Polymer Concrete Overlay of Lebanon Ditch Bridge

On Wednesday, August 26, 1981, a polymer concrete overlay was placed on the Lebanon Ditch Bridge on Highway 16 at milepost 13.56W. This bridge was selected for the experimental overlay because the deck had exposed and polished aggregate in the wheel tracks which reduced the skid resistant texture and moderate transverse cracking which allowed water to penetrate the concrete. The bridge was constructed in 1947.

The polymer concrete was composed of a polyester styrene resin (MR11044) and 3/8" minus aggregate. Details of the polymer concrete gradation and formulation are found in Tables 1 and 2.

The overlay was placed mainly by an eight man bridge maintenance crew. They were aided by two laboratory personnel who prepared and dispersed the resin. Unlike previous polymer concrete overlays that were placed in Oregon, the polymer concrete used in this project was mixed in a Concrete-Mobile mixer and finished with a conventional bridge deck finishing machine. Each piece of equipment was rented from a local contractor who also provided experienced equipment operators.

The installation of the polymer concrete overlay was considered successful although the surface texture was not entirely up to highway standards. Minor repairs were made during the week following the overlay by applying resin and #8 chips to the defective surface area. This repair greatly improved the riding surface.

Initial work for the project started two months before the overlay was placed when testing began to find a suitable aggregate source. Several commercial sources of dry aggregate were tested and found to be unsatisfactory.

Finally, a mixture of 3/8" to #4 stones, sand and a type F pozzolan was prepared and found to be acceptable. The design aggregate formulation consisted of 56 percent 3/8" to #4 coarse aggregate, 38 percent sand and 6 percent pozzolan. The specified aggregate gradation appears in Table 1.

In addition to the work with aggregates, the required resin and chemicals were ordered from suppliers and the necessary construction equipment was rented from local contractors.

Although a Bidwell low slump finishing machine was the original choice, the high rental fee requested by the two Oregon owners forced us to search for another machine. After several inquiries, a finishing machine with a heavy vibratory screed was found. This machine was subsequently tested when a polymer concrete overlay was placed on a 6 ft by 12 ft concrete slab. Because the material appeared well compacted and the surface satisfactory, this machine was rented from the Siuslaw Construction Company at one-third the cost of the Bidwell low slump concrete finishing machine.

A concrete mobile mixer was also rented from an Oregon company, Crown Gunite, which reduced mobilization costs.

During the week immediately preceding the overlay, chemicals were blended into the barrels of resin in preparation for the work. A Lightnin Mixer, Model #10x was used to stir the chemical additives throughout the resin. Each drum was mixed for a minimum of 30 minutes. Only the initiator was omitted. Seven drums of resin received the chemical necessary for the polymer concrete, while one drum was charged with chemicals for the tack coat. The chemical additives and their proportions are listed in Table 2.

While the chemical additives were being blended into the resin, two pumps were calibrated for use during the overlay. The pumps were one inch Sherwood gear pumps that were provided by the Daffin Mobile Mixer Company for experimental polymer concrete work. The pumps were driven by two 3/4 HP dc electric motors. The rate of speed of the motors and, thus, the rate of discharge of the resin was controlled by a portable control panel.

On the Monday and Tuesday preceding the overlay, the top 1/8" of deck surface was removed by a pneumatic McDonald scabbler at an approximate rate of 150 sq ft/hr. After scabbling, the deck was cleaned by compressed air. Anchor bolt holes were also drilled into the deck at this time to secure a 1 inch channel which served as a side form during construction. Although the finishing machine spanned the 34 ft wide deck and made it possible to overlay the entire section at one time, a decision was made to pour the overlay in two longitudinal sections. In this way the area of discharge from the mobile mixer was reduced and the area to which the tack coat had to be applied was diminished also. More manpower would have been required to overlay the entire deck at one time.

The deck was divided into one 14 ft lane and one 20 ft lane. These sections were later subdivided into 150 sq ft areas to help get a uniform application of resin tack coat.

While three members of the bridge maintenance crew prepared the deck, the remainder of the crew loaded aggregate into 5 cu yd dump trucks. The aggregate was purchased in sacks which had to be emptied into the trucks. The sand and pozzolan had to be premixed before being loaded into one of the bins because there were only two aggregate bins on the concrete mobile mixer. The method used to blend the sand and pozzolan consisted of mixing the materials with rakes and shovels. This method was very slow

and not very effective.

On the morning of the overlay all traffic was diverted from the bridge. Immediately thereafter the deck was broom cleaned and the pipe rails for the finishing machine were set and adjusted to grade. It required 2-1/2 hours to prepare the rails for the finishing machine.

While the rails were being placed, the Concrete Mobile mixer was calibrated to discharge the correct proportion of aggregate. The design rate of discharge was 546 pounds of aggregate per minute. By 11:30 a.m. the calibration of the mobile mixer and the installation of the pipe rails were completed.

The deck finishing machine was placed on the rails within a 15 minute period. Unfortunately, an electrical problem developed at one of the drive motors which prevented longitudinal movement. By 12:30 p.m. the finishing machine was operational and the clearance between the screed and the deck was measured at numerous locations along the bridge.

The Concrete-Mobile mixer was used principally to proportion the fine and coarse aggregate and to mix the polymer concrete. The resin had to be added to the mobile mixer from an adjacent truck. A carefully planned system was designed to accomplish the dispersion of the resin at the correct time and at the prescribed rate. The drums of resin were arranged on the truck to allow 18 gallons of resin to be pumped from full drums into topless half drums. An initiator was added to the resin in the half drums just before it was pumped into the mixing chamber of the mobile mixer. Here the resin and aggregate were mixed for approximately 30 seconds before being discharged. Only 18 gallons of resin were initiated at any one time which reduced the quantity of resin that may have been wasted if a prolonged delay occurred during construction. A drum of solvent was also stored on the

resin truck to allow the pumps and hoses to be cleaned of initiator and promoted resin before polymerization occurred.

The successful application of the polymer concrete overlay required many synchronized actions. First, the initiator had to be added to and mixed with the 21.5 lbs of tack coat resin that were stored in 5 gallon cans. Two laborers were then responsible for applying the resin evenly to a designated 150 sq ft area. While the tack coat was being applied, the resin in the half drum had to be initiated and mixed thorougly. Precise timing between pumping the resin and adding the aggregate to the mixer was a very critical function.

Before beginning the overlay, a trial batch of polymer concrete was prepared just off the end of the bridge. Approximately 8 gallons of resin were initiated in a half drum for the trial batch. After running the mixer for one minute, the polymer concrete began to look well mixed and consistent. This polymer concrete was wasted on the shoulder of the road. The mobile mixer and the resin truck were then directed on to the deck to begin the overlay.

When everything appeared ready a signal was given to begin the overlay. The tack coat resin was initiated, mixed and spread on the deck with 24 inch brooms. When an attempt was made to pump the resin into the mixing chamber of the mobile mixer, nothing happened. Because of the fifteen to twenty minute delay, the resin used in the trial batch solidified in the pump and in two hoses. The pump was then cleaned and the hoses replaced. After a 45 minute delay the overlay resumed. A second tack coat was applied to the first area and the polymer concrete was quickly mixed, placed and finished.

Once the placement began, the 14 ft by 75 ft lane was completed non-stop in 35 minutes. Because of the continuous action, the pumps and hoses

were not flushed with a cleaning solvent until the lane was completed. They were then cleaned with methylene chloride.

During placement of the 14 ft section, some finishing problems developed when too much polymer concrete was deposited in front of the screed. Even though there were two augers in front of the screed they were not effective in moving the polymer concrete ahead. The surplus material had to be continuously removed by shovel. The excessive polymer concrete created a large roll on the edge of the screed and because it was sticky, the roll picked up some of the surface fines. This left small voids and depressions in the surface behind the screed. Attempts to repair these areas by hand were not successful.

Another major problem occurred because the finishing machine was not able to consolidate the polymer concrete in the area immediately adjacent to the rail. The screed traveled to within 24 inches of the rail leaving this area to be finished by hand. Attempts to smooth this area with rakes and shovels were not successful and the polymer concrete was not consolidated in this area. The 24 inch strip was extremely uneven and had to be leveled with a scabbler on the next day.

The overlay was accomplished using a total work force of twelve. It required two men to apply the resin tack coat and three men to spread the polymer concrete in front of the finishing machine screed. Two additional workers were needed to drive the mobile mixer and the resin truck while two workers were needed to prepare and disperse the resin. Two experienced operators worked the finishing machine and the concrete mobile mixer. Finally, one worker was used to perform any miscellaneous tasks that evolved such as errands and clean up.

Approximately one hour was needed to prepare for the placement of the polymer concrete on the 20 ft wide lane. During this time the finishing machine was returned to the starting position and the side form channel was removed from the deck. The removal was greatly simplified because a light coating of grease was applied to the channel before the overlay was placed. The resin barrels were rearranged on the truck to reduce the handling problems.

Several changes were made during the placement of the 20 ft wide section. First, a smaller quantity of polymer concrete was deposited in front of the screed by the mobile mixer. This reduced the amount of roll on the edge of the screed and a smoother surface was attained. Also, the 24 inch strip near the rail that was not consolidated by the screed was compacted with a heavy plate shortly after the polymer concrete was placed. This improved the quality of the riding surface.

At 4:10 p.m., the overlay began on the 20 ft section and was completed at 5:00 p.m. Approximately mid-way through the pour, a fuse blew in the control panel causing a slight delay in mixing the polymer concrete. Because there were two controls within the panel that operated independently of each other, the motors were operated alternately on the one control until the fuse was replaced. After running the motor for a few minutes on the repaired control, the fuse blew again. This was repeated three times until a rectifier in the control finally failed. Fortunately, the pour was nearly completed and both motors were again run alternately on the one control until the overlay was finished. Although the polymer concrete was designed to provide an allowable 30 minute work time, the mix began to gel right behind the screed after a 15 minute pot life. The temperature during the overlay was in the low 80's (F) and the weather was partly sunny.

All equipment was removed from the bridge site within 1-1/2 hours after the overlay was placed. Traffic was allowed on the overlay at 6:30 p.m.

The quality of the polymer concrete overlay varied along the deck. The finishing machine appeared to have compacted the material sufficiently, but there were several areas where there were voids in the surface. This was especially true in the 14 ft lane.

There was also one section approximately 6 ft long in the 14 ft lane where the polymer concrete appeared to lack sufficient resin. This may have been caused by poor communication between the mobile mixer and the resin truck.

The deck was inspected two days after the overlay was placed (8/28/81). Some slight abrasion was noted in the dry area and the ride quality of the 14 ft section was less than acceptable.

On Wednesday, September 2, 1981 repairs were made on the surface of the 14 ft lane. Using some surplus resin (MR11044) and No. 8 Wedron Sand, a chip seal was applied to the irregular areas. The resin was broomed onto the overlay surface and the sand was broadcast by hand. In a few areas where deep depressions existed several applications of sand were necessary to completely fill the holes. This remedial work greatly improved the ride quality of the 14 ft lane. Traffic was allowed over the surface treatment 30 minutes after the last area was completed.

The concept of placing a polymer concrete overlay with conventional construction equipment is very viable, as demonstrated on the Lebanon Ditch Bridge. The Concrete Mobile-Mixer proportioned the aggregates and mixed the polymer concrete satisfactorily while the performance of the finishing machine was acceptable when the screed was not overloaded. On future projects it would be preferable to have a finishing machine that could

consolidate and finish the polymer concrete immediately adjacent to the curb. This is a critical area which deserves more attention especially in locations where deicing salts are used.

Preparing a trial batch of polymer concrete immediately prior to the overlay is a good procedure, but the pump and hoses should be flushed with a cleaning solvent to prevent them from becoming clogged.

One other area that needs improvement is in providing better communication between the concrete mobile mixer and the resin distributor. This would prevent errors in proportioning the resin. Ideally, the operator of the mobile mixer should control the flow of resin.

The cost breakdown for the polymer concrete overlay follows:

		Cost per sq yd
Materials		
Resin	$2,900	
Aggregates	930	
Chemicals	852	
Misc. Supplies	350	
	$5,032	$17.76
Equipment		
Concrete Mobile Mixer	$ 850	
Finishing Machine	1,500	
State Equipment	550	
Scabbler	350	
	$3,250	$11.47
Labor		
Preparation & Clean up	$3,700	
Overlay	1,300	
Traffic Control	500	
	$5,500	$19.41
		$48.64 Total

The use of conventional construction equipment reduced the manpower requirements for the project and greatly reduced the production time. Depending on the size of future jobs, it is estimated the cost of a one inch polymer concrete overlay could decrease to the $25 to $30 per sq yd range.

Table 1

Aggregate Gradation for Polymer Concrete

Sieve Size	% Passing
3/4	100
1/2	94-100
3/8	83-89
4	47-53
16	39-45
50	16-22
100	6-10
200	4-8

Table 2

Resin Formulation

		Polymer Concrete	Tack Coat
Resin	MR11044	10% by wt agg.	100%
Initiator	Hi - Point 90	0.95% by wt resin	0.95% by wt resin
Promoter	Cobalt Napthenate (12% Cobalt)	0.25% by wt resin	0.25% by wt resin
	N,N, Dimethyl Aniline	0.20% by wt resin	0.20% by wt resin
Cross Linking Agent	(A-174) Organosilane	0.75% by wt resin	1.50% by wt resin
Inhibitor	t-b-Hydroquinone	200 ppm	200 ppm
Wetting Agent	Surfynol 440	--------	1.0% by wt resin