EXPERIMENTAL USE OF COLD RECYCLED ASPHALT PAVEMENT ON VERMONT ROUTE 64

REPORT 88-2

MARCH 1988

REPORTING ON WORK PLAN 81-R-13

WILLIAMSTOWN ROUTE 64
HMA 2109

STATE OF VERMONT
AGENCY OF TRANSPORTATION

Susan C. Crampton, Secretary of Transportation
David B. Kelley, P.E., Director of Engineering and Construction
John R. Phalen, P.E., Materials and Research Engineer

Prepared By
Research & Development Subdivision

Reviewed By:
J R Phalen
John R. Phalen, P.E.,
Materials and Research Engineer

DATE: March 16, 1988

"The contents of this report reflect the views of the author who is responsible for the facts and the accuracy of the data presented herein. This report does not constitute a standard, specification or regulation. Anyone, other than the Agency using this report does so with awareness that the Agency does not guarantee the opinions, findings, or conclusions contained therein."

TABLE OF CONTENTS

ABSTRACT

Two and six tenths miles of Vt. Route 64 in the Town of Williamstown, Vermont were selected for cold recycling with fragmented bituminous concrete pavement available from runways at the E. F. Knapp airport in Berlin, Vermont. The existing surface treated gravel roadway was paved with a 2"± course of cold mix and then given a chip seal coat. The cold mix was made with a CSS-1 asphalt emulsion which included 30% RECYFLEX, an asphalt rejuvenator. The chip seal used a CRS2 emulsion.

This report includes detailed construction records and cost comparisons between the cold recycling process and the standard maintenance procedure plus comments on initial performance.

Based upon initial observations, the procedure and equipment appeared to be practical from the standpoint of construction feasibility and cost. Although the project did not achieve long term performance due to a number of factors, the study suggests that the use of reclaimed pavement as a cold mix overlay can result in significant cost, energy and resource savings.

INTRODUCTION

The increasing cost and scarcity of natural resources has caused many local and state transportation agencies to search for alternative methods of producing bituminous concrete overlays for existing roadways. Recycling asphalt pavement into hot and cold mixes is one method where significant savings might be realized.

This report deals with a recycled cold mix consisting of asphalt pavement that has been removed, processed, then combined with an asphalt emulsion binder. New aggregate was added to bring the material within the required gradation specifications. In addition, Recyflex, a commercially available additive, was included in the mix to rejuvenate the old asphalt.

An advantage of cold mix is that a high rate of production can be achieved. This is due to: continuous mixing rather than batching; portablilty of equipment; and low minimum temperature requirements. Although continuous mixing provides for high production rates, it also reduces the control over mixing ratios that is found in batching operations.

Haul distance can be reduced with portable mixing equipment in a cold mix recycle operation, especially when the road surface of the project is the source of the pavement to be recycled.

There are limitations to the use of cold mix. For example, the surface moisture content of the aggregate (or recycled pavement) has to be approximately 3% to facilitate good coating. Too little or too much surface moisture can cause problems in mixing, compaction or curing. A seal coat is needed when cold mix is used as a surface or wearing course.

This report examines the use of recycled asphalt pavement that was removed from an airport runway and used in a cold mix overlay. The project was undertaken by maintenance forces in the summer of 1981. A cost comparison is also made with conventional hot-mix applications. Performance and environmental benefits are also addressed.

BACKGROUND AND PRECONSTRUCTION CONDITION

The experimental construction took place on a section of Vermont Route 64, located in Williamstown, Vermont. This highway connects Vermont Route 12 in Northfield and Vermont Route 14 in Williamstown. The only major intersection is with Interstate 89, which meets VT 64 approximately 0.3 mile east of the Williamstown-Northfield Town Line. The overlay took place in Williamstown, beginning 0.3 mile east of Interstate 89 on a section of roadway locally known as Mill Hill.

Pertinant weather data for that area shows an air-freezing index of 2161. The average annual snowfall is 77 inches and there are approximately 118 freeze-thaw cycles per year.

The 2.6 mile treated roadway section has a winding horizontal alignment. Its 24 curves have degrees of curvature ranging from 2.8° to 17.5°. The vertical alignment has steep grades some of which are as much as 13%. The pavement was classified as surface treated gravel with the last treatment being accomplished in 1955. Friction data for the preconstruction surface was last collected in 1978. The SN_{40} for the project location was 45.6, which was a satisfactory value.

The photo above shows preconstruction condition (on the left) compared with the newly laid recycled pavement before sealing on the right.

Four locations were chosen as test sections to document the existing roadway condition. Each test section was 150' long and the combined lengths represented approximately 4% of the project length. Each section was analyzed for rutting and cracking. The rutting in the wheel path was between 4/16" and 15/16". There were 608 linear feet of cracks per 100' of road. Only one percent of the cracks were transverse. There were no transverse cracks that ran the entire width of the roadway which averaged 23.3'.

RECYCLED MATERIAL

Recycled material for the project was obtained from the E. F. Knapp airport in Berlin, Vermont. It consisted of base and surface coarse material that had been removed from a runway and stockpiled at the airport for approximately one year before the project began. It was estimated that there were about 2,000 cubic yards of material (2520 tons).

A 1-1/2" wearing course was planned with no leveling course. It was estimated that the material would produce about 2.6 miles of overlay.

Samples of the material were taken and crushed in a portable crusher. The crushed material was sent to Mulco, Inc. of Canada for testing. Several tests using different emulsions were performed as well as a sieve analysis.

The stockpiled material had pieces up to two feet in diameter and had to be crushed before it was usable. A portable crusher was used to process the material. During the crushing operations, samples of the processed material were taken by A.O.T. personnel and analyzed for gradation and asphalt content. The average gradation of the processed material was similar to Vermont State specifications for Type I bituminous concrete mix.

GRADATION OF PROCESSED PAVEMENT

Sieve	Mulco, Inc. % Passing*	AOT Lab % Passing**	Type I % Passing Specifications
1 1/2	100	100	100
1	93	90	95-100
3/4	92	82	74-86
1/2	79	56	60-80
#4	52	40	35-60
#8	2	2	0-4

* Result of 1 test ** Average of 14 tests

Extractions were performed on five samples of crushed material so that an average asphalt content could be found. This average was later used to calculate (approximately) the amount of asphalt to be added to the mix.

CRUSHING OPERATIONS

The portable crusher used to crush the airport material had a primary and a secondary system. Material was fed into the primary crusher which, using a screen and return belt, continually crushed material 2" and larger. Material smaller than 2" dropped into a secondary crusher which allowed only 1-1/2", or less, sized material to pass to the final conveyer belt. It was then emptied into an awaiting truck.

The crushing operation.

Crushing began during the second week of July. Initially some difficulty was encountered with large pieces jamming the hopper screen. This problem was solved by positioning two men with sledgehammers on a walkway to break apart the larger pieces.

Near the end of the crushing operation, the jaws of the crusher became worn. No adjustment was made immediately and this caused some material larger than 1 1/2" to be introduced into the stockpile.

Both actual and maximum production rates were calculated for the crusher. The overall production rate was 18 tons/hour.

Stockpile of crushed material.

The material was hauled about 13 miles from the crusher to where it was stockpiled at a district garage near the project site. The crushing operation lasted 14 days and produced 2520 tons of material.

CONSTRUCTION

Construction on Mill Hill began approximately two weeks after crushing began. The weather during the project was optimum for making cold mix. There was no precipitation; temperatures were between 50°F and 80°F and the humidity was low.

The mixing of the overlay took place at the district garage where the recycled material was stockpiled. A Barber-Greene portable pugmill, supplied by the contractor, was used for mixing.

The pugmill was rated to discharge three cubic yards of cold mix per minute at maximum speed. Two front end loaders were used to feed material into the pugmill hopper. The bottom of the hopper, moving back and forth, shook the material onto a conveyor belt. The flow of emulsion was controlled by a valve and meter which measured gallons per minute. The emulsion was applied to the pulverized pavement by spray bars located parallel to the twin shafts of the pugmill. Recycled material passed over the spray bars as it was dumped into the pugmill.

The emulsion used was a mixture of 70% asphalt emulsion (CSS-1), which is cationic and slow setting, and 30% Recyflex, an asphalt rejuvenator. It was delivered to the site by tankers which were then hooked directly to the control valve on the pugmill. The temperature of the first tanker of emulsion was 170°F. The contractor decided that a lower temperature would produce better coating, so subsequent loads were delivered at 145°F.

The pulverized pavement had a surface moisture content of 7.0% at the beginning of the project. The optimum moisture content recommended by the contractor was 3%, so it was decided to utilize one front end loader to aerate the pulverized pavement before loading it into the pugmill hopper. The moisture content after aeration dropped to between 4.0% and 5.8% where it remained for the duration of the project.

Based on the rated output of 3 cy/min. and an emulsion flow rate of 36 gal./min. an emulsion application rate of 12 gal./cy was computed. Later the output of the pugmill was determined to be 3.8 cy/min. based on the average time it took to fill 16 6-1/2 cy trucks. This change in the output caused a recomputed emulsion flow rate of 9.6 gal./cy. An observed incomplete coating of fine aggregate was then corrected by increasing the emulsion application rate to 11 gal./cy. This rate was later confirmed by dividing the total amount of emulsion used by the total amount recycled material.

$$\frac{22252 \text{ gal}}{2000} = 11.1 \text{ gal./cy}$$

A conventional paver was used for the placing of the cold mix. Since the old surface was to receive no patching or repair, and because of the severe rutting and potholing, a decision was made to make the surface course 2" rather than the originally planned 1-1/2". When completed the average thickness was 1-3/4". Because of the thickness and dryness of the mix, no heat was required on the paver screed. The material occasionally dragged on the screed due to infrequent, unusually large pieces of pulverized pavement which left holes in the surface. Very few other delays were encountered by the paver crew.

Each day's paving included both the eastbound and westbound lane. 3700 feet of roadway was done the first day, 5810 feet the second day and 4220 feet was paved the third day. Paving took 24.5 hours in the three days for a production rate of 560 feet of roadway per hour.

An eight ton steel-wheeled roller followed the paver. The surface was rolled twice, then 1/4" granite chips were placed at a rate of 10 to 15 lbs/SY. The chips were placed approximately 1000' behind the paver. A second roller was then used to set the chips into the cold mix. A minimum of 30 minutes elapsed before traffic was allowed on the surface.

When the emulsion application rate was increased, some sticking occurred on the wheels of the roller. This problem was corrected by spraying fuel oil on the roller wheels.

Application of the seal coat (chip seal) was begun during the second day of paving. The seal coat consisted of CRS-2 (a cationic, rapid setting emulsion) followed by 3/8" stone. The CRS-2 was applied at the rate of .35 gal./sy, and the stone was placed at a rate of 17 to 20 lbs./sy. Two 2000 gallon distributor trucks were used to spray the emulsion and a detachable hopper was used with several trucks to spread the stone. The surface was then rolled with a steel-wheeled roller. The 3/8" stone set well into the emulsion, although there was some loss when the surface was opened to traffic.

POST CONSTRUCTION CONDITION

The friction values of the completed surface averaged 47.9, a value slightly higher than that of the old pavement surface.

After construction the surface could be shoved with foot pressure. This condition persisted for several months, causing noticable rutting. Approximately one month after construction, agency personnel checked the four test sections to determine how much rutting had actually occurred. The worst rutting was found in test section two, located 1.1 mile east of the beginning of the project. Rutting in that section ranged from 5/16" to 12/16" while other sections ranged from 0" to 6/16". Visual observations also showed considerable shoving occurring on the steep grades.

Two months after construction the shoving had become bad enough in spots to warrant corrective action (See next photo). One area of the project was overlaid with conventional hot mix to remedy the problem. This section is located in the vicinity of test section three, 1.8 mile east of the beginning of the project. The section is located on two steep grades of 6.4% and 10%.

This photo shows a patch which has
been applied to correct shoving
in the recycled pavement overlay.

Cold mix is usually left for several months to cure before the seal coat is applied. This allows the solvent to completely evaporate which in turn causes the asphalt binder to harden. The severe rutting on Mill Hill may have been due in part to a lack of sufficient curing time. The water in the emulsion did not evaporate before the mix was sealed, which slowed the hardening rate and led to shoving and rutting.

This roadway is scheduled to be rebuilt beginning in the spring of 1988. It has been long recognized as substandard in horizontal and vertical alighment, width and ability to carry loads expected from heavy trucks and increased traffic.

Since the completion of the interstate in this area the road has been acting as an access road, a role for which it was not designed.

COST ANALYSIS

A conventional hot mix application would probably include a 3/4" leveling course, and a 1" wearing course. This means that a total of 1630 CY of hot mix would have been needed for the Mill Hill project. At 4000 lbs. per cubic yard, the total amount needed would be 3260 tons. In 1981 the District Engineer estimated that the in-place cost for hot mix was $32. per ton, based on projects completed during the previous year. The total cost for the Mill Hill project would then have been $104,320., or $3.11 per square yard.

The actual costs for the project in 1981 were:

	COLD MIX	HOT MIX
Labor	$10,922.24	Estimate
Equipment	11,911.50	@ $32./ton
Materials	54,094.22	in place...
Total	$76,927.96	$104,320.00
Per SY	$2.29	$3.11

The hot mix that was used to overlay the sections of road that had shoved increased the cost of the project. This increased cost was applied only to the .4 mile section where the hot mix was actually placed. The cost for that section was $3.68 per square yard.

ENVIRONMENTAL BENEFIT

The major environmental benefit to this type of overlay is the use of recycled pavement in place of new aggregate, which requires less energy than crushing stone or gravel for aggregate. Some crushed stone was used to increase the aggregate in the pulverized emulsified material, but much less than would be used normally.

The use of petroleum products usually associated with hot mix applications is reduced. No fuel is used to heat the aggregate and minimum amounts are needed to heat the emulsion. The portability of cold mix operations also makes the haul distances shorter, resulting in a fuel use reduction.

SUMMARY

The general condition of the existing roadway was very poor due to the presence of numerous cracks, patches and severe rutting. The overwhelming percentage (99%) of longitudinal cracks indicates insufficient base. The reclaimed pavement included up to 25% untreated subbase stone and topsoil which lowered the residual asphalt content to an average of 4%, and apparently increased the percentage of fines. A pugmill produced cold mix at a rate of 3.8CY per minute with 70% CSS-1 and 30% Recyflex added to the pulverized material at an average rate of 11 gallons per minute. Aggregate segregation was noted in the compacted pavement prior to application of 1/4" granite chips which were used in lieu of a light sand seal. A seal coat of CRS-2 emulsion and 3/8" stone was applied over the cold mix pavement the following day.

Wheelpath rutting was recorded at a number of locations approximately one month after placement. The most severe rutting, up to 3/4", was noted on test section number two. Pavement shoving also occurred at a few isolated locations and a .4 mile section of the eastbound lane in the vicinity of test section number three required a bituminous concrete overlay to remedy the problem. The rutting and shoving may have been partially due to insufficient curing of the cold mix prior to the application of the seal coat and also to lack of proper compaction.

The in-place cost of the recycled cold mix was $2.29 per square yard which was 26% less than the estimated cost of a 3/4" leveling course and a 1" wearing course of bituminous concrete pavement.

The poor performance of this project can be attributed mostly to several factors mentions throughout this report: insufficiant base material under the roadway; insufficient curing time before application of the seal coat; too much surface moisture in the material prior to adding emulsion; inadequate correlation of emulsion application and production rates, resulting in uncertainty about the percentage of emulsion and use of the roadway as a heavy traffic access road for which it was not designed.

CONCLUSION

Although the project did not achieve long term performance due to a number of factors the use of reclaimed pulverized pavement as a cold mix overlay can result in significant cost, energy, and resource savings. Due to its reduced stability its use should be limited to selected locations with comparatively low truck traffic and to roadways with subbases adequate to resist rutting and other forms of deformation. Another use for which recycled pavement appears suitable is as a base course when improving a gravel road.

Due to the planned reconstruction of this highway which will make further observation impossible, no further reporting is planned.