


RAP In Washington State
A 32 Year Legacy

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RAP in Washington State

- Hveem RAP mixes
 - Studies
 - Conclusions
- Superpave and RAP
 - Studies
 - Conclusions
- FHWA RAP ETG
- RAP Use as Base in Washington State
 - Ongoing Research



First WSDOT RAP Project

- Year 1977
- Project at the height of the energy crisis
- 5 miles of 4 lane divided highway, I-90 near Ellensburg, WA
- Mill and fill
- 100% RAP
- Considered:
 - Rejuvenating agent (Cyclepave) - To reduce (restore) binder viscosity
 - Additional AR 4000W (up to 2%)
 - Hveem mix design procedure (35 min stability)
- Reports:
 - "Rotomill Planing and Recycling Asphalt Concrete in Washington" by Roger LeCler, State Materials Engineer
 - "Recycling Asphalt Pavements" FHWA-DP-39-3 (Aug 1978)

1977 Project Details

- Final WSDOT mix design:
 - Used 27.5% new aggregate (chips, from 5/8" to 1/4")
 - 0.75% rejuvenating agent (about 16%-17% by weight of binder in old pavement)
 - No additional AR 4000W was added
 - Capped with a 0.06 ft. OGFC as wearing course
- Performance:
 - Good. No early rutting (no plastic flow).
 - Pavement would show good wear characteristics over the next 10 years.

1981: Second WSDOT RAP Project

- I-90, Yakima River to West Ellensburg I/C
- New steps:
 - Specification requires 100% of RAP must pass through a 1" screen
 - Contractor elects to crush RAP to meet specifications
- Pre-design work extensive and not easy to turn over to the contractor
 - **ONLY** a couple of Hveem Kneading Compactors in the entire state
- Problems:
 - Selecting proper type and amount of rejuvenator (contractor has options)
 - Estimating degradation of aggregates due to milling and subsequent increase in P-200
 - Determining proper amounts of new aggregates
- Report:
 - "Washington State Department of Transportation's Second Asphalt Concrete Recycling Project - Yakima River to West Ellensburg Interchange" by Jim Walter, P.E.

1981 Project - Results

- Successful
 - Air quality – in specification
 - Energy usage – lower than virgin mix
 - Performance under traffic – good performance for over 10 years
- Conclusion of the Report:
 - Recycled pavements perform satisfactorily
 - Recycled pavements are cost effective



Early HVEEM Project Results

- Conclusions:
 - Rejuvenators, both type and quantity, are key
 - Preliminary mix design is critical (need to verify asphalt contents)
 - Including multiple binder extractions
 - Milling generates large quantities of fines
 - Not all milling machines are the same
 - Small milling machines (samplers) do not produce representative RAP compared to large production milling machines
 - Speed of milling operation varies
 - Laydown, compaction behaved identical to a mix with 100% virgin aggregate
 - Poor air quality due to baghouse operation, not due to recycling

1977-1986 RAP Review

- Specs allow variable RAP, up to 100%
- 16 projects with RAP varying from 8% up to 79%, at contractor's choice
- All RAP areas were covered with OGFC except for a few test areas (WSDOT appeared to be nervous with regards to performance)
- Test area performed about the same as OGFC areas or better
- Saw up to 34% reduction in bid prices
- Projected 10-15 year wearing surface pavement life (typical average wearing surface life)

1977-1986 RAP Review

- Problems:
 - Too much effort in the preliminary mix design stage (and too many chemical extractions)
 - Actual RAP gradation not know until construction (delays in construction)
 - Too many unknowns at bid (amount of rejuvenator, amount and gradation of new aggregate, length of mix design process, risk to WSDOT)

Based on 1977-1986 Review

- 1988
 - Allow 10% RAP max. selected projects
 - Eliminate specialty preliminary mix design work
- 1991
 - Allow RAP on any project
 - Fix the maximum percentage at 20%
 - No change in bidding compared to virgin mix, so everyone bids on equal footing
 - No specialized preliminary mix design work

From Hveem to Superpave

- WSDOT Superpave projects began in late - 1990s
- Examined:
 - RAP effects on PG Binder
 - Superpave and RAP in field



RAP and PG Binder Testing

- "The Use of RAP with PG Asphalt Cement" by Bob Briggs
- Studied the impact of RAP to virgin binder properties
- Mixed virgin PG 64-28 and binder recovered from RAP
- Looked at different concentrations of RAP to virgin binder
- Results:
 - Found that adding up to 20% RAP reduced the reliability factor only slightly, from 98% to 95%.
 - Minor impact to grade of PG
 - RAP affects binder by slightly:
 - Reducing the potential for rutting
 - Increasing the potential for fatigue cracking
 - Increasing the potential for raveling

RAP and PG Binder Testing

- Conclusion:
 - We can use up to 20% RAP with little to no impact to the PG grade of asphalt cement as specified
 - Slight increased risk is lost in the "background noise" of other unknowns (temperature regime, traffic, QC and QA, etc.)

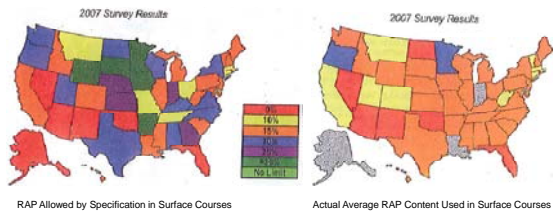


RAP and Superpave Today

- Specifications allow 20% RAP with Superpave with no other adjustments
- All Superpave specs intact
- Reviewed projects paved with Superpave and 20% RAP
 - No loss of performance to date
 - Most projects only ten years old or less
 - Appears our target pavement life will be met
- Per Washington Asphalt Paving Association (WAPA), we are recycling 100% of our asphalt pavements
- No reason to go beyond 20%
- Local agencies expanding use of RAP, following WSDOT lead

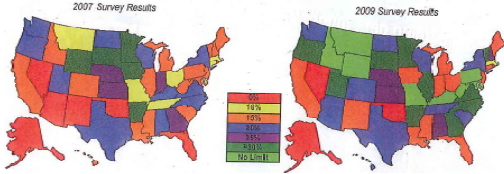
RAP Allowed and Used (Roads and Bridges October 2009)

- FHWA created the RAP ETG in spring 2007
- A Survey was sent to State ME in summer of 2007 to determine the percentage of RAP allowed by specifications
 - All 50 states responded
 - States were considering increased usage



RAP Allowed and Used
(Roads and Bridges October 2009)

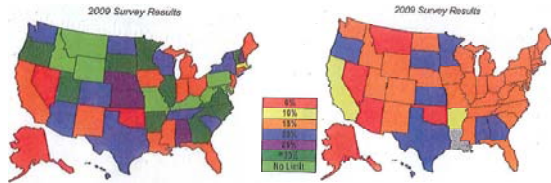
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RAP Allowed by Specification in Surface Courses

RAP Allowed and Used
(Roads and Bridges October 2009)

- A second survey was sent in the spring of 2009 and found that 22 states have increased allowable percentage of RAP

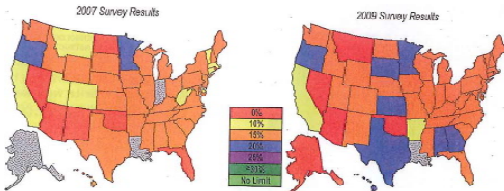


Actual Average RAP Content Used in Surface Courses

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Actual Average RAP Content Used in Surface Courses

RAP Allowed and Used
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- The surveys asked about the major barrier preventing increased RAP usage
 - Managing RAP stockpiles (controlling gradation, origin of RAP, contamination and additional testing)
 - Long-term performance (lack of a true performance test)
 - Binder issues (when to bump, availability of softer binder, softer grade costs and additional storage at the plant)
 - Availability of RAP (rural areas may not have the supply to support higher use)
 - Other responses (RAP mixes were lower in quality, industry could not consistently produce high RAP mixes, the quality of RAP mixes was difficult to evaluate and additional research is needed)

Recycled Asphalt Pavement as Base in Washington State

- Many states have allowed the use of RAP to be blended with untreated aggregates base course to produce a composite base course
- The percentage of RAP may vary from 25 to 100 percent
- WSDOT currently allows up to about 20 percent RAP to be blended with crushed aggregates
- As more RAP material is incorporated into the base course material concerns among specifying agencies include:
 - Impact on pavement design
 - Appropriate compaction requirements
 - Drainage characteristics
 - Long term performance of HMA and PCCP structures

Recycled Asphalt Pavement as Base in Washington State

- Some studies have been conducted on recycled materials focusing primarily on laboratory evaluation of physical properties
- Little work has been done considering:
 - Field performance
 - Life cycle cost analysis of costs
 - Energy usage
 - Greenhouse gas emissions
 - Construction issues such as acceptance and compaction

Recycled Asphalt Pavement as Base in Washington State

Construction issues such as acceptance and compaction

- Compaction methods tried in Washington:
 1. Modified rice density testing
 2. AASHTO T-180
 3. WSDOT T-606 Maximum Density
 4. Roller Pattern
- The problem with each is what is a representative sample?

Recycled Asphalt Pavement as Base in Washington State – Current Practices

- WSDOT currently does not have an official specification, however there have been instances where RAP as base has been used such as:
 - Low risk applications
 - Use on thick full depth shoulders
 - Use on very low volume traffic applications
 - Design Build projects (WSDOT's stamp verses the Design Builders)
 - Replace the lower portion of aggregate base course with RAP
 - Shouldering up adjacent to HMA overlays
 - Trial sections
 - Just do it by change order without the necessary approvals

WSDOT's Investigation of RAP as a Base Course Material

Study Objective:

- Engineering performance of RAP, in terms of stiffness (modulus), rutting, potential, permeability, degradation due to moisture damage, and effect of temperature. Also, the performance of RAP as base materials in previous WSDOT pavement will also be reviewed
- Field acceptance specifications, especially the density. This includes determination of maximum dry density in the lab and field density.
- Quantification of contribution of sustainability, in terms of costs, energy, and greenhouse gas emission.

Thanks

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