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Polymer-Concrete Bridge-Deck Overlays

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SPECIAL REPORT 110

ENGINEERING RESEARCH AND DEVELOPMENT BUREAU
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16. Abstract

This report summarizes the results of a survey of polymer-concrete bridge-deck installations (test patch and overlay) in New York, and canvassing of the experience of other states with these overlays. In New York, two types of polymer overlay materials have been used -- thin epoxies and a thicker polyester -- with one thin epoxy in NYSDOT Region 1, two polyesters in Region 10, and two thin epoxies in Region 11. In inspections during the summer of 1991, condition and performance of most of these overlays was found to be satisfactory, but the installations were determined to be best suited only to urban areas.

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METRIC (SI*) CONVERSION FACTORS

APPROXIMATE CONVERSIONS TO SI UNITS

Symbol	When You Know	Multiply By	To Find	Symbol
LENGTH				
in	inches	2.54	millimetres	mm
ft	feet	0.3048	metres	m
yd	yards	0.914	metres	m
mi	miles	1.61	kilometres	km
AREA				
in²	square inches	645.2	millimetres squared	mm²
ft²	square feet	0.0929	metres squared	m²
yd²	square yards	0.836	metres squared	m²
mi²	square miles	2.59	kilometres squared	km²
ac	acres	0.395	hectares	ha
MASS (weight)				
oz	ounces	28.35	grams	g
lb	pounds	0.454	kilograms	kg
T	short tons (2000 lb)	0.907	megagrams	Mg
VOLUME				
fl oz	fluid ounces	29.57	millilitres	mL
gal	gallons	3.785	litres	L
ft³	cubic feet	0.0328	metres cubed	m³
yd³	cubic yards	0.0765	metres cubed	m³

NOTE: Volumes greater than 1000 L shall be shown in m³.

TEMPERATURE (exact)

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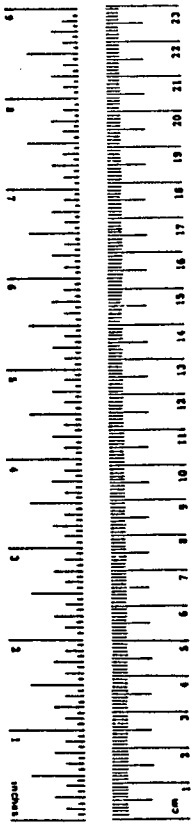

APPROXIMATE CONVERSIONS TO SI UNITS

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LENGTH				
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m	metres	3.28	feet	ft
m	metres	1.09	yards	yd
km	kilometres	0.621	miles	mi
AREA				
mm²	millimetres squared	0.0016	square inches	in²
m²	metres squared	10.764	square feet	ft²
km²	kilometres squared	0.39	square miles	mi²
ha	hectores (10 000 m²)	2.53	acres	ac
MASS (weight)				
g	grams	0.0353	ounces	oz
kg	kilograms	2.205	pounds	lb
Mg	megagrams (1 000 kg)	1.103	short tons	T
VOLUME				
mL	millilitres	0.034	fluid ounces	fl oz
L	litres	0.264	gallons	gal
m³	metres cubed	35.315	cubic feet	ft³
m³	metres cubed	1.308	cubic yards	yd³

TEMPERATURE (exact)

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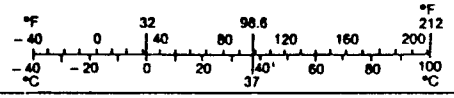

These factors conform to the requirement of FHWA Order 5190.1A.

* SI is the symbol for the International System of Measurements

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I. INTRODUCTION

A. Objective

Polymer concrete (PC) overlays are an alternative bridge deck treatment. They are highly impermeable, protecting steel reinforcing bars from corrosive deicing salts while restoring skid resistance. The objective of the study reported here was to document their performance to date in New York and other states. This report describes the condition of PC overlays used in rehabilitating bridge decks in New York State after various periods of service, and summarizes an informal survey of experience of other states with such overlay materials.

B. Background

Bridge deck deterioration due to reinforcement corrosion caused by chloride infiltration continues to be a problem for many state highway agencies. Methods currently used by New York to protect existing steel in rehabilitation work include 1) overlays with low-slump, high-density concrete, microsilica concrete, and latex-modified concrete, and 2) coating the reinforcing steel with epoxy for new deck construction. Limitations of concrete overlays include 1) situations where the existing structure cannot adequately support the additional dead load of a concrete overlay, 2) instances where reduced clearance cannot be tolerated, and 3) urban areas where rapid construction is essential due to heavy traffic and/or excessive costs for traffic control.

PC can overcome many of these limitations of other types of overlay materials. Most interest is in urban areas because of their quick-curing, high-early-strength characteristics, resulting in shorter times required for detouring traffic and lane closures, which are extremely costly (1,2). Also attractive are the product's excellent bond strength, lighter weight, flexibility, and restoration of skid resistance to polished decks (3). Thin overlays (up to 1/2 in.) have the additional advantage of dispensing with modification of expansion joints or building up the approaches, which can result in significant cost-savings (4).

PC consists of a resin binder and an aggregate filler. Initially, the resin is a liquid monomer, which after addition of an initiator becomes a solid through a chemical reaction called "polymerization." The rate of polymerization, or cure, depends on many factors, including temperature, humidity, chemical additives, and ultraviolet rays of the sun. There are two types of PC overlay: thin PC and polyester PC. Thin PC overlays can be methylmethacrylate (MMA) or

epoxy concrete. PC types used in New York State have included both thin epoxy and thick polyester. One of three methods of construction is typically used:

1. Multiple-Layer

   Two or more layers of polymer binder and gap-graded, clean, dry angular broadcast aggregate.

2. Slurry

   A polymer aggregate slurry struck off with gage rakes and covered with broadcast aggregate.

3. Premixed

   A PC mixture consolidated and struck off with a vibratory screed and covered with broadcast aggregate.

Although the first two methods have been used, that now preferred in New York is premixed automated application.

C. Materials (5,6,7,8,9,10,11)

1. Early Work

New York has tried various PC types in overlays since 1961. A wide variety have been used, most containing epoxies or polyesters. Also tried were a few applications of polyurethanes, latexes, neoprenes, and silicone rubbers. Periodic inspections of early installations determined that surface overlays developed appreciable distress within 2 to 3 years after application. Thin overlays could not withstand exposure to the damaging effects of traffic and weather (5). A new generation of products were introduced in the late 1970s, but overlays once again exhibited distress in the form of debonding and cracking within 2 to 3 years of application (6).

2. Test Patch Program

Further refinements from 1980 to 1984 resulted in the more flexible epoxies and MMAs now being used. As manufacturers have continued to improve their products, New York has continued to be a site of polymer concrete testing (9,10,11). Three test patches were installed on the lower roadway of the Queensboro Bridge in May 1980 (Duracryl and Flexolith by Dural International Corp. and Silikal R7 by Transpo Materials). In September and October 1983, a test section was placed on the Brooklyn Bridge (30,000 sq ft of Flexolith), and test patches were installed on the lower roadway of the Manhattan Bridge (Silikal Urethane Modified Acrylic Overlay by Silikal North America, Dural

317 and Flexolith by Dural International, Concresive 2020/2042 by Adhesive Engineering, T17XA by Transpo Industries, and Flexogrid by Roadway Safety Service/Polycarb). In August 1985, five test patches were installed on the westbound I-90 bridge over I-787 in Albany (Transpo T17X, Dural Flexolith, Dural Coal Tar Epoxy, Dural Methyl Methacrylate, and Polycarb Flexogrid).

The St. Lawrence Seaway Authority has a program to evaluate test patches on the Cornwall Bridge and Thousand Island Bridges over the St. Lawrence River between New York and Ontario, Canada. Product installation on the Cornwall Bridge in August and September 1991 included Nitobond (Fosroc), FX761 (Fox Industries), Sternflex, Transpo T-38 and T-48, Degadur 330, Sikadur 81-32, Flexolith, Flexogrid, and Bridge Master. Those on the Thousand Island Bridges included Sikadur, Flexolith, and Transpo T-45 and T-48 in September 1992, with Flexogrid, Degadur, and Bridge Master scheduled for May 1993.

As these new products were developed and laboratory testing proceeded, experimental overlays were installed to relate test results to field performance (3,12,13,14,15,16,17,18,19,20,21,22). Two types of PC bridge deck overlays are now in place in New York: 1) thin PC, using either epoxy or MMA as a binder, placed in a thin (1/2-in.) layer, and 2) blended polyester in a 3/4-in. thick overlay.

3. Polyester Overlays

Two overlay sites in Suffolk County on Long Island used polyester resin with basalt aggregate. An overlay consisting of 15,500 sq ft was placed on Yaphank Avenue (BIN 1064160) over the Long Island Expressway in 1982. In 1983, 12,100 sq ft were placed in another overlay near Yaphank, on East Main Street (BIN 1064180) over the Long Island Expressway. Seven additional polyester overlays of various designs are in Suffolk County near the Robert Moses Causeway (Deer Park Avenue over the Sunrise Highway, Higbie Lane over the Sunrise Highway, the Sunrise Highway over Howells Road, Fifth Avenue over the Sunrise Highway, Brook Avenue over the Sunrise Highway, and Brentwood Road over the Sunrise Highway). After premature failure of the Brook Avenue overlay, the others were overlaid and the project discontinued (Appendix A). Sealing the decks was this project's primary objective.

4. Thin Epoxy Overlays

Based on successful results of the thin-overlay test-patch program, 89,388 sq ft of Flexolith was placed on the south upper roadway of the Queensboro Bridge under Contract D250039 with work starting in October 1984. A small area (4572 sq ft) near the Manhattan anchor pier was completed in June 1985, and the bridge opened to traffic that July (7). In July 1985, work began on the suspended-span Manhattan-bound and Brooklyn-bound roadways of the Brooklyn Bridge; under Contract D251251, 183,500 sq ft of Flexolith were

Figure 1. Adhesion testing included partial-depth coring (upper left) through the overlay to the underlying slab, epoxying a steel plug to the core (lower left), and use of a reaction frame and load cell (right).

placed (8). In July 1988, 89,500 sq ft of Flexolith was installed on the north upper roadway of the Queensboro Bridge under Contract D500191. In October 1990, 57,342 sq ft of Transpo T17X was to be placed on the Crown Point bridge to Vermont under Contract D253114 (Appendix B); this work was only partially completed, with the remainder installed in September 1991. In July 1991, 13,077 sq ft of Flexolith was placed on the West 207th Street Bridge over the Harlem River (the University Heights Bridge) under Contract D500777. Polymer systems currently in the Materials Bureau's Proprietary Special Products Specification (Appendix C) are manufactured by Dural (Flexolith), Transpo (T17X), and Silikal (urethane-modified acrylic overlay). All these are thin-overlay materials.

D. Investigative Procedures

1. Survey of Other States

An electronic mail (e-mail) survey was conducted to determine experience of other states with these products.

2. Adhesion Testing

Overlay bonding to the existing concrete surface (substrate) is an extremely important consideration in placing any overlay, because any bond deficiencies may lead to later delamination or punchout of the overlay. To test this tensile bond of the epoxy overlays, equipment was built to specifications established in the ACI field test for surface soundness and adhesion of epoxy compounds (12). The apparatus used for this surface adhesion test is shown in Figure 1. Tests involved partial-depth coring through the overlay into the existing slab. After cleaning and drying the overlay surface, steel plugs were epoxied to the surface of the partial-depth core. A reaction frame and calibrated load cell measured the force required to pull the overlay from the existing substrate.

3. Distress Survey

PC overlays in place in New York were visually inspected by two project engineers in August and September 1991. Overlay condition was classified as 1) good, 2) peeled due to poor bond, 3) cracked or worn, or 4) patched. Estimates of surface area of each type of distress were mutually agreed upon. No chain drag or other means were used to determine delaminated areas. Each type of overlay distress is shown in Figure 2.

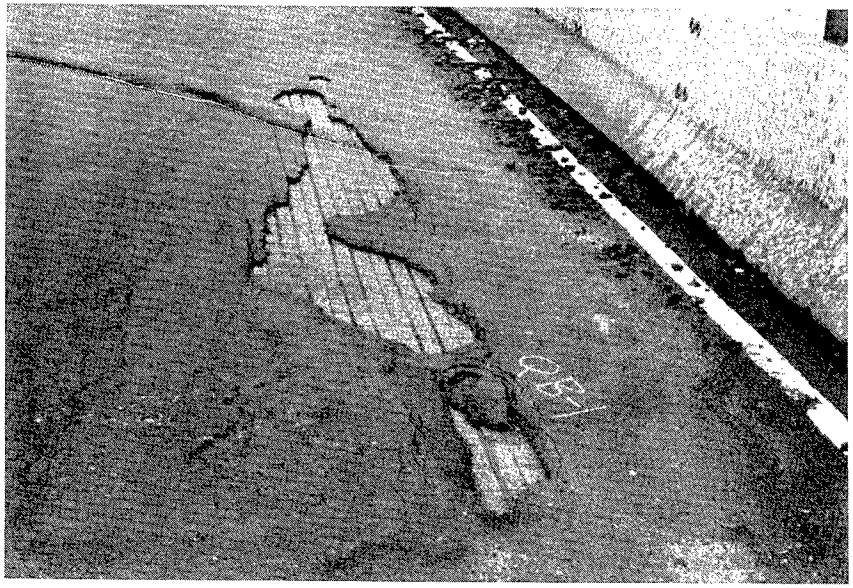
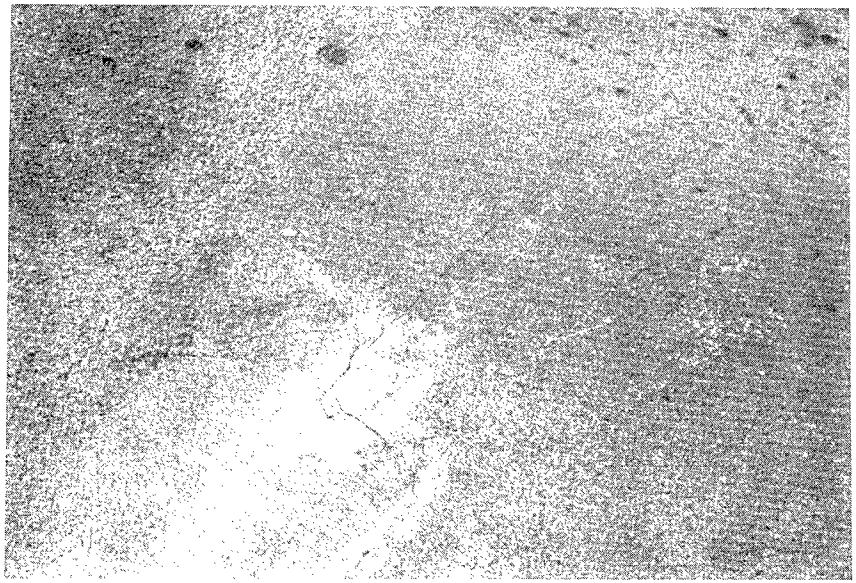
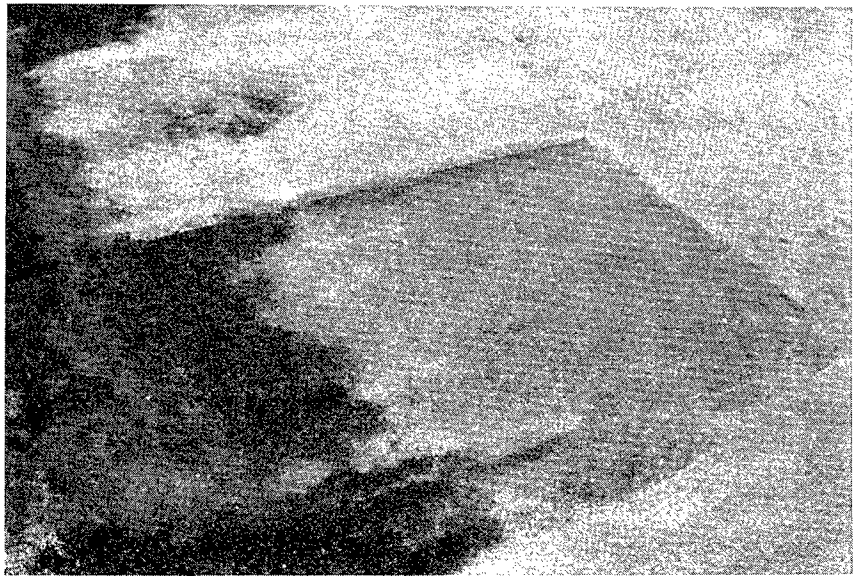


Figure 2. Surveys recorded peeling of overlay, exposing underlying steel (upper left), cracking (lower left) and patching (right).





II. RESULTS AND DISCUSSION

A. Survey of Other States

Several different PCs have been used in various parts of the country, on projects involving different types of polymers with varying properties and methods of application (19,20). An informal survey to evaluate their experiences produced responses from 25 agencies (60 percent), varying in form (fax, phone, e-mail, reports, specifications), as summarized in Table 1. Of the respondents, only 4 (16 percent) use PC overlays as a standard treatment, and 10 (40 percent) use no

Table 1. Responses to e-mail survey

State	PC Used?	PC Type Used	Remarks
Alabama	Provisionally (4 yrs)	Polyester	"No problems" (23)
Arkansas	Not used	--	--
California	Standard (10 years)	Polyester	Used extensively
	Experimental	Epoxy	(13,24,25,26,27,28,29,30)
Idaho	As crack sealer only	MMA	No Overlays
Illinois	Special installations	Epoxy	"Not truly impermeable" (31)
Indiana	Standard (12 yrs)	Polyester	"No success with thin overlays" (32)
Kansas	Not used	--	--
Kentucky	Not used	--	--
Louisiana	Experimental	Epoxy	Being evaluated (33)
Minnesota	Not used	--	--
Missouri	Experimental (2 yrs)	Epoxy	30+ bridges (34)
Nebraska	Not used	--	--
Nevada	Standard (3 yrs)	Polyester	"No problems" (15,35)
New Mexico	Not used	--	--
N. Carolina	Experimental	Epoxy	1 installation (36)
N. Dakota	Experimental	MMA	4 years service (37)
Oklahoma	Not used	--	1 experimental deck (replaced)(38)
Pennsylvania	Experimental	Epoxy	3 bridges (39,40,41,42)
S. Dakota	Not used	--	--
Texas	Experimental	Polyester	1 installation (43)
Vermont	Experimental	Epoxy	3 installations (44,45)
Virginia	Standard	Polyester	Used extensively (16,17,46,47)
Washington	Experimental Feature	Epoxy	Since 1984
		Polyester	Since 1989 (48)
Wisconsin	Not used	--	2 experimental deck failures (49)
Wyoming	Experimental	MMA	2 installations (50)

PC overlays of any type. Two states -- Wisconsin and Oklahoma -- use no PC overlays, after experiencing failures of experimental installations. Idaho uses a polymer material (MMA) as a crack sealer, but not as a deck overlay. The other states having most experience with these materials and the most extensive programs are in California and Virginia, using polyester rather than thin epoxy overlays. New York apparently has more experience with thin epoxy overlays than any of the states replying to the survey.

Other states generally report performance of these systems to be limited by the surface on which they are placed. Successful use depends on proper surface preparation. The deck to which the overlay is applied must be sound. The substrate as well as the aggregate used to extend the mix must be dry and clean.

B. PC Overlay Performance in New York

PC deterioration occurs in many forms, due to thermal stresses, moisture, or other factors. Common forms of early deterioration are raveling and delamination and cracking, which can occur anywhere over the deck. Bond is lost because the modulus of elasticity of PC is much greater than that of the substrate concrete, leading to possible delamination of the overlay with large changes in temperature. Where the surface cracks, potential for accelerated deterioration is present because moisture can cause the overlay to delaminate from the deck surface.

Typical comments during the visual inspections included:

- o Overlay badly peeled and cracked
- o Surface worn away in patches
- o Wear, some peeling of overlay
- o Peeling at joints, some cracks
- o Satisfactory except for small spalls at transverse joints.

As these comments illustrate, distressed areas often exhibited more than one type of distress. Such localized "patchy" failures with multiple distress types are probably related to construction practices, with material failures likely to be more uniform across the deck. The visual distress survey is summarized in Table 2. Overlay construction was observed on the Crown Point and University Heights bridges, but they were not surveyed because they had not been opened to traffic.

NYSDOT bridge inspection personnel from the Main Office and regions rate individual bridge elements biennially on a per-span basis, as mandated by the 1978 Surface Transportation Act. Estimates of overall condition of bridge decks and changes in that condition with time are obtained from the Department's semiannual bridge inspection and condition inventory. This inventory uses a numerical rating system to describe condition of individual bridge elements, and inspection report summaries can be obtained for specific bridges or structural elements and summarized by age, region, or other categories of interest. The condition of each bridge element is rated numerically into one of the following categories:

Table 2. Surface Overlay Conditions

	Structure and % of Surface Failed				
	Queensboro				
Distress	North Upper Roadway	South Upper Roadway	Brooklyn	Yaphank	Main St.
Peeled	0.19	0.09	0.00	1.55	0.20
Patched	1.21	0.00	0.13	0.00	0.00
Worn	1.48	0.25	0.32	0.00	0.00
Total	1.88	0.34	0.45	1.55	0.20

1. Potentially hazardous
2. Use to shade between ratings of 1 and 3
3. Serious deterioration or not functioning as originally designed
4. Use to shade between ratings of 3 and 5
5. Minor deterioration and functioning as originally designed
6. Use to shade between ratings of 5 and 7
7. New condition.

Although information from the inventory files is useful for an overview of relative condition of various bridge elements, it does not identify specific conditions leading to a low rating nor the contributing factors associated with any deterioration.

In the most recent inspections of these overlays, low values for the wearing course were 5 on the Queensboro Bridge (10/18/90), 2 on the Brooklyn Bridge (12/20/90), 4 at Yaphank, (5/31/91), and 5 at Main Street (6/14/91). Median value for the wearing course were 6 (35 of 37 spans) on the Queensboro, 5 (73 of 75 spans) on the Brooklyn, 4 (all spans) at Yaphank, and 6 (2 of 4 spans) at Main Street. Overall condition of these overlays is satisfactory at this time.

1. Queensboro Bridge, South Upper Roadway

   Delamination and patching occurring on one deck section is attributable to malfunction of the contractor's automated mixing equipment, and are not included in the distress analysis because this is not a materials problem.

2. Queensboro Bridge, North Upper Roadway

   This section is performing well.

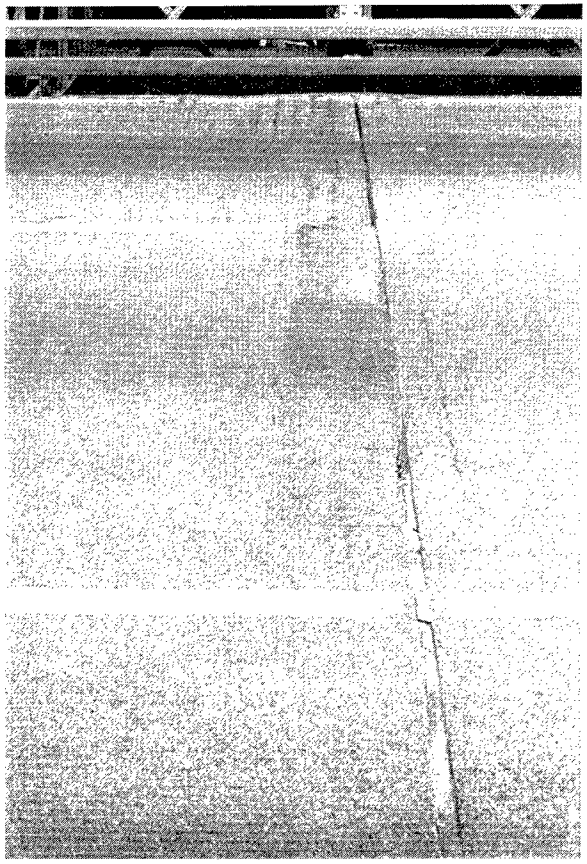
3. Brooklyn Bridge

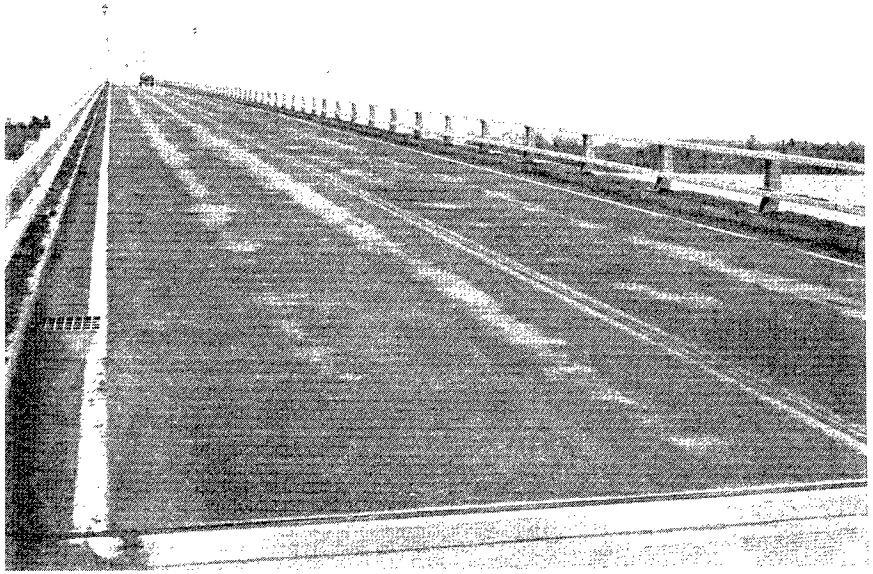
   Cracking was observed at the roadway relief joints, and was found to result from structural inadequacies of the floor system at the roadway

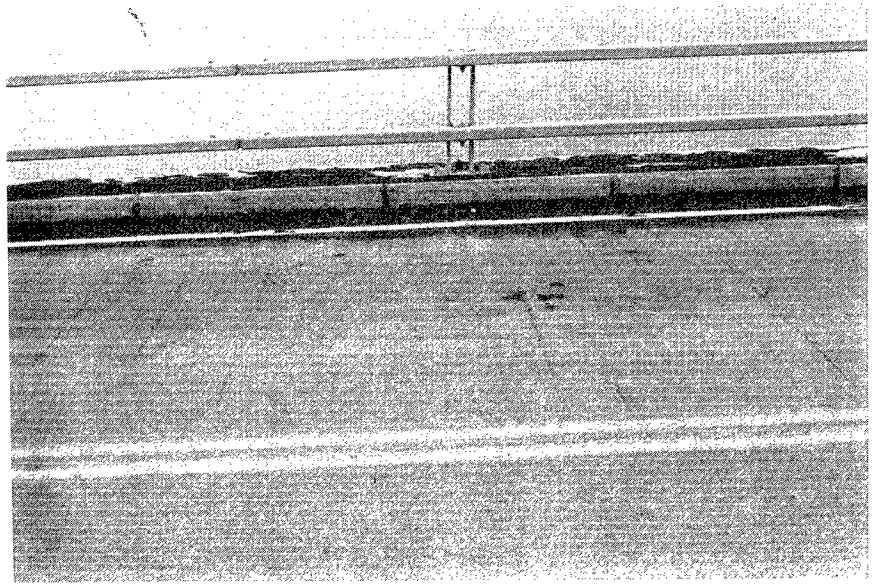
Figure 3 (below). Cracking at relief joint had been patched.

Figure 4 (upper right). "Washboard" deterioration on the Crown Point bridge.

Figure 5 (lower right). Cracking possibly resulting from deck flexure.







joint, but not from any inherent deficiencies of the Flexolith (8). These cracks have since been patched (Fig. 3), and also are not included in the distress analysis since they are not a materials problem.

4. Crown Point Bridge

The PC wearing course was not well suited to this bridge. The product in the Materials Bureau's Proprietary Special Products Specification was obsolete, and the manufacturer had to prepare a special batch for this job. Because of the bridge's steep grade and the PC's flow characteristics, it tended to run and it proved difficult to achieve a smooth riding surface. The first 100 ft of the wearing course's first application was broomed and seeded to fill, or removed and replaced, because of an unacceptable riding surface caused by the product's tendency to run. The manufacturer modified the product a number of times to try to minimize this problem.

To characterize the resulting "washboard" effect (Fig. 4), roughness was measured with a Soiltest road roughness indicator (roughometer). Measurement of pavement roughness is a primary indicator of riding quality -- a general reading that translates the effect of all distress into the road-user's frame of reference. Roughness due to any factor can lead to additional deterioration by inducing more vertical movement of vehicles, producing more frequent and increasingly severe impact loads.

The roughometer ran twice on the approach section, midspan, and leave sections in both the eastbound and westbound directions, and the readings were averaged to determine average roughness in inches per mile. For comparison, readings were taken on a bridge with similar geometry on Congress Street (Rte 2) over the Hudson River in Troy (BIN 1004279). Average roughness on the Crown Point Bridge eastbound was 140 in./mi and 134 in./mi westbound. Average roughness on the Rte 2 bridge was 109 in./mi eastbound and 119 in./mi westbound. In the most recent inspections of these overlays, the wearing course low value was 6 on the Rte 2 bridge (9//21/90), and 6 at Crown Point (1/21/92). The wearing course median value was 6 (all spans) on Rte 2 and 6 (all spans) at Crown Point. Based on these measurements, performance at Crown Point is comparable after only 1 year of service to Rte 2 after 7 years. However, condition of both is satisfactory at this time, and they are expected to provide long service lives.

After 10 months, the initial partial installation was in good condition, except for transverse cracking (Fig. 5). Its cause is unclear, but it may be occurring due to flexing of the deck (52). Results of surface adhesion tests [as recommended by ACI Committee 503 (12)] on the epoxy overlays are summarized in Table 3. In addition, the 30,000 sq ft Flexolith test section on the Brooklyn Bridge has been in service 8 years and averaged 206 psi for nine tests. Similarly, the Flexolith test patch on the Manhattan Bridge has been in place 8 years and averaged 137 psi for six tests. Minimum desired bond strength for this particular adhesion test is 250 psi. None of the installations with more than 3 years service attained this value, nor did the University Heights Bridge,

Table 3. Adhesion test results (51,52).

Location	Age, years	Overlay Material	Total Tests	Avg Bond Strength, psi
Queensboro				
South Upper Roadway	7	Flexolith	6	239
South Upper Roadway	7	Flexolith	8	99
North Upper Roadway	3	Flexolith	7	336
Brooklyn	6	Flexolith	9	224
Crown Point	1	Transpo T17X	9	267
Crown Point	0	Transpo T17X	9	324
University Heights	0	Flexolith	8	221

Table 4. Thin polymer overlay cost comparison.

Contract	Letting Date	Location	Quantity, sq ft	$/sq ft
D250039	3/11/82	Queensboro, SB Upper Roadway	89,388	10.98
D251251	11/8/84	Brooklyn	183,500	10.50
D500191	4/4/85	Queensboro, NB Upper Roadway	89,500	15.86
D500777	2/2/89	University Heights	13,077	12.00
D753114	12/14/89	Crown Point	587,342	10.00
		Average Cost for Overlay Materials (1990)		
		High-Density, Low-Slump		5.00
		Latex-Modified		4.75
		Microsilica		4.35

which was not open to traffic. These low values are not reflected in distress reported in Table 2, and failure was typically in the concrete rather than at the concrete-overlay interface.

Use of this family of products has two drawbacks: cost and loss of bond between the overlay and concrete deck surface. Cost data for thin polymer installation in New York is summarized in Table 4. The Crown Point overlay is Transpo T17X, and the others are Flexolith. This is a substantial cost increase when compared to conventional overlay costs.

III. CONCLUSIONS AND RECOMMENDATIONS

The objectives of the study reported here were to outline what is already known about PC bridge-deck overlays, and to document their performance in New York State and elsewhere:

1. Earlier generations of PC overlays had a poor performance record. Testing to date supports optimism for suitability and durability of newer polymer systems, although there is no way to predict their long-term performance at this time.

2. Performance of these systems is limited by the surface on which they are placed. Successful use depends on proper surface preparation. The deck to which the overlay is applied must be sound. The substrate as well as the coarse aggregate used to extend the mix must be dry and clean.

3. New York, Virginia, and California have most experience with these materials, with generally favorable results. The e-mail survey documented mixed results from other states, which had only limited experience.

4. PC overlays in New York appear to meet expectations, showing good performance during their first 5 to 7 years. Principal long-term concerns to be resolved are whether they will retain adequate bond to concrete, and resist wear where traffic volumes remain high. Because of variable field conditions, screening tests may be poor indicators of performance when installed in the field. Continued monitoring and expansion of the test patch program thus seems necessary.

Based on this review of past performance of PC overlays, cost of the installations, and the types of distress noted on bridge decks, their consideration is recommended only in two special cases: 1) for bridges where weight of the overlay is critical, such as movable-spans, or 2) where extended traffic disruptions are intolerable, as in urban areas.

Use of PC overlays with high-strength, fast-curing characteristics and reasonable durability can result in minimal traffic delays and improved safety, and in some cases may eliminate the need for expensive detours. These desirable characteristics must be weighed against the need for continuing maintenance patching of the overlay to prevent possible failures due to loss of adhesion.

There is no apparent difference in effectiveness of the various materials used in New York. Long-term studies should continue to investigate the nature of deterioration of the polymer after application and of polymer-deck concrete

interactions. This could lead to development of life-cycle models for the various polymer products. Continued testing is also necessary to identify changes in deck conditions, and to monitor performance of existing overlays.

Further investigation of polyester overlays seems warranted, based on overlays placed on Long Island, and positive experiences of other states.

ACKNOWLEDGMENTS

This study was performed under administrative direction of Dr. Robert J. Perry, Director, and technical supervision of Wes Yang, Engineering Research Specialist II, Engineering Research and Development Bureau, New York State Department of Transportation. The authors thank the many contributors to this work. Data collection and laboratory analysis were performed by the Materials Bureau, at the request of Dave Richards and Cathy Cowan. Regional personnel were most cooperative during the field observations, especially Lou Adams and Barry Galowin of Region 10; Carlos Pinlac, John Kwok, Richard Lee, and Tom Bowers of Region 11; and Elias Haddad of Region 1. Marie Gaudreault of the St. Lawrence Seaway Authority arranged for observation of test patch installations and continues to provide information on their sites. The research suggestion that led to this work was submitted by Joe Savoie, Region 1 Structures Engineer. Contributions to planning of the project by Daniel C. Merkel are also gratefully acknowledged.

REFERENCES

1. Jenkins, J.C., Beecroft, G.W., and Quinn, W.J. Polymer Concrete Overlays, Interim User Manual, Method A. Report FHWA-TS-78-218, Oregon State Highway Division, Office of Research and Development, December 1977.

2. Webster, R., Fontana, J., and Kukacka, L.E. Polymer Concrete Overlays, Interim User Manual, Method B. Report FHWA-TS-78-225, Brookhaven National Laboratory, February 1978.

3. ACI Committee 548. "Guide for the Use of Polymers in Concrete." ACI Materials Journal, Vol. 83, No. 5 (September-October 1986), pp. 798-829.

4. Durability of Concrete Bridge Decks. Synthesis of Highway Practice 57. National Cooperative Highway Research Program, May 1979, pp. 27-28.

5. Corbisiero, J.A., Radliff, R.K., and Irwin, R.J. Durability of Concrete Bridge Decks in New York State. Research Report 68-11, Bureau of Physical Research, New York State Department of Transportation, October 1968.

6. Irwin, R.J. and Corbisiero, J.A. Protective Coatings for Concrete Bridge Decks: Interim Report. Research Report 69-4, Engineering Research and Development Bureau, New York State Department of Transportation, June 1969.

7. Evaluation Report Phase I Flexolith Epoxy Overlay South Upper Roadway Queensboro Bridge over East River between Boroughs of Manhattan and Queens. Steinman Boynton Gronquist & Birdsall Consulting Engineers, New York, New York, July 1985.

8. Technical Report on Flexolith Epoxy Overlay Brooklyn Bridge over East River between Boroughs of Manhattan and Brooklyn. Steinman Boynton Gronquist & Birdsall Consulting Engineers, New York, New York, June 1987.

9. "Brooklyn Bridge, Evaluation of Flexolith Epoxy Overlay, Final Report." Unsigned internal memorandum, New York State Department of Transportation, November 1986.

10. "Manhattan Bridge, Evaluation of Thin Bridge Deck Overlays." Internal memorandum signed J.J. Murphy, Materials Bureau, New York State Department of Transportation, December 17, 1986.

11. "Manhattan Bridge, Evaluation of Thin Bridge Deck Overlays." Unsigned internal memorandum, New York State Department of Transportation, November 30, 1988.

12. "Field test for surface soundness and adhesion." In "Masonry, Precast Concrete, Special Processes," Part 5, Manual of Concrete Practice, American Concrete Institute, 1990, pp. 503R-30, 530R-31, and 503R-32.

13. Ferroni, L. "How to Place Polymer Concrete." Highway and Heavy Construction, August 1988, pp. 56-59.

14. Munn, W.D. "Teflon-Lined Paver Places Polymer Concrete Surface." Highway and Heavy Construction, April 1989, pp. 54-56.

15. Saiidi, M., and O'Connor, D.N. A Comparison of the Basic Properties of Portland Cement Concrete and Polyester-Styrene Polymer Concrete. Department of Civil Engineering, University of Nevada, Reno, August 1990.

16. Sprinkel, M.M. "Thermal Compatibility of Thin Polymer-Concrete Overlays." Transportation Research Record 899, Transportation Research Board, 1983, pp. 64-73.

17. Sprinkel, M.M. "Thin Polymer Concrete Overlays for Bridge Deck Protection." Transportation Research Record 950, Vol. 1, Transportation Research Board, 1984, pp. 193-201.

18. Vipulanandan, C., and Paul, E. "Performance of Epoxy and Polyester Polymer Concrete." ACI Materials Journal, May-June 1990, pp. 241-251.

19. Pagan, A.R. "Polymer Concrete: an engineer's overview." Better Roads, April 1991, pp. 42,46.

20. Cremaschi, J. "Polymer Concrete Bridge Overlays." Concrete International, May 1986, pp. 58-60.

21. Fairweather, V. "Filling the Cracks." Civil Engineering, October 1986, pp. 38-41.

22. Tarricone, P. "Overlays on Deck." Civil Engineering, September 1992, pp. 42-45.

23. "Concrete Bridge Deck Overlay." Special Provision 1131, Alabama Highway Department, July 12, 1991.

24. "Polyester-Styrene Deck Overlay." Internal memorandum signed L.E. Dunn, California Department of Transportation, October 21, 1983.

25. "Polyester Overlay, Hayfork Bridge." Internal memorandum signed E.D. Maggenti, California Department of Transportation, August 7, 1984.

26. "Inspection of Beegum and Hayfork Creek Bridges." Internal memorandum signed P. Krauss and K. Harper, California Department of Transportation, November 30, 1984.

27. "Review of Polymer Overlays on Four Bridges in Siskiyou County." Internal memorandum signed W. L. Nielsen, California Department of Transportation, undated.

28. "Report on Condition of Polyester Concrete Overlay at Soda Springs." Internal Memorandum signed J.F. Staton, California Department of Transportation, April 12, 1985.

29. "Polyester Concrete Overlay on Rte 32, Chico Creek Bridge, Bridge No. 8-67." Internal memorandum signed K. Foster, California Department of Transportation, December 8, 1987.

30. "Deer Creek et al. Bridges, Polyester Overlay & Chip Seals." Interim Field Report (internal memorandum) signed R. Maggenti, California Department of Transportation, August 4, 1989.

31. Telephone conversation with Don Armstrong, Illinois Department of Transportation, November 22, 1991.

32. Telephone conversation with Don Leonard, Indiana Department of Transportation, January 8, 1991.

33. Rasoulian, M., and Rabalais, N. Evaluation of Thin Epoxy System Overlays for Concrete Bridge Decks. Unpublished report on HPR Study 84-2C, Louisiana Department of Transportation, undated.

34. Personal communication from Bill Trimm, Missouri Highway and Transportation Department, November 4, 1991.

35. "Bridge Deck Seal Concrete." Specification Section 496, Nevada Department of Transportation, undated.

36. Personal communication from Shin Wu, North Carolina Department of Transportation, November 26, 1991.

37. Personal communication from Robert Peterson, North Dakota Department of Transportation, December 3, 1991.

38. Borg, T.M. "Polymer Concrete Overlay on SH 51 Bridge Deck." Basic Agreement DOT-FH-11-9124, Project 80-03-1, Item 2409, Research and Development Division, Oklahoma Department of Transportation, March 1982.

39. Knight, N.E. Polymer Concrete Overlays. Report FHWA-PA-85-048+83-29, Pennsylvania Department of Transportation, June 1986.

40. Knight, N.E. Polymer Concrete Overlays: Flexolith. Report FHWA-PA-86-005+83-29, Pennsylvania Department of Transportation, September 1986.

41. Arellano, J. L. Polymer Concrete Overlays for Bridge Decks. Report FHWA-PA-87-030+83-29, Pennsylvania Department of Transportation, June 1988.

42. Ramirez, T.L. Polymer Concrete Overlays: Flexogrid. Report FHWA-PA-89-003+83-29E, Pennsylvania Department of Transportation, August 1988.

43. Banks, R.K., O'Connor, D.L., Butler, H.D., Hustace, D., and Craig, F.S. Final Report on Polymer Concrete Overlays. Basic Agreement DOT-FH-11-8608, Task Order 18, FCIP Study 1-3D-80-542, Texas State Department of Highways and Public Transportation, January 1982.

44. Winters, P.C. "Project Evaluation P87-33, Initial Report, Polycarb Flexogrid." Vermont State Agency of Transportation, August 4, 1987.

45. Winters, P.C. "Product Evaluation P87-35, Final Report, Polycarb Flexogrid." Vermont State Agency of Transportation, September 3, 1987.

46. Sprinkel, M.M. Final Report on Polymer Concrete Overlay on the Big Swan Creek Bridge -- Condition of Overlay After Two Years in Service. Research Report VHTRC 86-R37, Virginia Highway and Transportation Research Council, June 1986.

47. Sprinkel, M.M. Evaluation of the Construction and Performance of Multiple Layer Polymer Concrete Overlays -- Interim Report No. 2 -- Condition of the Overlays After Five Years of Service. Report FHWA/VA-87-28, Virginia Department of Transportation, May 1987.

48. Bridge Deck Program. Bridge Planning and Technology Unit, Bridge and Structures Branch, Highway Division, Washington State Department of Transportation, May 1990.

49. Roberts, R.O., and Rutkowski, T.S. Evaluation of the Experimental Installation of Two Different Types of Epoxy Bridge Floor Overlay Systems: Flexolith and Flexogrid. Research Report PE 89J04/05, Division of Highways and Transportation Facilities, Wisconsin Department of Transportation, January 1989.

50. "Special Provision for Bridge Deck Overlay (Methyl Methacrylate Concrete), SP-500HX." Wyoming Highway Department, undated.

51. "Adhesion Testing of Transpo T17X Thin Polymer Overlay." NYSDOT internal trip report signed D.K. Richards, undated.

52. "Flexolith Epoxy Overlay Test Results." Unsigned NYSDOT internal memorandum, undated.

APPENDIX A

1984 Memorandum Cancelling
Polyester Overlay Program

COPY

DATE : November 5,1984

SUBJECT : CANCELLATION OF 1985/86 SPECIAL PROJECT PROGRAM

FROM : H. Boettcher, Regional Bridge Maintenance Engineer

TO : T.D. Gibbons, Regional Highway Maintenance Engineer

cc : A. Levine, Regional Structures Engineer
Darrell E. Maret, Senior Project Manager - Structures, FHWA
J.J. Murphy/D. Richards, Materials Bureau, Bldg. 7A, Rm 200

This memo is to advise you that I propose to cancel the 1985 Special Project Program I requested in my July 25, 1984 memo.

This project was to place a thin polymer overlay on four bridge decks over Route 495 in Suffolk County for a total material cost of $140,000.

The included bridges were BIN 1-06421-0, Week Rd/495, BIN 1-06422-9 Wading River Rd/495, BIN 1-06423-0 Freeman Ave/495 and BIN 1-05326-0 Halsey Manor Rd/495.

We have attempted during the past two years to resolve the many problems that were associated with a thin polymer overlay of monolithic decks using the broom and seed method of application.

While we did resolve many of these problems, we continue to get improper curing of the epoxy binder at random locations which usually results in delamination and thus eventual failure of the overlay. Perhaps more sophisticated machinery is necessary to assure quality control of these delicately balanced chemical systems.

We, in cooperation with the material manufacturers, have experimented with different aggregates, aggregate gradations, aggregate spreaders, mixing methods and times for both epoxy and polyester and curing times for the epoxy prior to the polyester overlay. While some methods have worked better than others, none were completely satisfactory to me.

I can, however, at this point make the following recommendations to those individuals that wish to pursue this method of overlaying monolithic bridge decks.

1. The epoxy binder must be allowed a 24 hour cure time before the polyester overlay may begin. Significant bond strength loss occurs if the epoxy is not allowed to fully cure. This is most likely caused by the chemical interaction between the partially cured epoxy and the polyester.

2. Use of basalt aggregate is superior to the sandblast sand previously used as it offers greater skid resistance, is better graduated without an excess of fines which could affect curing time and provides a generally better finished appearance.

3. The most significant problem remains the improper curing of the epoxy. The A & B components have been mixed per manufacturers recommendations (3 minutes per 3 gallon batch with drill mounted paddle mixers) but uncured areas continue to produce delamination failures. These curing deficiencies could still be a result of improper proportioning or mixing, but more likely a result of pavement surface temperature, condition or type, atmospheric condition or material deficiency. I do not wish to experiment further to determine the cause.

4. The polyester resin generally performed better than the epoxy as full cures were always achieved. The polyester was both promoted and initiated in the field by the Bridge Crew personnel.

Based on the above, please instruct J.J. Thomas' office to delete the material requirements for this 1985 project and reassign the $140,000 TIM Funds. I have no other projects to submit at this time.

I am by copy of this memo notifying both the FHWA Demonstration Projects Division and our Albany Materials Bureau of the above.

HB/JR

APPENDIX B

1987 NYSDOT Procedure
For Thin Polymer Concrete Overlays

ITEM 18555.3525 THIN POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS

DESCRIPTION. This work shall consist of furnishing and applying a thin polymer overlay where indicated on the Contract Plans and as directed by the Engineer. The work shall include the preparation of concrete surfaces.

The Contractor shall have the option of using any of the polymer overlay systems included in this specification except that only one system may be used on any one structure.

MATERIALS.

A. Thin Polymer Overlay. Materials for this work shall be one of the following systems:

1. DURAL FLEXOLITH. This overlay shall consist of an epoxy binder and aggregate, all as manufactured by Dural International Corporation, Deer Park, New York.

   The epoxy binder shall be Dural Flexolith and the aggratate shall be Dural Tuff-Grane, Type A, containing aluminum oxide.

2. TRANSPO T17X. This overlay shall consist of a two-component methyl-methacrylate polymer concrete (PCMMA) as manufactured by Transpo Industries, Inc., New Rochelle, New York.

   The liquid shall be Transpo T17 resin and the powder shall be Transpo T17X powder component.

3. SILIKAL URETHANE MODIFIED ACRYLIC OVERLAY. This overlay shall consist of a primer, a urethane-modified base course, and wearing surface, all as manufactured by Silikal North America, Inc., Stratford, Connecticut.

   The primer shall be Silikal R41S, the base course shall be Silikal R17 (Modified), and the wearing surface shall be Silikal R7X.

B. Patching Material. The material used to repair deck spalls prior to overlay application will be dependent on the overlay system chosen. The patching material shall be as recommended by the overlay manufacturer and shall be approved by the Director, Materials Bureau prior to commencement of work.

At least ten (10) days before the start of work the Contractor shall submit to both the Materials Bureau and the Engineer a written identification of the patching material proposed for use. At a minimum this identification shall include the physical characteristics, and the directions for use and curing of the patching material.

ITEM 18555.3525 THIN POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS

C. Samples. Samples of materials for all components of the overlay system excluding patching material shall be submitted by the manufacturer to the Materials Bureau a minimum of thirty (30) days prior to overlay application. Samples shall be representative of the materials to be used in the overlay application and shall consist of a one (1) gallon sample for each liquid component and a five (5) pound sample for each dry component.

These samples will be evaluated to verify that they are representative of the same product previously tested and accepted for use.

D. Packaging and Shipment. All components shall be shipped in strong, substantial containers, bearing the manufacturer's label specifying date of manufacture, batch number, brand name, quantity, and date of expiration or shelf life. In addition, the mixing ratio shall be printed on the label of at least one of the system components.

E. Basis of Acceptance. Project acceptance of thin polymer overlay materials will be based on the following:

1. Delivery of the overlay materials to the project site in acceptable containers bearing all the label information as required in this specification.

2. Verification testing by the Materials Bureau to determine that the samples submitted are representative of the same materials previously approved by the Materials Bureau.

CONSTRUCTION DETAILS.

a. General. At least ten (10) days before the start of work the Contractor shall provide the Engineer with two (2) copies of the manufacturer's written instructions for the installation of the overlay system.

When directed by the Engineer, the manufacturer's technical representative shall be made available for up to five (5) working days to make recommendations to facilitate the overlay installation. This shall include, but not be limited to, surface preparation, overlay application, and overlay cure.

During surface preparation and blast cleaning work, precautions shall be taken to assure that traffic is protected from rebound and dust. Appropriate shielding shall be provided as required and directed by the Engineer.

ITEM 18555.3525 THIN POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS

During overlay application, the contractor shall provide suitable coverings (e.g. heavy duty drop cloths) to protect all exposed areas not to be overlaid, such as curbs, sidewalks, parapets, etc. Any damage or defacement resulting from this application shall be cleaned and, or repaired to the Engineer's satisfaction, at the Contractor's expense.

B. Storage of Materials. All materials shall be stored in accordance with the manufacturer's recommendations to insure their preservation until used in the work.

C. Equipment.

1. Surface Preparation. All equipment to be used for surface preparation shall be as specified by the overlay manufacturer and approved by the Engineer. Unless otherwise specified, the Contractor shall use automatic shot blasting units to clean pavement surfaces. In those areas not accessible to this machinery, the surface may, with the Engineer's approval, be cleaned with sandblasting equipment.

   Automatic shot blast units shall be self propelled and include a vacuum to recover spent abrasives. The abrasive shall be steel shot. Magnetic rollers shall be used to remove any spent shot remaining on the deck after vacuuming.

2. Application. The equipment used for proportioning, mixing, and applying overlay materials shall meet the overlay manufacturer's requirements and shall be approved by the Engineer. The proportioning equipment shall be adjustable so that mixing ratios may be altered to account for temperature fluctuations.

3. Finishing. Screeding shall be performed using a viabratory-type mechanical screed riding on preset rails. Screeds shall be approved by the Engineer prior to the application of the overlay.

D. Surface Preparation. All structural slab surfaces and other surfaces against which the polymer system is to be placed shall be prepared as follows:

1. All spalls and other surface defects shall first be repaired with patching material in accordance with patching material in accordance with manufacturer's recommendations. Work shall be performed as directed by and to the satisfaction of the Engineer.

ITEM 18555.3525 THIN POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS

2. After the patching material has completely cured all concrete surfaces shall be shot blasted using the equipment and procedures recommended by the overlay manufacturer. Concrete surfaces not accessible for cleaning with shot blasting shall be dry sandblasted using conventional methods approved by the Engineer. At no time will wet blasting be allowed.

3. Wherever the overlay will abut transverse expansion joints, open steel grates or scuppers the structural slab concrete shall be removed to a minimum depth of 1/2 inch (See Details 1 and 2). This removal shall extend a minimum of two feet in all directions, on all surface to be overlayed. The method and extent of concrete removal will be as directed by the Engineer.

   Concrete removal shall not be required on structural decks consisting of concrete filled steel grids. If the Engineer determines that a smooth transition over joints, etc. is required the overly shall be feathered at joints, grates and scuppers. Feathered edges shall have a minimum thickness of scuppers. Feathered edges shall have a minimum thickness of 1/8 inch at their termination edge. The length of taper (transition) shall be as directed by the Engineer (see Detail 3).

4. All steel surfaces that will be in contact with the overlay shall be cleaned in accordance with SSPC-SP No. 10, Near-White Blast Cleaning, except that wet blasting methods shall not be allowed.

After cleaning and concrete removal operations are complete there shall be no visible evidence of oil, grease, dirt, rust, loose particles, spent abrasives or other foreign material on any of the surfaces to be overlayed.

E. Application. On any portion of the pavement surface no more than one working day shall elapse between the completion of surface cleaning and overlay application. If the overlay is not applied within one working day the pavement shall be recleaned as directed by and to the satisfaction of the Engineer. No additional payment will be made for recleaning work.

The application of the polymer overlay shall be performed in accordance with the manufacturer's written instructions. Materials shall only be applied to dry surfaces and when surface and ambient temperatures are above 40°F and below 100°F.

The overlay shall be placed at a minimum thickness of 1/2 inch. If the Silkal overlay system is used the base course and wearing course shall each be a minimum 1/4 inch thick. Screeding shall be done continuously to avoid producing an uneven surface.

ITEM 18555.3525 THIN POLYMER OVERLAY WEARING SURFACE FOR STRUCTURAL SLABS

Termination edges of the overlay may require application and finishing by hand trowel due to obstructions such as a curb. All hand trowelling shall be followed by broadcasting aggregate and/or surface texturing to provide acceptable surface friction characteristics.

Provisions shall be made to protect expansion joints by masking or other method so that no polymer seeps into a contaminates the joint openings.

F. Surface and Thickness Requirements. The overlay surface shall be checked at random by the Engineer during the application of the overlay to assure that no depressions exist that will pond water. The surface shall be tested with a straight-edge not less than ten (10) feet long. The straight-edge shall be placed in contact with the overlay surface in successive positions parallel to and perpendicular to the deck's centerline. All depressions greater than 3/16 inch shall be repaired after the overlay hardens in the manner recommended by the manufacturer and approved by the Engineer.

To insure adequate pavement friction, the completed overlay surface shall be free of any smooth or "glassy" areas such as those resulting from insufficient quantities of surface aggregate. Any such surface defects shall be repaired in the manner recommended by the manufacturer and approved by the Engineer.

Thickness of the overlay shall be checked prior to its initial set using a ruler. If the Engineer determines that the minimum thickness has not been attained, an additional layer shall be applied after the overly hardens. This layer shall be a minimum of 1/4 inch and shall be applied at no additional cost to the State.

G. Curing. The polymer overlay shall be allowed to reach final cure before subjecting it to traffic or loads of any nature that may damage it. Cure time is dependent upon the ambient and deck temperatures. Actual degree of cure and suitability of the overlay for traffic shall be as determined by the manufacturer and directed by the Engineer.

METHOD OF MEASUREMENT. The work shall be measured by the number of square feet of the polymer overlay stated in the Estimate of Quantities. No field measurements will be taken except to provide progress payments.

BASIS OF PAYMENT. The unit price bid per square foot shall include the cost of all labor, materials, equipment, and incidentals necessary to complete the work. The unit price bid shall also include the cost of having the polymer manufacturer's representative present as required. Under no circumstances shall the total of all progress payments exceed the Estimate of Quantities.

APPENDIX C

NYSDOT Specification
For Thin Polymer Concrete Overlays

ITEM 18555.XXXX THIN POLYMER OVERLAY

DESCRIPTION. This work shall consist of preparing concrete surfaces and furnishing and placing a thin polymer overlay as indicated on the plans, in accordance with these specifications, and as directed by the Engineer.

The Contractor shall have the option of supplying any of the polymer overlay systems included in this specification except that only one system may be used on any one structure.

MATERIALS.

A. Materials for this work shall consists of one of the following systems:

1. DURAL FLEXOLITH. This overlay shall consist of an epoxy binder and aggregate as manufactured by Dural International Corporation, Deer Park, New York.

   The epoxy binder shall be FLEXOLITH and be a two-component 100% solids type system consisting of a resin base and hardener.

   The aggregate shall be Dural Tuff-Grane aggregate, Type A, and shall contain aluminum oxide. The aggregate shall conform to the following gradation:

U.S. STANDARD SIEVE (ASTM E-11)	% RETAINED
#6	0-1%
#10	50-70%
#20	29-45%
PAN	0-5%

2. TRANSPO T17X. This overlay shall consist of a two-component methyl-methacrylate polymer concrete (PCMMA) as manufactured by Transpo Industries, Inc., New Rochelle, New York.

   The liquid component shall be formulated to allow curing of the system within 45 minutes to 2 hours under actual field conditions when surface and air temperatures are from 40° F to 100°F.

   The powder component shall be a pre-mixed material consisting of polymer, initiator, fine filler and aggregates.

3. SILIKAL URETHANE MODIFIED ACRYLIC OVERLAY. This overlay shall consist of a urethane-modified base course and wearing surface as manufactured by Silikal North America, Inc., Stratford, Connecticut. The base course shall be Silikal's modified R17 and the wearing surface shall be Silikal's R7X.

B. Samples. Samples of materials for all components of the overlay system shall be submitted by the manufacturer to the Director, Materials Bureau a minimum of thirty (30) days prior to overlay application. Samples shall be representative of the materials to be used in the overlay application and shall consist of a one (1) gallon sample for each liquid component and a five (5) pound sample for each dry component.

C. Packaging and Shipment. All components shall be shipped in strong, substantial containers, bearing the manufacturer's label specifying date of manufacture, batch number, brand name, quantity, mixing ratio, and date of expiration or shelf life.

D. Basis of Acceptance. Acceptance of materials for all components of the overlay shall be contingent on delivery to the job site in acceptable containers bearing all the necessary label information as required in this specification.

CONSTRUCTION DETAILS.

A. General. At least ten (10) days before the start of work the Contractor shall provide the Engineer with two (2) copies of the manufacturer's written instructions for the installation of the overlay system.

If directed by the Engineer, the manufacturer's representative shall be made available for up to five (5) working days to make recommendations as to the acceptability of the overlay installation. This shall include surface preparation, overlay application, and overlay cure as well as type of equipment, mixing of overlay components, method of application, and finish.

During surface preparation and blast cleaning work, precautions shall be taken to assure that traffic is protected from rebound and dust and that no dust or debris leaves the roadway deck. Appropriate shielding shall be provided as required and directed by the Engineer.

During overlay application, the contractor shall provide suitable coverings (e.g. heavy duty drop cloths) to protect all exposed areas not to be overlaid, such as curbs, sidewalks, parapets, etc. Any damage or defacement resulting from this application shall be cleaned and/or repaired to the Engineer's satisfaction, at the Contractor's expense.

B. Storage of Materials. All materials shall be stored in accordance with the manufacturer's recommendations to insure their preservation until used in the work.

C. Equipment.

1. Surface Preparation. All equipment to be used for surface preparation shall be in accordance with the overlay manufacturer's requirements and approved by the Engineer prior to the start of work. Unless otherwise recommended, to clean pavement surfaces, the contractor shall use automatic shot blast cleaning units except in those areas that are not accessible by this machinery. Inaccessible areas shall be blast cleaned using conventional methods, subject to prior approval by the Engineer.

   Automatic shot blast units shall consist of a blasting unit and a vacuum unit, both self-propelled. The abrasive shall be steel shot and the unit shall recycle the abrasives and contain them so that no steel shot is projected into adjacent traffic lanes. The vacuum unit shall collect all dust and contaminants so that the view of motorists in the adjacent roadway is not obstructed. Any spent shot remaining on the deck after cleaning shall be picked up with magnetic rollers.

   At no time shall waterblasting be allowed to clean pavement surfaces.

2. Application. The equipment used for proportioning, mixing, and applying overlay materials shall meet the overlay manufacturer's requirements and shall be approved by the Engineer prior to the start of work. The proportioning equipment shall be adjustable to account for any temperature fluctuation that may require the alteration of mixing ratios.

3. Finishing. The method of finishing the mixed overlay material to assure a minimum thickness of ½" above the concrete surface shall be as recommended by the overlay manufacturer and approved by the Engineer prior to the start of work. Screeding shall be performed using an approved vibratory-type mechanical screed and shall be done continuously to avoid providing an uneven surface.

D. Surface Preparation. Surface preparation work shall not begin until all major deck repair and patching has been completed and the minimum specified curing time has elapsed or until the new concrete has cured for the time specified by the overlay manufacturer, whichever is greater. If directed by the Engineer, shall localized areas of deteriorated concrete, that are no deeper than 1½" may be chipped out and patched using excess slurry during application of the overlay.

Using the equipment and procedures recommended by the overlay manufacturer, the concrete pavement shall have its surface prepared by removing all loose, deteriorated, or unsound concrete. The exposed concrete shall be free of any oil, solvent, grease, dirt, loose particles, and other foreign matter just prior to the application of the overlay.

All steel surfaces (e.g. armored joints, steel-faced curb, etc.) that will be in contact with the overlay shall be cleaned in accordance with SSPC No. 10, Near-White Blast Cleaning. The surfaces, after cleaning, shall be defined by SSPC-Vis 1, Pictorial Standards ASa 2½, BSa 2½, or CSa 2½ as applicable.

All pavement surfaces not accessible for cleaning by automatic shot blast cleaning units shall be blast cleaned using conventional methods approved by the Engineer.

On any portion of the pavement surface no more than one working day shall elapse between the completion of surface cleaning and overlay application. If the overlay is not applied within one working day the pavement shall be recleaned as directed by and to the satisfaction of the Engineer. No additional payment will be made for recleaning work.

E. Application.

1. General. Application of the polymer overlay shall be performed in accordance with the manufacturer's written instructions. Materials shall only be applied during favorable atmospheric conditions as determined by the Engineer. No material shall be placed when surface or ambient temperatures are below 40°F or above 100°F.

2. Mixing. The mixing ratio for overlay materials shall be in accordance with the overlay manufacturer's recommendations. All mixing and dispensing shall be accomplished with approved equipment.

3. Placement. Except for feathered edges, the overlay shall be placed at a minimum thickness of ½ inch, after curing.

   Concrete surfaces shall be overlaid as soon as possible and in no case more than one working day after the surface preparation is completed in order to prevent contamination of the cleaned surface. If, in the opinion of the Engineer, the surface has become soiled or contaminated prior to the application of the overlay, it shall be cleaned again in accordance with this specification, at no additional cost to the State.

   Placement of the overlay shall be performed using approved equipment. If necessary, screed rails shall be set to provide a minimum thickness of ½" above the existing roadway deck surface.

4. Finishing. Termination edges of the overlay may require application and finishing by hand trowel due to obstructions such as a curb. All hand trowelling shall be followed by broadcasting aggregate and/or surface texturing to provide acceptable surface friction characteristics.

The contractor shall feather the edge of the overlay at all expansion joints to a thickness of 1/8 inch so as to provide a smooth transition across the joints. This feathering shall be accomplished with hand trowelling followed by aggregate broadcasting or texturing.

Provisions shall be made to protect expansion joints by masking or other method so that no polymer seeps into or contaminates the joint openings.

F. Surface and Thickness Requirements. The overlay surface shall be checked at random by the Engineer during the application of the overlay to assure that no depressions exist that will retain rainwater. The surface shall be tested with a straight-edge not less than ten (10) feet long. The straight-edge shall be placed in contact with the overlay surface in successive positions parallel to and perpendicular to the deck's centerline. Any unacceptable depressions or other surface irregularities, as determined by the Engineer, shall be repaired after the overlay hardens in the manner recommended by the manufacturer and approved by the Engineer.

Thickness of the overlay shall be checked prior to its initial set by using a ruler, marked off in 1/8" increments, that can penetrate the overlay to determine the thickness. If the Engineer determines that the minimum thickness has not been attained, an additional layer shall be applied after the overlay hardens. This layer shall be a minimum of 1/4 inch and shall be applied at no additional cost to the State.

G. Curing. The polymer overlay shall be allowed to reach final cure before subjecting it to traffic or loads of any nature that may damage it. Cure time is dependent upon the ambient and deck temperatures. Actual degree of cure and suitability of the overlay for traffic shall be as determined by the Manufacturer and directed by the Engineer.

Should external heating of the overlay become necessary due to field conditions or traffic constraints, the Contractor's methods and equipment shall be approved by the Engineer prior to the commencement of any such work. This work shall be accomplished at no additional cost to the State.

H. Pavement Friction Requirements. The completed overlay shall exhibit adequate pavement surface friction characteristics as determined by the Engineer. The surface shall be free of any smooth or "glassy" areas such as those resulting from insufficient surface aggregate or texturing. Any such surface defects shall be repaired after the overlay hardens in the manner recommended by the manufacturer and approved by the Engineer.

METHOD OF MEASUREMENT. The work shall be measured by the number of square feet of the polymer overlay satisfactorily installed and accepted by the Engineer.

BASIS OF PAYMENT. The unit price bid per square foot shall include the cost of all labor, materials, equipment, and incidentals necessary to complete the work. The unit price bid shall also include the cost of having the polymer manufacturer's representative present as required.