Laboratory Mixing and Compaction Temperatures for Asphalt Binders

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Laboratory 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 for laboratory prepared specimens
      – Aggregate packing and available void space
Background

- The Asphalt Institute equiviscous concept works well for unmodified, unfilled binders.
- For most modified binders, the equiviscous concept results in excessively high mixing and compaction temperatures:
  - Creates concerns about emissions
  - Creates concerns about binder/modifier degradation
- Most specifying agencies have relied on binder suppliers to recommend appropriate temperatures.
  - No consensus exists on how that should be done.
Background

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

- Modified Asphalt Binders in the Superpave Mix Design System
  - Produced lower air voids, higher density
    - Shear compaction with fixed angle, pressure
      - Not as affected by mix stiffness (i.e., not as significantly affected by temperature as Marshall)
  - Short-term Mix Conditioning
    - Four hours at 135°C or two hours at compaction temperature
    - Different absorption?
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

• **Steady Shear Flow Test (Reinke)**
  – Uses DSR
  • High shear stress sweep
    – 50 to 1000 Pa
    – 8 total data points
  • Multiple temperatures
    – 88°C to 112°C
  • Parallel Plate
    – 25 mm plates
    – 0.5 mm gap
PG 64-34 (SBS-modified)

Mixing  |  Compaction
SSF     |  153C  |  143C
RV      |  195C  |  185C
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 M332 asphalt binders with an “S” designation
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 \(\geq 92\) degrees; or (b) AASHTO M332 asphalt binders with an “H”, “V”, or “E” designation
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.
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 for HMA
    - based solely on the ability of the compaction equipment available for the project to achieve adequate in-place density.
Thanks!

In life, questions are guaranteed, answers are not.