Recycled Tires in Asphalt Mixtures and Other Civil Engineering Applications

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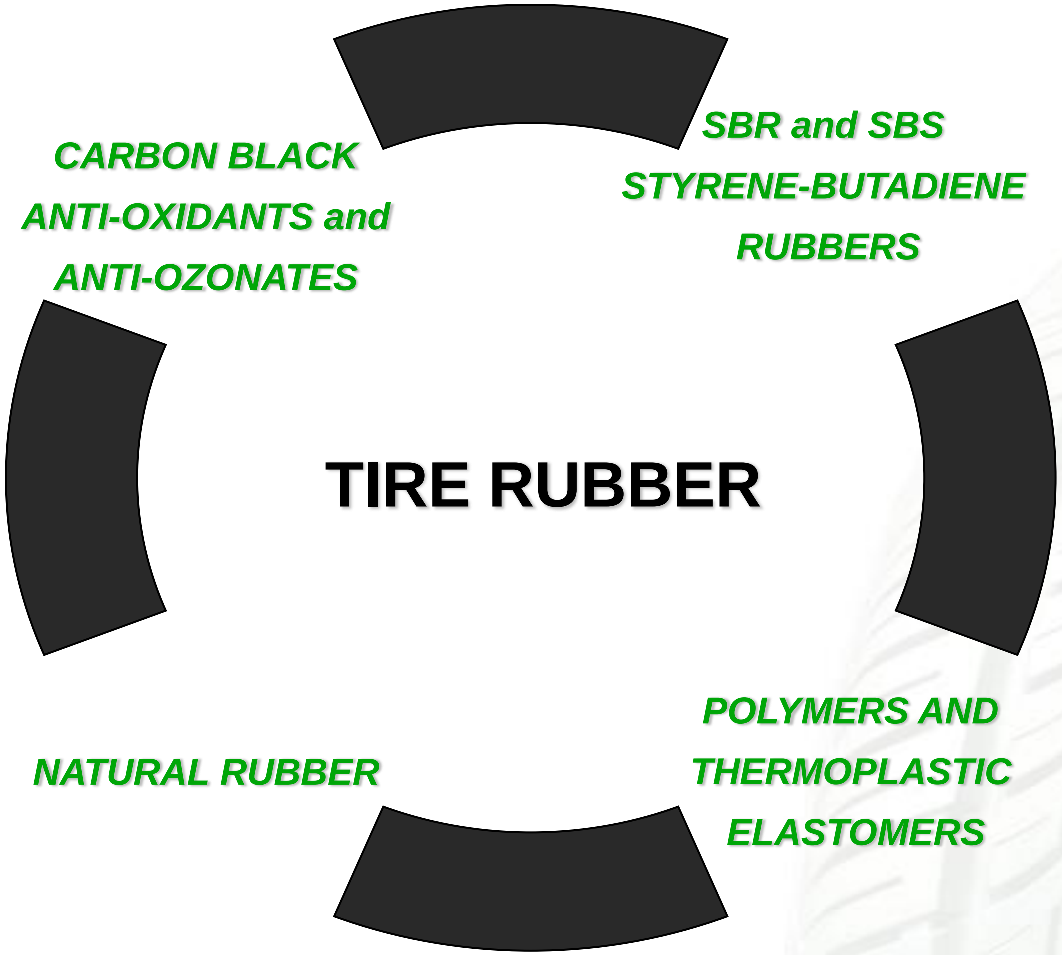
Mid-Atlantic Asphalt Expo & Conference
Dec 07, 2023

About Liberty Tire

Recycled Tire Rubber Composition – Good Stuff for Roads!



Infrastructure Opportunities

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

Carbon Management

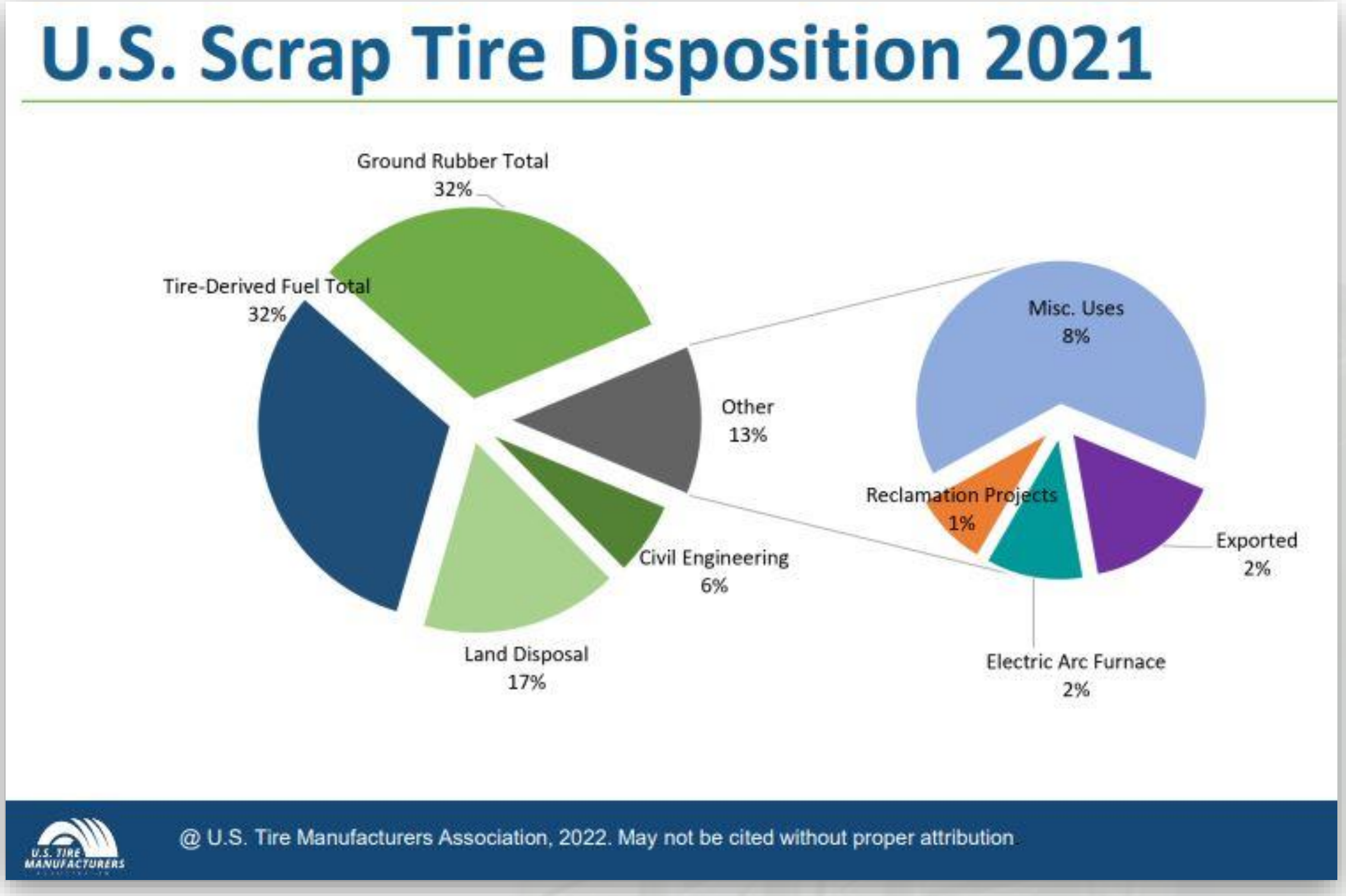
- Recycling rubber tires means that millions of scrap tires are no longer dumped in landfills or along the side of the road and in sensitive habitats. Instead, **more than 90 percent of these tires are being recycled and reused annually**
- Recycling saves impressive amounts of energy, which ultimately 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
- US EPA Warm model provides a **reduction (0.38) $MTCO^2$/MT** of RTR when used as a component of a new material.

Presentation Outline

- A look at Tire Processing and Markets
- Old School Rubberized Asphalt is OK – Wet Processes, Field Blend or Terminal Blend
- Innovations in Next Generation Dry Process
  - » Pelletized Rubber Modified Binder
  - » Engineered Crumb Rubber
  - » Reacted Rubber Particle Technology - SmartMIX™
- Balanced Mix Design (BMD)
  - » Test Sections at NCAT, MnRoad
  - » ALDOT 458 Hot Indirect Tensile Test and modified IDEAL-CT, ALDOT 459 Alabama Cracking Test
  - » Use more Reclaimed Asphalt Pavement (RAP) and Recycled Tire Rubber (RTR)
- Coffee County, Alabama, County Road 110 Project using BMD

Recycled Rubber Products and End Uses

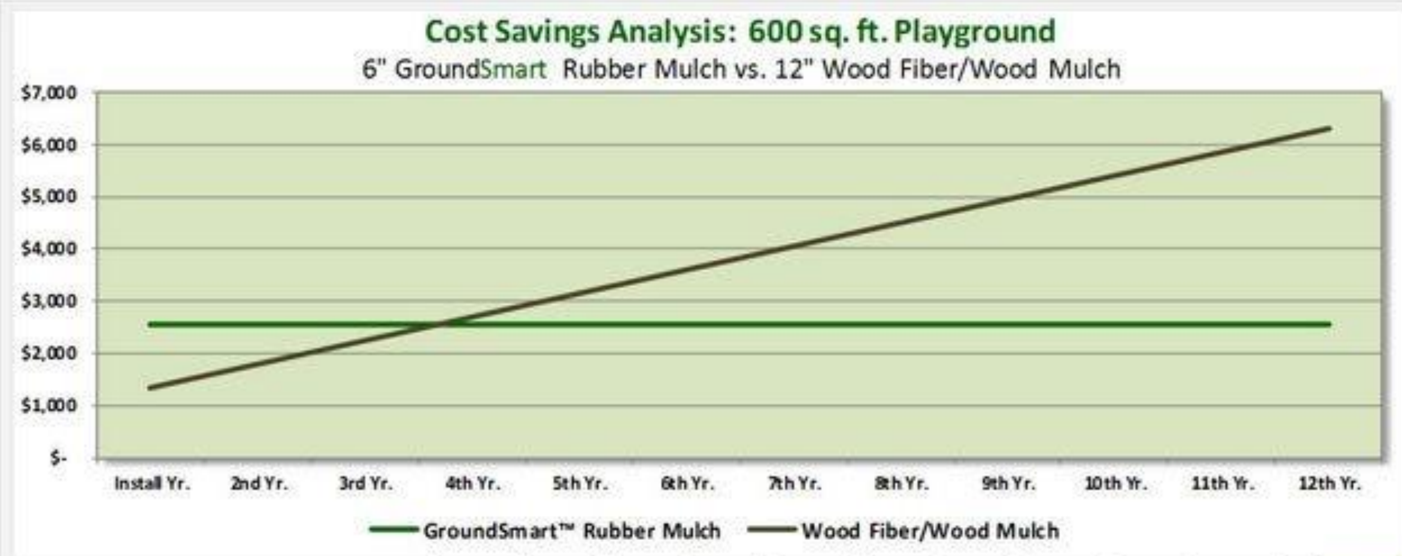
- Sports Surfacing
  - » Synthetic turf infill
  - » Running tracks
  - » E-layers
- Playgrounds/Mulch
  - » Retail
  - » Loose fill playgrounds
  - » Poured-In-Place surfacing
- Asphalt
  - » Rubber modified asphalt
  - » Crack sealants
- Molded/Extruded Products
  - » Compression molded and extruded products
- Automotive & Export



TDF

- Industry Consolidation
- Regulatory Impact
- Facility Maintenance
- Use of Coal
- Cost of Alternatives
- Grandfathered Permits

Mulch

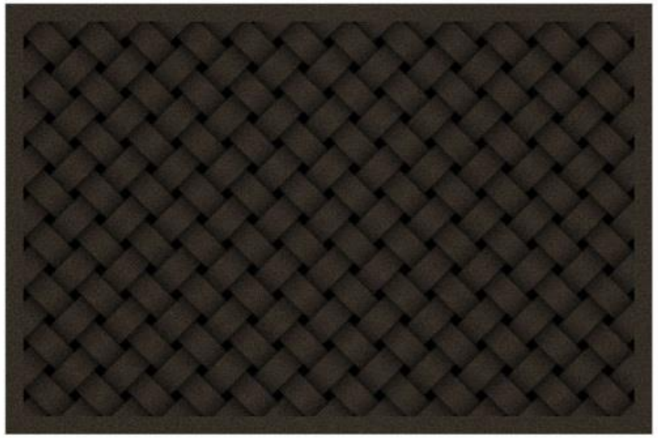


	Install Yr.	2nd Yr.	3rd Yr.	4th Yr.	5th Yr.	6th Yr.	7th Yr.	8th Yr.	9th Yr.	10th Yr.	11th Yr.	12th Yr.	Total
GroundSmart™ Rubber Mulch	$ 2,564	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ 2,564
Wood Fiber/Wood Mulch	$ 1,350	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 450	$ 6,300
GroundSmart™ Savings "Dollars"	$ (1,214)	$ (764)	$ (314)	$ 136	$ 586	$ 1,036	$ 1,486	$ 1,936	$ 2,386	$ 2,836	$ 3,286	$ 3,736	$ 3,736
GroundSmart™ Savings "Percent"	-89.9%	-42.5%	-14.0%	5.0%	18.6%	28.8%	36.7%	43.0%	48.2%	52.5%	56.2%	59.3%	59.3%

- Steady growth (slow)
- LCCA Economic benefits realized
- Efficiencies in market place
- Cost

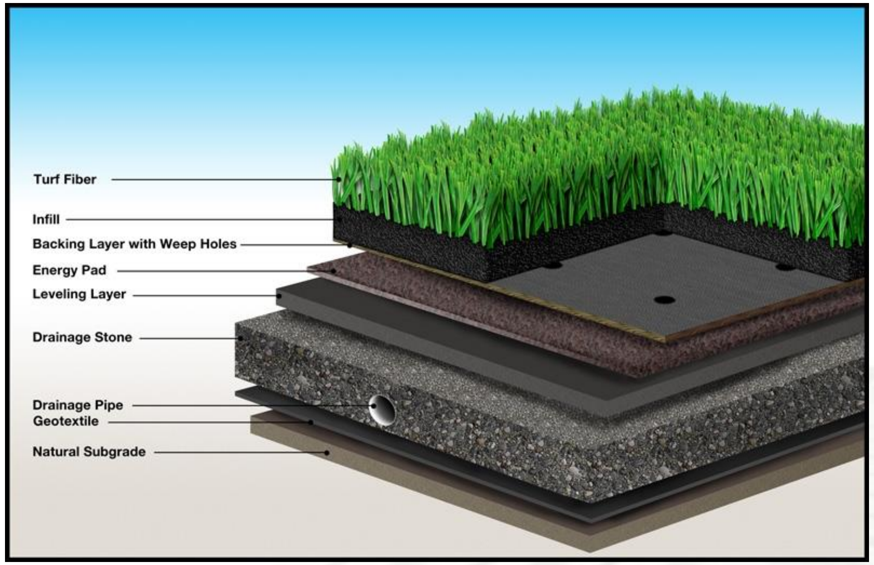
Industrial/Molded Products

- More niche markets discovered daily
- Suppliers more savvy to specifications and previou experiences
- Small volume projects
- Tire rubber physical properties beneficial



Turf

- 15 years of steady growth
- Toxicology scare
- 90 plus scientific studies indicating non toxic
- Longterm use of recycled tire rubber in other markets without incident
- High exposure in tire manufacturing, retail, recycling, and general public without incident
- Reclaim and reuse of old rubber
- Alternative fill materials
- ~250,000 pounds per field



Tire Recycling Process

- Scrap tires generated at tire dealers/shops
- Haulers contract to pick up and dispose, or deliver to recycling facility.
- Recycling facilities process tires to fill available markets.

Images Courtesy of Entech Rubber

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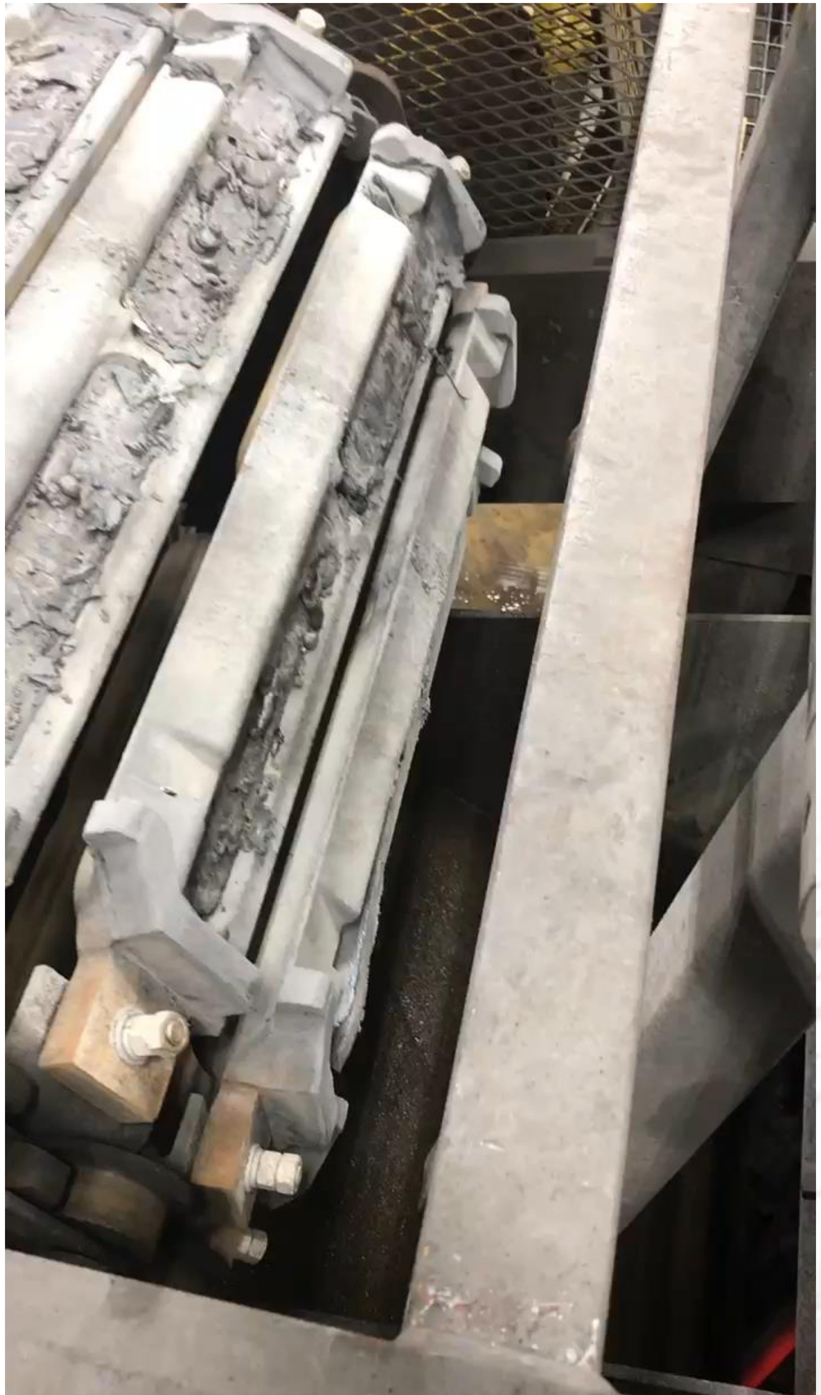


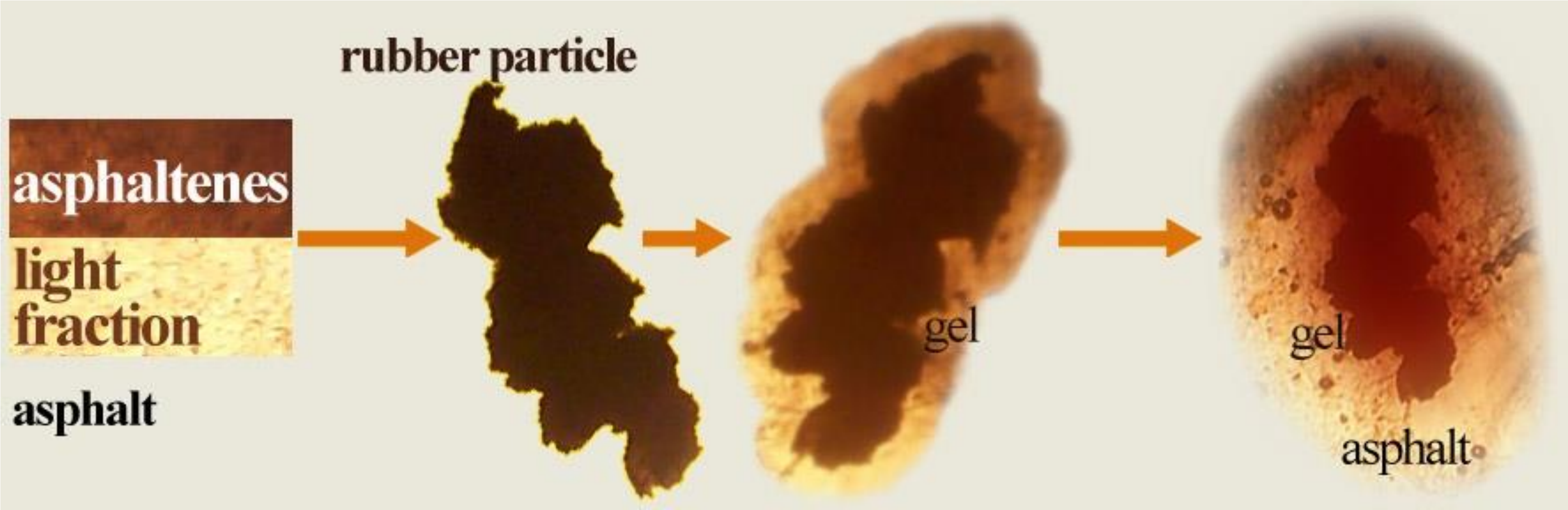
Images Courtesy of Entech Rubber

Liberty
TIRE RECYCLING

Old School Wet Process

There is Science in Everything!

The Wet Processes Reaction



Rubberized binder specifications:

1. Require 45 min to 4 hour cooking time until the rubber “Gels and Swells”,
2. Have viscosity limits (if too thick, can’t pump, spray or coat aggregate),
3. Need heated and agitated storage tanks,
4. **Benefits - the binder can be tested prior to use and can be successful if industry mfg and supply chain is set up to handle particulate binder systems.**

Mobile Blending Equipment Is Great, If You've Got It.

Evaluation of Ground Tire Rubber in Asphalt Binders and Mixtures

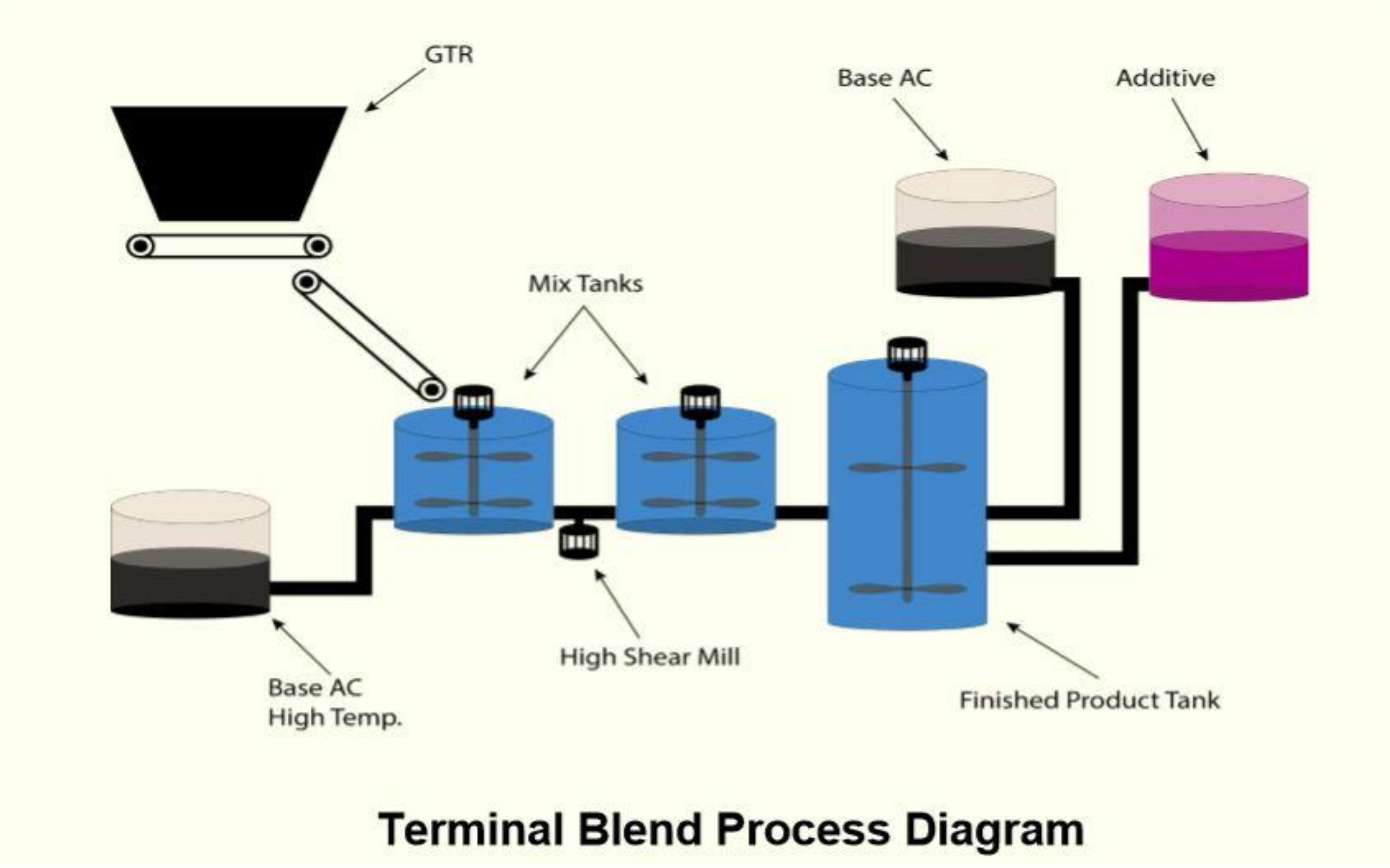
Liberty
TIRE RECYCLING

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

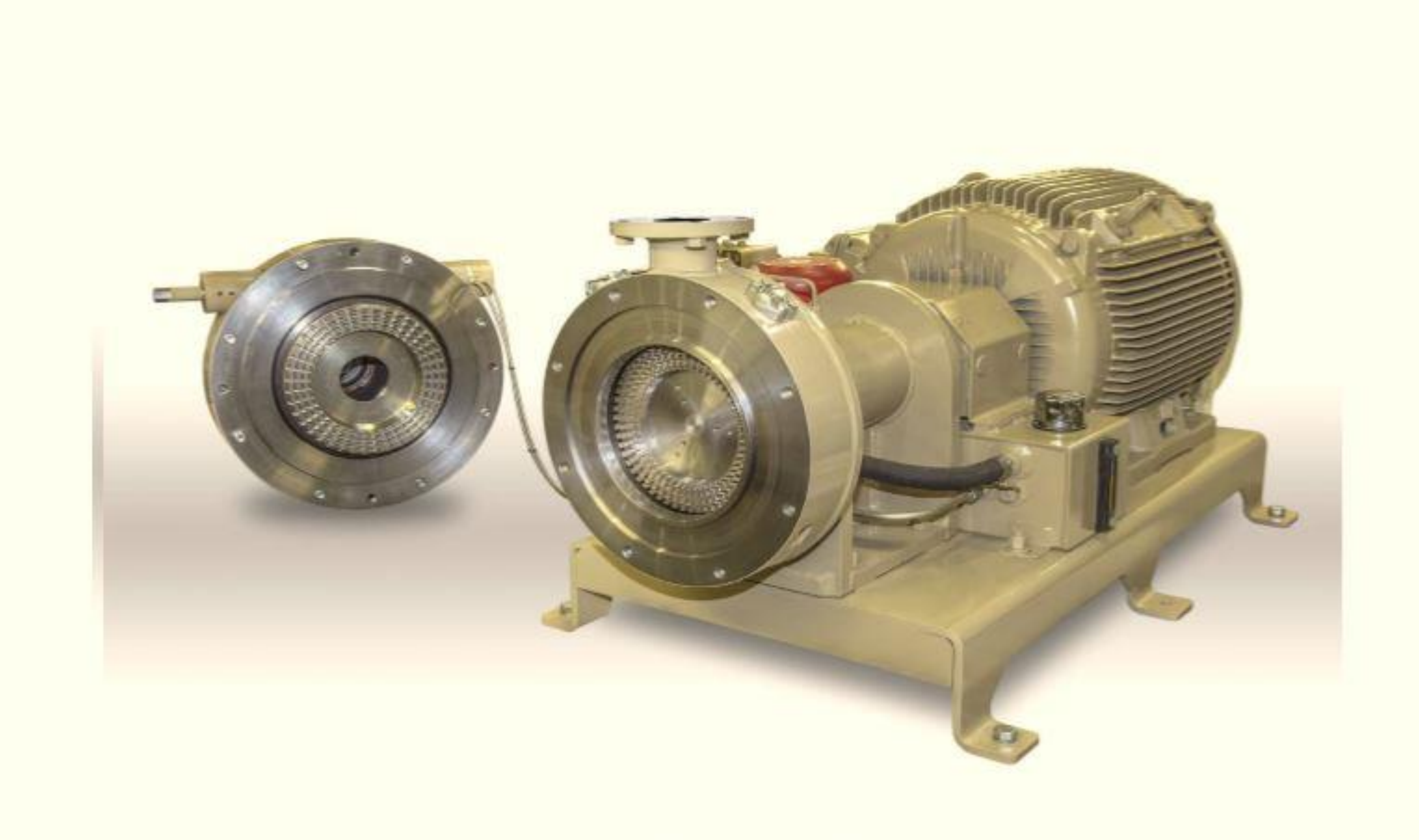
PG Results

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



High Shear Mill



Types of Mixers

Tanks require mixers - Low shear tank mixer

Wetting Can High Shear Mixer

Example of Trial Rubber Binder Design

		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

Project :	np
Tests on Original Asphalt	
Apparent Viscosity at 135°C, Pa-s	
Flash Point, °C	
Elastic Recovery, 77°F, %	
Softening Point, °F	

		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

	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
est Method	Spec	
ASHTO T316	3.0 max.	*5.58
ASHTO T48	232 min.	(1)
STM D6084	65 min.	78
ASHTO T53	135 min.	143

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)

A Rubber Blending System at a Terminal - Needs dedicated storage tanks down stream

WARM TECHNOLOGY
Spray Applied

Next Generation Dry Process – What is it?

- Old dry process worked on some occasions, but too many variables caused too many problems.
- New systems have:
  - » **Lower rubber content** to match other Performance Grade modified asphalt systems ~10% rubber by weight of binder
  - » **Finer rubber gradation** ~30 mesh to ensure faster absorption of binder into rubber before placement (some require 45 minutes before paving)
  - » **Beneficial additives** with rubber – Engineered Crumb Rubber
  - » Can be used with **standard mixes**

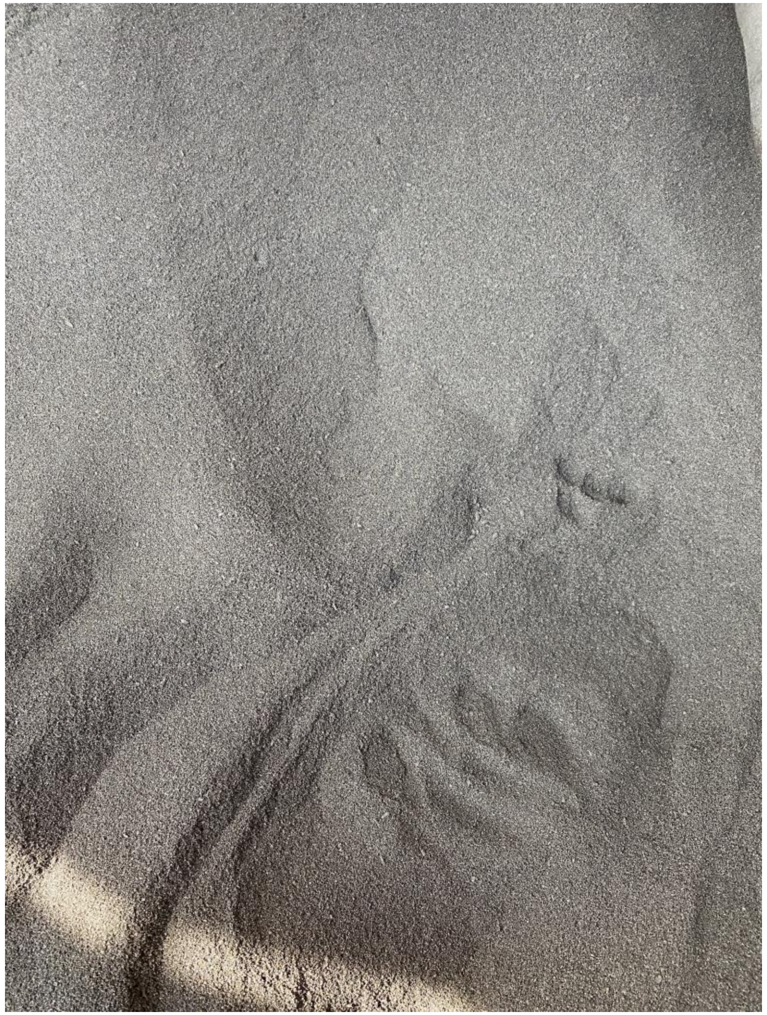
Next Gen Mix Additives – ECR, PelletPave, RARX, and SmartMIX™

- Engineered Crumb Rubber (ECR) - Rubber mixed and treated with additives used in asphalt providing multiple benefits to the mix producer.

- Pelletized Rubber Binder – Terminal Blend, pelletized, added with RAP

- Reacted Rubber Particle Technology – (RARX, SmartMIX™) binder or extender oil pre-mixed with rubber at wet process time and temp, mixed with anti-strip powder additives, cooled down and packaged. Handles like a dry rubber powder at the plant.

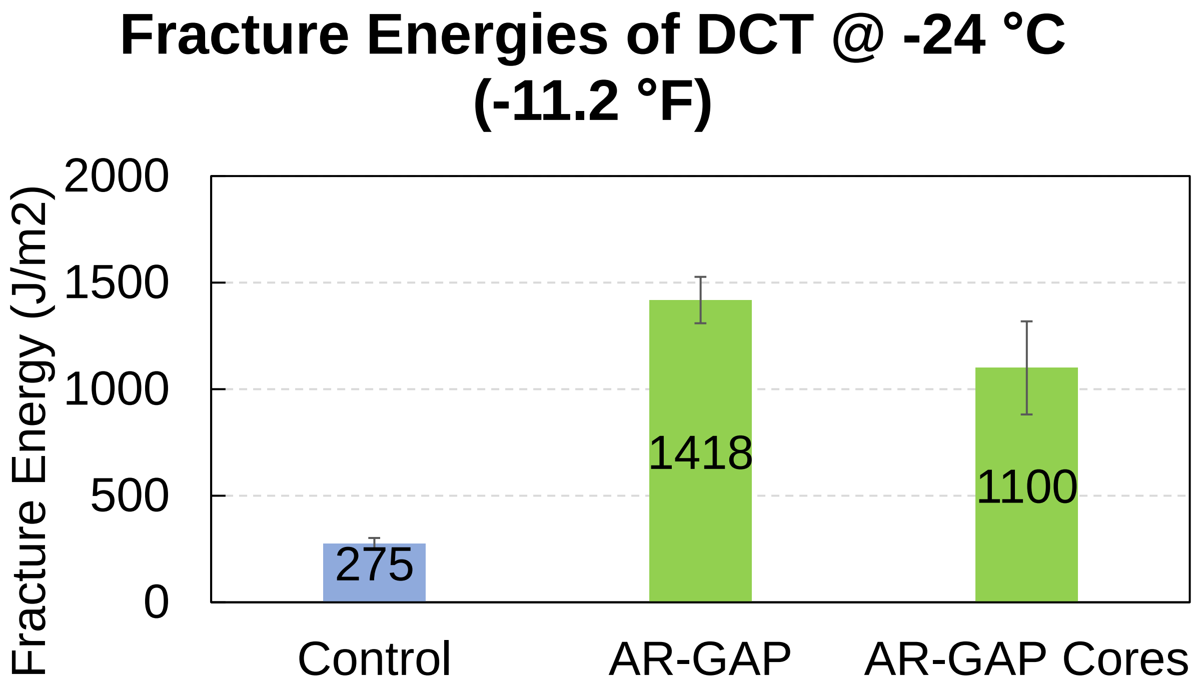
A Type of ECR – "TOR" Liquified and Coated Onto Rubber for Greater Homogeneity



RAR X™

Enhanced Elastomeric Asphalt Extender

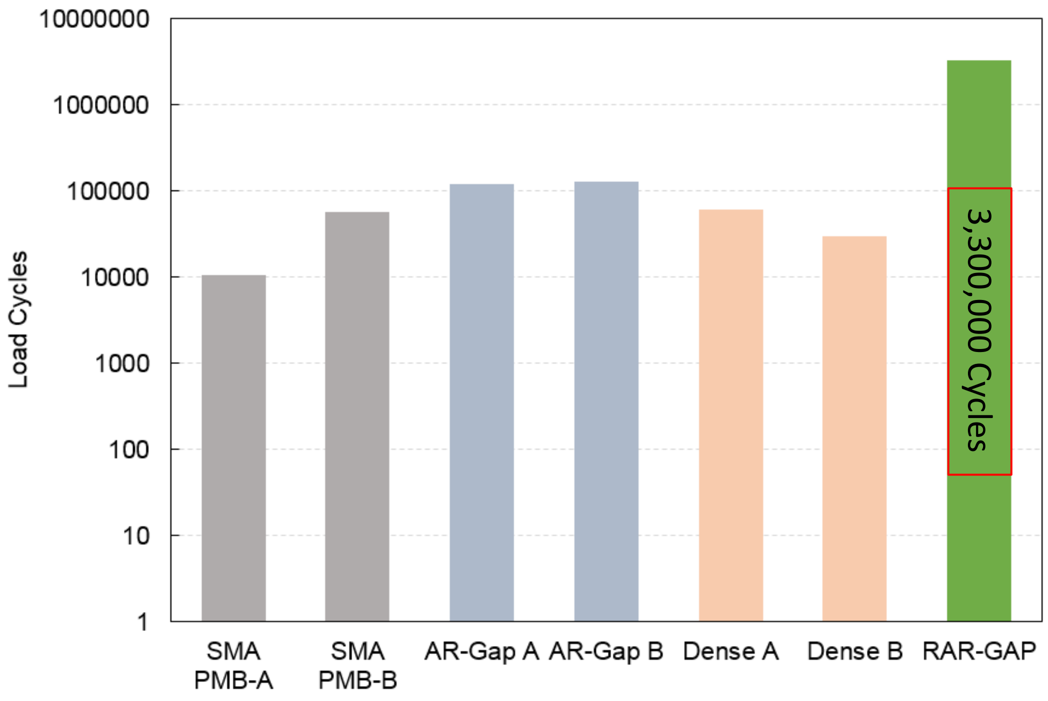
Experimental Program
Low Temperature Cracking Test

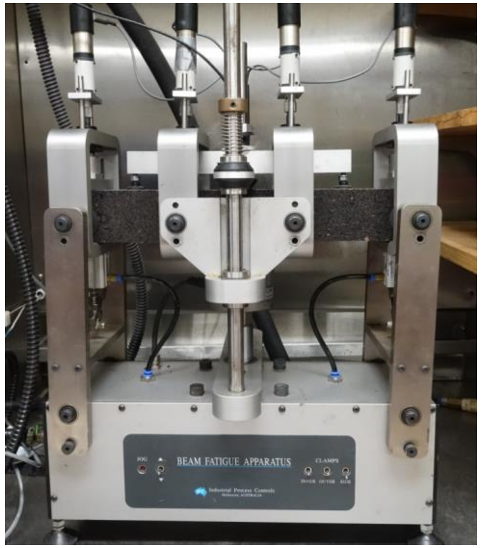


DCT Sample

- 4 to 5 times higher fracture energy than control mix

Experimental Program
Flexural Fatigue Test (AASHTO TP8)





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

- Excellent fatigue cracking resistance

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.

Warm Mix Wax Treated Rubber

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

Kenny Road 2017 (One Year)

Phoenix Industries PelletPAVE Technology - Pelletized Rubberized Binder

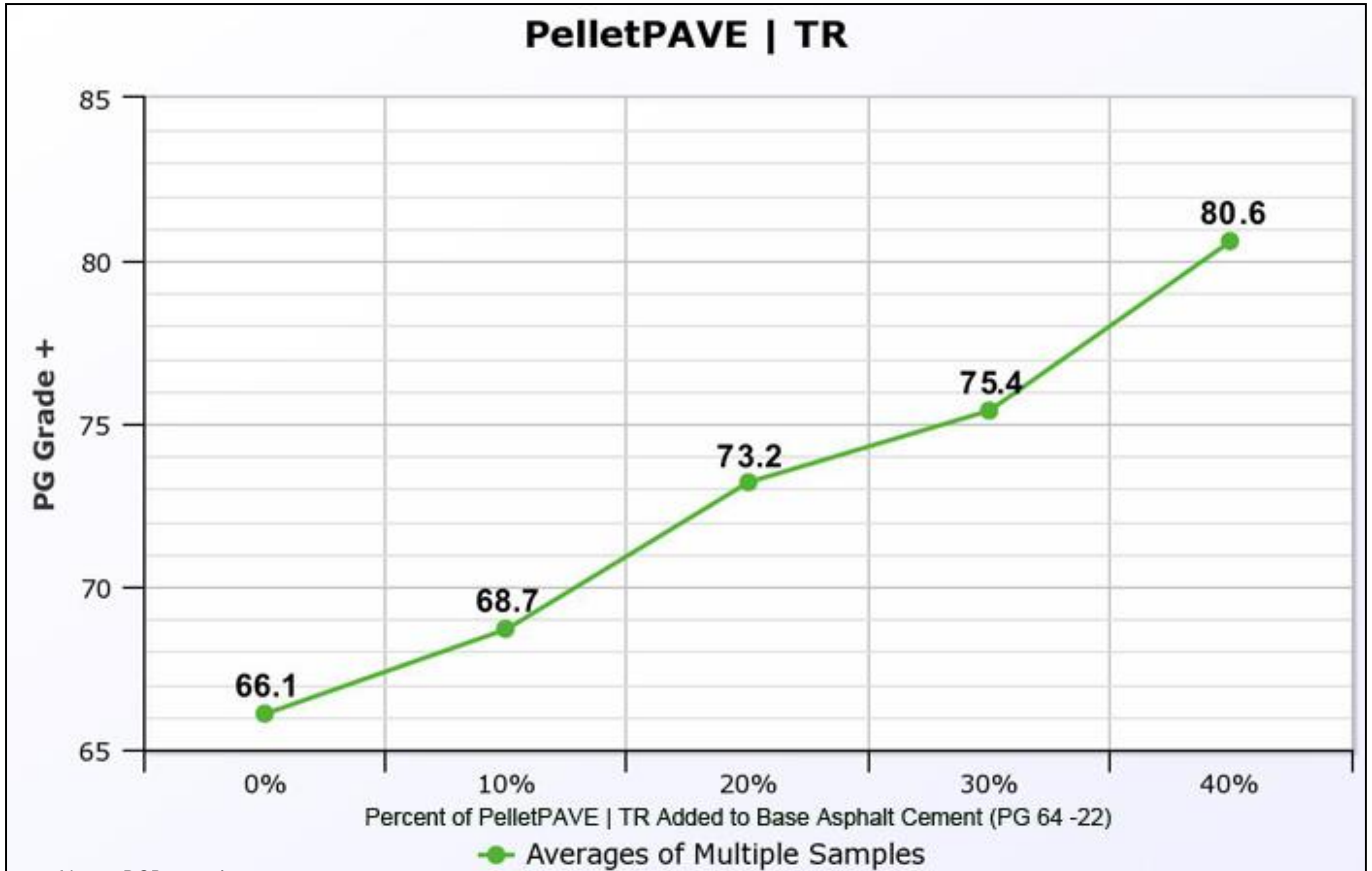
*Pellet*PAVE | TR

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

What is SmartMIX™?

- SmartMIX™ pre-treated recycled tire rubber (RTR) is a dry, free-flowing rubber for **direct addition to asphalt mixtures** at the mix plant via the recycled asphalt stream.
- Its use is controlled with on/off switch at the mix plant, meaning that there are **no wasted materials**.
- SmartMIX™ is a pavement properties enhancer, **NOT a binder modifier.**
- Use of SmartMIX™ will yield a pavement competitive to one made with polymer modified binders with **similar or better properties at a lower cost**.

SmartMIX™ is **patented technology** for asphalt mix formulations.

SmartMIX™ is easily added at the mix plant.

Lake Lansing Road Pilot Validation of SmartMIX™

Similar mixes placed in 2015, with and w/o SmartMIX™

Photos from
May 2021

Mixes contain
33% RAP

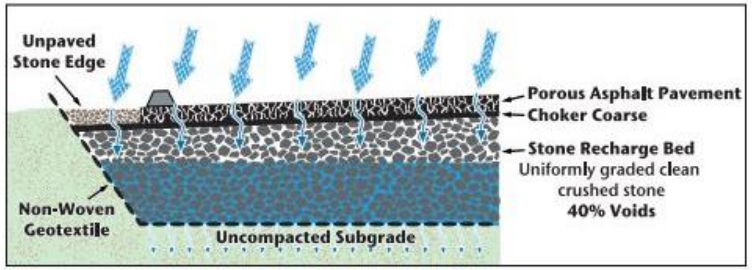
Lake Lansing Project Image from May 2021

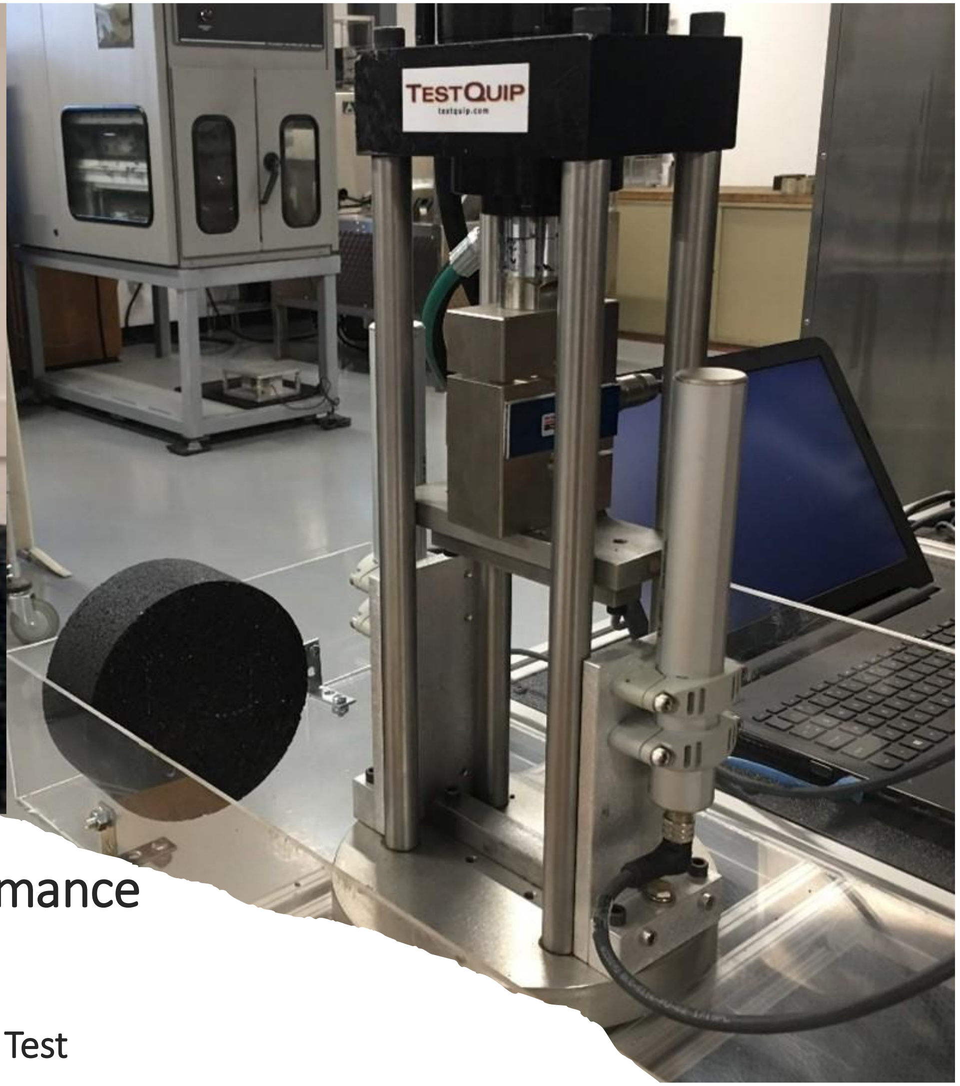
- Darker color in SmartMIX™ due to tire rubber and carbon black
- Darker potentially due to higher maltene content from extender oil
- Maltenes are lost as asphalt ages, SmartMIX™ adds Maltenes

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





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

The Alabama County Experience With BMD

The BMD mixtures contained 35% RAP (compared to 20% RAP for the Superpave mix designs).

BMD mix had higher total binder contents, between 0.5% and 0.75% more asphalt compared to Superpave.

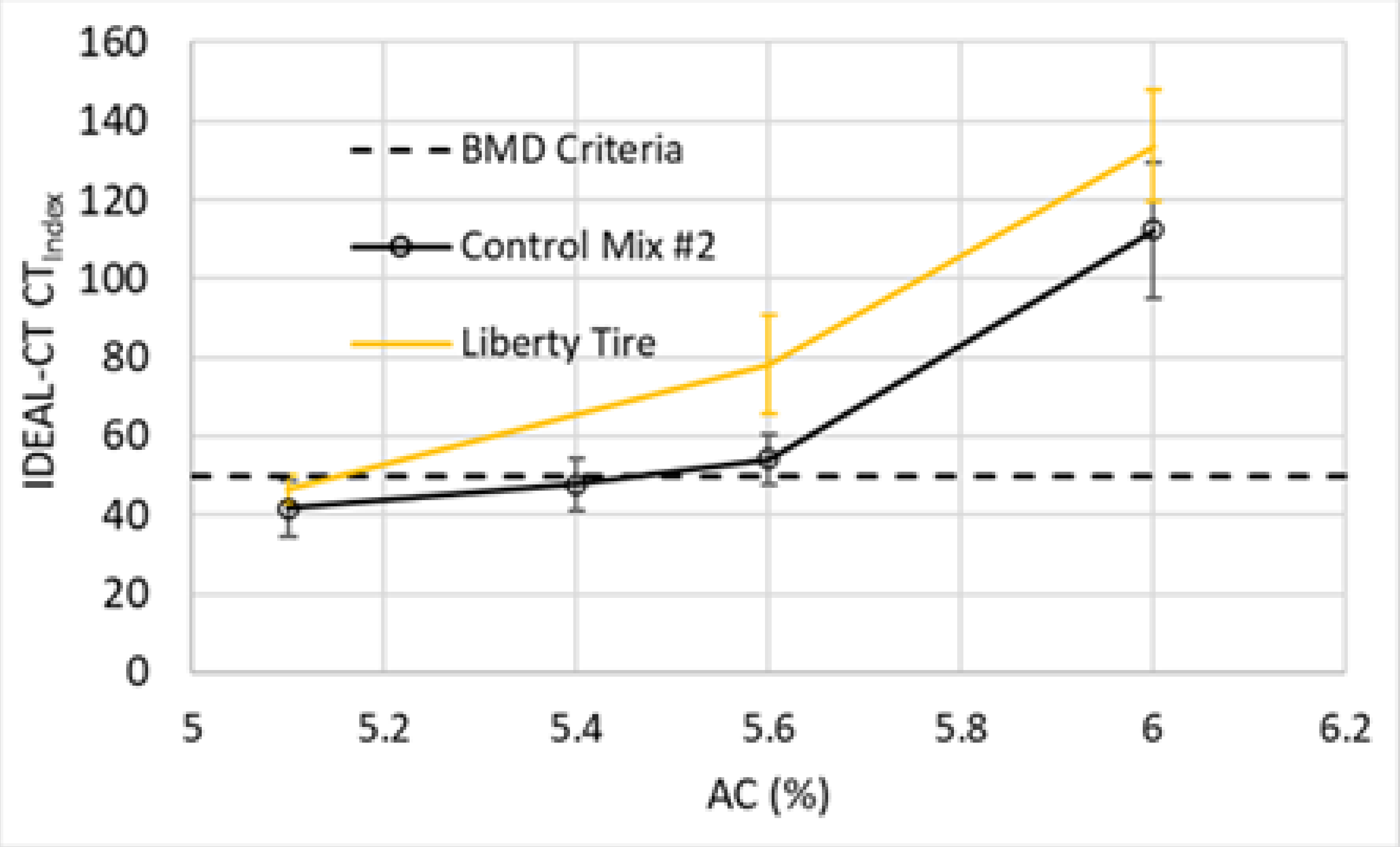
In 2020 the bid price was 6% lower than comparable Superpave mixtures within the same work year.

It is expected that the overlays will have a longer service life based on observations during laydown and early performance assessments.

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

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

County Road 110 - Maximizes Sustainability

Beneficial reuse:

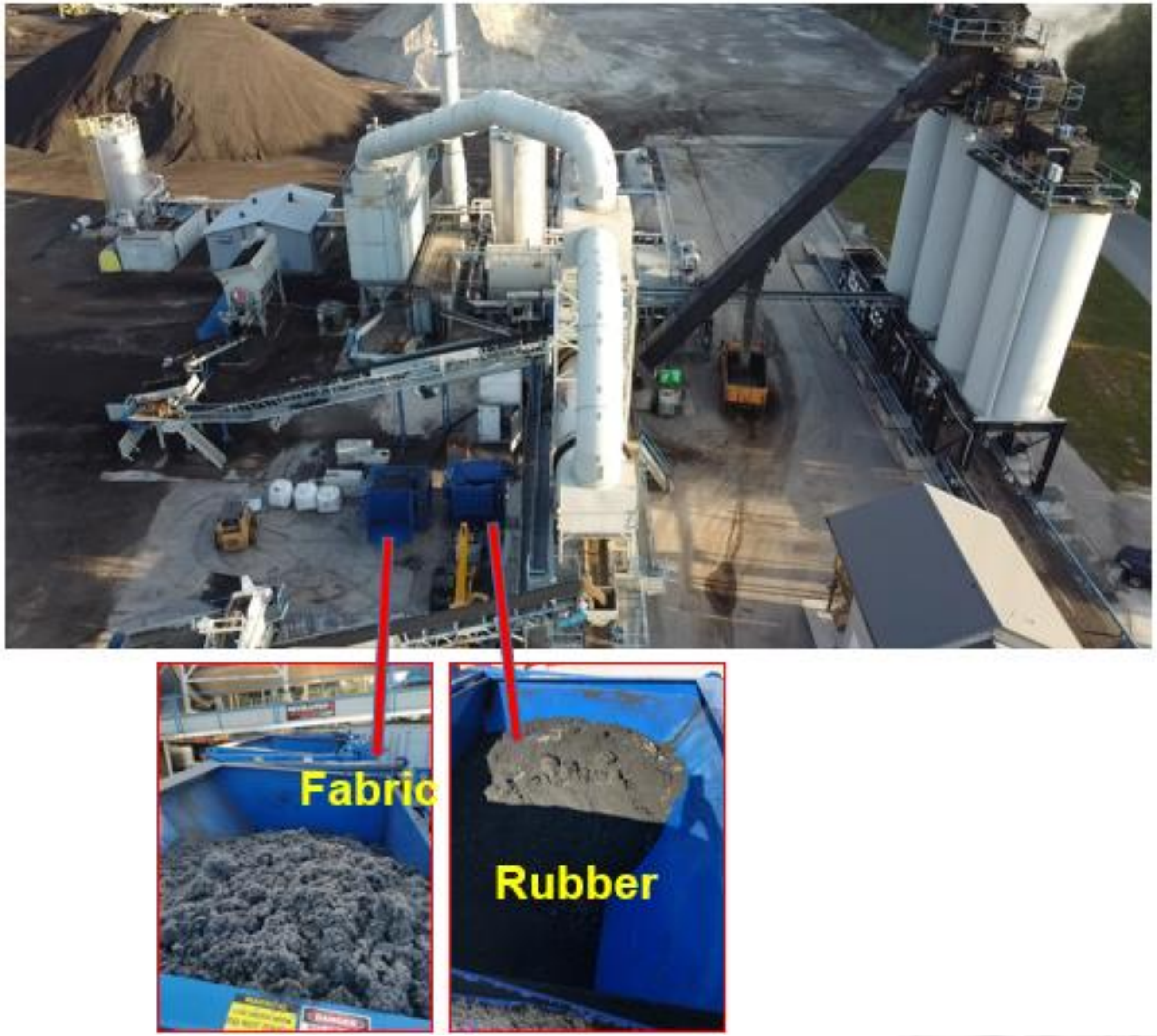
- 1,500 scrap tires
- 600 tons of RAP

Old Spec:

- 0 tires
- 510 tons of RAP

Develop BMD in Your Local Agency

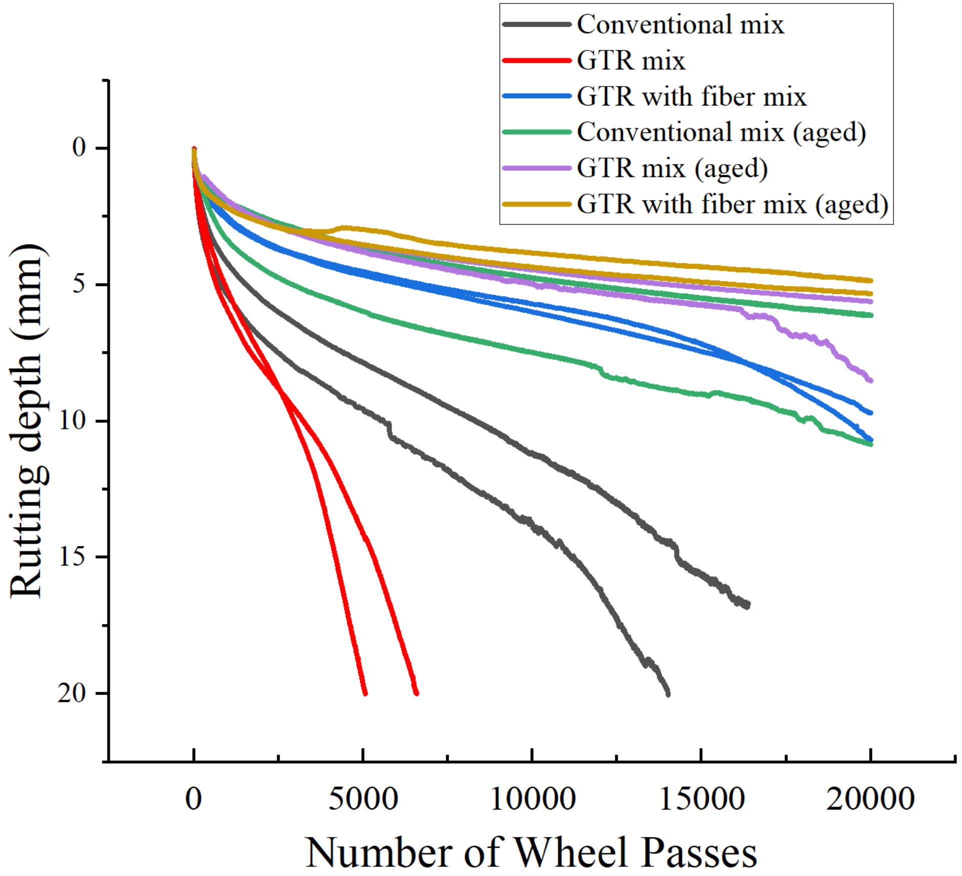
Tire Fiber Pilot Project with Rubber

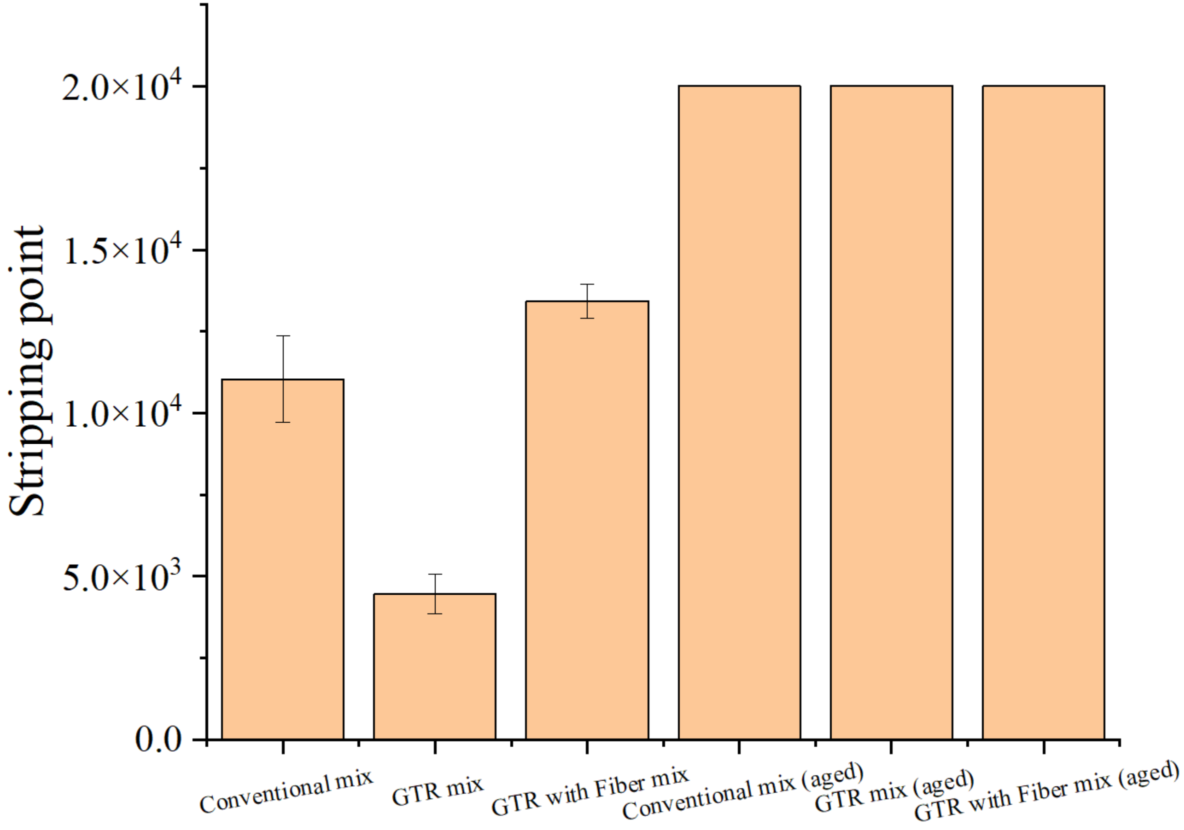


Liberty TIRE RECYCLING

Tire Fiber Metering

Hamburg wheel tracking device (HWTD) test

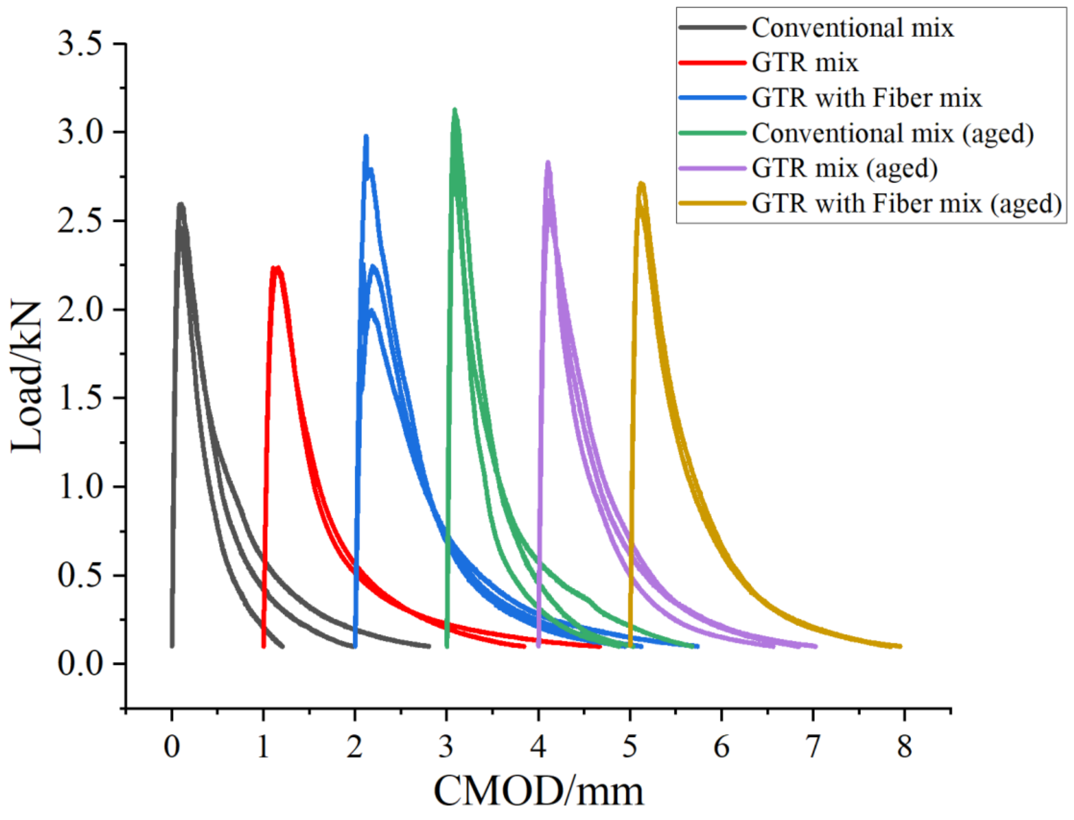




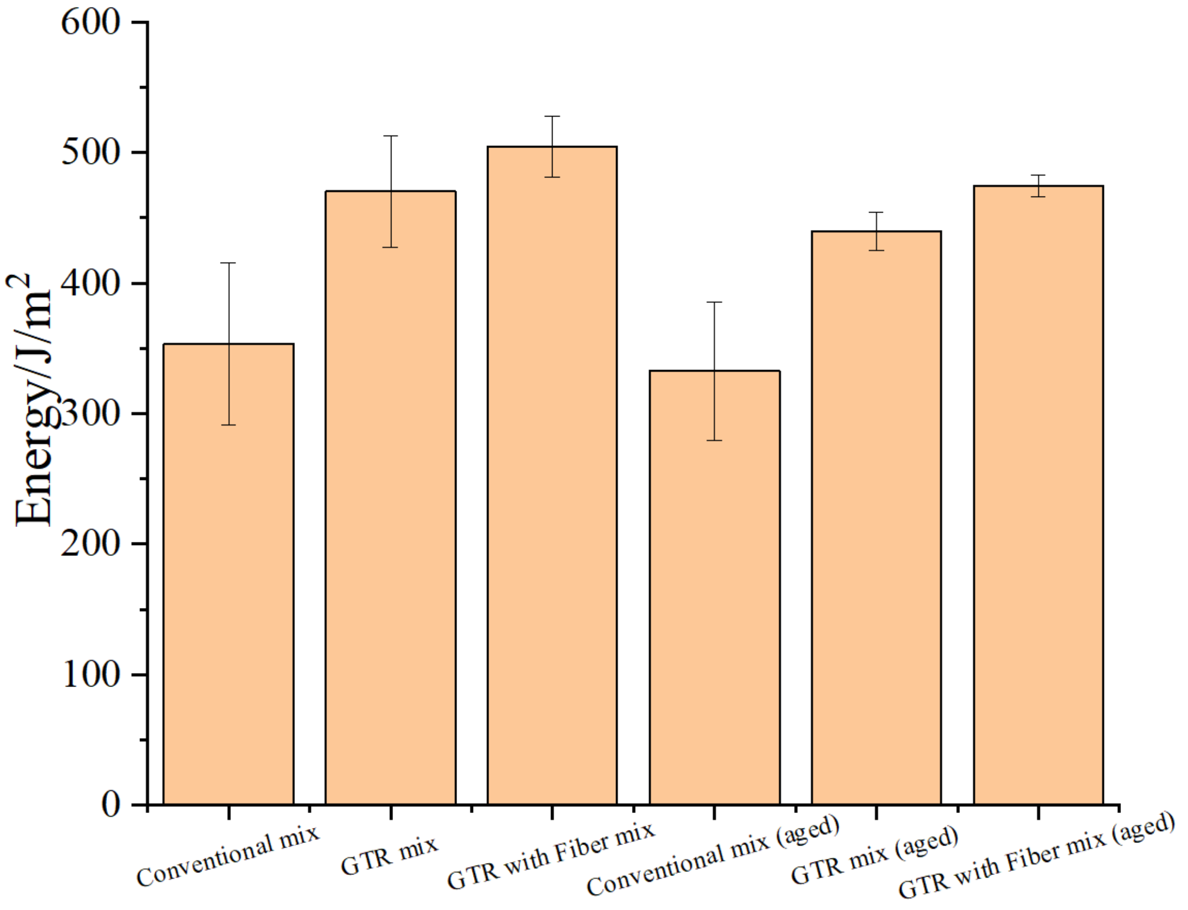
Michigan Technological University 1885

Testing data courtesy of MTU, Dr. Zhanping You

Disc-shaped compact tension (DCT) test



DCT fracture energy test result



The correlation between the maximum CMOD and fracture energy

Testing data courtesy of MTU, Dr. Zhanping You

Mechanical Concrete and Tire Derived Aggregate (TDA) in subgrade

Mechanical tire stabilized aggregate in Ingham County MI

6 inches of tire-derived aggregate in Clare County construction, MI

For more information, contact:

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Opportunities in IRA and IIJA

- Develop Life Cycle Assessments for all components in infrastructure construction.
- Develop Environmental Product Declarations for materials.
- Determine Global Warming Potential of material manufacturing and production.
- Determination of Green House Gas reductions achieved through more sustainable manufacturing and construction processes.
- FHWA Low Carbon Construction Materials Grant 100% Funded, no State Matching Requirement, plus 2% rebate.