

APPLICATION AND PERFORMANCE OF
EPOXY SEALANTS ON BRIDGE DECK AND WALKS
Houghton-Hancock Lift Bridge (B01 of 31012)

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Background

Leakage at the junction of the steel curb to the concrete-filled steel grid deck, and scaling and cracking of concrete on the deck and walks of the Houghton-Hancock Bridge were reported by H. J. Rathfoot in memoranda of July 13 and 23, 1962, to W. W. McLaughlin. Cooperation was requested in inspecting the structure and recommending corrective treatment. W. W. McLaughlin's letter dated July 18, 1962, authorized M. G. Brown of the Research Laboratory Division to cooperate with the Office of Maintenance in making the inspection. His Research Report No. R-394, dated August 8, 1962, summarized the inspecting group's findings regarding problem areas on the 260-ft lift span as follows:

1. A gap averaging 3/16-in. wide between the bottom of steel curbs and the concrete-filled deck at the median and the walks of the lift span's upper deck, permitted leakage through the deck and corrosion of the underlying steel floor beams.

2. Transverse reflection cracking had developed in the concrete-filled steel T-grid surface of the walks on both the upper and lower decks.

3. The lift span's upper deck, consisting of a concrete-filled steel grid with stay-in-place form, showed evidence of leakage at the junction of the concrete and steel grid, corrosion of the metal pan, some unevenness of the concrete-grid surface, and some spalling.

The leakage at the curb-deck juncture was corrected by application of a viscous, coal-tar epoxy sealant (Resiweld 633) as coving, by an Office of Maintenance crew from October 2 to 4, 1962, with R. H. Merrill assisting and observing. His Research Report No. R-402 dated November 6, 1962, summarized details of this operation.

Remedial treatment for the decks and walks by applying an epoxy sealant was postponed until 1963. This work was completed under contract

on September 13, 1963, by C. L. Wolff and Sons of Benton Harbor, in accordance with "MSHD Specifications for Repair of Scaled Concrete and Application of Epoxy Resin Seal Coat, Houghton-Hancock Lift Bridge" dated 6-17-63. The coal-tar-modified epoxy sealer "Guardkote 140" was purchased from the H. B. Fuller Co. It was applied with a Broyhill Resinous Paver (Fig. 1), rented from Fuller whose representatives M. Evans and J. Davis provided working and technical assistance during application of the epoxy sealer with their equipment.

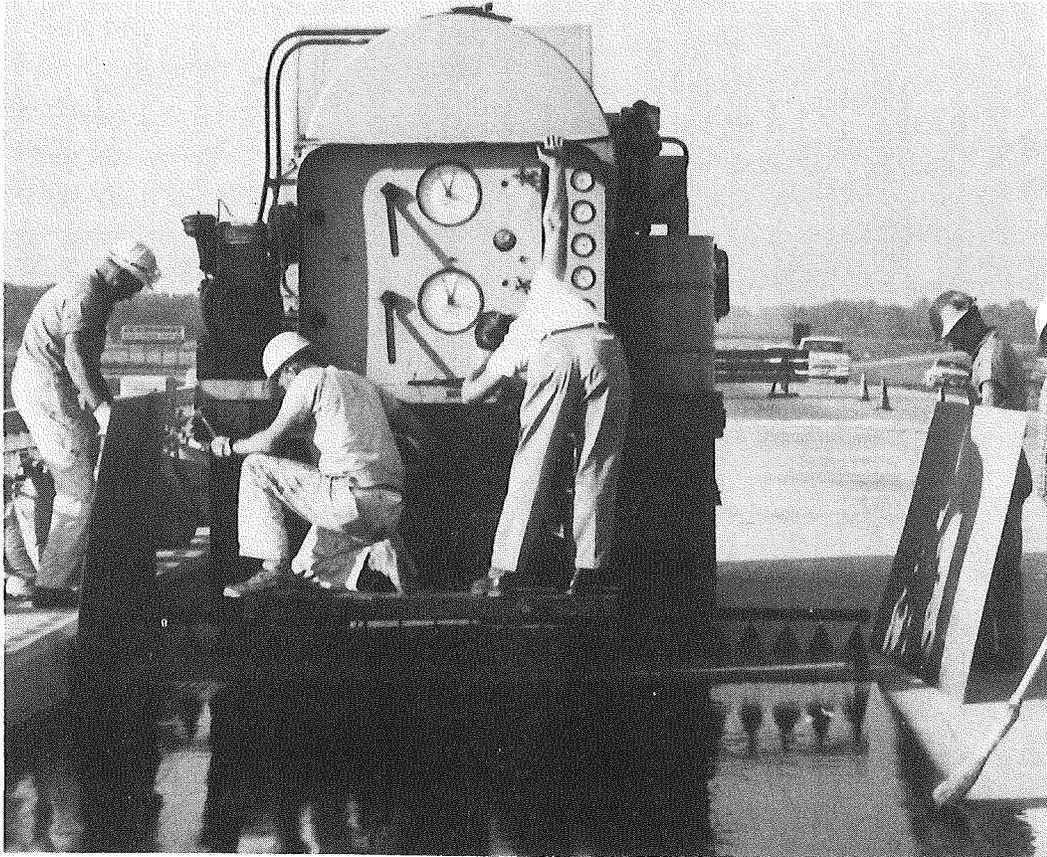


Figure 1. Broyhill Resinous Paver applying coal tar epoxy premixed at a ratio of 1:1 by volume (photo: 9-11-63).

The contract specified application of a coal-tar modified epoxy sealer at 3 lb per sq yd on the upper deck of lift span, 2 lb per sq yd on both upper and lower walks, and a 200 sq ft per gal brush coat of flow-resistant epoxy on the steel faces of the walk and median curbs on the upper level. Crushed No. 5 Ohio quartz (14-36 mesh) was to be broadcast on the wet epoxy of the deck and walks to provide a skidproof surface.

Summary of Sealing Operations (August-September 1963)

The contract provided for 1) coating the steel curb faces on the upper deck, 2) sealing the concrete walks on both levels, 3) removing and patching of scaled areas on the upper deck roadway, and 4) etching and sealing on the upper deck roadway.

The steel curbs on the upper deck were sandblasted to remove all paint and rust, with care taken not to damage the epoxy fillet that had been placed at the junction of the curb and the deck in 1962. After sandblasting they were coated by roller with flow-resistant Guardkote 140 FR using about 75 sq ft per gal (Fig. 2).

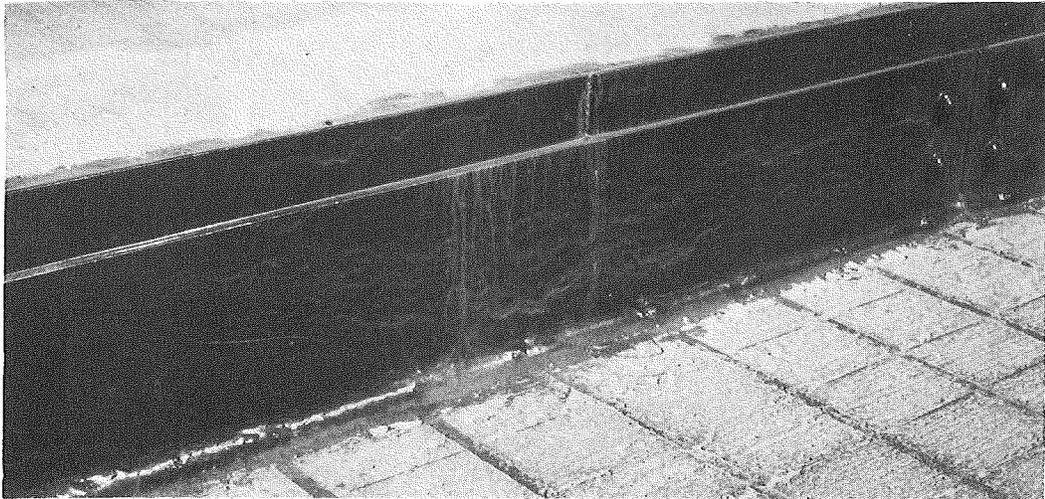


Figure 2. Steel curb just after coating with flowing resistant coal tar epoxy (Guardkote 140 FR). Coving (Resiweld 633) visible at curb-deck joint was done in 1962 (photo: 8-30-63).

The design of the walks was similar to that of the deck, both being concrete-filled steel grid over a metal pan. On the walks the concrete surface was finished about 1/2-in. above the T-grid, while the deck was screeded off level with the steel. Transverse cracking of concrete had developed above the steel in the walks, allowing water and chloride to seep through and cause deterioration of the steel and concrete. The specifications required a 2-lb per sq yd coating of Guardkote 140 with about 10 lb of embedded crushed quartz per sq yd. Preparation of the walks consisted of a general sandblasting to remove surface laitance and contamination. This was complicated somewhat by spots of cable lubricant found in great numbers at each end of the span. Sandblasting would not

remove them because their resiliency caused the sand to rebound. Wire brushing with toluene followed by sandblasting proved to be the most satisfactory method of removal.

The Guardkote 140 was applied using a hand spray bar attached to the Broyhill Resinous Paver. This provided a positive measurement of the two components as they came from the Paver and assured a 1:1 mixture, by volume, in the spray bar. Areas that could not be reached with the bar (such as under railing and splash guards) were coated with mohair rollers. Immediately after epoxy application, quartz was broadcast by hand into the epoxy until no wet areas were visible. After the epoxy had cured the excess quartz was swept off for re-use on the deck. Stages of walk repair are illustrated in Fig. 3.

Considerable preliminary preparation of the upper deck was required prior to its sealing. An area of about 69 sq yd on the south end was badly scaled and required patching. Other areas were found where the steel grid was covered by only a thin layer of concrete. To prevent these areas from breaking loose after the deck was sealed, it was decided to chip them off and patch the resulting depression. Patching was accomplished 1) by chipping out all unsound concrete, 2) by brushing on a tack coat of Guardkote 140, and 3) by patching with a fairly stiff Guardkote 140 mortar which was screeded off level with the top of the steel grid. Sand was sprinkled on the patches to provide a better bond with the subsequent seal coat. Some difficulty was encountered in removing spots of cable lubricant that had been tracked across the deck, since they could not be removed by sandblasting; the same method of removal that had been used on the walks proved successful although time-consuming. Steps in deck preparation are illustrated in Fig. 4.

Acid etching with 5-percent hydrochloric acid was done with the Broyhill Paver which was equipped with a water tank, mixing pump, and spray bar. Carboys of acid were placed on the paver and the acid pumped directly from them to the water-acid mixing valve, making the whole operation nearly automatic. The acid was broomed around the deck, flushed off, and the deck blown free of standing water to retard the rusting of the steel grid and to dry the surface. After chipping, spot sandblasting, patching, acid etching, and rinsing, and when the deck had dried thoroughly, the Guardkote 140 seal was applied to the deck using the Broyhill Paver, at a coating rate of 3 lb per sq yd. About 15 lb of quartz was broadcast per sq yd or until no wet areas were visible, to improve skid and wear resistance. After the epoxy had cured the excess quartz was broomed off and wasted.

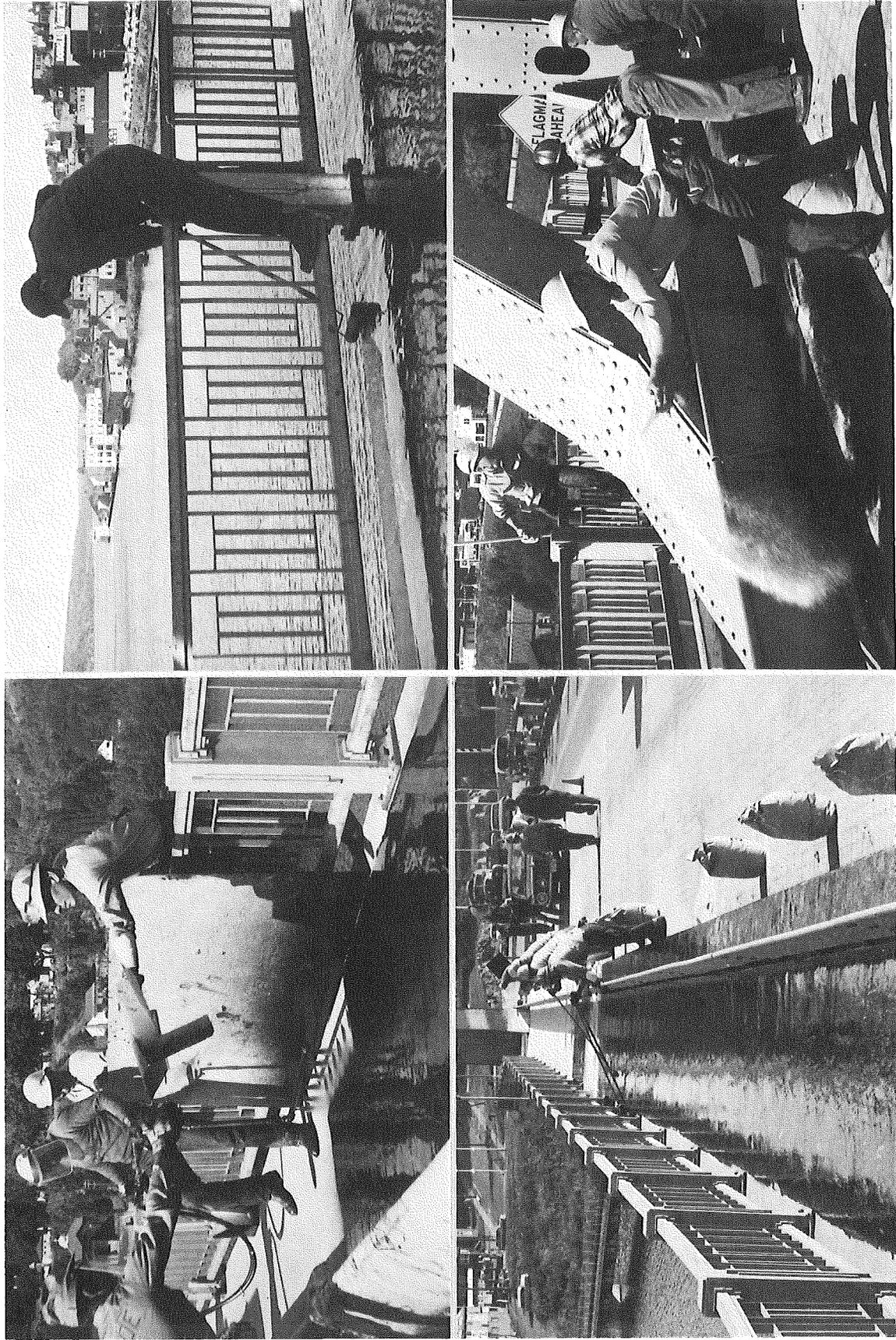


Figure 3. Application of epoxy sealer to walks included use of hand-held spraybar on accessible areas (upper left), and mohar rollers under railings (upper right and lower left). After epoxy was applied, quartz aggregate was spread over the fresh surface (lower right).

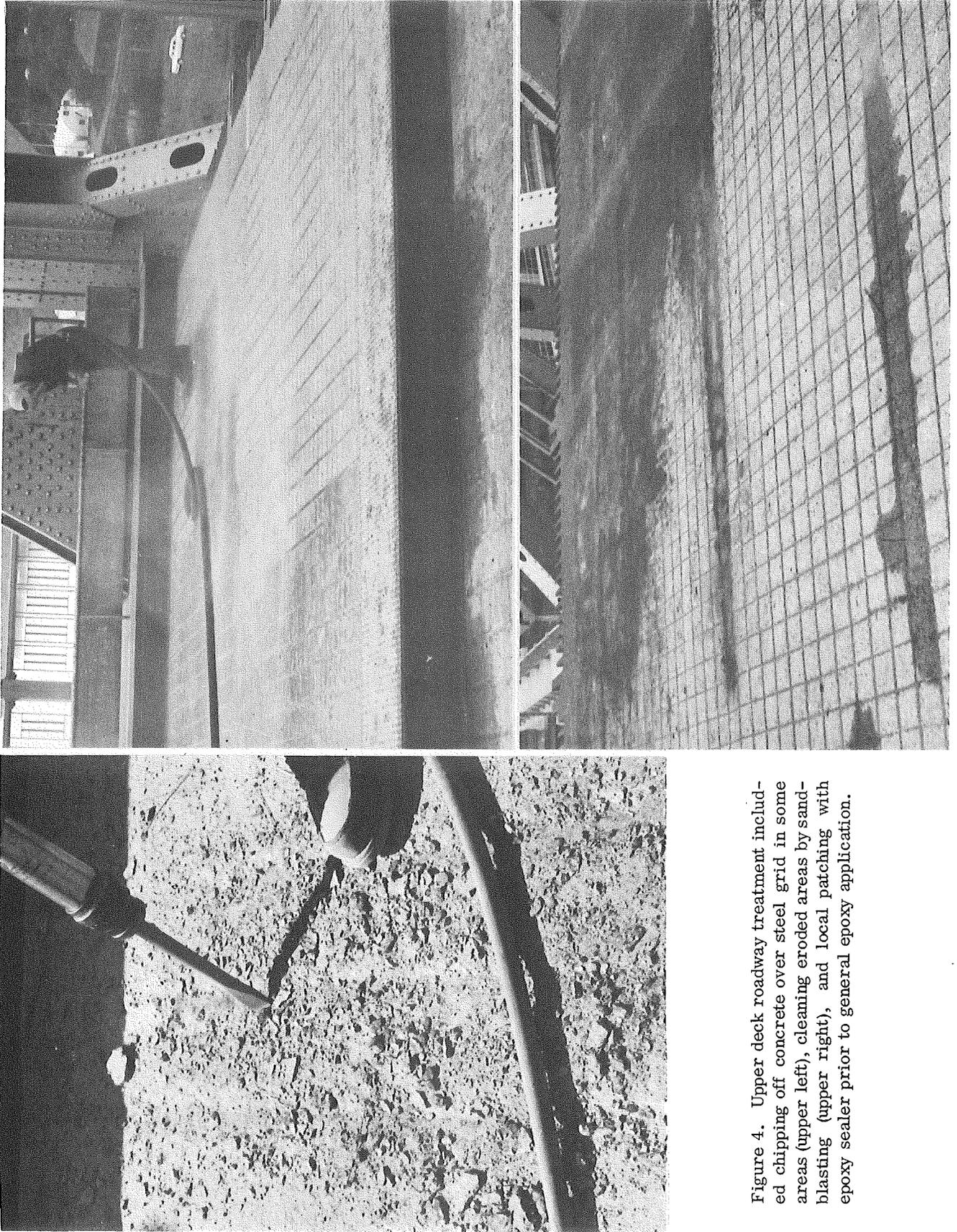


Figure 4. Upper deck roadway treatment including chipping off concrete over steel grid in some areas (upper left), cleaning eroded areas by sandblasting (upper right), and local patching with epoxy sealer prior to general epoxy application.

The Broyhill Resinous Paver is a unique machine developed expressly for applying a two-component epoxy system. It contains a large tank for each component with facilities for heating the contents. Each component can be pumped and metered at any rate desired to provide a specified mixture such as 1:1 or 2:1 by volume. The two components are thoroughly mixed just before they enter the spray bar by passing through a column-type mixer filled with steel shavings. By adjusting the rate of flow to the speed of the truck and length of the spray bar, a very uniform coating of known thickness can be obtained.

Preparation and sealing of the curbs, walks, and deck required a total of 19 working days. Since this was a double-deck lift span, no traffic problem was encountered during deck sealer application. Stages in preparing and sealing, and the material quantities used, may be summarized as follows:

1. Coating Curb Faces. This operation consumed six full working days (August 24 to 26, and August 28 to 30, 1963). August 27 was rainy and wet so there was no work done.

Material Used: 6.9 gal Guardkote 140 FR (flow resistant)
Area Coated: 520 sq ft
Rate of Coverage: 75 sq ft per gal
Specified Rate: 200 sq ft per gal

2. Sealing Walks. Sandblasting the walks took place on August 30 and 31 and September 1 through 4. As there was no acid etch and drying required the walks were all sealed on September 4.

Material Used: 220.4 gal Guardkote 140
108 bags of No. 5 quartz (10,800 lb)
Area Coated: 1051 sq yd
Rate of Coverage: 2 lb Guardkote 140 per sq yd
Specified Rate: 2 lb per sq yd

3. Preparing the Deck. Preparation work such as chipping and sandblasting took place on August 28 to 31 and September 3 to 12. Most of the patching took place on September 7 and 8.

Material Used: 40 gal Guardkote 140
20 bags of No. 5 quartz (2000 lb)
Area Patched: 262 sq yd

4. Sealing the Deck. The southbound lanes were sealed on September 11 and the northbound lanes on September 12. The lift span was lowered for the spray application of the Guardkote 140, then raised for quartz application and the curing period. Some rain fell during the quartz application on the northbound lanes after the Guardkote was applied.

Material Used:	southbound lanes - 278.3 gal Guardkote 140 113 bags of No. 5 quartz (11,300 lb)
	northbound lanes - 283.7 gal Guardkote 140 116 bags of No. 5 quartz (11,600 lb)
Area Coated:	southbound lanes - 751 sq yd northbound lanes - 751 sq yd
Rate of Coverage:	southbound lanes - 3.5 lb Guardkote 140 per sq yd northbound lanes - 3.6 lb Guardkote 140 per sq yd
Specified Rate:	3 lb Guardkote 140 per sq yd

Inspection (October 1963) and Condition Survey (May 1964)

The Highway Bridge Deck Committee inspected the newly applied sealers on October 16, 1963 and found the deck, walks, and curbs in good condition (Fig. 5).

R. H. Merrill conducted the first in a contemplated series of annual condition surveys on May 20, 1964, to determine the quality of epoxy sealer performance after eight months of service, including the first winter season, with the following results:

Upper Deck Roadway. In the northbound lanes, about 70 spots were found where the transverse steel grid was exposed, primarily in wheel-track areas (Fig. 6). As yet, no loss of epoxy bond to concrete was apparent surrounding spalls over the steel grid. In the northbound traffic lane, grid exposure at about 15 locations varied in length from 6 in. to 3 ft, mostly in the outer wheelpath and in the central third of the span. In the northbound passing lane, the situation was more serious and the grid was exposed to varying degrees at about 50 locations, mostly in the outside wheel track. By contrast, both southbound lanes were in good condition with the grid visible at only three points in the traffic lane. At the time of inspection, the steel grid pattern beneath the sealant was visible, reflected as discoloration on the deck epoxy surface (Fig. 7). It appears that rust is coming through the coating, which suggests that the epoxy seal is less waterproof than expected.

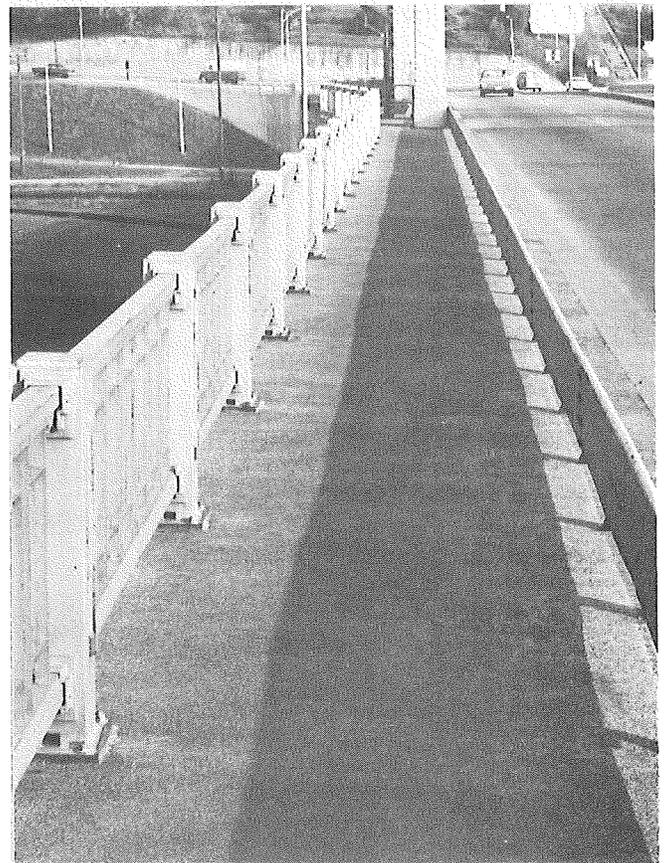


Figure 5. General views after sealing of lift span upper deck (top: sealed 9-11 and 12-63, photographed 10-16-63), and west walk (bottom: sealed 9-4-63, photographed 10-16-63), both looking north.

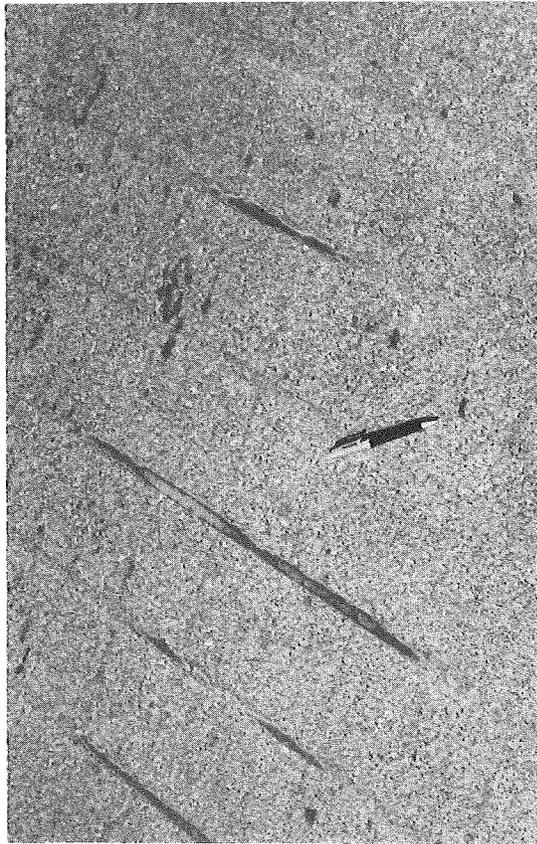


Figure 6. Typical area where transverse steel bars have become exposed through the epoxy seal coat (photo: 5-20-64).

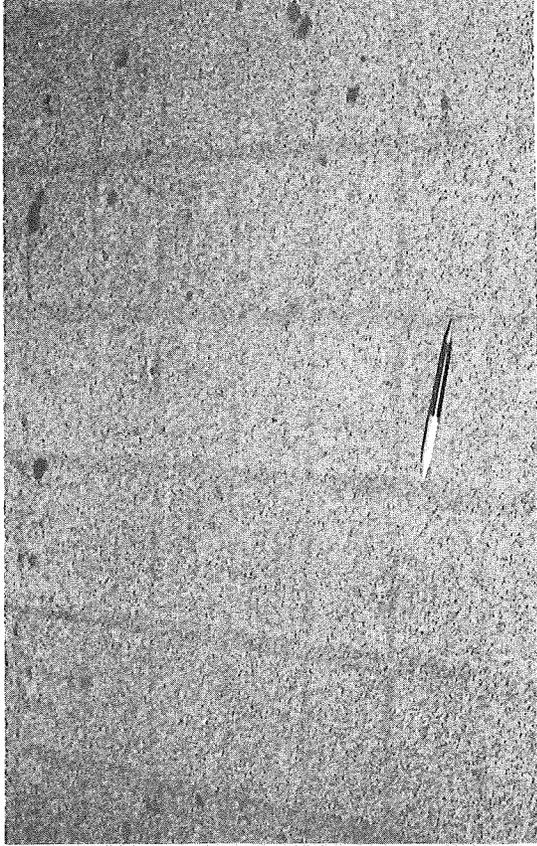


Figure 7. Discoloration in coal tar epoxy sealant coating above the steel grid (photo: 5-20-64).

Figure 8. Epoxy flaked off of upper deck west walk between curb and splash guard; poor adhesion surrounds flaked area (photo: 5-20-64).

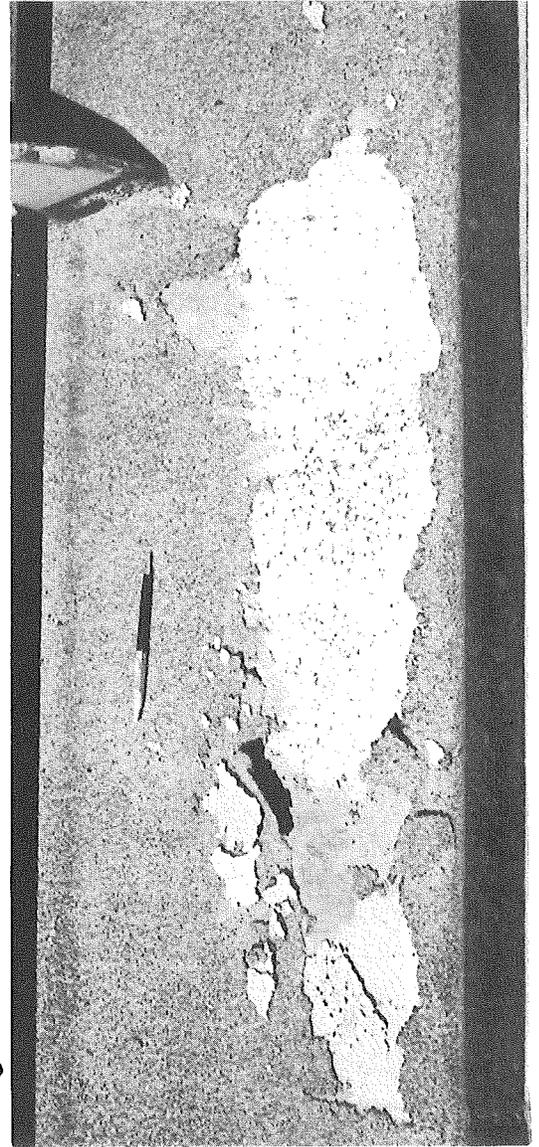
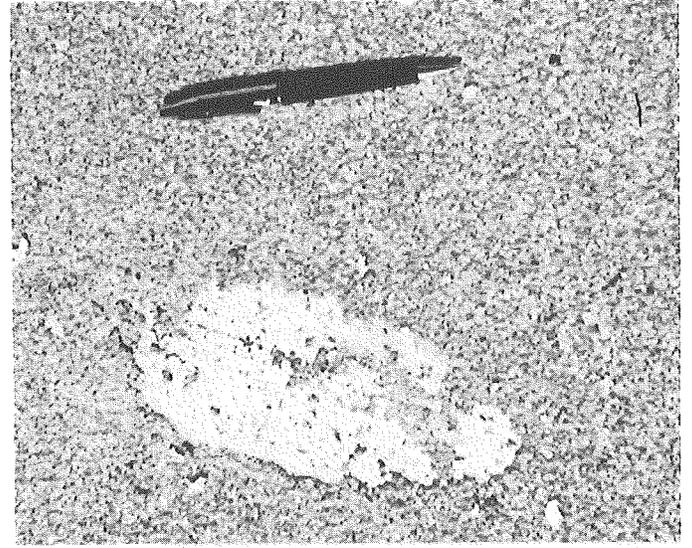


Figure 9. Small adhesion loss found in the lower deck east walk seal coating (photo: 5-20-64).



Upper and Lower Deck Walks. The upper deck walks were generally in good condition, with one small hole near the splash guard at the north end of the east walk where a worker apparently had stepped into the epoxy before it had hardened, and another larger hole about 90 ft from the south end of the upper deck west walk. Here, epoxy in an area about 2 ft square between the curb and splash guard had lost bond with the concrete (Fig. 8), and material around this hole was losing bond and will probably flake off. It appears that this material was sprayed on over a thin laitance film which sandblasting did not remove. The lower deck walks were both in good condition with only a few small holes visible on the east walk (Fig. 9).

Upper Deck Curbs. The steel curbs were generally in fair condition, with rust visible along bottom edges and beginning to show at other points where the epoxy is thin. This apparent rusting of the steel might be attributed to traffic and snow plows, but more probably is caused by moisture penetrating through pinholes in the sealer, since similar discoloration was noted on the deck surface. The older epoxy between the curb and deck (applied in 1962) was in good condition and appeared to be well bonded.

Conclusions and Recommendations

The curb coving seal, applied in 1962 appears to be well bonded after two winters of exposure. The repair and sealing of 1963, generally looks good, except for the areas noted (primarily in the northbound roadway).

The probable causes for the differences in coal tar epoxy durability between the northbound and southbound deck lanes could include: 1) dampness, 2) inadequate cure, or 3) high steel.

1. Soon after the epoxy had been sprayed on the northbound lanes and before all the quartz aggregate had been applied, it rained. The water probably did not seep through to the concrete and steel, but undoubtedly would cause poor bond of epoxy to the quartz. This would tend to weaken the composite seal coat.

2. The weather turned cooler after the northbound lanes had been coated, and since the curing rate for this type of epoxy depends on temperature it is possible that the deck was opened to traffic before curing adequately. If this was the case, the coating could have been rolled thin by traffic in the wheel track areas.

3. It was noticed at the time of repair that some of the steel grid protruded above the level of the concrete in the northbound lanes. This would tend to leave a thin coating over the steel. It should be noted that although high steel was observed at the time of repair, it was not in sufficient evidence to cause this much damage to the seal coat.

Although no indication of leaking has been noted under the upper bridge deck, which was the primary reason for having the bridge sealed, steps should be taken for immediate repair of the defective areas before they cause loosening of the epoxy seal coat in adjacent areas. The supplier of the coal-tar-modified epoxy materials should be consulted, to obtain his views on the noted failures and his recommendations for corrective treatment.