Surface course trials of 50% Reclaimed Asphalt in conjunction with and without bio-rejuvenators on the SRN in England

Matthew Wayman

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Introduction

- National Highways – Net Zero 2030/2040/2050 plan aims to achieve net zero for construction and maintenance by 2040.
- The use of RA in surface courses has been identified as an important decarbonisation lever.
- Increased levels of RA in surface courses makes better use of high-quality aggregate with high polished stone value (PSV) levels, reduces resource demand and minimises transportation costs.
- In the UK, 10% RA is commonly incorporated into surface course materials as standard practice. With the permitted limit set to rise from 10% to 20%.
- Net Zero research project commissioned to investigate emerging low carbon technologies.
- Presentation focuses on a recent trial on the A21, which assess the performance of 50% RA in conjunction with & without bio-rejuvenator.

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Surface Course Trials with >20% RA in the UK with >5 years in-service

Site	Installed Date	Commercial Vehicle Flow (CV/l/day)	RA Content	Surface Course	RA Properties				Service Life
					RA Source	Penetration (dmm)	Softening Point (°C)	RA PSV	
A405 Bricket Wood	2004	1423	**10 & 30%**	SMA	Porous Asphalt	Not Declared	Not Declared	Not Declared	Sections in service for up to 17 years
M4 Cardiff	2006	3123	**25%**	TSCS	Porous Asphalt	16	69.6	Not Declared	Replaced after 10 years
M25 J6-7 CW	2007	5658	**23%**	14mm TSCS	Porous Asphalt	19	67.8	59	Lane 1 replaced after 15 years with Lane 2 & 3 replaced after 17 years
M25 J6-7 ACW	2009	1701	**40%**	20mm TSCS	Porous Asphalt	Not Declared	Not Declared	Not Declared	In-service
M20 J2-3 SB	2016	306	**30%**	14mm TSCS	Existing TSCS	18	67.4	61	In-service
A1 (Mill Hill)	2016	2599	**50%**	14mm SMA	SMA	18	67.0	63	In-service
A40	2017	2706	**50%**	14mm AC	N/A	24	65.0	63	In-service
M3	2019	3005	**20%**	14mm TSCS	Existing TSCS	16	68.8	62	In-service
M25 J26-25	2019	7639	**50%**	14mm TSCS	Existing TSCS	34	63.0	65	In-service
M3 NB J6	2021	4471	**50%**	14mm TSCS	10/14 SMA	11 / 23	68.2 / 71.2	65	In-service

Further 9 sites have been installed in the last 5 years

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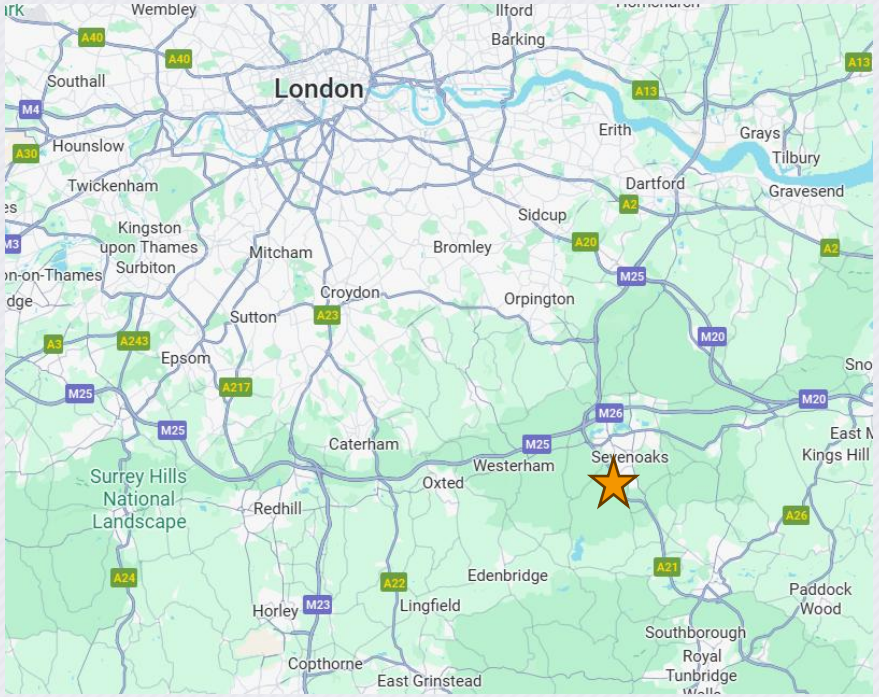
A21 Trial Design

- In total six trial sections were installed on Lane 1 and 2 of A21 in South East England.
- This section of carriageway is subject to an annual average daily flow of 18,408 vehicles per day (one-way).
- 50mm 0/14 Thin Surface Course System selected for the trial – common surface course in England (AC mixture).
- Mixes with both Polymer Modified Binder (PMB) (lane 1)
- Mixes with 40/60 penetration grade binder (lane 2).
- Trial include 0% RA, 50% RA & 50% RA with a bio-rejuvenator.



Mix Designation	TSCS 0% RA (PMB)	TSC 50% RA (PMB)	TSCS 50% RA + Bio-Rej (PMB)	TSCS 0% RA (Pen)	TSC 50% RA (Pen)	TSCS 50% RA + Bio-Rej (Pen)
Trial Length (m)	694	740	754	694	740	754
Lane	Lane 1			Lane 2		
Binder	PMB	PMB	PMB	Pen	Pen	Pen
RA Content (%)	0%	50%	50%	0%	50%	50%
Bio-rejuvenator	No	No	Yes	No	No	Yes

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A21 – Trial Collaboration

- Extensive collaboration to successfully deliver trial in 6 months:
  - Trial design
  - Departure from Standard Approval
  - RA sourcing & testing
  - Mix Design
  - Installation
  - Sampling
  - Testing

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The University of Nottingham

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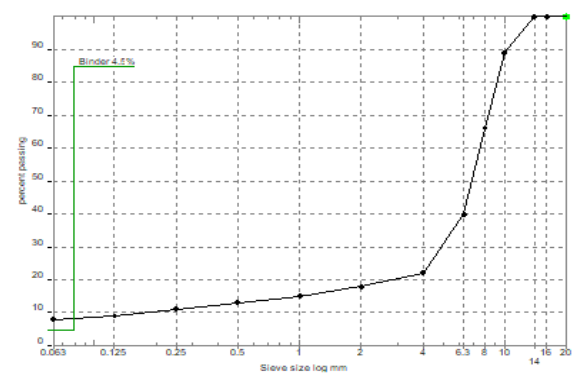
Constituents

Reclaimed Asphalt

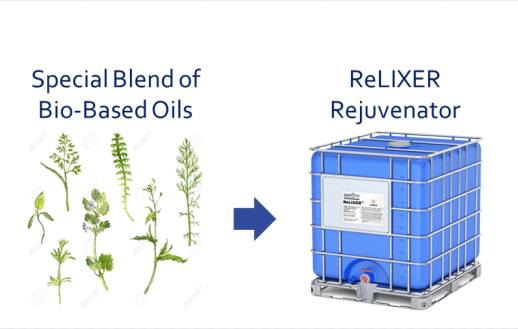
RA	Property	Grading Curve
Binder Content (%)	4.5	
Recovered Penetration @25oC (dmm)	17	
Recovered Softening Point (°C)	66.2	
Polished Stone Value	56	
Aggregate Abrasion Value	12	

- RA sourced from Thin Surface Course System from strategic road network.

Binder

- PMB = 75-130/75. Enhanced polymer content used for 50% RA.
- Pen = 40/60 pen. A 160/220 pen used for correction for 50% RA.

Bio-rejuvenator



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Mix Design

Mix Ref	1A	1B	1C	2A	2B	2C
Constituent	TSCS 0% RA (PMB)	TSCS 50% RA (PMB)	TSCS 50% RA + Bio-Rej (PMB)	TSCS 0% RA (Pen)	TSCS 50% RA (Pen)	TSCS 50% RA + Bio-Rej (Pen)
Coarse Aggregate	63%	41%	41%	63%	41%	41.1%
Fine Aggregate	24%	0%	0%	24%	0%	0%
Reclaimed Asphalt	0%	50%	50%	0%	50%	50%
Filler	7%	5%	5%	7%	5%	5%
Fibre	0.4%	0.4%	0.4%	0.4%	0.4%	0.4%
Virgin Binder Added (%)	5.4%	3.4%	3.4%	5.4%	3.4%	3.4%
WMA	0.1%	0.1%		0.1%	0.1%	
Bio-Rejuvenator	-	-	0.1%	-	-	0.1%

- Same coarse aggregate, fine aggregate, RA & filler used for all mixes.
- Designed to provide the same total binder content.
- WMA not used in bio-rejuvenator mixes due to limitations at asphalt plant regarding chemical lines.
- Presentations focuses on PMB mixes 1A-1C.

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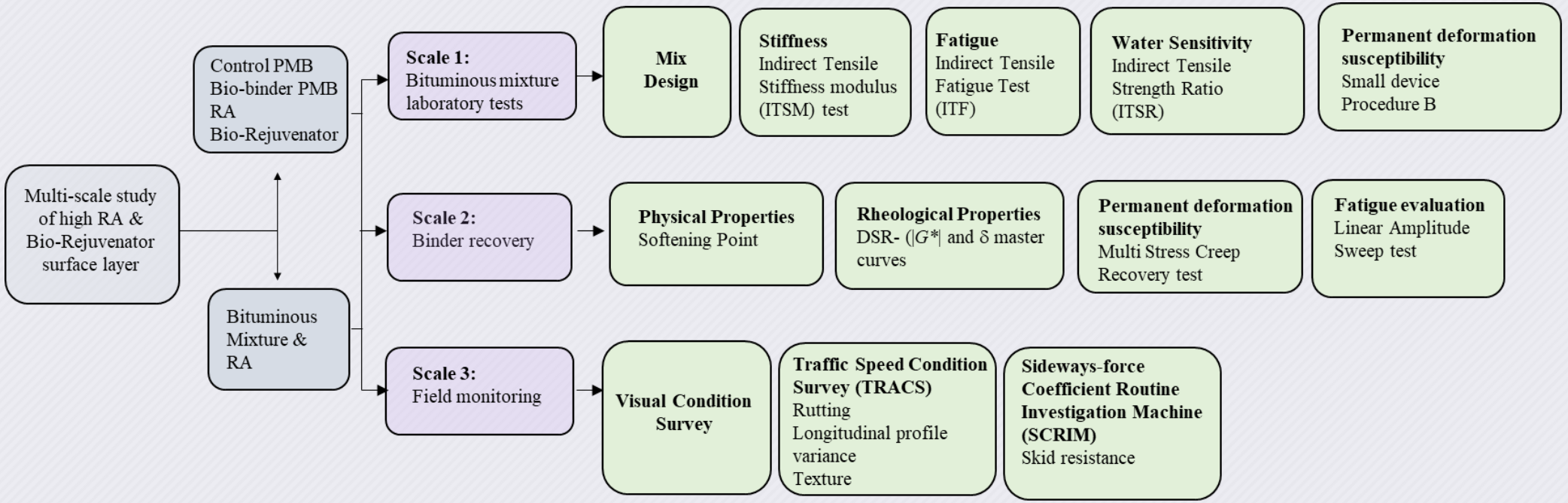
Production & Installation

- All surface courses were produced and installed by FM Conway between 4-12th September 2024.
- The 50% RA mixes were produced using a parallel drum – RA drier.
- Bio-rejuvenator added directly to the mixer box.
- Installation complied with the specification requirements.
- Samples taken at asphalt plant for testing.
- Surface macro-texture & regularity measured during installation.

Section Ref	Section	Surface Macro-texture (mm) BS EN 13036-1
1A	TSCS 0% RA (PMB)	1.5
1B	TSC 50% RA (PMB)	1.8
1C	TSCS 50% RA + Bio-Rej (PMB)	1.8
2A	TSCS 0% RA (Pen)	1.5
2B	TSC 50% RA (Pen)	1.7
2C	TSCS 50% RA + Bio-Rej (Pen)	1.7

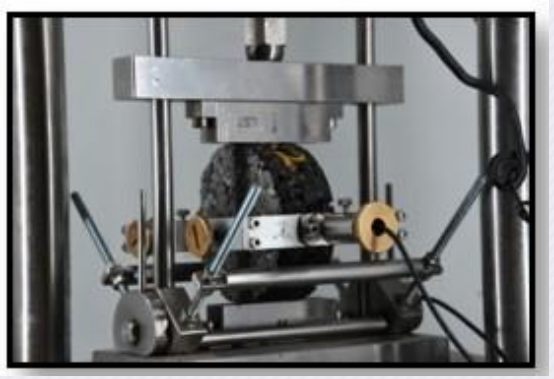
Experimental Programme



Bituminous Mixture Testing

Indirect Tensile Stiffness Modulus @ 20ºC

Mix Ref	Bituminous Mixture	Air Void Content (%)	Mean Indirect Tensile Stiffness Modulus (MPa)
1A	TSCS 0% RA (PMB)	1.5	5,687
1B	TSC 50% RA (PMB)	3.1	4,997
1C	TSCS 50% RA + Bio-Rej (PMB)	2.5	3,623



Water Sensitivity – Indirect Tensile Strength Ratio

Mix Ref	Bituminous Mixture	Air Void Content (%)	Indirect Tensile Strength Ratio (%)
1A	TSCS 0% RA (PMB)	4.9	104
1B	TSC 50% RA (PMB)	6.4	87
1C	TSCS 50% RA + Bio-Rej (PMB)	5.6	98

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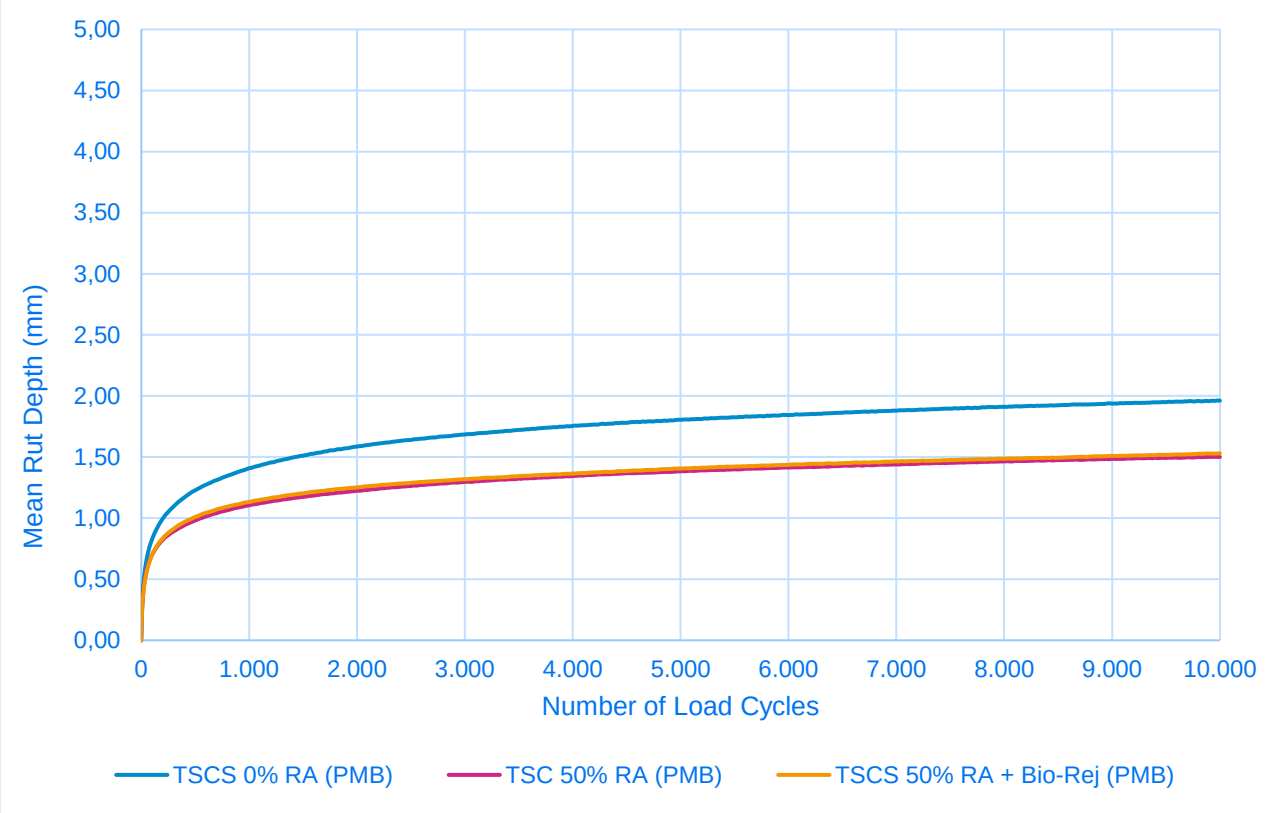
Bituminous Mixture Testing

Wheeltracking
Small Device @ 60ºC



Mix Ref	Bituminous Mixture	Air Void Content (%)	Mean slope WTS_{AIR} (mm per 10^3 load cycles)	Mean Proportion Rut Depth PRD air (%)	Mean Rut Depth RD at 10,000 Cycles (mm)
1A	TSCS 0% RA (PMB)	3.3	0.04	3.8	2.0
1B	TSC 50% RA (PMB)	3.9	0.03	2.8	1.5
1C	TSCS 50% RA + Bio-Rej (PMB)	3.8	0.03	2.9	1.5

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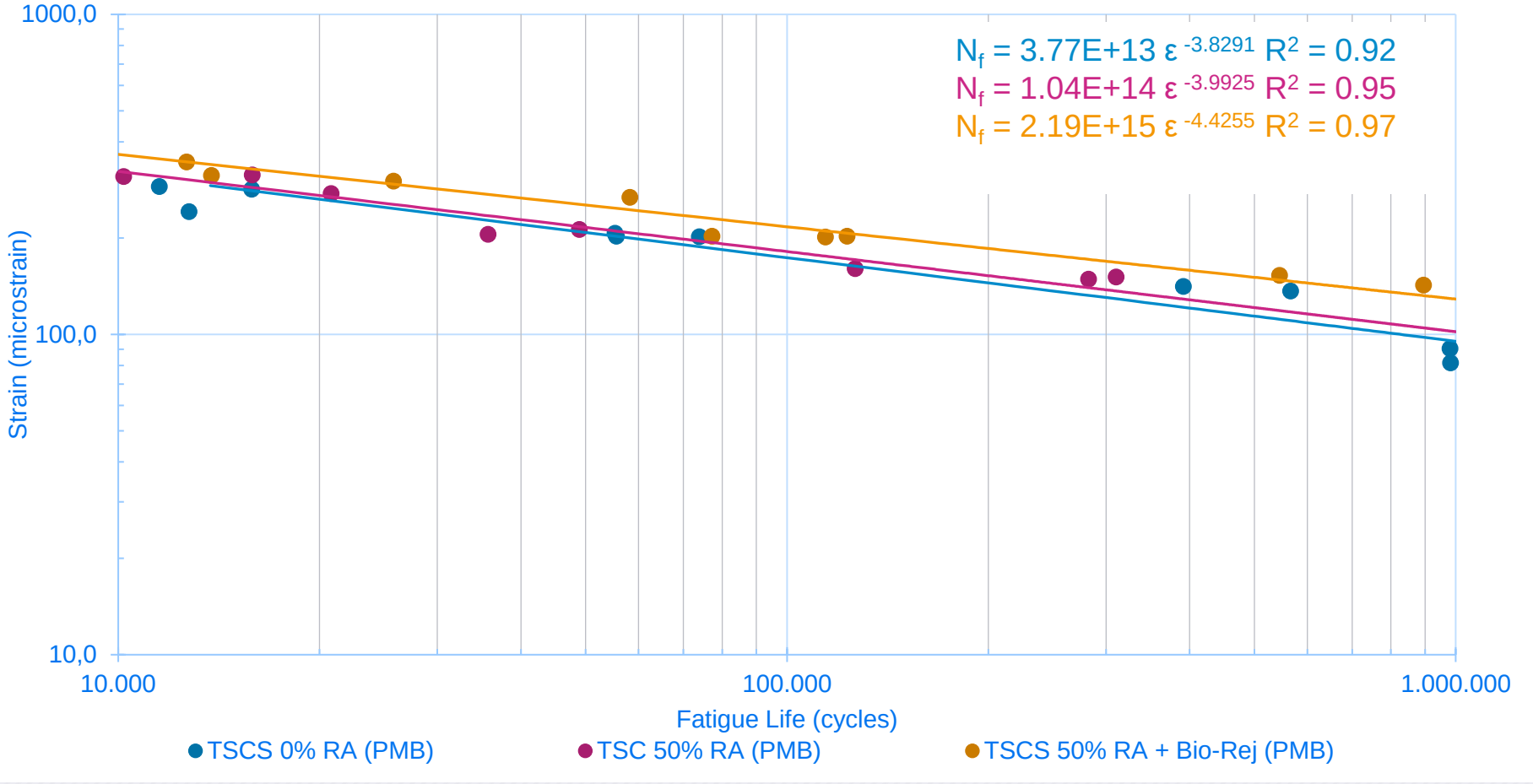
Bituminous Mixture Testing

Indirect Tensile Fatigue Test @ 10ºC



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Recovered Binder Results from Bulk Samples

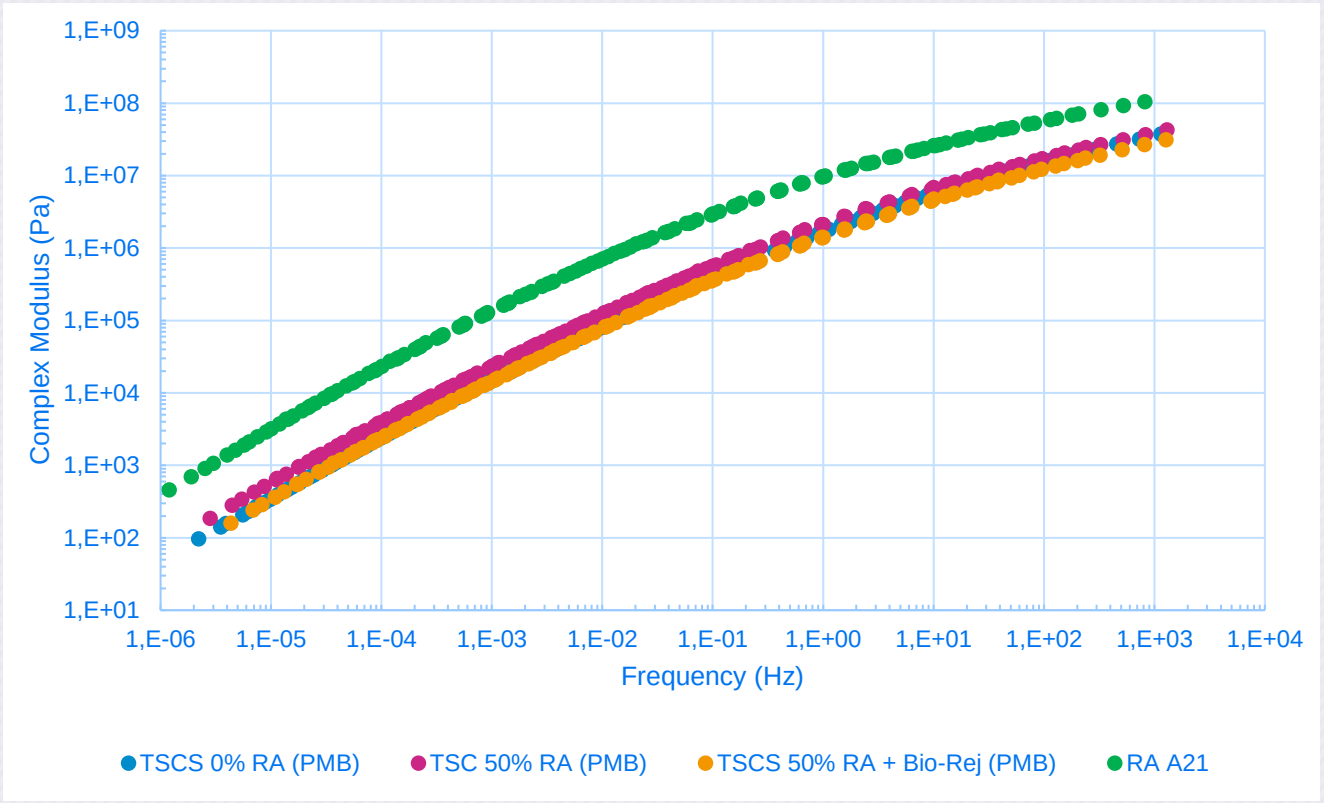
Recovered Penetration

Mix Ref	Recovered Binder from Mix	Recovered Penetration (BS EN 1426) (dmm)
1A	TSCS 0% RA (PMB)	51
1B	TSC 50% RA (PMB)	41
1C	TSCS 50% RA + Bio-Rej (PMB)	46

Recovered Softening Point

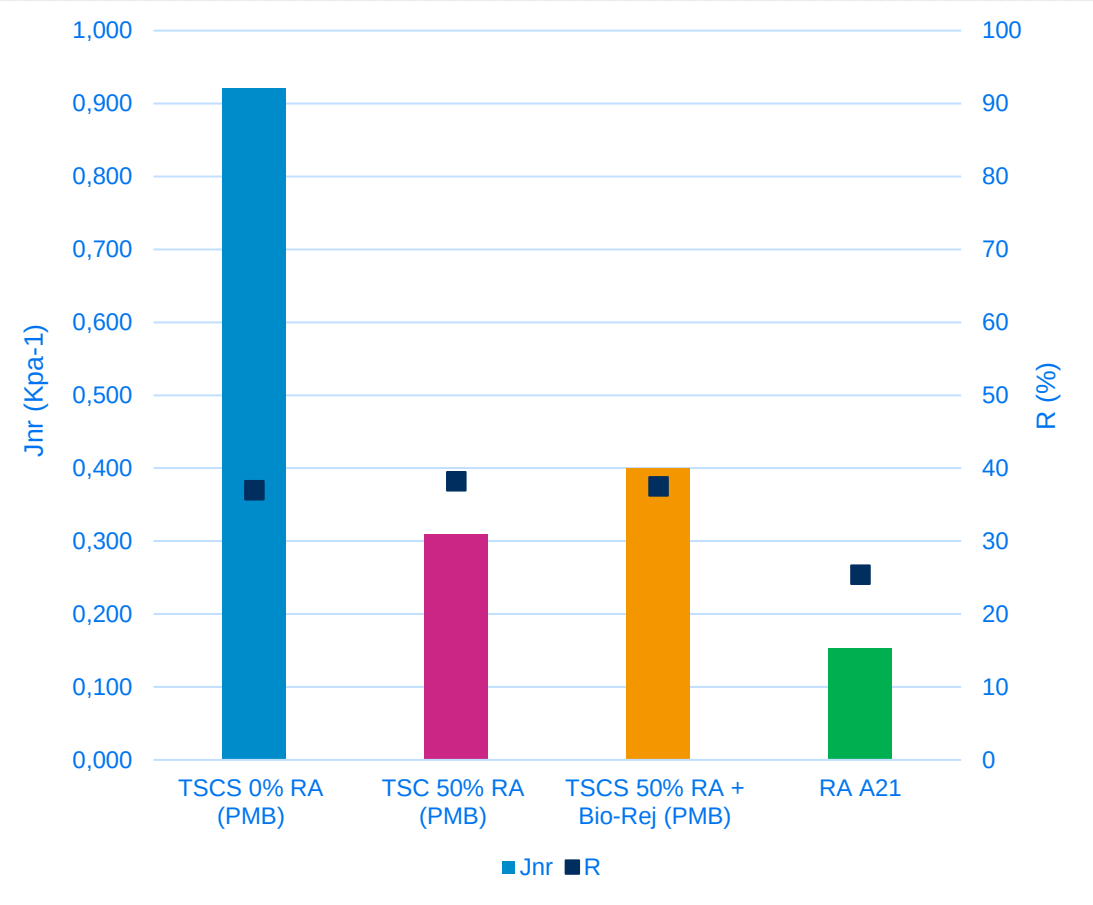
Mix Ref	Recovered Binder from Mix	Recovered Softening Point (BS EN 1427) (ºC)
1A	TSCS 0% RA (PMB)	57.4
1B	TSC 50% RA (PMB)	61.0
1C	TSCS 50% RA + Bio-Rej (PMB)	60.8

DSR – Complex Modulus Master Curve (25ºC)

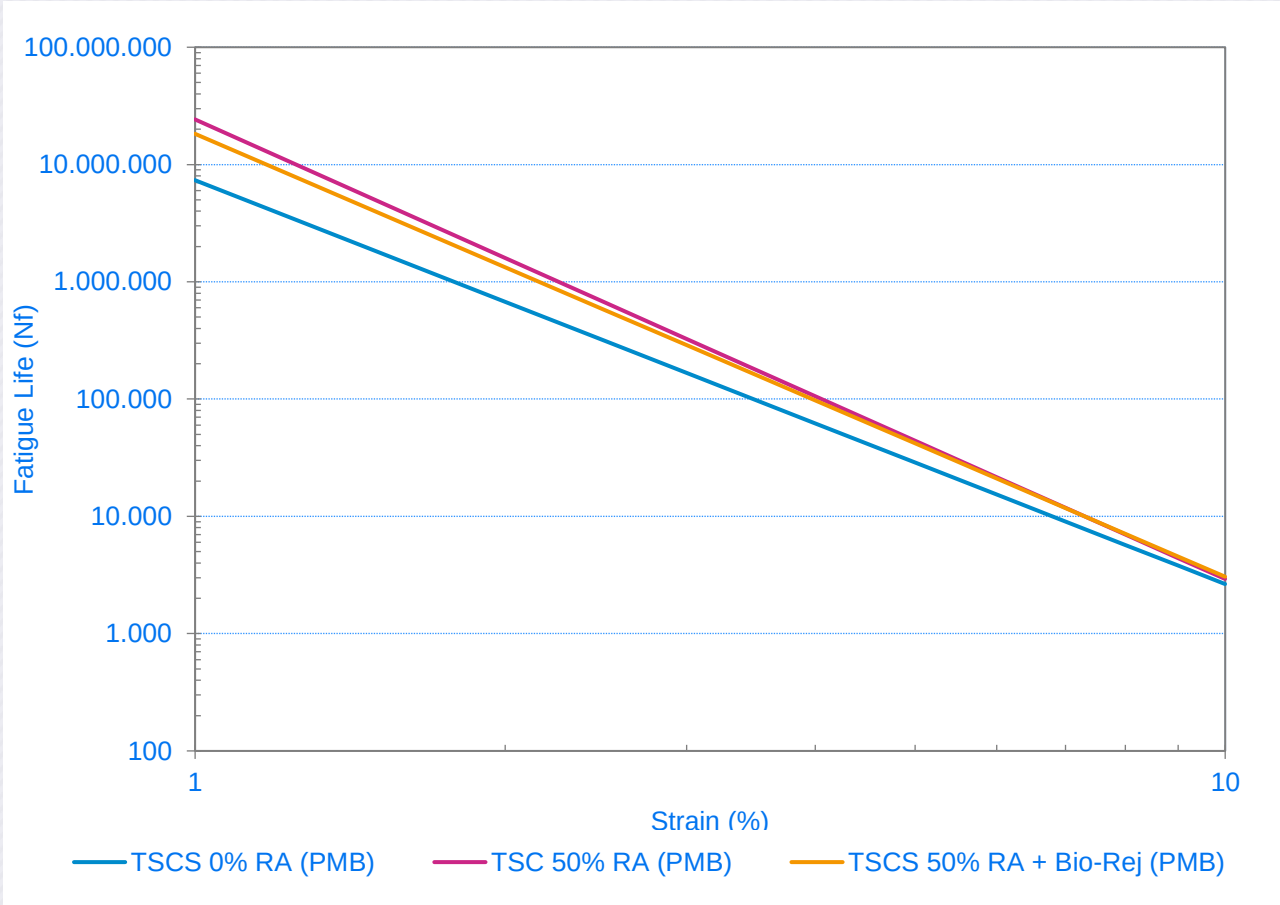


Recovered Binder Results from Bulk Samples

MSCRT - Jnr & %R at 3.2kPa & 60ºC



LAS – Fatigue Line



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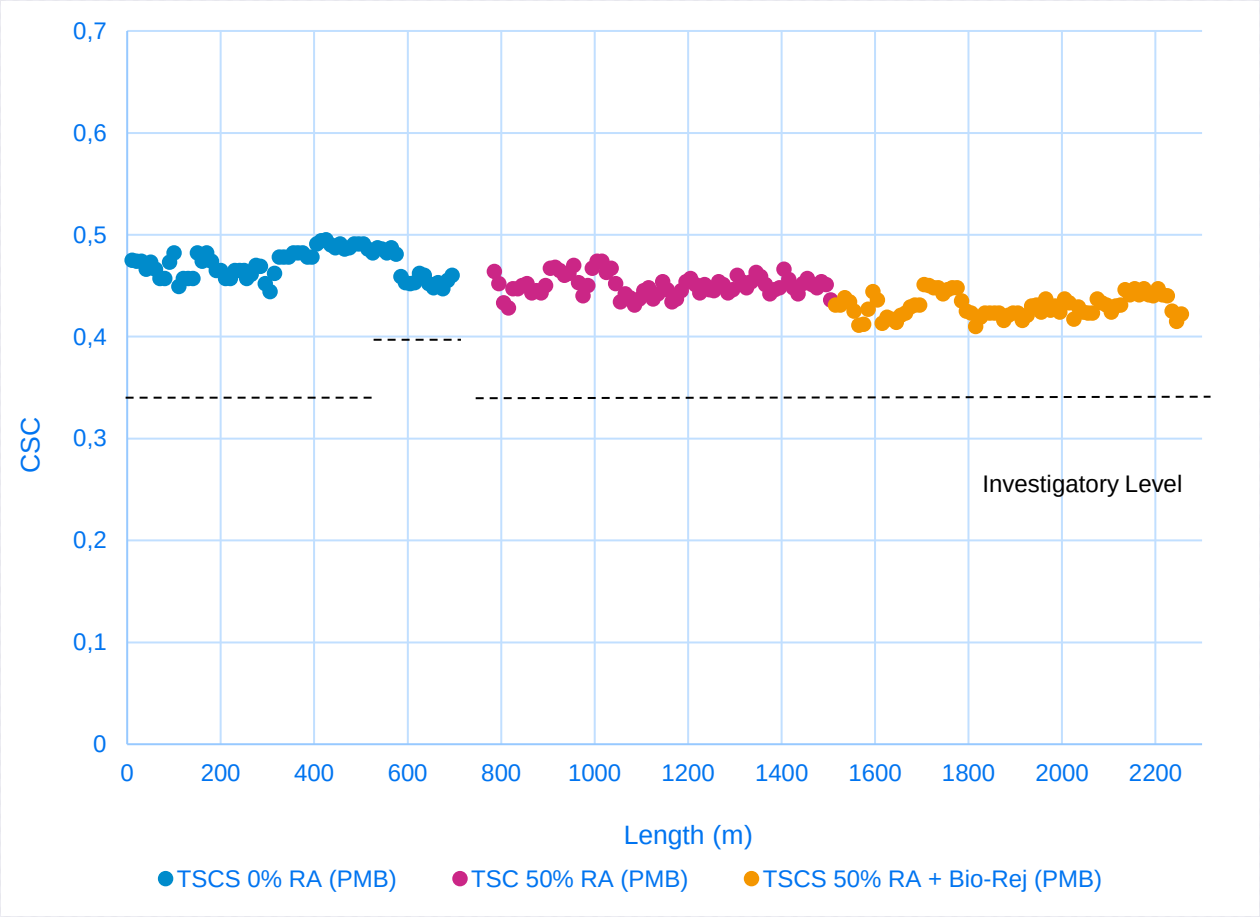
In-Service Performance (May 2025 - 7 months old)

Section 1A TSCS 0% RA (PMB) (Control)

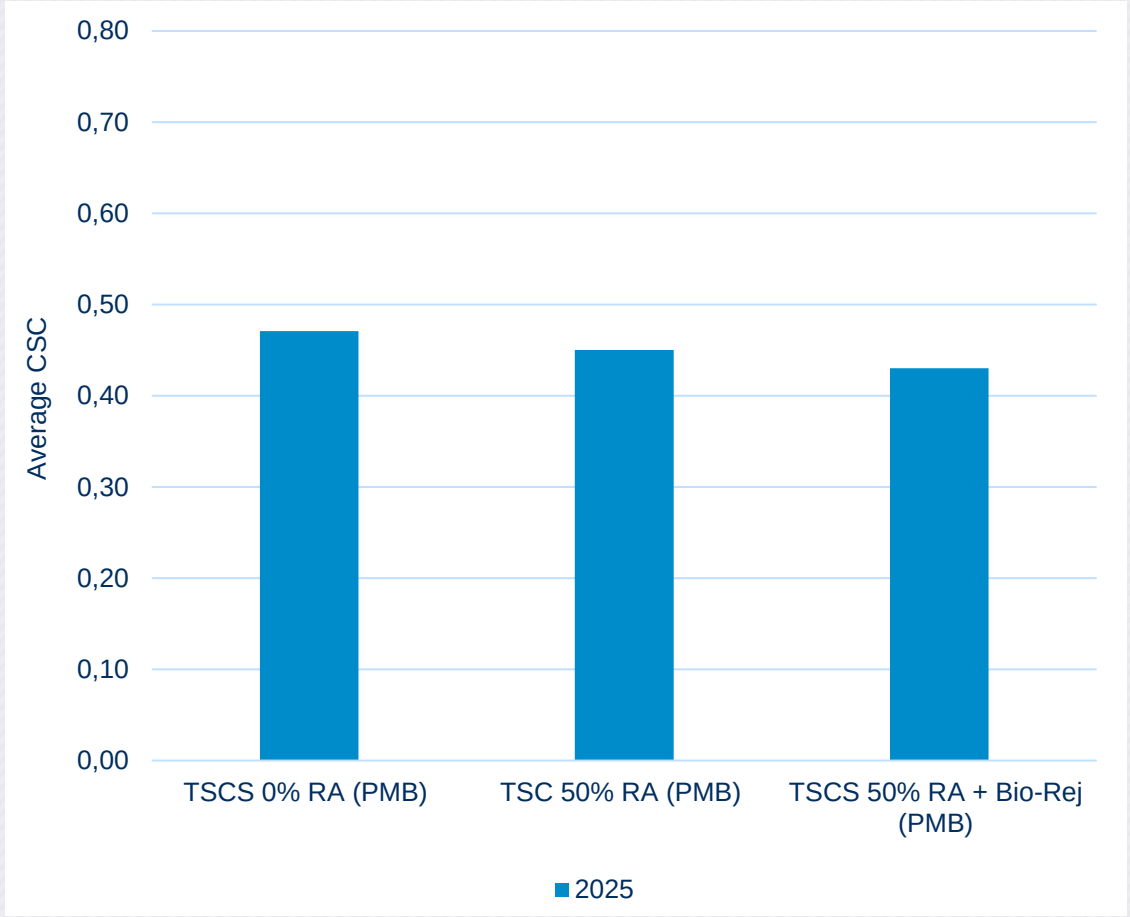
Section 1B TSCS 50% RA (PMB)

Section 1C TSCS 50% RA + Bio-Rej (PMB)

Skid Resistance – SCRIM® (1 year)



SCRIM relative to scheme chainage



Average SCRIM

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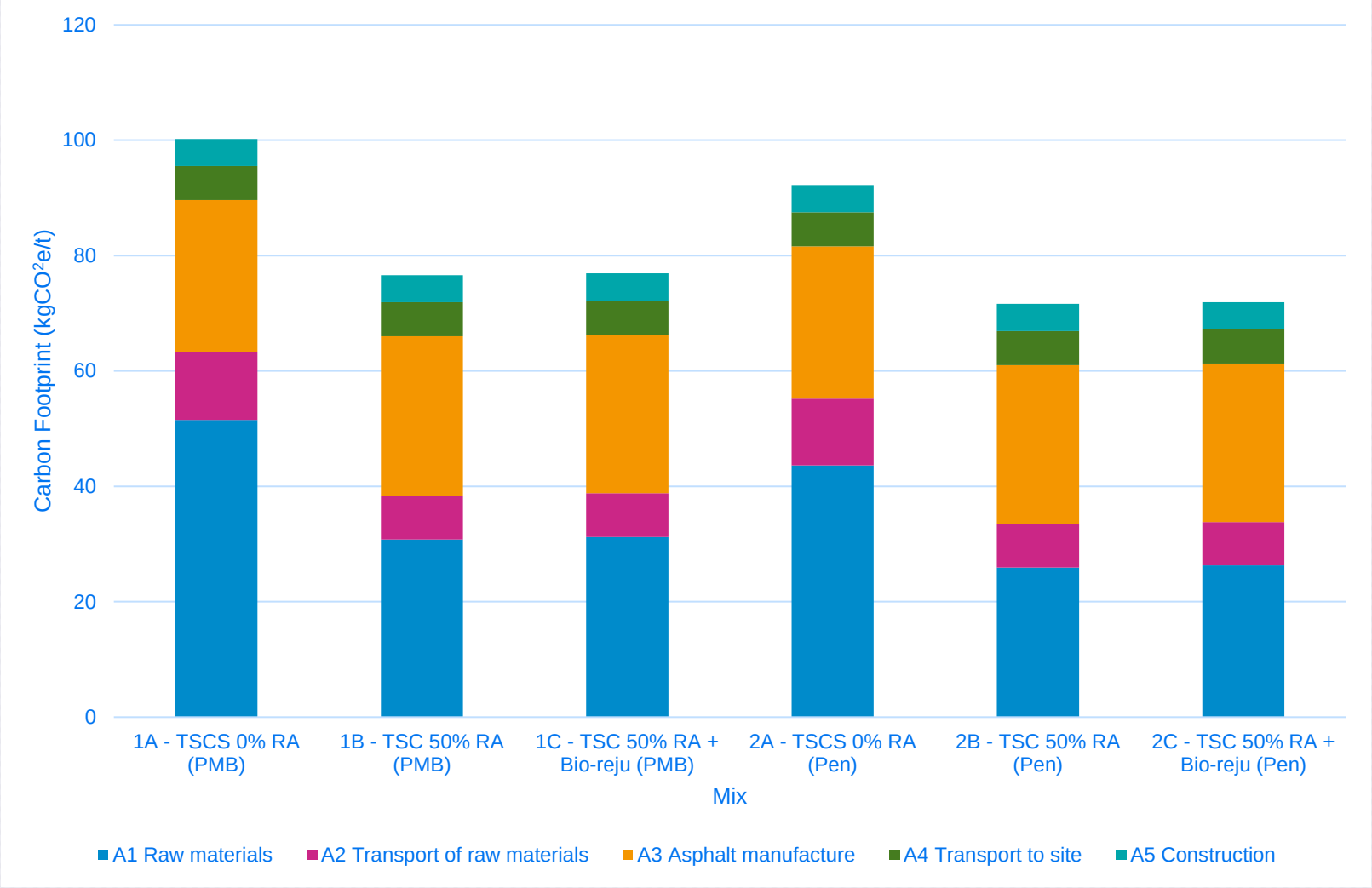
Carbon Footprint Analysis



- Carbon Footprint calculations based on the principles of the asPECT v4.2 tool (Wayman et al. (2014)).
- The analysis demonstrated saving of ~23 kgCO2e/t (23%) for the PMB mixes and ~20 kgCO2e/t (22%) for the penetration grade mixes through the incorporation of 50% RA in Stages A1-A3.

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A21 Trial Summary

- The laboratory results demonstrate the feasibility to incorporate 50% RA and achieve the performance requirements defined for the SRN in England based on the RA and controls used for this study.
- The testing demonstrated that the inclusion of bio-rejuvenator reduced the stiffness of the mixes and increased both the water sensitivity and fatigue performance relative to the 50% RA mix without bio-rejuvenator.
- It was noted that the bio-rejuvenator increased the penetration and reduced the complex modulus of the recovered binders. This indicates that bio-rejuvenators can influence the overall properties of the bituminous mixture.
- The carbon footprint results indicate that higher RA contents have significant potential to reduce the carbon footprint.
- The site trial will continue to be monitored through annual visual assessments, traffic speed condition surveys (TRACS) and Sideway Coefficient Routine Investigation Machine (SCRIM) surveys for skid resistance testing.

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Net Zero Asphalt Research

- Programme of further trials focused decarbonisation leavers including stacking technologies:

- Bio-based Binders
  - A30 Cutteridge – bio-based binder (x2) installed 2023
  - A34 Chieveley and A2 Kingston – bio-based binder, WMA and up to 30% RA installed 2024.
  - A1 Tuxford – bio-based binder with 20% RA installed 2025.

- Lignin Modifiers
  - A590 – Lignin binder & filler replacement installed 2025.
  - M53 – Lignin binder replacement scheduled for September 2025.

- Graphene additives
  - A12 Hatfield – graphene modified asphalt and up to 40% RA installed 2023.

Embodied carbon of bitumen

Use of warm mix asphalt

Use of recycled asphalt

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The road to net zero