Laboratory Mixing and Compaction Temperatures for Asphalt Binders

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Lab Mixing and Compaction Temperatures

- Background
  - MS-2
    - Recommended laboratory mixing and compaction temperature ranges for Marshall mix design based on viscosity (Saybolt Furol) as early as 1962
      - Changed to absolute and kinematic viscosity in 1974
      - 170 ± 20 centistokes for mixing
      - 280 ± 30 centistokes for compaction
  - Purpose
    - normalize the effect of asphalt binder stiffness on mixture volumetric properties
      - Aggregate packing and available void space

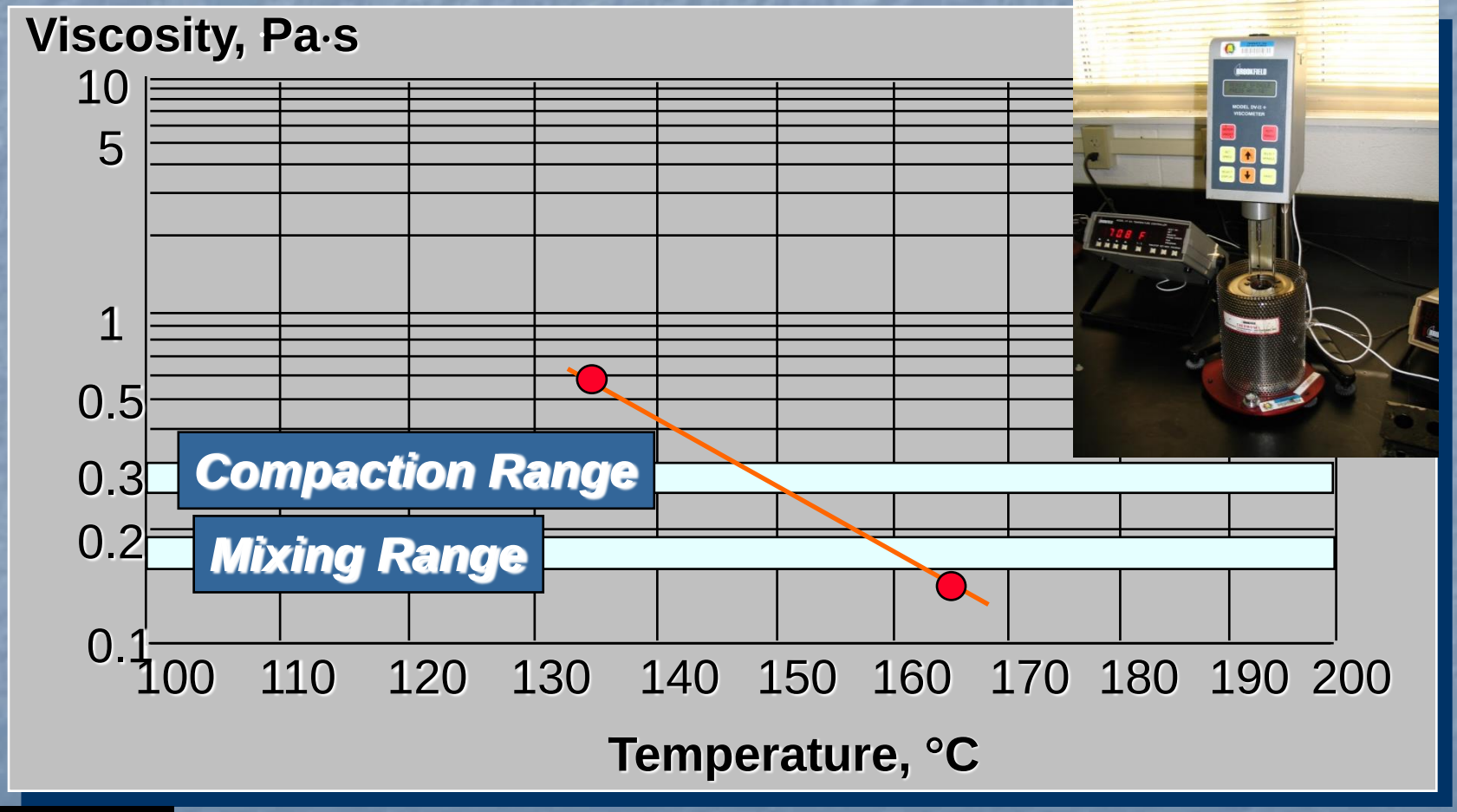
Lab Mixing and Compaction Temperatures

- Background
  - Modified Asphalt Binders in the Superpave Mix Design System
    - Adopted old (Marshall) standard in 1993
      - 0.17 ± 0.02 Pa-s (mixing)
      - 0.28 ± 0.02 Pa-s (compaction)
    - Manufacturer's recommendation for modified asphalt binders

Lab Mixing and Compaction Temperatures

- Background
  - Modified asphalt binders in the Superpave mix design system
    - Produced lower air voids, higher density
      - Shear compaction with fixed angle, pressure
        - Not generally affected by mix stiffness (i.e., not significantly affected by temperature)
  - More heavily modified binders have a more pronounced effect

NCHRP 9-39:
Mixing & Compaction Temperatures



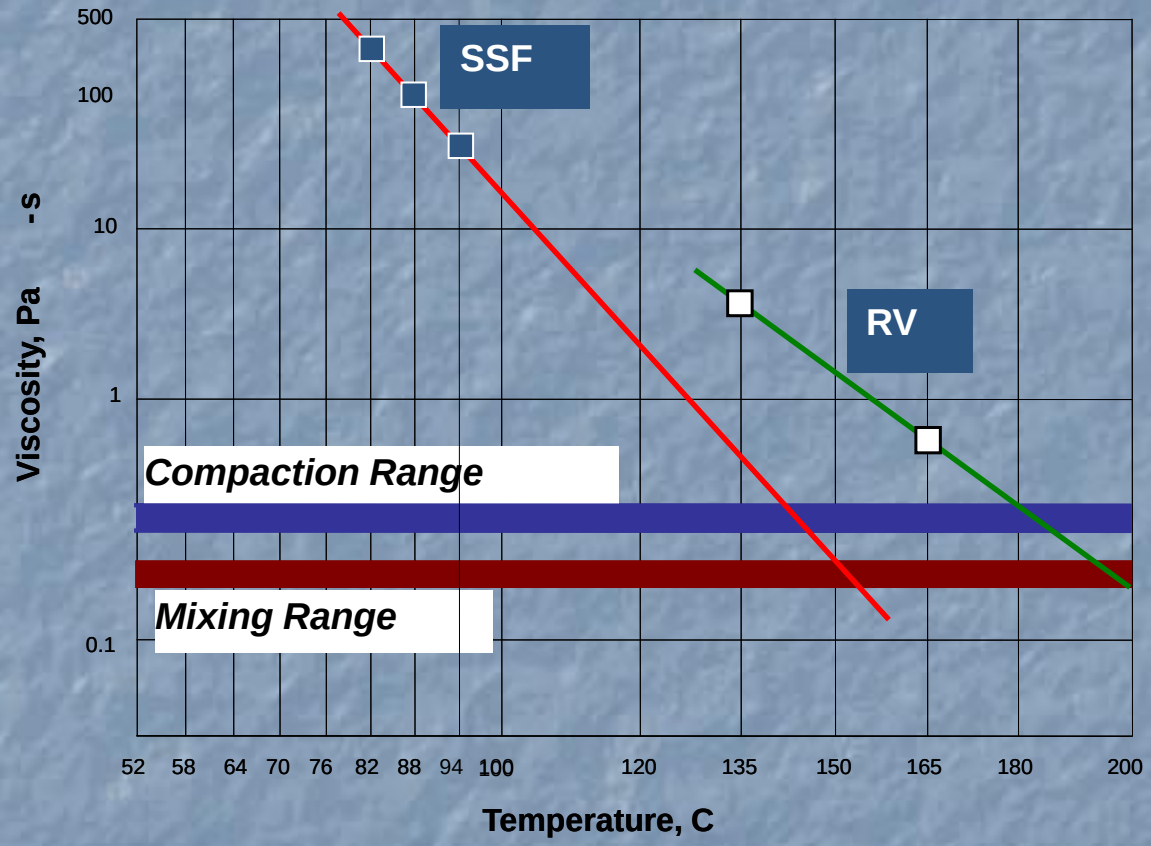
Background

- The Asphalt Institute equiviscous concept works well for unmodified binders
- For most modified binders, the equiviscous concept results in excessively high mixing and compaction temperatures:
  - Emission concerns
  - Binder degradation concerns
  - Cost (heating costs and plant wear)
- Most specifying agencies have relied on binder suppliers to recommend appropriate temperatures.
  - No consensus exists on how that should be done

Research on Lab Mixing and Compaction Temperatures

- NCHRP 9-39, *Procedure for Determining Mixing and Compaction Temperatures of Asphalt Binders in Hot Mix Asphalt*
  - Purpose
    - Identify or develop a simple, rapid, and accurate laboratory procedure for determining the mixing and compaction temperatures of asphalt binder
  - NCHRP Report 648 (2010)
- Steady Shear Flow (SSF) DSR method
  - Reinke

SSF Procedure: PG 64-34 (SBS-modified)



RV *195C mixing* *185C comp.*

SSF *153C mixing* *143C comp.*

Asphalt Institute Guidance Document

- For unmodified[1] asphalt binders…
  - laboratory mixing and compaction temperature may be determined using:

    (1) the rotational viscosity procedure (AASHTO T316) at two test temperatures; or

    (2) the rotational viscosity procedure at 135°C in combination with the dynamic shear rheometer procedure (AASHTO T315) at a single test temperature

[1] Also identified as: (a) AASHTO M320 asphalt binders that have a useful temperature interval (UTI) of < 92 degrees; or (b) AASHTO MP19 asphalt binders with an "S" designation

Asphalt Institute Guidance Document

- For modified[2] asphalt binders…
  - laboratory mixing and compaction temperature may be determined using:

    (1) the DSR Phase Angle Procedure; or

    (2) the DSR Steady Shear Flow Procedure, as recommended by NCHRP Report 648.

    In addition, the recommendation of the supplier may be used, as many suppliers have determined mixing and compaction temperatures for their individual products that have proven to be appropriate.

    [2] Also identified as: (a) AASHTO M320 asphalt binders that have a useful temperature interval (UTI) of ≥ 92 degrees; or (b) AASHTO MP19 asphalt binders with an “H”, “V”, or “E” designation

OHMPA Study – Phase I (draft)

asphalt institute
Laboratory services

Comparison of Laboratory Mixing-Compaction Temperature Ranges in Polymer Modified Asphalt Binders Using Rotational Viscometer & Steady Shear Flow (DSR) Test Methods

Sample ID			EM-01	EM-02	EM-03	EM-04	EM-05	NB-01	NB-02	NB-03	ZN-01
Grade			PG 64-28	PG 64-28	PG 58H-34	PG 64-34	PG 58-34	PG 70-28	PG 64-34	PG 70-34	PG 64-28
Rotational Viscometer Method	Avg Mixing Temp (˚C)		183	196	173.5	174.5	176	177	167.5	176	190.5
	Avg Compaction Temp (˚C)		167	178.5	159	160	161	163	153	161	173.5
Steady Shear Flow (DSR) Method	Avg Mixing Temp (˚C)		155.5	165	158	160	161	167	156	159	154
	Avg Compaction Temp (˚C)		142	149.5	142	143.5	144	150.5	140.5	143.5	141
Specification			MTO SP 111 F09 v2015-02	City of Kingston	OHMPA MG 58H-34	MTO SP 111 F09 v2015-02 and ExBBR	MTO SP 111 F09 v2015-02 and ExBBR	MTO SP 111 F09 v2015-02	MTO SP 111 F09 v2015-02	MTO SP 111 F09 v2015-02	MTO SP 111 F09 v2015-02
Recommended Mixing and Compaction Temperatures (˚C)	2015	Mixing	155	155	155	155	155	160	155	165	160
		Comp.	138	135	140	140	140	150	145	155	150
	pre 2015	Mixing	155	155	165	165	163				
		Comp.	138	135	155	155	153				

- Second phase evaluating the effect of mixing and compaction temperature on mix design is underway
- CTAA Paper in November 2016

Lab Mixing and Compaction Temperatures: Caveats

- Regardless of the selected procedure, recommend that laboratory mixing temperatures do not exceed 177°C.
- Not applicable to asphalt binders that have been modified with ground tire rubber (GTR)
  - The NCHRP 9-39 research did not evaluate GTR-modified asphalt binders
  - Unknown how the recommended procedures will work with this class of modified asphalt binder.
  - Refer to other existing practices for GTR-modified asphalt binders.

Project Mixing and Compaction Temperatures

- Laboratory mixing and compaction temperatures
  - intended for determining design volumetric properties of the asphalt mixture
  - not intended to represent actual mixing and compaction temperatures at the project level
  - Once we finish the study and suppliers modify their mixing and compaction charts, the temperature will likely be a good place to start

Project Mixing and Compaction Temperatures

- Project-level mixing and compaction temperatures
  - Mixing temperature
    - can best be defined as the temperature at which the aggregate can be sufficiently and uniformly coated.
    - as with the lab temperatures, the mixing temperature should not exceed 177°C.
  - Compaction temperature
    - usually in the range of 135-155°C
    - may be a bit higher for highly modified binders
    - based solely on the ability of the compaction equipment available for the project to achieve adequate in-place density

Practical Considerations

- Plant mixing temperature is dependant on achieving adequate compaction in the field
  - Time of year
  - Silo storage time
  - Haul distance (cooling in transport)
  - Spreading procedures and compaction equipment on site
- Highly modified binders may be more sensitive to pickup issues with pneumatic tyre rollers
  - More sensitive to a difference between tyre and mix temp
  - Issues with stopping – even for short intervals
  - Look for appropriate release agent – spray bars vs misting

Thanks!

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KJ Beamish Ltd
Yellowline Asphalt Products Ltd.