National Center for Asphalt Technology
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Draft Outline for

Evaluating Options for Selecting Virgin Binders for Plant-Produced Mixtures Containing RAP and/or RAS

Background Information

The RAP ETG recently compiled research reports that provide guidance on binder replacement for high RAP mixtures. Of particular concern are when to use the standard grade of virgin binder and when to use a softer grade of virgin binder. About 12 to 13 reports were collected and reviewed and there was still not clear direction on a national basis for setting limits to properly select binder grade. Based on technical information from the RAP ETG, a study is recommended that includes several State highway agencies from various regions. The purpose of this document is to provide guidance on how to organize a research project that will help further develop specifications for mixtures containing RAP and/or RAS

Research Objectives

The primary objective is to compare mix properties of plant-produced mixes with low and high recycled binder contents and to determine if certain techniques, if any, may be suitable to obtain equal or better properties for high recycled binder content mixes.

An underlying assumption of the experimental plan is that the current standard practice of using the standard grade of virgin binder with low RAP content mixtures is appropriate since this approach has historically provided good performance.

A second objective is to assess the degree of blending between recycled and virgin binders in plant-produced mixtures. The blending analysis will be conducted following the "Bonaquist Approach."

Scope

Find a willing contractor to produce the following mixtures:

Mix 1: a control mix with RAP binder content below 15% of the total binder.
Mix 2: a mixture with high RAP binder content (25 to 50% of total binder) with the same virgin binder as Mix 1.
Mix 3: same as Mix 2 with a softer virgin binder grade (lower PG grade at top and bottom).
Mix 4 (optional): same as Mix 2 produced with a WMA technology at a production temperature at least 25°C lower than Mix 2.
Mix 5 (optional): same as Mix 2 except that the virgin binder content is increased by 0.1% for every 10% of RAP binder (e.g. if the RAP binder content is 40% of the total binder, then increase the virgin binder by 0.4% above that used in Mix 2)
Mix 6 (optional): a mixture with a RAS binder content of ≥20% the total binder.

All mixtures within a comparison set must have the same NMAS, use the same source of materials, meet the state's current mix design criteria, and have reasonably similar effective asphalt contents (Pbe within ± 0.25%).

Recommended Testing

- Permanent Deformation: Flow Number (TP 79) or APA (TP 63)
- Fatigue: Bending Beam Fatigue (T 321) at 2 or more strain levels, SVECD, Energy Ratio, or Fracture Energy (choose one)
- Moisture Damage: T 283 or Hamburg (T324)
- Thermal Cracking: IDT Creep Compliance & Strength (T 322), SCB, BBR on mix beams, TSRST (This may be eliminated from the testing plan in climates where low temperature cracking is not a concern)
- Stiffness (MEPDG input): Dynamic Modulus (TP 79)
- Standard Tests: Gmm; Gmb; asphalt content; gradation
- Recovered binder (T 319 or T 164 method A and method and type of solvent) on RAP, RAS, and mixes; PG grading of recovered binder (true grade: high, intermediate, and low) and freq. sweep.

Note: the Texas Overlay Tester is not recommended as an alternate fatigue test. The strains applied to specimens in this method are not realistic.

Replicates as required by each method

Comparative Analyses

Statistical Analyses

Hypothesis: properties of the mixes are not different. Test the hypothesis for each property using t-tests.

- Comparison of Mix 3 to Mix 2 and Mix 1 will help determine if using a softer virgin binder is beneficial to mix properties.
- Comparison of Mix 4 to Mix 2 and Mix 1 will help determine if using a WMA technology with high RAP content mixes is beneficial to mix properties.
- Comparison of Mix 5 to Mix 2 and Mix 1 will help determine if increasing the virgin binder content is beneficial to mix properties.

Practical Significance - Compare results of each mix to criteria established for that test.

Analysis of Blending using the Bonaquist Approach

This analysis follows the approach Dr. Ray Bonaquist developed to assess the degree of blending of recycled and virgin binders using plant produced mixes. The general steps are as follows:

1. Prepare and tests specimens for unconfined dynamic modulus following TP 79
2. Extract and recover the binder from the tested specimens
3. Perform DSR testing to obtain the binder modulus master curve.

4. Estimate E* with the Hirsh model (or other validated technique) using the effective shear modulus from step 3 and specimen volumetric properties
5. Compare the estimated dynamic moduli from step 4 to the dynamic moduli from step 1. Good blending is indicated when the results compare. If predicted and measure E* do not compare, can the difference be attributed to insufficient mixing, incompatibility of binders, etc.

Additional Required Project Documentation

General information: Date of mix production, contractor contact information, agency contacts
Materials information: Mix design, sources, additives, WMA technology
Plant information: Address, make and model, discharge temperature(s), fuel type
Project information: Project number, location, thickness of layer, type of layer (e.g. surface, base, intermediate, shoulder)

If the mixtures are placed as the surface layer, it is highly desirable to follow the performance of the sections with the different mixtures in order to relate laboratory results to field performance.

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