

BBR with Mix Slivers

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Bending Beam Rheometer

- Binder thermal cracking test
- Applies load at center of beam
- Tested at low temperature
 - -1 and -11°F
- Stiffness of mix



Calculations

- Modified Hirsch Model

$$S_{mix} = P_c \left[E_{agg} \left(1 - \frac{VMA}{100} \right) + S_b \left(\frac{VFA * VMA}{10000} \right) \right] + (1 - P_c) \left[\frac{1 - \frac{VMA}{100}}{E_{agg}} + \frac{VMA}{VFA * S_b} \right]^{-1}$$

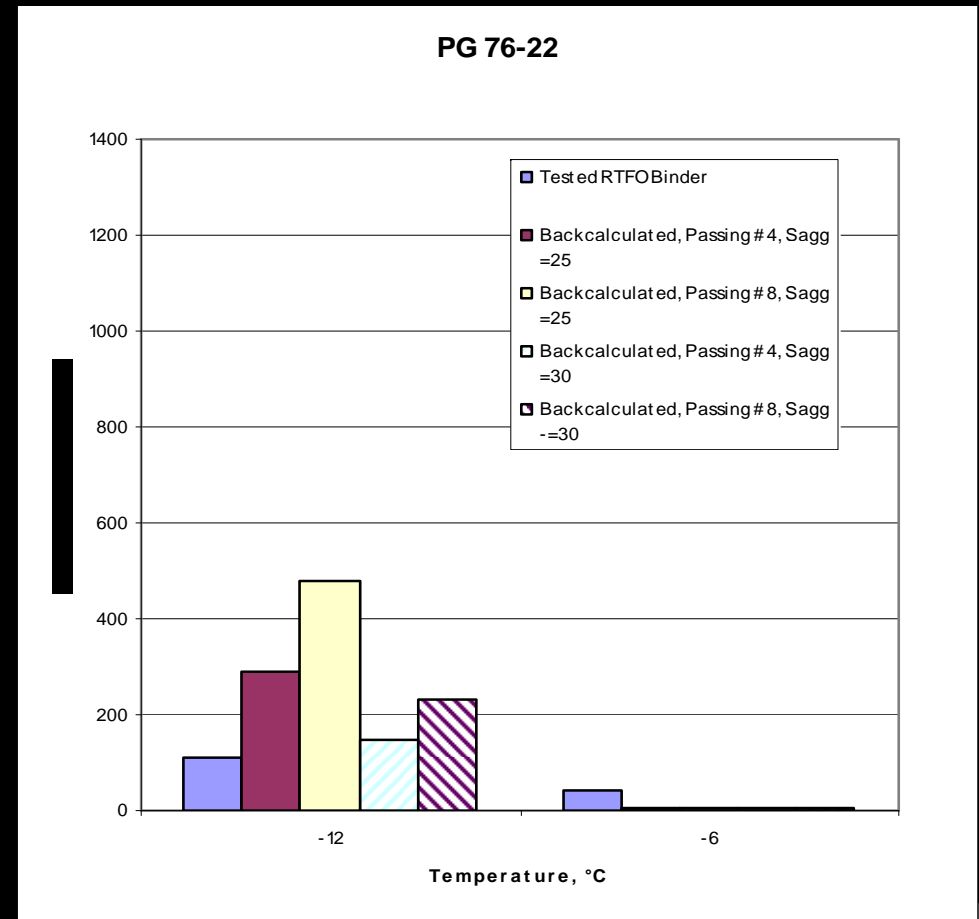
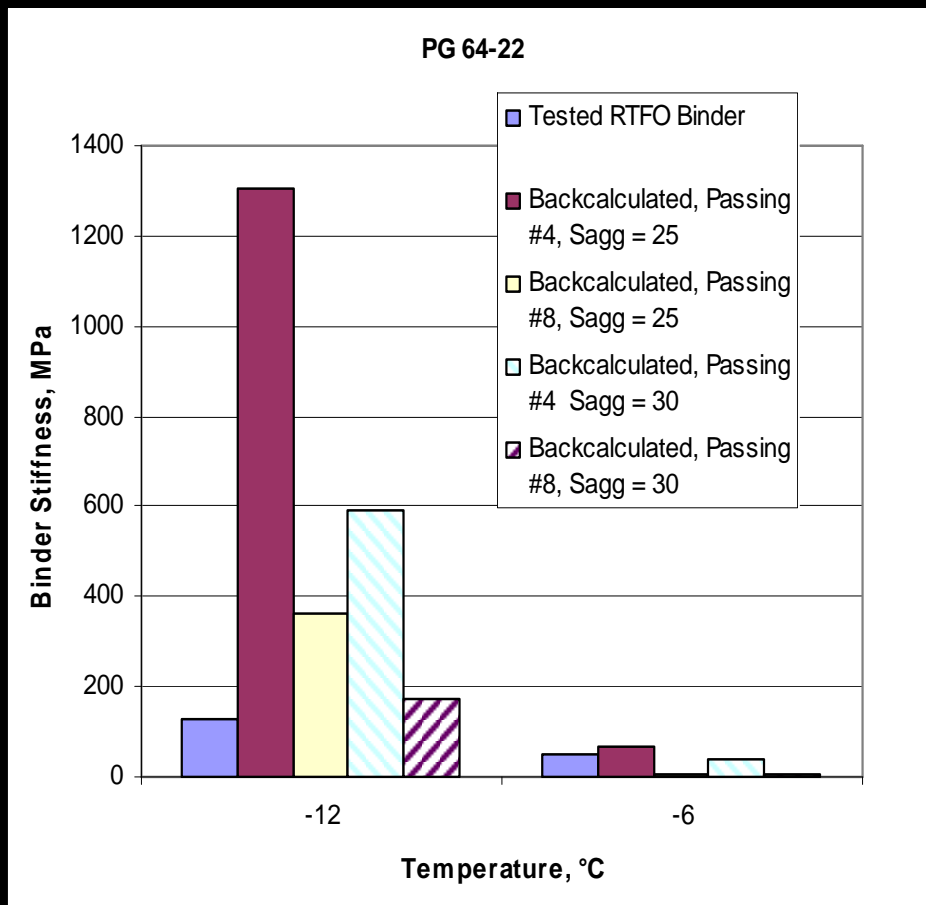
$$P_c = 0.100 * LN(S_b) + 0.609$$

- S_{mix} = Mixture Stiffness, GPa
- S_b = Binder Stiffness, GPa
- E_{agg} = Aggregate Elastic Modulus, GPa
- VMA = Voids in Mineral Aggregate, %
- VFA = Voids Filled with Asphalt, %
- P_c = Contact Factor

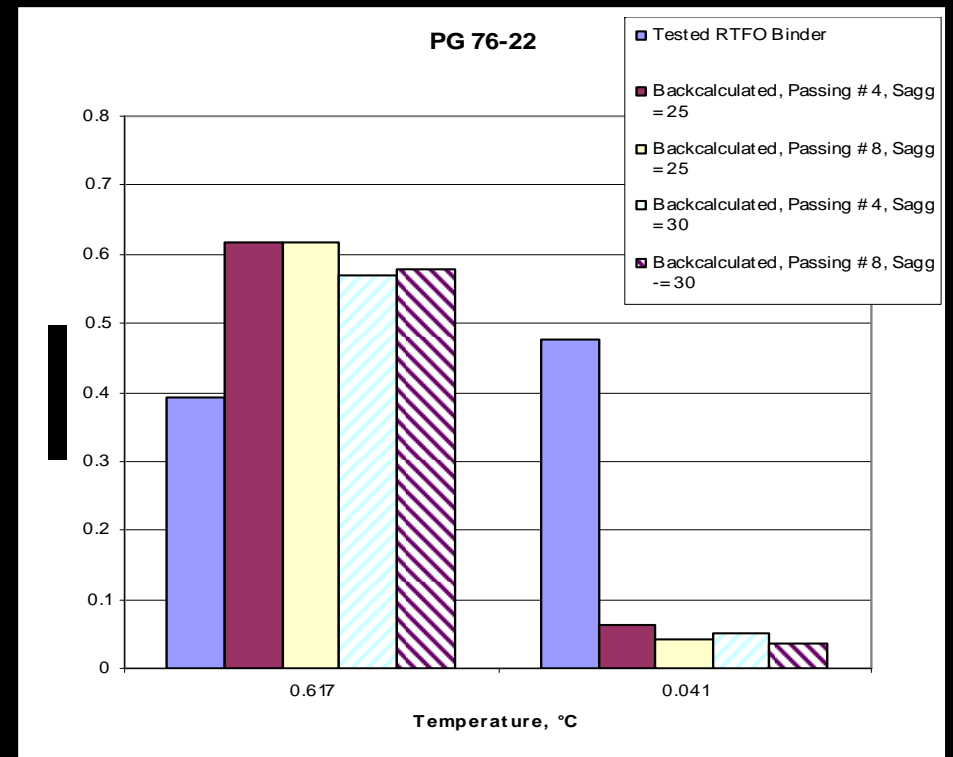
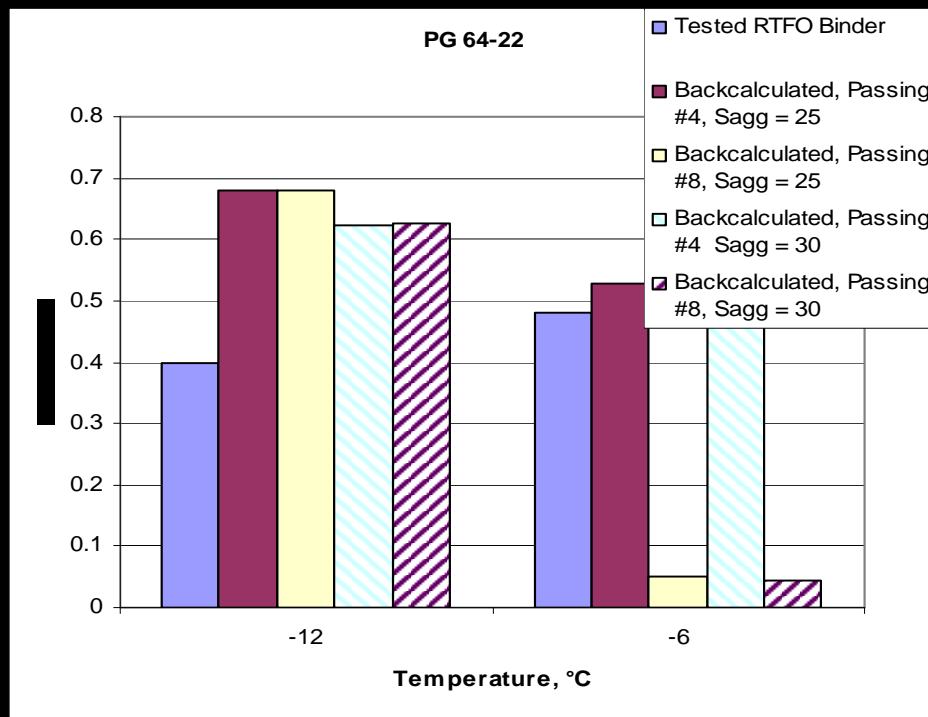
Elastic Modulus for Aggregate

- Zofka Recommends 30 GPa for Granite and 25 GPa for Limestone.
- Will be very difficult to estimate this value for RAP specimen.
- Both recommended values used for virgin mixes and results compared to determine sensitivity.

Backcalculated Stiffness Results – Virgin Mixes



Backcalculated m-value Results – Virgin Mixes



Virgin Results

- Backcalculation overestimates stiffness at -12°C
- Backcalculation results at -6°C closer to binder results, but all values are very low.
- $E_{agg} = 25$ GPa overestimates stiffness in most cases.
- $E_{agg} = 30$ GPa closer to binder results (we used limestone aggregates for virgin mixes)

Virgin Results

- No difference in stiffness results for PG 67-22 at -6°C between passing #4 and passing #8.
- PG 76-22 at -6°C stiffness values for passing #8 samples closer than passing #4

Virgin Results

- M-values do not show any consistent trend between conditions.

Decisions from Virgin Testing

- Use Passing #8 material for RAP beams (the passing #4 was too stiff)
- $E_{agg} = 30 \text{ GPa}$

RAP Results

- Issues
 - Used PAV aged binder results – gave better correlation than unaged binder results
 - Many RAP beams were too stiff to test – either broke during testing or had deflections that were too low for software to read

RAP Results

- Issues
 - Repeatability was not good between replicates – possibly due to aggregate segregation at test location.
 - 0, -6, and -12 were too cold to test many specimen – our BBR can't handle temperatures above 0C

RAP Results

- In most cases, backcalculated stiffness results were overestimated compared to binder results.
- $E_{agg} = 30$ gave best correlation
- M-value correlates better than stiffness



Questions?

