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On certain types of bridges, considerable economy can be achieved, through a reduction of dead weight, by substituting for the conventional Portland Cement Concrete pavement a light weight steel deck with a proper wearing surface. Steel decks, whether smooth, checkered or of the open grid type have proved too hazardous from the skid standpoint. The California Division of Highways has for a number of years been investigating the problem of providing these steel decks with a relatively thin wearing surface exhibiting good bond and skid resistance.

The research program has consisted of the development and testing of special binding agents which must resist the tractive effects of heavy loads and provide a proper bond to steel, wood or concrete surfaces. The binder must also withstand considerable vibratory and deflection stresses under rapid impact loading of relatively light steel plates and exhibit good durability qualities in its ability to withstand water action, and changes in physical characteristics. The aggregates, constituting the wearing cover must provide an anti-skid surface as well as offer a high resistance to crushing under impact loads.

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USE OF ASPHALT-LATEX EMULSION IN THE CONSTRUCTION OF THIN WEARING SURFACES FOR STEEL BRIDGES AND STRUCTURES

By

Ernest Zube

Supervising Materials and Research Engineer

Presented at the 34th Annual Meeting
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USE OF ASPHALT-LATEX EMULSION IN THE CONSTRUCTION OF THIN WEARING SURFACES FOR STEEL BRIDGES AND STRUCTURES

By

Ernest Zube*

Synopsis

On certain types of bridges, considerable economy can be achieved, through a reduction of dead weight, by substituting for the conventional Portland Cement Concrete pavement a light weight steel deck with a proper wearing surface. Steel decks, whether smooth, checkered or of the open grid type have proved too hazardous from the skid standpoint. The California Division of Highways has for a number of years been investigating the problem of providing these steel decks with a relatively thin wearing surface exhibiting good bond and skid resistance.

The research program has consisted of the development and testing of special binding agents which must resist the tractive effects of heavy loads and provide a proper bond to steel, wood or concrete surfaces. The binder must also withstand considerable vibratory and deflection stresses under rapid impact loading of relatively light steel plates and exhibit good durability qualities in its ability to withstand water action, and changes in physical characteristics. The aggregates, constituting the wearing cover must provide an anti-skid surface as well as offer a high resistance to crushing under impact loads.

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Original field trials in 1947 were made on a bascule bridge with a wooden deck where asphalt-latex emulsion was used as the binder for the crushed aggregate providing the wearing cover. This wearing surface is in good condition after seven years of service and is carrying a fairly large volume of heavy traffic. In the summer of 1952, another experimental surface was placed on a relatively large steel plate deck bridge crossing Ulatis Creek in Solano County. This bridge was decked with both plain and checkered steel plates and was surfaced with screenings bonded to the deck with asphalt-latex emulsion and lumnite cement-latex.

Judging by the performance record of the two projects it appears entirely feasible to apply adequate light weight wearing surfaces, exhibiting suitable elastic properties to resist severe conditions of vibration and deflection and also provide desirable skid resistance qualities.

These surfaces may also be used on existing structures such as bridges or parking roofs requiring repair of the wearing course without major addition of dead weight. By removing the Portland Cement Concrete pavement on existing long span bridges and substituting light weight steel decks, and thereby reducing the dead load, it may be possible to permit heavier traffic loads or even the addition of extra traffic lanes.

Introduction

One of the most important objectives of designers and builders of highway bridges is to provide a bridge deck which will insure the same safe conditions and travel comfort on the bridge as is encountered on the highway. In the majority of cases, present design provides such a surface by construction of reinforced concrete decks. This type of construction adds considerable weight to the dead load and adversely affects the overall cost. In the past ten years the bridge designers of the California Division of Highways have given increasing attention to the possibility of reducing the weight of the deck particularly on steel structures. A number of methods have been proposed and used, such as light weight concrete, open steel gratings and "battle deck" steel plates of various designs. However, steel decks usually leave something to be desired. The noise produced by traveling cars on open grid decks is objectionable and all steel decks tend to be hazardous from the standpoint of skidding.

The modernization of many miles of secondary roads to new standards of geometrical design has presented further problems to the bridge engineer. Many bridges on these roads are built of timber and decked with heavy timber planks. This type of deck has not proved adequate for the increasing volume of high speed traffic involving heavy vibratory loads. In many cases the underlying structure is still sound and of sufficient structural strength. However, the replacement of the deck with an adequate wearing surface has presented a number of problems. The first is the necessity of keeping the dead weight of the deck close to the original design load and the second is the construction time required to make the change. The availability of detours is also a factor. Some of these wooden decks have been covered with bituminous surfacing, but unless a substantial thickness is applied, the numerous cracks transmitted from the wooden deck cause early deterioration. There are also instances where extensive cracking of existing reinforced concrete decks may require a waterproofing non-skid surface of light weight. The need for a thin, but tough and durable wearing surface exhibiting considerable elastic properties has been apparent for some time.

A similar situation involves long span bridges where the original construction provided only a two or three lane travelway. With modernization of the existing roadway to a standard four lane highway on either end of the structure it becomes mandatory to provide changes in the bridge travelway. The bridge designer has only two alternatives. He may decide to construct a twin bridge with large initial cost or attempt to increase the width of the existing bridge by structural changes. The second alternative is of course the most desirable from an economical standpoint. One solution would be to remove the existing concrete pavement, thereby reducing the dead load, and substituting light steel decks thus permitting heavier traffic loads or under certain conditions even the addition of extra traffic lanes.

The Bridge Department of the division has conducted a special design study on the problem of providing light weight bridge decks for both existing and new bridges. An intermediate design, which reduced the dead load weight of the original battle deck floor was developed in 1947. This design has been described by Mr. C. H. Darby[1]. The next fundamental problem was the development of a suitable wearing surface having good non-skid qualities. Previous experience indicated that checkered plate and special grid designs did not provide sufficient anti-skid properties especially during cold and rainy weather. The first trial of this intermediate design required an overlay of rather thick bituminous surfacing, which definitely increased the dead load of the deck. It was believed that if the surfacing could be materially reduced, a very marked improvement in this design would result. The problem of developing such a light weight surfacing for use on existing bridge decks and proposed new steel decks was referred to the Materials and Research Department for study and development.

The primary function of a surfacing on this type of deck is to provide adequate non-skid properties for high speed traffic. A seal coat type of surface seemed to offer the best possibilities of success since its average thickness is 3/8 in., and involves only a single application of binder and screenings thus providing a surface of minimum dead weight. The following requirements for the materials to be used in this type of surface were believed necessary for successful performance:

1. The binder must develop sufficient bond to both the steel deck and the screenings to prevent displacement.
2. The binder must be sufficiently elastic to accommodate vibratory stresses, especially at low temperatures.
3. The binder must be durable and provide maximum bond when subjected to severe water action.
4. The surface should provide non-skid characteristics and the screenings resist crushing under impact loads.

Further the surface should be such that necessary repairs could be made in a minimum length of time, since the closing of any lane on a bridge creates serious delay or traffic hazards.

At the start of this investigation it was readily apparent that the main problem would be the development of a suitable binding agent. Experience with seal coat design and construction indicated that aggregates of proper gradation and capable of resisting severe impact loads were available.

About twenty years ago the Materials and Research Department began a series of studies on the development of an improved joint sealing material for concrete pavements. These studies ultimately lead to the development of a material known as asphalt-latex emulsion joint sealer which has been used to a considerable extent for this purpose(2). It can be handled cold or with a mild application of heat, adheres well to concrete and possesses rather remarkable elastic properties especially at low temperatures. Further studies indicated the ability of this material to adhere well to other materials such as wood and steel and to act as an adhesive for holding screenings to such surfaces. Therefore, when problems were presented to us which required an elastic durable adhesive it was natural to think first of the asphalt-latex material.

It is the purpose of this paper to outline our development of the asphalt-latex emulsion and certain variations as a binder for screenings for light weight bridge decks and to report on the construction and performance of these wearing surfaces on various bridges in California.

Development of Binders

As mentioned before, the asphalt-latex emulsion used in these studies was originally developed for joint sealing operations in concrete pavements. This material is produced by emulsifying a paving asphalt of any desired grade with either natural or synthetic rubber latex. The proportions, normally used are 60 parts asphalt and 40 parts of latex (by volume) having a solids content of about 40%. The emulsifying agent is generally half strength sodium silicate and five to ten parts of this agent are added to the above combination. The emulsion is prepared by heating the rubber latex and sodium silicate to about 140 F. and slowly adding, with continuous stirring, the asphalt previously heated to about 190 F. The resulting emulsion has a relatively low viscosity and can be sprayed at normal atmospheric temperatures without heating. The material is now manufactured on a commercial basis by a number of California producers and may be obtained in drum shipments.

Our first studies involving the possible use of this material as a binder on bridge deck surfacings, was in 1947 in connection with the proposal to resurface the existing wooden deck of a bascule type bridge over the Sacramento River at Rio Vista. The requirements for a binder in this case were that the surfacing remain intact not only under vehicle traffic, but that no slippage should occur when the bridge deck was raised to a near vertical position, sometimes for rather extended periods of time. This was of special importance during the summer season when the deck temperatures were quite high. In preliminary studies for this job, which will be described later in more details, we prepared several wooden test panels using the standard grade of asphalt-latex emulsion as a binder and medium screenings as a cover. These screenings have a maximum size of 3/8 in. For comparison, we also used two different grades of paving asphalt (30-40 penetration and 200-300 penetration) as a binder with the same screenings cover. After curing for a few hours the panels were placed outdoors in a 45 degree position and exposed to the summer temperature. Within a matter of minutes the 200-300 penetration asphalt seal coat began to flow and slip off and within a few hours both paving grade asphalts had almost completely slipped off the wooden test panels. Figure 1. On the other hand, the asphalt-latex panels showed no signs of distress whatsoever and after long exposure in near vertical position to both summer and winter conditions for a period of about three years still retained the screenings cover with no sign of slippage. The adhesion to both the wood and the screenings was very good and it was extremely difficult to remove the rock particles from the panels. On the basis of these tests a recommendation was made to the Bridge Department for a trial of this type of surfacing on the bascule bridge.

The second phase of our laboratory studies began after the Bridge Department's design of a modified light weight steel deck in 1947. Also about that time our Bridge Department began studies to provide additional traffic lanes across the Carquinez

Straits. The present Carquinez Bridge constructed in 1928 is composed of two 500 ft. anchor spans and two 1100 ft. cantilever spans with a deck consisting of a Portland cement concrete slab. The bridge provides a three lane roadway which is entirely inadequate for the present day traffic of about 30,000 vehicles per day. One of the various alternatives considered was providing additional traffic lanes by strengthening the present structure. It was calculated that by removing the existing Portland cement concrete deck and substituting a light weight steel deck the dead load would be sufficiently reduced to permit the adding of additional traffic lanes by cantilever or second story construction requiring only nominal strengthening of the existing structure.

Laboratory Studies

At the start of this study it was realized that such decks might be used in any location in the State and under various traffic conditions. The fact that the asphalt-latex composition is a thermoplastic indicated the possibility of failures in regions of extremely high summer temperatures and on bridges subjected to marked acceleration or deceleration of traffic. Therefore, in addition to the asphalt-latex the development of other binders was undertaken, especially those which might exhibit the same adhesive properties as the asphalt-latex but would remain relatively non-plastic with any change in temperature.

A number of industrial companies were also canvassed in an effort to see if any of the newly developed products might be suitable for this purpose. One compound that looked promising is a combination of lumnite cement and neoprene latex which was suggested by a representative of the DuPont Company.

The laboratory work consisted of trying out a large number of mixtures of the asphalt-latex and latex-cement with screenings embedded in the mixtures on small steel plates of both smooth and raised pattern design. It was felt that the raised pattern type would provide additional resistance to any shearing stresses that might be set up by sudden acceleration or deceleration of heavy vehicles. For the asphalt-latex, various grades of asphalts ranging from 50-60 to 200-300 penetration with synthetic rubber or reclaimed rubber and also some twenty different types of tack coats were tried on steel plates. Combinations that appeared satisfactory when cured at room temperature were retested after curing at various other conditions of temperature and humidity.

For the special neoprene latex-lumnite cement mixture it was found after numerous trials that a combination of 74% by weight of lumnite cement and 26% of the neoprene latex produced the most satisfactory results. The latex must be stabilized with casein and the Ph adjusted to about 11 with potassium hydroxide in order to prevent breaking on contact with the cement. The two materials combine readily to form a creamy mass of light color, which must be applied with some form of a squeegee or templet because it is too thick to handle in spray equipment.

Various combinations of Portland cement with the ordinary variety of synthetic rubber latex were also tried, since both are less expensive. However, the results were definitely inferior when compared with the neoprene lumnite-cement product especially in their resistance to water.

Various amounts of the binders to be tested were placed on the plates and screenings were immediately applied and rolled. The screenings were in most cases a standard crushed medium type of 3/8 in. x #6 size. However, light weight types such as "Haydite" were also included.

After applying the screenings the specimens were cured outdoors during both summer and winter conditions. Other samples were cured for equal periods of time indoors and short curing periods were also studied using a 140 F. oven. The testing or rating of the various specimens was performed by attempting to determine the elasticity and bond of the binder by visual inspection using a spatula and trying to pry off the binder from the steel plates. The panels were rated, under the same atmospheric conditions, by different operators and the average values obtained.

These studies definitely indicated that a high degree of bond could be attained on smooth, sand blasted steel plates when using either the asphalt-latex or lumnite-cement compositions. The bond did not appear to be improved by any of the numerous "tacking" agents. Under the curing conditions, used in these laboratory studies, the lumnite-cement composition showed outstanding adhesion to both steel and aggregate and its non-thermoplastic properties indicated that resistance to whip off would be good at elevated pavement temperatures. The asphalt-latex also performed well after proper curing and exhibited more elasticity than the lumnite-cement composition.

Following these preliminary studies, it was decided to prepare trial panels for actual tests by vehicles. The correct amounts of each binder, previously determined in our preliminary trials, was applied to 2- by 2- ft. sand blasted steel plates of smooth and checkered design which were identical to those proposed for use in the field. An application of crushed screenings was immediately made and the surfacing rolled. These plates were cured for short intervals and then fastened into position in the wheel track of the travelway used by vehicles and trucks servicing the laboratory. Figure 2. The plates were subjected to traffic for some months and no noticeable differences were visible, although skid tests made by locking the brakes of a heavily loaded pickup indicated that some difficulty might be encountered from rapid acceleration or deceleration stresses on the asphalt-latex at elevated summer temperatures. Tests on the lumnite-cement were very satisfactory. The main problem with both binders was the relatively long curing period required for adequate adhesion and bond strength. This problem is not important for new construction, where the deck may be cured for a week or ten days prior to opening to traffic. However, for any repairs such as maintenance patching, the time required for curing becomes an important factor.

Following the successful performance of the asphalt-latex in field trials, to be described later in this paper, it was decided to conduct further trials on the problem of decreasing the curing time. This problem involves the rapid removal of the water contained in the emulsion. This water constitutes approximately 30% of the composition and must be quite completely removed before sufficient binder strength is developed to prevent loss of the screenings under traffic action. In concrete crack filling operations a gelling agent (sodium fluosilicate) is commonly added, during pouring operations, which causes the material to "set up" shortly after pouring, but there has been some difficulty in properly incorporating this material in the asphalt-latex in the type of work described here. After a number of trials, it was found possible to heat the finished surfacing, immediately after placing, with some form of burner, applying heat until frothing of the emulsion occurs. Trial panels indicated that sufficient bond strength to resist vehicle stresses could be obtained by this procedure in a few hours after application of the surfacing. Field trials of this method will be described later.

Recently our Chemical laboratory initiated some tests on the possible use of plastic Epoxy resins as a binder, modified with an addition of Thiokol rubber, for improvement of elasticity. This material is rather expensive, but preliminary trials indicate exceptional bond to steel and aggregate when used in comparatively light applications.

Although successful field trials will be described, in which binders of the type noted above have been used, we are continuing our efforts to secure a more economical product which will provide maximum durability and non-skid properties on light weight steel decks.

Rio Vista Bridge

The first light weight bridge deck surfacing was placed, for trial purposes, on the Rio Vista Bridge which spans the Sacramento River in the Delta region of Solano County and is located on State Route No. 12. It consists of approach spans and a two leaf 226 ft. long bascule span constructed in 1917. The roadway of the bascule span was provided with a wooden plank deck, Figure 3, and is rather narrow.

As this bridge carries considerable traffic with a large number of heavy trucks, particularly during the harvest season, it was decided to protect the wooden deck with a light wearing surface which would not appreciably increase the dead weight of the old structure. Also, when opening the span, the binder is subjected to high shearing stresses and the ability of the surface to remain on a near vertical slope could be tested on this structure.

In May of 1947, a wearing surface in the form of a seal coat approximately 1/4 in. thick consisting of asphalt-latex as a binder and crushed rock screenings was placed on the timber deck, Figures 4, 5 and 6.

The asphalt-latex emulsion was supplied to the job in 50 gallon drums. An Alemite pump was placed in the open end barrels and the emulsion was sprayed onto the deck at the rate of approximately 0.40 gallons per sq. yd. by air pressure supplied by a 60 cu. ft. per min. compressor. Medium fine screenings (5/16 in. x #8) were applied by hand and were lightly rolled. As the bridge had to be kept open to traffic one-half of the roadway was constructed at a time. In order to hasten the setting of the emulsion, some attempt was made to heat the screenings in the truck bed by means of a weed burner. It is interesting to note that the bridge had to be opened to near vertical position a number of times during construction with only a 20 minute notice and no loss of screenings or binder was apparent, even though the material had been in place less than 1/2 hour.

Some of the latex and screenings were inadvertently spilled on an exposed steel plate along the centerline of roadway. When later examined and after the roadway had been subjected to considerable traffic, it was noticed that the latex showed remarkable adhesion to the steel. This confirmed our previous observation of strong adhesion of this material to concrete and steel and encouraged the belief that the asphalt-latex would be useful on steel decks.

As this was our first venture into the field of this type of surfacing, the cost naturally was high and amounted to about $2.00 per sq. yd. The unfamiliarity of this prodoct to the workmen, inadequate width of the roadway which had to be kept open to traffic and delays due to opening of the span contributed to the high cost.

At the end of 1954 the bridge deck is still in serviceable condition, although some shrinkage cracks between the wooden planks have occurred, Figures 7 and 8. As far as the asphalt-latex binder is concerned it still adheres tenaciously to the wood and it is rather difficult to pry off. There is every reason to believe that an asphalt-latex screenings seal coat properly placed over a well seasoned timber deck would give satisfactory service for many years even under heavy traffic.

Ulatis Creek Bridges

The construction of two parallel bridges in the summer of 1952 over Ulatis Creek on Road X-Sol-7-C,Vac,D under Contract No. 51-10TC15-F provided an opportunity to carry out our field studies on steel decks, using two different formulations; one composed of asphalt-latex and the other of lumnite-cement and neoprene-latex, Figure 9. The decks of both bridges consisted of steel plates with one bridge having the smooth type and the other a checkered raised pattern type, Figures 10 and 11. The raised pattern extended about 1/4 in. above the surface. Each bridge had a deck area of 409 sq. yd. and was on a grade of 3%. Both units carry traffic in two lanes, composed of a travel and passing lane. The use of these two parallel units allowed us to make a study of the effect of the plate pattern on both formulations, under the same traffic and weather conditions. Each bridge was divided into two equal sections so that both the traffic and passing lanes could be coated with the same adhesive agent. The asphalt-latex combination was placed on the west one-half of each bridge and the lumnite-cement neoprene-latex was placed adjacent on the east half. The only variable was that the northerly bridge carried up grade traffic, which is somewhat more severe on the deck, whereas the southerly one was subjected to down grade traffic. Both decks were sand blasted prior to application of the binders.

The materials used as deck surfacing consisted of the following:

(1) The asphalt-latex emulsion was made to the specifications for asphalt-latex joint filler using a base of 200-300 penetration asphalt, see Appendix A. When tested, the following results were obtained:

Viscosity S.F. at 77 F.	65 secs.
Elasticity, % Recovery at 77 F.	93%
Penetration with grease cone after gelling at 77 F.	184

The original emulsion contained approximately 30% water.

(2) The neoprene-latex consisted of the DuPont product stabilized to a Ph of 11 with casein and KOH. The latex emulsion contained 61.6% water. The specific gravity of this material is about 1.08 at room temperature.

(3) Lumnite-cement. This is a quick setting calcium-alumnate cement produced by the Atlas Cement Company and recommended for this particular work. No tests were made on the cement other than mixing it with the neoprene-latex to test for bond and stability.

(4) Screenings consisted of the medium fine size (5/16 in. x #8). The sieve analysis of the material as used is as follows:

Grading Analysis

Sieve Size	% Passing
3/8	100
No. 3	81
No. 4	53
No. 8	8
No. 16	3
No. 30	2
No. 50	2
No. 100	1

Equipment

The special equipment furnished by the Contractor for this work consisted of a Spearwell Patch Heater for heating the screenings, an Alemite grease pump operating on compressed air for pumping the asphalt-latex from barrel to spray nozzle, a fertilizer spreader for spreading screenings, a metal drum hand roller, squeegees for spreading a uniform layer of neoprene-latex and cement on the decks and an L & W Manufacturing Company three sack plaster mixer for mixing the neoprene-latex and cement.

The Spearwell Patch Heater, Figure 12, consisted of a revolving metal cylinder about 7 ft. long and 16 in. in diameter equipped with a hopper at each end and a gas burner at the lower end. The capacity is controlled by changing the angle of the cylinder with the horizontal, this together with the flame size, controls the temperature of the screenings. This piece of equipment worked very satisfactorily for a small dryer or heater.

The Alemite grease pump, Figure 13, operating on 130 psi. from a compressor worked very satisfactorily for spreading the asphalt-latex through the spray nozzle.

Rubber edged squeegees, Figure 16, such as are used for washing windows, with a nail set in each end to give the proper thickness of application were used to spread the neoprene-latex cement on the deck. This procedure, although satisfactory, was slow.

To spread the screenings a small hand operated fertilizer spreader, Figure 12, which consisted of a "V" shaped hopper mounted between two small rubber tired wheels was brought to the job. However, it did not work too successfully and the screenings were finally spread by hand.

A hand operated roller consisting of a metal drum 24 in. in diameter and 40 in. long was used for rolling the screenings into the asphalt-latex. After a few passes with this roller, it was found to be riding on top of high spots of the spread screenings. This method was abandoned in favor of rolling with a dual wheel flat-rack truck.

Asphalt-Latex Type Binder

The asphalt-latex binder was spread under pressure through a fan shaped spray, Figure 14. On the raised surface deck it was found somewhat difficult to determine the spread. The material formed a skin almost immediately so that it could not be satisfactorily gauged. The most satisfactory method found was to mark off an area on the deck and by gauging the drum, the coverage was calculated. About 0.45 gallons per sq. yd. was applied to both bridges. No significant flow of the emulsion due to the 3% grade of the deck was noticed.

The contract provisions required the addition of one to five percent (by weight of the emulsion) sodium fluosilicate either incorporated in the asphalt-latex or to be sprinkled on the surface.

An 8 in. diameter 100 mesh sieve was mounted on a 3 ft. handle and the powder was sifted over the emulsion. However, it required considerable care to obtain uniform distribution by this method, Figure 14.

The screenings were heated in the Spearwell Heater to a temperature of about 250 F. As mentioned previously, the spreader did not function satisfactorily and the screenings were spread from a wheelbarrow by hand at the rate of approximately 20 pounds per sq. yd.

After spreading, the screenings were immediately hand broomed lightly to a uniform thickness. They were then rolled about three passes with a dual wheel flat rack truck. This rolling embedded the screenings very thoroughly into the asphalt-latex emulsion. Since an excess (about 25%) of screenings was used no excessive pick-up on the truck tires was noted. The general appearance after rolling was very good, Figure 18.

When inspected after five days of curing at an average daytime temperature of 88 F. it was found that the asphalt-latex had not yet completely bonded to the steel deck. It was then rolled a few more times with a truck and this additional rolling seemed to increase the bond greatly.

Neoprene-Latex Lumnite-Cement Type Binder

The neoprene-latex and lumnite-cement were mixed in a three sack plaster mixer, Figure 15. The cement was proportioned by the sack and the neoprene-latex by weight. Each batch consisted of one sack (94 pounds) of lumnite-cement and 33 pounds of latex.

About 15 minutes were required for mixing each batch. After mixing, the batch was dumped into a flat bottomed trough from which it was shoveled into the wheelbarrow and then spread over the deck with squeegees, Figures 16 and 17, having nails set at the ends to give the proper thickness. The nails were omitted on the raised figure surface deck. Proper spread was determined by marking off 4 ft. wide strips on the deck to give the proper area per batch. The average spread was about eight pounds per sq. yd.

The first three or four batches were spread with difficulty due to the stiff and pasty nature of the mix. Also, it was found that the mix was setting up before the screenings could be rolled, although the rolling was being accomplished within the specified 30 minutes after spreading. The rapid set was undoubtedly due to the high summer temperature. The air temperature was about 90 F. with a hot drying wind and the temperature of the steel deck about 125 F. To reduce the stiffness of the mix, two quarts of water were added to each one sack batch, this produced a much more workable mix. Screenings were spread and broomed, as soon as the mix was put down. Rolling was done with a small hand roller weighing about 125 pounds followed by the dual wheel truck.

With the equipment used, it was difficult to get a uniform spread on the raised figure surfaced deck. During rolling it was not possible to keep the tires at times from running on material that had been previously rolled. It was felt that due to the quick hydration of the cement paste, once the surfacing had been rolled it should not be disturbed after the initial set.

Although the finished surface was sprinkled lightly with water at frequent intervals, it was apparent that the high temperatures were not conducive to satisfactory application of this product.

After curing for a period of several days an inspection indicated that a few small areas of the latex lumnite-cement section, where the screenings had not been embedded satisfactorily, would have to be patched before opening to traffic. While patching, the temperature had dropped to 64 F. and cloudy weather with occasional showers prevailed on the following two days which should have favored satisfactory curing. This cooler weather was quite significant in the final analysis as will be mentioned later.

Cost Comparison

Due to the experimental nature of this work no effort was made to keep an accurate cost analysis of this project. However, rough calculations indicate that including a contractor's profit of 15%, the price of the asphalt-latex seal coat amounted to about \$1.30 per sq. yd. and for the neoprene-latex lumnite-cement seal about \$1.50 per sq. yd. For comparison, the cost of a three in. thickness of plant mixed surfacing is about \$1.00 per sq. yd.

Observations

An inspection of the surfacing was made after both bridges had been opened to traffic for a little over a month. The asphalt-latex section appeared to be in excellent condition except for a very small area, about eight in. square, showing the bare metal. It appeared that this was caused by solvent spilled during the painting operation of the bridge.

The neoprene-latex section of the north bridge, except for the areas that had been patched, showed serious failure. This failure consisted of a loss of screenings followed by gradual wearing away of the latex lumnite-cement paste from the deck. On the south bridge which had not been subjected to traffic as long, the failure was not as extensive but it appeared to be progressing.

It was noticed that the patched areas which had been placed during cooler weather were far superior to the rest of the deck where the seal coat had been placed during hot weather.

Another inspection was made in September 1952, at which time the bridge had been opened to traffic about three months. The neoprene-latex cement seal was in poor condition, the extent of failure being about the same on both, raised grid and smooth plate sections. The patches, placed during cooler weather, appeared in better condition in respect to bond and hardness.

The asphalt-latex seal appeared to be in good condition. The raised figures of the checker plate pattern were beginning to show on the surface of the seal but the tops were still covered. The seal on the smooth steel appeared in excellent condition.

As the neoprene-latex cement seal was generally poor, it was felt that resealing this portion of the bridge was warranted before the advent of winter, especially from the standpoint of skid hazard on the smooth deck.

Asphalt-Emulsion Seal Coat

The Maintenance Department decided to try a conventional seal coat using medium-fine screenings and penetration type asphaltic emulsion such as is applied to the surface of bituminous pavements and the seal was applied in September 1952.

No attempt was made to remove the remaining portions of the neoprene cement seal prior to resealing. The only preparation was to hand broom the surface. Penetration type emulsion was applied through a hand spray at the rate of 0.2 gallons per sq. yd. Screenings similar to the ones used in the original seal were used. The weather conditions were ideal for rapid breaking of the emulsion (dry bulb 91 to 97 F. relative humidity 18% to 24%). The screenings were slightly damp and showed no dust when spread with a standard Buckeye Spreader. A dual tired truck was used for rolling.

After permitting the seal to cure for about one hour, controlled traffic was permitted for an hour. After that time, both lanes were opened to high speed traffic.

The asphalt emulsion seal coat was inspected in October 1952, after having been subjected to traffic for about four weeks. The general condition of the seal was quite good except for some bleeding in the wheel tracks of the traveled lanes on both bridges, although some slight distress in one or two areas of the smooth plate deck were noted.

By the summer of 1953, considerable distress was noted in the wheel tracks of the west bound (up grade) traffic lane (smooth deck) in the asphalt emulsion seal coat. The passing lane appeared in good condition. On the checkered deck, which is on the down grade, both traffic lanes appeared in satisfactory condition.

As the asphalt-latex seal coat had given satisfactory results, Figure 19, it was decided to remove the asphalt emulsion seal coat in the failed area and replace it with an asphalt-latex seal similar to the original application on the east end of both bridges.

Replacement of Asphaltic Emulsion Seal Coat With Asphalt-Latex Emulsion Seal on North Bridge

Because of the limitations of closing the bridge to traffic during day light hours only, it was necessary to find ways and means of speeding up the curing time. As mentioned before, it was found that heating the asphalt-latex emulsion after the screenings were spread was reasonably effective. The heat was supplied by weed burners and applied to the surface of the screenings. It was found that although heating the seal coat did not complete dehydration or cure the asphalt-latex it was cured to a sufficient depth to provide a well keyed mat that would withstand the normal stress of traffic providing it did not involve sudden starting or stopping.

The amount of heating was a little more than that necessary to cause the asphalt-latex to boil up around the aggregates. Longer periods of heating appeared to be burning the binder in the upper portion of the seal coat. It was also noticed that rolling the screenings before heating, as well as after, aided in bonding them together and also in bonding them to the deck.

In the summer of 1954, the travel lane only on the north bridge (containing the asphalt emulsion seal) was repaired. The area repaired was 65 ft. long and 9 ft. wide, the inner edge of the area being very close to the centerline stripe, Figure 21.

The remaining portion of the old emulsion seal was removed by heating with a pavement heater followed by scraping the old seal off with square pointed shovels. After the major portion of the old seal had been removed, kerosene was sprayed on the surface and allowed to soak for a few minutes after which sand was spread over the surface. This was then broomed thoroughly to remove the sand and dissolved asphalt. Although the method used removed a good deal of the asphalt, considerable residue remained. The neoprene-latex cement seal in the areas which had been previously patched during the cool weather could only be removed by chiseling the material off with a pick.

The asphalt-latex was spread through a distributer spray nozzle with a hand cranked rotary pump. Control of the spread was obtained by gauging the tank from which the latex was pumped. The spread was at the rate of about 0.33 gallons per sq. yd.

The medium-fine screenings, not heated, were spread by hand immediately after the latex spread. The seal coat was then rolled one pass with a dual wheel truck.

As soon as the screenings were rolled the surface was heated with the weed burners. Heat was applied until the asphalt-latex boiled up around the aggregates. A portion of the area was heated by using the weed burners on our small pavement heater, Figure 22. Two large size weed burners were arranged on the carriage so that the flame would be discharged under the flat hood and spread over a larger area of the surface and also to conserve heat. The hood is mounted on a carriage so that it may be pulled along over the surface. However, the small metal wheels on the carriage tended to loosen and pick up the screenings and therefore, the remaining area was heated with the weed burners used independent of the pavement heater, Figure 23. This method was satisfactory except for the greater length of time required due to loss of heat and also two men were required instead of one. Heating of the 100 sq. yd. area required approximately 2-1/2 hours.

After the heating was finished, sufficient sand was spread on the surface, to blot up the exposed latex that had boiled to the surface during heating. The surface was then rolled two passes with the truck and just prior to opening to traffic it was given a third rolling.

The curing time between heating and opening to traffic was 2-1/2 hours. The temperature of the deck just prior to opening to traffic was 132 F., maximum air temperature 104 F.

Inspection of the seal just prior to opening showed a very good interlock and bond within the screenings. The binder surrounding the screenings appeared quite well cured but bond to the deck was not complete because of the fact that the asphalt-latex close to the deck still contained some water. When inspected later, however, this area appeared to be in very good condition, Figure 24.

Based on the above experience it can be stated that the curing time of an asphalt-latex seal coat can be greatly reduced by applying heat to the surface of the completed seal coat. This is of prime importance in obtaining a satisfactory job when the time element is an important factor.

Sand Seal on South Bridge

On the west half of the south bridge which contained the asphalt-latex seal coat, the raised pattern of the decking was showing through the screenings seal in some places, Figure 20, and it was decided to apply a light sand seal coat on this area as long as the equipment was already on the site for the repair operations just described.

No special preparation of the surface was made prior to application of the seal. Asphalt-latex was sprayed on the surface at the rate of approximately 0.08 gallons per sq. yd. and the sand was applied by casting with a shovel at the rate of about four pounds per sq. yd. After the sand was spread, it was rolled with a dual wheel truck. No heat was applied.

When inspected later, it was noticed that the raised pattern was still showing in a few isolated areas but in general the sand seal appeared to be in good condition.

Knights Landing Bridge Walkway

Another example of the light weight steel construction is the walkway on the Knights Landing Bridge which is located in Yolo County. The work, performed in the summer of 1953, consisted of a general reconstruction of the old concrete bridge and included the construction of a steel plate walkway 1-1/2 ft.

wide along each side. To provide a non-slippery surface for this sidewalk a surface consisting of an asphalt-latex seal coat was placed.

The steel walkway was sand blasted to remove scale, dirt and rust. In order to prevent the rolled edge of the walkway, which was on the roadway side of the bridge, from being splattered with latex it was masked with an adhesive faced tape about 4 in. wide procured by the Contractor as a surplus Army item. This tape worked very well, was easily placed and easily removed after completion of the job.

The asphalt-latex was placed at the rate of 0.5 gallons per sq. yd. by hand spraying from a pressurized tank, Figure 26. A light application of sodium fluosilicate was immediately sprinkled on the surface of the asphalt-latex using a 100 mesh 10 in. diameter sieve.

The screenings were spread at a rate of about 15 pounds per sq. yd. after the asphalt-latex and demulsifier had been placed on the deck, Figure 27. Prior to spreading, the screenings were heated to between 250 and 350 F. in a homemade heater, Figure 25, consisting of a 50 gallon drum with a hinged lid and butane heater attached.

After cooling for 30 minutes to one hour the screenings were rolled with a small 6 in. wide, 75 pound roller and the seal coat permitted to cure several days before brooming to remove excess screenings.

The aggregate consisted of pea gravel with the following screen analysis:

Sieve	% Passing
3/8	100
#3	74
#4	4
#8	0

The asphalt-latex emulsion was similar to the one previously described.

When inspected on numerous occasions, the seal coat on the walkway was found to be in excellent condition with the asphalt-latex emulsion well bonded to the deck, Figure 28.

Parking Deck Roof

A portion of the roof area of one of the State buildings in Sacramento was designed as a parking deck for passenger vehicles, Figures 29 and 30. The construction consisted of a reinforced Portland cement concrete deck slab, a sand cushion (for insulating purposes) and the concrete ceiling. Some time after construction, the deck developed numerous cracks resulting in leakage during the rainy season. On the strength of previous experience in successfully sealing with asphalt-latex emulsion some leaking expansion joints in a concrete roof slab on a large State building, the Division of Architecture decided to apply an asphalt-latex seal to the cracked and leaking parking deck.

The seal was placed in December 1953 during adverse weather conditions. The emulsion was applied at the rate of about 0.2 gallons per sq. yd. and after some curing a coat of polystyrene was applied at the rate of approximately one gallon per 300 sq. ft. The purpose of the polystyrene was to prevent oil and gasoline drippings from attacking the asphalt-latex. About two weeks later the seal was covered with sand at the rate of approximately three pounds per sq. yd. The sand failed to embed itself properly into the asphalt-latex as the time interval had permitted the latex mixture to set up sufficiently to resist the penetration of the sand particles.

Some weeks later distress was noted in a few spots in the form of the latex seal peeling from the concrete deck, Figure 31, particularly where cars made turns. The exposed concrete appeared to be quite wet and it was evident that heat from the deck caused by the sun's rays and aided by heat from the offices below had driven moisture vapors from the previously saturated sand layer to the surface, thereby destroying the bond in these isolated areas.

When last inspected in December 1954, the deck appeared to be in satisfactory and serviceable condition with the exception of a few local spots.

The parking deck project is presented simply to illustrate another of the various possible uses of the asphalt-latex seal. There is good reason to believe, judging from past experience, that if the work had been performed under favorable weather conditions and had the sand been placed immediately following the application of emulsion, a completely satisfactory job would have been obtained.

Epoxy Resin Binders

This department has also investigated the possibility of using some of the newly developed synthetic products as a binder for sticking screenings to steel surfaces. One of the most promising appears to be a synthetic resin of the Epoxy group blended with Thiokol rubber, for necessary flexibility. This material appears to possess excellent possibilities as a binder. It adheres tenaciously to steel and aggregates, is not affected adversely by heat or cold and will withstand the action of traffic within three hours after placing. At the present time its high cost (about $7.00 per gallon) makes its use as a seal coat binder prohibitive. However, its use for special applications in highway construction is not being overlooked.

While applying the asphalt-latex seal coat to a portion of the Ulatis Creek Bridge in July 1954 a small trial area in the wheel tracks, about 3- by 6-ft., was prepared using a combination of Epon and Thiokol as the binder and fine screenings (100% passing #4 sieve) as the cover. After six months of service this trial area appears to be in excellent condition.

Use of Asphalt-Latex Emulsion on Other Structures

In addition to the projects described in this report, the asphalt-latex emulsion seal has also been used for similar purposes on one or two other bridge structures. In the summer of 1953 the steel walkway of three pedestrian overpasses crossing the San Francisco Bayshore Freeway have been provided with an asphalt-latex seal coat similar to the Knights Landing walkway described in this report. Limited use has been made by the Bridge Department with the asphalt-latex emulsion, mixed with aluminum paste, for painting concrete curbs and hand rails, showing distress, at high altitudes to prevent moisture from entering the cracks with resulting freezing and spalling of the concrete.

Besides the previously mentioned extensive use of the asphalt-latex emulsion for joint sealing of Portland cement concrete pavements it has also been combined with titanium dioxide, forming a light gray colored mass, strongly resembling concrete in appearance for the purpose of filling spalled areas in a newly opened concrete pavement.

One of California's Counties(3) has also used, successfully, asphalt-latex seal coats as a wearing surface on small steel bridges.

Conclusions

Of the two principal binders described, namely neoprene-latex lumnite-cement and asphalt-latex emulsion, the asphalt-latex unquestionably was the easier to place. The material is readily available on a commercial basis. The price varies from $1.20 to $1.50 per gallon depending upon quantity. The neoprene-lumnite cement paste requires the mixing of two ingredients on the job site. The cost of the combined mixture does not vary greatly from that of the asphalt-latex emulsion. Labor cost of application for the two materials are not materially different, although applying the neoprene-lumnite cement uniformly presents a problem. While the initial cost of these types of seal coat is relatively high, care and strict attention to detail in placing should result in a thin wearing surface much superior to the conventional seal coat. Our experience has shown that weather conditions at the time of placing either of the two materials is a factor of prime importance. Whereas warm or hot weather is desirable during the placing of the asphalt-latex, cooler weather and proper curing methods are required for the latex-lumnite cement. If noticeable deflections or vibrations are to be considered, the asphalt-latex should be the more desirable. Considering the two binders more specifically, the following additional conclusions can be reached:

Neoprene-Latex Lumnite-Cement Section

Although this section did not perform satisfactorily, it is felt that the failure can be contributed almost entirely to the prevailing weather conditions at the time of placing. The hot steel deck and high atmospheric temperature produced a very fast set of the 1/8 in. thick layer of paste and hydration of the cement had taken place before the screenings could be properly embedded in the matrix. The noticeable deflection of the deck and strong vibratory stresses set up by the heavy fast moving trucks undoubtedly contributed to the failure of the weak paste. A more satisfactory method than the one used will have to be developed to obtain uniform application of the binder. Perhaps, equipment similar to that used in gunniting work could be adopted for its use. It is the writer's opinion that if the seal coat could have been placed during cooler weather a satisfactory job would have resulted. This seems to be borne out by the fact that the experimental plates placed in the laboratory driveway showed no distress after two years and the patches on the bridge deck placed during cool weather exhibited a very strong bond to the steel deck and in later patching operations had to be chiseled off the deck.

Asphalt-Latex Emulsion Section

The application of a thin light-weight bituminous wearing surface, giving satisfactory service, to either steel or wooden bridge decks has been demonstrated. It would be difficult to predict its probable useful life at this date. Traffic and climatic conditions could influence its life considerably. The Rio Vista Bridge surfacing is still in serviceable condition after 7-1/2 years and the seal coat on the Ulatis Creek Bridge which has been subjected to very heavy truck traffic for 2-1/2 years is in excellent condition. The smooth deck of the latter project when compared to the one with the raised pattern gives the better appearance.

Although both decks are exposed to heavy traffic, we do not consider it advisable to place this thin seal coat on smooth steel decks which might be subjected to sudden stops or accelerations particularly of heavy vehicles.

It is of primary importance that the asphalt-latex emulsion be placed during favorable weather conditions in order to develop a satisfactory bond. The curing time can be materially reduced by applying heat to the surface of the seal coat. It seems to be borne out that once a good bond is established, the asphalt-latex seal coat provides a very satisfactory anti-skid wearing surface and is able to withstand considerable deflection and vibratory stresses.

Acknowledgements

The work described herein was performed under the general direction of Mr. F. N. Hveem, Materials and Research Engineer, California Division of Highways. The bridge work was under the direction of Mr. F. W. Panhorst, Bridge Engineer. The laboratory and field work was under the direct supervision of the writer.

Acknowledgement is made to Mr. John Skog, Associate Chemical Testing Engineer, for his contributions and assistance during the preliminary laboratory work and field work and to Mr. Frank Kinsman, Assistant Physical Testing Engineer who was engaged in some of the early experimental work. The writer wishes to especially acknowledge the work of Mr. R. M. Hammond, Assistant Highway Engineer, who performed most of the experimental and preliminary testing and assisted the resident engineers and Maintenance Department during the placing of the various seal coats.

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2. T. E. Stanton, Asphaltic Oil-Latex Joint Sealing Compound, Journal of the American Concrete Institute Discussion, Vol. 18 No. 4, Dec. 1946 p. 580-1.
3. H. F. Cozzens, County Cuts Small Bridge Costs, Western Construction, April 1954.

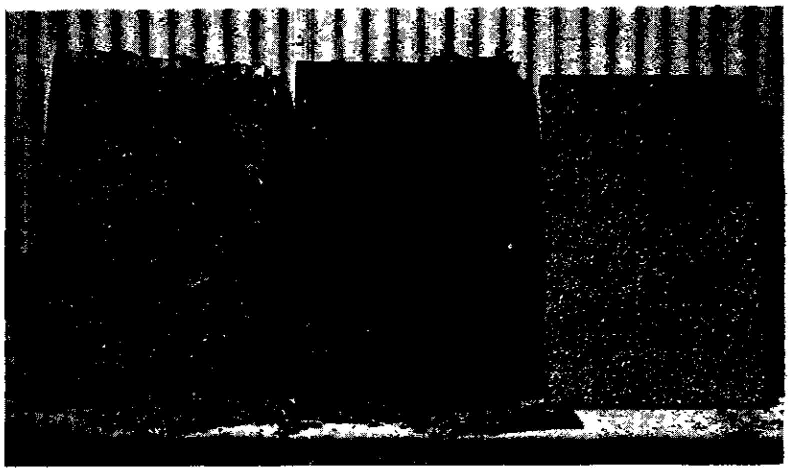

Fig. 1
Wood Test Panels
Left: 30-40 Penetration Asphalt
Middle: 200-300 Penetration Asphalt
Right: Asphalt-Latex Emulsion

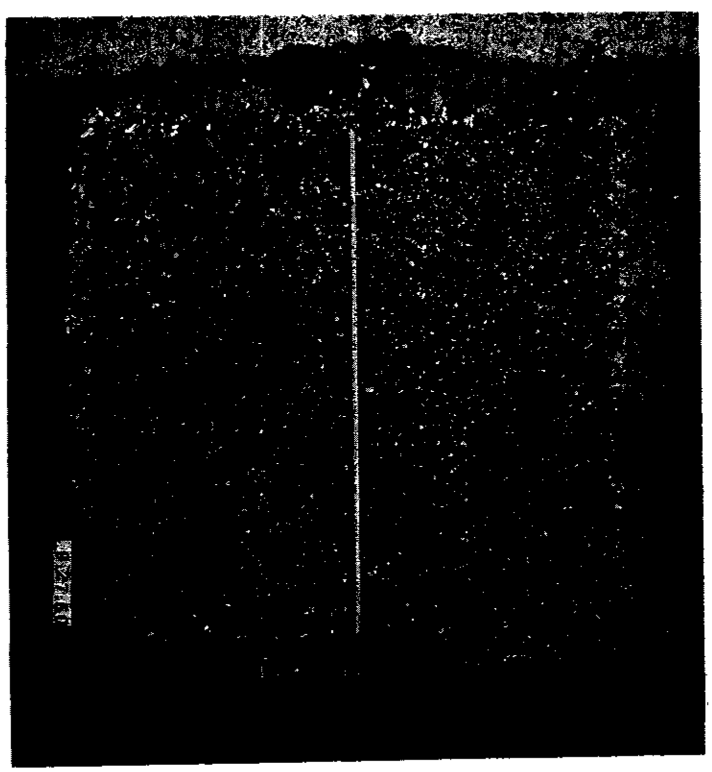

Fig. 2
Steel Plate Fastened to Concrete Driveway
Asphalt-Latex Binder and Screenings

RIO VISTA BRIDGE

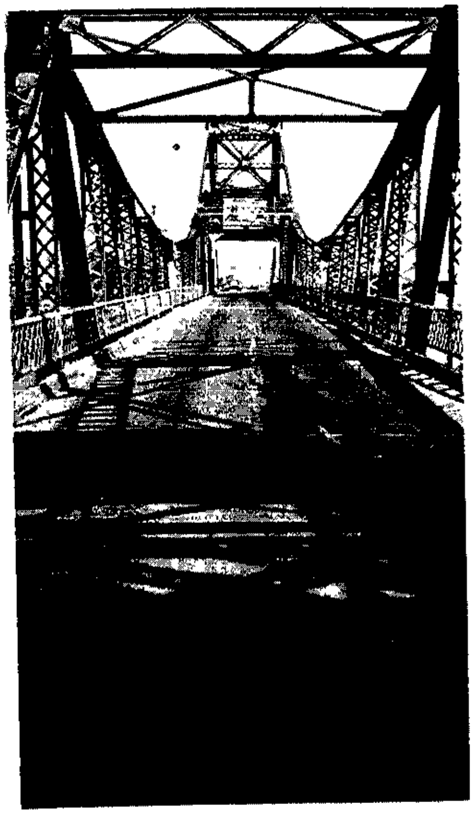

Fig. 3
General View

Fig. 4
Placing of Asphalt-Latex Emulsion Seal Coat

Fig. 5
Placing of Asphalt-Latex Emulsion Seal Coat

RIO VISTA BRIDGE

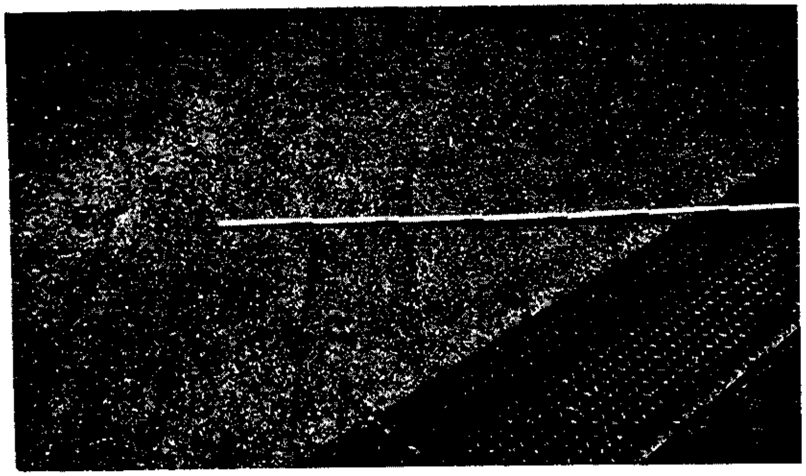

Fig. 6
Appearance of Seal Coat
after Placing, May 1947

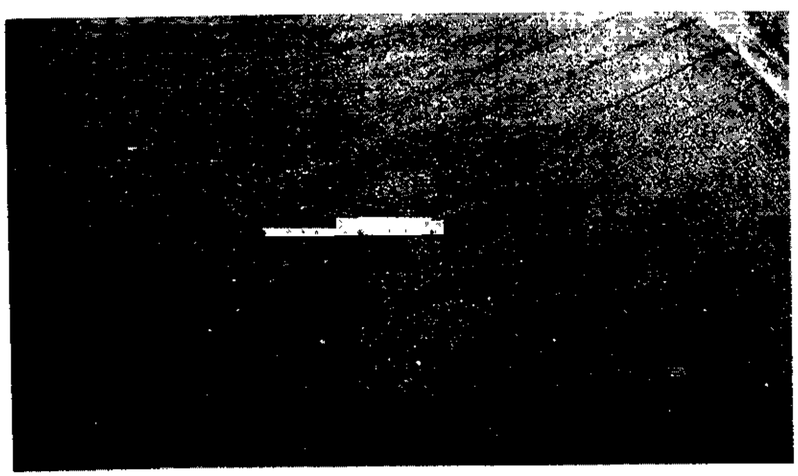

Fig. 7
Appearance of Seal Coat
after 3 Years, May 1950

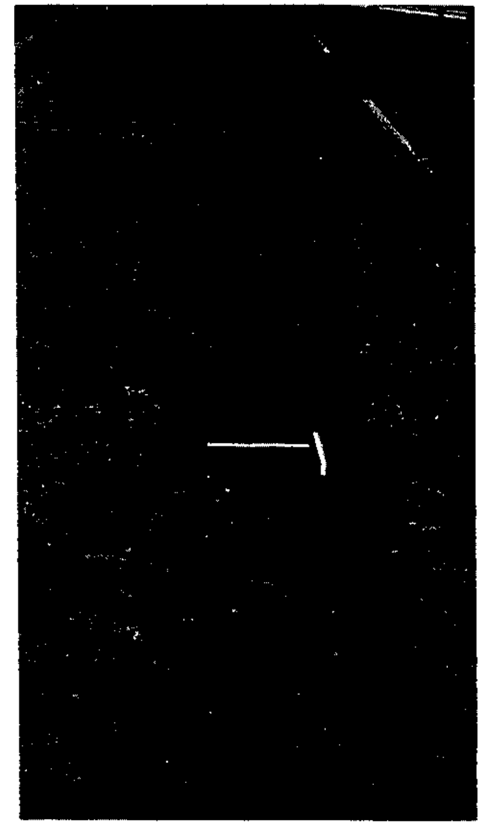

Fig. 8
Appearance of Seal Coat
after 7 Years, May 1954

ULATIS CREEK BRIDGE

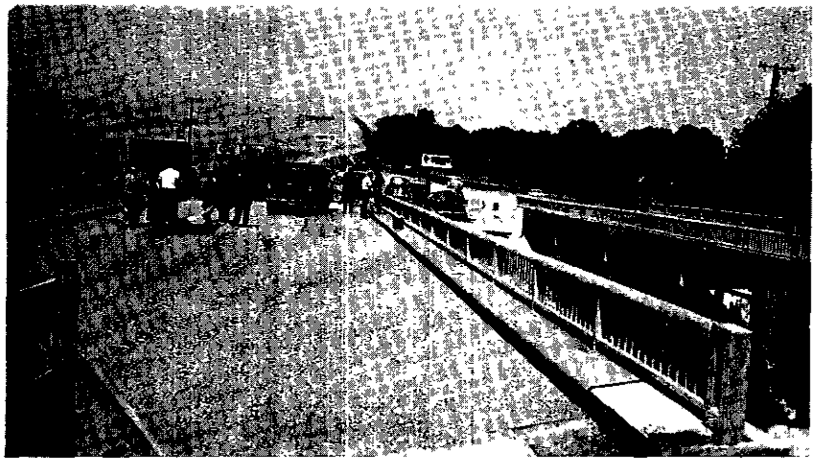

Fig. 9
General View

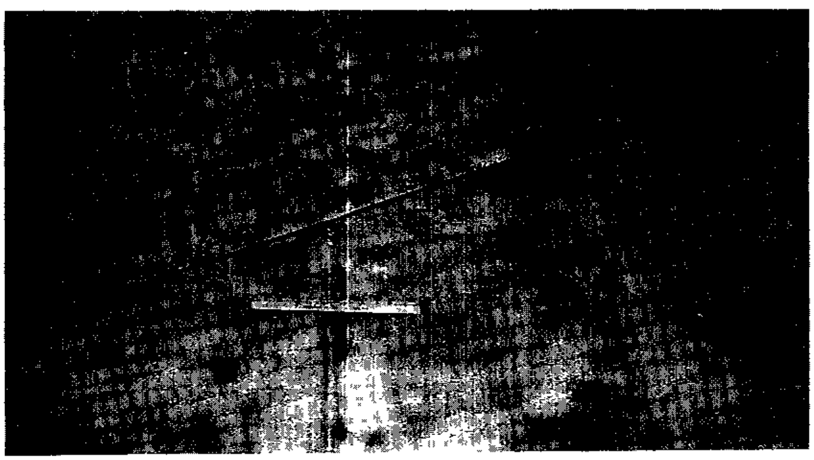

Fig. 10
Smooth Steel Deck

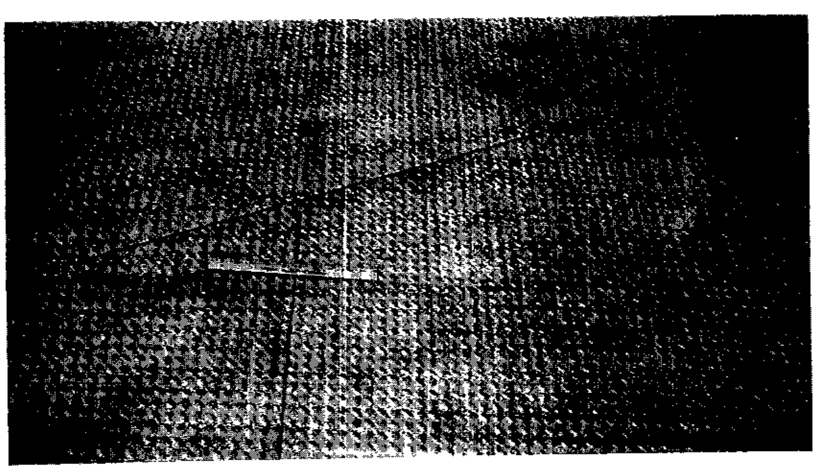

Fig. 11
Raised Pattern Steel Deck

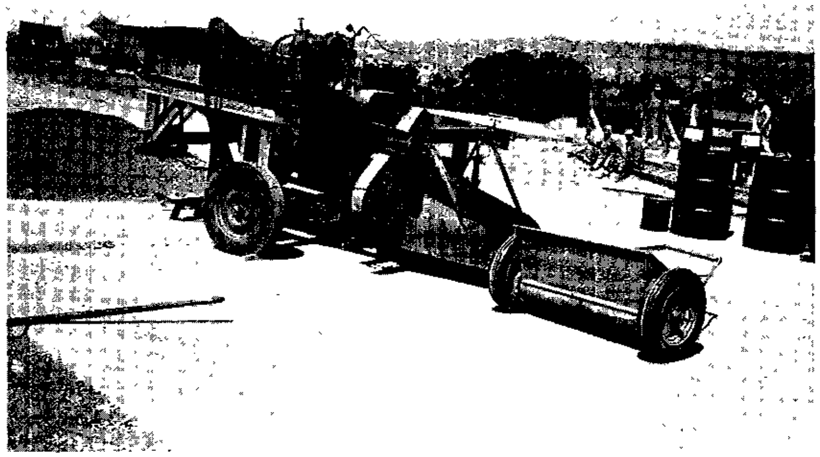

Fig. 12
Heater and Spreader for Screenings

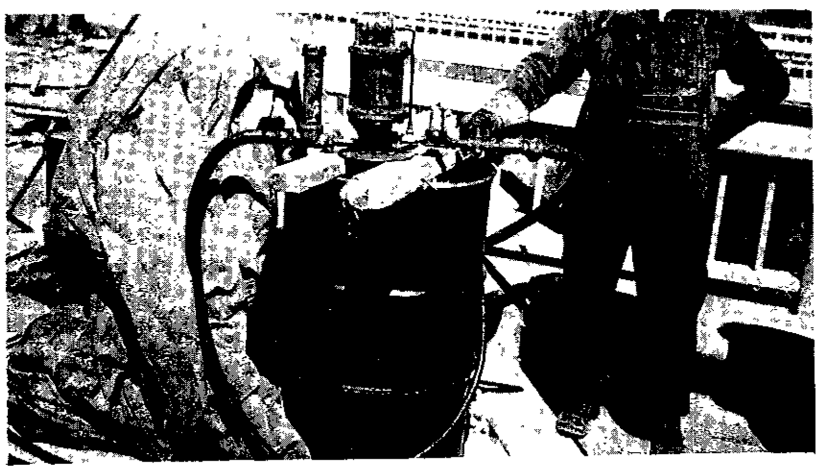

Fig. 13
Alemite Pump for Spraying
Asphalt-Latex Emulsion

Fig. 14
Applying Asphalt-Latex Emulsion
Sifting Sodium Fluosilicate on Emulsion

ULATIS CREEK BRIDGE

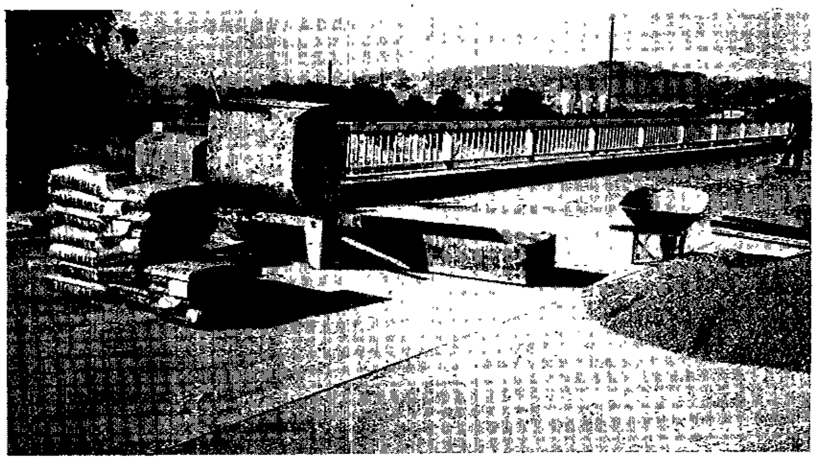

Fig. 15
Plaster Mixer for Mixing
Neoprene-Latex and Lumnite Cement

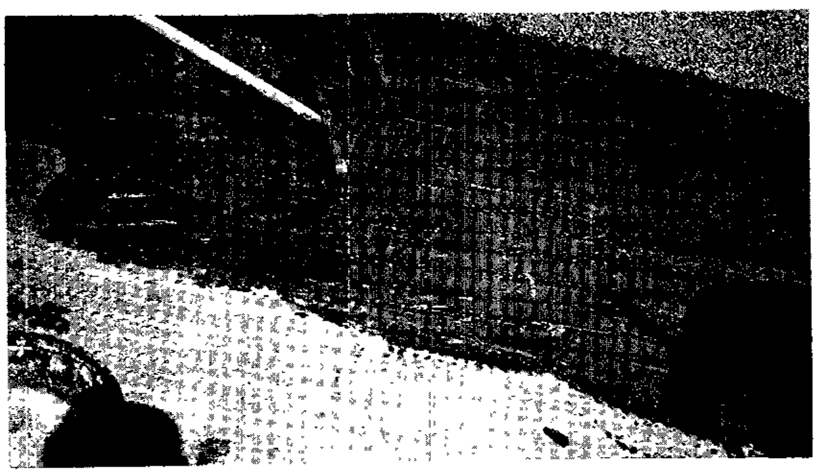

Fig. 16
Spreading Latex-Lumnite
Cement Mix with Squeegees

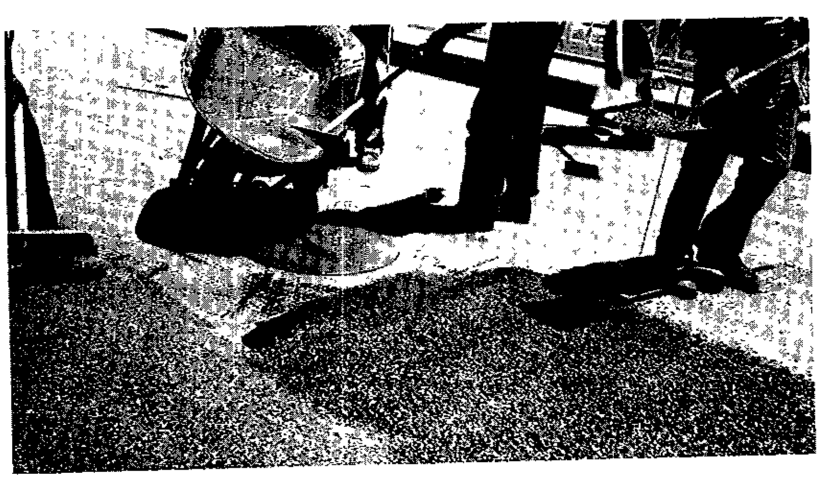

Fig. 17
Latex-Lumnite Cement
Mixture and Screenings

ULATIS CREEK BRIDGE

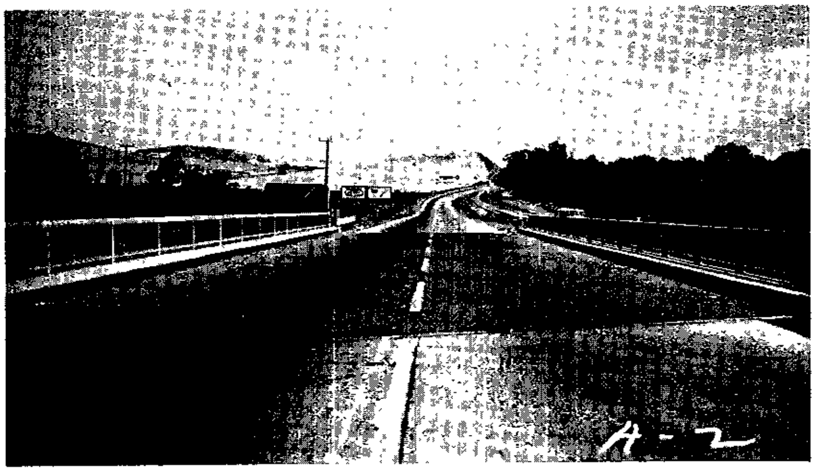

Fig. 18
Smooth Deck, Asphalt-Latex Seal Coat in Foreground
Latex-Lumnite Cement Seal Coat Background, July 1952

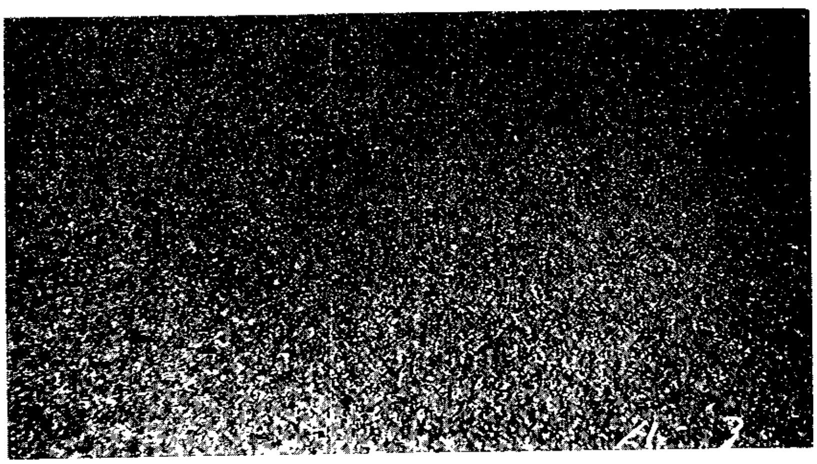

Fig. 19
Close-up of Asphalt-Latex Seal Coat
After One Year, August 1953

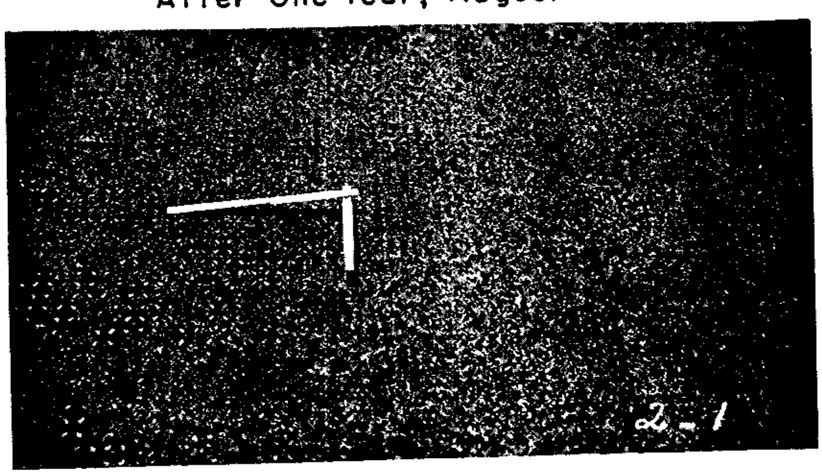

Fig. 20
Close-up, Raised Pattern Steel Deck with Asphalt-Latex
Emulsion Seal Coat, Before Applying Sand Seal, 1954

ULATIS CREEK BRIDGE

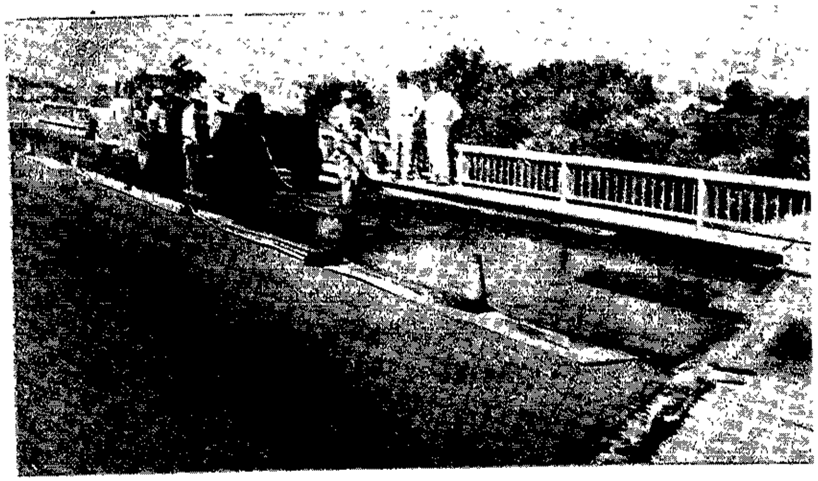

Fig. 21
Applying Asphalt-Latex in Travel Lane to Smooth Deck, July 1954. Asphalt-Emulsion Seal Coat on Left. Asphalt-Latex Seal Coat Placed in June 1952 in Background.

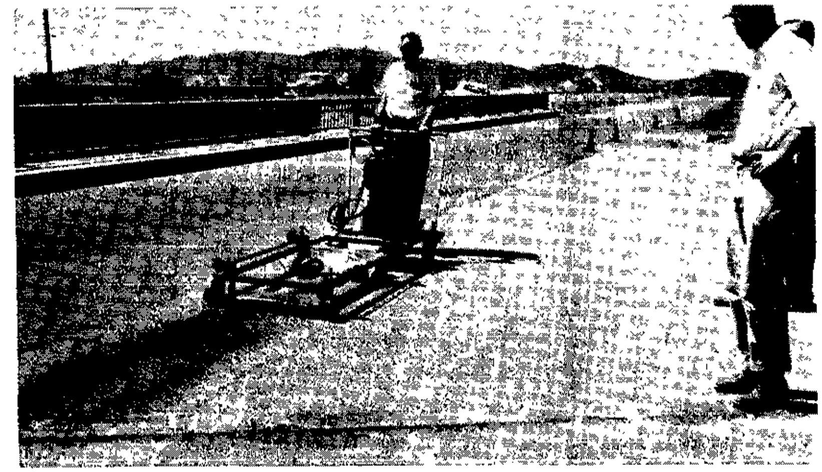

Fig. 22
Heating Screenings with Pavement Heater

Fig. 23
Heating Screenings with Weed Burners

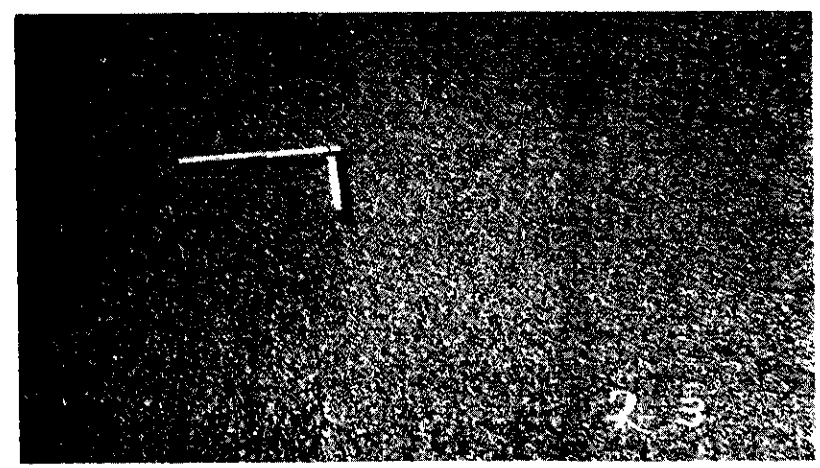

Fig. 24
Finished Surface after Heating Screenings, June 1954

KNIGHTS LANDING BRIDGE

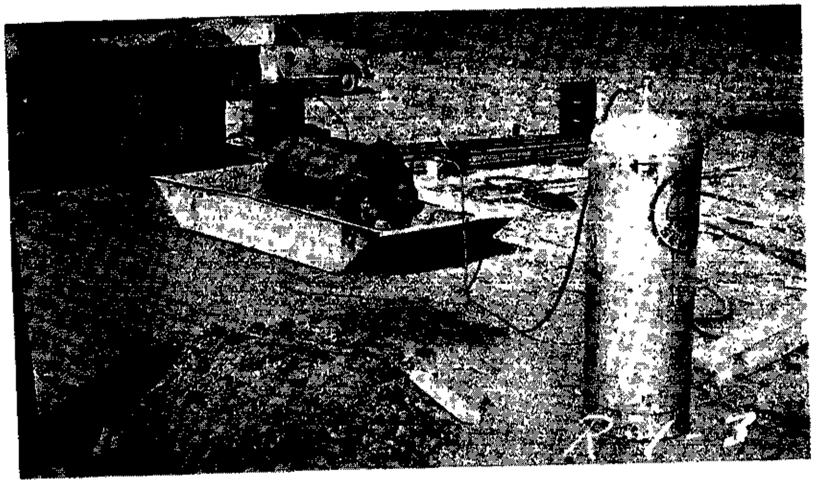

Fig. 25
Drum Heater for Heating Screenings

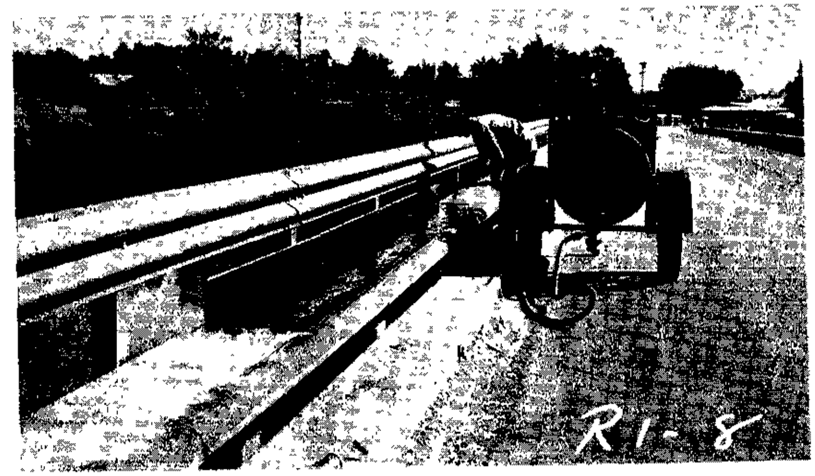

Fig. 26
Applying Asphalt-Latex Emulsion
Foreground Sodium Fluosilicate
Sifted on Top of Emulsion

Fig. 27
Applying Screenings
Sodium Fluosilicate Applied
to Emulsion in Background

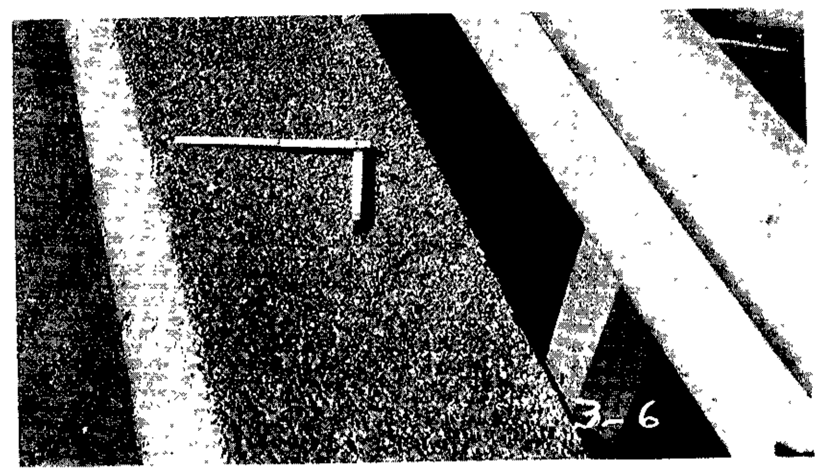

Fig. 28
Appearance of Walkway After $1\frac{1}{2}$
Years of Service, 1954

PARKING DECK ROOF

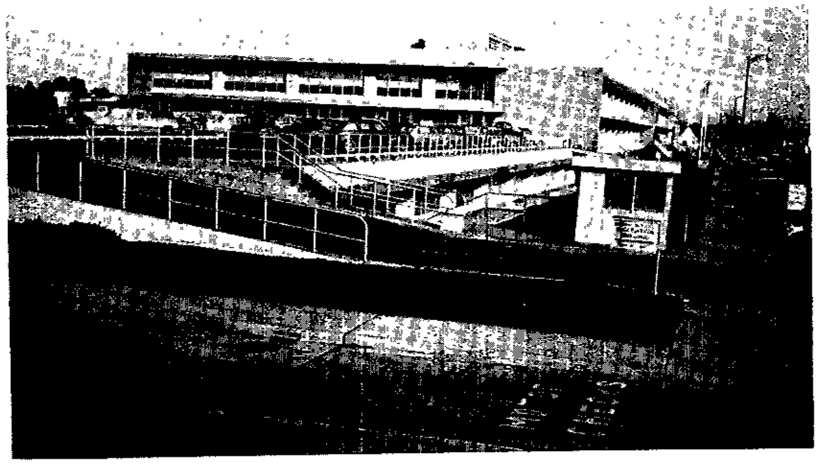

Fig. 29
General View

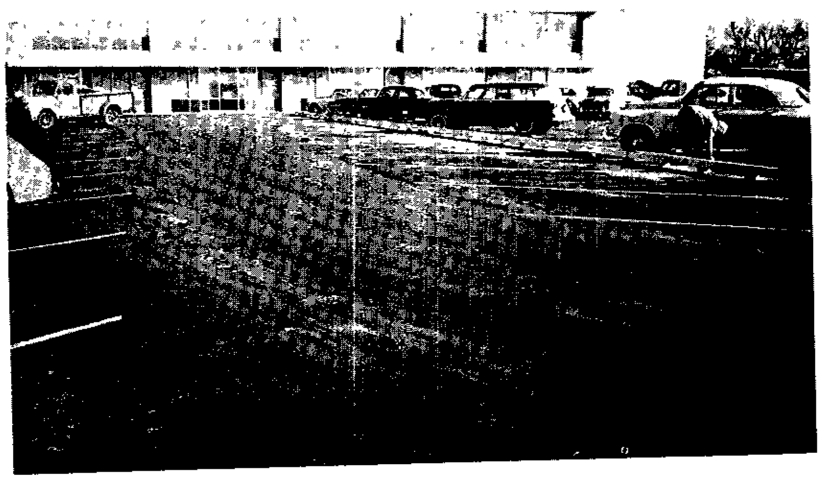

Fig. 30
Appearance of Parking Deck After
One Year of Service, December 1954

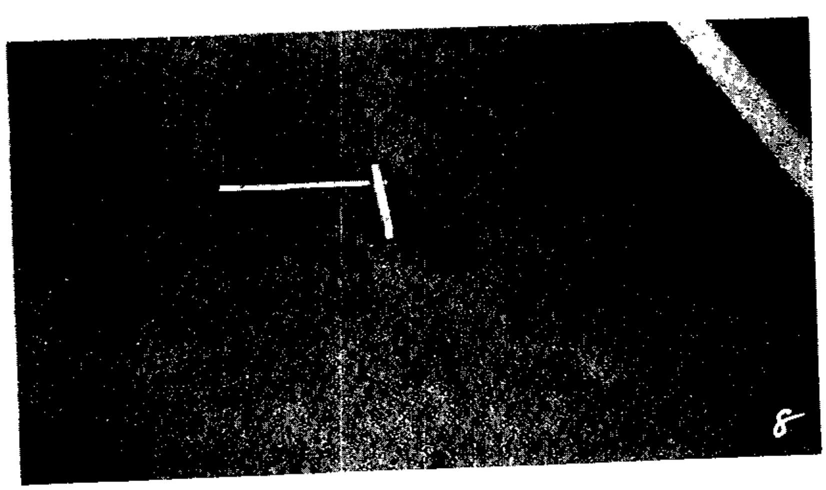

Fig. 31
Close-up of Area Showing Distress, 1953

December 15, 1954

Appendix A

STATE OF CALIFORNIA
DIVISION OF HIGHWAYS
MATERIALS AND RESEARCH DEPARTMENT

Tentative Specifications for Placing of
Asphalt-Latex Emulsion Wearing Surfaces on Bridge Decks.

General

The area to be surfaced shall be covered with a relatively thin wearing course consisting of screenings incorporated in a binder composed of rubber latex and asphalt and designated as asphalt-latex emulsion. The binder shall be used on the areas as indicated on the plans or as directed by the Engineer. On wood decks the surface shall be thoroughly broomed and all cracks and crevices shall be swept clean. Any cracks shall be calked with a suitable calking compound prior to application of the binder. Steel decks shall be cleaned of scale, grease or dirt by sand blasting and just prior to placing the binder the entire deck shall be swept clean.

Asphalt-Latex Emulsion

Asphalt-Latex Emulsion shall be prepared by emulsifying 200-300 penetration paving asphalt with commercial rubber latex in the presence of an emulsifying agent.

The resulting emulsion shall consist of:

60 parts by volume of paving asphalt 200-300 penetration.

40 parts by volume of rubber latex of either natural plantation rubber or synthetic latex designated as GRS-Type 4 (formerly GRS-Type 3) containing approximately 40% solids.

5 to 10 parts of one-half strength of sodium silicate, commercial grade, shall be used as the emulsifying agent, or any other suitable agent approved by the Engineer.

The rubber latex asphalt emulsion shall comply with the following specification requirements:

Designation	Test Method	Limits	Remarks
Viscosity Furol, 77 F., Sec.	AASHO T72-46	50-250	
Sieve Test, Max.	AASHO T59-49	1.0%	
Penetration 77 F. (Grease Cone)	ASTM D217-52	50-250	Test made at 77 F. in air bath 30 minutes after adding 5% sodium fluosilicate.
Elasticity, Min.	Calif. Highways	70%	After the addition of 5% of sodium fluosilicate and curing for 24 hours at 100 F., the specimen shall have an elastic recovery of not less than 70% when tested in a modified ductility mold.
Dehydration Loss - % Max.	Calif. Highways	30%	Twenty-five grams of emulsion, prior to adding the gelling agent, is placed in an 8-ounce flat ointment can and dehydrated in a suitable oven maintained at a temperature of 200 F., ± 2 F. for a period of 24 hours.
Time of "Set"	Calif. Highways	15-60 Min.	After mixing the emulsion with 1% to 4% by weight of powdered sodium fluosilicate, the emulsion shall harden or develop a "set" in from 15 to 60 minutes, under field conditions.

Screenings

Screenings shall consist of broken stone, crushed gravel, or both, and shall be hard, tough, durable and sound. Crushed gravel shall consist of not less than 90%, by weight, of particles having at least one fractured face. Screenings shall not contain thin or elongated pieces.

They shall be of the medium-fine grade, conforming to the specifications noted below, and shall be clean and free of dust and shall be washed if necessary to insure the removal of all dust and clay coatings.

When tested, the loss shall not exceed the following:

Wet Shot Rattler Test	37%
Los Angeles Rattler Test (after 100 revolutions)	10%
Los Angeles Rattler Test (after 500 revolutions)	40%

Screenings shall conform to the following grading requirements:

Sieve Size	% Passing
3/8"	100
#3	70-90
#4	30-60
#8	0-15
#16	0-5
#30	0-3
#200	0-2

Application

The asphalt-latex emulsion shall be applied to the deck with suitable spraying equipment at the rate of between 0.4 and 0.5 gallons per sq. yd., the exact rate of application to be determined by the Engineer. Immediately after the binder is spread, sodium fluosilicate shall be uniformly sifted over the emulsion at the rate of approximately three to five percent by weight of the emulsion. (Sodium fluosilicate is a poison and care must be exercised to prevent injury to workmen or to the traveling public while the powder is being applied). No traffic of any kind shall be allowed on the freshly spread latex prior to placing screenings.

Immediately following the application of sodium fluosilicate, the surface shall be covered with medium-fine screenings heated to a temperature between 250 F. and 300 F. and spread at the rate of from 16 pounds to 20 pounds per sq. yd.

Screenings shall be spread by means of a chip spreader, equipped with a mechanical device capable of spreading the screenings in a uniform thin sheet over the full width of the area to be treated.

After the screenings have been spread on the latex treated surface, any piles, ridges, or uneven distribution shall be carefully broomed by hand to insure against permanent ridges or humps in the completed surface. Additional screenings shall be spread by hand in whatever quantities may be required to prevent picking up by the rollers or traffic, after which the surface shall be lightly rolled, by pneumatic-tired rollers. Excessive rolling or brooming will not be permitted.

Pneumatic-tired rollers shall be of the single or double axle type, having a width of not less than four feet, nor more than seven feet, and equipped with pneumatic tires of equal size and diameter, with treads satisfactory to the Engineer. The tires shall be uniformly inflated so that the air pressure in the several tires will not vary more than five pounds per sq. in. Pneumatic-tired rollers shall be so constructed that the total weight of the roller can be varied to produce an operating weight per tire of between 1,000 and 2,000 pounds, and during operation, the total operating weight of the roller shall be varied as ordered by the Engineer. On small jobs, when approved by the Engineer, a dual tired truck, preferably with smooth tires, may be substituted for the pneumatic roller.

After rolling has been completed, all excess screenings shall be removed as directed by the Engineer, care being taken not to disturb screenings which are set in the rubber-latex binder.

Traffic shall not be permitted on the surface, when in the opinion of the Engineer the latex binder has not set up sufficiently hard or developed sufficient bond to withstand the action of traffic. Under average summer weather conditions, the curing interval on a dry wood deck bridge may be from two to four hours while a steel deck may require from three to four days or longer.

At no time shall the emulsion be subjected to a temperature below 40 F. Prior to application, the material may be warmed, if necessary to facilitate handling. The method of heating shall be carefully controlled to avoid overheating of any part of the container or mixture and under no circumstances shall the emulsion be heated to a temperature greater than 130 F.

No rubber latex emulsion shall be spread during unsuitable weather or when the atmospheric temperature is below 50 F or when weather conditions indicate that the temperature may fall to 32 F within 24 hours.

The surface of the deck shall be dry before application of the binder

Payment

Asphalt-latex seal coat will be paid for at the price per gallon for latex asphalt emulsion and the price per ton or cubic yard for screenings. The price or prices shall include full compensation for furnishing all labor, materials, tools and equipment and doing all the work involved in applying the wearing course and all incidental work connected therewith.