Innovations in Rubberized Asphalt Technologies

Liberty TIRE RECYCLING

Doug Carlson VP Asphalt Products

Prepared for:

ARIZONA PAVEMENTS/MATERIALS CONFERENCE

ASU • ADOT • Industry • Local Governments

The 19th Arizona Pavements/Materials Conference Nov 16-17, 2022

Presentation Outline

- Benefits of Recycled Rubber
- Tired And True Technology – Asphalt Rubber
- Newer Developments with Recycled Tire Rubber in Asphalt
  - Performance Grade Binders and Additives
  - Devulcanized Rubber = SBS
  - Pelletized Rubber Binders
  - Next Generation Dry Process
  - Reacted Rubber Particle Technology

Environmental Benefits of Recycled Rubber

- ✓ Recycling rubber tires means that millions of scrap tires are no longer dumped in landfills or along the side of the road and in sensitive habitats. Instead, **more than 90 percent of these tires are being recycled and reused annually**

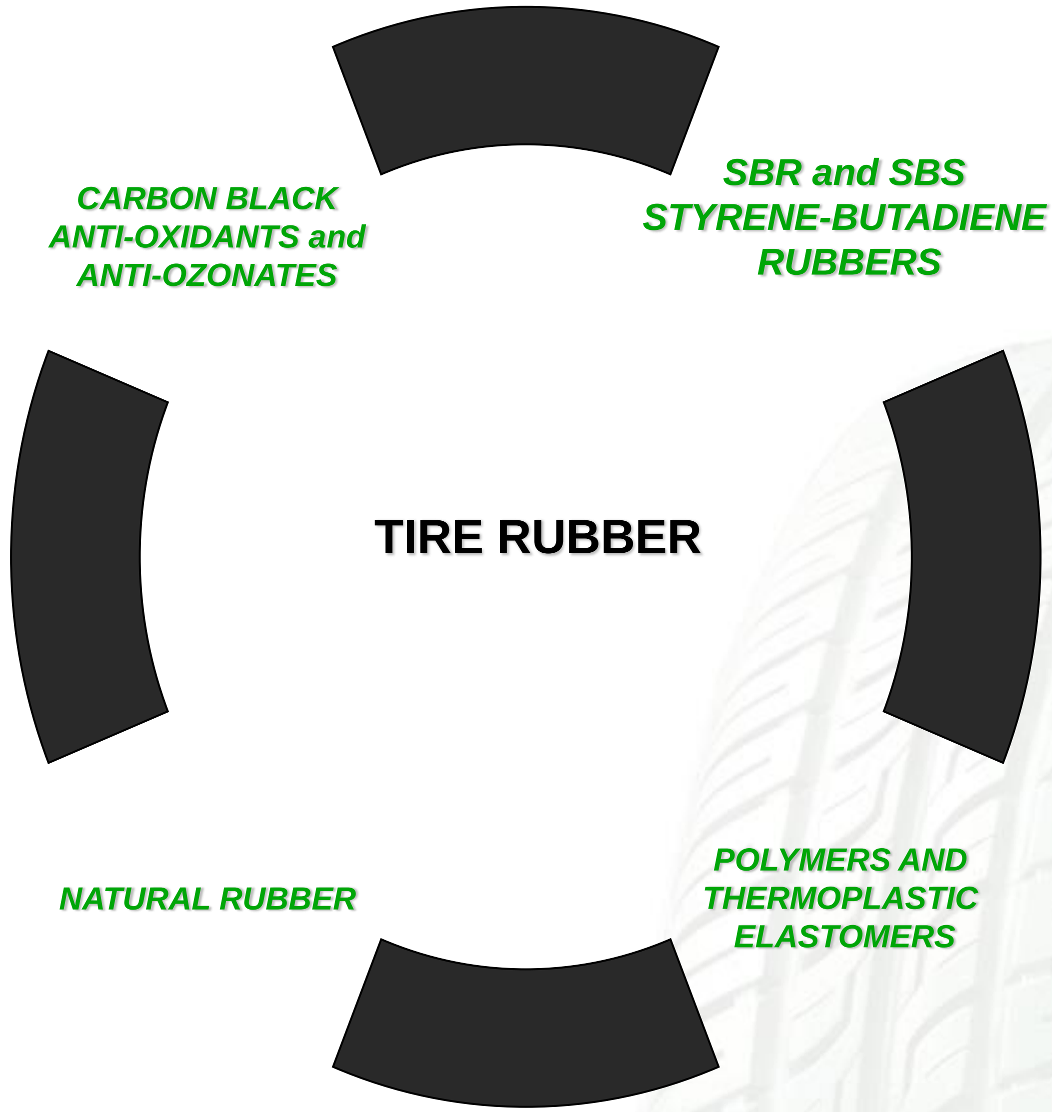
- ✓ Recycling saves impressive amounts of energy, which ultimately reduces greenhouse gas emissions. For example, **recycling four tires reduces CO2 by about 323 pounds,** which is equivalent to 18 gallons of gasoline

- ✓ Using recycled rubber in molded products, for example, creates a **substantially smaller (by a factor of up to 20 times) carbon footprint** as compared to using virgin plastic resins

Infrastructure Opportunities

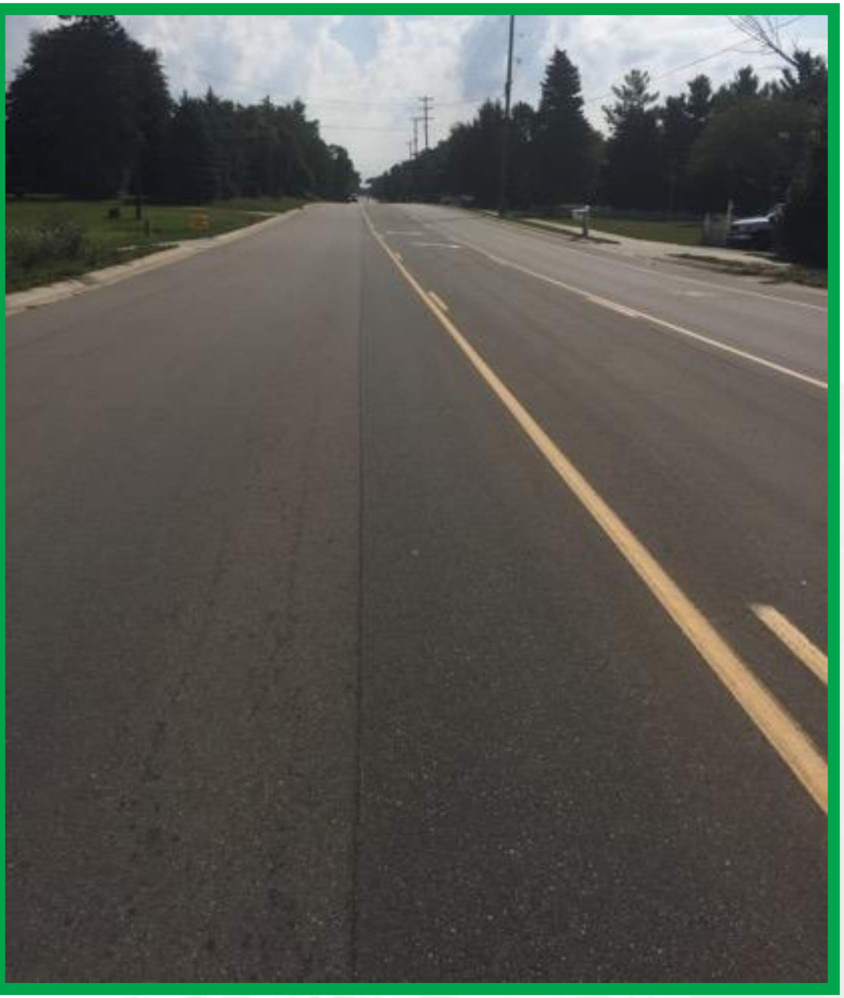
- Asphalt
  - Roads, parking lots, trails/walkways
  - Permeable and impervious applications
- Road bases
- Surface stabilization
- Traffic safety
- Rubber/fiber reinforced concrete

Recycled Tire Rubber Composition – Good Stuff for Roads!



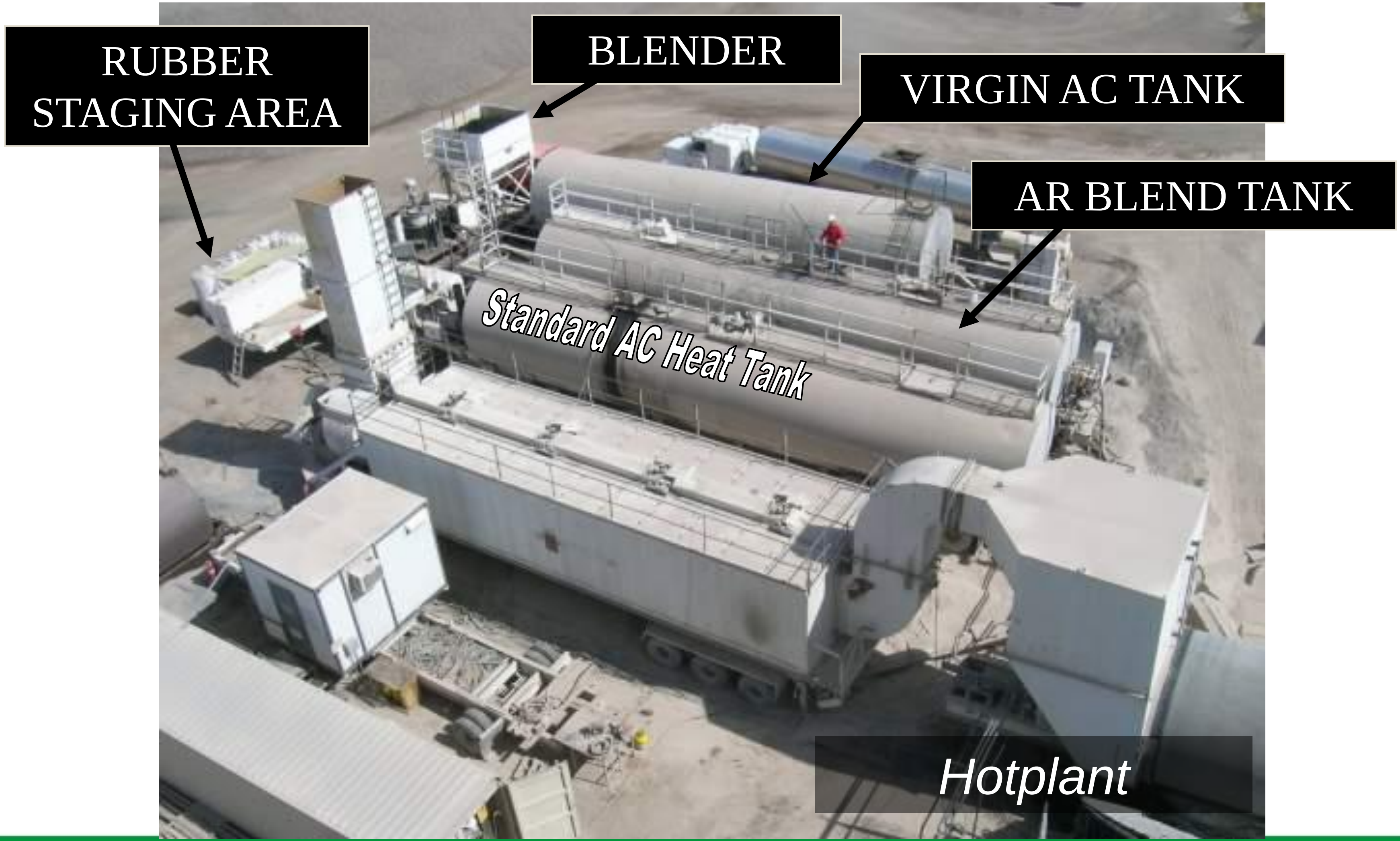
Greatest Potential: Asphalt

- Proven benefits
- Industry innovating to overcome market challenges

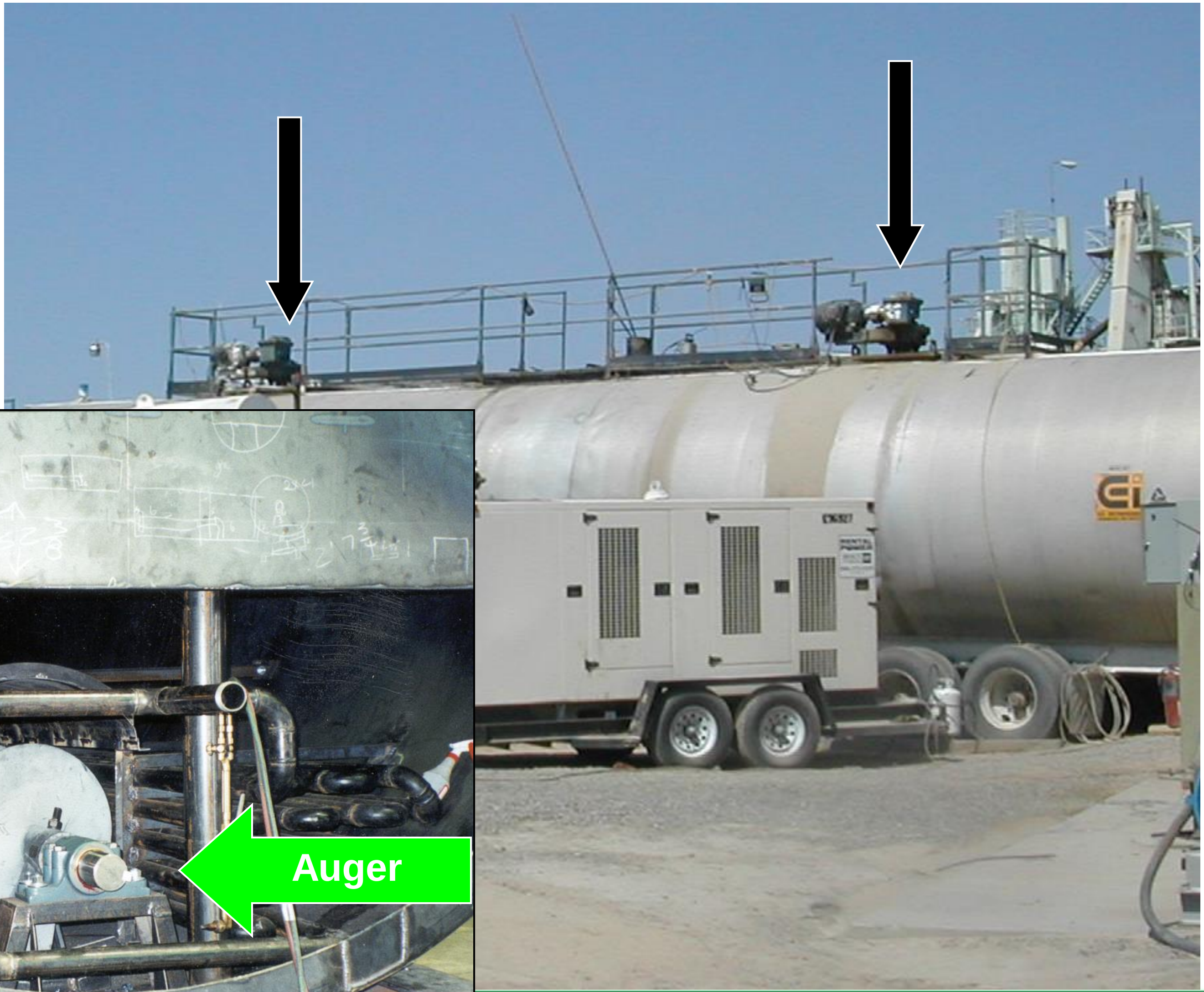


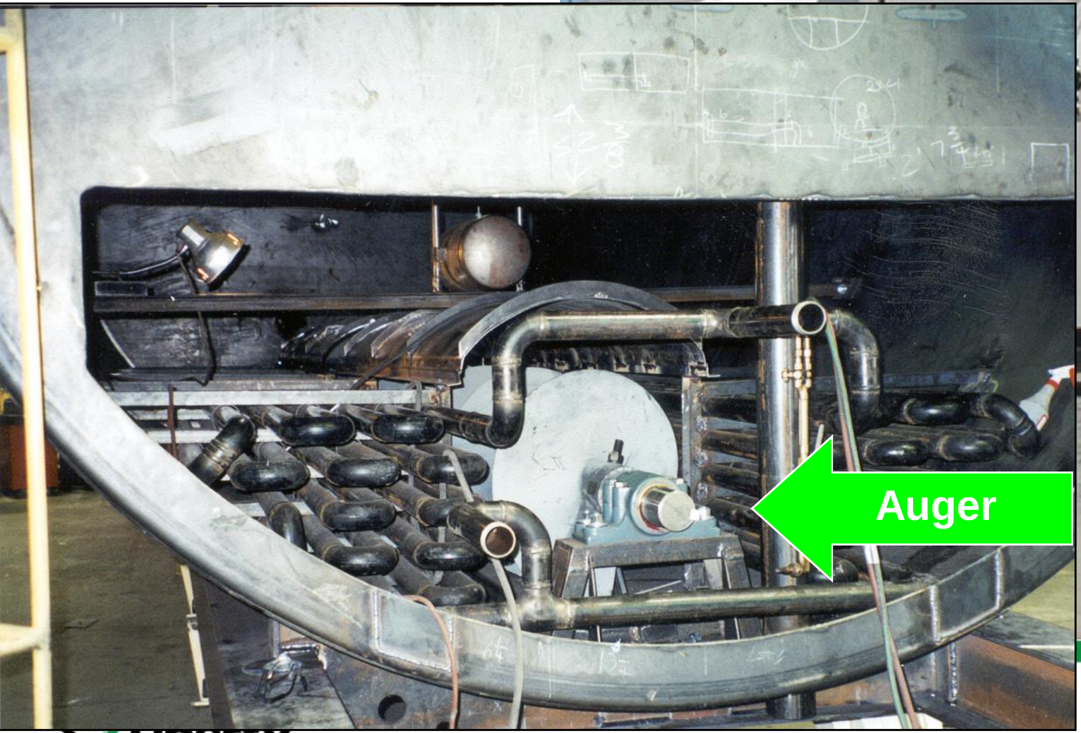
Recipes and Ingredients Matter:

Modern Blending Technology Improves Quality Control On Site


RUBBER STAGING AREA
BLENDER
VIRGIN AC TANK
AR BLEND TANK
Standard AC Heat Tank
Hotplant

Agitation Systems

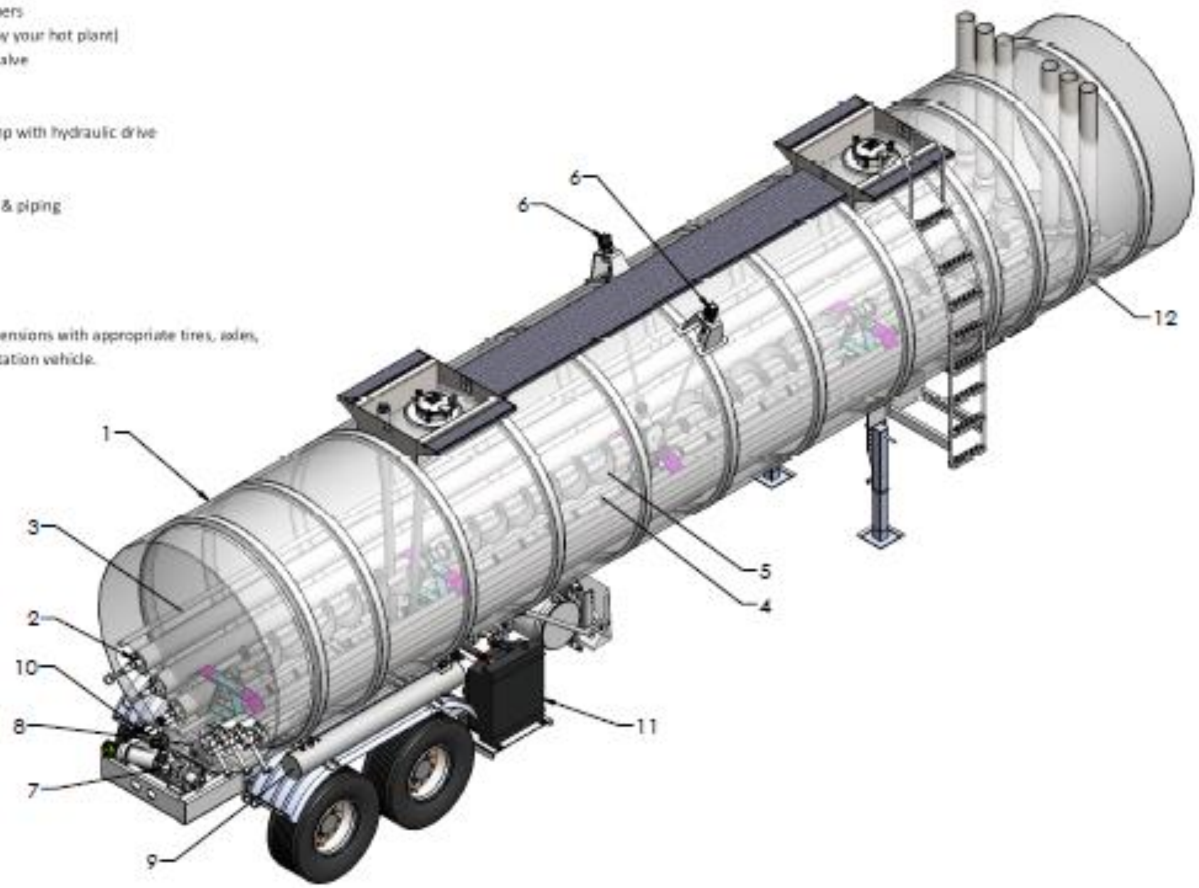


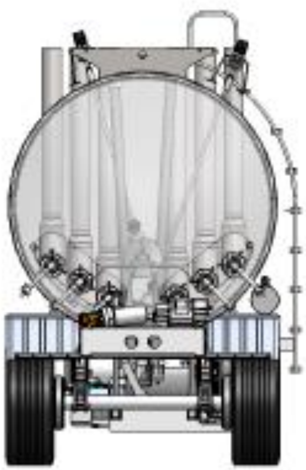


A Rubberized Asphalt Storage Trailer

1. 10,000 Gallon clean-bore Tank – 3/16 steel
2. Six (6) Full length single pass flues with propane burners
3. Eighteen (18) passes of 2" pipe for hot oil (supplied by your hot plant)
4. 10" bottom auger for moving material to discharge valve
5. 14" Right – left mixing auger
6. Hydraulic auger drive motors thru internal gearbox
7. 4" (or 6") Bear Cat asphalt rubber hot oil heated pump with hydraulic drive
8. 5" Heated tank valve
9. Electric hot oil heater 220v single phase
10. Hot oil circulation pump to asphalt pump, tank valve & piping
11. 50 hp Izusu diesel engine for hydraulics
12. 4" Insulation with .032 alum skin

This towable storage & mixing trailer will be hi-way legal dimensions with appropriate tires, axles, suspension and lighting. Not intended as a material transportation vehicle.





BEARCAT MFG.

TITLE: TOWABLE STORAGE & MIXING TRAILER

DO NOT SCALE DRAWING

MAKE OR BUY: M

	NAME	DATE
DRAWN	JDC	11-18-10
CHECKED		
ENG APPR.	EH	11-18-10

SIZE B | DWG. NO. 206482 | REV REL

SCALE: NONE | SHEET 1 OF 3

FINISH N/A

BearCat Mfg.

CONVERSION CHART	
1/16" = .0625	9/16" = .5625
1/8" = .125	5/8" = .625
3/16" = .1875	11/16" = .6875
1/4" = .250	3/4" = .750
5/16" = .3125	13/16" = .8125
3/8" = .375	7/8" = .875
7/16" = .4375	15/16" = .9375
1/2" = .50	1" = 1.00

Maintaining Heat and Agitation is Key

RTR switch for SBS

Evaluation of Ground Tire Rubber in Asphalt Binders and Mixtures

Liberty TIRE RECYCLING

National Center for Asphalt Technology NCAT at AUBURN UNIVERSITY

Evaluation of Ground Tire Rubber in Asphalt Binders and Mixtures

Objective - Assess how particle size and grinding technique affect the properties of asphalt binder

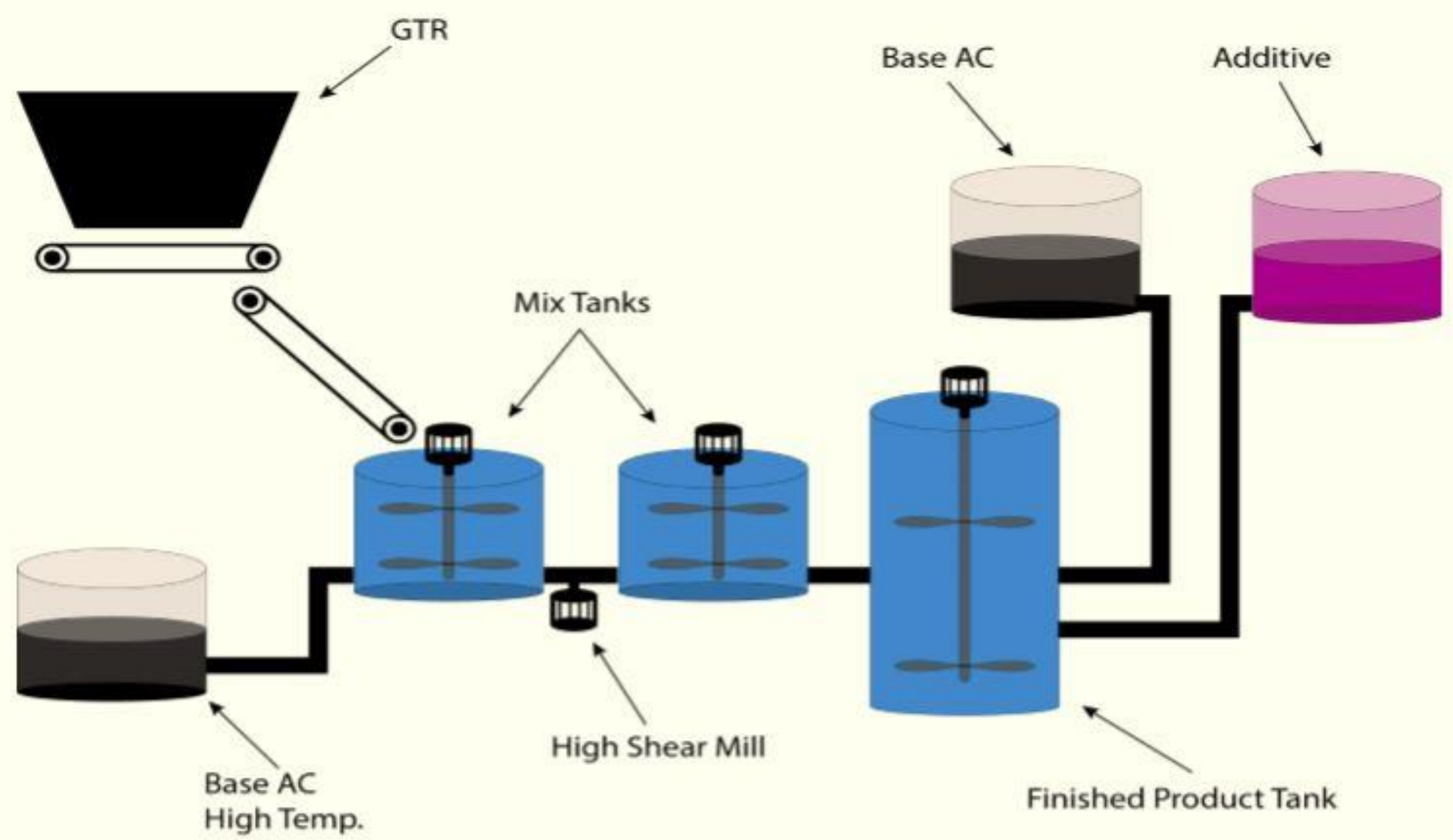
Project Sponsors - Blacklidge Emulsions, Lehigh Technologies, Liberty Tire Recycling

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

PG Results

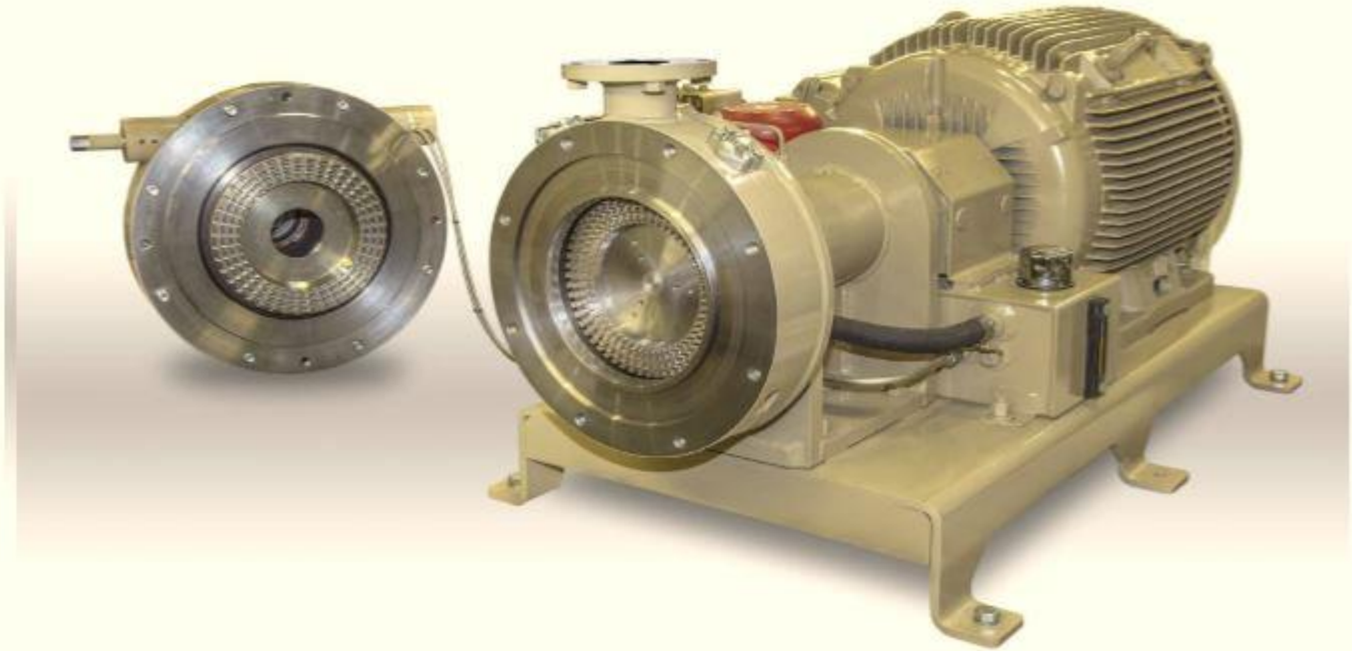
Rubber Product	Dosage Rate, %	True Grade	Performance Grade
-80/140	10%	83.6 – 24.9	82 – 22
MD-180-TR	10%	72.8 – 25.1	70 – 22
MD-400-TR	10%	80.4 – 24.2	76 – 22
MD-402-TR	10%	79.0 – 23.0	76 – 22
MD-105-TR	10%	77.9 – 25.6	76 – 22
-30 Liberty	10%	80.7 – 23.6	76 – 22
-20 Liberty	10%	83.1 – 24.6	82 – 22
-20 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

Typical Process



Terminal Blend Process Diagram

High Shear Mill



High Shear Mill

Types of Mixers

Tanks require mixers - Low shear tank mixer

Wetting Can High Shear Mixer

A Rubber System at a Terminal

Rubber feed hopper, batch method

Example of Trial Rubber Binder Design

	Test Method	Spec			
Project :			np	np	np
Sample ID.:			90/10 Blend	88/12 Blend	86/14 Blend
AMEC Lab No.:			1240001	1240001	1240001
Date Received:			07-11-2012	07-11-2012	07-11-2012
Sample Date:			07-12-2012	07-12-2012	07-12-2012
Sample Type:			Lab Blend	Lab Blend	Lab Blend
Tests on Original Asphalt	Test Method	Spec			
Apparent Viscosity at 135°C, Pa-s	AASHTO T316	3.0 max.	2.13	2.69	*5.58

	Test Method	Spec	
Project :			np
Sample ID.:			90/10 Blend
AMEC Lab No.:			1240001
Date Received:			07-11-2012
Sample Date:			07-12-2012
Sample Type:			Lab Blend
Tests on Original Asphalt	Test Method	Spec	
Apparent Viscosity at 135°C, Pa-s	AASHTO T316	3.0 max.	2.13
Flash Point, °C			
Elastic Recovery, 77°F, %			
Softening Point, °F			

	Test Method	Spec	
Project :			np
Sample ID.:			86/14 Blend
AMEC Lab No.:			1240001
Date Received:			07-11-2012
Sample Date:			07-12-2012
Sample Type:			Lab Blend
Tests on Original Asphalt	Test Method	Spec	
Apparent Viscosity at 135°C, Pa-s	AASHTO T316	3.0 max.	*5.58
	AASHTO T48	232 min.	*(1)*
	ASTM D6084	65 min.	78
	AASHTO T53	135 min.	143

	Test Method	Spec	
Project :			np
Sample ID.:			88/12 Blend
AMEC Lab No.:			1240001
Date Received:			07-11-2012
Sample Date:			07-12-2012
Sample Type:			Lab Blend
Tests on Original Asphalt	Test Method	Spec	
Apparent Viscosity at 135°C, Pa-s	AASHTO T316	3.0 max.	2.69
Flash Point, °C	AASHTO T48	232 min.	520
Elastic Recovery, 77°F, %	ASTM D6084	65 min.	75
Softening Point, °F	AASHTO T53	135 min.	140

New Technologies

Warm Mix Wax Treated Rubber

- Rubber heated to 220F, saturated and coated with wax
- Terminal Blend (Can be added dry)
- Grade bump PG 64-22 to PG 70-22
- Kenny Road, Columbus 2016

Kenny Road 2017 (One Year)

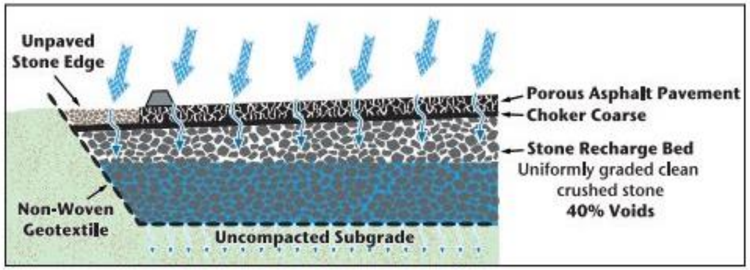
WARM TECHNOLOGY
Spray Applied

Liberty TIRE RECYCLING

July 2019
Longmeadow, MA Parking Lot

0.25% Dosage of SmartMIX with 1% Fibers. More economical than load of latex binder or latex injection.

Typical Porous Pavement Cross Section
Replace Liquid Modifiers in Porous Pavement Design



Crosslinker Liquified and Coated Onto Rubber for Greater Homogeneity

Tire Fiber Project

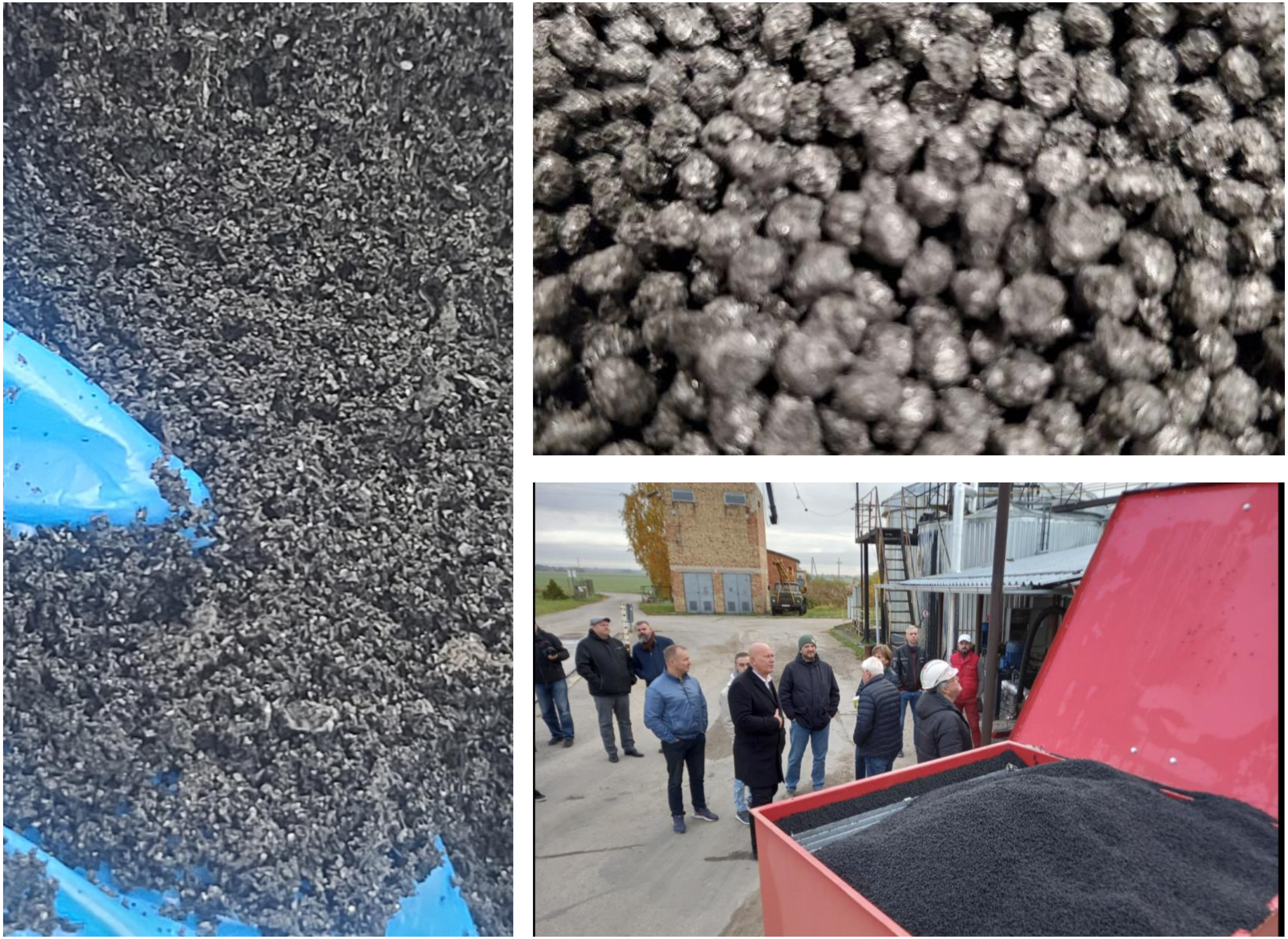
Devulcanization

- Break sulfur bonds to reuse rubber in a virgin like form.
- Rubber goes through extruder with heat, mechanical and chemical inputs.
- Works very well in Terminal Blends as SBS Substitute
- Provides storage stability in binders similar to SBS (0.6%, 4°F)

		Sample Type:	Lab Blend
Tests on Original Asphalt	Test Method	Spec	
Apparent Viscosity at 135°C, Pa-s	AASHTO T316	Report	0.795
Dynamic Shear, G*/sinδ, kPa (1)	AASHTO T315		
70°C		1.00 min.	1.67
76°C			0.82
Pass/Fail Temp., °C		Report	74.3
Tests on Residue from RTFO	AASHTO T240		
Mass Change, %	AASHTO T240	1.00 max.	-0.325 (Loss)
Dynamic Shear, G*/sinδ, kPa (1)	AASHTO T315		
70°C		2.20 min.	5.94
76°C			3.10
82°C			1.76
Pass/Fail Temp., °C		Report	79.6
Tests on Residue from PAV @ 110°C	AASHTO R28		
Dynamic Shear, G*sinδ, kPa	AASHTO T315		
31°C *(specified temperature, -16 Grade)*		5000 max.	2,675
28°C *(specified temperature, -22 Grade)*			3,921
Pass/Fail Temp., °C		Report	26.0
Creep Stiffness, S, at 60s, MPa	AASHTO T313		
0°C		300 max.	94.6
-6°C			175
Pass/Fail Temp., °C		Report	-11.3
Slope, m-value	AASHTO T313		
0°C		0.300 min.	0.331
-6°C			0.284
Pass/Fail Temp., °C		Report	-4.0
Performance Grade	AASHTO M320		PG 70-10
True Grade			PG 74-14

Remarks: *(1) Gap on DSR for Orginal and RTFO was increased to 2.5 mm for testing.*

Blend Components:



Images courtesy of Rubbintec ELTC (Devulcanized Rubber)

Pelletized Asphalt Binder

PelletPAVE™

*Pellet*PAVE | TR

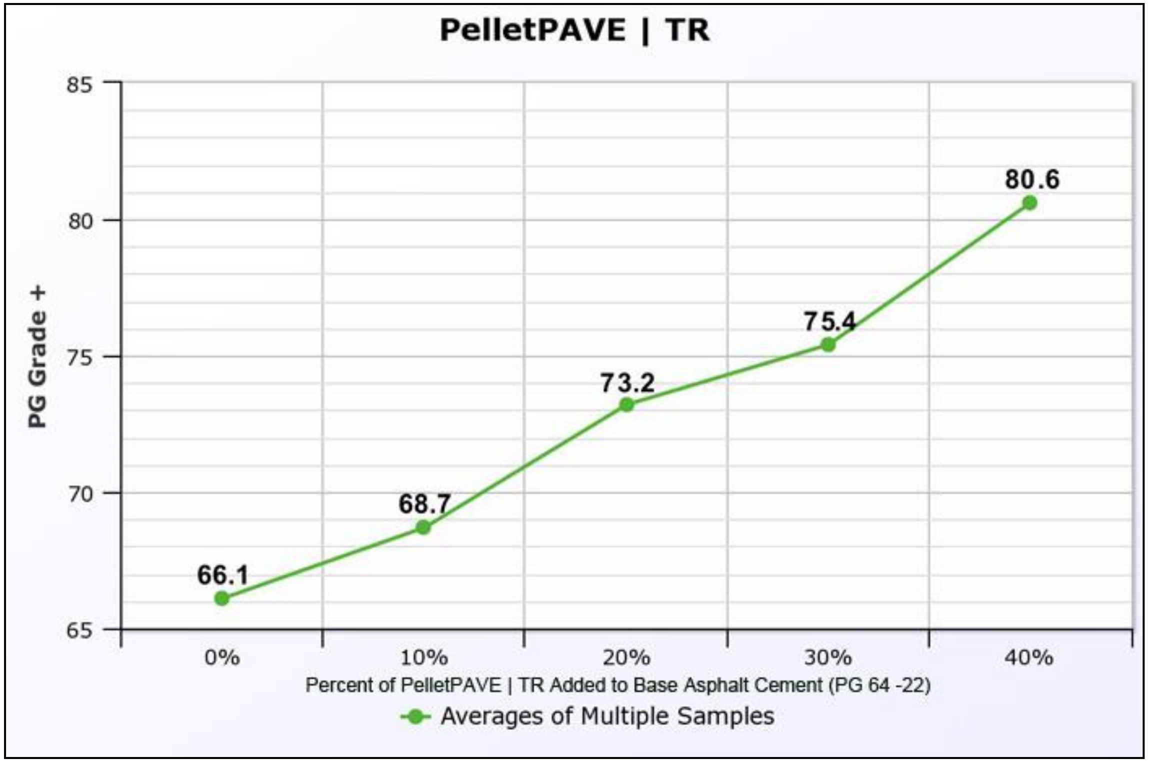
Used as an alternative for terminal blended type rubber modified binders. This product is a specifically formulated PG 64 -22 binder with SBS polymer and 12% - 15% of a fine ground tire rubber powder. It is typically used to enhance the performance of dense graded mixes.

Application Rate

(by weight of total binder)

SMA 20% - 30%

Dense 10% - 20%



Note: DSR gap 1mm

The Next Generation Dry Process Technology

Dry Mix Delivery Systems

- Shifts from binder testing to mix testing
- Driven by state agencies moving to Balanced Mix Design (BMD) specifications

What is the Dry Process?

Historic Dry Process - too many variables caused problems.

- Viewed as part of the aggregate structure
- Large particle size to complement traditional aggregate (8 mesh)
- Dosed at very high rates (3% of total weight or 400 lbs/ton)

Today's technology:

- Pelletized Binder
- Rubber is engineered or pre-swelled and reacted prior to delivery. Finished product co-mingles with binder when it's added to the mix onsite.
- Lower rubber content to match other modified asphalt systems (~10% by weight of binder)
- Finer rubber gradation to ensure full absorption of binder into rubber before placement (~30 mesh, a 20 minus)
- Rubber can act as a vehicle for other additives that are beneficial to the performance of the mix – ie: latex, liquids, anti-strip & warm mix technologies.
- Can be used with standard mix designs

Mix Additives - ECR, RARX™, and SmartMIX™

- Engineered Crumb Rubber (ECR) - Rubber mixed and treated with additives used in asphalt providing multiple benefits to the mix producer.
- RARX, SmartMIX, Hybrid Wet/Dry– binder or extender oil pre-mixed with rubber at wet process time and temp, mixed with powder flow agent additives, cooled down and packaged and handles like a dry rubber powder at the mix plant.

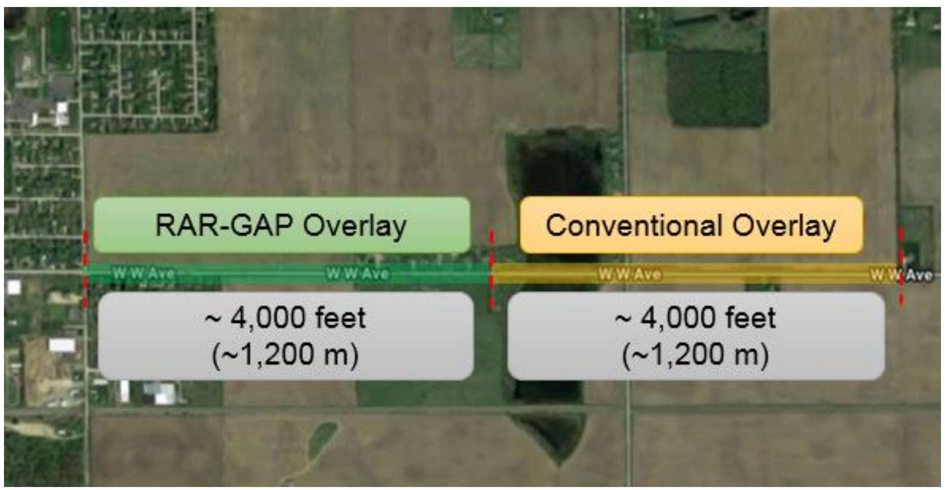
RAR X™

Enhanced Elastomeric Asphalt Extender

Demonstration Project

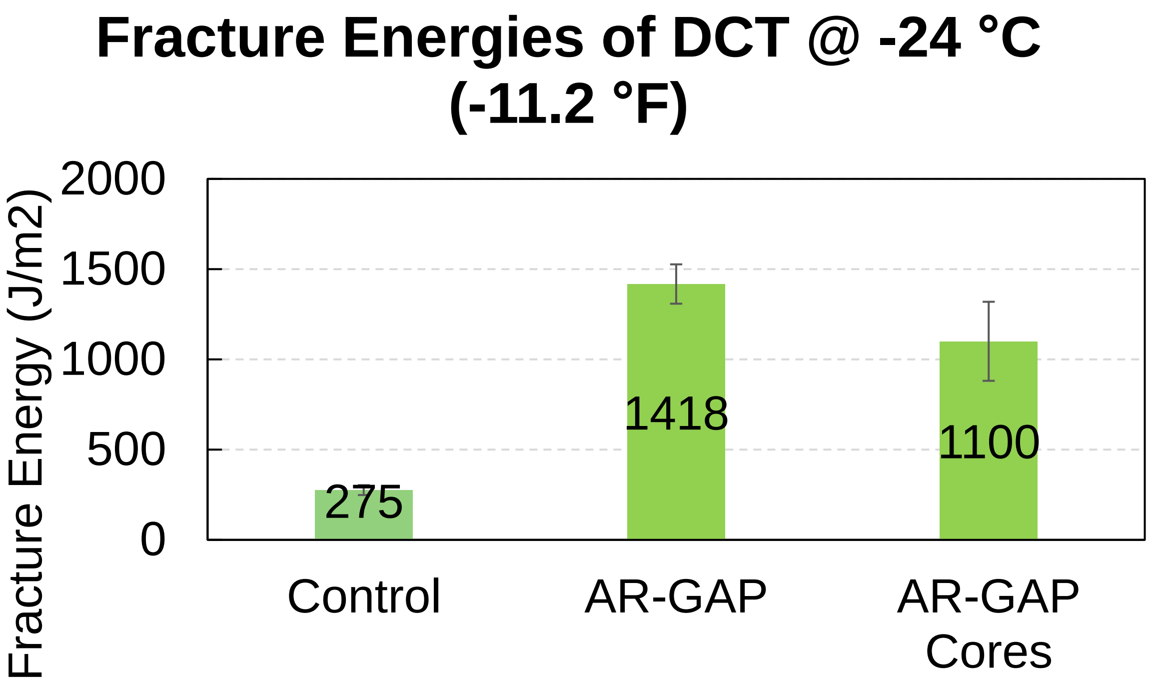
Michigan Technological University

- 1.5 miles (2.4 km) section, Kalamazoo, Michigan
  - RAR-GAP Overlay Dosed at 4.5%
  - Conventional overlay



Experimental Program
Low Temperature Cracking Test

- 4 to 5 times higher fracture energy than control mix

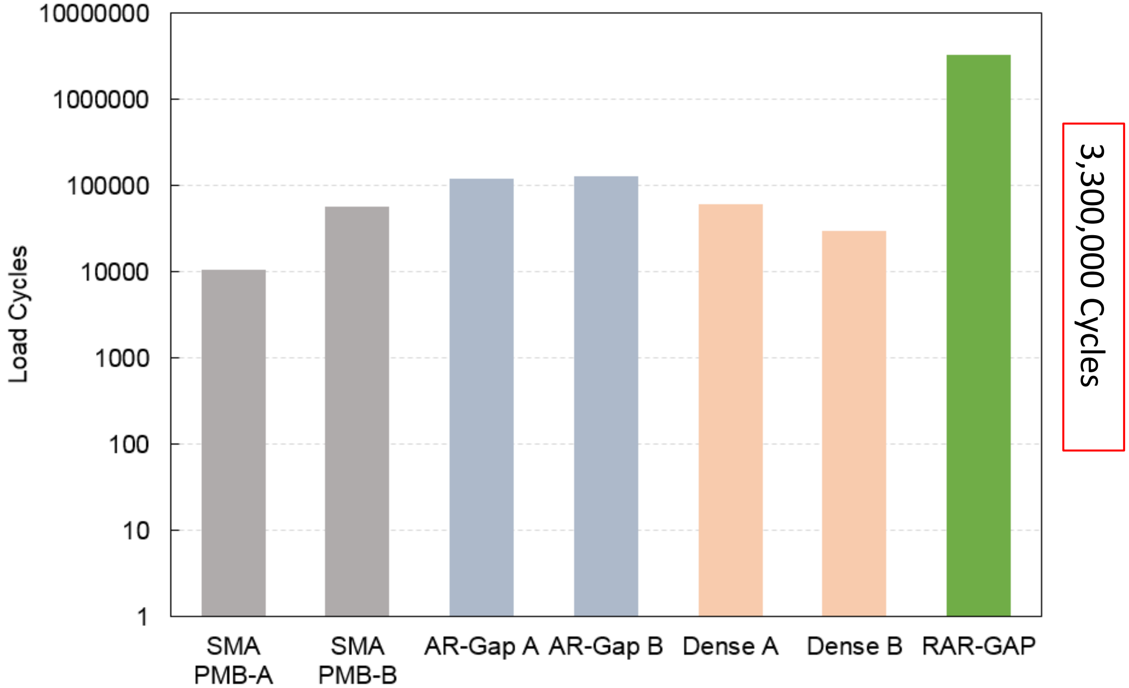


DCT Sample

LIBERTYTIRE.COM
(412) 926-1700

Experimental Program
Flexural Fatigue Test (AASHTO TP8)

- Excellent fatigue cracking resistance



SMA PMB – Polymer Modified SMA Mix
AR-Gap – Wet Process Asphalt Rubber Gap Mix
Dense – Dense Gradation Mix
RAR-GAP – RAR Modified Gap Mix

RARX™ in a Hot Applied Chip Seal

- Pre-reacted rubber may eliminate storage and hauling of rubberized binders from terminals.
- Can lower viscosity and potentially increase rubber contents.

Acknowledgements

DEQ Department of Environmental Quality

Michigan Technological University 1885

Road Commission of Kalamazoo County

RAR X™ Enhanced Elastomeric Asphalt Extender

Rubber Metering at Plant

https://www.youtube.com/watch?v=eclzBIqAsUU
https://www.youtube.com/watch?v=9n8TpYeV7Uo
https://www.youtube.com/watch?v=VJm8VHNHYak

Project Facts

- Mixtures compliant with MDOT Superpave 3E1, 4E1, and 5E1 Mixes (standard dense grade highway mix with design life of 1 million Equivalent Single Axle Load (ESALs)).

- Mixtures contain 33% RAP

- Binder in mixes unmodified PG 58-28

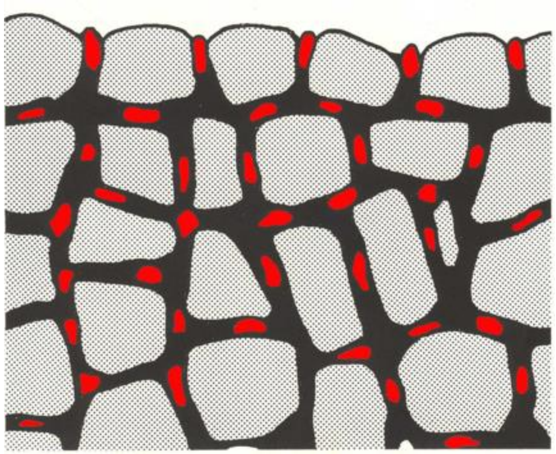
After 5 Winters, Regular Section Cracking, Few Cracks in Lake Lansing Road

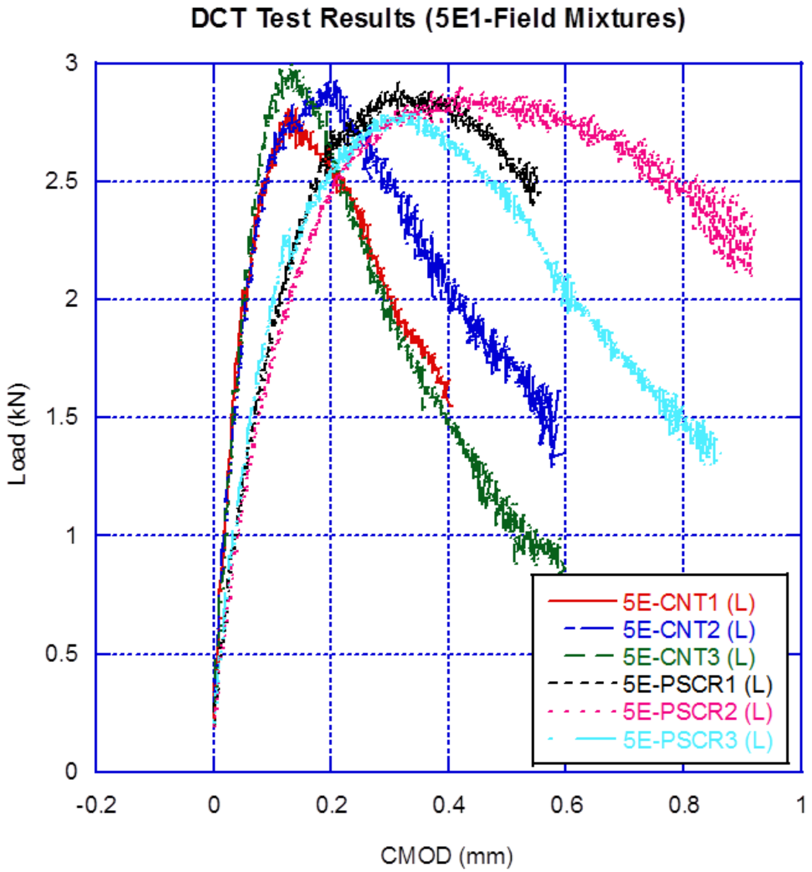
Project Images from May 2021 (6 years in place)

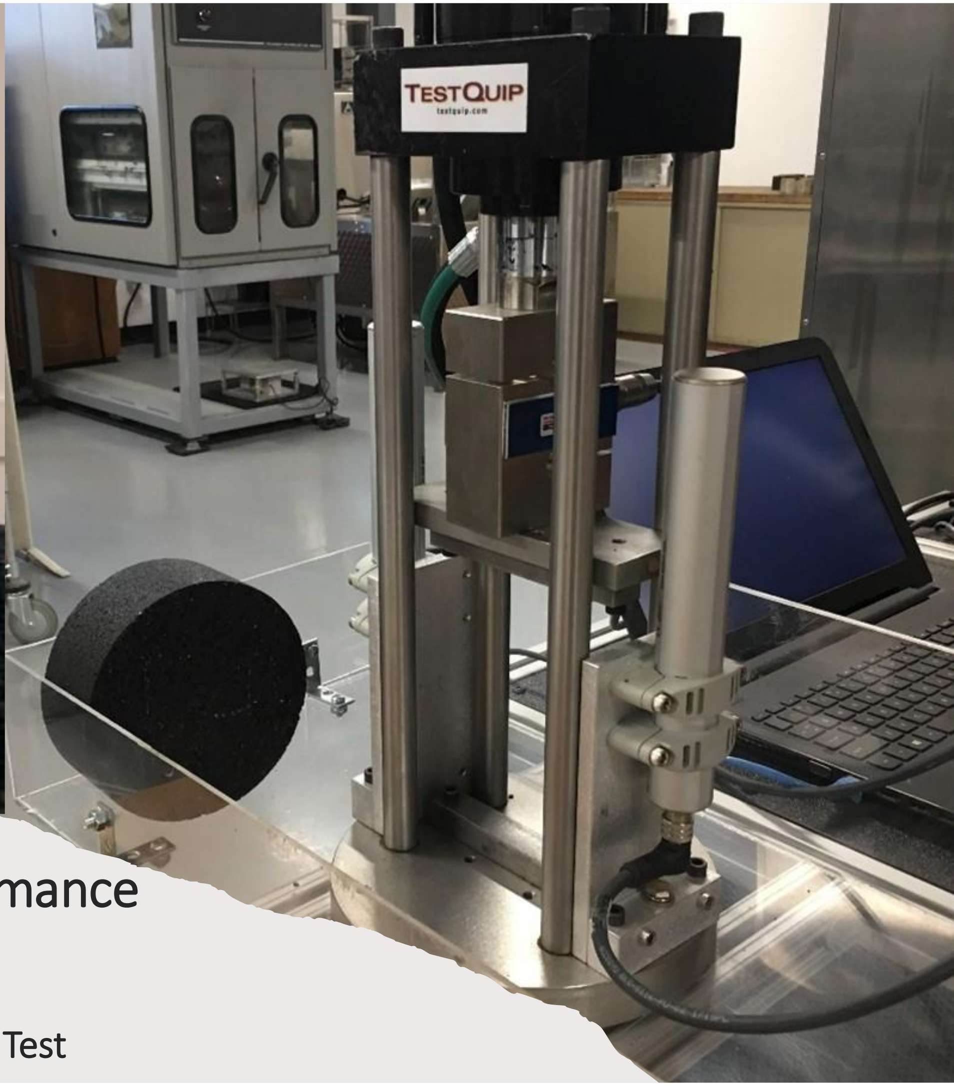
- Darker color in PSCR due to tire rubber and carbon black
- Darker potentially due to higher maltene content
- Maltenes are lost as asphalt ages, PSCR adds Maltenes

Cracks Take Longer To Propagate Through SmartMIX™

The strength of PSCR mixtures were almost the same as control mixtures, which means that the load required to initiate cracks in both mixtures are about the same. However, the required energy for propagating the crack has increased in the PSCR mixtures. So, the resistance against cracking has been improved in the new PSCR mixtures.







Balanced Mix Design – Tests mix for performance related to rutting and cracking resistance.

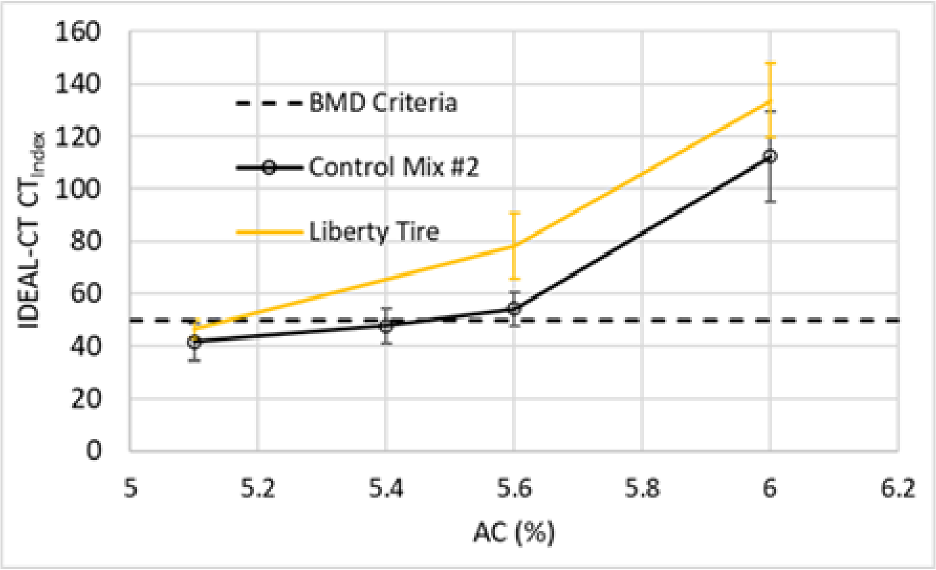
Rutting - ALDOT 458 Hot Indirect Tensile Test

Cracking - Modified IDEAL-CT, ALDOT 459 Alabama Cracking Test

Coffee County, AL
County Rd 110
Oct 2020

- First County Project using SmartMIX™ in Balanced Mix Design Specification
- Balanced Mixes compared to Superpave Mix for control
- BMD mixes the same except one with SmartMIX™
- BMD mixes with 35% Recycled Asphalt Pavement, Superpave 20% RAP

IDEAL-CT Results



- Control Mix –AC =5.6%; CT_{Index}=54
- Selected AC for SmartMix =5.6%
- 12% SmartMIX added by weight of total binder
- SmartMIX CT_{Index}=78

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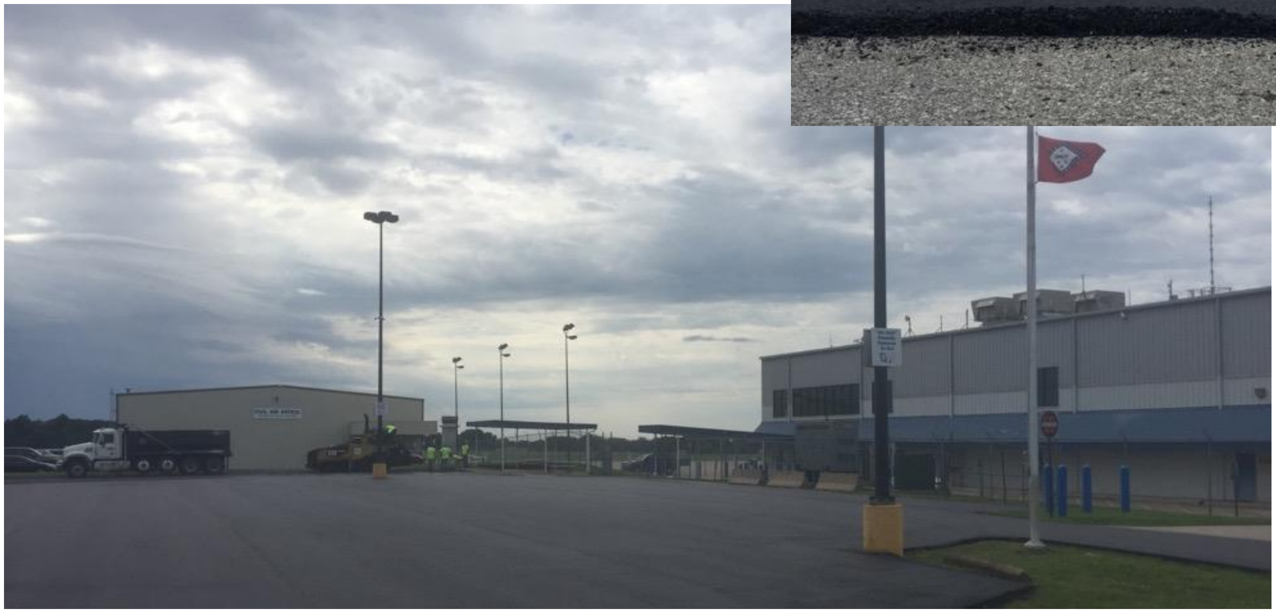
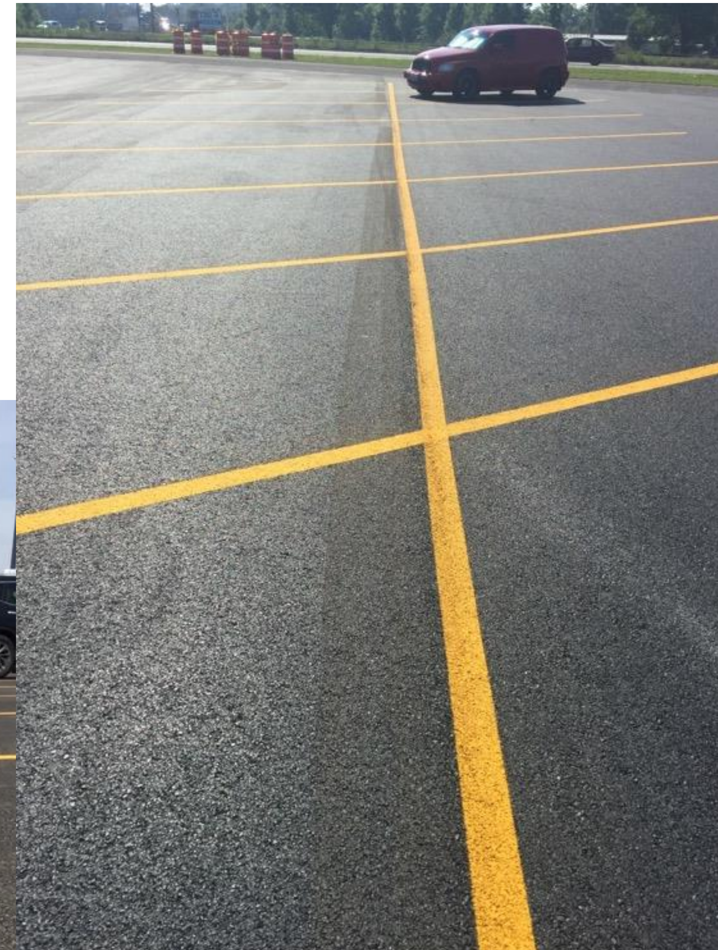
Overlay
Application: Parking Lot



Placed July 13, 2017

The use of Next Generation Dry Process allows parking lot facility owners a cost-effective path toward sustainability

August 25, 2017



The Benefits of Next Generation Dry Process

COST-EFFECTIVENESS

- Performance comparable to polymer modified mixes, but with a **lower cost**.
- Can be used with Warm Mix technology.
- Beneficially **recycles** one scrap tire per ton of mix in minimum dosages.
- Can be shipped to any mix plant and its use controlled with on/off switch, meaning that there are **never any wasted materials**.

DURABILITY

- **Passes Hamburg rutting and moisture resistance tests.**
- Has improved low temperature **crack resistance**.

EASE OF USE

- NGDP is added directly to a mix plant **eliminating the need for modified binder storage**
- Mixes can be transported and **placed with normal paving equipment**.
- Does **not require any changes** to standard mixes in min dosages.
- Typically has **better mix workability** than wet processed rubber.
- Allows for more **rapid compaction** than normal asphalt mixes.

For more information, contact:

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