COLD RECYCLED BITUMINOUS PAVEMENT
DERBY-CHARLESTON VT105

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STATE OF VERMONT
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MATERIALS AND RESEARCH DIVISION

PATRICK J. GARAHAN, SECRETARY OF TRANSPORTATION
ROBERT L. MERCHANT, DIRECTOR OF CONSTRUCTION AND MAINTENANCE
ROBERT F. CAULEY, MATERIALS AND RESEARCH ENGINEER
RONALD I. FRASCOIA, RESEARCH AND DEVELOPMENT SUPERVISOR

Prepared By:

Robert E. Brunelle, Technician IV
Research and Development Subdivision

Reviewed By:

Robert F. Cauley

R.F.Cauley,
Materials and Research Engineer

Date: 12 Aug 94

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16. Abstract

This report describes the process for cold recycled bituminous pavement as performed on the Derby-Charleston Project STP9248(1).

This report includes initial data for a performance evaluation of rutting, international roughness index (IRI) and falling weight deflectometer (FWD) values.

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COLD RECYCLED BITUMINOUS PAVEMENT
RTE 105 DERBY-CHARLESTON

INTRODUCTION:

As pavement recycling technology advances, four concerns have yet to be answered definitively, and remain as the determining factors relative to the general acceptance of the cold recycled bituminous pavement (CRBP) approach:

1. Is CRBP truly cost effective when compared to the standard overlay? To answer this question in respect to the needs of Vermont, this project, and other similar projects utilizing the various approaches to cold recycling have been included in a long term pavement study designed to determine service life and annualized costs. The long term performance of each of these projects will be compared and evaluated relative to the standard overlay.

2. Will the degree of compaction of the recycled mix be sufficient to prevent further consolidation under traffic?

3. If the recycled depth does not extend to the subbase, is the chance of reflective cracking increased?

4. Will the placement of the recycled material between two more rigid and dense layers be conducive to flexural stress failures ? One indicator of this would be excessive longitudinal cracking in the wheel paths.

PROJECT LOCATION AND DESCRIPTION:

The Derby-Charleston project, STP 9248(1)/C1, began at km 1.287 (MM 0.800) of VT 105 in Derby and extended easterly for 7.828 km (4.864 mi) to km 1.287 (MM 0.800) in Charleston. Work performed included 102 mm (4 in) cold recycled bituminous pavement, resurfacing of the existing highway with a 44.5 mm (1.75 in) binder course of Type II bituminous concrete pavement and a wearing course of 38.1 mm (1.50 in) of bituminous concrete pavement, associated pavement markings, and incidental items.

VT ROUTE 105 PRIOR TO CONSTRUCTION:

From its beginning at VT 105 km 1.287 (MM 0.800) in Derby to the end of project STP 9248(1)S at km 1.287 (MM 0.800) in Charleston, the existing highway was originally constructed in 1936 under project numbers FAP 90-C and FAP 90-D. It has a traveled way that is 6.7 m (22 ft) wide and total roadbed width is 8.23 m (27 ft). Average daily traffic (ADT) on VT 105 varies from a high of 3130 at the beginning of the project at km 1.29 (mm 0.800), to a low of 1690 at the end of the project in Charleston.

Cores taken along the entire project length revealed a pavement structure with a depth varying from 89 mm (3.5 in) to 254 mm (10 in).

The ride quality of the existing highway was evaluated via MAYS meter on 07/28/92 and the average International Roughness Index (IRI) for the project was 230, with a high value of 332 and a low of 182.

Based on the projected 514 daily equivalent single axle loadings (ESAL) for the 10 year design life, the Agency's Pavement Management Division had estimated a required 4.8 design structural number (SN) through the length of the project. Structural numbers were derived utilizing falling weight deflectometer (FWD) equipment at various times through the progress of the project. Preconstruction FWD data indicated an average SN of 3.34. Since a structural number loss of approximately -0.12 per 25.4 mm (1.0 in) of recycled material is normally anticipated, the resulting projected post CRBP SN of 2.86 would have required an approximate 152 mm (6 in) overlay to achieve the design 4.8 SN (assumed layer coefficient for bituminous concrete pavement is 0.32/in). Deeming an overlay of that thickness impractical from an economic standpoint, a compromise design, including 83 mm (3.25 in) of bituminous concrete pavement was incorporated into the project.

The table below shows the structural numbers of the pavement within each of the test sections for the original pavement structure, after the cold recycling process (but prior to resurfacing) and after resurfacing:

km (MM)	Orig.	Post CBRP	CBRP Loss	Type II	Type III	Str.Incr.
1.609 (1.000)	3.95	3.64	-.31	4.19	4.96	+1.01
2.253 (1.400)	3.61	3.33	-.28	3.98	4.66	+1.05
3.219 (2.000)	3.27	3.23	-.04	3.87	4.49	+1.22
4.506 (2.800)	3.09	3.27	+.18	3.66	4.07	+0.98
5.311 (3.300)	2.89	3.18	+.29	3.57	4.03	+1.14
6.115 (3.800)	2.89	3.03	+.14	3.54	4.22	+1.33
6.711 (4.170)	3.05	3.05	+.00	3.42	3.95	+0.90
7.017 (4.360)	3.00	3.17	+.17	3.60	4.32	+1.32
7.403 (4.600)	4.10	3.46	-.64	4.09	4.56	+0.46
0.640 (0.400)	3.55	3.25	-.30	3.28	4.73	+1.18

TOTAL = -0.96 ÷ 10 ÷ 4" = -0.02 /in.

Fortunately, FWD values taken before and after the CRBP indicate that structural loss due to the recycle activity was minimal in the case of this project, resulting in a reduction in the difference between the design SN and the actual post-construction SN.

THE CONSTRUCTION TEST SECTION:

Section 415 of the Agency's Supplemental Specifications directs the construction of a test section (TS) prior to cold recycle activity on any project. The intent of this requirement is twofold. The first function of the test section is to provide a means for the contractor to demonstrate that the ability of his equipment and procedure are capable of accomplishing the goals of the project, and to make modifications to each as necessary. Secondly, the test section provides a site for process control sampling, either before construction begins or very early during project construction. Process control determines the best asphalt emulsion (AE) addition rate to achieve optimum density. Section 415 gives the contractor the option of doing the control testing either before the test section is constructed with cored material which has been pulverized to emulate the characteristics of the milled material, or with milled material from the test section. In the case of the Derby-Charleston project, the testing was done under both sets of conditions,

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giving somewhat different results. The first samples, in the form of cores, were taken at the designated test section in early June of 1993 prior to its construction and the optimum density was determined through testing by an independent laboratory. The Marshall series was run with a controlled moisture content of 2% and the best results were achieved with an AE addition rate of 1.1% at that time. Subsequently, samples of the millings were taken during the construction period and a different optimum value was derived.

EXPERIMENTAL CONTROL AND TEST SECTIONS:

The following table shows the location of each of the test sections (including the two control sections) and the treatment within each:

TEST SECT.	km	(MM)	TOWN	TREATMENT & BIT. OVERLAY
1.00	1.609	(1.00)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
1.27	2.044	(1.27)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
1.40	2.253	(1.40)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
2.00	3.219	(2.00)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
2.84	4.570	(2.84)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
3.318	5.340	(3.318)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
3.80	6.115	(3.80)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
4.17	6.711	(4.17)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
4.36	7.017	(4.36)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
4.60	7.402	(4.60)	Derby	CRBP + 83 mm (3.25 in) Bit.Conc.
0.357	0.575	(0.357)	Charleston	CRBP + 83 mm (3.25 in) Bit.Conc.
0.63	1.014	(0.63)	Charleston	Control 76 mm (3.25 in) Bit.Conc.
0.71	1.142	(0.71)	Charleston	Control 76 mm (3.25 in) Bit.Conc.

TS Derby	Cracks m/100 m (ft/100 ft)	Ave Ruts mm (1/16 in)	IRI mm/km (in/mi)
1.00	554(554)	7 (5)	DERBY km 1.287
1.27	434(434)	5 (3)	(mm 0.80)
1.40	411(411)	10 (6)	
2.00	309(309)	8 (5)	
2.84	1034(1034)	6 (4)	CRBP
3.318	1240(1240)	13 (8)	Av. 3472 (220)
3.80	1520(1520)	8 (5)	
4.17	1366(1366)	10 (6)	
4.36	1180(1180)	8 (5)	
4.60	410(410)	11 (7)	
Charleston			(mm 0.630)
0.357	830(830)	11 (7)	CHARLESTON km 1.013
0.630	405(405)	8 (5)	Control
0.710	666(666)	11 (7)	Av. 3678 (233)
			CHARLESTON km 1.287
			(mm 0.80)

Long term evaluation of this project will be accomplished through observation of eleven test sections (TS) and their comparison with the two standard overlay control sections. Each of the test sections is 30.48 m (100 ft) long and will be monitored on an annual basis for cracking and rutting. Both of these attributes were measured at each of the Test Sections described above prior to the construction.

CONSTRUCTION HISTORY:

Recycle activity for the Derby-Charleston project STP 9248(1) C/1 and C/2 began on 6/14/93 and was completed 12 days later on 6/25/94. The first day of activity included the construction of a test strip between km 1.287 (MM 0.800) and km 1.456 (MM 0.905), and four samples of the millings were taken for process control testing. The optimum density of this material was determined through a second Marshall series, resulting in a best AE addition rate of 0.75%. Finally, a third sampling was tested on 6/17/94, resulting in a duplication of the results derived from the first milled samples (i.e. 0.75%). The large disparity between the cored and crushed samples taken prior to construction of the test strip and the milled samples was noted, and the decision was made jointly by the contractor and the resident engineer to start the recycle process with an AE application rate of 1.25% and to adjust as indicated. Based on the final project quantities of 159.72 t (3514 CWT) for Item 404.65 (mod.), 59,482 m^2 (71,142 SY) for Item 415.20, Cold Recycled Bituminous Pavement, and a unit weight of the recycled material of 2,122 kg/m^3 (132.2 lbs/cf), the average AE addition rate for the project was 1.24 %. The final production rate for the CRBP item was 4,957 m^2/day (5929 SY/day).

Prior to the commencement of resurfacing activity, cores were taken in the recycled material at various points on 07/06/93 to check recovery depth. The results were as follows:

km	MM	Pos.	Recovery	Days Cured
1.48	0.92	Rt.	82.55 mm (3.25 in)	22
1.48	0.92	Rt.	88.90 mm (3.50 in)	22
2.671	1.66	Rt.	50.8 mm (2.00 in)	21
6.534	4.06	Rt.	38.1 mm (1.50 in)	19
5.311	3.30	Lt.	38.1 mm (1.50 in)	12
1.915	1.19	Lt.	38.1 mm (1.50 in)	11

Paving operations began on 7/09/93 and continued through 09/08/93. Compaction tests were run on the recycled material on 07/12/93 and all results were acceptable, ranging from 92.1% to 93.4%. Four cores taken on the Type II binder course on 07/16/93 were analyzed on 03/14/94, yielding an average recovery depth of 31.75 mm (1.25 in) and an average unit weight of 2,142 kg/m^3 (133.4 lb/cf). When follow-up cores were taken in late May of 1994, average depth of the two courses of pavement was 79 mm (3.1 in), and average recovery depth and unit weight of the recycled material were 106 mm (4.16 in) and 2,229 $kg/^3$ (138.9 lb/cf), respectively.

POST CONSTRUCTION OBSERVATIONS:

The project was surveyed for post-construction conditions on 10/06/93 and no cracking or rutting was detected on any of the test sections at that time. IRI testing was done on the completed project on 09/20/93 and average IRI was 994 mm/km (63 in/mi).

COSTS:

The cost to reclaim 101.6 mm (4 in) of pavement on the Derby-Charleston STP 9248(1)S project was $\$2.54/m^2$ ($2.12/SY). The total cost included $\$1.98/m^2$ ($1.65/SY) for item 415.20 and an average cost of $\$0.56/m^2$ ($0.47/SY) for the asphalt emulsion. The total cost of the pavement rehabilitation, including the addition of 82.6 mm (3.25 in) of bituminous concrete pavement was $\$9.54/m^2$ ($7.97/SY). The cost of the 82.6 mm (3.25 in) overlay alone was $\$7.00/m^2$ ($5.85/ SY).

PRELIMINARY OBSERVATIONS AND CONCLUSIONS:

After one winter, the project appears to be performing very well. A drive-by survey was performed by research personnel during early May of 1994 to evaluate the extent of cracking. The only cracking that was observed was at bridge approaches (minor transverse cracking) and at the two control (3.25" overlay) test sections, TS 0.63 and TS 0.71, which had 105 m/100 m (105 ft/100 ft) and 471 m/100 m (471 ft/100 ft) of (predominantly reflective) cracking respectively.

FOLLOW-UP:

Performance monitoring for the Derby-Charleston project will continue on an annual basis until the effectiveness of the treatment has been established.

COLD-IN-PLACE RECYCLE
DERBY-CHARLESTON
VT 105
COMPLETED 1993