Rubberized Modified Asphalt

Tracing The Past And Exploring Advanced Toward Sustainable Roadway Materials

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Presentation Prepared for:
CAPTG – SWIFT 2024
September 16, 2024

Recycling is crucial, benefiting <u>not just us</u> but also ensuring a sustainable future for <u>coming generations</u>


DECARBONIZATION
2030 & 2050
Change in Materials


CLIMATE
CHANGE
EVER-INCREASING
TRAFFIC


EXTREME
EVENTS


Don Valley
Parkway
401
300 m
Sheppard
Avenue

WORLD IS CHANGING

NEED SHIFT IN THINKING

RESILIENCY AND SUSTAINABILITY

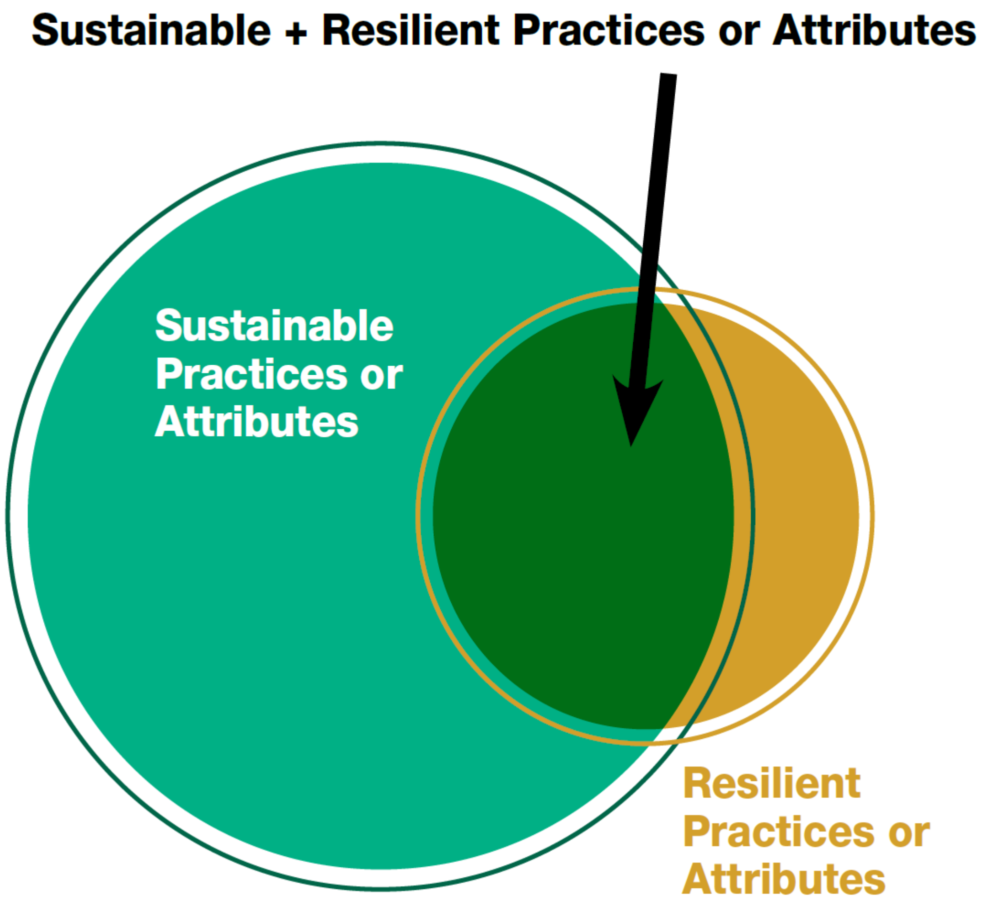


Figure 1. Venn Diagram of Sustainable, Resilient, and Resilient + Sustainable Practices and Attributes for Asphalt Pavements

RESILIENCY AND SUSTAINABILITY

Sustainable + Resilient Practices or Attributes

- Warm Mix Asphalt (low emissions + increase in haul distance)
- Porous pavement systems (stormwater management + nuisance flooding)
- Perpetual Pavement Design
- Deep reconstruction of pavement (increase deep layer moduli)
- Rapid construction
- Ability to adjust pavement design to climate / climatic events to extend pavement life

Sustainable Practices or Attributes

- Use of recycled materials
- Cold Recycled Asphalt
- Asphalt mix and plant optimization

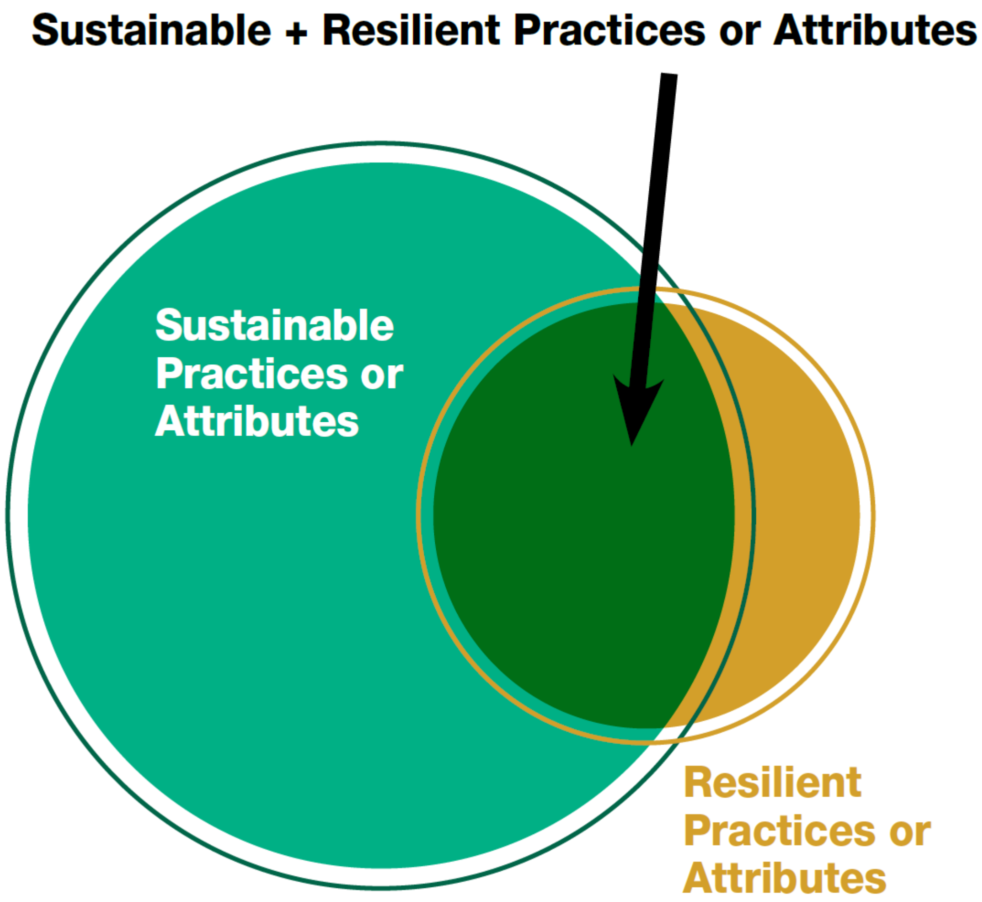
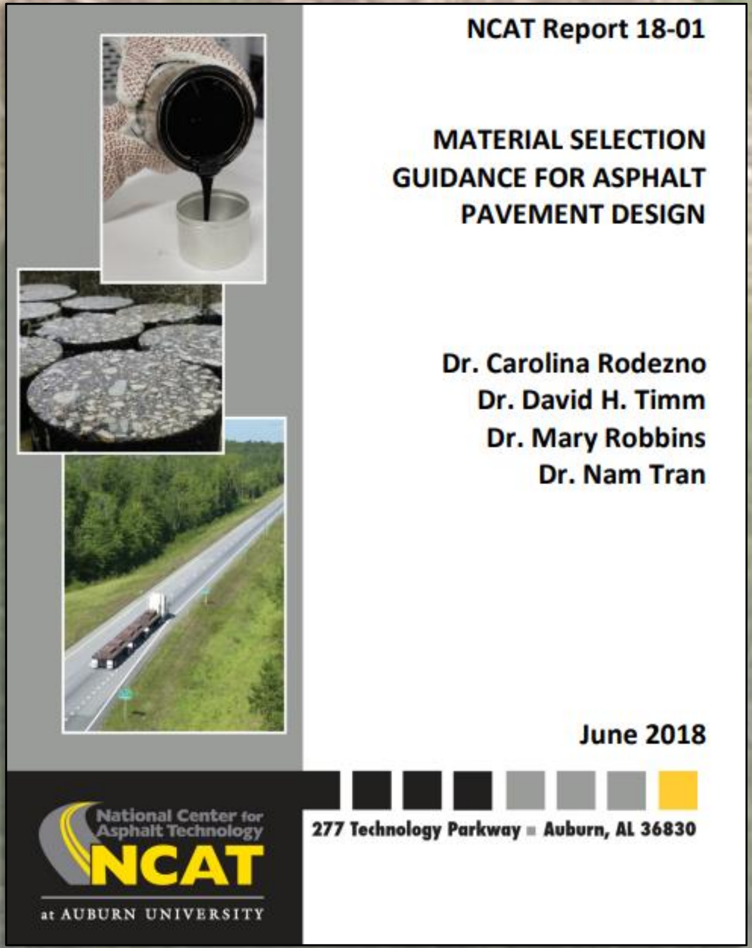


Figure 1. Venn Diagram of Sustainable, Resilient, and Resilient + Sustainable Practices and Attributes for Asphalt Pavements

Resilient Practices or Attributes That Are Not Sustainable

- Use of novel materials with unknown environmental or safety risks
- Use of climate adaptable materials when the social and environmental benefits do not outweigh the costs (e.g., use of polymer modified binders for low volume roads)
- Over-designing for low-risk catastrophic events

PROVEN TECHNOLOGIES FOR GREEN & RESILIENT ROADWAYS


NCAT Report 18-01

MATERIAL SELECTION GUIDANCE FOR ASPHALT PAVEMENT DESIGN

Dr. Carolina Rodezno
Dr. David H. Timm
Dr. Mary Robbins
Dr. Nam Tran

June 2018

National Center for Asphalt Technology
NCAT
at AUBURN UNIVERSITY

277 Technology Parkway ▪ Auburn, AL 36830

"Asphalt pavement materials and technologies that have been identified as potential candidates for ***cost-effective and sustainable*** *asphalt pavement systems:*

a) Warm mix asphalt

b) Reclaimed asphalt pavement (RAP)

c) Recycled asphalt shingles (RAS)

d) Recycled tire rubber (RMA)

e) Stone matrix asphalt

f) Cold recycling *and*

g) Polymer-modified asphalt"

CHALLENGES WITH CURRENT MINDSET IN APPROACHING GREEN SOLUTIONS

Valued greatly, but We have a part-time commitment!

Undertaking a limited number of projects, often only when prompted.

We tend to stay on the side of caution, relying heavily on previous experience and conventional materials/processes.

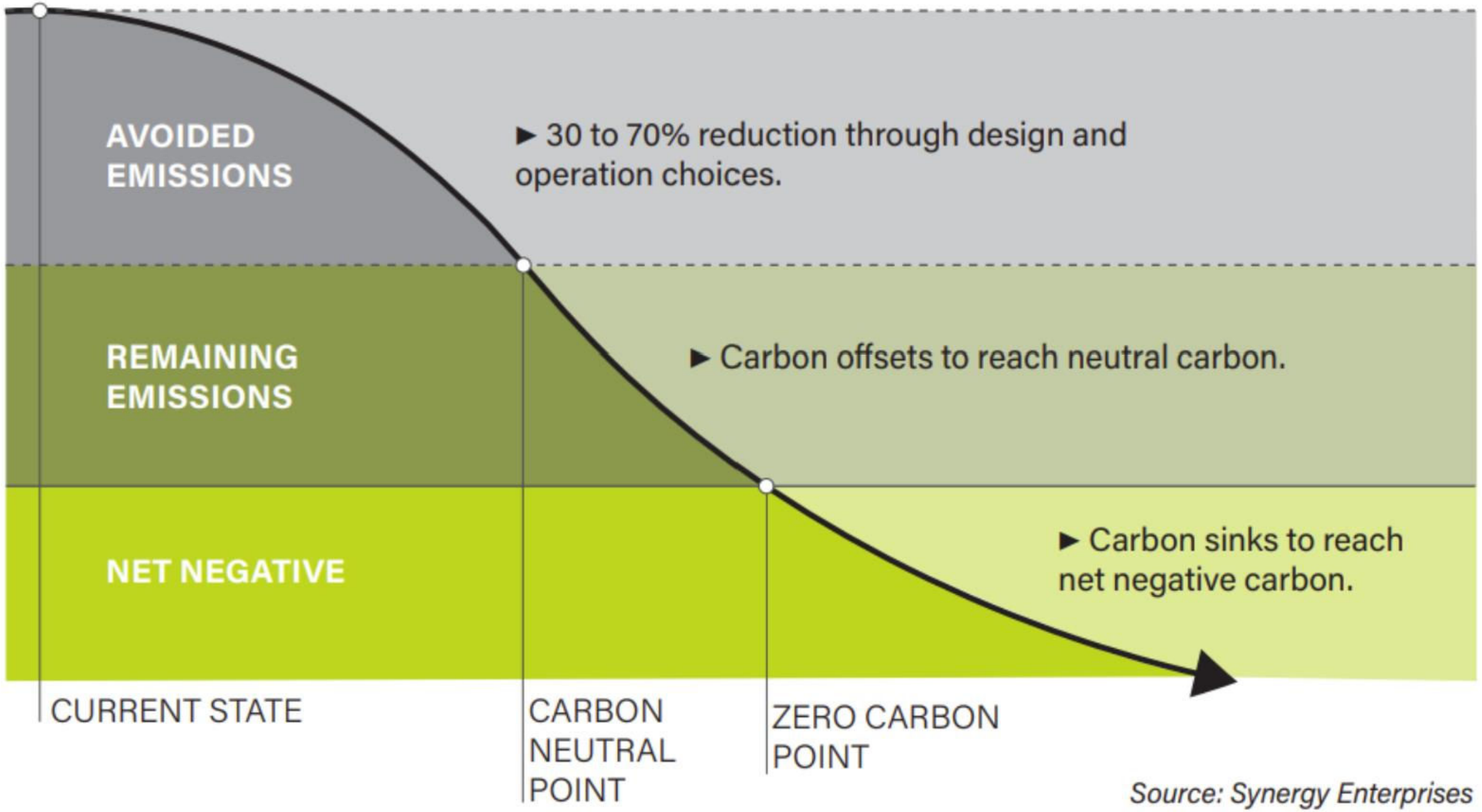
Need for ***policies and incentives***
Leadership and commitment
Integration in specs and projects

CHANGE IN MINDSET IS NEEDED

The *Canadian Net-Zero Emissions Accountability Act*

Law to achieve net-zero emissions by 2050

THE DECARBONIZATION PATHWAY
Materials and Processes



Decarbonization Opportunity.. EPDs

Environmental Product Declaration

"Nutrition label" for asphalt pavement products

EPD "Nutrition" Label

Your Building Product

Amount per Unit

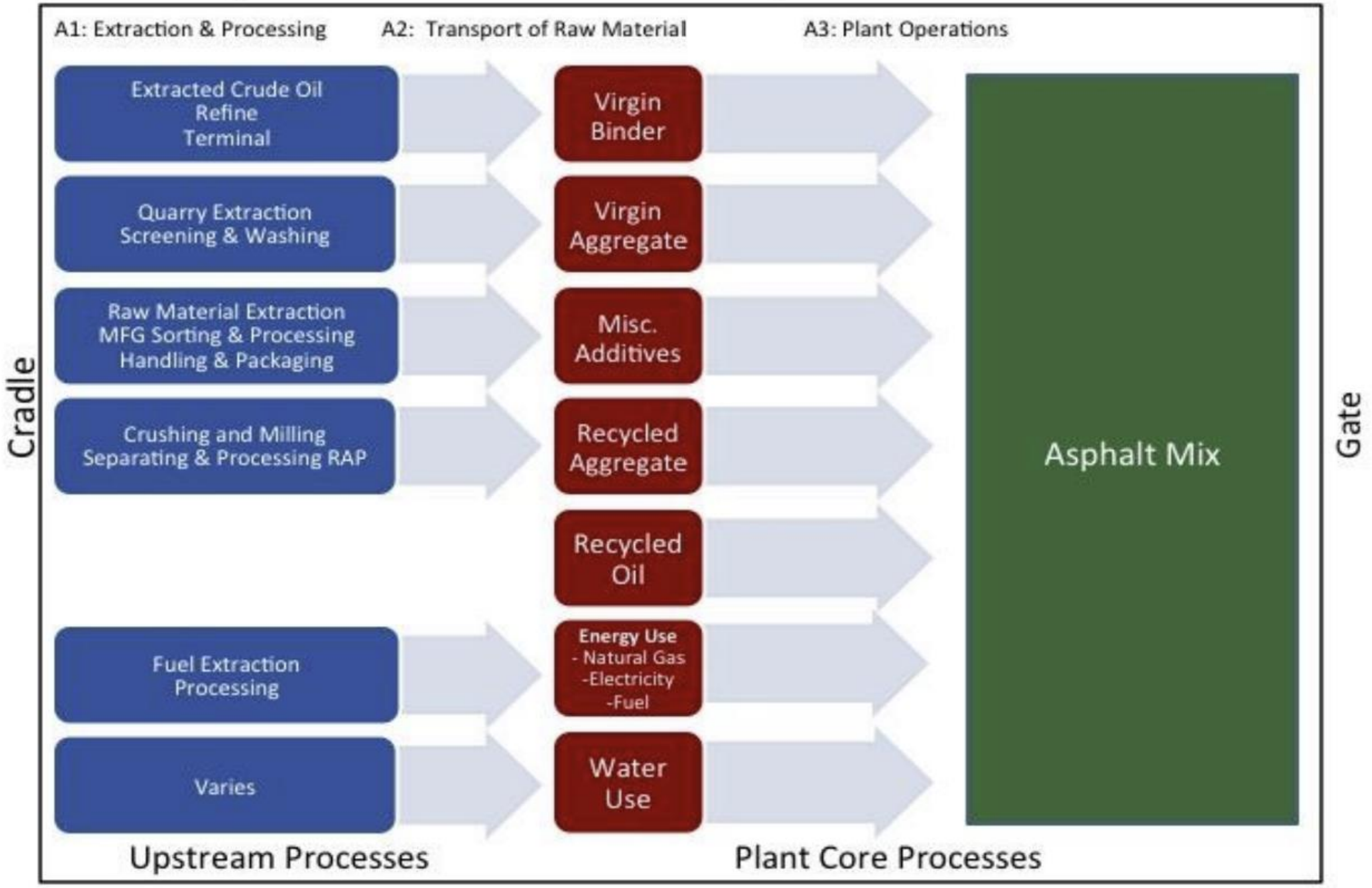
LCA IMACT MEASURES	TOTAL
Primary Energy (MJ)	12.4
Global Warming Potential (kg CO^2 eq)	0.96
Ozone Depletion (kg CFC- 11 eq)	1.80E-08
Acidification Potential (mol H^+ eq)	0.93
Eutrophication Potential (kg N^- eq)	6.43E-04
Photo-Oxidant Creation Potential (kg 03 eq)	0.121

Your Product's Ingredients: Listed Here

AREAS OF IMPROVEMENT

Life Cycle Assessment of Asphalt Mixtures in Support of an Environmental Product Declaration

Key Processes Within System Boundaries



EXAMPLE OF CURRENT "BUY-CLEAN" POLICY EUROPE - NORWAY

Contract awarded to the lowest price after CO_2 price adjustment

Year	2019	2020-2023	2024
CO_2-value NOK/kg	2	5	7,5
CO_2-value USD/kg	0,19	0,47	0,70

Source: Norwegian Public Roads Administration, public information

- **Example case (stretching numbers to make the case clearer)**
- Tender 50.000 tons asphalt mix (produced and installed)
- CO_2-value: 0,70 USD/kg

Contractor	Price offering USD	EPD A1-A5 Kg CO_2/ton	△kgCO_2/ton above baseline	CO_2 Penalty △CO_2*tons*value	CO_2 adjusted price
A	5.270.000	50	15	+ 525.000	5.795.000
B	5.090.000	60	25	+ 875.000	5.965.000
C	5.710.000	**35 (baseline)**		-	5.710.000

Bitumen availability and sustainability pushing for innovation and alternative binders

Presented by:
Eivind Olav Andersen
Veiteknologen AS

Typical Asphaltic Surface Mix

(low RAP Mix)

MATERIALS (A1) ≈ 60% KG CO2e

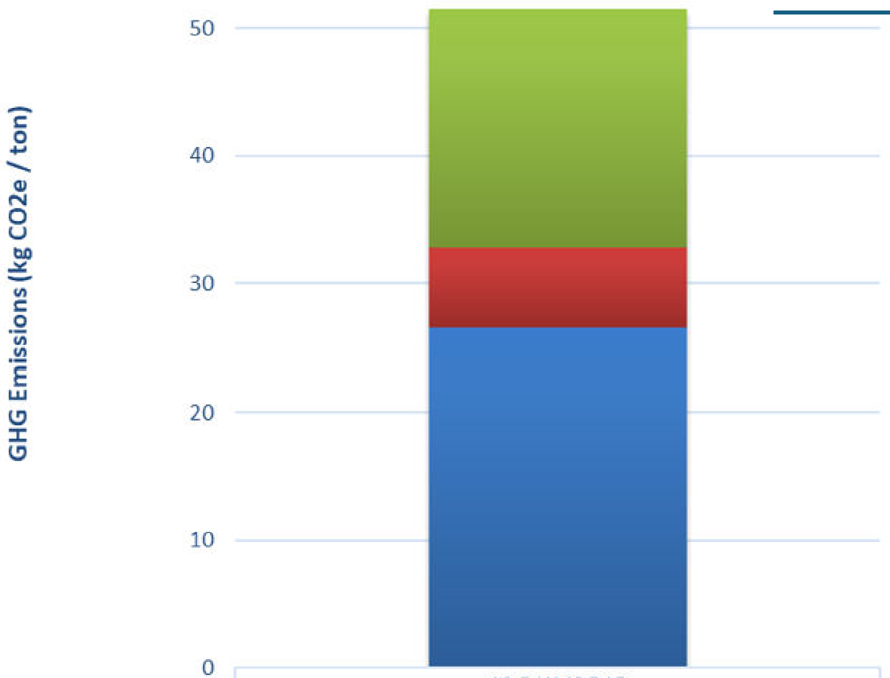
PLANT OPERATIONS (A2) ≈ 33% KG CO2e

TRANSPORTATION (A2) ≈ 7% KG CO2e

RAP IMPACT ON EPD

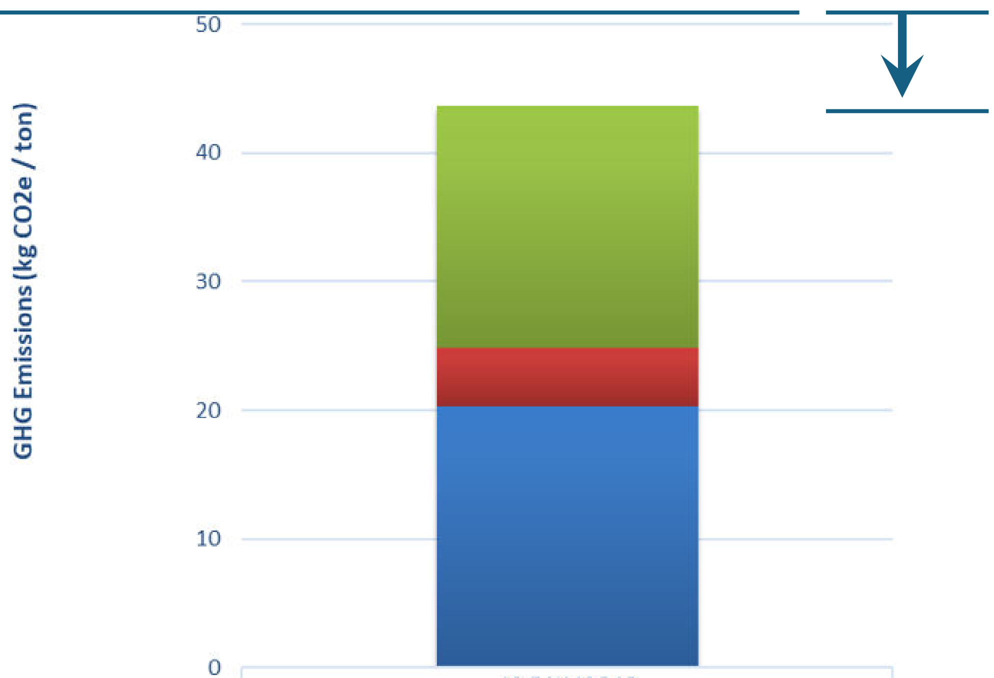
single variable isolated example of a specific regionalized plant

20% RAP



	12.5 NMS RAP
Plant Ops. (A3)	18.72
Transportation (A2)	6.20
Materials (A1)	26.60
Total (A1-A3)	51.51

40% RAP



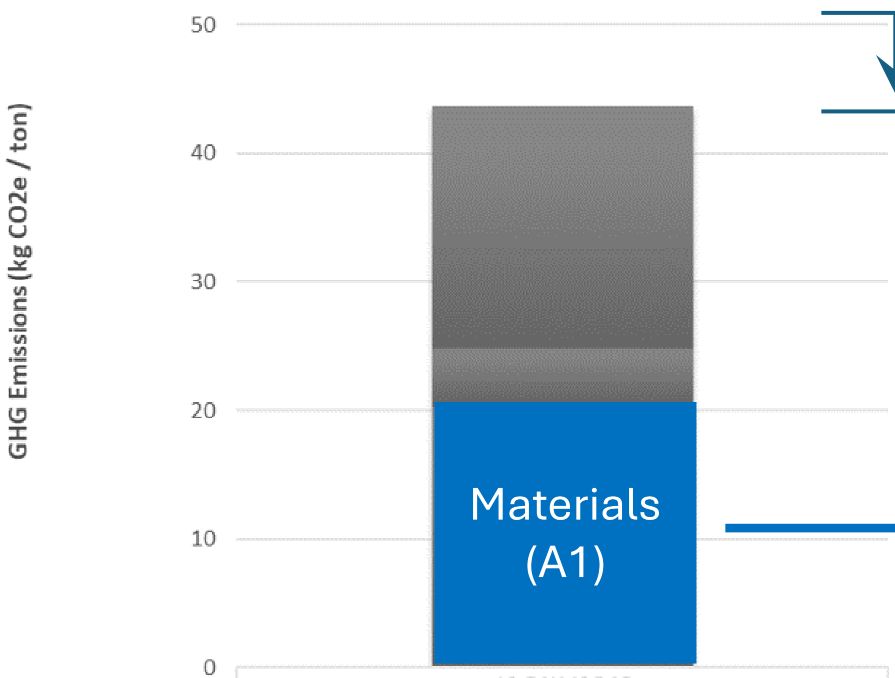
	12.5 NMS RAP
Plant Ops. (A3)	18.72
Transportation (A2)	4.65
Materials (A1)	20.25
Total (A1-A3)	43.62

CRH DATA/INFO
Presented at
CTAA-CUPGA 2023

Achieving More than 20% Decarbonization

single variable isolated example of a specific regionalized plant

40% RAP



	12.5 NMS RAP
Plant Ops. (A3)	18.72
Transportation (A2)	4.65
Materials (A1)	20.25
Total (A1-A3)	43.62

15%

Reduction
Kg CO2e

Bio Additives, Oils, Softeners, Rejuvenators

Circular Materials – *especially with biogenic modifiers*

Biogenic Binders

BACKGROUND DATA FROM CRH DATA/INFO
Presented at
CTAA-CUPGA 2023

POTENTIAL IMPACT PER TON

Actual Rubberized Asphalt Paving Project in US

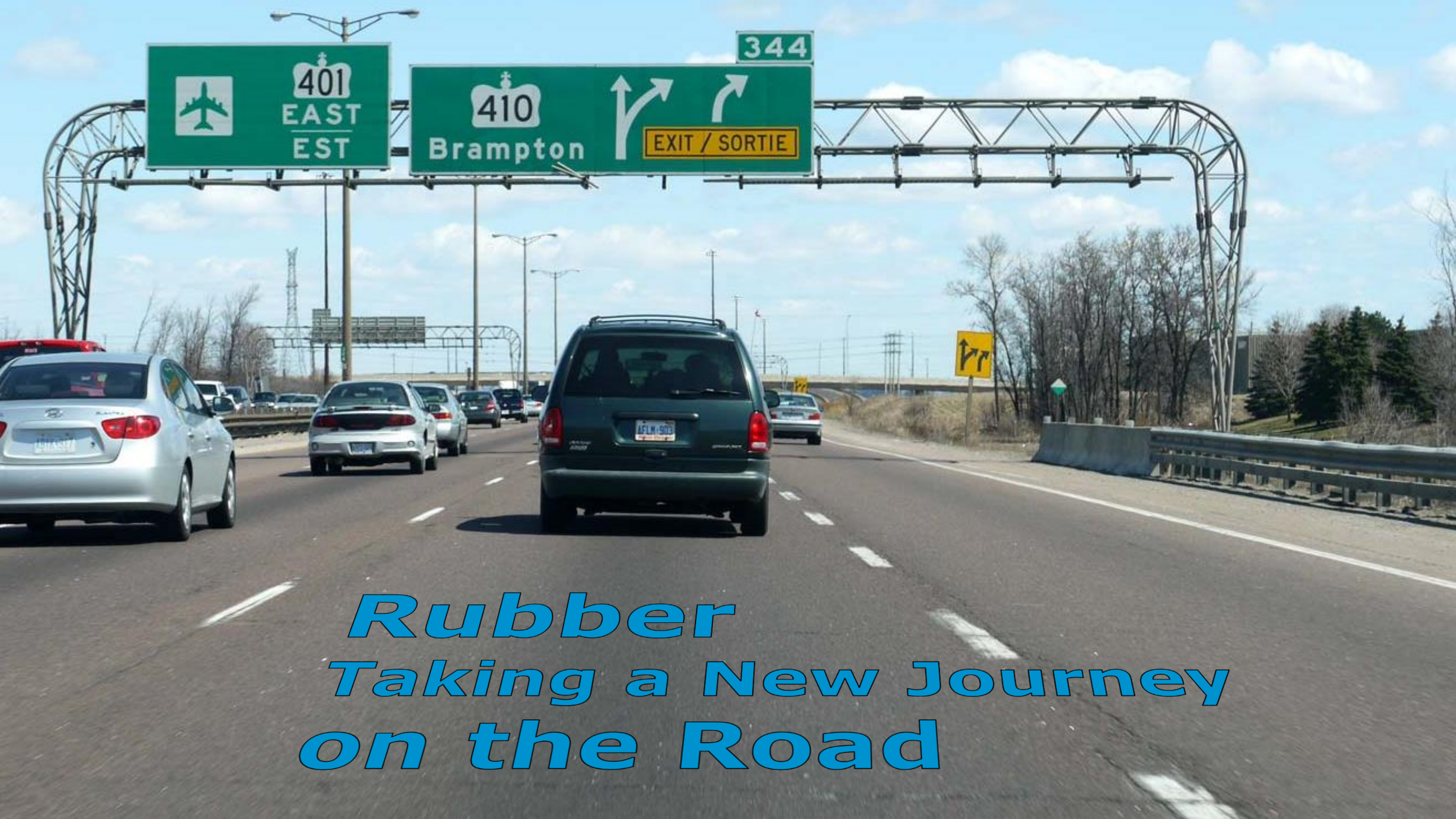
Rubberized Mix + 14% RAP

56.02 kg CO2e

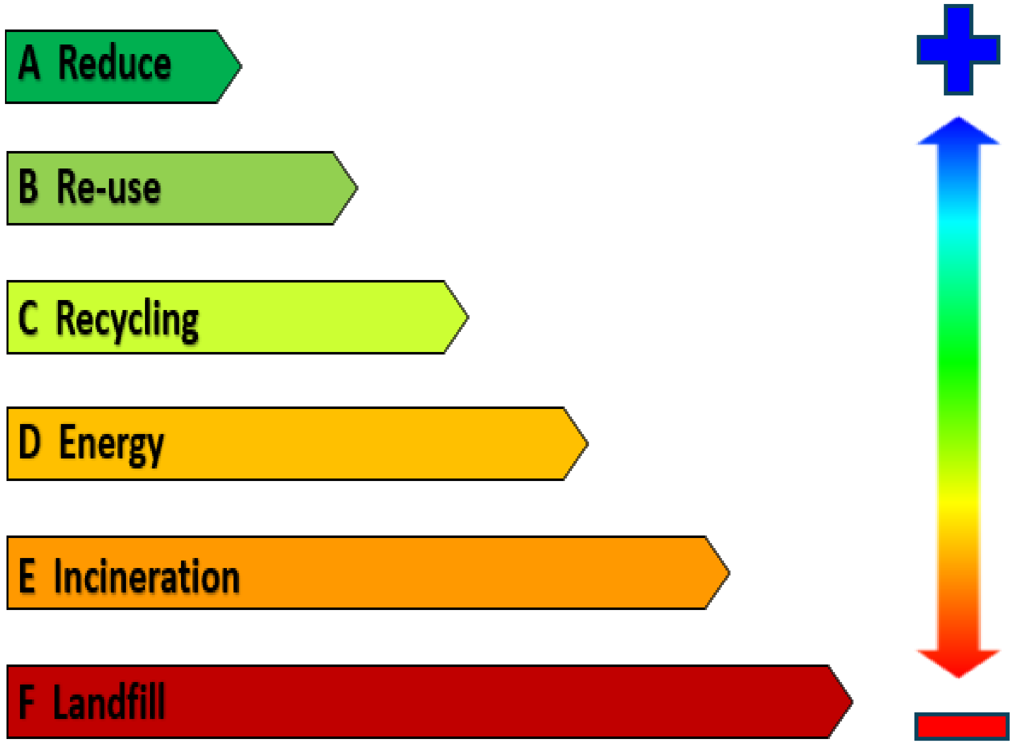
Polymer SBS Mix + 14% RAP

58.26 kg CO2e

Emerald ECO LABEL


401
EAST
EST
410
Brampton
EXIT / SORTIE
344
Rubber
Taking a New Journey
on the Road

Global End-of-Life Tire (ELT) Management Waste Hierarchy



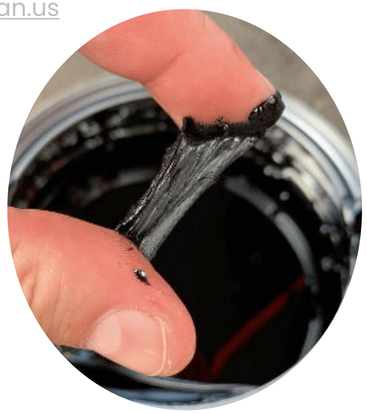
Reuse – Domestic market
Retreading
Reuse – Export to markets that do not have tire recycling programs / capacity
Recycled Rubber in Tire Manufacturing
Recycled Rubber in Asphalt
Recycled Rubber in Sports Fields
Recycled Rubber in Moulded Products – Commercial/Industrial markets
Recycled Rubber in Moulded Products – Consumer Markets
Recycled Rubber Mulch
Tire-Derived Aggregate (TDA)
Tire-Derived Fuel (TDF)
Alternative Daily Cover
Monofill
Incineration
Landfill

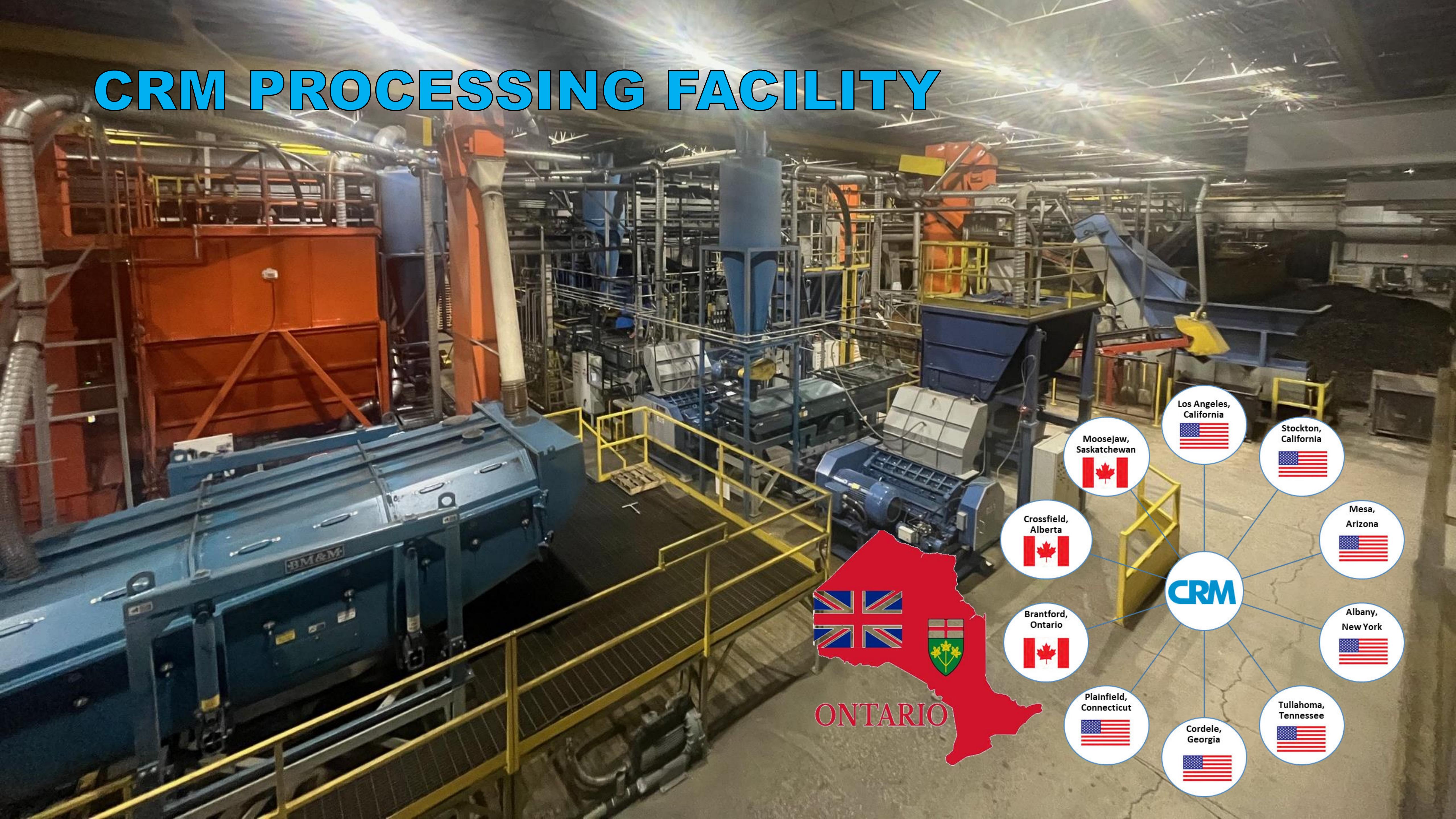
Rubberized Modified Asphalt

Complex, highly-engineered composite for wide range of loading and climatic applications

Premium Polymers in Tires

Natural Rubber/Latex (biogenic)
Styrene Butadiene Rubber (SBR)
Styrene Butadiene Styrene (SBS)
Butadiene Rubber (BR)




CRM PROCESSING FACILITY
BM&M
ONTARIO
CRM
Los Angeles, California
Stockton, California
Mesa, Arizona
Albany, New York
Tullahoma, Tennessee
Cordele, Georgia
Plainfield, Connecticut
Brantford, Ontario
Crossfield, Alberta
Moosejaw, Saskatchewan

CRM Production Technologies

AMBIENT

Shredded into two- inch chips processed further at ambient temperature

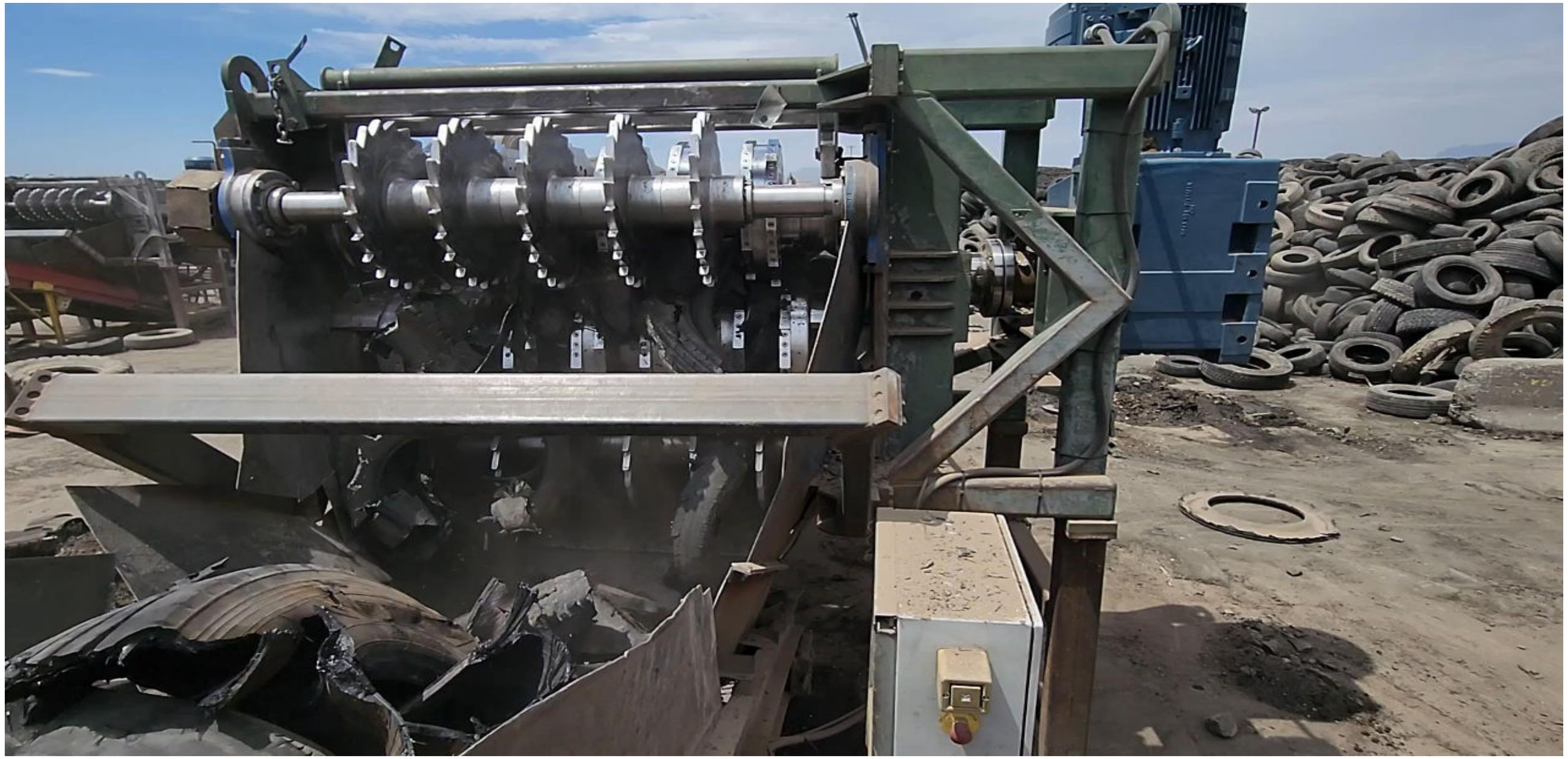
Further granulation of chips awhile separating steel and fabric

CRYOGENIC

Advanced rotating freeze chamber from ambient to glass transition temperature of -200C

Impacting force to granulate

CRM
Primary Shredding Department



CRM
Secondary Shredding Department

Metal Detection

Wire Separation

Fiber ("Tire Fluff") Separation

Classification (Sieving) Department

Bagging Department

Final Product & Shipping

GROUND TIRE RUBBER (GTR) Rigorous Specification

30- Mesh

- Uncured or de-vulcanized rubber will not be permitted.
- The GTR shall not exceed 2 mm (1/16 in.) in any dimension
- Shall contain no free metal particles or other foreign contaminating materials.
- The GTR shall be stored in a dry location protected
- from the rain.
- The GTR shall have a maximum of 0.75% moisture by weight and shall be free flowing.
- When the GTR is combined with the asphalt cement, the moisture content of the GTR shall not cause foaming of the blend.

GROUND TIRE RUBBER (GTR) For Asphalt Applications

30- Mesh

Sieve Analysis Required

Ambient or Cryogenic can be used – Cryogenic is recommended

Sieve Size (mm)	**% Passing**
1.18 mm (No. 16)	100
600 Microns (No. 30)	95 ± 5
300 Microns (No. 50)	> 20

No. 200 sieve is 74 Microns , human hair thickness is 20 too 100 microns

A Mineral powder (such as Talc) meeting AASHTO M17, Mineral Filler for Bituminous Paving Mixtures, may be added up to 4% by weight of GTR

GTR
Premium Asphalt Applications

80- and 100- Mesh Sizes
Using **Micronizing** process

Sieve Size (mm)
165 Microns (No. 80)
149 Microns (No. 100)

This rubber specification is mainly used in Automotive and Rubber Molded Product industries, but
Can be used in premium RMA applications

WHY TIRE RUBBER IN ASPHALT?

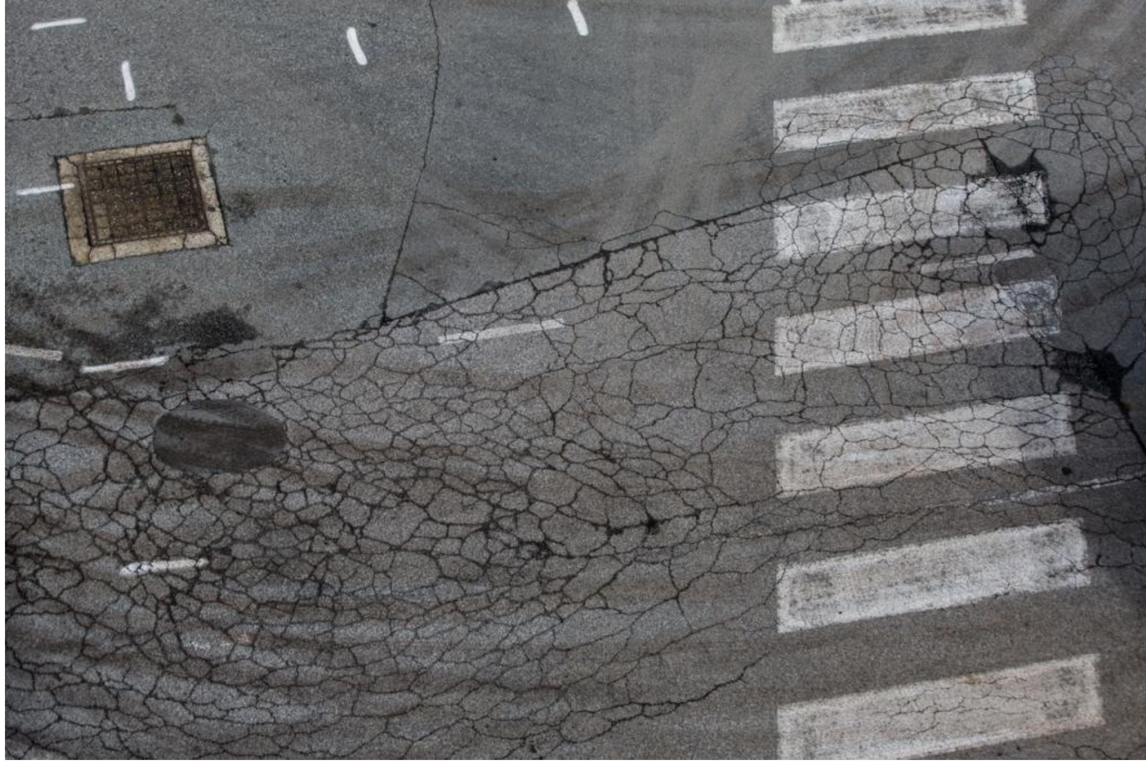
Asphalt Cement and Need for Modification

- Cracking due to colder fall and winter temperatures

- Permanent Deformation (i.e. “Rutting”) due to high summer temperature

Sensitivity to loading frequency and intensity

Resulting in shorter life of pavements & increased maintenance costs over time



NEED FOR ENGINEERED MODIFIERS

Flux Oils and Extenders

PPA - Polyphosphoric acid

Polymers

- Elastomers
  - Enhance strength at high temp and elastic at low temp (rubber)
  - *SBR Latex*
  - *SBS – Styrene Butadiene Styrene*
  - *GTR (Containing SBS & SBR, NR, BR)*
- Plastomers
  - Enhance strength but not elasticity (Plastic)…mostly used in hot climates

Any responsible usage of the above modifiers

GTR in Asphalts

The purpose is not to get rid of tires but to enhance the performance of the binder.

Objective

"Leveraging the sophisticated engineering of tires to enhance a wider range of performance characteristics and create asphalt pavement applications that rival the efficiency and durability of tires"

HISTORY OF GTR IN ASPHALT

Developed in **1960's** by City of Phoenix Engineer, Charles McDonald

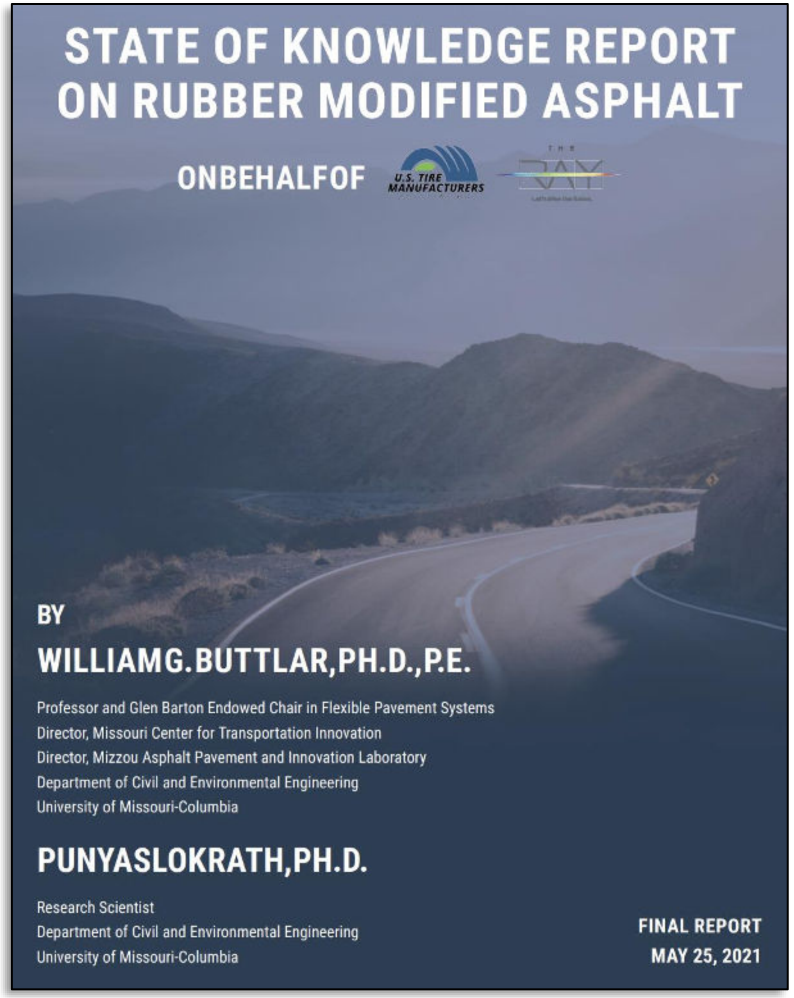
- Often referred to as the "wet process" or McDonald Process
- Large amount of crumb rubber used as a Binder Modifier for a patching mix "band-aid"
- Needs constant agitation – instability issues
- ASTM D6114 definition – 15% rubber minimum but in practice 18% - 22% (AC wt.)
- Expand to applications such as: surface treatments, interlayers, and AR open-graded friction courses (AR-OGFC).

1991, the Intermodal Surface Transportation Efficiency Act (ISTEA) required states to use a minimum amount of crumb rubber from recycled tires in asphalt surfacing placed each year beginning with the 1994 paving season

- Some processes were not well developed
- Lack of experience and little expertise in controlling quality
- Many of the projects went horribly wrong
- When a new technology goes bad = wait until people retire to try again! Big enough push back from the states, the mandate was reversed.

PROVEN PERFORMANCE BENEFITS

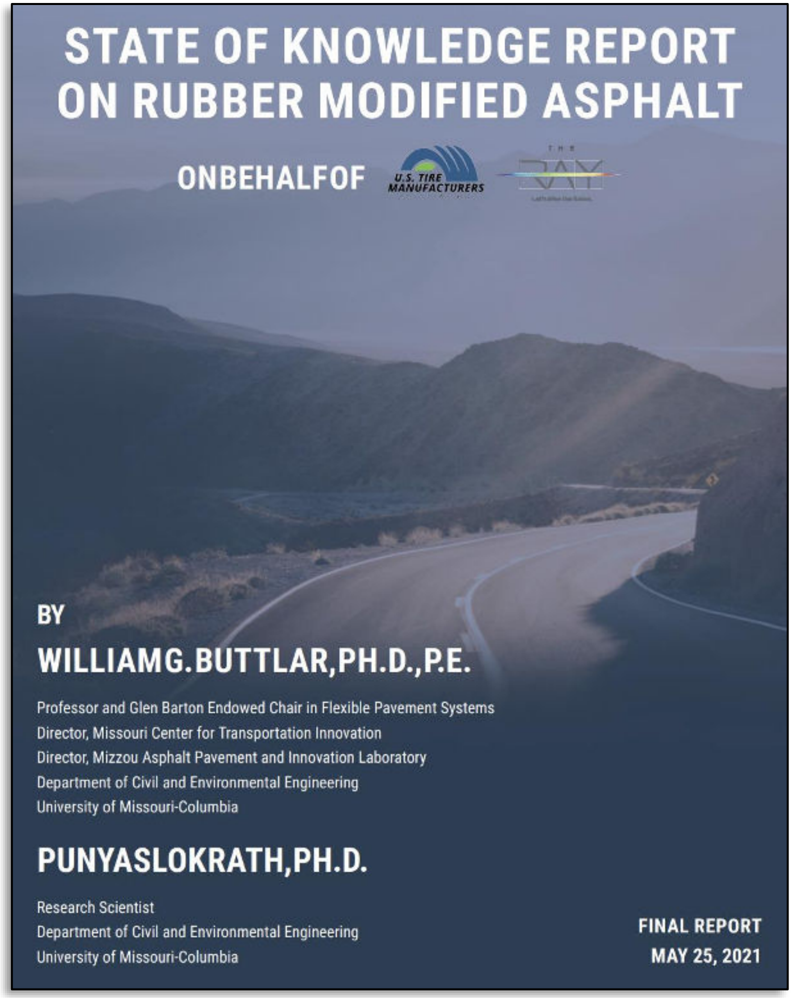
Over 20 years of field performance



- **Longevity** - The past two decades of research indicate that all three primary RMA approaches, i.e., traditional wet process, terminal-blend wet process, and the modern dry process (engineered crumb rubber) lead to **extended pavement life** as compared to pavements made with unmodified binders. Moreover, RMA can provide similar performance as pavements constructed with costly polymer-modified binders (West et al 2012; Willis, 2013). RMA is particularly **resistant against early pavement rutting failures**, owing to the stability provided to the liquid binder system imparted by the swollen, elastic rubber particles (Choubane, Sholar, Musselman, & Page, 1999; G. B. Way, 2012). RMA is also **very resistant to fatigue cracking in high traffic volume applications and to low temperature cracking** (W. Buttlar et al., 2021; Raad, Saboundjian, & Minassian, 2001; Souliman, Mamlouk, & Eifert, 2016; Tao Wang, Xiao, Amirkhanian, Huang, & Zheng, 2017).
- **Pavement noise reduction** - or more precisely, the mitigation of road noise emanating from vehicles, has been quantified in several studies in recent years. **Noise reduction arising from RMA use has been measured to range from 1-10 decibels**, depending on a mix type, traffic level, vehicle speeds, and other environmental variables. Due to the exponential nature of the dB scale, **a reduction of just 2-3 dB creates a similar environmental benefit as a 50% reduction in traffic noise intensity**. In addition, long-term field observations have indicated that noise reduction due to RMA decreases over the years but at a substantially lower rate as compared to other surfacing alternatives (Carlson, Zhu, & Xiao, 2003; P. Donavan & Janello, 2018; Sacramento County Public Works Agency, 1999).
- **Ride Quality and Safety** - RMA has been shown to **create smoother pavements and therefore better ride quality for motorists** (Vázquez, Luong, Bueno, Terán, & Paje, 2016). In addition, the use of RMA provides **better pavement skid resistance, which can reduce traffic accidents during wet weather** (Texas Department of Transportation, 2003b).

PROVEN PERFORMANCE BENEFITS

Over 20 years of field performance

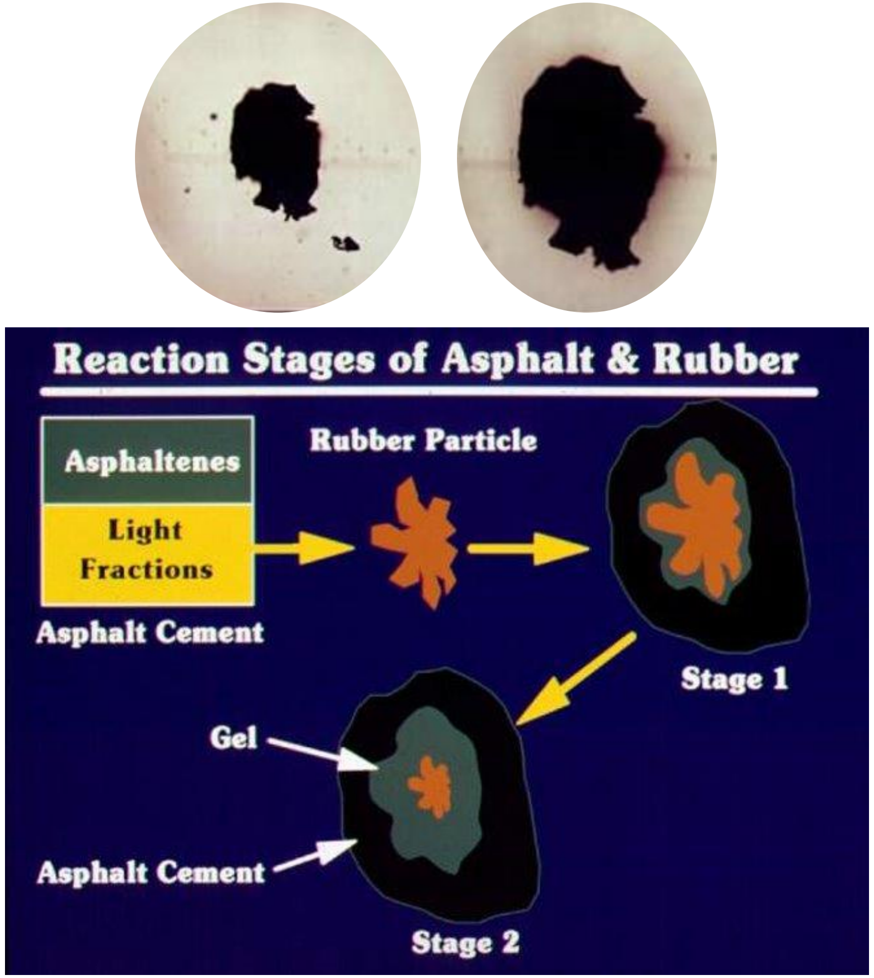


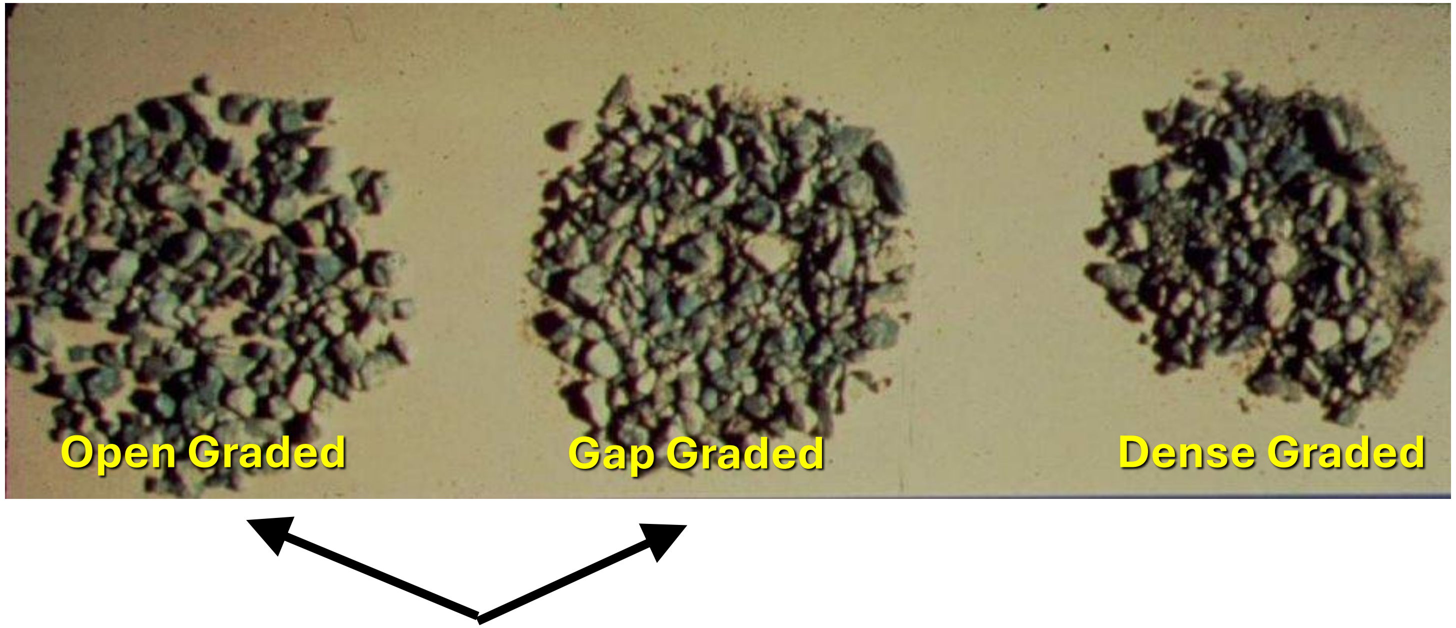
- Initial costs – Based on initial, per-ton costs only, RMA is generally more expensive than unmodified asphalt, but less expensive than polymer modified asphalt (Howard, Baumgardner, Jordan, Hemsley, & Hopkins, 2021). However, in the case of asphalt overlay rehabilitation projects on a cost-per-square-yard basis, it has been shown that **thin RMA overlays can be built at a lower cost as compared to unmodified asphalt overlays - approximately 43% less cost with a 10% boost in pavement life** (William G. Buttlar & Rath, 2019). Similarly, an earlier study (Harvey, Bejarano, Fantoni, Heath, & Shin, 2000) demonstrated that **a 50% reduction in pavement layer thickness can be achieved by using RMA in lieu of unmodified mixtures while achieving better performance**.
- Life cycle cost savings – Life cycle cost analysis (LCCA) studies have reported life cycle cost savings for RMA spanning widely, from a range of 4% to 40% savings in a study compiled for Caltrans (Dingxin Cheng, Hicks, & Rodriguez, 2012) to more than 400% savings (Souliman et al., 2016) when basing the results on laboratory-based fatigue performance. More work is needed to develop a more comprehensive national database of pavement costs, including both initial costs and subsequent maintenance costs, and pavement service life, which can be used to more accurately assess the life cycle cost benefits of RMA.

GTR BENEFITS

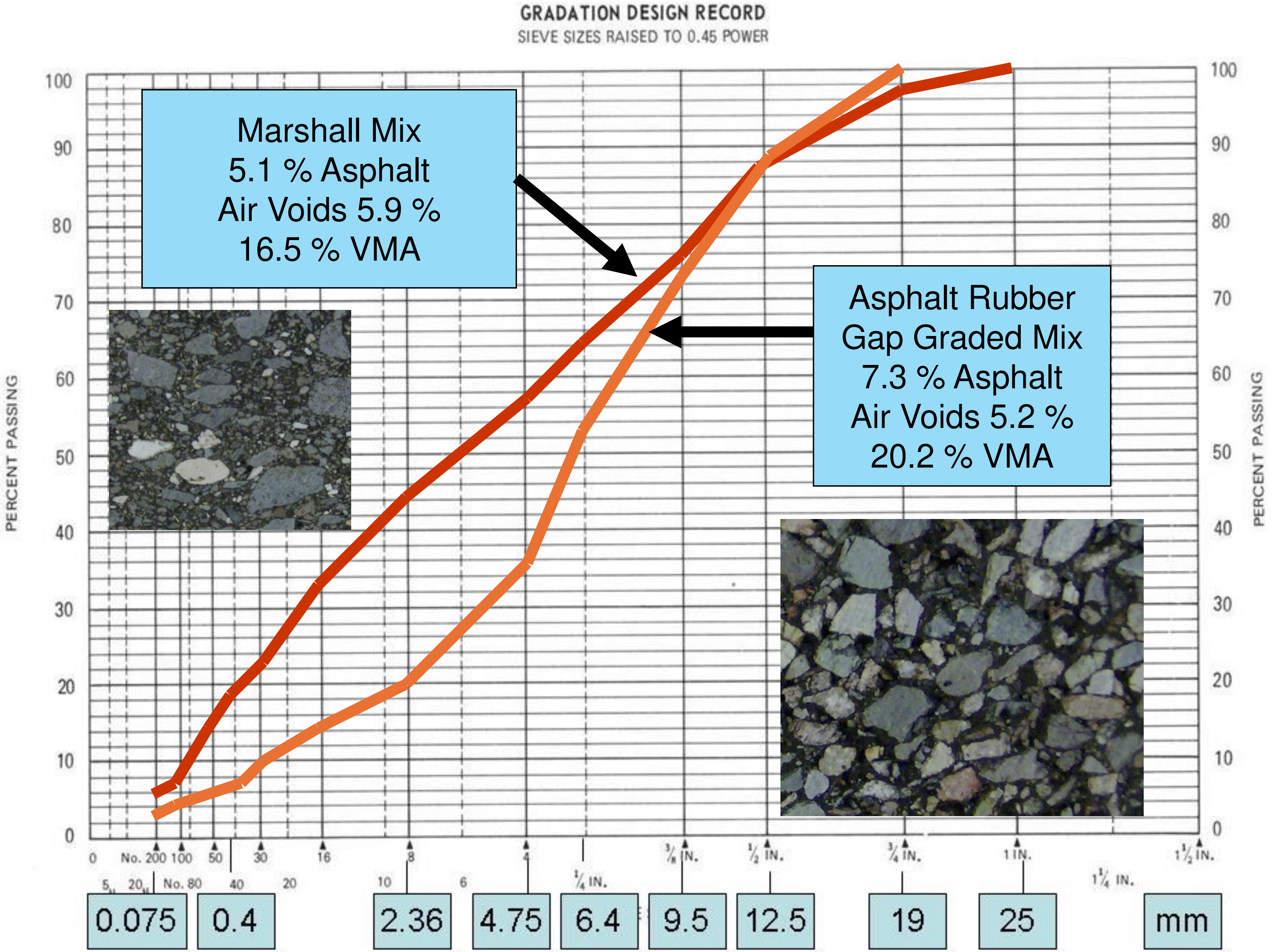
It allows use of larger size aggregate and more stones in aggregate structure - moving toward SMA

It allows more binder in the mix without bleeding or flushing

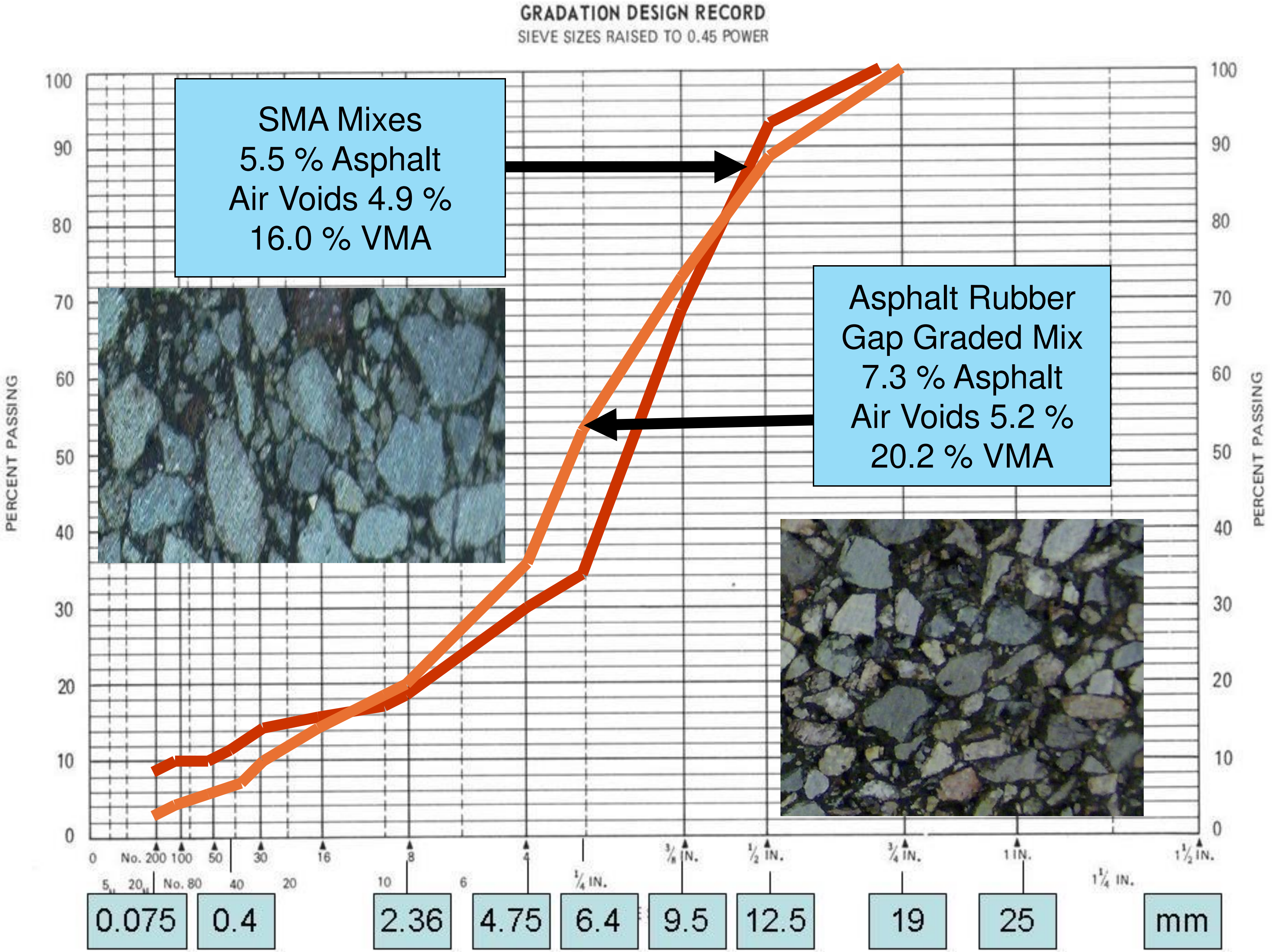




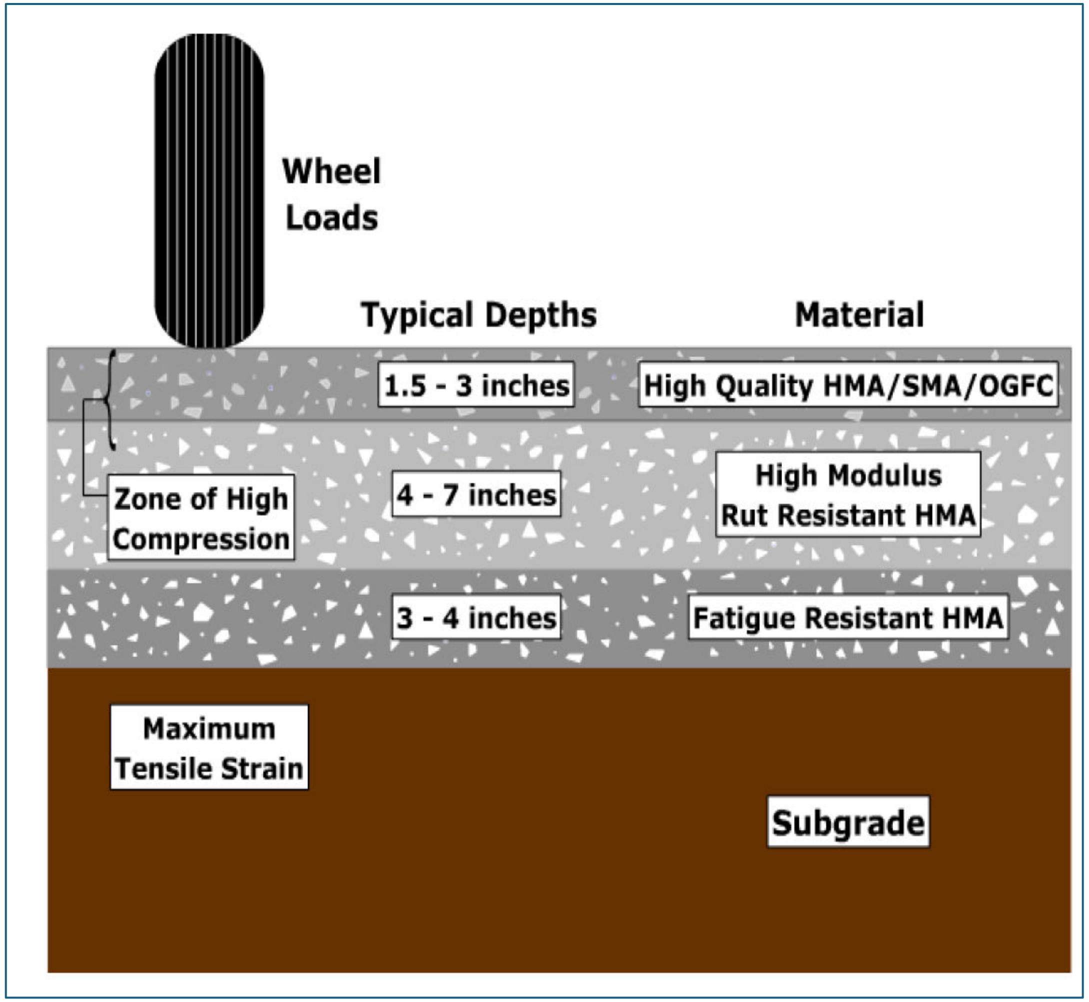
Use with Rubber



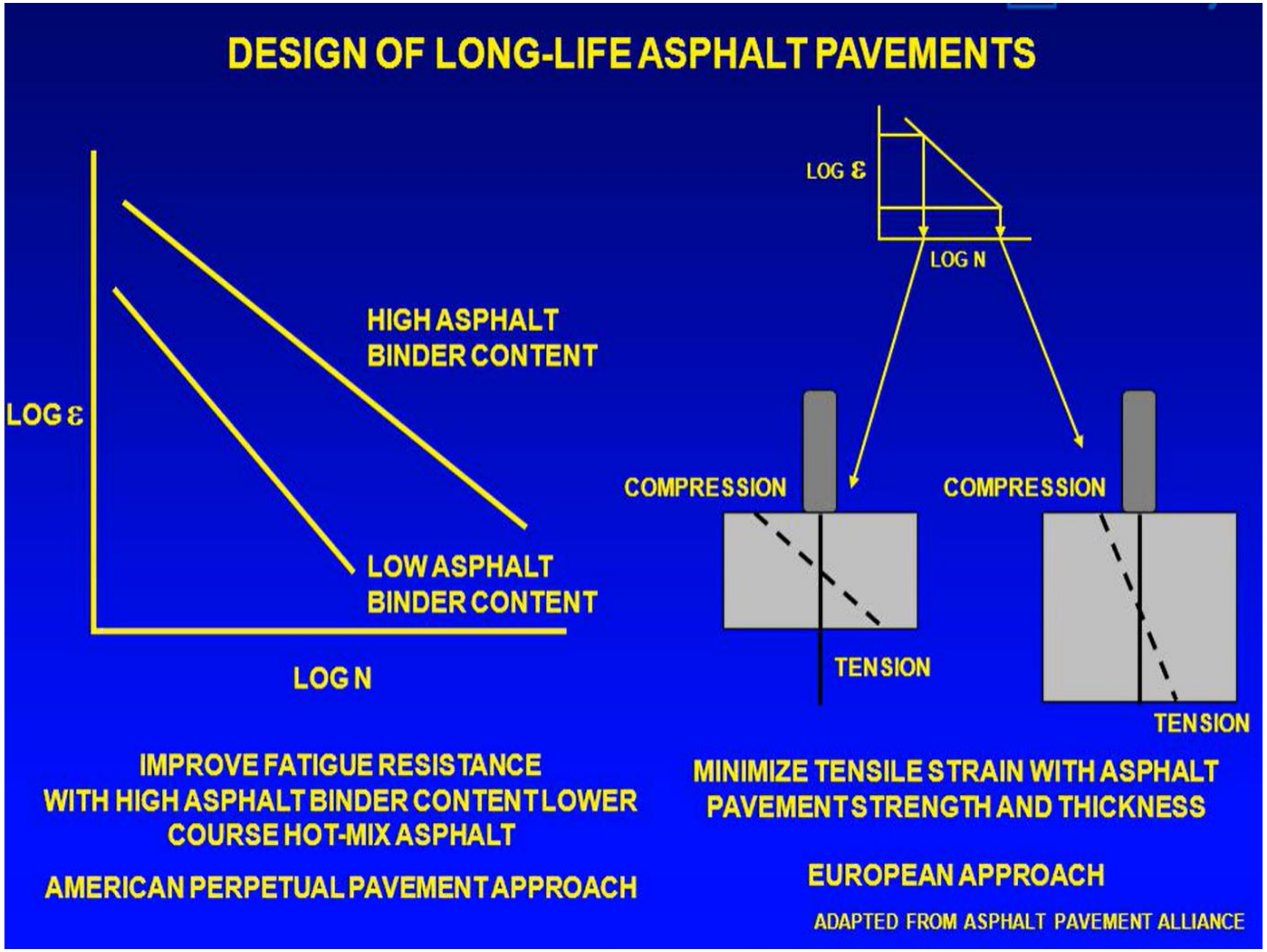
GRADATION DESIGN RECORD
SIEVE SIZES RAISED TO 0.45 POWER
PERCENT PASSING
Marshall Mix
5.1 % Asphalt
Air Voids 5.9 %
16.5 % VMA
Asphalt Rubber
Gap Graded Mix
7.3 % Asphalt
Air Voids 5.2 %
20.2 % VMA
No. 200
100
50
30
16
8
4
3/8 IN.
1/2 IN.
3/4 IN.
1 IN.
1 1/2 IN.
No. 80
40
20
10
6
1/4 IN.
1 1/4 IN.
0.075
0.4
2.36
4.75
6.4
9.5
12.5
19
25
mm


GRADATION DESIGN RECORD
SIEVE SIZES RAISED TO 0.45 POWER
SMA Mixes
5.5 % Asphalt
Air Voids 4.9 %
16.0 % VMA
Asphalt Rubber
Gap Graded Mix
7.3 % Asphalt
Air Voids 5.2 %
20.2 % VMA
PERCENT PASSING
0
10
20
30
40
50
60
70
80
90
100
No. 200
100
50
30
16
8
4
No. 80
40
20
10
6
¼ IN.
⅜ IN.
½ IN.
¾ IN.
1 IN.
1¼ IN.
1½ IN.
0.075
0.4
2.36
4.75
6.4
9.5
12.5
19
25
mm

RUBBERIZATION TO PREPUTIAL ROADWAYS



(Newcomb, 2001)



(Dr. John Emery, CUPGA 2007)

GTR IN ASPHALT

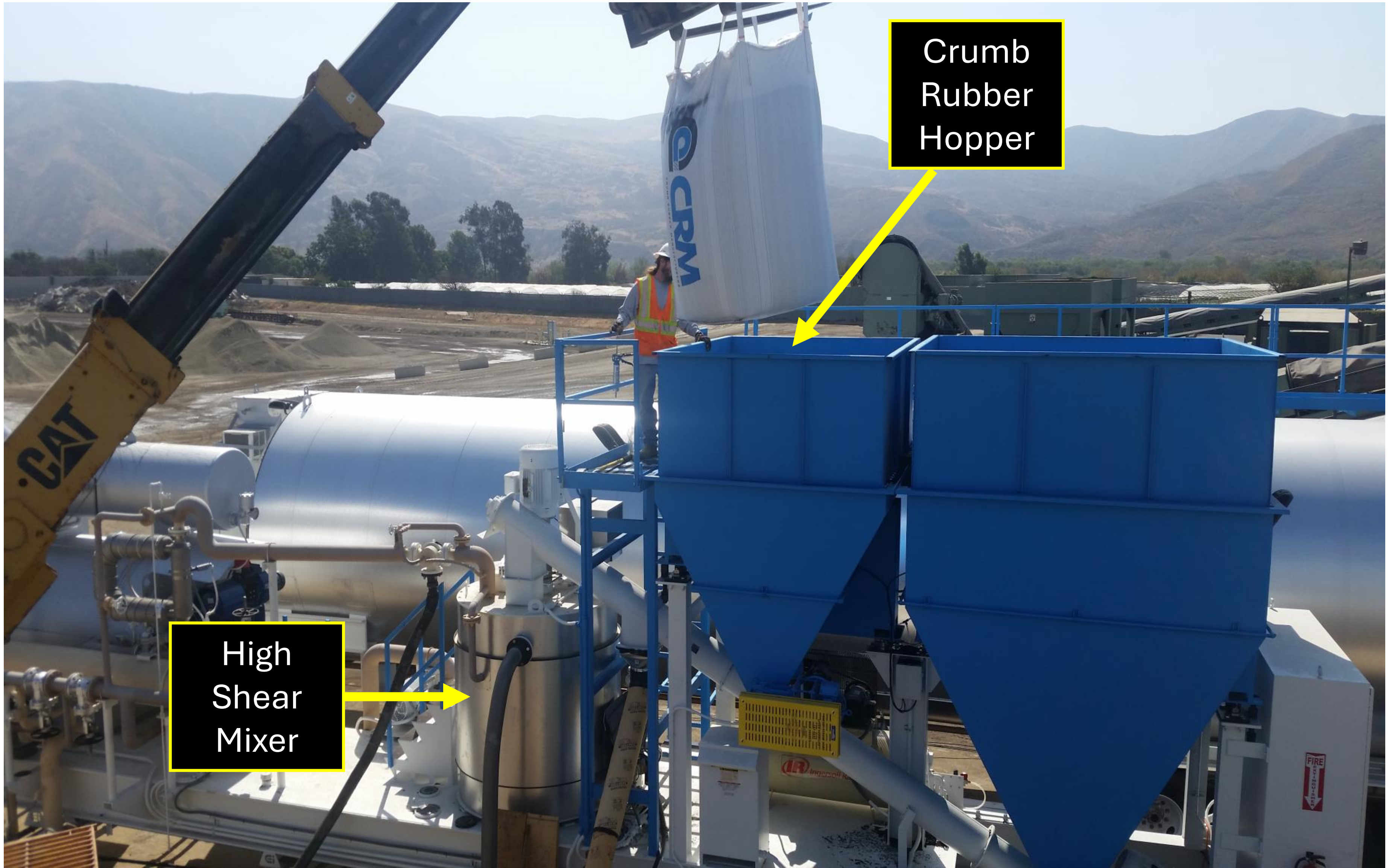
Utilization Methods

Wet Process – Rubber is added to liquid asphalt

Dry Process- Rubber is added often through RAP collar

- Substitute for 1-3% of Aggregate

WET PROCESS



WET PROCESS

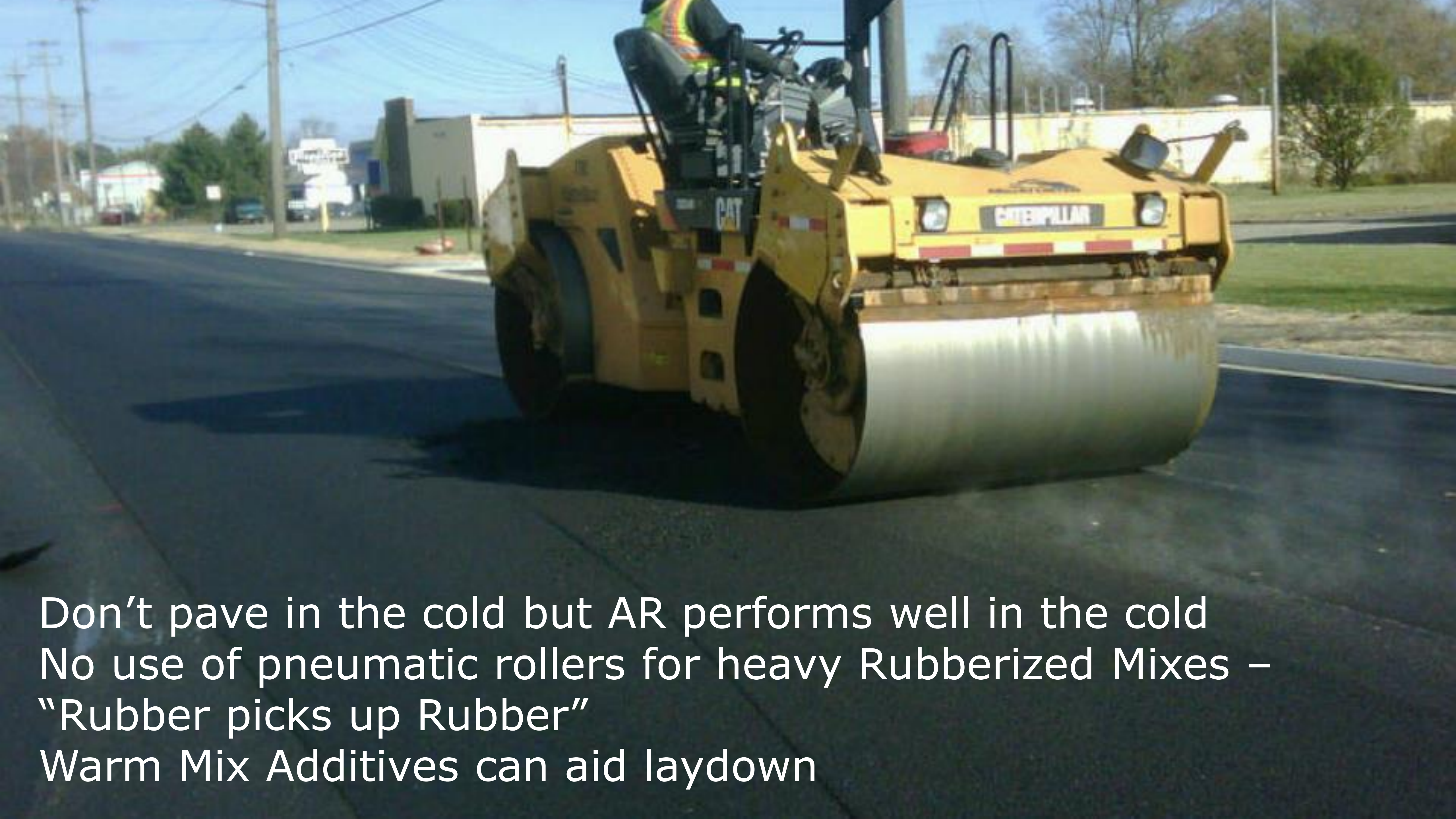
WET PROCESS

Paving Experience
"Business as usual"

Sheridan Road Saginaw, MI 081005

Paving Experience

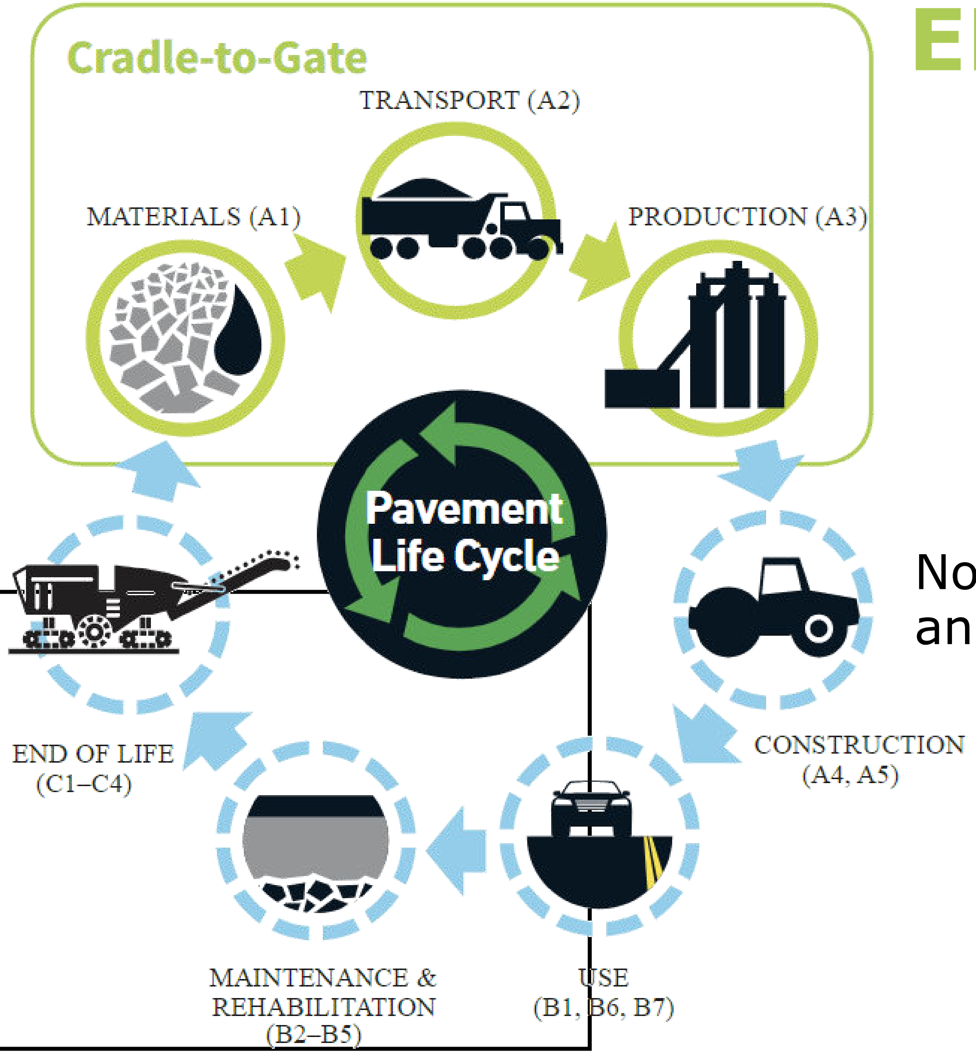
Paving Experience with Warm Mix Additives



Don’t pave in the cold but AR performs well in the cold
No use of pneumatic rollers for heavy Rubberized Mixes –
“Rubber picks up Rubber”
Warm Mix Additives can aid laydown

BALANCING MINDSET

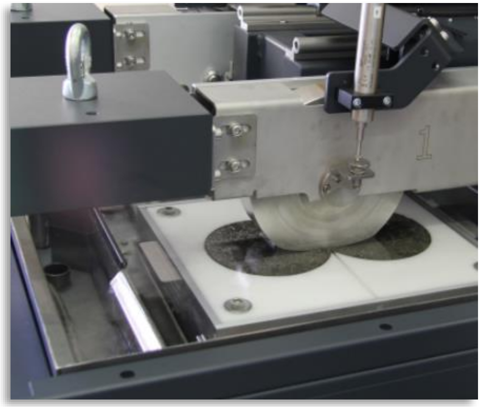
Focusing on EPDs considering Low-Carbon Life Cycle Analysis (LCA)



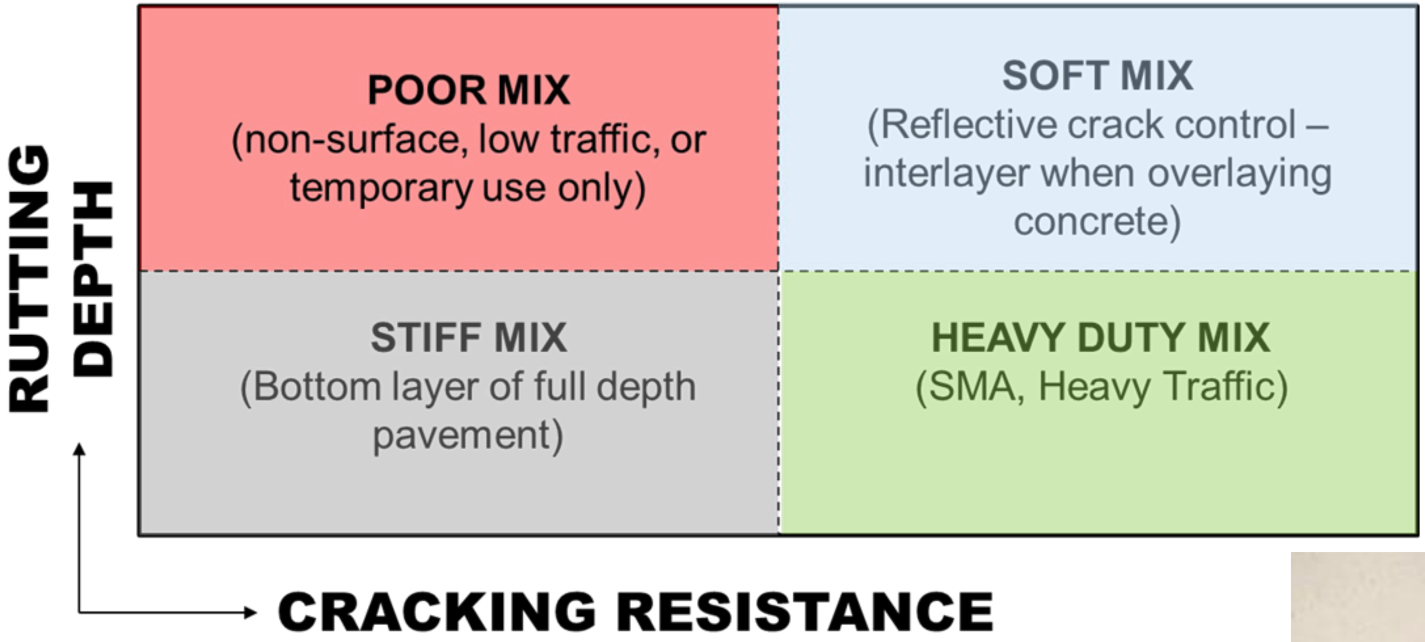
No Impact on Workability and Constructability

Performance Testing to ensure durability
(PROPOSED)

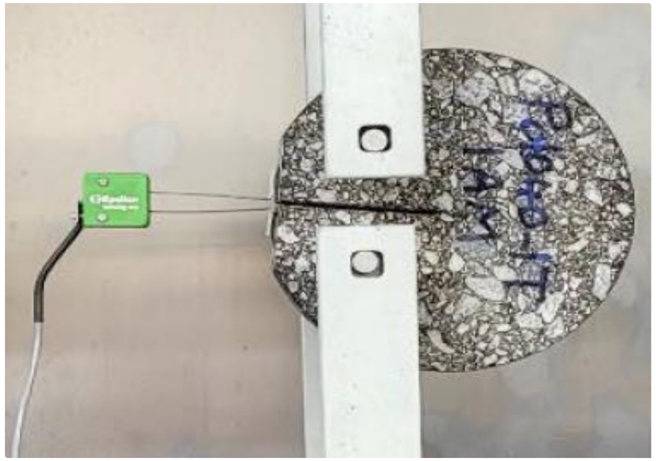
BALANCING
kg CO2e VS. PERFORMANCE Ontario Example



Hamburg Wheel Tracking



DCT Thermal Cracking



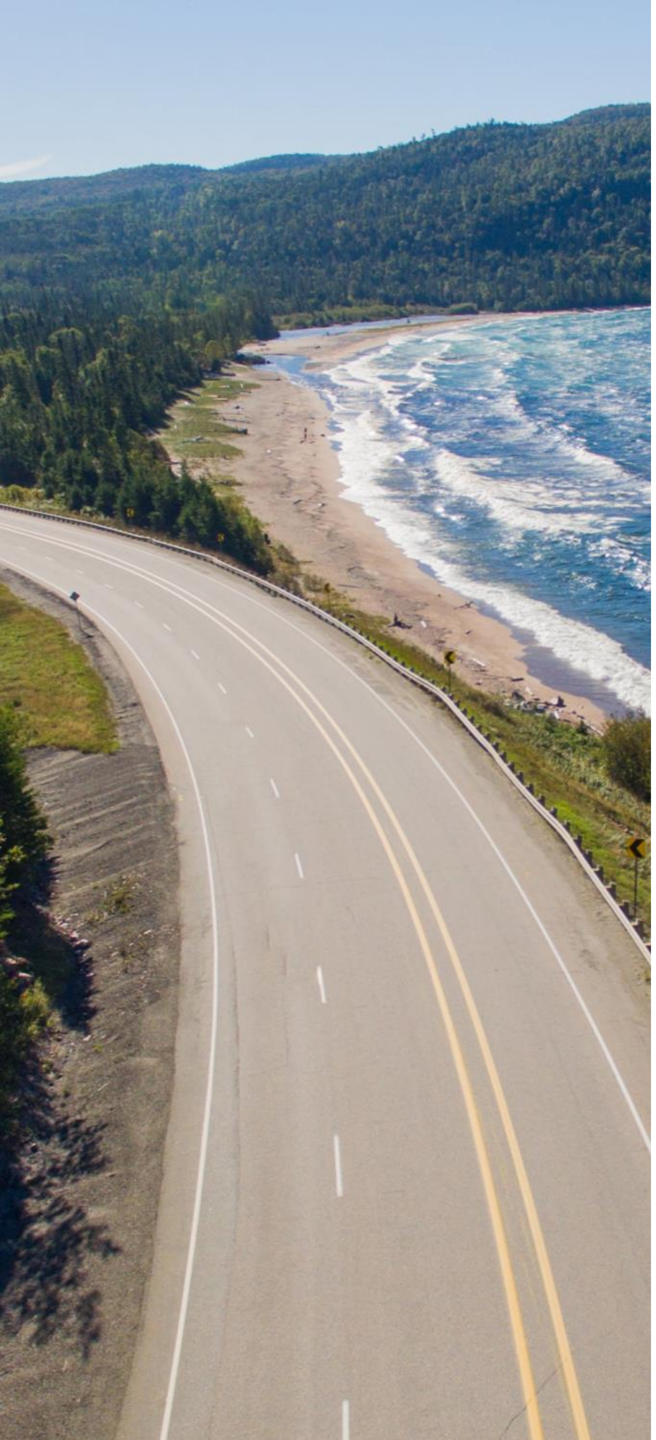
Proposed Buy-Clean Policy:

Bid Value

CO2e Adjustment

Performance/Application Adjusted

SCB Fatigue



Last Few Words...

ACCELERATED INNOVATION AND ADAPTATION The asphalt sector must intensify its efforts in embracing innovation and sustainable practices more in the next six years than it has in the previous twenty-five.

CULTURAL SHIFT Transition from a 'Market Push' approach, which is driven by the supply side, to a 'Market Pull' mentality that responds to demand and sustainability goals.

UNIFIED EFFORT There must be an unwavering commitment to sustainability from all parties involved in the asphalt industry, indicating a joint responsibility.

TECHNOLOGY AND RECYCLING Acknowledge the availability of advanced technologies and recycling methods; these should be actively supported and promoted

POLICY AND INCENTIVE DEVELOPMENT Implement policies and incentives that foster innovation and commitment to sustainable practices within the industry.

LEADERSHIP AND SPECIFICATION INTEGRATION Strong leadership is required to integrate sustainable practices into the specifications and execution of projects.

Last Few Words..

- Rubber Modified Asphalt (RMA) and Ground Tire Rubber (GTR) integration in asphalt applications is an established and beneficial technology.
- A dependable supply coupled with strict quality control ensures consistent availability of this source for projects at all levels.
- It is versatile for **HMA/WMA** applications, dense-graded mixes, hot-applied and emulsified surface treatments such as chip seals, as well as hot-applied sealants and membranes.
- RMA is a substantial driver for carbon footprint reduction in terms of **equivalent CO_2**. Its impact is especially significant if Environmental Product Declarations **(EPDs)** and **'buy clean' policies** gain widespread adoption.
    - Highly compatible with RAP and Warm Mix additives
    - Compatible with other type of polymers
    - Compatible with bio-oils or known as biogenic oils, bio-oils, and other oil-derived circular materials
- Collaboration between Tire Rubber Association of Canada members (ELT Committee) with other road builders, agencies, and technical associations
- Education of the benefits of RMA

QUESTIONS

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