RECLAIMED BASE STABILIZATION
JAMAICA VT ROUTE 30

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16. Abstract

In 1986, VT Route 30 in Jamaica was rehabilitated using three different rehabilitation techniques. These were standard overlay, bituminous base stabilization with emulsified asphalt additive and bituminous base stabilization without the additive. Analysis of related performance data suggests the following:

1. The "selective recycling" concept appears to be cost effective.

2. The addition of emulsified asphalt to the recycled material seems to improve certain performance factors in some situations.

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RECLAIMED BASE STABILIZATION
JAMAICA VT ROUTE 30

INTRODUCTION:

This report describes the rehabilitation of a section of VT Route 30 in Jamaica. Project HMA 2639 was initiated to identify and implement the best construction solution for a section of VT 30 which had exhibited roughness, extensive cracking and other severe distortions of the roadway surface.

During the late autumn of 1984, an 8.85 km (5.5 mi) section was identified by the Pavement Management Team as a candidate for rehabilitation. The segment began at km 5.351 MM (3.325) in the village of Jamaica and ended at km 14.202 (MM 8.825). Selection was based on values for Pavement Serviceability Rating (PSR), International Roughness Index (IRI), the overall Highway Sufficiency Rating and the foundation component of the Highway Sufficiency Rating. A Materials and Research investigation and its related report, dated December 6, 1985, also included the following key information:

a) The existing pavement structure consisted of five to eight different courses with total thickness varying from 127 mm - 203 mm (5-8 in) and averaging 152 mm (6 in). Pavement condition varied considerably, with some sections exhibiting only superficial distress while other areas clearly showed evidence of foundational failures.

b) Beneath the failed pavement, the foundational structure was basically sound with good subbase and excellent subgrade materials.

c) Pavement failures were attributable to poor drainage, a sidehill location, a high water table and heavy truck traffic loading (ADT was approximately 2040 +/- in 1986 and percent trucks was approximately 10%).

The Materials and Research investigation report indicated a need for a treatment that would diminish the detrimental effects of subsurface water and offset the tendency of the heavily cracked existing pavement toward reflective cracking, while taking advantage of the relatively strong existing foundational base. One choice, untested in Vermont at that time, was reclaimed bituminous base stabilization. This treatment broke up the existing pavement, blended it in-place with the existing subbase and optionally added a stabilizing agent (emulsified asphalt) prior to compaction.

The Materials and Research report also suggested varying treatments, based on the changeable condition of the existing roadbed. This resulted in the "selective recycling" concept. In order to gain the best return on the recycling investment, only the more severely distressed segments of the 8.85 km (5.5 mi) project would receive full depth reclamation, while the remainder would get a leveling course and a 32 mm (1.25 in) standard overlay. Good engineering judgement was required to determine which sections would receive the base stabilization treatment and which would receive the standard overlay.

The Jamaica HMA 2639 project was the first full depth reclamation project in Vermont, and two questions relative to the process were raised during its development:

1. Is the "selective recycling" concept a viable one? Opponents suggested sections that were recycled would have different stability, stress points and compaction values and would be susceptible to differential settlements or frost heaves, especially in areas of transition.

2. Is the addition of a stabilizing agent to the pulverized pavement-subbase blend cost effective? This became a central issue.

Since reclaimed bituminous base stabilization was new in Vermont, a third question related to its cost effectiveness as compared with a standard overlay. No controls were specifically designed to evaluate this, however, and subsequent developments have shown that performance data acquired through this research cannot be used to support conclusions in respect to the overall cost effectiveness of the bituminous base stabilization rehabilitation technique.

PRECONSTRUCTION PERFORMANCE DATA:

Prior to the beginning of construction, the condition of the existing road surface was evaluated. The testing was conducted during the months of July and August of 1986. Average values for rutting, roughness and cracking are shown below.

RUTTING	IRI	CRACKING
24 mm	2210 mm/km	540 m/100 m
(15/16 in)	(140 in/mi)	(540 ft/100/ft)

The IRI appears to be low for a section of highway scheduled for rehabilitation. The "average" does not, however, present an accurate picture. The condition of the road is quite variable as noted previously, and the roughness data ranges from a low of 85 to a high of 296. This extremely variable nature of the pavement condition was one motivation for the "selective recycling" concept.

EXPERIMENTAL CONTROLS:

Three typical sections were designated as experimental controls within the project.

Standard Overlay:

Twenty segments containing test areas, representing 4.80 km (2.98 mi) (or approximately 54% of the project length) received the standard overlay. These were segments that showed only moderate levels of cracking and/or other evidence of foundational stress. The treatment consisted of a 169 t/km (300 tn/mi) leveling course of Type IV bituminous concrete and a 32 mm (1.25 in) wearing course of Type III bituminous concrete. In addition to the 20 segments described above, another 2.46 km (1.53 mi) section received the standard overlay but was not selected for testing.

Bituminous Base Stabilization with and without Additive (MS-2 Emulsion):

Pulverization depth varied from 203 mm to 305 mm (8 to 12 in) for the 24 segments treated. The total length of the 24 segments was 2.403 km (1.493 mi). Thirteen of the segments, totaling 1.127 km (0.70 mi) were pulverized and compacted with no stabilizing agent for comparison with the remaining 1.277 km (0.794 mi) that had been stabilized with MS-2 emulsion. Those sections receiving bituminous base stabilization but no MS-2 emulsion were paved with a 32 mm (1.25 in) binder course and a 32 mm (1.25 in) wearing course of Type III bituminous concrete.

OPTIMUM ASPHALT EMULSION APPLICATION RATE:

Lab work to determine the emulsion application rate was done during the late summer of 1986. Variables considered included depth and composition of the existing pavement, moisture, material gradation and penetration characteristics of the additive. The application rate finally used was 4.53 l/m^2 (1 gal/SY) which is approximately equal to 2% by weight, assuming the penetration depth to be 101 mm (4 in).

Eleven segments received the stabilizing additive at this application rate and were paved with a 13 mm (0.5 in) binder course and a 32 mm (1.25 in) wearing course of Type III bituminous concrete.

PROJECT CONSTRUCTION:

Reclaimed bituminous base stabilization began on 29 Jul 86 and was completed on 25 Sep 86. Twenty three days of stabilization work produced 20,505 m^2 (24, 524 SY). Production rates varied from 585 m^2/day (700 SY/day) to 1948 m^2/day (2330 SY/day) and averaged 891 m^2/day (1066 SY/day). Four alternatives used were as follows:

1. Pulverize to 305 mm (12 in) depth, with equal amounts of gravel and existing pavement (152 mm (6 in)).

2. Pulverize to 203 mm (8 in) depth, including 152.4 mm (6 in) of existing pavement and 51 mm (2 in) of gravel.

3. Reclaimed base stabilization with addition of emulsified asphalt.

4. Reclaimed base stabilization without addition of emulsified asphalt.

The project also included repair/replacement of existing drainage and installation of new underdrain facilities as directed by the engineer. It was hoped that the subdrains would correct problems due to high moisture content in the subbase detected during the 1986 Materials and Research investigation. The project work was completed on 30 Oct 86.

POST-CONSTRUCTION PERFORMANCE:

After construction, each of the 44 segments was tested periodically for rutting, roughness and cracking. Average values for each treatment type (standard overlay, reclaimed bituminous base stabilization or reclaimed bituminous base stabilization/w stabilizing additive) were reported.

AVERAGE CRACKING:

	Std. Overlay	Stab. w/add	Stab. w/o add
1989			
m/100 m	**	78	73
(ft/100 ft)	**	78	73
1990			
m/100 m	**	231	187
(ft/100 ft)	**	231	187
1991			
m/100 m	**	273	228
(ft/100 ft)	**	273	228
1992			
m/100 m	**	311	302
(ft/100 ft)	**	311	302
1993			
m/100 m	71	551	523
(ft/100 ft)	71	551	523
1994			
m/100 m	91	814	616
(ft/100 ft)	91	814	616

** Data not available

AVERAGE RUTTING:

	Std. Overlay	Stab. w/Add.	Stab. w/o Add.
1986			
mm	**	3	3
(1/16 in)	**	2	2
1988			
mm	5	6	6
(1/16 in)	3	4	4
1989			
mm	**	8	8
(1/16 in)	**	5	5
1990			
mm	5	6	6
(1/16 in)	3	4	4

AVERAGE RUTTING: (Cont'd)

	Std. Overlay	Stab. w/Add.	Stab. w/o Add.
1991			
mm	**	8	6
(1/16 in)	**	5	4
1992			
mm	**	14	13
(1/16 in)	**	9	8
1993			
mm	7	14	11
(1/16 in)	4	9	7
1994			
mm	8	14	16
(1/16 in)	5	9	10

Inconsistencies in the rutting data are probably attributable to the use of two different rutting gauges, one graduated in sixteenths of an inch and the other in eighths. Additionally, several different inspectors took measurements during the eight data collection events.

AVERAGE ROUGHNESS (IRI):

	Std. Overlay	Stab. w/Add.	Stab. w/o Add.
1986			
mm/km	1247	1326	1357
(in/mi)	79	84	86
1987			
mm/km	1436	1389	1563
(in/mi)	91	88	99
1988			
mm/km	1594	1610	1847
(in/mi)	101	102	117
1989			
mm/km	1831	1815	1989
(in/mi)	116	115	126
1992			
mm/km	2115	2241	2873
(in/mi)	134	142	182
1993			
mm/km	2257	2289	2809
(in/mi)	143	145	178

AVERAGE ROUGHNESS: (Cont'd.)

	Std. Overlay	Stab. w/Add.	Stab. w/o Add.
1994			
mm/km	2746	2762	3236
(in/mi)	174	175	205

DISCUSSION:

Difficulties in interpreting the data from the Jamaica HMA 2639 project occurred because too many variables were introduced and experimental controls became difficult to properly design and manage. Two features of the project which were designated for evaluation and factors which complicated an assessment of the data are discussed below:

1. **The "selective recycling" concept.**

The data present adequate evidence to support selective recycling as viable. However, conclusions regarding comparison of the recycled sections with the standard overlay sections have been complicated by several factors.

Sections of the project selected for bituminous base stabilization were in a more advanced state of decline than those selected for the standard overlay. For valid comparison of the two treatments it was assumed all problems not related to the pavement structures being compared which might influence performance had been addressed by the construction. This might not have been the case.

One problem identified during the early stages of the project was subsurface water. In November of 1985 a test pit revealed spring water just below subbase depth, and other test pits showed moisture levels of 10% or greater in the subgrade. Noting the sound condition of the existing road foundation and observing the areas of load related distress, the report of the test pit investigation stated:

"In general, the roadway has a reasonably good base but the pavement has areas with severe distress. Such areas often occur in side hill cut-to-fill sections which suggests drainage has had an effect on pavement performance."

Subsequent to the construction of the Jamaica project, it was noted in a Materials and Research internal memo that, **"The installation of lateral underdrains adjacent to 21 of the 24 recycled sections may have improved the new pavement performance at some locations, but was not adequate to insure good performance at all locations. Two of the three sections without underdrains have developed rutting of 1" to 1-1/4".**

These statements suggest that the load related cracking and rutting problems of the pre-construction pavement were caused by subbase moisture at those areas that were selected for recycling, and that the better condition of sections not selected for recycling was attributable to an absence of moisture. With these moisture problems not properly addressed (as implied by the second statement made in the Materials and Research memo) the different levels of performance prior to construction have carried through to the present and serve to confuse the results of the evaluation.

2. Comparison of sections recycled with bituminous base stabilization with an additive (emulsified asphalt) to promote stability, with recycled sections without the additive.

In order to determine the cost effectiveness of the additive, two alternative designs provided equivalent structural numbers, based on the estimated difference in layer coefficients between the additive-fortified stabilized bituminous base and the stand alone material. Since layers of bituminous concrete pavement of unequal thickness were applied to the two treatments and since neither pavement thickness was adequate in light of current practice, performance was difficult to measure and compare.

Valid research controls for the Jamaica project were at cross purposes with what was perceived at that time to be good design. This resulted in an overly complicated and confusing set of evaluation parameters which made it difficult to arrive at clear and concise conclusions.

An overall comparison of the bituminous base stabilization rehabilitation method with the standard overlay is thus very difficult. Other complicating factors are the varying pavement designs as well as differing pulverization depths and application rates of the emulsified asphalt.

During the summer of 1994, eight years after HMA 2639 was completed, the condition of VT Route 30 in Jamaica had deteriorated sufficiently to warrant maintenance. Approximately 2.90 km (1.80 mi) was leveled with bituminous concrete pavement which ranged in thickness from 13 mm to 17 mm (0.5 in to 0.75 in). It is notable that only 0.76 km (0.47 mi) or 26% of the required resurfacing was within areas that had been previously recycled.

COSTS:

Savings were realized through the implementation of the "selective recycling" concept. The total area recycled through the 7.19 km (4.47 mi) section of the project, which lies easterly of the village, is 20,505 m^2 (24,524 SY) and the total incremented length of the sections recycled is 2.40 km (1.49 mi). The calculated average width of these sections is 8.53 m (28 ft) and the area of the section which was resurfaced without bituminous base stabilization, as indicated by the "selective recycling" concept, was 40,928 m^2 (48,951 SY). This represents a savings in excess of $159,000, since the low bid cost of the bituminous base stabilization item was $3.89/$m^2$ ($3.25/SY). This economy is especially significant when the better performance of the standard overlay is considered.

The cost/m^2 (cost/SY) for each of the three treatments varies as shown in the table on the following page:

COST COMPARISON

Design Feature	Simple Overlay	Bit.Base Stab. W/O Additive	Bit. Base Stab. W/Additive
Leveling	$0.98/m^2	–	–
	($0.82/SY)	–	–
Overlay	$2.46/m^2	$4.92/m^2	$3.44/m^2
	($2.06/SY)	($4.11/SY)	($2.88/SY)
Bit. Base Stab.	–	$3.89/m^2	$3.89/m^2
	–	($3.25/SY)	($3.25/SY)
Emulsif. Asphalt	–	–	$1.08/m^2
	–	–	($0.90/SY)
Total Cost	$3.44/m^2	$8.81/m^2	$8.41/m^2
	($2.88/SY)	($7.36/SY)	($7.03/SY)

Note that the cost for Bituminous Base Stabilization, Item 310.15, was $3.89/m^2 ($3.25/SY) for the Jamaica project. This was extremely high in light of recent bid experience, where the 1994 average weighted low bid price was $2.03/m^2 ($1.70/SY). One possible reason for this was the "selective recycle" activity which demanded that the work be done in short lengths, reducing quantities and requiring frequent delays while equipment was moved to the next work station. The high bid price for this item may not have been entirely attributable to the special character of the work, however, and other cost factors might have been involved. This was a first effort at this rehabilitation technique for the contractor and it required a large capital outlay for the necessary heavy equipment. It is probable that the high bid price for bituminous base stabilization was at least partly the result of the contractor's attempt to recapture part of his equipment investment.

SUMMARY & CONCLUSIONS:

1. The "selective recycling" concept appears to be a viable one. Rutting, cracking and roughness data all indicate superior performance of the standard overlay sections. There has been no sign of pavement distress at recycle transition points as had been originally anticipated. This approach should be considered for further evaluation.

2. Addition of emulsified asphalt to the stabilized bituminous base product improves some performance factors, but not others. For example, roughness data show a clear superiority of the pavement with the additive over that without, but there is a reverse relationship when cracking data are considered. Rutting is about equal for all recycled sections. Evaluation of data should be considered in light of subsequent experience, which has for the most part discredited the cost effectiveness of the stabilizing additive. Since construction of the Jamaica, HMA 2639 project, advocacy for the use of an additive for full depth reclamation projects has diminished.

3. Lateral underdrains may have alleviated the effects of moisture in the subbase and subgrade, but the wide range of values, particularly in rutting, suggests that the design was not adequate at all locations. Variations in subdrainage placement further complicated the evaluation.

4. After eight years of evaluation, the performance of the experimental features introduced into the Jamaica HMA 2639 project has been documented such that clear trends have been established and further evaluation would probably not yield additional meaningful data. Further evaluation would also be complicated by maintenance activities which have already begun. Therefore, this report is the last of the study.

5. An important lesson learned during the development, construction and evaluation of the Jamaica project, is that every attempt must be made to designate test sites that are similar in every aspect except for the (single) feature being evaluated. Too many variables confuse results and make it difficult to draw valid comparisons and conclusions.

RECLAIMED BASE STABILIZATION
JAMAICA Vt ROUTE 30
CONSTRUCTION 1984