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Maine Department of Transportation

Transportation Research Division

Technical Report 97-20

Subsurface Drainage for Rehabilitation of PCC Pavement – Rt. 202 Gray – New Gloucester

Final Report, December 2003

Transportation Research Division

Subsurface Drainage for Rehabilitation of PCC Pavement

Introduction

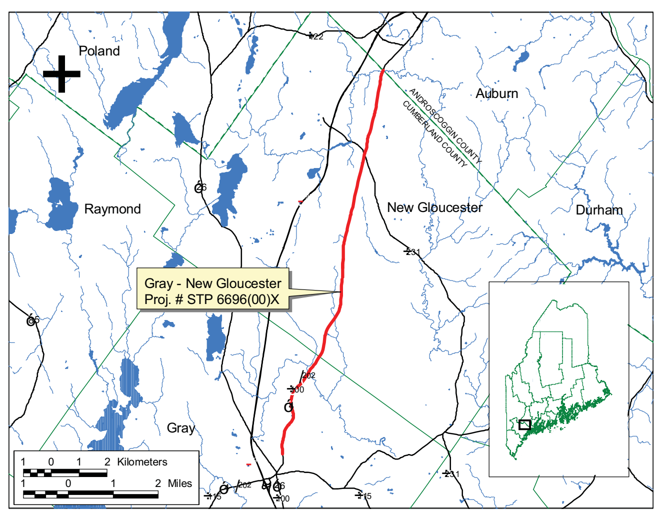
Many existing roadways are being enhanced due to the pressures of increased vehicular traffic. Some of these improvements involve widening the present travel way to accommodate a turning lane and/or additional travel lanes. This often necessitates removing unsatisfactory material in the existing shoulder and replacing with more freely draining materials containing fewer fines in an attempt to reduce differential movement between existing and new traveled ways, and to more nearly equate their load carrying abilities. Many existing roadways consist of bituminous pavements and are underlain by 5.5 or 6 m (18 or 20 ft) wide Portland Cement Concrete (PCC) pavements, further complicating the transition from existing to new pavement.

Objectives

The existing pavement may not have a well-drained granular base or subbase especially after years of infiltration by finer adjacent soils and winter sands. Therefore, it is proposed to install subsurface drainage systems longitudinally at one or both sides of the existing roadway subbase and the proposed granular subbase shoulder replacement.

Project Location/Description

Project number STP 6696(00)X, PIN 6696.00, Gray - New Gloucester, has been selected as a primary candidate for this experiment. The beginning point is 0.5 km (0.29 mi) north of Route 26, and extends northerly 14.29 km (8.88 mi) on Routes 4/100/202. This project has 6 m (20 ft) wide PCC under the roadway and is scheduled to have both Level I and Level II resurfacing areas, with the experimental features proposed to be installed on both. These areas are located as follows:



Station	Scope
Sta. 0+203 - 2+100	Level II
Sta. 2+100 - 7+480	Level I
Sta. 7+480 - 14+493	Level II

Level I treatment is resurfacing of a highway that is considered to be built to established standards ("A" highway) for the first time or the next resurfacing after a more intensive resurfacing project. The treatment is concentrated on extending the life of the pavement, usually by resurfacing with a goal of at least 75 percent of the project cost in pavement items. Work is concentrated on the surface of the roadway between shoulder berms with only an occasional item beyond what is necessary to maintain the core of the roadway. Nonfunctional guardrail systems will be repaired or replaced. Other components such as ditching, culverts and roadside safety are in satisfactory condition.

Level II is treatment to an “A” highway for the second time after it is constructed, often alternating with Level I treatments. This level emphasizes pavement expenditures but also maintains drainage structures, ditches, replaces culverts, updates or replaces guardrail as necessary, addresses roadside safety issues, and upgrading of bridge guardrail connections. Pavement treatments include overlays, grinding and overlay, cold in-place recycling, among others.

Experimental Features

The following Special Provision and Standard Specifications describe the experimental features of each test area:

SPECIAL PROVISION
SECTION 605.40
SUBSURFACE DRAINAGE FOR REHAB OF PCC PAVEMENT

COMMON ITEMS

Description. This work shall consist of furnishing and installing a series of experimental subsurface drainage membrane systems in accordance with these specifications and as shown on the plans. Although there are five (5) different systems utilized in this experiment, many features are common to more than one. These common features will be described first.

Drainage Geotextile. The drainage geotextile used shall satisfy the requirements of Section 722.02, Drainage Geotextile, and shall be TC MIRAFI FW 40/10, as manufactured by the NICOLON MIRAFI GROUP, 3500 Parkway Lane, Suite 500, Norcross, GA, 30092, or approved equal. The local distributor is R.P. Martino & Co., 2 Ledge Drive, Georgetown, MA, 01822 Tel. (508) 352-2106.

EQUIPMENT

General. The equipment for installation shall be capable of meeting the provisions of the Construction Requirements of this Specification. Where required, cutting of the membrane shall be done with utility knives or other approved methods.

CONSTRUCTION REQUIREMENTS

General. The trench for each of the five (5) different experimental drainage cross sections shall be excavated to the width, depth, and location as shown on the plans. The trench shall be excavated in such a manner that the soil outside the eight (8) inch maximum width is not disturbed. The bottom of the trench shall be smooth with all impediments to gravity water flow removed, and conform to line and grade to assure flow toward the outlet at all points along the bottom.

Drainage Geotextiles. The drainage geotextile shall line the trench for its entire length in all five (5) experimental drainage sections, as shown on the plans. After the various drainage systems described under UNIQUE ITEMS are installed as required, the trench shall be filled with underdrain sand or crushed stone, as shown on the plans. The portion of geotextile protruding above the surface at the sides of the trench shall be folded over the top of the aggregate to form a double thickness the full width of the

trench. This shall be secured to prevent damage to or dislodgment of the textile during subsequent construction operations. The ends will be folded in a similar fashion to prevent infiltration of fine soils into the drainage materials.
The geotextile shall be placed smoothly against the trench sides and bottom, and be maintained in that manner during backfilling and other operations. Removal and replacement of unsatisfactory geotextile and all geotextile that is damaged by traffic or construction operations, as determined by the Engineer, shall be the responsibility of the contractor. Storage of the drainage geotextile shall be as recommended by the manufacturer.

Connection To Water Outlet. The five different experimental side drainage trenches shall be connected to cross pipes, catch basins as shown on the plan or outlet in other manners as directed by the Engineer. The backfill at the outlet ends of all five experimental areas shall be crushed rock, within the drainage geotextile to the top of the trench and for a distance of at least 2 meters (6 ft.) longitudinally. A length of perforated underdrain pipe 1800 mm long and 150 mm in diameter will penetrate this water collection pocket at least 1800 mm and be connected to a solid 150 mm pipe which will convey the collected ground water to the outlet.

UNIQUE ITEMS

Description. The following items are unique to the different experimental systems:

Underdrain Backfill Granular Material. This material shall conform to the Granular Material for Type B underdrain, as specified in Section 703.22. Placement shall be according to Section 605.04 (a), except that a) after the initial placement of backfill of not more than 300 mm (12 inches), compaction may be achieved by ponding the granular material with water, and b) the remainder of the trench may be backfilled in one lift, and compacted by ponding with water or by vibratory roller, utilizing low amplitude vibrations, at the surface.

Underdrain Backfill Crushed Material. This material shall conform to the specification 703.22, crushed material for Type C underdrain. Placement shall be according to Section 605.04 (b).

Perforated Underdrain Pipe. Materials for, and manufacturer of, this pipe shall conform to specification 605, except that the diameter shall be 100 mm (4 inches).

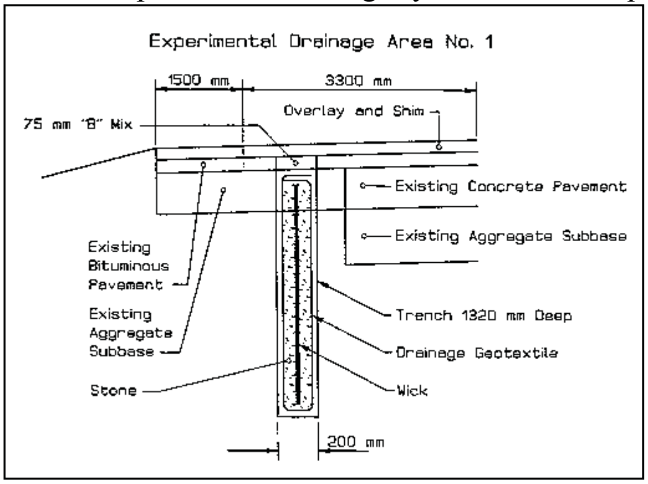
Prefabricated Drainage Composite. The prefabricated drainage composite shall be TC MIRAFI 5000, as manufactured by the NICOLON MIRAFI GROUP, 3500 Parkway Lane, Suite 500, Norcross, GA, 30092, or approved equal. The local distributor is R.P. Martino & Co., 2 Ledge Drive, Georgetown, MA, 01833, Tel. (508) 352-2106. Where joining of the sections is necessary, the recommendations of the manufacturer shall be followed.

EQUIPMENT

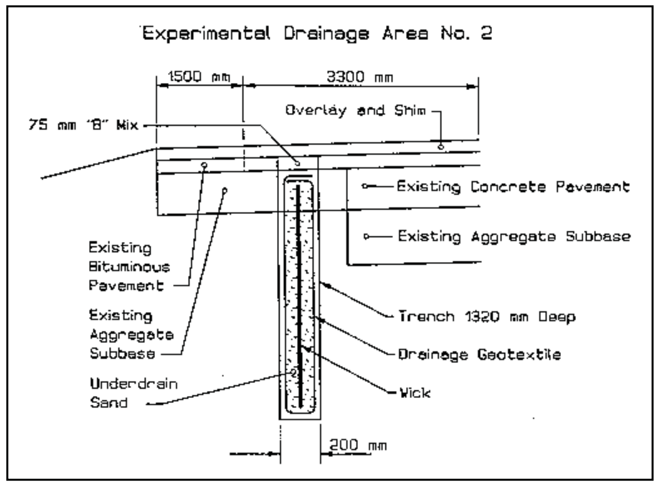
General. The equipment for installation shall be capable of meeting the provisions of the Construction Requirement of this Specification. Excavation shall be performed using a "Ditch Witch" or similar device capable of excavating a narrow trench in an expeditious manner. Backhoes or other equipment utilizing a wide bucket shall not be used without the consent of the Engineer.

CONSTRUCTION REQUIREMENTS

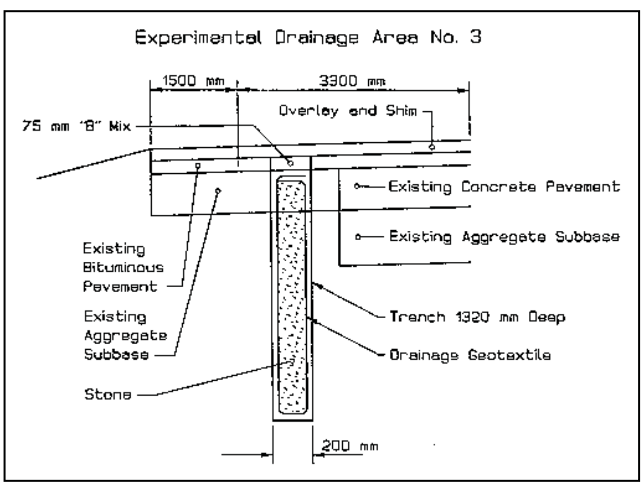
In addition to the Construction Requirements described under Common Items, each of the five (5) different experimental drainage systems have unique construction features which include the following:



Area 1. Before backfilling the trench, that has been lined with a drainage geotextile as described under Common Items, the drainage composite as described under Unique Items, Prefabricated Drainage Components, will be placed as shown on the plans, Experimental Drainage Area No. 1. Backfill material shall be as specified in Section 703.22, Underdrain Backfill crushed materials, for Type C Underdrain, and placed according to Section 605.0 4 (b). The outlet shall be constructed as shown on the plans, Outlet Ends for Experimental Areas 1, 2, and 3.

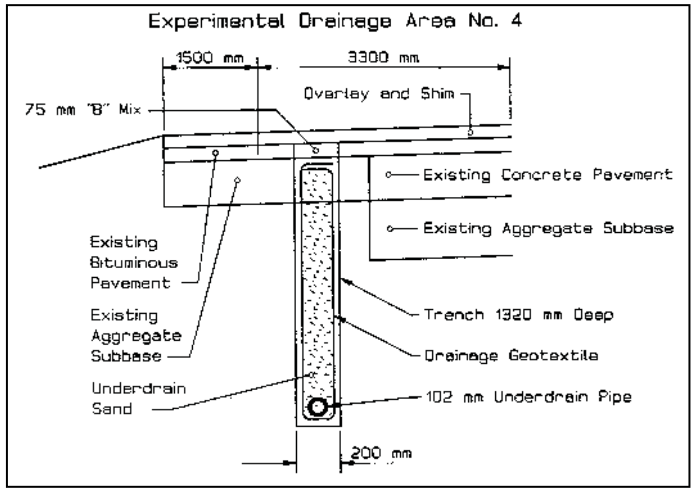


Area 2. Before backfilling the trench, which has been lined with a drainage geotextile as described under Common Items, the drainage composite as described under Unique Items, Prefabricated Drainage Composite, will be placed as shown on the plans, Experimental Drainage Area No. 2. Backfill shall be as specified in Section 703.22, Underdrain Backfill, Granular Material, for Type B underdrain, and placed according to Section 605.04 (a) except as noted under UNIQUE ITEMS, Underdrain Backfill Granular Material. The outlet shall be as shown on the plans, Outlet Ends for Experimental Areas 1, 2, and 3. As the trench backfill in this case is underdrain sand, the final portion of the trench within the drainage membrane around and above the 150 mm underdrain pipe, shall be filled with crushed stone meeting the requirements of Section 703.22 and installed according to Section 605.04 (b).

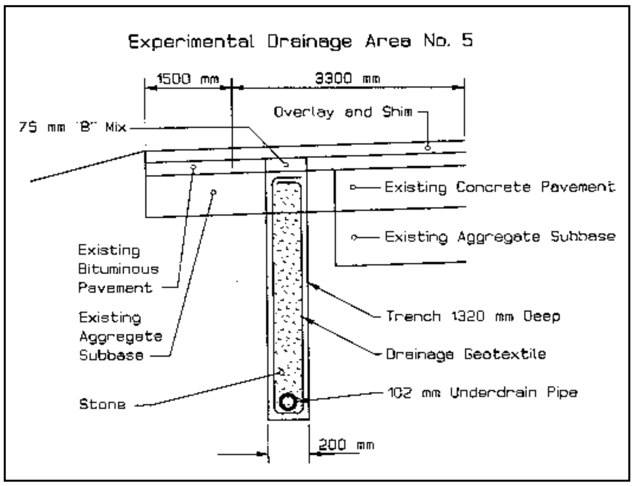


Area 3. This area utilizes crushed stone meeting the requirements of Section 703.22, and installed within the drainage geotextile in accordance with Section 605.04 (b). The outlet shall be as shown on the plans, Outlet Ends for Experimental Areas 1, 2, and 3.

Area 4. This experimental section shall contain a 100 mm (4 inch) diameter Underdrain Pipe placed full length of the trench at the bottom of the area enclosed by the drainage geotextile, as described earlier in this Special Provision. Backfill shall conform to the requirements of Section 703.22, Underdrain Backfill, Granular Material, and shall be constructed as required by Section 605.04 (a), except as noted under UNIQUE ITEMS, Underdrain Backfill Granular Material. The outlet of this 100 mm (4 inch) diameter Underdrain Pipe is to be cut into the cross pipe at station 1+274±, left.



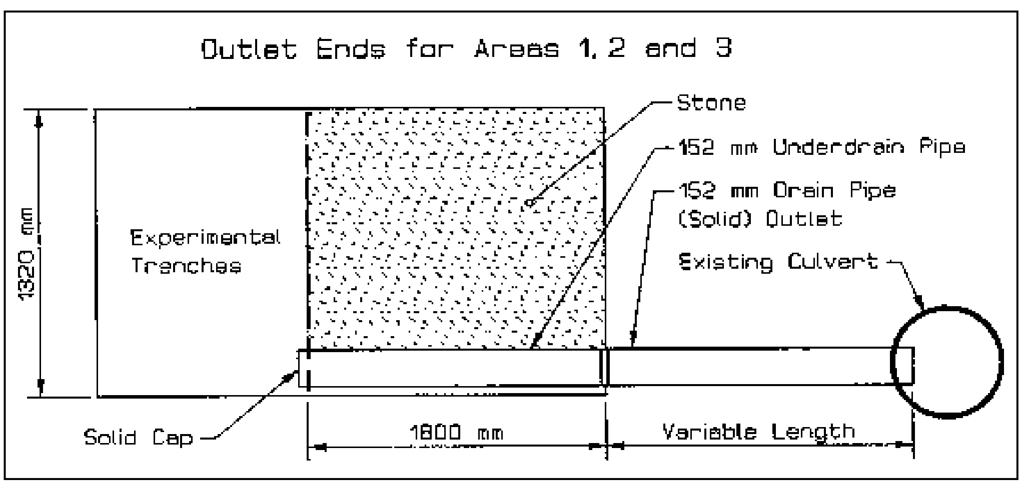
Area 5. Area 5 shall be similar to Area 4, except that the backfill material shall conform to the requirements of Section 703.22, Underdrain Backfill, Crushed Material, and shall be constructed as specified by Section 605.04 (b). The outlet of this 100 mm (4 inch) diameter Underdrain Pipe is to be cut into the cross pipe at station 1+274, right.



Removal and replacement of unsatisfactory drainage composite, and all other materials that are damaged by traffic or construction operations, as determined by the Engineer, are the responsibility of the contractor.

Method of Measurement. Each of the five (5) experimental drainage areas shall be measured by the meter (foot), in place.

Basis of Pavement. The accepted quantity of experimental drainage areas, Types 1, 2, 3, 4, and 5, will be paid for at the contract unit price per meter (foot). Payment will be full compensation for furnishing and placing the drainage geotextile, the drainage composite, the underdrain pipe and all other materials, labor and other incidentals necessary to complete the work.



Payment will be made under:

Pay Items		Pay Unit
605.400	Experimental Drainage Area No. 1	Meter
605.401	Experimental Drainage Area No. 2	Meter
605.402	Experimental Drainage Area No. 3	Meter
605.403	Experimental Drainage Area No. 4	Meter
605.404	Experimental Drainage Area No. 5	Meter

MAINE DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS
SECTION 605.04

605.04 Underdrain Construction.

(a) Underdrain, Type B. The trench shall be excavated to the required width and depth and a bed of the specified granular material, 75 mm [3 inches] in depth, prepared in thetrench. One Hundred Fifty millimeter [Six inch] perforated pipe shall be laid on this bed with the perforations as shown on the Standard Detail plans.

After the pipe has been firmly bedded and joints securely connected, it will be inspected before any backfill is placed. The remaining backfill shall be granular material meeting the same requirements as that used for bedding the pipe.

For underdrain placed under areas of proposed pavement, the material shall be placed in 200 mm [8 inch] layers, loose measure and thoroughly compacted except that the initial layer of backfill around the pipe may be placed in a layer not exceeding 300 mm [12 inches]. For underdrains placed under areas not proposed to be paved, the initial layer of backfill shall not exceed 300 mm [12 inches] and the remaining material may be placed in one lift to the elevation of the subgrade and compacted with heavy rubber tired or vibratory compaction equipment to the satisfaction of the Engineer.

The upstream end of all completed underdrain pipe shall be sealed with cement mortar or other acceptable material. Care shall be taken that soil does not enter the pipe. Pipe so contaminated before backfilling shall be removed, cleaned and re-laid.

(b) Underdrain, Type C. The trench shall be excavated to the width and depth as determined by the size and depth of the pipe to be installed.

The perforated pipe shall be laid to line and grade centered on the bottom of the trench with the perforations as shown on the Standard Detail plans.

After the pipe has been firmly bedded and all joints securely connected it will be inspected before any backfill is placed. The backfill shall be placed in accordance with Subsection 603.08 and as shown on the Standard Detail plans using the materials specified.

When Underdrain Type B or Underdrain Type C is constructed, backfill material beyond the underdrain trench lateral limits designated on the plans shall be material conforming to the requirements of Granular Borrow, Underwater Backfill. Material within the underdrain trench limits shall conform to the requirements of the type underdrain being constructed. The Contractor shall take precautions to prevent the underdrain backfill material from becoming contaminated with clay, silts, organic matter or other foreign matter. Methods of placing backfill material shall be limited to the use of equipment which will place material directly into the trench. Pushing material into the trench will not be allowed.

When underdrain is to be constructed in embankment fill, the excavation for the trench shall be done after the embankment has been completed to subgrade elevation.

MAINE DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS
SECTION 703.22

703.22 Underdrain Backfill Material. Granular material for Underdrain Type B shall be free from organic matter and shall conform to the following table:

Sieve Designation		Percentage by Weight Passing Square Mesh Sieves
Metric	English	
25.0 mm	1 inch	95-100
12.5 mm	1/2 inch	75-100
4.75 mm	No. 4	50-100
850 µm	No. 20	15-80
300 µm	No. 50	0-15
75 4 µm	No. 200	0-5.0

Crushed or uncrushed material for Underdrain Type C shall conform to the following table:

Sieve Designation		Percentage by Weight Passing Square Mesh Sieves
Metric	English	
25.0 mm	1 inch	100
19.0 mm	4 inch	90-100
9.5 mm	8 inch	0-75
4.75 mm	No. 4	0-25
2.00 mm	No. 10	0-5.0

MAINE DEPARTMENT OF TRANSPORTATION
STANDARD SPECIFICATIONS
SECTION 722.02

722.02 Drainage Geotextile. The geotextile shall have property values expressed in "minimum" or "minimum average roll" values that meet or exceed the values stated below, as determined by the most recent test methods specified below. All mechanical property values expressed as "average" or "typical" shall be reduced by 20 percent and then compared to the values stated below.

Both woven and nonwoven geotextiles are acceptable, however, no "slit-tape" woven fabrics will be permitted. The geotextile must meet the following requirements:

Geotextile Mechanical Property	Test Method	Minimum Permissible Value Class A*	Class B*
Grab Tensile Strength (Both directions)	ASTM D4632 or ASTM D5034 and ASTM D5035	800 N [180 pounds]	356 N [80 pounds]
Grab Elongation	ASTM D4632 or ASTM D5034 and ASTM D5035	15 percent	15 percent
Mullen Burst Strength	ASTM D3786 or ASTM D751	2000 kPa [2900 psi]	896 kPa [130 psi]
Puncture Strength	Modified ASTM D3787 or modified ASTM D751	56 N [80 pounds]	110 N [25 pounds]
Trapezoid Tear Strength	ASTM D4533 or ASTM D1117	220 N [50 pounds]	110 N [25 pounds]

Geotextile Hydraulic Property	Test Method	Permissible Value
Apparent Opening Size (AOS)	CW-02215	Sieves Sizes between 850 um and 150 um [U.S. Std. Sieve numbers) between No.20 and No.100]
Permeability	ASTM D4491	0.01 mm/sec

* Class A Drainage applications are those where installation stresses are more severe than Class B applications, such as where very sharp angular aggregate is in contact with the fabric, or a heavy degree of compaction is required.

* Class B Drainage applications are those where installation stresses are less severe such as where fabric is used with smooth graded surfaces having no sharp angular projections, no sharp angular aggregate is used, or where compaction requirements are light.

Construction

It was apparent from the start of the first edge drain trench that the trenching machine, capable of excavating a ditch 0.2 m (0.66 ft) wide, could not operate properly due to 152 mm+ (6 in+) stones in the shoulder material. A decision was made to excavate the remaining experimental edge drain trenches with a 0.6 m (2 ft) wide bucket. To compensate for the additional underdrain material to fill the edge drains; the depth of each trench was decreased from 1.22 m (4.0 ft) to 1.07 m (3.5 ft).

All five areas chosen for edge drains had a problem with underlying PCC either skewing away from the roadway or no PCC pavement at all due to reconstruction of the project in 1936. A location of the PCC and edge drain is as follows:

The first edge drain was installed on September 4, 5 and 8, 1997, in Area 3 between the outlet at Station 3+263 left and ending at Station 2+974 left. The underlying PCC slab started to skew away from the existing bituminous pavement edge at Station 3+200 to a maximum offset of 7.6 m (25 ft) left at Station 3+097 then returning to the bituminous pavement edge at Station 2+989. The contractor continued to install the edge drain along the PCC edge with no installation setbacks.

Area 5 was installed on September 8 and 9, 1997, between the outlet at Station 1+274 right and ending at Station 1+567 right. PCC pavement was not evident along the pavement edge while constructing this experimental area but, according to the 1936 plans, the edge of PCC is located 1.8 m (6 ft) right of CL up to Station 1+369 where the PCC was removed from Station 1+369 to 1+522. The drain trench was excavated to at a depth of 1.3 m (4 ft) from the top of the existing bituminous pavement. Ledge was encountered at Station 1+299 that changed the trench depth to approximately 600 mm (24 in) from the top of the existing bituminous pavement. The contractor continued to install the edge drain along the ledge for another 75 m (246 ft) where, due to the increased elevation of the pavement and the stable elevation of the ledge, the trench depth gradually increased to 1.1 m (3.6 ft) and continued at that depth to the end of Area 5 (station 1+567). The 100 mm (4 in) drainage pipe was supported at the bottom of the edge drain pocket to maintain a gradual pitch for proper drainage.

Area 4 was placed between the outlet at Station 1+274 left and ending at Station 1+522 left on September 9, 10 and 11, 1997. PCC pavement was evident at an offset of 3.7 m (12 ft) from CL up to Station 1+369 where, according to the 1936 construction plans, the existing reinforcing concrete was removed between Station 1+369 and 1+522. Edge drain installation continued beyond Station 1+369 along the existing Bituminous pavement edge up to Station 1+522 where PCC pavement reappeared, inhibiting installation of the remaining edge drain.

Another small section of Area 4 edge drain, labeled Area 4C, was installed between the outlet at Station 2+035 right and ending at Station 2+127 right on September 17. This location had no underlying PCC pavement along the pavement edge due to relocation of the roadway.

On September 15 and 16, 1997, Area 2 was installed. Construction began at Station 2+035 right and ends at the inlet at Station 1+720 right. Experimental edge drain was installed according to basic design. Due to the decreased trench depth the wick was curled up at the bottom, and then filled on both sides with Type B Underdrain. Due to relocation of this particular area of Route 4 in 1936, there is no PCC pavement under the roadway.

Area 1 was constructed on September 16 and 17, 1997. Installation began at the outlet at Station 2+035 left as per basic design. The wick for this section was also curled up at the bottom due to the modified trench depth. The contractor had difficulty placing equal amounts of Underdrain Type C on both sides of the wick resulting in a design modification at Station 1+944 left. The wick was placed against the roadway side of the trench then backfilled with Type C Underdrain. This modification continued to the inlet at Station 1+730 left. This area also has no PCC pavement due to relocation of the roadway in 1936.

A Control Area was set up between Stations 2+974 left and 2+693 left. The underlying PCC pavement for this section is at an offset of 2.7 m (9 ft) left.

A second Control Area (Control 2) that has no PCC pavement was created on October 17, 2000 between Stations 3+500 right and 3+800 right. This area will be used to evaluate experimental drainage areas that were not installed adjacent to PCC pavement.

Visual Inspection

A visual inspection was performed on October 30, 2002. Tables I and II contain summaries of the inspection.

Table I contains a Pavement Condition Summary (PCS) for 2002. This table portrays length of PCC edge cracking, cracking between wheel paths, edge of pavement, load and transverse cracking as well as rut depths. A column showing the percent of increased cracking compared to 2001's inspection is also included.

Table II breaks down the PCS data further to show pavement distress as a percent of the length of each section. Percentage of cracking along the PCC edge in Table II is based on the length of PCC under the roadway. Percentage of load cracking is based on the total area of each section [length of section by width of lane (3.3528 m)]. Centerline, between wheel path and pavement edge percentiles is based on the length of each section.

All types of cracking have increased in all sections as compared to last year's evaluation with the exception of Between Wheel Path cracking in Area 3. A portion of this type of cracking has deteriorated to the point that it is now labeled Load Cracking thereby reducing the quantity of Between Wheel Path Cracks.

The experimental and control sections will be divided into two sub-groups for further discussion, a Composite Roadway group and a Typical Roadway group.

The Composite Roadway Group contains Area 3, Area 4, and the Control Section. These sections have PCC under at least a portion of each section.

The Typical Roadway Group involves Area 1, Area 2, Area 4C, Area 5, and the Control 2 Section. These sections have no PCC under the roadway or the PCC pavement is offset to the extent that there is no PCC pavement under the travel lane.

Composite Roadway Group

Area 3

Photo 1. Area 3 PCC Related Edge Cracking

The length of PCC related edge cracking in Area 3 has increased dramatically from a total length of 5.3 m (17 ft) in 2001 to 28 m (92 ft) in 2002, an increase of 428% (Photo 1).

Centerline cracking increased slightly from 109.9 to 111 meters (361 to 364 feet) an increase of 1%.

Longitudinal cracking between the wheel paths has decreased from 18 to 16 meters (59 to 52 feet) a decrease of 11%. Portions of this type of cracking have deteriorated to the point that it is now recorded as load cracking.

Edge Cracking has increased 405% from a total length of 10.1 m (33 ft) in 2001 to 51 m (167 ft) in 2002.

The number of lane width transverse cracks has increased from a total of 13.5 to 21, an increase of 56%

Load cracking increased 46% from the last evaluation from a total of 60.9 m^2 (656 ft^2) to a total of 89 m^2 (958 ft^2).

Rut depths have remained the same at 6 – 12 mm (0.25 – 0.5 in).

Area 4

Photo 2. Area 4 PCC Related Edge Cracking

Area 4 PCC edge cracking increased 72% from a length of 12.2 m (40 ft) to 21 m (69 ft) in 2002 (Photo 2).

Centerline cracking increased 13% from a total length of 78.1 m (256 ft) to 88 m (289 ft). Forty two meters of this type of cracking has opened up greater than 25 mm (1 in) in width.

Cracking between the wheel paths did not occur in this section.

Edge of pavement cracking increased 8% from a total length of 55.5 m (182 ft) to 60 m (197 ft).

The number of full lane transverse cracks increased from a total of 7 in 2001 to a total of 11.25 this year, an increase of 61%.

Load cracking increased 38% from 14.5 m^2 (156 ft^2) to 20 m^2 (215 ft^2).

Rut depths have remained the same at 6 – 12 mm (0.25 – 0.5 in).

Control Section

Photo 3. Control PCC Related Edge Cracking

In the Control Section, PCC related edge cracking increased 11% from a length of 133.1 m (437 ft) in 2001 to 148 m (486 ft) in 2002 (Photo 3).

Centerline cracking has increased 25% from a length of 30.0 m (99 ft) to 38 m (125 ft)

There was no cracking between wheel paths in this section.

Edge of pavement cracking increased 20% from a length of 19.2 m (63 ft) to 23 m (75 ft) and the number of full lane width transverse cracks increased slightly from 17.5 to 18.0 cracks.

The amount of load cracking increased 12% from a total of 92.1 m^2 (991 ft^2) to 103 m^2 (1109 ft^2).

Rut depths have increased from a depth of 6 – 12 mm (0.25 – 0.5 in) to 12 – 18 mm (0.5 – 0.75 in).

Composite Roadway Summary

Table II displays pavement distress as a percentage of its section. Data reveals that both Area 3 and Area 4 had less load cracking, less PCC edge cracking, and less rutting (from Table I) than the Control Section. Load and PCC edge cracking as well as rutting are very good indicators of roadway longevity. This being the case Experimental Drainage Area 3 and 4 has reduced the amount of these types of cracking as well as rutting. Area 4 with Underdrain Sand and drainage pipe is outperforming Area 3 which contains Crushed Stone and drainage pipe.

In contrast, the Control Section had less centerline separation and edge of pavement or shoulder cracking than Experimental Areas 3 or 4. Edge of pavement cracking can be attributed to settlement of the Experimental Drainage under the roadway shoulder.

Typical roadway Group

Area 1

Photo 4. Area 1 Cracking

Centerline separation in Experimental Drainage Area 1 has increased 44% from the previous evaluation to a total length of 5.3 m (83 ft).

Between Wheel Path cracking has also increased from 10.8 m (35 ft) to 18 m (59 ft) and increase of 67%.

Edge of pavement or shoulder cracking has increased 333% from a total length of 26.1 m (86 ft) to 113 m (371 ft) (Photo 4).

The number of full lane transverse cracks has increased 73% from 2.75 cracks to 4.75 cracks.

Load cracking has increased 109% from a total area of 46 m^2 (495 ft^2) to 96 m^2 (1033 ft^2).

Rutting has remained the same at 6 – 12 mm (0.25 – 0.5 in).

Area 2

Photo 5. Area 2 Cracking

Centerline cracking in this area has increased 28% from 27.6 to 35.3 meters (91 to 116 feet).

Cracking between the wheel paths has increased slightly from a length of 40 m (131 ft) to 42 m (138 ft), an increase of 5% (Photo 5).

Edge and shoulder cracking has increased 59% from 33.9 to 54 meters (111 to 177 feet).

Full lane transverse cracking increased 71% from a count of 7.75 to 13.25.

Load cracking increased 14% from 53.4 m^2 to 61 m^2 (575 to 657 ft^2).

Rutting remained the same at 6 to 12 mm (0.25 to 0.5 in).

Area 4C

Photo 6. Area 4C PCC Edge Reflective Crack

Area 4C has 19.7 m (65 ft) of PCC running under the roadway. All of it is skewed across the lane due to realignment of the road as can be seen in Photo 6. The original composite road is where the truck is parked and you can see where the PCC pavement edge crack lines up with the edge of the original road. Although Area 4C has PCC under the roadway it is not included in the Composite Roadway Group because the PCC offset is great enough that the experimental drainage would have no influence on this section of road.

Centerline cracking has increased 181% from 29.5 to 83 meters (97 to 272 feet).

Cracking between wheel paths has increased 12% from a length of 14.3 m to 16 m (47 to 52 ft).

The length of cracking at the edge of pavement has also increased from 37.8 m to 43 m (124 to 141 ft).

The number of full lane transverse cracks has increased slightly from 3 to 3.25 cracks.

Load associated cracking has increased 83% from a total area of 21.9 to 40 square meters (236 to 431 square feet).

Rutting has remained the same at 6 – 12 mm (0.25 to 0.5 in).

Area 5

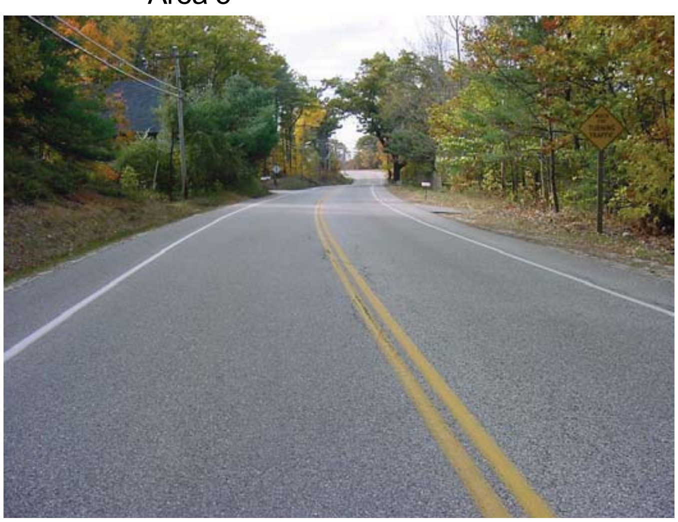


Photo 7. Area 5 (Left Lane)

Area 5 has a slight increase in centerline separation from 103.1 to 107 meters (338 to 351 feet). Forty seven meters of this cracking is greater than 25 mm (1 in) in width (Photo 7).

Between wheel path cracking has doubled from a length of 6 meters to 12 meters, an increase of 100%.

Edge of pavement cracking has increased 45% from a total length of 70.4 to 102 meters (231 to 335 feet).

The number of transverse cracks has increased from 2 to 5, an increase of 150%.

Load cracking has increased from 26.9 to 50 m^2 (289 to 538 ft^2), an increase of 86%.

Rutting has remained the same at 6 to 12 mm (0.25 to 0.5 in).

Control 2

Photo 8. Control 2 Cracking

There was a 6% increase in Centerline cracking from a length of 40.5 to 43 m (133 to 141 ft).

Between wheel path cracking has remained the same at a length of 23 meters (75 feet).

Edge of pavement cracks has increased 35% from a total length of 31.8 to 43 meters (104 to 141 feet).

The number of full lane transverse cracks has more than doubled from 11.75 to 26.25 cracks, an increase of 123%.

Load cracking has increased 22% from a total area of 189.9 m^2 to 231 m^2 (2044 ft^2 to 2486 ft^2) (Photo 8)

Rutting has increased from depths of 12 – 18 mm (0.5 – 0.75 in) to 18 – 25 mm (0.75 – 1.0 in).

Typical Roadway Summary

A review of Table II reveals that Areas 1 and 2 has slightly less centerline separation than the Control Section. Area 4C and 5 has considerably more centerline separation than the Control Section.

Areas 5 and 1 has slightly less cracking between the wheel paths when compared to the Control Section whereas Areas 2 and 4C has 5.6 and 9.7 percent more respectively.

As with the Composite Group, all Experimental Sections had greater amounts of cracking at the edge of pavement and in the shoulder when compared to Control 2 Section. This could be attributed to settling of the drainage systems.

All Experimental Drainage Sections have a reduced amount of load cracking than the Control 2 Section. Area 5 and 2 in particular have significantly less load cracking, followed by Area 1 and 4C.

Conclusion

Composite Roadway Group

Both experimental Area 3 and Area 4 have less PCC edge reflected cracking than the Control Section by 16.8 and 30.6 percent respectively. The amount of load cracking in Experimental Area 3 and 4 is also less than the Control Section by 1.7 and 8.5 percent respectively. In contrast the amount of centerline cracking in the Control Section is close to three times less than Area 3 and 4 and the only section showing cracks between the wheel path is Area 3. The amount of pavement edge cracking is twice as high in Area 3 as the Control Section and nearly three times greater in Area 4. Pavement edge cracking may be attributed to settlement of the experimental drainage systems causing the HMA surface to crack. This may migrate to the right wheel path and become load cracking in the future. If this type of cracking is attributed to settlement of the drainage system it may be due to poor construction techniques such as improper compaction of the Underdrain Sand or Stone Backfill rather than a failure of the drainage systems. Most if not all edge drains are installed in the shoulder area of the roadway whereas these edge drains are installed partially under the travel way and are exposed to traffic loading.

Although Experimental Drainage Area 3 and 4 has reduced the amount of load cracking and PCC reflective cracking over the five year study, edge cracking may migrate to the travel way and become load cracks reducing pavement service life. Because of this it is recommended that edge drains be installed in the shoulder area or at the edge of the travel way away from traffic loads for a valid evaluation of the drainage systems.

Typical Roadway Group

The Typical Roadway Group has no PCC pavement under the travel way. This group is experiencing similar pavement distress as the Composite Group. All Experimental Drainage Area's have reduced the amount of load cracking, in particular Area 5 and Area 2 has very little load cracking. Area 1 and 2 has less centerline cracking than the Control Section and Area 1 and 5 has less cracking between the wheel paths. As with the Composite Group, the Control Section has less cracking along the pavement shoulder than the experimental areas and this may be caused by settling of the experimental drainage systems. Although Experimental Drainage Area 1, 2, 4C, and 5 has reduced load cracking over the five year evaluation, the amount of cracking in the shoulder as a result of drainage settlement may defeat the purpose of the experiment over time and it is recommended that the drainage systems be installed at the edge of pavement for further evaluation.

A majority of the cracking in all experimental and control areas is due to reflective cracking because the project was resurfaced with bituminous shim and overlay. It is recommended that experimental edge drains be installed on a Full Depth Reclaim project and at the edge of the travel way for a thorough evaluation.

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Other Available Documents:
Construction and First Interim Report, September 1998
Second Interim Report, March 2000
Third Interim Report, November 2000
Fourth Interim Report, August 2002

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TABLE I. 2002 PAVEMENT CONDITION SURVEY

Section	Total Length of Underlying PCC		Longitudinal Cracking: Along PCC Edge [1]				Longitudinal Cracking: Centerline [2]				Longitudinal Cracking: Between Wheel Path				Longitudinal Cracking: Edge of Pavement				Transverse Cracking			Load Cracking				Rut Depth
	m	(ft)	m	(ft)	"01" PCS m	Percent Increase	m	(ft)	"01" PCS m	Percent Increase	m	(ft)	"01" PCS m	Percent Increase	m	(ft)	"01" PCS m	Percent Increase	Full Lane	"01" PCS m	Percent Increase	m^2	(ft^2)	"01" PCS m^2	Percent Increase	mm (in)
Composite Roadway Group																										
Area 3	78	(256)	28	(92)	5.3	428%	111	(364)	109.9	1%	16	(52)	18	-11%	51	(167)	10.1	405%	21	13.5	56%	89	(958)	60.9	46%	6-12 (0.25-0.5)
Area 4	95	(312)	21	(69)	12.2	72%	88	(289)	78.1	13%					60	(197)	55.5	8%	11.25	7	61%	20	(215)	14.5	38%	6-12 (0.25-0.5)
Control	281	(922)	148	(486)	133.1	11%	38	(125)	30.3	25%					23	(75)	19.2	20%	18	17.5	3%	103	(1109)	92.1	12%	12-18 (0.5-0.75)
Typical Roadway Group																										
Area 1							25.3	(83)	17.6	44%	18	(59)	10.8	67%	113	(371)	26.1	333%	4.75	2.75	73%	96	(1033)	46	109%	6-12 (0.25-0.5)
Area 2							35.3	(116)	27.6	28%	42	(138)	40	5%	54	(177)	33.9	59%	13.25	7.75	71%	61	(657)	53.4	14%	6-12 (0.25-0.5)
Area 4C			19.7	(65)	19.7	0%	83	(272)	29.5	181%	16	(52)	14.3	12%	43	(141)	37.8	14%	3.25	3	8%	40	(431)	21.9	83%	6-12 (0.25-0.5)
Area 5							107	(351)	103.1	4%	12	(39)	6	100%	102	(335)	70.4	45%	5	2	150%	50	(538)	26.9	86%	6-12 (0.25-0.5)
Control 2							43	(141)	40.5	6%	23	(75)	0		43	(141)	31.8	35%	26.25	11.75	123%	231	(2486)	189.9	22%	18-25 (0.75-1.0)

[1] Area 4C PCC edge cracking is skewed across the lane reflecting old PCC roadway edge.
[2] Areas 1 & 2 have 305 m and Areas 4 & 5 have 248 m of common centerline.
Shaded areas have drainage installed adjacent to PCC roadway.

TABLE II. 2002 PAVEMENT DISTRESS BY SECTION

Section	Length of Section m (ft)	Length of Underlying PCC m (ft)	Longitudinal Cracking: % along PCC edge	Longitudinal Cracking: % of Centerline	Longitudinal Cracking: % Between Wheelpath	Longitudinal Cracking: % edge of Pavement	% Load Cracking[1]
Composite Roadway Group							
Area 3	289 (948)	78 (256)	35.9	38.4	5.5	17.6	9.2
Area 4	248 (814)	95 (312)	22.1	35.5		24.2	2.4
Control	281 (922)	281 (922)	52.7	13.5		8.2	10.9
Typical Roadway Group							
Area 1	305 (1001)			8.3	5.9	37.0	9.4
Area 2	315 (1034)			11.2	13.3	17.1	5.8
Area 4C	92 (302)			90.2	17.4	46.7	13.0
Area 5	293 (961)			36.5	4.1	34.8	5.1
Control 2	300 (984)			14.3	7.7	14.3	23.0

[1] Based on total area of Section (length of section x width of lane).
Shaded areas have drainage installed adjacent to PCC roadway.