AN EVALUATION OF MASTIC-TYPE PAVING MIXTURES FOR RESURFACING A ROADWAY AND A BRIDGE DECK

MICHIGAN HIGHWAY RESEARCH LABORATORY SECTION

MICHIGAN DEPARTMENT OF STATE HIGHWAYS

AN EVALUATION OF MASTIC-TYPE PAVING MIXTURES FOR RESURFACING A ROADWAY AND A BRIDGE DECK

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INTRODUCTION

In spite of many years of research, a method is still being sought for economically waterproofing bridge deck surfaces. Surface water containing dissolved ice control chemicals soaks into permeable bridge deck materials and attacks the reinforcing steel. As it oxidizes, reinforcing steel expands, causing the deck surface to spall.

Another problem confronting highway engineers is the search for a pavement surface type that will provide long lasting skid properties together with structural durability.

It was reported that in Germany, pourable asphalt mixtures were being used which provided impermeable pavement surfaces of very great durability (1). Such mixtures were liquid when placed and required no rolling or compaction. The aggregate simply "floats" in the mix and, therefore, doesn't influence the structural properties of the pavement as strongly as does conventional asphalt.

The material, known as "Gussasphalt," was said to be virtually voidless and reports had indicated that under tire stud traffic it wore about thirty percent more slowly than conventional asphalt pavement (2). The material was said to be popular with German contractors who, according to their customary contracts, must guarantee their work for five years and pay any maintenance costs incurred during that period. However, a major disadvantage was the special construction methods required for placing Gussasphalt. First, heating and storage facilities for mineral filler were needed at the hot-mix plant. Second, "cookers," that is trucks with heated carrying tanks outfitted with agitators for transporting the mix, were believed necessary. Finally, a paving train riding on forms and equipped with a heated strike-off bar was used for placing the material by the German method (1).

Fortuitously, an asphalt membrane lining a large pumped storage reservoir near Ludington, Michigan, was being constructed in a joint venture by Morrison-Knudsen and Strabag Bau A. G. Strabag Bau A. G. of Cologne, West Germany, had done much development work on mastic-type asphalt mixtures[1] and the firms offered their joint services in constructing a trial section in Michigan. They offered to charge only for direct labor, material, and rental of third-party equipment. The Demonstration Projects Division, Federal Highway Administration encouraged development of the project, offering financial and technical assistance.

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[1] Mastics are generally thought of as being asphalt mixtures that are sufficiently fluid so they can be compacted by troweling or screeding.

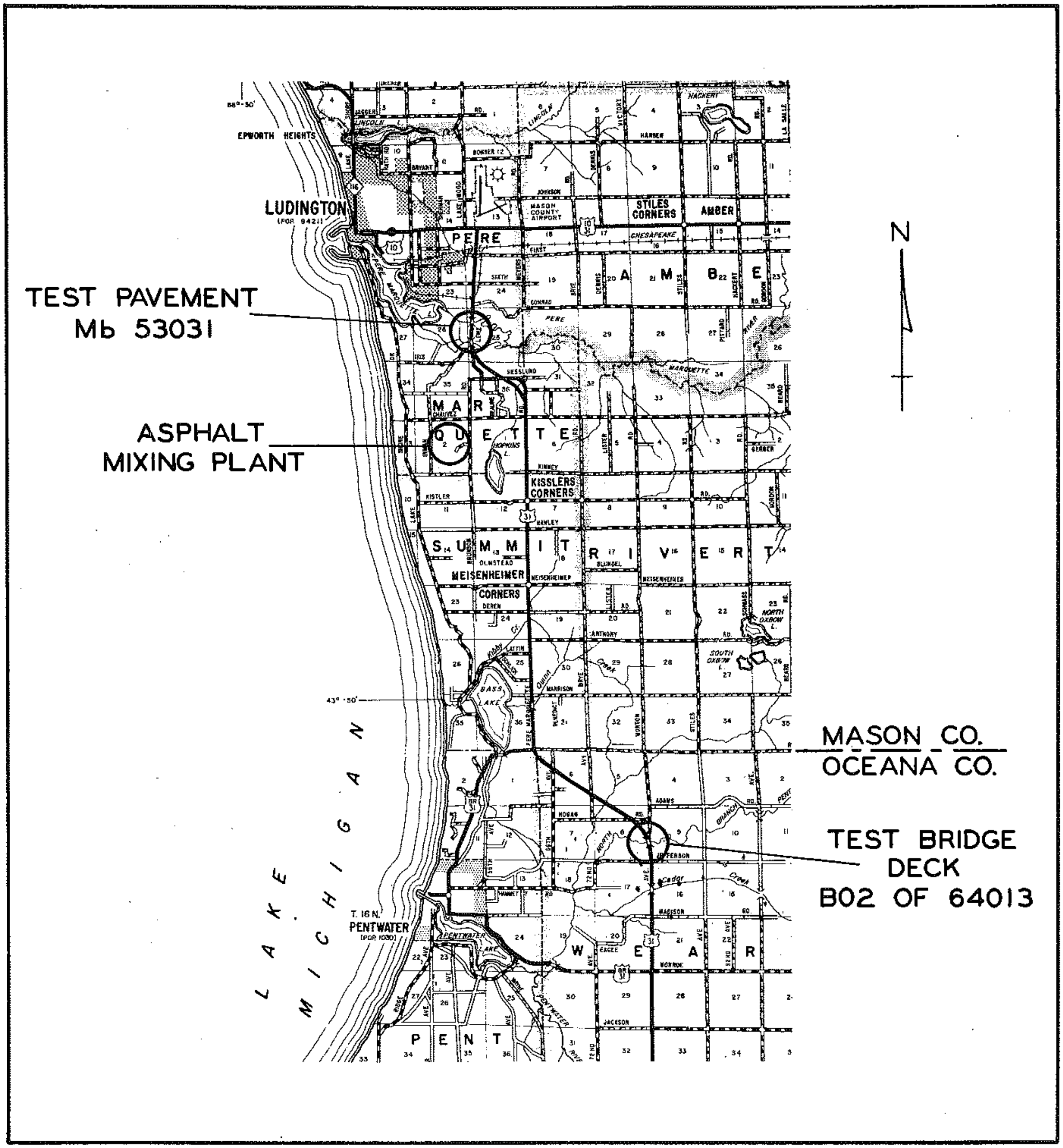

Figure 1. Sites of Mastic asphalt test areas.

Representatives of the Federal Highway Administration believed it was possible to construct a Gussasphalt pavement using conventional asphalt paving equipment with only slight modifications. If this were true, Gussasphalt could be tried extensively in the United States. Then, if the material became generally accepted, any special equipment that would streamline construction procedures could be obtained by contractors, knowing that they might use it on future projects.

Because of the expensive special equipment required for Gussasphalt, Strabag Bau A. G. had developed another type of mastic mix known as Mastiphalt (or Mastimac). Mastiphalt was designed to be constructed with conventional equipment. It is more viscous, in the fluid state, is more coarsely graded than Gussasphalt and requires rolling. Mastiphalt contains asbestos fibers but, unlike Gussasphalt, does not contain Trinidad asphalt [2]. Strabag Bau A. G. was enthusiastic about Mastiphalt and it was agreed that a test section of that material would also be constructed.

An area of roadway and a bridge deck were selected for resurfacing (Fig. 1). The existing roadway was a rigid pavement, 20 ft wide, constructed in 1937 and resurfaced with bituminous concrete in 1958. The bridge deck was a 3-span concrete structure, constructed in 1953 with a 42-ft clear roadway width.

DESIGN AND PREPARATION

It was agreed that a test section of roadway would be resurfaced with Gussasphalt and another with Mastiphalt, a proprietary asphalt mix developed and marketed by Strabag Bau A. G. Each of the mixes was to be placed on the roadway to a nominal 1-1/2 in. thickness (estimated at 160 lb/sq yd).

Preliminary mix design (Appendix A) of the Gussasphalt was carried out by representatives of FHWA in collaboration with the Asphalt Institute. Asphalt cement, penetration grade 40-50, was required in combination with Trinidad asphalt. Design of the Mastiphalt mix was entirely the work of the joint contractors. All preliminary pavement repair and shoulder work were to be performed by the Department who also was to furnish all traffic control devices.

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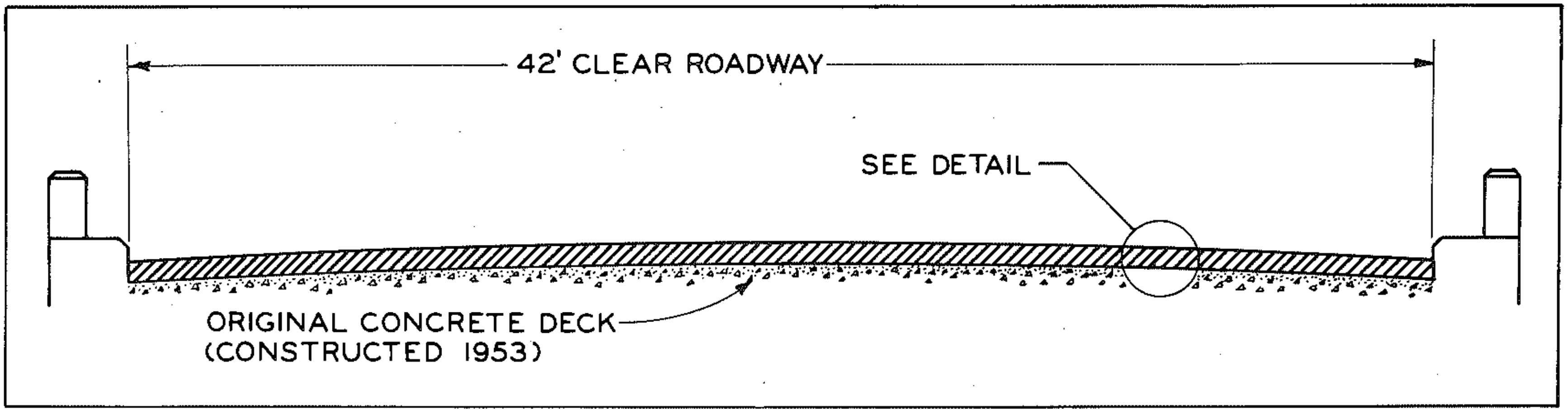
[2] Trinidad asphalt is a natural asphalt taken from a large lake on the Island of Trinidad. The crude material is uniform in composition. After refining by heating to drive off the gas and water, the material contains approximately 60 percent of very high viscosity bitumen and 40 percent of very fine volcanic ash.



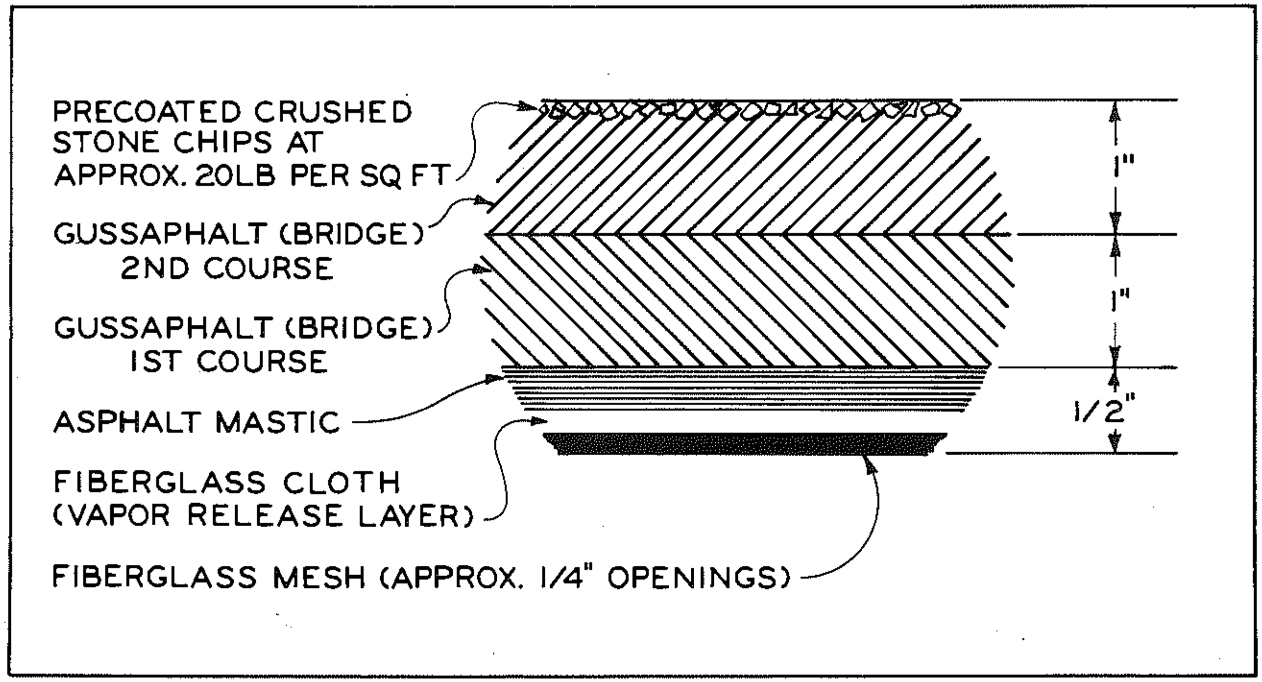


Figure 2. Typical proposed cross section of Gussasphalt waterproofing membrane.

Contingent upon satisfactory results on the roadway, Gussasphalt was to be constructed to a nominal thickness of 2 in. as the upper layer of a bridge deck waterproofing membrane. The membrane, shown in cross section in Figure 2, contained a fiberglass mesh layer next to the bridge deck to transfer water toward a row of weep holes 1/2 to 3/4 in. in diameter. Weep holes were drilled through the deck and lined with a tube projecting about 2 in. below the bottom of the deck. Thus, moisture in the deck vaporized by the hot Gussasphalt, would be transferred by the fiberglass to the weep holes and the lined weep holes would then permit moisture to drip cleanly without soaking the bottom of the deck. If provision for moisture release were not provided, the membrane surface would blister.

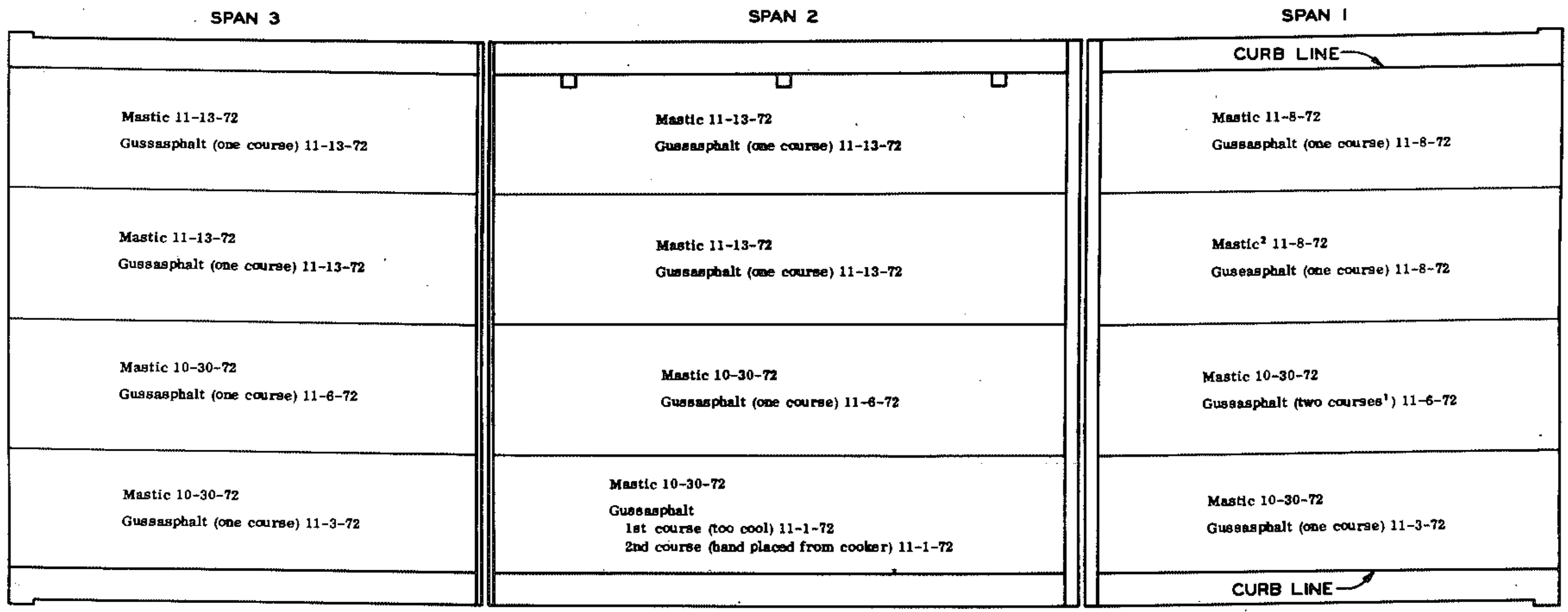
For sealing the membrane - curb interface, a different method was planned for each of the three spans: 1) placing the membrane directly against the curb face; 2) applying a coating of epoxy resin on the curb face and bridge deck extending about 6 to 10 in. from the curb, and; 3) using a formed-joint filled with conventional hot-pour joint sealer. Figure 3 is a diagram locating the span on which each type of sealer was used. Transverse joints in the bridge deck were to be built up in height to be flush with the Gussasphalt surface.

Repair of deteriorated surface areas, altering of joints, construction of weep holes, and applying epoxy to the curb were to be done by the Department.

The mastic mix to be applied in a thin layer directly on the fiberglass was designed by the contractor.

Materials used on the project were as follows:

Materials	Source
Aggregates 31A 3CS Crusher Dust	- Grand Rapids Gravel Co.
Mineral Filler - 3MF Limestone	- Vulcan Materials Co.
Asphalt Cement - (40-50)	- Total-Leonard, Inc.
Trinidad asphalt	- The Lake Asphalt and Petroleum Co.
Asbestos - 7M06	- Johns-Manville
Fiberglass Loose Weave Tight Weave	- Smid the Hollander, Netherlands



[1]Paver slipped off forms causing low grade and necessity for second course.

[2]Center two rows of top fiberglass mat are of United States manufacture.

Method of curb line seal:
- Span 1 Gussasphalt placed directly against curb face.
- Span 2 Joint formed and filled with Para-Plastic hot pour seal.
- Span 3 Curb face coated with epoxy and Gussasphalt then placed against the curb face.

Weep holes placed along west curb face.

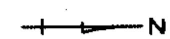


Figure 3. Construction sequence and placement dates of Gussasphalt waterproofing membrane (B02 of 64013).

CONSTRUCTION

The roadway resurfacing was carried out in late October 1972 and the bridge deck in early November. The Mastiphalt, Gussasphalt, and mastic mixtures were prepared in a 6,000-lb batch plant (Barber-Green Model No. BE-60). In addition to the conventional aggregate dryer, the plant had an attached Wibaw rotary dryer to preheat the large amount of limestone mineral filler used in Gussasphalt and mastic mixtures.

Mastiphalt and Gussasphalt mixtures were placed with a Barber-Green Model No. SA41 paver, and the mastic was manually placed on the bridge deck using a squeegee.

Mastiphalt

Mastiphalt was placed in the conventional manner for bituminous hot mix and produced a very coarse, open-texture surface. Mix design and laboratory extraction tests are as follows (see Appendix B for complete analysis):

Sieve Size	Batch Proportions	Extraction Test Results (Avg. of 3 Tests)
Stone, Ret #8	64.8	68.1
Sand, P#8-Ret#200	18.1	14.2
Filler, P#200	8.3	10.3
Asphalt	7.8	7.4
Asbestos	1.0	---

P = Passing, Ret = Retained

To evaluate the mix design before constructing the road surface, a test pad was constructed in the contractor's yard at the site of the asphalt plant. One load of Mastiphalt was placed at a temperature of 410 F. After rolling to desired compaction, the resulting pavement surface had the appearance of a very coarse-textured leveling course. This texture, according to the contractor, was typical of Mastiphalt pavement and approval was given to use the material on the highway.

Two lanes, each 500 ft long and 10 ft wide were paved on US 31 using the test pad design. At the paver, mix temperatures varied between 320 and 415 F; ambient air temperature was 42 to 44 F. The inability of the contractor to hold mix temperature at a constant desired level resulted from low production and the long wait between truck loads. During the second day of production, construction went more smoothly and mix temperatures were more consistent.

Some segregation was noticed in the Mastiphalt placed on the road but since none had been noticed on the test pad, it was concluded that segregation was caused by trucking over rough roads between the plant and job site. The distance from the plant to the job site was about 3-1/4 miles. Figure 4 shows typical Mastiphalt appearance.

On the northbound lane, Mastiphalt was compacted with a 6-ton tandem, steel vibratory roller and a 14-ton pneumatic roller with no formal rolling pattern. The southbound lane was compacted with a 6-ton steel roller for breakdown, a 14-ton pneumatic roller as intermediate, and the 6-ton tandem steel roller was used again for finishing the compaction. The mix was "tough," and would not feather out at the joint; probably because of the high mineral filler and stone content.

As shown in the following table, tests on cores showed the northbound lane to have only slightly greater density than the southbound lane. However, the void proportion was quite different between the two lanes.

Core Test	Northbound Lane	Southbound Lane
Specific Gravity	2.395	2.327
Air Voids, %	1.8	4.6

Gussasphalt

There were many problems with temperature control while producing the Gussasphalt. The dryer would not heat material to a temperature over 475 F. With the small tonnage produced, and because 20 percent mineral filler at a temperature of 350 F was added, it was difficult to produce a mix hot enough to provide a fluid material. Mixing time was one minute dry plus one minute after the asphalt cement had been added. The Trinidad asphalt was manually added into the pugmill after the aggregate but before the asphalt cement. Manual addition of the Trinidad proved to be a nuisance for the contractor in that it required a worker to carry the material up a ladder to the top of the pugmill for every batch.

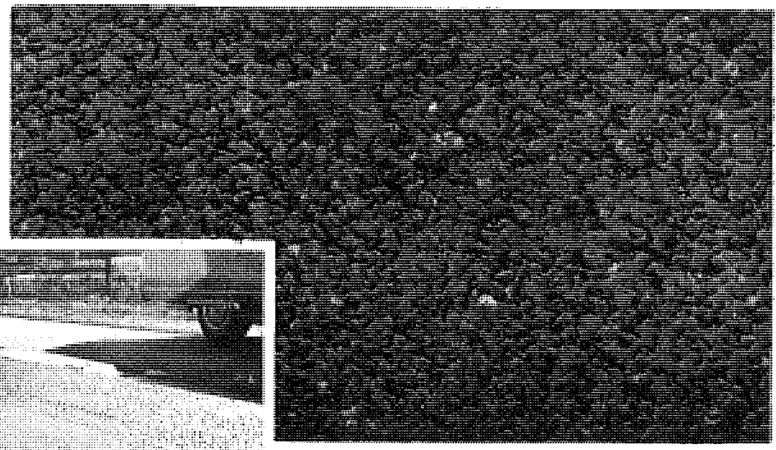
With the Barber-Green paver, a first trial load of Gussasphalt was placed onto a test pad after being heated and transported in a cooker. That load had a temperature of 470 F and was so fluid that it could not be retained within the confines of the paver.

A second trial load was placed on the pad from a dump truck after being heated only within the plant. The temperature of that mix was too low and the surface was torn by the screed (Fig. 5). Finally, after being heated only in the plant, a trial mix, at a temperature of 350 F was placed on the pad and found to be acceptable. Cores indicated that the test mat was uniform and almost voidless.

As a result of the trials, it was decided that Gussasphalt could be hauled to the roadway construction site in insulated trucks and then placed using 2 by 4-in. lumber to support the paver screed and to act as longitudinal forms. The distance from plant to construction site was slightly more than three miles. The finished mat appeared smooth and uniform (Fig. 6) except where the paver stopped moving to wait for material (Fig. 7). When the paver was not moving forward, the screed settled into the asphalt causing a ripple in the surface. The material remaining in the paver cooled if the pause were more than momentary and the pavement surface was sometimes torn by the screed as paving operations started again. The mixture was also found to be very "tough" and could not be hand-worked or feathered out at the joints. No rolling was needed to compact the mixture. At the recommendation of the Strabag Bau A. G. consultant the mix was modified before the southbound lane was constructed. Mix designs used and results of extraction tests are shown in Appendix A.

Cover stone precoated with 0.75 percent asphalt was spread by hand directly behind the paver (Fig. 8). After the mat had cooled sufficiently, the cover stone was rolled into the mat surface with a 1/2-ton steel roller and then finish rolled with a 14-ton pneumatic roller. Figure 9 shows the appearance of the surface before excess cover stone was swept off. It appears that excessive cover stone was used. The 31A cover stone was larger than specified or desired but the contractor could not obtain specification size (100 percent passing No. 4 sieve - 100 percent retained No. 8 sieve). The Strabag Bau A. G. consultant wanted the cover stone applied to provide high initial skid resistance. Traffic would then wear away the cover stone together with the asphalt sheen leaving aggregate exposed to provide long-term skid resistance.

Cooling of the mat took place quite rapidly because of low ambient temperatures. As a result, traffic was permitted on the surface about two hours after the last batch had been placed.



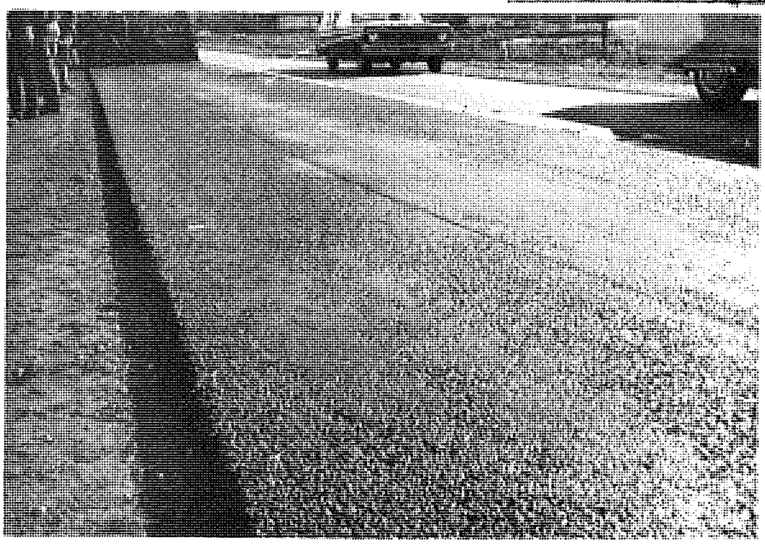


Figure 4. Mastiphalt pavement. Typical texture of surface is shown above. Note variation in surface texture caused by segregation in view at left.

Figure 5. Tearing of Gussasphalt by paver screed because of low mix temperature.

Figure 6. Typical appearance of Gussasphalt surface immediately after paving. Note surface stone being applied in background.

US 31 Bridge Deck Preparation and Paving

The bridge was located over 10 miles from the site of the asphalt mixing plant. The Department's Maintenance Division constructed weep holes through the bridge deck, modified trasnverse joints, and applied epoxy to curb faces as described earlier in this report.

Fiberglass to transport residual moisture from the bridge deck and prevent surface blistering was installed as shown in Figure 10. A coarse weave mesh of fiberglass (Fig. 11) with approximately 1/4-in. square openings was placed directly upon the existing concrete bridge deck. Moisture condensing in the mesh was supposed to flow to weep holes and then drain through the deck. Fine weave fiberglass cloth with 3/4-in. circular holes, spaced 3 in. center to center was placed on top of the coarse weave layer. This upper cloth was to protect the mesh from being impregnated by a special hot sealing mastic and the holes would permit the mastic to bond to the bridge deck.

The special mastic was transported to the job site in German made cookers which kept the material agitated and at a high temperature (Fig. 12). As shown in Figure 13, the material was spread manually using a squeegee. Mix design and laboratory extraction test results for the mastic are as shown in Appendix C.

The first load of Gussasphalt was transported to the bridge in an insulated dump truck and laid approximately 1-in. thick by the Barber-Green paver. Wooden (2 by 4 in.) longitudinal rails were used to support the paver screed. The mix was as hot as 365 F in the truck but was cool near the perimeter because of a 2 hour delay before placement. The mix had a temperature of only 305 F as it passed through the paver and, therefore, was torn by the screed. At that point, it was decided to transport Gussasphalt in cookers, rather than dump trucks, and to place the mix in one course instead of the proposed two. The thicker course retained heat and could be spread more easily than a thin layer.

The first cooker load was used for filling-in irregularities in the mat constructed with the cold mix, and for filling joints left by the wood rails. Therefore, the asphalt cement content was increased from 7.0 to 7.5 percent so the mix could be more easily spread. This material was inadvertently heated beyond its flash point (500+ F) because the cooker had no automatic temperature controls. In a few instances when material was overheated, small explosions occurred which, spectacularly and with a roar of flame blew the cooker tops open.

Figure 7. Transverse fault in Gussasphalt caused by settlement on screed when paver stopped moving.

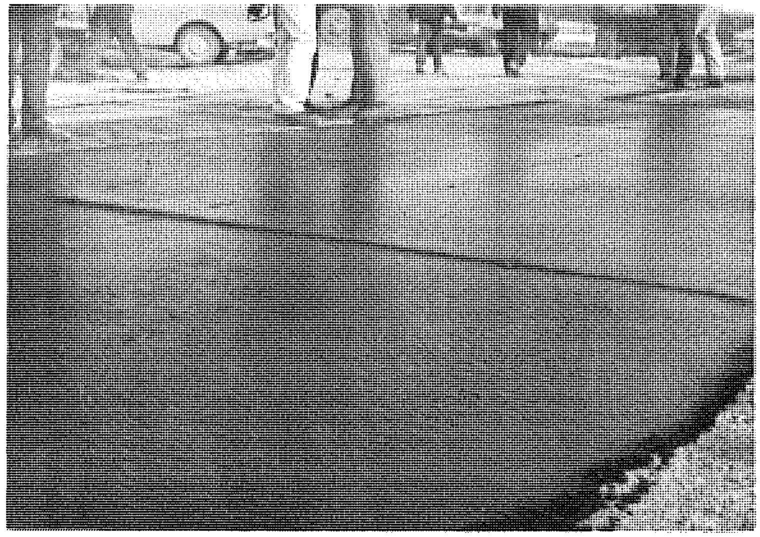


Figure 8. Spreading cover stone on Gussasphalt.

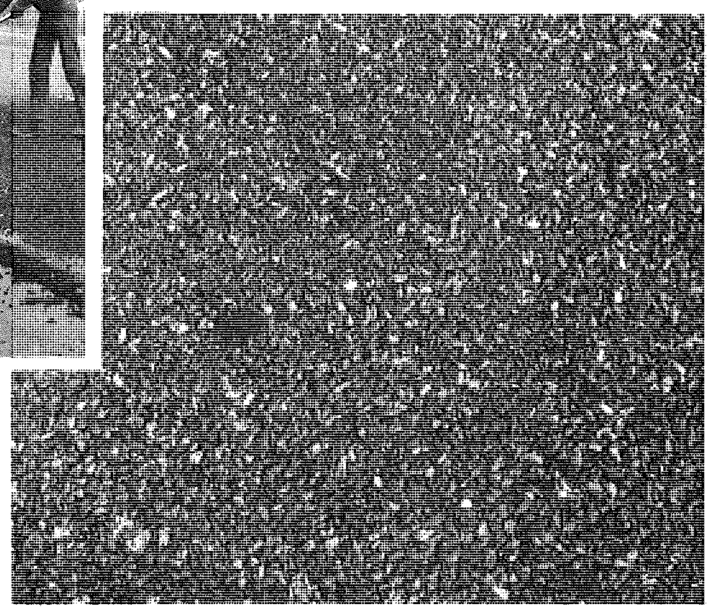


Figure 9. Cover stone after being rolled into Gussasphalt surface.

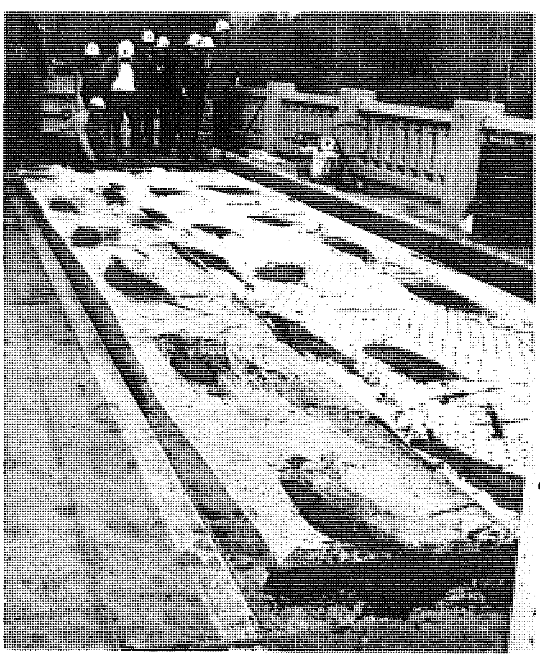


Figure 10. Installation of fiberglass on bridge deck. Note fiberglass mesh lying directly on deck and covered by fiberglass cloth. Patches of asphalt were used to cement mats to deck.

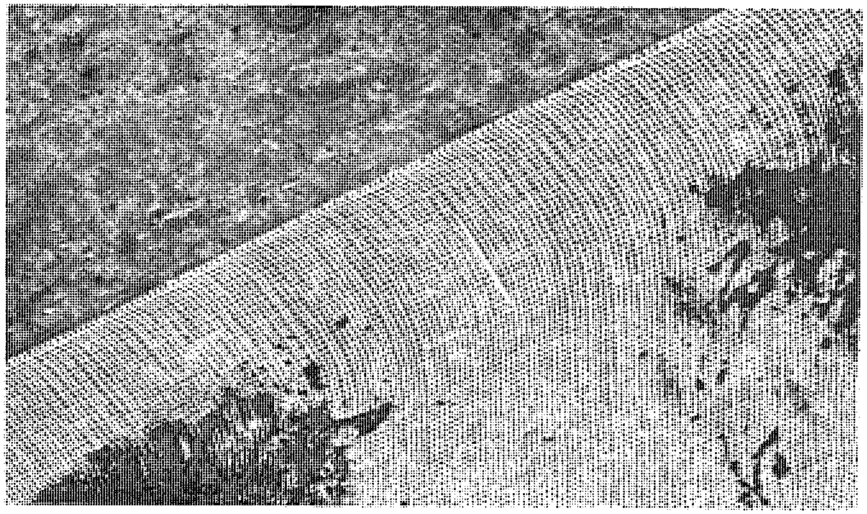


Figure 11. Fiberglass mesh placed directly on bridge deck.

Figure 12. Cooker for transporting asphalt. Cookers provided continuous agitation and heat.

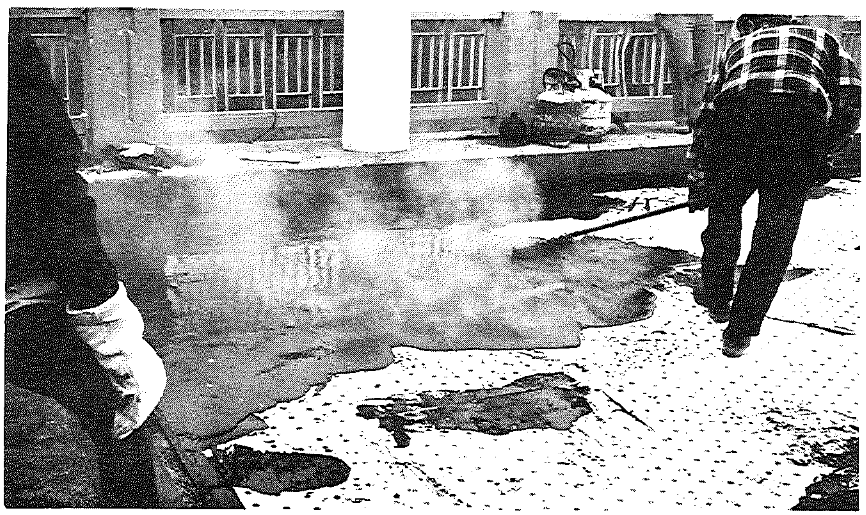


Figure 13. Manual spreading of mastic asphalt on bridge deck.

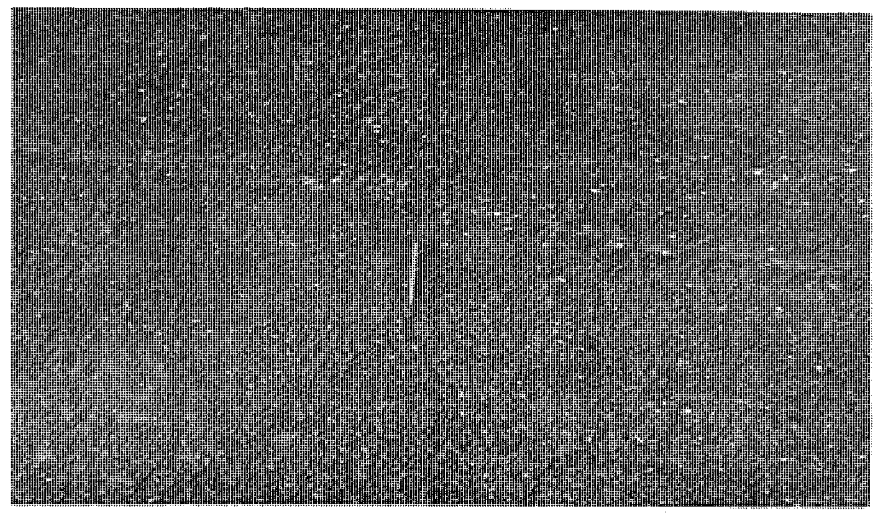


Figure 14. Surface of Gussasphalt after a few days service. Transverse ridge was caused by screed settling when paver stopped moving.

Temperatures in subsequent cooker loads of Gussasphalt varied from 375 to 490 F. At the higher temperatures, the material was so fluid it flowed down the superelevation and around the tires of the paver. It was also so fluid that it merely flowed off the back end of the barfeeders and under the auger instead of into it. Since the auger couldn't be lowered to contact the mix, Gussasphalt was manually placed in front of the ends of the screed.

PERFORMANCE

Permeability was evaluated by FHWA personnel by measuring the change in electrical resistance through a full thickness of the mat. The electrical resistance was measured between a metal plate placed under the mat during construction and another placed directly above and on top of the mat. Permeability was indicated by the change in resistance through the mat after the surface of the pavement had been flooded with water. The Mastiphalt was found to be permeable while the Gussasphalt on the roadway was treated and found to be impermeable. Using the Michigan skid trailer, skid resistance was measured on all mastic asphalt surfaces and on the adjacent original pavement surface. Results, as shown in the Appendix D, indicate excellent friction levels initially on the Gussaspbalt and acceptable levels on the Mastiphalt. Figure 14, shows the texture of the Gussasphalt at the time of initial skid testing and after traffic had removed some of the cover stone. After about two months service, measurements showed friction on the Mastiphalt to be improved while friction on the Gussasphalt, although still excellent, had decreased somewhat as the cover stone was worn away. Because of their coarse textures, it is anticipated that friction will improve further for both materials as the asphalt coating is worn off the pavement surface particles. Annual skid testing of the pavement surfaces will be repeated during the next few years.

Riding quality of the surfaces was fair. However, this is not unexpected since pavements of conventional types constructed in short lengths have often been observed to exhibit mediocre riding qualities (3).

DISCUSSION

Numerous small problems were encountered during construction but both Gussasphalt and Mastiphalt surfaces were successfully constructed using conventional paving equipment. Workmen on the project were relatively inexperienced at highway construction and the project was so small that there was almost no opportunity for familiarization with the process or to correct difficulties. Mastiphalt was placed with very little difficulty but Gussasphalt, which is much more fluid, did cause problems. Neither Mastiphalt nor Gussasphalt could be used for feathering joints. Perhaps if the weather were warmer, the material wouldn't have cooled so rapidly and it could have been feathered.

On the bridge deck, the Gussasphalt was hotter and, thus, less viscous than on the pavement. Therefore, on the bridge, the mix was not moved to the extremities by the paving auger and some manual work was necessary to spread the mix uniformly in front of the screed. The same problem existed to a lesser degree while paving the roadway. Also, on the bridge when the Gussasphalt was dumped into the paver in a large pile, it started to flow downhill over the superelevated deck surface. If the paver auger, which was fixed vertically, could have been lowered, the mix could have been spread rapidly to a thinner and stable thickness, preventing the unwanted flow. Therefore, when placing Gussasphalt on inclined surfaces, temperature should be controlled so the material is more viscous and under all circumstances a means should be provided for lowering the auger to spread the mix uniformly.

The patching of voids behind the paver was difficult because the Gussasphalt hardened quickly as it cooled. Whenever the liquid Gussasphalt flowed or was spilled outside the paver, it bonded tenaciously to any surface it contacted. Thus, care was required to prevent the material from flowing onto areas, such as adjacent lanes, where small lumps of hard material are objectionable.

Under all circumstances, automatic temperature controls must be provided if cookers are used since the explosions caused by overheating could be calamitous.

Although Trinidad asphalt is widely accepted as a necessary ingredient of Gussasphalt, it is difficult to see why. Trinidad asphalt is expensive and almost half its weight is inorganic ash (filler). Extraction tests don't indicate the presence of Trinidad asphalt, so post-construction checking on quality would be almost impossible. Also, it was costly and a nuisance to add to each batch of Gussasphalt. It would be worthwhile to evaluate some trial areas of Gussasphalt made without Trinidad asphalt. Perhaps, as with Mastiphalt, asbestos could be used as an ingredient to improve consistency, if an admixture is even necessary.

It was mentioned earlier that riding quality of the surfaces was not exceptionally good. The problem of obtaining a smooth surface was especially noticeable on the bridge deck which was superelevated and where the pavement had to be matched carefully to transverse joints. The bridge deck membrane could be modified so the Gussasphalt would be placed as a waterproofer, topped with a wearing surface constructed with conventional hot mix asphalt. In that way the waterproof membrane would be provided by Gussasphalt and good riding quality might more easily be obtained through use of conventional hot mix asphalt. Also, with a conventional wearing surface the pre-coated chips could be deleted.

Although Gussasphalt is known to cost more than conventional hot-mix asphalt concrete, the differences in cost between the two might easily be decreased. First, the aggregate could be preheated enough so the mix temperature would be 425 F even though unheated mineral filler was used. That would eliminate need for a separate dryer to preheat the mineral filler. Second, flyash could be used for mineral filler instead of costly limestone dust. Flyash is used in conventional hot-mix asphalt concrete and should be satisfactory in Gussasphalt. Also, as discussed in the preceding, Trinidad asphalt might be deleted from the mix.

CONCLUSIONS

1) Gussasphalt can be mixed and placed with very little modification of conventional paving equipment. If the plant is near the job site, the only special equipment that might be needed would be a dryer for preheating mineral filler. The extra dryer might be eliminated if the aggregate were heated so hot that the filler would not need preheating. If there were much delay time between plant and paver, cookers would be necessary for heating and agitating the mix.

2) Forms are needed for placing Gussasphalt.

3) Gussasphalt is impermeable; Mastiphalt is not.

4) Both Gussasphalt and Mastiphalt can provide coarse textured surfaces of high skid resistance.

5) When ambient temperature is low (near 40 F during this project) a mastic asphalt pavement of about 1-1/2 in. thickness can be opened to traffic about two hours after construction. Cooling would take place more slowly, of course, with higher ambient temperatures.

6) By modifying procedures as discussed, costs of Gussasphalt might be brought well into line with those for conventional hot-mix asphalt concrete.

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APPENDIX

APPENDIX A
GUSSASPHALT MIX PROPORTIONS

Sieve Size	Yard Trial				Northbound Roadway Paving				Southbound Roadway Paving				Bridge Deck Paving			
	Mix Design	Extraction Test Results			Mix Design	Extraction Test Results			Mix Design	Extraction Test Results			Mix Design	Extraction Test Results		
		Mean	Std. Dev.	Coef. Var., %		Mean	Std. Dev.	Coef. Var., %		Mean	Std. Dev.	Coef. Var., %		Mean	Std. Dev.	Coef. Var., %
Mix Proportions																
Ret 8	32.9	42.2	1.7	4	32.9	35.9	4.7	12.9	40.3	44.9	1.0	2.2	40.4	45.6	3.8	8.4
P8-Ret 200	40.1	32.3	1.3	4	40.3	37.9	4.3	11.4	32.9	28.2	1.4	5.0	32.9	27.5	3.5	12.7
P200	18.3	17.6	1.2	7	18.3	18.5	0.3	1.4	18.3	19.1	0.8	4.0	18.2	19.3	1.4	7.4
Asphalt	6.3	7.9	1.1	13.7	7.0	7.7	0.1	1.6	7.0	7.8	0.1	0.7	7.0	7.5	0.3	3.9
Trinidad	2.4	----	---	----	1.5	----	---	----	1.5	----	---	---	1.5	----	---	----
Aggregate Gradation																
Percent Passing																
3/4		100														
1/2		99	0.6	0.5		100				100				100	0.5	0.4
3/8		90	0.6	0.6		92	1.4	1.5		89	2.6	2.9		90	1.8	2
4		69	1.0	1.4		74	2.5	3.4		61	2.6	4.3		64	1.8	3
8		54	1.2	2.1		61	5.4	8.9		51	1.0	1.9		51	4.1	8
16		46	1.5	3.2		52	3.7	7.2		45	1.3	2.9		44	4.8	11
30		39	1.5	3.8		43	2.7	6.3		39	1.3	3.2		37	4.4	12
50		29	0.6	2.0		33	1.4	4.3		32	0.6	1.8		30	3.2	11
100		22	1.7	7.5		26	0.6	2.3		26	0.6	2.3		25	2.1	8
200		19	1.5	8.0		20	0.2	1.1		21	0.9	4.2		21	1.5	7
Asphalt																
Orig. Pen		41	7.5	18.2		47				46				50	4.1	8.3
Rec. Pen		28	1.0	3.6		30	1.0	3.4		32	2.4	7.4		26	3.1	12.0
Number of Tests		3	3	3			4	4		4	4	4		16	16	16

APPENDIX B
MASTIPHALT MIX PROPORTIONS

Sieve Size	Mix Design	Extraction Test Results Sampled 10-19-72	Sampled 10-19-72	Sampled 10-20-72	Mean
Mix Proportions					
Ret 8	64.8	67.4	67.5	69.5	68.1
P8-Ret 200	18.1	15.4	14.0	13.1	14.2
P200	8.3	9.7	11.1	10.0	10.3
Bitumen	7.8	7.5	7.4	7.4	7.4
Asbestos	1.0				
Aggregate Gradation					
Percent Passing					
3/4			100		
1/2		100	99	100	100
3/8		69	71	72	71
4		32	34	33	33
8		27	27	25	26
16		23	23	21	22
30		20	19	18	19
50		16	16	15	16
100		13	14	13	13
200		10	12	11	11
Asphalt					
Orig. Pen		---	---	---	---
Rec. Pen		34	29	33	---

APPENDIX C
MASTIC ASPHALT PROPORTIONS

Sieve Size	Mix Design	Extraction Test Results Mean	Std. Dev.	Coef. Var., Percent
Mix Proportions				
Ret 8	----	8.8	2.2	25.2
P8-Ret 200	45.0	47.8	3.5	7.3
P200	40.0	29.4	3.2	10.8
Bitumen	15.0	14.3	0.3	2.0
Aggregate Gradation				
Percent Passing				
3/8		100	---	0.9
4		99	0.9	3.0
8		90	2.7	5.6
16		78	4.4	6.9
30		67	4.6	4.6
50		51	2.3	7.4
100		41	3.0	11.2
200		34	3.8	----
Asphalt				
Orig. Pen		50	5.0	9.9
Rec. Pen		38	7.1	18.7
Number of Tests		5	5	5

APPENDIX D
GUSSASPHALT AND MASTIPHALT SKID TEST SUMMARY

Tested Surface	Test Lane or Direction	40 mph Coefficients of wsf[1]								
		10/27/72			11/10/72			1/18/73		
		Low	High	Avg	Low	High	Avg	Low	High	Avg
1958 Bit. Conc. N. of experimental surfaces (C.S. 53031)	NB	.35	.37	.36	---	---	---	.34	.37	.35
	SB	.33	.36	.34	---	---	---	.38	.40	.39
1958 Bit. Conc. S. of experimental surfaces (C.S. 53031)	NB	.38	.40	.39	---	---	---	Not Tested		
	SB	.31	.36	.33	---	---	---	Not Tested		
Gussäsphalt (C.S. 53031)	NB	.76	.82	.78	---	---	---	.57	.62	.60
	SB	.79	.83	.81	---	---	---	.63	.68	.66
Mastiphalt (C.S. 53031)	NB	.37	.50	.44	---	---	---	.48	.49	.48
	SB	.37	.49	.42	---	---	---	.54	.56	.55
Gussäsphalt (B. Z. of 64013)	NB	---	---	---	.73	.76	.74	.64	.68	.66
	SB	---	---	---	Not Completed			.63	.66	.64

[1] Tests made using Michigan skid resistance measuring instrument.