

FEASIBILITY OF WHITETOPPING IN CONNECTICUT

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<b>16. Abstract</b> The experience of whitetopping in Connecticut is limited mainly to a literature search, a research proposal and construction specification, and the construction process of a specific state project. To date, whitetopping has not been installed in Connecticut. This report however, is intended to be used as a reference for future consideration of placement of whitetopping in Connecticut and elsewhere.				
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### Disclaimer

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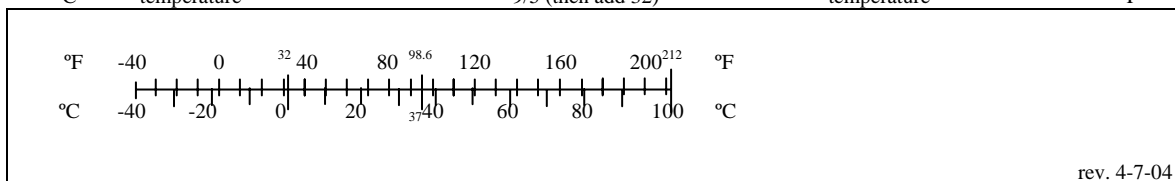
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# METRIC CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO METRIC MEASURES				
<u>SYMBOL</u>	<u>WHEN YOU KNOW</u>	<u>MULTIPLY BY</u>	<u>TO FIND</u>	<u>SYMBOL</u>
<b>LENGTH</b>				
in	inches	25.4	millimeters	mm
ft	feet	0.305	meters	m
yd	yards	0.914	meters	m
mi	miles	1.61	kilometers	km
<b>AREA</b>				
in <sup>2</sup>	square inches	645.20	square millimeters	mm <sup>2</sup>
ft <sup>2</sup>	square feet	0.093	square meters	m <sup>2</sup>
yd <sup>2</sup>	square yards	0.836	square meters	m <sup>2</sup>
mi <sup>2</sup>	square miles	2.59	square kilometers	km <sup>2</sup>
ac	Acres	0.405	hectares	ha
<b>MASS</b>				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000lbs)	0.907	megagrams	Mg
<b>VOLUME</b>				
floz	fluid ounces	29.57	milliliters	ml
gal	gallons	3.785	liters	l
ft <sup>3</sup>	cubic feet	0.028	cubic meters	m <sup>3</sup>
yd <sup>3</sup>	cubic yards	0.765	cubic meters	m <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°F	Fahrenheit temperature	5/9 (after subtracting 32)	Celsius temperature	°C

APPROXIMATE CONVERSIONS FROM METRIC MEASURES				
<u>SYMBOL</u>	<u>WHEN YOU KNOW</u>	<u>MULTIPLY BY</u>	<u>TO FIND</u>	<u>SYMBOL</u>
<b>LENGTH</b>				
mm	millimeters	0.039	inches	in
m	meters	3.28	Feet	ft
m	meters	1.09	Yards	yd
km	kilometers	0.621	Miles	mi
<b>AREA</b>				
mm <sup>2</sup>	square millimeters	0.0016	square inches	in <sup>2</sup>
m <sup>2</sup>	square meters	10.764	square feet	ft <sup>2</sup>
m <sup>2</sup>	square meters	1.195	square yards	yd <sup>2</sup>
km <sup>2</sup>	square kilometers	0.386	square miles	mi <sup>2</sup>
ha	hectares	2.47	Acres	ac
<b>MASS</b>				
g	grams	0.035	ounces	oz
kg	kilograms	2.202	pounds	lb
Mg	megagrams	1.103	short tons (2000lbs)	T
<b>VOLUME</b>				
ml	milliliters	0.034	fluid ounces	floz
l	liters	0.264	gallons	gal
m <sup>3</sup>	cubic meters	35.314	cubic feet	ft <sup>3</sup>
m <sup>3</sup>	cubic meters	1.307	cubic yards	yd <sup>3</sup>
<b>TEMPERATURE (exact)</b>				
°C	Celsius temperature	9/5 (then add 32)	Fahrenheit temperature	°F



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## FEASIBILITY OF WHITETOPPING IN CONNECTICUT

### Background and Significance

In Connecticut, whitetopping was originally proposed in a state reconstruction/rehabilitation project adjacent to a truck stop off I-95, interchange 40 in Milford, CT. The ramps and roadways in this area have a history of rutting (defined below) and need for more frequent paving. Therefore, to alleviate the rutting and repaving in this area, the use of whitetopping and Superpave Performance Grade 76-22 were proposed in the design of the paving structure for this state project. The Division of Research was made aware of this construction project and proposed to study these pavements that had not been placed in Connecticut before.

### **Description of Rutting**

The Distress Identification Manual for the Long-Term Pavement Performance Program defines a rut as a longitudinal surface depression in the wheel path. Figure 1 shows a profile of rutting in the left and right wheel paths. The manual states that severity levels of rutting are not applicable, but could be defined by categorizing the measurements taken. It further states that a record of the measurements taken is much more desirable, because it is more accurate and repeatable than are severity levels (1).



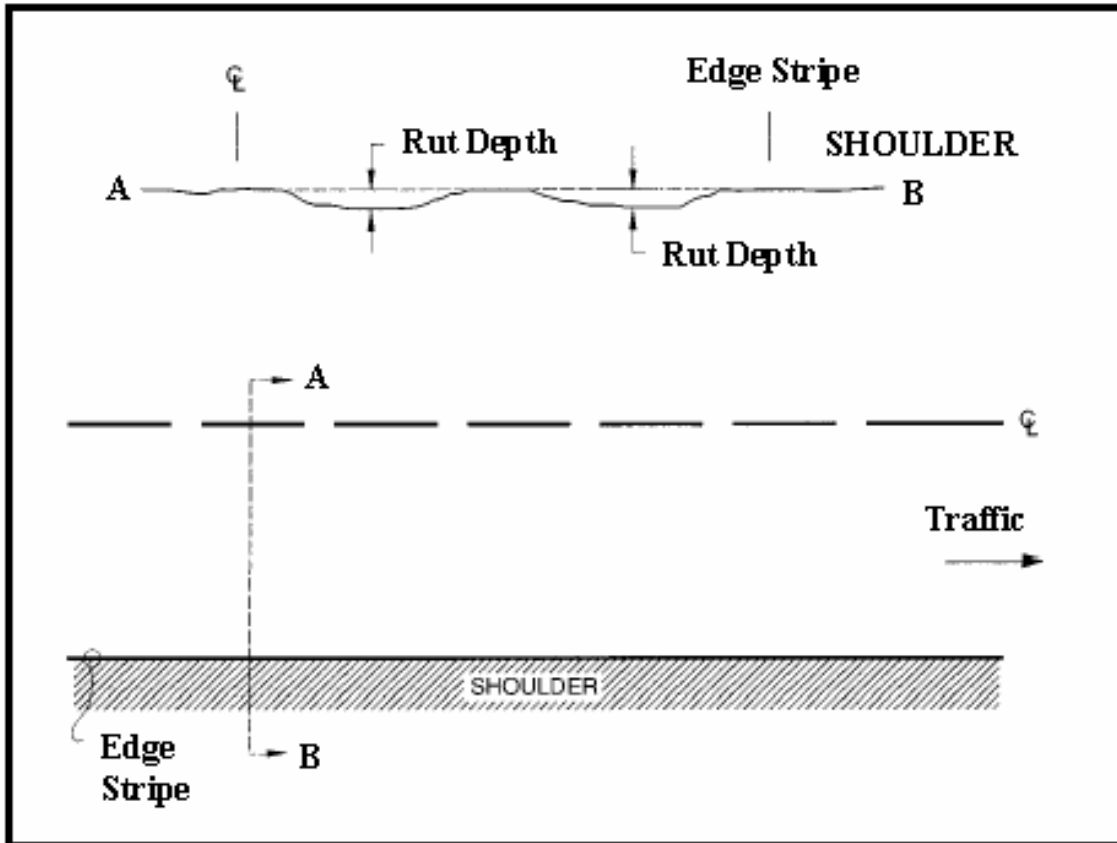


Figure 1. Rutting in Left and Right Wheel Paths (1)

In a pavement condition rating system prepared by the Ohio Department of Transportation severity levels are defined for rutting in flexible pavements. According to their pavement condition rating system, rutting severity is based upon rut depth as approximated visually (2).

- Low rutting is barely noticeable, depth between 1/8" and 3/8"
- Medium rutting is readily noticeable, depth > 3/8", < 3/4"
- High rutting is readily noticeable, depth > 3/4"

Highway agencies should try to determine the source of the rutting. If rutting has been determined to be caused by the base or subgrade layers, these base layers need to be replaced before

overlaying. The performance of the overlay may continue to be affected if the layers below are of poor quality (3).

#### **Definition of whitetopping**

Conventional whitetopping is the placement of a Portland Cement Concrete (PCC) overlay on an existing hot-mix asphalt (HMA) pavement. Whitetopping was designed as a rehabilitation technique for deteriorated HMA pavements that exhibit rutting, shoving, and alligator cracking (4). Conventional whitetopping is generally greater than 100 mm (4"). Ultra-thin whitetopping (UTW) is a thinner layer of PCC, generally 50 mm to 100 mm (2" to 4") thick and also placed on an HMA pavement typically with lower volumes than locations where conventional whitetopping has been placed.

Although UTW is a relatively new rehabilitation technique, the construction varies little from construction of a normal concrete overlay. The only extra step is that the existing asphalt surface must be milled and cleaned to promote bonding between the concrete and asphalt layers. The performance of UTW overlays to date has been very encouraging in that data suggests they will provide long-lasting durable surfaces for low-volume pavement applications (4). Table 1 compares conventional whitetopping to ultra-thin whitetopping.

**Table 1. Comparison of Conventional and Ultra-thin Whitetopping (4)**

	<b>Conventional Whitetopping</b>	<b>Ultra-thin Whitetopping</b>
Typical Thicknesses	102 to 305 mm (4 to 12 in.)	50 to 102 mm (2 to 4 in.)
Condition of Existing Pavement	All deteriorated HMA pavements	Low-volume deteriorated HMA pavements
Bonding Condition	Designed as unbonded, but some partial bonding occurs	Strong bond required between existing HMA pavement and new PCC overlay
Preoverlay Repair	<ul style="list-style-type: none"> <li>• Limited repair required (failed areas only)</li> <li>• Possible milling to correct profile</li> </ul>	<ul style="list-style-type: none"> <li>• Repair of areas unable to contribute to load-carrying capacity</li> <li>• Milling of the HMA surface</li> </ul>
Minimum Thickness of HMA	50 mm (2 in.) after any milling	76 to 152 mm (3 to 6 in. after any milling)
Special Design and Construction Considerations	<ul style="list-style-type: none"> <li>• Adequate support critical to performance</li> <li>• Adequate joint design (including joint spacing and load transfer)</li> <li>• Placement of a whitewash* on HMA surface on hot days</li> </ul>	<ul style="list-style-type: none"> <li>• Bonding with HMA pavement</li> <li>• PCC mix design is often high strength and/ or fiber modified</li> <li>• Extremely short joint spacing (typically between 0.6 and 1.8 m (2 to 6 ft.))</li> </ul>

\* Whitewashing can be accomplished using either a lime slurry mixture or a white pigmented curing compound and should be considered in order to reduce the temperature of the HMA interlayer when it exceeds 43°C (110°F).

**Description of Superpave**

Superpave, which is an acronym for Superior Performing Asphalt Pavements, is a mix design and testing process for hot-mix asphalt pavements. Superpave is a product of the Strategic Highway Research Program (SHRP), which began in the 1980s and eventually came under the purview of the FHWA. A national effort was developed by FHWA in the 1990s to implement Superpave throughout the United States. The original goal was to have Superpave utilized in all fifty states by 1998 (5).

Connecticut was one of the later states to come on-board with this effort. The first full-scale Superpave pavement constructed in Connecticut was on state route 2 in Colchester/Lebanon/Bozrah during 1997. Currently in Connecticut all new HMA pavement designs are required to include Superpave. To-date, ConnDOT has opted to use Superpave PG 64-28 as the default or 'workhorse' mix design for Connecticut. However, the Superpave system of design allows for adjustments to address high traffic loads, high or low ambient temperatures, and slow moving heavy traffic.

#### Study Objectives

##### **Original objectives as stated in the research proposal (5):**

The objectives of the proposed research are to monitor, evaluate and document the construction and performance of whitetopping on a highway exit ramp from I-95 northbound to Woodmont Road and on a service road intersection (Old Gate Lane & Woodmont Road) in Milford. In addition, an adjacent off-ramp and on-ramp from Woodmont Road to I-95 southbound and its associated intersection with Woodmont Road, which are constructed with Superpave PG 76-22, will be monitored. Of particular concern will be the Superpave design's ability to resist wheel path rutting and the whitetopping design's ability to resist cracking, during five years of in-service monitoring. A comparison will also be made to the on-ramp with Superpave PG 64-28 which, as noted, is the most common Superpave mix design currently being used in Connecticut.

##### **Revised Study Objectives**

Due to elimination of whitetopping from the construction project, the research study objectives were revised. The information obtained

about whitetopping, including the reasons for its elimination, is documented in this report. Superpave PG 76-22, which was actually placed, will continue to be monitored and compared to the Superpave PG 64-28. It may be determined that the PG 76-22 resists wheel path rutting better than the Superpave PG 64-28 and therefore may be used in more locations around Connecticut. The monitoring includes automated rut measurements and manual crack surveys.

### Literature Review

#### **History of Whitetopping in the United States**

The first conventional whitetopping overlay was built in 1944 on an airfield at the U.S. Air Force Base in Offut, Nebraska (6). Conventional whitetopping overlays generally have a minimum thickness of 125 mm (5") and have been used mainly in heavy-truck corridors to combat asphalt rutting. According to the article entitled, " Ultrathin Whitetopping State-of-the-Practice for Thin Concrete Overlays of Asphalt," published in August 1998, over 189 whitetopping projects have been built and documented since the first project in 1944.

Although whitetopping is a well-established rehabilitation process, ultra-thin whitetopping (UTW) is a newer overlay technique. Ultra-thin whitetopping is different from conventional whitetopping because there are specific steps taken to bond the overlay to the underlying asphalt and short joint spacings are used. The overlays are generally between 50 mm to 100 mm (2" to 4") thick. The first experimental UTW project in the United States was on a landfill disposal facility near Louisville, Kentucky, beginning September 1991 (6). The UTW overlays have been developed for low-volume pavements,

such as city streets and intersections where rutting and shoving is a problem.

### **Experiences of other states**

#### **Missouri**

The Missouri Department of Transportation performed a study to determine the feasibility of placing an ultra-thin whitetopping (UTW) overlay as a viable pavement rehabilitation method on low to medium volume asphaltic concrete (AC) pavements where rutting or shoving or both have become a problem (7). Three different construction projects placed UTW at intersections between April 1999 and June 2003. The locations ranged from 13,000 to 64,000 ADT (average daily traffic) with between 8% to 10% trucks. As of May 2004, all the projects are performing well and have eliminated the problems of rutting and shoving at the intersections. Visual distress surveys are continuing to be performed on a yearly basis.

#### **Florida**

In 1996, the Florida Department of Transportation (FDOT) began a research project to evaluate the design, construction, and performance of ultra-thin whitetopping (8). Three test tracks showed an excellent bond between the UTW and asphalt surface, so UTW was then installed at a truck weigh station; the first UTW project in Florida. The weigh station has more than 1,400 trucks travel through it daily. The trucks have to come to a complete stop before proceeding to the weigh platform.

#### **South Dakota**

South Dakota had performed earlier research on non-metallic fiber reinforced concrete (NMFRC) as a whitetopping. The sections performed

well for five years, but South Dakota wanted to do further research into the constructability of NMFRC, the behavior of jointed and unjointed overlays, and economic analysis, especially life cycle costs. For the joint spacing, South Dakota wanted to minimize the joints by testing wider joint spacing (6.1 m (20') to 15.25 m (50')). Five test sections were placed and evaluated. Several conclusions from this research are as follows (9):

1. UTW is a reliable alternative to milling and replacing with hot-mix asphalt frequently in deteriorated and/or damaged asphalt pavements. The procedure is technically sound and it reduces the time required to rehabilitate the roads. It eliminates ruts and provides a safer surface for traffic.
2. The NMFRC with enhanced fatigue, impact resistance, modulus of rupture, ductility and toughness properties is particularly suitable for the construction of UTW overlays.

#### **North Dakota**

In 1997, the North Dakota Department of Transportation placed an experimental section of whitetopping. Their objective was to determine if a thin lift of a polyolefin-fiber reinforced PCC (PFRPCC) can serve as an alternative to a conventional bituminous overlay of existing asphalt pavement especially in areas with rutting present. The monitoring and evaluation includes the distresses in the pavement, the fiber dispersion throughout the PCC, the overall pavement condition, the fibers effect on the ride of the PCC section, the fibers ability to control reflective cracking, and a comparison to an adjacent bituminous overlay section (10). The experimental section chosen has an average daily traffic of 1,700 (1998 estimate) vehicles with 11% trucks.

After one year, the whitetopping test section was performing well. There was some cracking, but the cracks are tight and not a problem for maintenance or a detriment to ride quality. The cracks also appeared to be concentrated near areas associated with larger joint spacings. There was no reflective cracking due to the underlying asphalt layer.

Whitetopping course - "PCC Overlays - State of the Technology"

The Federal Highway Administration (FHWA) sponsored a report and subsequent course in the interest of information exchange regarding Portland Cement Concrete (PCC) overlays. The report was published in April of 2002 (4), and workshops were held throughout the country subsequent to that. Connecticut requested a workshop, which was held on October 16, 2003. The various ConnDOT divisions represented at the workshop included Facilities Design, Research, Highway Design, Pavement Management, Construction, and Materials Testing. Several industry representatives as well as FHWA personnel were also present.

The agenda of the one day workshop included overviews of the different types of PCC overlays, as well as recommended applications, critical design elements, current overlay design methodologies, recommended construction practices, and performance highlights of each type. The main intent of the workshop was to share information on whitetopping with various Divisions throughout the Department for consideration of possible future installations.



## Whitetopping Construction Specifications

### **Missouri**

Ultra-thin whitetopping overlays are placed at 4" thickness. Conditions used for selecting good candidates for UTW overlays include:

1. a minimum of 3" of existing sound asphalt after cold milling.
2. the existing pavement must be over a sound base.
3. the traffic volume should be low to medium.

### **Florida**

For the research project performed, the thickness of the Ultra-Thin Whitetopping ranged from 80 mm (3") to 100 mm (4") with a joint spacing of 1.2 m (4') and 1.6 m (5') (8). High early strength concrete with polypropylene fibers was used for half of the sections in the research project and plain concrete used in the other half.

The first few years after implementation at the Ellaville weigh station, the following conclusions were drawn:

1. Primary emphasis should be on achieving a maximum bond between the UTW and the asphalt surface.
2. Compressive strength, shearing strength, and rideability should be specified as acceptance criteria to help produce better performance and ensure a smoother ride.
3. Both 1.2 m (4') and 1.6 m (5') joint spacing performed equally well.
4. The UTW on 32 mm (1") thick asphalt layer did not show any premature cracking.

5. A preconstruction meeting is essential to discuss the specific and unique features of the UTW.
6. The effect of fibers on the performance could not be determined. Sections with and without the fibers performed equally well within the first few years.
7. Sealing of the joints didn't seem to make a difference in the performance of the UTW.

### **South Dakota**

The results from the installation of test sections of UTW produced the following recommendations (9):

1. Only non-metallic fiber reinforced concrete (NMFRC) should be used in the construction of UTW (as opposed to plain concrete) because of its enhanced structural properties, which are desirable for UTW and because of its ability to restrict the widening of the cracks.
2. A fiber dosage of 14.8 kg/cu.m. (25 lbs/cu.yd.) is recommended.
3. The minimum thickness of the UTW should be 89 mm (3.5 in.).
4. Some additional mixing time is required for NMFRC over plain concrete (as determined by field trials), but otherwise the same construction procedures should be followed.
5. The joint spacing can be 6 to 9.2 m (20 to 30 feet). Joint sawing must be done as soon as the concrete can support the operator and equipment. Brooming and tining should also be done as early as possible.

6. The milled surface of the asphalt must be thoroughly cleaned with water jets to remove dust and sand particles.
7. Bonded overlay is desirable to provide a composite action for the slab which will reduce the potential tensile stresses and cracking in concrete overlays. A thin layer of cement slurry bonding agent could be used.

#### **North Dakota**

The experimental section of whitetopping (PFRPCC) placed had the following installation specifications (10):

1. The joints were cut using a soft-cut procedure which allowed the joints to be cut several hours sooner. The cuts were sawed at approximately 28 mm (1-1/8") deep (approx. 1/3<sup>rd</sup> thickness of the PFRPCC) and 3 mm (1/8") wide. The cuts were not sealed afterwards.
2. Various joint spacings were used, ranging from 2 m to 8 m (6 to 25 feet over the approximate 69 m (230 feet) length.
3. The specifications called for milling of 75 mm (3") of asphalt, which would still retain 75 mm to 100 mm (3" to 4") of an asphalt base.
4. 88 mm (3.5") of fiber enriched concrete would replace the milled asphalt. The constructed depth of the fiber PCC ranged from 88 mm to 113 mm (3.5" to 4.5"), therefore the evaluation on the depth was more difficult due to the variability.
5. The addition of the fiber to the concrete required more mixing time with no increased strength (neither compression or

flexural) in the cylinders tested. However, over time the fibers appeared to hold the cracks together.

### **Connecticut**

Based on information gathered from other state specifications, a specification for whitetopping was developed for this state construction project. The specification was compiled by the Pavement Management Division, who had made the recommendation to include it in the state construction project. A copy of the specification, as included in the project, is given in Appendix A. Included in the specification are two pages of diagrams illustrating the saw cut methods to be used. (Note: Recommendations for modifications to this specification are included later in this report under Whitetopping Installation Concerns.)

#### Proposed Installation in Connecticut

Whitetopping was proposed to be installed in State Construction Project 83-220. A description as to why this project was chosen for whitetopping installation is as follows (as described in the proposal (5)):

Due to extensive repetitive loadings from trucks, increasingly in slow-moving mode, wheel path rutting has become a problem in some areas. One particular location of note is the exit ramps and service roads adjacent to I-95 Exit 40, Woodmont Road, in Milford. This interchange has a significant amount of large trucks utilizing it due to the proximity of a truck service station adjacent to the exit.

This area, as well as most of Interstate 95, was built between 1956 and 1958. The majority of the roadway, including ramps, was

originally constructed of Portland Cement Concrete and has been subsequently overlaid more than once during the past 20 years with hot-mix asphalt pavement. This interchange, including mainline I-95 in this area, was identified to be in need of rehabilitation in 1993. A design was started shortly thereafter. During the final design stage in 2000, it was decided to utilize whitetopping in a few sections. It was also felt that this was a good candidate location to use Superpave PG 76-22 in order to assess its capabilities to withstand heavy truckloads.

The aforementioned project, State Project 83-220, at I-95 Exit 40 in Milford, originally included paving the mainline traffic lanes and one on-ramp with Superpave PG 64-28, paving one on-ramp and one off-ramp with Superpave PG 76-22, and paving one off-ramp to include 100 mm (4 inches) of whitetopping. Also, sections of the cross road (Woodmont Road) and service road (Old Gate Lane) were proposed to include portions with both Superpave and whitetopping. Figure 1 is the index plan for the original proposed surface layers for each section of roadway in the project limits. Figure 2 indicates the originally proposed cross-sections for the roadways in this state project. Due to several reasons, as stated later in this report, whitetopping was never placed in this project. Instead, Superpave PG 64-28 was used at the locations where whitetopping had been proposed.

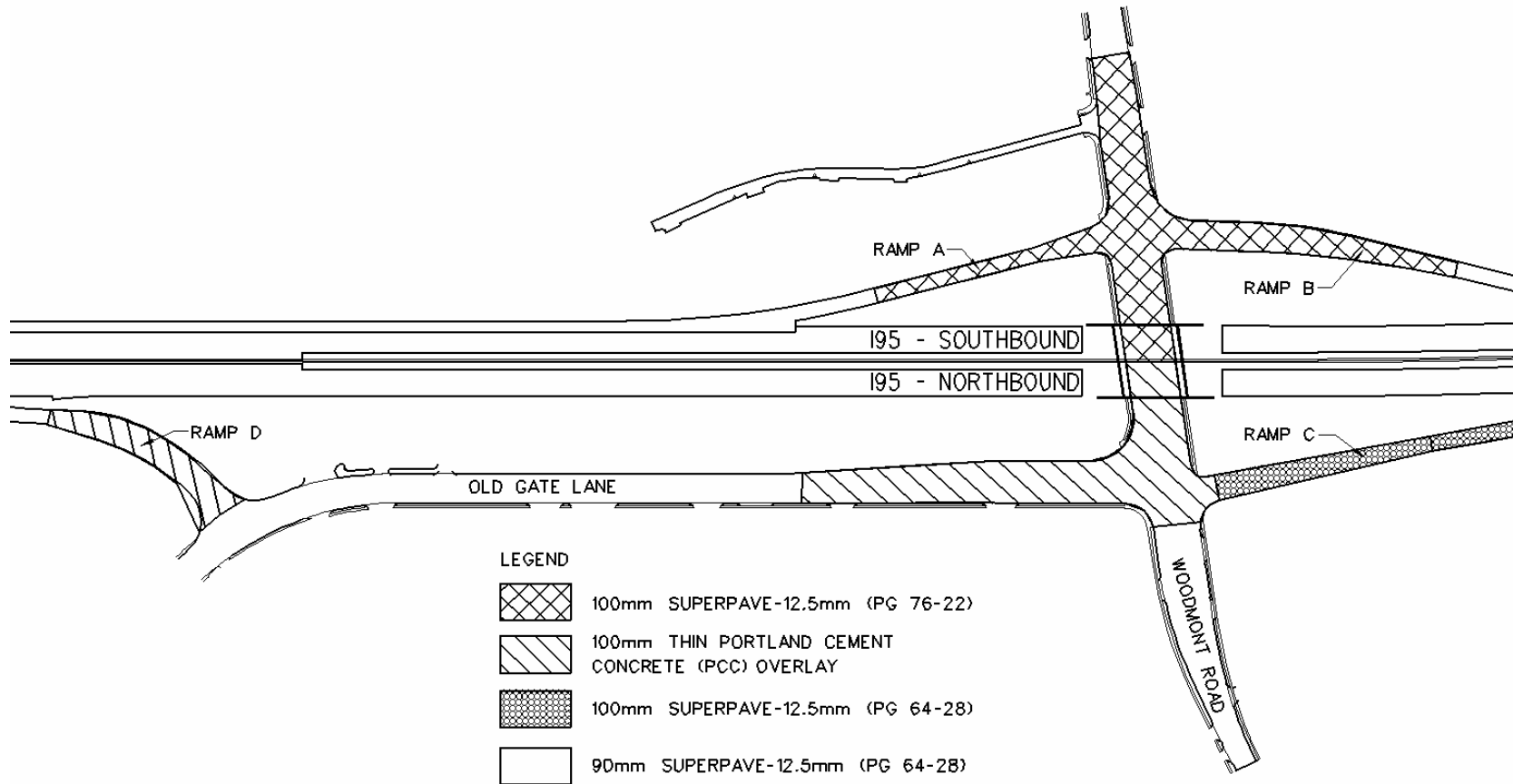
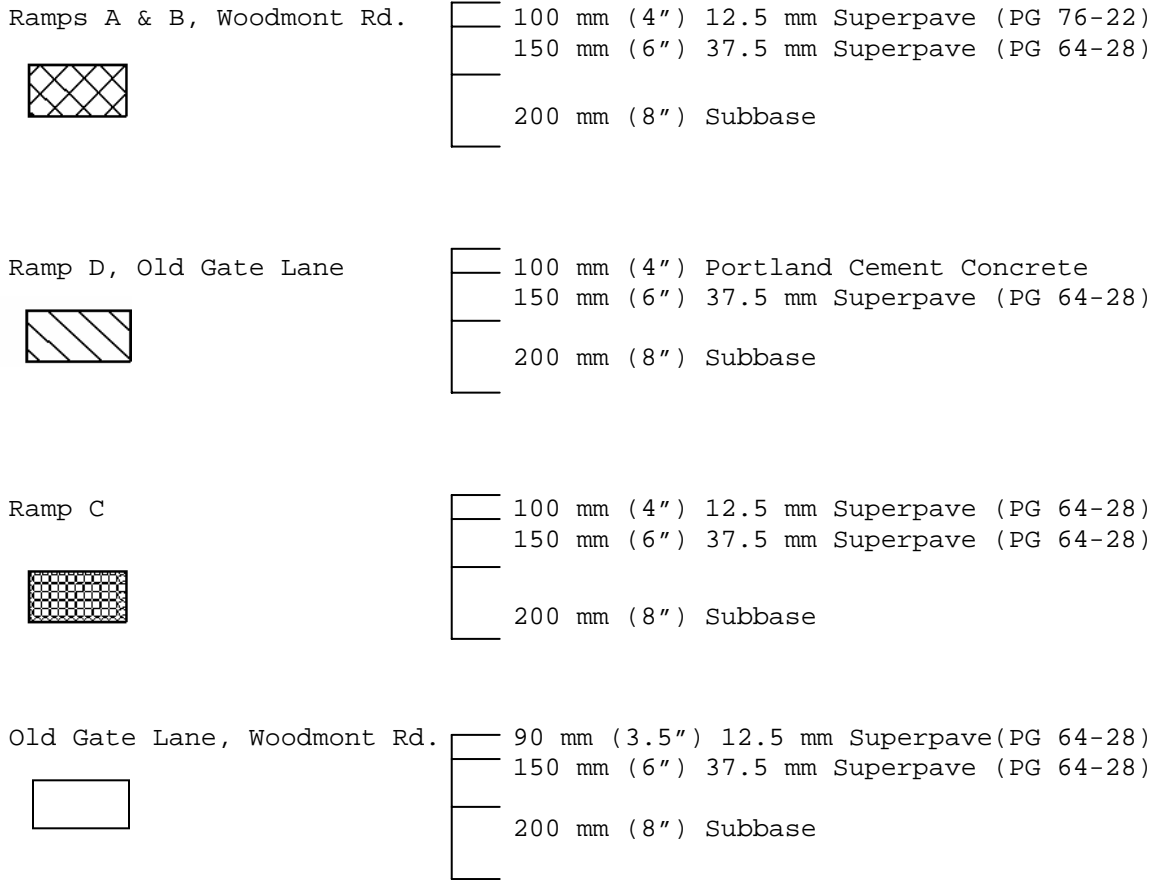


Figure 2. (Not to Scale) Index Plan for Original Proposed Surface Layers in State Project 83-220 on Ramps and Town Roadways at Interchange 40 in Milford, Connecticut

**Location**

**Cross- Sections**



**Figure 3. Originally Proposed Cross-sections for Ramps and Town Roadways in State Project 83-220**

**Comparison to Superpave PG 76-22**

To investigate another pavement surface alternative to help alleviate rutting, a Superpave mix design new to Connecticut was also proposed in the state construction project. The Superpave mix design commonly used in Connecticut is performance grade 64-28. The "64" is the maximum anticipated pavement temperature based on a 7-day average high air temperature in the area and -28 is the low pavement temperature based on a 1-day low air temperature in the area (11).

Superpave PG 76-22 was chosen because of its ability to withstand higher pavement temperatures (i.e. 76 degree C versus 64 degree C) when rutting of the pavement is most likely.

The Superpave PG 76-22 was installed on the I-95 Southbound off-ramp and on-ramp at Interchange 41 as indicated in Figure 1. A section of Woodmont Road also had this mix design installed. Data is being compiled over 5 years of monitoring and the results will be published in an interim and final report.

#### **Initial data collected (Pre-construction)**

##### 1. Rutting

Initial rutting measurements were taken with ConnDOT's Automatic Road Analyzer (ARAN) vehicle. The rut bar on the front of the vehicle was extended approximately 300 mm (1 foot) beyond the sides of the vehicle, however this length is not the full lane width. These initial measurements were taken prior to the roadways being paved over. The rut depths for Ramp D ranged from minimal rutting to 25 mm (1") or more at a few of the measured points. The project was already under construction however, so it was difficult to get measurements of all the lanes. Also, the existing lane arrangement prior to the project is different from the final lane arrangement, therefore it is difficult to compare the before and after readings for the same turning movements.

##### 2. Traffic Volumes

Vehicle classification counts were taken on each of the 4 ramps located within the project limits (Interchange 40). These counts were taken in 1993, 1999, and 2004 and are



summarized in Table 2. The percentage of heavy vehicles was extracted and can be compared for each of the years and types of vehicles.

**Table 2. ADT and Percent Heavy Vehicles for Each Ramp**

	1993 ADT	1993 %heavy vehicle	1999 ADT	1999 %heavy vehicle	2004 ADT	2004 %heavy vehicle
I-95 SB on-ramp	7000	10.19	7400	11.35	7800	16.45
I-95 SB off-ramp	6900	11.80	6800	14.33	6700	17.51
I-95 NB on-ramp	6900	11.24	7700	13.74	8000	16.65*
I-95 NB off-ramp	7800	11.50	9400	12.81	10100	17.84

\* Data not accurate due to vandalism of counting equipment.

**Data Collected (Post-Construction)**

1. Rutting

Rutting data has been collected yearly since the placement of the pavement. The data is gathered typically in late fall, after the warm summer months when rutting is most likely to occur. Data is collected for all of the turning lanes, through lanes, and ramps. The mean rut depths collected to date for each Superpave Performance Grade pavement on each off-ramp are given in Table 3. There has not been a considerable change in rut depths over the 3 years of post-construction data collected.

**Table 3. Mean Rut Depths (in millimeters) for each Superpave Performance Grade Pavement**

Post-construction data	I-95 Northbound off-ramp Superpave PG 64-28		I-95 Southbound off-ramp Superpave PG 76-22	
	Wheel path		Wheel path	
	Left	Right	Left	Right
Year				
2002	3	3	2	2
2003	3	4	3	3
2004	3	3	2	2
2005	3	3	2	2

2. Distress/ Crack Surveys

Initial manual distress surveys were conducted to get baseline measurements of any cracking. Stations were marked at 50 foot increments along the ramps and Woodmont Road for future reference. Using the pavement markings and stations as a guide, initial cracks and longitudinal paving joints were noted. To date, the most visible cracking is located along the longitudinal joints.

Whitetopping Installation Concerns

**Constructability Issues**

Whitetopping was not installed in State Construction Project 83-220 as originally proposed. One reason for this was that there was much concern about the constructability of the whitetopping. It had never been installed in Connecticut and it was difficult to find a Contractor with experience to install it at a reasonable price. The

Contractor qualifications stated in the specification (Appendix A) were extensive; requiring documented and proven experience with the installation of whitetopping.

Another major reason for whitetopping not being installed in this construction project was because of the potential disruption to traffic during construction. There was concern that too many businesses in the area could be adversely affected by this disruption. With construction delays already being a concern with area businesses and residents, it was imperative that the construction continue and be completed in a timely manner.

It would be difficult to maintain and protect traffic during the construction staging of the whitetopping installation mainly due to the curing times of the concrete before traffic could be placed on it. The curing times vary, but estimates range from 3 to 7 days before traffic can be placed on it using typical PCC pavement. To reduce this time, some states have used a Fast Track concrete that can support standard traffic loads within 8 hours and heavy traffic within 24 hours (9).

Maintaining traffic was also a concern during the placement of concrete in the middle of the intersection of Old Gate Lane and Woodmont Road as shown in Figure 2. Although staging plans had been part of the design of the project, there was concern that the whitetopping could not be built according to the plans and still be able to produce a good product. The location selection criteria for whitetopping in this area was rather complex and the location became too high profile for the placement of the experimental whitetopping. The potential for negative publicity was great.

## Specification Issues

The specification for Portland Cement Concrete Overlays, as given in Appendix A, was developed by the Pavement Management unit. This was the first time that whitetopping was proposed in Connecticut, therefore the specification is very thorough. There was concern that a contractor, unfamiliar with the installation, may install a poor quality product. However, the requirements were so stringent the Contractor claimed he could not meet the specification as written. Therefore, based on the field concerns and further research, the following modifications to the specification are recommended and should be considered prior to any future proposed installations.

- Under Contractor Qualifications, remove the strict critical workers resume requirements. Proven experience is desirable, but the Contractor still needs to meet the specification when performing the work.
- The thickness of the whitetopping should be a minimum of 4 inches. Recent research has indicated greater than 4 inches has improved the quality and longevity of the whitetopping.
- The minimum thickness of the hot-mix asphalt base should be indicated.
- Consider adding the use of the concrete maturity method in order to make estimates of the strength of the concrete overlay. This will aid ConnDOT to open the roadway to traffic as soon as possible.
- Under the section for placing concrete, the statement about discontinuation of any operation if the equipment is not working properly should be rewritten because it may have an adverse affect on the time table for opening the road to traffic.
- Under Placement section, there is inconsistency with the application of water desired. The statement, "Prior to placement, sprinkle water on the surface to thoroughly dampen the bituminous concrete surface immediately prior to placement of cement concrete without causing pooled or puddle water" should be removed. A prior sentence about spraying a fine water mist on the prepared surface to make it cooler prior to placement of the concrete overlay is sufficient.
- Under the Final Finish section, the desired tining, either longitudinal or transverse should be specified. Also, it may not be practical to remove and replace the concrete pavement

in full panel increments if a crack occurs prior to acceptance of the pavement. This needs to be further researched and discussed with other states.

- Under Method of Measurement, the pay incentive should probably not be used for the first few whitetopping projects or where the speed limit is low.
- The specification will need to be updated as more research is conducted in other states.

**Research into another location:**

Once whitetopping was removed from the project, another location for installation was sought. Various approaches were taken to do this:

1. All of the District maintenance offices were contacted to find areas that they were aware of with higher than usual rutting.
2. A list of locations throughout the state where rutting in both wheel paths was at least 12 mm (1/2 inch) was obtained from photolog data.
  - o Over 2000 initial locations were queried.
  - o This list was condensed to 165 where there were at least 2 points on a route not more than 10 meters (32.8 feet) apart. Limited-access highways (i.e. Route 2, I-95, etc) were excluded as well.
  - o The condensed list of locations was viewed on the photolog.
3. Major truck stop areas were also reviewed for rutting and proposed paving.

From all of these locations with greater than usual rutting, it was difficult to find proposed construction projects in the vicinity of this rutting that also addressed the constructability concerns.

Recommendations for Future Whitetopping locations

Although the installation of whitetopping did not occur as originally proposed in the state construction project, the use of whitetopping has been extensive throughout the United States and should

still be considered under certain circumstances in Connecticut. The background data gathered from this research, constructability issues encountered, and potential locations reviewed has generated the following recommendations for consideration of any future whitetopping installations.

1. An ideal test location for whitetopping to demonstrate its benefits, and assess constructability, would be at a rest area. Rutting usually occurs on the ramps to and from the rest areas and constructability issues could be minimized. Many of the rest areas are scheduled for reconstruction, but not for a few more years: FDPs of December 2007, December 2008, December 2009, and a few more in June 2011.
2. Although the rest areas are an ideal location, the reconstruction of them will not take place for several years, therefore if there is significant interest in Connecticut then other types of locations should be considered for testing of whitetopping. A new project could be recommended or whitetopping could be included in a project already in design. There are improvement projects scheduled for final design completion in the next several years where higher than usual rutting is currently occurring, such as Route 31 in Coventry (Project 32-130), Route 191 in East Windsor (Project 46-119), Route 319 in Stafford (Project 134-141), and Route 195 in Tolland (Project 142-146). Of these projects, priority should be made to the one with the least possible constructability issues.
3. Whitetopping of at least a 100 mm (4") depth has been found to be a viable solution in areas where there is low to medium traffic volume and a sound pavement base. For heavy traffic, concrete thicknesses of 100 mm (4") to 600 mm (12") would be recommended.

4. Preliminary data on Superpave PG 76-22 in Milford has shown it to be viable for roadways with medium to heavy traffic volume, as well as higher than usual truck volumes (approximate 17% heavy vehicles at this location).
5. Other types of pavements, such as Stone Matrix Asphalt, could be considered for testing for its ability to resist rutting.
6. The Florida Department of Transportation said that using a truck weigh station gave an ideal location for an accelerated evaluation because of the high volume of truck traffic (8).

#### Summary and Conclusions

Some states have found whitetopping to be a viable alternative to alleviate the pavement concerns in areas with higher than usual rutting or shoving. Many states have used and continue to propose it in certain locations. Although Connecticut has not installed whitetopping to date, based on much of the information in this report, it can be considered as a pavement option. Recommendations for the most ideal conditions for installation of whitetopping have been given for consideration of whitetopping. Additional information on experiences from other states continues to be published and should be considered in any future installations.

Superpave Performance Grade 76-22 will continue to be monitored where it was installed in Connecticut. A final report will be written after 5 years of monitoring. This performance grade may be considered another option for areas with greater than usual rutting and where there are constructability concerns; such as higher volumes and need for sustained maintenance and protection of traffic.

## References Cited

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[http://training.ce.washington.edu/WSDOT/Modules/05\\_mix\\_design/05-5\\_body.htm](http://training.ce.washington.edu/WSDOT/Modules/05_mix_design/05-5_body.htm), accessed April 5, 2006.



APPENDIX A

Specification Developed in May 2000 for Whitetopping Installation  
in Connecticut State Project 83-220

**ITEM # 401055A – PORTLAND CEMENT CONCRETE OVERLAY**

Contractor Qualifications:

The Contractor designated to perform the PCC paving shall submit to the Department a list of qualifications and projects demonstrating their ability to meet the scope and specifications for the PCC paving on the project. The PCC paving contractor must have a proven record of PCC paving with a vibratory screed on exterior paving projects. The background must include the use of highway straight edges and the ability to achieve rideability or flatness criteria on such project.

Contractors shall have a proven experience with Whitetopping (placement of portland cement concrete overlay on HMA- pavement surface) to be considered for this work. The Contractor shall submit, prior to commencement of the work, a resume, a list of all critical personnel working on the job, references for previous jobs that have been completed, and the proposed method of operations, to the engineer.

Resumes shall show the type, length, and number of Whitetopping projects each critical person has performed within the last three years. Critical personnel include, but are not limited to, project managers, superintendents, foremen and machine operators.

References shall include, but are not limited to, a description of the project, machinery used, completion date, contact person(s) and phone number(s).

**Article 4.01.01 – Description:** Delete the entire article and add the following:

This work shall consist of constructing a thin (50 – 150 mm), fiber-reinforced, accelerated strength portland cement concrete pavement wearing surface atop a prepared HMA- pavement surface in conformity with the lines, grades, thickness, and typical cross section as shown on the plans.

**Article 4.01.02 – Materials:** After the last sentence add the following:

The Contractor shall design and submit a high-early strength portland cement concrete mix to the Engineer for approval.

**Additional Materials:**

Insulating Material shall conform to the requirements of ASTM C578.  
Isolation Joint material shall conform to AASHTO M153, Type 2.

**Article 4.01.03 – Construction Methods:**

Construction methods not specifically covered in this specification shall conform to 4.01.03:

**A. Composition:**

The Contractor shall submit a mix design to the Engineer . The mix design calculations shall include certified test results documenting the strength requirements relative to the anticipated air temperature at the time of paving for the available cure time.

The mix design must be submitted at least 30 days prior to the start of paving.

Use 100 percent virgin polypropylene, fibrillated, multi-designed graded fibers, containing no reprocessed olefin material, specifically engineered and manufactured for use as secondary concrete reinforcement, subject to approval by the Engineer to produce fiber-reinforced concrete.

Add 1.80 Kilograms of fiber per cubic meter of concrete. Add bags in whole bag increments during batching. Use batch-specific bags or batch the appropriate volume of concrete such that only whole “off – the – shelf” bags are used. Mix the concrete in accordance with the fiber manufacture’s recommendations. A slight increase in w/c ratio may be needed to achieve the desired slump due to the added fibers.

Develop a mix design and prepare trial batch using those materials to be used on the project. Demonstrate the mix’s ability to achieve the specified properties to the Engineer. Changes other than minor fluctuations in admixture dosage rates will require a new mix design and trial batch. The Engineer may halt paving and order additional trial batches whenever the specified properties are not achieved.

The mix must meet the following requirements:

Property	Minimum	Maximum
18 Hour Compressive Strength (Trial Batch)	15 MPa	
18 Hour Compressive Strength (Project)	14 MPa	
28 Day Compressive Strength (Trial Batch)	30 MPa	
Air Content	5.0 %	8.0%
Slump	50 mm	180 mm

Alternative mix designs will be considered provided they meet the above requirements as determined by the Engineer.

**F: Placing Concrete:** Apply the requirements of Subarticle 4.01.03 F, Placing Concrete, except as modified herein.

Prior to any operation, review all equipment, construction methods, time and personnel requirements, and inspection procedures with the Engineer to ensure a well-coordinated placement.

Equipment: Bring all equipment needed to place, consolidate, finish, cure, texture, saw cut and test the PCC to the job sufficiently prior to the start of work to allow thorough examination by the Engineer. Repair or replace any equipment found to be defective before or during its use to the Engineer's satisfaction. Discontinue any operation if the equipment is not working properly or if unsatisfactory results are being obtained as determined by the Engineer. Use the following:

- A. Manual vibrator equipped power screeds and hand-held internal vibrators are to be used. Contractor's option to utilize a laser screed machine for placement.
- B. Lightweight diamond blade saw capable of cutting newly placed concrete after it has developed sufficient strength to accommodate the weight of the saw operator.
- C. Atomizing mechanical sprayers with tank agitators to apply the curing compound. The sprayers must be capable of applying consistent pressure without hand pumping. Use nozzle with spray shields to prevent drift. Keep an adequate supply of spare nozzles on hand.
- C. Portable compression testing machine conforming to ASTM C39.

Use other equipment subject to the approval of the Engineer.

**Conditioning of Subgrade or Base Course:**

Delete entire paragraph and replace with:

**Surface Preparation:** Mill the entire existing pavement surface to be overlaid to the line, grade, and cross section shown on the contract plans in accordance with the appropriate pay items "Milling of Bituminous Concrete (0 to 100 mm)" and "Milling For Transitions". Remove additional HMA as required to (1) accommodate form installation and (2) to provide a thickened transverse edge of PCC where it abuts the existing pavement to remain in-place, as depict in the attached detail. Airblast clean the surface as close to paving as practical. Airblast the surface after blast cleaning such that all debris and standing water are removed before paving.

Prior to placing concrete against any previously placed concrete, remove all the white pigment curing compound from its vertical face, by waterblast, to ensure a good bond between placements.

**Setting Forms:** Clean and oil forms before use. Set metal forms to accommodate a full day's paving before placing any concrete. Securely anchor the forms such that they do not move during placement and paving. Check the alignment and grade of the forms before paving. Remove and replace any damaged or unsuitable form to the Engineer's satisfaction. Place isolation joints only where the new concrete pavement will abut existing curbs, manholes and other fixed objects.

**Placement:** Completely clean the milled surface. Limit cleaning to area that will be overlaid the same day. Protect the cleaned and prepared surface from oil or grease drippings from compressors, concrete trucks, spreaders, pavers, etc. Remove all deteriorious materials prior to overlaying.

Determine the temperature of the prepared surface. If the temperature exceeds 38 °C, apply a fine water mist to the prepared surface such that the surface temperature drops below 38 °C but no standing water remains. Remove standing water by air blasting. Do not place concrete when the asphalt surface temperature is less than 5 °C.

When accepted by the Engineer, slipform equipment may be used. Furnish machines capable of spreading, consolidating, screeding and finishing concrete in one pass.

Prior to placement, sprinkle water on the surface to thoroughly dampen the bituminous concrete surface immediately prior to placement of cement concrete without causing pooled or puddled water.

Deposit concrete as near to final position as possible. Finish the concrete with a continuous forward movement of the equipment such that a smooth, homogenous, well consolidated pavement results with minimum hand finishing. Vibrate the surface of the concrete at a frequency of no less than 3500 vibrations/minute. Stop the vibrating elements if the forward movement of the paving equipment stops. If concrete has been deposited on the prepared surface for 30 minutes without finishing, remove it and construct an undoweled transverse construction joint at the end of the finished concrete. Thoroughly consolidate the thicken transverse edges using hand-held internal vibrators before finishing with the paving equipment. Only vibrate the concrete to consolidate it. Do not move concrete horizontally with vibrator. The addition of water to facilitate the finishing of the surface shall NOT be permitted. Finishing operations shall be completed before the initial set takes place.

**Final Finish:** Produce tine texture 3 – 4 mm deep with minimal aggregate dislodging as determined by the Engineer. Multiple tine passes in the same area are not permitted unless the surface is refinished between passes. Keep the tines free of hardened concrete.

Remove the formwork after the concrete has developed sufficient strength to allow removal without damaging the concrete. Repair concrete damaged during form removal as directed by the Engineer. Remove forms before saw cutting joints or saw cut into the forms as needed to provide full-width joints of the proper depth.

**Joints:** Use a lightweight saw with diamond blades to construct transverse and longitudinal joints. Make the cuts as soon as the concrete has developed sufficient strength to be cut without raveling or chipping. Sawcut the overlaid surface into square panels having dimensions equal to one-quarter the lane width. All transverse cuts shall be continuous across the roadway. Saw joints with a green cut saw to a depth of D/3 and a minimum width of 3 mm. The Engineer may alter joint locations to ensure the joints pass through embedded fixtures such as manholes or drainage outlets.

Do not saw the longitudinal joint between adjacent placements. Do not make second sawcuts nor seal the joints. Clean joints of all deleterious material after sawing.

Sawing must be done soon enough after placement to prevent random cracking. If necessary, conduct sawing operations continuously, both day and night, regardless of weather conditions. Omit sawing if a crack occurs at or within 0.45 meters of a joint location, prior to the sawing or during sawing. If a crack occurs prior to acceptance of the pavement, remove and replace the concrete pavement in full panel increments.

Other than white pigmented curing compound, remove any curing materials from the overlay, at the location where a joint is to be cut. Remove only sufficient covering to provide space necessary for sawing joints. As soon as the joint is made, replace the covering. The maximum time period allowed for pavement curing covers to be removed is ½ hour.

**Curing:** Apply white pigmented liquid curing compound, conforming to Subarticle 4.01.03-7a, except for the following:

- the application rate not less than one liter for 1.75 m<sup>2</sup>,
- the equipment need not be self-propelled, and
- the curing compound is applied in two passes, one forward, one backward, with no longer than 15 minutes between passes.

Provide adequate insulating material to prevent rapid heat loss when the ambient air temperature is anticipated to be 10°C or less. The insulating material shall be a minimum of 50 mm thick closed cell extruded polystyrene insulation board that conforms to the requirements of ASTM C578. It shall have a minimum certified R value of ten (10). The insulating material shall extend at least 300 mm beyond the limits of the paved area, and shall be kept in intimate contact with the pavement to prevent wind intrusion beneath. It shall be weighted down with sand bags weighing a minimum of 6.8 Kg each. Remove any insulation when a minimum compressive strength of 14 MPa has been attained. The insulation can be remove when the rate of the temperature change in the concrete does not exceed 5°C within any one hour period.

Patch the void resulting from form removal immediately after the PCC has achieved a compressive strength of 14 Mpa as discussed below in project strength determination. Use Bituminous Concrete Class 2 in a manner approved by the Engineer.

**Riding Surface Tests:** The finished surface of all mainline pavement shall be tested and corrected to a smoothness as described herein. The mainline pavement is defined as all pavement for traffic lanes, but excluding all taper sections, shoulders and intersections.

The Contractor will furnish and operate a California Type Profilograph in order to determine the smoothness of the pavement. The profilograph shall be equipped with a microcomputer capable of automatically reducing the recorded profilograph data and downloading it to a disk. The data on the disk shall be formatted to permit evaluation by the Engineer. If software is required for this evaluation, the Contractor shall provide copies of the software for the Engineer's use. A printer, compatible with the microcomputer, shall also be provided to print the profilogram and any other required data.

The data shall be processed using a third-order Butterworth filter with a cutoff wavelength of 600 mm. The computer shall generate a Profile Index using a 5 mm blanking band. Each profilogram trace shall show blanking band, data filtering, bump threshold areas to be ground, stationing, project number, lane, date tested, and operator's name.

The manufacturer's operator manual shall be used to provide instruction on the calibration, operation, and maintenance of the specific profilograph being used. A copy of this manual shall be provided to the Engineer upon request.

The Contractor will profilograph the pavement surface wheelpaths, develop a profile trace, and determine a preliminary profile index for each 160 m segment, or fraction thereof. Grind any surface irregularities equal to or exceeding 13 mm in 7.6 m. The grinding equipment shall be equipped with an on-board wet vacuum attachment capable of removing the runoff residue generated during grinding.

At least two weeks prior to any grinding operation, the Contractor shall submit to the Engineer for approval a comprehensive plan for the filtration and disposal of the runoff generated during the grinding operation. The plan shall ensure that all the particle matter is removed from the runoff residue prior to its release to the environment. The size and location of the disposal site sedimentation basin shall be properly sized so that overflow does not occur. At the conclusion of the grinding operation, the sedimentation basin and all debris shall be removed and the area restored to its original condition. The plan shall additionally conform to all applicable requirements of Section 1.10, Environmental Compliance of Standard Specifications.

After grinding, a Final Profile Index (FPI) will be determined for each segment. If the FPI exceeds 200 mm per kilometer, the entire segment must be diamond ground at no cost to the State such that the FPI is less than 200 mm per kilometer.

**Testing:** The Contractor shall make cylinders under the supervision of the representative of the Department. The dimensions and type of cylinder mold shall be specified by the Engineer. The Contractor will cast a minimum of one set (four total) of cylinders from

each days pour (in accordance with ASTM C 31). The Engineer will mark the cylinders and leave them adjacent to the pavement under similar curing conditions.

A portable compressive testing machine shall be provided by the Contractor and available on site for cylinder testing. All testing and equipment shall conform to ASTM C39. NOTE: This compression machine must be calibrated in accordance with the provisions of ASTM C39, Section 5,.

**Open to Traffic:** Traffic will be allowed on areas of the roadway where the Contractor has placed and finished the thin concrete overlay, after the attainment of 14 MPa compressive strength (minimum).

If the concrete has not attained the above compressive strength requirements prior to opening to traffic, the Contractor shall remove and replace the concrete overlay at his own expense during the next available work period.

Project testing of 28 days compressive strength is required.

**Article 4.01.04 - Method of Measurement:**

Method of measurement not specifically covered in this specification shall conform to 4.01.04:

Pay Adjustment for Surface Smoothness: Adjustments apply to the overlay item bid price per 160 m segment, or fraction thereof, based on the Profile Index per 160 m segment, or fraction thereof, according to the following table:

<u>Final Profile</u>	<u>Percent Paid</u>
0 – 40	105
41 – 80	104
81 – 120	103
121 – 160	102
161 – 180	101
181 – 200	100
200+	Grind

Grinding to incentive is not permitted.

**Determination of Pavement Thickness:** For projects at intersections, a minimum of two cores will be taken at random (per intersection).

**Measurement for Payment:** This work shall be measured in square meters of area from the payment lines shown on the plans and measurements made on the finished pavement surface. No deductions are made for catch basins, manholes, or other similar pavement



obstructions. The quantity of concrete is subject to proportional adjustment payment or non-payment as stated hereinbefore.

**Article 4.01.05 - Basis of Payment:**

Delete the entire article and substitute the following:

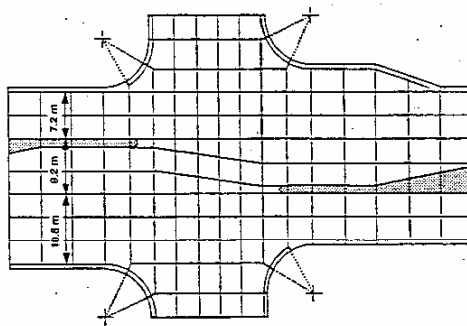
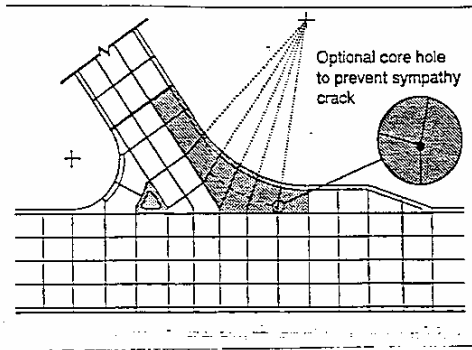
This work shall be paid for at the contract unit price per square meter for “Portland Cement Concrete Overlay,” completed in place. This price shall include the cost of all materials, equipment, and labor necessary to clean the milled surface and place, spread, consolidate, finish, texture, cure, and sawcut of the PCC.

No direct payment will be made for the concrete testing equipment or the instruction in its use; in-situ testing; the concrete in or curing of the required cylinders; furnishing and operating California Type Profilograph in order to determine the smoothness of the pavement as specified hereinbefore. The cost of this work shall be considered included in the general cost of the work.

Milling, sawcutting HMA pavement at the transition from PCC overlay to existing HMA and HMA placement associated with form removal are paid for under separate items.

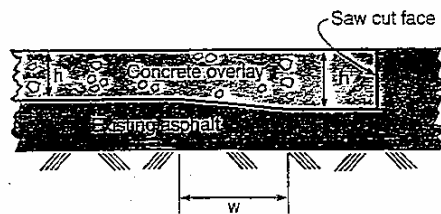
<u>Pay Item</u>	<u>Pay Unit</u>
PORTLAND CEMENT CONCRETE OVERLAY	m <sup>2</sup>

awed Intersection Layout Alternative



Handling Wide Medians and Dual-Left Turn Lanes

THIN PORTLAND CEMENT CONCRETE (PCC) OVERLAY TERMINI



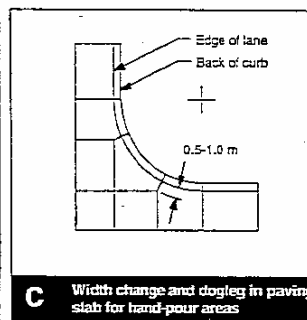
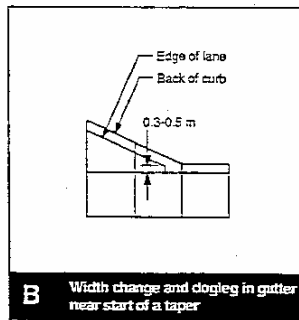
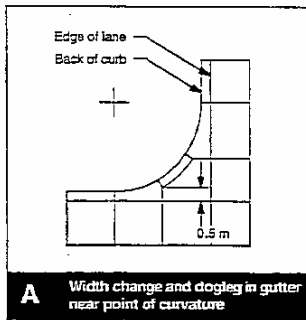
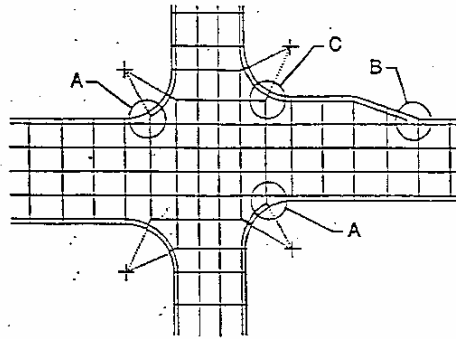
$w$  = approx. 2m (6 ft), extend over several slabs if necessary  
 $h'$  =  $h + 75$  mm (3 in.), minimum of 150 mm (6 in.)

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ITEM #401055

# Intersection Joint Layout



Note: The diagrams provided were obtained from the American Concrete Pavement Association Publications