Evaluating Diffusion and Aging Mechanisms in Blending of New and Age-Hardened Binders during Mixing and Paving

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Paper No. 16-4454

Introduction

• A number of studies have demonstrated that RAP does not behave as “black rock,” but rather the RAP binder blends appreciably with virgin binder, ultimately producing a composite binder that will influence pavement performance, especially when the mix contains a high RAP percentage (more than 25%).

• It is important to understand the mechanisms of blending and its evolution during mix production and paving.

Materials, Sample Preparation, and Testing

- New Binder: PG 58-22
- Age-Hardened Binder: PG87

(WAve produced with aging of a PG64 binder in PAV for 60 hrs. at 100°C with 2.1MPa air pressure)

Blending Mechanism

- The change in rheological properties of wafer composite binders can be explained through the diffusion mechanism over time.
- The diffusion process involves transferring new binder molecules from regions of higher concentration to regions of lower concentration, without requiring bulk motion.
- The concentration of new binder in the RAP binder film around the aggregate increases as a function of time until equilibrium is achieved.

Modeling of the Blending Mechanism

\( \frac{\partial C}{\partial t} = D \frac{\partial^2 C}{\partial z^2} \)

Where:
- \( D \) is the diffusion coeff. in m²/sec
- \( C \) is the concentration in percentage
- \( z \) is the position in m
- \( t \) is time in sec.

Incorporating aging effect during blending

\( G_{predicted} = G_{diffusion} + C \times t \)

Where:
- \( C \) is the aging coefficient, and
- \( t \) is the conditioning time.

Evolution of Binder Rheological Properties

Summary and Conclusions

- The DSR wafer composite binder testing method was shown to be an effective approach for examining the level of blending between new and age-hardened binders.
- The diffusion mechanism in the blending process was shown to be temperature and time dependent.
- The diffusion coefficient increased with temperature.
- It is recommended that the DSR wafer method be further refined and standardized. It is also recommended that the method be used to evaluate the effect of different WMA technologies and/or rejuvenating agents on blending between new and RAP binders, and potentially to develop test methods and specifications.