THE USE OF BITUMINOUS MATERIALS AS A CORRECTIVE MEASURE FOR PUMPING CONCRETE PAVEMENTS

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SYNOPSIS

The pumping of concrete pavement slabs on pavements in Ohio, which has developed since 1940, has followed the increase in volume of heavy truck traffic that has resulted from the concentration of war industries. A survey indicates that pumping has occurred mostly on soils of the A-4, A-6, or A-7 groups but is not confined exclusively to soils of these types. A study of the moisture contents of the subgrades at various depths indicates a maximum immediately beneath the pavements and a decrease with depth indicating that surface water is the chief source of the subgrade moisture that causes pumping. The use of transfer devices at joints and of granular subgrades have been found most effective in the prevention of pumping. The use of French drains in the shoulder was not effective in stopping pumping.

After experimenting with various soil-bituminous, portland cement mixtures and several grades of semisolid asphalts, it was found that an oil asphalt filler having a penetration of 30 to 45 at 77°F. was most satisfactory for filling the voids under pumping concrete slabs. This material is forced under the pavement by means of the hand spray equipment of a standard bituminous distributor through holes drilled in the pavement with a standard jackhammer and drill. The bituminous material forms a tight seal beneath the pavement and prevents the entrance of surface water and its stability is not affected by moisture from the subgrade. Although the costs of the asphalt is somewhat higher than any of the various soil-mixtures, a portion of this cost differential is equalized in the labor saved on the assembling and mixing of the various materials used in slurries.

Prior to 1940 pumping of concrete pavements was not prevalent in Ohio. However, the considerable concentration of war industries in the State with its attendant increase in truck loads and in volume of truck traffic has resulted in a very rapid increase in both the distribution and the rate of pumping concrete pavements.

In this area pumping is particularly prevalent over silty-clay and clay soils, Public Roads Administration Classes A-6, A-7 and plastic A-4. However, it is not confined exclusively to these types. On a heavily traveled section of U.S. Route 52, East of Portsmouth, constructed recently on a subgrade made up in part of about equal amounts of silts and clays, considerable pumping has developed. This project is described in detail in a paper by Mr. H. L. Krauser/1 and it is sufficient to point out

/1 - See page 67 of this publication.

in this discussion that 37 per cent of the joints were pumping where the subgrade consisted of sandy silt and silt, Ohio soil classifications Nos. 8 and 9, while 57 per cent of the joints were pumping over the silty clay and clay subgrade, Ohio classifications Nos. 11, 15 and 16. The Ohio soil classifications are shown in Table 1. The average test constants of the soil on this project are shown in Table 2.

It is generally agreed that most of the water contributing to pumping is surface water. A number of observations made in Ohio substantiate this point. On a project constructed about twelve years ago which had shown no signs of distress until wartime restrictions on a refinery in the southern part of the State resulted in a tremendous increase in truck shipments, pumping occurred generally throughout the section except for areas where the joints were tightly sealed, preventing the entrance of surface water. Further evidence that the water is derived principally from the surface is afforded by the fact that on most of the projects observed there is practically no difference in the amount of pumping on fill and in cut sections. It has also been noted on several projects that less pumping occurs in areas where there is a paved gutter at the edge of the pavement which carries off the surface water before it has an opportunity to reach the subgrade.

In connection with our study of pumping pavements during the past two years, a considerable number of samples have been taken of subgrade through holes drilled in the pavement, in an effort to learn something of the moisture condition of the subgrade soil. A sheet of a typical soil survey is shown in Figure 1. The locations of the joints, cracks and pavement failures together with the points where the pavement jacking was done and the samples taken are shown in the lower part of the Figure, while in the upper portion the soil type and moisture content of the subgrade are shown. It is of interest to note that the moisture content of the subgrade decreases with the depth through the range measured by these samples; averaging 26.4 per cent in the 0.6 of a foot immediately beneath the slab, 24.4 per cent in the next 0.9 of a foot and 21.4 per cent in the bottom 0.9 of a foot.

From the summary of test results in Figure 1, it will be noted that the subgrade in this section consists almost entirely of clay for which the average lower liquid limit is 46.8 and the average plasticity index is 25.2.

Table 3 shows average test results and moisture contents for samples of the subgrade soil on several projects which were treated during the unusually dry summer of 1944. This Table shows a considerable variation in moisture contents of the subgrade soil in the various groups. However, in about two-thirds of the cases in which samples were obtained at different depths beneath the pavement, the moisture content of the subgrade soil was highest immediately beneath the pavement and decreased with the depth through the range sampled.

PREVENTATIVE MEASURES

The treatment of pumping may be divided into two parts (1) measures which tend to check pumping on existing roads and (2) treatments during construction which tend to minimize or eliminate entirely the conditions which are conducive to pumping.

The use of steel reinforcing, load transfer devices, and the spacing and type of joints all have an important bearing on the susceptibility of a pavement to pumping. Pumping has been particularly severe on pavements constructed without load transfer

LEGEND AND CLASSIFICATION FOR SOIL TYPE IDENTIFICATION ON SOIL PROFILES

Soil Class Number	Symbol	Description	Public Roads Administration Groups	Coarse Aggregate Retained on #10 Sieve	Coarse Sand #10 to #60	Fine Sand #60 – #200	Silt #200–.005 mm.	Clay Below .005 mm.	Liquid Limit	Plasticity Index	Field Moisture Equivalent	Shrinkage Limit	Maximum Dry Weight
1		GRAVEL	A-3	50-100	0-40	0-30	0	10		NP-10			
2		GRAVEL, SAND & SILT	A-2	30-60	15-30	15-20	15	40	15-35	NP-15	10-30	10-25	120-135
3		GRAVEL & SAND	A-1 A-2	30-70	15-40	15-30	0	20	15-35	NP-10	10-30	10-25	120-130
4		SAND	A-3	0-30	50 — 100		0	35		NP-8			100-115
5		SANDY SILT WITH COARSE MATERIAL	A-4 WITH C M	20-30	15-35	5-20	20	50	15-35	NP-15			
6		CLAY WITH COARSE MATERIAL	A-7 WITH C M	20-30	15-35	5-20	20	50	35-50	15-30			
7		BERM MATERIAL		CLASSIFIED BY VISUAL INSPECTION									
8		SILT	A-4	0-5	0-10	0-30	50-95	5-35	15-30	NP-12			105-115
9		SANDY SILT	A-4	0-30	10-40	10-40	20-50	5-30	15-30	NP-10	10-25		110-120
10		TOP SOIL	A-4	LOAMY MATERIAL CONTAINING DECAYED VEGETABLE MATTER AND HUMUS CLASSIFIED BY VISUAL INSPECTION									
11		SANDY SILT & CLAY	A-4	0-10	0 — 35		30-65	15-35	20-35	10-15	10-30		105-115
12		ELASTIC SILT & CLAY WITH ORGANIC MATERIAL	A-5						35+	P.I. LESS THAN (L.L.-14.0)/1.6			
13		ELASTIC SILT & CLAY WITH MICA	A-5						35+	P.I. LESS THAN (L.L.-14.0)/1.6			
14													
15		CLAY & SILT	A-7	0-10	0-25	0-15	50	100	35-40	15-25	25-35		100-110
16		CLAY	A-7	0-10	0-25	0-15	50	100	40+	20+	35+		90-105
17		CLAY	A-6						35+	P.I. GREATER THAN (L.L.-14.0)/1.2			
18		CINDERS		CLASSIFIED BY VISUAL INSPECTION									
19		ROCK-SOIL MIXTURE		30-90 % LARGE ROCK — CLASSIFIED BY VISUAL INSPECTION									
20		ORGANIC MATERIAL: PEAT, COAL OR COAL BLOSSOM	A-8	0 — 30					60+				
21		SOFT SHALE		CLASSIFIED BY VISUAL INSPECTION									
22		LIMESTONE		CLASSIFIED BY VISUAL INSPECTION									
23		SANDSTONE		CLASSIFIED BY VISUAL INSPECTION									
24		SHALE		CLASSIFIED BY VISUAL INSPECTION									

LIQUID LIMIT:— The moisture content, expressed as a percentage by weight of the oven-dried soil, at which the soil will just begin to flow when jarred slightly.

PLASTIC LIMIT:— The lowest moisture content, expressed as a percentage by weight of the oven-dried soil, at which the soil can be rolled into threads 1/8 inch in diameter without breaking into pieces.

PLASTICITY INDEX:— The difference between the liquid limit and the plastic limit.

FIELD MOISTURE EQUIVALENT:— The minimum moisture content, expressed as a percentage by weight of the oven-dried soil at which a drop of water placed on the smooth surface of the soil will not be immediately absorbed but will spread out over the surface and give it a shiny appearance.

SHRINKAGE LIMIT:— The moisture content, expressed as a percentage by weight of the oven-dried soil at which a reduction in moisture content will not cause a decrease in volume of the soil mass but at which an increase in moisture content will cause an increase in the volume of the soil mass.

BUREAU OF TESTS
OHIO DEPARTMENT OF HIGHWAYS

DATE 4-20-44

SOIL CLASSIFICATION CHART

PLAN PREPARATION MANUAL

APPROVED [illegible] ACTING CHIEF ENGR.

No 1

TABLE 1

TABLE 2

SUMMARY OF TESTS OF SUBGRADE SAMPLES FROM SECTION OF U.S. 52 EAST OF PORTSMOUTH, OHIO

SHTL Class	No. of Samples	Mechanical Analysis: Agg. %	C. Sand %	F. Sand %	Silt %	Clay %	Physical Characteristics: Liquid Limit	Plasticity Index	Total Number Joints (Spacing 20')	Per Cent of Joints Pumping
8	6	1.8	4.8	10.4	52.8	30.2	28.6	8.4	154	33.1
9	7	7.1	4.7	21.8	42.4	24.0	24.7	6.2	220	39.0
Ave. 8 & 9	13	4.6	4.7	16.1	47.8	26.8	26.5	7.2	374	36.6
11	6	1.4	3.8	8.2	51.6	35.0	30.2	10.7	164	43.0
15 & 16	8	0.1	1.1	2.3	40.1	55.4	39.8	16.1	212	68.0

devices of any kind. It has been noted that in pavements which are practically continuously under compression the severity of pumping is very much reduced.

Perhaps the most generally accepted means of prolonging the life of the pavement is the improvement of the subgrade. During the past several years subbase courses consisting of predominantly granular materials have been provided under many of our new pavements. The thickness of the material used varies for different subgrade soils and traffic conditions from 6 to 24 in. Most of the material used to date has met one of the grading requirements given in Table 4. In general, very little distress has been observed to date in pavements constructed over this type of subgrade. However, a few instances of pumping have been noted, and it has been rather frequently observed that material furnished under these requirements may have very low permeability. To assure more positive drainage in this subbase the grading requirements have been changed to those given in Table 5.

CORRECTIVE MEASURES

The Maintenance Bureau of the Ohio Department of Highways has of necessity in the past few years done a considerable amount of corrective work in an attempt to minimize the damage done by pumping. Early efforts consisted of attempting to drain away the free water by stone drains at the edge of the pavement either parallel to the slab or, as was more frequently the case, by French drains through the shoulder, Figure 2. The voids beneath the slabs were then filled using the mixture of soil and cement which had been previously found successful in raising depressed slabs. It was soon found from observation of the drains, particularly the open French drains extending through the shoulder, that these drains in themselves were not sufficient to remove the water and to stop pumping which had already started. During the past several years various combinations of soil, cement and other materials have been used for mudjacking. During the fall of 1942 the following mixtures were tried on different sections of U.S. Route 20 near Oberlin:

Mix 1		Mix 2	
Asphalt Cement 50-60 Penetration		MC-1	1.0
		Portland Cement	1.0
		Gypsum Plaster	1.0
		Soil	5.5

Mix 3		Mix 4	
MC-1	1.0	Vinsol Resin	1.0
Portland Cement	1.0	Portland Cement	1.0
Limestone Dust	1.0	Gypsum Plaster	1.0
Soil	5.5	Soil	5.5

Mix 5	
Vinsol Resin	1.0
Portland Cement	1.0
Limestone Dust	1.0
Soil	5.5

It was originally planned to get this treatment in during the fall of 1942, however, freezing weather made it necessary to postpone most of the work until the following spring, by which time the pavement had become so badly cracked and broken that comparison of the effectiveness of the various mixes is very difficult.

During the past summer voids beneath a considerable number of pumping joints have been filled by the use of slurries composed of 1 part cement, 1 part liquid asphalt, 1 part limestone dust and 5 parts of soil, by volume, or in approximately the proportions reported used by the Illinois State Highway Department./2 This mix is reported to be the most satisfactory of any of the slurries tried.

Most of the soil mixes which have been tried in this State to prevent pumping have been only temporarily satisfactory. Where slurries have been used it has usually been necessary to return one or two years after the initial filling and refill the voids. During the removal of some badly cracked slabs on a project several years ago a sample was tken of old mudjack material. Of particular interest among the test results obtained on this sample is the very high moisture content of 50 per cent. The soil was a very poor subgrade material containing a high percentage of silt and having a high liquid limit and low plasticity index and should not be considered as typical of all mudjack material.

In order to overcome some of the objections to the usual mudjack materials, the Ohio Department of Highways in 1941 began experimenting with various mixes in which bituminous materials made up a principal part. The first mixes tried were mixtures of slow curing liquid asphalts, powdered asphalt, soil and cement./3

In the summer of 1942 in an attempt to find a material more satisfactory than the mud mixtures, the following materials were used: Mixtures of slow curing liquid asphalt and powdered asphalt, 60-70 penetration asphalt cement, and 50-60 penetration asphalt cement. The mixture of slow curing liquid asphalt and powdered asphalt was found to be impractical because of the difficulty of pumping the material with the equipment available and because the fluxing of the powdered asphalt with the liquid asphalt was very slow.

/2 - See Page 133 of Appendix

/3 - See Page 133 of Appendix

TABLE 3 - SUMMARY OF TEST RESULTS AND MOISTURE CONTENTS FOR 213 SUBGRADE SAMPLES TAKEN THROUGH HOLES DRILLED IN CONCRETE PAVEMENTS

Depth beneath pavement Inches	Soil Type Ohio Classification	No. of Samples	Average Test Constants: Pass #200 Sieve, %	Silt %	Clay %	Liquid Limit	Plasticity Index	Moisture Content, %: Max.	Min.	Ave.
LORAIN COUNTY, S. H. 291, SECTION E (PT.) & F (PT.), S. R. NO. 18										
3-6	2	2	36.4	-	-	29.1	10.1	14.6	13.6	14.1
13-15		1	36.1	-	-	27.6	11.3	12.9	12.9	12.9
3-6	9	2	56.7	-	-	24.6	9.4	15.9	10.6	13.2
15-18		2	68.4	-	-	24.7	8.5	13.6	11.7	12.6
3-6		5	71.3	-	-	28.8	11.5	18.7	11.7	16.5
15-18	11	6	69.5	-	-	31.6	13.2	20.8	13.6	17.9
27-30		8	75.0	-	-	30.1	12.6	17.1	13.7	15.4
3-6		1	83.6	-	-	36.0	16.9	20.1	20.1	20.1
15-18	15	2	80.2	-	-	33.6	17.0	17.0	16.1	16.6
27-30		1	81.4	-	-	35.5	16.6	19.1	19.1	19.1
3-6	17	1	76.2	-	-	37.4	21.1	21.4	21.4	21.4
15-18		1	83.7	-	-	52.5	34.3	17.6	17.6	17.6
SCIOTO COUNTY, S.H. 7, SECTION O (PT.), R-1, R-2a & R-2b, U.S.R. #52										
3-6	**	11	19.8	-	-	20.9	2.4	25.1	4.1	9.5
15-18	SS-112	11	5.9	-	-	21.0	1.2	9.2	4.6	7.0
27-30		3	7.4	-	-	Non-Plastic		7.2	6.4	6.7
27-30	2	1	34.2	-	-	31.2	12.4	23.0	23.0	23.0
3-6		1	14.0	-	-	17.6	3.5	10.8	10.8	10.8
15-18	3	1	8.1	-	-	Non-Plastic		6.3	6.3	6.3
27-30		5	7.7	-	-	Non-Plastic		6.9	5.7	6.6
3-6		6	87.1	-	-	30.1	7.7	31.9	18.5	23.1
15-18	8	6	80.2	-	-	28.2	7.6	21.7	15.5	18.5
27-30		11	82.5	-	-	28.0	6.6	26.3	12.7	18.9
3-6		8	69.5	-	-	25.6	6.8	20.7	15.0	17.6
15-18	9	8	67.4	-	-	24.9	5.2	21.1	11.0	16.2
27-30		8	64.0	-	-	24.3	5.9	18.5	12.9	16.2

** Granular subbase material furnished under specification shown in Table 4.

Depth beneath pavement Inches	Soil Type Ohio Classification	No. of Samples	Average Test Constants: Pass #200 Sieve, %	Silt %	Clay %	Liquid Limit	Plasticity Index	Moisture Content, %: Max.	Min.	Ave.
SCIOTO COUNTY (CONTINUED)										
3-6		8	77.4	-	-	33.5	10.9	25.6	17.0	20.7
15-18	11	7	80.4	-	-	34.1	11.6	24.2	17.0	21.0
27-30		6	89.0	-	-	34.2	11.5	27.4	16.3	20.6
3-6		1	97.2	-	-	39.3	13.1	21.6	21.6	21.6
15-18	12	3	92.0	-	-	40.0	13.0	29.4	20.3	24.1
27-30		2	90.0	-	-	39.9	12.5	33.3	24.3	28.8
3-6		5	93.6	-	-	41.1	16.0	26.5	21.5	24.9
15-18	15	4	95.2	-	-	41.0	16.2	28.0	20.5	25.[illegible]
27-30		3	97.5	-	-	39.9	15.3	26.9	24.0	25.0
27-30	16	2	96.3	-	-	48.9	22.2	27.5	25.8	26.6
***MEDINA COUNTY, S.H. 95, SECTION A & B (PT.), S.R. #18**										
0-10	8	3	78.6	52.2	26.4	24.0	7.1	24.7	14.8	19.2
10-22		2	82.5	61.9	20.6	23.1	5.7	22.3	18.8	20.6
0-8		7	63.1	39.4	23.7	25.4	8.1	26.9	14.9	18.3
8-20	9	5	69.5	42.9	26.6	24.4	8.2	22.0	13.6	16.4
20-30		3	53.8	33.0	20.8	24.3	8.3	17.7	15.0	16.1
0-8	11	4	73.1	44.2	28.9	30.9	13.2	23.1	14.6	18.7
8-20		5	74.9	44.4	30.5	28.5	12.0	20.1	15.4	16.9
0-12	16	1	72.9	43.5	29.4	47.7	27.0	15.2	15.2	15.2
***PORTAGE COUNTY, S.H. 322, SECTION L,W,T,V & U, S.R. #5**										
0-10	9	1	82.6	47.7	34.9	28.7	6.6	25.9	25.9	25.9
0-6		10	78.5	43.2	35.3	31.8	12.9	27.2	16.8	21.1
6-18	11	10	79.1	39.8	39.3	31.1	12.1	25.3	15.1	18.3
18-30		7	81.1	38.9	42.2	31.7	12.5	31.1	15.2	18.3
10-22	12	1	84.1	46.6	37.5	40.7	12.8	25.0	25.0	25.0
10-24	15	1	89.8	39.3	50.5	39.2	18.4	26.5	26.5	26.5

*Samples on these projects taken through holes drilled for pavement jacking.

SOIL PROFILE
HAMILTON CO.
S.H. 44
SEC. H

STATE HIGHWAY TESTING LABORATORY
O S U CAMPUS, COLUMBUS, OHIO

1/5

NOTE: THE INFORMATION SHOWN BY THIS SUBGRADE PROFILE WAS SECURED FOR THE INFORMATION OF THE STATE OF OHIO. THE STATE DOES NOT GUARANTEE THE CORRECTNESS THEREOF AND DOES NOT INCLUDE IT AS A PART OF THE PLANS GOVERNING THE CONSTRUCTION OF THE PROJECT

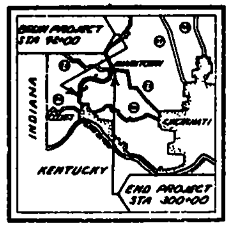
LEGEND FOR PROJECT-AVERAGE RESULTS OF TESTS-37 SAMPLES TESTED

	P.R.A. CLASS	B.H.T.L. CLASS	% AGG.	% C. SAND	% F. SAND	% SILT	% CLAY	LIQUID LIMIT	PLASTICITY INDEX	WATER CONTENT	SAMPLES TESTED
GRAVEL, SAND, & SILT	A-2	2	58.3	17.6	3.7	12.7	4.7	33.7	14.3	12.3	1
GRAVEL & SAND	A-2	3	46.7	32.7	6.2	13.3	1.1	17.4	3.4	4.7	1
SAND	A-3	4	2.8	58.1	14.3	14.4	8.4	18.5	4.4	6.2	1
SILT	A-4	8	-	1.0	0.4	67.2	31.4	32.4	11.5	12.4	1
SANDY SILT	A-4	9	4.8	18.3	22.2	38.2	18.5	21.9	6.2	17.1	2
SANDY SILT & CLAY	A-4	11	7.2	14.0	11.7	37.9	28.6	29.4	11.8	15.0	2
CLAY & SILT	A-7	15	1.0	4.5	6.5	51.3	36.7	36.8	17.8	22.8	4
CLAY	A-7	16	3.7	4.9	2.1	43.3	44.0	44.8	25.2	24.8	23
CLAY	A-6	17	-	6.0	6.7	46.7	40.6	40.5	23.1	22.2	2

- AUGER BORINGS - TO VERTICAL SCALE
- CRACK IN PAVEMENT
- BITUMINOUS CONCRETE PATCH
- HOLE DRILLED FOR MUD JACKING
- HOLE DRILLED FOR MUD JACKING. SUBGRADE SAMPLES TAKEN
- PAVEMENT

SAMPLES TESTED *
LAB. NOS. SO. 41187-41215 inc., 41868-41909 inc., 41935-41975 inc.

* INCLUDES SAMPLES TESTED FOR MOISTURE ONLY



LOCATION MAP

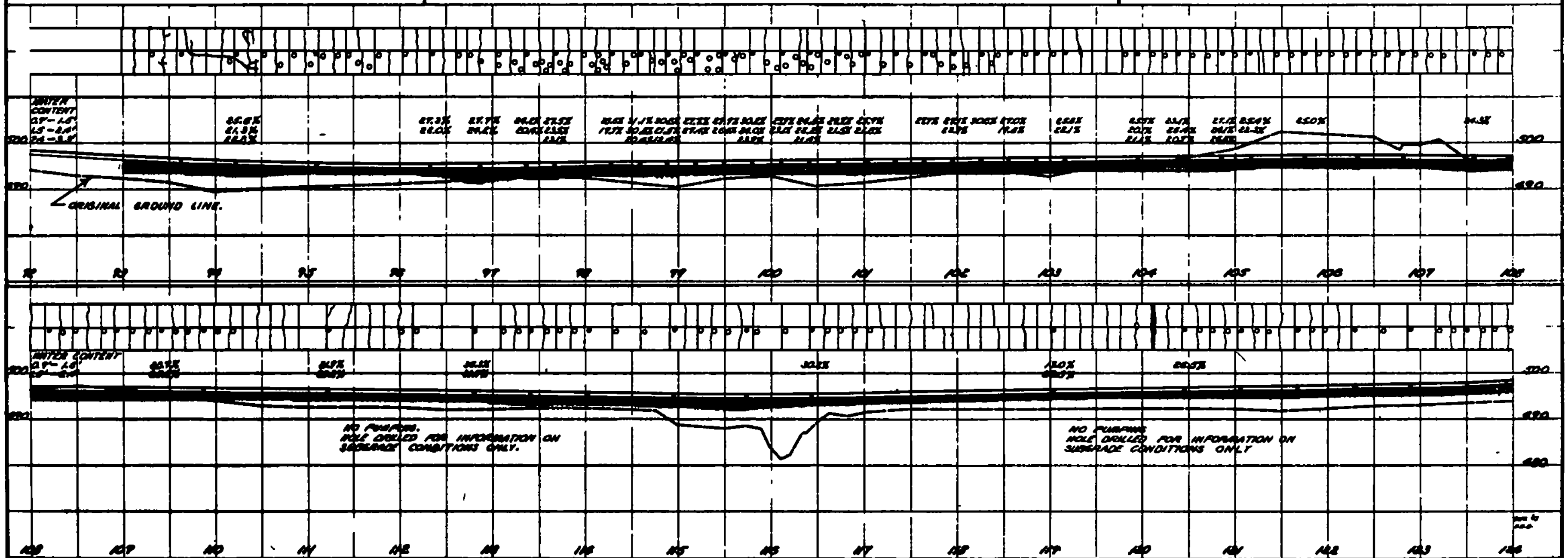


FIGURE 1

TABLE 4 - GRADING REQUIREMENTS FOR SUBBASE MATERIALS COMMONLY USED IN OHIO

Sieve	TOTAL PER CENT PASSING		
	Grading 1	Grading 2	Grading 3
3 Inch	100	100	
2 "			100
1 "	30-70	75-100	
1/2 "		50-90	
#10	0-25	35-75	50-100
#200		0-15	0-15

For the fraction of these materials passing the No. 40 sieve the liquid limit shall be not greater than 35 and the plasticity index not greater than 10.

TABLE 5 - GRADING REQUIREMENTS FOR SUBBASE MATERIALS PROPOSED FOR USE ON FUTURE PROJECTS

Sieve	TOTAL PER CENT PASSING			
	Grading A	Grading B	Grading C	Grading D
3 Inch	100			
2 "	30-70	100	100	100
1 "		70-100	70-100	
1/2 "		40-100		
3/8 "	15-40			
No. 4		0-40		
No. 10	0-15	0-15	35-75	50-90
No. 50			0-10	0-20

For the fraction of these materials passing the No. 40 sieve the liquid limit shall be not greater than 35 and the plasticity index not greater than 10.

Approximately a thousand joints and cracks were treated with 60-70 penetration asphalt in 1942 and only a very few of them were pumping mud in the early fall of 1944. However, there were some instances of exuding of the asphalt cement from the cracks and joints. About two hundred joints were treated this same year with the 50-60 penetration asphalt cement and although this asphalt showed less exuding than the 60-70 penetration material, it was thought that a higher melting point material with a lower temperature susceptibility would be desirable. Therefore, in 1943 and 1944 the Ohio Department of Highways' Specification M-5.4, F-1, approximating the A.A.S.H.O. Oil Asphalt Filler Grade A, Designation: M 18-42 was used. This material has given very satisfactory results to date and no difficulty has been experienced with bitumen exuding from the joints or cracks. In a few instances it has been necessary to go back over the pavement after the first treatment and retreat some joints that still pump.

As an indication of the amount of material necessary to treat pumping joints it was found that on one project treated this past summer that an average of 40 gallons per joint was used to treat 284 joints. The quantity of material, of course, varied considerably for individual joints. At some joints as much as 60 gallons of material have been used without raising the slab. Our Maintenance Bureau outlines the following equipment and procedure that has been used satisfactorily in conducting this work.

EQUIPMENT

Air compressor, jack hammer and drills to drill holes and blow out mud and water.

A bituminous pressure distributor equipped with a patching hose and a home-made barrel, bung type, bituminous pump nozzle which is to be put in the hole in the pavement and driven snug with a hammer before asphalt pumping is started. See Figures 3 and 4. The bituminous distributor should be equipped with a by pass pressure regulator so that pressures between 20 and 40 lbs. per sq. in. can be maintained. It should also be equipped with a reversible pump or a suck back arrangement so that a small amount of the asphalt may be sucked out of the hole immediately before removing the nozzle in order to prevent asphalt squirting out on the pavement.

A sprinkling can and water to wet the pavement around the hole so that any asphalt leakage can be easily removed. The water is also used to chill any asphalt that may break out of a crack or joint before the desired amount has been pumped under the pavement.

Soft wood cylindrical plugs turned to a diameter 1/8 in. larger than the hole to be driven in the hole after the treatment is completed.

LABOR

Six or eight men are required in the gang. Two or three with the compressor to drill and blow out holes and four or five with the distributor to do the pumping.

SEQUENCE OF OPERATION

A short trench is dug at each end of the joint or crack to be pumped to slightly below the depth of the pavement slab. This serves as a well for the mud and water blown from under the slab and also for observation when pumping in the asphalt. A hole is drilled through the pavement usually located about one foot ahead of the joint in

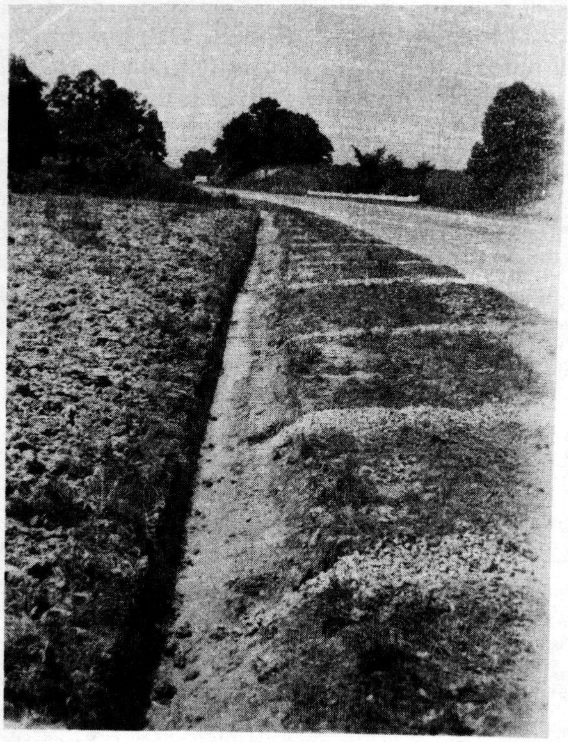


FIGURE 2. STONE DRAIN INSTALLATION FOR REMOVAL OF FREE WATER FROM BENEATH PUMPING JOINTS AND CRACKS.

FIGURE 3. NOZZLE FOR PUMPING BITUMINOUS MATERIAL BENEATH THE PAVEMENT.

the direction of travel and one to two feet away from the center longitudinal joint. Water and mud are blown out by forcing compressed air into the hole using the same type nozzle as described above. In especially wet areas it is desirable to blow out the water and the mud immediately before injecting the asphalt. In dry areas this operation may be carried out considerably in advance of pumping asphalt under the slab.

The asphalt to be used should be heated to a temperature of from 350° to 400° F. The injector nozzle is attached to the patching hose of the distributor and driven into the hole. Some water is sprinkled around the hole to wet the pavement so that any spillage may be removed easily and the asphalt pumping is begun.

Pressures of from 20 to 35 lbs. per sq. in. have been found to be entirely adequate in filling the space beneath the slab and even raising the slab. Using this comparatively low pressure it can be seen that a man standing on the nozzle plate will hold the nozzle securely in the hole.

The pumping is continued until the asphalt exudes from under the pavement at the observation trench or until the slab starts to raise. If the slab starts to raise before asphalt exudes from under the edge of the pavement or if asphalt exudes from one edge of the pavement and not the other, it may be desirable to drill another hole and attempt to force in more asphalt. Should

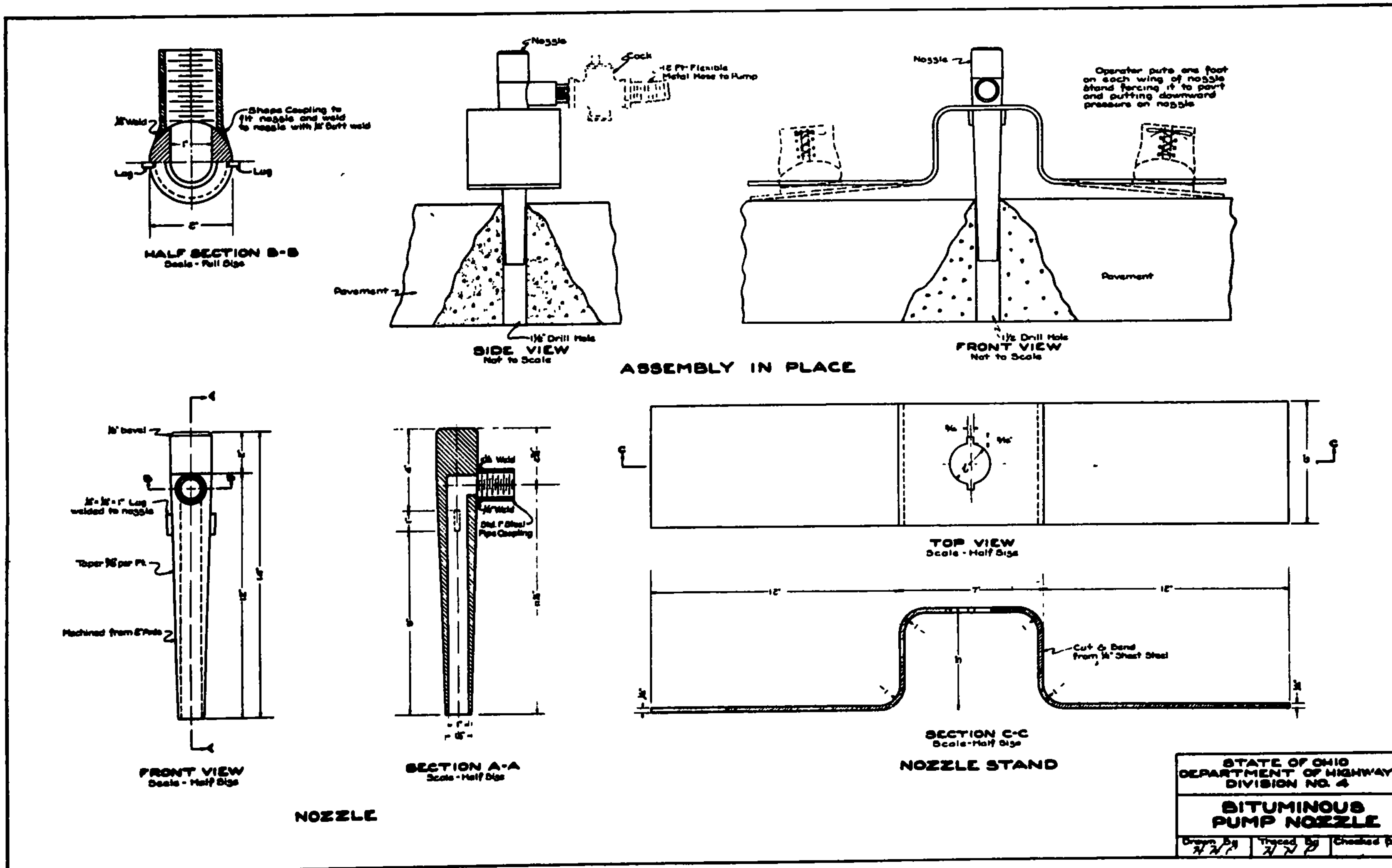

HALF SECTION B-B
Scale - Full Size
Shape Coupling to fit nozzle and weld to nozzle with ⅛" Butt weld
Lug
Nozzle
Cock
Flexible Metal Hose to Pump
Pavement
1½" Drill Hole
SIDE VIEW
Not to Scale
Operator puts one foot on each wing of nozzle stand forcing it to pavt and putting downward pressure on nozzle
FRONT VIEW
Not to Scale
ASSEMBLY IN PLACE
Taper per Ft.
Machined from 2" Axle
FRONT VIEW
Scale - Half Size
Std. 1" Steel Pipe Coupling
SECTION A-A
Scale - Half Size
NOZZLE
TOP VIEW
Scale - Half Size
Cut & Bend from ⅛" Sheet Steel
SECTION C-C
Scale - Half Size
NOZZLE STAND
STATE OF OHIO
DEPARTMENT OF HIGHWAYS
DIVISION NO. 4
BITUMINOUS
PUMP NOZZLE
Drawn By
Traced By
Checked By

Figure 4.

the asphalt break out at a crack or joint on the surface of the pavement during the pumping operation, pumping should be stopped a short time, the asphalt chilled with water and the pumping then continued. If the leakage continues after this treatment it can usually be stopped by placing over it a chunk of stiff clay or mud which is held down by a man standing on it. When sufficient asphalt has been pumped in, the pump is stopped but the nozzle is allowed to remain in the hole for 30 seconds before it is withdrawn. If the distributor is not equipped with a suck back arrangement, the pump motor should be reversed for a few seconds before the nozzle is withdrawn so that the asphalt will not exude from the hole before the plug can be inserted. Immediately upon the removal of the nozzle the soft wood plug is driven into the hole flush with the pavement and the spillage scraped off.

This same procedure has been used successfully to raise slabs except that the holes are usually drilled 18 to 24 in. from the crack or joint and midway between the center joint and edge of the pavement. Should the slab start to raise at a high place a loaded truck may be backed over it and thus hold down the part of the slab that is already high enough. We have generally obtained our asphalt shipped hot in insulated tank cars directly from the refinery. However, it generally arrives at slightly too low a temperature to be pumped into the distributor and some time it is necessary to heat eight or ten hours with steam at 80 to 90 pounds pressure. It usually can be pumped into the distributor at a temperature of from 280° to 300°F., after which it can be brought to application temperature in the distributor if heating in the distributor is found to be more desirable than raising the temperature the rest of the way in the tank car.

We have experienced no casualties in this operation from men being slushed with hot asphalt. However, as a safety precaution it would be desirable for men to wear heavy clothes, gloves and a welder's mask.

CONCLUSION

The use of bituminous material pumped beneath the slab to stop pumping of concrete pavements in this State has been much more successful than the various types of mud mixtures tried. In all probability one of the principal reasons for the success of this material is the fact that it forms a tight seal beneath the pavement and thus prevents the entrance of surface water. Further its stability is not appreciably affected by water which may reach it through the subgrade. Bituminous material is considerably easier to control when being pumped beneath the pavement since it apparently spreads more evenly than slurries. There is considerably less likelihood of cracking the slab than with slurries and it is easier to keep from raising the slab, or to control the amount by which the slab is raised if this is necessary. Although the costs of the material using asphalt are somewhat higher than for slurries, at least a portion of this cost differential is made up in the labor saved in assembling and mixing of the various materials.

From the experience gained to date, it is our opinion that bituminous materials show considerable promise as an effective treatment for the pumping of concrete pavements.