Research Project Brief

Report 26-R43: Recycled Binder Availability of Virginia RAP Materials and Its Effects on Asphalt Mixture Composition and Performance

VTRC Virginia Transportation Research Council

Background

Although most asphalt mixtures in Virginia contain reclaimed asphalt pavement (RAP), durability issues may arise if they are not properly designed. A key challenge is the uncertainty on the amount of RAP binder that is available and blends with the virgin binder. Although current specification assumes 100% availability, the partial availability assumption (i.e., < 100%) is recognized within the asphalt community to be more accurate. Giving full credit to the RAP binder may lead to under-asphalted mixtures, which can be especially critical at higher RAP contents. The lack of practical test methods further limits the adoption of partial availability concepts during design. This study allowed for quantifying the recycled binder availability (RBA) of RAP materials in Virginia using a practical and low-cost method and verifying its impact on asphalt mixture composition and laboratory performance.

Research Objectives

- Characterize the asphalt binder availability, activity, and contribution from RAP materials and corresponding asphalt mixtures.
- Evaluate the effectiveness of recycling agents (RAs) for improved blending with virgin binder.
- Assess the effect of RBA and RAs on asphalt mixtures volumetrics and performance.

Approach

- Literature review to identify laboratory tests to characterize RBA and the degree of activity (DoA) of RAP materials, and the recycled binder contribution (RBC) of corresponding asphalt mixtures.
- Characterization of RBA using sieve analysis method, DoA using RILEM and colorimeter methods, and RBC using the tracer-based microscopy method.
- RBA was incorporated by adding a virgin binder equivalent to the unavailable RAP binder, with mix design adjustments made as needed to meet volumetric requirements.
- Balanced mix design (BMD) and advanced laboratory tests to evaluate the performance of asphalt mixtures with different combinations of virgin binder performance grade, RA, and RBA.
- Pavement performance predictions using mechanistic-based simulations.

Outcomes

- RBA values determined by sieve analysis method for nine RAP sources ranged from 41.4% to 73.5% (average of 59.5%), with higher RBA values associated with finer gradations.
- Strong agreement was observed between RAP materials RBA and asphalt mixtures RBC.
- Assuming 100% RBA overestimates asphalt content, voids in mineral aggregate, and voids filled with asphalt and may incorrectly suggest compliance with volumetrics requirements, especially at RAP contents above 30%.
- Incorporating RBA or RA, or both, allowed to convert an otherwise failing mix into a mix that passes VDOT's BMD design performance criteria.
- Pavement simulations showed improved fatigue cracking resistance with RBA adoption.

Research Benefits

- Adopting RBA during design may optimize the BMD mix design process, supporting VDOT's BMD implementation in Virginia.
- Potential improvement in service life of asphalt pavements with surface mixtures designed under the partial RBA assumption.

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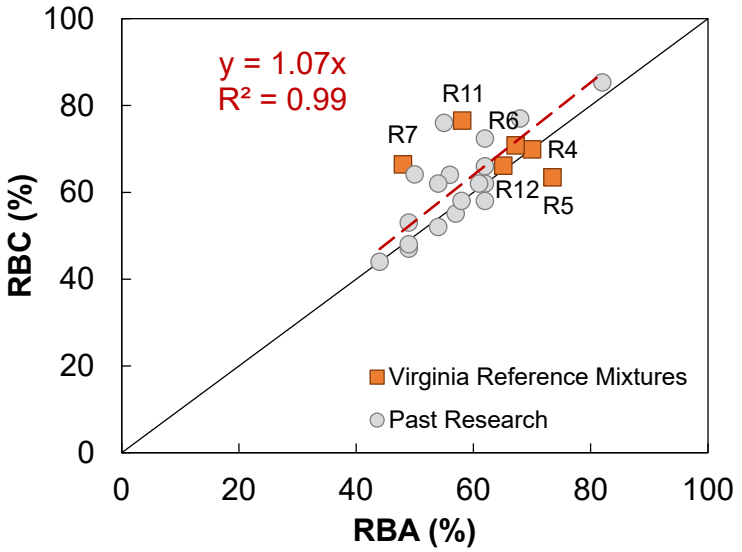
Research Findings

Strong Agreement between RBA and RBC

RBC is closer to the "true" RAP binder contribution within the asphalt mixture.

RBA can be used as an estimator of asphalt mixtures RBC.

Sieve analysis method can be adopted as a practical, simple, and low-cost method to estimate RBA and help manage RAP stockpile consistency (quantity based) throughout production.



Improved Asphalt Mixtures Laboratory Performance

An integrated approach using RBA and RA converted asphalt mixtures with failing Cantabro mass loss and cracking tolerance index (CT_{Index}) values into passing ones during design.

Minimum adverse effects to asphalt mixture rutting potential from Asphalt Pavement Analyzer (APA) results after incorporating RBA.

Good agreement in cracking and rutting test results between BMD and advanced mechanistic-based laboratory test methods.