Shingle Recycling Specifications
&
On Going Research

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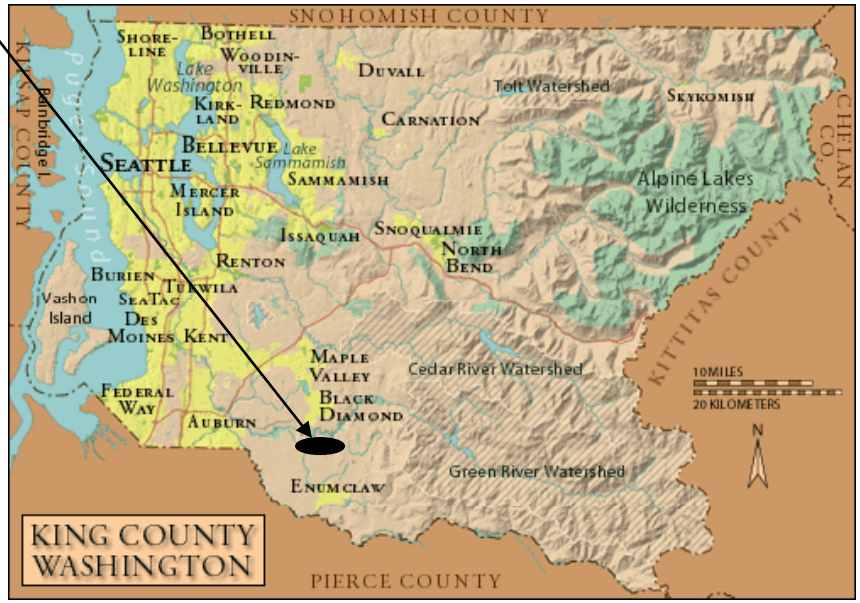
Shingles in Paving Demonstration
King County, Washington State
SE 416th St. Overlay

- Description of Work
  - Improvement of Two Miles
  - Planning of Existing Surface
  - Paving with Hot Mix Asphalt (HMA)
  - HMA Includes Recycled Asphalt Pavement (RAP) and Recycled Asphalt Shingles (RAS)



Shingles in Paving Demonstration
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- The Beginning (2007)
- Specifications
- Request for Information
- Preliminary Testing
  - RAS
  - Mix Design
- Actual Mix Design
- Production Data

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- The Beginning - 2007
  - Stake Holder Meetings
    - Discuss proposed use of RAS
  - Project Advisory Group
    - Define roles for members
  - Attend 3rd Asphalt Shingle Recycling Forum
    - Information gathering
    - Questions answered

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- Next Steps - 2008
  - Develop Specifications
  - AASHTO MP 15
    Use of RAS as an Additive
  - AASHTO PP 53
    Design Considerations using RAS
  - WSDOT Standards

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- RAS Specifications
  - Gradation
    - 100% passing 1/2 inch sieve
    - 95% passing 3/8 inch sieve
  - Extraneous Materials

    Lighter Material
    - 1.5% max. retained on #4 sieve

    Total Material
    - 3.0% max. retained on #4 sieve
  - Moisture Content
    - 5.0% max.

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- KCDOT Request for Information
  - Identify Interested/Qualified Suppliers of RAS
- RFI Included:
  - Supplier Qualifications
  - Preliminary RAS Sample
  - Supplier Test Data
  - Production/Stockpile

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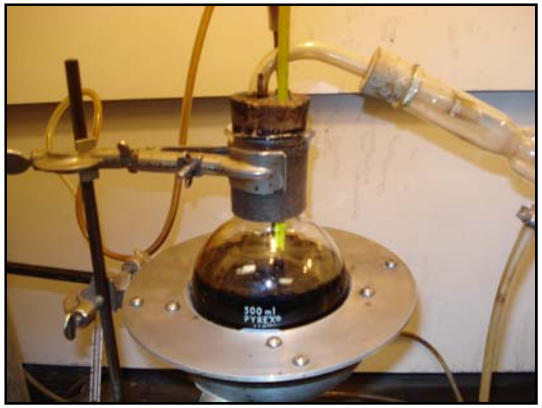
- Recovered Asphalt Binder Data
  - Tested
    - Neat Asphalt
    - Neat Asphalt & RAP Binder
    - Neat Asphalt, RAP & RAS Binder



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Recovered Asphalt Binder Test Data								
	Rotational Viscosity	Original DSR/Grade	**Original**	RTFO DSR/Grade	RTFO	PAV DSR/Grade	**PAV**	
82% Neat Asphalt 15% RAP & 3%RAS	Max 3	Min 1.00	**Tru-Grade**	Min 2.20	Tru-Grade	Max 5000	**Tru-Grade**	BBR Grade
RAS #1	0.7	1.64 / 70	**74.0**	3.36 / 70	73.3	4475 / -16	**-16**	-22
RAS #2	0.5	1.52 / 70	**74.5**	2.57 / 70	71.2	3905 / -16	**-19**	-22
RAS #3	0.6	3.1 / 88*	**88***	3.6 / 70	73.9	4505 / -16	**-16**	-16
Neat Asphalt & 15% RAP	0.4	1.9 / 64	**69**	4.9 / 64	70.0	3688 / -16	**-21**	-22
Neat Asphalt	0.4	1.45 / 64		3.61 / 64		3997 / -22		-22

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Preliminary Recycled Asphalt Shingles - Gradation & Percent Binder Averages											
	3/4"	**1/2"**	**3/8"**	**#4**	**#8**	**#16**	**#30**	**#50**	**#100**	**#200**	**Pb**
RAS #1	100	100	97	89	86	67	47	39	31	22.1	19.7
RAS #2	100	100	100	97	97	74	45	38	33	25.9	16.3
RAS #3	100	100	97	90	86	66	46	40	32	24.4	22.8

Before Extraction

After Extraction

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- Preliminary Mix Design Testing
  - Used Conventional ½ inch HMA
  - Extractions on RAP & RAS
  - Blended RAP & RAS
  - SGC Compaction @ 100 Gyration
  - Volumetric Analysis
  - Optimum Blending Ration

Preliminary Recycled Asphalt Shingles - Volumetric Comparison

Mix Design	Material			Volumetric Data										
	Virgin	RAP	RAS				Gmb @	Gmm @						
	Material %	Material %	Material %	Pb	Gmb	Gmm	Ndes	Nini	Va	VMA	VFA	Pbe	Gse	D/A
Virgin	100	0	0	5.5	2.378	2.478	96.0	86.3	**4.0**	**14.4**	**72**	4.5	2.700	1.4
RAP	80	20	0	5.5	2.392	2.478	96.5	86.8	**3.5**	**13.9**	**75**	4.5	2.700	1.4
RAS #1	97	0	3	5.5	2.359	2.466	95.7	86.1	**4.3**	**15.1**	**72**	4.7	2.685	1.3
RAS #1	95	0	5	5.5	2.323	2.464	94.3	85.4	**5.7**	**16.4**	**65**	4.7	2.682	1.3
RAS #1	77	20	3	5.5	2.365	2.474	95.6	86.0	**4.4**	**14.9**	**71**	4.5	2.695	1.4
RAS #1	75	20	5	5.5	2.350	2.460	95.5	86.4	**4.5**	**15.4**	**71**	4.8	2.677	1.3
RAS #2	97	0	3	5.5	2.351	2.472	95.1	85.9	**4.9**	**15.4**	**68**	4.6	2.692	1.3
RAS #2	95	0	5	5.5	2.349	2.458	95.6	86.4	**4.4**	**15.4**	**71**	4.8	2.675	1.3
RAS #2	77	20	3	5.5	2.385	2.466	96.7	87.5	**3.3**	**14.1**	**77**	4.7	2.685	1.3
RAS #2	75	20	5	5.5	2.363	2.468	95.7	85.8	**4.3**	**14.9**	**71**	4.6	2.687	1.3
RAS #3	97	0	3	5.5	2.345	2.467	95.1	85.5	**4.9**	**15.6**	**69**	4.7	2.686	1.3
RAS #3	95	0	5	5.5	2.317	2.485	93.2	84.2	**6.8**	**16.6**	**59**	4.4	2.708	1.4
RAS #3	77	20	3	5.5	2.368	2.463	96.1	86.7	**3.9**	**14.8**	**74**	4.7	2.681	1.3
RAS #3	75	20	5	5.5	2.327	2.463	94.5	85.2	**5.5**	**16.2**	**66**	4.7	2.681	1.3

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- HMA Mix Design
  - Contractor HMA Mix Design
  - WSDOT Verification
- WSDOT RAP/RAS Mix Design
  - Volumetric Analysis
  - Moisture Susceptibility
  - Ignition Furnace Calibration

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Actual Recycled Asphalt Shingle Mix Design - Volumetric Analysis														
Mix Design	**Material**			**Volumetric Data**										
	Virgin	**RAP**	**RAS**				**Gmb @**	**Gmm @**						
	Material %	Material %	Material %	**Pb**	**Gmb**	**Gm m**	**Ndes**	**Nini**	**Va**	**VMA**	**VFA**	**Pbe**	**Gse**	**D/A**
Contractor's Blend	82	15	3	5.4	2.382	2.478	96.1	N/A	3.9	14.3	73	4.5	2.695	1.4
WSDOT's Blend #1	82	15	3	5.1	2.350	2.478	94.9	85.9	5.2	14.6	65	4.1	2.633	1.5
WSDOT's Blend #2	**82**	**15**	**3**	**5.6**	**2.374**	**2.463**	**96.4**	**87.0**	**3.7**	**14.1**	**74**	**4.5**	**2.632**	**1.4**
WSDOT's Blend #3	82	15	3	6.1	2.389	2.444	97.8	87.8	2.3	14.1	84	5.1	2.635	1.2

Pb Breakdown	**Virgin Asphalt**	**RAP Asphalt**	**RAS Asphalt**	**HMA Total Pb**
	4.3	0.6	0.7	**5.6**

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- Moisture Susceptibility
  - WSDOT T 718

Anti-strip	TSR
0.00%	94%
0.25%	92%
0.50%	89%
0.75%	97%
1.00%	106%

- Recommendation

  0.00% Anti-strip

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- Ignition Furnace Calibration
  - AASHTO T 308

    IFCF = 0.76*

  * Extraneous material and RAP had negligible impact on asphalt content determination

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- Production Paving Results
  - HMA/RAP Test Data
  - HMA/RAP/RAS Test Data

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Production Paving Results

Data Sampled	Material			Volumetric Data										
	Virgin	RAP	RAS				Gmb @	Gmm @						
	Material %	Material %	Material %	Pb	Gmb	Gmm	Ndes	Nini	Va	VMA	VFA	Pbe	Gse	D/A
9/22/2009	85	15	0	5.3	2.399	2.485	96.5	N/A	3.5	13.9	74	4.5	N/A	1.3
9/22/2009	85	15	0	5.5	2.409	2.483	97.0	N/A	3.0	13.7	78	4.6	N/A	1.3
9/24/2009	85	15	0	5.7	2.426	2.481	97.8	N/A	2.2	13.3	84	4.7	N/A	1.4
9/24/2009	85	15	0	5.4	2.426	2.485	97.6	N/A	2.4	13.0	82	4.5	N/A	1.4
Average				**5.5**	**2.415**	**2.484**	**97.2**		**2.8**	**13.5**	**79**	**4.6**		**1.4**

Gradation and Asphalt Content Results											
	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Pb
9/22/2009	100	94	82	58	39	26	18	12	9	5.9	5.3
9/22/2009	100	95	83	55	36	25	18	12	9	5.9	5.5
9/24/2009	100	92	83	57	38	26	18	13	9	6.5	5.7
9/24/2009	100	95	84	57	37	26	18	13	9	6.4	5.4
Average	**100**	**94**	**83**	**57**	**38**	**26**	**18**	**13**	**9**	**6.2**	**5.5**

Production Paving Results

Data Sampled	Material			Volumetric Data										
	Virgin Material %	RAP Material %	RAS Material %	Pb	Gmb	Gmm	Gmb @ Ndes	Gmm @ Nini	Va	VMA	VFA	Pbe	Gse	D/A
9/23/2009	82	15	3	6.4	2.423	2.450	98.8	N/A	1.1	14.0	92	5.5	N/A	1.3
9/23/2009	82	15	3	6.3	2.428	2.451	99.1	N/A	0.9	13.7	93	5.4	N/A	1.3
9/25/2009	82	15	3	5.5	2.383	2.489	95.7	N/A	4.3	14.6	71	4.5	N/A	1.6
9/25/2009	82	15	3	5.7	2.404	2.464	97.6	N/A	2.4	14.0	83	5.0	N/A	1.4
9/25/2009	82	15	3	5.8	2.405	2.472	97.3	N/A	2.7	14.1	81	4.9	N/A	1.4
Average				**5.9**	**2.409**	**2.465**	**97.4**		**2.3**	**14.1**	**84**	**5.1**		**1.4**

Gradation and Asphalt Content Results

	3/4"	1/2"	3/8"	#4	#8	#16	#30	#50	#100	#200	Pb
9/23/2009	100	91	82	58	39	27	19	14	10	7.2	6.4
9/23/2009	100	91	81	56	38	27	19	13	9	6.8	6.3
9/25/2009	100	95	87	61	42	29	21	15	11	7	5.5
9/25/2009	100	95	84	57	39	27	19	14	10	7.2	5.7
9/25/2009	100	92	83	57	38	26	19	13	10	6.8	5.8
Average	**100**	**93**	**83**	**58**	**39**	**27**	**19**	**14**	**10**	**7.0**	**5.9**

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The End

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