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Binders in RAP
Field Aging and Blending Charts

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Source of Information

- Disclaimer -- nothing new
- Binder ETG data 1995-96
- AAPT papers
- TRB papers

Outline

- Properties of binders in RAP.
  - Implications and Magnitude of Asphalt Aging in the field
  - Rheological changes due to aging
  - Field validation carried during SHRP
- Estimation of effect of RAP on Binder Grades
- Suggested ideas to increase RAP use

High Variability in Viscosity Change with Age

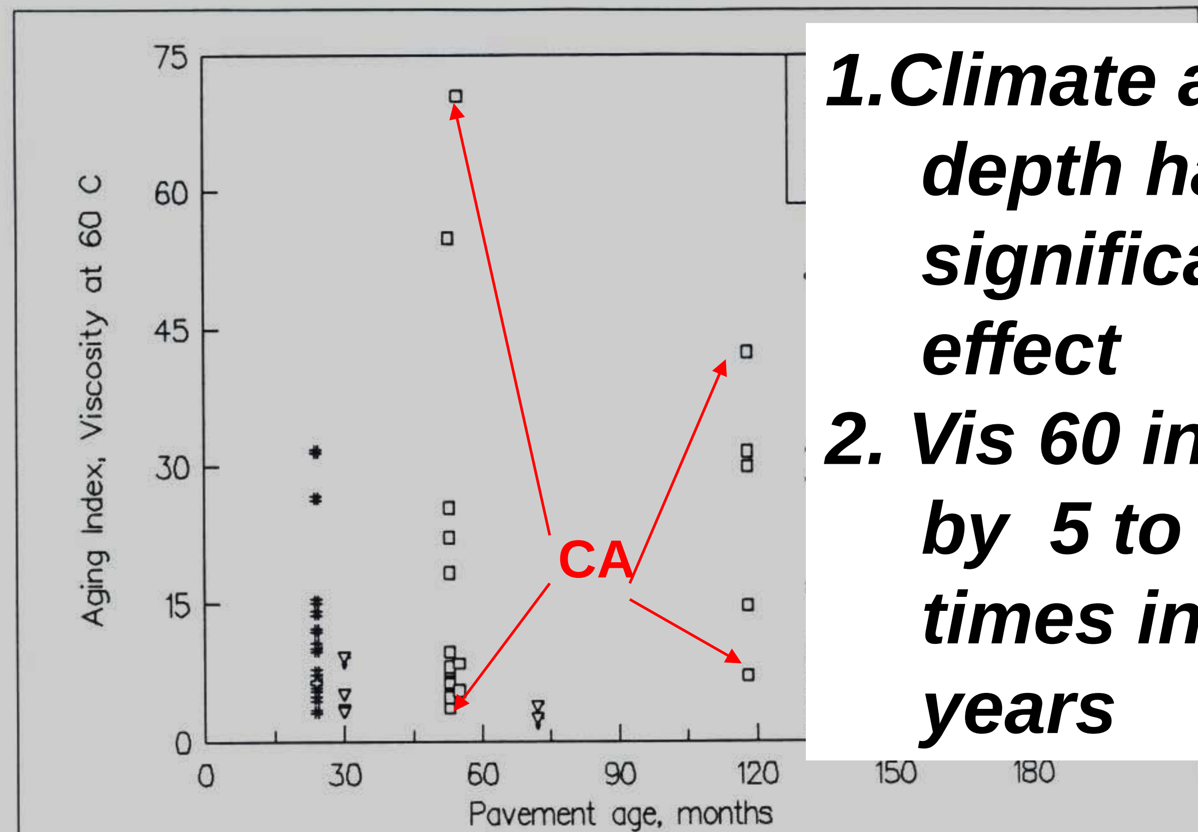

Figure 2. Aging indices in terms of absolute viscosity for a number of asphalts used in test section in the United States.

1. ***Climate and depth have significant effect***
2. ***Vis 60 increase by 5 to 75 times in 5-10 years***

High Variability in Penetration Retained with Age

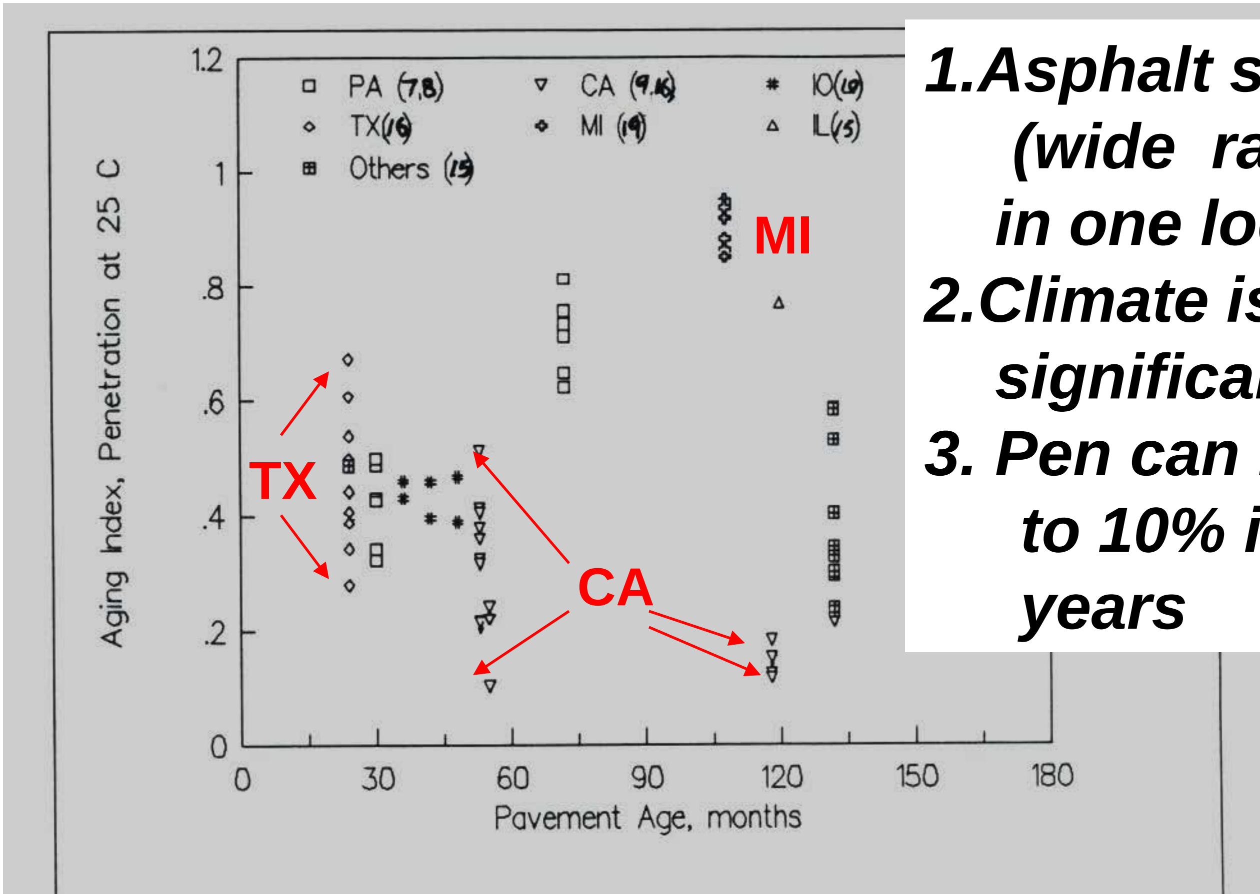

Figure 1. Penetration retained for a number of asphalts used in test sections in the United States.

1.Asphalt specific (wide range in one location)
2.Climate is very significant
3. Pen can reduce to 10% in 5-10 years

When RAP is used, Magnitude of Aging Should be Quantified

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- Asphalt aging vary widely
- Source of binder is not the only controlling factor
- Temperature appears to be one of the most important factors.
- Depth is also important but is related to temperature
- Mixture type, permeability, aggregates. Not well studied, many opinions.

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Implications of Field Aging

- All asphalts become harder, more elastic, and possibly more brittle.
- Fatigue and low temperature cracking are commonly seen after age.
- *It is not clear if that is due to repeated loading and accumulation of damage or due only to aging.*

Binder Aging Mechanism

- It is a diffusion-reaction process
- Air diffusion is related to free volume, which is controlled by chemistry
- Hardening is the result of a complex chemistry affecting molecular weight and interactions.
  - No one chemical compound could be blamed for it.
- *Rate is highly affected by both diffusion and chemical reaction. Separation of effects is almost impossible.*

Effect of Aging – In Lab

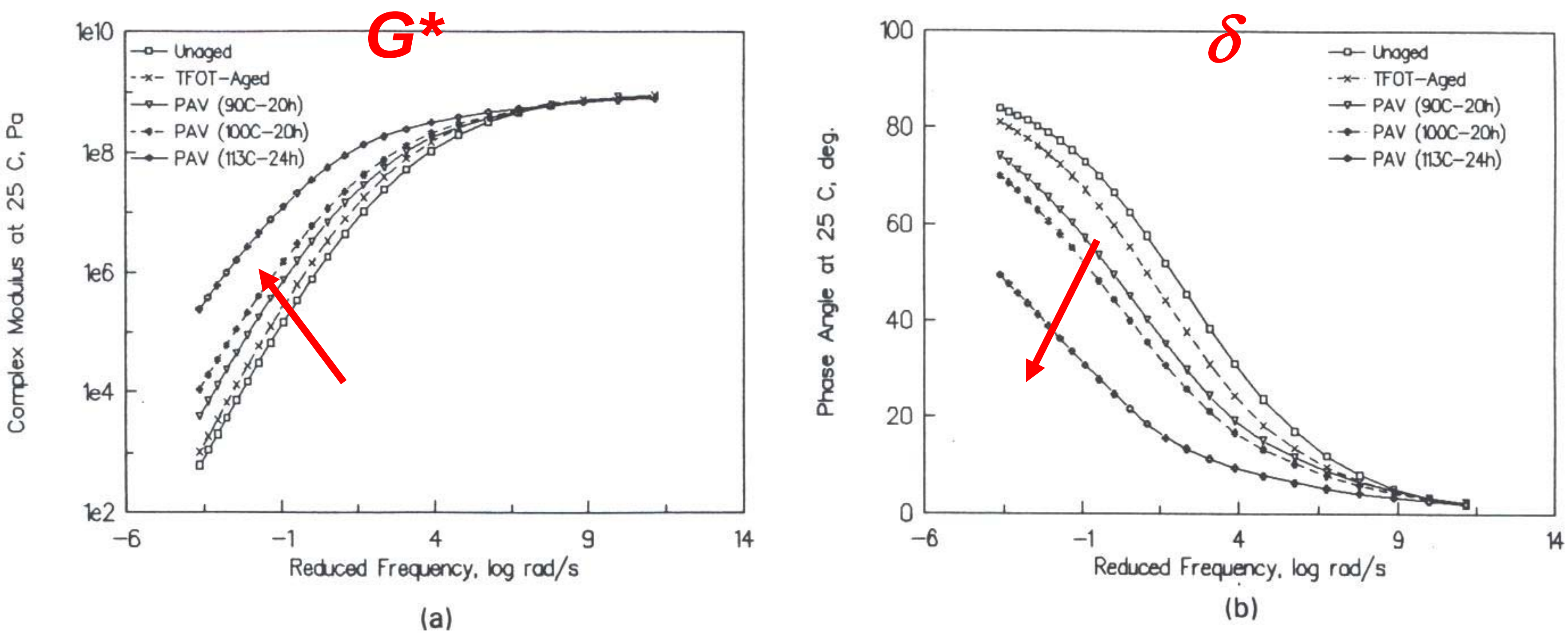


Figure 5. Effect of oxidative aging in the PAV on rheological master curves of a typical asphalt. (a)complex modulus, (b) phase angle.

Effect of Aging in Field Sample Data Tested in 1991

- CA: 1 section built 1987
- PA: 4 sections 1976
- WA: 4 sections 1972, 75, 85
- FL: 2 sections 1984
- WY: 1 section 1987

- Test rheology, failure, chemistry
- Include TFOT and PAV conditioned

Comparison of PAV with Field 8 years in Florida

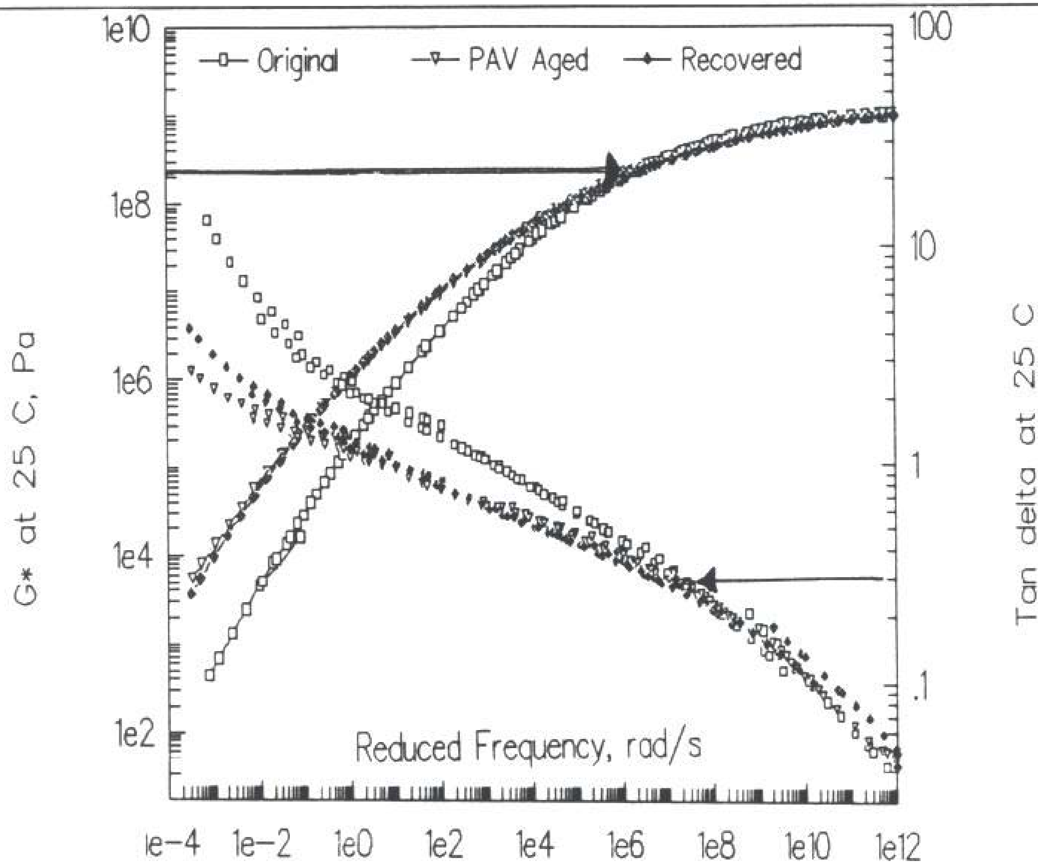


Figure 8. Comparison of effects of PAV aging and field aging on rheological master curves of an asphalt extracted from an 8-year old test section.

Comparison of PAV with Field 19 years in WA

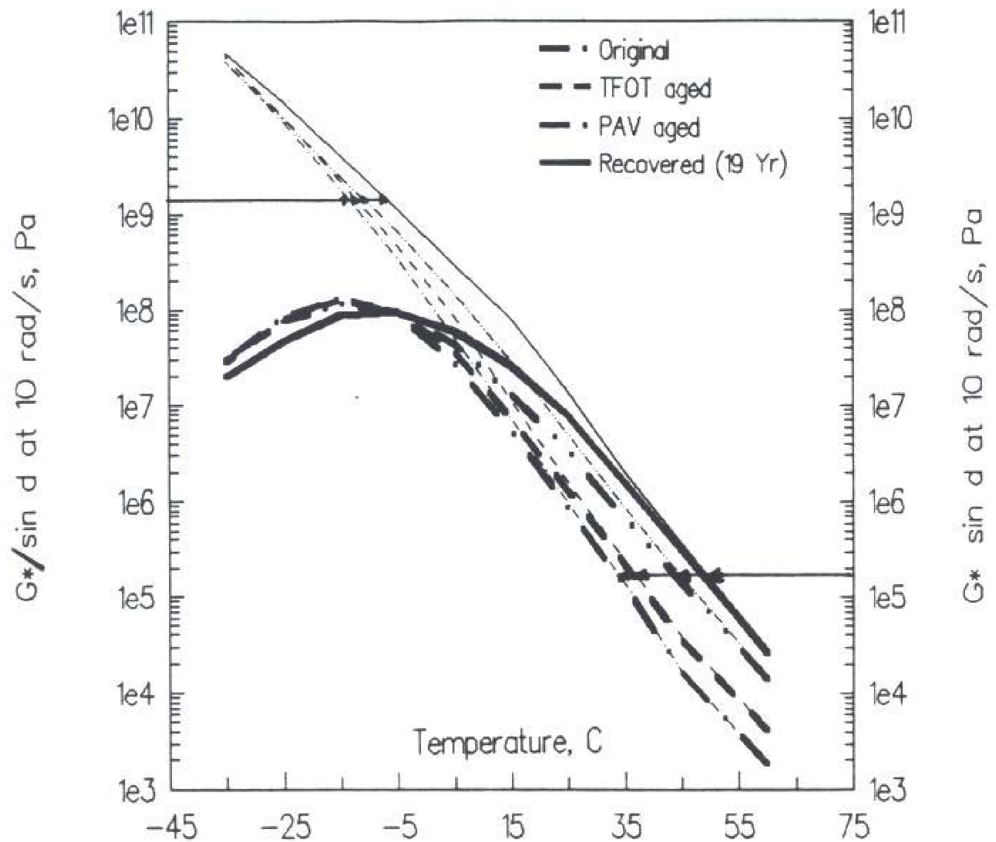
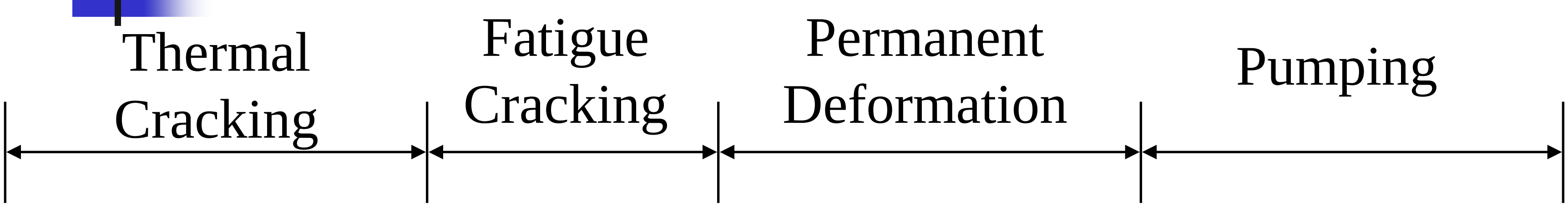
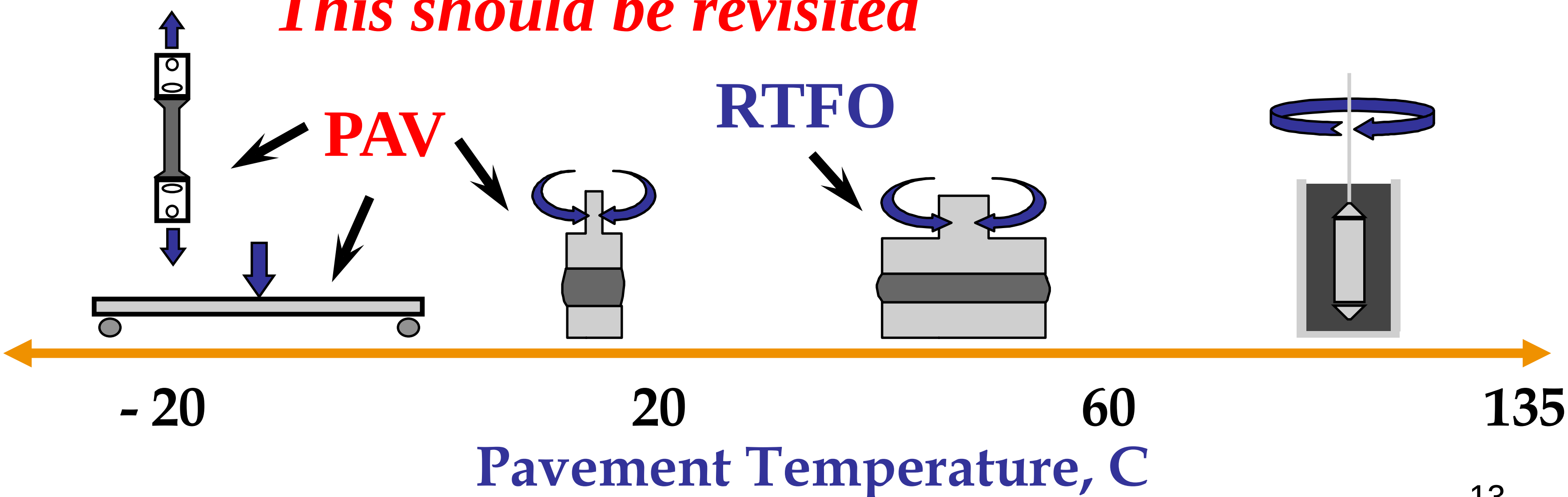


Figure 10. Changes in new SHRP specification parameters after aging in the laboratory using the PAV and after 19 years in the field.

Current Challenge:
How to include RAP Effects on PG Grade



PAV does not measure aging potential !
It is used to provide aged sample only.
This should be revisited



Field Sections Compared to Specification limits

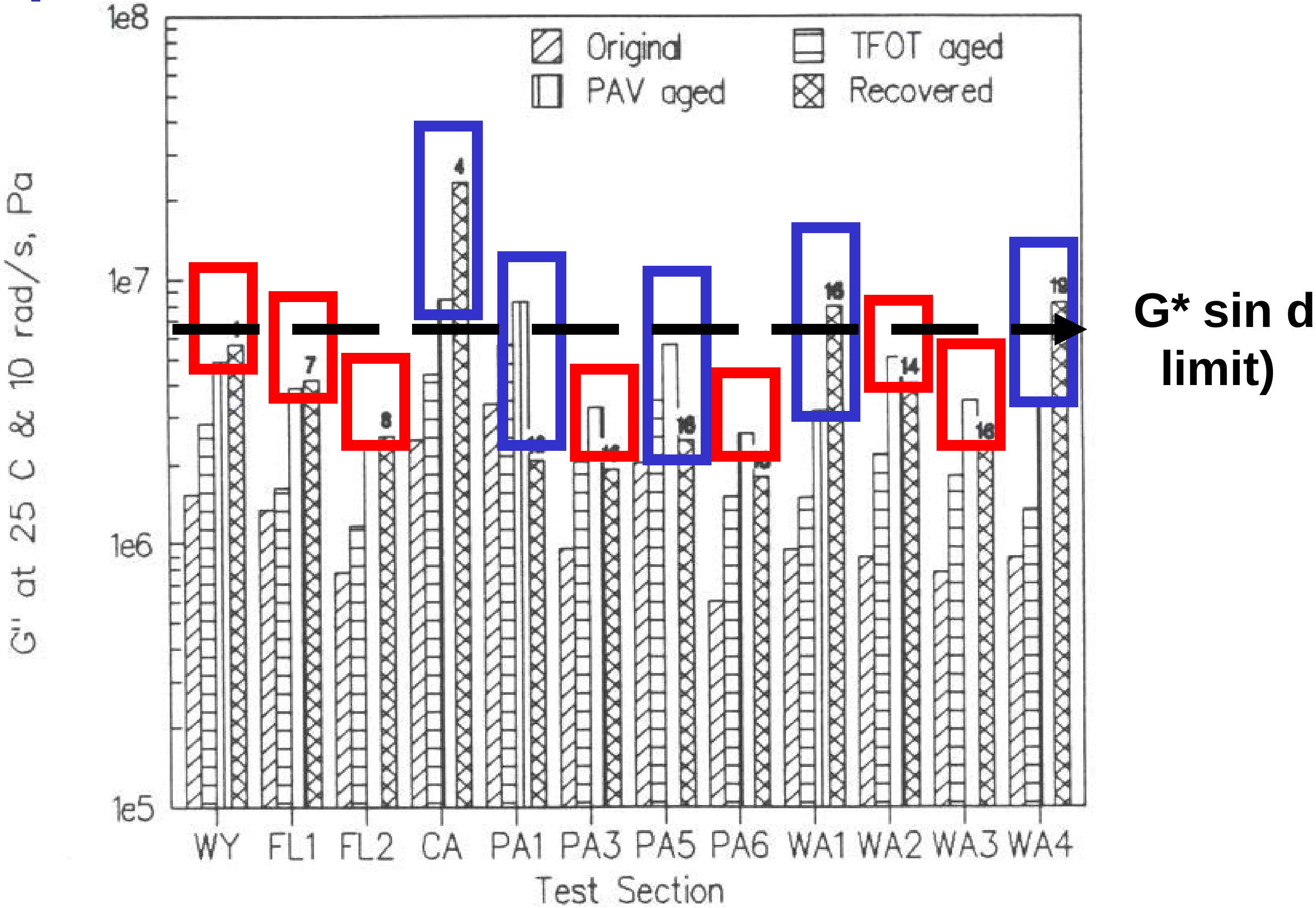
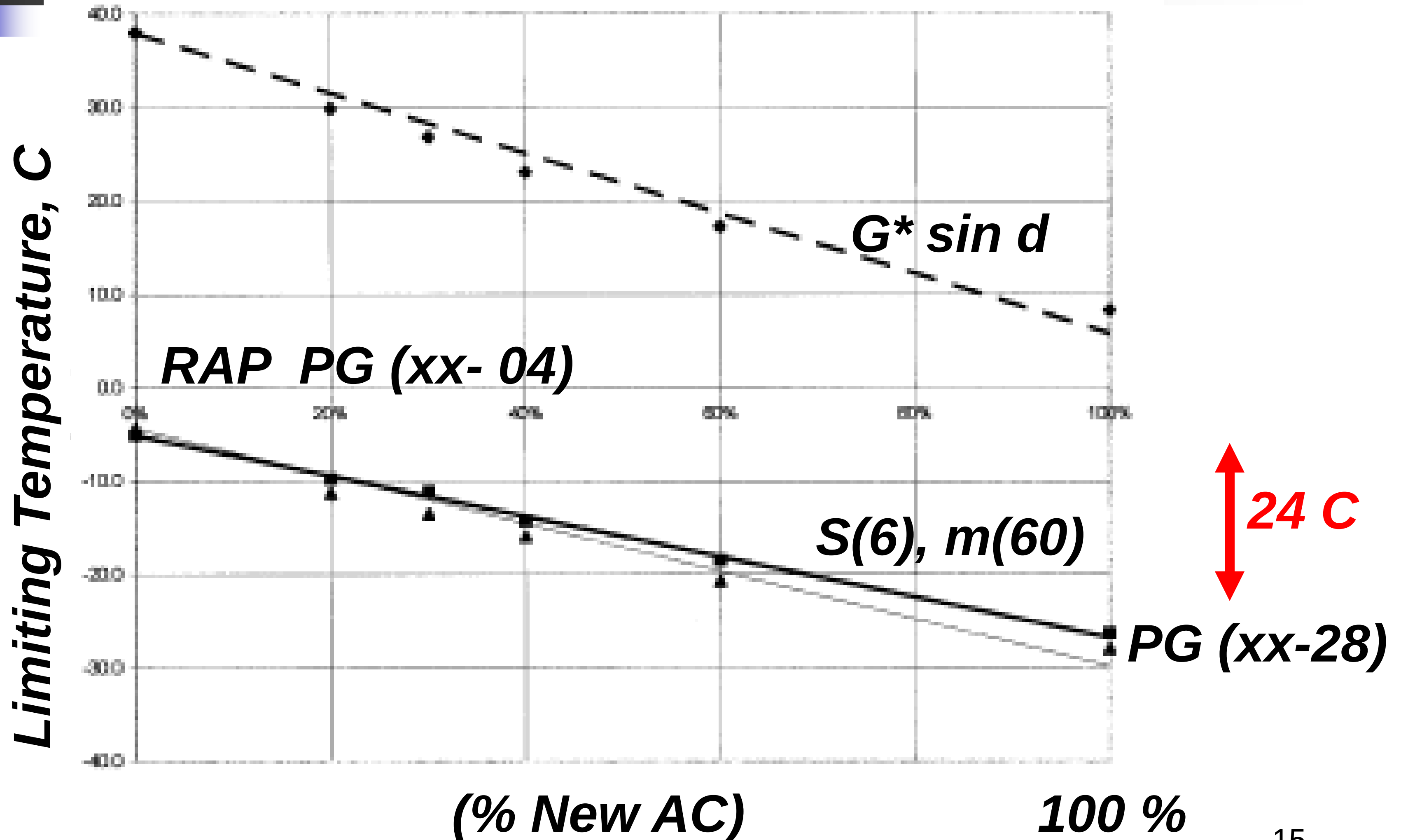


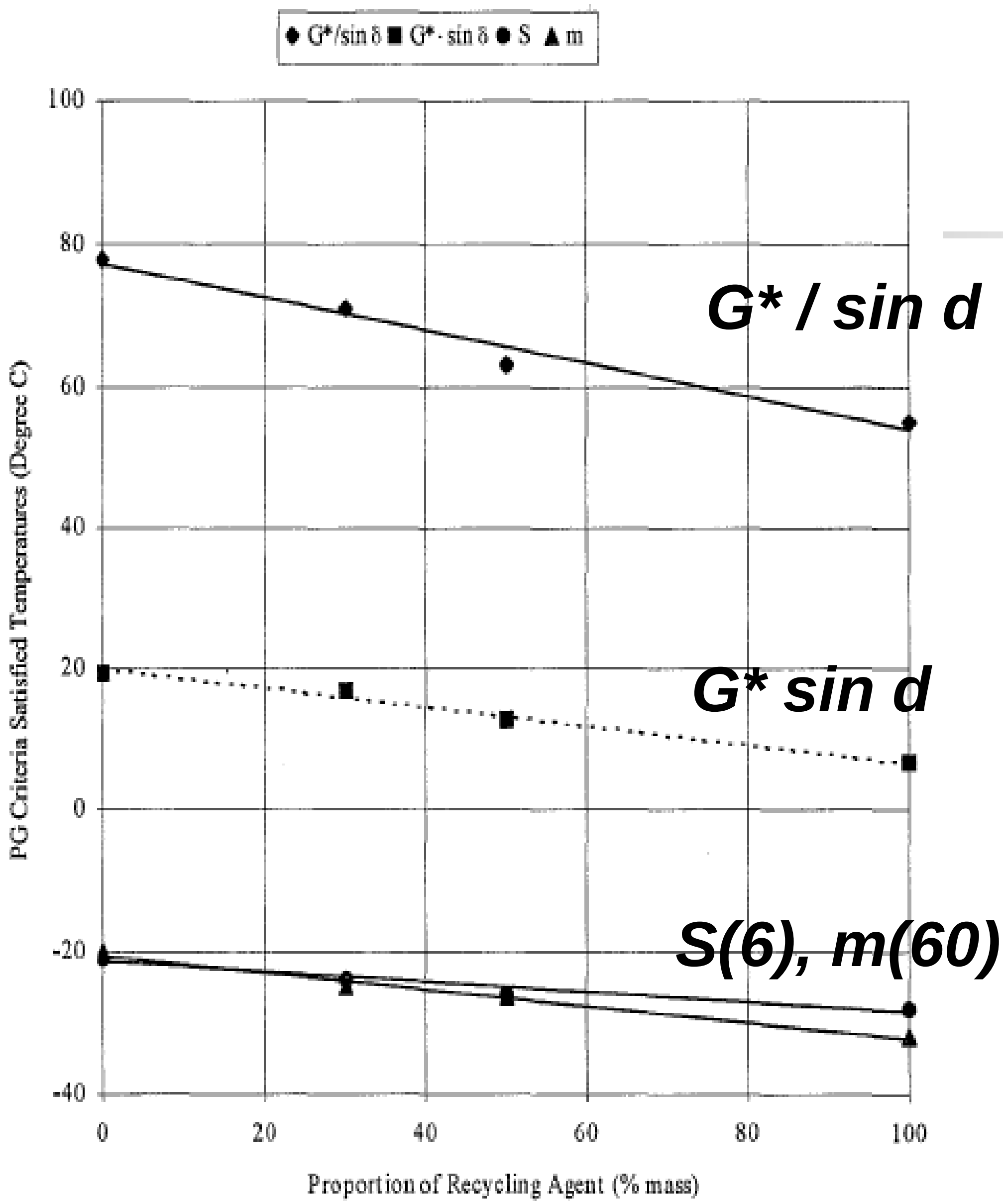
Figure 11. Comparison of G* sinδ changes after PAV aging and after field aging for 12 sections included in the PAV validation experiment.

Effect on Grade

Blending of RAP Binder with Virgin Binder



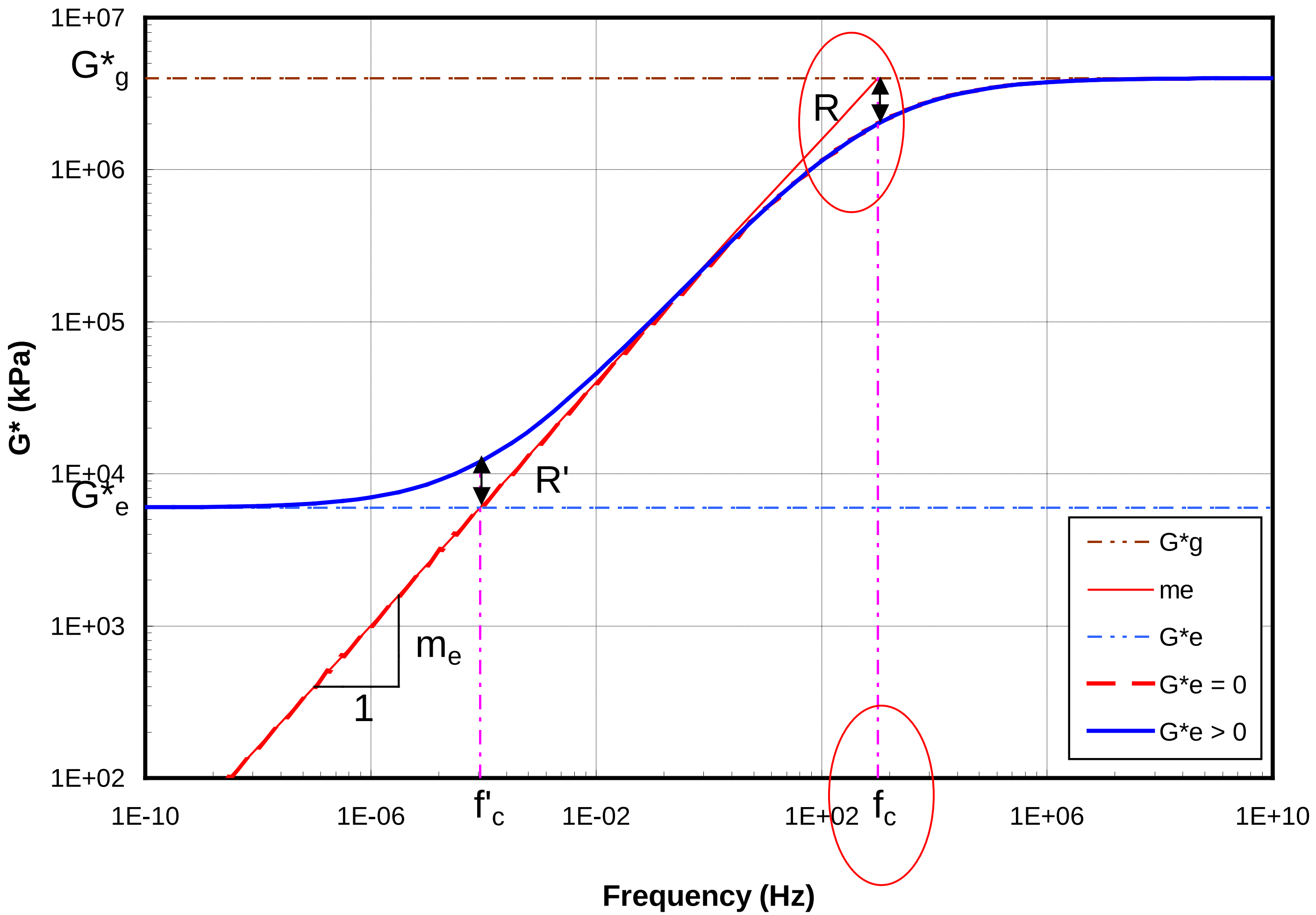
RAP PG Grade Adjustment Chart



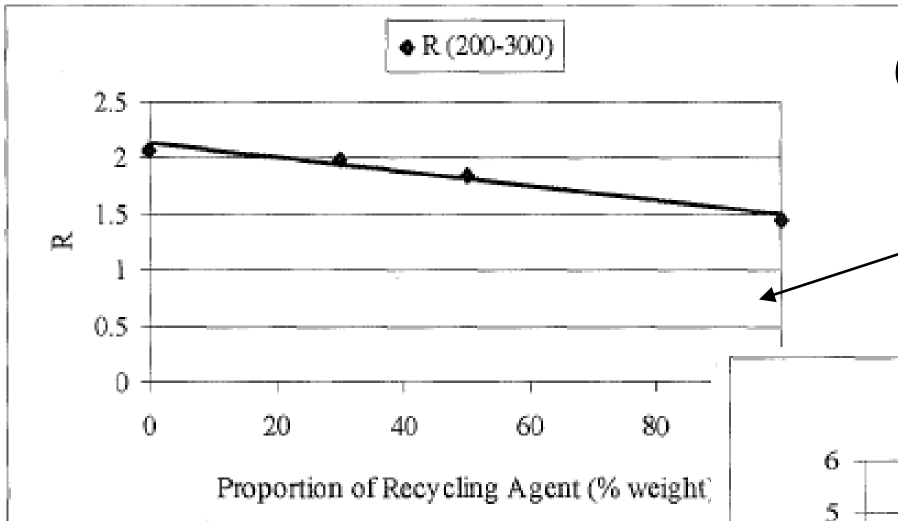
What about
Mixing and Compaction Temps ?

Binders	Blending Ratios (% by mass)	Kinematic Viscosity (cP) @135°C	Absolute Viscosity (P) @60°C	Penetration 0.1 mm @25°C	Rotational Viscosity(cP) Unaged @135°C	Rotational Viscosity (cP) Aged @135°C	Aging Index[a]
150-200	-	380	1729	174	350	1025	2.92
200-300	-	209	471	252	187.5	525	2.8
300-400	-	173	309	365	162.5	450	2.77
N1	70% 150-200 Aged +30% 200-300	543	4395	67	637.5	2250	3.53
N2	50% 150-200 Aged +50% 200-300	411	2283	92	412.5	1550	3.75
M1	70% 150-200 Aged +30% 300-400	520	4139	64	450	1288	2.86
M2	50% 150-200 Aged +50% 300-400	396	2202	90	337.5	987.5	2.92
C1	95% 150-200 Aged +5% Cyclogen	654	7546	50	642.5	2375	3.69
C2	85% 150-200 Aged +15% Cyclogen	312	1665	100	332.5	1850	5.56
C3	70% 150-200 Aged +30% Cyclogen	125	290	276	125	844	6.75
F1	95% 150-200 Aged +5% Flexon	557	5549	63	437.5	1263	2.88
F2	90% 150-200 Aged +10% Flexon	544	5404	65	131	1182	3.57
F3	85% 150-200 Aged +15% Flexon	199	737	176	112.5	962.5	8.55

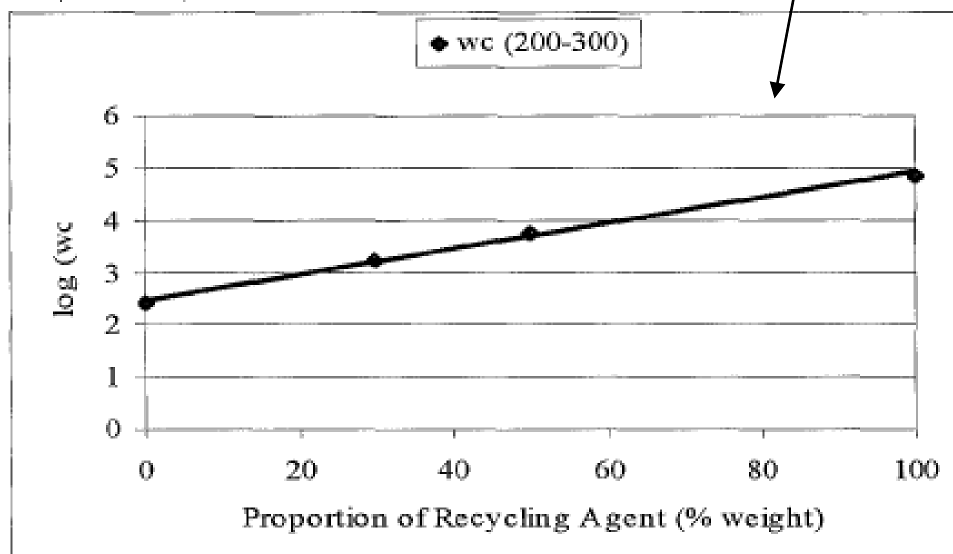
Illustration of G* master-master curve



Effect on Rheology Appears to be simple



Changes in R, and Fc



Closing Remarks

- Aging in the field is affected not only by kinetics, but by many other factors.
  - Temperature variation (climate and depth)
  - Film thickness
  - Water/moisture
  - Mineral surface
  - Air voids
  - Light , etc…
- Temperature is used in the PG grading and appears to have a highly significant effect.

Closing Remarks

- Changes in PG grading and in rheology are simple to predict:
  - A linear relationship is shown adequate for the prediction of changes in PG grading
  - Linear relationship can predict the change in rheological index (R) and crossover frequency
- Compatibility remains to be a concern. Literature indicates this is a possibility and thus need to be checked

Closing Remarks- How to increase RAP use

- Some ideas to consider
  - *Develop Non solvent separation of binders or mastics*
  - *Develop realistic lab blending methods*
  - *Check compatibility and aging based on relative effects .*
  - *Estimate variability in stock piles and agree on typical values for use*
  - *Adjust grade based on application.*
    - *For subsurface layers require less adjustment and more RAP (no cracking).*

Thank You

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SHRP program