The Use of Natural Rubber Latex in Modified Asphalt Road Binders in the UK

Colin Ruggles – Revertex Malaysia Sdn Bhd

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Introduction.

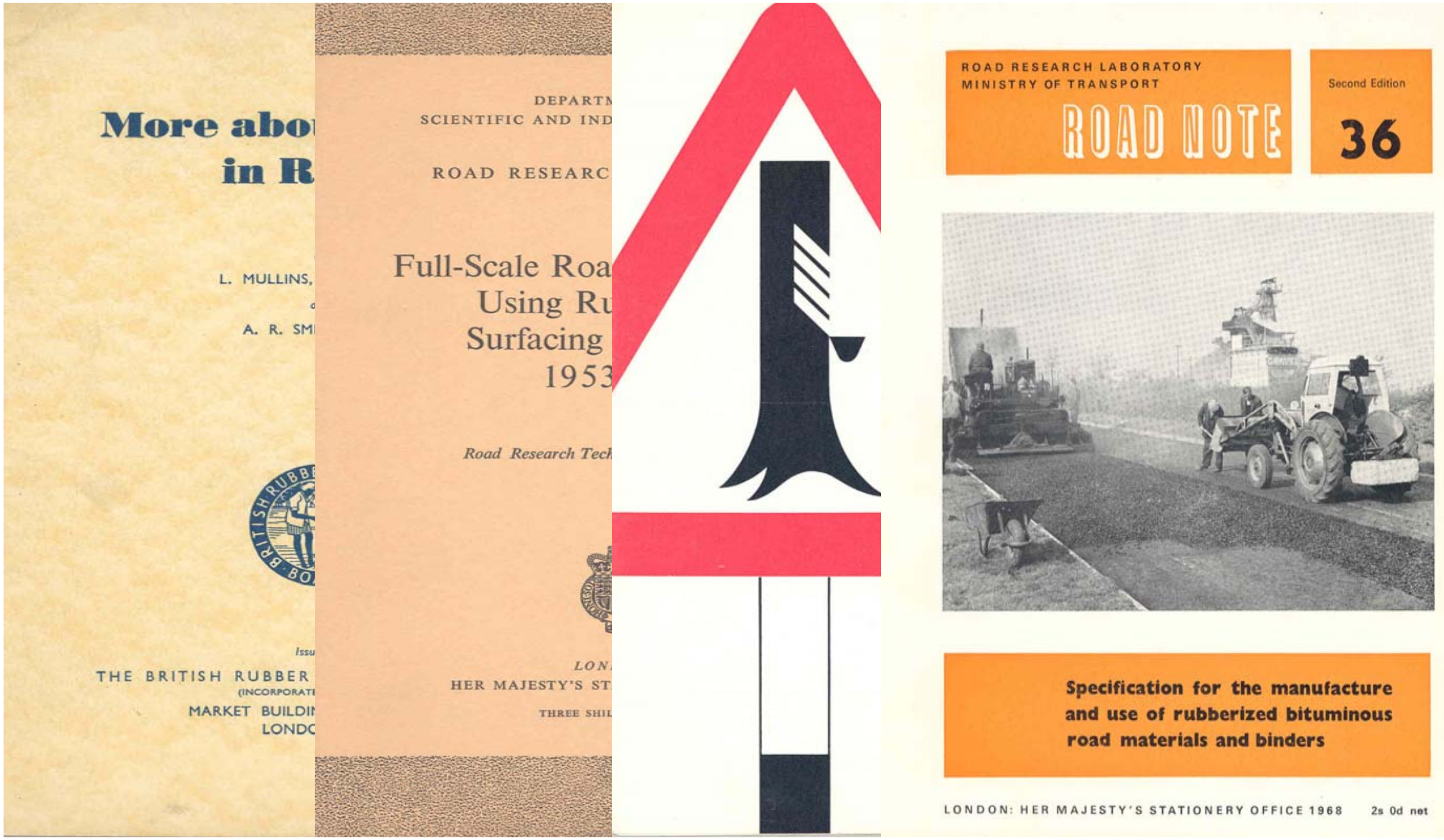
- Asphalt roads have been in existence since early 20th century.
- Asphalt road surfacing is extremely versatile, easy to apply, cost effective, and quiet.
- The binder (bitumen) is adequate for most situations, but in harsh conditions it properties are not sufficient.
- By as early as 1920-30's researchers were assessing additives to enhance asphalt binder properties.
- Natural Rubber was studied as a polymer modifier for asphalt extensively in the 1950-70's in the UK and abroad.

Early Studies into Use of Natural Rubber Latex in Roads in UK

- Joint research by NRPRA and Road Research Laboratory in UK into use of NRL in Asphalt Roads took place during 1950-60's.

- This ultimately lead to publication of 'Road Note 36'.

Early Research Articles 1950 – 1960's



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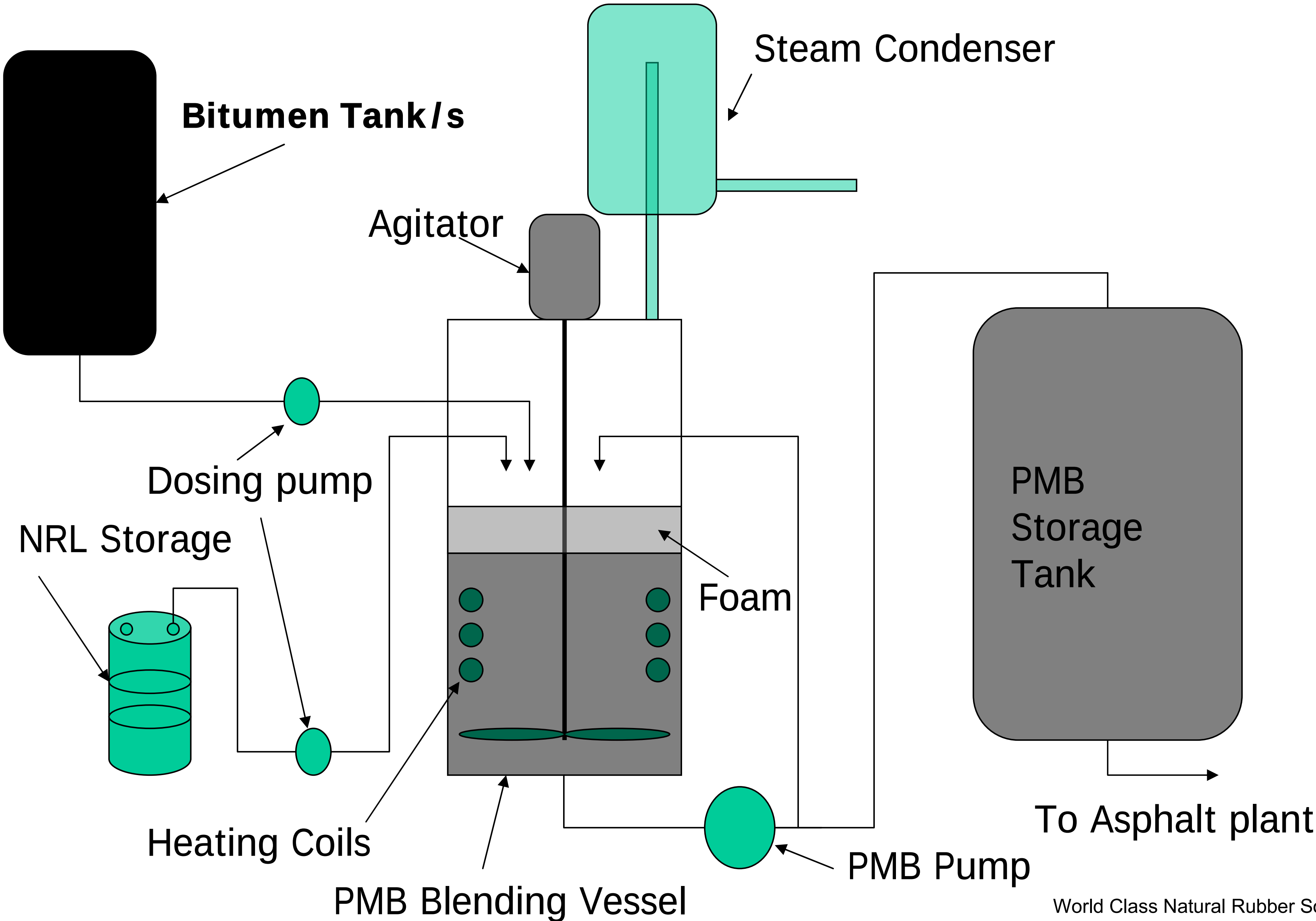
Observed Natural Rubber modified binder properties (1950-1960's).

- Increased Softening Point
- Penetration of base bitumen enhanced
- Increased level of binder stiffness and viscosity.
- Penetration index improved
- Greater resistance to cracking at low temperatures

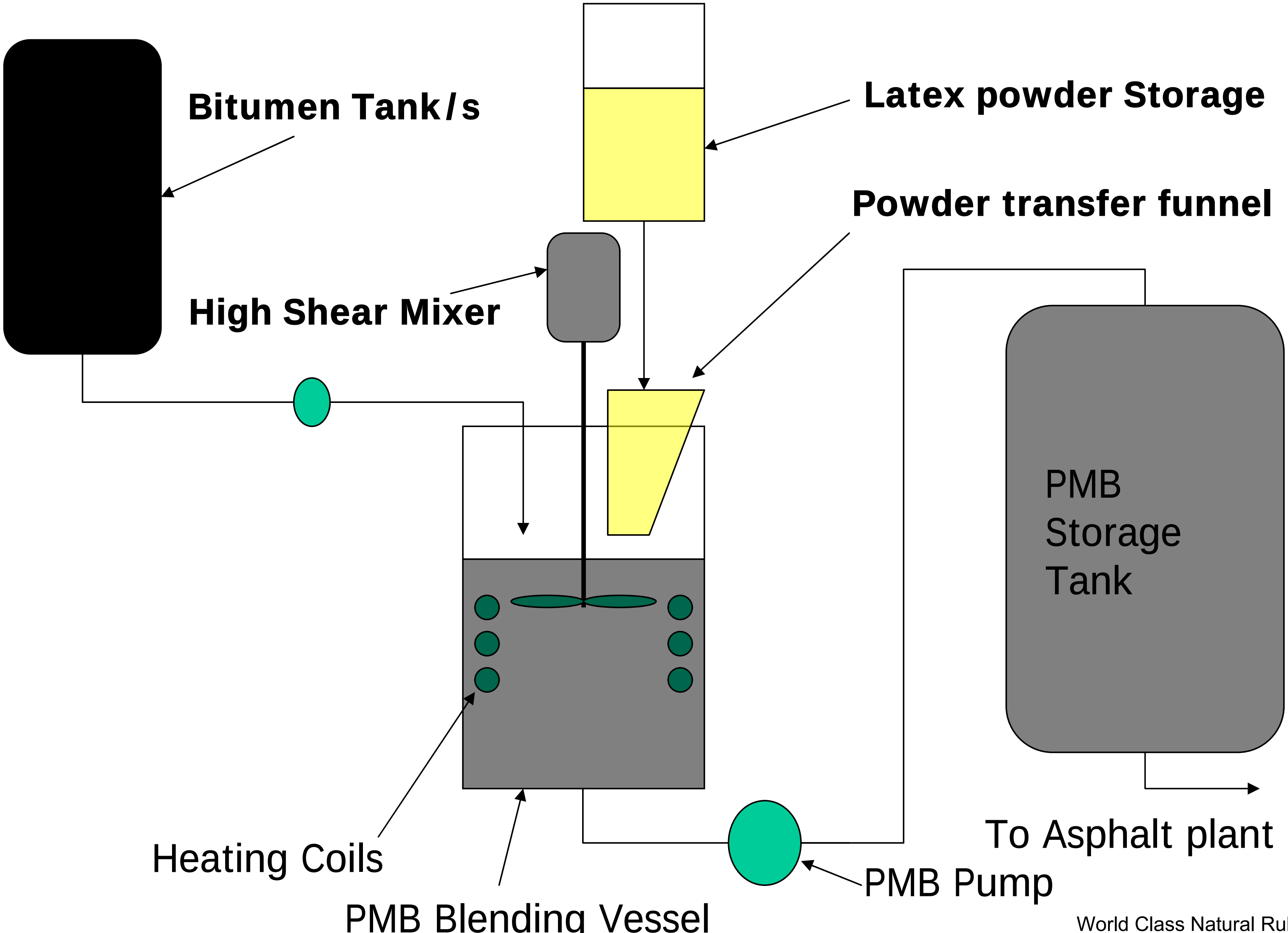
Early Research Articles 1950 – 1960's

- Early research studied natural rubber both in powder (unvulcanised and scrap tyre) and latex form.
- Road Note 36 provided details on how to prepare the modified binder…. But the process had some drawbacks.

Road Note 36: Schematic of Latex / Bitumen Preblend Plant



Road Note 36: Schematic of Powder / Bitumen Preblend Plant



Early Research Articles 1950 – 1960's

Powder Form:

Advantages:

- Non foaming

Disadvantages:

- High dosage needed (>10%)
- Long mixing time
- High mixing temp.
- Inconsistent performance (Tyre Scrap)

Latex Form:

Advantages:

- Low dosage vs powder (<5%)
- Lower mixing temp.
- Faster mixing time

Disadvantages:

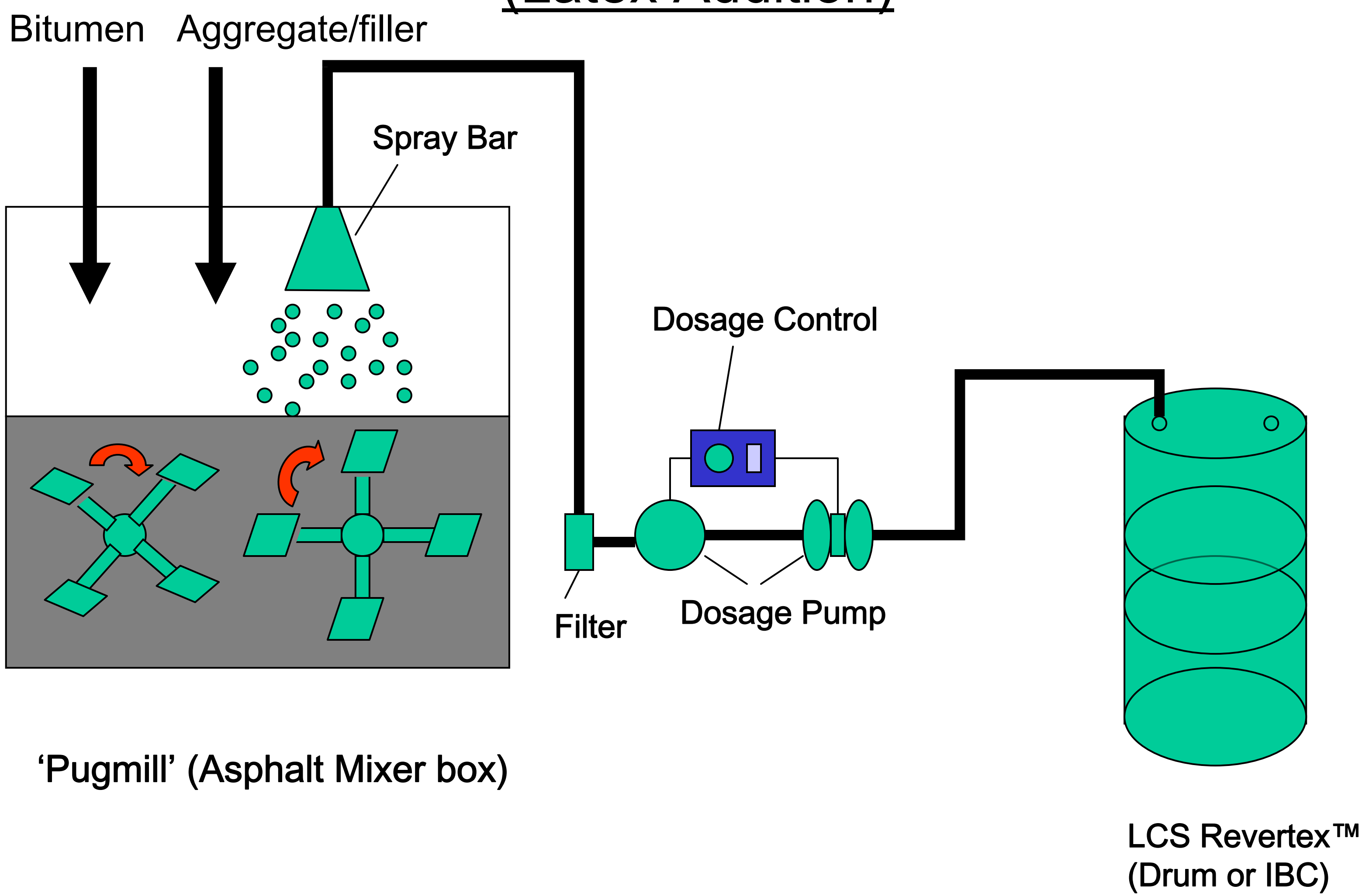
- Foaming
- Ammonia vapour
- Heat loss

Thermal degradation on storage.

Conclusions and Actions Taken to Overcome Processing Issues (1960's onwards)

- Latex addition was most energy and cost efficient option.
- Powder from scrap tyres was inconsistent and difficult to manage supply.
- Availability of NRL powder (unvulcanised) had ceased by the early 1970's.
- A natural rubber latex was readily available that was ammonia free (LCS Revertex).
- Experiments found an inexpensive and efficient method for adding Natural rubber in latex form…..
- Addition of latex at asphalt plant was not only faster, but also eliminated thermal degradation problems.

Improved method for Latex Metering System at Asphalt Plant (Latex Addition)

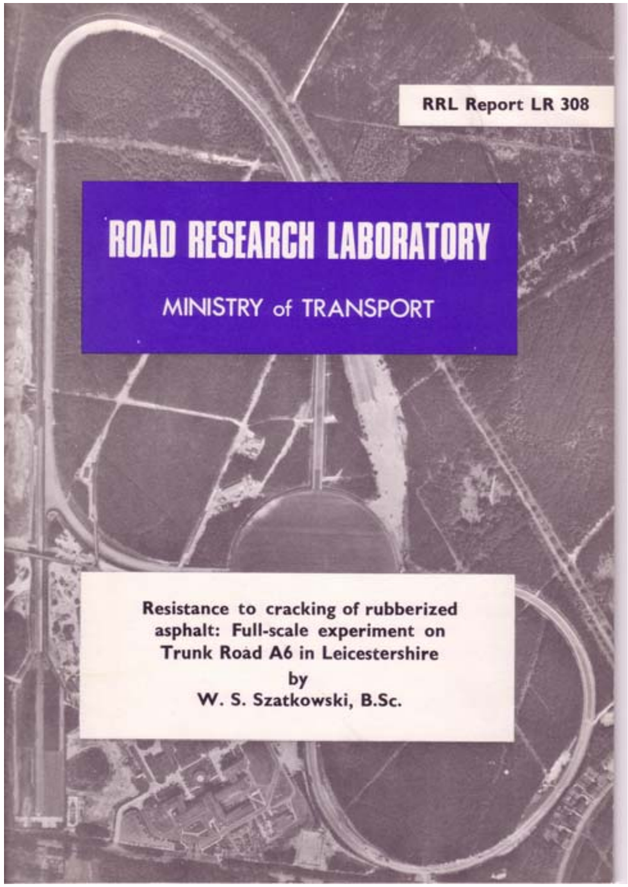


Optimised NR Latex Addition Process.

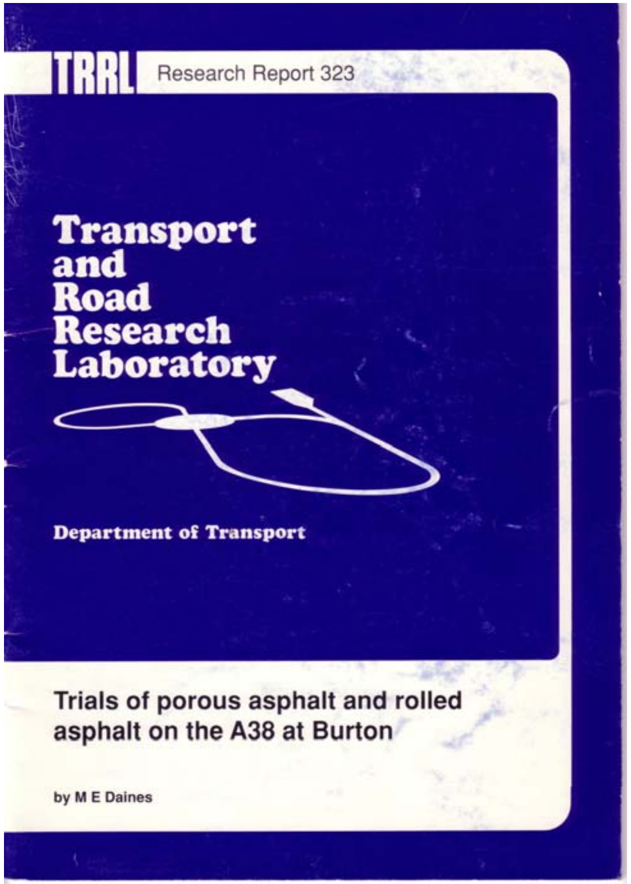
- Adding NR latex at asphalt plant required minimal plant or mixing time adjustments.
- In practice a NRL dosage of between 3-5%d/d was found to give best compromise between cost and performance.
- Simple NR latex modification coupled with source of Ammonia-free NR latex stimulated research and regular use of NR modified binders on UK roads.
- Research focussed on solutions to persistent problems on UK road network or on new road surfacing materials.
- Some Studies also included synthetic polymers that were beginning to be promoted at this time.

Road Trials/ Applications 1970 – 1990's

NRL modified Asphalt as Concrete Overlay ca.1970.



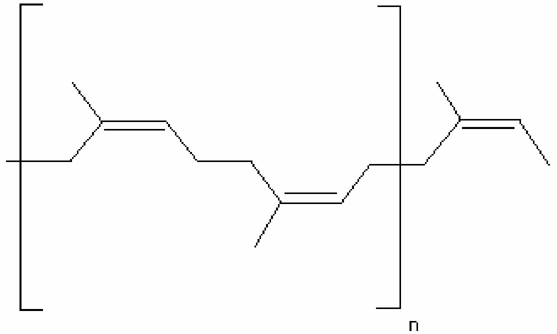
NRL modified Porous Asphalt Trials ca. 1992.



Effect of NR Latex on Bitumen and Asphalt Properties

Natural rubber latex:

- Cis-1,4 polyisoprene
- Colloidal dispersion
- Water based
- pH ca. 11.0 (LCS)
- TSC ca 68% (LCS)
- Particle Size: 0.1 - 5µm



cis-1,4 polyisoprene

320 < n < 35,000

- Unsaturation allows cross-linking reactions
- However for asphalt applicaition's X-linking is undesirable (unvulcanised).

Effect NR Latex on Bitumen/ Asphalt Properties

- Softening point of base binder is increased.
- Penetration of base binder is reduced.
- Fraass Point is reduced
- Viscosity is increased.

	Pen., dmm	Softening Pt. (R&B), °C	Viscosity @25 °C, Pa.s	Fraass, °C
Bitumen	50	48.5	2.56×10^6	-18
+1.0% NRL	45	54	4.35×10^6	-18
+2.5% NRL	30	62	1.01×10^7	

Same effects are even seen when NRL is added as separate phase into bitumen emulsions…

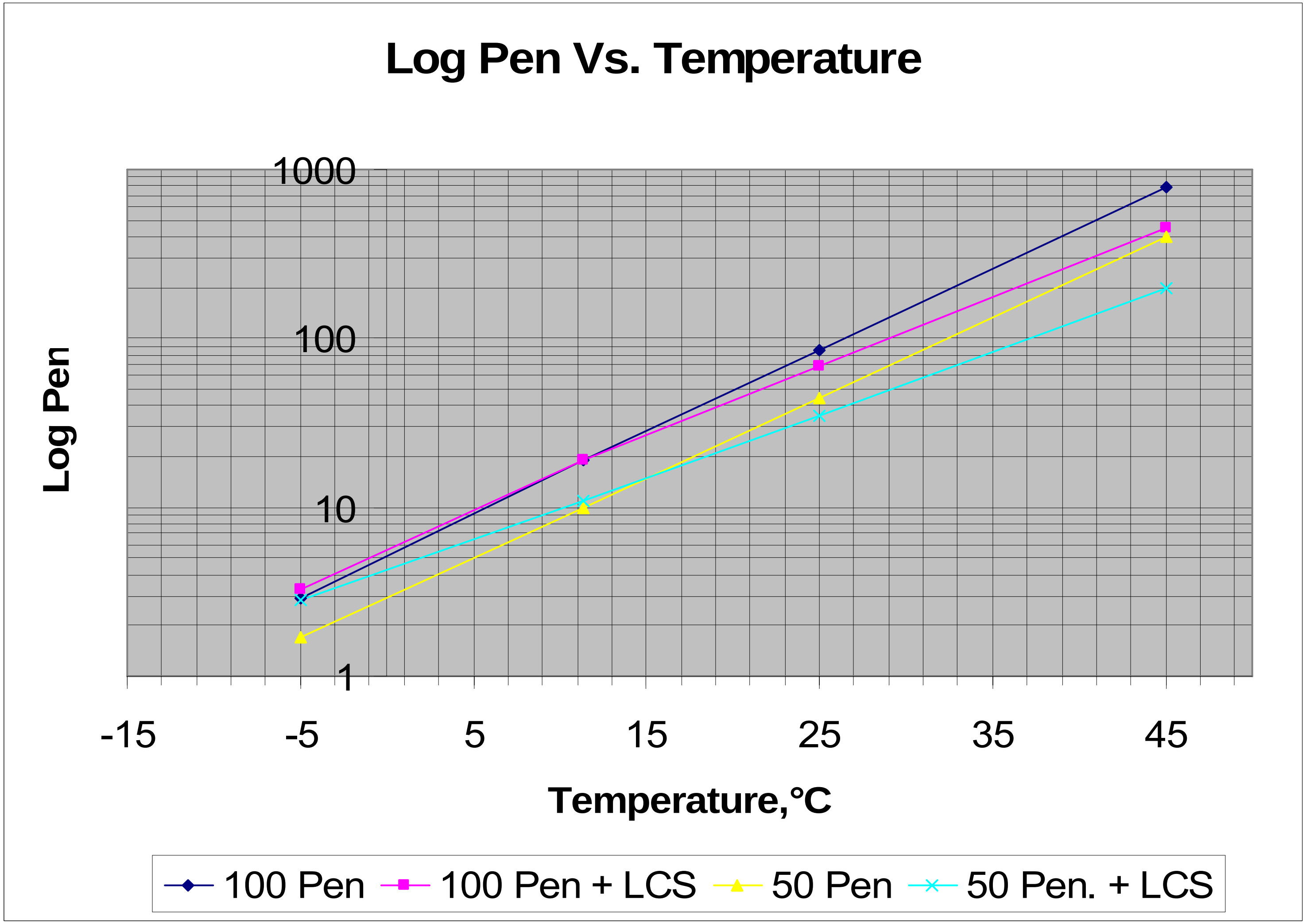
	Emulsion Type	Pen., dmm	Softening Pt. (R&B), °C	Fraas,°C
Unmodified	K1-70	200	35	-10
+4%d/d NRL	K1-70	110	47	-22
Unmodified	K3-60	125	46	-17
+4% d/d NRL	K3-60	85	56	-18.5

Effect of NRL modification on Wheel Tracking (Rutting).

35%/ 14mm Rolled Asphalt (TBC 7.4%)

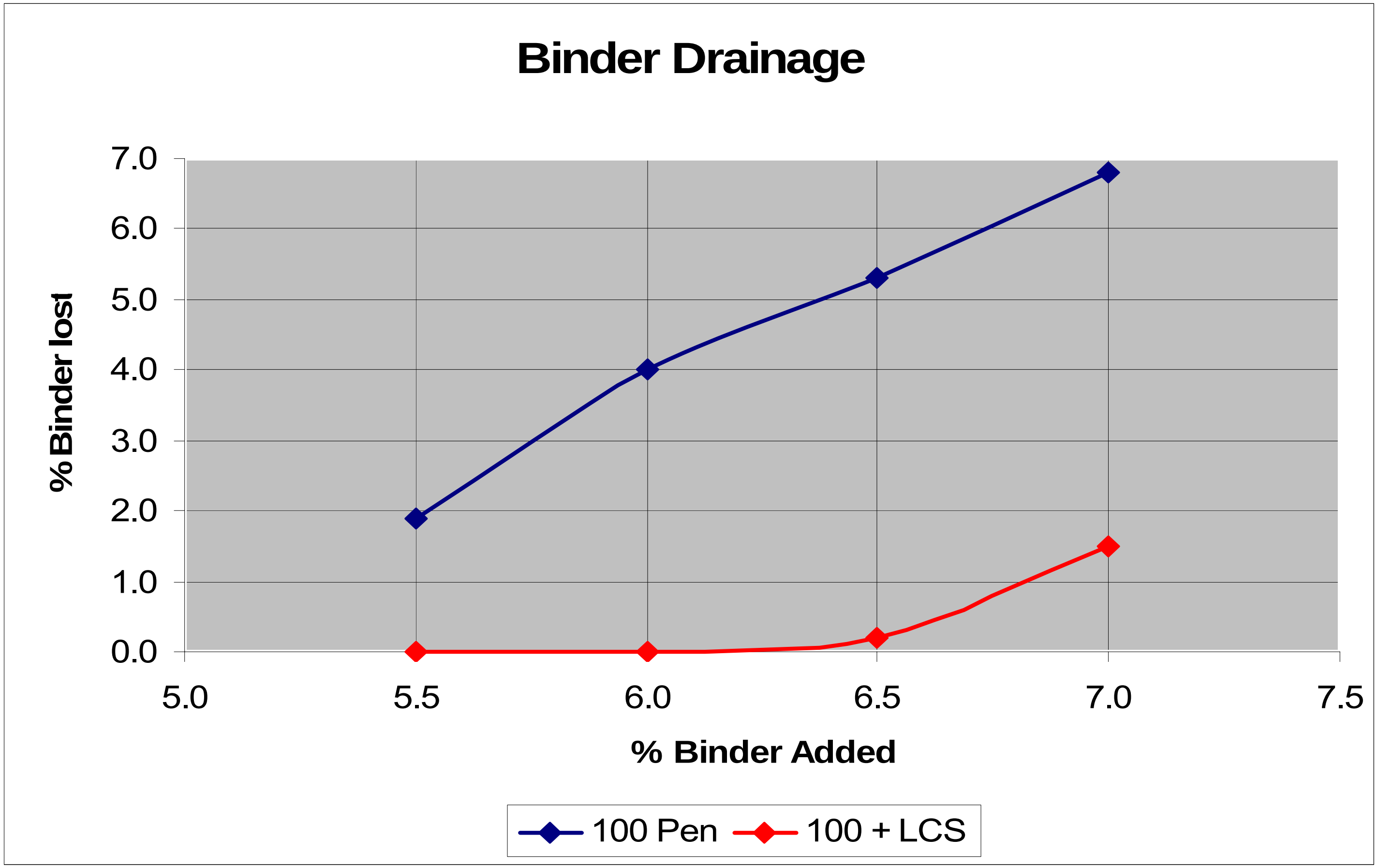
Temperature	Rut Depth, mm			Wheel Tracking Rate, mm/hr		
	Spec	50 Pen	+4% NRL	Spec	50 Pen	+4% NRL
45°C	<4	3.9	2.8	<2	1.6	1.0
60°C	<7	11.6	5.9	<5	9.2	4.4

Effect of NRL on Penetration.



Effect of NRL modification on Binder Drainage

14mm SMA / 100 pen vs. 100 pen +3%(dry) NRL.



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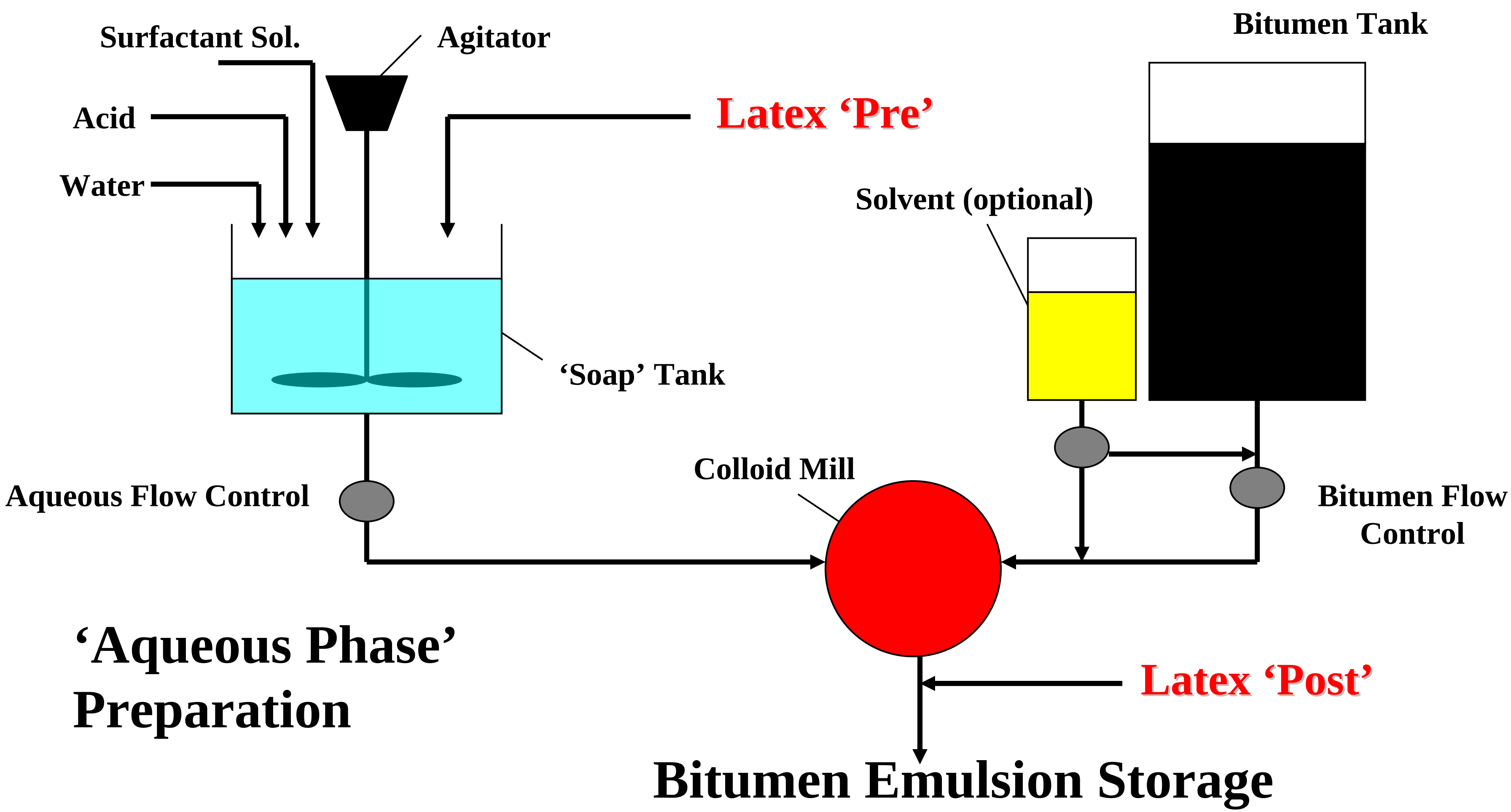
C. Ruggles. AMAP meeting 31.1.05 – 2.2.05

Natural Rubber Latex in Cationic Bitumen Emulsions in UK.

- In 1960’s cationic bitumen emulsions were replacing anionic and hot mix systems for surface dressing, tack coats and slurry seals.
- Unmodified CBE’s were satisfactory for low traffic volume roads but restricted wider application on road network.
- This ultimately lead to research and introduction of first polymer modified CBE system: ‘Ralumac’.

Ralumac: Natural rubber latex modified cationic bitumen emulsion

- System is 2 stage process:
  Stage 1: NRL is made compatible with cationic emulsion.
  Stage 2: NRL is mixed with emulsifier acid in aqueous phase and then converted to CBE.
- Process not suited to continuous bitumen emulsion plants, however introduction of proprietary NRL and Synthetic latexes suitable for direct addition to CBE's has increased use enormously.
- Typical NRL latex is 1497C/HS. This product allows NRL to be used on both batch and continuous bitumen emulsion plants.



Schematic of bitumen emulsion plant incorporating NRL addition

Natural Rubber Latex in Cationic Bitumen Emulsions in UK.

- In UK, natural rubber latex modiifed emulsions are used mainly for micro-surfacing and tack coat systems.
- Surface dressing is predominantly based upon SBS binders.
- Tack coats based upon NRL are preferred due to their high adhesion properties.

Properties of NRL Cationic Bitumen Emulsions Vs. Synthetics.

	Unmodified	Natural Rubber Latex		Styrene Butadiene Rubber Latex		SBS Block Copolymer	
Polymer Level, %dry/dry	0	3	4	3	4	3	4
Emulsifier Dosage, %dry/dry	0.25	0.12	0.12	0.17	0.17	0.25	0.25
Emulsion Properties: Binder Content, %d/d	70	72.4	72.6	71.9	72.0	70.0	70.0
Viscosity (Redwood II), s	30	37	33	23	20	20	20
Recovered Binder Properties:							
Penetration, dmm	200	**112**	**110**	135	118	155	147
Softening Point (R&B), °C	35	**47**	**50**	42	49	58	63
Fraass, °C	-10	**-26**	**-22**	-22	-14	-18	-25
Toughness & Tenacity, N: @ 5°C	-	**1356**	**1022**	1608	1448	-	-
@ 25°C	-	**93**	**104**	66	71	41	51
@ 35°C	-	**21**	**33**	18	21	-	-
Performance Testing:							
Vialit Test, % Retained Chippings @ -10°C		**90**	**97**	68	88	94	
@ 0°C		**98**	**100**	97	99	99	
@ 20°C		**100**	**100**	100	100	100	
@ 40°C		**100**	**100**	100	100	100	
Mini Fretting Test, % Retained @ -10°C		**89**	**89**			81	91
@ 40°C		**91**	**91**			81	89

Performance of NRL modified Bitumen Emulsions versus EU Specifications

Emulsion Properties:

	K1-70 NRL	K1-70 Spec	K3-60 NRL	K3-60 Spec
Base Bitumen Pen, dmm	171		125	
Emulsifier Level, %d/d	0.23		0.8	
Binder Content, %	**69.2**	69 –71	**63.9**	58 - 65
Viscosity BTA (4mm) @20°C, S	**7**	≥ 7	**6.2**	< 15
Viscosity Englera, °E	**-**	-	**4.3**	> 3
Coagulum (0.5mm Sieve), %	**1.5**	< 5	**0**	< 0.2
Sedimentation (5 Days), %	**1.5**	< 5	**4.9**	≤ 5
Adhesion to Basalt, %	**100**	≥ 85	**100**	≥ 85
Adhesion to Granite, %	**100**	≥ 85	**100**	≥ 85
Breaking Index, g/100g	**74**	< 90	**125**	> 120

Performance of NRL modified Bitumen Emulsions versus EU Specifications

Recovered Binder Properties:

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Base Bitumen Pen, dmm	171		125	
Emulsifier Level, %d/d	0.23		0.8	
Pentration, dmm	**110**	70 – 240	**85**	70 – 240
Softening Point (R&B), °C	**44**	≥ 42	**56**	≥ 37
Fraass, °C	**-21.5**	≤ -15	**-18.5**	≤ -15
Elastic Recovery @ 25°C, %	**35**	≥ 60	**51**	> 40
Vialit Test @ -15°C, % retained	**100**	≥ 5	**95**	> 40
Vialit Test @ 60°C, % retained	**100**	≥ 85	**100**	> 80

Performance of NRL modified Bitumen Emulsions.

- NRL modified bitumen emulsions perform extremely well alongside synthetic polymers.
- Both at low and high temperatures NRL modified emulsions perform as well as synthetic polymers.
- Elastic Recovery does does not correlate with low or high temperature performance of the recovered binder.
- Some EU specifications require compliance with Elastic recovery. As NRL does not meet requirements for Surface dressing systems, but can be blended with Synthetic polymers to meet requirements.
- UK market does not have ER requirements, however there is no data that indicates UK emulsion based systems do not perform as good as systems in other EU countries.

Conclusions

- Natural rubber latex has been used successfully on UK roads for over 5 decades.
- Natural rubber latex has found uses in both traditional and modern hot mix pavement systems and in bitumen emulsions.
- Natural rubber latex can be added efficiently and provide cost effective high performance road surfacing.
- Natural rubber latex continued use may be at risk through improper specification of application tests that do not accurately reflect polymers properties in practice.
- Natural rubber offers unique opportunity to road industry as a performance enhancing, renewable, sustainable and ecologically beneficial resource available to the road sector.
- Carbon Trading and other environmental factors will ensure natural rubber latex will have a future as polymer modifier in roads.


Thank You For Listening!