PAVEMENT LIFE RESEARCH PROJECT
INTERSTATE 89
BOLTON-COLCHESTER MM 71/50-91/20

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Reporting On
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STATE OF VERMONT
AGENCY OF TRANSPORTATION
MATERIALS & RESEARCH DIVISION

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ABSTRACT

This study was undertaken to determine what rehabilitation method(s) should be specified to correct existing pavement distress and prevent additional failures from occurring on the Bolton-Colchester Interstate overlay project constructed in 1975.

The report includes information on problems which occurred from the time of construction to the present period and the current condition of the roadway.

The results of an extensive laboratory testing program offer assurance that the 1975 overlay material can be either hot or cold recycled satisfactorily.

A total of 11 different treatments were considered for use on the subject area with 5 considered potentially satisfactory candidates.

The final recommendation is to remove the 1975 overlay and specify either an Open Graded Asphalt Friction Course, hot recycling by batch plant or drum mixer or a standard bituminous concrete overlay on the 7.6 mile northbound section and postpone treatment on the 20.3 mile southbound lane until the performance of the northbound section can be evaluated.

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INTRODUCTION

In 1975, pavement overlay projects were let on Interstate Route 89 covering a length of 20.3 miles (Bolton-Williston I 89-2 (23) and Williston-Colchester I 89-3 (51) (MM 71/50-91/70). The projects included an area composed of all or part of ten initial construction contracts which had been completed 11 to 13 years earlier and had been opened to traffic in November of 1963 and 1964.

The justification for the overlay projects was based on a review of field observations and measurements which revealed "considerable rutting, longitudinal and transverse cracking --- wheel path cracking --- pitting and loss of matrix --- surface moisture penetration". The analysis indicated that "the existing pavement is deficient in structural strength for today's traffic and related loads and is inadequate for the projected requirements".

The specification for the 1975 overlay included a strain relieving interlayer (SRI) which had shown conclusive benefits in reducing reflective cracking in pavements following experimental applications on Interstate 91 in Putney (1973) and Derby (1974). The treatment consisted of vulcanized rubber shreds and fine aggregate in an emulsion slurry placed in a 3/8 inch total thickness.

Placement of the rubber slurry began in June of 1975. As the project progressed and the first of two courses of bituminous mix was placed over the SRI, pavement distress in the form of shoving or raveling was observed at random locations following exposure to traffic. During the removal of distressed pavement, observations revealed that the bituminous concrete

was experiencing severe stripping problems. A number of adjustments were made in the construction procedure and materials in an attempt to combat the problem. They included increasing the first course of pavement from 1 inch to 1 1/2 inches, changing the asphalt from AC 5 to the more viscous AC 10 grade, switching from Type III to the more stable Type II mix and prohibiting traffic until both courses were in place. The changes appeared to reduce the level of pavement failure but did not totally eliminate the problem. Accordingly, a decision was made to discontinue the use of the rubber slurry on the remaining 12.8 miles of northbound highway from the area of Richmond Interchange to Colchester (MM79/05 - 91/84).

During the past four years, areas treated with the SRI have required random pavement removal and replacement which has consumed an increasing amount of maintenance funds. In all cases, the distress has occurred in the form of raveling of the 1975 overlay with the major cause attributable to stripping of the asphalt from the coarse aggregate. The stripping action is initiated by a number of factors working in different combinations. The SRI is undoubtably the major factor due to its tendency to act as a moisture barrier or dam which causes surface moisture to be retained in the overlay. This belief is supported by the increased requirement for pavement patching immediately following extended periods of wet weather. The flexibility of the interlayer also tends to reduce the overall stability of the overlay under traffic. The belief that the SRI is a major factor leading to the stripping action is supported by the fact that the 12.8 miles of Northbound overlay placed

without the SRI has not developed any areas of distress. Other contributing factors include the coarse aggregates' basic susceptability to stripping, the asphalt in the bituminous mix, and the traffic volume on the roadway.

This study was undertaken to determine what rehabilitation method(s) should be specified to correct existing pavement distress and prevent additional failures from occurring on the 1975 overlay project.

Preliminary findings presented in an initial report completed in February 1980 have been restated in this final report.

PRESENT ROADWAY CONDITION

A detailed survey of the north and southbound lanes was completed on December 27, 1979. The survey revealed a total of 538 patches, totaling approximately 4,060 square yards in area, or 1 percent of the roadway surface. Approximately 94 percent of the patches are located in the travel lane; presumably due to higher traffic volumes, with the greatest share bordering on either the ten foot shoulder or the center Tine.

Sixty-three percent of the distress has occurred on the northbound lane where 386 patches, totaling 2550 square yards in area, amount to 2.4 percent of the roadway surface on the 7.6 mile section. Ninety-six percent of the patched area was noted in the travel lane.

The southbound lane contained 152 patches totaling 1510 sy. in area. The patches amounted to 0.5% of the roadway surface on the 20.3 mile section with 92% of the patched area located in the travel lane. It should be noted that 98% of the patches on the southbound lane were located on the northerly 11.1 miles of the roadway between the Colchester Interchange and a point 1 1/2 miles south of the Williston rest area at MM 80/60. A breakdown of the pavement condition between southbound interchanges is as follows:

Area	Length	# Of Patches	SY Patched Area
Colchester-Williston	7.61 Mi.	70	709
Williston-Richmond	5.80 Mi.	78	790
Richmond-Bolton	6.75 Mi.	4	12

The rate of pavement failure did not vary significantly during the period 1976 through 1979. The higher tonnage of hot mix used for patching in 1979 was due in part to poor weather conditions and the breakdown of equipment which prevented the completion of the late fall patching in 1978. A summary of the maintenance carried out is as follows:

Year	Tons Of Patch Material	% Of Total
1976	232	21
1977	203	19
1978	153	14
1979	493	46

Maintenance activities carried out following the pavement survey completed in December, 1979 through June 1980 resulted in the use of 56 additional tons of patching material. The relatively low level of spring maintenance required is believed due in part to lower than normal precipitation during the period.

Mays Meter readings taken in November 1979 on the northbound Bolton-Richmond section averaged 36.4 inches of roughness per mile while the southbound from Richmond to Williston averaged 27.9 inches and the Bolton-Richmond area averaged 25.4 inches. In comparison, the southbound from Bolton to Waterbury immediately south of the 1975 overlay was 163% rougher with an average of 66.7 inches per mile.

Temporary patch adjacent to previously repaired area

DISCUSSION OF RECYCLING FEASIBILITY

Since several different recycling methods were considered likely candidates for rehabilitating the distressed pavement, an extensive laboratory testing program encompassing nearly 400 tests was carried out by the Bituminous Concrete Subdivision. The testing was carried out on pavement samples taken from both the north and southbound sections of the interstate. The objectives of the investigation and the results obtained are as follows:

Acceptability for Cold Recycling

Tests to determine the correct asphalt and moisture contents for cold recycling were conducted according to previous test methods developed by the Research & Development Subdivision. The methods were established as a result of the Sherburne cold recycling project of 1978.

The tests were run using the only material available, a medium set emulsion that had a very soft base asphalt with a penetration value exceeding 300. Results of the testing indicate that the pavement can be cold recycled; even with an undesireable emulsion that gives a poor to fair coating and lower than desired stabilities. In all probability, a CMS-2 emulsion, such as that used sucessfully on the Sherburne project, would produce an acceptable stabilized base course for a new bituminous concrete pavement of proper depth.

Concern has been expressed that the use of cold recycled material as a base course may cause a rutting problem on a roadway with a heavy traffic volume, such as Interstate 89. Although only moderate rutting has occurred in the wheel paths of the travel lane on the recycled section of I 91 in

Derby, it is recognized that the traffic volume would be approximately five times greater on I 89. For this reason our recommendation would be to pulverize only the 1975 overlay if a cold recycling process was specified.

Rejuvenating Agent

Tests were conducted on samples of the existing surface pavement to determine if a rejuvenating agent would be required. The tests included gradation, asphalt content, properties of the asphalt cement recovered by the Abson Method, Marshall stability and flow, air voids, and unit weight. The average results of these tests indicated that the gradation, asphalt content and percent air voids of a 100 percent recycled mix would be within our specification limits for Type III mix. In addition, the average Marshall stability, flow and % air voids values were excellent; 1689, 12, and 5, respectively. Properties of the asphalt cement recovered from the Abson Method produced an average penetration of 55, and an average Absolute Viscosity of 7,208 poises at 140^{0} F. These results indicate that a rejuvenating agent would not be required if the material was to be hot or cold recycled.

Anti-Strip Requirement

Since the question of stripping aggregate is of great concern, several tests were conducted on the pavement in its existing condition and in a recycled condition. First of all, crushed pavement, which appeared to be suffering from severe stripping, was subjected to the stripping test (boiling method). No further stripping was evident. Next, crushed pavement was reheated, recoated and then subjected to the same test. Again less than 5 percent stripping was evident, an acceptable level which was repeated again in additional tests.

The results are puzzling since the virgin aggregate used in the mix is susceptible to stripping. Perhaps the results have something to do with the properties of the aged asphalt cement, which may resist stripping. An anti-strip agent would not be recommended for use with either of the cold recycling processes under consideration. It is recommended that an anti-stripping agent be used for hot recycling since it would include the use of virgin aggregate.

Hot Recycle Mix Design

The next segment of the lab investigation was to determine what mix properties could be expected from a hot recycled mix with varying percentages of pavement combined with virgin aggregates and additional asphalt cement. The tests were conducted using pavement samples taken from deteriorating areas on the northbound lane, which would be expected to produce the minimum in recycle values. Virgin aggregates were acquired from the two hot mix producers in the Burlington area. The asphalt cement used to achieve the desired asphalt content was a 150-200 penetration grade from Canada having a penetration of 152.

Gradations were run on the virgin aggregates and on extracted ~~samples of crushed pavement. Mixes were then designed utilizing 20, 30,~~ 40, and 50 percent crushed pavement combined with virgin aggregates and new asphalt cement. All mixes were designed within the specification limits for a type III mix with 6.4 percent asphalt content. A total of eight mixes were designed, four from each mix producer. Each mix was then produced and evaluated with the same series of tests that were run on the preliminary pavement samples. The average values obtained indicate that

the pavement in question can be hot recycled; either by means of a conventional hot mix plant or by a drum mix plant. The values also indicate that quality mixes can be produced utilizing any percentage of old pavement material consistant with the type of plant used. The average stability and percent air voids of these mixes were 898 and 4.1 respectively. The values obtained from testing the recovered asphalt cement, indicate that the addition of a 150-200 penetration grade asphalt cement, would rejuvenate the old asphalt cement sufficiently. The average Absolute Viscosity and penetration values were 1888 and 85 respectively. These values are equivalent to a new mix that would be made using an asphalt cement with a penetration in the range of 120-140. These results indicate that an 85-100 penetration grade could be used in a recycled mix if increased stability values were desired.

Effect of Rubber Slurry

The presence of the rubber slurry interlayer material in the hot recycle mix design test series did not have an adverse effect on mix values. Additional testing revealed negative effects on mix stability, air voids and flow values only when excessive amounts of rubber were added to a variety of recycle mixtures. The amount of rubber present in the existing pavement would not be detrimental to a recycled mix under normal conditions.

Summary of Recycling Feasibility

1. The 1975 overlay pavement can be cold recycled to provide an acceptable stabilized base course for a new bituminous concrete pavement of proper depth.

2. A rejuvenating agent would not be required to improve the properties of the old pavement.

3. An anti-stripping agent is recommended for use if the pavement is to be hot recycled.

4. A quality hot recycled mix can be made utilizing any percentage of old pavement material consistent with the type of plant used.

5. The presence of rubber slurry particles in the quantity that exists in the pavement would not be detrimental to a hot or cold recycled mix.

POTENTIAL CORRECTIVE TREATMENTS

A total of 11 different treatments were considered for use on the subject area. Furthermore, a number of different variations could be used with a majority of the treatments systems.

The treatments considered are as follows:

Cold Recycle (Bell & Flynn)

Cold Recycle (Sherburne Process)

In Place Hot Recycle

Hot Recycle (Plant Method)

Hot Recycle (Drum Mixer)

Pavement Patching & Bituminous Overlay

Bituminous Concrete Overlay

Open Graded Asphalt Friction Course

Pavement Resurfacing Membrane

Stress Absorbing Membrane Interlayer

Asphalt Rubber Surface Treatment

Objectives and values to be considered when evaluating prospective corrective treatments are:

1. Cost Effectiveness
    A. Potential for averting a premature failure.
    B. Initial cost vs. performance life.
    C. Prevention or reduction of reflective cracking.

2. User Comfort and Safety
    A. Surface ride.
    B. Friction values.
    C. Noise levels.

3. Energy Conservation
    A. Energy required to produce product.
    B. Energy required for equipment.

4. Conservation of Resources
    A. Utilization of existing roadway material.
    B. Asphalt required.

5. Roadway Interruption Time
    A. Inconvenience and cost to user.
    B. Safety.

Following are brief descriptions and comments on each treatment.

COLD RECYCLE
(USING BELL & FLYNN PAVEMENT RECLAMATION PROCESS)

DESCRIPTION - - Pulverize 1975 overlay.

- Add moisture, shape and compact the pulverized material.
- Place 1/2" leveling course.
- Place 1 1/2" wearing course, Type II mix.

COMMENTS - This process was used on 2 miles of I 91 in Derby, Vermont, in September 1974. The treated area has remained free of transverse cracks or serious rutting through the present date, a period covering six winter seasons. New Hampshire is using the process of 1 to 4 projects per year with similar success reported. They use $2.50 per s.y. for estimating purposes but are getting bid prices as low as $2.00 per s.y.. Stabilization of the pulverized pavement is achieved without the addition of asphalt, resulting in a savings of time, asphalt, and energy. Bell & Flynn can mobilize sufficient equipment to prepare 3 1/2 miles of 24' roadway per week.

ESTIMATE OF COST -

Pulverize and Shape (3"-24') $2.50/sy =	$ 35,200/Mile
1/2" Leveling (24') 396 Tons/mile @ $35.00/Ton =	13,860/Mile
1 1/2" Bituminous (24'+Taper) 1840 Tons/mile @ $35.00/Ton =	64,400/Mile
Total Cost Per Mile	$113,460/Mile

ADVANTAGES OF TREATMENT -

1. May retard reflective cracking.
2. Utilizes all existing pavement material.
3. Provides 40%± savings in energy over a removal & replacement treatment.

DISADVANTAGE OF TREATMENT -

1. Estimated 15% longer construction period (interruption to roadway users).
2. Rutting possible under heavy traffic volume.

COLD RECYCLE
(USING SHERBURNE PROCESS)

DESCRIPTION - - Pulverize 1975 overlay.

- Add moisture, asphalt, shape and compact pulverized material.
- Place 1/2" leveling course.
- Place 1 1/2" wearing course, Type II mix.

COMMENTS - This process was used on 1.5 miles of U.S. Route 4 in Sherburne, Vermont in October 1978. Performance of the test section has been satisfactory through two winter seasons. The process will utilize existing material and thereby conserve aggregate, asphalt, and energy. It may be difficult to pulverize the material placed in 1975 with cold planing equipment since the overlay is not securely bonded to the original pavement surface and will probably separate in large pieces. Lab tests indicate the pavement would produce an acceptable stabilized base course for a new bituminous concrete overlay.

ESTIMATE OF COST -

Pulverize, Stabilize, Shape (3"-24') $4.50/sy =	$ 63,360/Mile
1/2" Leveling (24') 396 Tons/Mile @ $35.00/Ton =	13,860/Mile
1 1/2" Bituminous (24'+Taper) 1840 Tons/Mile @ $35.00/Ton =	64,400/Mile
Total Cost Per Mile	$141,620/Mile

ADVANTAGES OF TREATMENT -

1. May retard reflective cracking.
2. Utilizes all existing pavement material.
3. Provides 35%± savings in energy over removal & replacement.

DISADVANTAGES OF TREATMENT -

1. Estimated 15% longer construction period (interruption to roadway users).
2. Cost is 25% higher than cold recycling with Bell & Flynn Method and 25% higher than the standard overlay.
3. Rutting possible under heavy traffic volume.

IN PLACE HOT RECYCLE

DESCRIPTION - - Remove 1975 overlay.

- Heat and scarify the upper 1 to 1 1/4" of pavement.
- Add and mix a liquid rejuvenator into the scarified pavement.
- Add 1 1/2" of new bituminous mix to the surface of the scarified pavement.
- Place 1 1/2" wearing course, Type II mix.

COMMENTS - This recycling process has been used with varying degrees of success in a number of states. The process was bid at approximately $2.85 per s.y. as an alternate treatment on I 91 in Springfield, Vermont in 1979.

ESTIMATE OF COST -

Pavement removal (24') 14080 sy/Mile @ $2.00/sy	=	$ 28,160/Mile
Heat, scarify, additive and pave @ $2.85/sy	=	40,128/Mile
3" Bituminous (24') 2376 Tons/Mile @ $35.00/Ton	=	83,160/Mile
Total Cost Per Mile		$151,448/Mile

ADVANTAGE OF TREATMENT -

1. May reduce the rate of reflective cracking.

DISADVANTAGES OF TREATMENT -

1. Does not utilize existing pavement overlay material.
2. Cost 35% higher than the standard overlay.

HOT RECYCLE
(USING STANDARD BATCH PLANT)

DESCRIPTION - - Remove 1975 overlay.

- Size and stockpile the processed material.
- Produce recycled mix.
- Place 1 1/2" lift of the recycled mix.
- Place 1 1/2" wearing course, Type II mix.

COMMENTS - The process will utilize a portion of the existing material and thereby conserve aggregates and asphalt. Region 15 Demonstration Project funds would be available to Vermont if hot recycling is utilized. Lab tests indicate a quality hot recycled mix can be made utilizing the old pavement material.

ESTIMATE OF COST -

Pavement removal (24') 14080 sy/Mile @ $2.00/sy =	$ 28,160/Mile
Crush, mix, and pave 1 1/2" lift = 1188 Tons/Mile @ $35.00/Ton =	41,580/Mile
1 1/2" Bituminous (24') 1188 Tons/Mile @ $35.00/Ton =	41,580/Mile
Total Cost Per Mile	$111,320/Mile

ADVANTAGES OF TREATMENT -

1. Process could utilize up to 30% of the material removed.

DISADVANTAGES OF TREATMENT -

1. Lack of experience with hot recycling increases the risk of problems.
2. Process will not eliminate reflective cracking.

HOT RECYCLE
(USING A DRUM MIXER)

DESCRIPTION - - Remove 1975 overlay.

- Size and stockpile the processed material.
- Produce recycled mix.
- Place 1 1/2" lift of the recycled mix.
- Place 1 1/2" wearing course, Type II mix.

COMMENTS - The use of a drum mixer could double the amount of allowable recycled material which could be used in a hot recycling process. Maine completed a 19 mile project in 1979 using 100% recycled material at a cost of $16.00 per ton or a $5.00 per ton savings over their average cost for bituminous concrete. Use of a drum mix plant may require an EPA polution variance. Selection of this process could encourage bids by a larger number of contractors. Region 15 Demonstration Project funds would be available to Vermont if hot recycling is utilized. Lab tests indicate a quality mix can be made utilizing the old pavement material.

ESTIMATE OF COST -

Pavement Removal (24') 14080 sy/Mile @ $2.00/sy =	$ 28,160/Mile
Crush, Mix, and Pave 1 1/2" Lift = 1188 Tons/Mile @ ~~$35.00/Ton~~ =	~~41,580/Mile~~
1 1/2" Bituminous (24') 1188 Tons/Mile @ $35.00/Ton =	41,580/Mile
Total Cost Per Mile	$111,320/Mile

ADVANTAGES OF TREATMENT -

1. Process could utilize up to 70% of the material removed.

DISADVANTAGES OF TREATMENT -

1. Lack of experience with hot recycling increases the risk of problems.
2. Process will not eliminate reflective cracking.

PAVEMENT PATCHING & BITUMINOUS OVERLAY

DESCRIPTION - - Patch existing pavement as required.

- Apply tack coat.
- Place 1" binder course, Type III mix.
- Place 1" wearing course, Type III mix.

COMMENTS - This treatment could be considered on the southerly 9 miles of the southbound roadway where patching has been required on only 25 square yards of surface area.

ESTIMATE OF COST -

Patch removal 119 sy/Mile @ $5.00/sy =	$ 595/Mile
Patch Material 20 Tons/Mile @ $35.00/Ton =	700/Mile
Tack Coat 60 CWT/Mile @ $16.50/CWT =	990/Mile
1/2" Leveling Course 396 Tons/Mile @ $35.00/Ton =	13,860/Mile
2" Bituminous (24'+ Taper) 2426 Tons/Mile @ $35.00/Ton =	84,910/Mile
Total Cost Per Mile	$101,055/Mile

ADVANTAGES OF TREATMENT -

1. Shortest period of interruption to users.
2. Cost 11% lower than the standard overlay.

DISADVANTAGES OF TREATMENT -

1. Potential for failure great if maintenance procedure fails to remove all unstable pavement areas.
2. Requires 19% more bituminous mix than the standard overlay.
3. Does not reduce reflective cracking.

BITUMINOUS CONCRETE OVERLAY
(CONSIDERED THE STANDARD TREATMENT FOR COMPARISON PURPOSES)

DESCRIPTION - - Remove 1975 overlay.

- Apply tack coat.
- Place 1/2" leveling course.
- Place 1 1/2" binder course, Type II mix.
- Place 1" wearing course, Type III mix.

COMMENTS - The utilization of a standard overlay procedure reduces the risk of unanticipated problems which often occur with experimental treatments.

ESTIMATE OF COST -

Pavement Removal (24') 14080 sy/Mile @ $2.00/sy =	$ 28,160/Mile
Tack coat (24') 60 CWT/Mile @ $16.50/CWT =	990/Mile
1/2" Leveling (24') 396 Tons/Mile @ $35.00/Ton =	13,860/Mile
2 1/2" Bituminous (24') 1980 Tons/Mile @ $35.00/Ton =	69,300/Mile
Total Cost Per Mile	$112,310/Mile

ADVANTAGES OF TREATMENT -

1. Provides low risk of premature failure.

DISADVANTAGE OF TREATMENT -

1. Does not utilize existing pavement material.
2. Does not reduce reflective cracking.

OPEN GRADED ASPHALT FRICTION COURSE

DESCRIPTION - - Remove 1975 overlay including shoulder material.

- Apply tack coat.
- Place 1/2" leveling course.
- Place 3/4" Open graded asphalt friction course.

COMMENTS - This treatment would offer a high probability of success based upon the performance of friction courses placed on I 91 in Norwich-Fairlee and I 89 in Royalton-Randolph. The surface provided is safer and quieter and may reduce winter maintenance costs.

ESTIMATE OF COST -

Pavement removal (38') 22,294 sy/Mile @ $2.00/sy =	$44,588/Mile
Tack coat 60 CWT/Mile @ $16.50/CWT =	990/Mile
1/2" Leveling (24') 396 Tons/Mile @ $35.00/Ton =	13,860/Mile
3/4" Friction Course (24') 624 Tons/Mile @ $35.00/Ton =	21,840/Mile
Total Cost Per Mile	$81,278/Mile

ADVANTAGES OF TREATMENT -

1. Provides safe, quiet riding surface.
2. Cost 28% lower than the standard overlay.
3. Requires 57% less bituminous mix than the standard overlay.
4. Reduces the rate of reflective cracking.

DISADVANTAGES OF TREATMENT -

1. Does not utilize existing pavement material.

PAVEMENT RESURFACING MEMBRANE

DESCRIPTION - - Remove 1975 overlay.

- Apply tack coat.
- Place 1/2" leveling course.
- Place pavement resurfacing membrane (fabric).
- Place 1 1/2" binder course, Type II mix.
- Place 1" wearing course, Type III mix.

COMMENTS - The four more commonly used fabrics installed on a 1200 lineal foot section of Route 15 in Colchester have not reduced reflective cracking in the 1 1/2" bituminous concrete overlay. However, information from other States including New Hampshire indicates the fabrics can reduce the level of reflective cracking when they are placed beneath overlays of 2 1/2" or greater thickness. Maine reports that the fabrics have reduced reflective cracking by 25% on a section overlaid with 3 to 3 1/2" of pavement.

ESTIMATE OF COST -

Pavement removal (24') 14080 sy/Mile @ $2.00/sy	=	$ 28,160/Mile
Tack coat (24') 60 CWT/Mile @ $16.50/CWT	=	990/Mile
~~1/2" Leveling 396 Tons/Mile @ $35.00/Ton~~	=	~~13,860/Mile~~
Fabric & tack coat 14080 sy/Mile @ $2.00/sy	=	28,160/Mile
2 1/2" Bituminous 1980 Tons/Mile @ $35.00/Ton	=	69,300/Mile
Total Cost Per Mile		$140,470/Mile

ADVANTAGE OF TREATMENT -

1. May reduce the rate of reflective cracking.

DISADVANTAGES OF TREATMENT -

1. Does not utilize existing pavement material.
2. Cost 25% higher than the standard overlay.

STRESS ABSORBING MEMBRANE INTERLAYER (SAMI)

DESCRIPTION - - Remove 1975 overlay.

- Apply tack coat.
- Place 1/2" leveling course.
- Place Stress Absorbing Membrane Interlayer.
- Place 2 - 1" wearing courses, Type III mix.

COMMENTS - The one mile section of asphalt rubber stress absorbing membrane interlayer placed on I 91 in Springfield did not prevent reflection cracks from occurring in a 1" bituminous concrete overlay.

ESTIMATE OF COST -

Pavement removal (24') 14080 sy/Mile @ $2.00/sy =	$ 28,160/Mile
Tack coat (24') 60 CWT/Mile @ $16.50/CWT =	990/Mile
1/2" Leveling Course (24') 369 Tons/Mile @ $35.00/Ton =	13,860/Mile
Membrane Interlayer (24') @ $2.00/sy =	28,160/Mile
2" Bituminous (24') 1584 Tons/Mile @ $35.00/Ton =	55,440/Mile
Total Cost Per Mile	$126,610/Mile

ADVANTAGES OF TREATMENT -

1. Cracks in the bituminous overlay partially heal during ~~warm weather.~~

DISADVANTAGES OF TREATMENT -

1. Does not utilize existing pavement material.
2. Does not eliminate reflective cracking.
3. Cost 13% higher than the standard overlay.

ASPHALT RUBBER SURFACE TREATMENT (SAM)

DESCRIPTION - - Remove 1975 overlay.

- Apply tack coat.
- Place 1/2" leveling course.
- Place 2 - 1 1/4" courses, Type III mix.
- Place Asphalt Rubber Surface Treatment.

COMMENTS - Our limited experience with the treatment on I 91 in Springfield and on I 89 in Richmond indicates the treatment is susceptible to the loss of cover stone and does not prevent underlying cracks from reflecting up through the surface treatment.

ESTIMATE OF COST -

Pavement removal (24') 14080 sy/Mile @ $2.00/sy =	$ 28,160/Mile
Tack coat (24') 60 CWT/Mile @ $16.50/CWT =	990/Mile
1/2" Leveling Course (24') 396 Tons/Mile @ $35.00/Ton =	13,860/Mile
2 1/2" Bituminous (24') 1980 Tons/Mile @ $35.00/Ton =	69,300/Mile
Asphalt Rubber Surface Treatment @ $2.00/sy =	28,160/Mile
	$140,470/Mile

ADVANTAGES OF TREATMENT -

1. Surface cracks partially heal during warm weather.

DISADVANTAGES OF TREATMENT -

1. Greater risk of failure than with other potential treatments.
2. Does not utilize existing pavement material.
3. Does not eliminate reflective cracking.
4. Estimated 5% longer construction period (interruption to roadway users).
5. Cost 25% higher than the standard overlay.

SUMMARY

Performance and cost information combined with physical requirements suggest that of the 11 treatments considered, only 5 are worthy of further consideration. The 5 treatments (not necessarily listed in order of preference) and their major advantages are as follows:

Cold Recycle (Bell & Flynn)

May reduce reflective cracks, utilizes all existing material, provides savings in energy.

Hot Recycle (Batch Plant)

Utilizes up to 30% of the existing material.

Hot Recycle (Drum Mixer)

Utilizes up to 70% of the existing material.

Bituminous Concrete Overlay

Non-experimental, provides the lowest risk of premature failure.

Open Graded Asphalt Friction Course

Provides safe, quiet riding surface, cost 28% less than the standard overlay, requires 57% less bituminous mix than the standard overlay.

The 6 treatments not recommended for use are as follows:

Pavement Patching and Bituminous Overlay, the only treatment which does not include the removal of the 1975 overlay, is not recommended due to the risk of continuing random failures.

Although satisfactory performance would be expected from the Sherburne method of Cold Recycling, it is not recommended due to high construction costs.

In Place Hot Recycle, Pavement Resurfacing Membrane, Stress Absorbing Membrane Interlayer and Asphalt Rubber Surface Treatment are not recommended for use based upon increased construction cost without any substantial guarantee of increased pavement life.

FINAL RECOMMENDATIONS

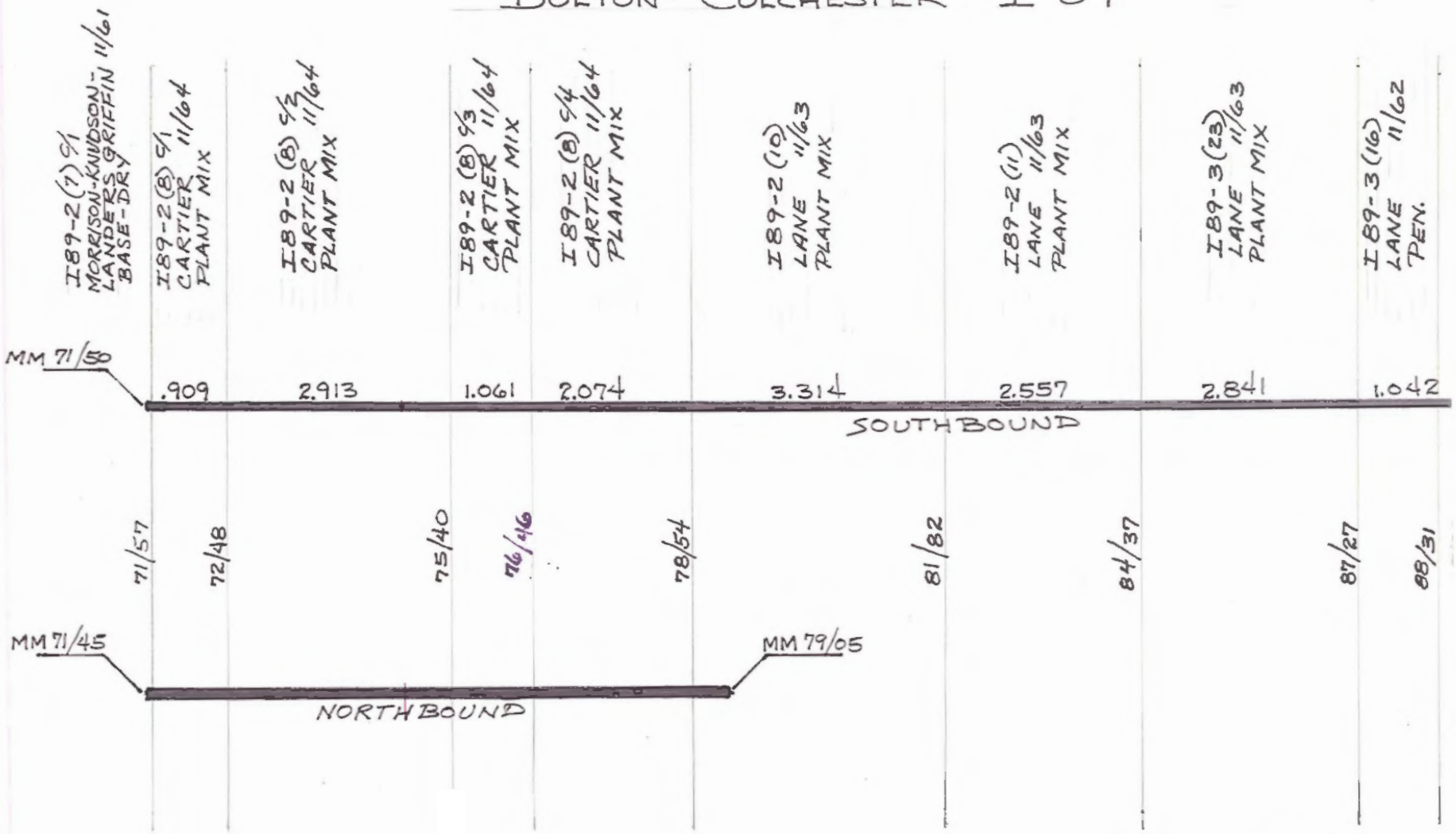
Based upon the condition of the existing roadway and the potential rehabilitative treatments available to the Agency, corrective treatment is recommended as follows:

1. Remove the 1975 overlay and specify either an Open Graded Asphalt Friction Course, hot recycling by batch plant or drum mixer, or a standard bituminous concrete overlay on the 7.6 mile northbound section.

2. Postpone treatment of the northerly 11 mile section of the southbound lane until the performance of the northbound section can be evaluated for at least 1 full year.

3. Postpone treatment of the southerly 9 mile section of the southbound lane until surface conditions require rehabilitative treatment.

BOLTON - COLCHESTER I-89



SOUTHBOUND

0.07 MILE DRY BASE
16.853 MILES PLANT MIX
3.388 MILES PEN.

TABLE 2

COST & BITUMINOUS MIX SUMMARY

Treatment	Cost/S.Y.	Cost/Mile	Tons Bituminous Mix/Mile
Cold Recycle (Bell & Flynn)	$ 8.06	$113,460	2236
Cold Recycle (Sherburne Process)	10.06	141,620	2236
In Place Hot Recycle	10.76	151,448	2376
Hot Recycle - Plant Method	7.91	111,320	2376*
Hot Recycle - Drum Mixer	7.91	111,320	2376**
Pavement Patching & Bituminous Overlay	7.18	101,055	2822
Bituminous Concrete Overlay	7.98	112,310	2376
Open Graded Asphalt Friction Course	5.77	81,278	1020
Pavement Resurfacing Membrane	9.98	140,470	2376
Stress Absorbing Membrane Interlayer	8.92	126,610	1980
Asphalt Rubber Surfact Treatment	9.98	140,470	2376

* Includes up to 356 tons of recycled material.

** Includes up to 832 tons of recycled material.