

RURAL COLD RECYCLING

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Cold recycling of deteriorated pavements in two National Parks is discussed. Information on the cost saving is presented. A tabulation of some cold recycle projects is presented. It is concluded that cold recycling is a viable economic rehabilitation process.

This paper covers rural recycling. Specifics on one recycling project in an eastern National Park are presented, a summary of a second Park project, and tabulation of other cold recycling projects are given.

The specific project discussed is one built in the Cape Cod National Seashore Park in Massachusetts. This project consisted of recycling an existing pavement in place. The roadway was closed to traffic during the construction except for emergency traffic. This project was successful and presented no problem.

The second Park project consisted of recycling an existing pavement after removal in Catoclin Mountain Park near Thurmont, Maryland. Part of this second project used an emulsion as a compaction aid. This project had a number of problems from which modifications for future projects of this type are under consideration.

Cape Cod National Seashore Park

This project consisted of reconstruction of 0.96 km (0.6 mi) of Moor's Road and 3.52 km (2.8 mi) of Province Lands Road in the Cape Cod National Seashore located near Provincetown, Massachusetts.

The existing pavement on 2.56 km (1.6 mi) of the Province Land Road consisted of 10 cm (4 in) of bituminous concrete (two, 5 cm (2 in) wearing

courses of different ages); 10 cm (4 in) of sand-asphalt; and 15 cm (6 in) of a sand-clay mixture over a sand subgrade.

The remaining 0.8 km (0.5 mi) of Province Lands Road had a similar section. This portion of the road had been recently rebuilt and had only minor surface cracking so it was overlaid with 3.13 cm (1.25 in) of hot bituminous concrete.

The existing pavement on 0.96 km (0.6 mi) of Moor's Road was also recycled. The layers in this roadway were as follows: 7.5 cm (3 inch) of old bituminous concrete surface; 7.5 cm (3 inch) of sand asphalt; and 15 cm (6 inch) of sand-clay mixture.

This section of the roadway had been recently rebuilt and had only minor surface cracking.

The typical sections for the two roads as they existed prior to construction appear in Figure 1. The existing pavement condition of these roadways is shown in Figures 2 and 3. Thermal cracks are evident in both roadways. The existing asphalt appeared to be oxidized and brittle and to have undergone considerable oxidation since placement.

The National Park Service recommended that reprocessing and relaying the existing roadway material prior to placing a new wearing course be considered during the design stage in lieu of adding a new leveling course and wearing course to the existing pavement.

Pavement Design

Based on the findings of the field investigation, on the flexible pavement design analysis (1, 2), and considering the National Park Service's request, the following pavement structures were recommended. See Figure 4.

Figure 1. Typical roadway sections before construction.

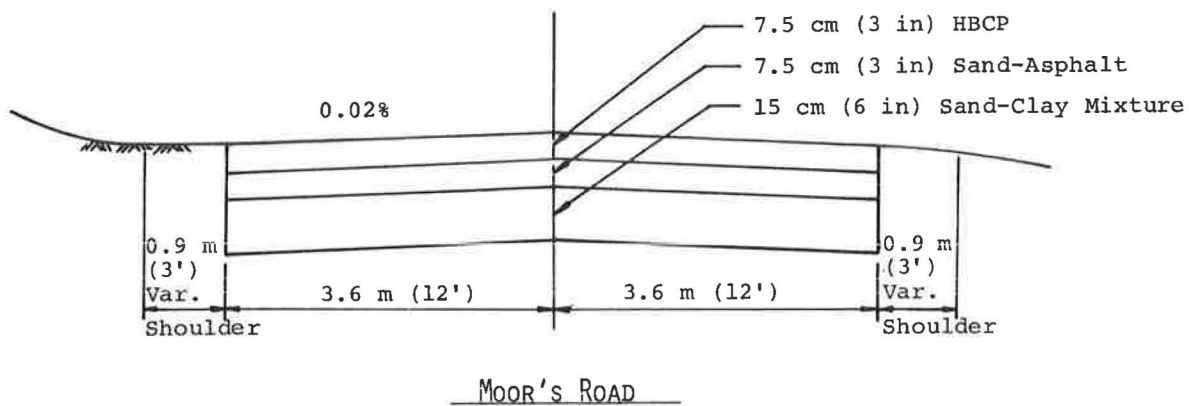
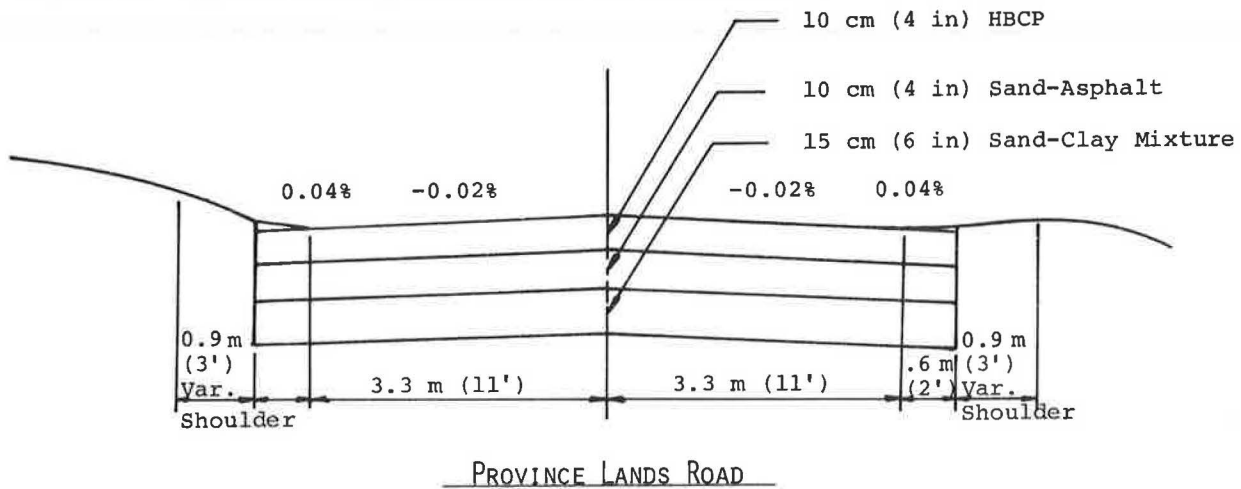


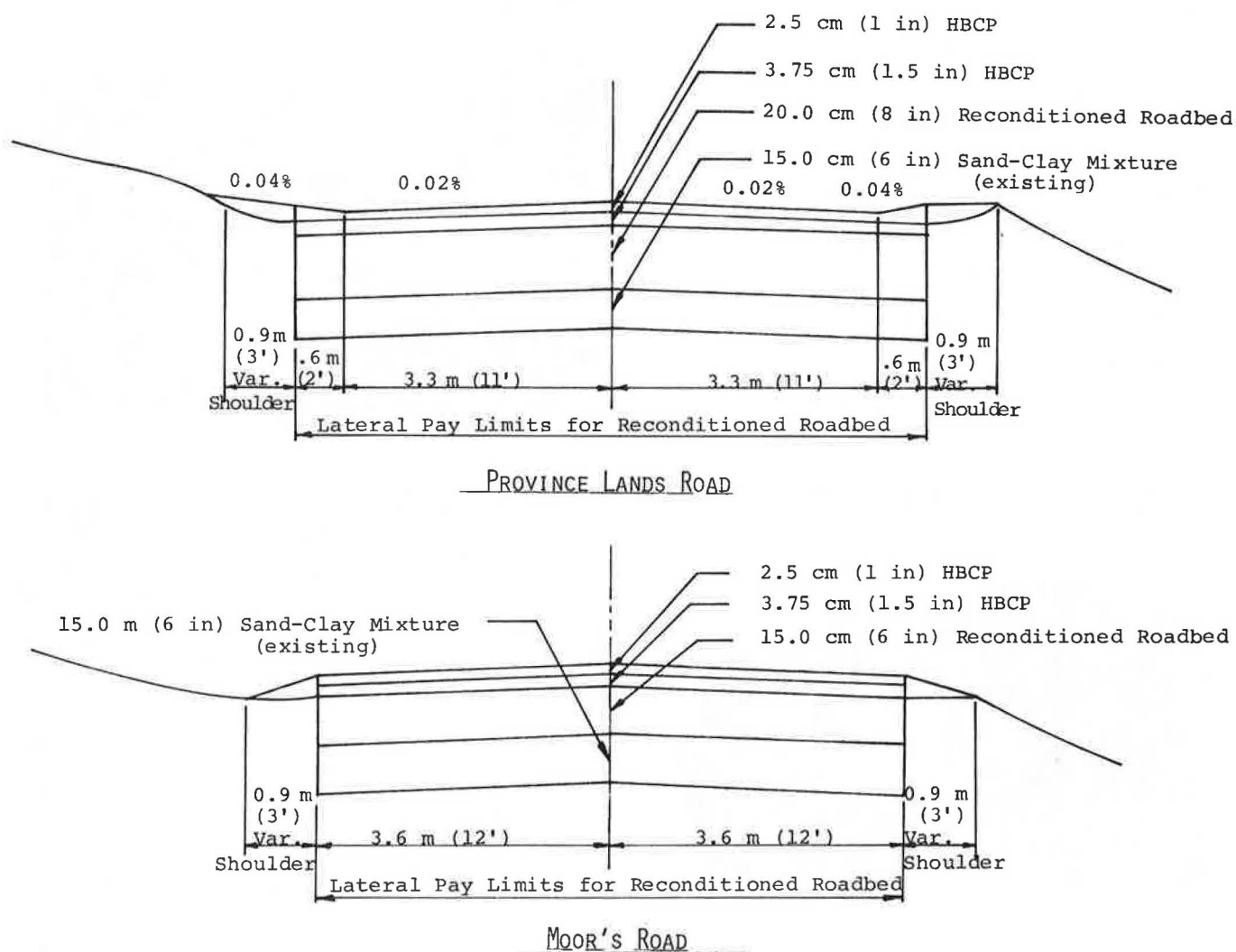
Figure 2. Transverse cracks in the existing pavement.



Figure 3. Localized deterioration in the existing pavement.



Figure 4. Typical sections for new roadways.



1. Province Lands Road. Section 1 (2.56 km (1.6 mi)).
6.25 cm (2.5 in) hot bituminous concrete
20.0 cm (8.0 in) cold recycled material
2. Province Lands Road. Section 2. (0.8 km (0.5 mi)).
3.12 cm (1.25 in) hot bituminous concrete
3. Moor's Road (0.96 km (0.6 mi)).
6.25 cm (2.5 in) hot bituminous concrete
15.0 cm (6.0 in) cold recycled material

Pulverization and cold recycling of the existing bituminous surfacing material was recommended in lieu of overlaying to prevent reflective cracking and to provide a base of uniform strength and cross section. A layer coefficient of 0.25 was used for the recycled

pavement in this analysis. This is equivalent to the value normally recommended by the AASHTO pavement design guide (2) for cold mix material.

Construction

Contractor. The prime contractor for this project was M. F. Roach of North Eastham, Massachusetts. He subcontracted the recycle work, called "reconditioning of roadbed" under this contract, to Bell and Flynn of Stratham, New Hampshire. They had done previous work of this type for the State of Maine, so were familiar with this type of operation.

Recycling. Reconditioning of the roadbed was accomplished by cold recycling the existing 20 cm (8 in) of bituminous pavement. A grader equipped with a ripping tooth scarified the existing pavement into relatively small pieces ie. 30 cm (24 in)

by 90 cm (36 in) or less. The material was then bladed into a windrow. A BROS preparator, portable hammermill, was then towed by a front end loader over the windrow. After each pass of the hammermill the material was reformed into a windrow for additional passes of the BROS preparator until the material was broken down to the desired size and uniformity. The specifications required 100 percent passing the 5 cm (2 in) sieve. There was no problem meeting this requirement with this material since it was primarily sand-asphalt concrete, which readily broke down under the action of the hammermill. Water was added during the processing with the hammermill to control dust, and keep the hammers cool by reducing friction. After the material was properly pulverized it was shaped by the grader and compacted. See Figures 5, 6, and 7.

Figure 5. Front end loader towing BROS preparator.



Figure 6. BROS preparator pulverizing windrowed material.



Figure 7. Partially compacted recycle material.



The project was designed for the finished grade of the recycled base material to match the original grade of the old roadways. Due to the recycling process and widening of the roadways this could not be accomplished and the finished grade of the base material was lowered approximately 3 cm (1.2 in). This did not affect the overall depth of the base material.

A prime coat was not used on the cold recycle material as the existing roadways had been constructed on a layer of clay or "hardening" used as the subbase to bridge the underlying sand. This added clay helped to make the resulting recycled base very tight and impervious to the penetration of the prime so it was eliminated.

Compaction. The compaction requirement for the recycled base material was 95 percent of AASHTO T-180 Method D (3). Since asphalt was present, a correction factor had to be determined for the nuclear density gauge being used to control compaction. This was done as recommended by the manufacturer of the gauge. A Troxler Model 3411 moisture-density gauge (4) was used.

Bituminous Concrete. A 3.75 cm (1.5 in) hot bituminous concrete binder course was placed over the recycle material and was followed by a 2.5 cm (1 in) wearing course. The gradations for the binder and wearing courses met the Massachusetts Specifications for Class I bituminous concrete pavement (5). These are nominal 1.9 cm (3/4 in) and 0.38 cm (3/8 in) dense graded mixes. These mixes were placed using a Blaw Knox track paver and compacted with two, 2-axle tandem steel rollers. See Figures 8 and 9.

Berms. Since the prevalent material on Cape Cod is sand and it is highly erodable along highways, surface drainage is controlled by the use of "Cape Cod" bituminous concrete berms and waterways. Figures 9, and 10 show the placement and end product of this operation.

Cost Comparison

Equivalent Hot Mix Cost. A cost comparison between the recycled pavement and an equivalent amount of new hot mix was made.

The structural coefficient for the recycled mix was assumed to be 0.25 as mentioned before. For the 20 cm (8 in) recycled pavement on the 2.56 km (1.6 mi) of Province Lands Road, 12.5 cm (5 in) of hot mix would be needed for an equivalent thickness using 0.40 for the hot mix coefficient. At a price of \$19.80/t (\$22/ton) this 12.5 cm (5 in) section of hot mix would cost \$139,000.

For the 15 cm (6 in) of recycled pavement on the 0.96 km (0.6 mi) of Moor's Road, 9.38 cm (3.75 in) of bituminous concrete would be needed or 1476t (1640 tons) of 720 cm (24 ft) wide pavement. At a price of \$19.80/t (\$22/ton) this 9.38 cm (3.75 in) would cost \$36,000. The total would be \$175,000.

Figure 8. Placement of wearing course over newly placed binder course.



Figure 9. Compacting the wearing course.



Figure 10. Placement of bituminous concrete berm.



Figure 11. Completed section of berm.



Recycle Cost. The recycle was paid for under three different pay items. One was by 30.3 m (100 foot - station) for Province Lands Road, one by square kilometers (sq yds) for Moor's Road, and one for the water in 760 ML (Mgal) for all recycle.

The contract and total costs for these items were as follows:

1. Recycle-Province Lands Road
 $30.3 \text{ m} \times \$4108.75/\text{m} = \$124,495$
 $(116.18 \text{ Sta.} \times \$1072/\text{Sta.} = \$124,495)$
2. Recycle-Moor's Road
 $2,424 \text{ m}^2 \times \$4.313/\text{m}^2 = \$10,454$
 $(3,030 \text{ yd}^2 \times \$3.45/\text{yd}^2 = \$10,454)$
3. Water
 $760 \text{ ML} \times \$2.631/\text{ML} = \2000
 $(200 \text{ Mgal} \times \$10/\text{Mgal} = \$2,000)$
 Total = \$136,949

Savings. Based on this data the savings would have been as follows:

Additional hot mix	\$175,000
Recycle mix	\$136,949
	\$ 38,051

This amounts to \$38,051/3.52 km (2.2 mi) = \$10,810/km (\$10,378/0.6 mi). This does not include the added hauling cost to dispose of the old pavement.

Summary

This project proved very successful in that there were not any construction problems and the completed pavement looked excellent. See Figure 12. Also, the roadway has not shown any signs of problems in its one year life.

Figure 12. View of completed pavement.



Catoctin Mountain Park

Project Location

This project consisted of recycling an existing Pavement in Catoctin Mountain Park near Thurmont, Maryland. This location may be familiar to the reader because "Camp 3" or "Camp David," the President's retreat, is adjacent to the park grounds. In fact the construction work on this project had to be discontinued when the Egyptian - Israeli Summit Conferences were held there in 1979.

Construction

The project was four miles long and included reconstruction of the existing pavement with some widening and some new alignment. The roadway was essentially closed to traffic during construction. The existing roadway that was recycled consisted of a 5.4 m (18 ft) wide pavement of variable depth bituminous concrete of 7.5 cm (3 in) to 20 cm (8 in) thickness, the latter thickness being at the pavement edge. A CMI PR-750 Roto Mill was used to remove the old pavement - see Figure 13. The thicker pavement at the edges of the roadway that was not removed by rotomilling was crushed in place with a D-7 dozer and became part of the subgrade.

The material removed was stockpiled at two parking areas adjacent to the main roadway. A "Pelican" portable pugmill was used to mix the blend of 50 percent recycled material and 50 percent crushed stone with 4 percent emulsion (SS-1h) and 1 percent water - see Figure 14. The material was then placed on the prepared subgrade with a Barber Greene Paver and compacted with a 10-ton Hyster roller - see Figure 15. The final 5 cm (2 in) bituminous concrete overlay was placed after the recycled material had cured.

Figure 13. Roto-Mill removing old pavement.



Figure 14. Portable pugmill mixing emulsion with recycle-aggregate blend.



Problems

There were some problems encountered on this project as follows:

1. The stockpiled recycle material hardened in storage and had to be broken down with a bulldozer.

Figure 15. Placement of recycled material.



2. There were some oversize pieces in the stockpile because the Roto-Mill did not break up alligatored pieces of pavement during removal. These had to be scalped on the feed bin to the pugmill.
3. Crushed stone had to be blended with the recycle material to facilitate feeding the material through the cold feed hopper.
4. The maximum particle size requirement of 7.5 cm (3 in) for the recycled material prevented converting the lift thickness to two 5.0 cm (2 in) thick lifts to accelerate curing of the SS-1h emulsion.
5. The late fall season and forest location with considerable shade and high humidity caused delays in curing the emulsion type used here.

Specification changes

Based on this experience we are considering the following specification changes on future projects of this type.

1. Cement should be used with all slow set emulsions.
2. The use of mixing grade emulsions should be allowed as an alternate to the slow set type, particularly when the project may carry over into the late fall, the work is to be done in high humidity areas, and/or the use of pugmill mixing and machine placement is utilized.
3. Some laboratory and in place strength measure should be incorporated into the specifications for material containing an emulsion for a compaction aid.

Other Projects

There have been many reports (6,7,8) in the literature describing cold recycling projects on interstate highways, county and State roads, city streets, and park and Indian reservation roads. Various additives and/or stabilizing agents such as lime, liquid asphalts, emulsions, asphalt cements, and portland cement have been used. The end use of these cold recycled materials has normally been as a base material and usually protected by a bituminous overlay or seal coat. Table 1 presents a summary of some of these projects.

Summary

Cold rural recycling is a viable construction procedure that utilizes existing materials in an economic manner and provides improved roadway structures.

References

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Table 1. Cold Recycling Projects (6,7,8).

State	Roadway	Recycled Material	Agent	End Use
California	S.R. 45	A.C. Pavement and base bituminous materials	Lime	Base 6.25 cm (2.5 in)
Indiana	C.R. 28/80	A.C. Pavement and gravel base	Chemical + Liquid A.C.	Base
Maine	I-95, S.R. 9, S.R. 17	A.C. Pavement	Cut back + emulsion	Base
Michigan	I-75	A.C. Pavement	Asphalt Cement	Base
North Dakota	US 281	A.C. Pavement	none	Shoulder
Kansas	S.R. 568	A.C. Pavement	Cutback	Pavement (+seal)
Texas	US 277	A.C. Pavement	Rejuvenation & emulsion	seal
FHWA (Reg. 15)	C.R. "M"	A.C. Pavement	Chemical & none & Emulsion	Base
FHWA (Reg. 15)	Cape Cod NSP	A.C. Pavement	None	Base
FHWA (Reg. 10)	BIA Reservation	Emulsion Base	Emulsion	Base
California	C.R. (Modoc)	A.C. Pavement + untreated base	Cement	Base
Illinois (Peoria)	City Streets	A.C. Pavement	Cement	Base
Utah	US 160	A.C. Pavement	Cement	Base
Nevada	US 40	A.C. Pavement + base	Cement	Base
Alabama (Montgomery)	City Streets	A.C. Pavement + base	Cement	Base
Virginia	City Streets	A.C. Pavement + base	Cement	Base