Binder Modification to soften Grades

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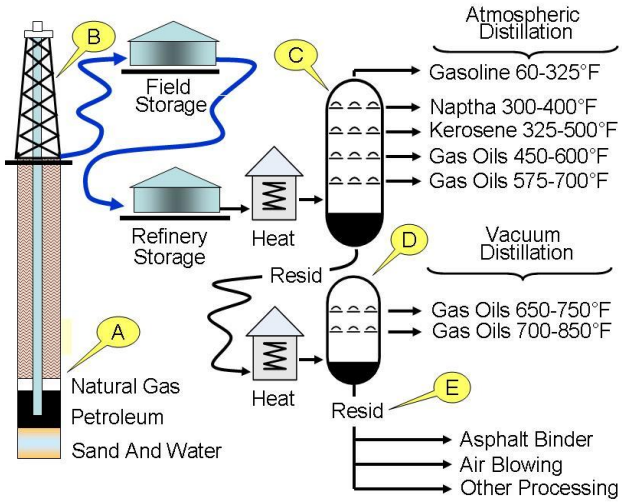
Demand for soft grades of Binder

- There is an increased demand for softer grade asphalt binders such as PG 58-28, 52-34 .
  - Increased RAP usage
  - Use of RAS
  - Increased demand for improved low temperature grades to reduce cracking.
- Limits on the availability of crudes to produce softer grade straight binders.

Definition - Asphalt

A high molecular weight, thermoplastic hydrocarbon constituent, found in a large number of petroleum crude oils. Although some asphalts do occur naturally, asphalt as we know it, and as discussed herein, is derived from fractional distillation of petroleum crude oil.

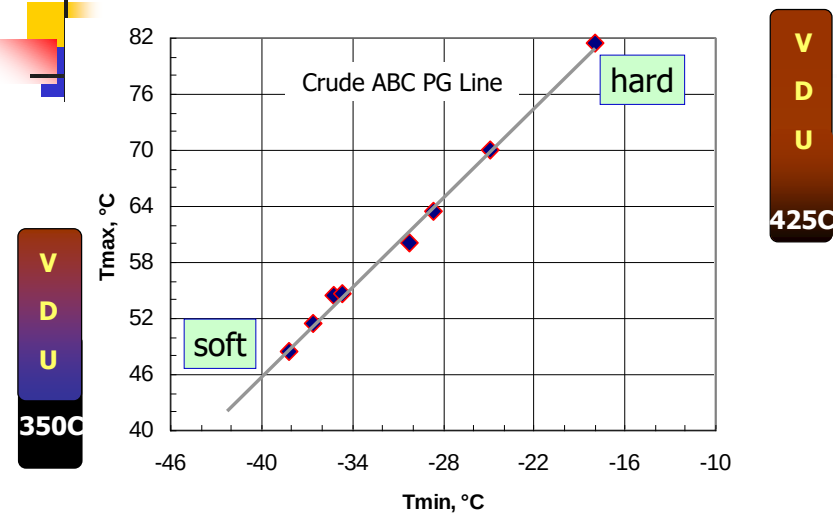
Flow diagram for typical refinery



UTI of Performance Grade Asphalts

- A PG 64-22 would have a UTI of 86 C°
- A PG 58-28 also has a UTI of 86 C°
- If we needed a PG 76-22, which has a UTI of 98 C° - how is this accomplished?
- As a "rule of thumb", to achieve a UTI of >92 C°, or 86 C° V or E Grade MSCR the asphalt has to be "modified".
- Depending on crude source, some binders with more narrow UTI's of 86 and 89 C° may also require modification

For a given crude, asphalt grade is defined by refinery processing conditions



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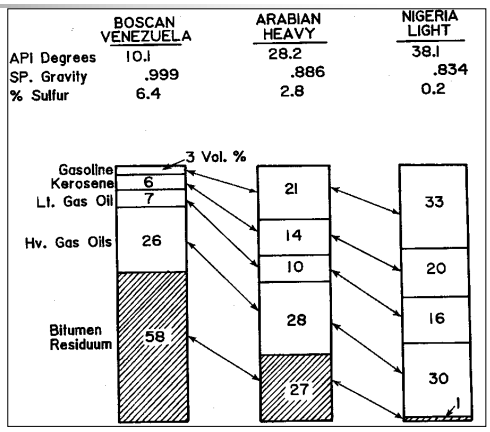
Refining Crude Oils

- Refinery output driven by
  - Crude source
  - Refinery configuration
  - Economics

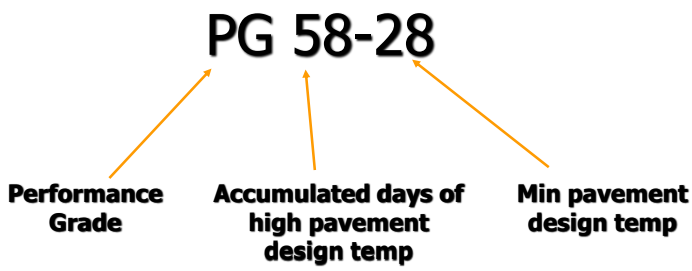
Crude Oil

- Different crude oils will produce different asphalt binders with different properties.



Grading System

- Based on Climate



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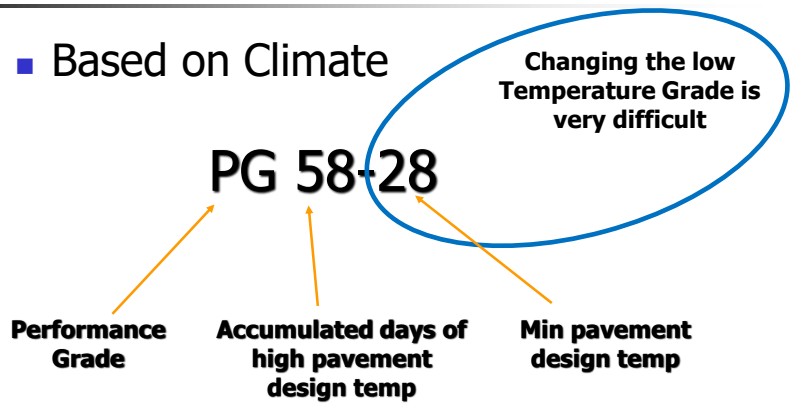


Softening agents

- There are limited ways to produce asphalt binder with lower, low temperature grades.
  - Heavy Vacuum Gas Oils
  - Tall Oils
  - Aromatic Oils
  - Recycled Oils
  - Bio Oils
- Most are expensive and have limited effect

Component makeup of the 2 asphalt binders

Property		Test Method	AC 1	AC 2
Basic Composition: As Received				
Ash, %		AASHTO T 111	0.04	0.06
Solubility, %		ASTM D 2042	99.98	99.94
Component Fractions, %	Asphaltenes	ASTM D 4124, SARA Fractions by Iatroscan	14.9	14.2
	Polar Aromatics		39.7	39.7
	Naphthene Aromatics		34.6	36.9
	Saturates		10.8	9.9

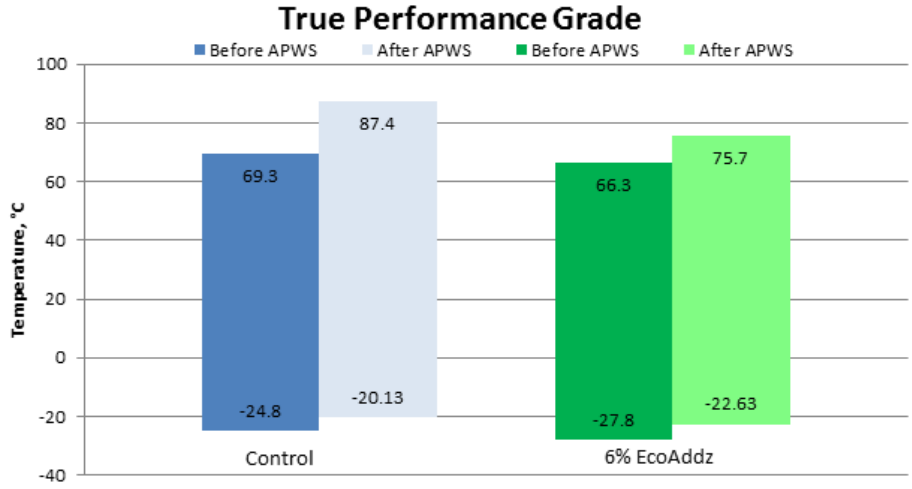
Change in SARA with aging and RAP

DATA / RESULTS:

Property		ASTM Test Method	RESULTS: Sample ID / #				
			-01	-02	-03	-04	-05
			4362 Original	4362 RTFO	4362 PAV	4362 Double PAV	CS-1 Top
Component Fractions, %	Asphaltenes	D 4124 by Iatroscan	16.6	19.6	23.4	26.2	23.9
	PA's		49.5	46.9	43.7	43.1	48.8
	NA's		22.4	22.0	21.5	19.6	15.9
	Saturates		11.5	11.5	11.4	11.1	11.4

Property		ASTM Test Method	RESULTS: Sample ID / #				
			-06	-07	-08	-09	-10
			CS-1 Bottom	CS-1 Top PAV	CS-1 Bottom PAV	CS-4 Top PAV	CS-4 Bottom PAV
Component Fractions, %	Asphaltenes	D 4124 by Iatroscan	25.5	29.4	30.2	28.4	30.3
	PA's		47.4	47.1	46.8	46.8	45.6
	NA's		15.7	12.8	12.4	13.5	13.3
	Saturates		11.4	10.7	10.6	11.3	10.8

Recovered Binder after APWS N70 RAP Mix



VTAE affects on binder grade and aging

Lab Blends %	AASHTO M 320, Table 1, PG continuous grade & Difference between S and m grade temperature					
	0	2	4	6	8	20
PG 64-22 1 w/VTAE 1	67.3-26.2	68.3-25.0	64.9-26.5	64.2-27.6	62.6-26.5	55.6-26.6
Difference Between S & m grade	-1.5	-4.6	-3.6	-3.7	-6.9	-15.2
PG 64-22 1 w/VTAE 2		65.9-24.8	66.0-25.7	65.6-25.9	64.9-27.6	61.5-26.0
Difference Between S & m grade		2.2	-4.6	-5.7	-4.5	-9.8
PG 64-22 2 w/VTAE 1	66.5-25.9	64.7-26.7	63.9-27.2	62.6-28.1	61.0-27.4	55.8-29.8
Difference Between S & m grade	0.2	-0.5	-1.8	-2.5	-4.8	-7.9
PG 64-22 2 w/VTAE 2		65.5-26.0	64.3-27.1	63.9-27.7	63.3-27.3	60.1-31.0
Difference Between S & m grade		-3.7	-4.3	-5.7	-4.5	-12.1

Blends Continuous Grades

Original and Recovered

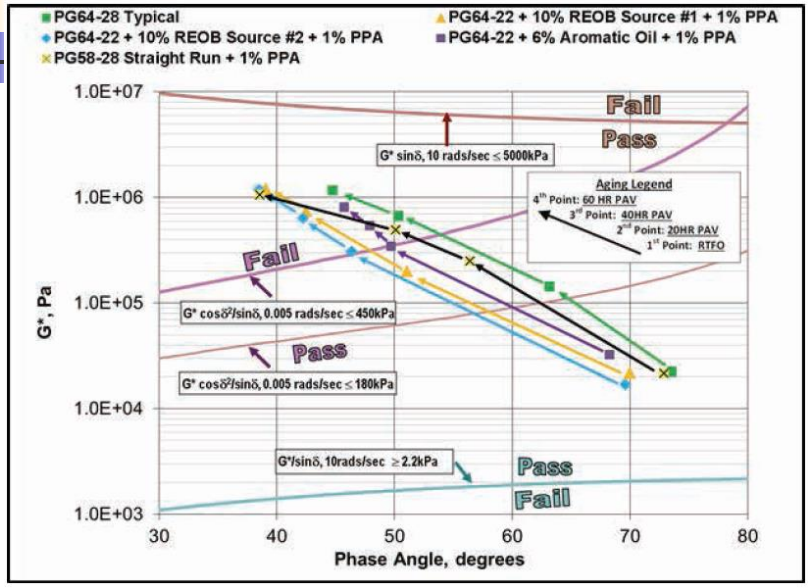
PROPERTY	RESULTS Recovered Binder Mix with 5% RAS 0.5% Antistrip:			
	Control	VTAE		
		8%	16%	24%
AASHTO M 320 SUPERPAVE™ Binder Grade, PG:	76-16	70-22	70-22	70-22
Continuous Grade	79.7-21.4	74.3-24.8	73.8-23.2	74.4-23.6
Difference Between S & m grade	-4.3	-5.4	-12.6	-14.4

Lab Blends %	AASHTO M 320, Table 1, PG continuous grade & Difference between S and m grade temperature			
	Control	6% VTAE	6% VTAE & 0.5% AS	10% VTAE
AASHTO M 320 SUPERPAVE™ Binder Grade, PG:	64-22	58-22	58-22	58-28
True Grade	66.2-25.61	62.0-27.45	61.2-29.09	59.8-28.83
Difference Between S & m grade	2.3	-1.2	-1.5	-3.3

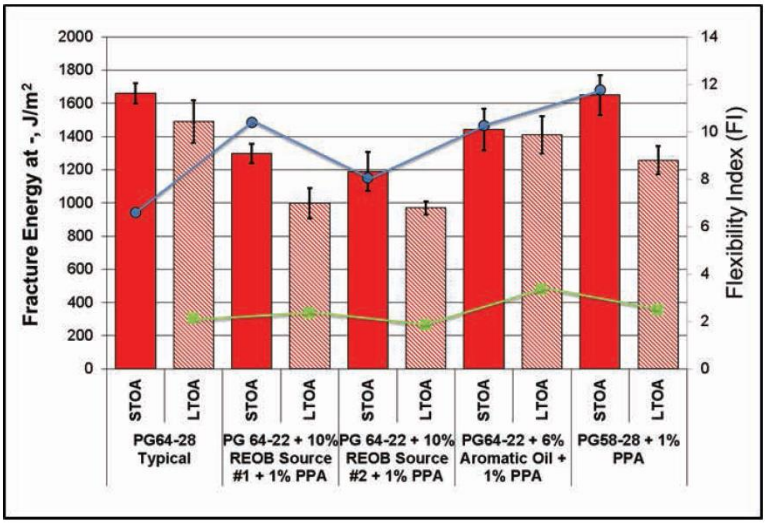
Study Walaa Mogawer UMass

Binder	Modifier (s)	Continuous Grade	Performance Grade
PG64-28	Unknown - Typical Binder	CG 65.6-29.4	PG64-28
PG58-28	1% PPA	CG 67.0-29.1	PG64-28
PG64-22	2% REOB Source #1 + 1% PPA	CG 72.0-26.1	PG70-22
PG64-22	6% REOB Source #1 + 1% PPA	CG 67.7-27.4	PG64-22
PG64-22	10% REOB Source #1+ 1% PPA	CG 64.4-29.8	PG64-28
PG64-22	13% REOB Source #1 + 1% PPA	CG 61.6-30.4	PG58-28
PG64-22	18% REOB Source #1 + 1% PPA	CG 58.8-32.0	PG58-28
PG64-22	8% REOB Source #2 + 1% PPA	CG 64.5-28.8	PG64-28
PG64-22	10% REOB Source #2 + 1% PPA	CG 63.8-29.6	PG58-28
PG64-22	6% Aromatic Oil + 1% PPA	CG 66.9-30.0	PG64-28
PG64-22	10% Aromatic Oil + 1% PPA	CG 61.4-32.3	PG58.28

Glover Rowe Cracking Criteria



SCB I Fit 64-28



TTI NCHRP 9-58 RA Dosage Selection Overall G-R Results

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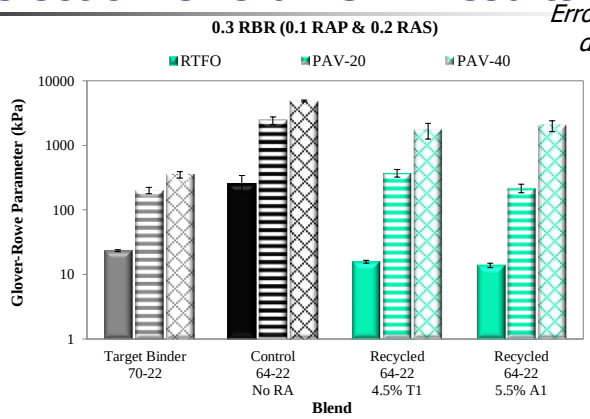
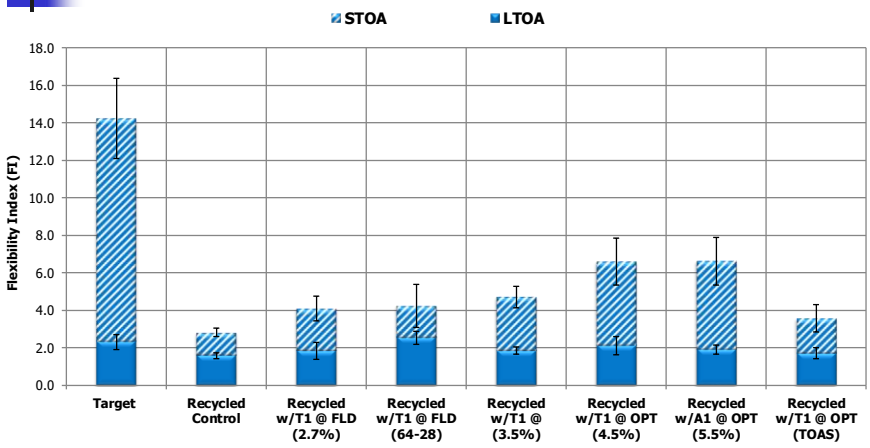


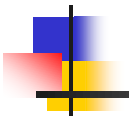
Target Binder ≤ Recycled Blends @ opt RA < Recycled Blend no RA

TTI NCHRP 9-58
RA Dosage Selection – Mixture Validation - SCB



Summary

- Producing Softer PG binders generally not economical.
- Multiple additives available to soften binders.
- Each has advantages and limitations.
- Significant Engineering is needed to optimize performance.



Thank You!