Thin Overlay Custer Way Undercrossing 5/316

WA-RD 244.1

Post Construction Report
October 1991

Washington State Department of Transportation
Program Development Division
Bridge and Structures

in cooperation with the
United States Department of Transportation
Federal Highway Administration

WASHINGTON STATE DEPARTMENT OF TRANSPORTATION

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The study was conducted in cooperation with the U. S. Department of Transportation, Federal Highway Administration.

16. ABSTRACT

A polymer concrete thin overlay, EPI/FLEX III (epoxy) was applied to the deck of the Custer Way Undercrossing, Bridge No. 5/316, under Contract No. 3361, SR 5 Trosper Road Interchange to Capital Lake Interchange. This bridge crosses mainline I-5 in Tumwater, Washington.

This report describes the construction and provides data on the post-construction evaluation of the completed overlay.

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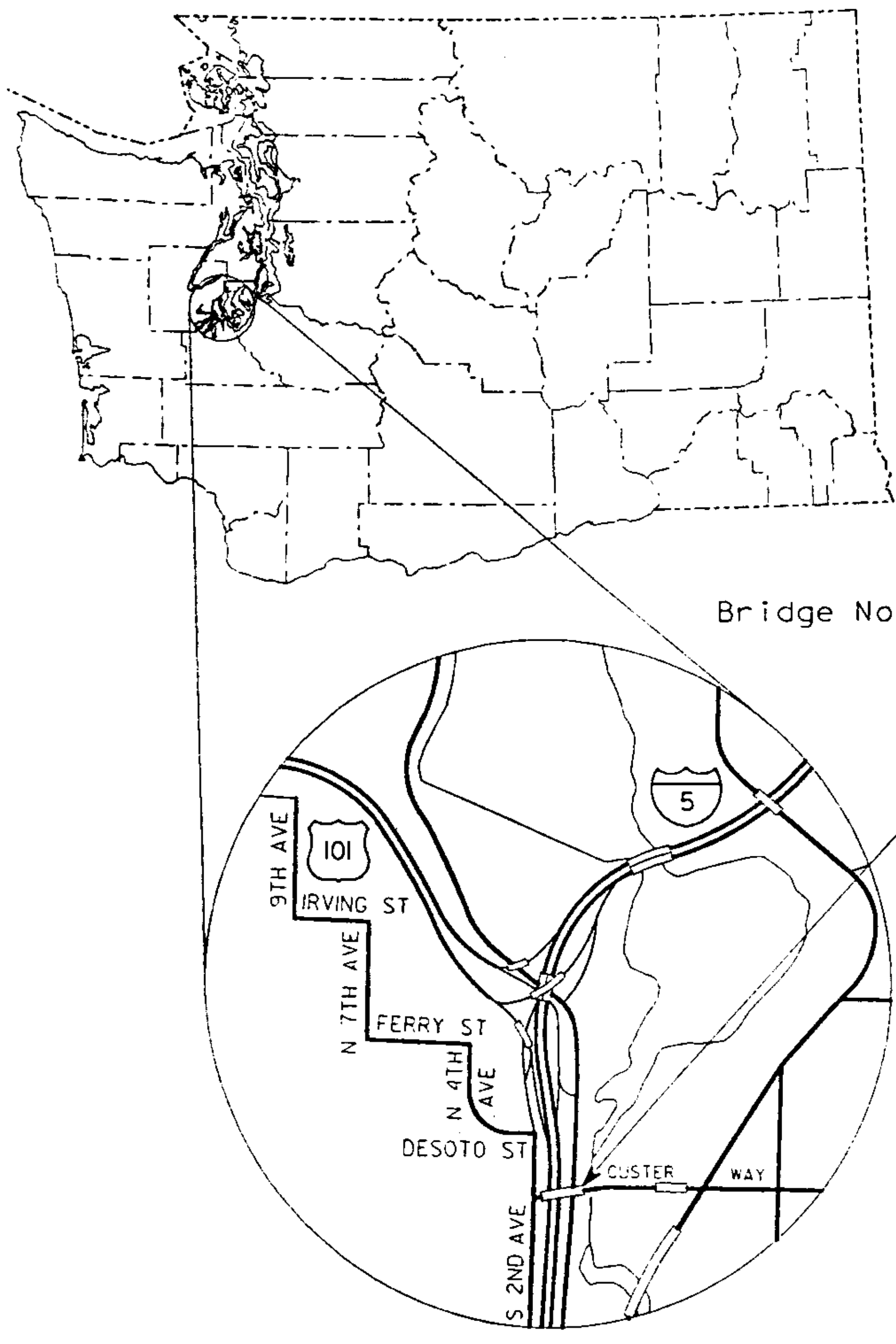


PROJECT SITE

INTRODUCTION

This is the eighth bridge in a series of eight federal participating bridge deck overlay projects using thin polymer concretes. Each deck in the series has been constructed using a different commercially available polymer concrete system, with work performed under a standard WSDOT contract. Each deck will be monitored over a ten-year period to evaluate the long-term performance. A description of the total experimental project design can be found in Appendix A.

STUDY SITE

The polymer concrete thin overlay was applied to the deck of the Custer Way Undercrossing 5/316, under Contract No. 3361, SR 5 Trosper Road Interchange to Capital Lake Interchange. This bridge is on mainline I-5, in Tumwater, Washington.

The approach spans to the existing 165 foot arch were replaced in this project. The arch deck was widened to 37 feet 4 inches. The arch was originally designed for light truck loading. A 1-1/2 inch latex modified concrete deck overlay was not desireable, due to the additional dead load. A thin overlay added much less dead load to the existing structure.

The existing deck was worn to aggregate in the wheel line, with scattered mud ball holes. The deck also had many transverse and diagonal leaching cracks, with scattered light scaling. Fifty percent of the chloride samples had chlorides greater than 2 lbs. per cubic yard. The deck had no delaminations. Rebar cover varied from 1 to 2 inches. Wheel rut values ranged up to 1/8 inch.

INSTALLATION PROCEDURE

The EPI/FLEX 111 (epoxy) thin polymer concrete overlay was installed on the concrete deck of the Custer Way Undercrossing Bridge No. 5/316 from September 17, 1990, to September 21, 1990. The product was supplied by Adhesives Technology Corporation.

The existing bridge deck had a sidewalk on each side. The contract plans provided for removal of the sidewalks prior to the overlay, and channelization to accommodate an additional lane. When the sidewalks were removed, the underlying deck was found to be extremely irregular. Due to the unevenness of the deck, a corrective plan was established to repair the areas and provide for proper drainage of the deck. The plan entailed milling the areas 3/4 inch deep and patching back with a 3/8 inch Class M concrete. The approximate area of the patch was 288 square yards. This work was treated as "Bridge Deck Repair," a contract item.

The subcontractor, David A. Mowat, began preparing the deck for the polymer overlay following 12 days cure of the bridge deck patch. The polymer material was not placed until the patch had actually cured for 14 days.

The area of the bridge deck overlay was 968 square yards. Traffic was detoured outside the work area. The subcontractor elected to overlay the bridge in halves, using the center of the structure as a staged dividing line. The contractor began preparing the north half of the bridge deck by shotblasting and sandblasting. The shotblast was the primary means for cleaning the existing surface, with sandblasting used adjacent to the traffic barrier and along the steel expansion joints. A power broom and high pressure air were used to complete the cleaning process. No water was allowed on the deck, due to the sensitivity of the epoxy polymer to moisture.

All expansion joint surfaces which were not to receive the overlay were covered with duct tape. Duct tape was also laid down on the center of the deck to contain the epoxy and keep it from bleeding onto the unprepared half of the deck. The tape on the center provided for a neat match line at the completion of the first overlay stage.

The placement operation began by setting up the epoxy mixing station. The station was located on the newly constructed bridge deck, which was not to be overlayed, well removed from the overlay area to ensure that the section to be overlayed remained clean. The area of the bridge deck around the mixing station was covered with polyethylene sheeting for protection. The mixing station was equipped with a portable generator; power drill (high speed); mixing paddle attachment for the drill; two 55-gallon drums cut in half; two piano dollies; and 55-gallon drums filled with the epoxy resin. The epoxy was mixed in approximately 20 gallon quantities in the half drums and transported to the work area on the dollies. The aggregate was located next to the work area in 1 cubic yard bags.

The epoxy was mixed, wheeled to the overlay area, and dumped on the deck. Two laborers spread the epoxy over the deck, with 3 foot wide serrated squeegees. The serrated squeegees were designed to allow the proper amount of epoxy to remain on the deck. Immediately after the epoxy was spread, three laborers began hand broadcasting aggregate, from 5-gallon pails, over the epoxy. The aggregate was broadcast in sufficient quantity to ensure 100 percent coverage. The aggregate was placed up to 1 inch thick in areas, to cover any additional bleeding areas which might appear. The bleed areas resulted from thick placement of the epoxy in isolated low spots. The cure period began at the conclusion of the aggregate placement, and took 3 hours. The epoxy had hardened by this time and a power broom was used to remove excess aggregate. The ambient temperature was approximately 70 degrees Fahrenheit.

This contract required a 1/4 inch overlay consisting of two layers of resin/aggregate. The second coat was applied exactly the same as the first, except there was no preparatory work for the second coat other than the sweeping. The second coat was completed at approximately 6 p.m., and was allowed to cure until 7 a.m. It was noted that the second coat required 1-1/2 times the amount of epoxy used for the first coat, due to the increased surface coarseness created by the aggregate of the first coat.

Cure on the second coat was attained, the deck was swept, and all duct tape was removed. The north half of the deck was now complete and the contractor began preparing the south half. The preparatory and placement sequence was exactly the same on the south half as it was on the north half.

Once the south half was complete, the entire deck was swept. The deck was now ready to accept traffic. The deck was not opened to traffic for three days following completion of the overlay, due to adjacent roadway work that was not yet completed.

The overlay, from start to finish, took only four days (two preparatory and two placement).

CONSTRUCTION PROBLEMS

There were no construction problems associated with the installation of this product.

ACCEPTANCE TESTING

Specifications required a minimum of 300 psi for the average bond strength, or failure in the bridge deck Portland cement concrete. All bond tests were satisfactory.

All friction tests were satisfactory. Values ranged from 76 to 84. Contract specifications required a minimum of 50.

Contract specifications required 70 percent of resistivity test readings to be above 250,000 ohms, with no single reading less than 100,000 ohms. This test showed satisfactory results except for two small areas, each approximately 3 square yards.

CONCLUSIONS AND RECOMMENDATIONS

The ease of placement, weight, and fast cure time makes this product a viable option for use in areas where rapid construction or dead load considerations control the overlay selection. Employees of the subcontractor, David A. Mowat, performed the work efficiently. The Department received an excellent final product.

Comparing the constructability of this polymer overlay to a rigid Portland Cement based concrete overlay, the polymer has several advantages. This product took four days to construct, including cure time. Placement of a rigid 1-1/2 to 2 inch concrete overlay could have taken up to three weeks on a deck this size. A rigid concrete overlay would have required more equipment, larger equipment, and far more manpower. The placement of the polymer overlay also required only six workmen.

There were no contract change orders associated with this polymer concrete overlay.

APPENDIX A

TOTAL EXPERIMENTAL PROJECT DESIGN

TOTAL EXPERIMENTAL PROJECT DESIGN

General Background

Over time, the top few inches of a concrete structure can become contaminated with salt from a saltwater marine environment or deicing agents used during the winter months. This condition destroys the passivity of the reinforcing steel and provides a favorable environment for the development of corrosive anode-cathode relationships on the surfaces of the reinforcing steel. The salt and moisture in the concrete serve as the electrolyte. A reinforcing bar will corrode at the anodes, with the rust expanding and cracking the concrete. Delaminations and spalls occur in the deck with resulting deterioration.

Latex modified concrete (LMC), low slump dense concrete (LSDC), and asphalt concrete with waterproofing membranes are the most common systems being used for bridge deck overlays to restore deteriorated decks and to help prevent further penetration of chloride into the deck concrete. These systems add extra weight to bridges. In addition, the latex modified and low slump concrete overlays require careful quality control during construction and, generally, 48 to 96 hours of cure time before traffic can be restored to the structure.

In recent years, polymer concrete (PC) in the form of 1/4 inch thin bridge deck overlays has shown promise of providing a long-lasting, maintenance-free deck protection system. It is impervious to the penetration of salt, can be constructed with relative ease and with relatively simple construction equipment, allows traffic to be restored within 1 to 12 hours, and provides good skid resistance. The polymer concrete's adhesive properties also preclude the need to scarify the existing bridge deck before overlayment (a major advantage for decks with inadequate concrete cover over the deck reinforcing steel). Therefore, there is less potential for damage to rebars.

These polymer concretes have a cross-linked polymer that replaces Portland cement as a binder in the concrete mix. Epoxy resins are commonly used in polymer concretes, but much attention has also been focused on the use of vinyl monomers, such as polyester-styrene, methyl methacrylate, high molecular weight methacrylate, furane derivative, and styrene. Since the polymer constitutes the continuous phase, behavior of the PC is determined by the specific polymer used.

Purpose

The purpose of the experimental project is to gain knowledge about field installation techniques and procedures and to assess the performance and effectiveness of the PC thin overlays over time.

General Program Description

WSDOT has elected to use PC overlays on eight federal aid and 16 state-funded bridges that needed deck rehabilitation and protection. The normal delamination and spall repairs have been followed by the application of thin (usually 1/4 inch) PC overlays. These PC overlays were done under usual WSDOT contracts. Ten different thin PC systems have been used on WSDOT bridges to date. Contract documents specify the type of overlay system for each bridge. A total of approximately 130,000 sq. ft. of bridge deck, involving eight of the PC systems, is included in the FHWA experimental feature project portion of this study.

General Project Description

Installation of the PC overlay for the bridge deck has been in compliance with the manufacturer's recommendations. Contract documents required that a supplier's field representative be present during installation of the system. Complete records of field observations, testing, and subsequent monitoring is maintained for each installation, with emphasis on the cause and resolution of problems during any phase of the project. The district field office provides an end of construction report on each installation.

Annual inspections and testing of the experimental feature projects will be made over a ten-year period. The WSDOT Materials Laboratory will be responsible for all field testing and reporting on all field activities. See Appendix B for scheduled testing and reporting.

Control Section

The final performance evaluation report for each thin overlay application will include a comparison of the installation techniques and procedures with those for latex modified and low slump concrete overlays. The effectiveness of the permeability for deck protection and length of service life will be compared to the LMC and LSDC overlays in similar environments and service conditions.

The current "Bridge Deck Program Development" includes research for "Evaluation of Concrete Overlays for Bridge Applications." The data collected and analyzed in that research will be utilized, to the fullest extent possible, as the basis for comparative evaluation of the overlays in this experimental feature project.

Tests

Annual inspections and testing of each federal aid bridge will be made over a ten-year period. The testing will include: 1) friction measurements for skid resistance of the overlay surface; 2) half-cell for corrosion activity; 3) chloride content for intrusion of corrosive chloride ions; 4) pachometer for rebar depth; 5) pull-off for bond strength; and 6) visual inspection for detection of surface deterioration, such as cracks, spalls, or delaminations. These tests will be performed according to the schedule in Appendix B.

Reporting

A post-construction report will be issued after completion of the construction project. Annual Form 1461 reports summarizing the performance of the overlay will be submitted to FHWA through the WSDOT Research Office. The testing results for each year will be reported to the Research Office with a brief report summarizing any observations or conclusions that can be made at that point. A final report will be issued at the end of the evaluation period. This report will contain the observations, test results, and conclusions from the study, along with any appropriate photographs.

APPENDIX B

PROJECT LIST AND TEST PLAN

Experimental Bridge Deck Thin Overlay Projects

	Federal Aid Projects	District	Deck Area (Sq. Ft.)	Install Date	Contract Number	System Type	Dollars Per Square Yard
403/7	Grays R. Rosburg	4	5,360	8/86	3090	Degussa	35
12/915	Snake R. Clarkston	5	56,940	6/86	3107	Flexogrid	40
82/114S	Yakima R.	5	11,370	7/87	3131	Concressive 2020	77
82/115S	Naches R.	5	11,370	7/87	3131	Concressive 3070	77
900/12W	SR 5 OC	1	13,950	11/86	3189	Flexolith	60
900/13W	SR 5 OC	1	13,950	6/87	3189	Sika Pronto 19	55
5/316	Custer Way UC	3	6,190	1990	3361	EPI/Flex III	62.60
5/523E	S 154th St. OC	1	7,300	8/88	3354	Conkryl	100
	Non Federal Aid Projects						
167/102	Third Ave. SW OC	3	7,216	8/87	3078	Flexogrid	43
167/104	Ellingston Rd. OC	3	7,172	8/87	3078	Flexogrid	43
167/106	First Ave. N OC	3	6,424	8/87	3078	Flexogrid	43
161/10	SR 512 OC	3	11,120	6/86	3100	EPI/Flex III	40
167/21	Milwaukee Ave. OC	3	6,864	8/87	3183	Degussa	43
512/40	SR 167 OC	3	12,806	8/87	3183	Degussa	43
529/20W	Steamboat SL	1	20,472	10/87	XE 2625	Flexogrid	40
529/20E	Steamboat SL	1	21,840	10/87	XE 2625	Flexogrid	40
104/5.2	Hood Canal E 1/2	3	101,388	7/88	3316	Flexogrid	32
82/10S	Thrall Rd. O-Xing	5	18,992	4/85	2857	Flexolith	82
101/115	Chehalis River Br.	3	14,508	8/84	2643	Flexogrid	65
101/514	Mottman Road O-Xing	3	6,640	8/85	2945	Degussa	45
16/120	Olympic Inter UC	3	6,417	7/88	3336	Degussa	42
99/530	Duwamish R. (Bascule) (Wheel Paths)	1	17,028	8/88	3432	Flexogrid	Unk.
520/8	Evergreen Point (Drawspan) (Wheel Paths)	1	20,070	8/88	3432	Flexogrid	Unk.
97/2	BN RR OC	4	5,876	6/89	3530	Degussa	55
5/532.5	Albro St. UC	1	12,628	6/90	3737	Sikadur-21	47
5/534N-W	N-W Ramp RR OC	1	6,111	6/90	3737	Sikadur-21	47
5/534A	N-W Ramp Airport W OC	1	27,348	6/90	3737	Sikadur-21	47
5/534S-W	S-W Ramp Lucile St. OC	1	17,050	6/90	3737	Sikadur-21	47
5/539S-W	S-W Ramp Forest St.	1	14,658	6/90	3737	Sikadur-21	47
27/3	Missouri Flat Cr.	6	2,728	8/90	XE2822	Silikal	100
410/101	White R.	1	8,176	10/90	3744	Sikadur-21	49
410/115	Scatter Cr.	1	7,000	10/90	3744	Sikadur-21	49
410/123	Slippery Cr.	1	2,964	10/90	3744	Sikadur-21	49
536/15	Skagit R. CS2907	1	18,900	8/90	3777	Sikadur-21	45

THIN OVERLAY EXPERIMENTAL PROJECT
TESTING AND ANALYSIS COSTS PER AVERAGE 13,000 FT.^{2} BRIDGE

Responsible Unit	Work Item	Pre-Construct.	Post-Construct.	Year* 1	2	3	4	5	6	7	8	9	10	Totals
HQ ML	Friction Testing (x hrs) at $100/hr		(1 hr) $ 100	(1 hr) $ 100	(1 hr) $ 110	(1 hr) $ 121	(1 hr) $ 133	(1 hr) $ 146	(1 hr) $ 161	(1 hr) $ 177	(1 hr) $195	(1 hr) $ 215	(1 hr) $ 237	$1,695
HQ ML	Electrical *** Resistivity (x hrs) at $108/hr		(6 hrs) $ 648	(6 hrs) $ 648	(6 hrs) $ 713	(6 hrs) $ 784		(6 hrs) $ 948		(6 hrs) $1,147			(6 hrs) $1,527	$6,415
HQ ML	Half-Cell Testing (x hrs) at $108/hr	(8 hrs) $ 864				(1 hr) $ 131				(1 hr) $ 192			(1 hr) $ 255	$1,442
HQ ML	Chloride Testing (x hrs) at $108/hr	(2 hrs) $ 216				(1 hr) $ 131				(1 hr) $ 192			(1 hr) $ 255	$ 794
HQ ML	Rebar Depth (x hrs) at $108/hr	(2 hrs) $ 216												$ 216
HQ ML	Bond Testing (x hrs) at $108/hr		(2 hrs) $ 216	(2 hrs) $ 216		(2 hrs) $ 262							(2 hrs) $ 510	$1,204
HQ ML	Visual Observation (x hrs) at $108/hr		(2 hrs) $ 216	(2 hrs) $ 216	(2 hrs) $ 238	(2 hrs) $ 262		(2 hrs) $ 317		(2 hrs) $ 384			(2 hrs) $ 510	$2,143
**HQ Br. Branch & ML	Analysis & Report Writing (x hrs) at $27.50/hr		(40 hrs) $1,100	(8 hrs) $ 220	(8 hrs) $ 242	(8 hrs) $ 266	(4 hrs) $ 147	(8 hrs) $ 322	(4 hrs) $ 177	(8 hrs) $ 389	(4 hrs) $ 214	(4 hrs) $236	(40 hrs) $2,590	$5,903
	TOTALS	$1,296	$2,280	$1,400	$1,303	$1,957	$ 280	$1,733	$ 338	$2,481	$ 409	$ 451	$5,884	$19,812
	TOTAL CONTRACT FUNDING		$3,576											- 3,576
													TOTAL EXPERIMENTAL PROJECT FUNDING	$16,236

* 10% Annual Inflation Rate Assumed.

** Field data reporting will be by Materials Lab (ML).
Analysis of data and final report by Bridge Branch.

*** Deleted per agreement with FHWA.

APPENDIX C

TEST RESULTS

CUSTER WAY U'XING
5/316
CONTRACT 3361

TESTING REQUIREMENTS

	Post Const 1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
FRICTION	11/90	4/91	x	x	x	x	x	x	x	x	x
RESISTIVITY	11/90										
BOND	11/90	x		x							x
HALF-CELL				x				x			x
CHLORIDE				x				x			x

x = To Be Tested

Bridge
Orientation

```
                 7--------------------------------------9
      N          /+                                     +
                 /+                                     +
     /+          /+                                     +
    / +          /+        CUSTER WAY U'XING            +
      +          /+      THIN POLYMER SECTION           +
      +          /+              5/316                  +
      +          /+                                     +
      +          /+                                     +
      +          /+                                     +
      +          /+                                     +
                 /+                                     +
                 1--------------------------------------3
                 |                                      |
                STA                                    STA
                0+00                                   2+21
                                                         \
                                         TO CAPITOL WAY   \
                                        -------------------
```

BOND TEST RESULTS
CUSTER WAY U'XING 5/316

Year	Station	Offset*	Depth	Load	PSI	Comments
1990	0+27	3.5	3/16	170	54	Break in PCC
	0+82	5.5	3/16	1400	446	DITTO
	1+34	9.0	1/4	1375	438	DITTO
	1+86	7.3	----	1425	454	Test appr. failure
	2+12	7.7	1/4	1180	376	Break in PCC
	0+16	19.7	3/16	1300	414	DITTO
	0+42	18.5	1/8	1800	573	DITTO
	0+90	18.0	1/8	1900	605	DITTO
	1+42	21.0	1/4	1500	478	DITTO
	1+94	20.3	1/4	800	255	DITTO
	0+27	32.0	3/16	600	191	DITTO
	0+70	28.0	1/4	1100	350	DITTO
	1+33	33.5	3/16	375	119	DITTO
	1+74	33.0	3/16	1125	358	DITTO
	2+00	45.0	1/4	1050	334	DITTO

*NOTE: Offset is feet right of north bridge rail.

FRICTION TEST RESULTS
CUSTER WAY U'XING 5/316

DATE	DIR	FN	AVE	RANGE
11/90	E	77		
		78		
		82		
		77		
		76	78	76-82
	W	80		
		84		
		81		
		80	81	80-84
04/91	E	63		
		61		
		63	62	61-63
	W	62		
		60		
		63		
		61		
		64	62	60-64

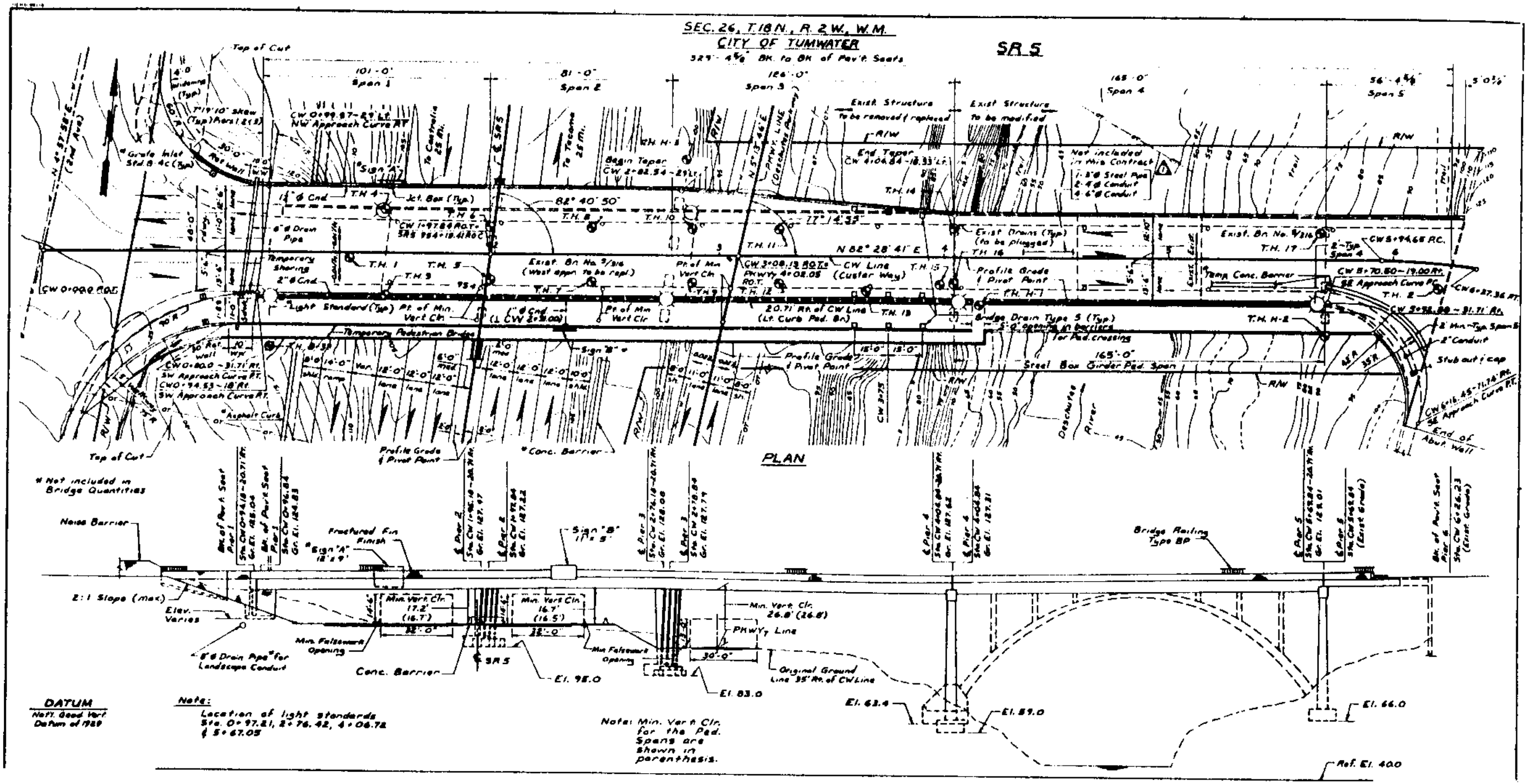
FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF

DATE	DIR	FN	AVE	RANGE

FFFFFFFFFFFFFFFFFFFFFFFFFFFFFFF

APPENDIX D

GENERAL LAYOUT



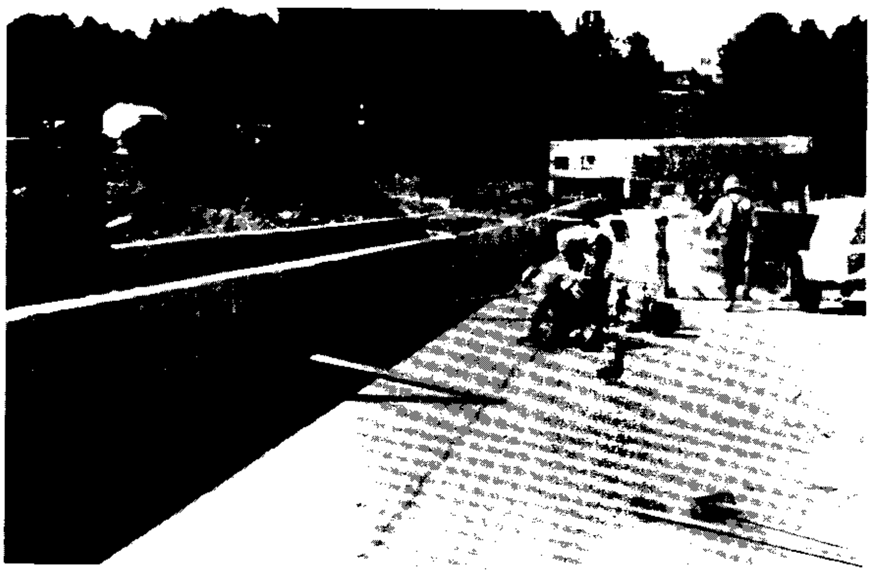
SEC. 26, T.18N., R.2W., W.M.
CITY OF TUMWATER
SR 5
PLAN
DATUM
Nat'l. Geod. Vert. Datum of 1929
Note:
Location of light standards Sta. 0+97.21, 2+76.42, 4+06.72 & 5+67.05
Note: Min. Vert. Clr. for the Ped. Spans are shown in parenthesis.
Not included in Bridge Quantities

APPENDIX E

PROJECT PHOTOGRAPHS

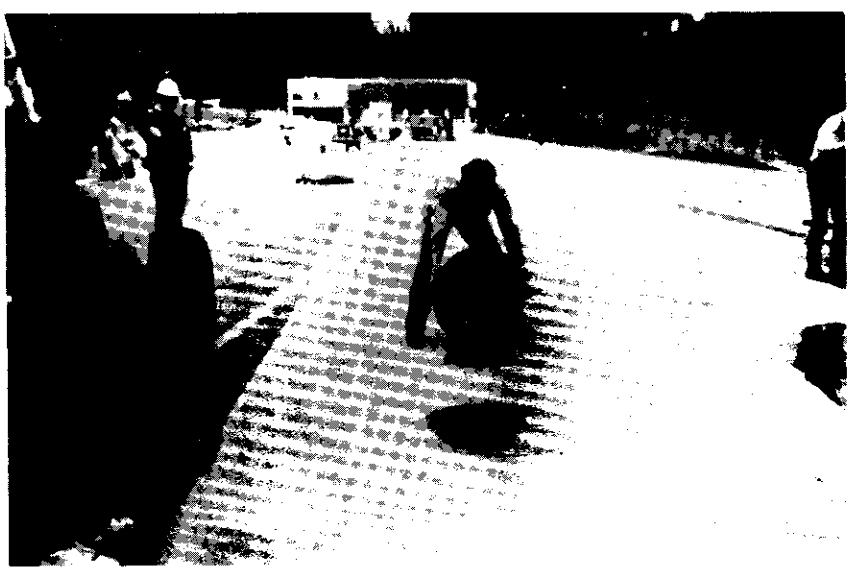
Sidewalk removal

area after milling

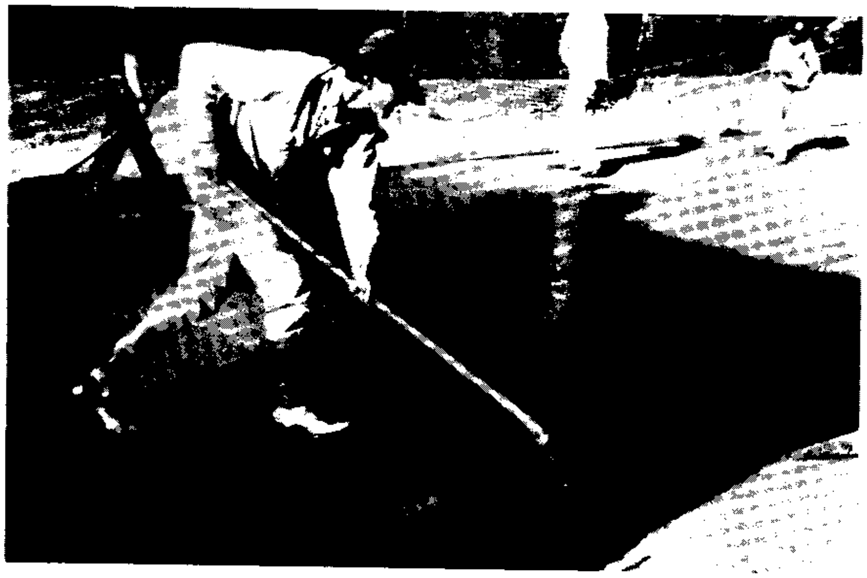


Sidewalk removal area deck patching.

Pouring epoxy on deck from 55-gallon drums cut in half..



Another view of pouring.



Spreading epoxy on deck with squeegee.

Another view of spreading.

Spreading aggregate from 5-gallon pail.

Another view of spreading

One-half of finished overlay.