# Report on Pavement Research Project in Ohio

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This project was built in the summer and fall of 1952 in an attempt to determine the performance of various thicknesses of subbase on a main truck route. The project is four miles long, of 9-in. uniform thickness, and is 24 ft. wide. It is divided into four sections, two with contraction joints on 100-ft. centers and two with contraction joints on 20-ft. centers.

The four sections are divided into subsections using the following types of subbase: (1) control with no subbase, subgrade is a known pumping soil; (2) open-textured granular subbase material, 3, 5, and 8 inches thick; (3) dense-graded granular subbase material, 3, 5, and 8 inches thick; (4) cement-modified soil 6 inches thick, with cement contents of 5, 7, 9, and 11 percent; and (5) soil-cement mixture 3 and 5 inches thick.

Eighteen 24-hr. traffic counts made since the project was constructed show that the test lanes carry approximately 1,844 combination trucks in 24 hours. Many of these have axle loads exceeding 18,000 lb.

● THE Department of Maintenance, in its "Final Report of Project Committee No. 1, Maintenance of Concrete Pavement as Related to the Pumping Action of Slabs," (1) recommended that future research be conducted to investigate the thickness and characteristics of subbases necessary to prevent pumping of portland-cement-concrete pavements placed over potentially pumping soils, and the relationship of traffic and slab end deflections to pumping.

The Bureau of Public Roads recommended a continuation of the study, and several states were invited to participate by constructing test raods which would incorporate features particularly suitable for this investigation.

The Ohio Department of Highways and the Bureau of Public Roads cooperated in the construction of such a test road in the summer and fall of 1952. These two organizations and the Portland Cement Association are cooperating in the testing.

While this report is concerned mainly with the construction of the test road, the performance observations made to date are included although it is much too early to attempt to draw any conclusions from them.

## DESIGN AND CONSTRUCTION

### Project Location

The report of the project committee showed conclusively "that the repeated passage of heavy axle loads is the primary activating element in pumping at joints and cracks in concrete pavements" and that "free water and fine-grained subgrade soils are the other two contributing factors." Therefore, it was essential that the test road be constructed where the subgrade soil was conducive to pumping and where the anticipated number of heavy axle loads would be sufficient in magnitude to assure that these elements which are known to cause pumping were present.

The location finally selected for the Ohio test road was approximately four miles of the eastbound roadway of US 20 in Sandusky County between Fremont and Clyde. Being a part of a main route east of Toledo, the road carries a large number of freight vehicles many of which haul heavy loads.

### Construction Specifications

In general the specifications under which this test road was constructed were the "State of Ohio, Department of Highways, Construction and Material Specifications," dated January 1, 1951. Certain additions and modifications of these specifications, which are included in the following paragraphs, were necessary so that a complete record of the materials that went into its construction and the in-place condition of the

TABLE 1
STRENGTH OF PAVEMENT CONCRETE

| Type of Specimen | Age, Days | No of Tests | Strengths | |
|---|---|---|---|---|
| | | | Compressive, psi | Modulus of Rupture, psi |
| Cylinders | 7 | 97 | 3,456 | - |
| Cylinders | 28 | 110 | 4,757 | - |
| Cores | 28[a] | 68 | 4,852[a] | - |
| Beams | 3 | 117 | - | 609 |
| Beams | 5 | 128 | - | 632 |
| Beams | 7 | 228 | - | 652 |

[a] The cores were cut and tested at various ages ranging from 2½ to 7½ months. The average age was 6 07 months and the average strength was 5,794 psi The equivalent 28-day strength is given in the table.

subgrade, subbase, and surface course might be available for future study.

When any course of any 500-ft. subsection was completed, the contractor was required to allow the project engineer up to three working days in which to make in-place tests of the completed course.

## Pavement

The pavement was built of mesh reinforced air-entrained portland-cement concrete. It has a 9-in. uniform thickness and is 24 ft. wide. The concrete was placed using full width construction. The test road was divided into four sections, each approximately 6,500 ft. in length. In the first and third sections the contraction joints were spaced at 100-ft. intervals, while in the second and fourth sections, they were spaced at 20-ft. intervals. Expansion joints were only used between sections and on each side of the one major bridge. All of the joints have load transfer devices.

The materials used in the concrete were crushed-limestone coarse aggregate, manufactured sand, and portland cement entraining 3 to 6 percent of air, each from one approved source.

The results of tests of beam and cylinder specimens cast at the time of construction are shown in Table 1.

## Subgrade

In order to insure a reasonably uniform subgrade within the limits of what is known to be a pumping soil, the upper foot of the subgrade was required to conform to the following gradation:

Aggregate retained on a No. 200 sieve (0.07 mm.) . . . . . 0 - 60%[a]
Silt (0.074 mm. to 0.005 mm.) . . . . . . . . . . . . . . . . . 0 - 85%
Clay (smaller than 0.005 mm.) . . . . . . . . . . . . . . . . . 15 - 100%

[a] If the plus No. 200 mesh sieve aggregate exceeds 45 percent, the silt content shall not exceed 15 percent and the clay content shall not exceed 40 percent.

The characteristics of the upper foot of the in-place subgrade were obtained by the sampling of each 500-ft. length of roadway, a complete summary of which is given in Table A (appendix). The upper foot of the subgrade soil ranges between A-6(8) and A-6(12) of the AASHO Designation M145-49, with the exception of a small quantity of A-7-6(13) material. A table of ranges and averages which characterize the material is listed in Table 2.

TABLE 2
RANGES AND AVERAGES OF SUBGRADE CONSTANTS

| Classification | Range | Ave. Value |
|---|---|---|
| Passing No. 10 | 89% - 100% | 95% |
| Passing No. 200 | 63% - 92% | 77% |
| Silt | 31% - 55% | 43% |
| Clay | 29% - 45% | 36% |
| Liquid Limit | 30 - 42 | 35 |
| Plasticity Index | 12 - 22 | 16 |

## Subbase

Each section, except the fourth, is divided into twelve different subbase treatments and one length of no subbase. These subsections are 500 ft. long and consist of: (1) open-textured granular subbase material, 3, 5, and 8 inches thick; (2) dense-graded granular subbase material, 3, 5, and 8 inches thick; (3) soil-cement, 3 and 5 inches thick; and (4) cement-modified soil, 6 inches thick, with cement contents of 5, 7, 9, and 11 percent.

The fourth section is divided into only 11 subbase treatments, the 11 percent cement-modified subsection being omitted. The

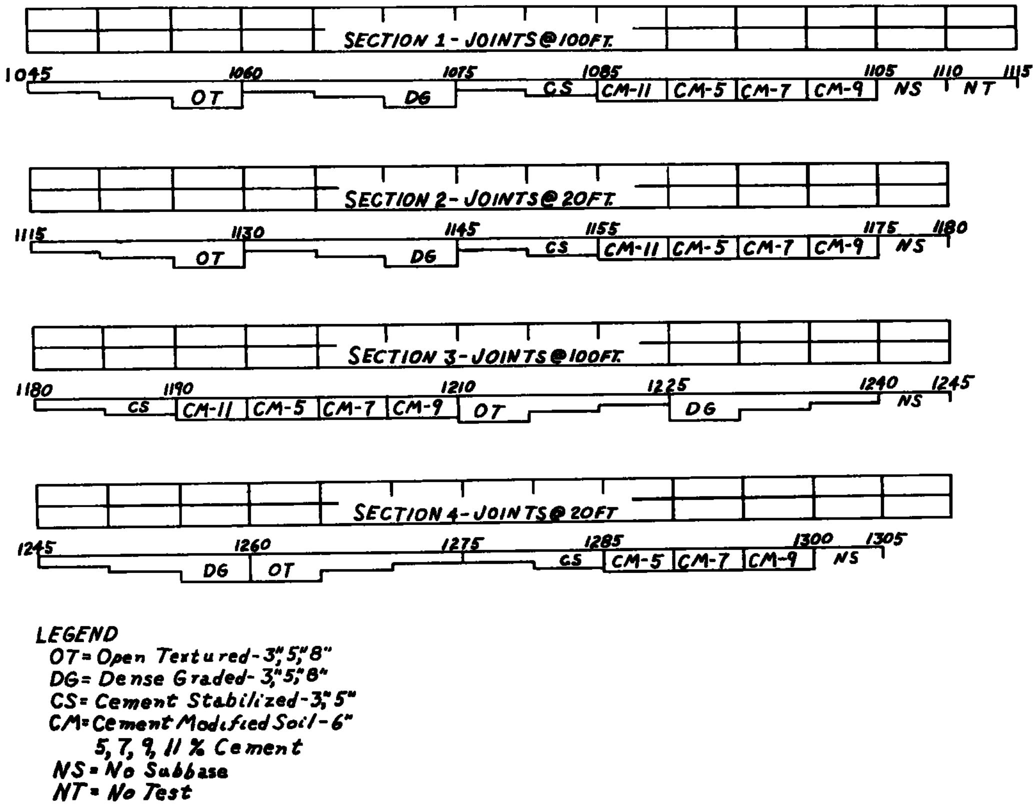


Figure 1. Arrangement of subbase treatments on the Ohio subbase test road.

specific arrangement is shown in Figure 1.

The material used for the open-textured granular subbase was crushed limestone. The specifications required that the coefficient of permeability be not less than 500 feet per day and that the grading conform to the following:

| Sieve Size | Total Percent Passing |
|---|---|
| 1½ in. | 100 |
| 1 in. | 50-100 |
| No. 4 | 30-100 |
| No. 40 | 0-35 |
| No. 200 | 0-15 |

The material used for the dense-graded granular subbase was also crushed limestone. The coefficient of permeability was required to be not greater than 2 feet per day and the grading was required to conform to the following:

| Sieve Size | Total Percent Passing |
|---|---|
| 1½ in. | 100 |
| 1 in. | 95-100 |
| No. 40 | 20-65 |
| No. 200 | 15-30 |

A brief summary of the average characteristics of these granular subbase materials is given in Table 3. Characteristics of samples from each treatment are listed in Table B in the appendix.

The soil for the soil-cement subbase met the grading requirements of the upper foot of the subgrade. The pulverized soil was required to have a minimum of 80 percent of the mixture by weight passing a No. 4 sieve, exclusive of the gravel or stone retained

TABLE 3
CHARACTERISTICS OF GRANULAR SUBBASE

| Subbase Treatment and Soil Classification | Gradation Total Percent Passing No. 4 | No. 40 | No. 200 | Permeability Coefficient, Ft./Day | AASHO Max. Dry Density, Pcf. | Optimum Moisture, % |
|---|---|---|---|---|---|---|
| Open-textured A-1-a(0) | 38 | 11 | 7 | 590 | 125 | 12 |
| Dense-graded A-1-b(0) | 99 | 36 | 22 | 0.21 | 128 | 11 |

on a No. 4 sieve. The soil-cement contained 14 percent cement by volume. A soil-stabilizing machine was used to pulverize the soil, spread the cement and water, mix the materials and spread the mixture. For the initial compaction, a tamping roller was required. A smooth-wheeled tandem roller and pneumatic tired rollers were required for final compaction. The contractor was required to cure the completed course with earth or saturated straw for a minimum of 7 days or until the portland-cement concrete was placed on the subbase.

When tested in accordance with the requirements of the Standard Method of Freezing-and-Thawing Test of Compacted Soil-Cement Mixture, AASHO Designation T 136-45, representative soil-cement cylinders showed a loss after 12 cycles of 5 percent. Cylinder strengths from 2-by-2-in. representive soil-cement cylinders are as follows:

| Age, days | Strength, psi. |
|---|---|
| 2 | 254 |
| 7 | 350 |
| 28 | 497 |

The cement-modified soil subbase and the soil-cement subbase were constructed of the same materials and by the same methods except that for the cement modified subbase a minimum of 70 percent cement pulverization was permitted and no curing was required.

The effect of cement modification of the soil is shown by the data in Table 4.

TABLE 4
EFFECT OF CEMENT MODIFICATION CN SOIL CHARACTERISTICS

| Cement Content | 0% | 5% | 7% | 9% | 11% |
|---|---|---|---|---|---|
| Physical Constant | Numerical Value of Constant at Cement Contents Listed Above | | | | |
| Liquid Limit | 39 | 39 | 37 | 37 | 36 |
| Plastic Limit | 19 | 25 | 25 | 27 | 29 |
| Plasticity Index | 20 | 14 | 12 | 10 | 7 |
| Shrinkage Limit | 19 | 25 | 26 | 28 | 32 |
| Soil Classification | Percent in Each Classification at Above Cement Contents | | | | |
| Coarse Sand | 4 | 20 | 24 | 26 | 31 |
| Fine Sand | 14 | 18 | 18 | 25 | 22 |
| Silt | 39 | 38 | 36 | 34 | 32 |
| Clay | 42 | 23 | 21 | 14 | 14 |

A brief summary of the average characteristics of both of the cement-treated subbases is given in Table 5. Characteristics of samples from each treatment are listed in the appendix.

## OBSERVATIONS OF PERFORMANCE

### General

Observations of the performance of the various subbase treatments will probably continue for several years. Traffic studies, records of moisture and temperature changes, pavement deflections studies, studies of pavement strains and visual observations of distress are being made at the present time.

### Traffic Studies

The Ohio Highway Department began making traffic counts and weight surveys of the vehicles using the test road in

TABLE 5
CHARACTERISTICS OF CEMENT TREATED SUBBASES

| Subbase Treatment | Max. Lab. Dry Wt. (Incl. Cem.), Pcf. | Max. Lab. Wet Wt. (Incl. Cem.), Pcf. | Wet Wt. as Placed Pcf. | Opt. Moist., % | Moist. as Placed, % |
|---|---|---|---|---|---|
| Soil-cement | 105.8 | 126.4 | 125.0 | 18.8 | 19.5 |
| Cement-modified | 106.0 | 126.8 | 125.2 | 18.7 | 19.3 |

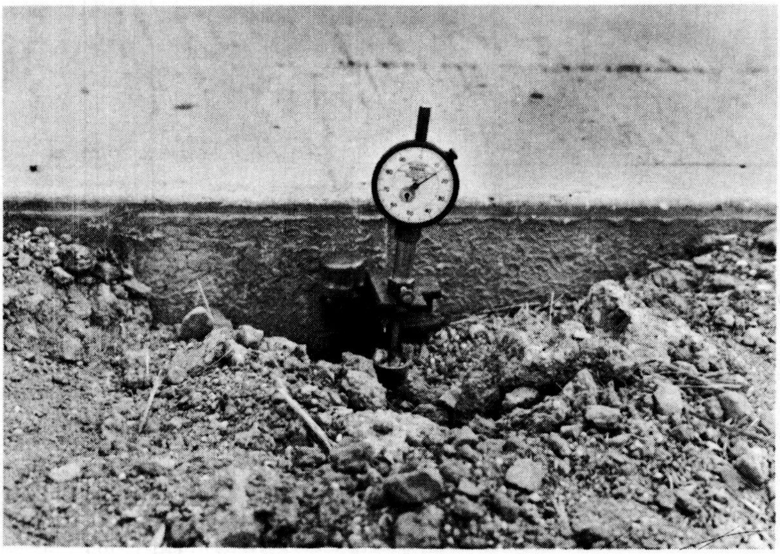

Figure 2. Deflectometer installation.

January, 1953. With a few exceptions traffic counts and weight surveys have been made monthly since that time. These traffic studies indicate that the test raod is well located with respect to traffic loads and frequency. On an average yearly weekday 5,749 vehicles pass over the test road. Of this amount 2,130 are heavy trucks. Based on weight surveys, 21 percent of the axles of the heavy trucks weigh more than 14,000 lb. The results of these monthly traffic counts and weight surveys will be found in the appendix.

Moisture and Temperature Records

Provisions were made during construction for the installation of fiberglas electrical soil-moisture instruments which contain thermisters for temperature determinations also. A discussion of the basic design of this instrument can be found in "The Place of Electrical Soil-Moisture Meters in Hydrologic Research," by E.A. Colman (2). Improvements in this basic design had been made in the instruments used. These improvements are discussed in "The Fiberglas Soil-Moisture Instrument," by E.A. Colman and T.M. Hendrix (3).

These fiberglas soil-moisture cells were installed in the subbase and subgrade beneath the pavement at each of seven locations along the test road. In addition four of the cells were placed along the right-of-way line at various depths so that the effect of the pavement slab might be observed. The Ohio Department of Highways and the Bureau of Public Roads are cooperating in the interpretation of the data being obtained from these cells.

TABLE 6
MAXIMUM DEFLECTIONS RECORDED IN JULY 1953
(Deflections in Thousandths Inches)

| Subbase Type | 20 Foot Slabs Joints | 20 Foot Slabs Midslabs | | | 100 Foot Slabs Joints | 100 Foot Slabs Midslabs | | |
|---|---|---|---|---|---|---|---|---|
| | t = 15 | t = 15 | t = 13 | t = 2 | t = 12 | t = 12 | t = 15 | t = 1 |
| 3in O T | 10 | 11 | 14 | 18 | 20 | 20 | 13 | 26 |
| 5in O T | 9 | 9 | 10 | 14 | 15 | 16 | 13 | 23 |
| 8in O T | 13 | 14 | 14 | 23 | 17 | 9 | 8 | 13 |
| 3in D G | 14 | 15 | 17 | 18 | 38 | 20 | 14 | 19 |
| 5in. D G | 11 | 13 | 12 | 15 | 24 | 9 | 9 | 17 |
| 8in. D G | 12 | 10 | 12 | 14 | 26 | 12 | 11 | 18 |
| 3in. S C | 11 | 11 | 13 | 16 | 23 | 13 | 10 | 15 |
| 5in S C | 8 | 8 | 10 | 14 | 12 | 11 | 9 | 12 |
| 5% C M | 8 | 14 | 16 | 25 | 16 | 12 | 9 | 14 |
| 7% C M | 8 | 13 | 14 | 21 | 15 | 12 | 8 | 17 |
| 9% C M | 8 | 11 | 7 | 11 | 13 | 12 | 8 | 15 |
| 11% C M | 9 | 8 | 10 | 21 | 14 | 12 | 10 | 17 |
| N S | 23 | 22 | 21 | 20 | 99 | 20 | 16 | 18 |

t = Temperature of top of slab minus temperature of bottom of slab

## Deflection and Strain Studies

Two types of deflection studies are being made. The first is an overall evaluation program in which a controlled load moves past an arrangement of maximum reading deflectometers. The arrangement is such that the maximum deflections of the outer corners and edges of several slabs in each treatment on one section are recorded within a short interval of time. This method serves to reduce the effects on deflection readings of changes in the shape of the slab due to temperature differences.

A second type of study is being made at a limited number of locations. At these positions, deflections and strains are read continously during the passage of the load. Only two of the four test sections are instrumented for these tests, namely, the second and third sections which have 100-ft. and 20-ft. joint spacings, respectively.

The loading truck being used in these studies is a 3-axle dump truck loaded to a gross of approximately 31,500 lb. on the tandem axles.

In the general evaluation study only the maximum deflections are desired. They are being obtained by measuring the relative desplacement between the slab edge and the top of a rod driven through a casing into the subgrade. The deflectometer used to measure slab deflections with respect to the rod is shown in Figure 2. In each subsection of the two sections selected for study there are deflectometer installations at the midpoint of three slabs and within 6 inches of each side of one joint.

The maximum deflection data that has been obtained to date is summarized in Tables 6 and 7. The figures representing corner deflections are averages of three runs at each of two adjacent corners and those in midslab columns are averages of three runs at each of three positions at the pavement edge midway between joints.

The effect of temperature upon the magnitude of panel deflections is very noticeable. In Table 7, under 100-foot slabs, the tests made in the early morning with a slab differential, temperature of top of slab less temperature of bottom of slab, of 0 F. gave corner deflections about twice as large as those made in the afternoon with a slab differential of +12 F. The same trend is observed under 20-foot slabs but the differences between early morning deflections and afternoon deflections are not quite as large.

From the maximum deflection data obtained thus far, it is quite evident that all of the subbases are of some value in the reduction of slab deflection below that found in the no-subbase sections. Thus far, of those being tested, the most effective in the reduction of slab deflection are the cement-modified subbases. Next in rank are the soil-cement subbases and the least effective are the open-textured and dense-graded subbases.

To ascertain the magnitude of strains in the portland-cement-concrete road slabs associated with the slab deflections, several of the installations for maximum deflections have been selected for further study and these are instrumented to provide a continuous strain and deflection record for each pass of the test vehicle.

The linear variable differential trans-

TABLE 7
MAXIMUM DEFLECTIONS RECCRDED IN APRIL 1954
(Delfections in Thousandths Inches)

| Subbase Type | 20 Foot Slabs Joints | | 20 Foot Slabs Midslabs | | 100 Foot Slabs Joints | | 100 Foot Slabs Midslabs | |
|---|---|---|---|---|---|---|---|---|
| | t = 4 | t = 10 | t = 0 | t = 1 | t = 0 | t = 12 | t = -1 | t = 12 |
| 3in O T | 34 | 27 | 20 | 17 | 38 | 19 | 29 | 13 |
| 5in O T | 28 | 18 | 16 | 10 | 34 | 13 | 32 | 14 |
| 8in O T | 47 | 22 | 24 | 16 | 36 | 12 | 23 | 10 |
| 3in D G | 36 | 19 | 20 | 17 | 60 | 30 | 24 | 21 |
| 5in D. G | 29 | 15 | 17 | 13 | 29 | 14 | 20 | 15 |
| 8in D G | 28 | 20 | 19 | 13 | 36 | 19 | 23 | 14 |
| 3in S C | 41 | 23 | 21 | 15 | 62 | 38 | 18 | 15 |
| 5in S C | 40 | 16 | 18 | 10 | 30 | 18 | 16 | 14 |
| 5% C. M | 38 | 23 | 27 | 20 | 27 | 12 | 13 | 11 |
| 7% C M | 28 | 17 | 24 | 16 | 42 | 15 | 17 | 11 |
| 9% C M | 30 | 17 | 15 | 10 | 38 | 15 | 15 | 11 |
| 11% C M | 31 | 19 | 17 | 11 | 29 | 19 | 15 | 14 |
| N S. | 53 | 35 | 20 | 20 | 103 | 78 | 25 | 21 |

t = Temperature of top of slab minus temperature of bottom of slab

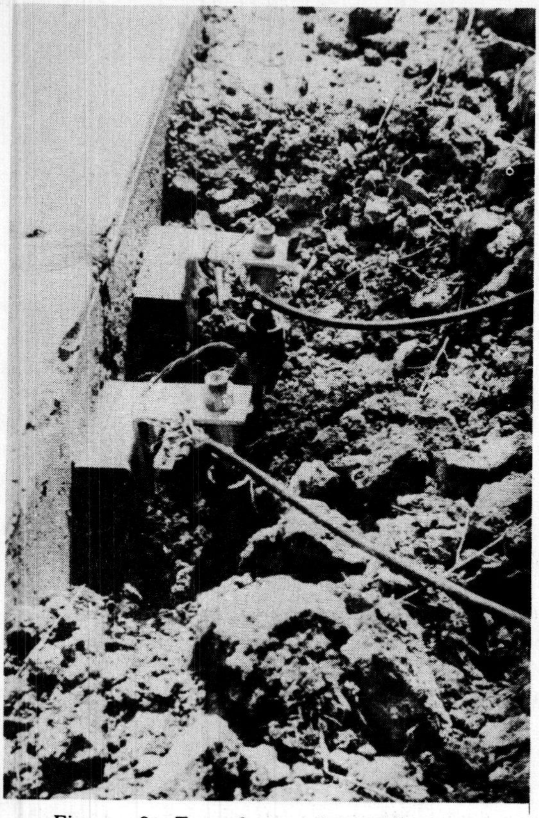

Figure 3. Transformer installation.

formers being used for the continuous deflection measurements are mounted in a manner similar to the maximum reading deflectometers. The housing is held in an angle bracket which is clamped to the unistrut section and the iron core pin rests on the top of the reference rod which was driven through the casing into the subgrade. They are coupled directly to a Sanborn automatic strain recorder. A view of the transformers installed at a joint is shown in Figure 3.

For the measurement of strains for the continuous record study Baldwin SR-4 Type A-9 gages are cemented to the upper surface of the portland-cement concrete close to the edge. The Sanborn recorder indicates these strains simultaneously with the deflections indicated by the transformers.

One of the SR-4 Type A-9 gages is mounted midway between the ends of the slab and two gages are placed at a distance from the corner which has been found by trial to be the position giving maximum response with corner loads. These positions have been found to be 4½ feet from the joint in 20-foot panels and 8 feet from the joint in 100-foot panels. The distances are not critical.

A summary of maximum deflections and strains from the tests made to date is presented in Table 8. No constant temperature differential could be attained in these tests due to time requirements.

When the truck wheels were crossing the joint, the maximum tension in the upper face of the concrete slab was seldom as large as the maximum compression recorded

TABLE 8
MAXIMUM STRAINS AND DEFLECTIONS FROM CONTINUOUS RECORDS

| Subbase Type | 1953 Deflections (.001 in.) | | | | 1953 Strains (.000001 in./in.) | | | 1954 Deflections (.001 in.) | | | | 1954 Strains (.000001 in./in.) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | t | Corner | | Mid- | Corner | | Mid- | t | Corner | | Mid- | Corner | | Mid- |
| | | App. | Lv. | Slab | App. | Lv. | Slab | | App. | Lv. | Slab | App. | Lv. | Slab |
| **20-Foot Slabs** | | | | | | | | | | | | | | |
| 5 in. O. T. | 4 | 15 | 16 | 12 | 27 | 26 | 29 | 3 | 29 | 25 | - | 27 | 23 | - |
| 5 in. D. G. | 4 | 18 | 16 | 25 | 33 | 30 | 41 | 3 | 11 | 18 | 20 | 34 | 26 | 31 |
| 5 in. S. C. | -2 | 54 | 34 | 23 | 41 | 39 | 31 | 4 | 24 | 28 | - | 25 | 29 | - |
| 7% C. M. | 0 | 26 | 26 | 21 | 28 | 28 | 36 | 6 | 22 | 24 | - | 29 | 28 | - |
| N. S. | 0 | 31 | 30 | 22 | 41 | 40 | 36 | 3 | 36 | 48 | - | 31 | 33 | - |
| **100-Foot Slabs** | | | | | | | | | | | | | | |
| 5 in. O. T. | 11 | 13 | 11 | 16 | 28 | 37 | 38 | 2 | 23 | 26 | 15 | 27 | 26 | 31 |
| 5 in. D. G. | 6 | 14 | 16 | 12 | 32 | 32 | 31 | 0 | 21 | 31 | 12 | 29 | 27 | 25 |
| 5 in. S. C. | 8 | 22 | 24 | 21 | 35 | 34 | 38 | 6 | 23 | 28 | 23 | 30 | 29 | 28 |
| 7% C. M. | 15 | 36 | 26 | 23 | 33 | 31 | 39 | 6 | 20 | 22 | 14 | 32 | 30 | - |
| N. S. | 9 | 61 | 60 | 15 | 33 | 47 | 39 | 8 | 57 | 75 | 27 | 38 | 40 | 39 |

t = Temperature of top of slab minus temperature at bottom of slab.

when a truck wheel was at the gage position. The larger of these two values was listed in Table 8. For this reason the tabulated corner strains do not differ greatly from those at mid slab.

Visual Observations of Pavement

Thus far, four condition surveys to observe the amount of joint pumping, edge pumping and edge blowing have been made by the Ohio Department of Highways. Previous surveys have led to the conclusion that curbs, acceleration and deceleration lanes materially reduce the surface evidence of pumping and edge blowing and that joint spacing has a material effect also. Therefore, in the composite summary of these surveys, the figures are based on 100 feet of uncurbed length and the different joint spacings are shown separately.

These surveys show that the opened-textured granular subbases have the least visual evidence of pumping and blowing. Next in rank are the dense-graded and last are the no-subbase sections. The soil-cement and cement-modified subbases are difinitely better than the no-subbase sections.

By April 1954, the faulting and cracking of one of the no-subbase subsections with 100-foot joint spacing had become so severe that corrective maintenance was required. The other no-subbase subsections had by this time shown definite indications of some loss of subgrade support. All of the no-subbase subsections were undersealed with bituminous material on April 21, 1954.

A featured crushed limestone granular shoulder, about 3 inches thick at the pavement's edge and about 3 feet wide, was placed along the outside pavement edge for the entire length of the test road in August 1954, to correct the dangerous shoulder condition of some of the subsections which was due largely to severe pumping and edge blowing action.

## TENTATIVE CONCLUSIONS

As previously stated, it is still too early to draw definite conclusions as to the relative merits of each subbase treatment. All treatments perform better than untreated subgrade. This is especially noticeable under the 100-foot slabs, where several failures have occurred on the subsections on the untreated subgrade and considerable maintenance has been required.

## *References*

1. Proceedings, Highway Research Board, Vol. 22, p. 281 (1948).
2. American Geophysical Union Transactions, Vol. 27, No. 6, Dec. 1946.
3. Soil Service, Vol. 67, No. 6, June 1949.

# Appendix

TABLE A
CHARACTERISTICS OF UPPER ONE FOOT OF SUBGRADE
(Field Density Tests Represent Top Six Inches Only)

| Type of Subbase | Station Limits | Sieve Analysis, % Passing #10 | Sieve Analysis, % Passing #200 | Based on Laboratory Tests of Samples of Delivered Material: Particle Size, % Coarse Sand | Particle Size, % Fine Sand | Particle Size, % Silt | Particle Size, % Clay | Plasticity Constants Liquid Limit | Plasticity Constants Plast Index | HRB[a] Soil Classification | Moist Den Test Max Lab Dry Wt, pcf | Moist Den Test Opt Moist % | Based on Field Density Tests: Opt Moist, %[b] | Comp Moist % | Max Lab Dry Wt, pcf[b] | Comp Dry Wt. pcf | Percent Comp |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3 in O T | 1045-1050 | 99 | 91 | 3 | 5 | 51 | 40 | 35 | 17 | A-6(11) | 109.4 | 16.7 | 14.6 | 8.8 | 114.5 | 116.1 | 101.3 |
| 5 in O T | 1050-1055 | 95 | 84 | 6 | 5 | 52 | 32 | 34 | 15 | A-6(10) | 109.6 | 16.9 | 16.4 | 11.6 | 110.8 | 114.0 | 102.9 |
| 8 in O T | 1055-1060 | 95 | 84 | 6 | 5 | 47 | 37 | 35 | 17 | A-6(11) | 108.1 | 16.7 | 16.2 | 10.9 | 111.3 | 113.1 | 101.6 |
| 3 in D G | 1060-1065 | 98 | 89 | 4 | 5 | 53 | 36 | 37 | 17 | A-6(11) | 108.9 | 16.9 | 16.5 | 12.5 | 110.4 | 115.1 | 104.2 |
| 5 in. D G | 1065-1070 | 100 | 90 | 5 | 5 | 55 | 35 | 36 | 16 | A-6(10) | 103.0 | 20.3 | 16.9 | 14.2 | 109.6 | 112.8 | 102.9 |
| 8 in D G | 1070-1075 | 97 | 80 | 8 | 9 | 46 | 34 | 35 | 14 | A-6(10) | 111.5 | 16.4 | 14.9 | 12.3 | 114.1 | 116.0 | 101.7 |
| 3 in S C | 1075-1080 | 99 | 92 | 3 | 4 | 47 | 45 | 38 | 19 | A-6(12) | 110.0 | 15.6 | 14.6 | 12.7 | 114.6 | 115.3 | 100.6 |
| 5 in S C | 1080-1085 | 95 | 85 | 6 | 4 | 46 | 39 | 40 | 18 | A-6(11) | 105.2 | 16.4 | 15.2 | 9.3 | 113.3 | 117.1 | 103.4 |
| 11% C M | 1085-1090 | 96 | 83 | 7 | 6 | 43 | 40 | 38 | 18 | A-6(11) | 107.1 | 18.6 | 14.6 | 11.5 | 114.6 | 115.2 | 101.0 |
| 5% C M | 1090-1095 | 98 | 83 | 8 | 7 | 38 | 45 | 33 | 14 | A-6(10) | 107.8 | 18.0 | 12.1 | 11.2 | 122.0 | 125.3 | 102.7 |
| 7% C M | 1095-1100 | 99 | 82 | 9 | 8 | 52 | 30 | 36 | 16 | A-6(10) | 104.6 | 20.0 | 12.0 | 8.3 | 121.8 | 125.3 | 102.9 |
| 9% C M | 1100-1105 | 99 | 90 | 5 | 4 | 51 | 39 | 37 | 18 | A-6(11) | 109.4 | 17.6 | 15.1 | 12.7 | 115.5 | 117.0 | 101.3 |
| N S | 1105-1110 | 97 | 86 | 5 | 6 | 45 | 41 | 35 | 16 | A-6(10) | 110.5 | 16.9 | 13.6 | 9.3 | 117.5 | 116.8 | 99.4 |
| 3 in O T | 1115-1120 | 96 | 76 | 11 | 9 | 39 | 37 | 31 | 14 | A-6(10) | 113.7 | 15.6 | 16.0 | 10.3 | 113.2 | 116.3 | 102.7 |
| 5 in O T | 1120-1125 | 97 | 78 | 7 | 12 | 38 | 40 | 34 | 17 | A-6(11) | 113.2 | 15.7 | 13.8 | 9.2 | 117.8 | 120.5 | 102.2 |
| 8 in O T | 1125-1130 | 95 | 68 | 9 | 18 | 39 | 29 | 32 | 14 | A-6(8) | 115.1 | 14.6 | 13.5 | 8.0 | 117.0 | 117.8 | 100.6 |
| 3 in D G | 1130-1135 | 98 | 81 | 7 | 10 | 44 | 37 | 37 | 19 | A-6(12) | 110.9 | 15.8 | 15.4 | 9.5 | 112.9 | 114.4 | 101.3 |
| 5 in D G | 1135-1140 | 96 | 77 | 9 | 10 | 39 | 38 | 32 | 16 | A-6(10) | 112.6 | 15.9 | 16.1 | 10.8 | 111.4 | 116.6 | 104.7 |
| 8 in D G | 1140-1145 | 98 | 75 | 10 | 13 | 43 | 32 | 30 | 13 | A-6(9) | 112.3 | 15.5 | 15.1 | 10.9 | 113.8 | 117.9 | 103.6 |
| 3 in S C | 1145-1150 | 97 | 72 | 11 | 14 | 42 | 30 | 30 | 12 | A-6(8) | 111.9 | 15.1 | 15.5 | 9.8 | 112.8 | 110.8 | 98.2 |
| 5 in S C | 1150-1155 | 94 | 75 | 9 | 10 | 46 | 29 | 35 | 15 | A-6(10) | 108.1 | 16.8 | 16.9 | 11.0 | 109.6 | 106.6 | 97.2 |
| 11% C M | 1155-1160 | 96 | 80 | 6 | 10 | 47 | 33 | 33 | 15 | A-6(10) | 108.9 | 16.7 | 15.8 | 10.6 | 112.0 | 107.9 | 96.4 |
| 5% C M | 1160-1165 | 97 | 78 | 8 | 11 | 44 | 34 | 37 | 17 | A-6(11) | 110.1 | 16.4 | 16.9 | 11.2 | 109.6 | 110.1 | 100.5 |
| 7% C M | 1165-1170 | 99 | 85 | 6 | 8 | 49 | 36 | 38 | 17 | A-6(11) | 108.9 | 17.6 | 18.8 | 16.1 | 105.5 | 107.7 | 102.1 |
| 9% C M | 1170-1175 | 99 | 85 | 6 | 8 | 52 | 33 | 36 | 15 | A-6(10) | 106.5 | 18.3 | 18.6 | 14.0 | 105.9 | 110.9 | 104.7 |
| N S | 1175-1180 | 97 | 82 | 8 | 7 | 45 | 37 | 40 | 18 | A-6(11) | 107.9 | 16.8 | 17.8 | 13.4 | 107.9 | 106.9 | 99.1 |
| 3 in S C | 1180-1185 | 94 | 76 | 10 | 8 | 47 | 29 | 37 | 16 | A-6(10) | - | - | 16.6 | 11.8 | 110.4 | 108.9 | 98.7 |
| 5 in S C | 1185-1190 | 90 | 74 | 8 | 8 | 43 | 31 | 39 | 18 | A-6(11) | - | - | 18.0 | 15.8 | 107.2 | 106.9 | 99.8 |
| 11% C M | 1190-1195 | 93 | 65 | 10 | 18 | 34 | 31 | 36 | 18 | A-6(8) | - | - | 14.6 | 16.6 | 114.6 | 105.0 | 91.7 |
| 5% C M | 1195-1200 | 97 | 74 | 9 | 14 | 36 | 38 | 42 | 22 | A-7-6(13) | - | - | 18.1 | 15.0 | 107.1 | 107.9 | 100.7 |
| 7% C M | 1200-1205 | 98 | 79 | 8 | 11 | 37 | 42 | 31 | 14 | A-6(10) | - | - | 14.1 | 11.6 | 114.5 | 116.3 | 101.6 |
| 9% C M | 1205-1210 | 97 | 76 | 11 | 10 | 34 | 42 | 38 | 18 | A-6(11) | - | - | - | - | - | - | - |
| 8 in O T | 1210-1215 | 94 | 70 | 12 | 12 | 36 | 34 | 34 | 15 | A-6(9) | 112.1 | 15.6 | 15.8 | 12.8 | 112.1 | 114.0 | 101.7 |
| 5 in O T | 1215-1220 | 94 | 69 | 13 | 12 | 31 | 38 | 34 | 16 | A-6(9) | 105.1 | 17.9 | 15.6 | 10.4 | 112.6 | 109.9 | 97.6 |
| 3 in O T | 1220-1225 | 92 | 69 | 12 | 11 | 36 | 33 | 36 | 17 | A-6(10) | 109.5 | 16.2 | 16.2 | 14.8 | 111.2 | 111.5 | 100.3 |
| 8 in D G | 1225-1230 | 94 | 70 | 11 | 13 | 37 | 33 | 39 | 19 | A-6(10) | 106.1 | 17.8 | 13.0 | 8.1 | 118.5 | 113.8 | 96.1 |
| 5 in D G | 1230-1235 | 96 | 73 | 11 | 12 | 39 | 34 | 35 | 15 | A-6(10) | 109.3 | 15.8 | - | - | - | - | - |
| 3 in D G | 1235-1240 | 91 | 66 | 12 | 13 | 31 | 35 | 32 | 15 | A-6(8) | 118.2 | 14.0 | 10.5 | 6.5 | 126.6 | 119.3 | 94.5 |
| N S | 1240-1245 | 94 | 69 | 12 | 13 | 36 | 33 | 31 | 14 | A-6(9) | 115.4 | 14.6 | 14.7 | 9.4 | 114.5 | 112.4 | 98.2 |
| 3 in D G | 1245-1250 | 95 | 69 | 12 | 14 | 34 | 35 | 33 | 16 | A-6(9) | 109.7 | 16.2 | - | - | - | - | - |
| 5 in D G | 1250-1255 | 98 | 70 | 11 | 17 | 36 | 34 | 36 | 18 | A-6(10) | 109.5 | 18.4 | 12.7 | 8.3 | 119.3 | 120.9 | 101.3 |
| 8 in D G | 1255-1260 | 94 | 69 | 12 | 13 | 33 | 36 | 35 | 18 | A-6(10) | 112.8 | 14.7 | 12.7 | 8.2 | 119.3 | 122.2 | 102.2 |
| 8 in O T | 1260-1265 | 98 | 80 | 9 | 9 | 37 | 43 | 42 | 21 | A-7-6(13) | - | - | 16.1 | 17.1 | 107.1 | 107.1 | 100.0 |
| 5 in O T | 1265-1270 | 90 | 65 | 13 | 12 | 32 | 33 | 36 | 18 | A-6(9) | 109.5 | 15.3 | 13.5 | 9.6 | 117.0 | 107.7 | 92.7 |
| 3 in O T | 1270-1275 | 89 | 63 | 14 | 12 | 33 | 30 | 36 | 17 | A-6(9) | 112.0 | 15.5 | 12.7 | 8.2 | 119.3 | 112.6 | 94.4 |
| 3 in S C | 1275-1280 | 94 | 68 | 13 | 13 | 34 | 34 | 38 | 17 | A-6(10) | 112.6 | 14.5 | 14.6 | 11.4 | 114.6 | 119.6 | 104.4 |
| 5 in S C | 1280-1285 | 92 | 73 | 9 | 10 | 39 | 34 | 33 | 15 | A-6(10) | 109.6 | 15.8 | 15.8 | 11.9 | 112.0 | 113.4 | 101.3 |
| 5% C M | 1285-1290 | 90 | 67 | 11 | 12 | 36 | 31 | 34 | 15 | A-6(9) | 110.9 | 15.3 | - | - | - | - | - |
| 7% C M | 1290-1295 | 91 | 68 | 11 | 12 | 32 | 36 | 35 | 16 | A-6(9) | 110.1 | 16.2 | 14.6 | 10.6 | 114.6 | 115.9 | 101.1 |
| 9% C M | 1295-1300 | 92 | 73 | 10 | 9 | 33 | 40 | 33 | 15 | A-6(10) | 111.4 | 15.5 | - | - | - | - | - |
| N.S | 1300-1305 | 93 | 72 | 11 | 10 | 34 | 38 | 32 | 15 | A-6(9) | 112.5 | 15.2 | - | - | - | - | - |
| Avg of | 1115-1160 | 97 | 78 | 8 | 11 | 44 | 34 | 34 | 16 | A-6(10) | 110.8 | 16.2 | 16.1 | 11.1 | 111.5 | 112.6 | 101.1 |
| Avg of | 1180-1245 | 94 | 72 | 10 | 12 | 37 | 35 | 36 | 17 | A-6(10) | 110.8 | 16.0 | 15.3 | 12.1 | 113.6 | 111.4 | 98.3 |
| Avg of | 1045-1305 | 95 | 76 | 9 | 10 | 41 | 36 | 35 | 16 | A-6(10) | 110.0 | 16.4 | 15.2 | 11.3 | 113.6 | 114.0 | 100.4 |

[a] "Classification of Highway Subgrade Material" as adopted by the Highway Research Board in 1945
[b] Data from typical moisture density curves

TABLE B
CHARACTERISTICS OF GRANULAR SUBBASES

| Comp. Thick-ness in. | Station Limits | Based on Laboratory Tests of Samples of Delivered Material: Sieve Analysis % Passing 1½" | 1" | ⅜" | 4 | 40 | 200 | Particle Size, % Coarse Sand | Fine Sand | Plasticity Constants Liquid Limit | Plast Index | HRB[a] Soil Classification | Permeability Coeff. ft./day | Moist. Den. Test Max. Lab. Dry Wt. pcf. | Opt. Moist., % | Based on Field Density Tests: Opt. Moist. %[b] | Comp. Moist. % | Max. Lab. Dry Wt. pcf.[b] | Comp. Dry Wt. pcf. | Percent Comp. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | | | | Open Textured | | | | | | | | |
| 3 | 1045-1050 | 100 | 100 | | 34 | 9 | 6 | 5 | 2 | 17 | N. P. | A-1a(0) | 279 | 123.2 | 13.8 | 10.1 | 6.5 | 126.9 | 132.4 | 104 4 |
| 3 | 1115-1120 | 100 | 100 | | 45 | 13 | 9 | 8 | 3 | - | N. P. | A-1a(0) | 224 | - | - | 10.2 | 4.8 | 126.8 | 126.3 | 99.8 |
| 3 | 1220-1225 | 100 | 100 | | 38 | 10 | 7 | 5 | 3 | 19 | 1 | A-1a(0) | 910 | 126.8 | 11.0 | 11.5 | 8.1 | 126.8 | 127.0 | 100.1 |
| 3 | 1270-1275 | 100 | 100 | | 36 | 9 | 7 | 5 | 2 | - | N. P. | A-1a(0) | 768 | 122.1 | 12.7 | 10.2 | 4.8 | 126.8 | 125.0 | 98.7 |
| 5 | 1050-1055 | 100 | 100 | | 37 | 11 | 8 | 7 | 2 | 18 | 1 | A-1a(0) | 500 | 124.8 | 12.0 | 10.1 | 4.9 | 126.9 | 126.5 | 99.8 |
| 5 | 1120-1125 | 100 | 100 | | 43 | 10 | 8 | 7 | 2 | - | N. P. | A-1a(0) | 538 | - | - | 10.6 | 6.0 | 126.8 | 121.1 | 95.7 |
| 5 | 1215-1220 | 100 | 100 | | 41 | 12 | 8 | 11 | 3 | 20 | 2 | A-1a(0) | 967 | 129.0 | 11.6 | 10.2 | 6.5 | 126.8 | 121.0 | 95.2 |
| 5 | 1265-1270 | 100 | 100 | | 32 | 12 | 9 | 4 | 2 | - | N. P. | A-1a(0) | 533 | 128.1 | 11.1 | 10.2 | 4.8 | 126.8 | 122.9 | 97.0 |
| 8 | 1055-1060 | 100 | 100 | | 43 | 13 | 7 | 8 | 2 | 16 | N. P. | A-1a(0) | 393 | 125.2 | 13.3 | 10.1 | 5.7 | 126.9 | 129.8 | 102 4 |
| 8 | 1125-1130 | 100 | 100 | | 42 | 12 | 8 | 7 | 3 | 20 | 2 | A-1a(0) | 513 | 125.0 | 10.4 | 10.2 | 5.9 | 126.8 | 126.3 | 99.6 |
| 8 | 1210-1215 | 100 | 100 | | 37 | 11 | 6 | 6 | 4 | 19 | 2 | A-1a(0) | 681 | 128.5 | 10.8 | 10.2 | 6.2 | 126.8 | 125.2 | 98 9 |
| 8 | 1260-1265 | 100 | 100 | | 26 | 8 | 6 | 4 | 2 | - | N. P. | A-1a(0) | 764 | 116.4 | 10.7 | 10.2 | 5.9 | 126.8 | 120.4 | 95 0 |
| | | | | | | | | | | | | Dense Graded | | | | | | | | |
| 3 | 1060-1065 | | | 100 | 99 | 36 | 18 | 41 | 8 | - | N. P. | A-1b(0) | 0.13 | 127.5 | 11.4 | 12.6 | 3.5 | 127.5 | 126.0 | 98.8 |
| 3 | 1130-1135 | | | 100 | 96 | 36 | 21 | 38 | 9 | - | N. P. | A-1b(0) | 0.20 | 128.1 | 11.1 | 11.5 | 2.9 | 128.3 | 126.5 | 98 5 |
| 3 | 1235-1240 | | | - | - | - | - | - | - | - | - | - | - | - | - | 11.5 | 4.2 | 128.3 | 126.5 | 98 6 |
| 3 | 1245-1250 | | | 100 | 99 | 38 | 26 | 43 | 7 | - | N. P. | A-2-4(0) | 0.08 | 127.4 | 10.8 | 11.5 | 5.0 | 128.3 | 127.5 | 99.4 |
| 5 | 1065-1070 | | | 100 | 100 | 36 | 25 | 39 | 6 | - | N. P. | A-1b(0) | 0.02 | 128.3 | 10.8 | 12.6 | 3.9 | 127.5 | 126.1 | 98.9 |
| 5 | 1135-1140 | | | 100 | 99 | 43 | 27 | 39 | 9 | - | N. P | A-2-4(0) | 0.10 | 128.0 | 10.6 | 11.5 | 4.1 | 128.3 | 120.5 | 93.7 |
| 5 | 1230-1235 | | | 100 | 99 | 35 | 21 | 42 | 8 | - | N. P. | A-1b(0) | 0.04 | 127.1 | 11.1 | 11.5 | 6.3 | 128.3 | 123 1 | 96.0 |
| 5 | 1250-1255 | | | 100 | 100 | 42 | 27 | 40 | 8 | - | N. P | A-2-4(0) | 0.14 | 130.0 | 11.0 | 11.5 | 8.4 | 128.3 | 124.2 | 96 8 |
| 8 | 1070-1075 | | | 100 | 99 | 24 | 17 | 39 | 4 | - | N. P | A-1b(0) | 1.02 | 127.6 | 11.7 | 12.6 | 3.9 | 127.5 | 126.2 | 99.0 |
| 8 | 1140-1145 | | | 100 | 98 | 36 | 22 | 42 | 7 | - | N. P. | A-1b(0) | 0.10 | 128.3 | 10.7 | 11.5 | 3.5 | 128.3 | 122.6 | 95.7 |
| 8 | 1225-1230 | | | 100 | 98 | 26 | 17 | 39 | 5 | - | N. P | A-1b(0) | 0.03 | 126.7 | 11.3 | 11.5 | 6.2 | 128.3 | 126.7 | 98.8 |
| 8 | 1255-1260 | | | 100 | 99 | 40 | 25 | 41 | 9 | - | N. P. | A-1b(0) | 0.45 | 127.9 | 10.7 | 11.5 | 9.0 | 128.3 | 126.4 | 98 5 |

[a] "Classification of Highway Subgrade Material" as adopted by the Highway Research Board in 1945.
[b] Actual laboratory tests representative of the material in place.

TABLE C

CHARACTERISTICS OF CEMENT TREATED SUBBASES

| Comp. Thick-ness, in. | Station Limits | Sieve Analysis, % Ret. on #10 | Particle Size % | | | | Plasticity Constants | | HRB[c] Soil Classification | Max. Lab. Dry Wt. (Incl. Cem.) pcf. | Max. Lab. Wet Wt. (Incl. Cem.) pcf. | Wet Wt. as Placed pcf. | Opt. Moist. % | Moist. as Placed, % | Cem. Cont., % | Remarks |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Coarse Sand | Fine Sand | Silt | Clay | Liquid Limit | Plast. Index | | | | | | | | |
| | | | | | | | | | Soil Cement | | | | | | | |
| 3 | 1075-1080 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 104.4 | 126.4 | 125.3 | 19.5 | 21.3 | 14.1 | |
| 3 | 1145-1150 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 104.6 | 125.8 | 123.6 | 20.2 | 18.4 | (1) | (1)1145+00 to<br>1147+50 -20.5%[a] |
| 3 | 1180-1185 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.3 | 125.8 | 124.5 | 19.5 | 19.1 | 14.4 | 1147+50 to |
| 3 | 1275-1280 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 109.3 | 128.3 | 125.5 | 16.0 | 19.3 | 14.4 | 1150+00 -20.9%[a] |
| 5 | 1080-1085 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.5 | 125.5 | 123.0 | 18.0 | 21.5 | (2) | (2)1080+00 to<br>1082+50 -14.1% |
| 5 | 1150-1155 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 103.1 | 124.4 | 124.9 | 21.1 | 20.0 | (3) | 1082+50 to<br>1085+00 -14.2% |
| 5 | 1185-1190 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.7 | 126.2 | 125.2 | 19.0 | 18.7 | 14.2 | (3)1150+00 to<br>1152+50 -20.7%[b]<br>1152+50 to |
| 5 | 1280-1285 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 108.8 | 128.4 | 127.6 | 17.5 | 17.9 | 14.1 | 1155+00 -18.9%[b] |
| | | | | | | | | | Cement Modified | | | | | | | |
| 6 | 1085-1090 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.8 | 126.9 | 123.4 | 18.5 | 20.2 | (4) | (4)1085+00 to<br>1087+50 -11.0% |
| 6 | 1155-1160 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.6 | 127.4 | 126.2 | 20.4 | 20.7 | 11.0 | 1087+50 to<br>1090+00 -10.0% |
| 6 | 1190-1195 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 104.7 | 126.8 | 123.6 | 20.0 | 18.3 | (5) | (5)1190+00 to<br>1192+50 -11.8% |
| 6 | 1090-1095 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 108.3 | 128.4 | 125.7 | 15.5 | 18.3 | 5.2 | 1192+50 to<br>1195+00 -11.0% |
| 6 | 1160-1165 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.1 | 125.8 | 123.4 | 19.5 | 18.8 | (6) | (6)1160+00 to<br>1162+50 -6.3% |
| 6 | 1195-1200 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.8 | 125.7 | 122.7 | 18.3 | 19.8 | 5.0 | 1162+50 to |
| 6 | 1285-1290 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 106.9 | 126.2 | 128.2 | 17.1 | 18.6 | 5.0 | 1165+00 -5.0% |
| 6 | 1095-1100 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 107.8 | 128.8 | 126.7 | 19.2 | 20.6 | 7.2 | |
| 6 | 1165-1170 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 104.7 | 124.9 | 123.2 | 18.9 | 17.0 | 7.0 | |
| 6 | 1200-1205 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 105.1 | 126.2 | 124.2 | 18.4 | 18.8 | 7.0 | |
| 6 | 1290-1295 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 106.7 | 127.0 | 127.2 | 18.0 | 18.5 | (7) | (7)1290+00 to<br>1292+50 -6.7% |
| 6 | 1100-1105 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 107.5 | 128.5 | 127.0 | 18.6 | 19.2 | 9.0 | 1292+50 to |
| 6 | 1170-1175 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 103.7 | 124.9 | 122.6 | 19.3 | 19.7 | 8.3 | 1295+00 -7.2% |
| 6 | 1295-1300 | 5 | 8 | 7 | 35 | 45 | 31 | 14 | A-6(10) | 109.7 | 130.2 | 129.5 | 18.2 | 18.4 | 9.0 | |

[a] Includes 6.1% additional cement added when section was reworded.
[b] Includes 4.9% additional cement added when section was reworked.
[c] "Classification of Highway Subgrade Material" as adopted by the Highway Research Board in 1945.

TABLE D
1953 24-HOUR WEEKDAY TRAFFIC COUNT

| Month | Light Vehicles | | Heavy Vehicles | | Total Heavy Vehicles | Total Vehicles |
|---|---|---|---|---|---|---|
| | Pass. Cars | Panels & Pickups | Single Unit Trucks | Combination Trucks | | |
| January | 2637 | 217 | 325 | 2309 | 2634 | 5488 |
| February[a] | 2360 | 178 | 237 | 2020 | 2257 | 4795 |
| March | 2306 | 163 | 189 | 1994 | 2183 | 4652 |
| April | 3121 | 290 | 344 | 2022 | 2366 | 5777 |
| May | 3137 | 247 | 295 | 2253 | 2548 | 5932 |
| June | 3920 | 267 | 406 | 1955 | 2361 | 6548 |
| July | 4696 | 227 | 372 | 1818 | 2190 | 7113 |
| August | 4993 | 291 | 340 | 2215 | 2555 | 7839 |
| September | 3879 | 252 | 278 | 1937 | 2215 | 6346 |
| October | 3122 | 245 | 366 | 1843 | 2209 | 5576 |
| November | 2888 | 192 | 269 | 1728 | 1997 | 5077 |
| December | 2644 | 180 | 241 | 1753 | 1994 | 4818 |
| Av. Yearly Weekday | 3309 | 229 | 305 | 1987 | 2292 | 5830 |

[a] Estimated

TABLE E
1954 24-HOUR WEEKDAY TRAFFIC COUNT

| Month | Light Vehicles | | Heavy Vehicles | | Total Heavy Vehicles | Total Vehicles |
|---|---|---|---|---|---|---|
| | Pass. Cars | Panels & Pickups | Single Unit Trucks | Combination Trucks | | |
| January | 2176 | 159 | 203 | 1794 | 1997 | 4332 |
| February | 2439 | 183 | 207 | 1844 | 2051 | 4673 |
| March | 2898 | 215 | 293 | 1873 | 2166 | 5279 |
| April[a] | 3307 | 217 | 272 | 1744 | 2016 | 5540 |
| May | 3715 | 219 | 251 | 1615 | 1866 | 5800 |
| June[a] | 4381 | 215 | 260 | 1577 | 1837 | 6433 |
| July | 5048 | 210 | 269 | 1538 | 1807 | 7065 |
| August | 4765 | 250 | 259 | 1485 | 1744 | 6759 |
| September[a] | 4139 | 234 | 262 | 1573 | 1835 | 6208 |
| October[a] | 3514 | 219 | 264 | 1661 | 1925 | 5658 |
| November | 2889 | 204 | 266 | 1748 | 2014 | 5107 |
| December | 2577 | 218 | 269 | 2107 | 2376 | 5171 |
| Av. Yearly Weekday | 3487 | 212 | 256 | 1713 | 1969 | 5668 |

[a] Estimated

TABLE F
TANDEM TRUCK AXLE FREQUENCY BY VARIOUS WEIGHT GROUPS FOR A 24-HOUR WEEKDAY

| Axle Weight Groups, Thousands of Pounds | Number of Tandem Axles, Listed Individually | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | | | | | | | | | | 1954 | | | | | |
| | Jan. | Apr. | May | June | July | Aug | Sept. | Oct | Nov | Dec. | Jan. | Feb | Mar. | May | July | Aug. |
| No Pay Load | 858 | 718 | 754 | 752 | 626 | 860 | 708 | 558 | 498 | 646 | 538 | 544 | 598 | 438 | 564 | 550 |
| Under 14 | 652 | 979 | 1095 | 936 | 1006 | 1049 | 981 | 724 | 921 | 985 | 1082 | 1120 | 1083 | 993 | 864 | 903 |
| 14 to 15 | 179 | 87 | 156 | 117 | 155 | 173 | 160 | 96 | 72 | 123 | 166 | 86 | 143 | 113 | 116 | 119 |
| 15 to 16 | 184 | 72 | 60 | 68 | 88 | 68 | 95 | 67 | 42 | 74 | 46 | 46 | 75 | 43 | 54 | 70 |
| 16 to 17 | 94 | 26 | 20 | 26 | 44 | 53 | 35 | 32 | 14 | 12 | 46 | 11 | 18 | 29 | 22 | 18 |
| 17 to 18 | 37 | 6 | 7 | 9 | 18 | 19 | 15 | 16 | 11 | - | - | 3 | 23 | 12 | 10 | 10 |
| 18 to 19 | 14 | - | - | 7 | 5 | 6 | 9 | 4 | 3 | 6 | - | 3 | 9 | 2 | 6 | 2 |
| 19 to 20 | 8 | - | - | 2 | - | 2 | 6 | 1 | 3 | 6 | - | - | 5 | - | 8 | 2 |
| 20 to 21 | - | - | - | 2 | - | - | 1 | - | - | - | - | 3 | - | - | - | 4 |
| 21 to 22 | - | - | - | - | - | - | 4 | - | - | - | - | - | - | - | - | 2 |
| 22 to 23 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 23 to 24 | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 24 & Over | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Total | 2026 | 1888 | 2092 | 1918 | 1942 | 2230 | 2014 | 1498 | 1564 | 1852 | 1878 | 1816 | 1954 | 1630 | 1644 | 1680 |

TABLE G
SINGLE TRUCK AXLE FREQUENCY BY VARIOUS WEIGHT GROUPS FOR A 24-HOUR WEEKDAY

| Axle Weight Groups Thousands of Pounds | Number of Single Axles | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | | | | | | | | | | 1954 | | | | | |
| | Jan. | Apr | May | June | July | Aug | Sept. | Oct. | Nov | Dec. | Jan | Feb | Mar. | May | July | Aug. |
| No Pay Load | 2815 | 2932 | 3240 | 2764 | 2454 | 3022 | 2633 | 2695 | 2262 | 1886 | 2304 | 2104 | 2171 | 1672 | 1986 | 1831 |
| Under 14 | 2855 | 2284 | 2465 | 2154 | 2014 | 2128 | 1899 | 2020 | 1994 | 2055 | 2132 | 2008 | 2173 | 1939 | 1545 | 1577 |
| 14 to 15 | 379 | 330 | 336 | 388 | 332 | 446 | 329 | 328 | 298 | 379 | 333 | 408 | 336 | 327 | 266 | 222 |
| 15 to 16 | 396 | 242 | 329 | 277 | 311 | 381 | 284 | 267 | 306 | 324 | 333 | 335 | 329 | 300 | 266 | 218 |
| 16 to 17 | 260 | 254 | 286 | 233 | 239 | 243 | 244 | 263 | 219 | 168 | 308 | 240 | 224 | 225 | 206 | 180 |
| 17 to 18 | 272 | 204 | 277 | 257 | 233 | 288 | 208 | 201 | 197 | 193 | 245 | 209 | 203 | 227 | 184 | 176 |
| 18 to 19 | 177 | 154 | 165 | 155 | 144 | 203 | 181 | 174 | 184 | 122 | 164 | 156 | 149 | 144 | 142 | 127 |
| 19 to 20 | 88 | 50 | 67 | 100 | 67 | 77 | 134 | 67 | 98 | 46 | 125 | 89 | 86 | 73 | 78 | 53 |
| 20 to 21 | 74 | 22 | 20 | 31 | 20 | 32 | 30 | 36 | 16 | 19 | 25 | 36 | 28 | 16 | 20 | 25 |
| 21 to 22 | 3 | 6 | - | 16 | 9 | 2 | 8 | 6 | 9 | - | 5 | 5 | 7 | 3 | 4 | - |
| 22 to 23 | 3 | - | 2 | 3 | 5 | 4 | 3 | 3 | 1 | - | - | - | 2 | 1 | 2 | - |
| 23 to 24 | - | - | - | - | - | - | 1 | - | - | - | 5 | - | - | - | - | - |
| 24 & Over | - | 3 | 2 | - | 2 | - | - | - | - | 6 | - | - | - | - | - | - |
| Total | 7322 | 6481 | 7189 | 6378 | 5830 | 6826 | 5954 | 6060 | 5584 | 5198 | 5979 | 5590 | 5708 | 4927 | 4699 | 4409 |

TABLE H
TOTAL TRUCK AXLE FREQUENCY BY VARIOUS WEIGHT GROUPS FOR A 24-HOUR WEEKDAY

| Axle Weight Groups Thousands of Pounds | Total Number of Axles | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1953 | | | | | | | | | | 1954 | | | | | |
| | Jan. | Apr | May | June | July | Aug. | Sept. | Oct. | Nov. | Dec. | Jan | Feb. | Mar | May | July | Aug. |
| No Pay Load | 3673 | 3650 | 3994 | 3516 | 3080 | 3882 | 3341 | 3253 | 2760 | 2532 | 2842 | 2648 | 2769 | 2110 | 2550 | 2381 |
| Under 14 | 3507 | 3263 | 3560 | 3090 | 3020 | 3177 | 2880 | 2744 | 2915 | 3040 | 3214 | 3128 | 3256 | 2932 | 2409 | 2480 |
| 14 to 15 | 558 | 417 | 492 | 505 | 487 | 619 | 489 | 424 | 370 | 502 | 499 | 494 | 479 | 440 | 382 | 341 |
| 15 to 16 | 580 | 314 | 389 | 344 | 399 | 449 | 379 | 334 | 348 | 398 | 379 | 381 | 404 | 343 | 320 | 288 |
| 16 to 17 | 354 | 280 | 306 | 259 | 283 | 296 | 279 | 295 | 233 | 180 | 354 | 251 | 242 | 254 | 228 | 198 |
| 17 to 18 | 309 | 210 | 284 | 266 | 251 | 307 | 223 | 217 | 208 | 193 | 245 | 212 | 226 | 239 | 194 | 186 |
| 18 to 19 | 191 | 154 | 165 | 162 | 149 | 209 | 190 | 178 | 187 | 128 | 164 | 159 | 158 | 146 | 148 | 129 |
| 19 to 20 | 96 | 50 | 67 | 102 | 67 | 79 | 140 | 68 | 101 | 52 | 125 | 89 | 91 | 73 | 86 | 55 |
| 20 to 21 | 74 | 22 | 20 | 33 | 20 | 32 | 31 | 36 | 16 | 19 | 25 | 39 | 28 | 16 | 20 | 29 |
| 21 to 22 | 3 | 6 | - | 16 | 9 | 2 | 12 | 6 | 9 | - | 5 | 5 | 7 | 3 | 4 | 2 |
| 22 to 23 | 3 | - | 2 | 3 | 5 | 4 | 3 | 3 | 1 | - | - | - | 2 | 1 | 2 | - |
| 23 to 24 | - | - | - | - | - | - | 1 | - | - | - | 5 | - | - | - | - | - |
| 24 & Over | - | 3 | 2 | - | 2 | - | - | - | - | 6 | - | - | - | - | - | - |
| Total | 9348 | 8369 | 9281 | 8296 | 7772 | 9056 | 7968 | 7558 | 7148 | 7050 | 7857 | 7406 | 7662 | 6557 | 6343 | 6089 |

TABLE I

EXPERIMENTAL SUBBASE PROJECT, FIELD SURVEYS TO DATE[a]

Summary of Pumping per 100 Foot of Uncurbed Length Itemized by Specific Subbase Type and Slab Length

| Type of Subbase | Number of Pumping Joints | | | | | | | | Number of Pumping Edges | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20-Foot Slabs | | | | 100-Foot Slabs | | | | 20-Foot Slabs | | | | 100-Foot Slabs | | | |
| | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. |
| 3 in. Open Textured | - | - | - | - | - | - | - | - | - | 0.1 | - | - | - | - | - | - |
| 5 in. Open Textured | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 in. Open Textured | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 3 in. Dense Graded | - | - | - | - | - | - | - | - | - | 0.9 | 0.4 | - | - | - | - | - |
| 5 in. Dense Graded | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| 8 in. Dense Graded | - | 0.1 | 0.2 | 0.1 | - | - | - | - | - | 0.4 | 0.1 | - | - | - | - | - |
| 3 in. Soil Cement | - | - | 0.9 | 1.0 | - | 0.6 | 1.1 | 0.8 | - | 1.4 | 2.7 | 0.2 | - | 1.1 | 0.8 | - |
| 5 in. Soil Cement | - | - | 0.7 | - | - | 0.2 | 0.4 | 0.2 | - | 1.0 | 2.5 | - | 0.1 | 0.4 | 0.4 | - |
| 6 in. Cement Modified 5% | - | 0.6 | 4.2 | 1.8 | - | 0.5 | 0.5 | 0.5 | 0.3 | 3.4 | 3.5 | 0.1 | - | 1.0 | 0.9 | 0.9 |
| 6 in. Cement Modified, 7% | - | 0.6 | 2.5 | 2.2 | - | - | 0.7 | 0.3 | 0.5 | 5.1 | 2.6 | 1.3 | - | 1.7 | 2.4 | 0.9 |
| 6 in. Cement Modified, 9% | 0.1 | 0.3 | 1.7 | 1.0 | - | - | 0.2 | 0.2 | 0.4 | 3.5 | 1.2 | 2.1 | - | 0.5 | 1.4 | 0.2 |
| 6 in. Cement Modified, 11% | - | 0.8 | 1.6 | 1.0 | - | 0.2 | 0.7 | 0.7 | 0.2 | 1.6 | 1.0 | 0.2 | - | 0.6 | 0.7 | - |
| No Subbase[b] | 0.7 | 1.3 | 7.0 | 4.7 | 0.1 | 0.1 | 0.7 | 0.2 | - | 1.7 | 3.4 | 1.0 | 0.1 | 0.9 | 1.4 | 0.1 |

Summary of Blowing per 100 Foot of Uncurbed Length Itemized by Specific Subbase Type and Slab Length

| Type of Subbase | Number of Blowholes | | | | | | | | Feet of Continuous Blowing | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20-Foot Slabs | | | | 100-Foot Slabs | | | | 20-Foot Slabs | | | | 100-Foot Slabs | | | |
| | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. |
| 3 in. Open Textured | 0.1 | 0.3 | 4.6 | 0.2 | - | - | 0.2 | - | - | - | - | - | - | - | - | - |
| 5 in. Open Textured | 0.2 | 1.7 | 2.4 | - | - | - | 2.2 | - | - | - | - | - | - | - | - | - |
| 8 in. Open Textured | 0.3 | 1.1 | 0.1 | - | - | - | 1.6 | - | - | - | - | - | - | - | - | - |
| 3 in. Dense Graded | - | 6.8 | 11.9 | 0.3 | - | 0.8 | 10.2 | 0.1 | - | 1.0 | - | - | - | 1.2 | - | - |
| 5 in. Dense Graded | 0.4 | 11.5 | 18.9 | - | - | - | 12.6 | 0.1 | - | 1.7 | - | - | - | - | - | - |
| 8 in. Dense Graded | 1.1 | 13.3 | 17.8 | - | - | 3.0 | 18.4 | - | - | 4.4 | 3.2 | - | - | - | - | - |
| 3 in. Soil Cement | 1.3 | 16.3 | 27.8 | 0.1 | 0.6 | 2.2 | 12.3 | 2.8 | - | 1.8 | - | - | - | 11.0 | 2.2 | - |
| 5 in. Soil Cement | 0.8 | 20.6 | 12.1 | - | 0.9 | 2.9 | 3.4 | 0.2 | - | 8.3 | 11.5 | - | - | 2.5 | 0.6 | - |
| 6 in. Cement Modified, 5% | 2.0 | 14.2 | 5.6 | 1.1 | 0.3 | 2.9 | 4.6 | 0.8 | - | 6.1 | 2.1 | - | - | 5.1 | 1.1 | - |
| 6 in. Cement Modified, 7% | 9.1 | 10.0 | 12.8 | 2.1 | 1.5 | 9.8 | 2.1 | 1.9 | 1.1 | 17.0 | 19.9 | - | - | 1.3 | 2.5 | - |
| 6 in. Cement Modified, 9% | 10.9 | 22.6 | 25.4 | 1.8 | 0.6 | 14.2 | 0.9 | 1.0 | 0.3 | 24.9 | 8.4 | - | - | 1.2 | 0.8 | - |
| 6 in. Cement Modified, 11% | 2.8 | 13.2 | 13.0 | - | 4.1 | 9.6 | 8.0 | 0.8 | - | - | 5.0 | - | - | 6.7 | 1.0 | - |
| No Subbase[b] | 4.4 | 19.5 | 3.4 | - | 0.1 | 1.7 | 1.6 | - | - | - | 8.7 | - | - | - | 1.3 | - |

[a] 1st., 2nd., 3rd. and 4th. refer to the field surveys of March 26, 1953, May 14, 1953, March 15, 1954 and December 10, 1954 respectively.

[b] All of the no-subbase sections were subsealed with bituminous material on April 21, 1954.

Note: On August 20 and 23, 1954, a feathered granular shoulder, about 3 inches thick at the pavement's edge and about 3 feet wide, was placed the full length of the project to correct the low shoulder condition.

TABLE J

EXPERIMENTAL SUBBASE PROJECT, FIELD SURVEYS TO DATE[a]

Summary of Pumping per 100 Foot of Uncurbed Length Itemized by General Subbase Type and Slab Length

| Type of Subbase | Number of Pumping Joints | | | | | | | | Number of Pumping Edges | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20-Foot Slabs | | | | 100-Foot Slabs | | | | 20-Foot Slabs | | | | 100-Foot Slabs | | | |
| | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. |
| Open Textured | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - | - |
| Dense Graded | - | - | 0.1 | - | - | - | - | - | - | 0.4 | 0.2 | - | - | - | - | - |
| Soil Cement | - | - | 0.8 | 0.5 | - | 0.4 | 0.7 | 0.5 | - | 2.7 | 2.6 | 0.1 | - | 0.7 | 0.6 | - |
| Cement Modified | - | 0.6 | 2.5 | 1.5 | - | 0.2 | 0.5 | 0.4 | 0.4 | 3.4 | 2.1 | 0.9 | - | 0.9 | 1.3 | 0.5 |
| No Subbase[b] | 0.7 | 1.3 | 7.0 | 4.7 | 0.1 | 0.1 | 0.7 | 0.2 | - | 1.7 | 3.4 | 1.0 | 0.1 | 0.9 | 1.4 | 0.1 |

Summary of Blowing per 100 Foot of Uncurved Length Itemized by General Subbase Type and Slab Length

| Type of Subbase | Number of Blowholes | | | | | | | | Feet of Continuous Blowing | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 20-Foot Slabs | | | | 100-Foot Slabs | | | | 20-Foot Slabs | | | | 100-Foot Slabs | | | |
| | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. |
| Open Textured | 0.2 | 1.0 | 2.4 | 0.1 | - | - | 1.3 | - | - | - | - | - | - | - | - | - |
| Dense Graded | 0.5 | 10.5 | 16.4 | 0.1 | - | 1.3 | 13.7 | 0.1 | - | 2.4 | 1.1 | - | - | 0.4 | - | - |
| Soil Cement | 1.2 | 18.5 | 20.0 | 0.1 | 0.7 | 2.6 | 7.8 | 1.5 | - | 5.0 | 5.8 | - | - | 6.7 | 1.4 | - |
| Cement Modified | 6.2 | 15.0 | 14.2 | 1.2 | 1.6 | 9.0 | 3.9 | 1.1 | 0.3 | 12.0 | 8.9 | - | - | 3.6 | 1.3 | - |
| No Subbase[b] | 4.4 | 19.5 | 3.4 | - | 0.1 | 1.7 | 1.6 | - | - | - | 8.7 | - | - | - | 1.3 | - |

Summary of Pumping and Blowing per 100 Feet of Uncurbed Length Itemized by General Subbase Type

| Type of Subbase | Pumping | | | | | | | | Blowing | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Number of Joints | | | | Number of Edges | | | | Number of Blowholes | | | | Feet of Continuous | | | |
| | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. | 1st. | 2nd. | 3rd. | 4th. |
| Open Textured | - | - | - | - | - | - | - | - | 0.1 | 0.5 | 1.8 | - | - | - | - | - |
| Dense Graded | - | - | - | - | - | 0.2 | 0.1 | - | 0.3 | 6.9 | 14.9 | 0.1 | - | 1.4 | 0.6 | - |
| Soil Cement | - | 0.2 | 0.7 | 0.5 | - | 1.7 | 1.6 | 0.1 | 0.9 | 10.5 | 13.9 | 0.5 | - | 5.9 | 3.6 | - |
| Cement Modified | - | 0.4 | 1.5 | 1.3 | 0.2 | 2.2 | 1.7 | 1.0 | 3.9 | 12.0 | 9.1 | 1.6 | 0.1 | 7.8 | 5.1 | - |
| No Subbase[b] | 0.4 | 0.7 | 3.9 | 2.5 | 0.1 | 1.3 | 2.4 | 0.5 | 2.2 | 10.6 | 2.5 | - | - | - | 5.0 | - |

[a] 1st., 2nd., 3rd. and 4th. refer to the field surveys of March 26, 1953, May 14, 1953, March 15, 1954 and December 10, 1954 respectively.

[b] All of the no-subbase sections were subsealed with bituminous material on April 21, 1954.

Note: On August 20 and 23, 1954, a feathered granular shoulder, about 3 inches thick at the pavement's edge and about 3 feet wide, was placed the full length of the project to correct the low shoulder condition.

## *Some H R B Publications Relating to Concrete and Maintenance*

Bulletin 21: MAINTENANCE COSTS (1949) 14 p. $.15

Progress Report of the Project Committee on Maintenance Costs, J. S. Bright, Chairman; Cost of Mechanical Loaders in Ditch Cleaning as Compared with Costs of Hand Operations in Virginia, J. J. Forrer; Economics of Resurfacing Disintegrated Pavements, C. Owen Beclkey.

Bulletin 29: MAINTENANCE COSTS (1950) 20 p. $.45

Progress Report of the Project Committee on Maintenance Costs, H. A. Radzikowski, Chairman; County Road Maintenance and Operation Costs, Roger H. Willard.

Bulletin 47: SALVAGING OLD PAVEMENTS BY RESURFACING (1952) 35 p. $.60

Bulletin 70: AIR-ENTRAINED CONCRETE: Properties of Air Voids and Service Record of Pavements (1953) 23 p. $.60

Determination of Properties of Air Voids in Concrete, Curtis Warren; Record of Experimental Air-Entrained Concrete 10 to 14 Years After Construction, L. E. Andrews; Discussion, William Lerch.

Bulletin 75: EFFECT IN CONCRETE OF PELLET AND FLAKE FORMS OF CALCIUM CHLORIDE (1953) 18 p. $.30

Bulletin 87: CONCRETE RESURFACING OF CONCRETE PAVEMENT IN VARIOUS STAGES OF DETERIORATION (1954) 39 p. $.60

Bulletin 116: EXPERIMENTAL CONCRETE PAVEMENTS (1955) 71 p. $1.35

Report on Pavement Research Project in Indiana, Walter T. Spencer, Harold Allen and Preston C. Smith; Report on Pavement Research Project in Ohio, Charles W. Allen and L. D. Childs, Appendix.

Bibliography 7: PRESTRESSING AND PRECASTING REINFORCED CONCRETE FOR USE IN HIGHWAY BRIDGES AND STRUCTURES (1949) 110 p. $.75

Bibliography 8: DURABILITY OF CONCRETE PHYSICAL REACTIONS (1951) 35 p. $.60

Bibliography 13: CALCIUM CHLORIDE IN CONCRETE Annotated (1952) 57 p. $.60

Special Report 4: ROAD TEST ONE-MD (1952) 169 p. $ 2.25

Introduction, General Summary of Project, Traffic Test Procedures and Results, Analysis of Soil Data, Analysis of Structural Effect of Heavy-Vehicle Loads, Appendix: Basic Data

Special Report 8: CONNECTICUT HIGHWAY MAINTENANCE PRODUCTION STUDY (1952) 220 p. $2.70

Special Report 14: STRUCTURAL EFFECTS OF HEAVY-DUTY TRAILER ON CONCRETE PAVEMENT: A Supplemental Investigation to Road Test One-MD (1953) 32 p. $.60

Current Road Problems 1-R: CURING OF CONCRETE PAVEMENTS (1952) 19 p. $.30

Current Road Problems 3: DESIGN OF CONCRETE PAVEMENTS REQUIRING A MINIMUM OF STEEL (1942) 13 p. $.15

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Current Road Problems 6: PATCHING CONCRETE PAVEMENTS WITH CONCRETE (1943) 16 p. $.15

Current Road Problems 13-R: USE OF AIR-ENTRAINED CONCRETE IN PAVEMENTS AND BRIDGES (1950) 74 p. $.45