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Assessing the validity of blending charts for rejuveanted RAP binders

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Asphalt rejuvenation

- Restore the balance between asphaltenes and maltenes.
- Improve asphaltene dispersion.
- Reduce stiffness.
- Increase in phase angle.
- Improve low-temperature cracking properties
- Improve cohesive and adhesive properties of asphalt.
- Durable performance

Effect of binder

- Soybean-based rejuvenator
- A neat PG58-28 and a polymer modified PG64-28.
- Two different mixing temperatures 120C and 140C.
- A split-plot repeated measure statistical analysis was performed.
- PG and mixing temperatures both found significant.

Low temperature performance

- Disk-shaped compact tension (DCT) test at -6C
- Rejuvenator increased the fracture energy denoting better low temperature cracking resistance

Mixture Type	Average fracture energy	COV
RAP/ PG58-28	377	0.17
RAP/ 12% PG58-28	424	0.18

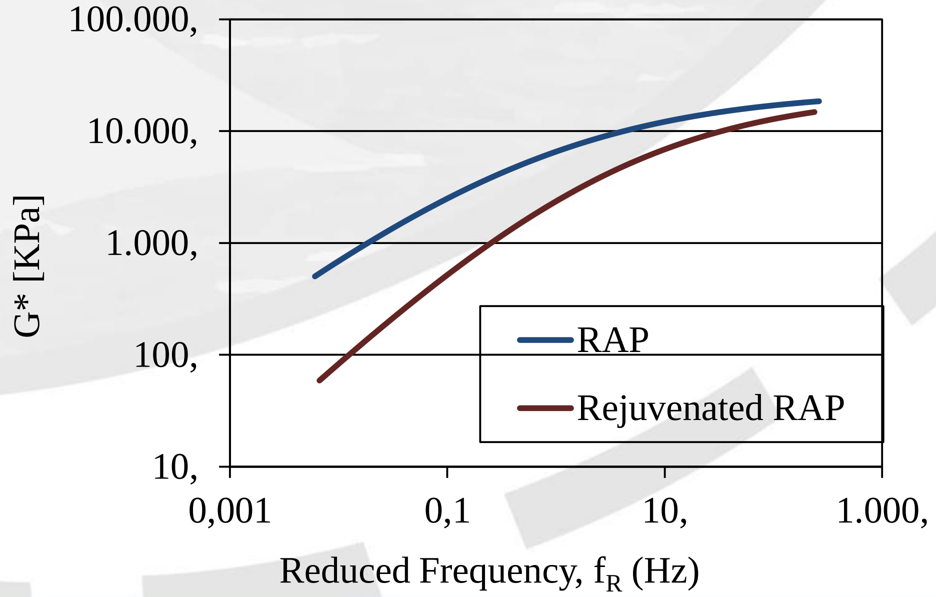
Effect on performance grade

- Lowers both the critical high temperature and low temperature
- Slight increase in mass loss within acceptable limits

Binder	RAP+PG58-28S	RAP+PG58-28S+3%SB	RAP+PG58-28S+6%SB
Unaged (High Temp.), ºC	66.6	59.5	54
RTFO (High Temp.), ºC	65.7	60.8	57.9
PAV (Low Temp.), ºC	-29.0	-30.8	-32.4
Performance Grade (PG)	64-28	58-28	52-28
Mass loss (%)	0.6	0.75	0.98

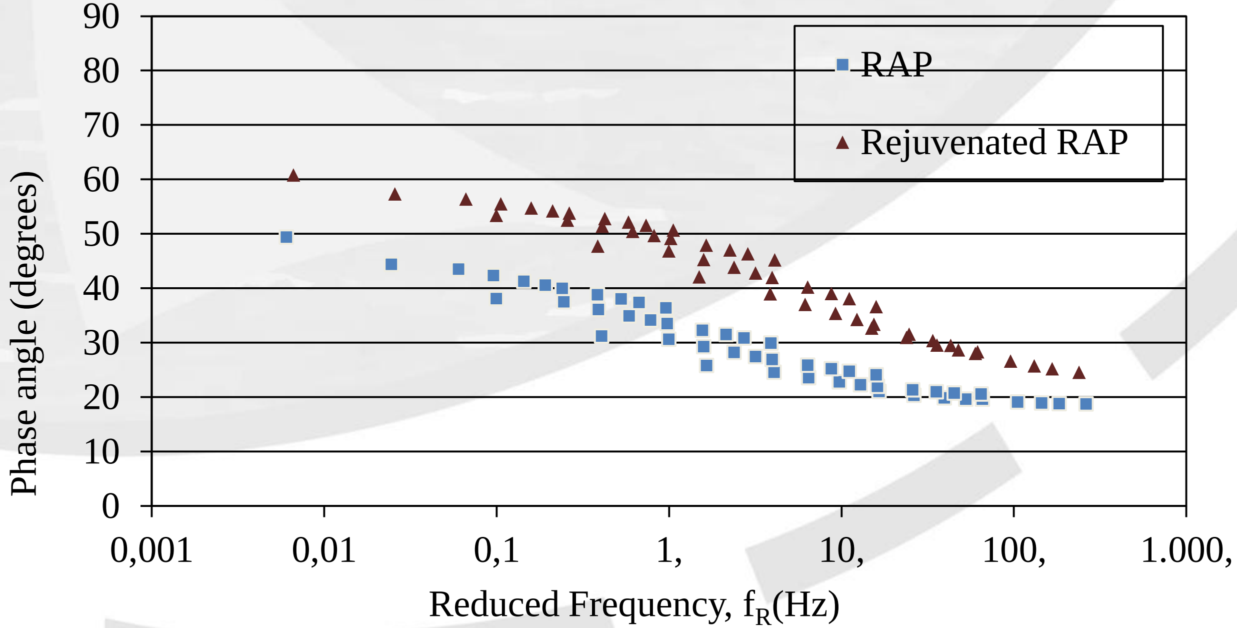
Effect on stiffness of binder

- Stiffness of binder decreased consistently with rejuvenation even after PAV aging



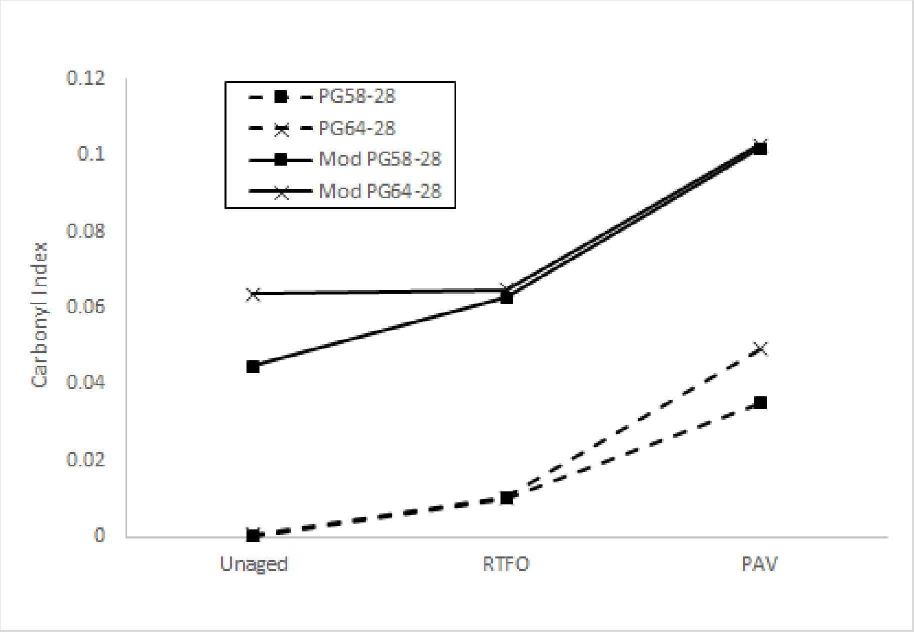
Effect on phase angle of binder

- Phase angle of binder increased consistently with rejuvenation even after PAV aging



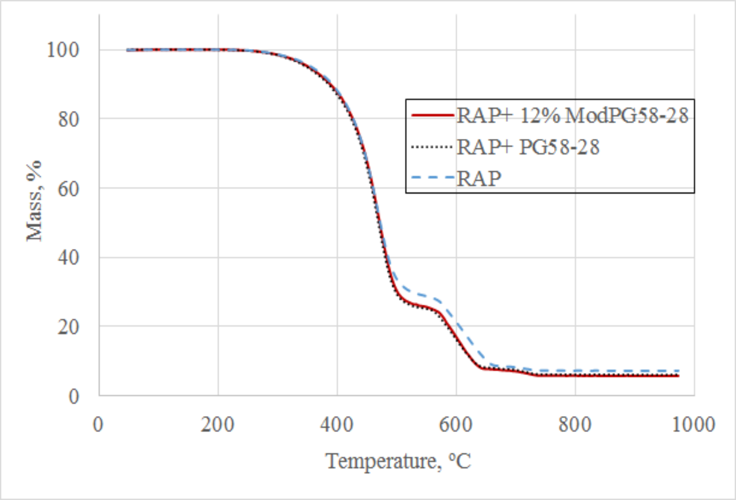
Durability

- ATR-FTIR was used to look at the carbonyl and sulfoxide functional groups.
- The rejuvenator did not adversely impact the aging behavior



Thermal stability

- Thermogravimetric analysis (TGA) was used to assess the thermal stability of the rejuvenated binders.
- The addition of the rejuvenator did not reduce the thermal stability of the binder



Blending Charts

- Blending charts were developed for neat binders
- Can we extend the concept of blending charts to include rejuvenated binders?
- Viscosity models can be used to predict the viscosity of blends.
- Will viscosity models provide a means to predict the viscosity of rejuvenated blends?

Viscosity models

- Linear blending charts are not accurate for low viscosity fluids.
- Two viscosity models were investigated in this study:

1) Chevron Model

$$\log(\eta_T) = \frac{3VBI_T}{1-VBI_T}$$

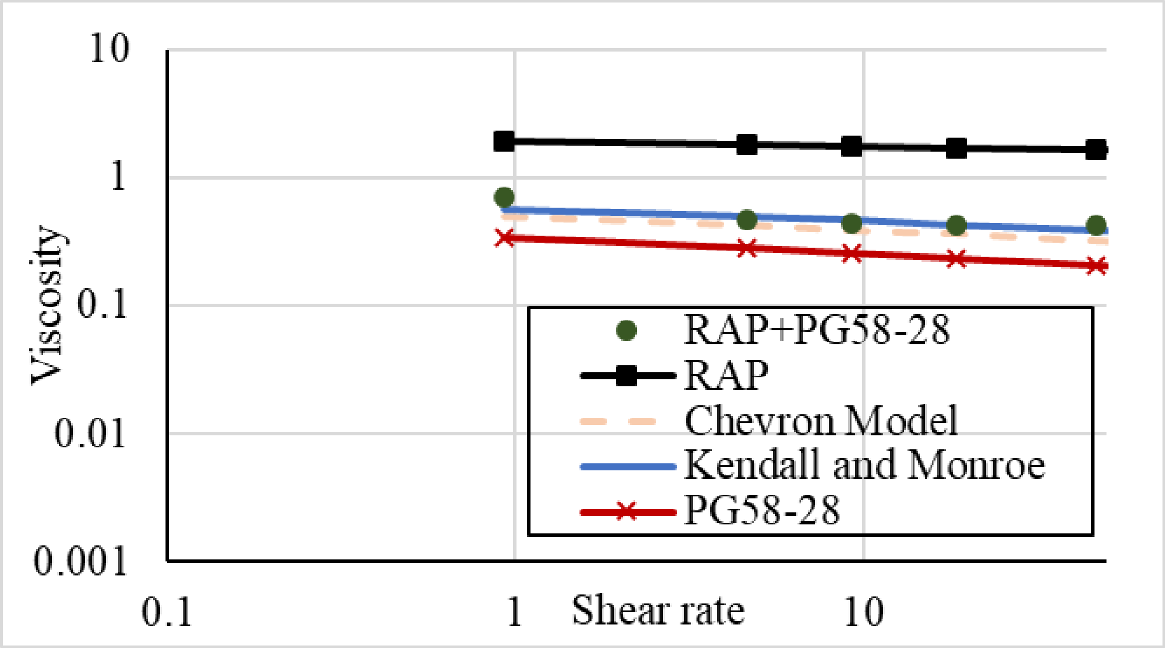
$$VBI_T = \sum_{i=1}^{n} r_i VBI_i \quad , \quad VBI_i = \frac{\log(\eta_i)}{3 + \log(\eta_i)}$$

2) Kendall and Monroe

$$\eta_T^{1/3} = \sum_{i=1}^{n} r_i \eta_i^{1/3}$$

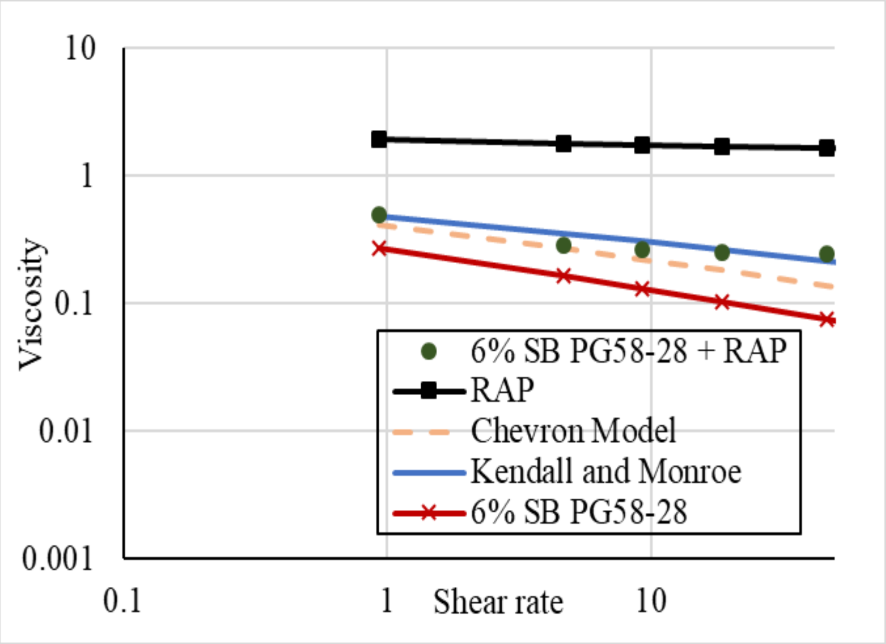
Blending of neat binders

- Models provided good prediction for the blends made with neat binders.



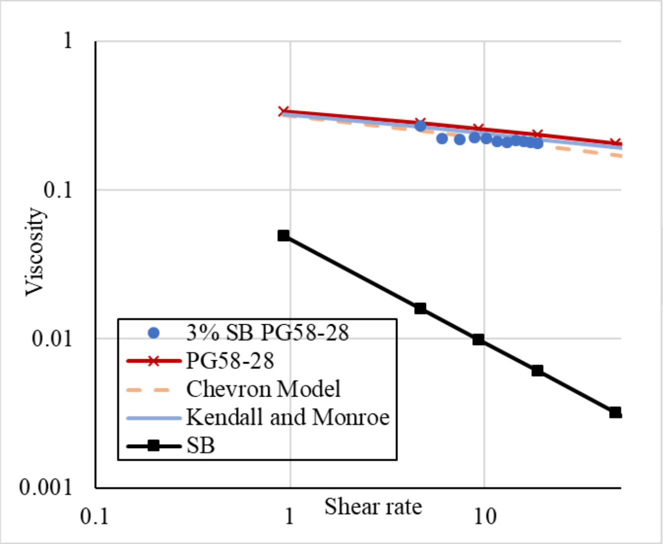
Blending of rejuvenated binders

- Models provided good prediction for the blending of a neat binder with a rejuvenated binder.



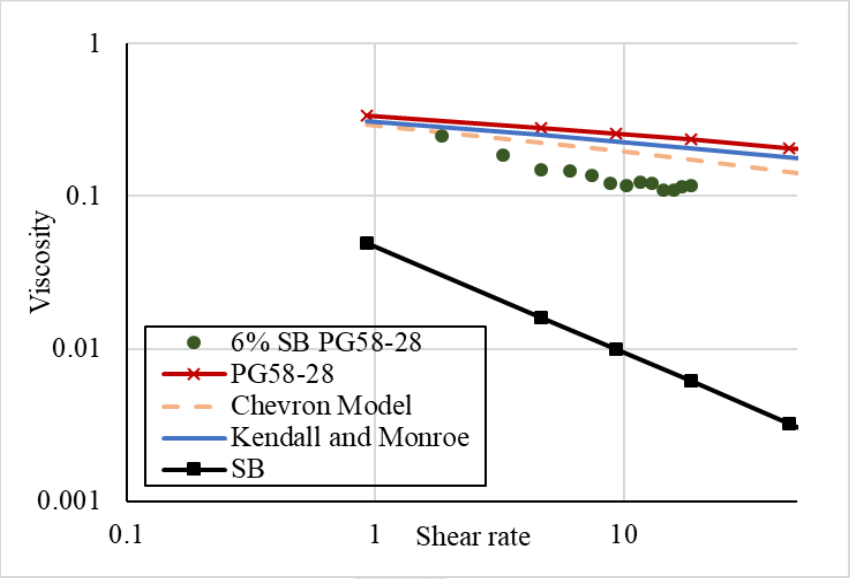
Blending of rejuvenators

- Models provided fair prediction when blending a rejuvenator with a neat binder at a low dosage (3%).



Blending of rejuvenators

- Models failed to predict the viscosity of the blends when rejuvenators were used at high dosage (6%)
- The drop in viscosity associated with adding 6% of the rejuvenator to the binder could not be explained by simple viscosity models.



Conclusions

- Viscosity models can be used to predict viscosity of binder blends containing a rejuvenated binder
- Viscosity models may be used with fair accuracy to estimate the viscosity drop in a binder due to the addition of a rejuvenator at low dosages (3%).
- At high dosages, the viscosity models fail to predict the viscosity drop due to the addition of a rejuvenator.
- These results indicate that simple viscosity models are not sufficient to explain the effect of rejuvenation which may involve not only physical but also chemical interaction.
- Future research will investigate additional models