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SMA In Virginia: A Ten-Year Performance Review

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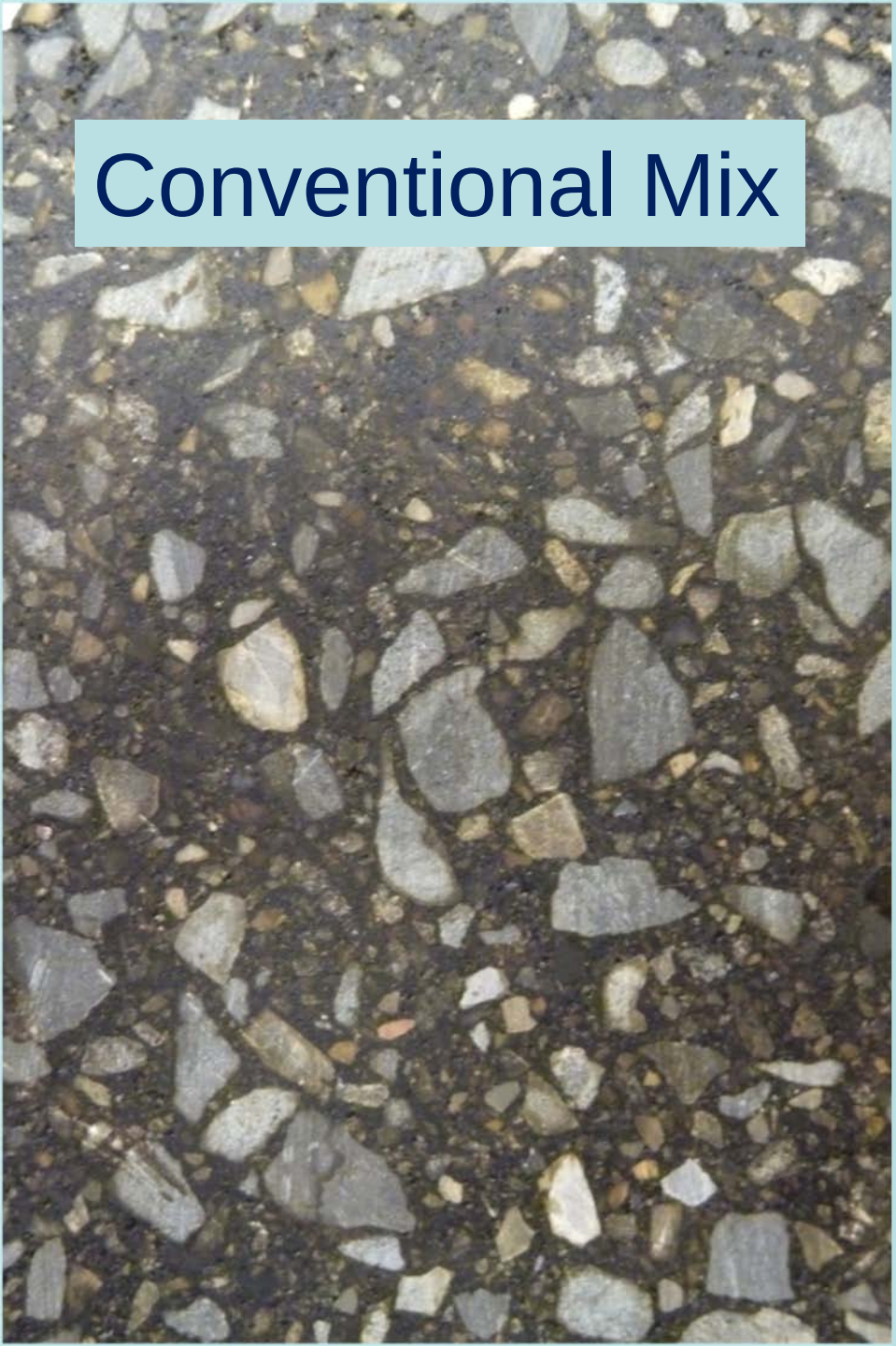
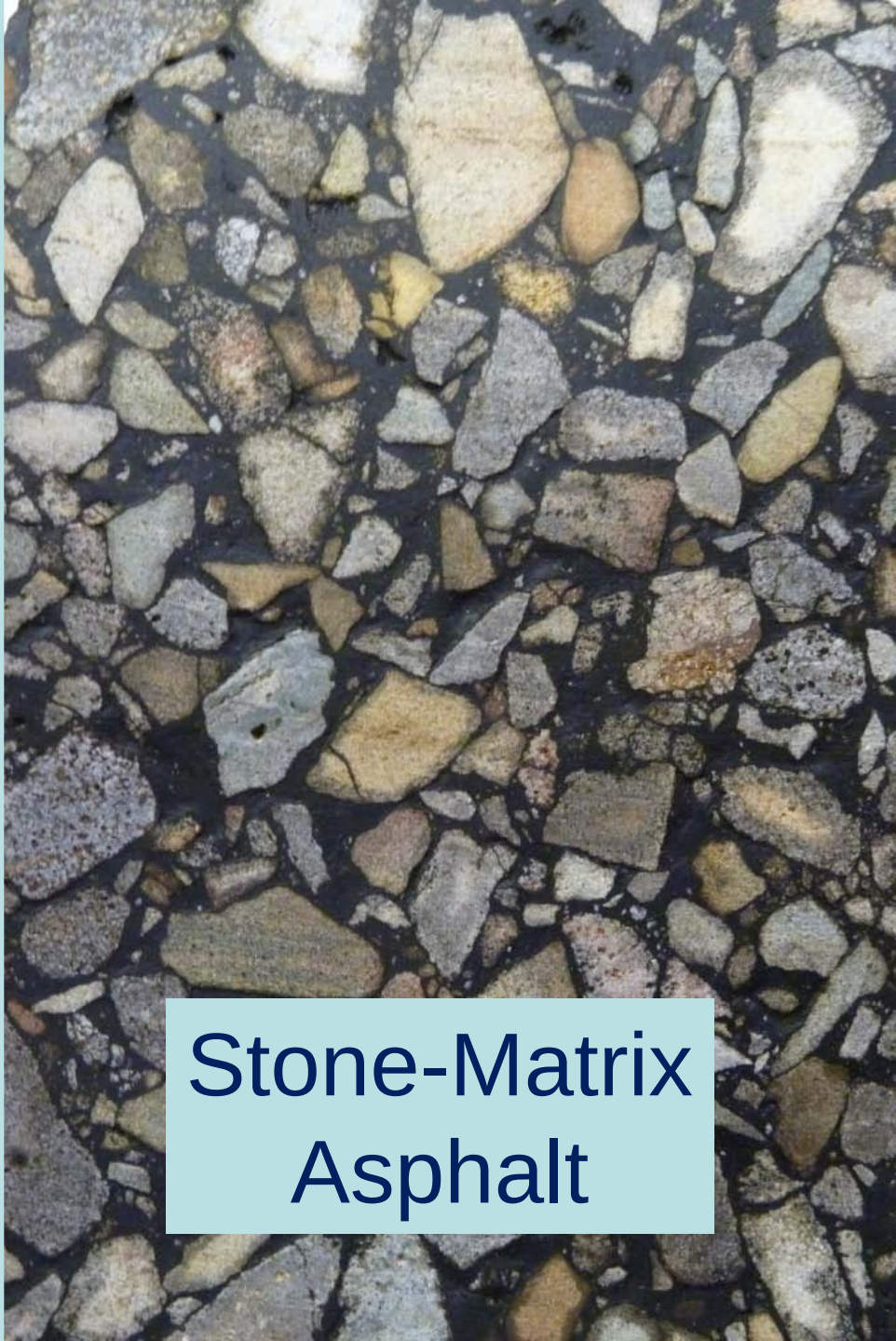
Overview

- History of SMA in Virginia
- Network Performance Analysis
  - Methods
  - Results
- Specific application/site review
- Conclusions
- Recommendations/Future Research

What is SMA?

- Gap-graded asphalt concrete mix
- Stone-on-stone aggregate structure
  - Hard, cubicle, and durable stone
- Rich mortar binder
  - AC Content = 6.0%+
  - Fibers (for drain-down)
  - Often polymer modified

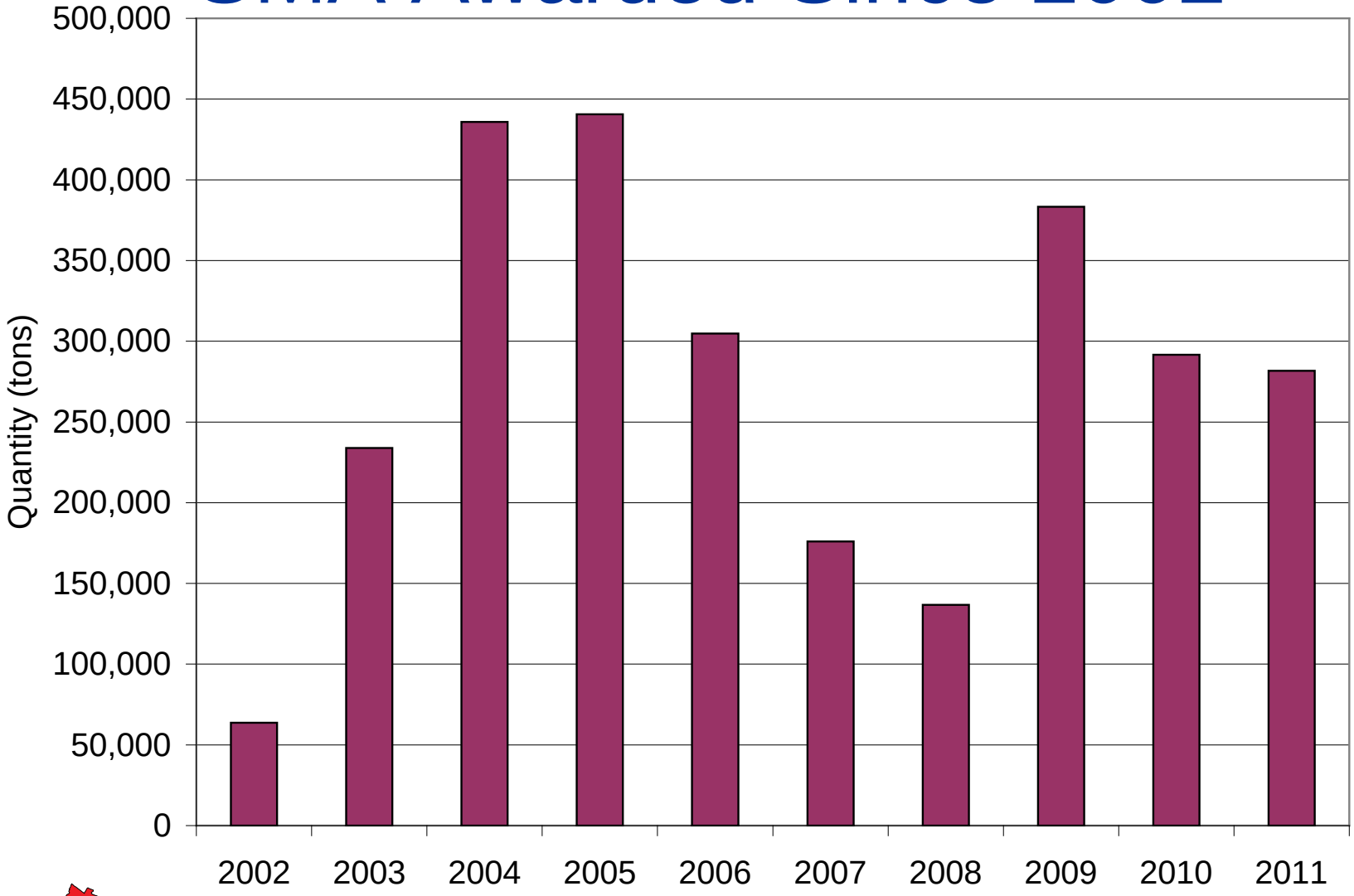

Conventional Mix


Stone-Matrix
Asphalt

History of SMA - Virginia

- Initial trial sections in 1993
- First large projects in 1995 (I-81, I-95 and I-295)
- Minimal use through mid-90's to 2001
- 2002/03 → the "Virginia SMA Initiative"

SMA Awarded Since 2002



Purpose of Study

- Evaluate performance of SMA
- Review cost-effectiveness of SMA, particularly as compared to conventional dense-graded mixes
- Evaluate selected projects and mixtures that were under/over-performing

Network Performance Analysis

- Service Life Prediction
  - Straight-line Projection (linear “best fit”)
  - VDOT PMS (Euler)
- Initial Cost Recovery (i.e., relative cost effectiveness)
  - Equivalent Uniform Annual Cost (EUAC)

Estimating Service Life

$CCI = CCI_0 - m(age)$ ➔ Linear projection

$CCI = CCI_0 - e^{(a-b*c^t)}$ ➔ Euler model

Where:

CCI_0 = condition new (100)

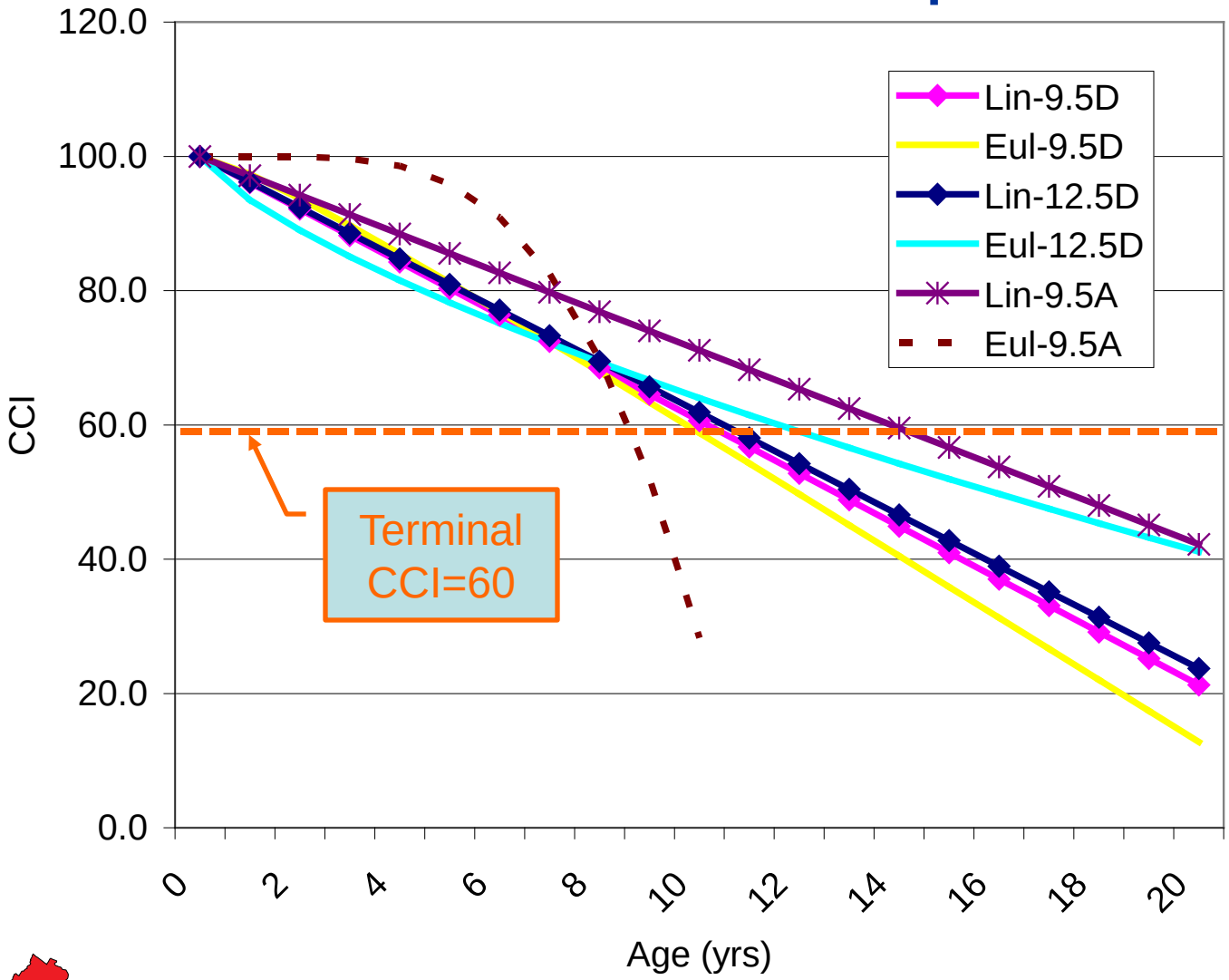
CCI = predicted condition

m = slope

a,b,c = model coefficients

t = ln(1/age)

Model Form Comparison

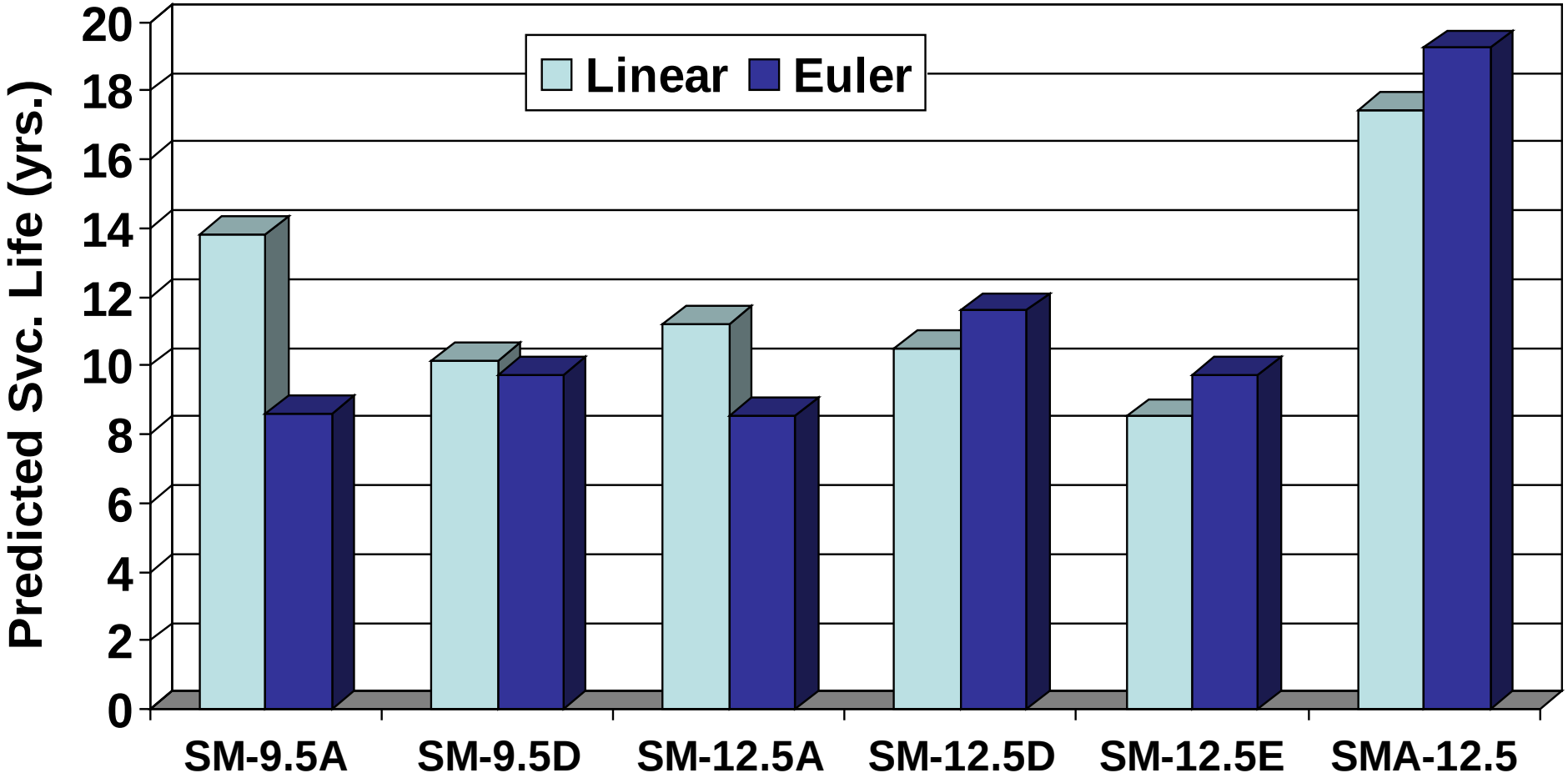


Service Life Models - Results

Mix	Approach 1 (Linear)		Approach 2 (Euler)			
	Slope	Terminal Age (yrs)	a	b	c	Terminal Age (yrs)
SM-9.5A	-2.89	13.8	18.59	26.27	1.30	8.6
SM-9.5D	-3.94	10.2	20.68	19.72	1.07	9.7
SM-9.5E	-3.95	10.1	3.56	26.02	11.53	25.0*
SM-12.5A	-3.57	11.2	26.35	26.97	1.08	8.5
SM-12.5D	-3.81	10.5	26.95	25.08	1.03	11.6
SM-12.5E	-4.69	8.5	26.85	24.32	1.02	9.7
SMA-9.5	-2.65	15.1	2.90	5.54	7.08	25.0*
SMA-12.5	-2.29	17.5	20.861	19.94	1.052	19.2

Terminal Age = Age when CCI reaches 60.

Service Life Models



Initial Cost Comparison

$$EUAC_i = \frac{P * r}{1-(1+r)^{-n}}$$

where:

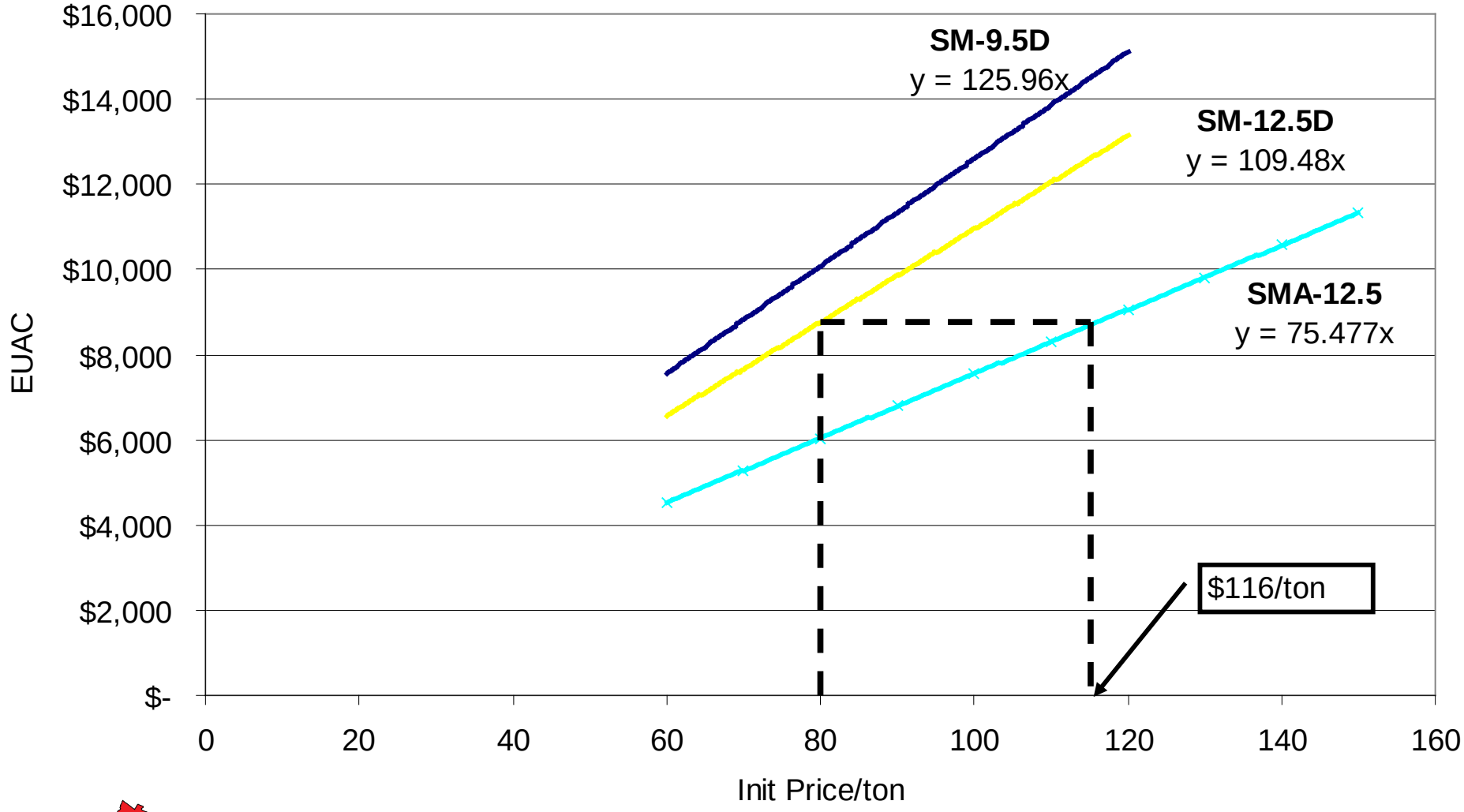
$EUAC_i$ = equiv. uniform annual cost

P = initial costs ($)

r = discount rate (4%)

n = predicted service life (yrs.)

Cost Comparison (Graphical)



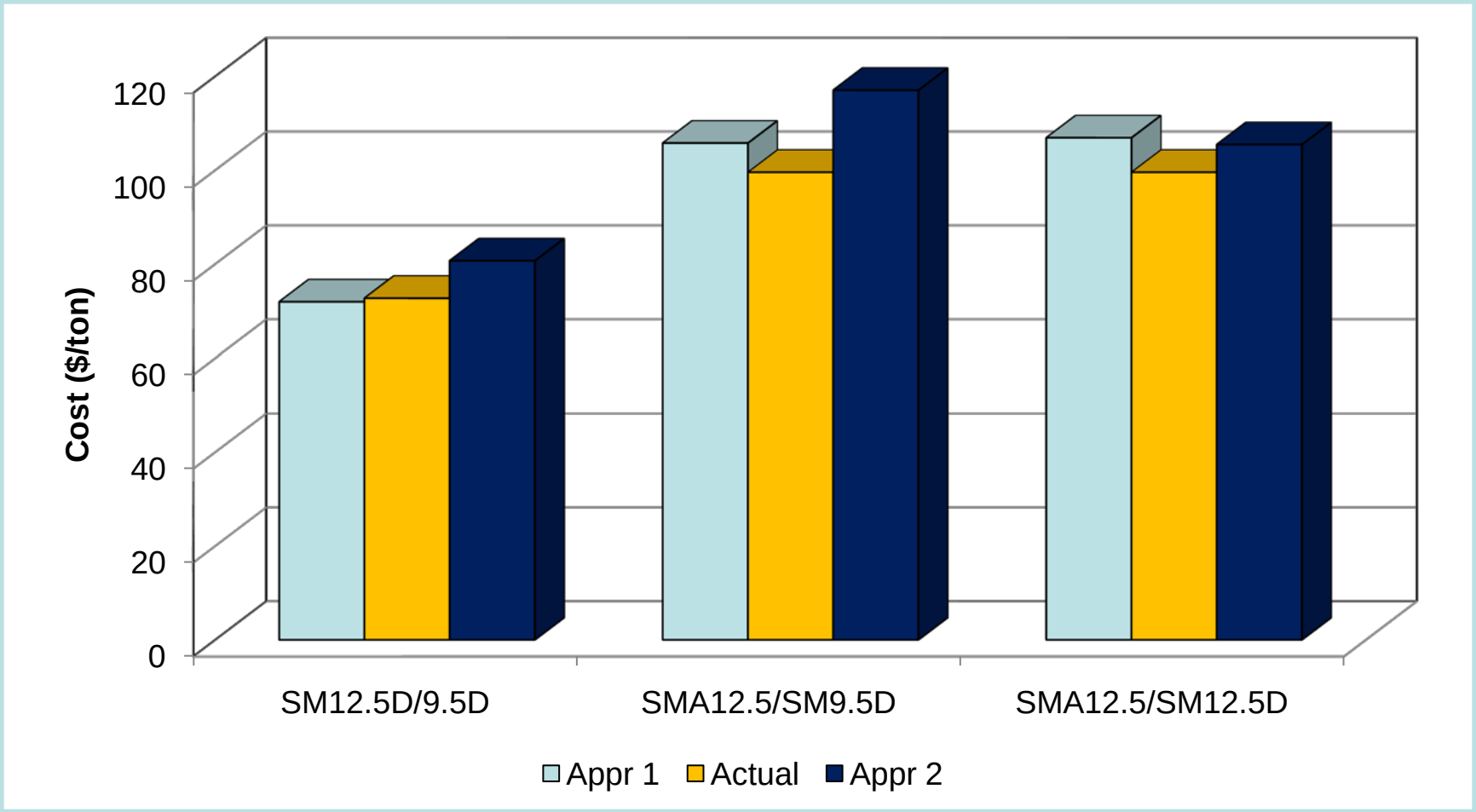
Break-Even "First" Costs

		Break-Even Difference		Justified for B*	
Default (A)	Compare (B)	Pred. Life Appr. 1	Pred. Life Appr. 2	Pred. Life Appr. 1	Pred. Life Appr. 2
SM-9.5D	SM-12.5D	2.6%	15.1%	$ 71.94	$ 80.70
SM-9.5D	SMA-12.5	50.8%	66.9%	$ 105.78	$ 117.05
SM-12.5D	SMA-12.5	47.0%	45.1%	$ 106.91	$ 105.47

Mix B is worth the price of Mix A plus the percentage shown.

*2011 Average Prices: SM-9.5D = $70.14, SM-12.5D = $72.71, SMA-12.5 = $99.57

Break-Even “First” Costs



Field Review of Selected Projects

- Site Selection
  - CCI ≤ 81 (i.e., “poor” performers)
    - Average Condition Rating ~ 90
    - Standard Deviation of 9 to 10
  - Non-VDOT maintained facilities
- Purpose of visits to “poor” performers
  - Material failures?
  - Pavement structure failures?
  - Incorrect application?

Field Review - Summary

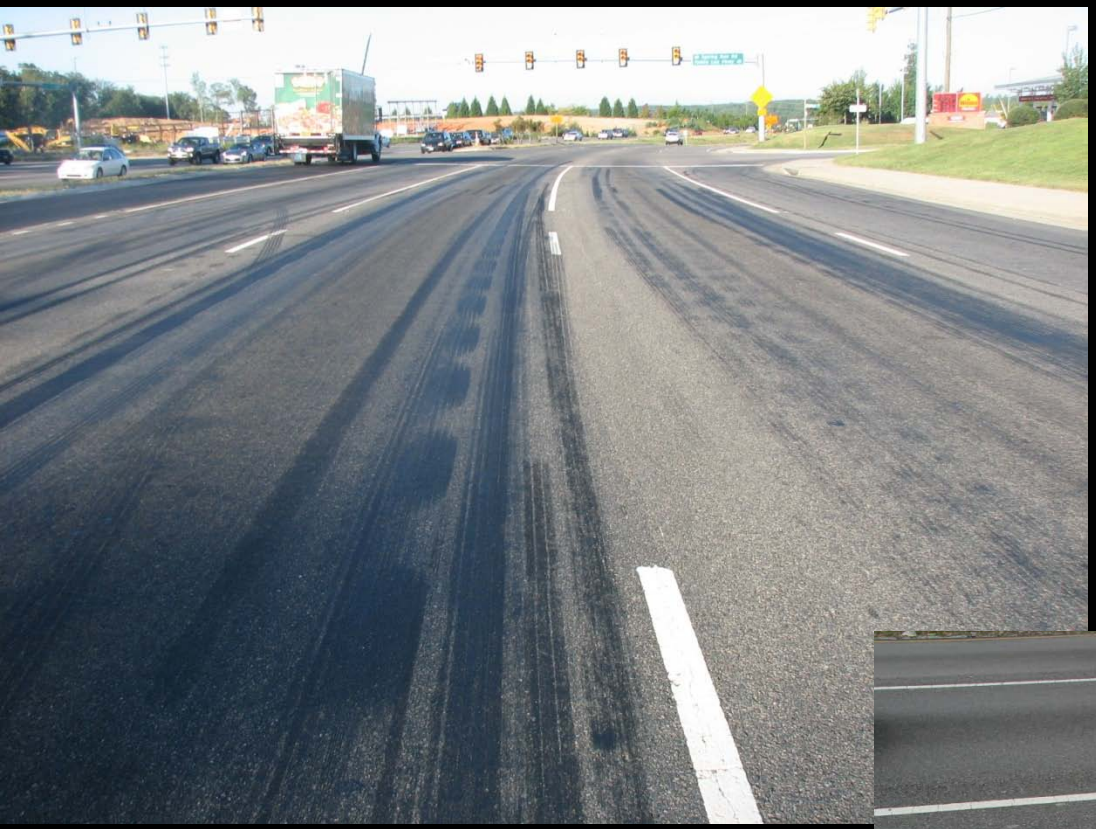
Mix Category	Observed Distress Types		
	Reviewed	Material	Structural
SMA 9.5(70-22)	8	5	1
SMA 9.5(76-22)	4	2	2
SMA 12.5 (70-22)	14	1	6
SMA 12.5(76-22)	2	1	1
Totals*	28	9	10

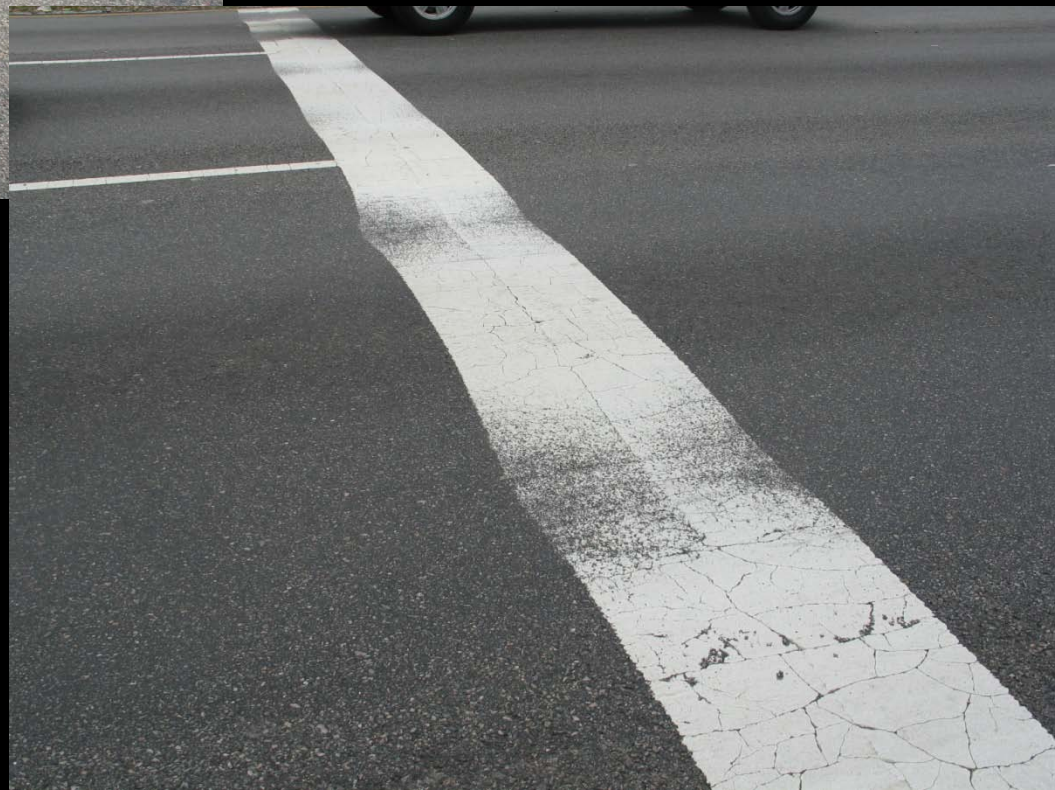
*Includes RAP and Virgin Mixes

Field Review - Findings

- Materials Related Failures (9 sites)
  - Flushing, rutting and surface distortions
  - Most flushing and surface distortions seen at intersections
  - Rutting noted in SMA-9.5 with PG 70-22 mainline

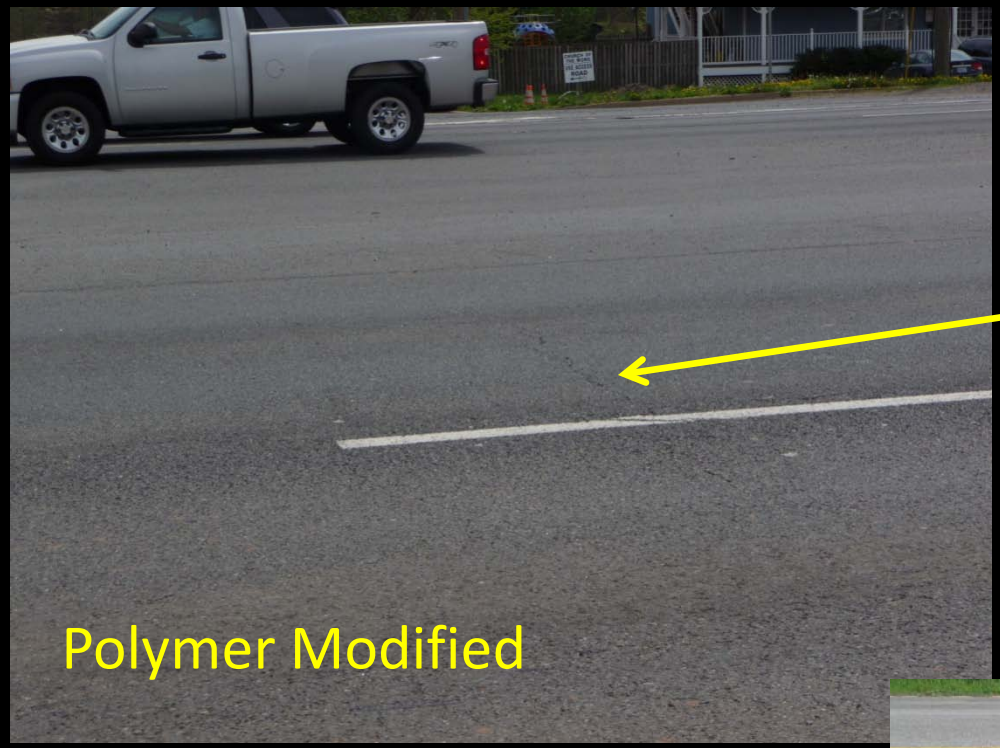
SMA-9.5 (Rutting, Flushing,Shoving)





Field Review - Findings

- Pavement Structure-Related Failures
  - Reflective cracking on composite pavement with underlying jointed concrete or when placed directly on JCP
  - Sections with PG 76-22 SBS had minimal raveling



Reflective Cracking

Dense-graded Turn Lane
No Sympathy Crack?
SMA Thru Lane

Field Review - Findings

- Failures Due to Incorrect Application
  - SMA at Intersections:
    - Localized failures prevalent for SMA-9.5 (70-22)
    - No known application-oriented failures for SMA-12.5

Conclusions

- Expected service life of SMA ranges from 15 to 20 years (8.5 to 14 years for conventional materials)
- The cost difference between SMA and conventional dense graded asphalt can be justified by superior performance (i.e., added life)
- Most SMA failures can be attributed to the underlying pavement and not the material
- Causes of material related failures have yet to be isolated
- SMA-9.5 mixes at intersections perform worse than SMA-12.5
- SMA with polymer modified binders outperform non-modified in high stress applications (e.g., over JCP)

Recommendations/Future Research

- Use PG 76-22 with SBS for SMA-9.5
- Use PG 76-22 with SBS on jointed concrete pavements and composite pavements
- Continue investigation of SMA-9.5 design
  - Field properties
  - Field gradations
  - Mix specification adjustments

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