Asphalt (Bitumen) Chemistry and Emulsion Performance

Glynn and Irina Holleran

INTRODUCTION

Bitumen Chemistry

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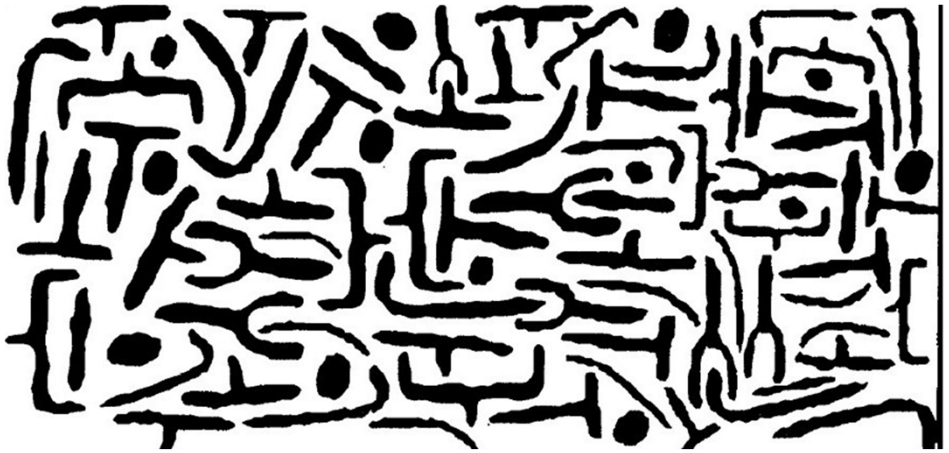
Outline

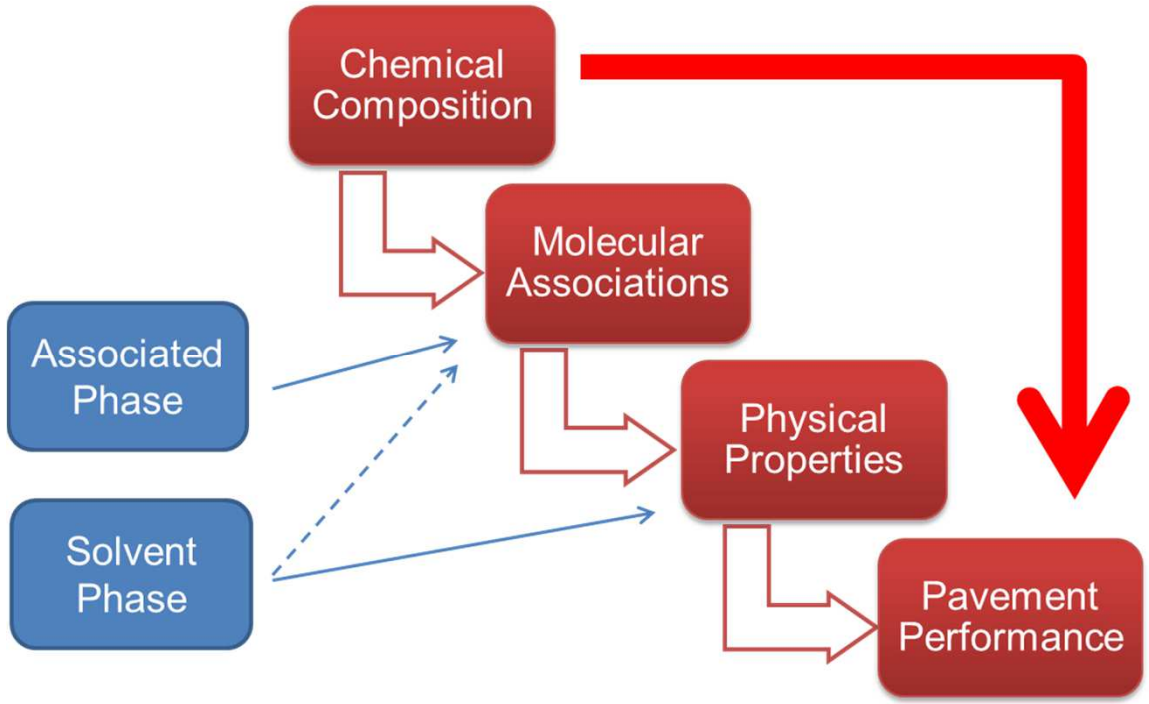
- Bitumen Chemistry
- Processing and Crudes in NZ
- Imported Bitumen New Zealand

Bitumen Chemistry

- Complex
- Codified by fractional- SARA testing
- Based on colloidal and associative models
- Emulsions based on associative phase dispersion and presence of aromatic and naphthenic oils- the internal compatibility of the bitumen

Polar Dispersed model





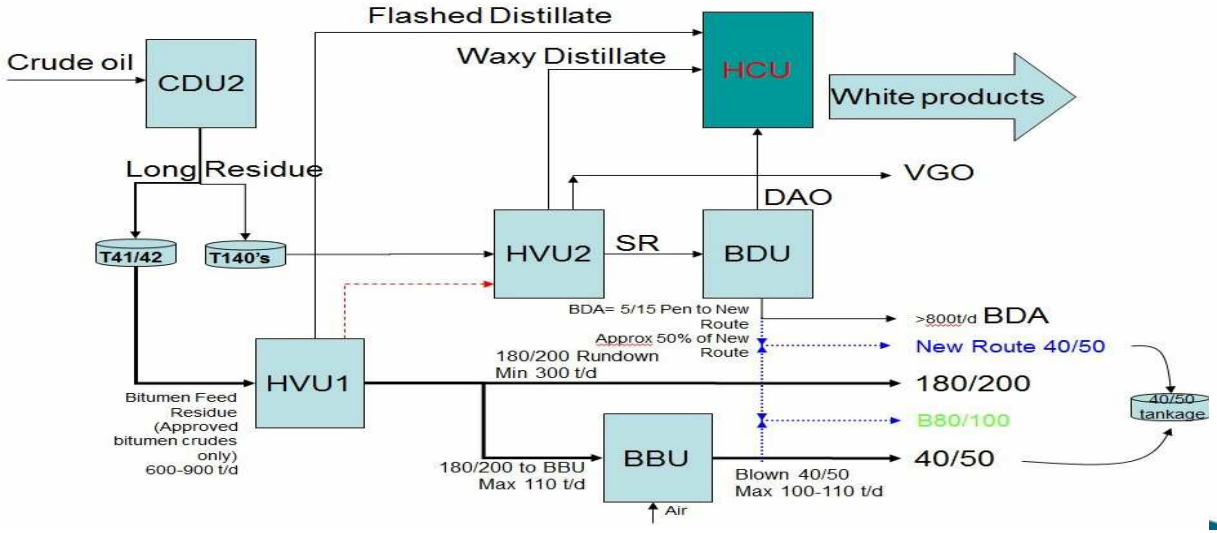
Symbol Parameters	Definition	Description
p_a	**The peptizability of associated species (asphaltenes)**	The tendency of associated species to exist as a stable dispersion in the dispersing medium
p_o	**The peptizing power of maltenes**	The ability of a dispersing medium to disperse associated species
P	**Bitumen/Binder State of Peptization**	A measure of the ability of the combination of a bitumen to form a stable dispersed system

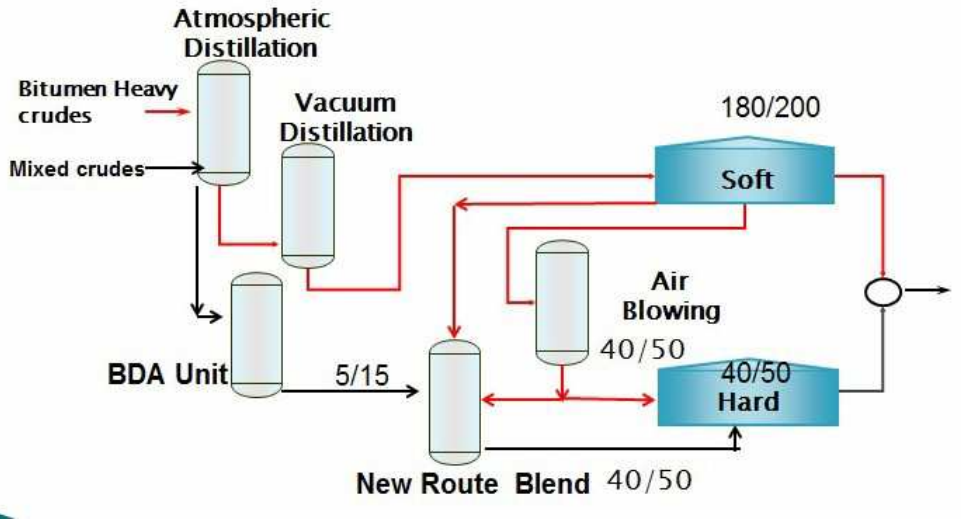
Fractions

- Saturates- part of maltenes
- Oils- aromatic naphthenic- part of maltenes
- Resins A- part of associated phase
- Resins B (Asphaltenes) part of associated phase (higher level)

Fraction	Compounds
Saturates	N and iso alkanes
Aromatics	Alkylated cyclo-pentanes and cyclo-hexanes, aromatic rings- pi bonding and H -bonding
Resins	Alkylated and cyclo-alkylated aromatic rings. Associated H- bonding
Asphaltenes	Alkylated condensed aromatic rings – highly associated hydrogen and associative bonding

Refining NZ





Crudes: Arab Heavy, Ratawi for 180/200

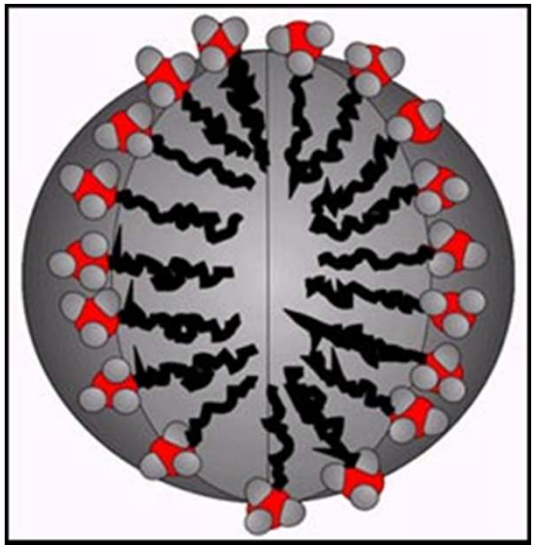
GP come from many areas in Australasia, Asia and others

Imported bitumen

- Asia- Singapore, South Korea, Thailand - mostly light Arab crudes – largely paraffinic
- USA- range of local and Venezuelan crudes

Main Interactions and Effect on Emulsion

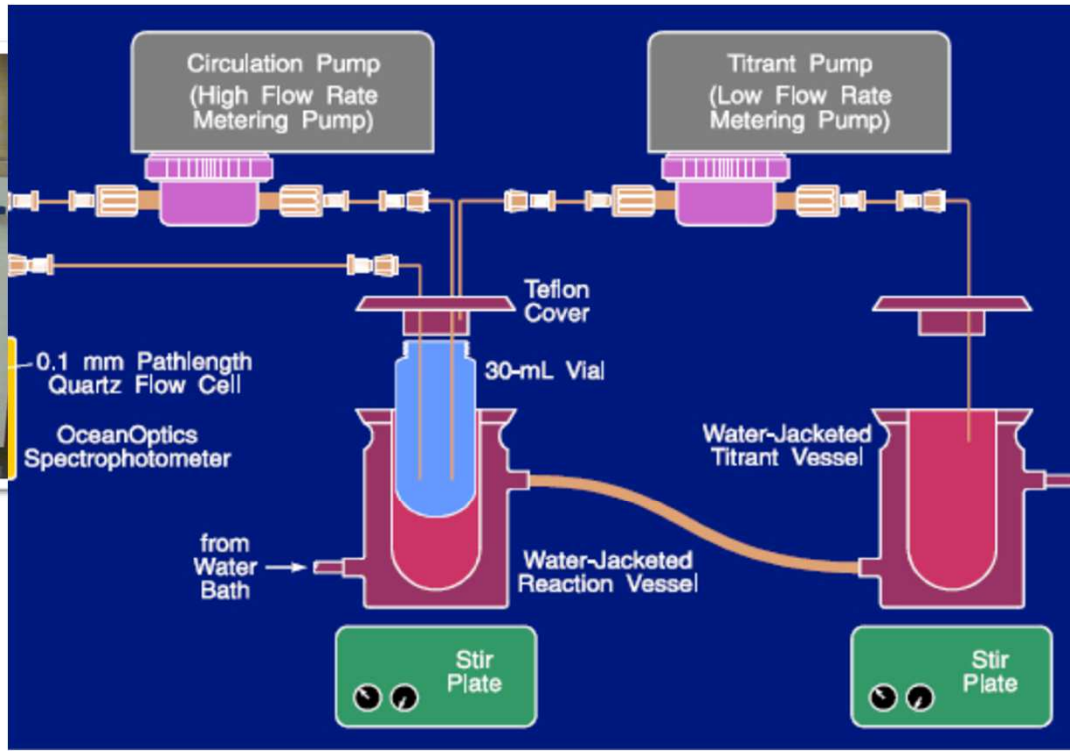
- Emulsions are created by development of a buffering double layer of emulsifier and particles of bitumen
- Emulsifier relative solubility determines stability
- Associated phase must be well dispersed to form a stable emulsion
- Saturates if elevated affect curing rate of emulsion
- Aromatic and naphthenic oils improve emulsion curing and stability



Potential Measurement

- Screening bitumen by composition can be looked at by looking at internal compatibility based on associated phase dispersion
- Heithaus parameters
- Ratio of associated to dispersing phase

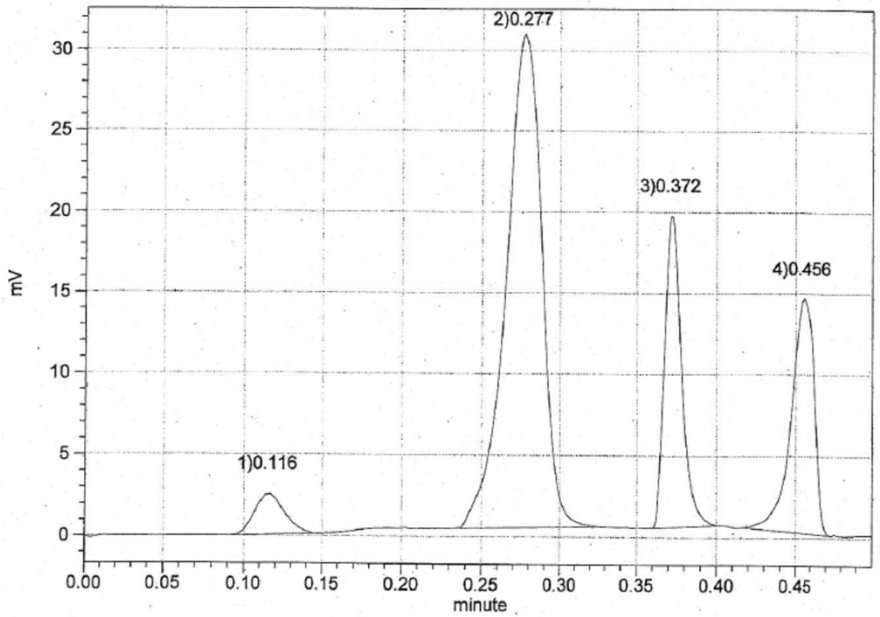
AFT



Basis

1. Dissolve bitumen in solvent
2. Titrate with alkane to precipitation point

SARA



BASIS: Dissolve Bitumen in solvent
Separate fractions base don polarity by successive “developing” with different solvents on silica rods
Burn with H2 to determine relative levels

Results on 10 Bitumens

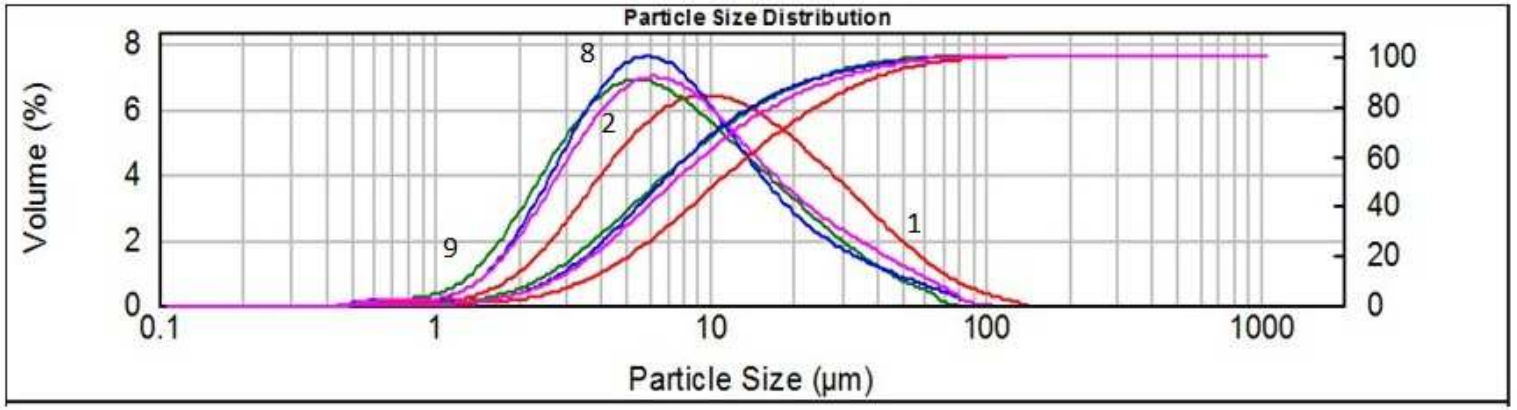
	Iatroscan								Heithaus			Emulsion
Bitumen	Saturates	Aromatics	Resins A	Resins B	Total Dispersing	Total Associative	Ass/disp	GI	p_a	P_o	P	Stability
1	4.0	57.3	13.4	25.3	61.3	38.7	0.63	0.41	0.6900	0.7100	2.2000	issues
2	5.0	60.9	12.9	21.2	65.9	34.1	0.51	0.35	0.7295	0.9166	3.3880	OK
3	4.6	59.2	12.0	24.2	63.8	36.3	0.56	0.40	0.7289	0.9182	3.3872	OK
4	6.3	50.3	18.0	25.4	56.6	43.4	0.77	0.46	0.7281	0.7826	2.8782	Issues
5	4.0	48.9	13.0	34.1	52.9	47.1	0.89	0.62	0.7131	0.8542	2.9774	issues
6	4.6	59.2	12.0	24.2	63.8	36.3	0.56	0.40	0.7138	1.0589	3.7004	OK
7	4.0	48.9	13.0	34.1	52.9	47.1	0.90	0.62	0.612	0.7613	1.9567	issues
8	6.2	64.2	13.3	16.3	70.5	29.5	0.41	0.29	0.7800	0.8700	3.9000	OK
9	4.7	58.6	15.2	21.6	63.3	36.7	0.57	0.36	0.7245	1.0193	3.7003	OK
10	6.0	49.0	14.5	30.4	55.0	44.9	0.81	0.57	0.7100	0.7500	2.5000	Issues

Bitumen is selected form NZRC and imported Bitumen tested and can be a variety of crude sources and emulsion grades. Binders are selected on their rheology for withstanding traffic in a chip seal . The Stability is based on emulsion Formulations as currently used and the results are comparative.

Heithaus and Iatroscan Parameters and Effect on Emulsion Stability

- Stability appears compromised when the ratio of the associative to dispersing phase is greater than 0.6 .
- Stability is compromised when P the state of peptisation is <3.0
- The Po – Peptising Power of the Maltenes should be > 0.87
- The Pa- peptisability of the Resins B should be >0.80
- Gaestel Index : GI is a general indication as it does not take functionality into account

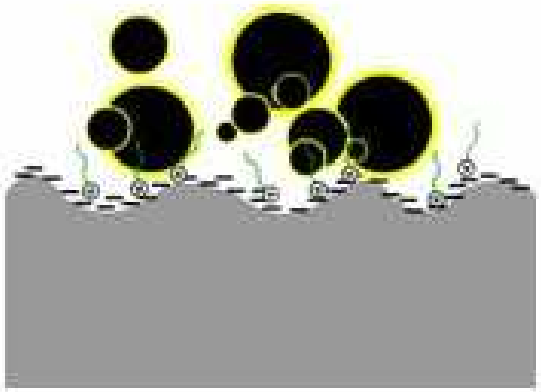
Shows Relative PSD is better for the indicated parameters



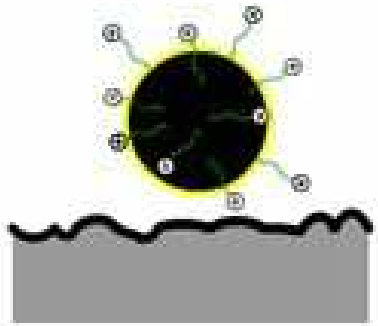
- **Finer emulsions coalesce more evenly**
- **Narrower distributions break faster**
- **Coating is controlled by PSD and PS**
- **Control of PSD can be achieved by formulation and mill type and application**
- **Control of PSD can be achieved by selection of Bitumen Composition**

EMULSION BREAK AND CURING | 2

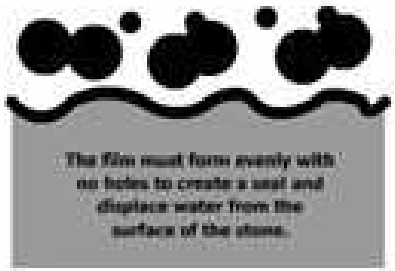
Break and Cure



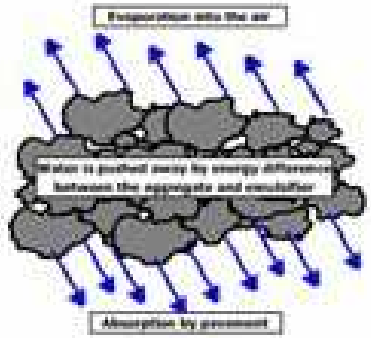
Destabilisation by Free Emulsifier Interaction



Destabilisation of Double Layer



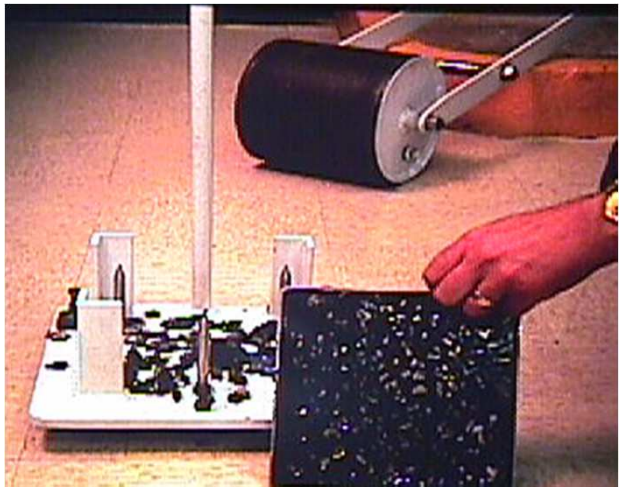
Film Formation Coalescence



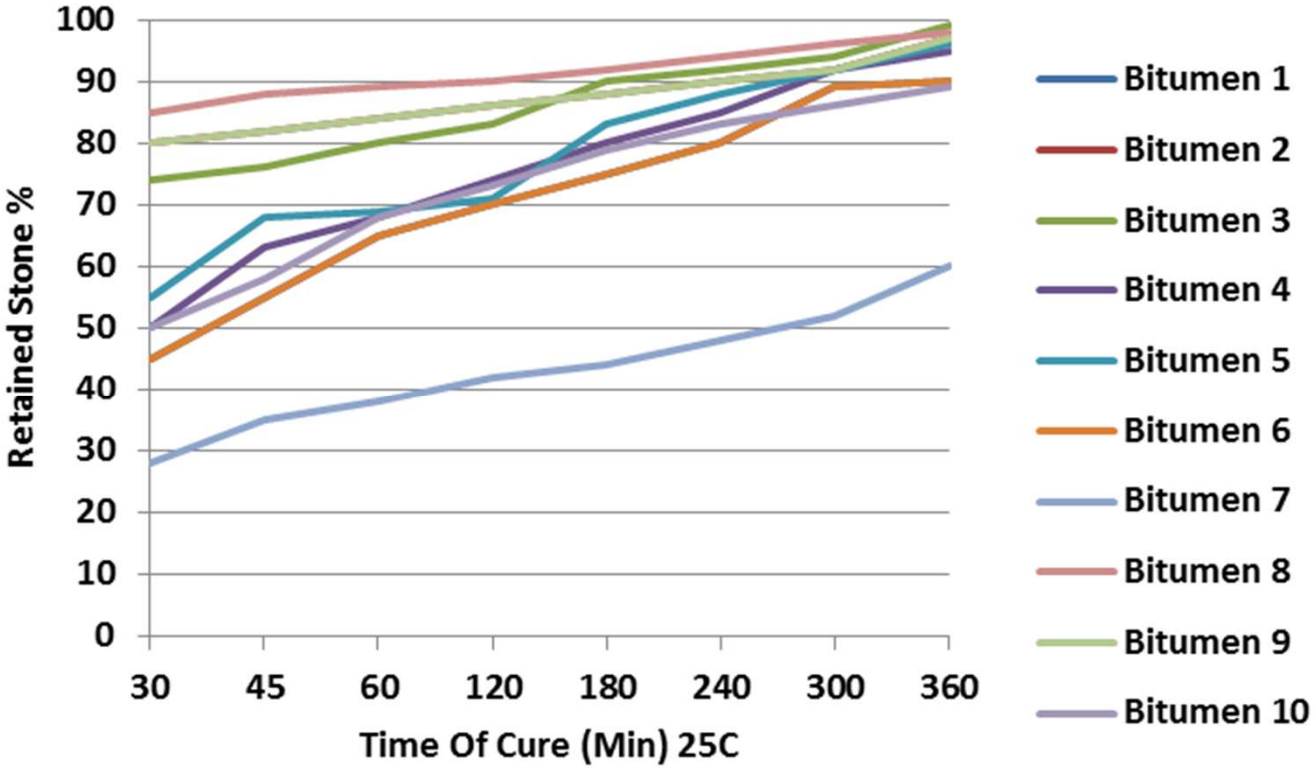
Curing- water Loss

Measurement

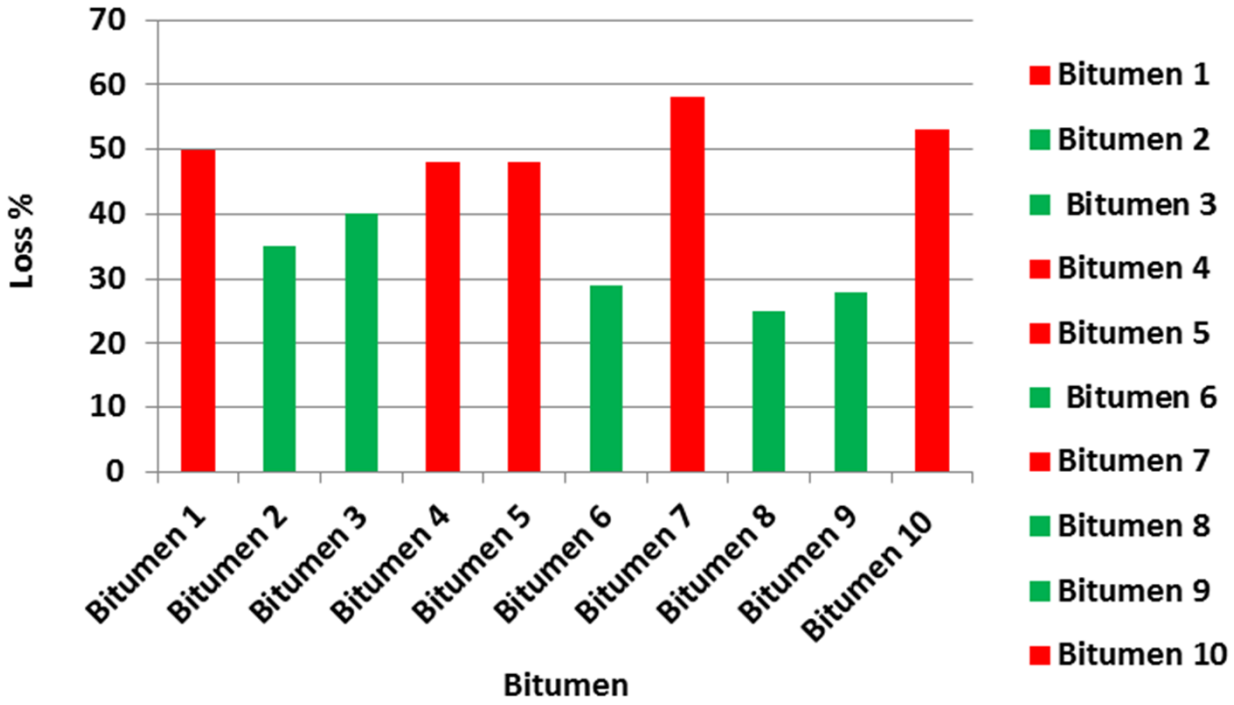
- Vialit Test
- Sweep Test
- Run Off



Results

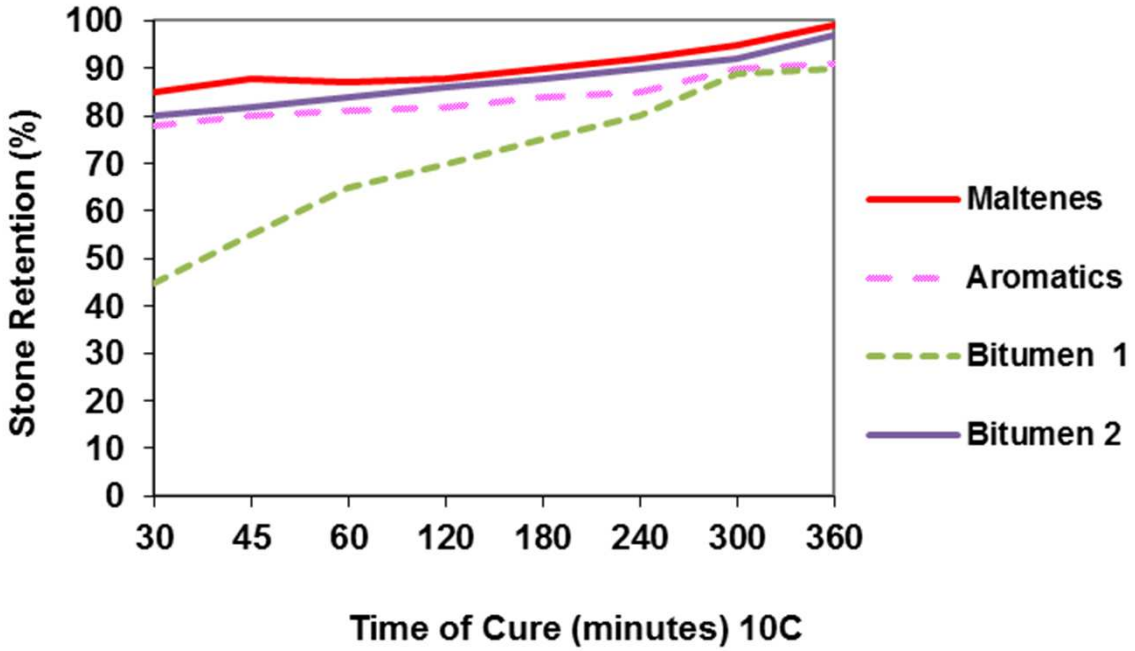

100
90
80
70
60
50
40
30
20
10
0
Retained Stone %
30
45
60
120
180
240
300
360
Time Of Cure (Min) 25C
Bitumen 1
Bitumen 2
Bitumen 3
Bitumen 4
Bitumen 5
Bitumen 6
Bitumen 7
Bitumen 8
Bitumen 9
Bitumen 10

Results Sweep Testing

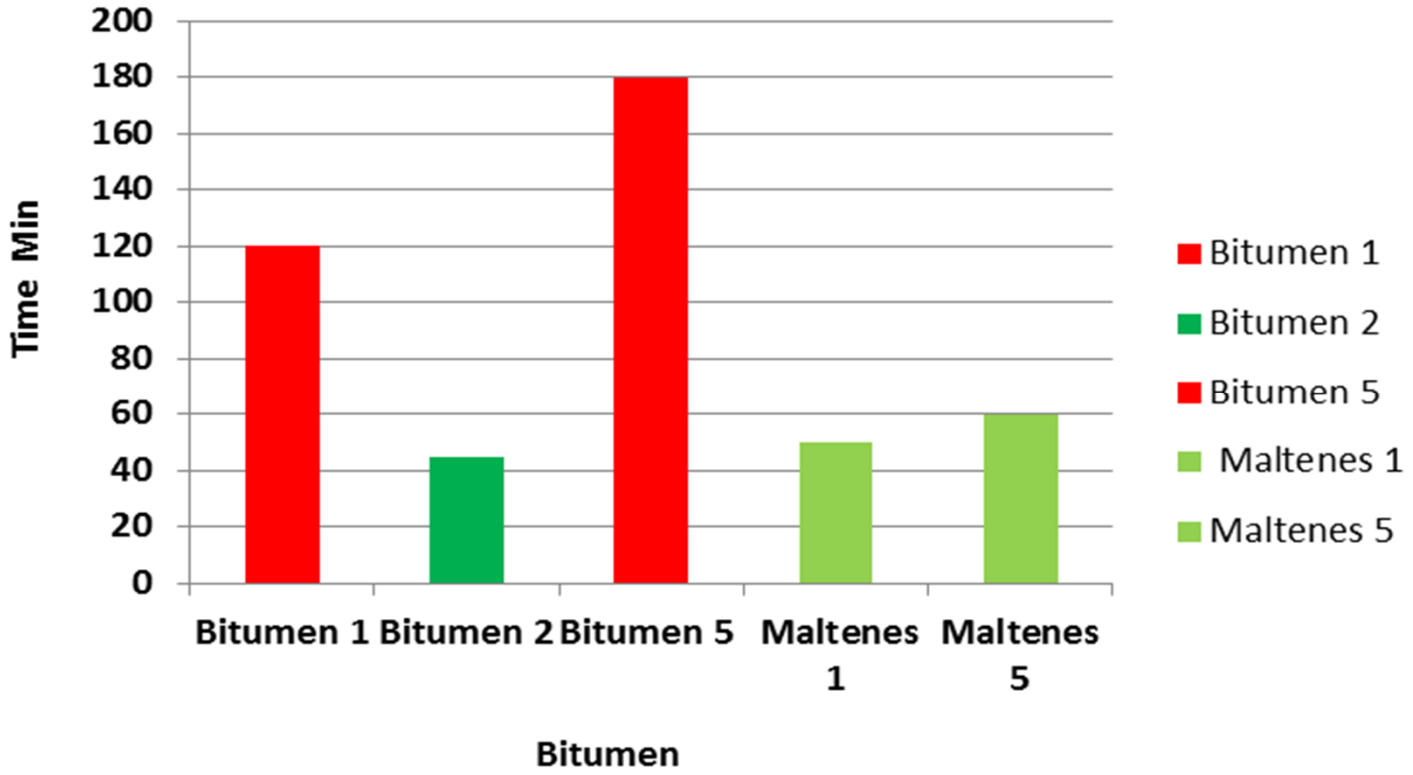


ADJUSTMENT OF COMPOSITION | 3

Effect Of Adjustments



Run Off Test


200
180
160
140
120
100
80
60
40
20
0
Time Min
Bitumen 1
Bitumen 2
Bitumen 5
Maltenes 1
Maltenes 5
Bitumen 1
Bitumen 2
Bitumen 5
Maltenes 1
Maltenes 5
Bitumen

CONCLUSIONS | 4

Main Conclusions

- Asphalt(Bitumen) Chemistry affects emulsion properties
- Bitumen can be screened for emulsability by use of internal compatibility testing and by comparison with SARA testing
- Bitumen chemistry could be thus be adjusted with additives and performance optimised by formulation