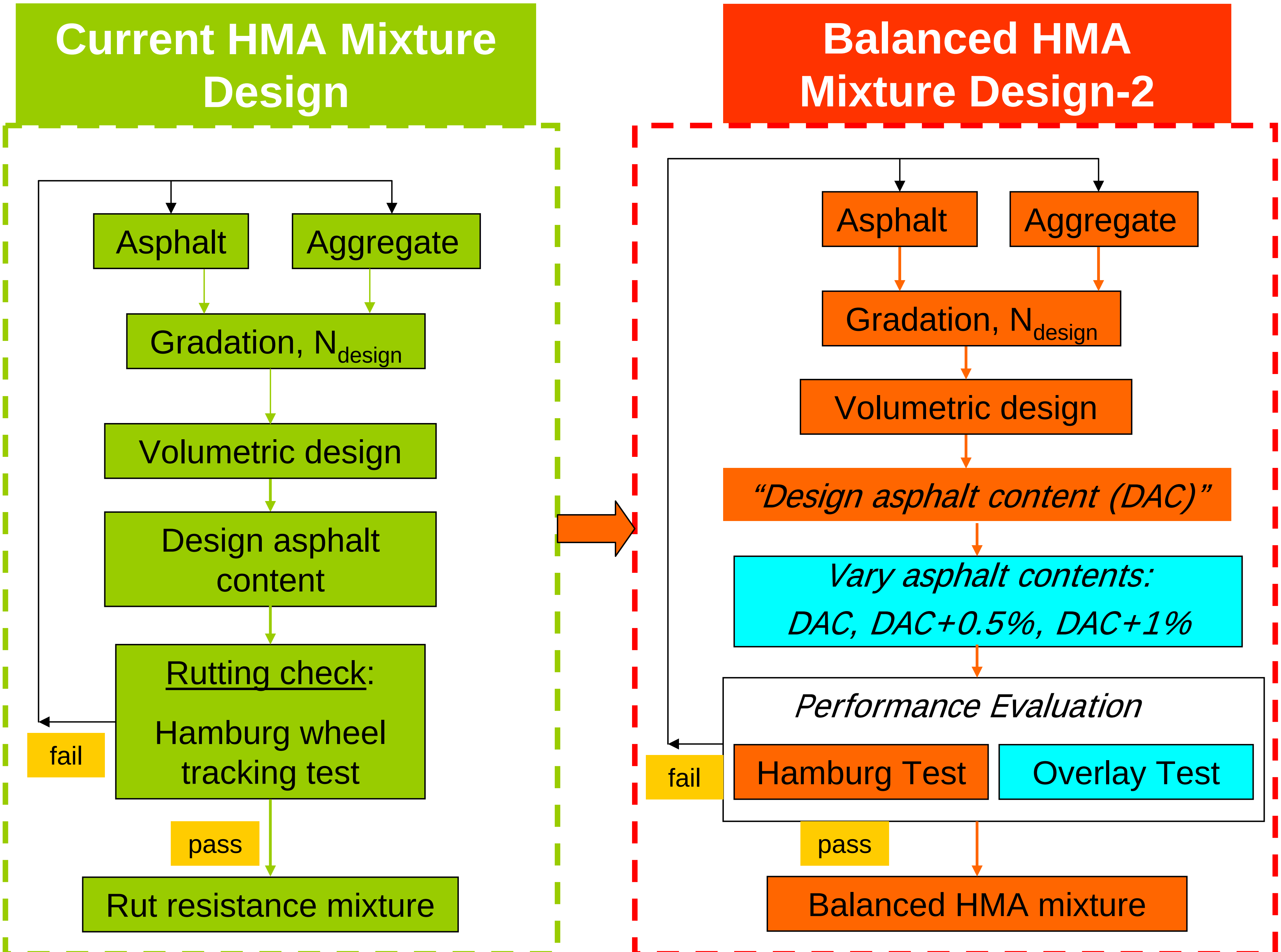
- Overlay tester: 300 cycles
  - Cracking life: 93% load reduction of max. load at first cycle



Current HMA Mixture Design
Asphalt
Aggregate
Gradation, N design
Volumetric design
Design asphalt content
Rutting check:
Hamburg wheel tracking test
fail
pass
Rut resistance mixture
Balanced HMA Mixture Design-1
Asphalt
Aggregate
Gradation, N design
Volumetric design
Design asphalt content
Performance check
Hamburg Test
Overlay Tester
fail
pass
Balanced HMA mixture

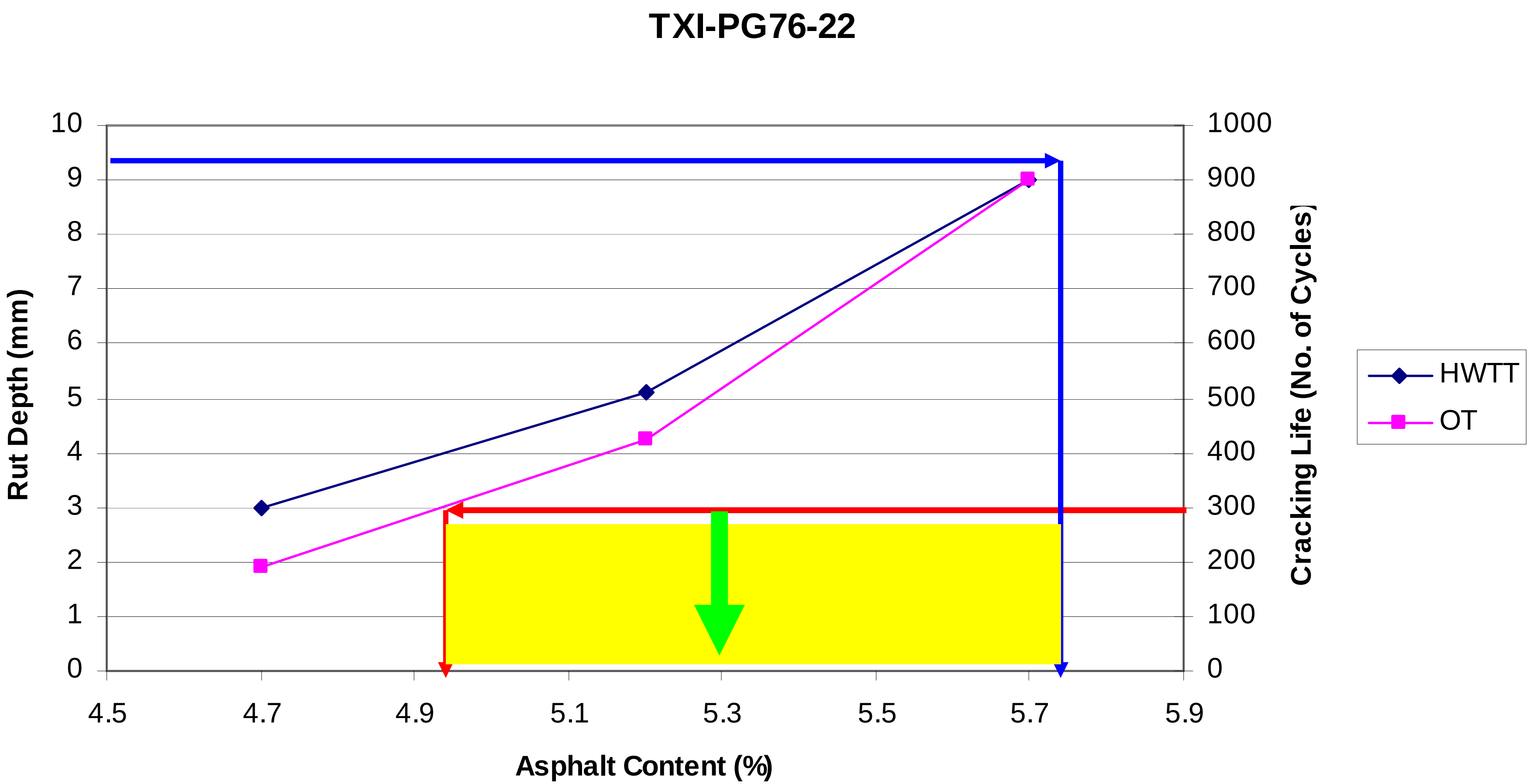
Lab testing: balanced HMA mixture design-1

Mixture type	Aggregate	Asphalt binder	Design AC (%)	VMA (%)	HWTT (mm)	OT (cycles)	Asphalt Absorption(%)
Type D	TXI-limestone	PG64-22	4.8	15.2	3.0	189	0.07
	TXI-limestone	PG76-22	4.7	15.2	5.0	200	0.14
	TCS-limestone	PG64-22	5.5	16.3	13.4	25	0.93
	Sandstone	PG76-22	5.4	16.0	4.6	580	0.16
Superpave-C N_{design}=100	Sandstone	PG64-22	5.0	15.1	5.9	112	1.07
	Sandstone	PG70-22	5.1	15.3	2.4	35	1.37
	Gravel	PG76-22	5.5	16.4	3.0	105	0.30
	Quartzite	PG76-22	5.4	16.3	3.0	230	0.63



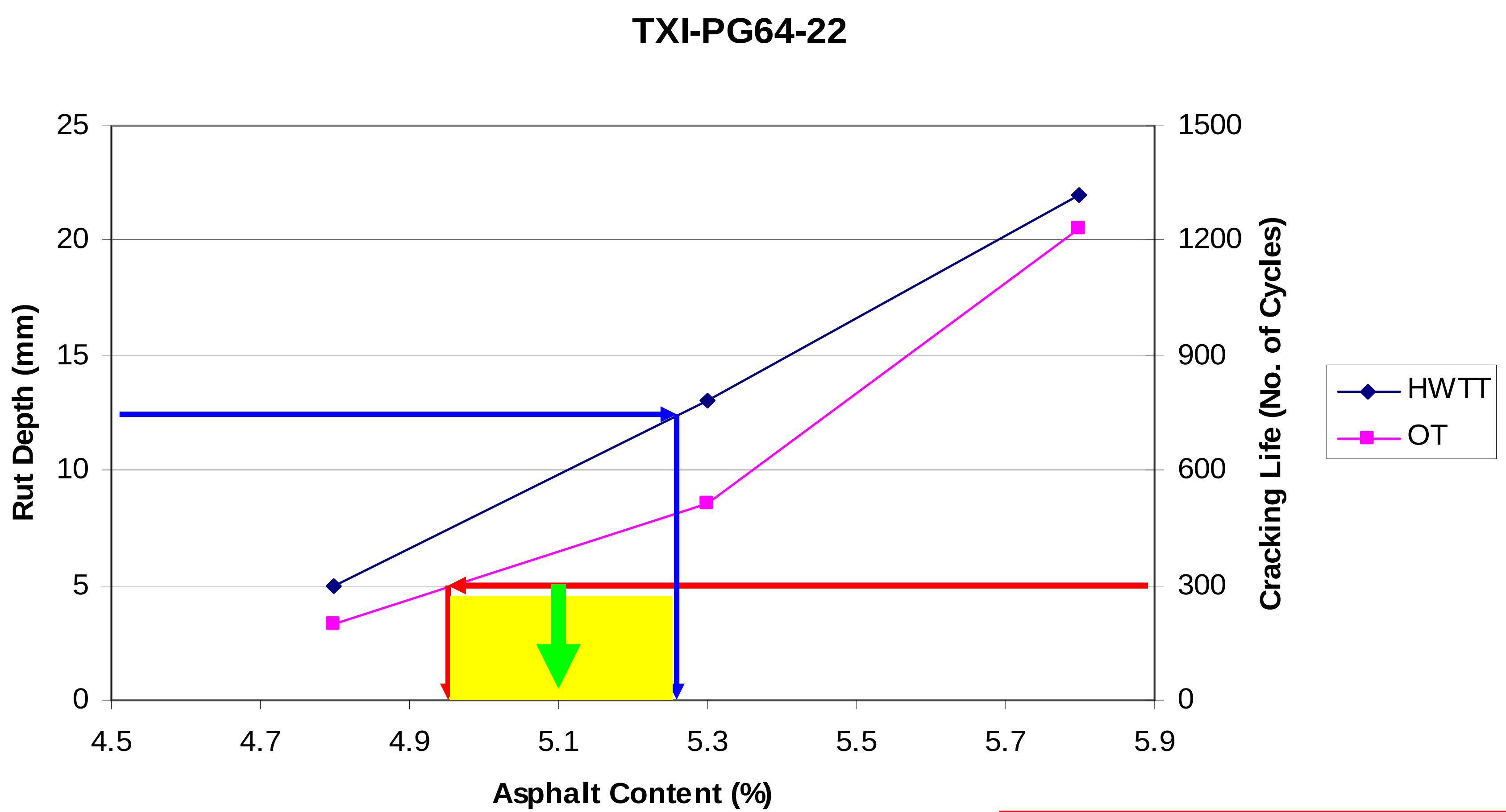
Current HMA Mixture Design
Asphalt
Aggregate
Gradation, N_{design}
Volumetric design
Design asphalt content
Rutting check:
Hamburg wheel tracking test
fail
pass
Rut resistance mixture
Balanced HMA Mixture Design-2
Asphalt
Aggregate
Gradation, N_{design}
Volumetric design
"Design asphalt content (DAC)"
Vary asphalt contents:
DAC, DAC+0.5%, DAC+1%
Performance Evaluation
Hamburg Test
Overlay Test
fail
pass
Balanced HMA mixture

Lab testing: Performance evaluation-Type D Mixtures



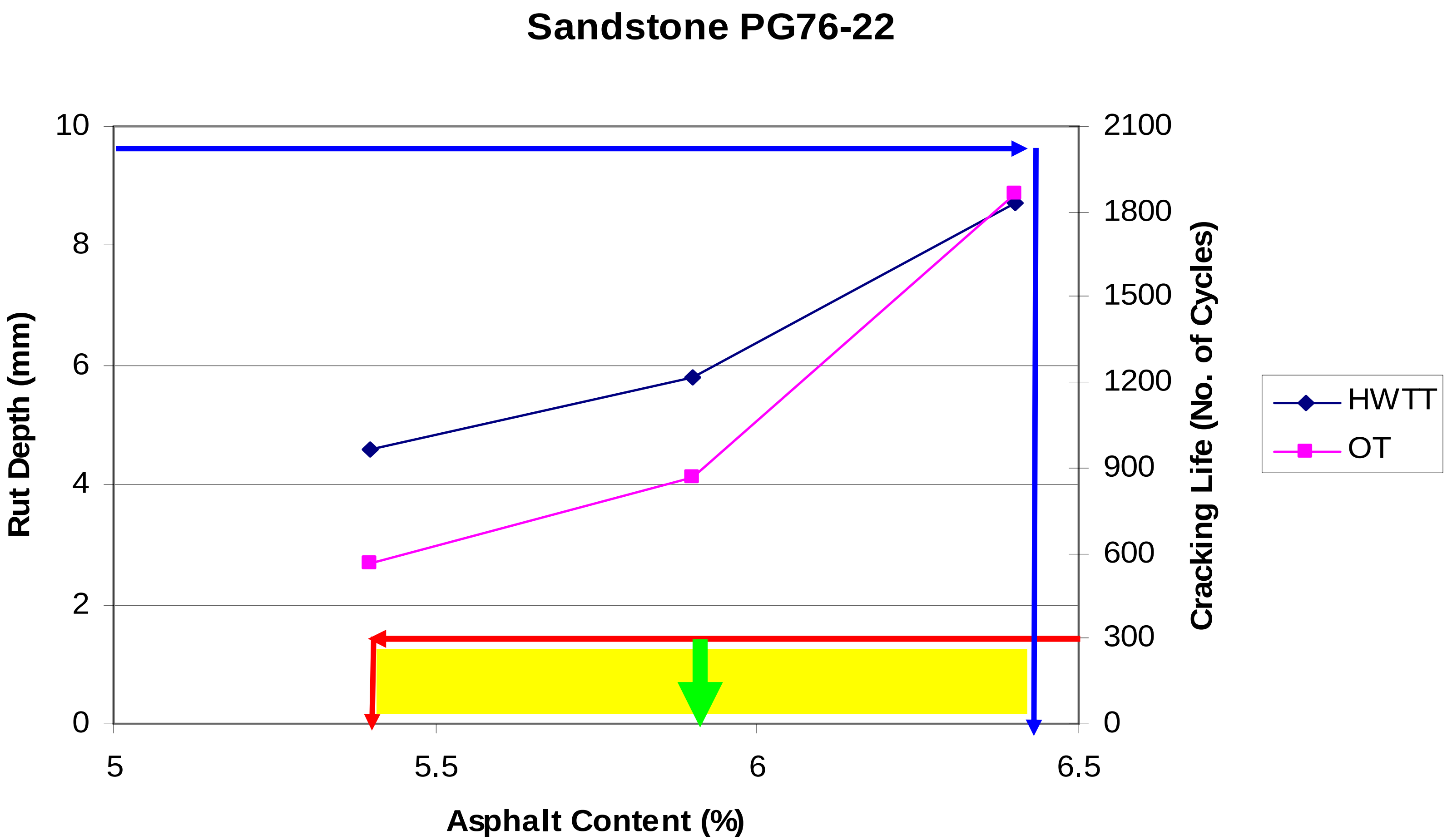
Balanced AC=5.3%

Lab testing: Performance evaluation-Type D Mixtures



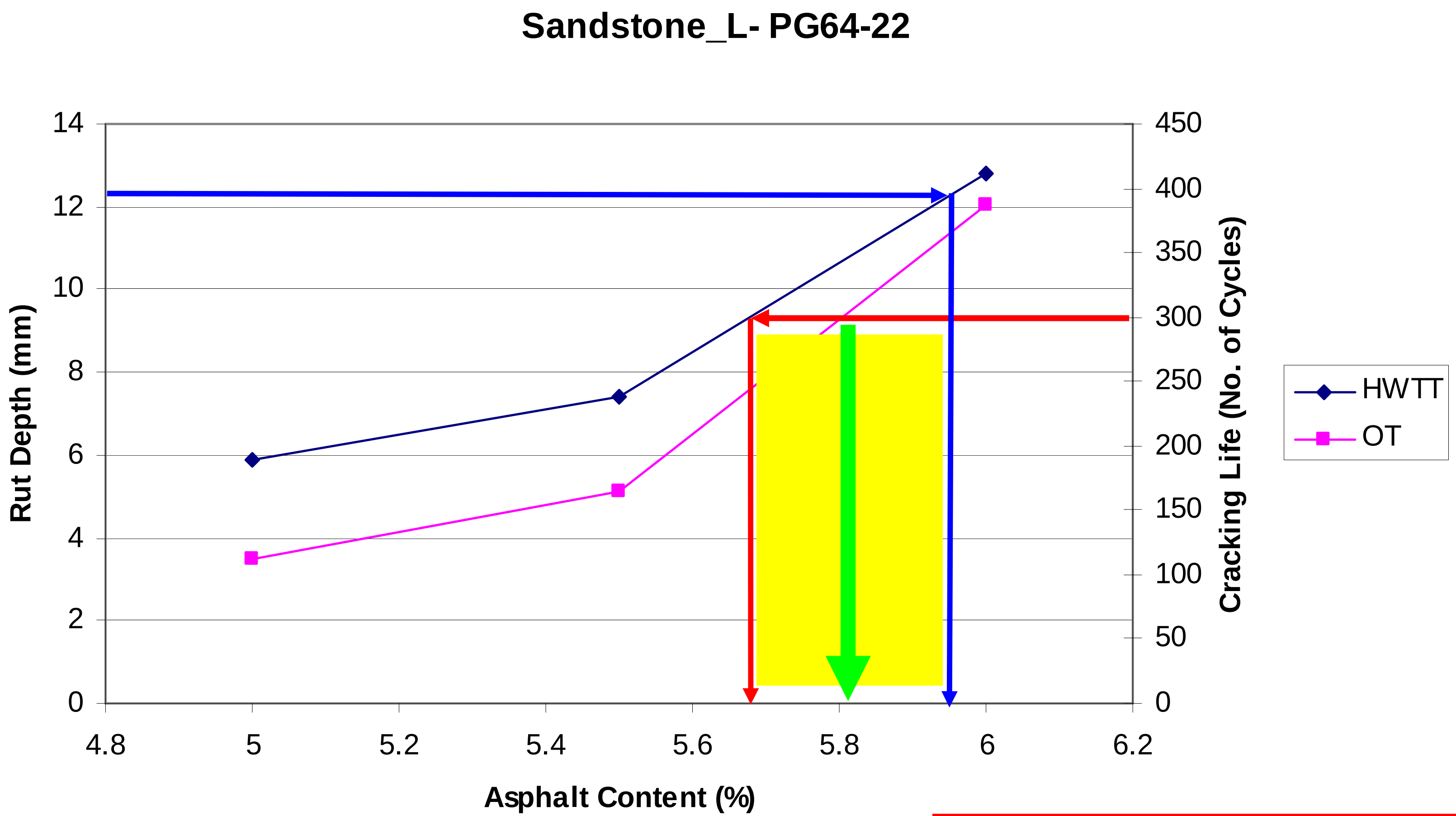
Balanced AC=5.1%

Lab testing: Performance evaluation-Type D Mixtures



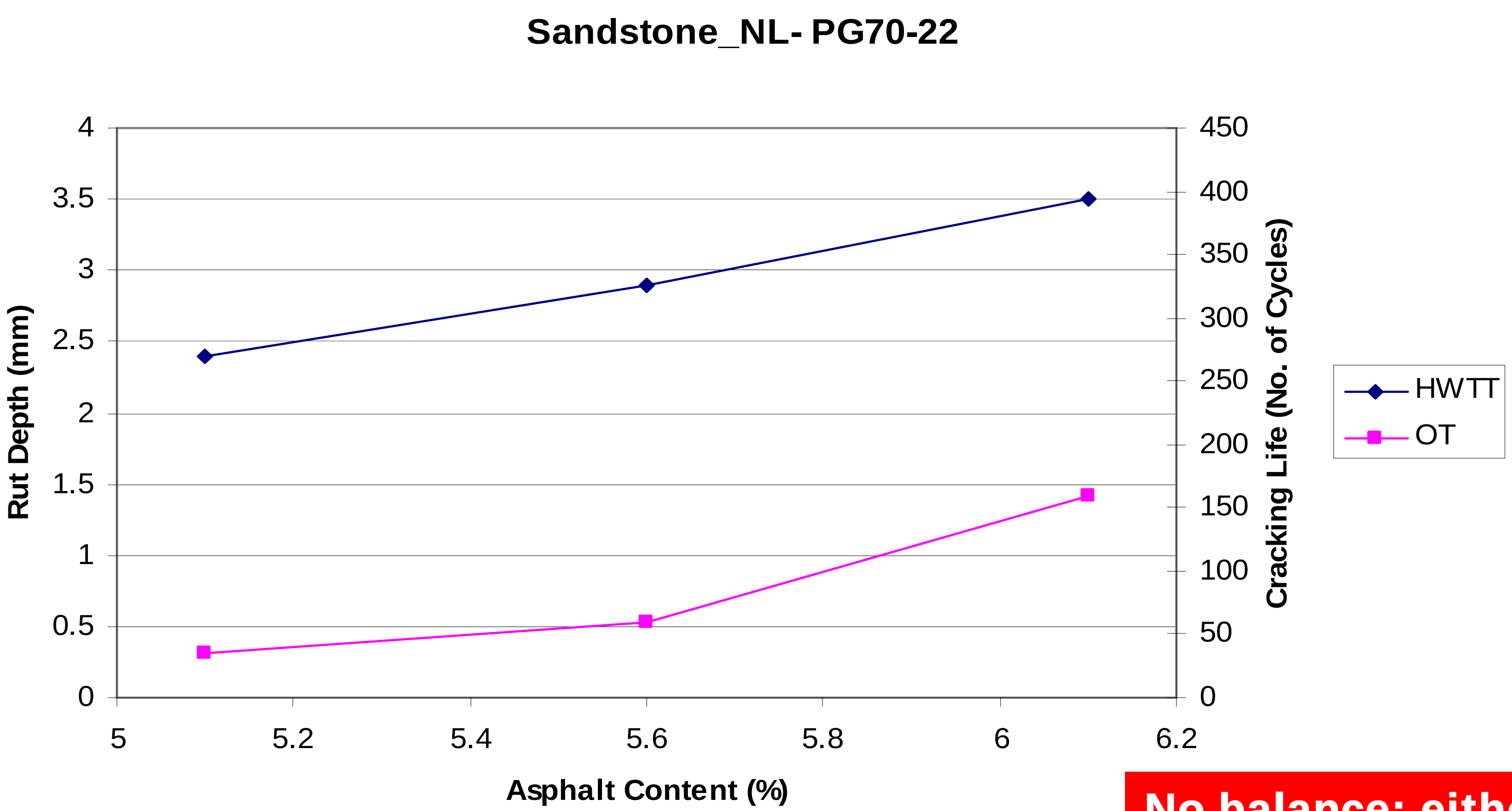
Balanced AC=5.9%

Lab testing: Performance evaluation-Superpave C Mixtures



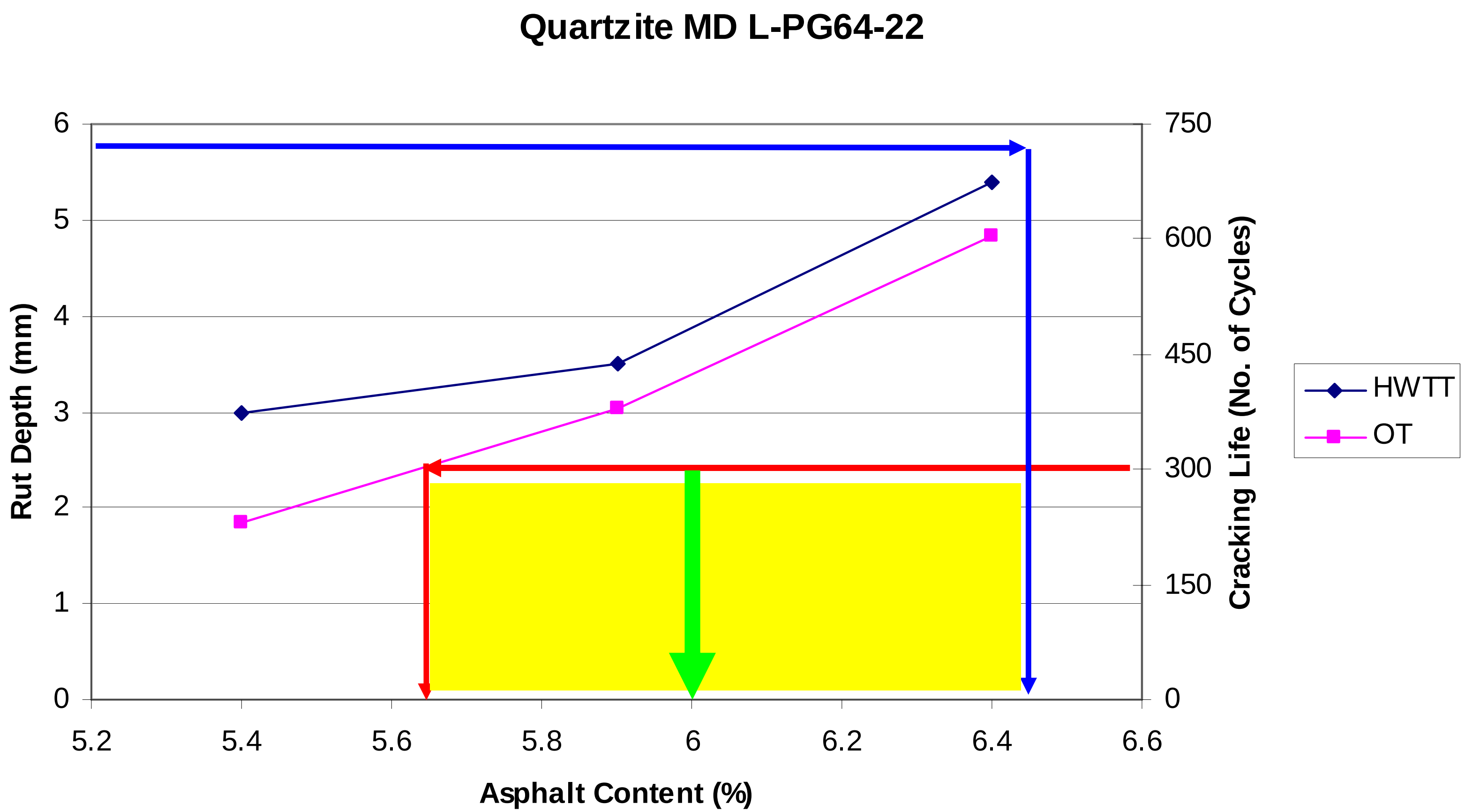
Balanced AC=5.8%

Lab testing: Performance evaluation-Superpave C Mixtures



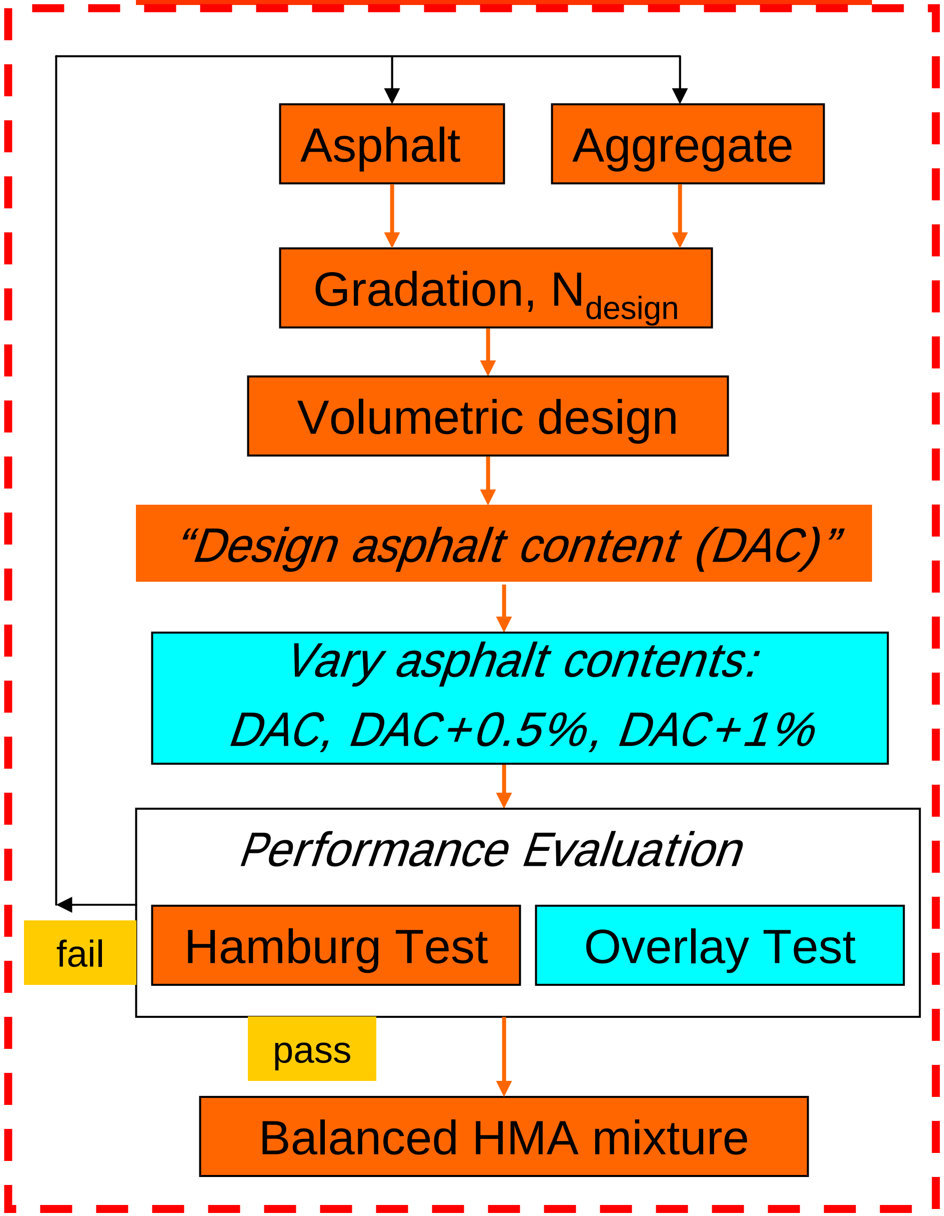
No balance: either redesign or increase asphalt content again.

Lab testing: Performance evaluation-Superpave C Mixtures



Balanced AC=6.0%

Balanced HMA Mixture Design



Summary & Conclusions

- Mixes such as SMA and CAM balance stability & durability very well
- For dense graded mixes, the current design procedure results in mixes that are stable but not very durable
- A “balanced” mix design procedure can be used to improve dense graded mixes
- This approach shows promise but is not ready for full implementation yet