



COMMONWEALTH OF KENTUCKY  
DEPARTMENT OF HIGHWAYS  
FRANKFORT

HENRY WARD  
COMMISSIONER OF HIGHWAYS

March 1, 1963

ADDRESS REPLY TO  
DEPARTMENT OF HIGHWAYS  
MATERIALS RESEARCH LABORATORY  
132 GRAHAM AVENUE  
LEXINGTON 29, KENTUCKY

D.1.7.  
C.2.8.

MEMO TO: A. O. Neiser  
Assistant State Highway Engineer

One of the major problems confronting highway departments today is the rapid deterioration of reinforced concrete bridge decks. The widespread use of de-icing chemicals has accelerated the occurrence of concrete failures.

For some years the Department, particularly the Maintenance Division, has been experimenting with various repair and coating systems for bridge decks. The Division of Research has participated in much of this work. Messrs. S. T. Collier, D. H. Sawyer, and Milton Evans, Jr., all former research engineers, have participated in either the laboratory or field evaluation of concrete durability.

We have made a concerted effort in the attached report, "Concrete Bridge Decks: Deterioration, Coatings, and Repairs," by Mr. J. H. Havens, Assistant Director of Research, and myself, to combine at least some data for all of the structures that have been repaired or analyzed for which we have records. As much repair or construction data as could be collected in the time available have been included. Undoubtedly, there have been some omissions, and we welcome you, or other members of the Research Committee, to contribute whatever additional information you may have.

Performance data of repaired sections are somewhat limited, particularly for recent installations. Considerable use has been made of photographs in showing procedures and performance. From the number of structures discussed, you may conclude that we are having some right serious problems with the weather durability of bridge decks -- I think that we are -- and, from recent surveys in Missouri, Illinois, Wisconsin, Iowa and New York, the problem appears to be rather widespread.

March 1, 1963

You will note in the report that we have outlined several apparently usable methods for repair and protection of existing concrete bridge decks. The solution, of course, is to eliminate the sources of trouble rather than to cover them up.

I am of the opinion that air-entrained (4% to 7%), properly designed, and finished concrete will resist the action of weather, and de-icing chemicals. I have discussed an innovation in the design and finishing procedures of the deck slabs with Mr. E. D. Smith, Director of Bridges, which I believe will vastly improve the durability of the concrete. It would require a joint at the face of the curb and the mounting of a fixed, steel section for a full-width (2-lane structure), deck-finishing machine to operate over. An angle section could be used with one leg of the angle set to the grade of the curb line for the screed to work over. The wheels of the finishing machine could operate on the other leg of the angle. This arrangement would eliminate the need for removal of the screed templates from the fresh concrete. A very high percentage of the template grooves show up in the weathered concrete and frequently provide channels for deck disintegration. Curb and walk finishing under our present design has required the workmen to operate from the freshly placed deck concrete, with resultant damage to the deck itself. Loss of entrained air, laitance, and filling of foot prints with very wet mortar has been observed.

It appears that the problem is critical enough to consider the structural requirements necessary to pass a reasonable finishing train over the bridge decks. Of course, the pouring pattern would have to be revised on some continuous structures, but I believe that these items can be resolved in the interest of providing sound, durable concrete. I believe that excellent ready-mixed concrete can be provided through close inspection and control.

Respectfully submitted,



W. B. Drake  
Director of Research

WBD:d1

Enc.

cc: Research Committee Members  
Bureau of Public Roads (3)

Commonwealth of Kentucky  
Department of Highways

CONCRETE, BRIDGE DECKS: DETERIORATION, COATINGS AND REPAIRS

by

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and

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Lexington, Kentucky

February, 1963

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## INTRODUCTION

This report is not wholly a culmination of a planned or programmed research project. It is a historical account of damage sustained by both new and old concrete bridge-decks -- through freeze-thaw, salt-action, etc. -- and of some expedient repairs which have been effected. The problem of durability in concrete bridge-decks has become increasingly critical during the past ten years or so and is now a major concern to highway engineers throughout the northern tier of states. While there is not yet a concerted agreement in regard to the cause of the trouble, relief is being sought through improved construction practices, air-entrainment, and protective coatings of various kinds. Similarly, relief from perpetual maintenance or complete replacement of existing bridge decks is being sought through improved methods for making repairs.

The performance of individual slabs in a deck is sometimes markedly different from that of a nearby slab; and, even within a particular slab, only one corner or one end may be affected. This signifies poor concreting practices. The concrete sustaining damage was undoubtedly over-watered, over-worked, de-aired, and segregated. The proper placement of deck concrete is perhaps the more serious aspect of the problem than the repair, because improper placement automatically incurs a premature maintenance liability. Of course, as the need for repairs arises in due time, reliable methods of repair should be employed. It is in this latter respect that the repair experiences recorded in this report are expected to be the most fruitful.

None of the damaged decks which have been observed thus far has shown any evidence of overloading by traffic (adjudged by the absence of any checker-board crack-pattern on the underneath side of the deck); the trouble seems to be attributable almost entirely to weathering; and the weathering invariably seeks out and attacks the poorest concrete often revealing the mistakes made by the workmen and their attempts to hide them.

Improper drainage of the deck and gutter can be one of the contributing factors to damage. Even slabs and gutters sometimes have "bird-baths" in them. Cinders, sand, road-debris, and snow sometimes impound water and prevent drying. Such areas are exposed to water and moisture beyond their normal time, and damage is often associated with these conditions.

#### The Freeze-Thaw Mechanism

In many respects, the mechanics of freeze-thaw damage to concrete is similar to the mechanism which causes a water pipe to freeze and burst. The density of water at 0°C is 0.9998 gms/cm<sup>3</sup> whereas the density of ice at 0°C is 0.917 gms/cm<sup>3</sup>. There is, therefore, an increase of approximately nine percent in volume when water freezes. Likewise, if a vessel is completely filled with water at 0°C and is sealed and if the water therein is frozen, the vessel must yield or dilate as much as nine percent by volume or else it will rupture. However, if the vessel were filled with water to 91.7 percent of its volume, the volume of ice produced would just equal the volume of the vessel and no dilation

of the vessel would occur. Moreover, if the water is un-restrained or fails to fill the vessel upon freezing and exerts no dilation pressure on the vessel, it freezes normally at 32°F; however, if the vessel offers restraint, each 1000 psi of restraining pressure lowers the freezing point of the water 1°F. The final freezing point of the water thus provides a measure of the dilation pressure. Final freezing points of 26°F have been recorded on laboratory specimens of concrete\*. This is equivalent to an active pressure of 5000 or 6000 psi.

If a specimen of concrete absorbs 10 percent water by volume and if this amount of water completely fills the voids in the concrete, the increase in volume of the specimen, upon freezing, would be approximately 0.9 percent. This amount of dilation would, in all likelihood, cause the concrete to rupture. Laboratory tests have demonstrated repeatedly that freeze-thaw damage is related to water absorption and to the degree of saturation (absorption in relation to porosity). Dry concrete can not be affected in this way; and it is fortunate indeed for the welfare of most exposed concrete and masonry structures that nature provides frequent periods of drying. Thus, the duration of wetting, either preceding or attendant to the onset of freezing, may largely determine the amount of damage incurred. Likewise, the resistance of concrete to freeze-thaw may be viewed wholly in terms of its

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\* "Thermal Analysis of the Freeze-Thaw Mechanisms in Concrete," by Jas. H. Havens, Bulletin No. 59, Engineering Experiment Station, University of Kentucky, March 1961.

resistance to saturation -- that is, the duration of wetting in comparison to the time that it takes for the concrete to become critically saturated.

Surface and shallow damage, sometimes called "frost-damage" or "scaling", is more prominent than deep damage; and this is attributable to the fact that there is greater opportunity and likelihood that critical saturation and freezing will occur near the surface, and this is so even during very brief periods of wetting if the concrete near the surface is porous and receptive to water.

Problems of durability of concrete in bridge decks and the effects thereon of de-icing salts in Kentucky parallel those experienced by neighboring states to the north and elsewhere. There is some possibility, perhaps, that Kentucky weather conditions are the more adverse -- that is, there may be more freezes by night and more thaws by day than the northern states experience. In any case, long periods of wetting, as might result from snow and ice melting during day-time warming or due to de-icer salts, are conducive to saturation; and the periodic freezing attendant thereto is much more damaging than a continuous, deep freeze. As an example, trucking companies have a rather serious problem in concrete durability at their loading docks where trucks carry in snow and slush from the roads and stand and drip.

There have been discussions, here and elsewhere, contrasting the durability of rather old bridge decks and the comparatively poor durability of many new ones. Similarly, contrasts have been recognized between the performance of deck concrete and pavement concrete abutting thereto.



In the same way, account has been given to the fact that recent experiences of poor durability parallel the more abundant use of de-icer salts\*. A recent account of experiences elsewhere is available in Bulletin 323, HRB, a symposium on "Effects of De-icing Chemicals on Structures," 1962.

### Concreting Practices

In addition to the fact that bridge decks may undergo more freezing cycles than pavements on the ground, there is a growing suspicion that concrete construction and finishing practices on bridge decks, in many instances, have permitted too much manipulation of the concrete by the workmen during its placement -- in other words, where hand-screeding and finishing have been permitted, there has been a tendency for the workmen to spread-out a lot of concrete, vibrate it, walk through it, trample it, and then to work-up enough laitance to fill in all of the boot-holes, low places, and to achieve a finish -- this procedure undoubtedly draws unwanted laitance to the top, dissipates the air, and invites scaling. The laitance is merely a thin, watery mortar, and it remains very porous and absorptive after the concrete has set. These practices are illustrated in Figs. 1, 2 and 3. The Department's Standard Specification disclosure regarding the placement of deck-concrete follows:

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\* First widespread use of rock salt in the Louisville area was in 1946-1947; See Annual Report of the Department of Highways, April, 1946 to March, 1947, p. 99.



Fig. 1. Broadway Bridge, North-South Expressway, Louisville; I-65-6(6)134; June-July, 1960.



Fig. 2. Sequence to Fig. 1, Above.

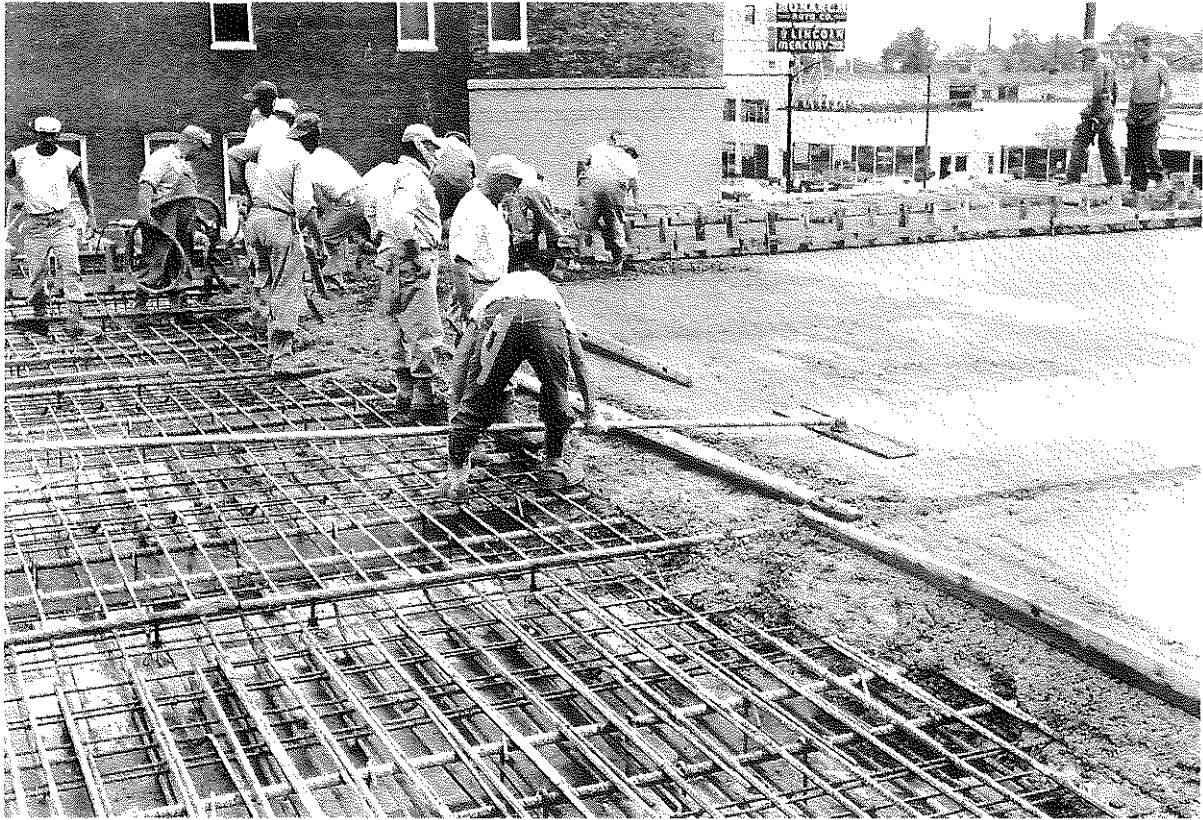


Fig. 3. Same Bridge as Shown in Figs. 1 and 2, but a Different Pour. Note that here the pipe templates are longitudinal to the survey and have been pulled ahead of the pour -- leaving a round groove to be filled in. Note, also, the men standing in the gutter line to manipulate the concrete in the side forms. Final finishing follows the rough leveling shown here ("An Evaluation of Four Retarding Admixtures in Structural Concrete," by Milton Evans, Jr., and Ralph R. Waddle, Feb. 1962; RHMRL, Vol. XVII, Part I, p. 228). It has been observed that scaling or erosion tends to occur along the lines where the templates have been removed and along the gutter line.

5.4.3-C-8-b. Before concrete for the floor is placed, the Contractor shall provide, at his own expense, metal templates, metal template supports, and straight edges of an approved type which shall be used as hereinafter specified. The metal template supports shall be bolts or other approved types of support which may be lengthened or shortened to adjust template to grade.

The metal templates shall be rigidly set to the typical cross-section of the bridge floor and shall be placed on the template supports so that the top of the templates will be flush with the finished elevation of the concrete. Templates shall be placed not more than eight feet apart, unless otherwise permitted, and at right angles to the center line of survey, and shall be supported at such intervals as will prevent any sag.

Concrete shall then be deposited between these templates to their full height and compacted. Consolidation of the concrete shall be accomplished by means of internal vibrators and by simultaneous supplementary spading along the forms. It is distinctly understood that spading will be required in addition to the vibrating to insure against the formation of honeycomb, voids, and air pockets against the forms. The types of vibrators used and the methods employed in vibrating shall be as set out in Article 5.6.3-C. The consolidation of the concrete shall be continued until contact between the reinforcing steel and the concrete is assured and until the mortar flushes to the top surface.

Immediately following the consolidation of the concrete, the surface shall be struck off to the finished elevation by means of a template screed of rigid construction until a satisfactory surface has been obtained. The metal templates shall be removed prior to the initial set of the concrete, and the groove in the concrete shall be satisfactorily eliminated.\*

Figure 4 illustrates a more mechanized operation which eliminated some of the interferences of the workmen. Deck concrete which is placed in the same way that pavement concrete is placed would be less likely to need a protective coating.

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\* Standard Specifications for Road and Bridge Construction, Kentucky Department of Highways, 1938, 1945 and 1956 Editions.

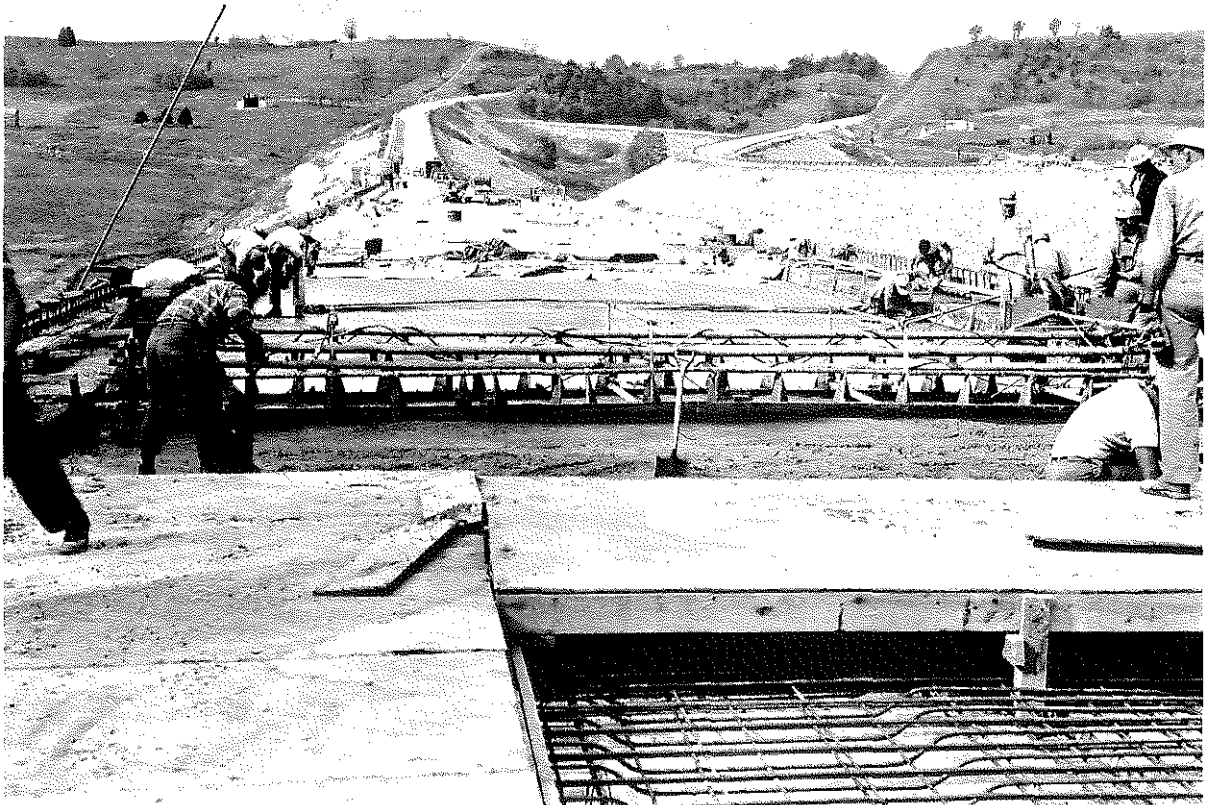


Fig. 4. I-64-4(8)54; Eastbound Bridge over Kentucky River, Franklin County, October, 1962. Full-width, vibrating screed rides on pipe templates set longitudinally about one foot from the curb wall. Note workmen standing in the gutter on each side. Set-retarding admixture (Sika's Plastiment) used in concrete on warm days. Note: A vibrating screed was used about two years previously on the Veach Dale Interchange Bridge, I-64, near Shelbyville (Sta. 990+00). Also, present plans provide for the use of a Rex finisher on the Louisville-Jeffersonville Bridge (I-65).

### Occurrence of Cracks in New Decks

Normally, concrete expands slightly during the early stages of hydration and then begins to shrink. The latter phenomenon is attributed to self-dessication -- that is, the fact that the cement uses up internal or free water. Premature drying, likewise, causes severe shrinkage before the concrete has developed sufficient tensile strength to resist contractive forces. Very fine, mesh-like cracks may occur before the final finishing of the concrete and be unwittingly covered over with laitance, or they may occur before the curing blanket is applied. Such cracks inevitably lead to spalling. These cracks are not as likely to occur on the bottom of slabs or at formed-surfaces inasmuch as the forms tend to prevent drying.

A random crack pattern in the bottom surface of a deck can also signify drying shrinkage or movement of the forms. Concrete which dries prematurely or which is consolidated and is beginning to set is quite friable and is easily broken.

Cracks which occur in a systematic pattern, i.e. transversely, or diagonally, may be attributed to flexure or to uniform shrinkage.

### Corrosion of Reinforcing Steel

Although corrosion of reinforcing steel does occur at some stage in the deterioration of concrete decks, it is not known definitely whether it is a cause or an effect. Perhaps in some instances it may be a cause -- particularly so if the steel is inadequately covered and if moisture and salts are accessible to it. Fine cracks and rust stains appear over

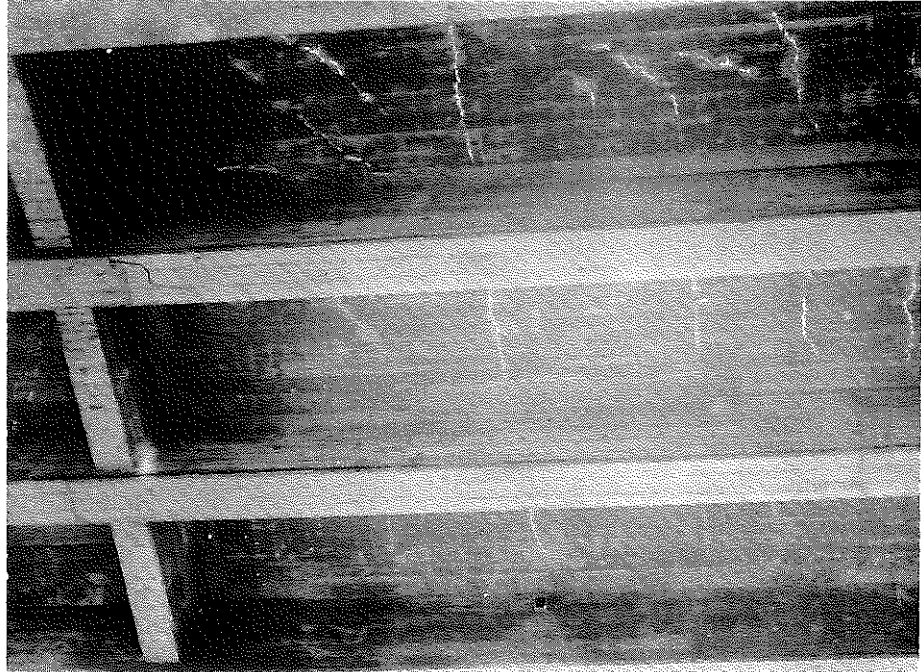


Fig. 5. Tell-Tale Signs of Cracks (Efflorescence) in Comparatively New Deck (State Route 8, Bracken County, Sept. 3, 1957); Cracks Were Sealed in Fall of 1959; Sika Epoxy Bonding Compound.

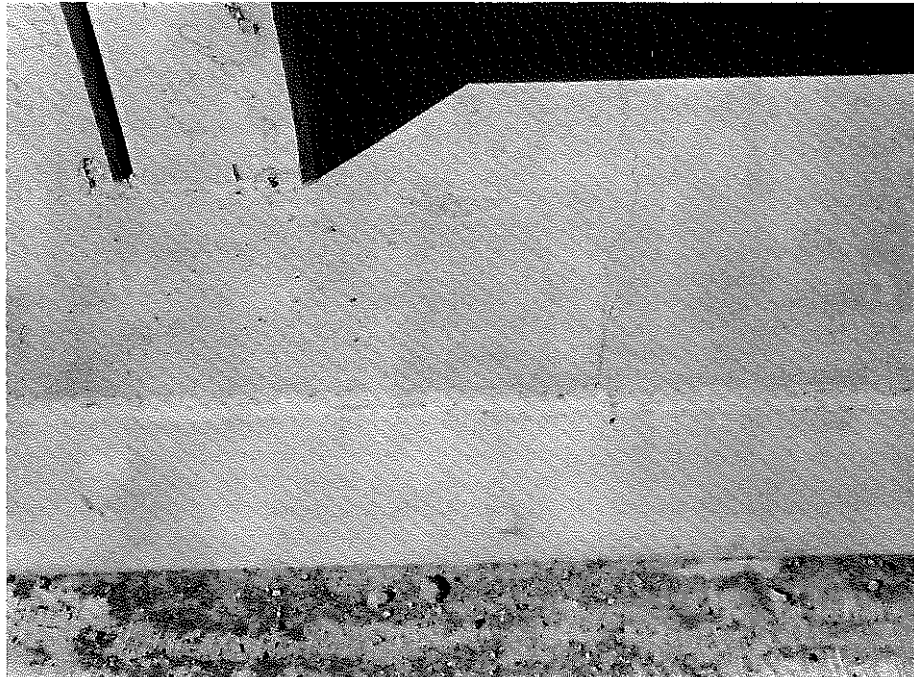


Fig. 6. Early Cracking in Curb-Section; State Route 8, Bracken County, Sept. 3, 1957.

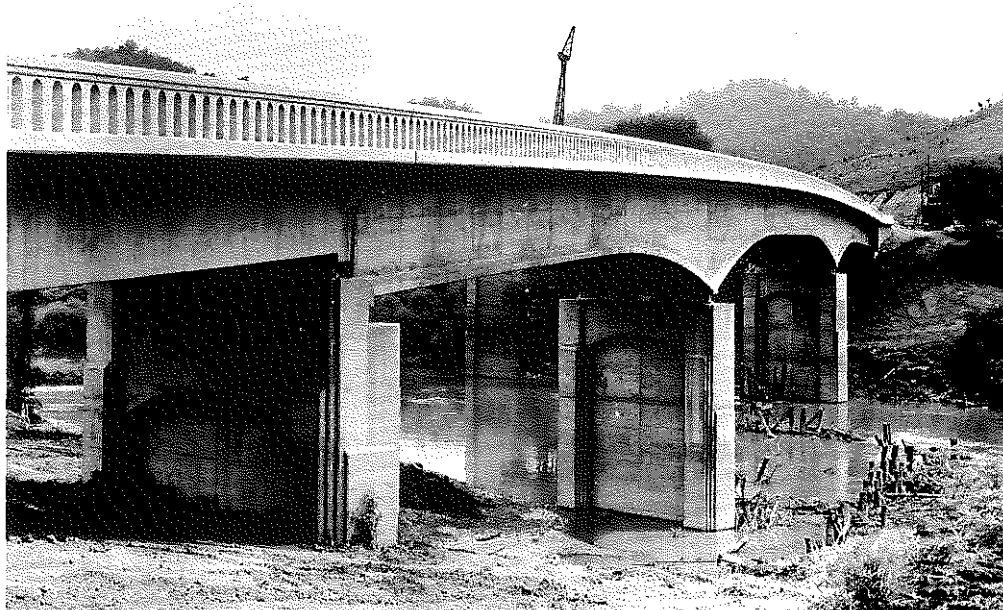


Fig. 7. Levisa Fork Bridge, Ky. 40, S-215(3). Cracks developed in the safety-walk when the false work wedges were removed, Dec. 18, 1957 (Ref.: Memo. to Area Engineer from Director of Construction, 12-20-57; Research Division File C.2.8.). Cracks were sealed, June-July, 1958.



Fig. 8. Levisa Fork Bridge. Cracks patched with Relcote 60 (epoxy) and sand (Ref.: "The Use of Epoxy Resin for Sealing Cracks in a Reinforced Concrete Bridge," by Milton Evans, Jr., July, 1959; RHMRL, Vol. XIV, p. 311).



the lines of steel as tell-tale signs of reaction. Spalling progresses from these points.

Shrinkage cracks in the deck and over-stressing undoubtedly contribute to loss of bond between the steel and concrete and permits the ingress of water and other corrosive agents. The volume of rust produced is more than 10 times greater than the volume of metal involved.

### Protective Coatings

A committee of experts recently stated: "Well-designed concrete structures made with top-quality, well-consolidated, air-entrained concrete using durable aggregates have little need for a protective coating."\* Nevertheless, coatings may eventually become a rather routine practice as a further assurance of durability and protection against de-icer salts. In the past, perhaps numerous bridge decks have been overlaid with bituminous concrete -- either in conjunction with roadway resurfacing or as a means of hiding and protecting an unsightly, deteriorated deck. Unfortunately, the Department's records of this kind of treatment are not adequate for any kind of analysis in this regard. However, current thinking here, as well as elsewhere, reflects some suspicion that ordinary, bituminous resurfacing (without special priming) may actually aggravate the deterioration, and this seems to be a definite

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\* "Durability of Concrete in Service," ACI Committee 201, Journal of the American Concrete Institute, December, 1962.

possibility if the overlay leaks or otherwise entraps water and hinders drainage and drying. Because of this, and for other reasons, it seems wise to regard sealants or coatings with some caution inasmuch as any kind of coating which merely retards the intrusion of water (breathing-type coatings) may likewise and subsequently retard drying. While there is perhaps some justification to disdain the use of coatings altogether on new concrete, they are at least seemingly necessary for the eventual welfare of the structure and more especially so in the repair and protection of existing, deteriorating decks.

It has been pointed out by others (ACI, op. cit.) that a breathing-type coating may lead to an accumulation of salts beneath the surface and to aggravate scaling. It might be argued in a similar way that moisture from the interior of the concrete may condense and collect beneath an impermeable coating when the exterior temperature is falling; and, upon freezing, this too could lead to rupture of the coating and to scaling. Complete sealing of concrete hardly seems attainable; and, even if it were attainable, it would be necessary to eliminate all moisture from the interior of the concrete before doing so. Therefore, from a practical point of view, the most logical recourse would be to use an impervious coating on only those surfaces directly exposed to moisture and to leave all others free to dry.

Apparently, laboratory freeze-thaw tests such as ASTM C 291 (... Freezing in Air and Thawing in Water) do not re-create actual exposure conditions, and their reliability for evaluating coatings remains somewhat dubious. Figure 9 shows a series of concrete specimens which were coated with various materials and subjected to freeze-thaw.

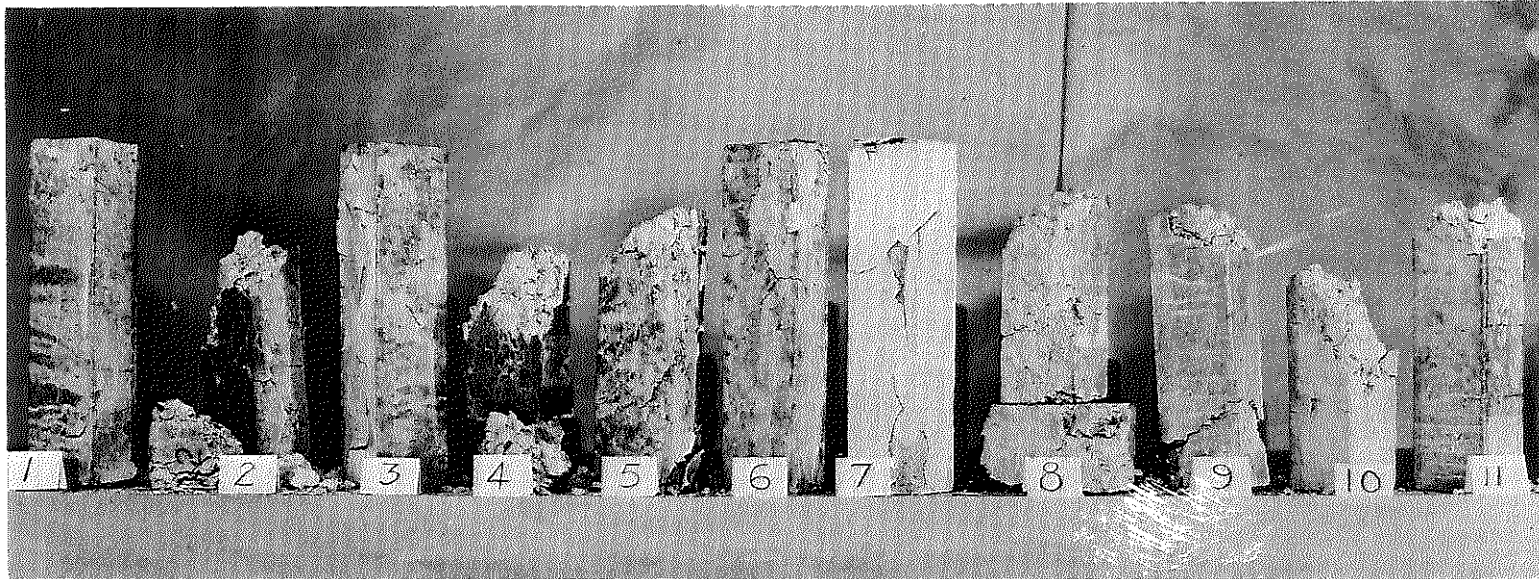


Fig. 9. Concrete Beams, 3x4x16 in.; Cured, Air-Dried, and Coated; Frozen in Air, Thawed in Water; Specimen No. 1, One Coat Meyer 402, Amine-Cured Epoxy (2-component); No. 2, Same as No. 1 (2 Coats); No. 3, Same as No. 1 (3 Coats); No. 4, Meyer 402-1, Cured with Modified Amine (1 Coat); No. 5, Same as No. 4 (2 Coats); No. 6, Same as No. 4 (3 Coats); No. 7, Meyer 401, Filled Epoxy-Amine Paste (Also Used for Caulking Cracks, Salt River Bridge); No. 8 and No. 9, George W. Whitesides; 56-E-2, Polystyrene; No. 10 and No. 11, Control Specimens (Uncoated). Control Specimens sustained 562 cycles of F & T; 4, 5, and 7 sustained 865 to 900 cycles; all others were approximately equal to or inferior to the Control Specimens of additional series (Not Shown), only Guardkote 140 and other thick-build coatings exceeded the durability of the Control Specimens. (July-August, 1960)

Figure 10 shows a series of concrete piers (Green River Bridge, US 62, at Rockport) which were completely encapsulated with an epoxy tar resin (Poxitar). The surfaces of the concrete were pervaded with map cracks. The coating will undoubtedly prevent rain from getting into the concrete, but it will not permit any moisture that might come up into the pier from the ground to escape. This could eventually lead to serious trouble, but only the passing of time will prove the worth of the treatment.

About 1955, there was some hope that silicone oils dissolved in naphtha or kerosene would prove to be an effective water-repellant. Silicone oils, like ordinary lubricating oils, do repel water when coated onto a porous surface (by negative capillarity) and yet permit water vapor to move freely -- both inwardly and outwardly. This type of coating is the ultimate, breathing type of coating. Used engine oil, paraffin, greases, etc. would provide such action; calcium stearates and oleates (long used in masonry mortars) are also effective. It seems, however, that organic oils and greases tend to oxidize with the passing of time and lose their oily qualities, but there was hope that silicones would be everlasting in this respect.

There is now some suspicion that water under slight pressure may force into the surface pores far enough to reach the untreated depths -- after which inner capillary suction would draw in the surface water. For this reason, it seems now that silicones are best suited to the treatment of vertical surfaces or surfaces on which water is not likely to stand (Note: Some five or six years ago the handrails and



Fig. 10. Green River Bridge, US 62, at Rockport; Tops of Some Piers Repaired with Gunitite; Widespread Surface-Cracking on all Piers; Coated with Poxitar (Coal Tar-Epoxy, Amine-Cured, Inertol Co.) by Bridge Maintenance Crew; Work began in Fall of 1959; Some Gunitite Repairs Made on the Deck. The piers are fully encapsulated with the black coating.

perhaps some other parts of the Tyrone Bridge (US 62 at Kentucky River), the Danville Bridge (US 150, West City Limits), and the Capital Street Bridge (Kentucky River) in Frankfort were treated with silicone in conjunction with gunite repairs).

Inner capillary suction is a problem to which all barrier-type, paint coatings are vulnerable. For instance, a mere pin-hole or scratch in the coating may allow a great amount of water to pass into the concrete. The same would be true of paint on wood, but it does not deter the use of paint on wooden structures. The advantages of painting wood and steel are well proven by a couple of hundred years of experience; the need for protective coatings for concrete has come to light during the past ten to fifteen years.

### Repairs

There is not yet a known instance in which a concrete deck on a major bridge in Kentucky has been completely removed, because of deterioration, and been completely re-constructed. Most of the major bridges have been built since 1928\*. Most, if not all, of them have

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\* Murphy Toll Bridge Act: Revenue bonds sold in September, 1930; Ohio River Bridge at Ashland, Cumberland River Bridge at Burnside, Green River Bridge at Spottsville; Ohio River Bridge at Maysville, Tennessee River Bridge at Paducah, Cumberland River Bridge at Smithland, Kentucky River Bridge at Boonesboro, Ohio River Bridge at Carrollton, Kentucky River Bridge at Tyrone, Tennessee River Bridge at Eddner's Ferry, and Cumberland River Bridge at Canton; Agreements made for Ohio River Bridge at Henderson; Report of the State Highway Commission, April 1, 1930, to November 1, 1931; The Irvine S. Cobb Bridge at Paducah, and the Clark Memorial Bridge at Louisville were also constructed about this time.

IRVINE S. COBB BRIDGE

Location: Paducah  
Project No.: MP 73-12-2  
Constructed: 1928-1929 (Toll Bridge Authority),  
Accepted by State 1935,  
Freed of Toll November, 1943.

Designed by Harrington, Howard and Ash of Kansas City.  
Deck and handrails constructed of reinforced, light-weight  
concrete (Haydite aggregate). Performance of the concrete  
has been somewhat infamous. In June, 1929, a 12-ft. section  
of the deck failed; between 1940 and 1952, 207 patches rang-  
ing from 3 x 5 ft. to 8 x 10 ft. were made, and the entire  
deck was overlaid with Kentucky Rock Asphalt.

## BALL'S FORK BRIDGE

Location: US 150, Danville-Stanford Road  
Project No.: MP 120-4  
Constructed: September, 1951  
Condition: Scaling and spalling of deck  
Repairs: May 20-25, 1955, gunite was used to patch one lane.

Daraweld (polyvinyl acetate latex) mortar was used to patch opposite lane and patches were feather-edged. Some spalling of patches was noted before the deck was surfaced with bituminous concrete. It has been revised to four lanes since 1957, and a parallel bridge constructed.

Patching on this bridge doubtlessly led to the use of Daraweld on the Russell Fork Bridge in Pike County and the Beuchel Railroad Overpass in Louisville.



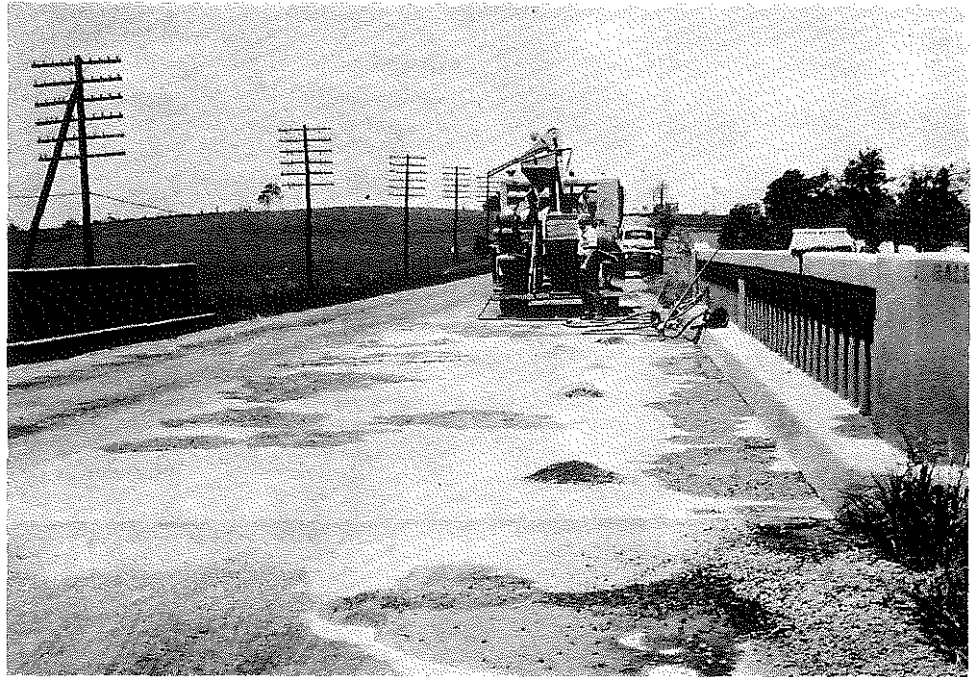


Fig. 11. Ball's Fork Bridge, US 150, Danville-Stanford Road. Gunite Repairs were made in right-hand lane; Daraweld-mortar used to patch left lane (eastbound).



Fig. 12. Ball's Fork Bridge, Summer 1957; Note Spalled Patches in Deck, Gunite in Left Lane.

## RUSSELL FORK BRIDGE

Location: Marrowbone-Ashcamp Road,  
Ky. 195, Pike County

Project No. MP 98-243-1

Constructed: 1921 by County,  
Accepted for Maintenance 11-27-34.

Type: Reinforced concrete deck; reinforced concrete,  
spandrel-braced, triple arch.

Aggregate: (Probably local creek gravel)

Condition: Deck, handrails, arch-members badly deteriorated;  
deck failure.

Repairs: Began October 25, 1955 (deck repairs). Arch-members  
and handrails were patched with gunite. Part of deck at the  
east end was removed and replaced, and remainder of deck was  
chipped down to remove dead concrete. Steel anchors or  
stirrups were grouted into deck, and entire deck overlaid with  
concrete -- 120 cu. yds, cost \$15,000.00. Daraweld (polyvinyl  
acetate latex, Dewey-Almy Chemical Company) was used as a  
bond-coat on 48 ft. at east end of deck, and recent reports  
indicate satisfactory performance.



Fig. 13. Russell Fork Bridge, Marrowbone-Ashcamp Road, Pike County, Ky. 195.

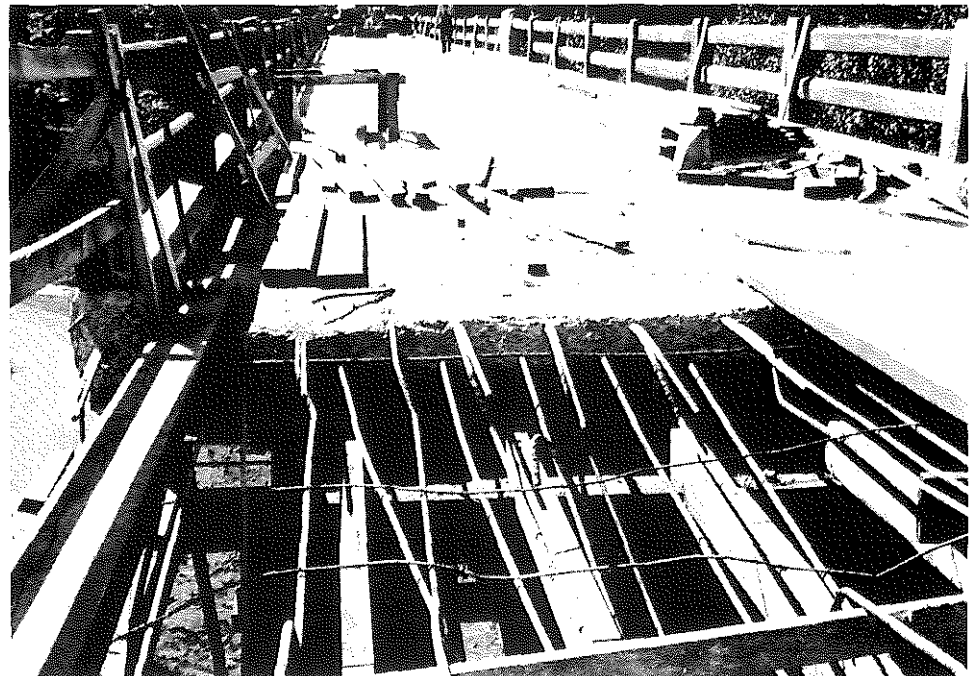


Fig. 14. Section of Deck Removed, Replaced with New Concrete, Russell Fork Bridge.

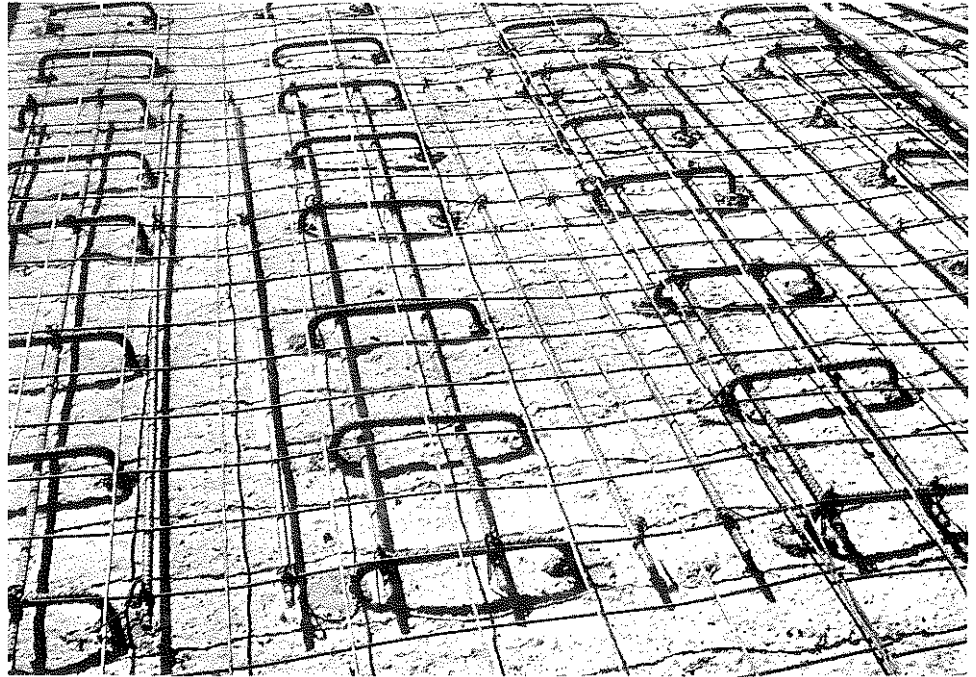


Fig. 15. Russell Fork Bridge, Deck Chipped Down, Anchors or Stirrups Grouted into Deck, and Overlaid with Concrete.

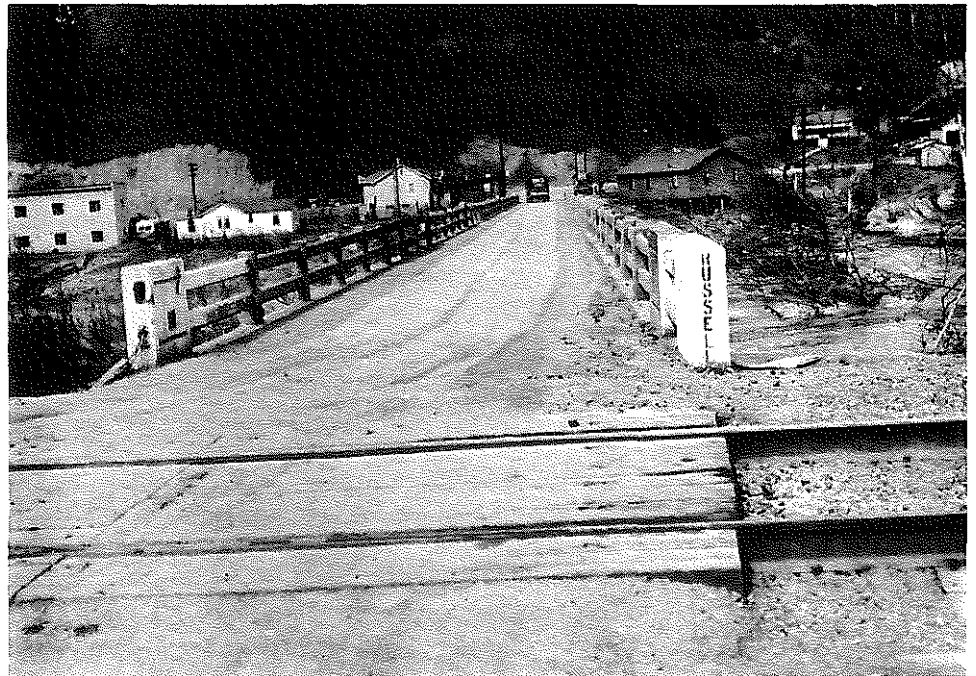


Fig. 16. East End of Russell Fork Bridge After Repairs. Daraweld was used in the first 48 feet.

RAILROAD OVERPASS, BEUCHEL

Location: US 31-E, Bardstown Road  
Jefferson County

Project No.: F 18(6)

Constructed: Concrete poured November 11, 1955;  
cracks occurred in first 24 hours.

Condition: Shrinkage cracks in deck slab section 3L;  
between piers 1 and 1A.

Repairs: September 27, 1956; Daraweld-Mortar (1 bag cement, 2 gal.  
water, 3.5 gal. Daraweld). Material was mixed at central  
batch plant, hauled to job in ready-mix truck, dumped, and  
scrubbed onto the deck with stiff brooms. 3/16 in. treatment,  
liquid curing compound, closed to traffic 2-1/2 days. Cracks  
reappeared in less than one year.

Reference: Memo. to W. S. Todd, Division of Construction, from D. H.  
Sawyer, July 9, 1956, and November 5, 1956 (Research Lab. Files  
P.3.3. & C.2.8.).

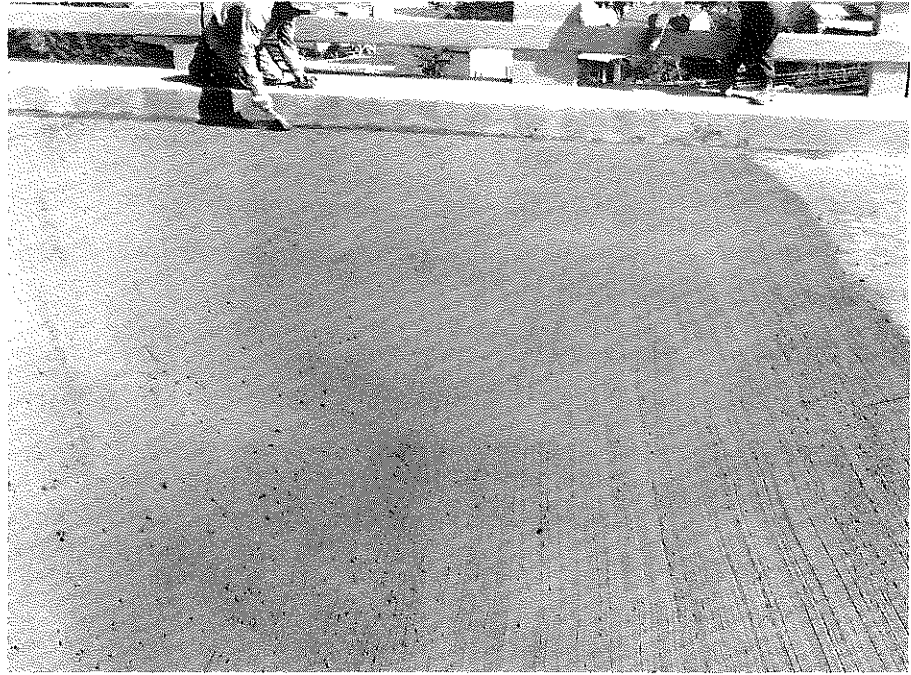


Fig. 17. Railroad Overpass, Beuchel, US 31-E; Daraweld-Mortar, Thin Patch.



Fig. 18. Reappearance of Cracks, First Year.

## CLARK MEMORIAL BRIDGE

- Location: Louisville, Ohio River
- Project No.: MP 56- 8118-7
- Constructed: 1928-29, Accepted for Maintenance November, 1946,  
Accepted from City 6-16-47.
- Aggregate: Ohio River Gravel
- Condition: Scaling, spalling, and deep deterioration; numerous bituminous patches, requiring continual maintenance during winter months, and numerous cracks in deck showing salt deposits on bottom sides.
- Repairs: Bituminous patches and dead concrete removed, and deep patching was done with portland cement concrete (by maintenance crew). Shallow patching (sand-asphalt) was included in surfacing contract. The surface was primed with a cut-back PAC-3, and 0.4 in. sand-asphalt was placed with a paver on October 22 to 30, 1958 (25,000 sq. yds, \$13,325.00). During the second winter, extensive spalling developed, and in March and April, 1960, extensive patching (with sand-asphalt) was required. On October 6, 1961, wet-bottom boiler slag seal-coat (Black Beauty, RS-2) was applied. In October, 1962, a Kentucky Rock Asphalt (from reserve supply) spinner seal treatment was applied to sections of the approaches.
- References: 1. "Bridge Resurfacing with Silica Sand-Asphalt Mixture," A Memorandum Report by L. H. Strunk, Dec. 1958, RHMRL, Vol. XIII, 1958, pp. 334-367.
2. "The Design of Thin, Silica Sand-Asphalt Wearing Surfaces for Highways and Bridges," by Robert L. Florence, July, 1959, RHMRL, Vol. XIV, 1959, pp. 253-310.

CLARK MEMORIAL BRIDGE (Cont'd.)

- References:
3. "Performance Report on Bridge Resurfacing with Silica Sand-Asphalt Mixture," by Robert L. Florence, March, 1961. RHMRL, Vol. XVI, Part I, pp. 175-202.
  4. "Seal Coat Application to Clark Memorial Bridge," by Robert C. Deen, January, 1962, RHMRL, Vol. XVIII, Part III, pp. 175-188.
  5. "Bridge Deck Repair Techniques on the New Jersey Turnpike"; Orrin Riley, Project Engineer, Howard, Needles, Tammen & Bergendoff; presented 42nd Annual Meeting of the Highway Research Board, January, 1963.

Interesting case-history of Passaic River Bridge, constructed about 1951; over a mile long, six lanes wide; spalling began in 1957; 200 to 1200 sq. ft. of spalling occurred each month; several slabs have failed, and the lanes have been closed while the slabs were being replaced; about 20% of the slabs had been replaced (\$360. per cu. yd., including removal of old concrete), the top 2 in. of the new concrete was Embeco; patching consisted of Embeco, non-shrink mortar, feathered patches failed 5 to 10 times more readily than sawed-edge patchwork; dead concrete was removed; Embeco patching or epoxy-coal tar (Guardkote 140) patches are used on the bridge as well as throughout the turnpike; choice is dependent upon closing the area to traffic; earlier work cost \$20. to \$25. per sq. ft., later costs were from \$8.50 to \$8.90 per sq. ft.; part of bridge has been sealed with Guardkote 140 and emery grit.



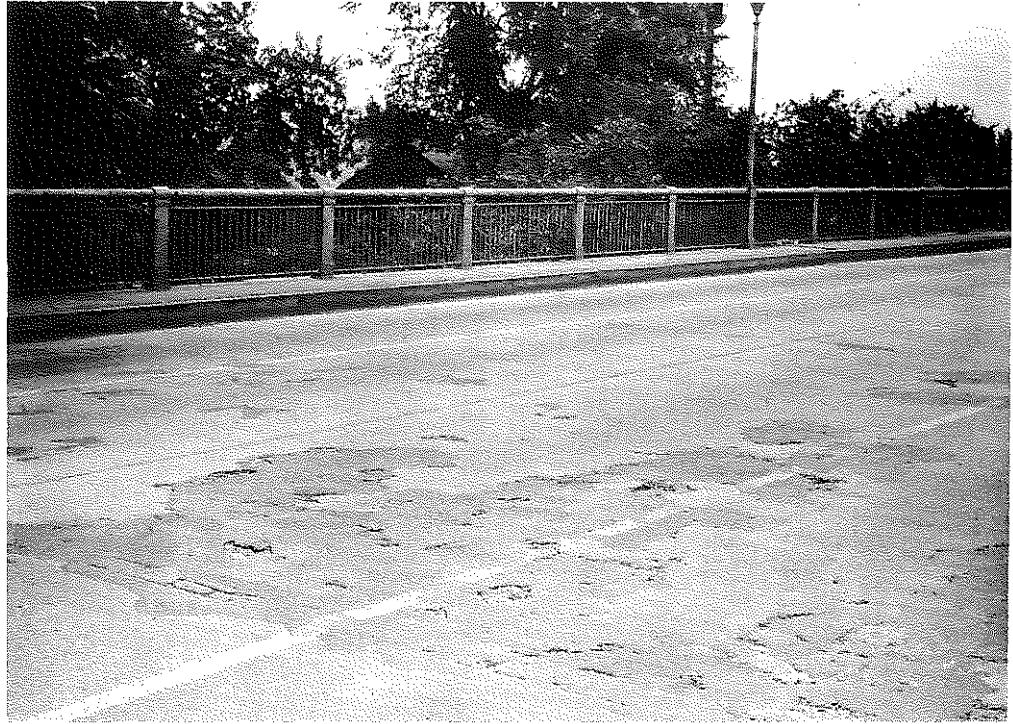


Fig. 19. Clark Memorial Bridge, North Ramp, Showing Bituminous Patches, August, 1958.



Fig. 20. Clark Memorial Bridge, South Ramp, After Bituminous Patches Removed, October, 1958.



Fig. 21. Clark Memorial Bridge, North Ramp, November, 1959,  
Sand-Asphalt Surface.



Fig. 22. Clark Memorial Bridge, South Ramp, November, 1959.  
Ripples in foreground are caused by deep sand-asphalt  
patches; one year after surfacing with sand-asphalt.



Fig. 23. Clark Memorial Bridge, North Ramp, March, 1960.



Fig. 24. Clark Memorial Bridge, North Ramp, March, 1960.



Fig. 25. Clark Memorial Bridge, Removing Dead Material Preparatory to Patching, March, 1960.



Fig. 26.

Clark Memorial Bridge, March, 1960, Spalls Cleaned and Primed (SS-1) Preparatory to Patching. Patching Material was also a sand-asphalt mix. Note exposed reinforcing steel.



Fig. 27. Clark Memorial Bridge, Patching Deep Spalls, Hot-Mix Sand-Asphalt, March-April, 1960.



Fig. 28. Same as Above, Showing Rolling of Patch Material.



Fig. 29. Clark Memorial Bridge, January, 1962, After Black Beauty Slag Seal. Note Patches and Deterioration of Sidewalk.

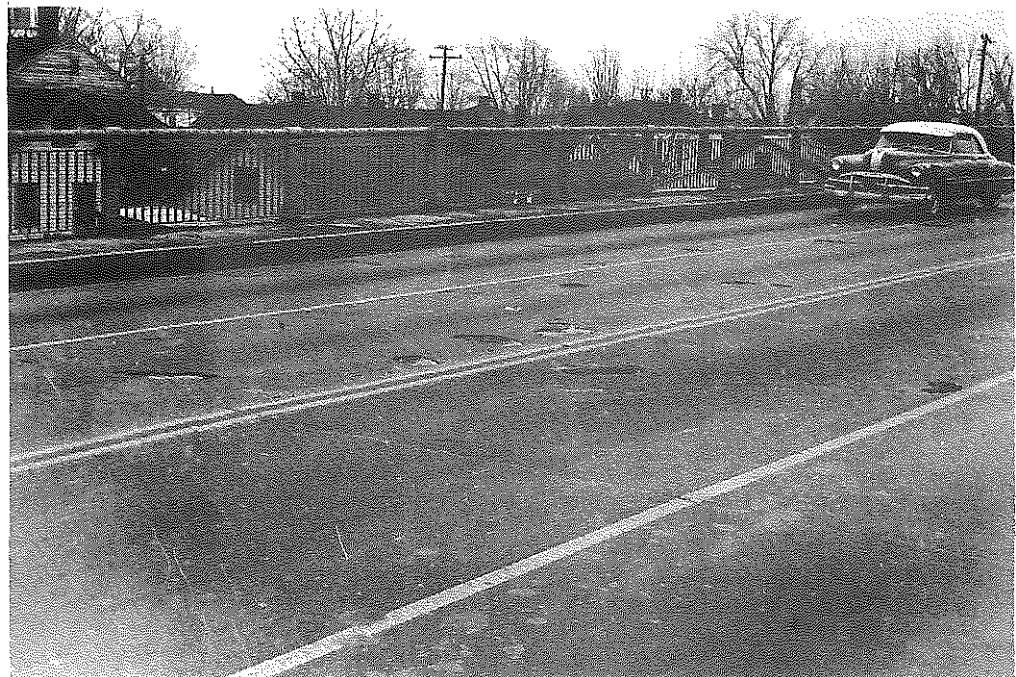


Fig. 30. Same as Above, Slightly Different View.

ASHLAND-COAL GROVE BRIDGE

Location: Ohio River

Project No.: MP 10-6025-1

Constructed: 1931

Type: Three-truss, reinforced concrete deck with Kentucky Rock Asphalt surface (original surface).

Condition: The original Rock Asphalt surface had been overlaid with Class I bituminous concrete (slag aggregate, 1951). A few areas had subsequently been patched, and presumably additional resurfacing was needed because the existing surface was slick.

Repairs (Treatment): Sand-asphalt surface, 0.4 in., and similar to that used on Clark Memorial Bridge, was placed September 14, 1958. Performance of the sand-surface has been generally good. Tire chains marked the surface during the first winter, and there is some localized surface failure where distress was apparent in the existing surface. Some maintenance patching has been required.

References: See Nos. 1, 2 and 3 listed for Clark Memorial Bridge.

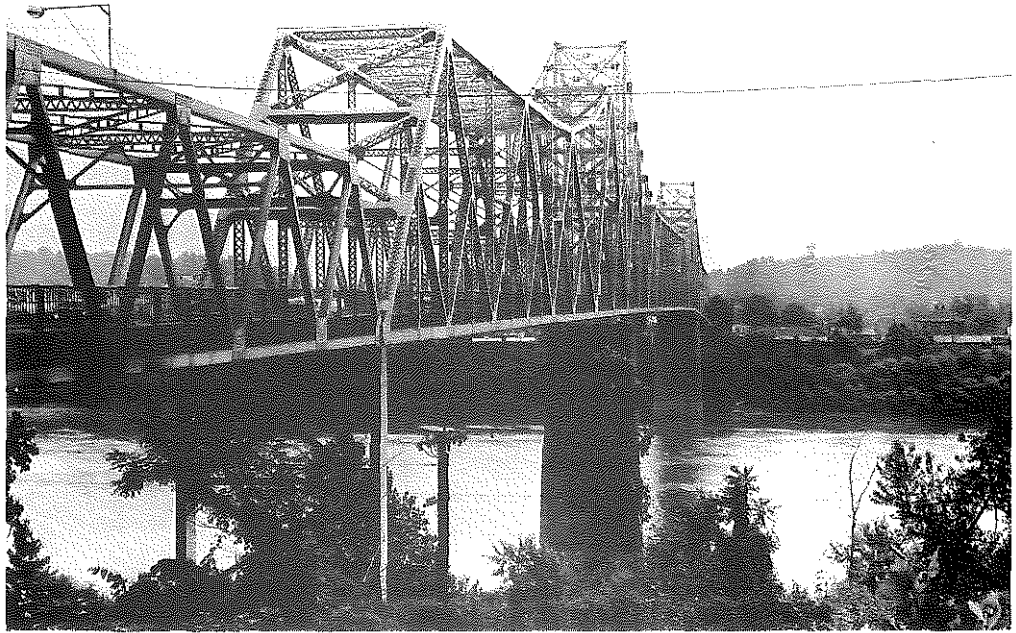


Fig. 31. Ashland-Coal Grove Bridge.



Fig. 32. Ashland-Coal Grove Bridge, Before Surfacing with Sand-Asphalt.





Fig. 33. Ashland-Coal Grove Bridge, February, 1960. Note snow and cinders in gutter and chain marks.



Fig. 34. Ashland-Coal Grove Bridge, March 1960. Note Cinders in gutter and distressed area in outer wheel track.

ST. CATHERINE'S STREET BRIDGE

Location: North-South Expressway  
Louisville

Project No.: MP 56-8798-HG 15  
I-65-6(7)133  
56-8798-11B1

Constructed: Completed 1-6-60

Condition: No significant distress. Bridge was arbitrarily selected for experimental treatment.

Treatment: May 19, 1960. Northernmost 3/4ths of southbound lanes treated (deck, safety walk, and half way across median) with George W. Whiteside's 56-E-2, poly-styrene penetrant, applied through low-pressure garden spray.

Southernmost 1/4th of southbound lanes treated with a brook-squeegee application of George W. Whiteside's J-151-40, two-component epoxy-polysulfide. The "40" refers to the percentage of non-volatiles (by volume, not shown in photos).

Note: Polysulfide rubber (Prestite), two-component, joint sealer was installed in expansion joint, north end of northbound lanes in May, 1962.



Fig. 35. St. Catherine's Street Bridge, Application of Polystyrene. Penetrant to Median Curb; Southbound Lanes, Looking South.



Fig. 36. St. Catherine's Street Bridge, Southbound Lanes, Looking North; Material Spread as Shown in Fig. 37.

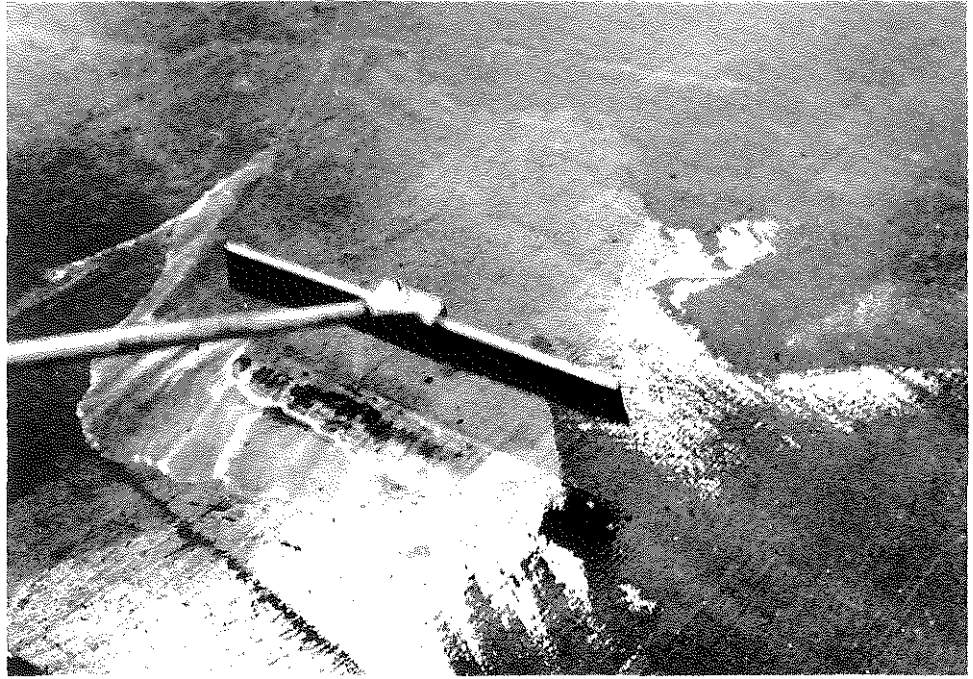


Fig. 37. St. Catherine's Street Bridge; Spreading Styrene Penetrant.



Fig. 38. St. Catherine's Street Bridge, Southbound Lanes, Looking North; Polystyrene Coating in Background.

SALT RIVER BRIDGE (TWIN)

Location: Kentucky Turnpike

Constructed: 1955.

Condition: Severe scaling on plinths and curbs; minor scaling on deck; numerous shrinkage and transverse cracks in deck (See Figs. 39-42).

Treatment: June-October, 1960; various coating materials applied experimentally. Technical supervision provided by contributors of materials. Figure 43 shows the locations and identifications of the various materials. The methods, procedures, and other details are shown in sequences of pictures. Except where it is noted otherwise, the surface of the deck was prepared by sand-blasting. Cleaning of the deck and routing of cracks was performed by Department maintenance crews. Except for the first section at the north end of the southbound bridge, all coatings contained sand or grit. All coatings gave light colored surfaces except the American Bitumals Company's Heavy Duty Resurfacer and, of course, the section where emery grit was applied to coal tar-epoxy. The Penntrowel section appears a light gray, but the Porter Paint section is slightly darker.

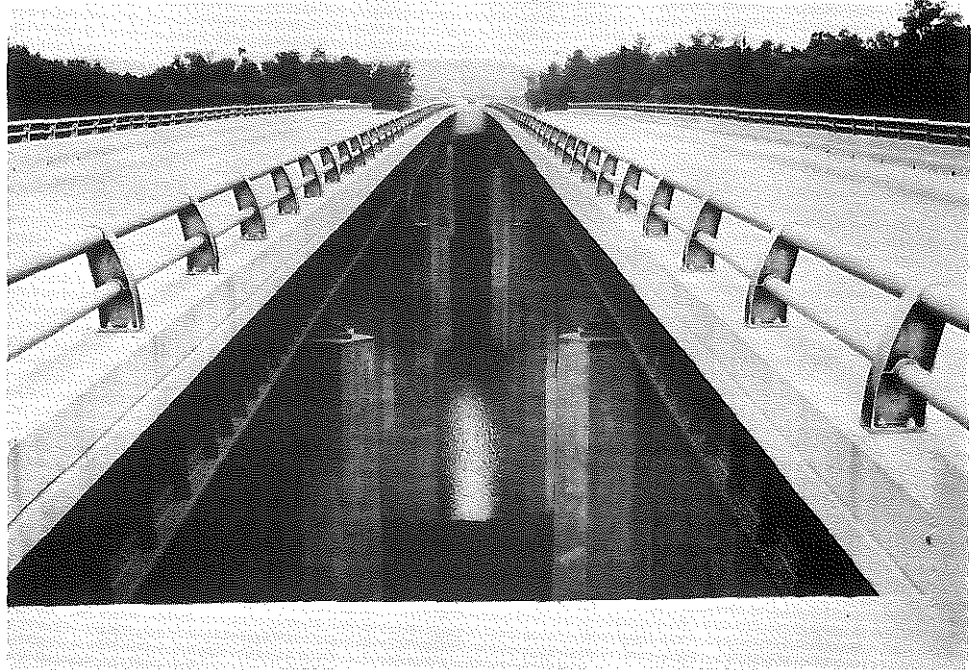


Fig. 39. Twin Bridge, Salt River, Kentucky Turnpike (Looking North).

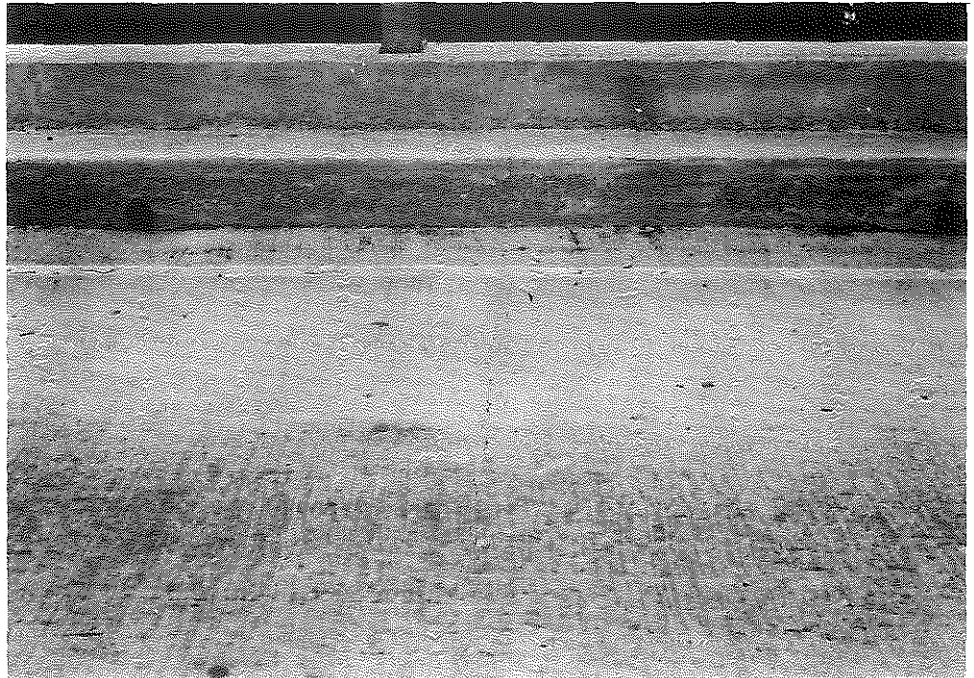


Fig. 40. Salt River Bridge, Kentucky Turnpike; Scaling Along Curb and Plinth, Cracking in Deck.

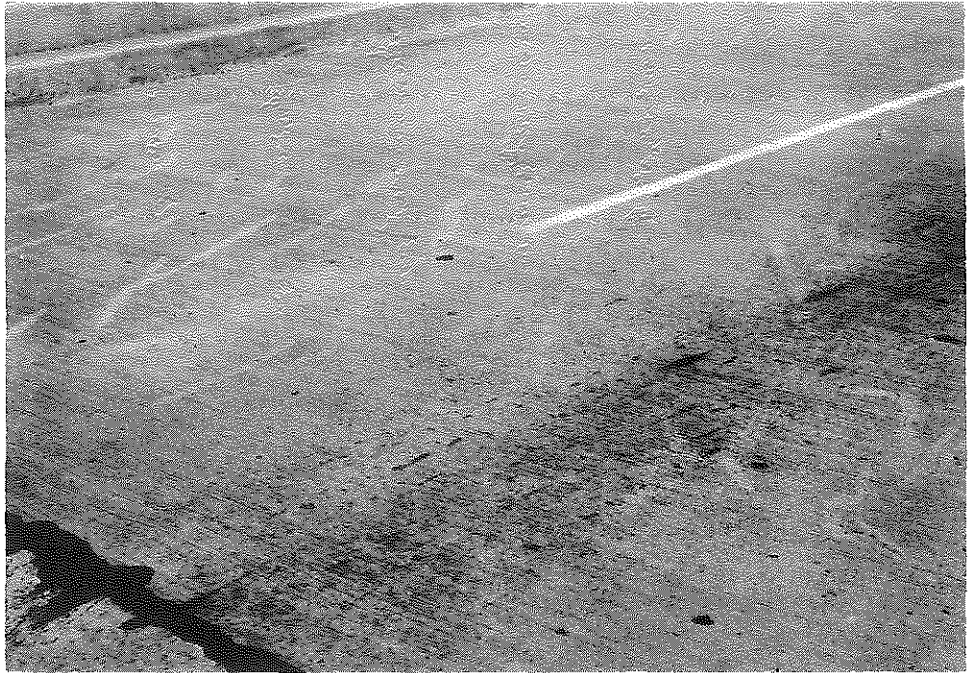
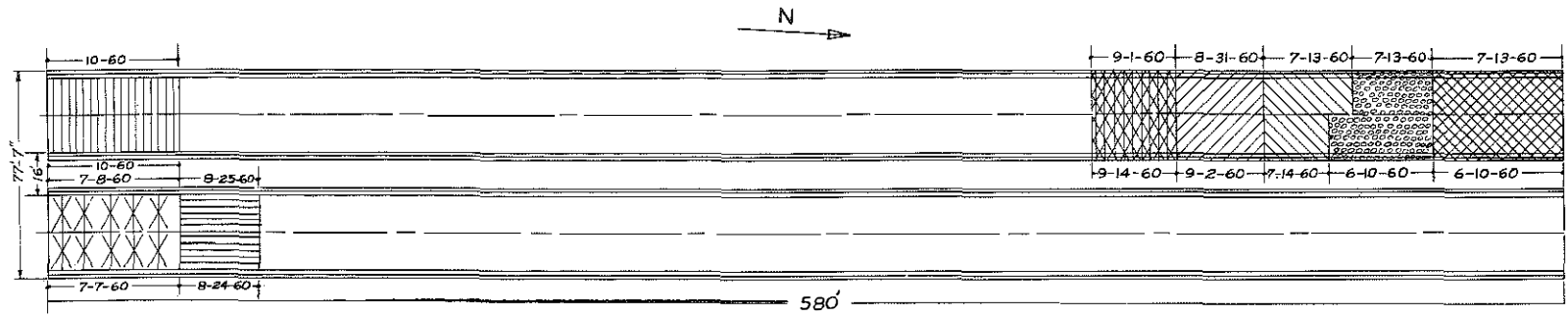


Fig. 41. Salt River Bridge, Kentucky Turnpike; Shrinkage Cracks in Deck, Outlined.



Fig. 42. Salt River Bridge, Kentucky Turnpike; Transverse Cracks, Underneath Side of Deck, Showing Deposits of Salt.



SALT RIVER BRIDGE

SCALE - 1" = 20'

LEGEND

MATERIAL TYPE	MATERIAL NAME	SYMBOL	APPLICATION RATE	THICKNESS	AGGREGATE
COAL TAR - EPOXY	GUARDKOTE 140		0.036 GAL/FT <sup>2</sup>	0.058 in.	EMERY & QUARTZ
LATEX ASPHALT EMULSION	HEAVY DUTY RESURFACER		0.171 GAL/FT <sup>2</sup>	0.24 in.	MARBLE CHIPS
EPOXY	PORTER PAINT SURFACER		0.030 GAL/FT <sup>2</sup>	0.046 in.	QUARTZ SAND - SILICA FLOUR
EPOXY	PENNSALT		0.072 GAL/FT <sup>2</sup>	0.052 in.	QUARTZ SAND - SILICA FLOUR
EPOXY	MEYER 402-1		0.917 LBS/FT <sup>2</sup>	0.060 in.	WHITE SILICA SAND
EPOXY	MEYER 402		0.64 LBS/FT <sup>2</sup>	0.060 in.	WHITE SILICA SAND
EPOXIDE ALKYD	MEYER 403		0.0138 GAL/FT <sup>2</sup>	0.010 in.	NONE
LATEX PC. MORTAR	DOW X-2144			0.25 in.	RIVER SAND

Fig. 43. Diagram Showing Dates of Application and Types and Identifications of Coating Materials.



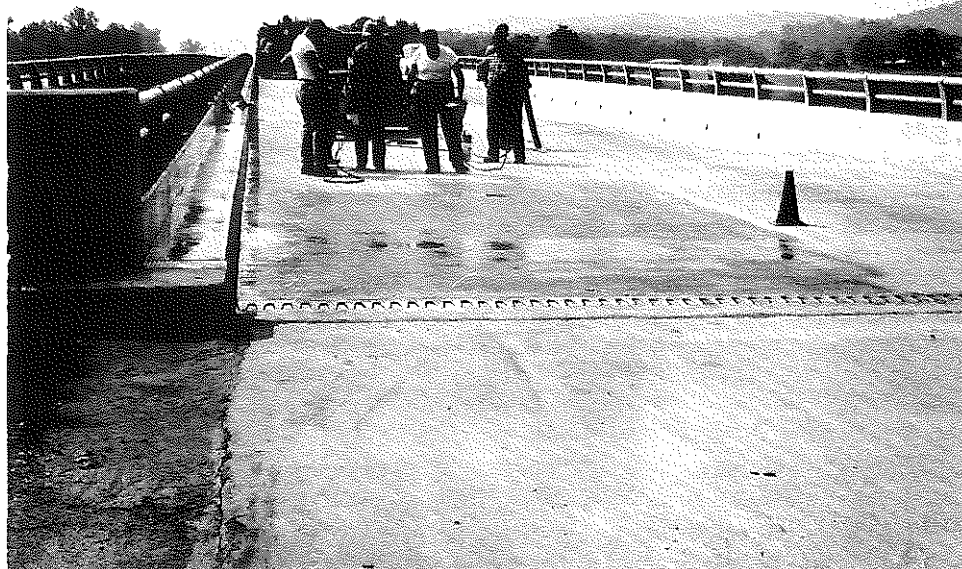


Fig. 44. Salt River Bridge, Kentucky Turnpike; Application of Epoxide-Alkyd, Meyer 403; Quickspray; No Sand or Grit Applied; North End of Southbound Bridge, Looking South, (6-10-60).

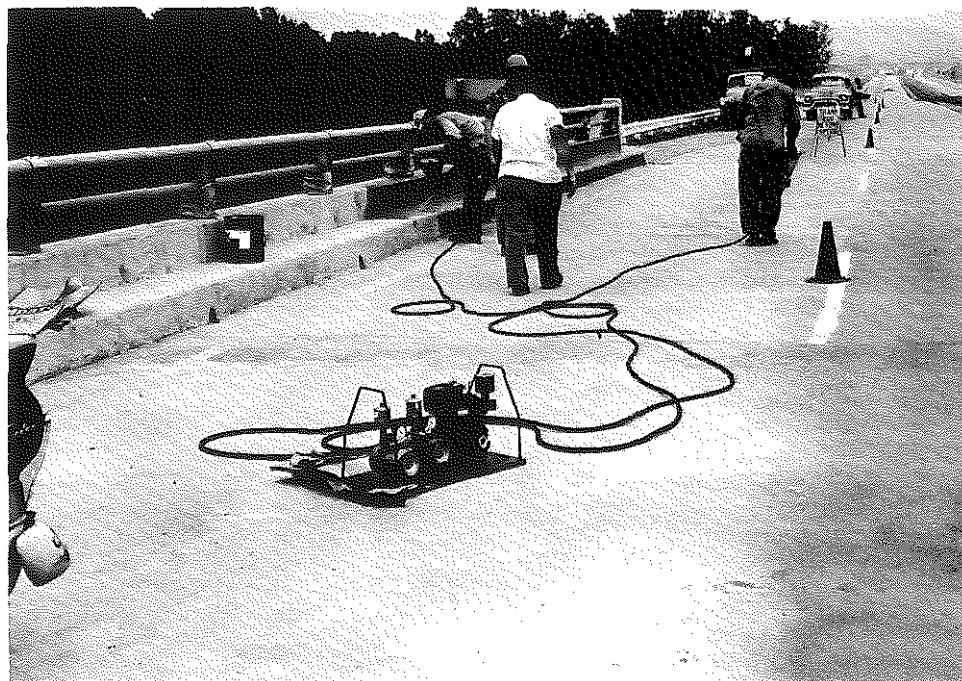


Fig. 45. Salt River Bridge, Kentucky Turnpike; Application of Epoxide-Alkyd, Meyer 403; North End, Southbound Bridge, Looking North, (7-13-60).

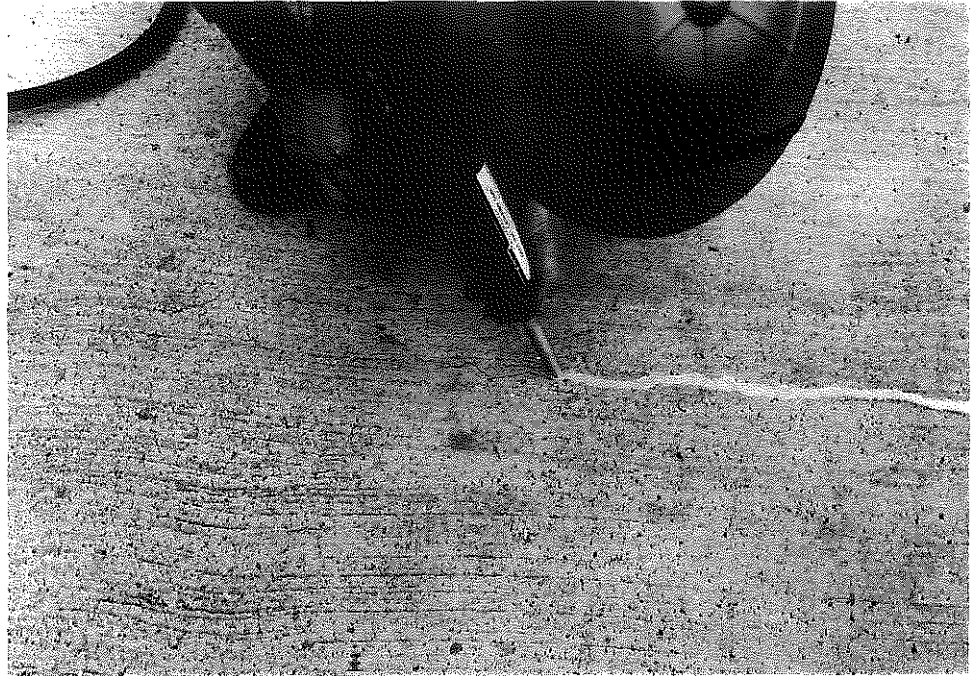


Fig. 46. Salt River Bridges, Kentucky Turnpike; Caulking Cracks, Epoxy Mastic Caulking, Meyer 401 (Filled Epoxy), (7-13-60).



Fig. 47. Salt River Bridges, Kentucky Turnpike; Quickspray Guns (7-13-60).

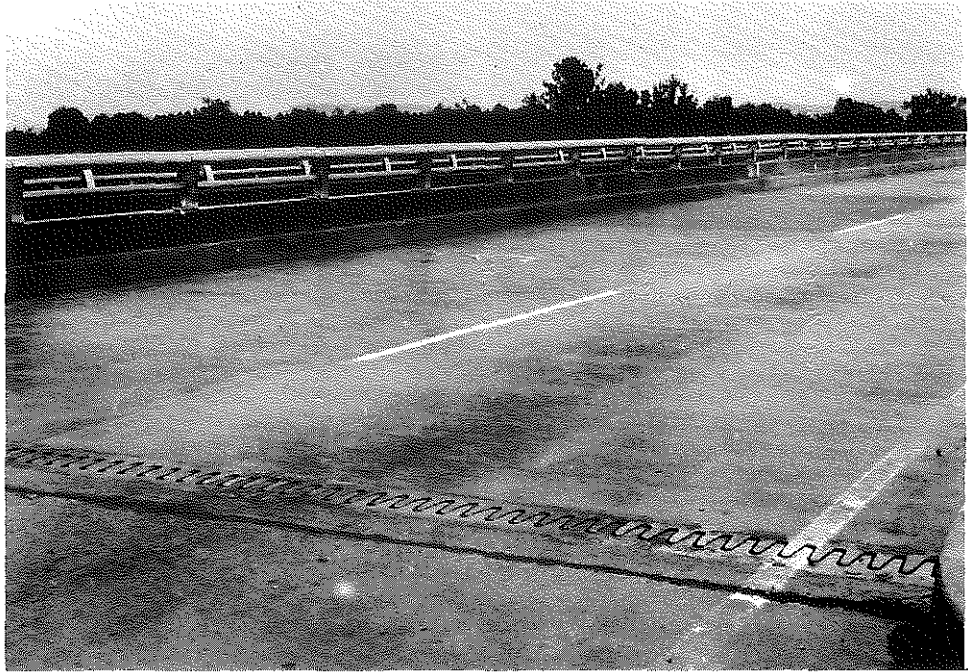


Fig. 48. Salt River Bridges, Kentucky Turnpike; Meyer 403, Foreground; Meyer 402 is in the Background.



Fig. 49. Salt River Bridges, Kentucky Turnpike; Epoxide-Alkyd Coating, after One Winter.

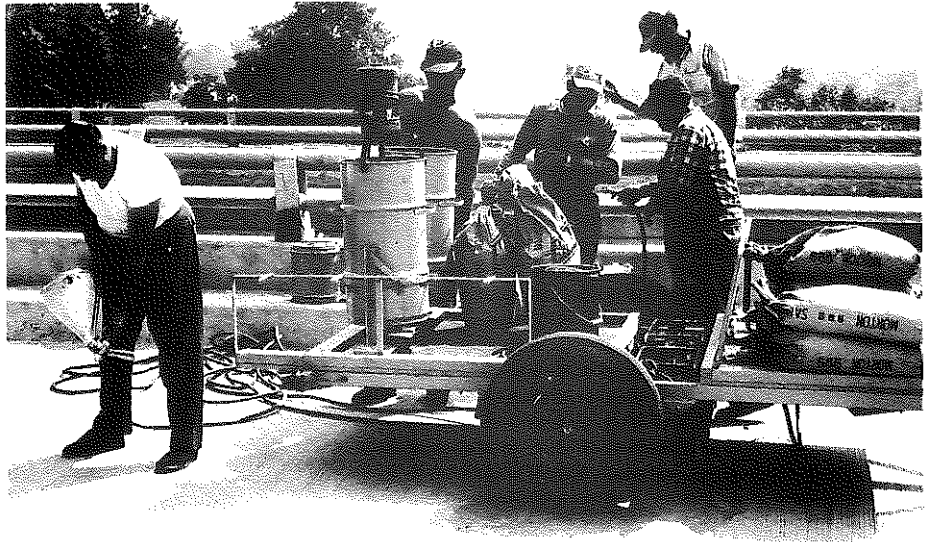


Fig. 50. Salt River Bridges, Kentucky Turnpike; Quickspray Mixer Used to Blend Batches of Epoxy Components and Sand, (6-10-60).



Fig. 51. Salt River Bridges, Kentucky Turnpike; Meyer 402, Epoxy Sand Mortar (Amine-Cured Epoxy; Ottawa, Flint Shot Sand), (6-10-60).

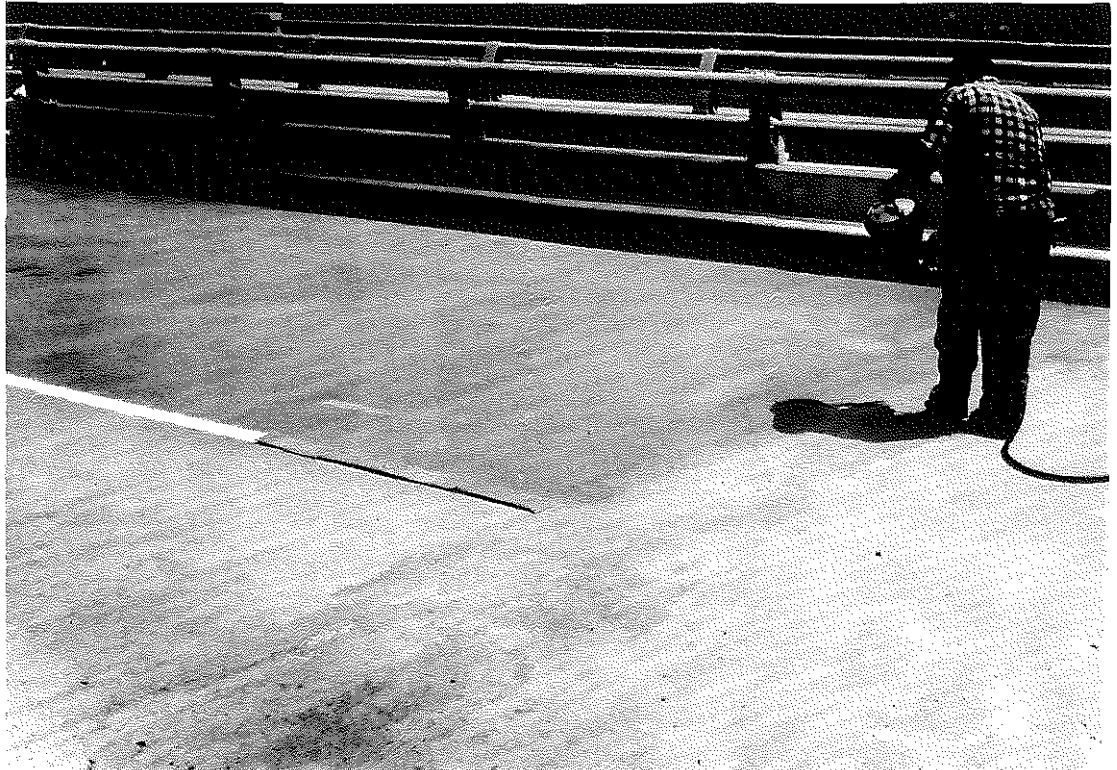


Fig. 52. Salt River Bridge, Kentucky Turnpike; Applying Meyer 402, Epoxy Sand Mortar, 6-10-60; also Applied 7-13-60 and 7-14-60 in Right-hand Lane; Meyer 402-1 Applied 8-31-60 and 9-2-60; 402-1 Contained Somewhat Greater Portion of Sand.



Fig. 53. Salt River Bridge, Kentucky Turnpike; Chipping Cracks, Preparatory to Sealing Them; Penntrowel Section, 8-31-60.



Fig. 54. Salt River Bridge, Kentucky Turnpike; Sealing Cracks with Furof Resin; Penntrowel Section.



Fig. 55. Salt River Bridge, Kentucky Turnpike; Pointing-Up Pop-Outs with Penntrowel Mortar.

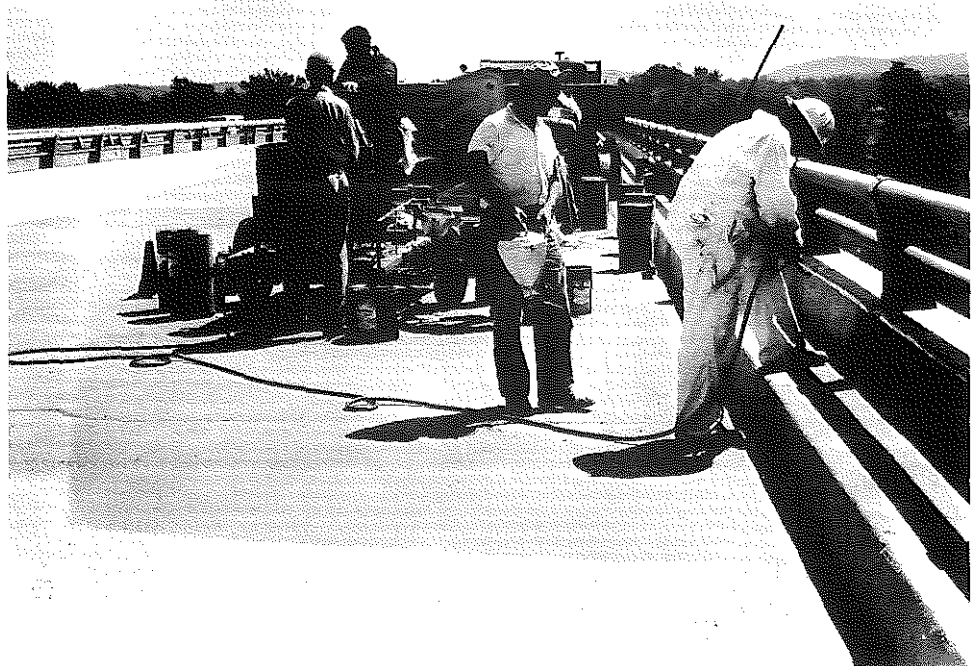


Fig. 56. Salt River Bridge, Kentucky Turnpike; Application of Penntrowel (Pennsalt Chemical Company) Floor Surfacers; Quickspray Equipment, (8-31-60).



Fig. 57. Salt River Bridge, Kentucky Turnpike; Wire-Brushing Surface of Deck in Preparation for Application of Porter Paint, Epoxy Surfacer; Pre-proportioned (packaged) Resin, Hardener and Filler or Grit; Applied in Same Way as Penntrowel (in Background), (9-1-60).





Fig. 58. Salt River Bridges, Kentucky Turnpike; Deep-Routing Transverse Cracks, Preparatory to Placing Latex-Mortar Overlay, October, 1960.



Fig. 59. Salt River Bridge, Kentucky Turnpike; Placing Latex (Dow 2144)-Mortar Overlay; Approximately 1/4 inch, October, 1960.

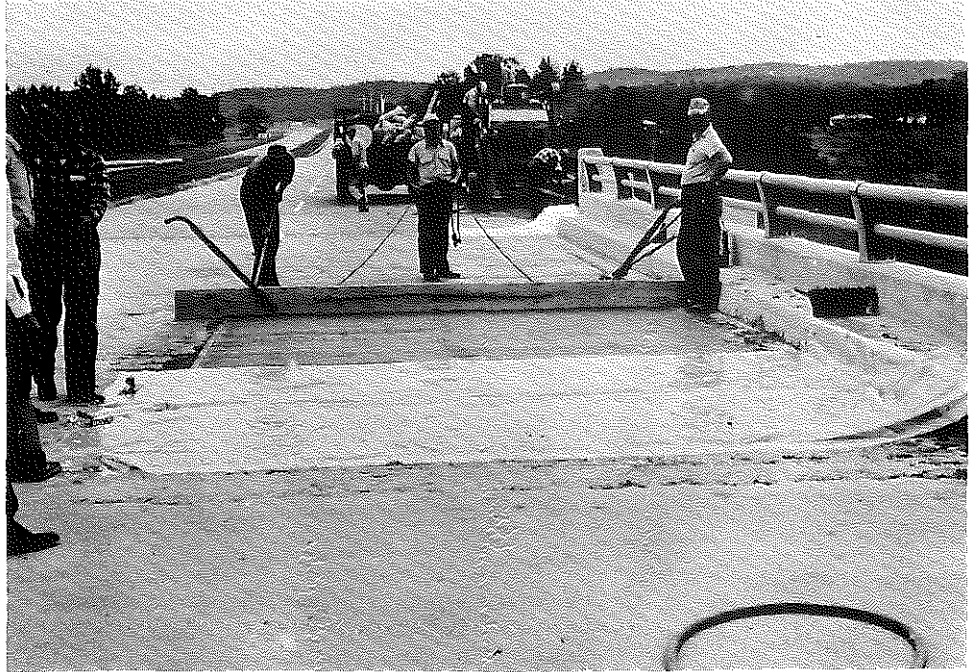


Fig. 60. Salt River Bridges, Kentucky Turnpike; Latex-Mortar Overlay, October, 1960.

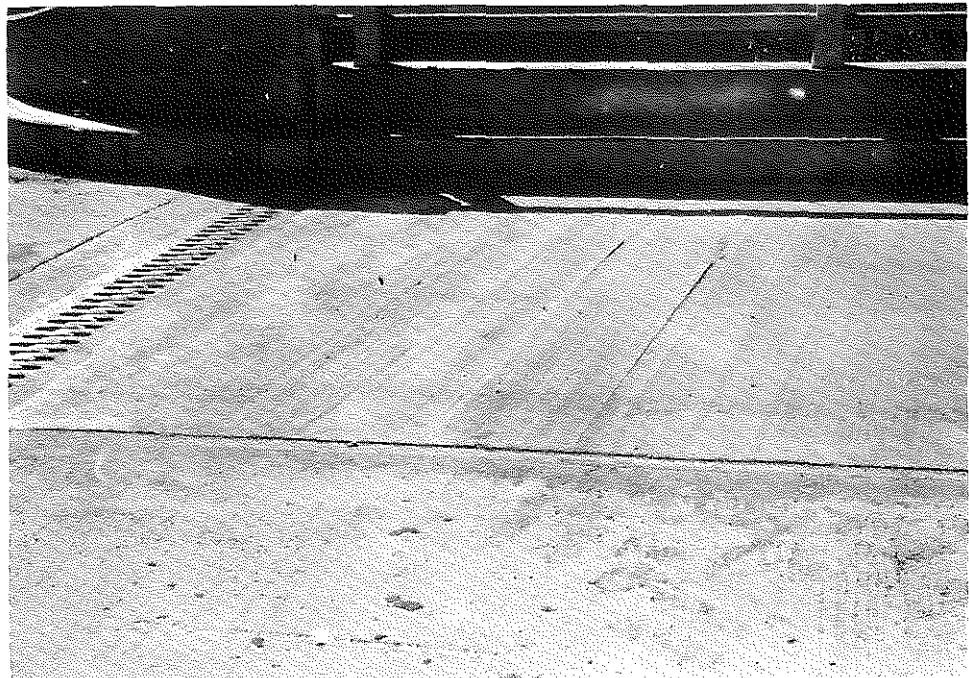


Fig. 61. Salt River Bridges, Kentucky Turnpike; Latex-Mortar Overlay, after Curing, October, 1960. Material Placed in Inner Lane about 10 Days Later.



Fig. 62. Salt River Bridge, Northbound, Kentucky Turnpike;  
Scrubbing Deck with Water and Tri-Sodium Phosphate,  
Preparatory to Applying American Bitumuls;  
Heavy Duty Resurfacer, July 7, 1960.

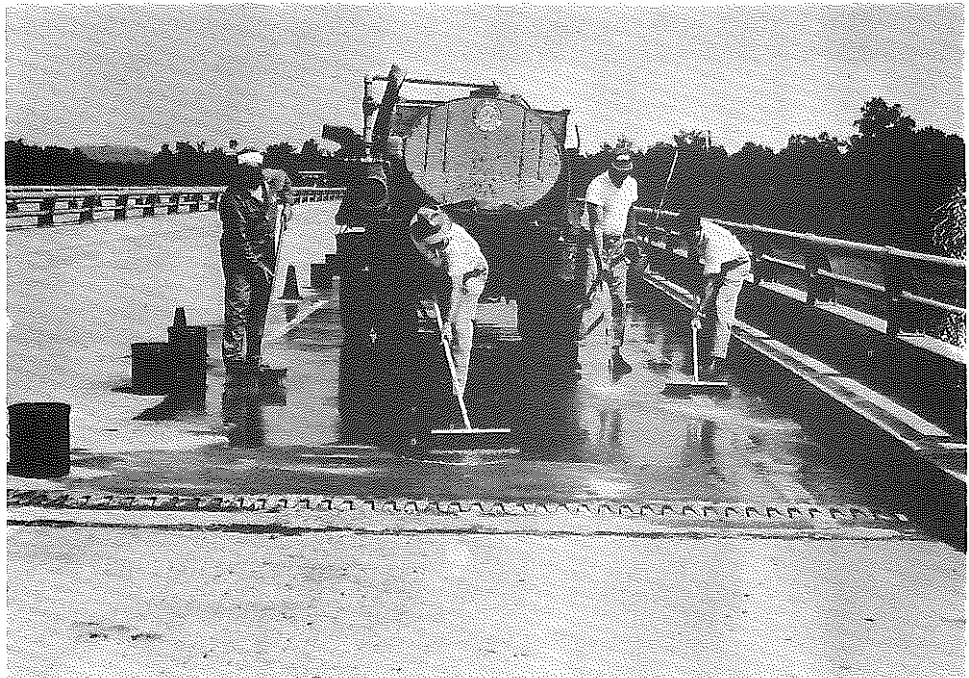


Fig. 63. Salt River Bridge, Kentucky Turnpike; Rinsing after  
Scrubbing; Preparatory to Application of American  
Bitumuls, Heavy Duty Resurfacer, July 7, 1960.



Fig. 64. Salt River Bridge, Northbound, Kentucky Turnpike; Application of Primer Coat; American Bitumuls, Heavy Duty Resurfacer, July 7, 1960.

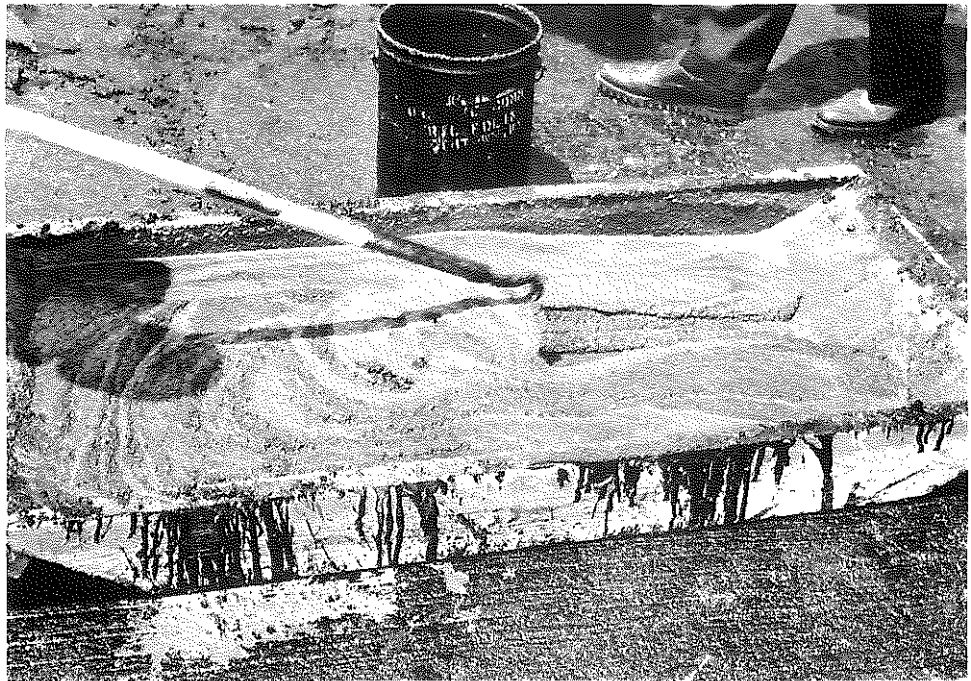


Fig. 65. Salt River Bridge, Kentucky Turnpike; Mixing Heavy Duty Resurfacer (Slurry); Neoprene Latex-Asphalt Emulsion - Premixed Filler, Grit, July 7, 1960.

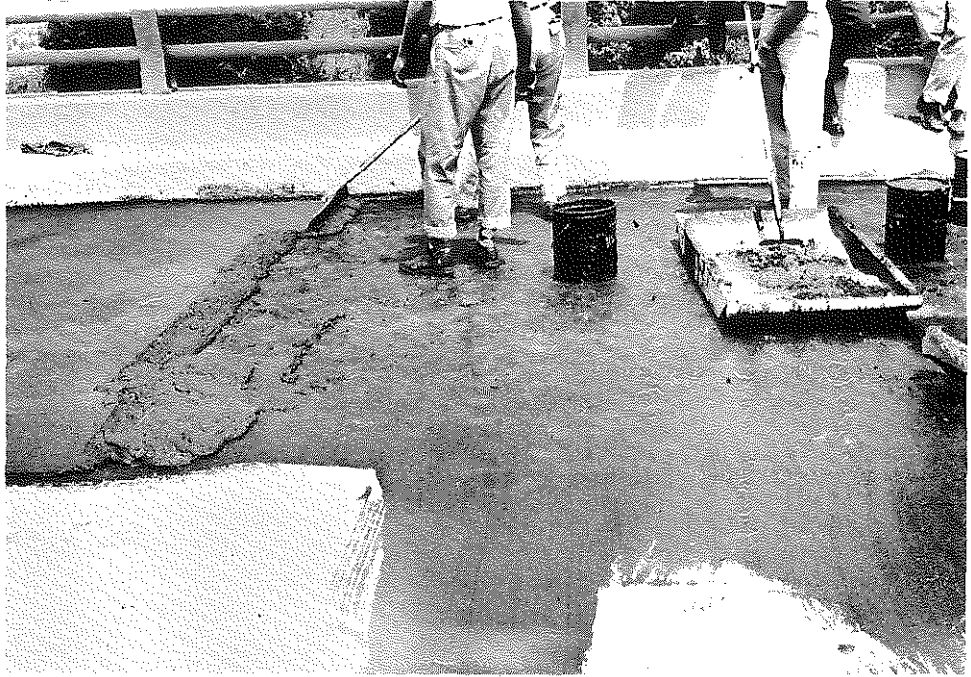


Fig. 66. Salt River Bridge, Kentucky Turnpike; Spreading American Bitumuls Heavy Duty Resurfacer, July 7, 1960.

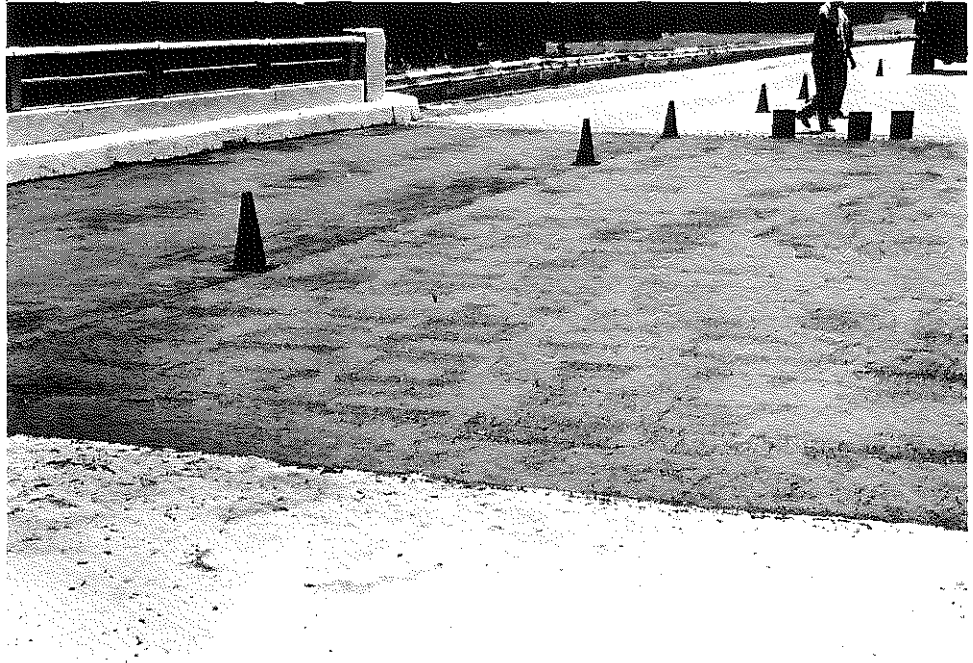


Fig. 67. Salt River Bridge, Northbound, Looking South; Heavy Duty Resurface; Left Lane opened to Traffic; July 8, 1960.

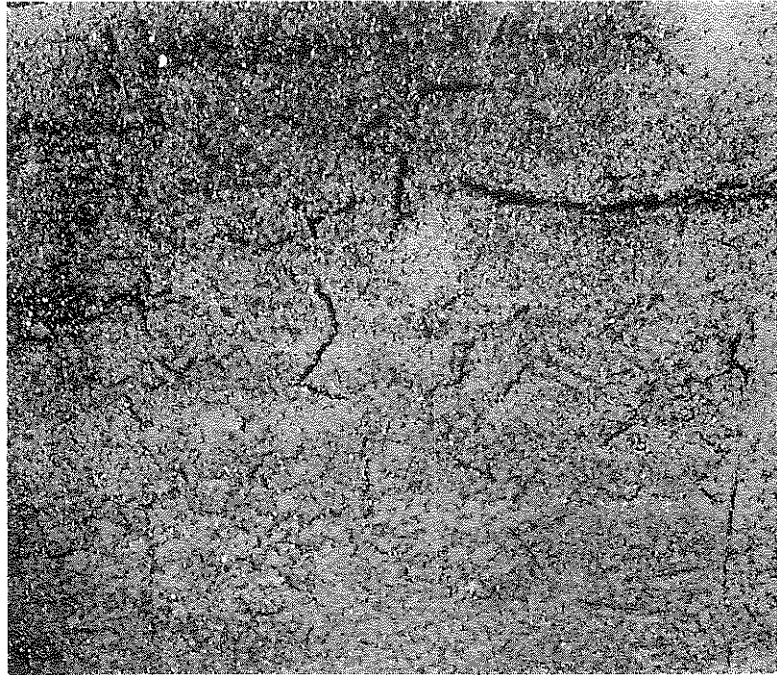


Fig. 68. Salt River Bridge, Kentucky Turnpike; American Bitumuls Heavy Duty Resurfacer; Severe Shrinkage Cracks; Ten Days to Two Weeks Afterwards.



Fig. 69. Salt River Bridge, Kentucky Turnpike; American Bitumuls Heavy Duty Resurfacer; Showing Peeling During First Winter.



Fig. 70. Salt River Bridge, North-bound, Kentucky Turnpike; Acid Etching, Preparatory to Application of Epoxy-Tar Seal (Guardkote 140), August 24-25, 1960.



Fig. 71. Salt River Bridge, North-bound, Kentucky Turnpike; Rinsing with Water, After Acid Treatment, August 24-25, 1960.

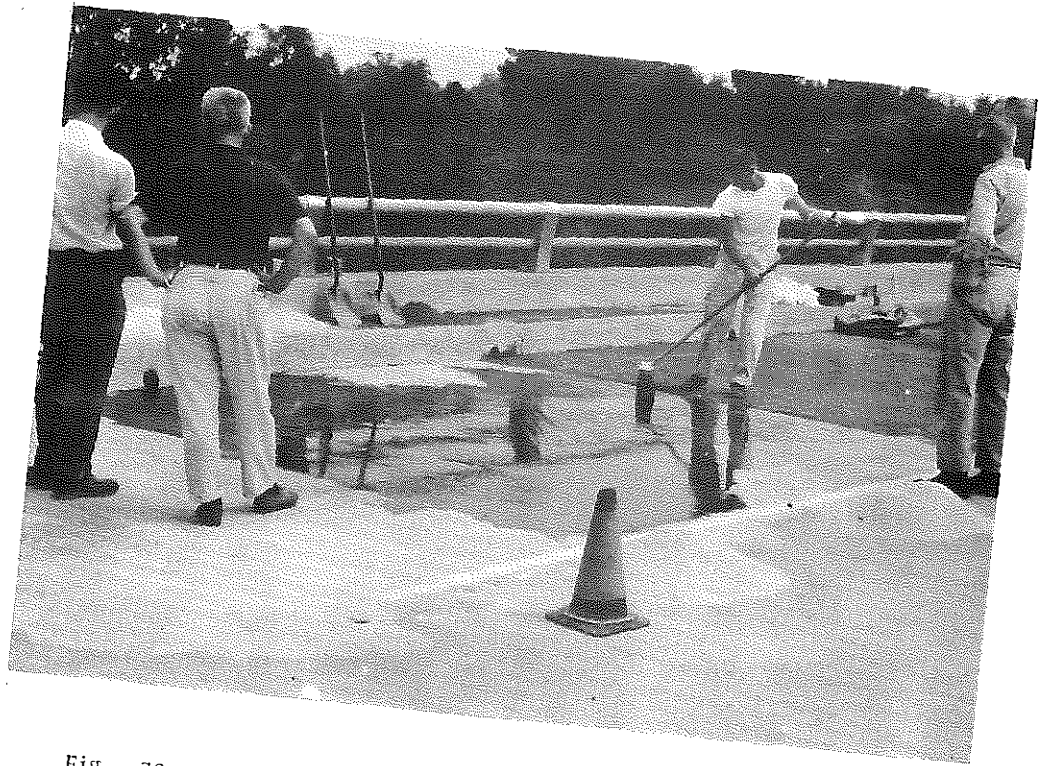


Fig. 72. Salt River Bridge, North-bound, Kentucky Turnpike;  
Brooming on Guardkote 140, Epoxy-Tar, August 24-25, 1960.

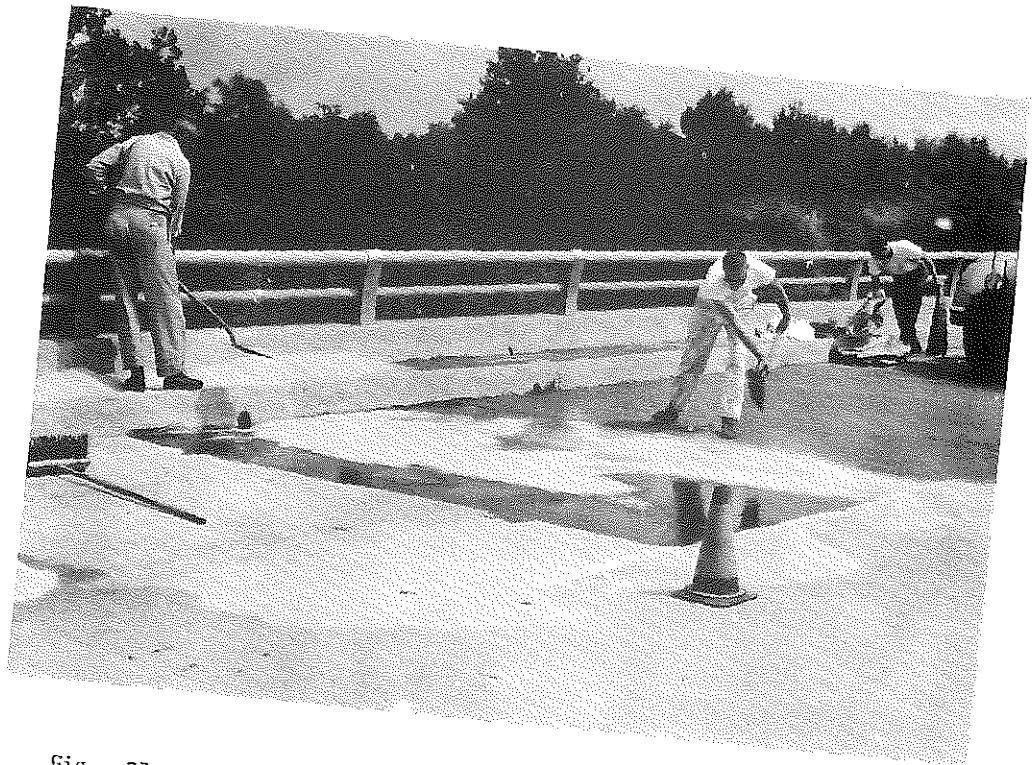


Fig. 73. Salt River Bridge, North-bound, Kentucky Turnpike;  
Broadcasting Sand over Fresh Epoxy-Tar, August 24-25, 1960.





Fig. 74. Salt River Bridge, North-bound, Kentucky Turnpike;  
Brooming-Off Excess Sand, August 24-25, 1960.

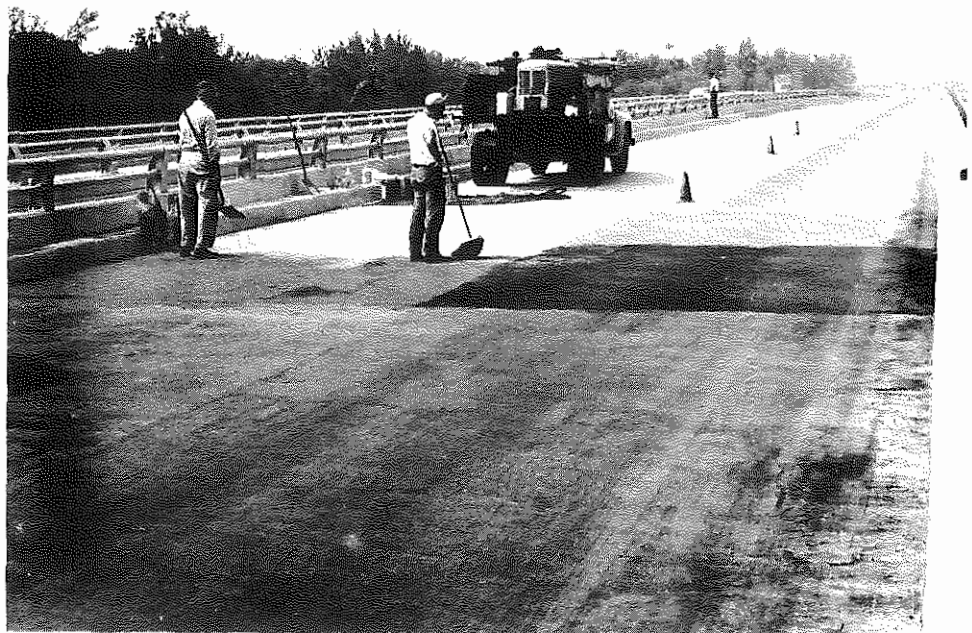


Fig. 75. Salt River Bridge, North-bound, Kentucky Turnpike;  
Dark Area at Right is Emery Grit, Guardkote 140;  
elsewhere White Sand Cover; Note: American Bitumuls  
Heavy Duty Resurfacer in Foreground.

PRICE PIKE BRIDGES (TWIN)

Location: I-75, South of Mile Post 179, Covington-Lexington  
Road, Boone County

Project No.: MP 8-550-HG4

Completed: 10-26-60 (date of acceptance)

Condition: Rain damaged fresh,uncovered concrete during construction;  
center span, northbound lanes.

Repairs: Summer, 1960; Sika Bonding Compound (epoxy-polysulfide)  
and 1/4-inch mortar topping; feathered edges; used to build up  
a smooth surface; bonded overlay covered about 75% of center slab.

Note: Scaling has been reported in the south span of the south-  
bound lanes.

TWIN BRIDGES OVER PRUITT ROAD

Location: I-64, Winchester-Mt. Sterling.  
Constructed: 1960  
Condition: Deck was uneven. Contractor was required to smooth by grinding and to build up low places with epoxy mortar.  
Repairs: June-July, 1960; Geo. W. Whiteside's 59-D-3 (polysulfide-epoxy) binder and sand used to build up surface of deck to template grade. A diagram, Fig. 76, shows the location and types of build-up attempted and more complete descriptions are given below:

- B - Build-up consisting of mop-coat of binder sprinkled with sand and broomed. This procedure was repeated until the desired template grade was reached.
- M - Binder and sand mortar-mix, was troweled into depressions and feathered.
- P - High places were ground down, painted with binder, and sprinkled with sand.

Figures 77 through 82 show the condition of the overlays as of the indicated dates.

Reference: "Those Wonderful Epoxies: What They Will and Won't Do," Feature Article, Engineering News-Record, July 12, 1962. A general treatise on epoxies.

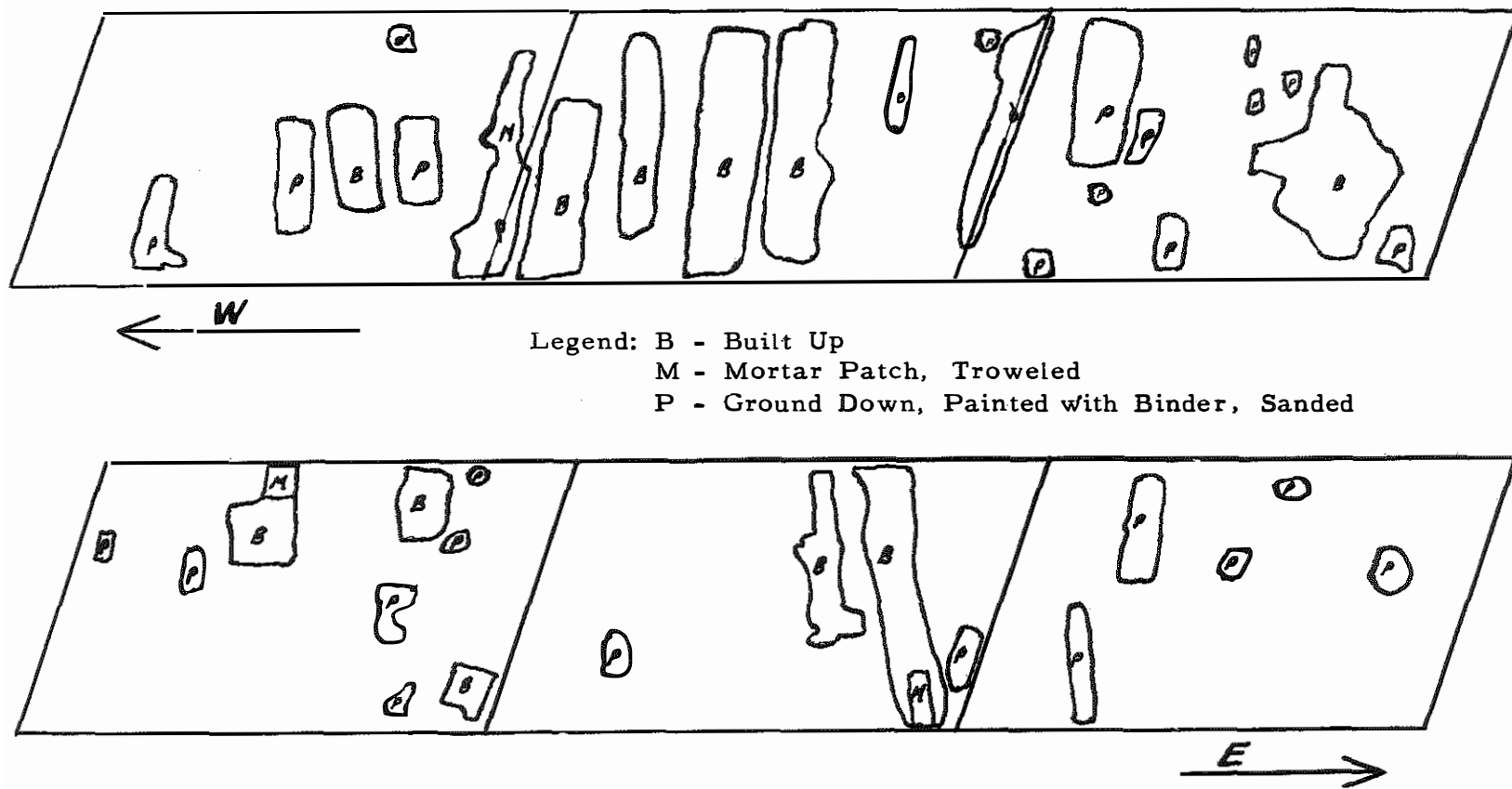


Fig. 76. I-64, Winchester-Mt. Sterling, Twin Bridges over Pruitt Road.

## LAKE CUMBERLAND BRIDGE

Location: Ky. 90, Burnside-Monticello Road

Project No.: MP 100-155-3

Constructed: Completed 8-21-51, Accepted 11-10-51

Type: Deck-Truss, Reinforced Concrete Deck, 8 Inches.

Condition: Deep deterioration in some slabs; seemed to be related to pouring pattern. Slabs 28-ft. in length were poured alternately. Adjoining slabs were markedly different in quality. Figures 83 through 86 illustrate typical condition.

Repairs: Summers of 1961 and 1962 (began July 24, 1961). The deck was originally intended to be scarified uniformly to a depth of 1/2 inch. Unsound concrete was removed by chipping and routing. Cutting to the full 1/2-inch depth proved to be too exhausting, and in order to decrease the amount of cutting to be done, the depth of the cut was reduced to 1/4 inch for most of the deck and to 1/8 inch for the remainder. It was necessary to cut the full 1/2 inch where approaching the finger dams and the ends of the bridge in order to allow 1/2 inch for the planned minimum thickness of overlay material. Of course, it was still necessary to cut considerably deeper in the places where the worst deterioration had occurred.

The cleaning was the most time consuming and expensive phase of the work. This included the use of: two Tennant routers to remove the undesirable surface of a concrete slab to a depth of from 1/4 inch to 1/2 inch in a 4-1/2 inch wide pass; one Triplex tamper equipped with three jackhammer drill bits;

conventional jackhammers for edging next to the curbs where a router could not reach; a sandblaster to remove paint and latex-cement slurry from the curbs and dirt and laitance from the sidewalks; stiff bristle street brooms and compressed air to remove dust and other debris. A concrete saw was also employed to cut expansion joints for filling with sealer.

The overlay material consisted of 1/2 inch of portland cement mortar containing experimental admixtures: Dow Latex 560 (saran, vinylidene chloride) and Dow Latex 2144 (a styrene-butadiene) (See Figs. 58 thru 61, Salt River Bridge, Kentucky Turnpike, October, 1960). These admixtures were acclaimed to improve the toughness of mortar and to greatly improve the bond strength between mortar toppings and old concrete. The Dow Company had agreed to furnish the latexes and sufficient epoxy resins to provide an epoxy-sand seal over the major portion of the mortar topping and to provide technical services during their application. The materials and preparations are listed in tabulations which follow. There also follows an accounting of estimated costs of the work. Figure 87 is a diagram which shows the location of the subject materials on the deck.

The appearance of the finished deck seems to be quite satisfactory. It is a tan color. The only seriously objectionable feature of the surface is the roughness in the east-bound lanes which was caused partially by attempts to strengthen

the epoxy-sand seal at the joints (See Fig. 99). Although templates were placed for the screed to travel on while placing the mortar topping, the mortar set very quickly and it was very difficult to smooth out any ridges that might have been left by manipulations of the screed. Curing was also rather critical -- drying shrinkage (cracks) developed unless the curing blanket was applied almost immediately following the screeding. Some of the flaws which contribute to the roughness are attributed to inadequacies in method of screeding and finishing.

Note: Comparative roughness ratings were obtained on the WB lane before any repair work was started and on the EB lane after completing the repair work (See Fig. 99). The WB lane rated 536 as compared to 811 for the EB lane (the higher rating indicates a higher degree of roughness; for further comparison of these ratings with respect to pavements in general, see: "Pavement Roughness Studies," by R. L. Rizenbergs, RHML, Vol. XVII, Part I, 1962, pp. 292.)

Descriptive photographs of the operations are given in Figs. 87 thru 100.

Mortar Mixes: Batch Quantities, Design Factors

Using Dow Latex X2144

X2144 Latex (Sp.G. 1.222).....	13.5 gal.
Cement (Type I) (Sp.G. 3.14).....	3 bags
Concrete Sand (River) (Sp.G. 2.64).....	65 gal. (bulk)
Diethylene Glycol (Sp.G. 1.118).....	2.5 qts.
Antifoam B .....	3 qts/bbl. of Latex
Water.....	Approx. 5 qts.

Percent Saran\* Solids, Dow Latex X 2144..... 50  
Saran Solids, % by weight of cement..... 24.4  
Ratio of sand to cement ..... 3:1  
Water - Cement Ratio, Theoretical..... 4.44 gal/bag

\* Vinylidene Chloride

Using Dow Latex 560

560 Latex (Sp.G. 1.01) ..... 10.5 gal.  
Cement, Type I (Sp.G. 3.14)..... 3 bags  
Concrete Sand (River)(Sp.G. 2.64)..... 65 gal.(bulk)  
Diethylene Glycol (Sp.G. 1.118)..... 2.5 qts.  
Antifoam B ..... 2 qts/bbl. of Latex  
Water ..... Approx. 8 qts.

Percent Resin\* Solids, Dow Latex 560 ..... 48  
Resin Solids, % by wt. of cement..... 15  
Ratio of Sand to cement..... 3:1  
Water-Cement Ratio ..... 3.24 gal/bag

\* Styrene-Butadiene

Epoxy Resin Proportions

Using Dow Epoxy Resin 331

D.E.R. 331 ..... 70 parts by wt.  
D.E.H. 14 (Versamid 140\*)..... 30 parts by wt.  
Xylol ..... 4 parts by wt.

\* General Mills

Using Dow Epoxy Resin X2679

D.E.R. X2679 ..... 70 parts by wt.  
D.E.H. 14 (Versamid 140\*) ..... 30 parts by wt.  
Xylol ..... 4 parts by wt.

\* General Mills

Cover Sand

Sewanee Silica Company, Sewanee, Tenn.; No. 6 (8 to 30 mesh,  
dustless).

Retention: Approx. 4 lbs./lb. of resin/sq.yd.) (See Fig. 100).



Resurfacing Costs

Materials Supplied by Dow

<u>Material</u>	<u>Quantity</u>	<u>Est. Unit Cost</u>	<u>Est. Total</u>
Dow Latex 560	33 Drums	\$4.60/gal.	\$8,349.00
Dow Latex X 2144	33 Drums	3.00/gal.	3,445.00
Antifoam B (Dow Corning)	1 Drum	4.71/gal.	259.00
Diethylene Glycol	5 Drums	1.00/gal.	275.00
Epoxy Resin X 2679	17 Drums	333.00/drum	5,661.00
Epoxy Resin 331	1 Drum	342.00/drum	342.00
Versamid 140	10 Drums	280.00/drum	2,800.00
Xylene	2 Drums	50.00/drum	200.00
Hydrochloric Acid	200 gal.	1.00/gal.	200.00
			<u>\$21,531.00</u>

Technical Services Supplied by Dow

Est. 64 Man-Days ..... (intangible)

Materials & Services Supplied by Sika

Igas Joint Sealer and Installation ..... (nominal)

Material, Equipment & Labor Supplied by  
Department of Highways

<u>Material</u>	<u>Quantity</u>	<u>Est. Unit Cost</u>	<u>Est. Total</u>
Cement	700 bags	\$1.00/bag	\$ 700.00
Concrete Sand	125 tons	4.00/ton	500.00
Sewanee Sand	25 tons	7.00/ton	175.00
Joint Sealer (Prestite)	1500 lbs.	.55/lb.	825.00
			<u>\$2,200.00</u>
Tennant Parts and Cutters.....			5,140.00
Misc. (Curing blankets, masonry saw blades, etc.)			2,160.00
			<u>\$7,300.00</u>
Labor (accepted 2-15-62).....			17,294.40
Equipment Rental, etc. (Accepted 2-15-62).....			7,921.05
Labor (Est. Appl. Epoxy Seal, Summer, 1962).....			3,500.00
Equip. ( " " " " " " ).....			1,050.00
			<u>\$39,265.45</u>

Technical Supervision (Research)

Est. 75 Man-Days ..... (intangible)

Estimated Total Cost of Work

Dow, Exclusive of Intangibles .....	\$ 21,531.00
Department, Exclusive of Intangibles.....	<u>39,265.45</u>
Grand Total (Estimated) ..	\$ <u>60,796.45</u>

References: "Latex Modified Portland Cement Mortar Renews Bridge Deck," Feature Article, Engineering News-Record, Sept. 7, 1961. (This is an account of the work on the Lake Cumberland Bridge during 1961. Photographs of the work and descriptions of the materials are included).

"Dow Latex 560 for Portland Cement Compositions," Bulletin Dow Chemical Company, Coatings Technical Service, Sept. 1959.

"Experimental Latex X-2144 Modified Portland Cement Mortars," A Technical Report (F 602), Dow Chemical Company, Coatings Technical Service.

"Resurfacing Concrete Bridge Decks with Dow Latex 560 Modified Portland Cement Mortar," A Technical Report, Dow Chemical Company, Coatings Technical Service, Feb. 1960.

"Latex Modified Mortar in the Restoration of Bridge Structure," S. M. Cardone, Chief, Maintenance and Operations, and M. G. Brown, Chem. Engr., Michigan State Highway Department; and A. A. Hill, Coatings Technical Service, Dow Chemical Company; Bulletin No. 260, Highway Research Board, 1960.

Note: Also refer to Ball's Fork Bridge MP 120-4, Russell Fork Bridge, MP 98-243-1, and to Railroad Overpass Beuchel; Daraweld (polyvinyl acetate latex) modified mortar overlays.

"Polyester Overlays for Portland Cement Concrete Surfaces," by L. E. Santucci, California Research Board, January, 1963.

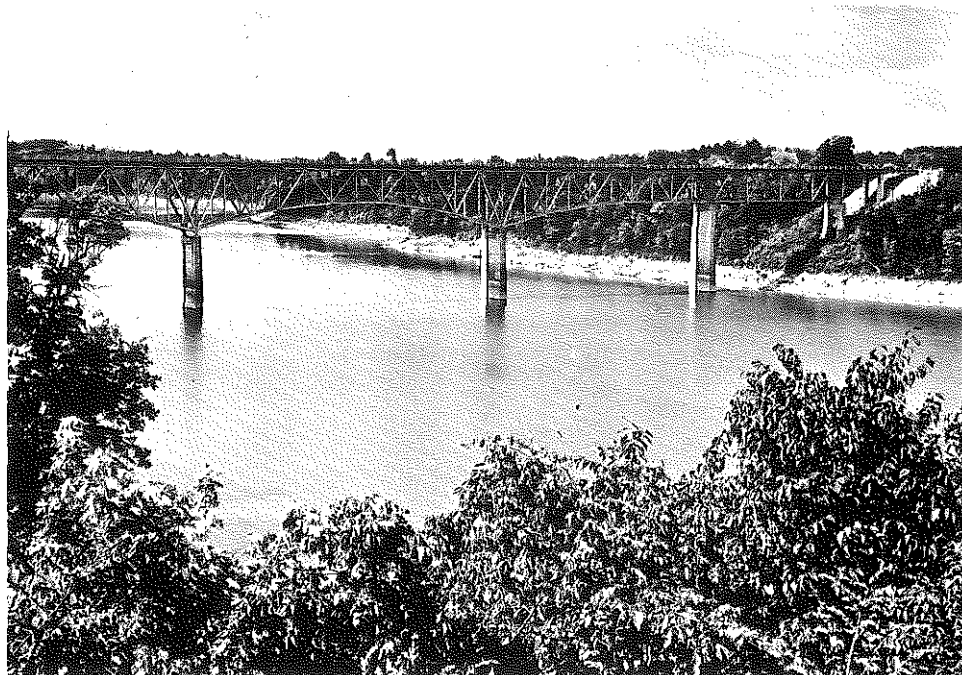


Fig. 83. Lake Cumberland Bridge, Ky. 90, Burnside-Monticello Road.



Fig. 84. Close-up View of Deck, Lake Cumberland Bridge. Note raveling and debris in gutter, 6-61.

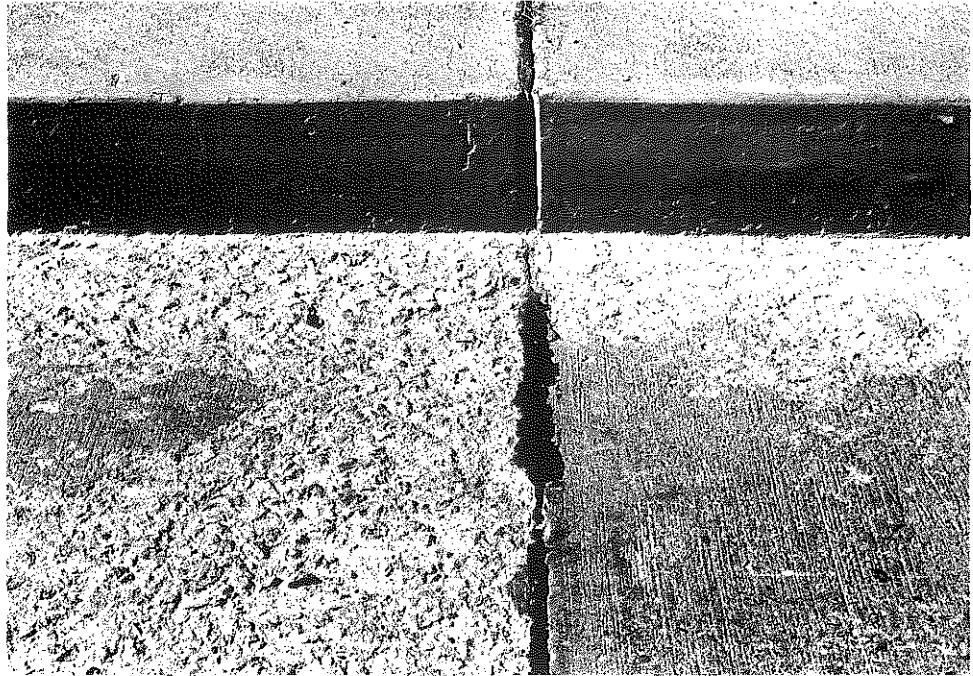


Fig. 85. Lake Cumberland Bridge; Showing Scaling on Corners of Adjoining Slabs.

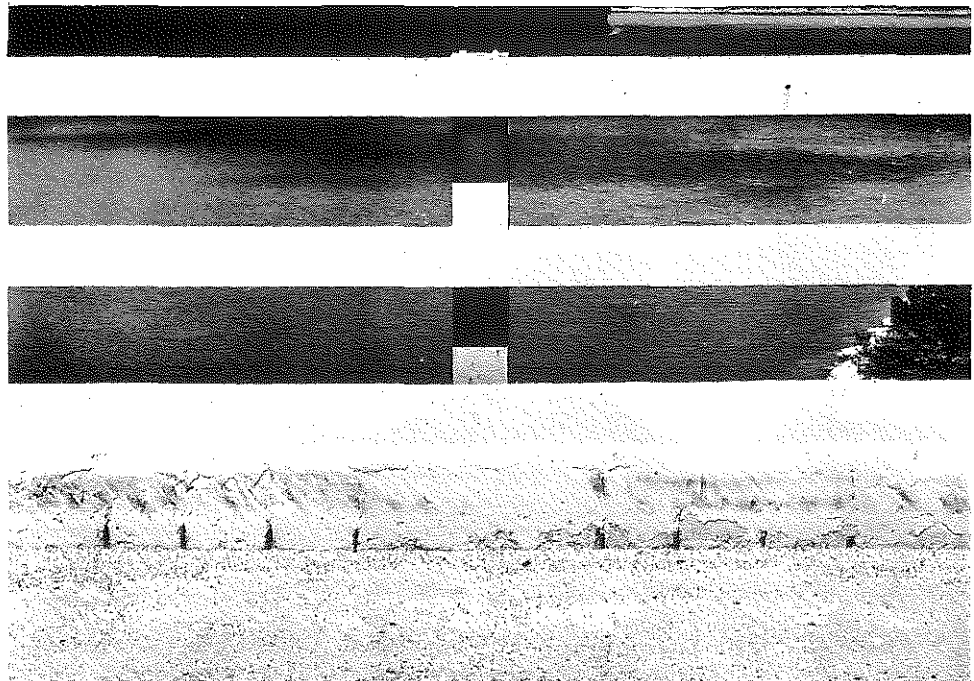


Fig. 86. Lake Cumberland Bridge; Showing Scaling Along Curb Wall and Exposure of Reinforcing Steel.

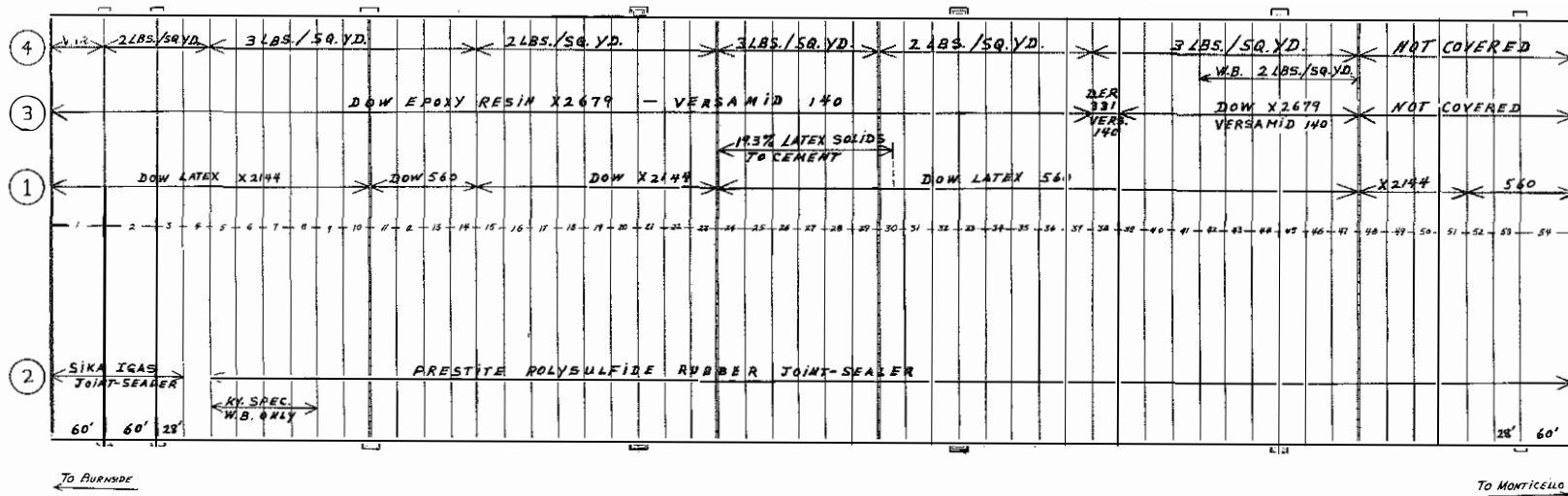


Fig. 87. Diagram of Lake Cumberland Bridge, Showing Location of Experimental Materials used in Resurfacing Deck. Although the eastbound lane (to Burnside) was completed and opened to traffic before work was started on the opposing lane, the lanes replicated each other in regard to apportionment and location of materials (exceptions are noted). Line 1, above, shows the portions (full width) of the deck in which the two latexes were used in the mortar topping (latex-modified mortars). Line 2, in the order of application, shows the location of joint sealers (full width, except as noted). Line 3 shows the scheduling (again full width) of epoxy resin seal materials, and line 4 shows their respective rates of application.

The application of latex-modified mortar began July 27, 1961, at the east end of the eastbound lane and the lane was completed September 5, 1961; the application of epoxy resin seal began September 11 (except for first 60 ft., east end, trial run, August 4), and was completed September 18; opened to traffic September 24, 1961. The application of latex-mortar in the westbound lane began at the west end October 16, 1961, and was completed October 19, 1961. Application of epoxy seal in westbound lane was deferred until June 21, 1962; completed June 28, 1962.

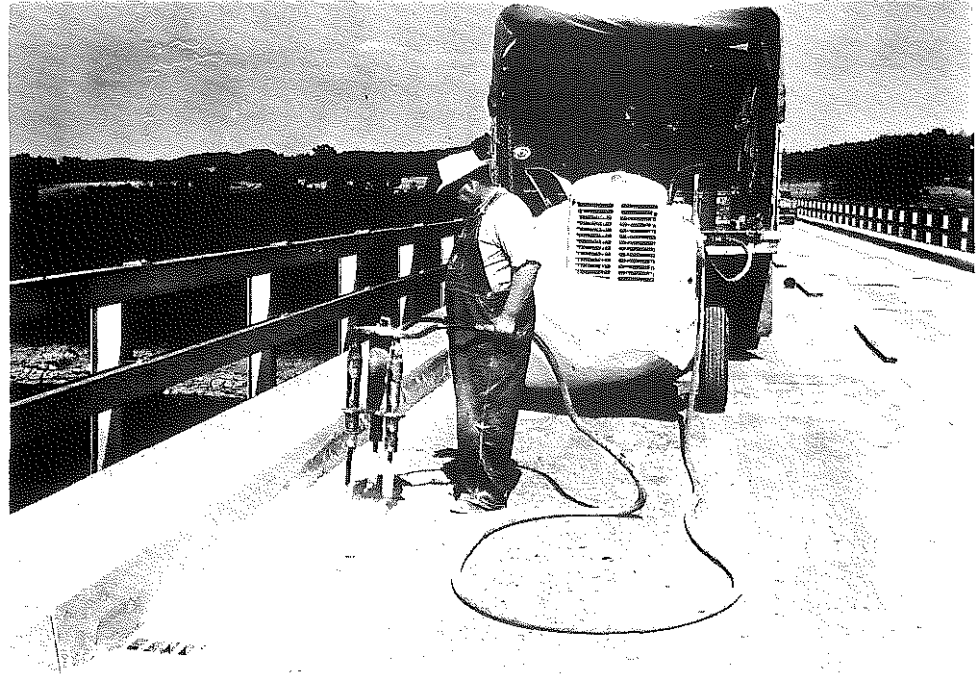


Fig. 88. Triplex Tamper Equipped with Star-Bits; Removing Unsound Concrete. Note diaper on air compressor to catch oil drippings.

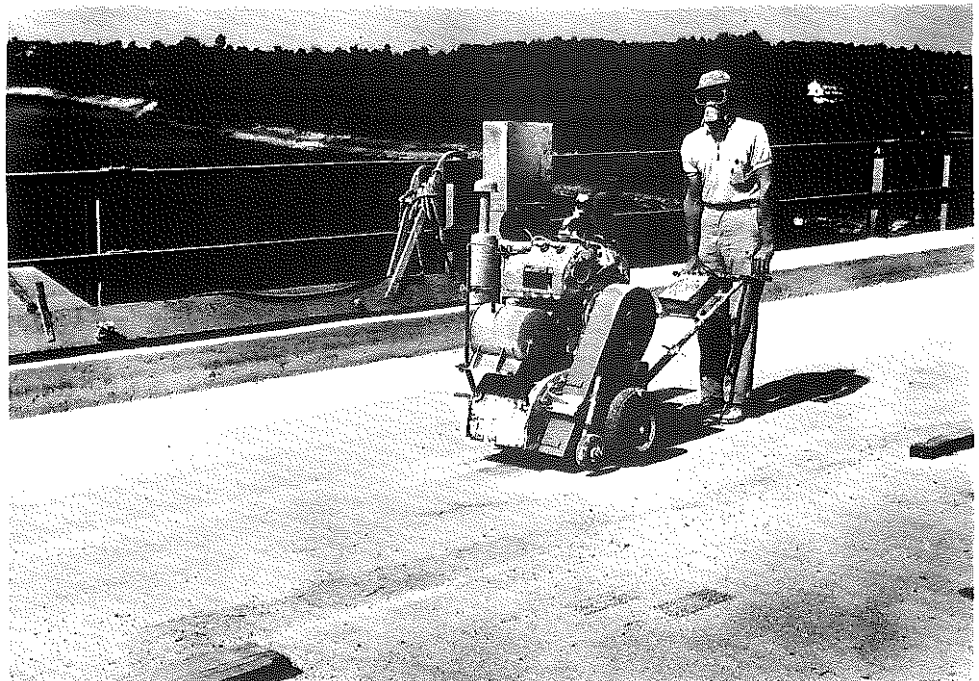


Fig. 89. Tennant Router used for Scarifying and Removing Dead Concrete.



Fig. 90. Lake Cumberland Bridge, Facing West. Foreground shows routed and scarified deck; background shows application of mortar topping; extreme background shows polyethylene curing-blanket. Left lane (eastbound) shows mortar overlay after curing and after epoxy-sand seal, open to traffic.

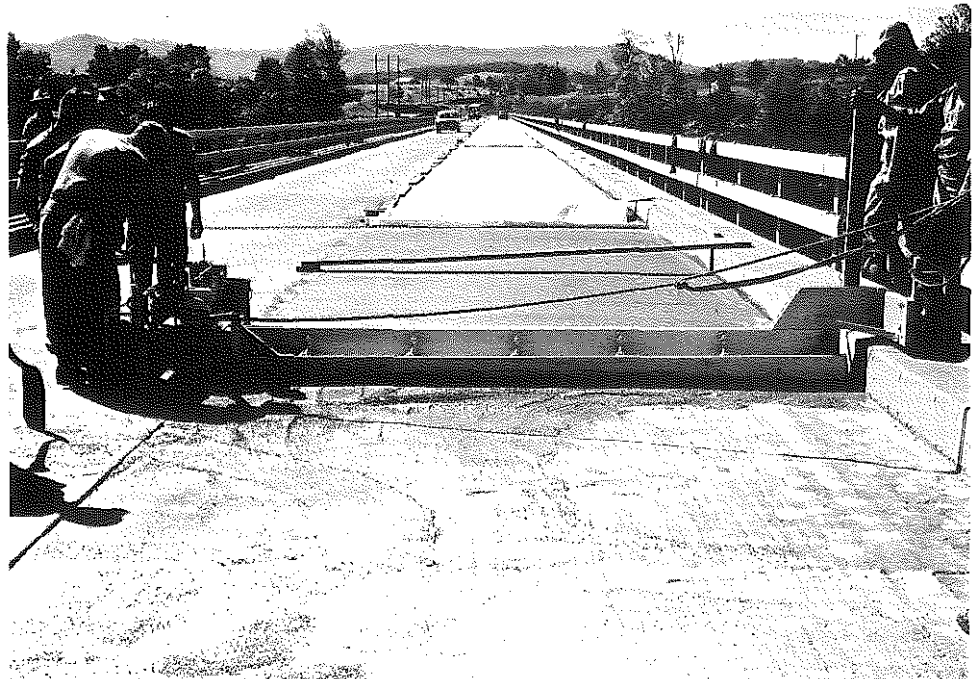


Fig. 91. Lake Cumberland Bridge, Same as Fig. 90, Showing Close-up View of Screeding Operations; Placing Mortar Topping. Concrete was wetted ahead and mortar was broomed into the old concrete ahead of the screed.



Fig. 92. Lake Cumberland Bridge, Over-all View, Facing East, Showing Joint-Sealing Operations in Eastbound Lane.

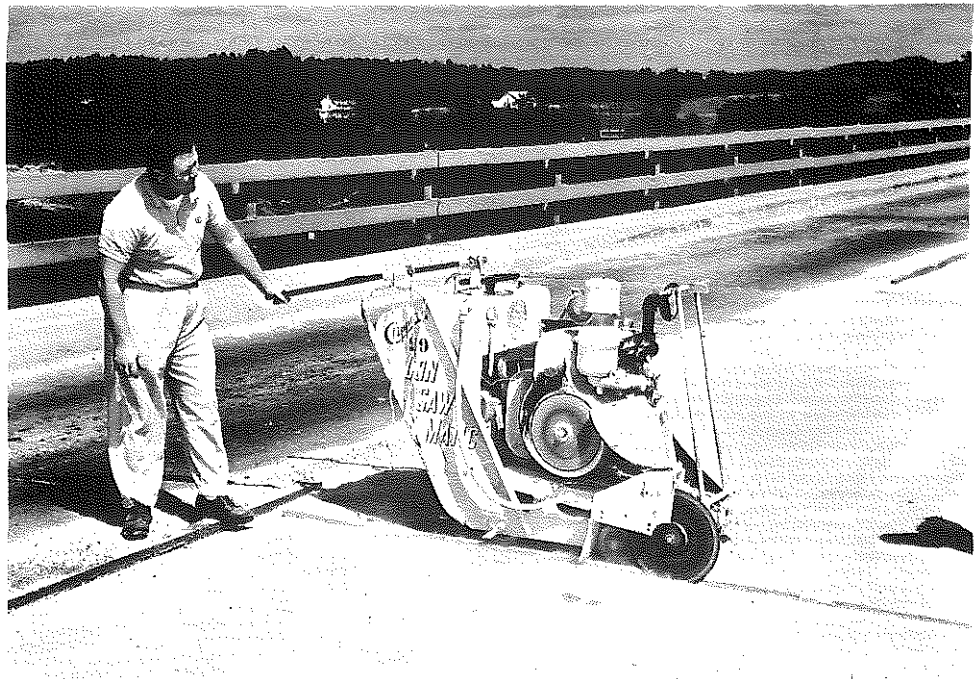


Fig. 93. Sawing out Wood Strips which were Placed in the Mortar Overlay to Preserve the Joints in the Deck -- to be Removed and Joints Resealed.





Fig. 94. Filling Joints with Prestite, No. 404, Pourable Joint Sealer (Two-Component, Polysulfide Rubber). Note: This material was later found to be reactive (de-polymerized, re-liquified) toward asphaltic materials. About 35 joints or portions thereof were reopened the following summer, 1962; sponge rubber inserts were installed in the joints to insulate new joint sealer from the asphaltic material below. The joints were repoured with the polysulfide compound.

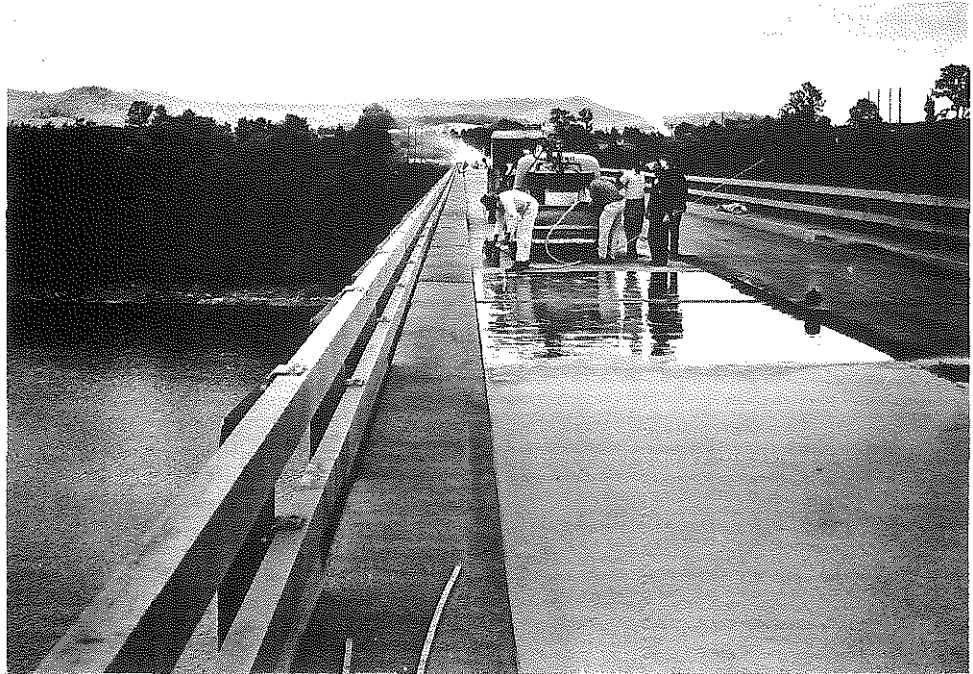


Fig. 96. Lake Cumberland Bridge, Facing East, Broadcasting Sand onto Newly Applied Epoxy Resin, September, 1961. Note: Curb and sidewalk section here were sandblasted and sealed with epoxy-sand ahead of the application to the deck -- elsewhere the two operations were carried along together.

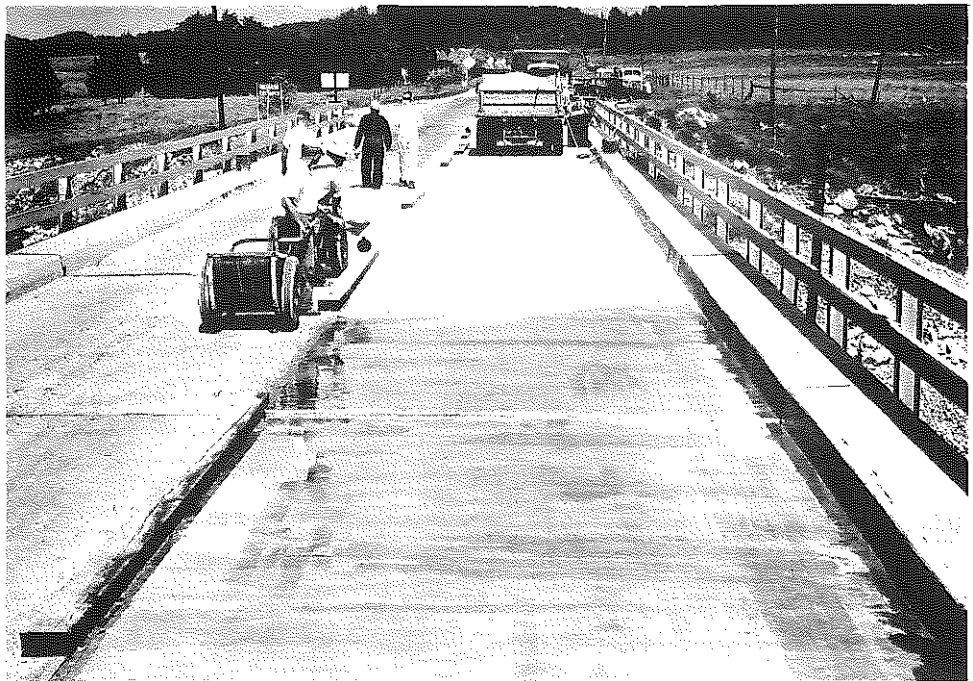


Fig. 95. Lake Cumberland Bridge, Facing West, Showing Application of Epoxy Resin to Mortar Overlay; Coarse Sand (from Sewanee, Tenn.) Applied in Foreground. Pyles mixing pump and drums of epoxy components were carried ahead in pick-up truck. September, 1961.



Fig. 97. Lake Cumberland Bridge; Eastbound Lane; Squeegee-Application of Dow 331 Epoxy Resin, September, 1961.



Fig. 98. Lake Cumberland Bridge; Westbound Lane, Facing East; Application of Epoxy Resin; Pyles Gun; Workman's Protective Suit Ventilated through Hose from Tanks of Compressed Breathing-air Carried in Truck. Wood laths were used as spacers to help gage application rate, July-August, 1962. Note: The latex mortar in this lane had been exposed to traffic through the winter sand blasting and other cleaning immediately preceded the application of epoxy.

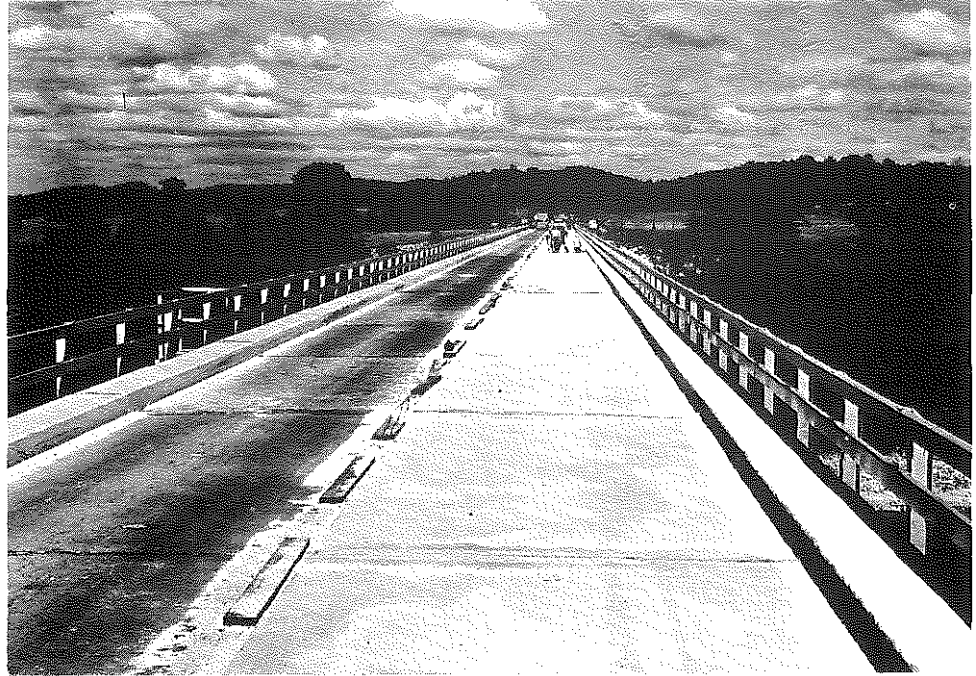


Fig. 99. Lake Cumberland Bridge; Eastbound Lane, Facing East; Showing Completed Surface before Brooming off Excess Sand. Note: Extra application of epoxy at joints caused thicker build-up and resulted in considerable roughness; westbound lanes (not surfaced in photograph) are noticeably smoother and joints there were not built up in this way.

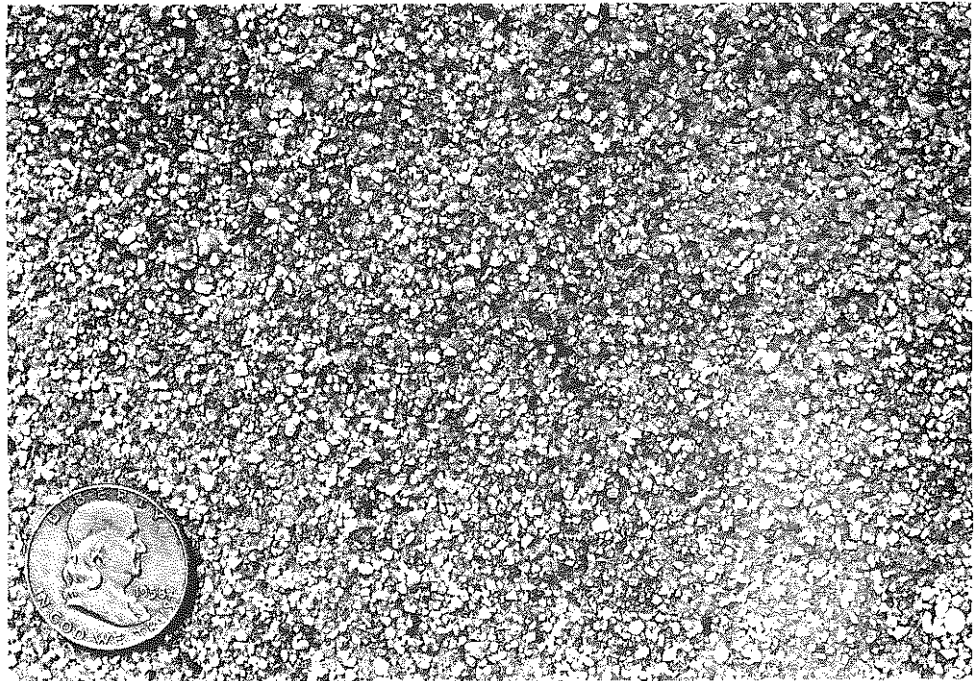


Fig. 100. Lake Cumberland Bridge; Close-up View of Epoxy-Sand Surface after Sweeping off Excess.

## SOUTHERN RAILROAD OVERPASS

Location: US 150, East City Limits of Danville

Project No.: MP 11-4300-OH1

Condition: Scaling and Deep Deterioration.

Repairs: Unsound concrete and bituminous patches routed out with air-hammers, holes cleaned with air-jet, and patches were made with Guardkote 140 (epoxy-tar) binder and sand. Patching was done in anticipation of applying a full epoxy-tar-sand seal, and components were purchased from the Permalistic Products Company, Detroit. Almost half of this material was used for patching in the late summer and fall of 1961. This patching was interrupted (Oct. 19, 1961) by cold weather and by the fact that the epoxy tar failed to set.

Mortar-patching, containing admixture of Berylex, continued until November 1, 1961. Cement slurry containing A/E Berylex was used as a primer coat, brushed in, and mortar toppings containing 1, 2 and 3 lbs. of Berylex per bag of cement were placed near the east end of the bridge, extending 215 ft., and in the westbound lane near the west end, first 10 slabs.

Epoxy-tar patching was resumed in late July, 1962, and a portion of the surface was sandblasted in preparation for sealing. A short section of the seal was applied, and it failed to set up. Three drums of the B-component were returned to the Permalastic Company and replaced. Meanwhile, traffic tracked considerable asphaltic material onto the deck from nearby resurfacing work. Work was deferred indefinitely, and the bridge has since passed another winter. Sufficient

materials are on hand for the completion of the seal -  
provided that extensive additional patching will not be  
required.

The present condition of the deck is shown in Figs.  
101 and 102.

## FIVE, FRANKLIN COUNTY, BRIDGES

Location: I-64, Westbound from US 127

Project Nos.: MP 37-905-HG6, over Cardwell Lane  
MP 37-905-HG4, over Evergreen Road  
MP 37-905-3, over South Benson Creek  
MP 37-905-HG2, over Alton Road  
MP 37-905-1, over Benson Creek

Constructed: 1960

Condition: Decks showed early stages of scaling.

Treatments: August 14-17, 1962. These bridges were selected because

of their age and close proximity to the Central Office -- not necessarily because of degree of deterioration. The coating materials used were considered to be experimental, although all had been widely acclaimed as concrete coatings and sealers. Each represented a category of coating materials in which application and performance experiences were sought. All of the coatings were applied by brooming and squeegeeing. No grit or sand was applied. The following list gives the identification of the coating materials and the bridge to which they were applied. Figures 103 to 113 are photographs of the respective bridges.

1. MP 37-905-HG6. Geo. W. Whiteside Company's 56-E-2 (polystyrene in coal tar solvents), concrete hardener; 0.072 to 0.087 gal/sq.yd.; applied with a bristle broom; 42 gal. used, two of which were applied to curb-section. Note: This material was used two years previously on the northern-most 3/4th of the southbound lanes of the St. Catherine Street Bridge on the North-South Expressway in Louisville; material furnished at no charge quoted price is \$2.25/gal. (quick drying).

2. MP 37-905-HG4. Linseed Oil (50%) and mineral spirits (50%), no driers used; furnished and applied by the Department; 45 gal. of the blend used; application was 0.081 to 0.092 gal./sq.yd. (slow drying), linseed oil approximately \$1.75 per gal., mineral spirit \$0.40 per gal.

3. MP 37 905-3. Guardian Chemical Company's Clear Bond, concrete hardener (styrene-butadiene in solvent); broomed on, 0.075 to 0.086 gal/sq.yd., 56 gal. used; although furnished without charge, the current quoted price of this material is about \$3.00 per gal. (quick drying).

4. MP 37-905-HG2. 15% solids, epoxy (2-component), in Xylol; material supplied at no charge by CIBA and H. B. Fuller Company, blended on job, applied by brooming, quick drying, 67.5 gal. used, 0.119 to 0.136 gal/sq.yd., estimated cost \$3.23 per gal.

(Note: A 2-component epoxy-polysulfide, Geo. W. Whiteside, J-151-40, was used on the southern-most 1/4th of the southbound lanes of the St. Catherine Street Bridge (N-S Expressway) about two years ago. This material contained 40% resin solids).

5. MP 37-905-1. Koppers Company's concrete sealer, 100% coal tar oils, non-drying, penetrating, 57 gal. used, 0.056 to 0.062 gal/sq.yd., applied by brooming, this material would be nominally cheaper than others, but produces objectionable darkening of the concrete, joint sealer tends to soften, and materials tend to be tracked onto abutting pavement; furnished without charge.



The last of the five bridges was coated August 17, 1962. Slipperiness tests (British Pendulum) were made immediately, and these tests indicated that the two bridges coated with styrene-type materials and the one coated with the epoxy were seriously slick. They were tested again on August 27, and the situation had not improved. This led to a decision to scatter loose, abrasive sand on these bridges during the first following period of wet weather; this was on September 14. On September 27, slipperiness tests were made again, and the skid-resistance of the two styrene-coated bridges had improved considerably; but the epoxy-coated deck remained unchanged. This seems to imply a serious objection to the epoxy-type coatings unless fine abrasive sand is incorporated into the coating film at the time of its application. This might well dispel all objections to both the styrene and epoxy materials. It further appears that this might permit the application of one or more base coats of these materials -- which, as in the case of linseed oil, seems to be needed for full protection of the concrete. Slipperiness tests were made again on December 18, 1962, and considerable improvement was noted on all of the bridges. The Alton Road bridge (epoxy coating) had recovered to a normal level of skid resistance over the major portion of the surface, although there were spots where the thick build-up of the coating remained; and these were still very slick.

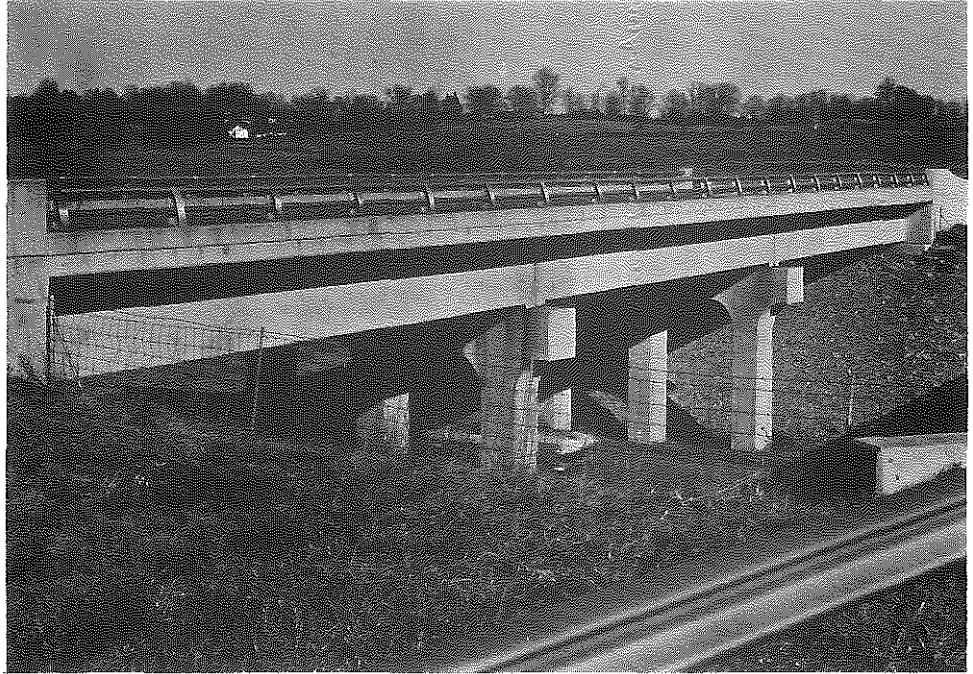


Fig. 103. Cardwell Lane Bridge, I-64, Westbound, MP 37-905-HG6; Oblique View, Facing Eastwardly.

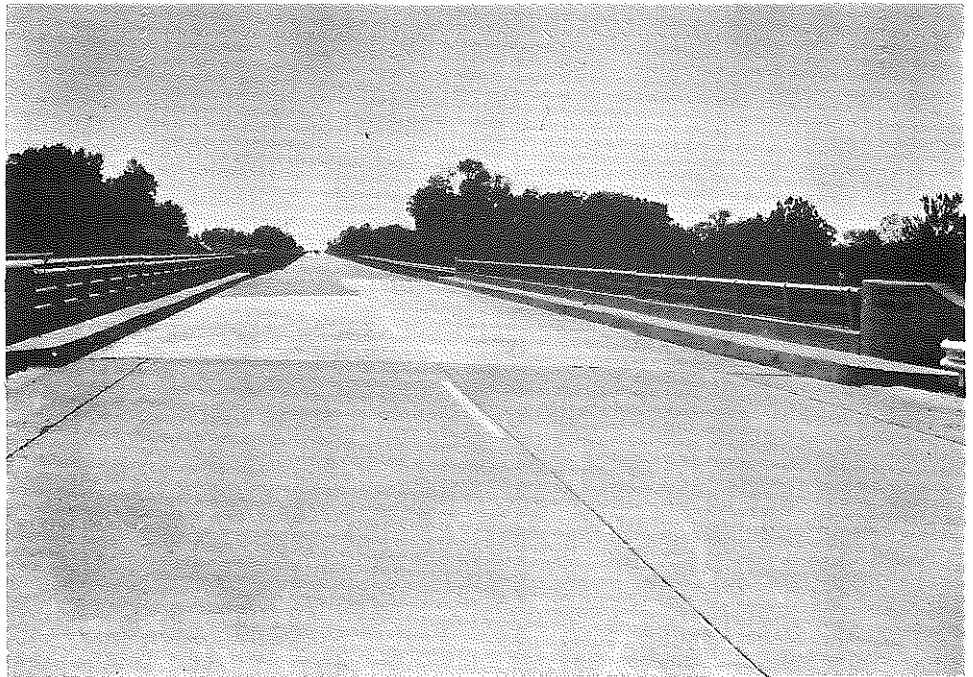


Fig. 104. Cardwell Lane Bridge Above; Facing West; Geo. W. Whitesides' S6-E-2, Polystyrene Coating, Unfinished Here. Coating was completed a short time after photograph was taken.



Fig. 105. Evergreen Road Bridge, I-64, Westbound, MP 37-905-HG4; Oblique View, Facing Eastwardly.

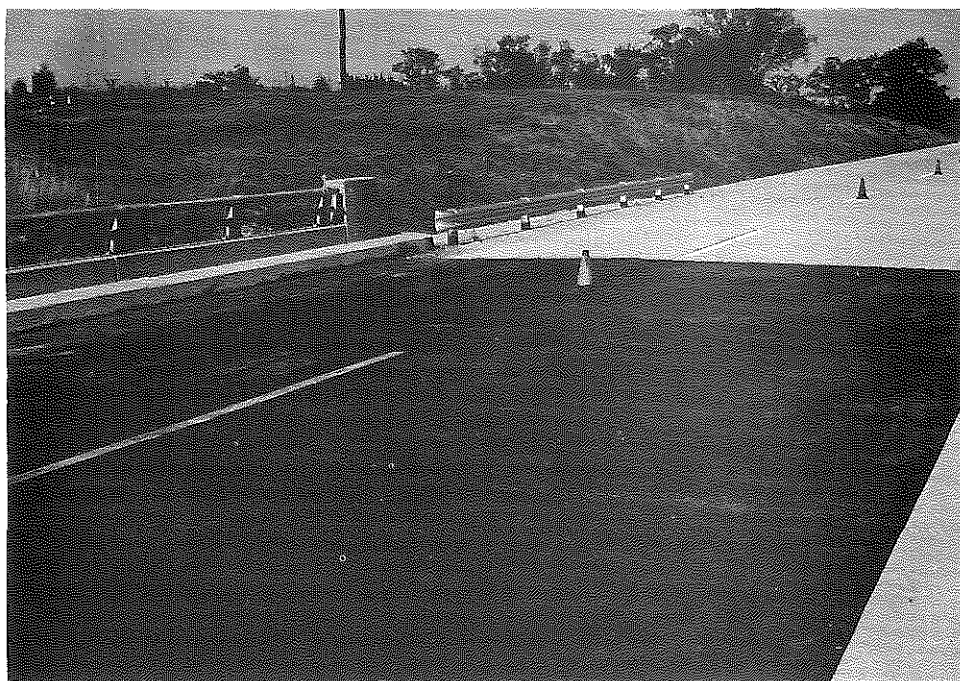


Fig. 106. Evergreen Road Bridge Above; Facing East (Showing East End of Deck); Linseed Oil Treatment. Deck appears much darker here than it actually was when the photograph was made. The coloration now is hardly noticeable. Note two transverse lines of scaling which conform to the positions where pipe templates were removed.

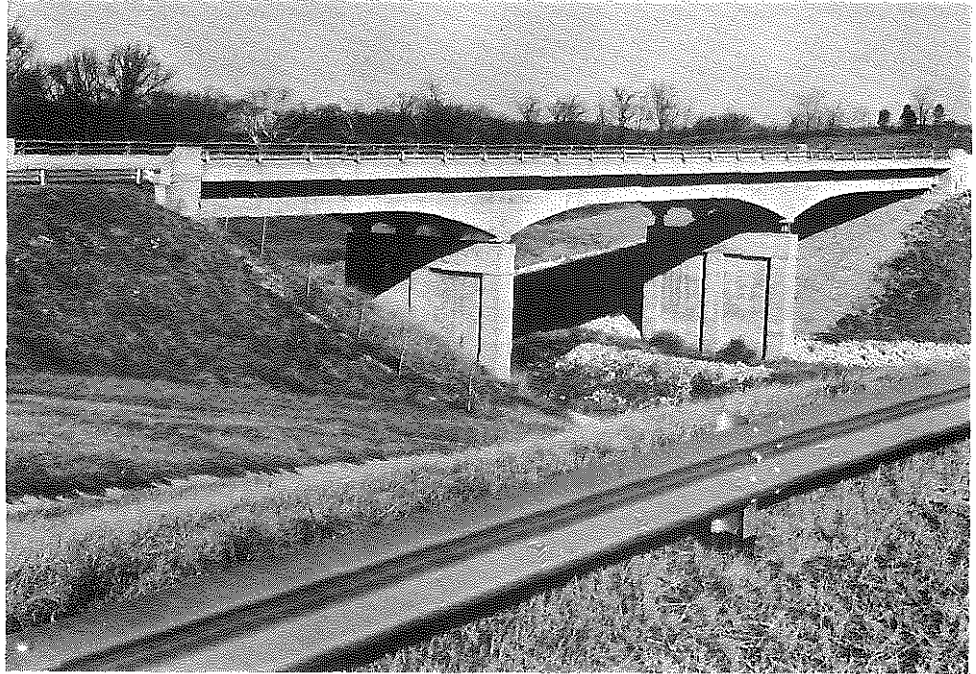


Fig. 107. South Benson Creek Bridge, I-64, Westbound, MP 37-905-3; Oblique View, Facing Eastwardly.



Fig. 108. South Benson Creek Bridge Above; Facing West; Guardian Chemical Company's Clear Bond (Styrene-Buladiene), Unfinished Here, Finished Later. Note scaling in left lane and transverse cracks conforming to construction joint and position of screeding templates.

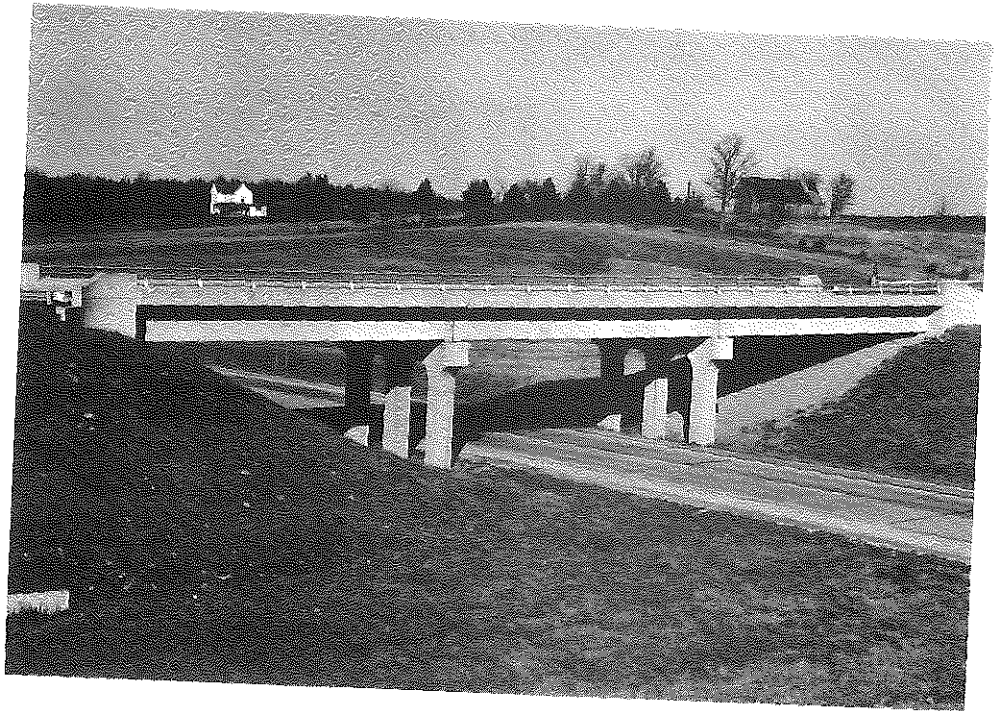


Fig. 109. Alton Road Bridge, I-64, Franklin County, Westbound, MP 37-905-HG2; Oblique View, Facing Eastwardly.

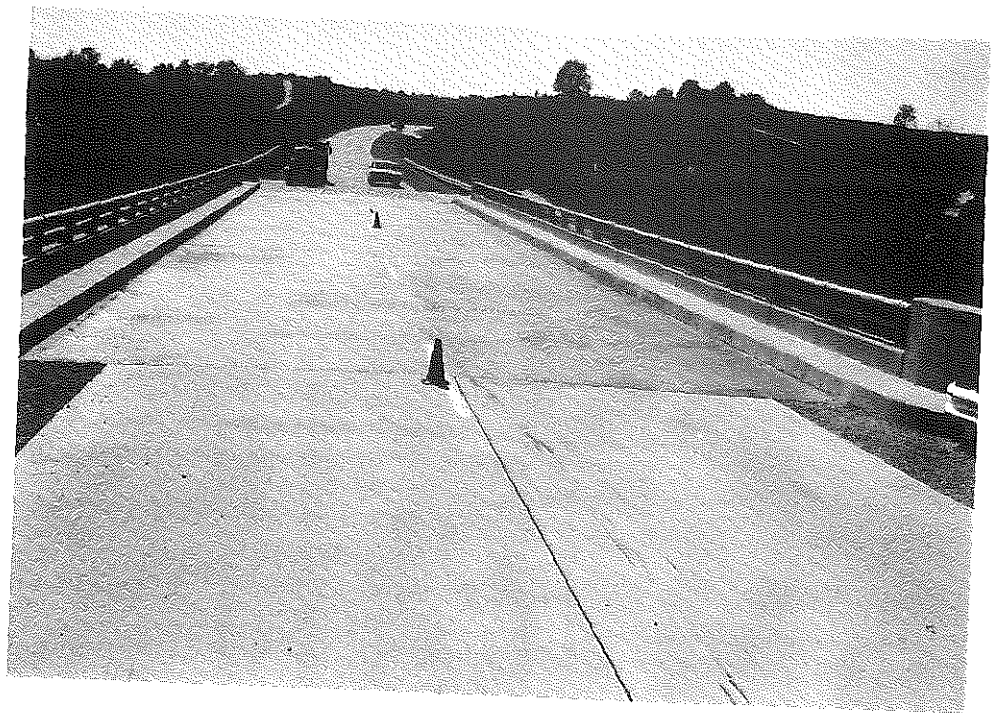


Fig. 110. Alton Road Bridge Above, Facing West. Treatment: 15% solids epoxy resin (dispersed in aromatic solvent), applied by brooming. Note again the effects from the screed template.

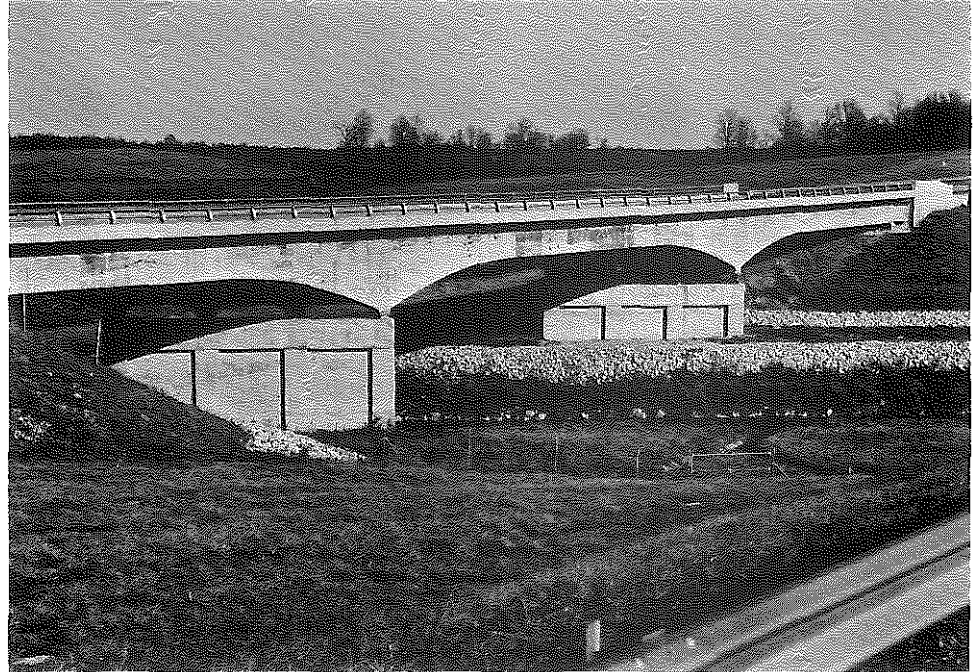


Fig. 111. Benson Creek Bridge, I-64, Westbound, MP 37-905-1; Oblique View, Facing Eastwardly.

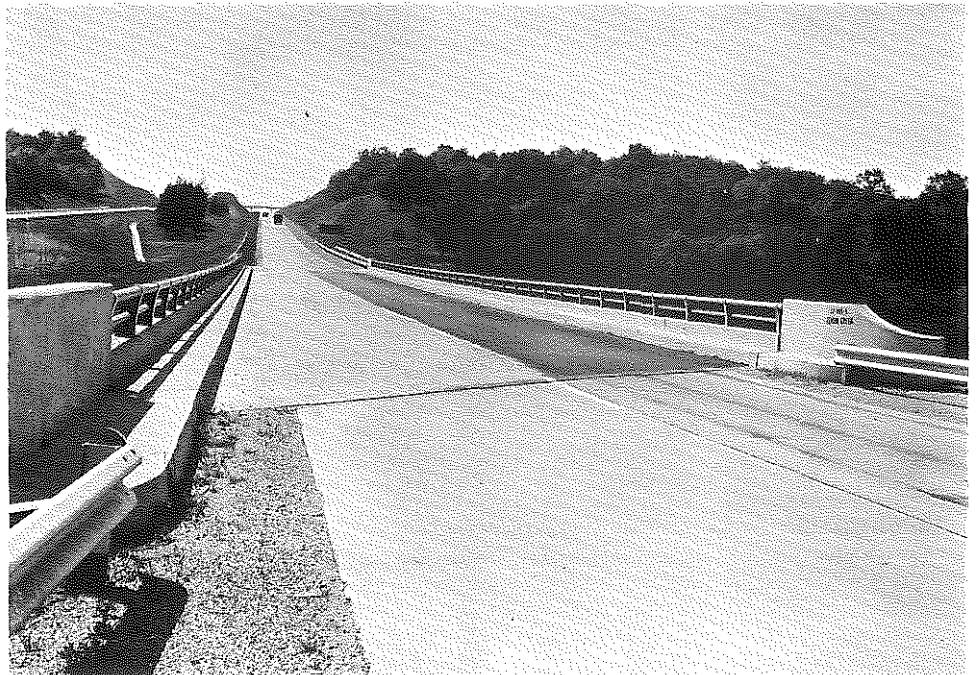


Fig. 112. Benson Creek Bridge Above, Facing West. Treatment: Kopper's (Coal Tar Oil) Concrete Sealer. The material was almost pitch-black when applied (applied to inner lane on following day). The material also tracked onto the pavement beyond the bridge, but it wore off rather quickly and the coloration has subsided considerably.

## OWENSBORO BRIDGE

Location: Ohio River

Project No.: MP 30-737-1

Constructed: WPA & Owensboro Toll Bridge Commission 1940,  
Accepted by State in 1954.

Condition: Scaling and rather deep deterioration on deck.

Repairs: Oct. 1962. Unsound concrete was routed out with air-hammers, holes were cleaned with an air-jet and patches were made with Guardkote 140 (epoxy-tar) binder and coarse silica sand. Entire deck was scrubbed three times with detergent, rinsed, etched with 15% HCl, and rinsed three times. After drying, 3.3 lbs. per sq. yd. of Guardkote 140 was applied through a Broyhill distributor, and this was followed immediately by an abundant application of white silica sand (Flaherty spreader). After about four hours the excess sand was swept up and removed. The application was made in the southbound lane on October 11, 1962, and in the northbound lane on the following day.

The patching, washing and rinsing and the application of sand were all performed by maintenance crews; and the application of acid and epoxy-tar was performed by the contractor -- these materials furnished by the contractor. The sand and other materials were furnished by the Department. The cost of the contracted operations was approximately \$10,200.00 (approx. \$3.00/sq.yd., 3,370 sq. yds.). The total unit cost, including patching and other work performed by the Department was approximately \$4.30/sq.yd.

Figures 113 through 118 are photographs which show the major operations performed.



Fig. 113. Owensboro Bridge (Ohio River); Facing North; Showing Application of Acid and Scrubbing. This treatment was preceded by washing with detergents.



Fig. 114. Owensboro Bridge, Above, Showing First Rinse; Followed by the Additional Rinses.





Fig. 115. Owensboro Bridge (Ohio River), Facing North; Showing Acid-Treated, Rinsed, Dried Deck (Left Lane) Ready for Application of Epoxy-Tar Seal. Note extensive patching (epoxy-tar binder in patch material). Patching was done by maintenance crew; acid-treatment and application of resin was done by contractor.



Fig. 116. Owensboro Bridge; Application of Resiweld Guardkote 140 (H. B. Fuller Company), Through Mixing Distributor; Application Rate, 3.3 Lbs. Per Sq. Yd. Note polyethylene sheet in foreground (for starting), followed immediately by application of sand.

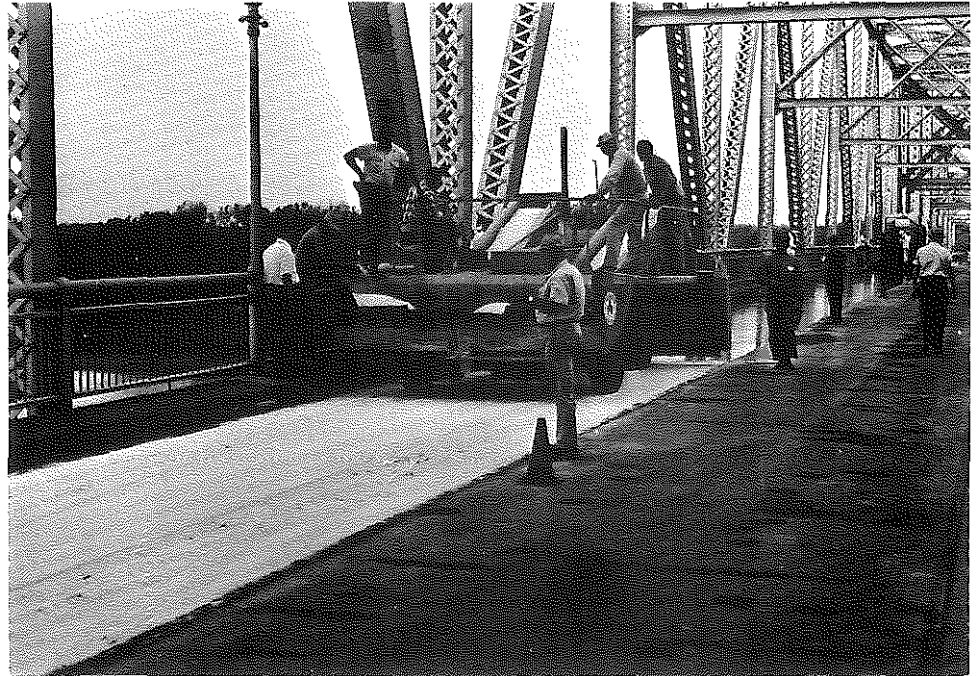


Fig. 117. Owensboro Bridge, Facing North, Application of 8- to 30-Mesh Sand (Sewanee, Tenn.), Immediately after Application of Binder. Sand was spread in great abundance (Flaherty Spreader). Wheels of spreader left tire marks in finished surface. The northbound lane was compacted with a light-pneumatic roller which smoothed out most of the spreader marks and improved retention of the sand.



Fig. 118. Owensboro Bridge (Ohio River); Completed Seal, After Brooming-Up Excess Sand and After Opening to Traffic. Note the absence of tread marks in the right-hand lane.

## BIG EDDY ROAD BRIDGE

Location: I-64, Franklin County (Eastbound)  
Project No.: MP 37-905-HG8  
Constructed: 1960  
Type: Reinforced concrete deck girder, three simple spans  
(See Fig. 119).  
Treatment: A rigid insulation of the polyether-type, self-extinguish-  
ing urethane foam was applied to the underside of the bridge  
deck. The urethane was applied by spraying on October 16-19,  
1962, as shown in Fig. 121. The accompanying photographs show  
some of the spraying work and equipment. The material was  
furnished and applied by the Dow Chemical Company.

Instrumentation: Thermocouples were installed in the center span of the  
bridge and in the approach slabs as indicated in Fig. 123.  
These thermocouples are connected to a 12-point temperature  
(Micromax) recorder. The temperature data will be analyzed  
by comparing differentials in temperature between the insulated  
and un-insulated sections and the approaches.

Objective To determine if the urethane foam is effective in:  
of 1. Equalizing deck and approach-slab temperatures so that  
Study: icing occurs at both locations at approximately the same time,  
and  
2. Reducing the number of freeze-thaw cycles to which the  
bridge deck is subjected.

A single temperature cycle, which was transcribed from  
monitored records, is shown in Fig. 124.

Note: Treated with linseed oil, two coats, 12-5-62.

References; "Urethane Foam Insulation for Bridge Decks," by H.B. Brittan, Sr. Structural Specifications Writer, New York State Department of Public Works, Albany; Highway Research Abstracts, Vol. 31, March, 1961.

Reports the use of foam insulation, Sept. 7, 1960, southbound structure, West Main Street Separation, I-81, Watertown, N. Y.; report indicates a reduction in number of salt applications and in number of freeze-thaw cycles.

"Progress Report of Effect of Insulating the Underside of a Bridge Deck," by E. O. Axon and R. W. Crouch, Missouri State Highway Department, Presented at the 42nd Annual Meeting of the Highway Research Board, Jan., 1963.

Urethane foam, 3/4 in. in thickness applied on one of twin bridges (No. A-153, I-70, Cooper County, Mo., Nov. 1961). Thermistors installed and temperature recorded thru April, 1962. Interpretation of data by the authors attribute great advantage to insulation -- that is, in reducing the number of cycles of freeze-thaw.

"Research Planned to Study Effect of Insulation on Bridge Icing," by Louis M. Bjorn, Bridge Engineer, Vermont Department of Highways, Better Roads, Sept., 1962, p. 31.

A report of planned work; I-89, bridge over Winooski River in Montpelier; temperature recordings expected to be started October 1, 1962.

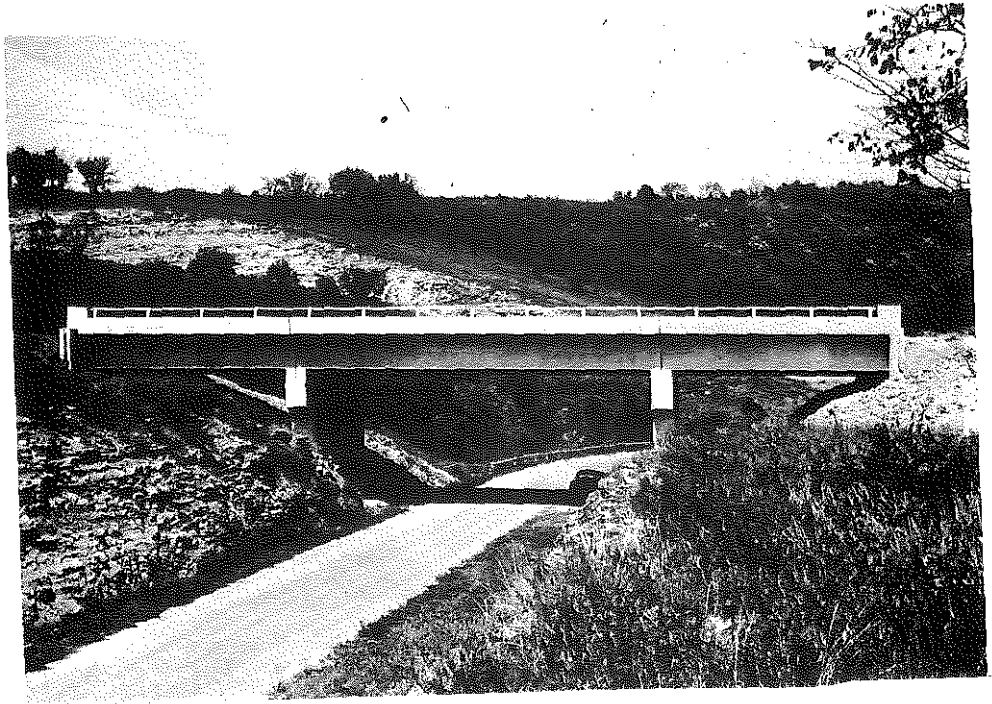


Fig. 119. Big Eddy Road (or Old Johnson Road), I-64, Eastbound Bridge.

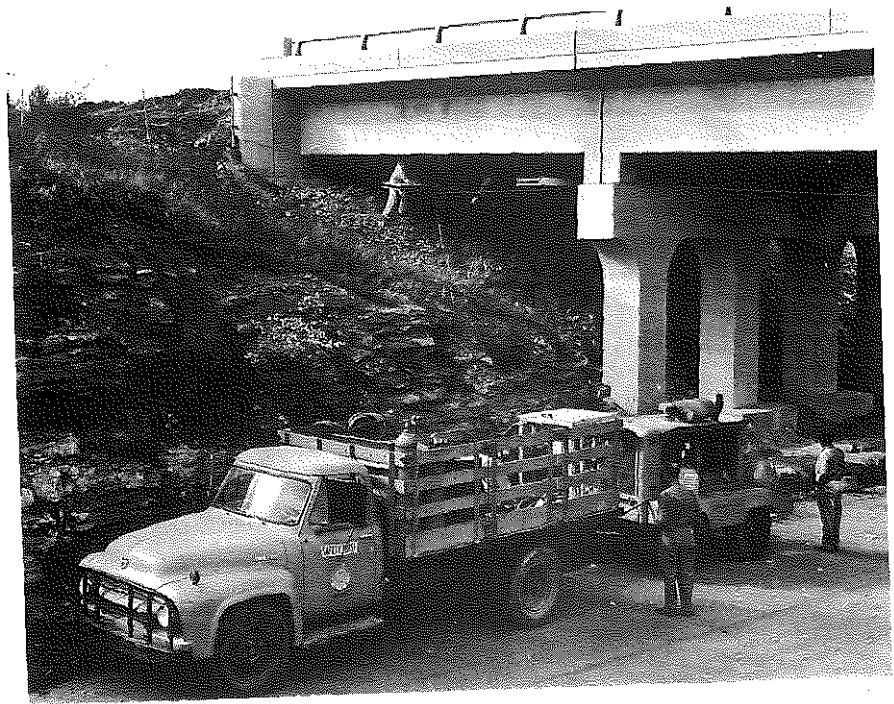


Fig. 120. Equipment used to Apply Urethane Foam; Air-Compressor, Mixing Pump (2-Component Resin), Spray Gun and Lines. Drums of the resin components are in the truck, 10-16-62.

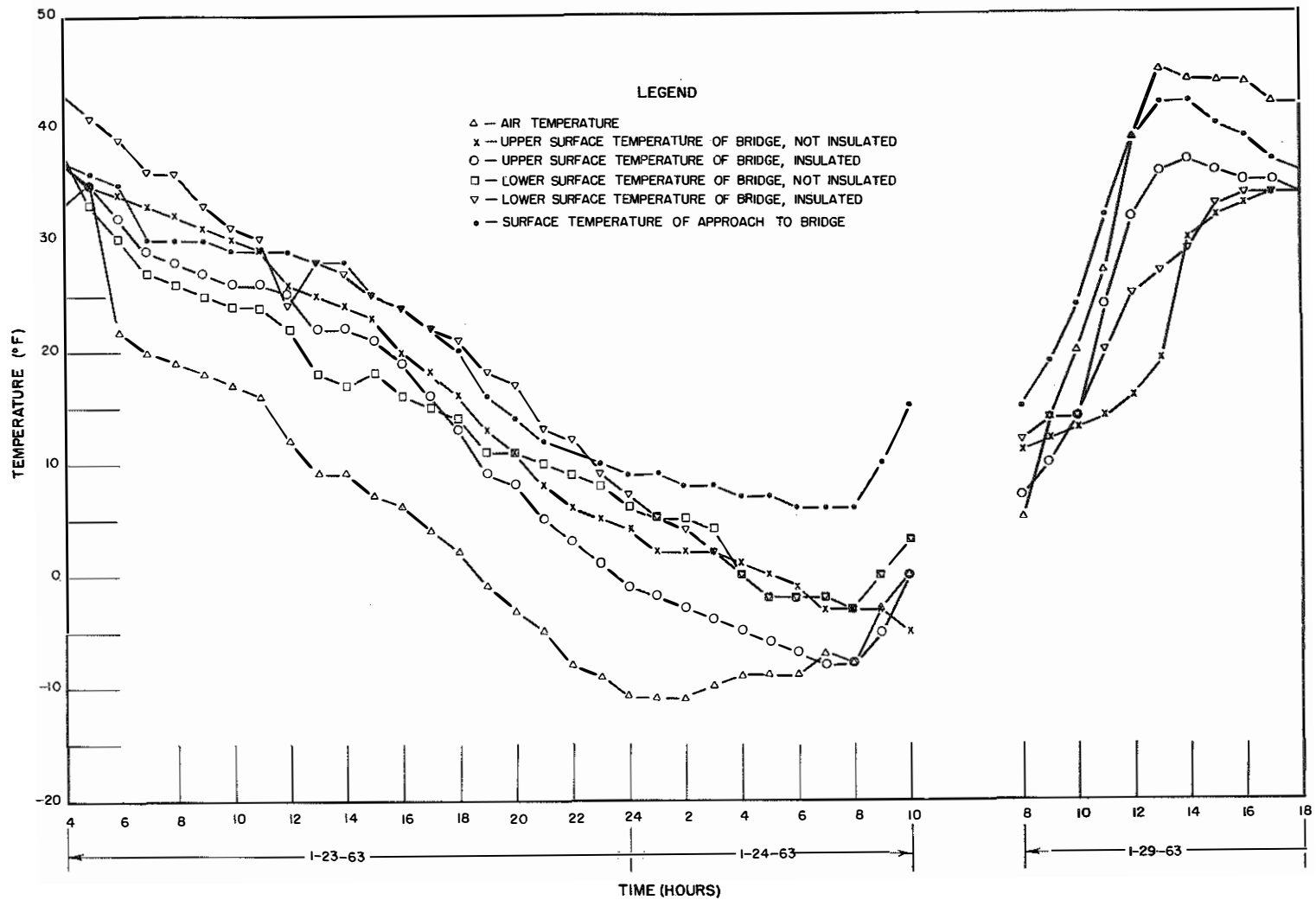


Fig. 124. Graph Showing a Single Temperature-Cycle; Transcribed from Monitored Record.

## KENTUCKY RIVER BRIDGE

Location: I-64, Franklin County (Eastbound)

Project No.: I-64-4(8)54

Constructed: New (Refer to Fig. 4; Method of Finishing Concrete).

Treatment: December 1, 3 and 4, 1962. The deck was completed in early October. Growing interest in protective treatments -- arising perhaps from previous experimental applications -- immediately west of Frankfort on I-64 -- led the Department to negotiate with the contractor for linseed oil treatment of this bridge. Estimates based on experiences elsewhere and on values suggested by the National Flaxseed Processors Association (\$0.03 per sq. yd., RMC; and \$0.03 per sq. yd. for application ; coverage of 40 to 50 sq. yds. per gal. of cut oil; 50% boiled linseed oil, 50% mineral spirits) were in the order of \$0.08 per sq. yd. This estimate was somewhat conservative inasmuch as the two-coat application cost of a considerable quantity of work in Illinois in 1962 was \$0.08 per sq. yd. (see reference). Failing to obtain a satisfactory price for the work from the contractor, the Department elected to apply the treatment with its own forces. In anticipation of contract work of this kind, the following Special Provision for Linseed Oil Protective Coating was drawn up.

Figure 125 shows the application, by spray, to the deck (deck was seemingly dry, although fog shrouds the background).

The plinth was coated by brushing. The rate of application varied from slightly less than one gallon per 50 sq. yds. to as much as 1.8 gal. per 50 sq. yds.-- as needed to provide ample coverage.

The Big Eddy Road Bridge in the background of Fig. 125 and in Figs. 126 and 127 was treated at the same time as the Kentucky River Bridge. Also, but not shown, the bridge over old US 127, now Ky. 420 (eastbound), immediately west of the Big Eddy Road Bridge was treated. Although treatments were scheduled for each companion (westbound) bridge, cold rainy weather delayed the work.

Subsequent to the above treatments, bids were invited on linseed oil protective treatments on the following projects (Feb. 15, 1963, Letting):

Perry County, F 102(14), SP 97-162; Campton-Hazard Road (Combs to Watertown) 8239 sq. yds.

Anderson County, RS 3-871; Cedar Creek Bridge (Stringtown-Tyrone) 805 sq. yds.

Fleming County, RS 35-990; Hunt Oakley-Storey Branch Road, 327 sq. yds.

Fayette County, I-75-4(14)104, SP 34-744; between Athens-Boonesboro Road and US 60, 6847 sq. yds.

Whitley County, I-75-1(6)4, SP 118-350; Saxton-Pleasant View, 3500 sq. yds.

References: "Linseed Oil Treatment on Bridge Structure," Henry E. Diers, Engr. of Maintenance, Illinois Division of Highways, Public Works, February, 1962, p. 115.



Approximately 1400 bridges were treated by Department forces in 1962; 58,025 gallons of boiled linseed oil used; applied in two coats (not more than 50 sq. yds./gallon; 0.02 gal./sq.yd.); labor cost \$0.08 per sq. yd.; material \$0.033 per sq. yd.; spec. requires concrete to be at least 14 days old; adequate drying between coats (48 hours); traffic withheld until tack-free.

"Effects of De-Icing Chemicals on Structures," a Symposium HRB, Bulletin 323, 1962.

"Protection of Existing Concrete Pavements from Salt and Calcium Chloride," Concrete Information Sheet (Highways & Municipal Bureau), Portland Cement Association.

COMMONWEALTH OF KENTUCKY  
DEPARTMENT OF HIGHWAYS

SPECIAL PROVISION

FOR

LINSEED OIL PROTECTIVE COATING

This Special Provision covers the material requirements and application procedures for a linseed oil-petroleum spirits mixture to be used as a protective coating for designated surfaces of concrete structures. This Special Provision shall be applicable to individual projects only when indicated on the plans, in the proposals, or in bidding invitations.

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I. DESCRIPTION

This work shall consist of the preparation of the surfaces to be treated, and furnishing and applying the materials, in two applications, as hereinafter specified.

II. MATERIALS

The protective coating mixture shall consist of 50 per cent boiled linseed and 50 per cent petroleum spirits by volume. The linseed oil shall comply with A.A.S.H.C. Specification M 126, except that the specific gravity shall be not less than 0.932. The petroleum spirits (mineral spirits) shall comply with A.A.S.H.C. Specification M 128.

III. APPLICATION

The protective coating shall be applied to the entire top surface of the bridge deck, the faces and top surfaces of curbs, the top surfaces of sidewalks, and the top and inside vertical surfaces of plinths or sidewalk parapets.

The concrete shall be at least 14 days old before the first coating is applied.

The concrete surfaces shall have at least a 48 hour drying period just prior to the application of the mixture and shall be cleaned of all oil, grime, and loose particles which will prevent the mixture from penetrating the concrete. Immediately before the application of the mixture, an air blast shall be directed over the surfaces to be treated so that all dust will be removed.

Each coat shall be applied by spraying at a rate of application not to exceed 50 square yards per gallon of the mixture. The spray nozzles shall be within 18 inches of the concrete or as otherwise directed by the Engineer. Hand methods may be permitted. The interior of the equipment shall be thoroughly cleaned prior to placing the mixture therein.

Unless otherwise directed by the Engineer, the temperature of the concrete and air shall be 50 degrees F. or higher at the time of application.

The second application of the protective coating mixture shall not be made until the concrete, in the opinion of the Engineer, has regained its dry appearance.

Caution: As the linseed oil-mineral spirits mixture has a low flash point and is readily flammable, all fires, including cigarettes and sparks, shall be carefully guarded against.

When practicable, the treated surfaces shall be closed to all traffic until the concrete has regained its dry appearance.

#### IV. MEASUREMENT

The actual area coated as specified shall be measured in square yards.

#### V. PAYMENT

The quantities thus measured shall be paid for at the unit price bid per square yard for "Protective Coating," which payment shall be full compensation for preparation of the surface, furnishing and applying the materials, and for furnishing all labor, equipment, and incidentals necessary to complete the work.

APPROVED

Oct. 25, 1962

D. H. Bray  
D. H. BRAY  
STATE HIGHWAY ENGINEER

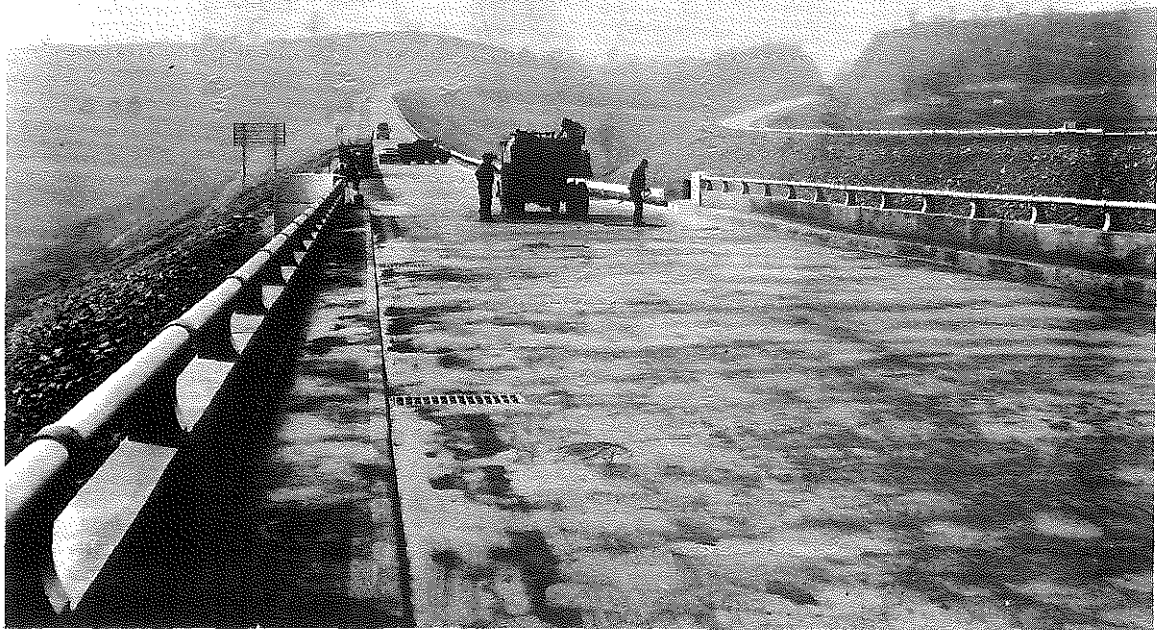


Fig. 125. Kentucky River Bridge, I-64, Franklin County, Eastbound; Facing West; Coated with Linseed Oil, Two Coats on Succeeding Days; First Coat, December 1-4, 1962. Note the fog; rain was impending when the last few square yards were sprayed. Big Eddy Road Bridge is in background. This bridge and bridge beyond hill in background (over old 127, MP 37-905-BHG7, also coated prior to opening to traffic, Dec. 6, 1962).

CLAYS FERRY BRIDGE

Location: Kentucky River  
US 25, Lexington-Richmond Road

Constructed: Opened August 17, 1947

Condition: Progressive damages sustained during past four or five years. Loose cinders, etc. in the gutter have aggravated damage through freeze-thaw, salt, etc. Present condition is portrayed by Figs. 128 thru 131.

Treatment: Treatment is being contemplated for the forthcoming season, no decision has been made in regard to the type of treatment.

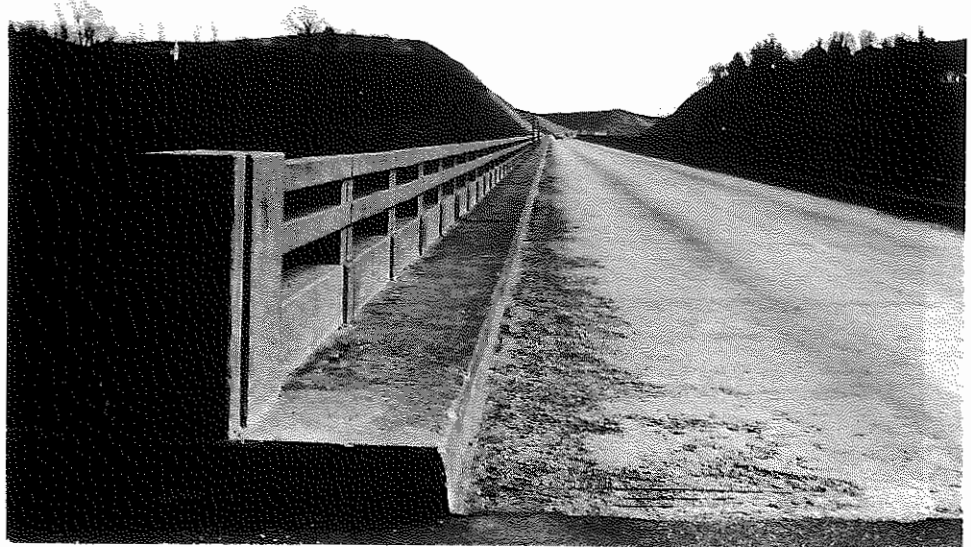


Fig. 128. Clays Ferry Bridge, Present US 25, Future I-75, Northbound Bridge; Lexington-Richmond Road, Facing South; Shows Scaling between Outside Wheel Path and Curb, Feb. 13, 1963.

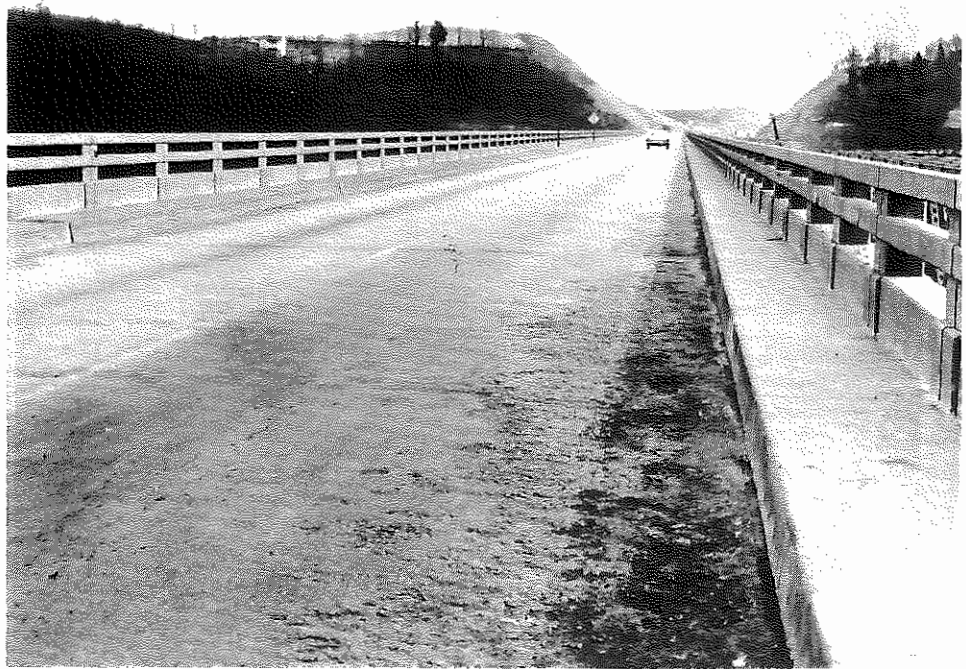


Fig. 129. Clays Ferry Bridge, Companion Photograph Showing Scaling in Opposite (Northbound) Lane. Note: New parallel bridge under construction at right of existing bridge. Feb. 13, 1963.

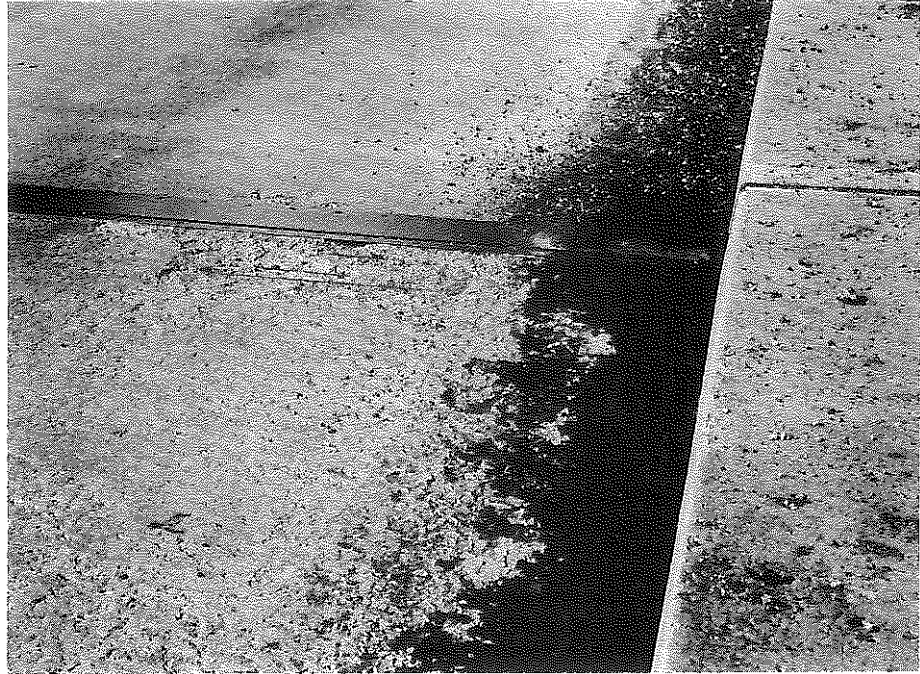


Fig. 130. Clays Ferry Bridge, US 25, Lexington-Richmond Road. A close-up view showing scaling at expansion joint and gutter line. Debris, which appears in the background, has been swept away in the foreground disclosing the persistence of aggravating moisture there.



Fig. 131. Clays Ferry Bridge. Close-up view of impending failure of deck, near south end of bridge.

## HEATING BRIDGE DECKS

Heating bridge decks to prevent icing and to remove snow is an alluring idea not only from the viewpoint of eliminating hazardous condition, but also from the viewpoint of eliminating damage to a bridge which otherwise might arise from freeze-thaw and de-icing salts. Two experimental installations of electrical heating elements in bridge decks have been made during the past two to three years. Brief annotations to these and to two other references to heating pavements follow in their chronological order:

"Snow and Ice Removal by Heating Cables," Feature Article, Electrical Construction and Maintenance, Vol. 58, March, 1959, pp. 85-87.

Heating cables were installed at 18 toll plazas, Dec. 23, 1958, on the Northern Illinois Tollways; each lane for a distance of 84 ft.; each installation used 1,183 ft. of No. 19 AWG wire; cables were taped to mesh-mats, imbedded 2 in. in concrete; manually operated switches (no thermostats); 208-volt, 3-phase system.

Note: Home-type units for installation in driveways and sidewalks are manufactured by Electromode Division of Commercial Controls, Corp., 570 Culver Rd., Rochester, N.Y., Easy-Heat, Inc., Lakeville, Indiana, and Chromelox, Electric Heat, Edwin L. Wiegard Company, 7500 Thomas Blvd, Pittsburgh 8, Pa.

"Sloping Driveway's Snow Melting System Assures Snowfree, Slipfree Pavement," John Rudberg, M.E., Ellerbe & Co.; Heating Piping and Air Conditioning, Vol. 31, Oct. 1959, pp. 112-113.

Some 18,000 sq. ft. of driveway at the Central Office Building of the Minnesota Department of Highways, St. Paul - 3/4 in. piping, 12 in. on centers, were buried 2-1/4 in. in concrete pavement; ethylene glycol (antifreeze) is circulated through the piping system from a steam-heated exchanger inside the building; the system is controlled manually.



Note: A somewhat similar system was installed earlier at the Greyhound Bus Terminal in New York City.

"Research Study, Ice Prevention on Bridge Decks, Interim Report," by M. D. Shelby, Research Engineer, and W. B. Ledbetter, Design Engineer, Texas Highway Department, January, 1962.

Half-inch diameter metal tubing was placed between the upper and lower layers of reinforcing steel; No. 19 AWG (insulated with glass yarn, silicone rubber, and tinned, copper braid) was threaded through the conduit; bridges are 120 ft. long; City View Drive, on US 287, northwest of Wichita Falls [F 119(11), U119(12)]; power provided ranged from 5 to 20 watts per sq. ft.; imbedment ranged from 1 to 3 inches; 74 amps at 490 volts (119 KWH); installation completed Jan. 20, 1961; no final conclusions drawn.

"Experimental Roadway Heating Project, Passaic River Bridge Approach - Routes US 1 & 9, Newark, New Jersey," by D. J. Henderson, Supervising Electrical Engineer, Bureau of Electrical Operations, New Jersey State Highway Department; presented at the 42nd Annual Meeting of the Highway Research Board, January, 1963.

Cites prior uses of electric heating cables: 1) the Mound in Edinburgh, Scotland, and 2) concrete deck of an overpass in Aberdeen, South Dakota (18 in. wide wheel tracks). Parallel U-loops 710 ft. long laid longitudinally on fill-section of bridge approach; 133 ft. continuous S-loops (1000 ft. cable) laid on first span of bridge; three-phase, 450 volts at 600 KVA used; cables were about 4 in. apart; cemented to pavement with asphalt joint-sealer; surfaced with leveling course and sand-asphalt; total cost of installation, including transformers and switches, \$2.19 per sq. ft., heating elements estimated to cost about \$1.10 per sq. ft.; monthly charge for 600 KVA service, \$400.00; estimated use, 125 hrs. per winter; cost of heating 67.7 hrs, \$2,958.00; designed for 35 to 40 watts per sq. ft., to melt one inch of snow per hour.

## SUMMARY

None of the major repair efforts thus far has proven to be ineffective except the sand-asphalt treatment on the Clark Memorial Bridge. Even in that instance, the sand-asphalt performed admirably as a wearing surface -- it simply was not effective in abating the deterioration of the underlying concrete. Of course, only four other major deck repairs have been attempted, i.e. the Lake Cumberland Bridge (Ky. 90), the Danville Bridge (US 150), the Owensboro Bridge (Ohio River), and the old Russell Fork Bridge in Pike County. The Danville Bridge, as previously mentioned, has been patched but remains unsealed. A need for some repair on the Clays Ferry Bridge seems imminent, and perhaps other bridges are being considered by the Division of Maintenance. Notwithstanding unforeseen calamitous performances, and relying somewhat upon performance records elsewhere, the epoxy-seal seems to offer the best means presently available to restore and further protect deteriorating decks. The particular epoxy system remains a matter of choice and economy inasmuch as the so-called flexibilized epoxies are available in the polysulfide formulations as well as in the amine-type formulations and the epoxy-tar formulations. The choice of patch material also remains optional between epoxy mortars and latex-modified portland cement mortars, although Embecco, non-shrink-type mortars or gunite might be considered alternatively. The most significant factors adversely affecting the performance of patches seems to be shrinkage of the patch material and failure to prepare square-cut margins around the patch area.

Preventive treatments such as linseed oil, styrene solutions, etc. are nominal in cost and seem to offer some re-assurance against premature scaling. The use of preventive treatments on new work, of course, presumes that the concrete is susceptible to scaling -- an inadmissible presumption, according to some authorities, if the concrete has been placed properly. Nevertheless, until confirming evidence can be established to the effect that improvements in concreting practices can wholly alleviate the problem of scaling, it seems advisable to pursue a preventive treatment program.