RTR Use in Asphalt and Concrete

Arizona
Pavements/Materials
Conference
Arizona State University
Tempe, AZ
Nov 13-14, 2013

Liberty
TIRE RECYCLING

ARIZONA

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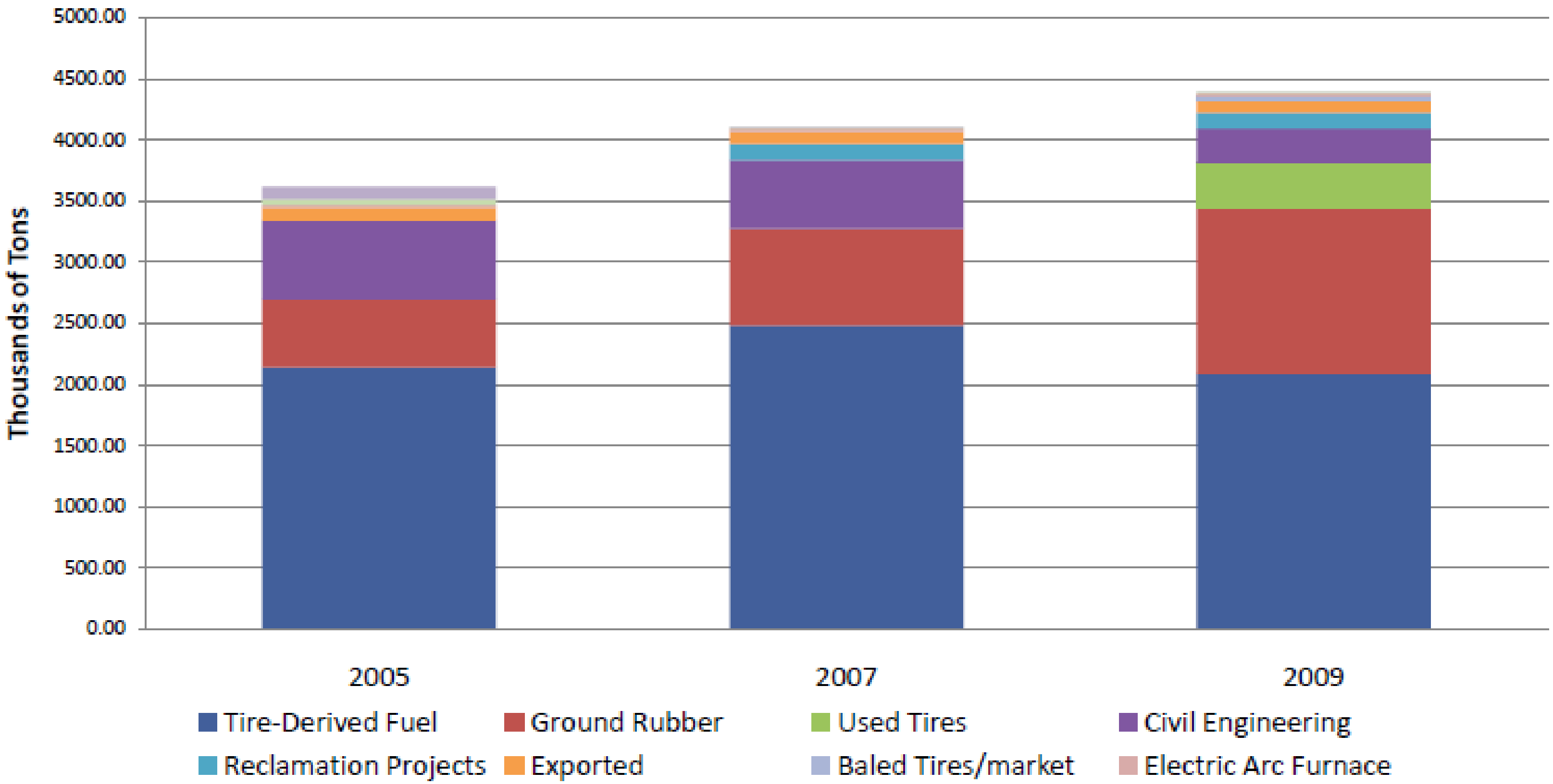
ARIZONA STATE

Recycled Materials Have To Perform Better, Save Money, and be Sustainable

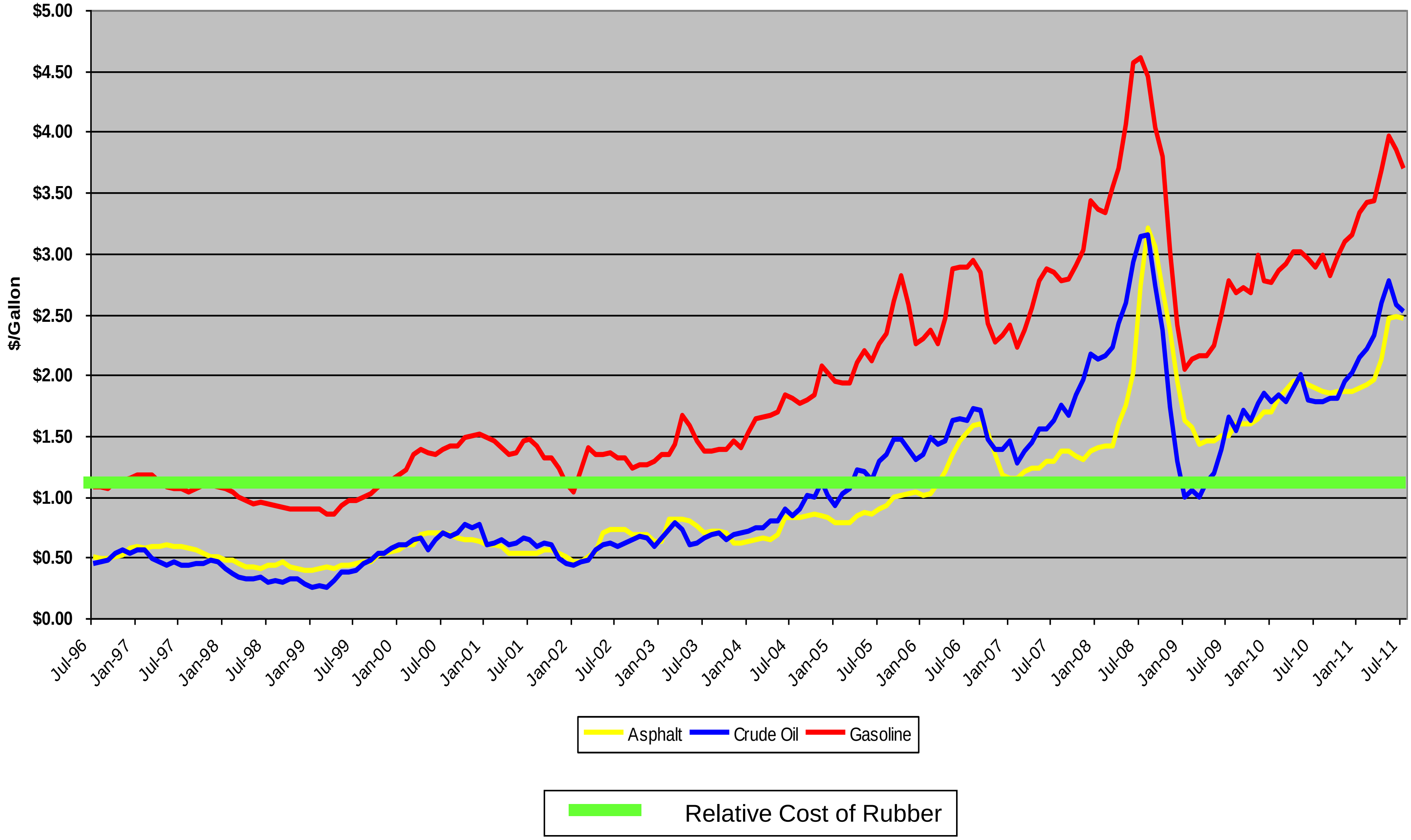
End of Life Tire Market

U.S. Scrap Tire Market Trends 2005 - 2009



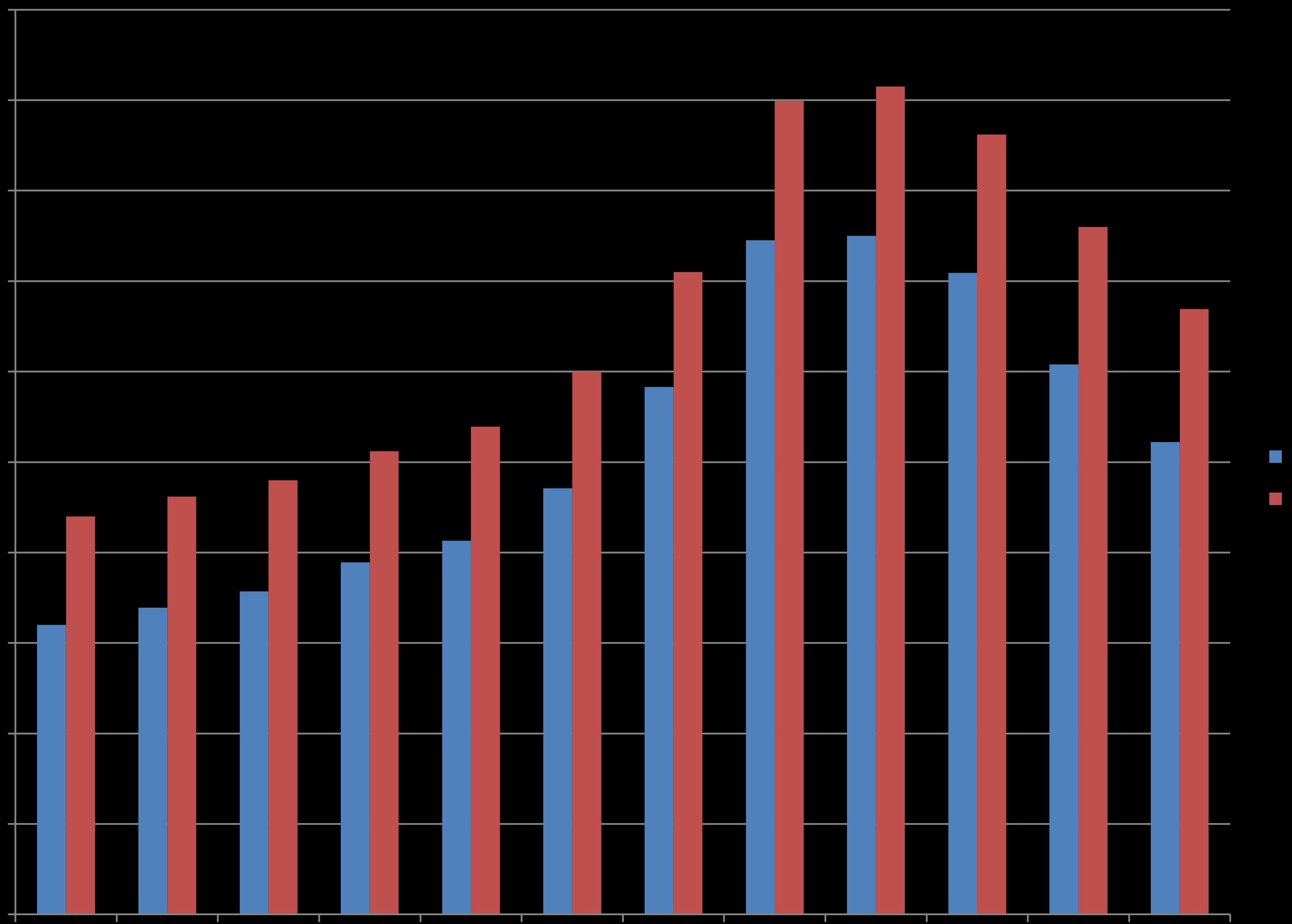
Dramatic Increase in Cost

Crude Oil, Gas and Asphalt Costs



The Cost of Newly Manufactured Modifiers is Tied to the Current Price of Oil

Regular and Modified Asphalt Costs 2008, crude oil hit $147 per barrel July



Source: Peter Wu, GA DOT

Evaluation of Ground Tire Rubber in Asphalt Binders and Mixtures

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National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

NCAT PG Results

Rubber Product	Dosage Rate, %	True Grade	Performance Grade
-30 Liberty	10%	80.7 – 23.6	76 – 22
-20 Liberty	10%	83.1 – 24.6	82 – 22
-20 Liberty	15%	87.9 – 21.3	82 – 16
Crackermill	10%	82.8 – 23.1	82 – 22
Cryo-Hammer	10%	82.2 – 23.2	82 – 22
Cryo-Hammer	15%	86.7 – 19.3	82 – 16
-30 Liberty Fines	10%	79.8 – 20.4	76 – 16
-16 Powderizers (1mm gap)	10%	76.3 – 21.8	76 – 16
-16 Powderizers (2 mm gap)	10%	84.7 – 21.8	82 – 16
Virgin Binder		69.2 – 24.7	67 - 22

RTR Alternative Modifier

- About 3 x RTR loading is needed compared to SBS for similar properties.
  - Example: 3% SBS content = 9% RTR Content
- Suppose SBS costs $2.00/Pound and RTR Costs $0.50/Pound
  - Example:
  - 3 Pounds SBS = $6.00,
  - 9 Pounds RTR = $4.50
- Project with 1000 Tons of Modified of Binder
  - SBS at 3% = 30 Tons Needed @ $2.00 = $120,000
  - RTR at 9% = 90 Tons Needed @ $0.50 = $90,000

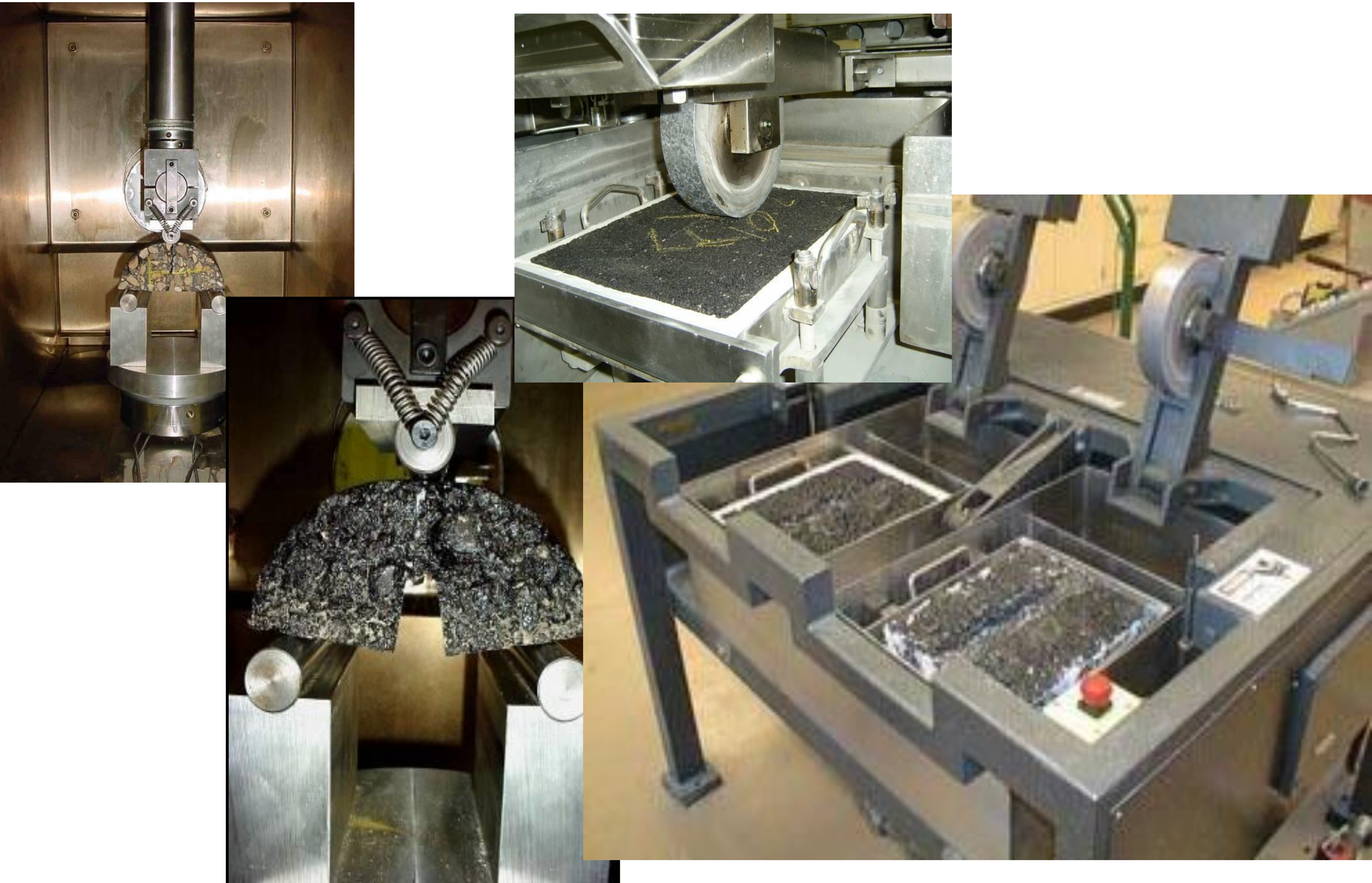
AASHTO CHANGES

- M320 – PG Asphalts, allow modifiers, particulate 600 microns in size (30 mesh)
- T44 – Solubility Test
- MP19 – PG Asphalt using MSCR
- T315 – The DSR, 2 mm gap

A Change in Acceptance Testing

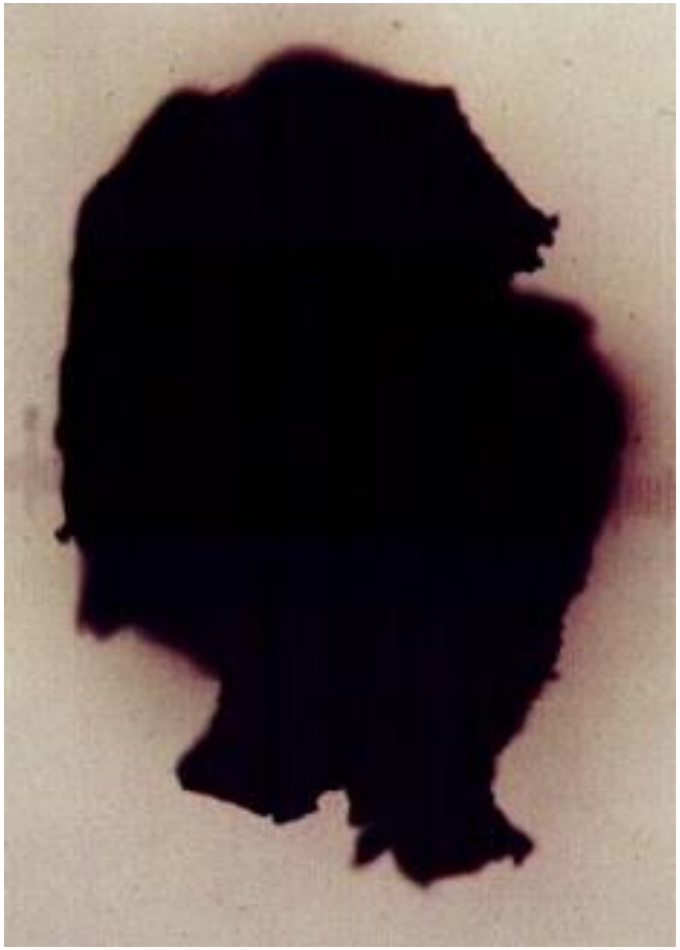
- In 2008, a substantial price spike in asphalt costs struck the paving industry nationwide.
- The use of Reclaimed Asphalt Pavement and Recycled Asphalt Shingles increased to solve the problem of high asphalt costs.
- The performance of RAP and RAS is measured through mix tests, not the liquid binder.
- This is a significant opportunity for Recycled Tire Rubber, as long as it costs less than asphalt and does not increase the liquid requirement (add cost) at the asphalt mix plant.

Mix Performance Tests Are More Common with the Use of RAP and RAS



New “Dry Process”

- Research Published at the LTRC, (Sam Cooper and Louay Mohammad), work underway at several Universities and with-in suppliers to the asphalt industry
- Rubber particles pre-treated with useful liquids before packaging, or co-packaged with low melt processing aids or powders before delivery to mix plant
- GA DOT using a co-packaged “Plant Mix” rubber



Test Section in Hawkinsville, GA on SR 26

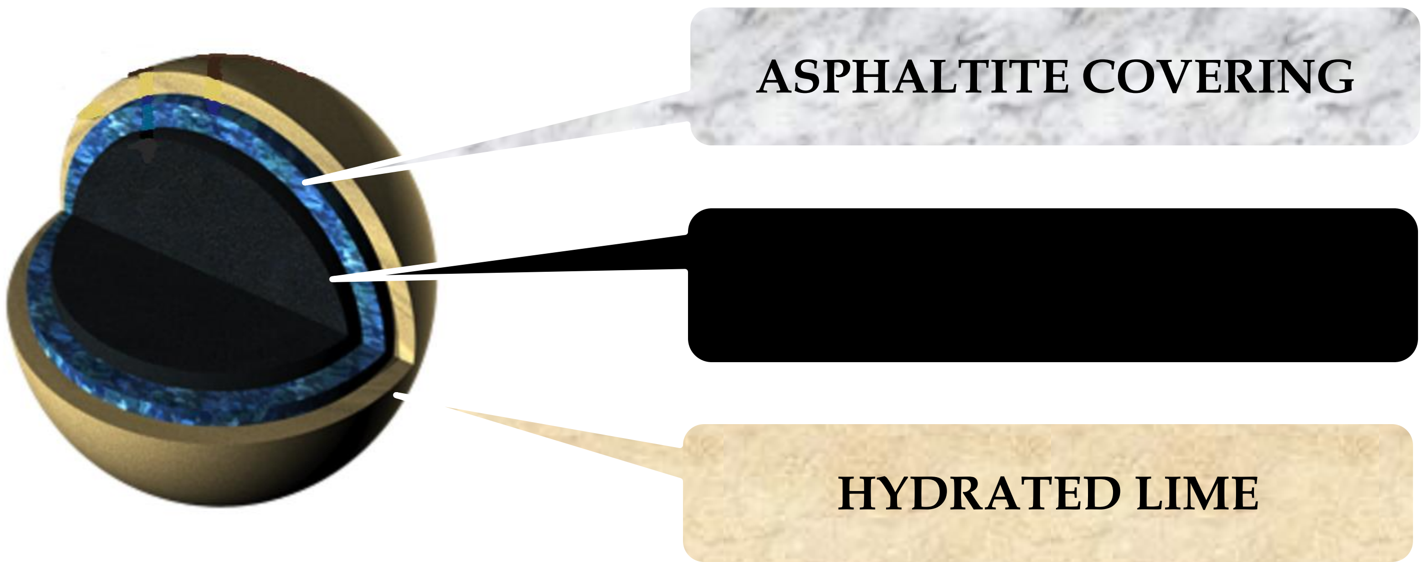
RTR Blended with Reactive Type of Polymer

Blended RTR Being Added To Plant at RAP Collar

Mixture	Control 58-28	Control & %10 Wet Processed Rubber	Control & %10 Pre-Treated Rubber	Spec.
Total Binder content	7.5	7.5	7.5	-
Virgin Binder Added, %	7.5	7.5	7.5	-
Air Voids,%	4.3	4.7	4.8	4-6
Voids in Mineral Aggregate %	19.7	21	20.5	18 min
Voids Filled with Asphalt, %	78.2	77.6	76.8	65-78
Binder Absorbed, %	0.62	0.16	0.48	-
Dust to Binder Ratio	0.67	0.63	0.62	-

Test Result	**Control 58-28**	**Control + 10% Wet Process Rubber**	**Control + 10% Dry GTR Mix**	**Control + 10% Pre-Treated Rubber**
Average Overlay Test (OT) Cycles to Failure	1466	381	230	1645

PELLETIZED ASPHALT-RUBBER



Emerging Technologies

PelletPAVE™

Providing Asphalt-Rubber Technology for Pavement Maintenance

Cost Effective and Convenient

Rubberized Asphalt Can Be Recycled

FEASIBILITY OF RECYCLING RUBBER-MODIFIED PAVING MATERIALS

State of California Department of Transportation
Materials Engineering and Testing Services
Office of Flexible Pavement Materials
5900 Folsom Blvd
Sacramento, California 95819

February 2, 2005

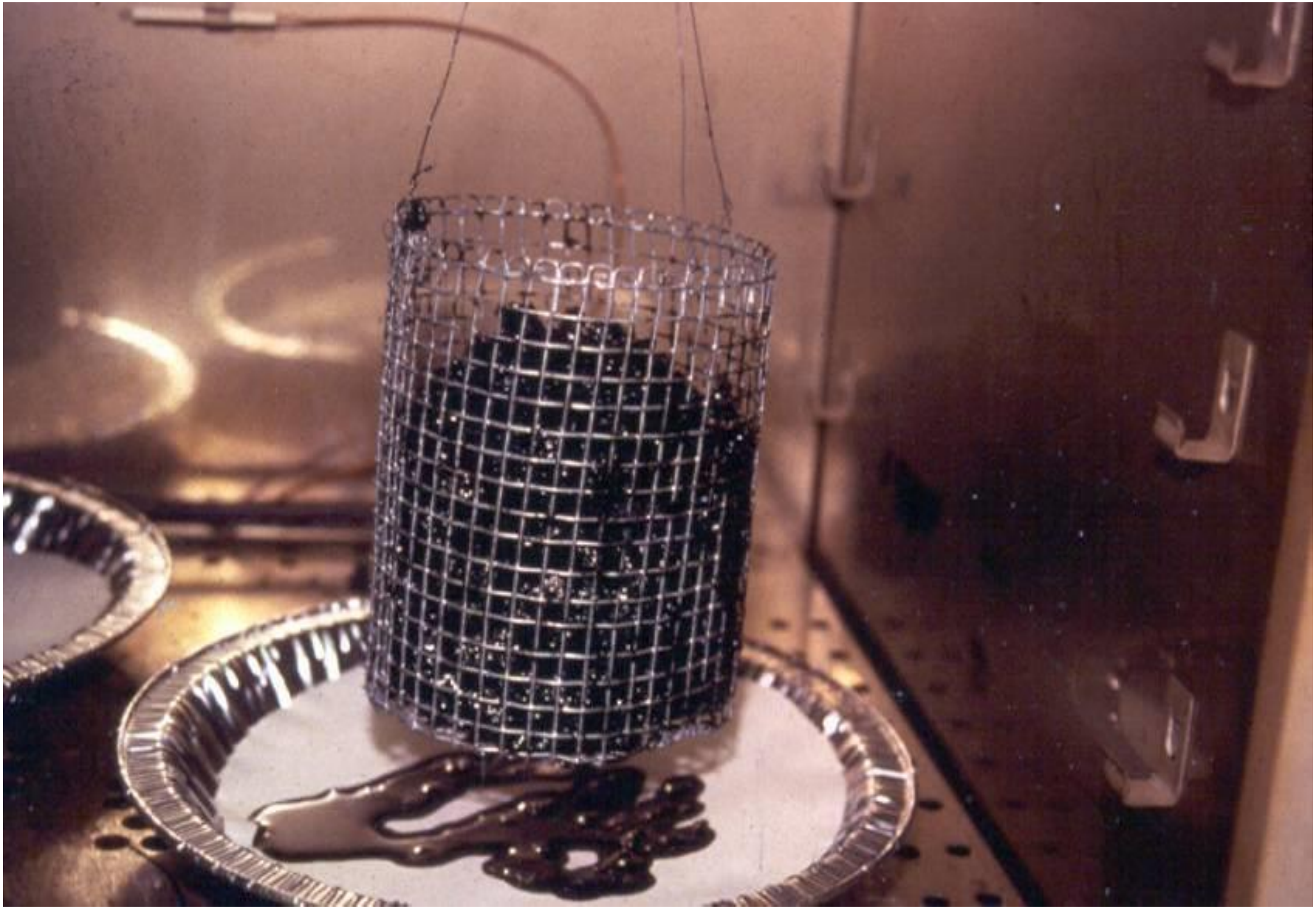
- Most Rubber Projects are still performing and do not need to be recycled.
- Over eight agencies have reported successful recycling projects at 15% or greater rubber Reclaimed Asphalt Pavement.

RTR Has Successful Performance With Warm Mix

Rubber friction course on I-78 in New Jersey.

Rubberized asphalt overlay on I-295 in Massachusetts.

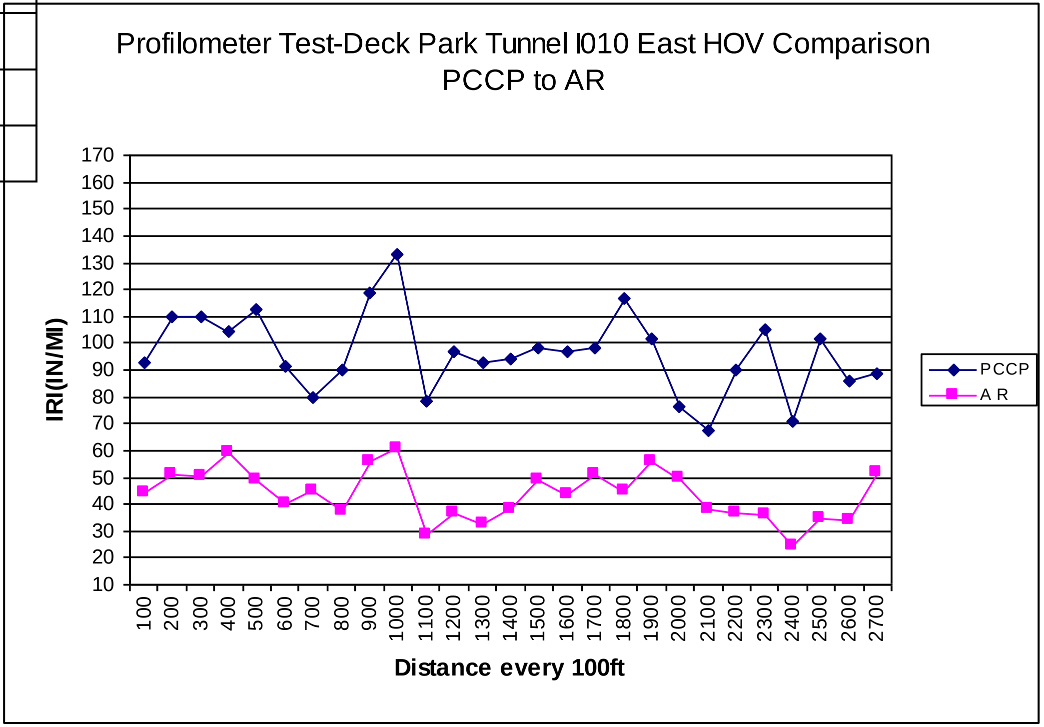
Draindown Test for SMA & PFC



	Dense Grade	GAP (SMA) Grade			
		Coarse Grind	Fine Grind	Polymer	Poly w Fiber
Binder Content	5.0%	8.0%	6.0%	6.0%	6.5%
Rubber Content		20.0%	10.0%		
Stones	25	30	30	30	30
Asphalt	28	35	30	33	36
Polymer				6	1
Fiber					7
Rubber		6	5		
Blending		1	1		0
Total Materials per Ton of Mix	53	72	65	69	73

Ride Quality / Roughness

LANE	IRI (in/mi)	
	PCCP	AR-ACFC
I010EHOV	96.34	43.57
I010ELN1	123.20	59.03
I010ELN2	104.29	48.81
I010ELN3	111.87	47.80
I010ELN4	115.30	52.91
I010WHOV	85.44	32.51
I010WLN1	87.94	37.79
I010WLN2	85.40	46.92
I010WLN3	96.83	46.11
I010WLN4	97.75	36.81



Rubberized Asphalt Performs Better, Saves Money, and is Sustainable

Hypothesis

- Rubber crumbs may function as a distribution of mini expansion / control joints inside the concrete.
- Thus, the crumb rubber concrete may exhibit good characteristics in controlling crack initiation and propagation.

Field Experiments

- Feb 1999, ASU sidewalk, 40 lbs.
- June 2001, ASU wheel chair ramp, 20 lbs.
- May 2001, ADOT parking lot, 60 lbs.
- March 2002, residential patio foundation in Mesa AZ, 20 cr/cy.
- April 2002, NAU campus (cold climate), 60 lbs
- March 2003, residential sidewalk in Scottsdale, AZ, 25 lbs.

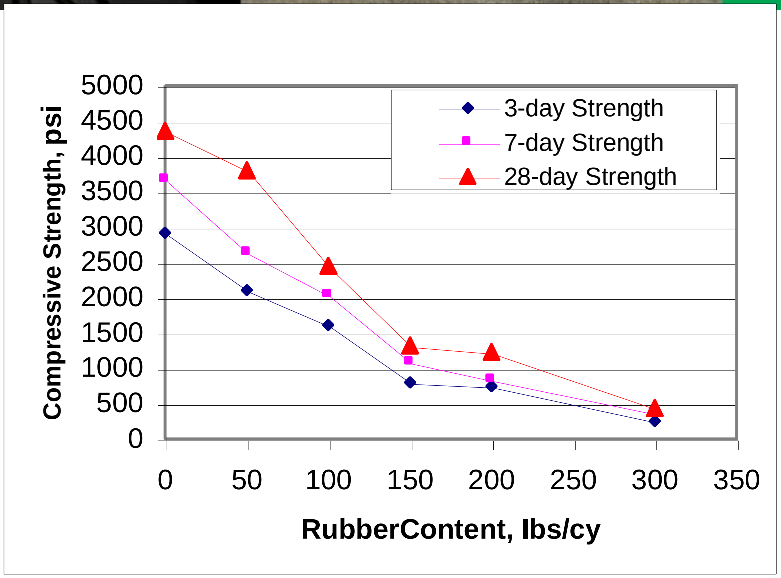
Tennis Court – Phoenix, AZ

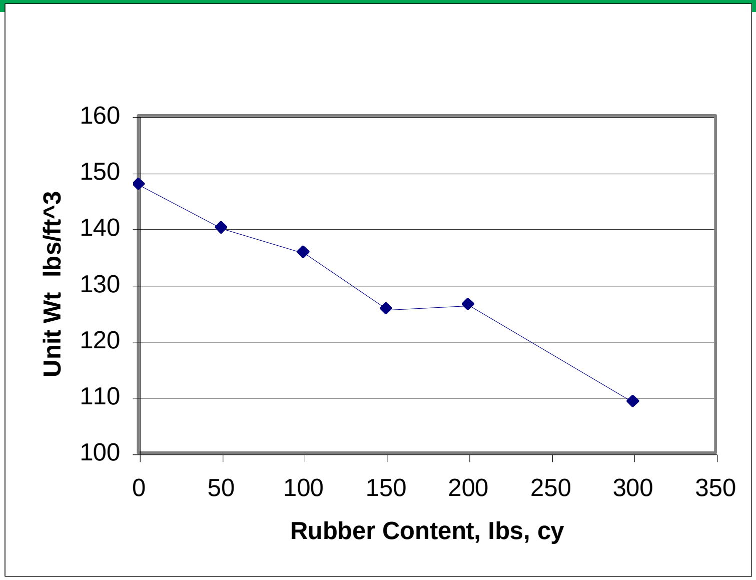
- At Hanson's Aggregates in Phoenix, AZ:
  - test slab 5 x 25 feet and 2 inches thick
  - 400 lbs of cr/cy, 25% of the concrete mix by volume
  - was placed without any joints
  - slab serves as a truck parking facility
  - no cracks have been observed as of 2006
  - provided useful experience about mixing, hauling, pumping, placing, finishing, and curing of crumb rubber concrete.

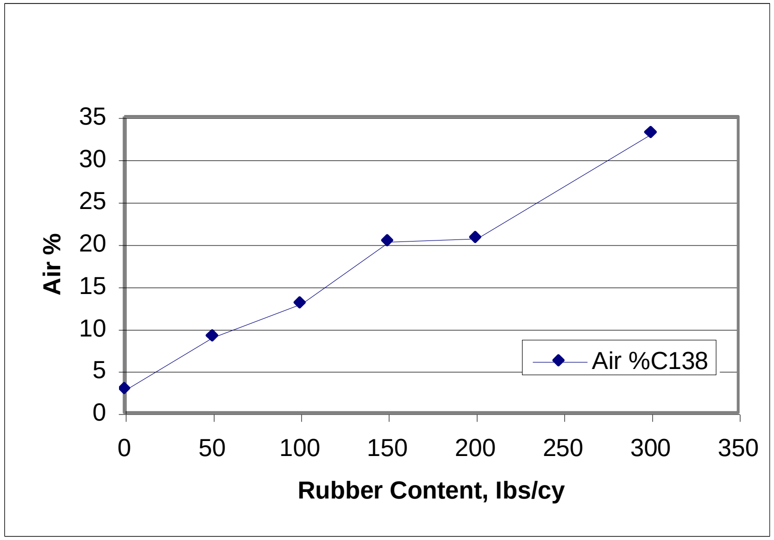
Tennis Court – Phoenix, AZ

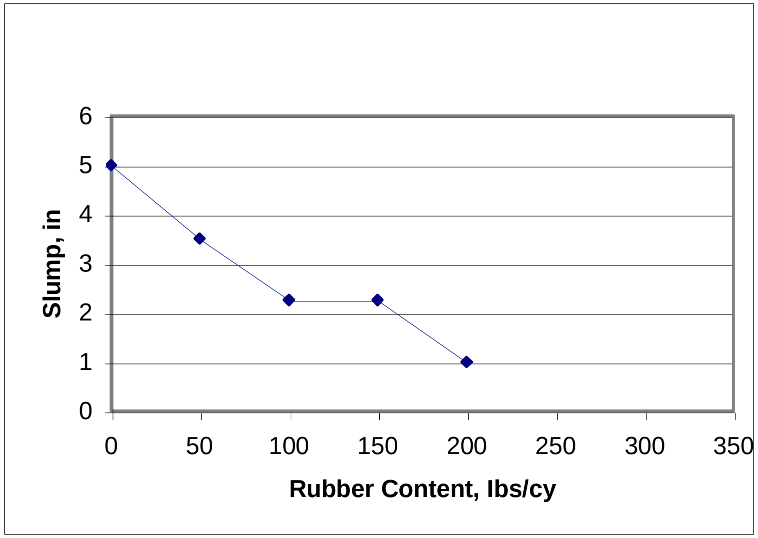
- January 2003: experimental test slabs
  - 2x4 ft in size
  - thickness 2 - 3 inches
  - 50 >-> 300 cr/cy.
- Tests included: compressive strength, flexural strength, indirect tensile strength, and thermal coefficient of expansion.


Mix Characteristics





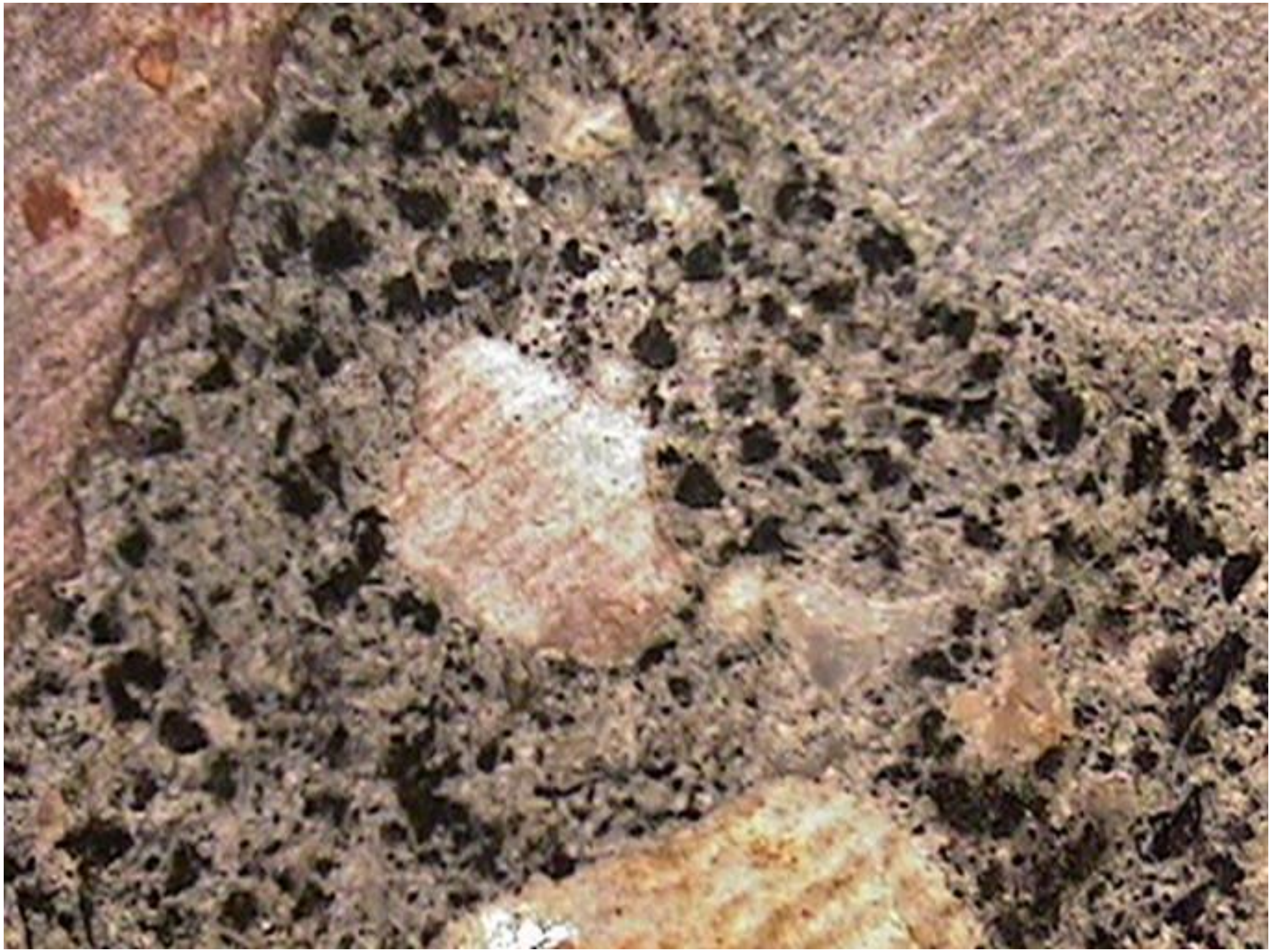




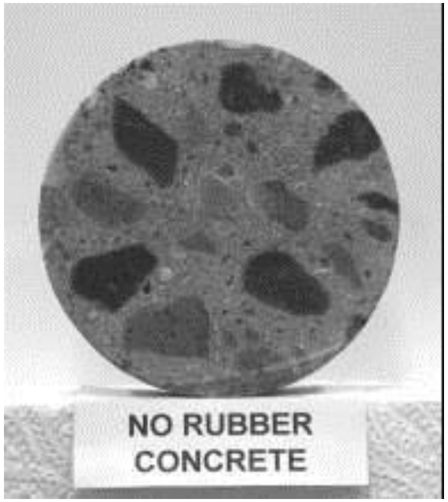
Tennis Court Trial Mixes

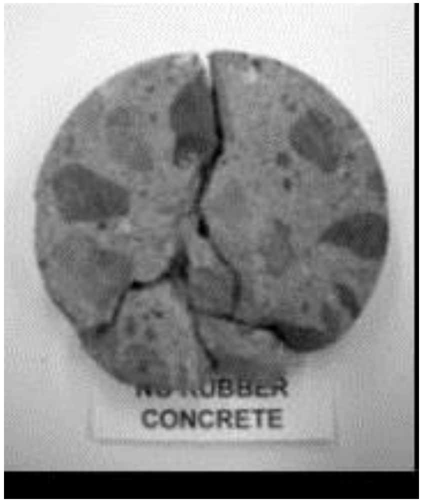
50 - 100 - 150 lbs

400 lbs / C.Y. Trial Mix

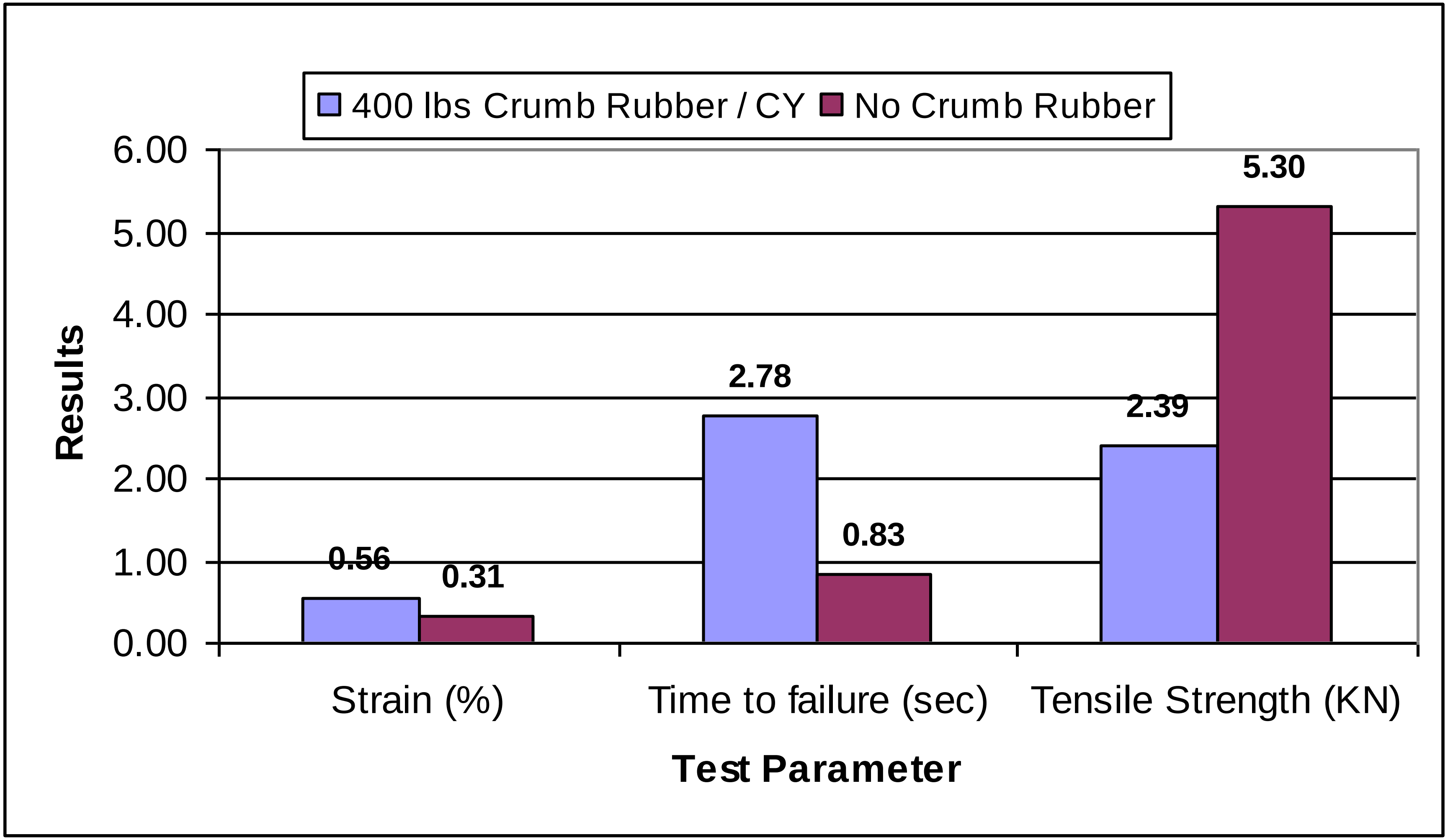


Mix Behavior





Initial Test Results



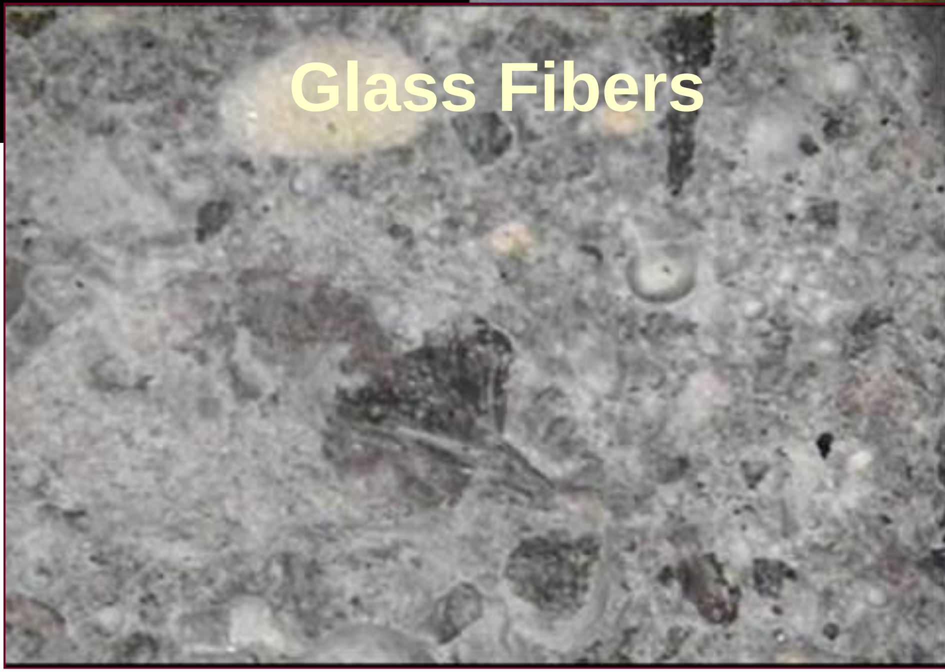
Tennis Court Before Overlay

Tennis Court Construction

- Evaluate CRC using fundamental tests.
- Build and monitor field demonstration test sections, and evaluate the long term performance and benefits of using crumb rubber concrete materials.
- Share findings with state governments, associations, industry and private sector

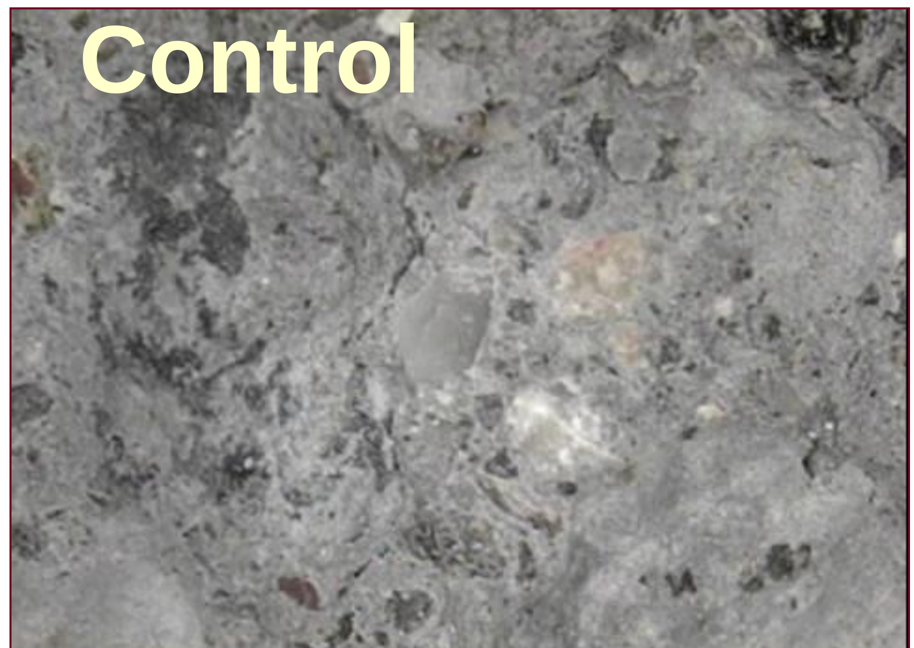
Highway Related Projects

Two UTW pavement test sections


Glass Fibers

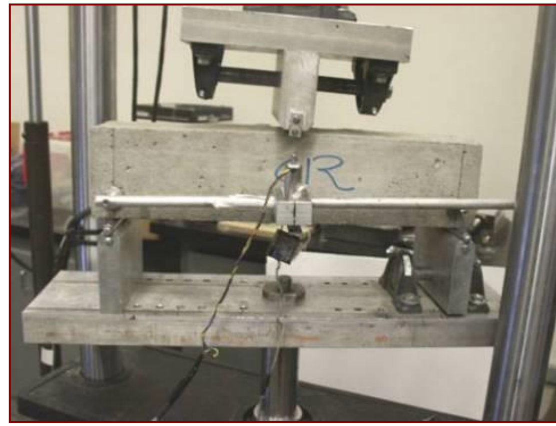

Polypropylene


Crumb Rubber 50


Control

Laboratory Tests

- Compressive Strength
- Three Point Bending
- Panel Test
- Shrinkage
- Coefficient of Thermal Expansion



Compressive Strength

MIX. ID	Age Days	Average Compressive Strength psi	Peak Axial Strain in/in (10^{-3})	Axial Modulus of Elasticity psi (10^{6})	Poisson's Ratio
300 lbs per Cyd *(Const.)*	7	822	9.65	0.15	NA
300 lbs per Cyd *(Const.)*	28	1080	10.32	0.16	NA
400 lbs per Cyd	14	546	6.50	0.11	NA
TW_CTR	14	5363	1.05	5.30	0.25
TW_CTR	28	5975	0.52	6.10	0.26
TW_CR 50	14	3704	1.29	3.14	0.25
TW_CR 50	28	4430	0.73	5.63	0.22

Parameters Measured in Flexural Test

- Flexural load (lbs)
- Deflection: Measured by the LVDT (in)
- Crack Mouth Opening Displacement (CMOD): Measured by the actuator (in)

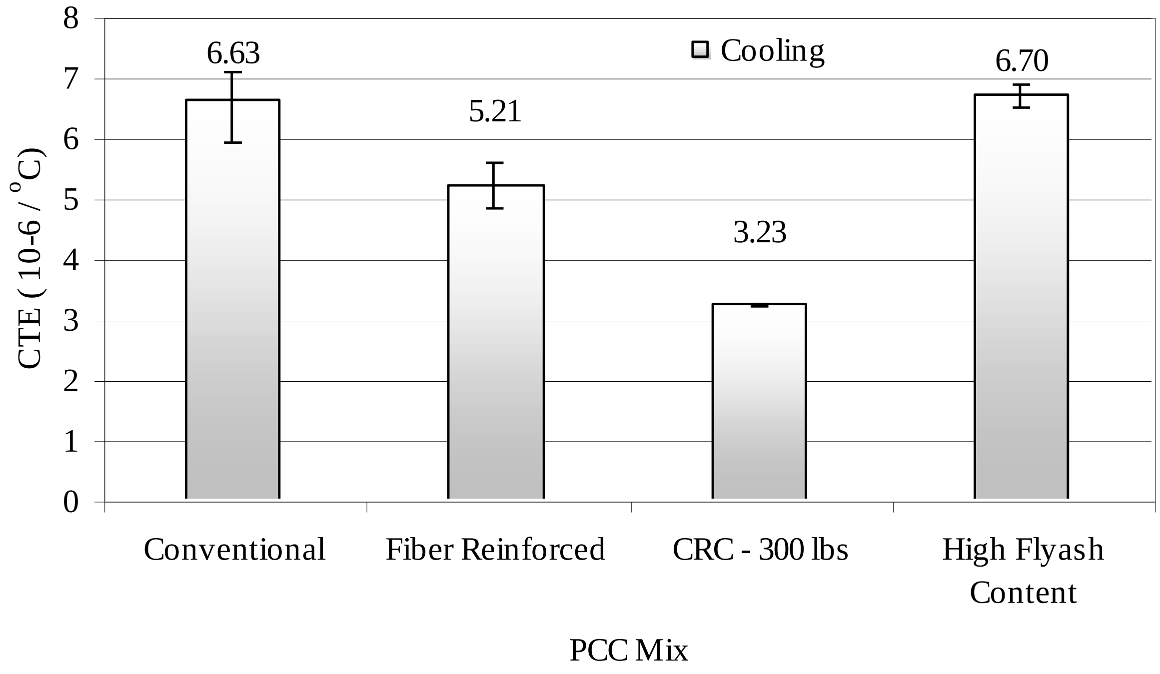
MIX. ID	Age Days	Flexural Load lbs	CMOD in (10^{-3})	Flexural Strength (psi)	Toughness psi x in
300 lbs per Cyd *(Const.)*	28	481	1.85	157	9.4
TW_CTR	14	1049	0.97	341	8.4
TW_CTR	28	1188	1.30	387	10.3
TW_CR 50	14	807	1.67	263	7.6
TW_CR 50	28	932	1.39	303	9.5

300 lbs / C.Y. Tennis Court Mix

CTE Comparison

The distresses are a function of the CTE values

Lower values of CTE in the mix results in less faulting, lower percentage of cracking.



Conclusions

- Advantage of unit weight reduction with increased crumb rubber content.
- Entrapped air and very high rubber content contribute to compressive strength reduction. However, higher strength values are achievable depending on design requirements.
- Similarly, flexural strength reduction may be compensated for by higher ductility and comparable toughness.
- Higher tensile strain at failure for CRC mixes is indicative of higher energy absorbent mixes and less prone to shatter.
- CTE results indicated that CRC mixes are more resistant to thermal changes.

Final Thoughts

- Performance monitoring is needed to validate durability and mix characteristics.
- There are advantages and disadvantages for the use of CR PCC, careful consideration should be given for each design case.
- Improved mixture characteristics are possible through mix optimization. Watch for entrapped air.
- Crumb rubber content is also specific for mix usage or application.