WEBINAR:

MAXIMIZING THE USE OF RECLAIMED ASPHALT PAVEMENT (RAP)

PRESENTED BY: CRAIG GOOD
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ARKEMA-ROAD SCIENCE

INSTITUTO BRASILEIRO
DE PETRÓLEO E GÁS

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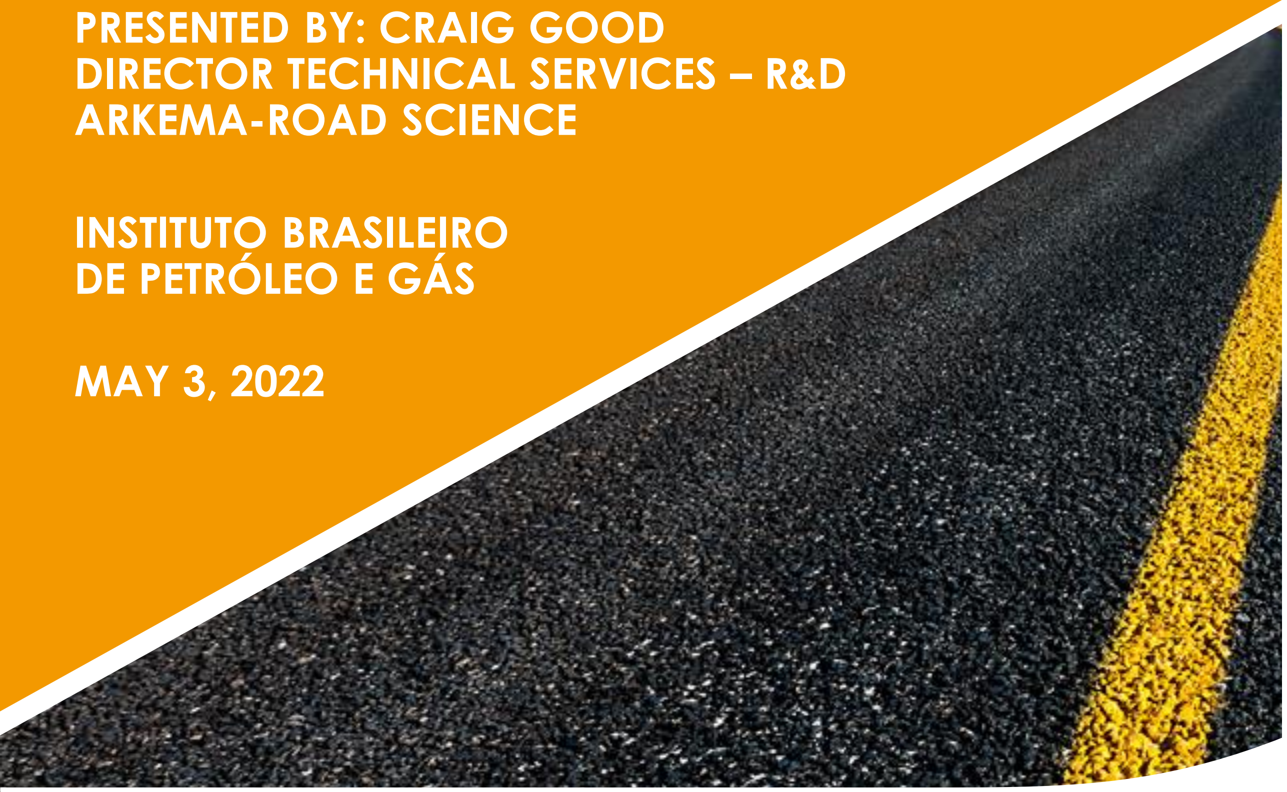

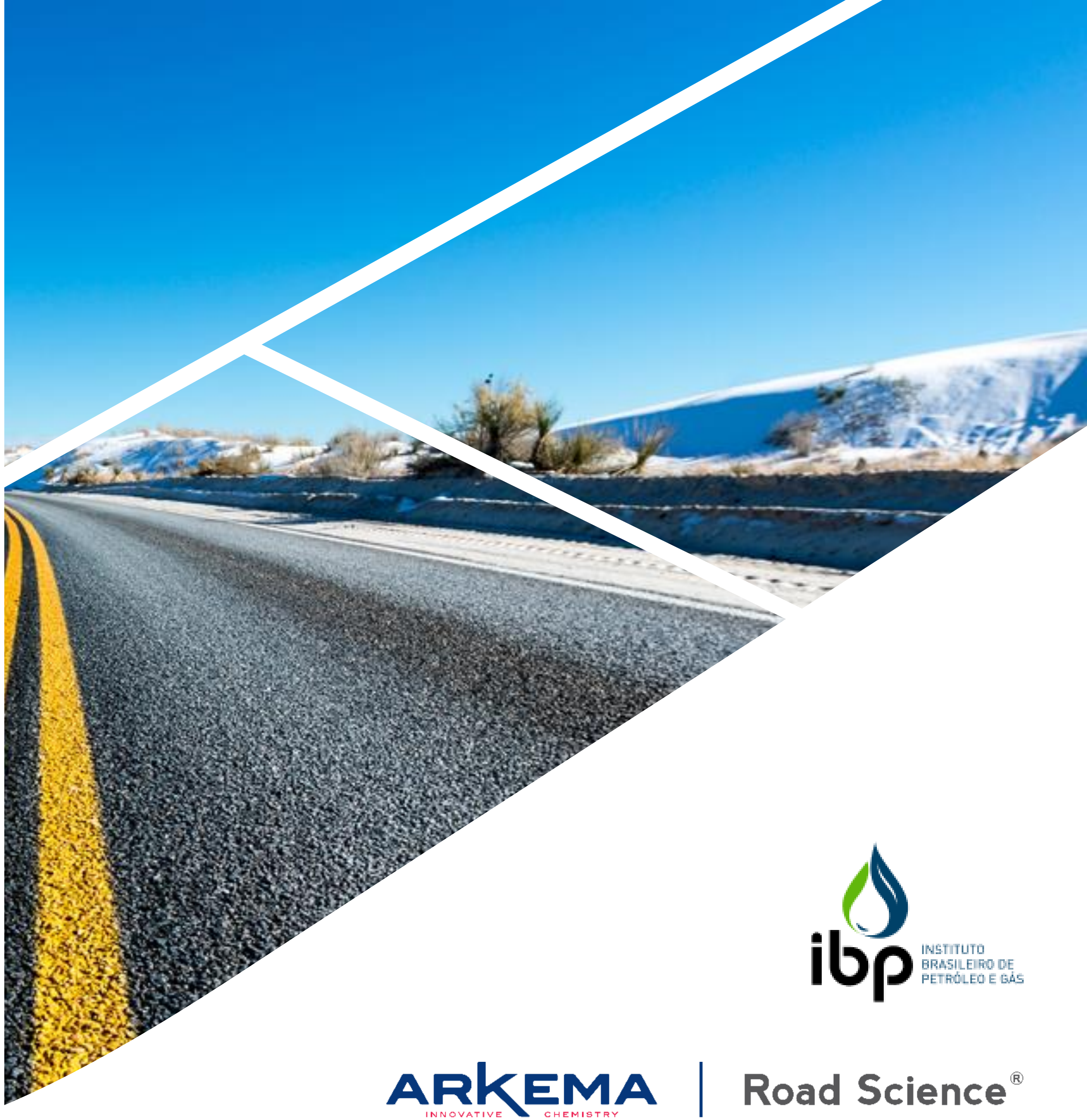

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BUILDING A NEW LEADER IN SPECIALTY SURFACTANTS

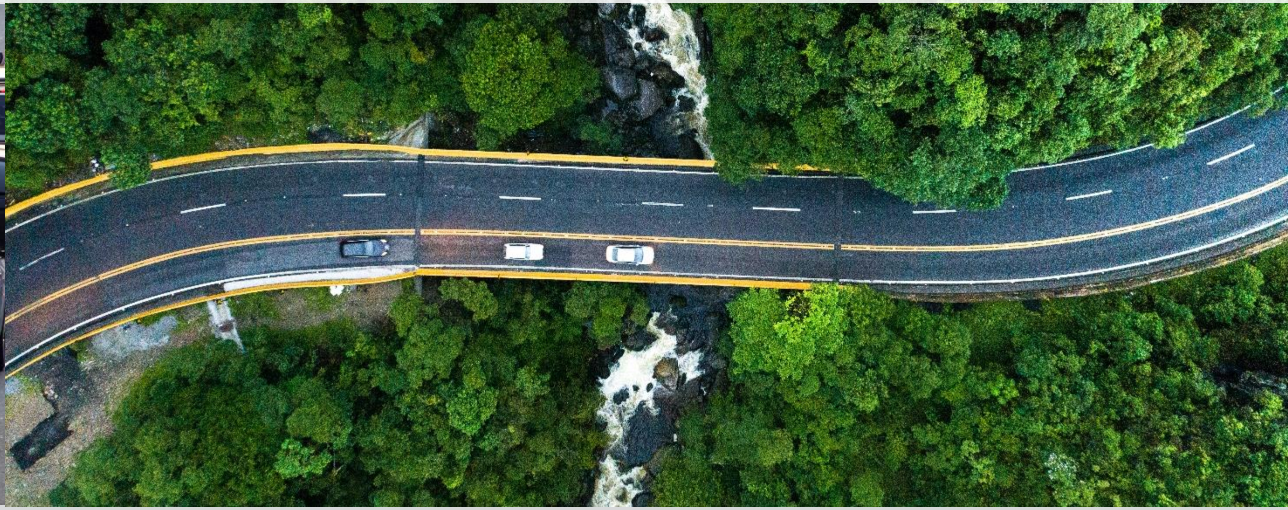
Today, the road paving industry is facing many challenges

Aging infrastructure

Tight budget constraints

Heavier than anticipated traffic loads

Protecting the environment



Recycling asphalt delivers significant economic and environmental benefits

Economic Benefits

- Reduced asphalt costs
- Reduced energy costs
- Lower road maintenance costs
- Saves taxpayers money

Environmental Benefits

- Asphalt can be recycled multiple times – longer life span
- Less road construction material waste in landfills
- Reduced oil consumption to make virgin asphalt
- Reduced green house gas emissions

But asphalt recycling can mean many things…

There are several processes and products associated with recycling / RAP

01 Hot Mix Asphalt (HMA) / Warm Mix Asphalt (WMA) with RAP

02 Central Plant Recycling

03 Cold in Place Recycling (CIR)

04 Full Depth Reclamation (FDR) In-Situ Recycling

In this webinar, we'll focus on two areas to maximize RAP use

Cost-effective and environmentally responsible options for road rehabilitation

Hot Mix Asphalt (HMA) / Warm Mix Asphalt (WMA) with RAP

Full Depth Reclamation
In-Situ Recycling

2 key methods to capture the economics of using RAP:

- Additives on the hot and warm side
- Engineered emulsions on the cold side

HMA / WMA with RAP

Additives on the hot and warm side

The Challenge: Combine RAP use with lower mix production temperatures

- **Recycling of asphalt pavement and the reduction of bituminous mixtures' production temperatures are interesting to combine, for both economic and environmental reasons**

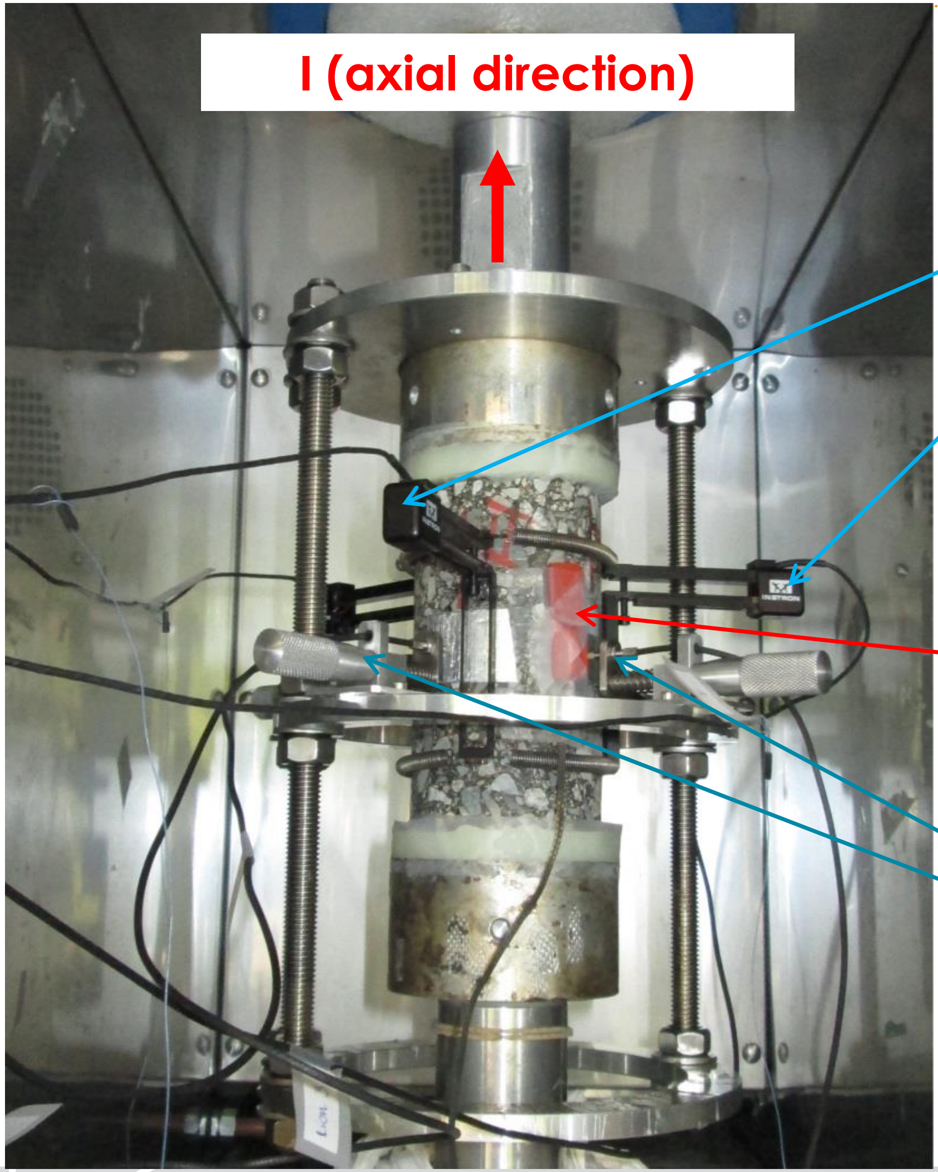
- **A large experimental campaign was initiated to lower mix production temperatures using additives and including RAP by:**
  - **Laboratory of Tribology and System Dynamics (LTDS) laboratory of the University of Lyon/ ENTPE**
  - **Arkema-Road Science**
  - **Malet company**
  - **French Agency for the Environment and Energy Management (ADEME)**

- **Findings were published on November 24, 2020 in *Sustainability***
  - ***Fatigue and Thermal Cracking of Hot and Warm Bituminous Mixtures with Different RAP Contents***
    - Nguyen Hoang Pham[1,2], Cédric Sauzéat[1,*], Hervé Di Benedetto[1], Juan A. González-León[3], Gilles Barreto[3] and Aurélia Nicolaï[4] (see Appendix)

The Approach: Different mixes, production processes, RAP content and additives

- **Testing objective is to address fatigue resistance and the thermal cracking of different bituminous materials**
  - Thermal Stress Restrained Specimen Test (TSRST) for thermal cracking
  - Fatigue at 10 °C, 10 Hz
- **Nine bituminous mixtures were tested**
- **Two types of production processes were considered:**
  - Hot bituminous mixture (HM), control material, mixing at 160 °C
  - Warm bituminous mixture (WM), mixing at 120 °C
- **Three RAP contents: 0%, 30% and 50% by weight of mix**
- **Two types of Arkema-Road Science surfactant-based additives**
  - Additive E and Additive B at 0.4% total asphalt

The Tests: Fatigue, Thermal Stress Restrained Specimen, Impact of Manufacturing

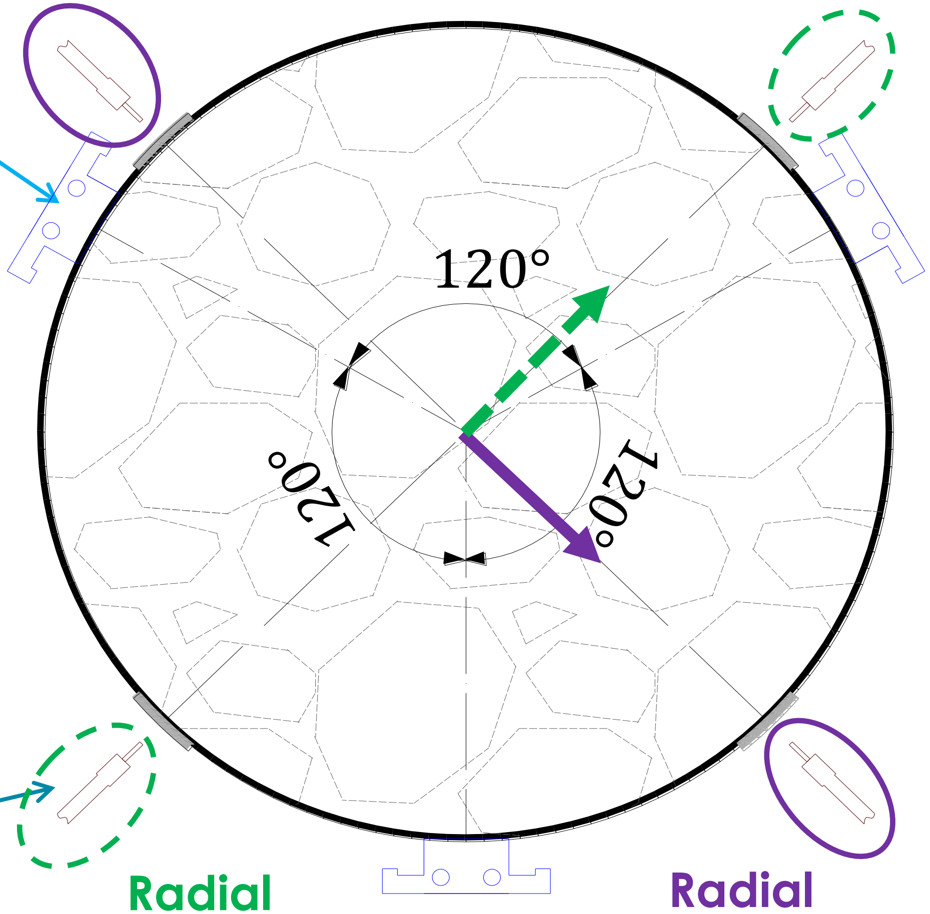


Axial extensometers

Temperature probe

Radial non-contact sensor

Section of cylindrical specimen



Radial direction III

Radial direction II

The Materials: Bituminous mixtures

- Fresh bitumen 38 dmm
- Recovered RAP bitumen 11 dmm
- Final blend adjusted to 38 dmm

50/70 and 70/100 for 30% RAP

50/70 and 160/220 for 50% RAP

Material number	M1/M1-2	M2/M2-2	M3	M4	M5	M6	M7
Material name	HM	HM30	WME0.4	WM30E0.4	WM30B0.4	WM50E0.4	WM50B0.4
Production process	Hot	Hot	Warm	Warm	Warm	Warm	Warm
%RAP	-	30	-	30	30	50	50
Type of additive	-	-	add. E	add. E	add. B	add. E	add. B
%Additive	-	-	0.4	0.4	0.4	0.4	0.4

The Results: Fatigue testing – influence of RAP and additive

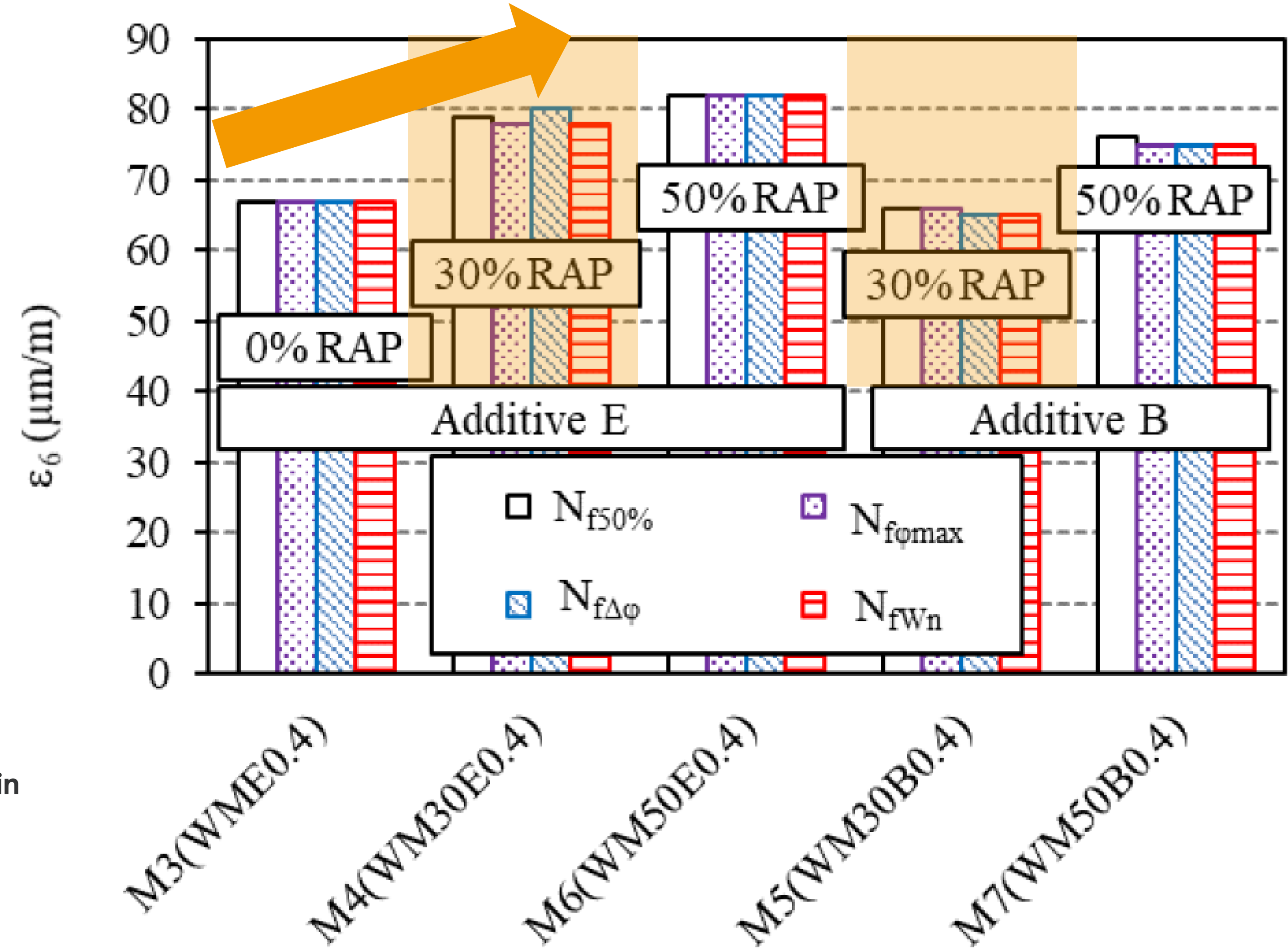
Additives together increase the strain tolerance of the mix

Fatigue - Influence of RAP

- For the standard hot mix, the fatigue performance of the hot mix decreases when adding RAP (reference report)
- For warm bituminous mixtures, accounting for the additives, the ε6 value increases when adding RAP

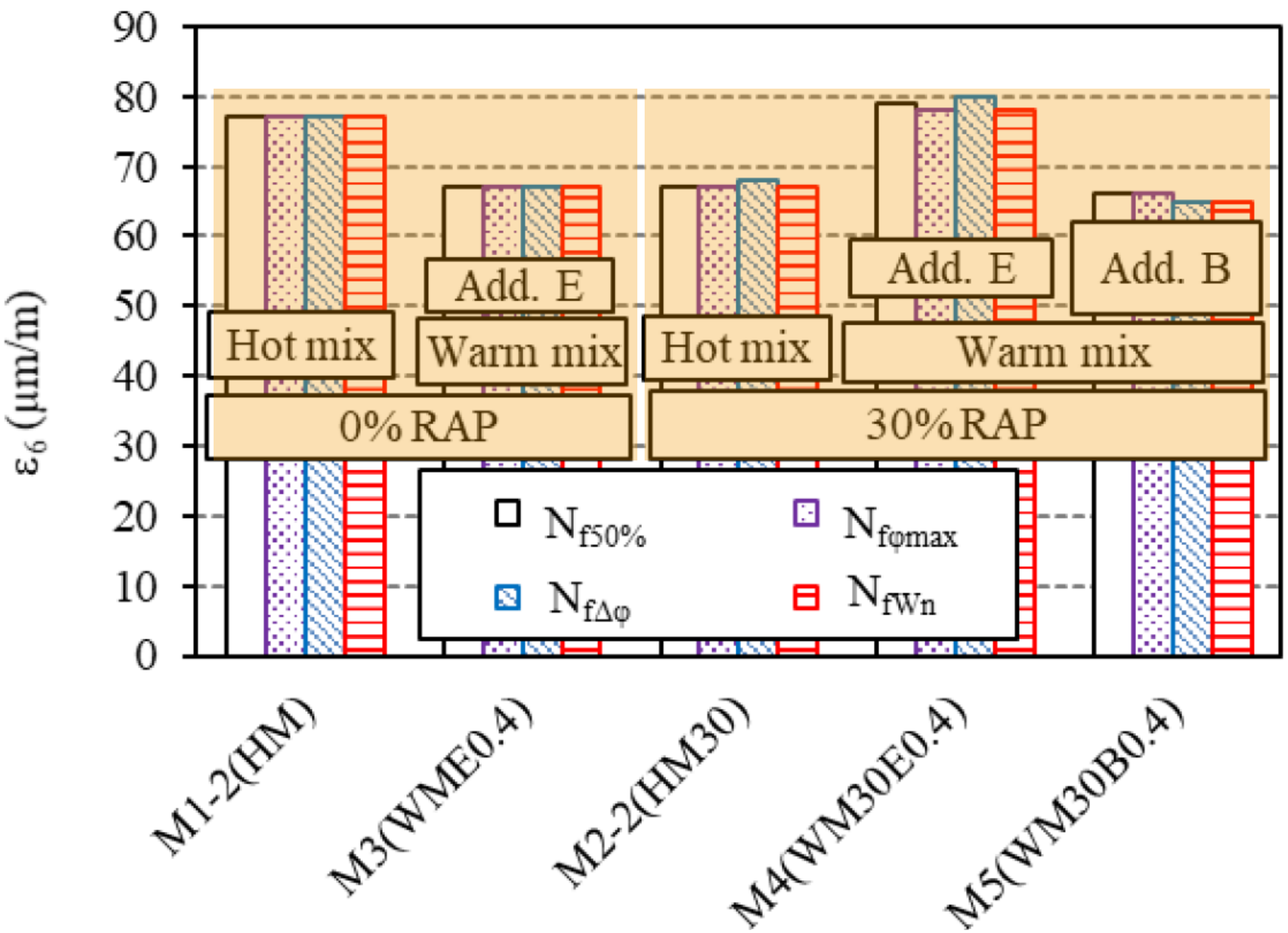
Fatigue - Influence of Additive

- Additive E provides higher values of ε6 than additive B, for warm bituminous mixtures with RAP



Reference Wöhler Curves used for fatigue cycles to failure versus strain amplitude (see report)
ε_6 represents the axial strain amplitude level for which the failure is obtained after one million cycles

The Results: Fatigue testing – influence of manufacturing



For bituminous mixtures without RAP hot bituminous mixture has higher ε6 value than warm bituminous mixture

Then for the bituminous mixtures without RAP, the fatigue performance of hot bituminous mixture is better than that of the warm bituminous mixture

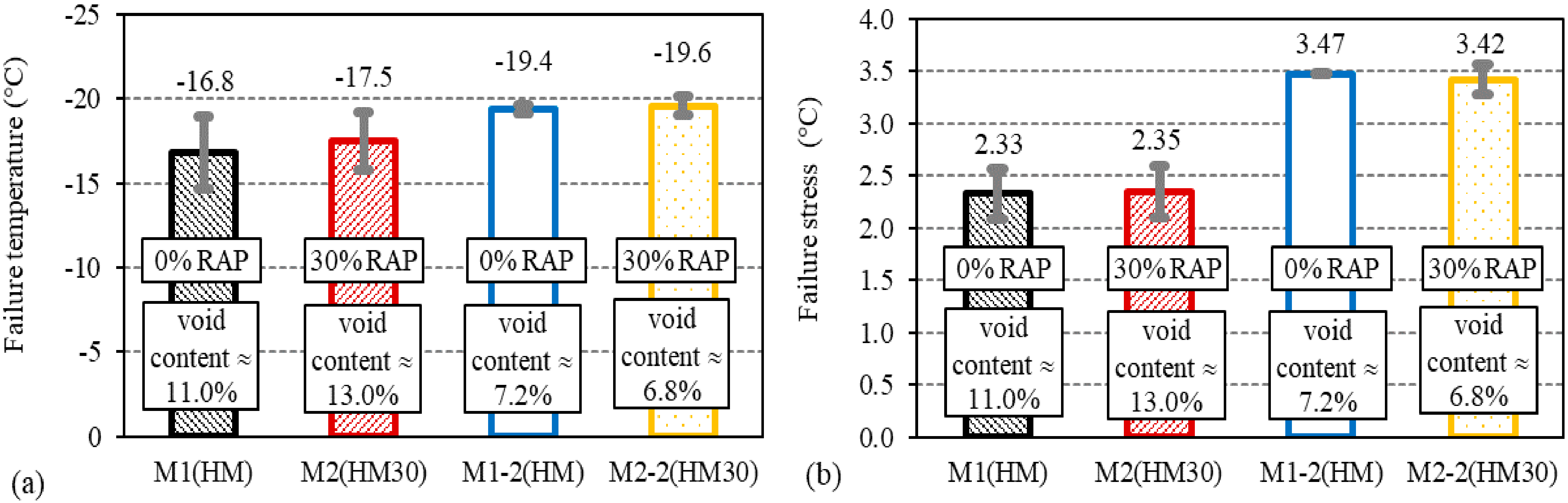
For bituminous mixtures with 30% RAP No clear trend emerges

The ε6 value of the hot bituminous mixture M2-2 is smaller than that of the bituminous mixture M4 (warm mix using additive E) and is equal to that of the bituminous mixture M5 (warm mix using additive B)

The Results: TSRST – influence of RAP and voids on HMA

Denser materials have better performance

RAP content seems to have little influence on the hot mixtures

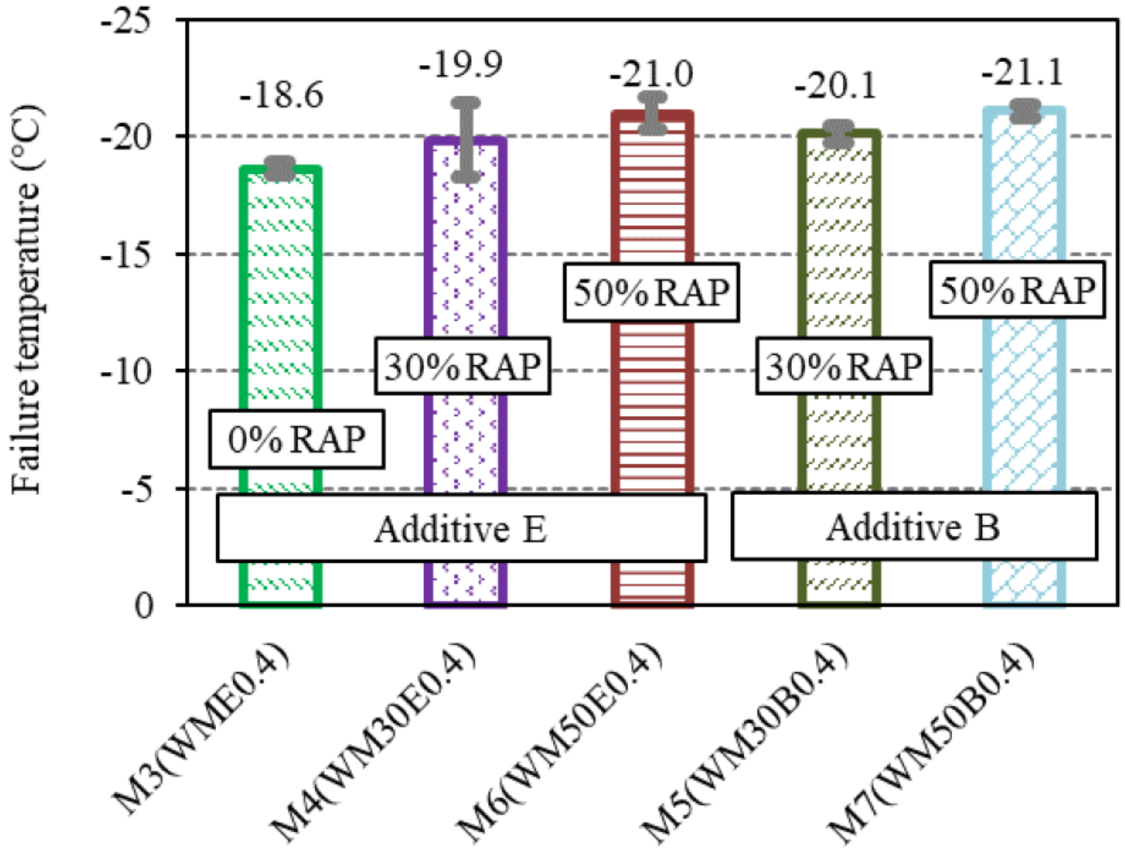


Failure Temperature **Failure Stress**

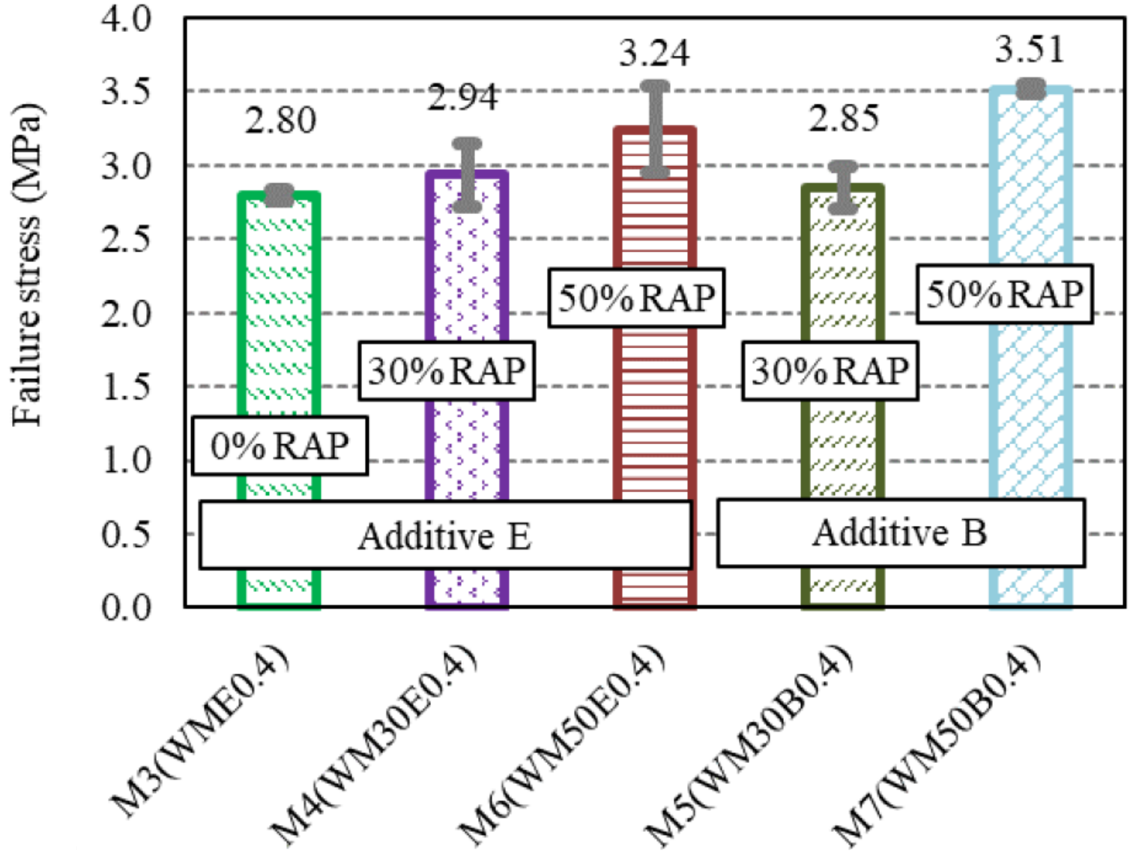
The Results: Influence of RAP with additive

For warm bituminous mixtures with additives, a clear trend emerges

- The failure temperature values decrease, and failure stress values increase when the RAP content increases
- RAP addition improves the performance of the tested warm bituminous mixtures



Failure Temperature

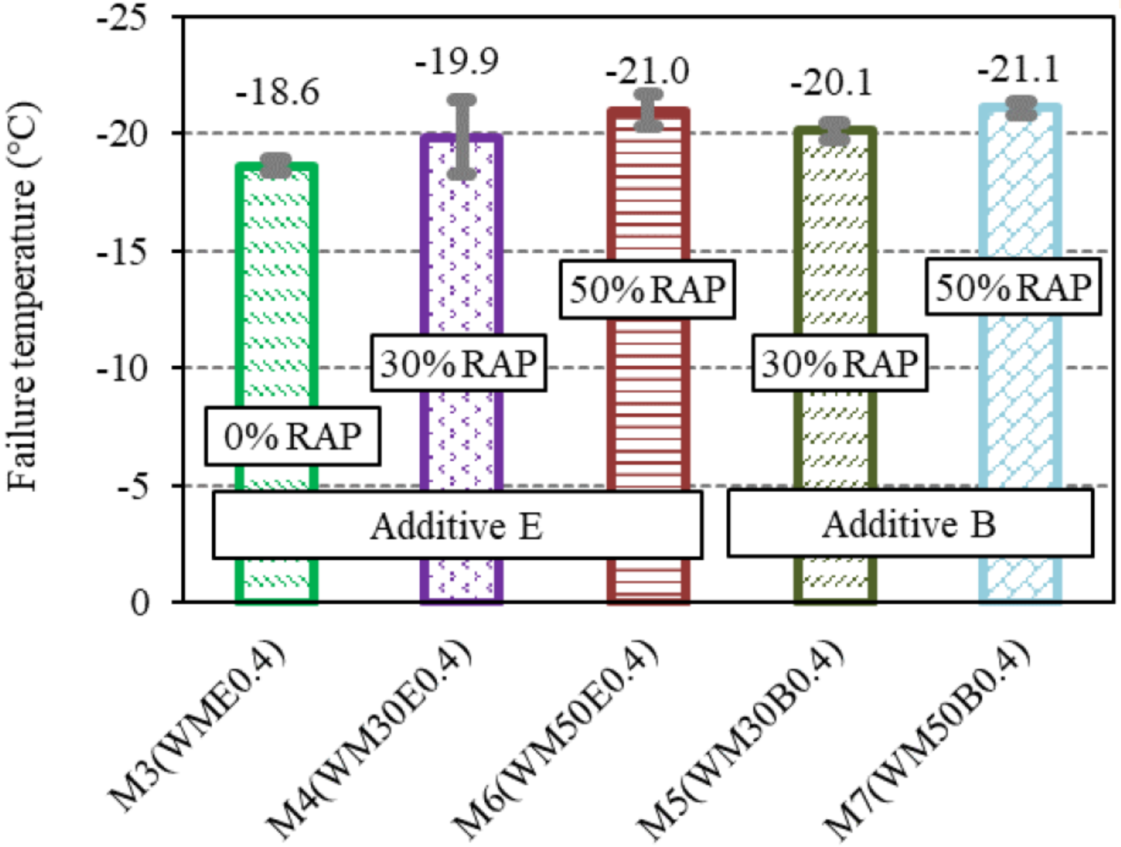


Failure Stress

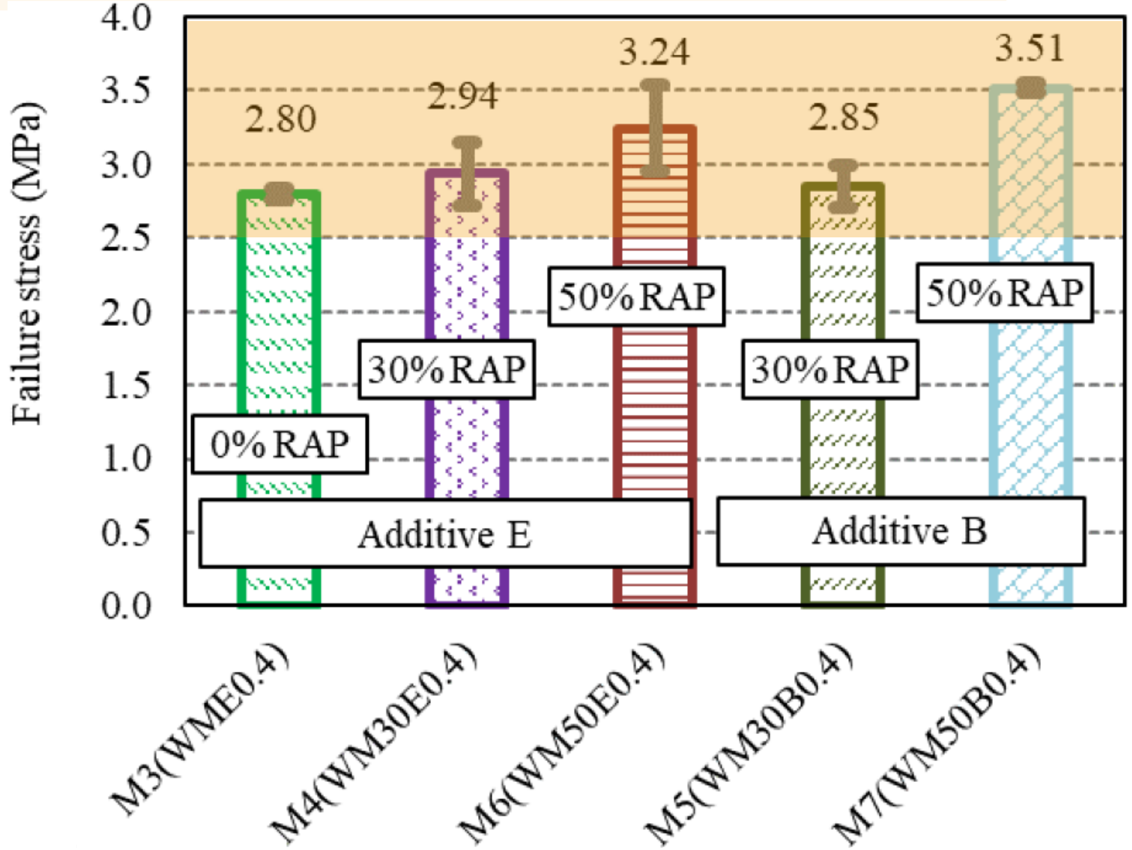
The Results: Influence of the type of additive

The effect of the two types of additives (E and B) on the failure temperature and failure stress of the warm bituminous mixtures is quasi-identical

- Additive B gives better results for warm bituminous mixtures with 50% RAP, but worse for warm bituminous mixtures with 30% RAP
- The discrepancy between the tests results is higher for this parameter and does not allow a definite conclusion



Failure Temperature



Failure Stress

Key Takeaways: Fatigue and TSRST Tests

- **Radial strain in two directions**
  - Gives information on the multi-axial behavior of the materials, which needs to be further investigated to better understand the bituminous mixtures' behavior – this is essential to improve the modeling and design of road structures
- **Four criteria were applied to determine fatigue life which gave similar results**
- **The repeatability of the TSRST was good based on temperature failure, stress failure and radial strain failure values**
- **A decrease in the voids content improves fatigue and TSRST test performance**

Key Takeaways: The importance of using the right additive

- The influence of the manufacturing process (hot or warm), RAP content and type of additive used for warm process were evaluated for both types of tests

- Overall, warm bituminous mixtures with RAP exhibit comparable performance with hot bituminous mixtures and, in some cases, even better performance

Full Depth Reclamation (FDR) In-Situ Recycling

Engineered emulsions on the cold side

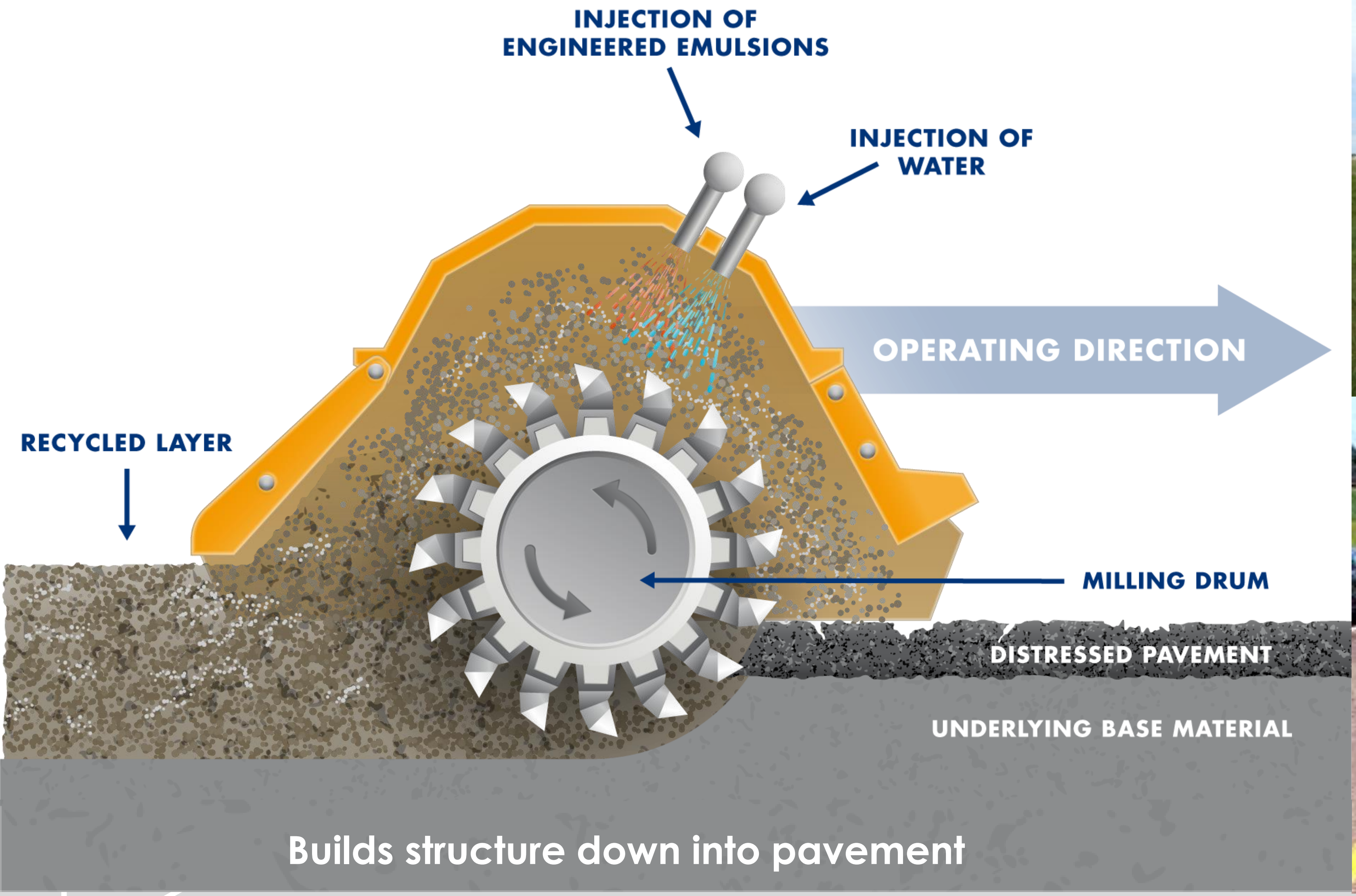
Full Depth Reclamation (FDR) is an effective road rehabilitation technique…

- **Asphalt pavement and a portion of underlying materials are pulverized and blended into a homogeneous base material**
- **Injected with engineered emulsion, the process produces a flexible yet strong stabilized base for structurally upgrading pavements**

…that addresses many kinds of pavement distresses

- All types of cracking
- Inadequate structural capacity
- Loss of bonding in between layers and stripping
- Poor ride quality
- Loss of surface integrity (raveling, potholes and bleeding)
- Excessive shoulder drop-off

The process involves pulverizing asphalt pavement layers and underlying base in-situ



The process involves pulverizing asphalt pavement layers and underlying base in-situ

Milling / addition of water and engineered emulsion

Compaction

Profile

Final moisture for optimal compaction and dust control

Profile compaction

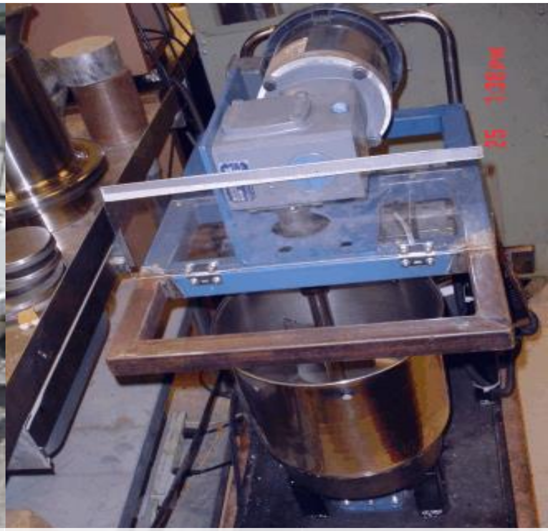
Final grade compaction

There are several key criteria required for success

- Pavement and material assessment
- Engineered mix design
- Performance related specifications
- Innovative emulsion technology
- Construction guidelines and QC specs

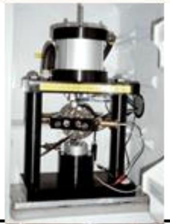
Superpave gyratory compactor

Falling weight deflectomer - FWD



Lab mixer

Each criteria directly impacts key performance parameters

Criteria		Performance Parameter
Short Term Strength by Cohesiometer ASTM D1560		*Determine if appropriate early curing is occurring*
Retained Strength ASTM D4867		*Resistance to moisture damage*
Resilient Modulus ASTM D4123		*Relative indicator of quality* Strain or deflection w/ applied load for structural design
Indirect Tensile Test (IDT) AASHTO T 322		*Thermal cracking resistance*
Construction & QA/QC Requirements		*Reliability*

FDR performance can be enhanced with an engineered emulsion

- Chemical break, solventless
- High asphalt content
- Flexible and strong bituminous layer
- Early strength and increased structural capacity
- Excellent coating
- Performance related specs
- Higher reliability (QC/QA practices)

RAP can deliver significant economic advantages

Base Treatment	Existing Road Material			
	Very Dirty	*Rounded Ag* High Fines	*Med Quality Ag* Med. Fines	*High Quality Ag* High RAP
Untreated	*< 0.10*	*0.10 - 0.12*	*0.12 - 0.14*	*≥ 0.14*
Hydrated Lime	*0.12*	*0.14*	*N/A*	*N/A*
Cement (CTB) (soil cement)	*0.14 - 0.23* *(depends upon % cement & material; lower for less cracking)*			
*Commodity (CSS, CMS) Emulsion**	*0.12*	*0.12 - 0.16*	*0.16 - 0.20*	*0.20 - 0.23*
EE Granular Base Stabilization	*N/A*	*0.18 - 0.20*	*0.21 - 0.22*	
EE Full Depth Reclamation	*N/A*		*0.22 - 0.24*	*0.25 - 0.28*
*Foam**				*0.25*
EE Cold in-place Recycling				*0.28 - 0.33+*
HMA			*0.34 - 0.40*	*0.40 - 0.44*

Coefficients rely on:

1. Material quality
2. Passing the mix design
3. Passing quality control requirements.

A larger coefficient results in a thinner pavement under the same traffic condition

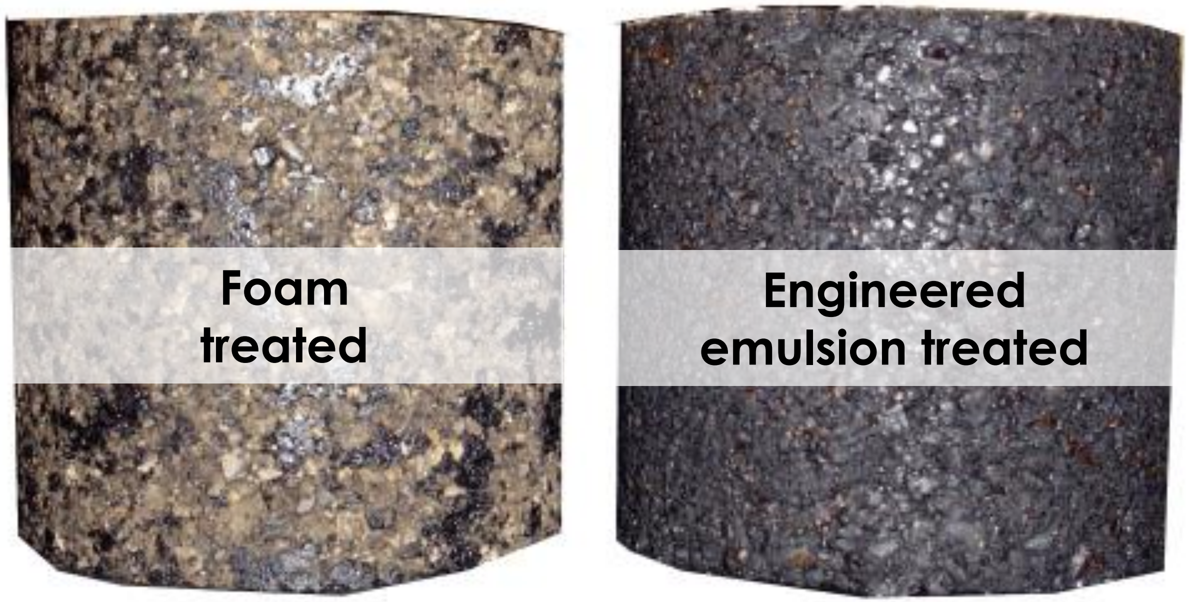
Less material = lower costs

*** Values are from the literature. All values here generalized; each agency has own point of view. FDR values validated by FWD***

Key takeaways: The benefits of Full Depth Reclamation

- **Flexible and strong bituminous stabilized base**
  - Strong enough for traffic before surface treatment
  - Resists rutting
  - Improved resistance to:
    - Thermal cracking
    - Fatigue cracking
    - Moisture damage
- **Early and increased strength**
  - Immediate compaction and same day return to traffic
  - Overlay within 3-10 days depending on weather and moisture
  - Uniform strength
- **Cost-effectiveness % economic flexibility, "Environmental Advantages," stage construction**
- **Excellent coating with engineered emulsion**

Same aggregate = Same residual asphalt content



Maximize RAP use with HMA/WMA or FDR In-Situ

- Additives on the hot and warm side
- Engineered emulsions on the cold side

Appendix

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THANK YOU
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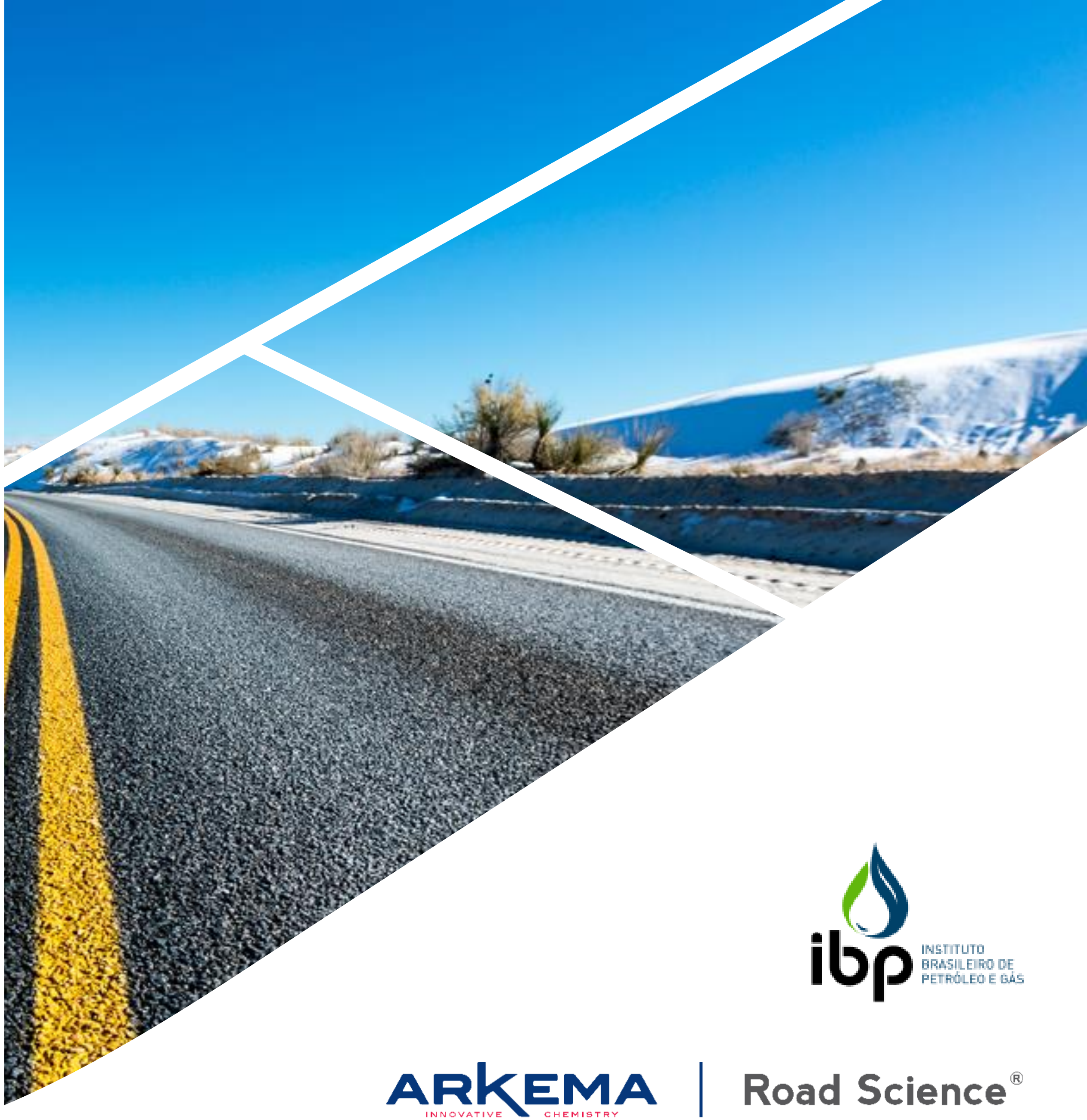

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