Research Project Work Plan

for

ASPHALT BINDER GRADE SELECTION AND IGNITION OVEN CALIBRATION FACTORS FOR HMAC WITH RECYCLED ASPHALT PRODUCTS

SPR713
[Revision 4]

Submitted by

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for

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1.0 Identification

1.1 Organizations Sponsoring Research

Oregon Department of Transportation (ODOT)
Planning and Research Unit
200 Hawthorne SE, Suite B-240
Salem, OR 97301-5192 Phone: (503) 986-2700

Federal Highway Administration (FHWA)
Washington, D.C. 20590

1.2 Principal Investigator(s)

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1.3 Technical Advisory Committee (TAC) Members

Cole Mullis, Oregon Department of Transportation
Larry Ilg, Oregon Department of Transportation
René Renteria, Oregon Department of Transportation
Norris Shippen, Oregon Department of Transportation
Anthony Boesen, Federal Highway Administration
Gary Thompson, Asphalt Pavement Association of Oregon
Kevin Brophy, Oregon Department of Transportation
Greg Bolt, ABC Roofing Co.
Dave Vogt, Hooker Creek

1.4 Project Champion

Elizabeth Hunt, Oregon Department of Transportation

2.0 Problem Statement

Oregon currently allows up to 30% recycled asphalt pavement (RAP) by weight to be used in hot mixed asphalt concrete (HMAC). While not in current practice at ODOT, the use of blending charts for RAP proportions greater than 15% by weight is recommended to: a) establish the maximum RAP proportion so that the virgin binder properties are not adversely affected; or b) adjust the grade of the virgin binder so that the blended binder possesses the desired properties.

ODOT has also been approached about allowing the use of recycled asphalt shingles (RAS) in HMAC. The two principal sources of recycled asphalt shingles include manufacturer waste (which is in limited supply in Oregon), and post-consumer waste arising from removal of old shingles from roofs (which are commonly referred to as tear-off shingles, and are in abundant supply in Oregon). Irrespective of the source, RAS contains asphalt binder that is substantially stiffer than that used in HMAC in Oregon; hence, inclusion of RAS in HMAC could significantly impact the properties of the blended asphalt binder.

A preliminary investigation is currently underway at ODOT and Oregon State University to investigate how varying percentages of added RAP with a single percentage of added RAS impact the blended binder properties. Additional research is needed to extend the preliminary investigation to include a wider range of percentages of RAP and RAS, to develop a design process for selecting the virgin binder grade based on the varying proportions of RAP and RAS, and to investigate how inclusion of RAP and RAS affects the mix design process for HMAC that include these materials. In addition, significant difficulties with regard to recovering the asphalt binder from shingles were encountered in the preliminary investigation; hence, additional work is needed to identify or develop an effective and efficient procedure for doing so.

A key issue concerning the design, manufacture, and acceptance of HMAC mixtures (with or without RAP and/or RAS) is accurately determining the content of the asphalt binder in the mixture. ODOT currently uses calibrated ignition ovens (incinerators) for determining asphalt binder content of HMAC for mix design verification purposes as well as for both quality control (QC) and quality assurance (QA) purposes. However, over the past few years ODOT has been experiencing an increasing number of issues in validating the contractor's test results for the asphalt binder content of mixtures containing RAP. Binder contents derived from QC/QA testing are used to determine pay quantities, payment for asphalt binder escalation, and price adjustments based on the ODOT statistical analysis processes. Accurate determination of the asphalt binder content (which requires an accurate determination of the calibration factor for a particular mixture and a particular ignition oven) is therefore essential for determining appropriate pay quantities and payment for asphalt binder in HMAC.

3.0 Objectives of the Study

The objectives of this research effort are to develop recommendations for:

1. A design process for selecting the grade of virgin asphalt binder for HMAC mixtures containing RAP or RAS, or combinations of RAP and RAS, such that the blended binder meets the design grade for the mixture;

2. A procedure for effectively and efficiently recovering asphalt binder from recycled asphalt shingles;
3. A procedure for batching virgin materials (binder and aggregate) with RAP or RAS, or combinations of RAP and RAS, for mix design purposes and ignition oven tests;
4. A procedure for determining ignition oven calibration factors for HMAC mixtures containing RAP and/or RAS;
5. QC/QA test procedures for mixtures incorporating RAP or RAS, or combinations of RAP and RAS, as well as independent assurance parameters associated with determining asphalt binder content based on incineration (ignition oven tests); and

The recommendations will be incorporated in a field pilot study that will evaluate the procedures when RAP and RAS are used in HMAC.

3.1 Benefits

The design process (i.e., blending charts or new procedure) will potentially allow an increase in the percentage of RAP, as well as the introduction of the use of RAS, in HMAC mixtures, thereby reducing the demand for virgin asphalt binder through reuse of a non-renewable resource. With sufficient quantities of RAP and/or RAS reduced cost of HMAC is likely. Adopting the new procedures in the mix design process as well as the new procedures for QC/QA testing will ensure that the desired properties of the blended asphalt binders are achieved so as to ensure acceptable long-term performance of HMAC mixtures that incorporate RAP and/or RAS.

The benefits to be derived from the work involving the ignition oven (incinerator) calibration factors include an improved (more accurate) determination of the binder content and material quality of HMAC mixtures incorporating RAP and/or RAS. This will allow better decisions in the field regarding mixture adjustments and material quality as well as allow ODOT to more accurately determine pay quantities, adjustments for asphalt binder escalation, and price adjustments. Implementation of the results could potentially result in savings in maintenance costs by virtue of placing HMAC mixtures more accurately designed to meet the expected traffic and environmental factors where RAP and/or RAS on are incorporated in paving projects.

4.0 Implementation

The recommended procedures will be utilized in the design and QC/QA processes for HMAC mixtures that incorporate RAP and/or RAS. They will also be used to determine more accurate pay quantities and price adjustments.

5.0 Research Tasks

Task 1 – Literature Review: Published literature will be reviewed and agency procedures will be investigated to:

a. Determine the state-of-the-practice regarding procedures for selecting virgin asphalt binder grades based on RAP and/or RAS proportions;

b. Effectively and efficiently determine how to recover asphalt binder from recycled asphalt shingles;

c. Establish how inclusion of RAP and RAS impacts the mix design process;

d. Determine the current state-of-the-practice for calibrating ignition ovens for determining asphalt binder content with emphasis on protocols specific to mixtures containing RAP and/or RAS;

e. Determine the state-of-the-practice regarding QC/QA testing procedures for mixtures containing RAP and/or RAS; and

f. Investigate whether or not fractionating RAP into more than one stockpile improves the quality of HMA mixtures incorporating RAP.

Time Frame: 3 months
Responsible Party: OSU
Cost: $14,391
Deliverable: Synthesis of literature review
TAC Decision/Action: Review of synthesis

Task 2 – Preliminary Procedures: Based on the findings from the literature review (Task 1), a set of preliminary procedures (or modifications to existing ODOT procedures) will be developed to:

a. Select the virgin binder grade for HMAC mixtures that will contain RAP and/or RAS;

b. Recover asphalt binder from recycled asphalt shingles;

c. Batch virgin materials (binder and aggregate) with RAP and/or RAS for mix design purposes and ignition oven tests;

d. Determine ignition oven calibration factors for HMAC mixtures containing RAP and/or RAS;

e. Conduct QC/QA testing on HMAC mixtures containing RAP and/or RAS.

Time Frame: 2 months
Responsible Party: OSU
Cost: $6,141
Deliverable: Preliminary procedures
TAC Decision/Action: Comments on procedures

Task 3 – Experiment Plan: An experiment plan for laboratory studies will be developed to:

a. Utilize and test the efficacy of the preliminary procedure for selecting the virgin binder grade for a range of RAP and RAS contents, as well as to gather requisite information to allow modifications to the preliminary procedure (if warranted). It is envisioned that this will involve using the preliminary procedure to select the "design" virgin binder grade (which will likely require a mix design for each combination of materials), batch and mix HMAC mixtures with various RAP and RAS proportions, and recover and grade the blended binder.

b. Investigate how the use of RAP and/or RAS in HMAC mixtures affects the mix design process. It is envisioned that this will involve batching, mixing, and compacting HMAC mixtures, and then determining the volumetric properties necessary for mix design purposes (e.g., mixture specific gravities, effective binder content, voids in mineral aggregate, voids filled with asphalt, etc.) and comparing these with those of mixtures without RAP or RAS. The same combinations of mixtures as that used for Part a. (above) will be used in the plan for this work.

c. Determine the ignition oven calibration factors for HMAC mixtures containing RAP and RAS. It is envisioned that this will involve a rigorous investigation of mixtures at varying proportions of RAP and RAS following the preliminary procedure (e.g., modified ODOT T323 or similar procedure) developed in Task 2. Other variables to consider in developing the experiment plan include number and type of ovens, number of aggregate types and gradations, and number of binder sources. The same combinations of mixtures as that used for Parts a. and b. (above) will be used in the plan for this work.

   Insofar as practical, multiple combinations of RAP and RAS proportions will be included in the experiment plan. Initial thoughts are to include recycled materials (RAP plus RAS) contents up to 50% by weight, but limit the RAS content to a maximum of 5% by weight in all but two of the combinations. Table 1 indicates one possible experiment design, where X represents the requisite number of specimens to satisfy Parts a., b. and c. (above), and R represents replicate specimens to establish an estimate of variance for statistical comparison purposes. *The actual experiment design for the lab work may be different from that shown below depending on findings from the literature review and input from the TAC.*

It should be noted that the preliminary experiment design indicates virgin binder grades identified as "West" and "East" to represent grades currently used by ODOT on the west side and east side of the Cascade Mountains (e.g., PG64-28 and PG70-28, respectively). Final decision of the virgin binder grades will be made following completion of the literature review (Task 1).

In addition to the above plan for the laboratory studies, a plan will be developed to evaluate an HMAC mixture with RAP and RAS placed during a pilot study. The proposed preliminary procedures for QC/QA testing will be utilized during construction (if possible) and a sufficient quantity of materials will be sampled from the project to conduct mix design verification.

Table 1 – *Draft* Experiment Design for the Laboratory Study

RAP Content[a]		0%				15%			20%		30%		40%		50%	
RAS Content[a]		0%	2%	5%	10%	0%	2%	5%	0%	5%	0%	5%	0%	5%	0%	5%
Total Recycled Material Content[a]		0%	2%	5%	10%	15%	17%	20%	20%	25%	30%	35%	40%	45%	50%	55%
Estimated Recycled Binder Content[b]		0.00%	0.50%	1.25%	2.50%	0.75%	1.25%	2.00%	1.00%	2.25%	1.50%	2.75%	2.00%	3.25%	2.50%	3.75%
Estimated Virgin Binder Content[c]		5.50%	5.00%	4.25%	3.00%	4.75%	4.25%	3.50%	4.50%	3.25%	4.00%	2.75%	3.50%	2.25%	3.00%	1.75%
Virgin Binder Grade[d]	West	X[e]+R[f]	X+R	X+R	X	X+R	X	X+R	X+R	X+R	X	X	X	X	X	X
	East	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X

[a] By weight of total mixture

[b] Assumes average RAP binder content of 5.0%, average RAS binder content of 25%, and all of the binder from the recycled materials contributes to the total binder content of the mixture

[c] Assumes a total binder content of 5.5% for the mixture

[d] "West" = grade for west side of the Cascades; "East" = grade for east side of the Cascades

[e] X represents the total number of asphalt cement specimens and mixtures specimens to be evaluated

[f] R represents replicate specimens

Time Frame: 1 month
Responsible Party: OSU
Cost: $2,954
Deliverable: Presentation of experiment plan at TAC meeting
TAC Decision/Action: TAC meeting/Approval of experiment plan

Task 4 – Laboratory Study: Conduct laboratory testing and analyses as per the experiment plan developed under Task 3. It is anticipated that this will entail a substantial amount of the lab work involving mix designs, binder extractions, rheological testing to determine binder grades (i.e., DSR and BBR testing), tests to determine volumetric properties of mixtures, and ignition oven tests.

Time Frame: 9 months
Responsible Party: OSU
Cost: $178,100
Deliverable: Summary of lab test results and analyses at TAC meeting
TAC Decision/Action: TAC meeting

Task 5 – Pilot Study Evaluation: Evaluate the QC/QA methods used during the construction of the HMAC pavement containing RAP and RAS. Collect materials and conduct mix design verification (MDV). Use the ignition oven calibration procedure during the MDV. It is envisioned to conduct this work during the 2010 construction season via change order to an existing contract, but given the amount of work required before this task can be conducted, it may occur during the 2011 construction season.

Time Frame: 2 months (targeted during the 2010 construction season)
Responsible Party: OSU/ODOT
Cost: $11,048
Deliverable: Findings from the evaluation
TAC Decision/Action: Review findings

Task 6 – Develop Recommended Procedures: Modify or finalize the preliminary procedures, or recommend new procedures, based on the findings from the lab work. These will be developed in the style of ODOT test methods such that they can be readily incorporated into the Manual of Field Testing Procedures. In addition, recommendations for modifications to the ODOT standard specifications will be provided to explicitly account for the grade of the virgin asphalt binder and the quantity of binder (i.e., virgin binder, RAP binder, and RAS binder) contained in the mixture.

Time Frame: 1 month
Responsible Party: OSU
Cost: $2,969
Deliverable: Recommended procedures
TAC Decision/Action: Review of recommended procedures

Task 7 – Report: A final report will be developed to document the efforts undertaken to accomplish Tasks 1-5. A preliminary outline of the report is as follows:

1.0 Introduction
2.0 Literature Review
3.0 Preliminary Procedures
4.0 Experiment Plan
5.0 Laboratory Studies
6.0 Pilot Study
7.0 Recommended Procedures
8.0 Conclusions and Recommendations

Time Frame: 3 months
Responsible Party: OSU
Cost: $9,397
Deliverable: Final report
TAC Decision/Action: Review of final report/TAC meeting

6.0 Time Schedule

The proposed schedule for this project is shown in the Figure 1. As indicated, it has a proposed duration of 18 months ending in March of 2011.

Task	ODOT FY 10-11									ODOT FY 11-12								
	CY 2009			CY 2010												CY 2011		
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M
1. Literature Review																		
2. Preliminary Procedures																		
3. Experiment Plan																		
4. Lab Study																		
5. Pilot Study Evaluation*																		
6. Recommended Procedures																		
7. Report																		

*Assumed period for the pilot study; evaluation duration of 2 months

Figure 1 – Proposed Project Schedule

7.0 Budget Estimate

A summary of the proposed budget by task for the project is provided in Table 2, whereas Table 3 summarizes the budget by fiscal year, and Table 4 provides a breakdown of costs (except tuition) listed under Other Expenses in Table 3. As indicated, the proposed cost of the project is $225,000.

Table 2 – Summary of Proposed Budget by Task

ODOT FY2010									
			TDC Less Tuition			Facilities & Adminstration Cost			
Task	Total Direct Cost (TDC)	Tuition	Total	Federal Portion	State Portion	Federal Portion	State Portion	Total F&A	Total Task Cost
1	$ 11,089.49	$ 3,258.00	$ 7,831.49	$ 6,265.19	$ 1,566.30	$ 2,894.52	$ 407.24	$ 3,301.76	**$ 14,391**
2	$ 5,285.73	$ 3,258.00	$ 2,027.73	$ 1,622.18	$ 405.55	$ 749.45	$ 105.44	$ 854.89	**$ 6,141**
3	$ 2,077.73	$ -	$ 2,077.73	$ 1,662.18	$ 415.55	$ 767.93	$ 108.04	$ 875.97	**$ 2,954**
4	$ 51,233.60	$ 3,258.00	$ 47,975.60	$ 38,380.48	$ 9,595.12	$17,731.78	$ 2,494.73	$20,226.51	**$ 71,460**
5	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
6	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
7	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
Total	**$ 69,687**	**$ 9,774**	**$ 59,913**	**$ 47,930**	**$ 11,983**	**$ 22,144**	**$ 3,115**	**$ 25,259**	**$ 94,946**

ODOT FY2011									
			TDC Less Tuition			Facilities & Adminstration Cost			
Task	Total Direct Cost (TDC)	Tuition	Total	Federal Portion	State Portion	Federal Portion	State Portion	Total F&A	Total Task Cost
1	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
2	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
3	$ -	$ -	$ -	$ -	$ -	$ -	$ -	$ -	**$ -**
4	$ 75,013.76	$ -	$ 75,013.76	$ 60,011.01	$15,002.75	$27,725.09	$ 3,900.72	$31,625.80	**$ 106,640**
5	$ 8,776.56	$ 3,388.00	$ 5,388.56	$ 4,310.85	$ 1,077.71	$ 1,991.61	$ 280.21	$ 2,271.82	**$ 11,048**
6	$ 2,088.56	$ -	$ 2,088.56	$ 1,670.85	$ 417.71	$ 771.93	$ 108.61	$ 880.54	**$ 2,969**
7	$ 7,615.12	$ 3,388.00	$ 4,227.12	$ 3,381.70	$ 845.42	$ 1,562.34	$ 219.81	$ 1,782.16	**$ 9,397**
Total	$ 93,494	$ 6,776	$ 86,718	$ 69,374	$ 17,344	$ 32,051	$ 4,509	$ 36,560	**$ 130,054**

PROJECT TOTALS									
			TDC Less Tuition			Facilities & Adminstration Cost			Total
Task	Total Direct Cost (TDC)	Tuition	Total	Federal Portion	State Portion	Federal Portion	State Portion	Total F&A	Project Cost
All	**$ 163,181**	**$ 16,550**	**$ 146,631**	**$ 117,304**	**$ 29,326**	**$ 54,195**	**$ 7,625**	**$ 61,819**	**$ 225,000**

Table 3 – Summary of Proposed Budget by Fiscal Year

Budget Category	ODOT FY2010				ODOT FY2011				TOTAL COSTS
Salaries	Rate[1]	FTE or HRS	Months	Salary/Wages	Rate[1]	FTE or HRS	Months	Salary/Wages	
Todd Scholz	$ 9,287.00	1.00	0.5	$ 4,643.50	$ 9,287.00	1.000	2.0	$ 18,574.00	**$ 23,218**
Grad Student	$ 3,543.00	0.49	9.0	$ 15,624.63	$ 3,649.29	0.490	9.0	$ 16,093.37	**$ 31,718**
Undergrad Student	$ 13.49	340	N/A	$ 4,586.60	$ 13.49	500	N/A	$ 6,745.00	**$ 11,332**
Total Salaries				**$ 24,855**				**$ 41,412**	**$ 66,267**
Fringe Benefits (OPE)	Rate[2]			Amount	Rate[2]			Amount	
Todd Scholz	25.0			$ 1,160.88	25.0			$ 4,643.50	**$ 5,804**
Grad Student	16.8			$ 2,624.94	16.8			$ 2,703.69	**$ 5,329**
Undergrad Student	8.0			$ 366.93	8.0			$ 539.60	**$ 907**
Total Fringe Benefits				**$ 4,153**				**$ 7,887**	**$ 12,040**
Total Personnel Costs				**$ 29,007**				**$ 49,299**	**$ 78,307**
Other Expenses									
Grad Student Tuition				$ 9,774.00				$ 6,776.00	**$ 16,550**
Equipment				$ 3,600.00				$ -	**$ 3,600**
Supplies				$ 444.44				$ 555.56	**$ 1,000**
Lab Services				$ 26,666.67				$ 36,433.33	**$ 63,100**
Domestic Travel				$ 193.97				$ 429.96	**$ 624**
Total Other Expenses				**$ 40,679**				**$ 44,195**	**$ 84,874**
Total Direct Costs				**$ 69,687**				**$ 93,494**	**$ 163,181**
Total Indirect Costs (F&A = 42.16%[3])				**$ 25,259**				**$ 36,560**	**$ 61,819**
TOTAL COSTS				**$ 94,946**				**$ 130,054**	**$ 225,000**

[1]Monthly rate for faculty and graduate student salaries, hourly rate for student wages

[2]OPE rates in percent

[3]F&A Rate = 80% federal/20% state split = (0.80 x 46.2%) + (0.20 x 26%) = 42.16%

Table 4 – Estimated Costs for Equipment, Supplies, Lab Services, and Travel

Equipment (Task 4)

Item	Unit Cost	Qty	Cost	Subtotal Cost
Extraction Vessel	$3,600	1	$3,600	$ 3,600
			TOTAL	**$ 3,600**

Supplies (Task 4)

Items	Subtotal Cost
Miscellaneous supplies for lab work: Plastic sample bags, sample labels, shipping boxes, solvent and other cleaning supplies, paper disks for compaction equipment, lab coats for GRA and student help, safety gear for GRA and student help (gloves, goggles, boots), etc.	$ 1,000
TOTAL	**$ 1,000**

Laboratory Study (Task 4)

Item	Unit Cost	Qty	Cost	Subtotal Cost
AASHTO T 319 (binder recovery)	$ 1,000	39	$ 39,000	$ 39,000
AASHTO T 313 (BBR)				
Neat binders	$ 160	2	$ 320	
Binders from Mixtures	$ 160	39	$ 6,240	$ 6,560
AASHTO T 314 (DTT)				
Neat binders	$ 85	2	$ 170	
Binders from Mixtures	$ 85	39	$ 3,315	$ 3,485
AASHTO T 315 (DSR)				
Neat binders	$ 150	2	$ 300	
Binders from Mixtures	$ 150	39	$ 5,850	$ 6,150
Batching	$ 85	39	$ 3,315	$ 3,315
Materials			$ 1,000	$ 1,000
Shipping			$ 500	$ 500
			TOTAL	**$ 60,010**

Pilot Study (Task 5)

Item	Subtotal Cost
Materials	$ 100
Mix Design Verification	$ 3,000
TOTAL	**$ 3,100**

Travel

Task	Destination/Purpose	Subtotal Cost
3. Experiment Plan	Salem/TAC Meeting	$ 50
4. Laboratory Study	HMA Plants/Materials Collection	$ 314
5. Pilot Study Evaluation	Site Visits/Materials & Data Collection	$ 200
7. Report	Salem/TAC Meeting	$ 50
	TOTAL	**$ 614**