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Maine Department of Transportation

Transportation Research Division

Technical Report 99-11

Innovative Solutions to Buried Portland Cement Concrete Roadways

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Transportation Research Division

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Introduction

Forty or more years ago hundreds of miles of Maine highways were constructed of Portland Cement Concrete (PCC) to a width of 5.5 to 6.0 m (18 to 20 ft). Since that time these same highways have been paved and widened to 6.7 or 7.3 m (22 or 24 ft) with hot bituminous pavements to accommodate increased traffic volumes and enhance roadway safety. Bituminous materials were used in place of concrete due to the ease of placement and price of material.

PCC is a rigid pavement capable of supporting weight with little deflection. In contrast, hot bituminous pavement is flexible and will flex to distribute weight across the roadway. When the highway is expanded beyond the concrete slab, there is a sharp decrease of support for the bituminous pavement resulting in settlement over prolonged use. This settlement may also be compounded by poor drainage capabilities of the underlying soils causing the unsupported pavement to drop lower than the existing height of the concrete supported pavement. This creates a longitudinal crack aligning with the concrete slab edge roughly 0.3 to 1 m (1 to 3 ft) from the right edge of pavement. Pavement to the right of this crack deteriorates to the point where maintenance crews attempt to smooth it out with cold patch year after year. Paving over the entire roadway is an option but, due to reflective cracking, the edge of pavement begins to deteriorate within 2 or 3 years.

It is the intent of this experimental project to explore various shoulder treatments to increase support of the extended roadway and hopefully decrease or eliminate deterioration of the shoulder pavement.

Background

Project No. STP-8651(00)X on Route 100 between the towns of Benton and Pittsfield is 26.9 km (16.7 mi) long and scheduled for an overlay of maintenance mix. This is a 7.3 m (24 ft) wide bituminous roadway over 6.2 m (20 ft) of PCC that is 230 mm (9 in) in depth. The 0.6 m (2 ft) edge of pavement on both sides has deteriorated, creating a traffic hazard and maintenance problem for years. Condition of the drainage ditch is poor along the entire project and there is very little underdrain. A section of this project beginning 4.5 km (2.8 mi) north of the junction of Route 100A in Benton and extending north 2.5 km (1.6 mi) to the town of Clinton was selected to construct four experimental shoulder rehabilitation sections. This project was

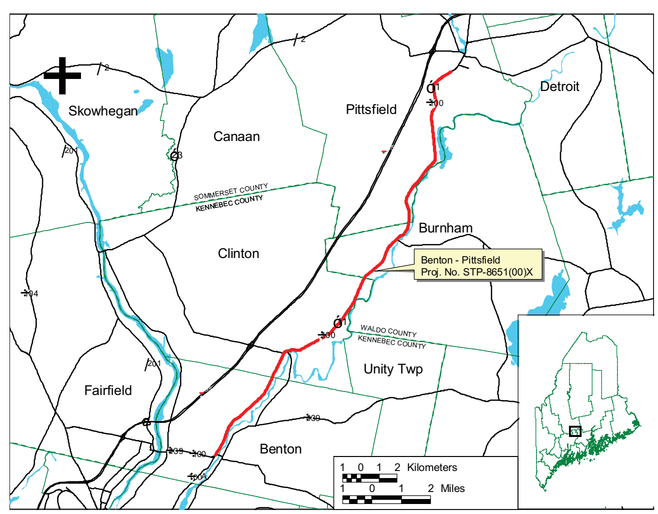

Fig. 1 Location map

activated in August with a deadline of October 30, 1998, so time and available money to develop experimental sections was limited. An E-mail request, phone interviews, and literature search of AASHTO members were conducted to gather information on techniques used to correct composite roadway shoulder problems. A panel, with personal from Highway Design, Construction, and Geotechnical Divisions plus the Bureau of Maintenance and Operations, used this information as well as ideas of their own to design four experimental sections, each 500 m (1640 ft) in length plus a control section 500 m (1640 ft) in length.

Another shoulder rehabilitation experiment that is not part of the Benton - Clinton project but will be included in this report was constructed in 1997-98 on Route 2 in Veazie. This is a 6.6 m (22 ft) bituminous highway over 5.2 m (18 ft) of PCC. This project also had poor drainage and a deteriorated pavement edge causing traffic hazards and maintenance headaches. The experimental section begins 100 m (328 ft) north of Chase Road in Veazie and extends north 190 m (623 ft).

Construction

Benton - Clinton Project No. STP-8651(00)X

Construction of each shoulder treatment went smoothly. Most of the material excavated from the shoulders consisted of granular soil not clay as expected and the depth of each trench did not penetrate the clay subgrade.

Figures 1 - 4 contain cross sections for each experimental treatment. Limits and a brief description of each section are as follows:

Control Section, Maintenance Mix

This section is located between station 0+500 and 1+000. There is no shoulder rehabilitation and the roadway is treated with an estimated average thickness of 20 mm (0.75 in) of 9.5 mm (0.374 in) maintenance mix.

Section 1, Cold Recycled Pavement

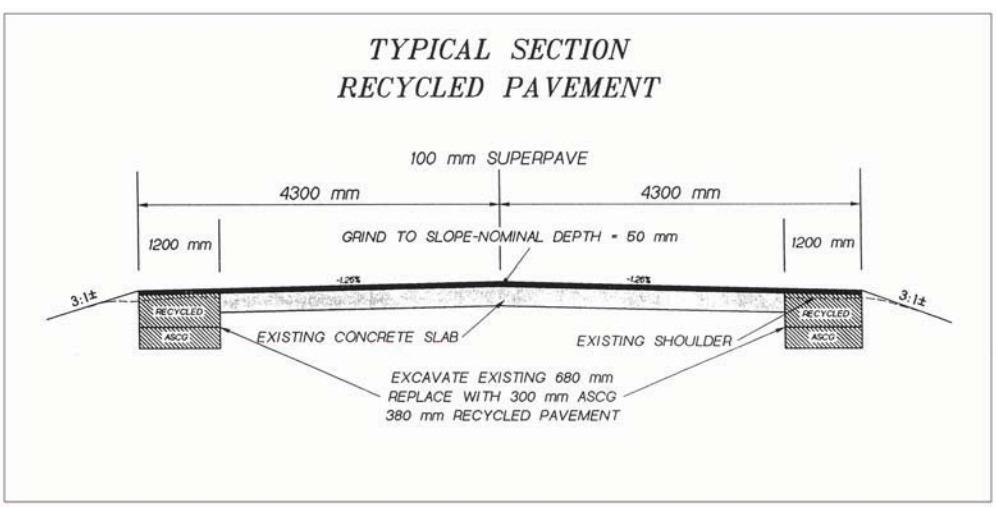

Fig. 2 Section 1

This section is located between station 1+000 and 1+500. Figure 2 contains a typical cross section. The existing pavement was ground to slope to a nominal depth of 50 mm (2 in). The shoulders were excavated adjacent to the existing PCC slab edge to a depth of 680 mm (27 in) and width of 1200 mm (47 in). The boxed shoulder was then filled with 300 mm (12 in) of Type D

Aggregate Subbase Coarse Gravel (ASCG) MDOT Standard Specifications Item Number 703.06 and 380 mm (15 in) of Cold Recycled Pavement.

The roadway and shoulders were then paved with a 60 mm (2.4 in) layer of 19 mm (0.75 in) Superpave Binder and surfaced with a 40 mm (1.6 in) layer of 12.5 mm (0.5 in) Superpave wearing coarse.

Section 2, Flowable Fill

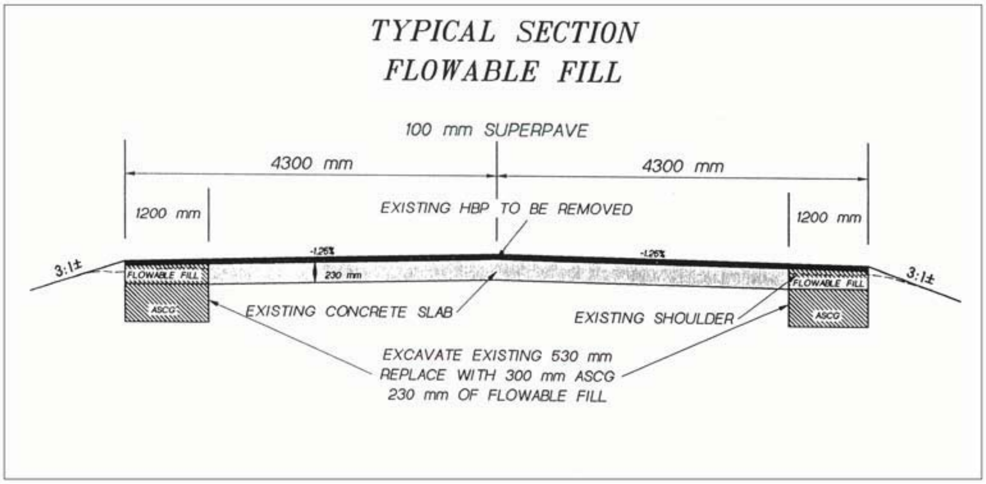

Fig. 3 Section 2A

Flowable Concrete Fill is a concrete mixture that includes 245-105 kg cement/M³ with a water-cement ratio low enough to prevent segregation of the mix and a target Air Content of 5-15 percent. A modified slump test spread of 225 - 350 mm (8.9 - 13.8 in) is considered flowable. The slump spread is obtained by setting a 75 mm x 150 mm (3 in x 6 in) cylinder mold, open on both ends, on a flat surface, then filling the cylinder and striking off the top. During a count of three seconds, lift the cylinder straight up allowing the sample to spread on the flat surface. The spread diameter is measured to the nearest 15 mm (0.6 in).

All existing pavement was removed to the PCC surface and the shoulders were excavated adjacent to the PCC slab to a depth of 530 mm (21 in) and width of 1200 mm (47 in). The exposed PCC slab could not hold up to traffic and had to be shimmed with 9.5 mm (0.374 in) bituminous mix.

There are two separate shoulder treatments within this section. Section 2A located between station 1+500 to 1+970 right and 1+500 to 2+000 left. This section has 300 mm (12 in) of ASCG and 230 mm (9 in) of Flowable Fill. Figure 3 contains a cross section of Section 2A.

Section 2B is located between station 1+970 and 2+000 right. This section has no ASCG and 530 mm (21 in) of Flowable Fill.

Surface treatment for Section 2 consists of 60 mm (2.4 in) of 19 mm (0.75 in) Superpave Binder and 40 mm (1.6 in) of 12.5 mm (0.5 in) Superpave wearing coarse.

Section 3, Superpave

This section is located between station 2+000 and 2+500. The existing pavement was removed and shoulders were excavated beside the PCC slab to a depth of 530 mm (21 in) and width of 1200 mm (47 in). As with Section 2, the exposed PCC slab could not hold up to traffic and had to be shimmed with 9.5 mm (0.374 in) bituminous mix. A typical cross section of Section 3 is displayed in figure 4.

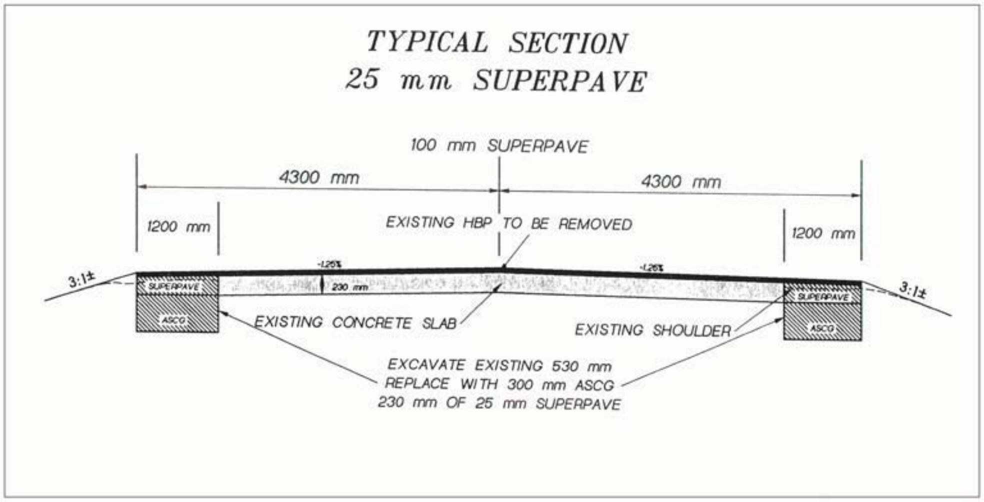

Fig. 4 Section 3

MDOT specifies that traveled way surface mix can be placed between the dates of April 15th and the Saturday following October 15th. The surface deadline was nearing before Section 3 shoulder construction was completed. To avoid the deadline, the roadway was paved with 60 mm (2.4 in) of 19 mm (0.75 in) Superpave Binder and 40 mm (1.6 in) of 12.5 mm (0.5 in) Superpave wearing coarse to an offset of 3 m (10 ft) left and right of centerline. Reconstruction of the shoulder continued after the roadway was paved. The shoulder treatment consists of 300 mm (12 in) of ASCG and 230 mm (9 in) of 25 mm (1 in) Superpave Binder. Binder and surface mix was placed on the shoulders after shoulder reconstruction was complete. This left a longitudinal joint 3 m (10 ft) left and right of centerline.

Section 4, Heavy Overlay

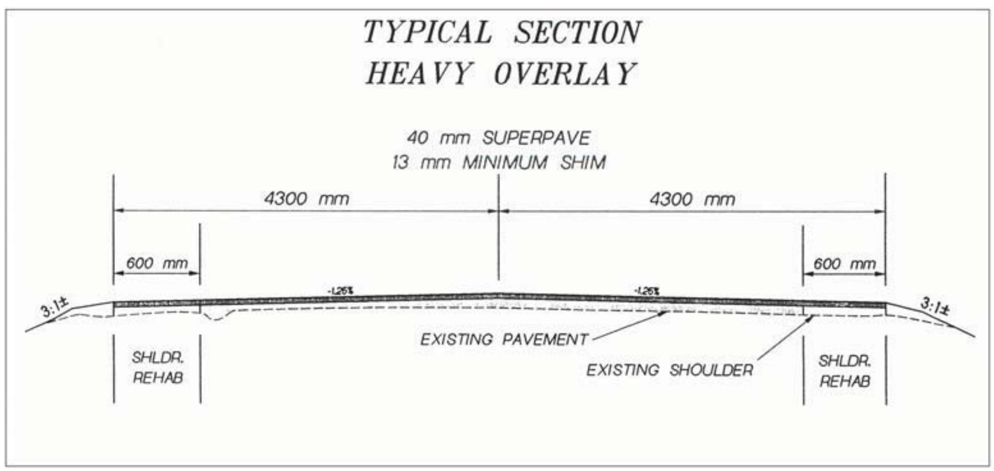

Fig. 5 Section 4

Section 4 is located between station 2+500 and 3+000. The existing shoulders were graded and compacted. All unsuitable material was removed and areas that were below grade were filled with ASCG and compacted to required grade. The roadway was then shimmed with a minimum of 13 mm (0.5 in) of 9.5 mm (0.374 in) bituminous mix. Then the roadway and shoulders were paved with 40 mm (1.6 in) of 12.5 mm (0.5 in) Superpave wearing coarse. A typical cross section of this treatment is displayed in figure 5.

Veazie - Orono Project No. STP-6683(00)X

Construction of this shoulder treatment and application of the self-adhesive mesh went smoothly with no setbacks.

A description and location for each section is as follows:

Self-Adhesive Mesh Section

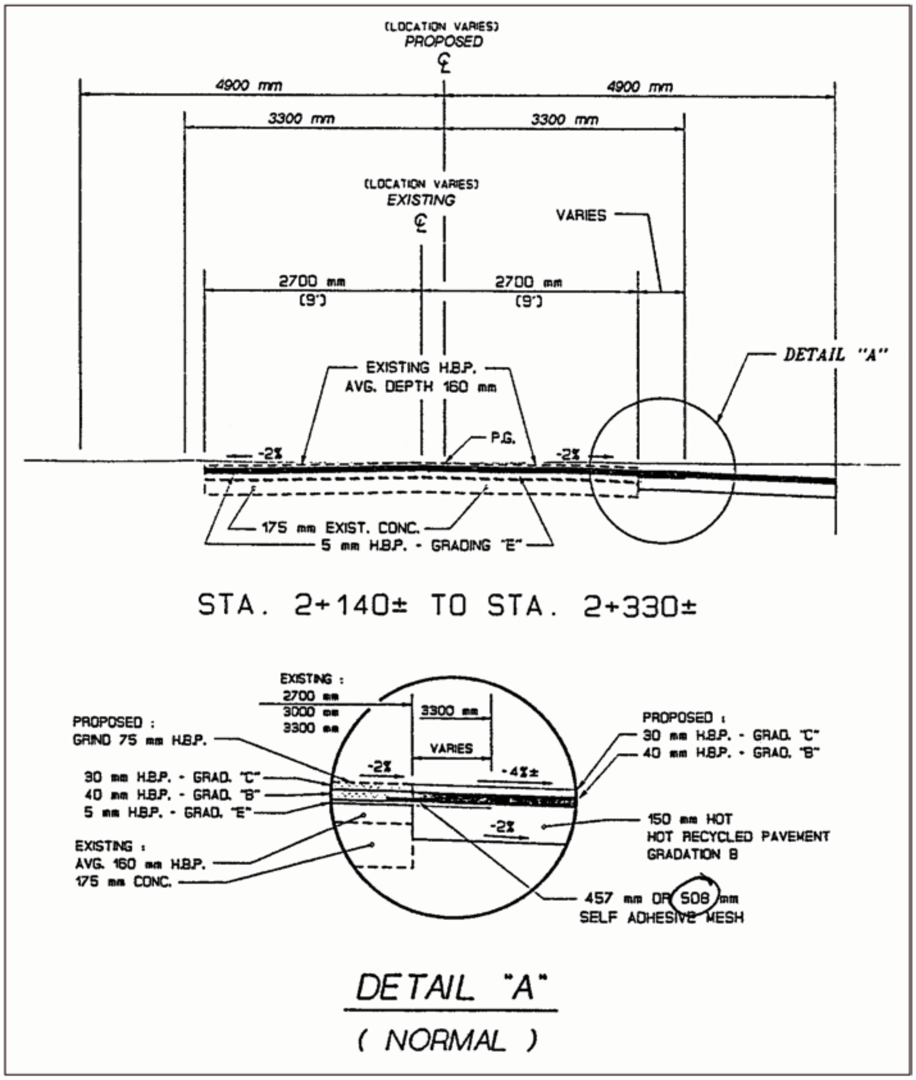

Fig. 6 Self-adhesive mesh

Figure 6 contains a cross section of the Self-Adhesive mesh section. This experimental area begins at station 2+140 and ends at 2+330. The project entails grinding 75 mm (3.0 in) of existing pavement then shimming with 5 mm (0.2 in) of 4.75 mm (0.187 in) bituminous mix.

The shoulders were trenched to a depth of 150 mm (6 in) below height of the milled and shimmed pavement and to a variable width of 0.6 to 2.5 m (2 to 8 ft). This trench is then filled with 150 mm (6 in) of Hot Recycled Pavement made up of a blend of 60 percent virgin aggregate and 40 percent recycled pavement with an asphalt content of 2.5 to 4.5 percent using AC-20 grade asphalt cement. A layer of PavePrep SA7 self-adhesive mesh, manufactured by Contech Construction Products Incorporated, 508 millimeters (20 inches) wide was placed to bridge the transition between concrete supported pavement and Hot Recycled shoulder.

The roadway and shoulders were then paved with 40 mm (1.5 in) of 19 mm (0.75 in) binder and 30 mm (1.2 in) of 12.5 mm (0.5 in) wearing course.

Control Section

This section is located between station 3+230 and 3+420. The existing pavement was milled to a depth of 75 mm (3.0 in) then shimmed with 5 mm (0.2 in) of 4.75 mm (0.187 in) bituminous mix.

Shoulders were excavated to a width of 600 mm (22 in) beyond the PCC edge and depth of 150 mm (6 in) below the milled pavement surface. This boxed shoulder area was filled with 150 mm (6 in) of Hot Recycled Pavement.

The highway and shoulders were then surfaced with 40 mm (1.5 in) of 19 mm (0.75 in) binder and 30 mm (1.2 in) of 12.5 mm (0.5 in) wearing course.

Cost Analysis

A cost summary of each shoulder treatment for the Benton - Pittsfield project is listed in Table 1. The Cost column represents the cost per centerline meter from shoulder to shoulder. Please note that the Control Section and Section 4 shoulder treatment costs represent a 0.6 m (2 ft) wide shoulder whereas Section 1, 2A, 2B, and 3 costs are for a 1.2 m (4 ft) shoulder.

Table 1. Route 1, Benton – Pittsfield Cost Summary

Section	Treatment	Station	Cost
Control	Maintenance Mix Overlay	0+500 - 1+000	$12.59
1	Cold Recycled Pavement	1+000 - 1+500	$156.60
2A	230 mm Flowable Fill	1+500 - 2+000 Left 1+500 - 1+970 Right	$174.44
2B	530 mm Flowable Fill	1+970 - 2+000 Right	$199.98
3	230 mm 25 mm Superpave	2+000 - 2+500	$223.70
4	Heavy Overlay	2+500 - 3+000	$58.87

A review of the data reveals that Section 3 with Superpave had the highest cost followed by Section 2B with Full Depth Flowable Fill, Section 2A with 230 mm (9 in) Flowable Fill, Section 1 with Cold Recycled Pavement, Section 4 with Heavy Overlay and finally Control Section Maintenance Mix.

Table 2 contains a summary of costs per meter for the Veazie - Orono project. The cost column represents the cost per centerline meter from shoulder to shoulder. Since the Experimental Section has a wider shoulder treatment than the Control Section, the cost analysis for this section is based on a 0.6 m (2 ft) shoulder.

Table 2. Route 2, Veazie – Orono Cost Summary

Section	Treatment	Station	Cost
SAM	Self Adhesive Mesh	2+140 - 2+330	$78.85
Control	150 mm Hot Recycled Pavement	3+230 - 3+540	$60.85

Falling Weight Deflectometer Test Results

Photo 1. Falling Weight Deflectometer

Falling Weight Deflectometer (FWD) readings were collected for the Benton - Clinton project on August 12, 2003. Deflections were recorded on the experimental shoulders and on the PCC supported roadway adjacent to each shoulder test. Table 3 illustrates average FWD deflections recorded from sensor # 1 as well as the difference between roadway and shoulder deflections and the average five-year variance. Raw deflections were used due to software limitations when processing data collected on composite roads containing PCC. FWD deflections could not be collected on the Veazie – Orono project because of the limited space between the PCC edge and sidewalk curb.

Roadway and shoulder deflections recorded in 1999 will not be included in Table 3. Shoulder deflections were collected on or very close to the PCC edge resulting in abnormally low readings.

Deflections indicate that:

- Both roadway and shoulder deflections have decreased from year 2002 deflections.

- Average roadway deflections are very consistent within each section. Average deflections range from a high of 8.97 in the Control Section to a low of 6.27 in Section 2B.

- Shoulder deflections have a wide range of values from a high of 26.42 in the Control Section to a low of 6.45 in Section 2B.

- The Control Section with Maintenance Mix, and Section 4, Heavy Overlay, continue to have the highest shoulder deflections (less stability) at 26.42 and 20.39 mils respectively.

- Section 2B with 530 mm of Flowable Fill continues to have the lowest average shoulder deflection at 6.45 mils and the least amount of PCC related edge cracking (summarized later).

- Section 3 with Superpave continues to be very stable with an average shoulder deflection of 9.46 mils. This section also has a low amount of PCC related edge cracking.

Table 3. Falling Weight Deflectometer Summary

Benton - Clinton Project No. STP-8651(00)X

	Treatment	Average Shoulder Deflection (mils)					Average Roadway Deflection (mils)					Shoulder vs Roadway Variance (mils)					
Section	Type	1998	2000	2001	2002	2003	1998	2000	2001	2002	2003	1998	2000	2001	2002	2003	Average
Control	Maintenance Mix	30.26	34.73	25.93	33.19	26.42	10.85	11.88	9.79	9.58	8.97	19.41	22.85	16.14	23.61	17.45	19.89
1	Recycled Pavement	15.46	14.73	15.82	14.67	12.12	9.44	9.76	8.12	9.10	7.86	6.02	4.97	7.70	5.57	4.26	5.71
2A	230 mm Flowable Fill	17.87	17.30	16.57	17.68	14.62	9.29	10.31	8.78	9.36	8.11	8.58	6.99	7.79	8.32	6.50	7.64
2B	530 mm Flowable Fill	NA	9.44	6.73	6.83	6.45	NA	8.24	5.82	7.10	6.27	NA	1.20	0.91	-0.27	0.18	0.50
3	Superpave	8.44	9.05	10.58	9.65	9.46	7.49	7.45	6.36	6.56	6.53	0.95	1.60	4.22	3.09	2.93	2.56
4	Heavy Overlay	29.66	30.65	26.23	29.16	20.39	7.39	8.35	7.13	7.76	7.37	22.27	22.30	19.10	21.40	13.02	19.62

Lower deflection (mils) denotes greater stability

- Section 2A, 230 mm Flowable fill, and Section 1, Recycled Pavement, continue to have the highest shoulder deflections of the four treated shoulders with an average of 14.62 and 12.12 mils respectively. These sections continue to have the greatest amount of PCC related edge cracking of the four treated shoulders.

Additional analysis of shoulder deflections utilizing Tukeys Studentized Range (HSD) Test is displayed in Table 4.

Analysis indicates that:

- Deflections in Section 2B are similar to Section 3 but significantly lower (greater stability) than Sections C, 4, 2A, and 1.

Table 4. Statistical Analysis of Shoulder Deflections

Class Level Information

Class	Levels	Values
Section	6	1 2A 2B 3 4 C

Number of observations: 159

Dependent Variable: ShoulderDeflection

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6449.493210	1289.898642	75.53	<.0001
Error	153	2612.817886	17.077241		
Corrected Total	158	9062.311096			

R-Square	Coeff Var	Root MSE	ShoulderDeflection Mean
0.711683	25.78269	4.132462	16.02805

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Section	5	6449.493210	1289.898642	75.53	<.0001

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Section	5	6449.493210	1289.898642	75.53	<.0001

Tukey's Studentized Range (HSD) Test for ShoulderDeflection

NOTE: This test controls the Type I experimentwise error rate.

Alpha	0.05
Error Degrees of Freedom	153
Error Mean Square	17.07724
Critical Value of Studentized Range	4.08167

Comparisons significant at the 0.05 level are indicated by ***.

Section Comparison	Difference Between Means	Simultaneous 95% Confidence Limits		
C - 4	6.028	2.949	9.108	***
C - 2A	11.803	8.723	14.883	***
C - 1	14.298	11.218	17.378	***
C - 3	16.961	13.881	20.040	***
C - 2B	19.975	15.442	24.508	***
4 - C	-6.028	-9.108	-2.949	***
4 - 2A	5.775	2.695	8.854	***
4 - 1	8.270	5.190	11.349	***
4 - 3	10.932	7.853	14.012	***
4 - 2B	13.947	9.414	18.480	***
2A - C	-11.803	-14.883	-8.723	***
2A - 4	-5.775	-8.854	-2.695	***
2A - 1	2.495	-0.585	5.575	
2A - 3	5.158	2.078	8.237	***
2A - 2B	8.172	3.639	12.705	***
1 - C	-14.298	-17.378	-11.218	***
1 - 4	-8.270	-11.349	-5.190	***
1 - 2A	-2.495	-5.575	0.585	
1 - 3	2.663	-0.417	5.742	
1 - 2B	5.677	1.144	10.210	***
3 - C	-16.961	-20.040	-13.881	***
3 - 4	-10.932	-14.012	-7.853	***
3 - 2A	-5.158	-8.237	-2.078	***
3 - 1	-2.663	-5.742	0.417	
3 - 2B	3.015	-1.518	7.548	
2B - C	-19.975	-24.508	-15.442	***
2B - 4	-13.947	-18.480	-9.414	***
2B - 2A	-8.172	-12.705	-3.639	***
2B - 1	-5.677	-10.210	-1.144	***
2B - 3	-3.015	-7.548	1.518	

- Section 3 is structurally similar to Sections 2B and 1 but has greater stability than Sections C, 4, and 2A.

- Stability in Section 1 is similar to Sections 2A and 3 but significantly stronger than Sections C and 4.

- Section 2A is similar in strength to Section 1 and significantly stronger than Section C and 4.

- The Control Section and Section 4 have significantly less stability than the remaining Sections.

Statistical comparisons were not performed on roadway deflections due to variable HMA thicknesses between the Control Section, Section 4, and the experimental sections skewing sensor one readings. In addition, the FWD may have collected deflections near or on the PCC joint, resulting in erroneous deflections. With this in mind, the shoulder/ roadway comparison may be skewed slightly.

Visual Evaluation

Table 5 contains a pavement condition summary for the Benton - Clinton and Veazie - Orono projects.

Benton - Clinton Project No. STP-8651(00)X

A visual evaluation was conducted on October 1, 2003.

Control Section, Maintenance Mix

Rut depths have increased in severity throughout this section. Thirty five percent of the section has rut depths in the range of 6 to 13 mm (0.25 to 0.5 in), and sixty five percent are greater than 13 mm (0.5 in) in depth.

Centerline joint separation has increased from 65.2 to 95.5 percent over the past year.

The number of full and half roadway transverse cracks have increased dramatically. The number of full width cracks increased from 64 to136 and half width cracks increased from 81 to 123. Transverse cracks are extending beyond the PCC edge into the shoulder. Transverse cracks between wheel paths have decreased from 277 to 125. Many of these cracks have developed into full or half roadway transverse cracks.

Photo 2. Control Section Cracking

PCC related cracking is evident throughout the entire section. Shoulder elevation has dropped 4 to 12 mm (0.2 to 0.5 in) below roadway elevation and greater than 13 mm (0.5 in) in a 50 meter (164 foot) section. Photo 2 illustrates load associated alligator cracking and rutting with missing HMA. Maintenance has patched a number of small areas of the shoulder to improve hazardous driving conditions.

Section 1, Cold Recycled Pavement

This Section has the least amount of rutting with 85 percent in the < 6 mm (< 0.25 in) range and 15 percent in the 6 – 13 mm (0.25 to 0.5 in) range, a slight increase from the 2002 evaluation.

The entire length of centerline joint has separated.

Full and half roadway transverse cracks have increased from 16 to 35 and 6 to 19 respectively. A

Photo 3. Section 1 Transverse Crack

majority of the cracks are PCC joints reflecting through the pavement. The shoulder treatment is preventing the cracks from migrating beyond the PCC edge as depicted in Photo 3. The number of transverse cracks between the wheel path has decreased from 13 to 8. A number of these cracks have extended across the roadway and are now full width transverse cracks.

Photo 4. Section 1 Shoulder Settlement

PCC edge related longitudinal cracking has increased slightly from 71.2 to 79.9 percent. Initial load cracking was observed in a number of areas at the PCC edge. There is little elevation change between the roadway and shoulder in the north bound lane. The south bound shoulder has dropped between 6 and 13 mm (0.25 and 0.5 in) in a few small areas. Photo 4 displays the shoulder settlement. Section 1 has the second lowest amount of shoulder settlement of the experimental sections.

Section 2A, 230 mm Flowable Fill

Severity of rutting has increased in this section. Ruts < 6mm (0.25 in) in depth decreased from 80 to 57 percent. Rutting in the 6 to 13 mm (0.25 to 0.5 in) range has increased from 5 to 23 percent and rutting greater than 13 mm (0.5 in) increased from 15 to 20 percent. All of the severe rutting is located in the south bound lane near the north end of the section (across from Section 2B).

Centerline joint seperation is evident throughout the section.

The number of transverse cracks has increased. Full roadway increased from 18 to 32, half roadway decreased from 19 to 18 and cracks between wheel paths increased from 14 to 18.

PCC edge cracking increased from 71.1 to 83 percent. The majority of which is in the south bound lane near the north end of the project.

Shoulder elevation change has dramatically increased in a 40 meter (131 foot) portion of the south bound lane at the north end of the section. The shoulder has dropped more than 24 mm (1 inch) with initial load cracking and missing HMA. Photo 5 reveals the extent of PCC edge cracking.

Photo 5. Section 2A PCC Edge Cracking

Section 2B, 530 mm Flowable Fill

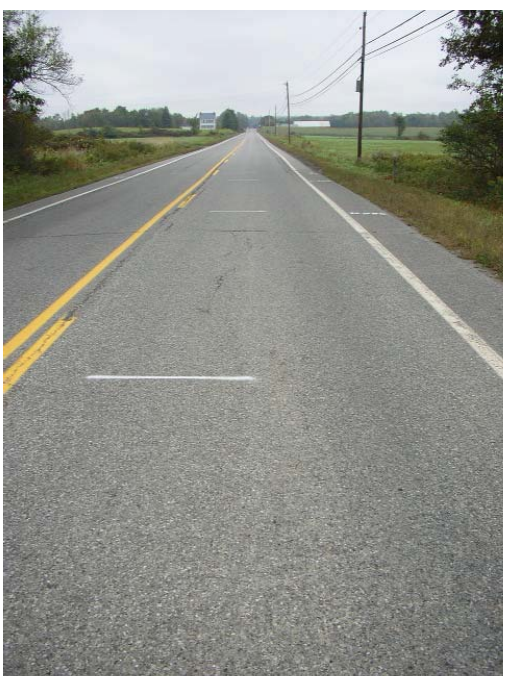

Photo 6. Section 2B

This section continues to outperform the remaining experimental sections.

Rut severity has increased slightly. Rut depths less than 6 mm (0.25 in) in depth decreased from 100 to 80 percent. Rut depths in the 6 to 13 mm (0.25 to 0.5 in) range increased 20 percent. There are no rut depths greater than 13 mm (0.5 in).

The centerline joint has separated along the entire length of the section.

There are two full roadway and one half roadway transverse cracks with no cracks between wheel paths.

Twenty percent of the PCC edge has reflected through the HMA with an elevation change of less than 6 mm (0.25 in). This is the lowest amount of PCC edge cracking of all sections. A view of the section is illustrated in Photo 6.

Section 3, 230 mm of 25 mm Superpave

The experimental shoulder on this section was surfaced differently than the other sections. Each lane of Section 1, 2A, 2B, and 4 from centerline to the shoulder edge, a width of 4.3 m (14 ft), was surfaced in one pass. Due to seasonal restrictions, each lane of Section 3 was surfaced to within ± 150 mm (± 6 in) of the PCC edge prior to shoulder treatment. The shoulder was then constructed and surfaced leaving a longitudinal joint 2.9 m (9.5 ft) left and right of centerline. Photo 7 displays a typical construction joint.

Photo 7. Section 3 HMA Construction Joint

One hundred percent of the shoulder construction joint has separated with HMA missing in portions of the joint as illustrated in Photo 8.

Severity of rutting has increased. Rutting <6 mm (<0.25 in) in depth decreased from 60 to 2 percent. Rut depths between 6 and 13 mm (0.25 and 0.5 in) increased from 25 to 46 percent of the section and rutting greater than 13 mm (0.5 in) in depth increased from 15 to 52 percent. All rutting greater than 13 mm (0.5 in) in depth is due to shoulder settling.

Section 3 continues to have the least amount of centerline joint separation. It was reported in the fourth interim report that Section 3 had 17.4 percent of centerline separation; this was an error, the correct amount is 8.7 percent. This year centerline separation increased to 15 percent.

The number of transverse cracks has increased. Full width increased from 11 to 31, half width increased from 9 to 18, and cracks between the wheel paths decreased from 13 to 7. The amount of transverse cracks is about the same as Sections 1 and 2B.

Photo 8. Section 3 Construction Joint

The amount of PCC related edge cracking has increased from 26.1 to 38.6 percent.

A portion of the north bound shoulder that begins at the transition between Section 2A and 3 and extends 250 m (820 ft) has an elevation that is 25 mm (1 in) higher than the roadway. It appears that the Superpave shoulder has shifted laterally and rolled up possibly due to poor gravel support. In other areas the shoulder has settled below the roadway creating rut depths greater than 13 mm (0.5 in).

Section 4 Heavy Overlay

Depth of rutting has increased. The quantity of ruts < 6mm (< 0.25 in) in depth decreased from 50 to 10 percent. Rutting between 6 and 13 mm (0.25 to 0.5 in) in depth increased dramatically from 8 to 40 percent. Rut depths greater than 13 mm (0.5 in) in depth has increased slightly from 42 to 50 percent. The entire length of the south bound lane has ruts greater in depth than 13 mm (0.5 in) due to settlement of the PCC related reflective cracking. North bound rutting is less severe.

Centerline joint separation was evident throughout the entire section.

Photo 9. Section 4 PCC Reflected Edge Crack

The number of full width and between wheel path transverse cracks increased from 28 to 44 and 21 to 36 respectively while the number of half width cracks decreased from 17 to 12.

PCC related edge cracking has increased from 68.6 to 86.6 percent. This is slightly less than the Control Section and slightly more than the experimental Sections 1 and 2A. Experimental Sections 2B and 3 continue to have significantly less PCC edge cracking.

Shoulder elevation remains even with the roadway in both lanes but HMA at the reflected PCC edge crack has settled resulting in increased rutting as can be observed in Photo 9.

Veazie - Orono Project No. STP-6683(00)X

This project was inspected on October 10, 2003. A natural gas pipeline was installed at an offset of between 4 and 5 m (13 and 16 ft) right of centerline on the entire project.

Self Adhesive Mesh Section

The severity of rutting increased. Depths between 6 and 13 mm (0.25 to 0.5 in) decreased from 100 to 80 percent and rutting greater than 13 mm (0.5 in) in depth increased from 0 to 20 percent.

The centerline joint looks very good with little joint separation. Cracking increased from 5.8 to 8.4 percent of the section.

The number of full and half roadway transverse cracks has increased from 2 to 7 and 2 to 5 respectively. Transverse cracking between wheel paths has decreased from 4 to 2.

Photo 10. Self Adhesive Mesh PCC Edge Cracking

The Self Adhesive Mesh continues to retard reflective cracking of the PCC roadway edge. Cracking has increased from 16.8 to 29.6 percent which is 12.5 percent less than the Control section. A majority of the edge cracking is in the north bound lane. Photo 10 illustrates cracking in the north lane. Shoulder elevation has not changed and is still even with the roadway.

Table 5. Pavement Condition Summary

Benton - Clinton Project No. STP-8651(00)X

Section	Rutting (%)															Centerline Joint Condition										Number of Transverse Cracks															PCC related longitudinal cracks (%)					Shoulder elevation change				
	< 6 mm					6 – 13 mm					> 13 mm					Ravel (%)					Separation (%)					Full width (across two lanes)					Half width (across one lane)					Between wheel path														
	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'
Control	65	32	25	3	0	0.8	64	65	42	35	4	4	10	55	65	0	0	2.4	0	0	0	6.1	51.4	65.2	95.5	25	47	47	64	136	12	20	36	81	123	102	321	348	277	125	49.5	85.7	92.7	99	100	0	0	-4	-12	>-13
1	100	100	100	88	85	0	0	0	12	15	0	0	0	0	0	90	90	3	4.8	0	0	0	95.1	95.2	100	0	0	1	16	35	1	2	10	6	19	0	2	40	13	8	0.6	7.7	28.5	71.2	79.9	0	0	0	0	-6
2A	100	96.7	83.4	80	57	0	3.3	10.8	5	23	0	0	5.8	15	20	83	83	0	1.5	0	0	0.2	98.5	98.5	100	1	3	12	18	32	0	5	10	19	18	0	4	10	14	18	0	25.3	49.2	71.1	83	0	0	0	0	>-24
2B	100	100	100	100	80	0	0	0	0	20	0	0	0	0	0	0	0	0	0	0	0	3	73	85.3	100	0	1	1	1	2	0	0	0	0	1	0	0	0	1	0	0	3.3	8.3	9.3	20	0	0	0	0	<-6
3	100	91.7	77	60	2	0	6.4	18	25	46	0	1.9	5	15	52	30	30	24	0	0	0	0	8.1	8.7	15	0	0	1	11	31	0	0	4	9	18	0	0	5	13	7	10.7	14.5	22.7	26.1	38.6	6	13	25	30	30
4	100	100	88.9	50	10	0	0	11.1	8	40	0	0	0	42	50	85	85	7.2	0	0	0	0.3	85.1	97.1	100	8	9	21	28	44	11	12	12	17	12	13	16	20	21	36	0.4	14.6	40.3	68.6	86.6	0	0	0	0	0

Veazie – Orono Project No. STP-6683(00)X

Section	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'	'99'	'00'	'01'	'02'	'03'
SAM	100	100	0	0	0	0	0	100	100	80	0	0	0	0	20	0	0	0	0	0	0	0	0	5.8	8.4	2	2	2	2	7	2	2	2	2	5	2	2	2	4	2	2	2	5.9	16.8	29.6	0	0	0	0	0
Control	100	100	0	0	0	0	0	68.4	65	57	0	0	31.6	35	43	0	0	0	0	0	0	0	0	1.8	1.8	2	2	2	3	6	0	0	1	2	2	1	1	3	4	1	28	30.6	33.3	36.8	42.1	0	10	6	6	>25

Control Section

Rut depth severity has increased. Rutting in the 6 to 13 mm (0.25 to 0.5 in) range decreased from 65 to 57 percent and ruts greater than 13 mm (0.5 in) in depth increased from 35 to 43 percent.

Centerline joint separation has remained the same at 1.8 percent.

The number of transverse cracks has increased. Full width increased from 3 to 6, half width remained the same at 2, and between wheel path cracks decreased from 4 to 1.

PCC edge related cracking has increased from 36.8 to 42.1 percent. Shoulder elevations are 6 mm (0.25 in) below the roadway in this area with a small portion that is greater than 25 mm (1.0 in) below the roadway. The majority of cracking is in the north bound lane. Photo 11 and 12 illustrates PCC reflected cracking and elevation change.

Photo 11. Control Section PCC Edge Cracking

Photo 12. Control Section Shoulder Elevation Change

Summary

Benton - Clinton Project No. STP-8651(00)X

Section 2B with 530 mm (21 in) of Flowable Fill has effectively slowed the occurrence of PCC edge related cracking. Although this is a small section at 30 meters (98 feet) in length only 20 percent of the PCC roadway edge has reflected to the surface and shoulder elevation has remained fairly stable. Sections 2A and 3 on either end have PCC edge cracking and shoulder deformation that ends at the transition with Section 2B. Statistical analysis of FWD deflections confirms that Section 2B is structurally similar to Section 3 but significantly stronger than the remaining sections.

Section 3 utilizing 230 mm (9 in) of Superpave is also reducing the amount of PCC edge cracking. This section has a longitudinal construction joint that parallels the PCC roadway edge making it difficult to evaluate. The construction joint was constructed poorly allowing the joint to ravel and crack. The outside edge of the PCC roadway is at an offset of 150 mm (6 in) from the construction joint. Longitudinal cracking observed outside the construction joint were considered PCC edge cracks as illustrated in Photo

7. Only 38.6 percent of PCC edge cracking was observed. This equates to 18.6 percent more than Section 2B and 41.3 percent less than Section 1, the next best treatment. Shoulder elevation changes are more prevalent especially the first 250 meters (820 feet) of the north lane beginning at the end of Section 2B. Shoulder construction began at this point and it appears the contractor made construction adjustments for the first 250 meters (820 feet) resulting in shoulder elevation differences.

Section 1 utilizing recycled asphalt pavement is performing well. PCC edge related cracking was apparent in 79.9 percent of the section. There is very little shoulder elevation change in the north bound lane and between 6 and 13 mm (0.25 and 0.5 in) in the south bound lane. Statistically, Section 1 is similar in strength to Sections 3 and 2A, weaker than Section 2B and stronger than Sections 4 and C.

Section 2A with 230 mm (9 in) of Flowable Fill has the poorest performance of the four experimental sections. Concrete roadway edge has cracked to the surface in 79.9 percent of the section and shoulder elevation has dropped more than 25 mm (1 in) in the north end of the section across from Section 2B. A majority of the edge cracked areas have alligator type cracking with missing HMA. Deflection comparisons reveal that Section 2A is structurally similar to Section 1, weaker than Sections 3 and 2A and stronger than Sections 4 and C.

Section 4, heavy overlay of the mainline and shoulders, is performing slightly better than the Control Section. PCC roadway edge cracking is evident in 86.6 percent of the section. Shoulder elevation has not changed but HMA at the PCC edge crack has settled below the pavement surface creating a dip in the HMA. A few areas have settled by as much as 24 mm (1 in). Statistical comparison of FWD tests shows that Section 4 is significantly stronger than the Control Section and significantly weaker than the remaining sections.

The Control Section has failed completely. All of the PCC edge has reflected to the surface and shoulder elevation has dropped more than 13 mm (0.5 in) below the roadway throughout the section. Analytical comparison reveals that this section has significantly higher deflections than the remaining sections.

Veazie - Orono Project No. STP-6683(00)X

The Self Adhesive Mesh combined with recycled pavement continues to reduce the amount of PCC related edge cracking and rutting. Shoulder elevation is even with the roadway and the number of transverse cracks is similar to the Control Section. PCC edge cracking has increased from 16.8 to 29.6 percent. Self Adhesive Mesh combined with recycled pavement and relatively low cost is a reliable treatment to bridge the transition between PCC and shoulder.

PCC edge related cracking in the Control Section has increased from 36.8 to 42.1 percent and the shoulder elevation has dropped considerably to more than 25 mm (1 in) below the roadway in areas. As mentioned in the Third Interim Report, most of the PCC related cracking is adjacent to the gas pipeline construction. It’s possible that construction of the pipeline could have caused the shoulder to shear aiding in the development of PCC edge cracking. The opposite lane has a total of 21.1 meters (69 feet) of PCC edge cracking.

Recommendations

Based on visual and deflection analysis the following recommendations can be made:

- Flowable Fill is an effective shoulder treatment to extend the width of composite roads. The depth of material should be a minimum of twice the depth of the PCC slab.
- Superpave or HMA is an effective shoulder treatment to extend the width of composite roads. Aggregate base material for this application should be well compacted prior to placement.
- PavePrep SA7 combined with Hot Recycled Pavement can be used to extend the width of composite roadways.
- PavePrep SA7 in combination with Flowable Fill or HMA may be a good application to extend composite roadways.
- Recycled Asphalt Pavement is not as effective as Flowable Fill or HMA but could be used as a shoulder treatment if treated with a stabilizing agent and bridged with PavePrep SA7.
- Heavy overlay only slows the progression of PCC related edge cracking and roadway deformation.
- Maintenance mix overlay is not considered a viable application to reduce deformation of composite roads.

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TR 99-11 Construction Report, January 1999
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