Test Installations of Silica Sand Resurfacing

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This paper discusses the method used by The Port of New York Authority to determine when a pavement should be resurfaced, the problems involved, and the materials used.

Special problems arise when bridges, tunnels and in some cases airports, are to be resurfaced. In tunnels these problems include headroom and drainage. In bridges they include additional weight and expansion joints, while on airports the principal cause for concern is one of economics. In our opinion the solution of some of these problems indicated the need for the development of new materials. The paper describes the new materials tested, their costs, anticipated life, and advantages and disadvantages as we see them.

GENERAL

●THE PORT AUTHORITY operates 19 public land, sea, air and transportation facilities, including 4 bridges, 2 vehicular tunnels, 4 airports, a heliport, 4 marine terminals and 3 inland terminals for trucks and buses. The bridges and tunnels connect New Jersey with either Manhattan or Staten Island. They are the George Washington Bridge, the 3 Staten Island Bridges, the Holland Tunnel and the Lincoln Tunnel. The airports are New York International, La Guardia, Newark and Teterboro.

The bridges, built between 1928 and 1931, originally had concrete roadways with both sliding plate and finger type expansion joints.

On the three Staten Island Bridges only normal maintenance was required until 1948. In 1948 spalling and scaling of the concrete pavement along the curbs of the Bayonne and Outerbridge Crossing, required the removal of two in. of portland cement concrete and replacing it with two in. of asphaltic concrete. Except at the toll booths, the George Washington Bridge pavement has not required major repairs.

The Lincoln Tunnel (South Tube opened 1937, North Tube opened 1943) has brick pavement, while the Holland Tunnel, opened in 1927, was originally paved with granite block. This block was removed and the roadway repaved with asphalt in 1949. We believe this was the first time asphalt was used in a subaqueous vehicular tunnel.

Maintenance on the South Tube of the Lincoln Tunnel roadway became increasingly costly and it was only because traffic conditions made it just about impossible to close, that it has not been repaved. The recent opening of the Third Tube will now allow this repaving to be done.

Surveys and Analyses

In an effort to determine when it would be desirable or economically necessary to resurface the bridges and tunnels, a plan was set up whereby periodic surveys of the following data were analyzed: (a) cost of routine maintenance (b) visual inspection, and (c) results obtained by the use of a BPR road roughness indicator. Insofar as maintenance costs were concerned the figures were readily obtained from cost records.

Visual inspection was made by an experienced engineer and included a thorough inspection for spalling or scaling that usually results in surface disintegration and ultimate exposure of re-enforcing steel. As we all know, this deterioration, if not corrected, will eventually require reconstruction of the entire concrete slab. Another point to be considered in the visual inspection is the surface wear which results from heavy traffic. This wear polishes the pavement surface to the point where its skid resistance qualities all but disappear. With brick, trouble comes from cushion failure. The best of joint filler is soon pulled out. After it is gone the edges of the brick break down, a one-quarter inch joint becomes one-half inch and larger. Water finds its way in, the cushion becomes soft, the bricks move under traffic and soon you have depressions.

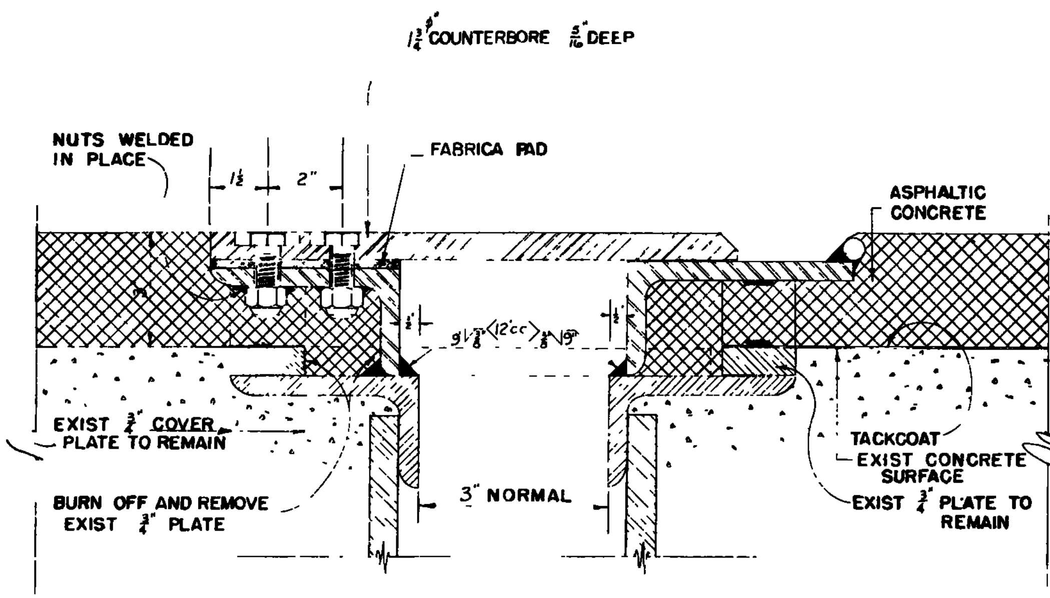

Figure 1. Typical method of raising sliding plate type expansion joint 3 in. asphalt resurfacing.

We have not only experienced spalling and scaling, but also wear due to tremendous traffic, notably at the George Washington Bridge. We have found that scaling, spalling and wear occur and progress at widely varying ways, presumably due to variations in traffic, weather, workmanship and materials incorporated in the initial installation. In general, we have found that a concrete bridge deck, assuming that it was properly constructed of good materials and workmanship, will require resurfacing because of one reason or another after 25 to 30 years of service. Our experience with granite block and brick pavement shows they have an economic life of about 20 years. Prior to resurfacing the Goethals Bridge in 1957 we had the opportunity of using a BPR road roughness indicator. This device was designed in an effort to establish quantitative data on the roughness of the road. Our readings on the Goethals Bridge showed 230 in. per mi which indicated resurfacing was necessary. We feel that most bridge surfaces should not show readings over 175 in. per mi.

Problems of Resurfacing

In the past some original bridge designs included little or no tolerance for future resurfacing and the additional weight which would be involved by adding a two to three inch thickness of asphaltic concrete. An example of this is a major bridge in the New York area where we understand to resurface the concrete deck, it was necessary to remove three-quarters of an inch of the top concrete surface prior to the installation of asphaltic concrete. Another example is the George Washington Bridge. This bridge was designed with an allowance for both resurfacing and adding a second deck for rapid transit. However, plans have changed with the changing times and the second deck, which will be constructed within the next four years, will be for 6 lanes of vehicular traffic rather than for 2 tracks of rapid transit. The result is most of the weight allowance contemplated for resurfacing is now going into the de-

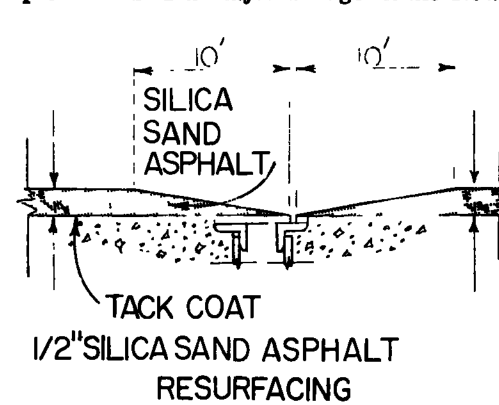

Figure 2.

sign change. We felt it most necessary to seek a means of resurfacing which would keep the additional weight to an absolute minimum.

A very important question in resurfacing any roadway, not alone that of a bridge, is the raising of manholes, curb drains, and expansion joints to the new grade in order to permit smooth riding. This work, particularly that of the expansion joints on bridges, is very expensive, time consuming and interferes with traffic.

In tunnels the problem is different. We are not concerned with weight but we are concerned with headroom and curb drainage. Because of these conditions it is impossible to resurface in the usual manner, and it becomes a problem of removing the existing pavement and completely repaving. Since this is usually night work, it is expensive.

On airport runways and taxiways, differential settlement causes irregularities which create a hazard to planes and must be eliminated. The tight CAA grade change tolerances often makes it necessary to resurface large areas in order to eliminate this condition and still get a smooth riding surface.

Decision to Resurface and Scheduling

As a result of the periodic surveys and cost analyses, a scheduling for resurfacing was adopted in 1955. This schedule called for completely resurfacing the three Staten Island bridges between 1955 and 1957 with the exception of the main span of the Bayonne Bridge.

The main span of the Bayonne Bridge was delayed in an effort to design a more satisfactory method for raising the finger type expansion joints to accommodate three inches of asphaltic concrete. An initial survey of these expansion joints indicated that it would

Figure 3. Bayonne Bridge, test section of silica sand asphalt after 10 months of service 7,000 cars per day.

Figure 4. Goethals Bridge, removing excess joint material prior to resurfacing.

be necessary to remove the existing fingers and replace them at an estimated cost of $80,000.

Need for New Resurfacing Material

In view of the weight problems and high costs the Port Authority initiated a program to secure a new resurfacing material that would be lighter and more economical.

In addition to being light in weight and having low installation costs the new material would also have to fulfill the following conditions:

1. Excellent adherence to existing surface.
2. Be skid-resistant under all conditions.
3. Would not shove, rut or become wavy under heavy traffic and extreme weather conditions.
4. Must wear well under heavy traffic.
5. Construction and installation must require a minimum of time with a minimum of traffic interference.

In order to satisfy all the above conditions, various thin resurfacing materials were investigated of which the following were the most promising: (a) Vultite, (b) Epoxy Resins, (c) Silica Sand Asphalt, (d) Rockite.

Vultite is a proprietory product containing asphalt emulsion, cement, sand and water. The ingredients of this material are mixed in a concrete mixer, spread and screeded to a thickness of ½ to ¾ in., floated with a mechanical float and rolled with a one-ton roller. After one year, the test section of Vultite installed on the George Washington Bridge is in good condition except for two holes about 6 in. in diameter which appear to be adhesion failures.

Epoxy Resins. This material, which was the subject of a paper at the last meeting of this group, is a plastic developed by Shell Oil and the Reliance Steel Products Co. of McKeesport, Pennsylvania. The chemical ingredients are mixed in the correct proportions in a flat bed truck, discharged into a hopper, and spread in strips on the bridge deck. A special paint-like roller spreads these strips into a uniform coating of the predetermined thickness. Sand is then spread over the liquid epoxy and rolled with a small one-ton roller. The thickness used in our test sections was $\frac{1}{16}$ and ⅛ in. The test section, about one year old at the George Washington Bridge, which was installed on asphaltic concrete pavement, is in good condition. The test section on Portland cement concrete pavement shows a few failures, all apparently due to lack of adhesion.

Silica Sand Asphalt. A material known as silica sand asphalt is a mixture of almost pure silica sand of certain gradation, asphaltic cement and mineral filler. It should be noted here that this is not the same as sheet asphalt. It is similar to, but not, Kentucky Rock Asphalt.

Rockite. A proprietory material called Rockite is another thin surfacing asphaltic material. It contains aggregate up to one quarter inches. It is made cold, but the exact method of manufacture is not available for publication. We do know powdered asphalt is used in its manufacture. We have installed a test section of this material in the fall of 1957 and will observe it closely.

Cost. Estimates of the cost of the different materials installed on our bridges were as follows:

1. Vultite - $1.80 to $2.70 per sq yd installed.
2. Epoxy Resins - $2.00 to several times this amount per sq yd installed.
3. Silica Sand Asphalt - $.40 to $.50 per sq yd installed.

Figure 5. Goethals Bridge, cleaning concrete pavement with compressed air prior to applying tack coat.

4. Rockite - $.40 to $.50 per sq yd installed.

5. Three inches asphaltic concrete including the cost of raising expansion joints, but not for removing the existing pavement, - $2.50 to $4.10 per sq yd.

6. Three inches of asphaltic concrete including the cost of raising expansion joints and removing the existing pavement - $6.00 to $8.00 per sq yd.

From the information we had gathered up to this time, all indications pointed to the further development of silica sand asphalt.

Development of Silica Sand Asphalt

Research work on silica sand asphalt was originally done by the Virginia State Highway Department in an effort to find a synthetic substitute for a natural de-slicking material they had found very satisfactory. Actually, the Virginia Highway Department had used this anti-skid material in thicknesses of about ⅛ in. or 10 to 15 lb per sq yd. Members of The Port of New York Authority and the New Jersey State Highway Department, working jointly after inspecting some of the Virginia installations, made several tests using various mixes of silica sand and asphalt. They concluded that a ½-in. thick pavement resurfacing, weighing about 50 lb per sq yd should satisfactorily carry heavy traffic without shoving or rutting.

Design

To gain insight into the factors that might influence the design of the silica sand asphalt, a series of exploratory laboratory tests were run. Analyses were run on various silica sands available in the Metropolitan Area. Benefitting by the Virginia Highway Department findings, the sands were subjected to the boiling stripping tests in order to determine their moisture resistant qualities. Fortunately, the results of these tests were satisfactory and we did not believe it necessary to add hydrated lime or such admixtures as Kling or Pave in order to get the desired results.

We believed the percent of voids in the combined mix to be extremely important. In our opinion, it should not be less than ten percent and may run as high as 18 percent. While stability is important, it is not as important as in regular asphaltic concrete

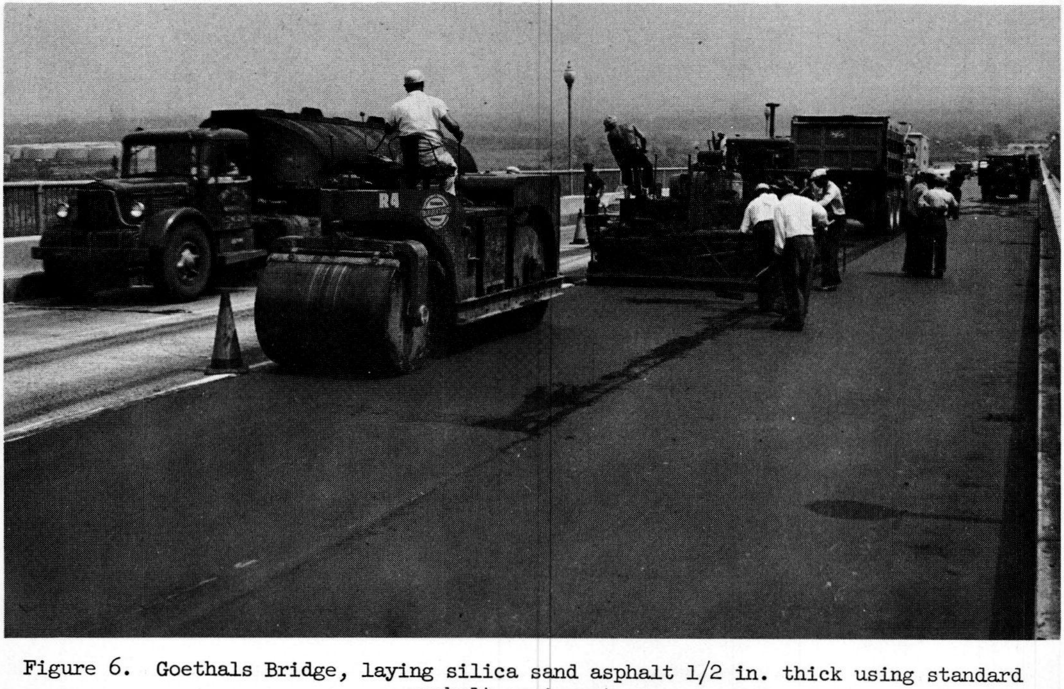

Figure 6. Goethals Bridge, laying silica sand asphalt 1/2 in. thick using standard asphalt equipment.

TABLE 1

SILICA SAND GRADATIONS WHICH HAVE PROVED SATISFACTORY FOR USE IN SILICA SAND ASPHALT

Sieve	Total Passing (By Weight) (a)	(b)	(c)
4	100	100	100
10	100	100	99
40	93	85	86
80	14	25	40
200	1	2	7

TABLE 2

RECOMMEND SPECIFICATION GRADATIONS OF COMBINED AGGREGATE, INCLUDING FILLER, FOR SILICA SAND ASPHALT

Sieve Sizes	Combined Aggregate Including Filler, Total Passing Percent By Weight
4	100
10	90-100
40	40-85
80	10-40
200	0-8

Asphalt cement shall conform to the requirements for 85-100 penetration grade asphalt cement.

mixes. A Marshall stability of 250 will probably give a satisfactory pavement as long as the flow is less than $\frac{3}{10}$ in. Filler should be kept to a minimum. Asphaltic cement of 85 to 100 penetration and varying between seven and nine percent has been used in the tests. The quality and gradation of the sand is extremely important. Sharp silica sands of gradation which have given satisfactory results can be found in Table 1. Recommended combined aggregate mixes can be found in Table 2. Table 4 shows a typical laboratory trial and final mix sheet.

Test Installations

The next step was to make some test installations. It was decided that the New Jersey Highway Department would put down a test section over asphaltic concrete pavement and the Port Authority would put down a test section over portland cement pavement.

In September of 1956, these test installations were installed. Each was approximately 500 ft long and 22 ft wide. Using their own forces, the New Jersey Highway

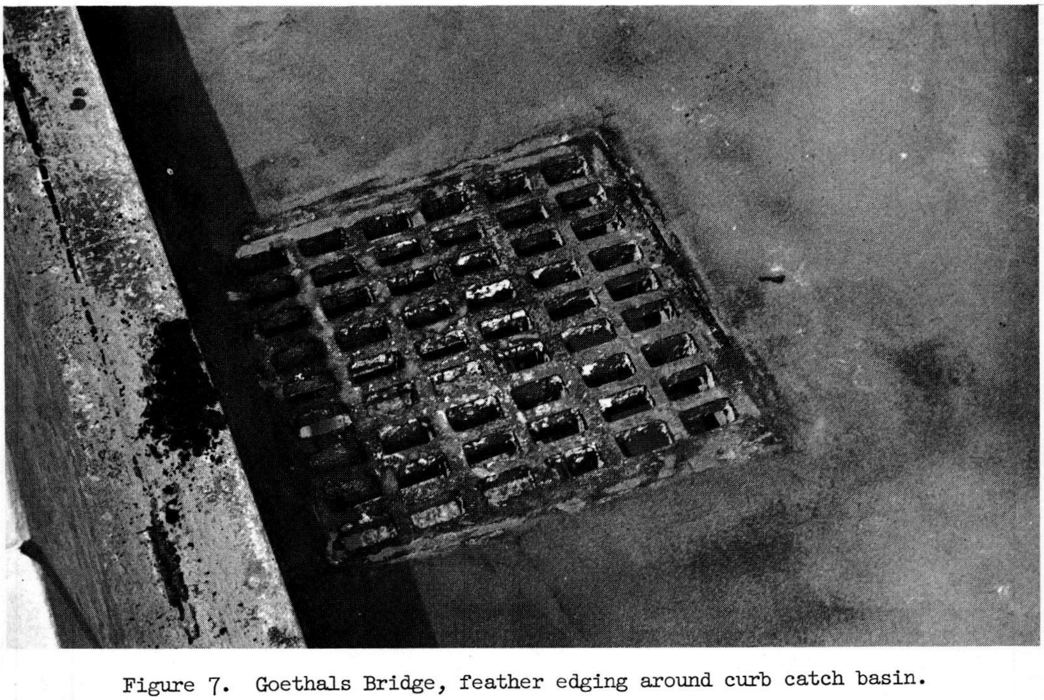

Figure 7. Goethals Bridge, feather edging around curb catch basin.

TABLE 3

COMPARISON OF VARIOUS RESURFACING MATERIALS TESTED BY THE PORT OF NEW YORK AUTHORITY

RESURFACING MATERIAL	Approx. Cost Per Sq. Yd.	Riding Qualities	Wt. Per Sq. Yd. at Thickness Indicated	Approximate Life	Adherence to Exist. Surf.	Skid Resistance	Coefficient of Friction Aver. Test Results	Ease of Patching	Rate of Wear	Traffic Interference	Ability to Feather edge	Availability of Materials	REMARKS
Aspholtic Concrete 3" Thick on Original Surface	$2.50 to $4.10	Good to Excellent	350#	Long	Good to Excellent	Average	Varies	Good	Good	(2) Long to Min.	Fair	Good	High weight on bridges Expansion jts. must be raised on bridges High costs
Asphaltic Concrete Remove 2" of Original Surface Add 3" Thick Asphaltic Concr	$6.00 to $8.00	Good to Excellent	350#	Long	Good to Excellent	Average	Varies	Good	Good	(2) Long to Min.	Fair	Good	Same as above except very high costs.
Epoxy Resin 1/8" Thick With Sand or Aluminum Silica	$2.00 and UP (NA)	Excellent	20#	(1) Varies	Fair	Good to Excellent	0.56	Good	Fair	Fair	Excellent	Good	High Cost Adhesion failures may lead to short life
Vultite 1/2" thick on Original Surface	$1.80 to $2.70	Excellent	55# to 65#	(1) Long	Good	Good	(NA)	Good	Good	Fair	Good	Good	Light weight for bridges and thin enough to not require raising expansion joints on Bridges but high in cost.
Silica Sand Asphalt 1/2" thick on Original Surface	$0.40 to $0 50	Excellent	50# to 60#	(1) Long	Excellent	Excellent	0.65 @ 40 MPH wet pave.	Good	Good	Min.	Excellent	Good to Poor	Lightweight, thin, no expans. jt raising, low in cost In NY area mat is avail. Only time will tell if there are any serious faults but none are apparent.
Rockite 1/2" thick on Original Surface	$0.40 to $0.50	Good to Excellent	55#	(NA)	(NA)	Good	(NA)	Good	(NA)	Min.	Good	Good to Poor	The qualities of this mat. are similar to those of Silica Sand Asph , but the inform. available is inconclusive.

(NA) Insufficient information available.
(1) Based on 1 yr. to 1-1/2 yr. testing periods
(2) Where plate or finger type expansion joints are involved, they must be raised to meet the elevations of the new resurfacing. This increases the traffic delays. See Figures 1 & 2.

TABLE 4

SILICA SAND PAVING MIXTURE FOR USE ON BAYONNE BRIDGE

Spec. No.	% A. C. Total Mixture	Mineral Aggregate Proportions % by Weight: Sand	Filler	Quality Attributes - Average Marshall Values: % Voids Filled	Degree of Compaction	Stability Pounds	Flow Inches
1-4	7.0	100.0	-	34.6	76.6	140	0.17
5-8	7 0	97 9	2.1	36.7	78.1	190	0.20
9-12	7.5	100 0	-	42.1	80.9	190	0.19
13-16	7.5	97.9	2.1	42.6	81.1	200	0.20
17-20	8.0	100.0	-	43.7	80.9	210	0.23
21-24	8.0	97.9	2.1	46.6	82.7	290	0.21
25-28 *	8.0	95.7	4.3	44.0	81.2	260	0.18

* Characteristics of Mixtures Recommended for Surface Course

Sieve Sizes	Combined Agg. - Total Passing % by Weight: Job Mix	Tollerable Range
#4	100	100
#10	99	95-100
#40	88	84-88
#80	31	27-35
#200	8	7-9
Comb. Agg.	92.0	91.7-92.3
Asphalt Cement	8.0	7.7-8.3

Department put their test section down on Route 440 in Jersey City. The original pavement was asphaltic concrete on a penetrated stone base. This route carries about 28,000 vehicles per day including a high percentage of heavy trucks. The original surface showed minor cracking, but could be considered fair to good. A tack coat of rapid-curing asphalt cutback was applied at the rate of 0.1 gal per sq yd. A Barber Green Paver was used, and it was the intention to put the material down ½ in thick. In order to gain additional information, the thickness was actually varied. The maximum was 1 in., and it was found possible to feather-edge to nothing. All that was necessary was to lower the paver screed until it rode the existing surface. As of last month, this test section was still in excellent condition. Some of the cracks of the underlying pavement had reflected through the resurfacing, but since they were very narrow it is felt they will heal next summer.

The Port Authority put their test section over one-half the width of a 500 ft long section of the concrete pavement on the Bayonne Bridge. It was put down by a contractor, using his normal asphalt crew and equipment. It was feather-edged at the centerline, at the transverse expansion joints and at the curb scuppers. Resurfacing procedures were the same as on Route 440, except that the thickness was held constant at ½ in. and the concrete pavement was blown with compressed air prior to applying the tack coat in order to remove any dust which might tend to prevent good adhesion. As of last month, this test section was still in excellent condition.

An extremely rugged test was made on the traffic circle at US 1 and 3 near the entrance to the Lincoln Tunnel. One-half in. of sand-asphalt was applied over the original pavement. The adjoining concrete slabs in this section showed as much as one-half inch difference in elevation. As a result, some of the areas were covered with ⅛ in. and others with almost 1 in. The traffic on this circle is about 50,000 cars per day, of which a large number are heavy trucks.

After a year, some of the thin spots are worn down to the original pavement and there is some evidence of pushing in the thicker areas. Considering the severe punishment the pavement takes at this location, we believe that the material held up very well, especially when it is noted that no air cleaning was done on this area prior to tack coating.

Certain important construction points became evident during these test installations. For example, tack coating is of prime importance. The areas to be resurfaced must be completely covered but must not be too heavily coated. RS1 emulsion, RC2 or RC1 cut-back applied at the rate of 0.08 to 0.10 gal per sq yd is satisfactory. In general, the

Figure 8. Goethals Bridge, 1/2 in. silica sand asphalt resurfacing at abutment joint.

sand-asphalt should not be laid until the tack coat has had at least 30 minutes to "set" or "break". Also, care must be taken when laying. A ½-in. thick course compresses very little under the roller. It cools quickly and must be rolled as soon as the roller can get on it. A word of warning at the start of the work, a cold roller wheel may pick the material up. It must be put down by machine. Hand work should be kept to a minimum. You cannot get a satisfactory job by hand placing. Materials broadcast over a machine laid area will not "knit" as normal asphalt pavement does. Cleaning the existing surface with compressed air prior to tack coating appears to be advantageous.

Installation on Bridges

The Pulaski Skyway, a 2½-mi viaduct across the New Jersey Meadows, between Jersey City and Newark, is part of US 1. It carries between 50 and 60 thousand vehicles a day. The original concrete riding surface was constructed about 1930 and while the riding quality of this roadway was still very good in 1956, the aggregate had polished to the point where accidents occurred when the pavement was wet. It was necessary that something be done. Raising the expansion joints in order to accommodate two to three inches of asphaltic concrete made this type of resurfacing questionable. The results of the original test sections of silica sand-asphalt were so satisfactory that it was decided to resurface the viaduct with this material. It was expected that this would serve a two-fold purpose, (1) reduce accidents; (2) provide a larger and more severe test section. Due to the short time the test sections were down, it might seem that there was a considerable risk involved in doing this, but one of the advantages of experimenting with this sand-asphalt is the fact that it is economical and no great danger is involved if it does not achieve the desired results. Work was started by the New Jersey Highway Department in the latter part of October 1956 and the 85,000 sq yd was completed in 10 working days. Construction was done during the day with a minimum of interference to traffic. It was carried on in the same manner as the previous test and as of Jan. 1958, the entire section was still in excellent condition. Accidents have been reduced and it is one of the best riding surfaces in the metropolitan area. I believe the total cost was under $40,000.

In June of 1957 the Port Authority resurfacing schedule called for surfacing the Goethals Bridge and the main span of the Bayonne Bridge. Because of the difficulty involved in altering the expansion joints to conform with the 3-in resurfacing (see Fig. 1) especially on the Bayonne Bridge, $200,000 had been budgeted for this work. The test sections were closely examined. A section of the Bayonne Bridge test section laid a year previous was removed to determine the adhesive qualities of the new material. Rock salt is used in connection with snow removal on this bridge and it was necessary to determine whether the original concrete pavement, especially in the areas that had shown previous spalling, showed any additional signs of deterioration. Adhesion was found to be good and there was no sign of deterioration. It was then decided to resurface these bridges with sand-asphalt. The 8,750 ft Goethals Bridge was resurfaced in six working days and the 1,675 ft span of the Bayonne Bridge was resurfaced in one day. The total cost of the work by contract was less than $18,000 representing a saving of some $180,000. As of Jan. 1958 this pavement, carrying some 7,000 vehicles per day, was in excellent condition. There were some reflection cracks at the concrete slab joints but nothing serious.

Since it will be necessary to resurface the George Washington Bridge in the near future and because of the reasons previously stated, a test section covering five of the eight lanes, and varying in length from 200 to 700 ft, was installed in the latter part of September of 1957. This bridge carries about 100,000 veh per day and as of last week, this section was in excellent condition.

Test Installation in Tunnels

The brick pavement in the North Tube of the Lincoln Tunnel is now 14 years old. Maintenance costs are going up steadily and because of conditions previously mentioned it would normally be necessary to repave in a few years. While we did not expect any great success, it was decided to cover a section of this brick pavement with ½ in. of silica sand. This was done in September of 1957. Of course it is still too early to tell, but after three months we feel more optimistic than we did before it was installed.

If this material proves satisfactory it is estimated that we can resurface an 8,000 ft long tunnel for $20,000 against $150,000 for a complete repaving job.

In 1949, we repaved the Holland Tunnel with asphaltic concrete. After eight years it is still in excellent condition. Maintenance costs have been practically nil. We do, however, have one difficulty. Millions of cars using the same wheel tracks eventually compress the asphalt pavement. As of now some sections have a depression in the wheel lanes as much as ⅜ in. This does not affect the riding qualities but does contribute to maintenance. Because of the grades, when the walls are washed, water had a tendency to run longitudinally in the wheel depressions rather than transversely across the crown and into the curb gutters. This means that the water stays on the roadway longer and more gets splashed back on the walls.

When it becomes necessary, we plan to fill these wheel track depressions with silica sand asphalt. Not only will it be economical but it will improve the skid resistance of the original pavement.

Airports

We have found that sand-asphalt can affect considerable savings when used for airport runway maintenance. By using sand-asphalt we can feather edge so well it becomes possible to fill the depressions, meet the high spots and still get a smooth riding surface. Without the sand-asphalt, either excavation or the use of larger quantities of asphaltic concrete would be necessary.

At Newark Airport sand-asphalt was used from nothing at the existing pavement to

¾ in. thick where it met the new asphaltic concrete. Several of the installations were in landing areas. Repeated landings of the largest commercial planes have caused no failure of any sort.

EVALUATIONS

Wear: One of the apparent advantages from a silica sand asphalt installation is the method in which it deteriorates, namely wear. Our experience to date, from the various test sections and installations we have made, indicates that the only deterioration we have had is wear. We have not experienced any of the usual type of failures of sheet asphalt such as cracking. The sand-asphalt is worn down in some spots to the original pavement, but there are no holes or sharp edges, for when the material wears it wears away completely. This means that it is very thin adjacent to the bare spots and results in maintaining a smooth riding surface.

This wearing form of failure, if it can be called a failure, has several advantages. Original spalled concrete with its low areas, results in a heavier thickness of silica sand than the high areas and therefore will give a smooth riding surface even after the thin areas or high spots have completely worn off. The pavement as a whole still maintains most of its skid resistant qualities.

Expected Life

The expected life of this material naturally depends on the volume of traffic, but we estimate it at 7 to 10 years with traffic of 5 to 7 thousand vehicles per day and 4 to 5 years with 50 to 60 thousand vehicles per day.

A test section of Kentucky Rock asphalt was installed on the bridge over the Potomac River by the Virginia State Highway Department several years ago and tends to confirm these figures.

Skid Resistant Qualities

Silica sand asphalt has excellent skid resistant qualities. After three months of use, co-efficient of friction tests taken on the Goethals and Bayonne Bridge, both with the stopping distance and the Taply Decelorometer methods, averaged 0.65 on wet pavements at 40 mph. This is very close to what the Virginia Highway Department found when using this material as a de-slicking agent. Because there is no stone to polish, we expect this pavement to retain its skid resistant qualities.

CONCLUSIONS

We believe the easiest way to summarize the results of our experience with thin resurfacing materials, (especially on bridges) is to list the various materials used and note their advantages and disadvantages. This is done in Table 3.

Based on information obtained to date, we are of the opinion that a silica sand asphalt pavement ½ in. thick will give a smooth, long wearing, skid resistant pavement. We are not convinced that this is the ultimate answer to thin resurfacing. We believe that certain refinements can be made which will increase the life and to that extent we have installed two test sections on the Goethals Bridge. One is stone filled sheet asphalt and the other is silica sand asphalt with a 100 - 120 penetration asphalt.

We believe we have made progress and are on the right course. Only time will tell.

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