REPORT ON LIMESTONE DUST AS A FILLER FOR ASPHALT PAVEMENTS

THESIS FOR THE DEGREE OF B. S.

K. M. Knudson

1930

Pavements, Asphalt
Roads

Civil engineering - Railroads + roads

REPORT

ON

LIMESTONE DUST AS A FILLER FOR ASPHALT PAVEMENTS

A Thesis Submitted to

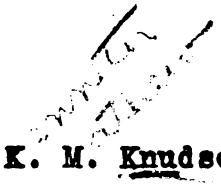
The Faculty of

MICHIGAN STATE COLLEGE

OF

AGRICULTURE AND APPLIED SCIENCE

By



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Candidate for the Degree of

Bachelor of Science

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The work was carried out under the direct supervision of Mr. E. A. Finney, to whom I especially desire to express appreciation for his many efforts and helpful suggestions.

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HISTORY OF ASPHALT AND ASPHALTIC PAVEMENTS

The earliest recorded use of asphalt by the human race was by the pre-Babylonians, known as the Sumerians, who inhabited the Euphrates Valley about 3000-2500 B.C.; by the Persians, about 2800-2500 B.C.; the early Egyptians, about 2500 B.C., and by the Babylonians about 700-500 B.C.

Asphalt was discovered in Cuba in 1535, however to Sir Walter Raleigh goes the credit for the discovery of the so-called "Pitch Lake" at Trinidad, on the north coast of South America, situated a short distance from the mainland of Venezuela, between the Caribbean Sea on the west and the Atlantic Ocean on the east. This deposit is one of the largest in the world. "Trinidad Asphalt Lake", as the main deposit is known, is situated on La Brea Point, in the Wards of La Brea and Guapo, on the western shore. The lake, which is one hundred thirty-eight feet above sea level, is located on the highest part of La Brea Point. In shape it is nearly circular, comprising approximately one hundred fifteen acres, situated in a slight depression at the crest of the hill. An interesting fact in connection with this lake is that it is in an old volcano crater, which possibly accounts for its existence as well as immense size. On the surface of the lake small trees and shrubs grow in isolated groups. These are known as islands, and slowly migrate

from place to place with the movement of the asphalt. This movement is the result of one, or a combination of one or more, or possibly by all five causes listed below:

1 - Effect of Heat

2 - Hydrostatic Pressure

(a) Largely responsible for pool and reservoir accumulations

3 - Capillarity

(a) Takes place in dry porous rocks

4 - Gas Pressure

(a) Forces liquid and volitle matter upward

5 - Gravitation

(a) Responsible for "seepages".

Bitumens and pyrobitumens, with few exceptions, are found in sedimentary deposits of sand, sandstone, limestone and sometimes in shale and clay. Also rare occurrences have been reported in igneous rock, but in every case of this kind, the quantities have been practically insignificant.

Bitumens and pyrobitumens are found in nature in the following ways:

1 - Overflows

(a) Seepages

(b) Lakes

(c) Springs

2 - Impregnated Rocks

(a) Subterranean pools

(b) Horizontal rock strata

(c) Vertical rock strata

3 - Filling Veins

(a) Vertical Cleavage

(b) Upturning

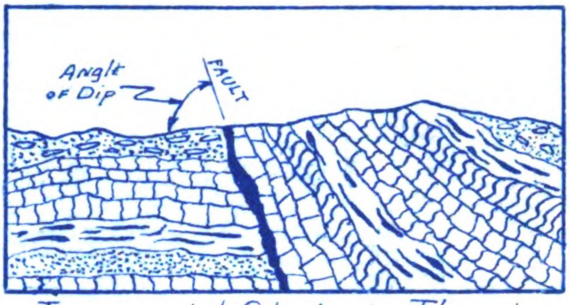
(c) Sliding

(d) Sedimentation.

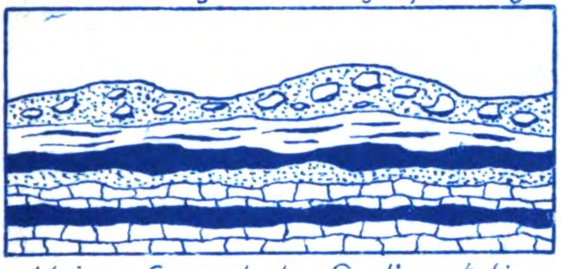
An intelligent understanding of the various modes of occurrence may be obtained from a careful study of the accompanying diagrams.

The first sheet asphalt pavement of Trinidad Asphalt to be laid in the United States, was on Pennsylvania Avenue, Washington, D.C. - per Richardson - in 1876. Since that date, the use of asphalt as a paving medium has tremendously increased. Like any other industry, this amaxing progress, if I may so designate it, has brought forth problems of minute importance. Rapidly increasing traffic, both in numbers and tonnage, present more and more problems to the asphalt technologist. He is called upon to meet these problems, which are presenting themselves too rapidly to be immediately coped with. Strange as it may seem, the asphalt industry is only in its infancy, despite the fact that it was used better than a half century ago.

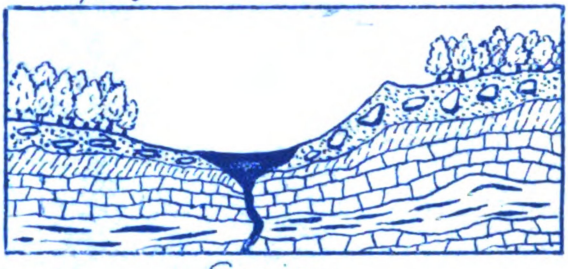
Fault Filling caused by Upturning



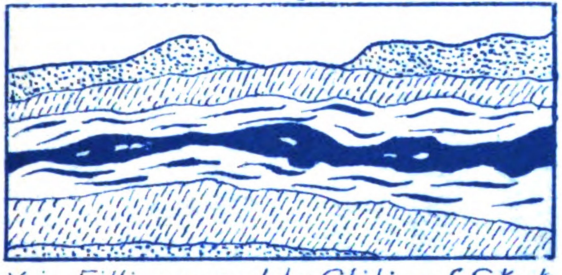
Impregnated Strata in Thrust



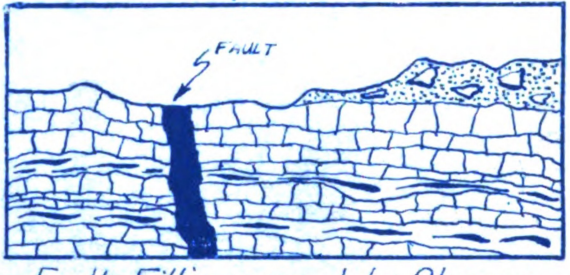
Veins formed by Sedimentation



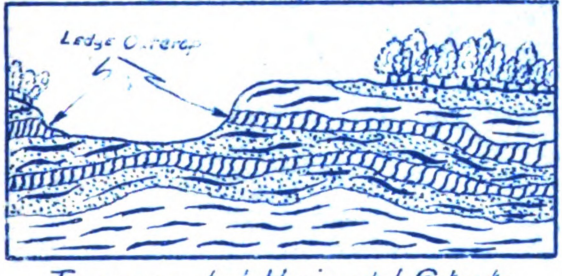
Spring



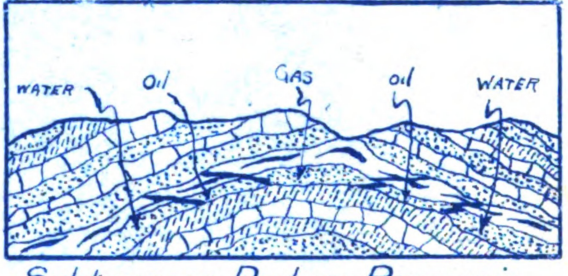
Vein Filling caused by Sliding of Strata



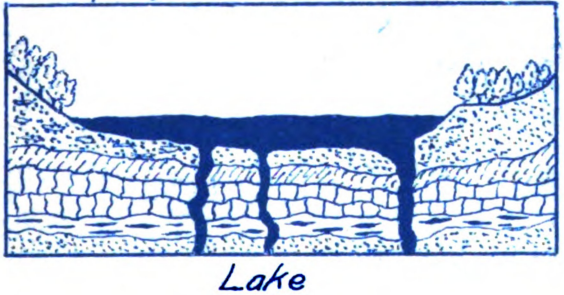
Fault Filling caused by Cleavage



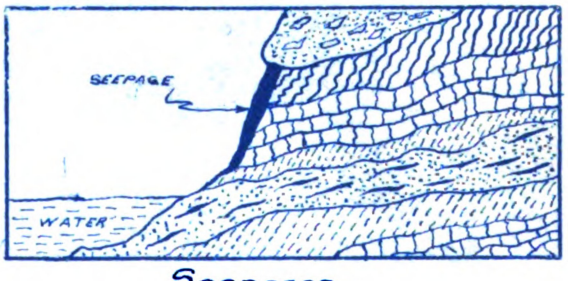
Impregnated Horizontal Strata



Subteranean Pool or Reservoir



Lake



Seepages

Designed and built expressly for this test.

GENERAL DISCUSSION

With the advent of the automobile, it became necessary to design pavements to withstand the resulting increase in displacement action. It also became necessary not only to construct durable pavements, but also to resurface, or top cover, many miles of roads, which could not be wholly reconstructed because of remote location or finances. To withstand this enormous traffic increase it was necessary to delve with increased vigor into the many ever existing and increasing problems. At the present time remarkable progress has been made. General principles can be laid down, but not stringent rules, as mixtures must be designed to fit the materials. The engineer on any job must know the limits within which he can vary materials.

Failures, as in any work, are always greatly exaggerated. These are not wholly due to any fault of the mixture or any phase thereof, but can, and are, often times traced back to faulty foundations, poor subgrade drainage and others of a purely extraneous nature.

Modern traffic defects may be either of a surface displacement nature, or cracking. Men versed in this particular phase are almost unanimous in the statement that 95% of cracking, in asphalt pavements, is merely a surface reproduction of cracking in the base or subgrade.

There are two well defined classes of distortion as regards traffic. One a forward displacement which is due to heavy, slow-moving traffic; the other, lateral displacement, due to swiftly moving traffic, such as is common to the boulevard type of paving. Another type of distortion, while not due to any inherent defect of the mixture, is rutting. This undesirable condition may be noted near the curb on asphalt streets which are subjected to constant parking of motor vehicles. This is due to gasoline and oil drippings entirely. One method for eliminating this feature is to place a concrete or brick strip next to the curb on portions of the street where this condition may result. It is a well known fact that asphalt is not at its best under the above conditions.

The most prevalent and also most objectionable defect that modern traffic has created, during recent years, is mixture displacement. An excess of bitumen in the mix is one of the principal reasons. Density is of primary importance also. High density, when coupled with just enough bitumen content to just sufficiently coat the particles without any excess, does more to insure freedom from displacement than any other one thing. High density is obtained by careful grading of the aggregate and by the use of an asphalt cement with the lowest possible penetration without danger of cracking. Within certain limits, the heavier and denser the traffic, the lower the

permissible penetration. Care must be taken not to leave mechanical defects which might act as a starting point for displacement.

BRIEF ON VOLUME-WEIGHT

Construction

Where extensive use of asphaltic mixtures is made, for example in paving work, attention to volume-weight may prove an important, as well as financial, consideration. Therefore, at least some attention to this phase should be made. This is most clearly illustrated by the following facts and example.

Suppose, for instance, filler #1 is being used on this particular job. (General trend at asphalt plants is to mix by weight as a matter of convenience.) For some reason a change in fillers is made and filler #2, now in use, has a smaller percentage of weight per unit volume. As a direct result of this, the following things may happen.

1. Lower density of the finished product.
2. Resulting increase in volume of aggregate giving new mix a dry appearance.
3. Checking, etc., during construction, if new mix is deficient in bitumen.
4. Increased volume of material in mixer box.
5. Increased yardage of pavement of a given thickness, or may result in laying extra depth of pavement without being aware of the fact, or giving impression of under-run of bitumen (as an under-run in concrete work).

Yield

In the matter of yield we again find volume-weight to be an important factor. For clarification, I cite the following example: one filler may yield a weight of mixture of 100 pounds per square yard, another, a mixture of 50 pounds per square yard. It is quite obvious, both fillers being comparable in other respects, that the 50 pound per square yard mixture is the logical mix to use. Fantastic as this may seem to one unacquainted with this subject, logical reasoning will show it to be exactly the reverse.

REPORT ON LIMESTONE DUST AS FILLER FOR ASPHALT PAVEMENTS

Introduction

Asphalt pavements are naturally divided into two distinct groups: the penetration type, in which the asphalt filler is applied externally and penetrates the structure by gravity; and the premixed type, in which aggregates and binder are together in given proportions before they are applied. There are numerous variations of these two fundamental types of asphalt pavement. Modification as to composition enables both types to be used as foundation and wearing surface, and both may be constructed with or without the aid of heat. This report concerns only asphaltic mixtures of the premixed type, no consideration being given to the penetration type.

The purpose of this investigation has been to determine, by laboratory tests, the relative stablizing and water proofing values of limestone fillers as used in asphalt paving mixtures.

Asphalt

In all tests an asphalt having properties as listed below, was used. This is the same as used by the City of Lansing.

Name of material - Asphalt cement

Source of material - City of Lansing

Sampled from - Storehouse

Used on - Streets of Lansing, Michigan

Received at Lab. - May, 1929.

Sp. gravity	1.050
Flash point °F	540
Fire point °F	590
Penetration, 100 gram weight for 5 sec. at 77°F	49.5
Bitumen soluble in CS_2 - %	99.85
Heated to 630°F	no foaming

Sand

The sand used in these tests is one which is used by the City of Lansing, Michigan, for asphalt pavement construction. Only that portion of the sand, passing a 10 mesh sieve and retained on 200 mesh sieve, was used, as specified by Lansing City engineer. Analysis as shown below: (500 g. sample)

SIEVE ANALYSIS

Retained on.	Weight (grams)	Percentage
10	53.5	10.69
16	10.8	2.16
20	13.6	2.72
30	15.1	3.02
40	46.4	9.28
50	56.5	11.30
80	174.1	34.80
100	48.5	9.62
200	59.3	11.97
pan	22.2	4.44
	500.0	100.00

Filler

The fillers used in this test were furnished through the courtesy of the Black-White Lime Company, Quincy, Illinois. Physical properties of the fillers as given below: (Each 100 g. sample)

LIMESTONE DUST #1

Retained on	Weight (grams)	Percentage
40	0.40	0.40
50	1.95	1.95
80	13.00	13.00
100	9.55	9.55
200	28.25	28.25
pan	46.85	46.85
	100.00	100.00

LIMESTONE DUST #2

Retained on	Weight (grams)	Percentage
50	0	0
80	1.30	1.3
100	2.00	2.0
200	13.00	13.0
pan	83.70	83.7
	100.00	100.00

Method of Mixing

All test specimens were mixed in the following manner: Dry sand and filler were weighed out to 0.1 grams. This

was then heated to 350°F, and thoroughly mixed. The asphalt is then weighed in to 0.1 gram and contents mixed for approximately 2-3 minutes or until thorough incorporation of the asphalt is insured, using a flat knife as a mixer and finishing the mixing with an ironing pressure between the flat blade of the knife and side of dish, to iron out all lumps. Then approximately 150 grams of mixture is placed in heated mold, tamped, compressed with a pressure of 5,000 pounds per square inch, pressure being immediately released. The cylinder is then forced out of the mold, placed in an upright position and allowed to cool over night.

Each cylinder was mixed separately, merely as a means of possibly obtaining greater precision in results.

Mixtures Tested

In this test the percentage of asphalt was varied from 9% to 13% inclusive. The filler was in percentages of 10-12-14-16-18, thus giving 75 different mixes for each filler tested. Sand as heretofore mentioned.

Method of Shear Test

Each specimen is tested by placing it, original top end down, in the testing mold and inserting the plunger. Pressure is applied fairly rapidly. As the test mixture is loaded, it distorts at the orifice in the testing ring. The pointer will rise quite rapidly to a maximum just

before the bond is broken. Continuation of pressure results in the load fluctuating below the maximum as flow of the mixture progresses. The maximum load registered by the pointer is recorded as the stability value of the specimen. After testing, the mold is cleaned before progressing to the next specimen.

All testing was done in a water bath at 135°F to 140°F, generally regarded as the most severe temperatures to which an asphalt pavement will be submitted.

WATER ABSORPTION TEST

Discussion

Absorption is primarily a function of degree of compression, i.e., relative denseness. Mixtures with low mixture-voids will show low absorption. As asphalt is defined as "a mixture of bitumens mutually dissolved", these bitumens being in a fluid state at ordinary temperatures and are almost totally immiscible with water. Upon this the water repellent properties of asphalt depend.

Another factor is polymerization. By this is meant the combination or fraternization of tow or more molecules of a substance, resulting in a change of properties, which is usually quite marked.

There is a very definite minimum film thickness below which one cannot go without destroying the water-resistant qualities of the pavement. This film thickness obtained with any bitumen content depends entirely on the area that bitumen has to cover, and the film thickness determines the weather resistant qualities of the pavement.

Method

The cylindrical briquettes were totally immersed in the water bath, which in this test was held at 75°F, for 24 hours. The weight of the briquette is taken before immersion and then after the 24 hour period. The percentage of water absorption for this period is then determined

by the formula, $P = \frac{B - A}{A} \times 100$, where:

A = initial weight of briquette

B = weight after immersion period

P = percentage absorbed.

GENERAL CONCLUSIONS

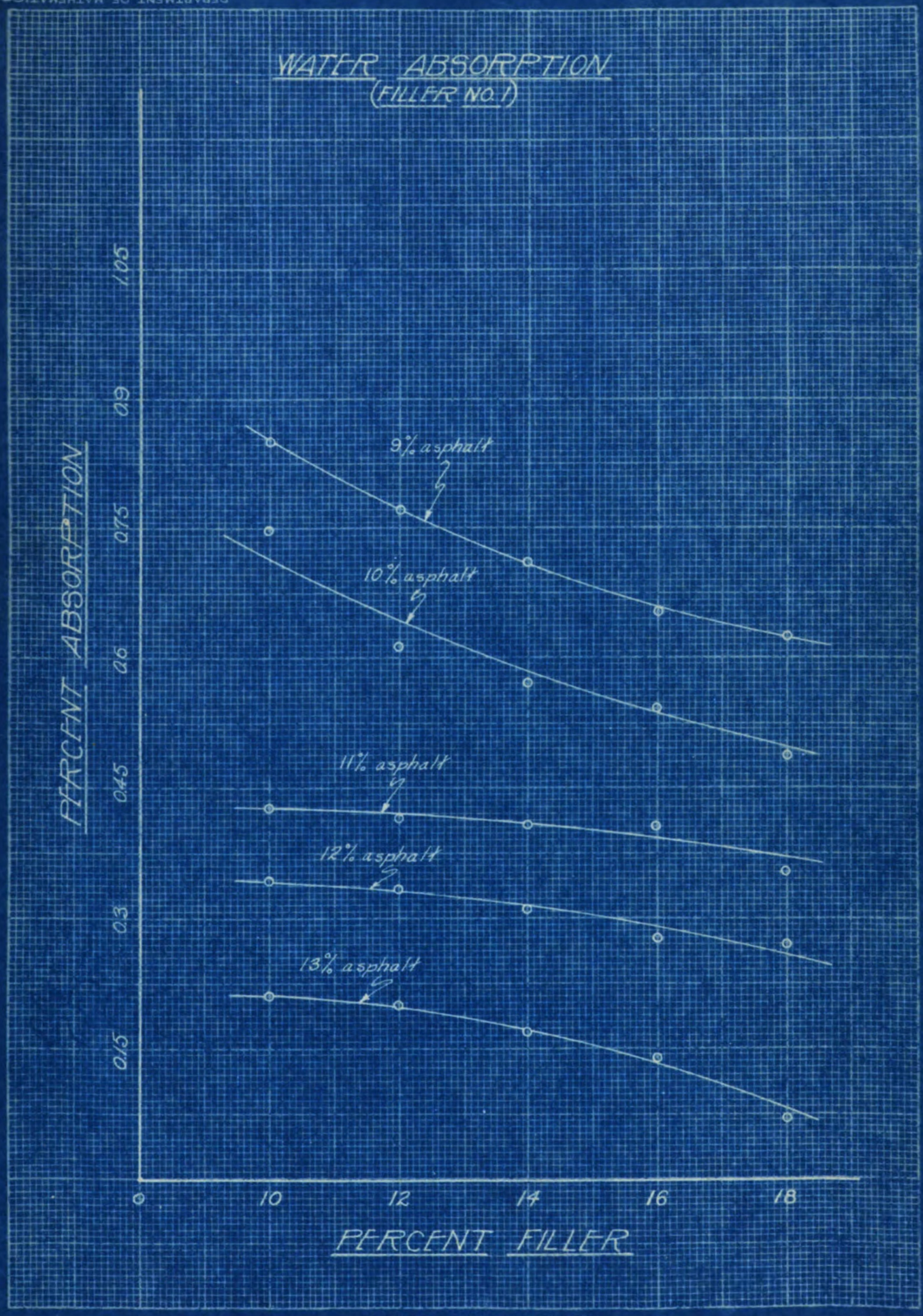
The tests show filler number two to be the most desirable, both from a standpoint of absorption and stability. A mix of 10-16-74 produces most desirable results being high in stability while low in absorption. This mix is workable and easily compressible.

These results were to be expected as filler number two contains about 86% of material passing the 200 mesh sieve, which is the grade used most extensively in highway work. This percentage of fine material gives good density, stability and absorption properties to the mix.

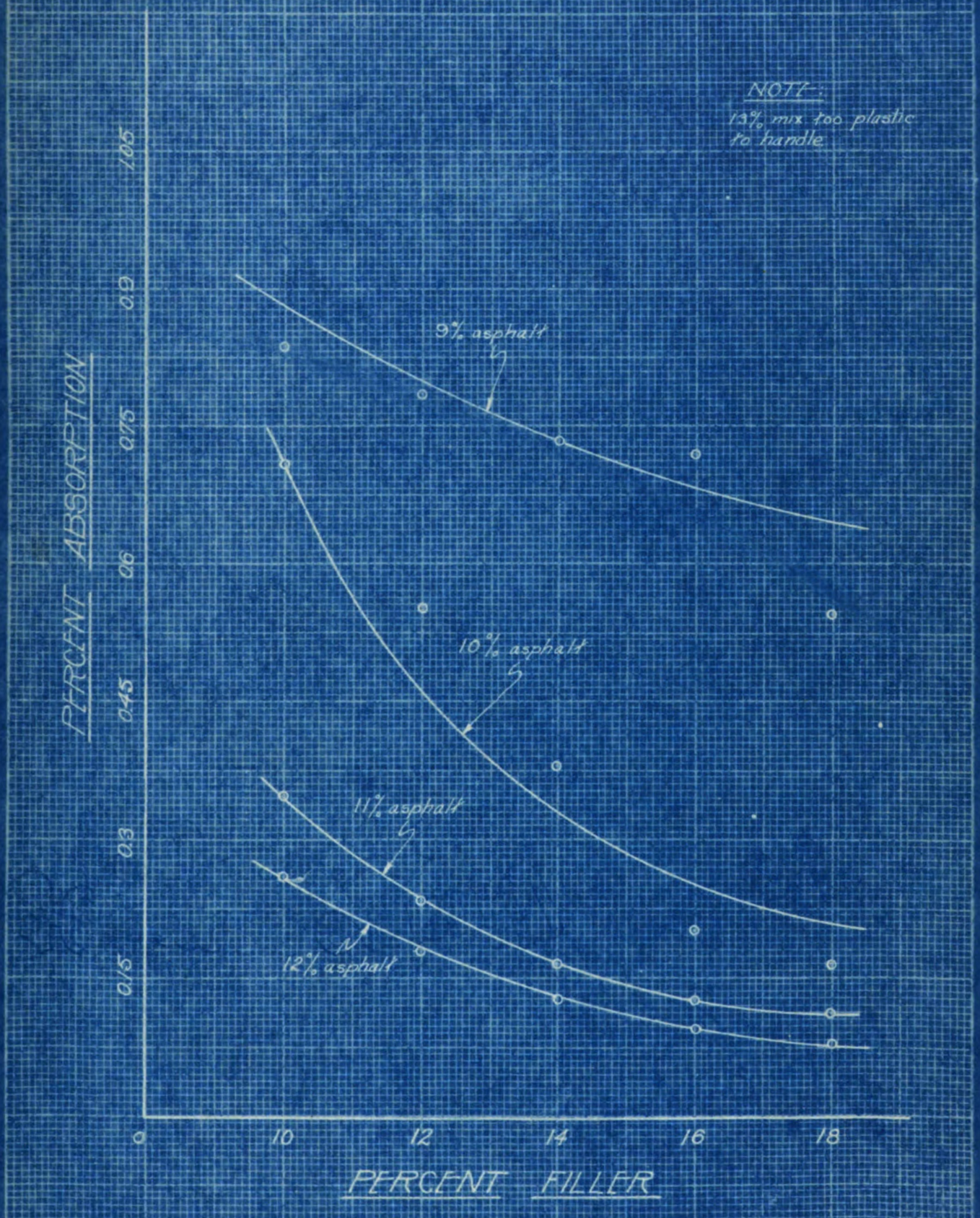
The main reason for these tests was to determine the suitability of these certain fillers when used in conjunction with the specified sand, as at present Silica Dust is being used as a filler.

DATA

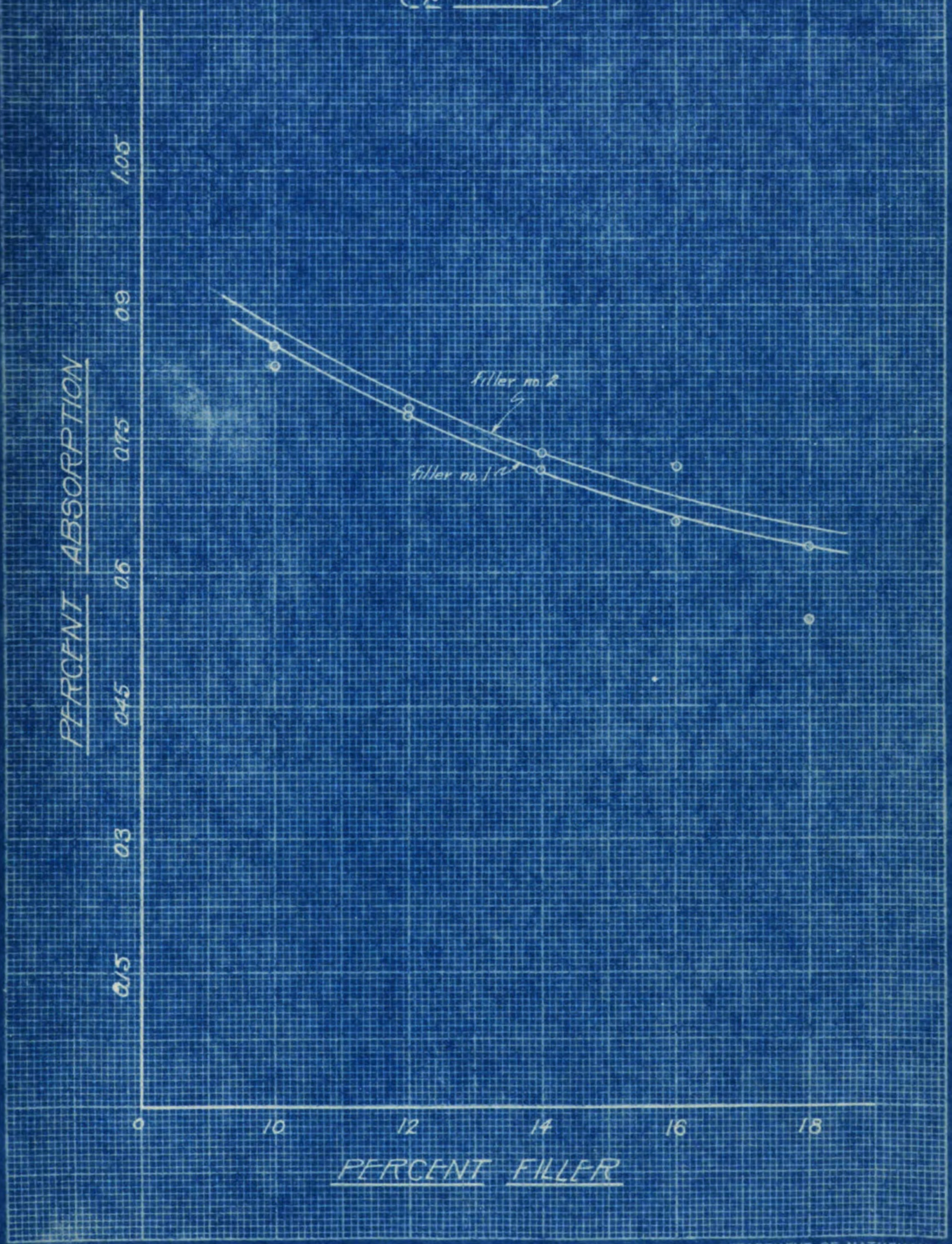
Mix	Absorption (percent)		Stability	
	Filler #1	Filler #2	Filler #1	Filler #2
9-10-81	0.85	0.83	4460	2630
9-12-79	0.77	0.79	4680	3060
9-14-77	0.71	0.74	4130	3390
9-16-76	0.67	0.73	4020	3360
9-18-77	0.62	0.53	3920	3350
10-10-80	0.75	0.72	3510	2970
10-12-78	0.61	0.58	3680	3490
10-14-76	0.57	0.42	3690	3580
10-16-74	0.55	0.20	3640	4057
10-18-74	0.48	0.16	3560	3880
11-10-79	0.43	0.35	3230	2610
11-12-77	0.42	0.23	3070	3000
11-14-75	0.41	0.16	2940	3040
11-16-73	0.41	0.13	2810	3020
11-18-71	0.35	0.097	2670	2450
12-10-78	0.34	0.26	2810	2190
12-12-76	0.33	0.18	2840	2430
12-14-74	0.31	0.13	2850	2130
12-16-72	0.28	0.095	2660	2040
12-18-70	0.27	0.071	2550	1650
13-10-77	0.21	-	1640	-
13-12-75	0.20	-	2290	-
13-14-73	0.17	-	2320	-
13-16-71	0.14	-	1970	-
13-18-69	0.07	-	1230	-



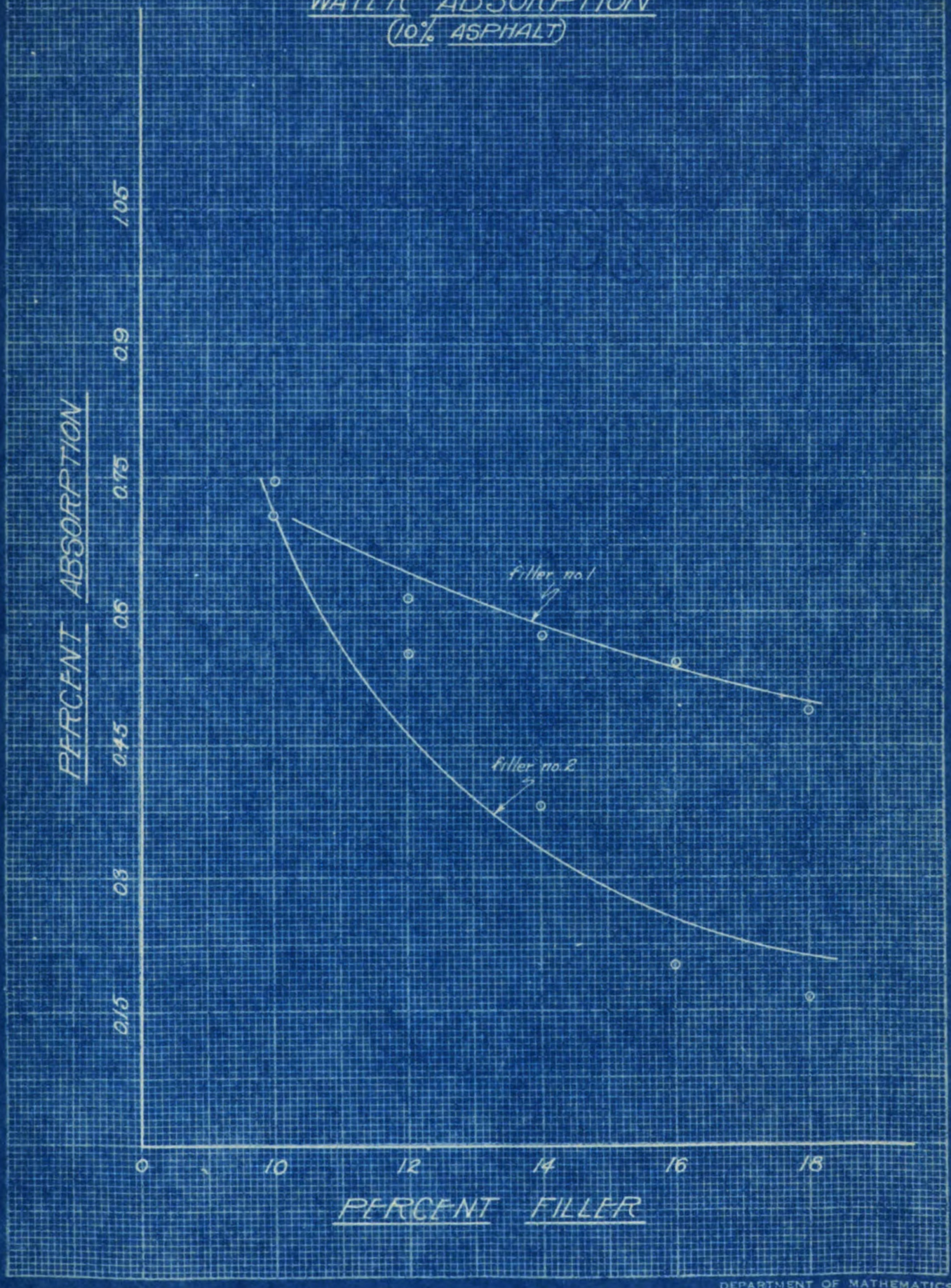
WATER ABSORPTION
(FILLER No 2)



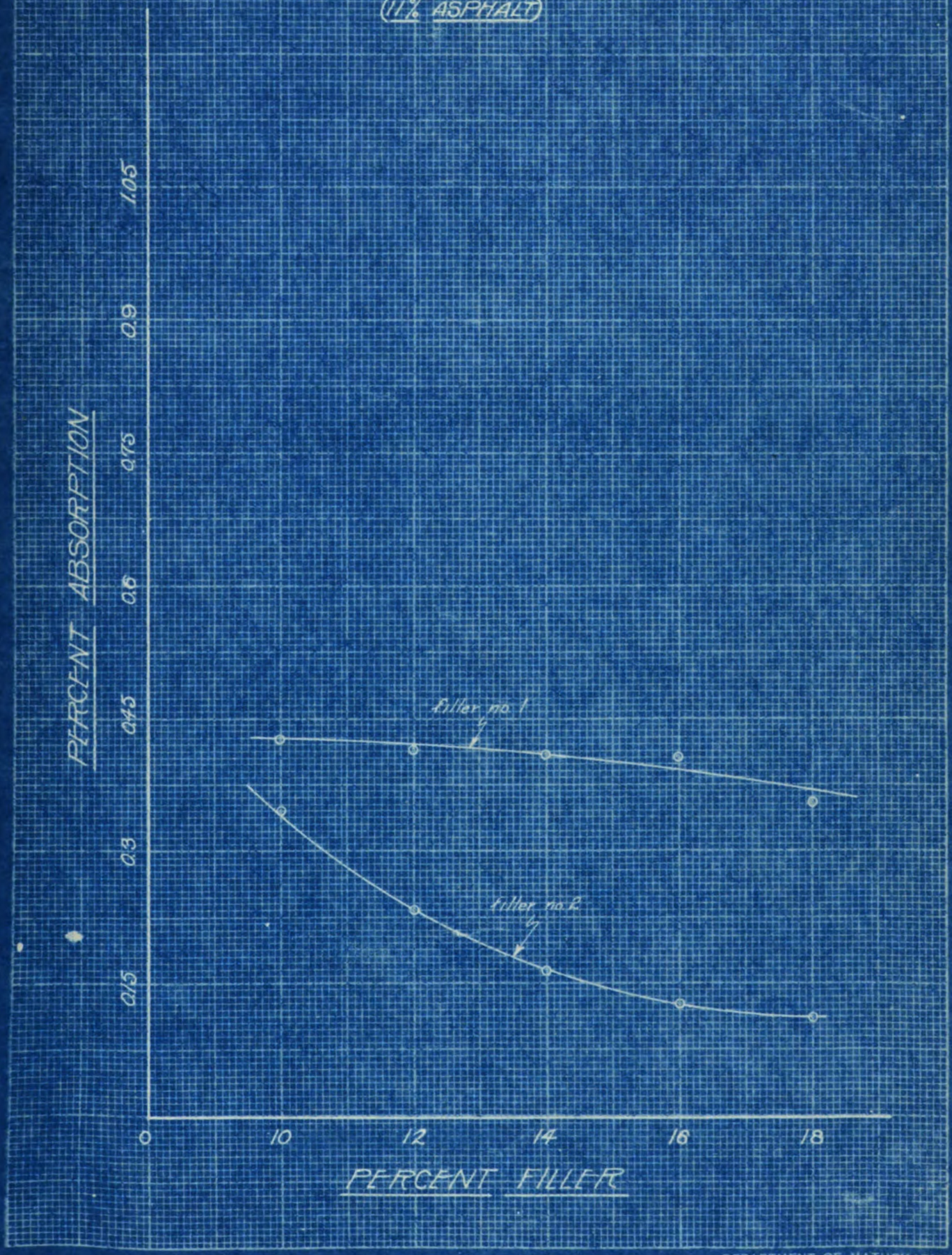
WATER ABSORPTION
(9% ASPHALT)

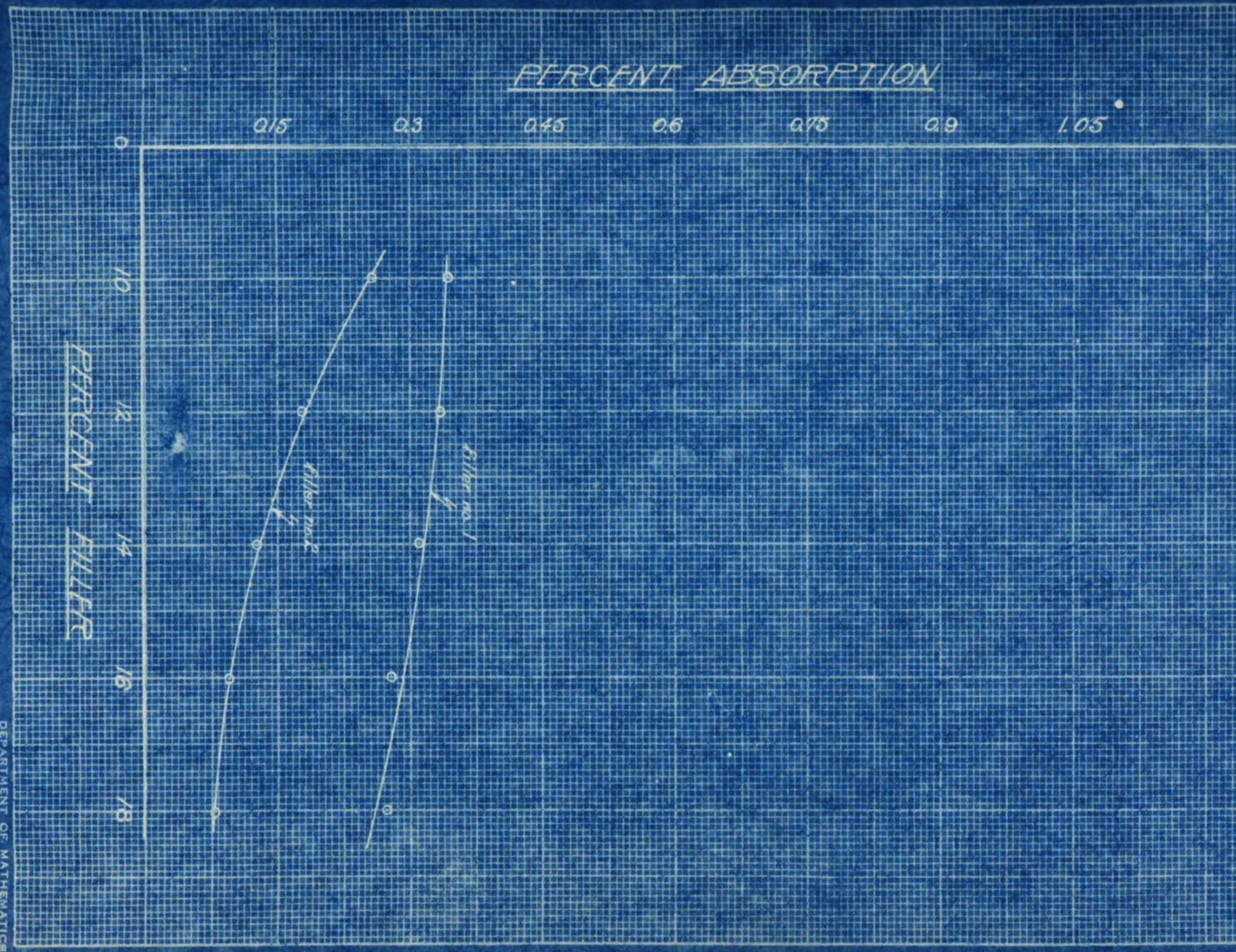


WATER ABSORPTION
(10% ASPHALT)

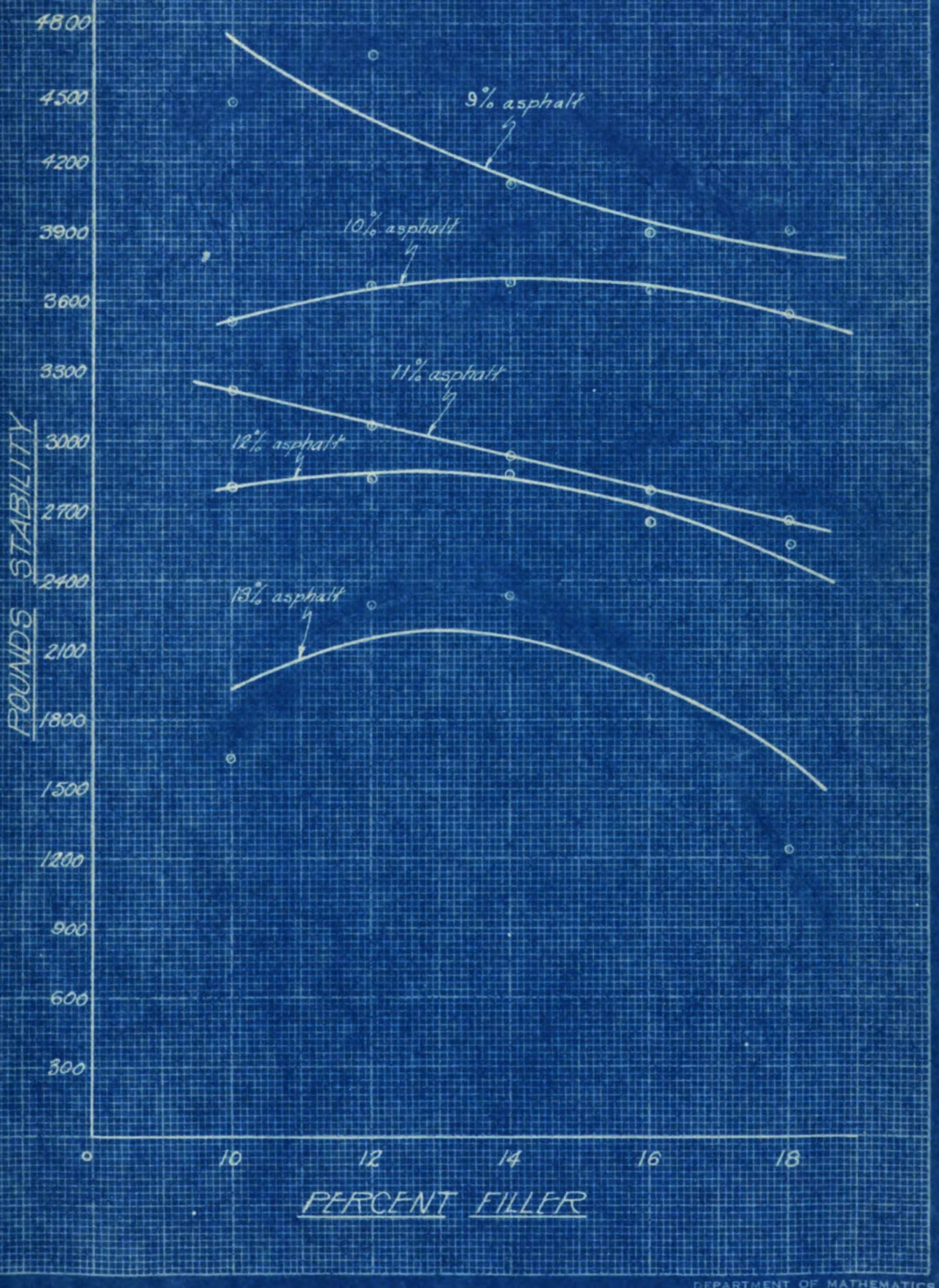


WATER ABSORPTION
(11% ASPHALT)





STABILITY TEST
(FILLER NO. 1)



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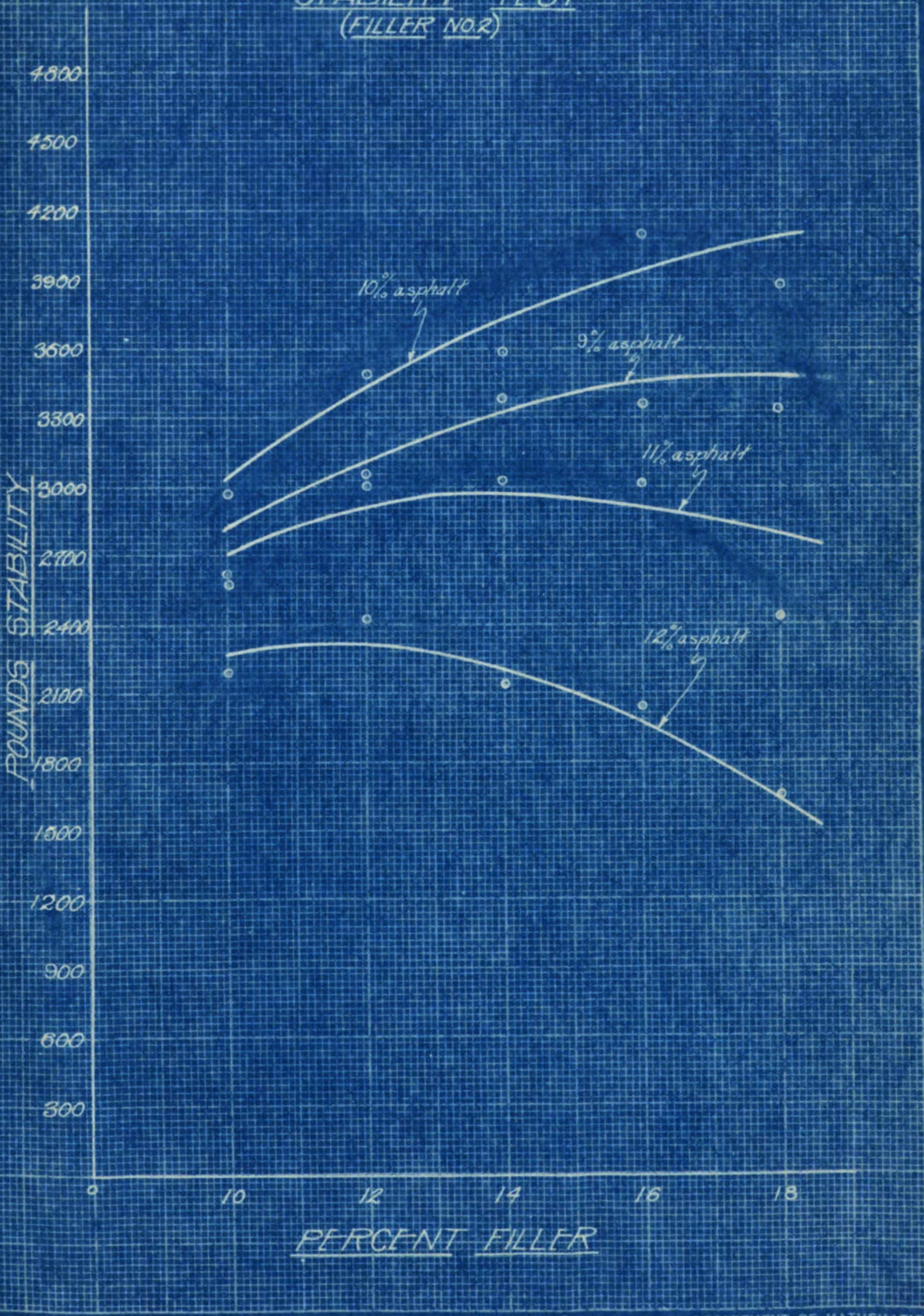
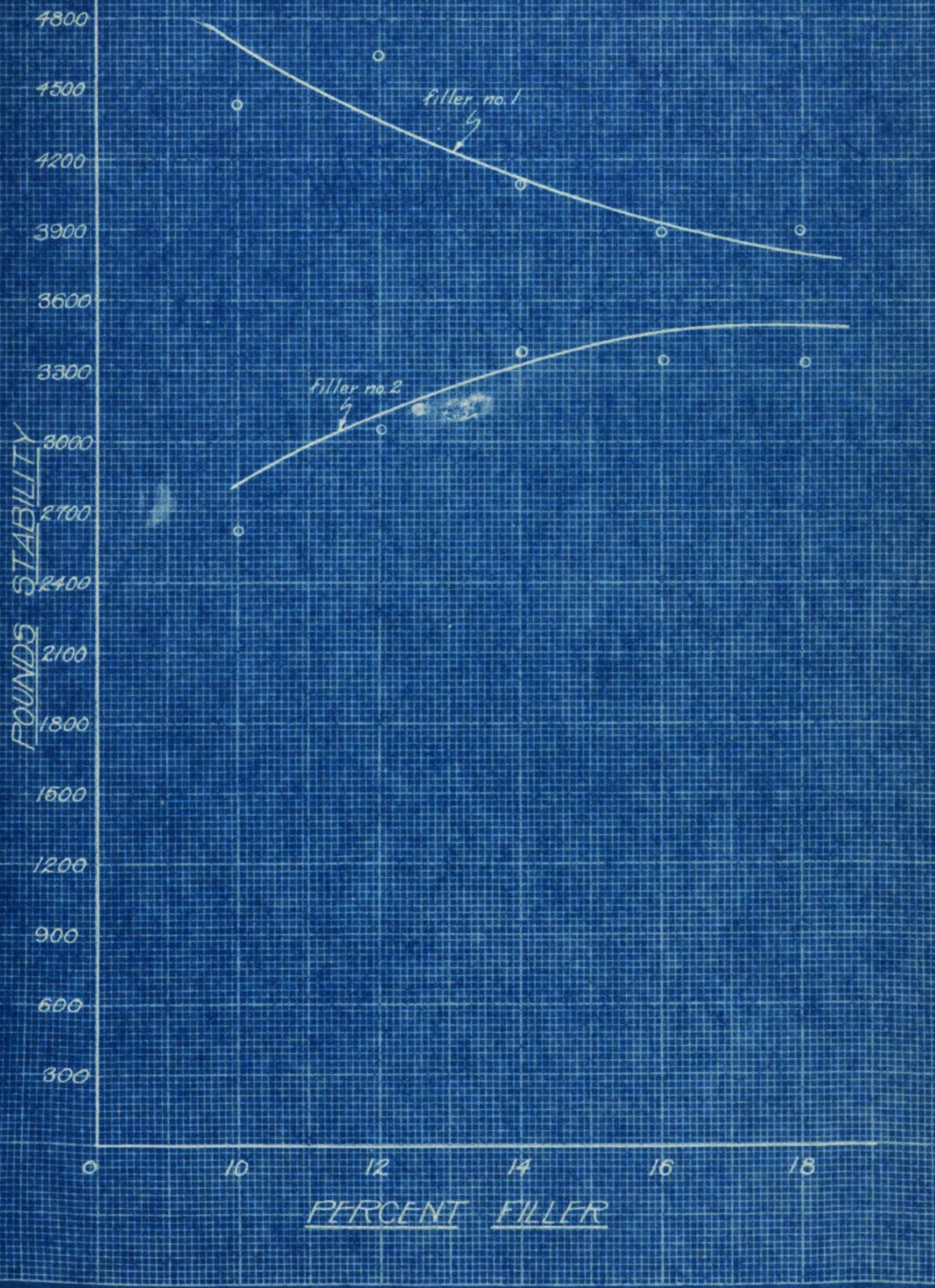
(FILLER NO.2)



STABILITY TEST
(9% ASPHALT)



STABILITY TEST
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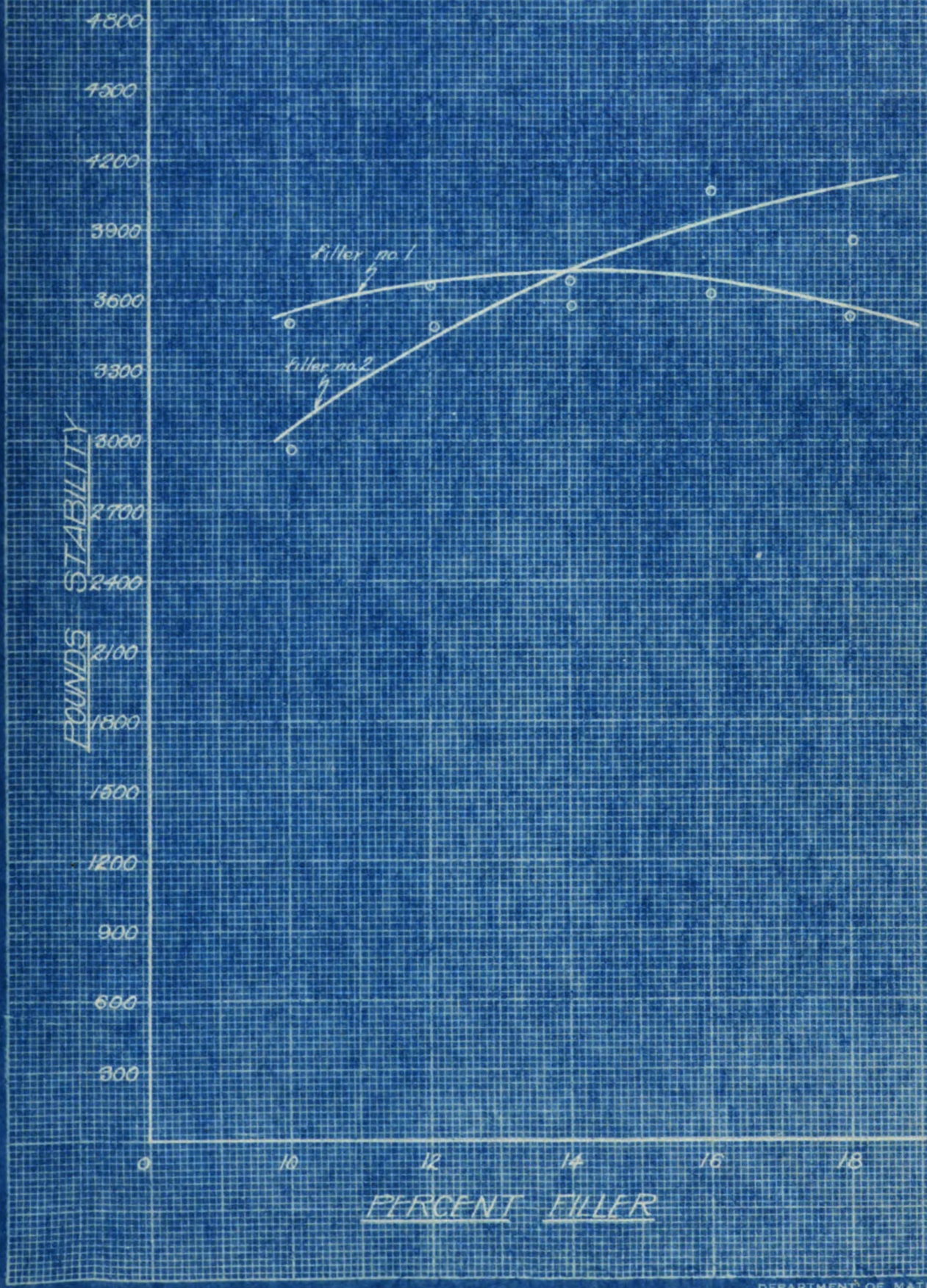
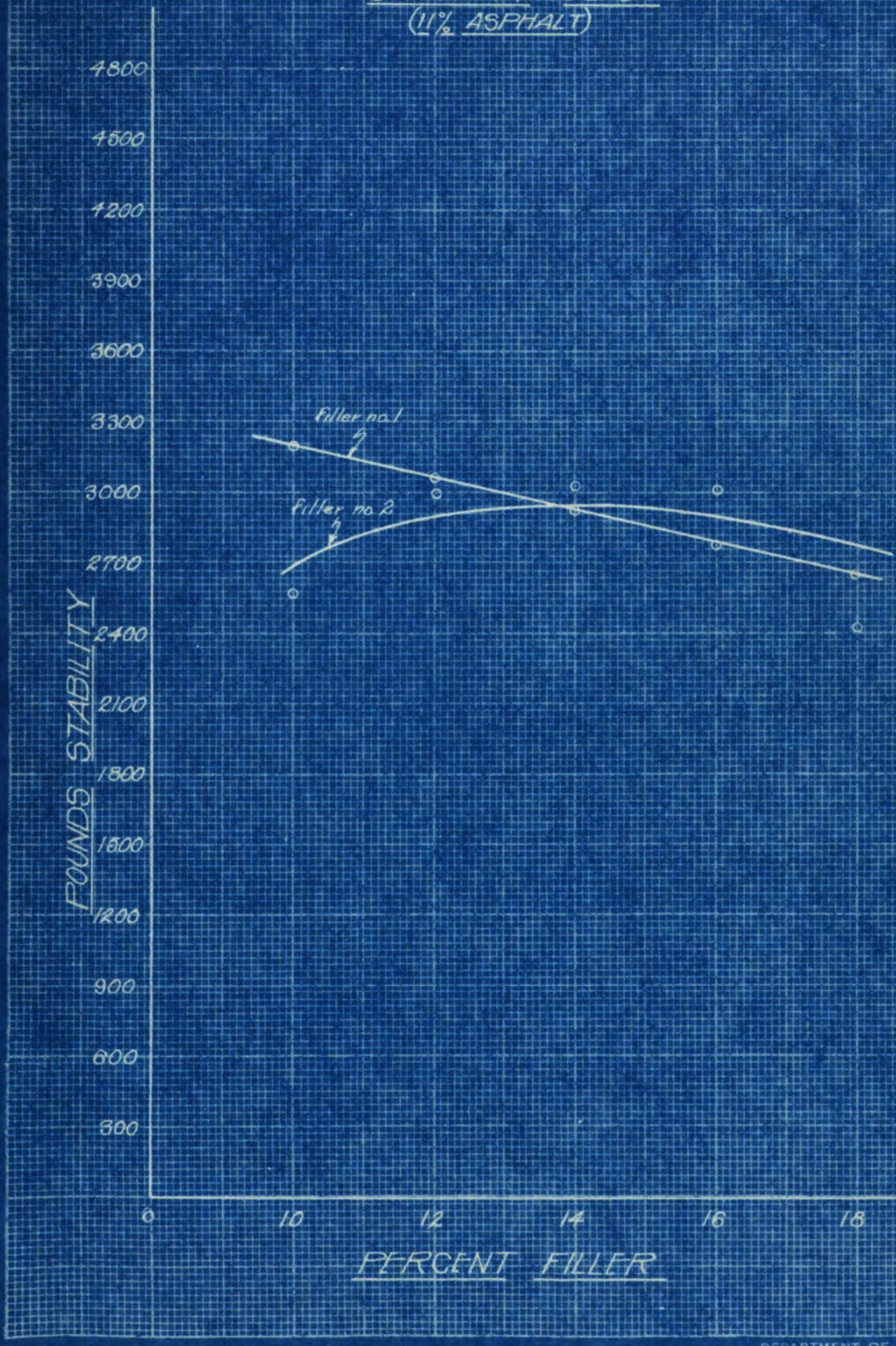
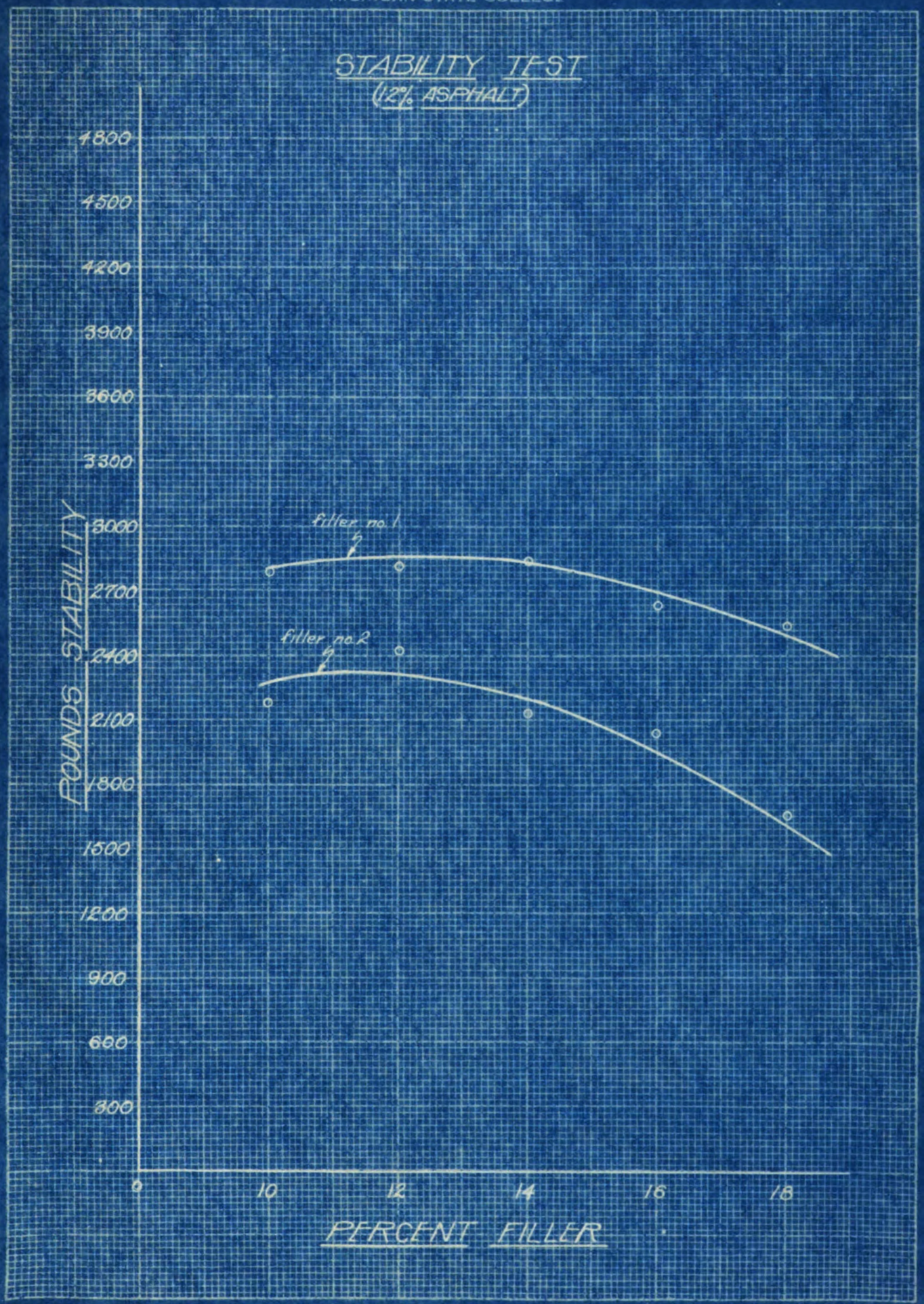


STABILITY TEST
(11% ASPHALT)




STABILITY TEST
(12% ASPHALT)
4800
4500
4200
3900
3600
3300
3000
2700
2400
2100
1800
1500
1200
900
600
300
POUNDS STABILITY
filler no. 1
filler no. 2
0
10
12
14
16
18
PERCENT FILLER

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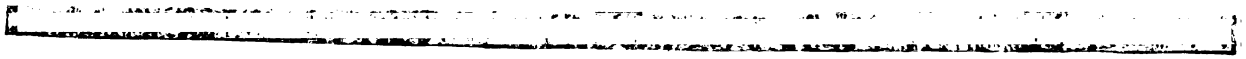
Practical Application of the Shear Test to Bituminous Mixtures

Linking Design and Field, by H. W. Skidmore. Reprinted from Roads and Streets, January, 1929.



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