TERMINAL BLEND ASPHALT RUBBER BINDER
LOWELL-WESTFIELD VT. ROUTE 100

INITIAL REPORT 94-9
DECEMBER 1994

REPORTING ON WORK PLAN 94-R-3

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS AND RESEARCH DIVISION

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16. Abstract

In the interest of finding a solution of the problem of growing stock piles of used tires, the State of Vermont is evaluating asphalt rubber hot mix (ARHM) technology. The wet-process, terminal-blend ARHM liquid binder used on the Lowell-Westfield Project F029-2(11) was manufactured by Bitumar, of Montreal, Quebec.

Mix production, testing and paving operations for this project were relatively trouble free. Evaluation of performance factors will continue.

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LOWELL-WESTFIELD VT. ROUTE 100
F 029-2(11)
TERMINAL BLEND - ASPHALT RUBBER BINDER

INTRODUCTION:

Section 1038 of the Intermodal Surface Transportation Efficiency Act (ISTEA) of 1991 requires an expanding usage of recycled rubber. Beginning during fiscal year 1994, ISTEA requires that a minimum of 5% of all asphalt tonnage produced within each state for use on federally funded projects will contain a nominal amount of recycled rubber from scrap tires. This percentage increases each year by 5% to a final 20% level in fiscal 1997 and is to be maintained at 20% each year thereafter. This requirement was initiated in response to growing stockpiles of used tires nationwide, and the lack of environmentally sound ways to dispose of them.

The U.S. Secretary of Transportation has expressed concern over this pressing issue, citing the crucial need for solutions to the used tire recycling problem, weighed against the substantial cost increases that would accrue as a result of full implementation of this policy. As of late 1994, the Federal Government is not pursuing strict enforcement of Section 1038, but has adopted a "wait and see" attitude, contingent upon several unresolved questions:

1. Is the use of crumb rubber threatening to human health or the environment?

2. Can asphalt pavements containing crumb rubber be recycled?

3. Do pavements modified with recycled rubber perform adequately?

The Vermont AOT is interested in the environmental issues related to rubber tire waste, and is undertaking a limited number of asphalt rubber hot mix (ARHM) projects to demonstrate a willingness to deal with the problem voluntarily, without federal oversight.

It is not the goal of this investigation to seek conclusions for either of the first two questions shown above, since they must be answered on the basis of broad experience. Rather, it is the issue of performance that will be addressed. Since performance and cost effectiveness concerns will most likely be finally settled at the state level, this evaluation and others which focus on asphalt rubber hot mix (AHRM) projects are of national as well as state significance.

PROJECT DESCRIPTION:

The 1994 Lowell-Westfield, project F 029-2(11) began on VT Route 100 at km 4.609 (MM 2.864) and extended northerly for a distance of 14.270 km (8.867 mi) to km 7.564 (MM 4.700). The project included a 3.293 km (2.046 mi) control section which was paved full width (pavement and shoulders) with a standard overlay of 38.1 mm (1.5 in) Type III bituminous concrete pavement wearing course, beginning at km 4.609 (MM 2.864) in Lowell and continuing to km 7.902 (MM 4.91). The remainder of the project, from km 7.90 MM (4.91) in Lowell to

km 7.564 (MM 4.70) in Westfield, a distance of 10.977 km (6.821 mi), was paved full width with a 38.1 mm (1.5 in) ARHM overlay. Both sections were leveled with 384 t/km (680 tn/mi) which is approximately equal to an additional 25.4 mm (1.0 in) overlay thickness. Average 1994 daily traffic on this section of VT Route 100 is 1778 vehicles.

PRECONSTRUCTION CONDITION DATA:

Four test sites were established within the 3.219 km (2 mi) control section (standard overlay) prior to construction, and seven were situated within the ARHM overlay section. Each of these sites was evaluated for cracking, rutting and roughness both prior and subsequent to construction.

CONTROL (STANDARD OVERLAY) TEST SECTIONS

km (MM)	Cracking m/100 m (ft/100 ft)	Rutting mm (1/16 in)	IRI mm/km (in/mi)
5.25 (Lowell) (3.26)	415 (415)	6 (4)	↑
5.47 (3.40)	575 (575)	14 (9)	AVE. 2951 (187)
6.12 (3.80)	654 (654)	10 (6)	
6.53 (4.06)	747 (747)	6 (4)	↓

ARHM TEST SECTIONS

9.87 (6.13)	630 (630)	10 (6)	↑
0.64 (0.40)(Westfield)	1045 (1045)	10 (6)	
2.90 (1.80)	744 (744)	10 (6)	AVE. 3172 (201)
4.22 (2.62)	483 (483)	8 (5)	
4.83 (3.00)	775 (775)	14 (9)	
5.44 (3.38)	694 (694)	11 (7)	
5.84 (3.63)	903 (903)	11 (7)	↓

A post-construction survey conducted on 08/25/94 revealed that there had been no cracking or rutting on either the standard overlay or ARHM sections. International Roughness Index testing was conducted on 08/31/94 and an average value of 1436 mm/km (91 in/mi) was obtained for the control section and a value of 1499 mm/km (95 in/mi) was generated in the rubber modified section.

MIX PRODUCTION & TESTING:

The ARHM liquid binder (conventional FHWA terminology for this product is crumb rubber modified (CRM) binder) utilized for the project was a terminal-blend product, known as Ecoflex, produced by Bitumar Inc. of Montreal, Quebec. As specified, the ARHM liquid binder contained a minimum 10% reclaimed, vulcanized tire rubber and exceeded the contract specification for a SHRP grade of PG 52-34 through PG 58-46 with a PG grade of 64-34. The binder for the standard mix was AC 20, provided by Petro Canada, also of Montreal. Both mixes were produced at Pike Industry's 2.3 t (2.5 tn) Coventry plant, utilizing a combination of crushed gravel and quarried stone aggregate from Calkins Sand & Gravel. A brief description of the three (wet blend, dry blend and terminal blend) ARHM processes which are in current use is included in this report, as Appendix A.

Leveling course paving began on 06/15/94, using the standard (Type IV) mix and continued through the end of paving operations which occurred on 07/27/94. Wearing course paving in the control (standard overlay) section began on 06/24/94. Paving of the wearing course with the ARHM began on 07/07/94 and continued through 07/27/94. Total ARHM production was 9409 t (10350 tn) and average daily production of that mix was 1882 t (2070 tn).

In order to estimate the numbers of scrap tires which were recycled for this project, the following assumptions were made:

a) The ARHM mix design required an asphalt binder content of 5.8% (see mix design sheets, Appendix B).
b) The ARHM liquid binder contained 10% scrap tire rubber.
c) A typical scrap tire (passenger car) weighs 9.88 kg (20 lbs). (Report No. FHWA-SC-92-04).

Using these assumptions it can be estimated that approximately 6000 (passenger car) scrap tires were recycled for the Lowell-Westfield project.

Testing performed during mix production indicated a product of reasonably consistent quality. Some 306 tests were performed on 51 samples with a failure rate of less than 3%. All of the test failures were due to deficiencies in allowable air voids. The air voids test has an acceptability range of 3% to 5%. Test failures were isolated in most cases and failure margins were all less than 1%.

No significant problems were noted by the resident during the construction period. On 07/06/94, however, the second day of ARHM paving, several loads of mix had lay down temperatures which exceeded specifications 160 C to 170 C (320 F to 338 F) with high temperatures ranging from 171 C to

180 C (340 F to 355 F). The concentration of fumes caused some of the workers to complain.

COST:

The project was paved with 9418 t (10350 tn) of ARHM at a cost of $41.80/t ($38.00/tn) and 3012 t (3313 tn) of standard mix at $36.30/t ($33.00/tn).

The cost to resurface the control section with a 38 mm (1.5 in) overlay and a 384 t/km (680 tn/mi) leveling course was $5.48/$m^2$ ($4.58/SY) while the cost for the ARHM overlay and leveling was $6.09/$m^2$ ($5.28/SY).

SUMMARY:

No significant problems were encountered during production of either the crumb rubber modified asphalt or the conventional mix. Similarly, no notable problems were encountered with the lay-down characteristics of either pavement material.

The post-construction performance values for cracking, rutting and IRI are as expected for new pavements, and it is far too early at this point to identify any trends.

FOLLOW - UP:

Performance monitoring on the Lowell - Westfield project will continue on an annual basis with emphasis on the potential difference between the standard and asphalt rubber pavements.

There are currently three methods by which recycled rubber can be introduced into hot mix; the dry process or "dry blend", the wet process or "wet blend" and terminal blending.

DRY BLEND PROCESS

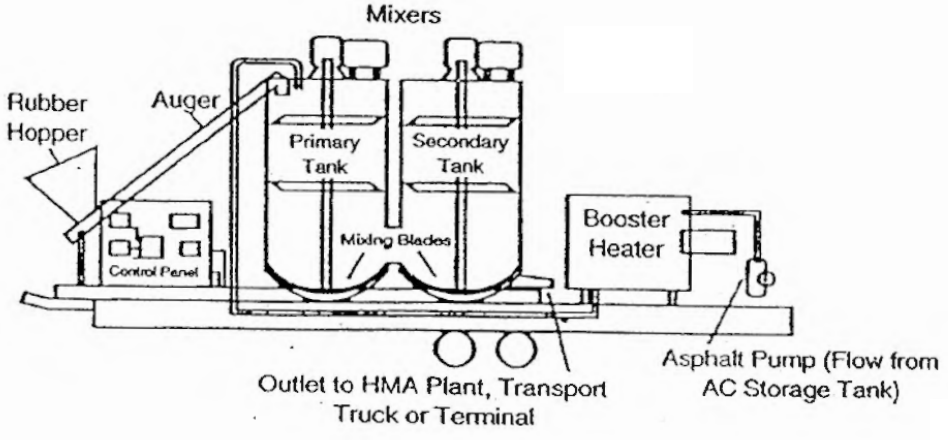
The dry blend process uses the crumb rubber as a component of the aggregate which is incorporated into a gap graded aggregate prior to mixing with the asphalt cement. The crumb rubber modifier is dry mixed with the hot mineral aggregate prior to mixing with asphalt cement. The limited reaction time allows the surface of the coarse rubber particles to react with the asphalt cement, but does not permit sufficient time for the reaction to penetrate the entire rubber mass. This creates an asphalt/rubber interface which bonds the two materials together.

Distributors of this technology maintain that the coarse rubber particles act as elastic aggregates which flex on the pavement surface under traffic and break ice. They also claim increased fatigue life, resistance to reflective, shrinkage and thermal cracking, ice debonding and resistance to rutting.

WET BLEND PROCESS

Wet blend process is employed when the crumb rubber is blended with the asphalt binder prior to mixture with the aggregate. The reaction which occurs during the wet process is not a melting of the crumb rubber. The reaction which occurs is similar to a compressed, hard, dry sponge being placed in a water bath. The crumb rubber swells and softens and becomes sticky, increasing the viscosity of the mixture.

There are two prevailing technologies which utilize a wet blend process, the batch plant technology and the continuous blending technology. In the batch plant technology the CRM is mixed in a blending tank and reacted in a holding tank before introduction into the mix. In this process the liquid CRM binder is synthesized at the hot mix plant.



Continuous blending technology differs from the batch plant technology in that the CRM material used in the liquid binder is a finer grind. The mixing of the CRM binder and the asphalt cement is accomplished in a self-contained, portable blending/metering unit (shown on the previous page).

The continuous blend system can be set up at the hot mix plant site and interlocked into the existing asphalt binder system.

Proponents of the wet blend process make claims of reduced aging, increased mix flexibility, increased softening point temperature and improved performance during both hot and cold weather.

TERMINAL BLEND PROCESS

The terminal blend process is similar to wet blending in that the rubber is blended into the asphalt binder before it is mixed with the aggregate. This process is distinct in several ways, however. Blending takes place at an asphalt terminal and the rubber blended asphalt binder is kept in storage tanks until it is transported to the hot mix plant as needed.

Terminal blending utilizes a finer gradation and requires complete dissolution of the crumb rubber in the asphalt binder. Performance characteristics of this product are similar to those of the wet blend material.

STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION – BITUMINOUS CONCRETE SUBDIVISION

APPENDIX B(1)

6332

Design of Bituminous Concrete Mixtures

Town MASTER Project No. .....

Gentlemen:

In accordance with the specification requirements for the above project I submit the following job mix formula:

Pavement Type III Produced By: PIKE INDUSTRIES INC. Plant Location COVENTRY Vt. PL. 905

Blows per Side 50 Stockpile Gradations — % Passing

Size	% Used		1½	1	¾	½	⅜	4	8	16	30	50	200	
WA SAND	21						100	99	83	57	34	15	2.5	
WA. S S	35							100	80	51	34	23	6	
3/8"L	21					100	98	30	4	2	1	1	.5	
1/2"L	23				100	98	30	4	2	1	1	1	.1	
Resultant	100				100	99	84	63	47	31	20	12	2.8	

Hot Bin Gradation — % Passing

Bin	% Used		1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55							100	82	56	36	22	5.5	
2	28					100	96	27	5					
3	17				100	97	10	3	2					
4									–					
5														
Resultant	100				100	100	84	63	47	31	20	12	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2334	1185	720			261	4500

			1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	99	84	63	47	31	20	12	3	5.80
Job Aim					100	95/100	78/90	57/69	43/51	27/35	16/24	8/16	2/4	
Specification Limits					100	95/100	70/90	42/75	28/56	18/41	11/31	4/22	2/6	3/8

Source of Materials

Aggregates		Asphalt	
Coarse:	CALKINS S & G - COVENTRY, VT.	~~AC-10~~	
Fine:	CALKINS S & G - COVENTRY, VT.	~~AC-20~~	
		ECOFLEX PG 64-34	10% Rubber
		Other: BITMAR INC.	MONTREAL

comp. temp. ≥ 265°F

Mixing Times — Dry: 6 Wet: 36 Total: 42 Temperature: 320-338°F

Submitted by: J. A. Wilson (signature) Date: 6 20 1994

Company Pike Industries Inc. Title Quality Control Superintendent

FOR STATE OF VERMONT USE ONLY

Comments: This design is approved as submitted based on Marshall design and tray drop. Minor adjustments may be required. Continued use is contingent on further testing meeting all specifications.

Signature Charles E. Jerd Title Bituminous Concrete Supervisor

Date June 28, 1994

TA 556

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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION - BITUMINOUS CONCRETE SUBDIVISION

Design of Bituminous Concrete Mixtures

6333

Town MASTER Project No. .....

Gentlemen:

In accordance with the specification requirements for the above project I submit the following job mix formula:

Pavement Type III Produced By: PIKE INDUSTRIES INC. Plant Location COVENTRY Vt.

Blows per Side 50 Stockpile Gradations — % Passing PL. 905

Size	% Used		1½	1	¾	½	⅜	4	8	16	30	50	200	
WA SAND	21						100	99	83	57	34	15	2.5	
WA. S S	35							100	80	51	34	23	6	
3/8"C	21					100	98	30	4	2	1	1	.5	
1/2"C	23				100	98	30	4	2	1	1	1	.1	
Resultant	100				100	99	84	63	47	31	20	12	2.8	

Hot Bin Gradation — % Passing

Bin	% Used		1½	1	¾	½	⅜	4	8	16	30	50	200	
S	55							100	82	56	36	22	5.5	
2	28					100	96	27	5					
3	17				100	97	10	3	2					
4														
5														
Resultant	100				100	100	84	63	47	31	20	12	3	

Batch Weights	Bin S	Bin No. 2	Bin No. 3	Bin No. 4	Bin No. 5	AC	Total
	2343	1190	720			247	4500

			1½	1	¾	½	⅜	4	8	16	30	50	200	AC
Job Mix Formula					100	99	84	63	47	31	20	12	3	5.50
Job Aim					100	95 / 100	78 / 90	57 / 69	43 / 51	27 / 35	16 / 24	8 / 16	2 / 4	
Specification Limits					100	95 / 100	70 / 90	42 / 75	28 / 56	18 / 41	11 / 31	4 / 22	2 / 6	3 / 8

Source of Materials

Aggregates		Asphalt	
Coarse:	CALKINS S & G - COVENTRY, VT.	AC-10	
Fine:	CALKINS S & G - COVENTRY, VT.	AC-20	PETRO, MONTREAL, CANADA
		Other:	

comp. temp. 285+/-10°F

Mixing Times — Dry: 6 Wet: 36 Total: 42 Temperature: 310+/-20°F

Submitted by: J. A. Wilson (signature) Date: 6 20 1994

Company Pike Industries Inc. Title Quality Control Superintendent

FOR STATE OF VERMONT USE ONLY

Comments: This design is approved as submitted based on Marshall design and trial drop. Minor adjustments may be required. Continued use is contingent on further testing meeting all specifications.

Signature Charles E. Jerd Title Bituminous Concrete Supervisor

Date June 30, 1994

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ARHM (TERMINAL BLEND)
LOWELL-WESTFIELD
Rt.100 CONSTRUCTED 1994