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REPORT ON LIMESTONE DUST AS A
FILLER FOR ASPHALT PAVEMENTS

THESIS FOR THE DEGREE OF B. S.
K. M. Knudson
1930

THESIS

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Pavements, Asphalt Roads

Civil engineering

Railroads + roads

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**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


K. M. Knudson

**Candidate for the Degree of
Bachelor of Science**

June, 1930

THESIS

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ACKNOWLEDGEMENT

The writer wishes to express his appreciation for the very cordial assistance of Mr. Hugh Skidmore, President of the Chicago Paving Laboratories; the Black-White Lime Company, Quincy, Illinois; Johns-Mansville Corporation, Chicago, Illinois; and Mr. Scott Baker, City Engineer of Lansing, Michigan

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.

CONTENTS

General History	Page 1
General Discussion	4
Brief on Volume-Weight	7
Introduction	9
Materials Used:	
Asphalt	9
Sand	10
Fillers	11
Method of Mixing	11
Mixtures Tested	12
Method of Shear Test	12
Water Absorption Test	14
General Conclusions	16
Data Obtained	17
Bibliography	18

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Photograph

Shear Machine

oOo

Prints

Modes of Occurrences

Water Absorption Curves

Stability Curves

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 volatile 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

• The first step in the process of creating a new product is to identify a market need. This is often done through market research, which involves gathering information about potential customers and their needs. Once a market need is identified, the next step is to develop a concept for a product that meets that need.

• The second step is to develop a business plan. This involves determining the costs of production, the pricing strategy, and the marketing strategy.

• The third step is to create a prototype. This is a small-scale version of the product that is used to test the concept and gather feedback.

• The fourth step is to conduct a pilot run. This involves producing a small quantity of the product and selling it to a limited number of customers.

• The fifth step is to launch the product. This involves producing a larger quantity of the product and selling it to a wider market.

• The sixth step is to monitor the product's performance. This involves tracking sales, customer feedback, and other metrics to determine if the product is successful.

• The seventh step is to make improvements. This involves using customer feedback and other data to make changes to the product or the marketing strategy.

• The eighth step is to expand the product line. This involves creating new products that build on the success of the first product.

• The ninth step is to maintain the product. This involves ensuring that the product continues to meet customer needs and that it is profitable.

• The tenth step is to exit the market. This involves selling the product or the business to another company.

• The final step is to evaluate the overall success of the product. This involves comparing the product's performance to the goals that were set at the beginning of the process.

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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 amazing 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.

THEORY OF THE EARTH

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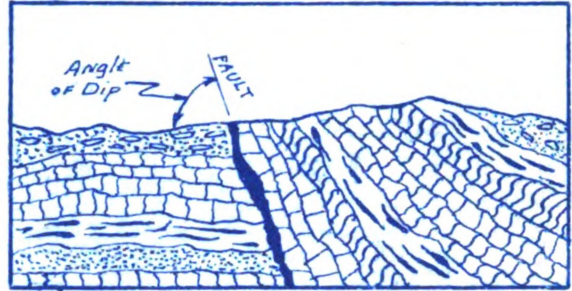
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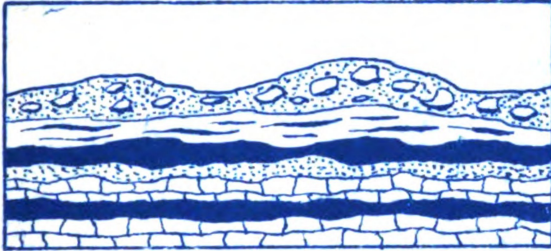
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Fault Filling caused by Upturning



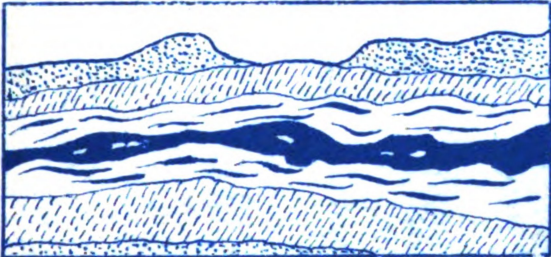
Impregnated Strata in Thrust



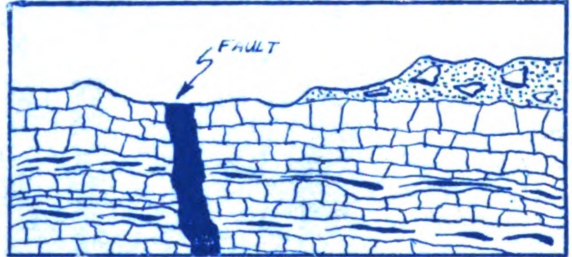
Veins formed by Sedimentation



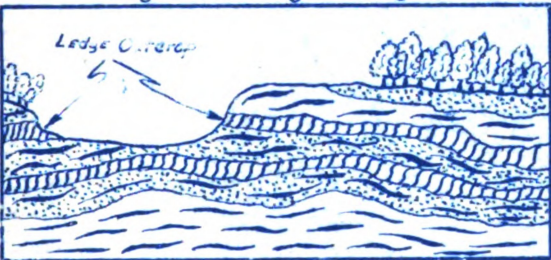
Spring



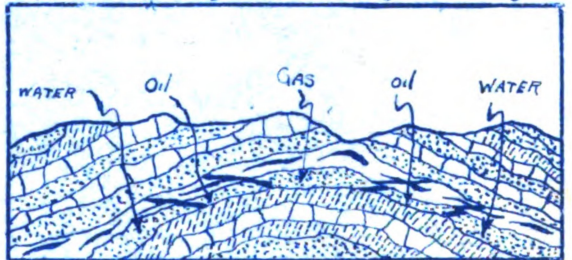
Vein Filling caused by Sliding of Strata



Fault Filling caused by Cleavage



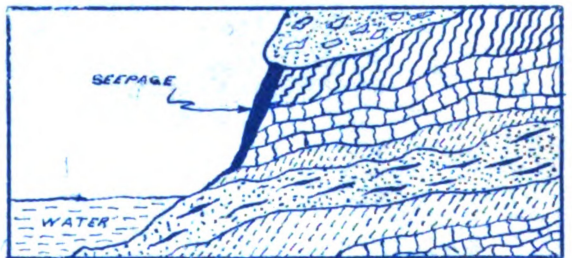
Impregnated Horizontal Strata



Subterranean 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.

— The first step in the process of creating a new product is to identify a market need. This involves conducting market research to determine what consumers want and need. Once a need is identified, the next step is to develop a concept for a product that meets that need. This is often done through brainstorming and sketching. The third step is to create a prototype, which is a small-scale model of the product. This allows the designer to test the product and make any necessary adjustments. The fourth step is to create a business plan, which outlines the costs of production, the pricing strategy, and the marketing plan. Finally, the product is manufactured and distributed to the market.

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• The fifth step in the process of creating a new product is to manufacture and distribute the product to the market. This involves finding a manufacturer, negotiating terms, and setting up a distribution network. The final step is to monitor the product's performance in the market and make any necessary adjustments.

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

the first of these is the fact that the system is not a simple one, but a complex one, in which the various parts are interrelated and interdependent. The second is that the system is not a static one, but a dynamic one, in which the parts are constantly changing and evolving. The third is that the system is not a closed one, but an open one, in which the parts are constantly interacting with the environment. The fourth is that the system is not a linear one, but a non-linear one, in which the parts are constantly interacting with each other in a non-linear fashion. The fifth is that the system is not a deterministic one, but a probabilistic one, in which the parts are constantly interacting with each other in a probabilistic fashion. The sixth is that the system is not a simple one, but a complex one, in which the parts are interrelated and interdependent. The seventh is that the system is not a static one, but a dynamic one, in which the parts are constantly changing and evolving. The eighth is that the system is not a closed one, but an open one, in which the parts are constantly interacting with the environment. The ninth is that the system is not a linear one, but a non-linear one, in which the parts are constantly interacting with each other in a non-linear fashion. The tenth is that the system is not a deterministic one, but a probabilistic one, in which the parts are constantly interacting with each other in a probabilistic fashion.

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).

1. *Journal of the American Medical Association*, 1997; 277: 1033-1036.

•

• **What is the purpose of the study?** The purpose of the study is to determine the effect of the use of a mobile phone on the performance of a simulated driving task.

1. *Journal of the American Medical Association*, 1997; 277: 1033-1036.

• *Journal of Management Education* 32(10):1039-1050

--- *Journal of Management Education* 31(10):1131-1144

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.

•

• 11/11/11

• The first part of the paper is a review of the literature on the effects of the 2008 financial crisis on the global economy. It discusses the impact of the crisis on the world's major economies, including the United States, Europe, and Asia. The paper also examines the role of the International Monetary Fund (IMF) in providing financial assistance to countries affected by the crisis.

• The second part of the paper focuses on the impact of the crisis on the global financial system. It discusses the collapse of Lehman Brothers and the subsequent loss of confidence in the financial system. The paper also examines the role of the G20 in coordinating a global response to the crisis.

• The third part of the paper discusses the impact of the crisis on the global labor market. It examines the rise in unemployment rates in many countries and the impact of the crisis on the global supply chain. The paper also discusses the impact of the crisis on the global environment, including the impact of the crisis on the global climate and the impact of the crisis on the global energy market.

• The fourth part of the paper discusses the impact of the crisis on the global political system. It examines the impact of the crisis on the global political system, including the impact of the crisis on the global political system and the impact of the crisis on the global political system.

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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 stabilizing 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

<u>Retained on.</u>	<u>Weight (grams)</u>	<u>Percentage</u>
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
	<u>500.0</u>	<u>100.00</u>

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

<u>Retained on</u>	<u>Weight (grams)</u>	<u>Percentage</u>
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	<u>46.85</u>	<u>46.85</u>
	100.00	100.00

LIMESTONE DUST #2

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

The first part of the report deals with the general situation of the country and the position of the various groups. It is a very interesting and well-written account of the country and its people. The second part of the report deals with the various groups and their position. It is a very interesting and well-written account of the various groups and their position.

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The seventh part of the report deals with the various groups and their position. It is a very interesting and well-written account of the various groups and their position. The eighth part of the report deals with the various groups and their position. It is a very interesting and well-written account of the various groups and their position.

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.

The first of these is the fact that the
 government has been unable to
 maintain a consistent policy
 towards the economy. This has
 led to a series of crises
 which have severely damaged
 the country's reputation
 and its ability to attract
 foreign investment. The
 second is the fact that the
 government has been unable to
 reform the judicial system.
 This has led to a lack of
 confidence in the courts and
 a widespread belief that
 the law is only for the rich.
 The third is the fact that the
 government has been unable to
 reform the education system.
 This has led to a lack of
 confidence in the schools and
 a widespread belief that
 the education system is only
 for the rich.

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 two 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.

QUESTION 1

- a) Suppose that the demand curve for a good is given by $Q = 100 - 2P$, where Q is the quantity demanded and P is the price. Suppose that the supply curve for the good is given by $Q = -50 + 10P$, where Q is the quantity supplied and P is the price. Suppose that the government imposes a tax of $\$10$ per unit of the good.
 - Find the equilibrium quantity and price in the market.
 - Find the equilibrium quantity and price in the market after the tax is imposed.
 - Find the deadweight loss of the tax.
 - Find the total revenue of the government from the tax.
 - Find the total surplus in the market before and after the tax is imposed.
- b) Suppose that the demand curve for a good is given by $Q = 100 - 2P$, where Q is the quantity demanded and P is the price. Suppose that the supply curve for the good is given by $Q = -50 + 10P$, where Q is the quantity supplied and P is the price. Suppose that the government imposes a tax of $\$10$ per unit of the good.
 - Find the equilibrium quantity and price in the market.
 - Find the equilibrium quantity and price in the market after the tax is imposed.
 - Find the deadweight loss of the tax.
 - Find the total revenue of the government from the tax.
 - Find the total surplus in the market before and after the tax is imposed.

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	2430
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	-

续前

项目	单位	数量	单价	合价
1. 土方工程				
挖土方	m ³	100	1.20	120.00
填土方	m ³	50	0.80	40.00
运土方	m ³	200	0.50	100.00
2. 砌体工程				
砖墙	m ³	100	1.50	150.00
砂浆	m ³	50	0.80	40.00
3. 混凝土工程				
现浇混凝土	m ³	100	2.00	200.00
预制混凝土	m ³	50	1.00	50.00
4. 钢筋工程				
钢筋	t	10	1.00	10.00
5. 模板工程				
模板	m ²	100	0.50	50.00
6. 脚手架工程				
脚手架	m ²	100	0.20	20.00
7. 垂直运输工程				
垂直运输	m ²	100	0.10	10.00
8. 其他工程				
材料费				
人工费				
机械费				
管理费				
利润				
税金				
合计				

WATER ABSORPTION (FILLER NO. 1)

PERCENT ABSORPTION

1.05

0.9

0.75

0.6

0.45

0.3

0.15

0

10

12

14

16

18

PERCENT FILLER

9% asphalt

10% asphalt

11% asphalt

12% asphalt

13% asphalt

WATER ABSORPTION (FILLER No 2)

NOTE:
13% mix too plastic
to handle

PERCENT ABSORPTION

1.05

0.9

0.75

0.6

0.45

0.3

0.15

0

10

12

14

16

18

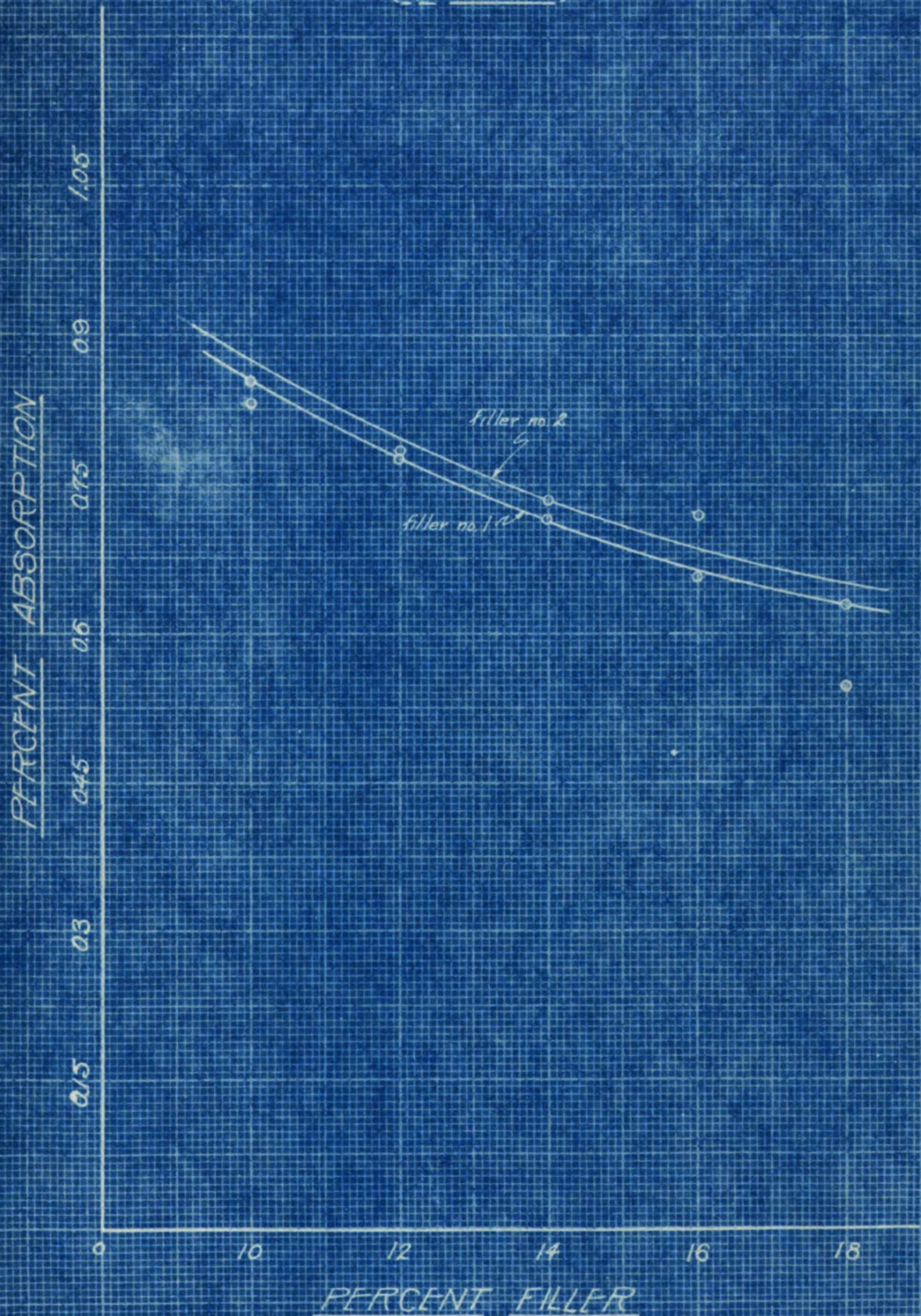
PERCENT FILLER

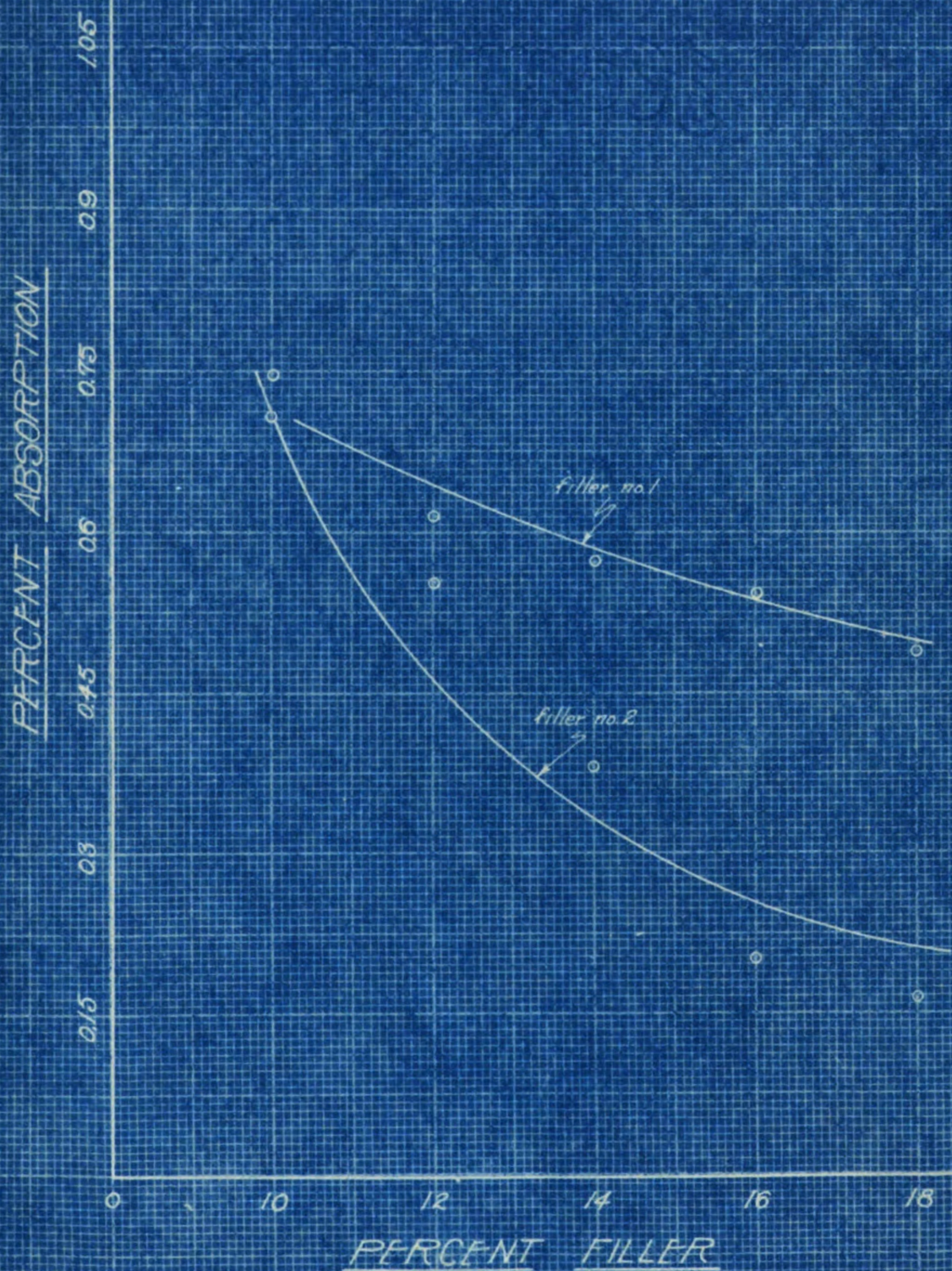
9% asphalt

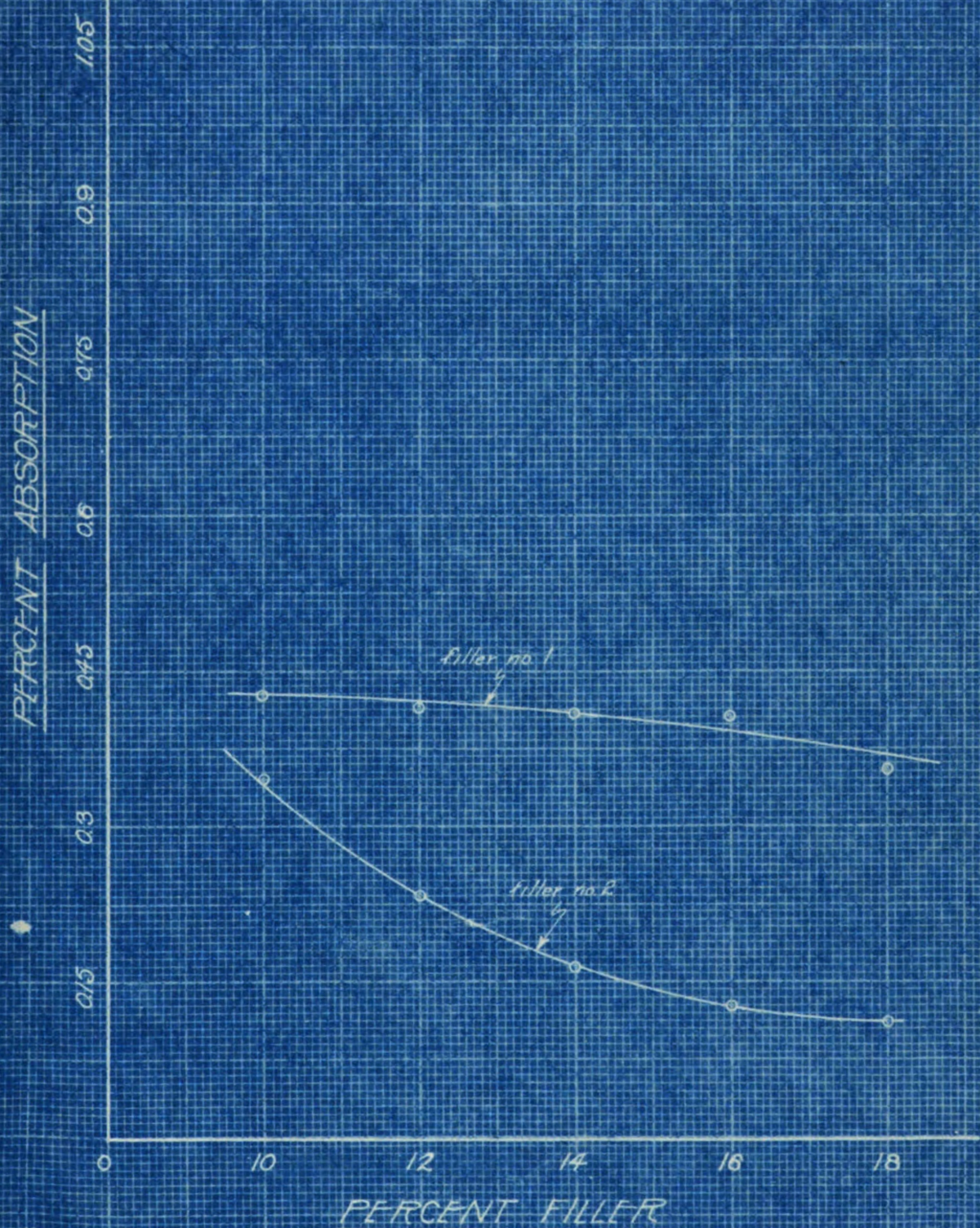
10% asphalt

11% asphalt

12% asphalt

WATER ABSORPTION
(9% ASPHALT)

WATER ABSORPTION
(10% ASPHALT)

WATER ABSORPTION
(1% ASPHALT)

PERCENT ABSORPTION

1.05

0.9

0.75

0.6

0.45

0.3

0.15

0

10

12

14

16

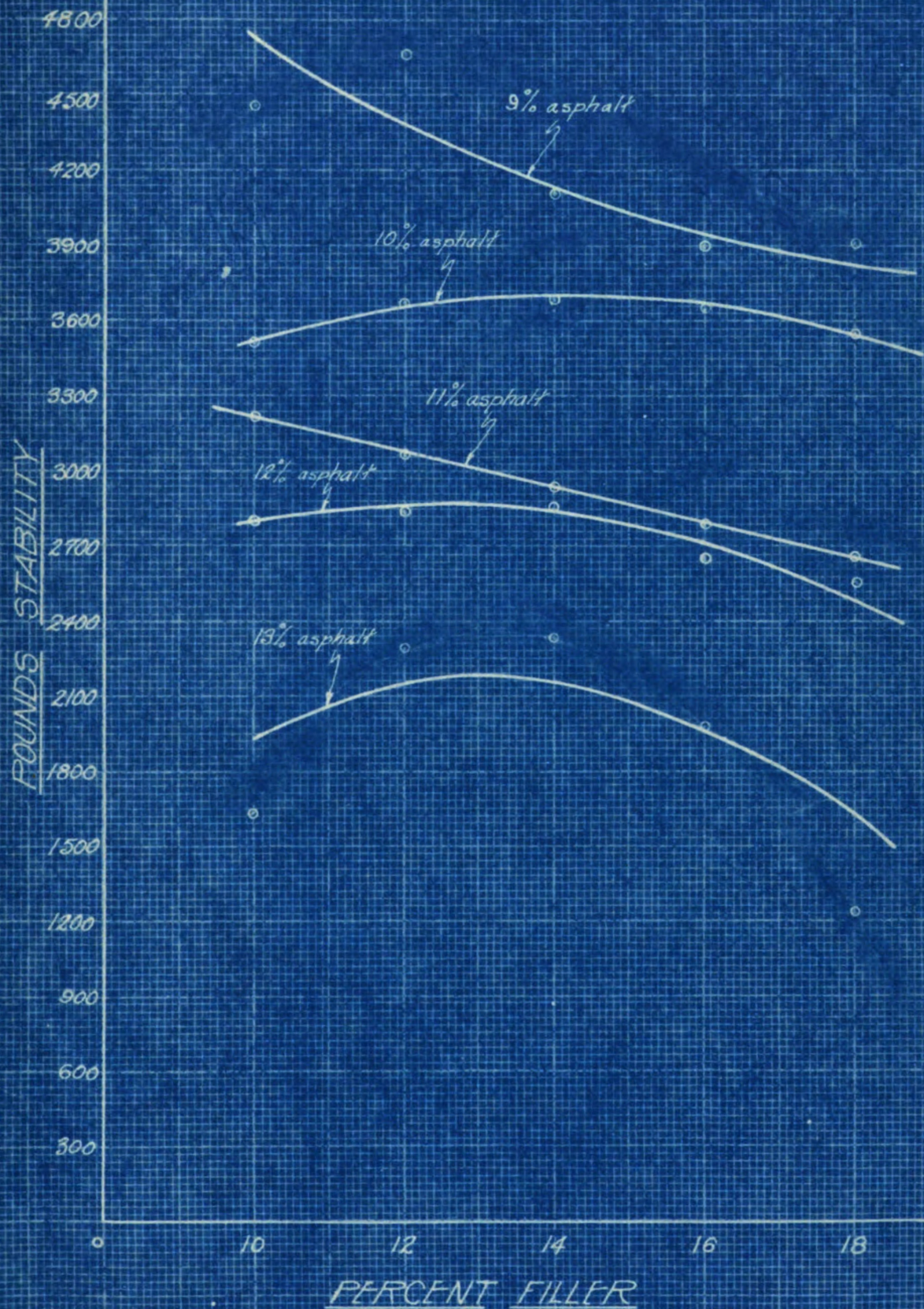
18

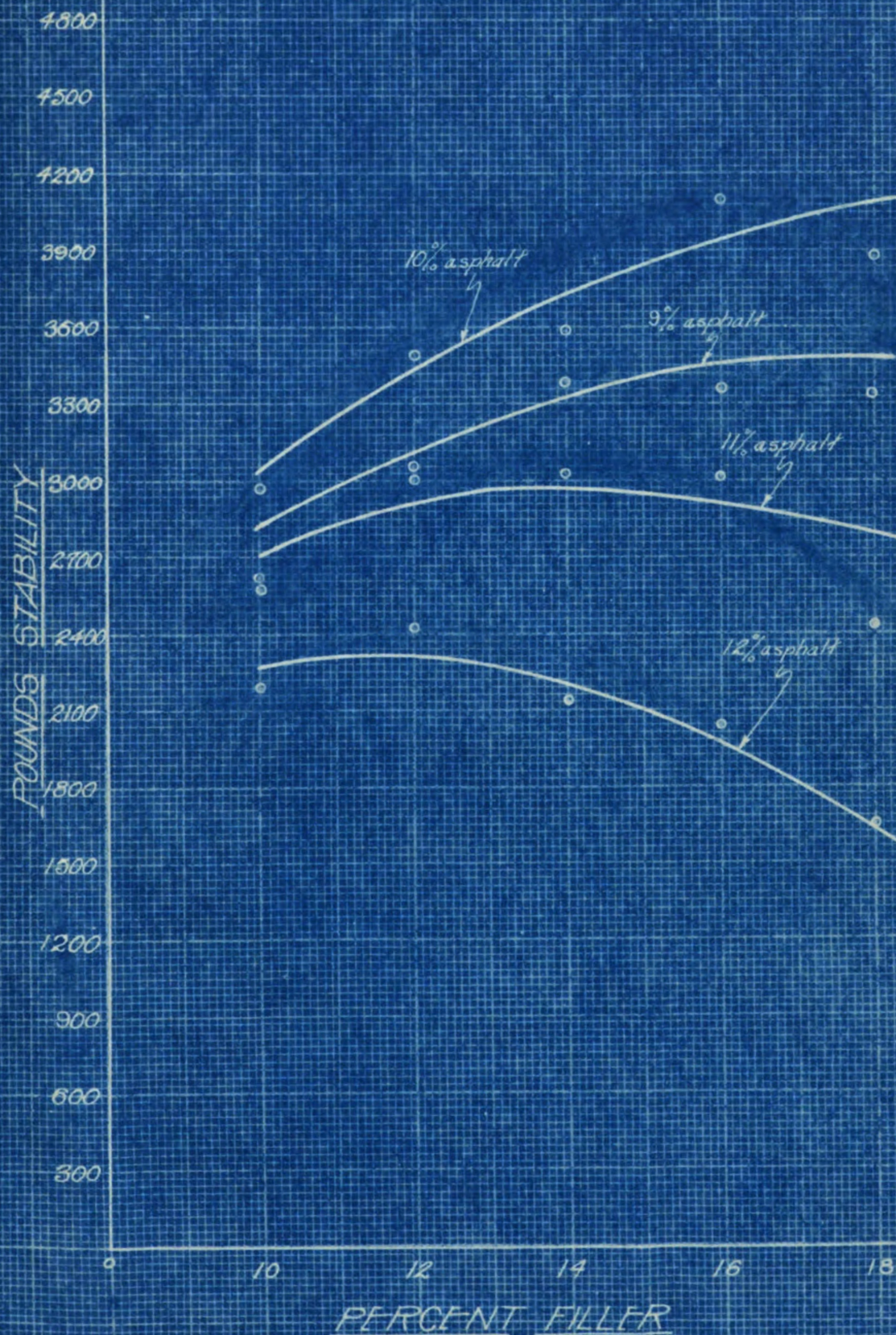
PERCENT FILLER

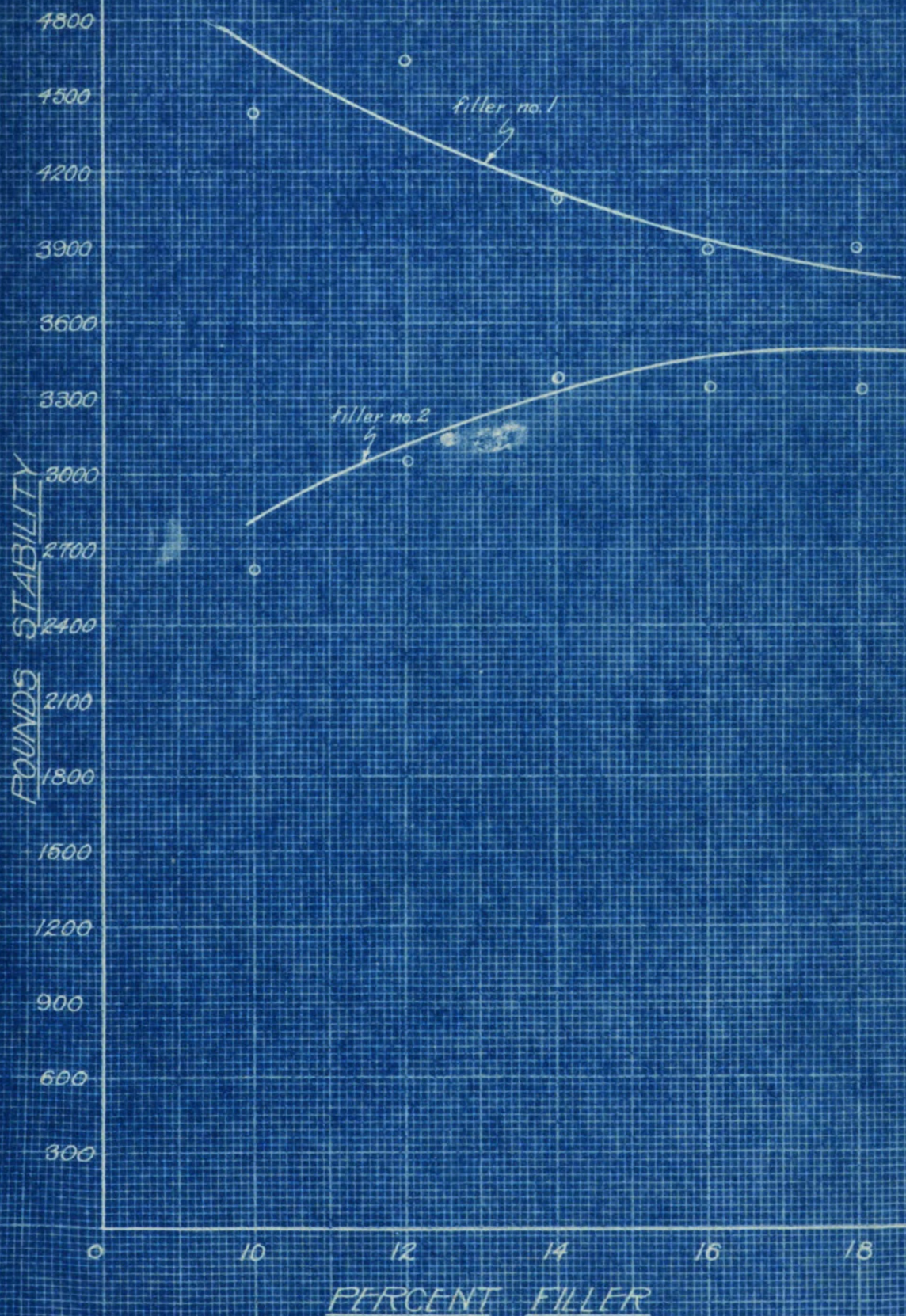
filler no. 1

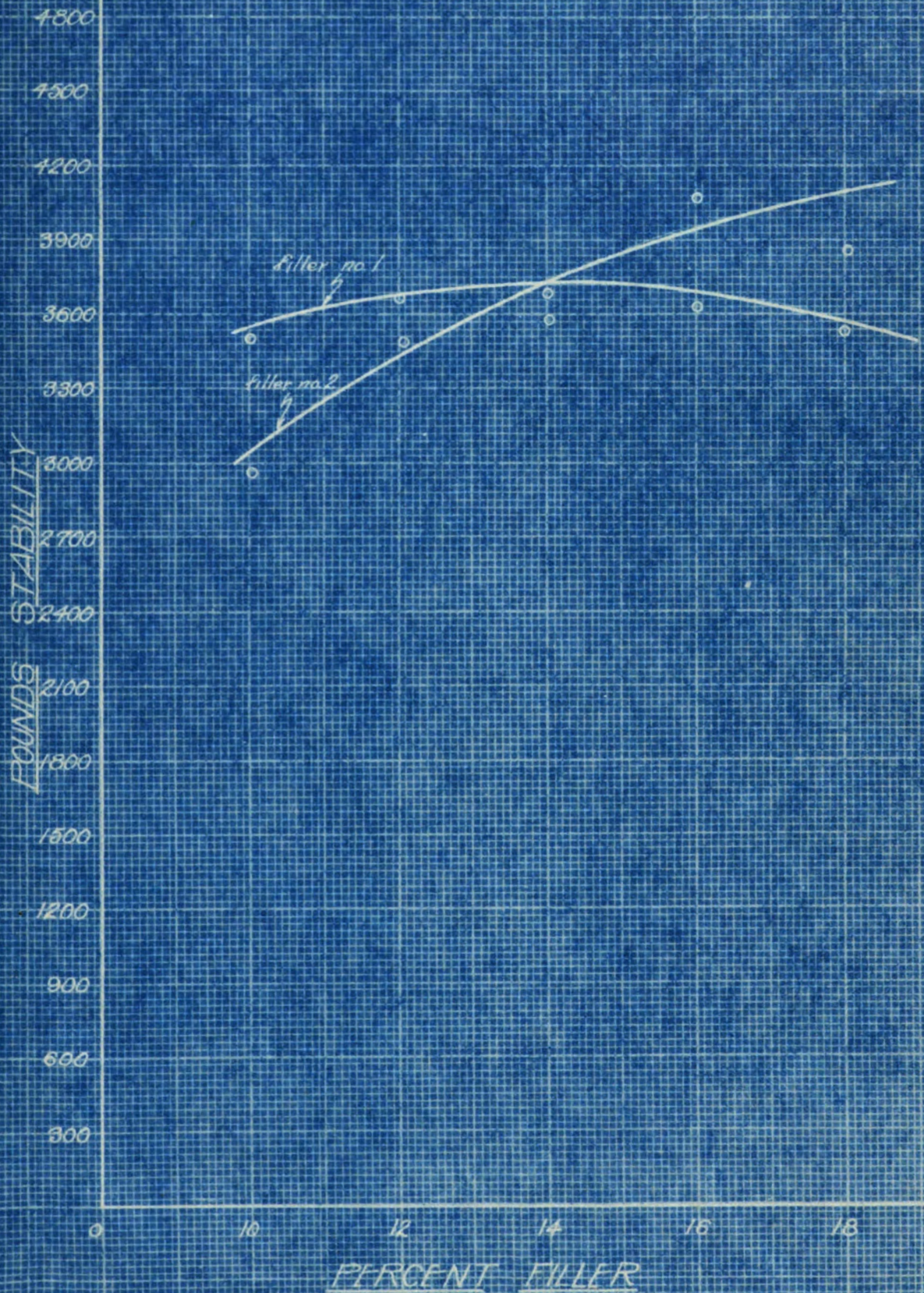
filler no. 2

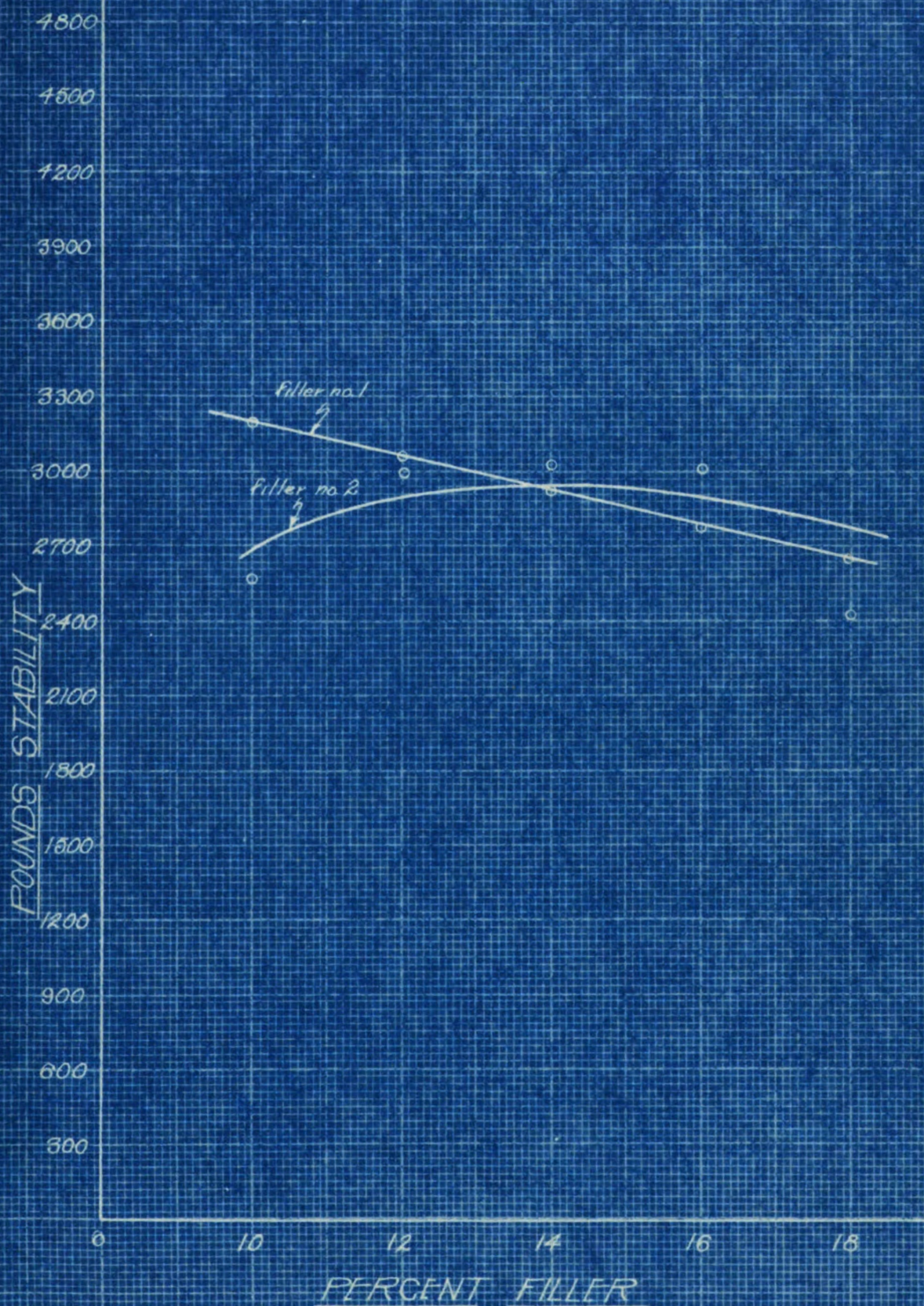
STABILITY TEST (FILLER No. 1)

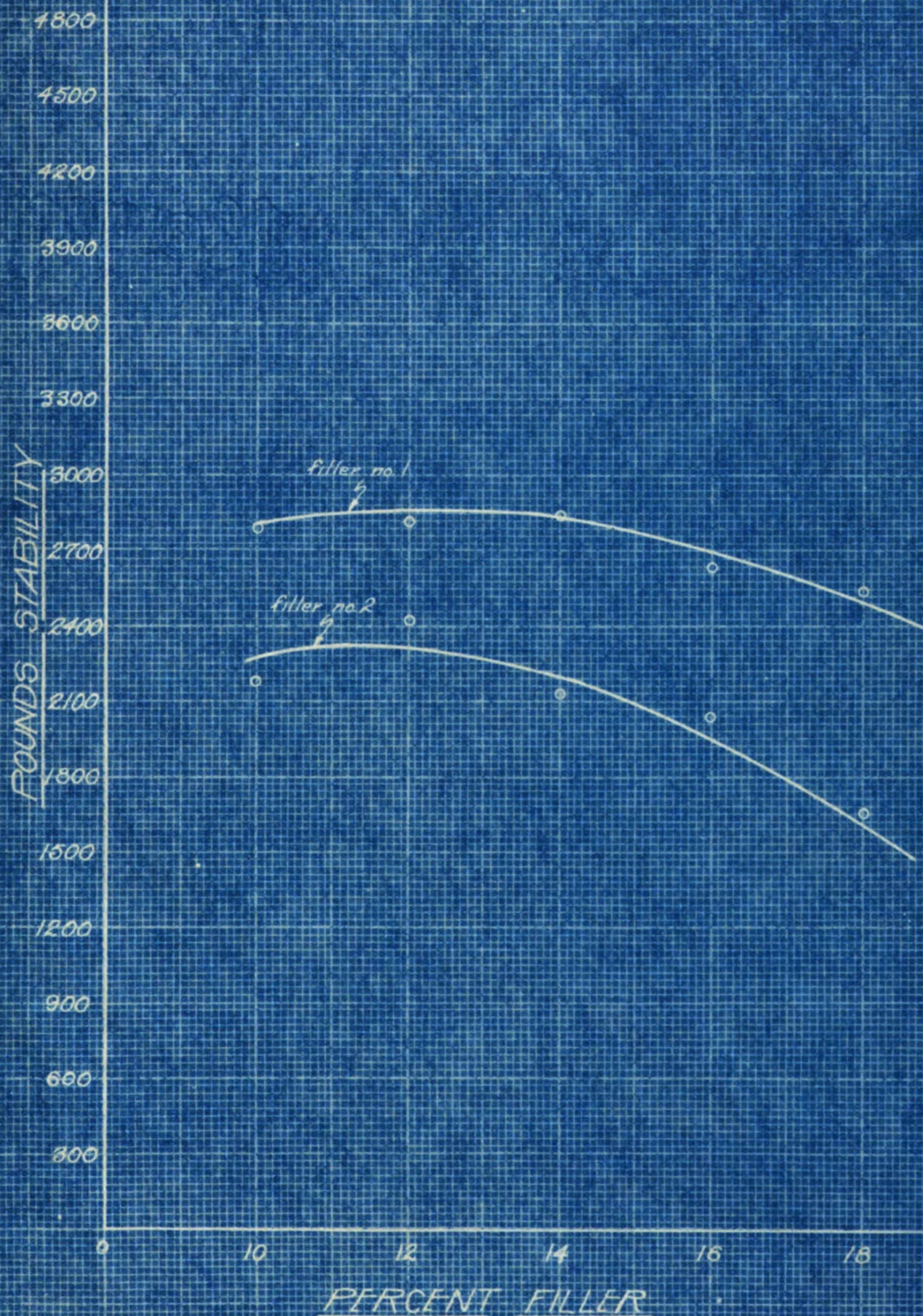


STABILITY TEST
(FILLER NO. 2)

STABILITY TEST
(9% ASPHALT)

STABILITY TEST
(10% ASPHALT)

STABILITY TEST
(1% ASPHALT)

STABILITY TEST
(12% ASPHALT)

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100

• *Chlorophyll a* and *Chlorophyll b* were determined by the method of Arar and Collins (1987). The concentration of chlorophylls was expressed in $\mu\text{g mL}^{-1}$ of the sample.

[illegible]

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1. *Journal of the American Medical Association*, 1990; 263: 1025-1028.

the 1990s, the number of people in the world who are illiterate has increased from 1.2 billion to 1.5 billion. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015. The number of illiterate people in the world is projected to reach 1.7 billion by the year 2015.

1996, 1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 26

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...and the fact that the *Journal of the American Medical Association* is the most widely read journal in the United States, the *Journal of the American Medical Association* is the most widely read journal in the United States.

1. *Journal of the American Medical Association*, 2000; 284: 2689-2694.

• **Prevalence** = the proportion of a population that has a disease at a particular point in time

1997, 1998, 1999, 2000, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016, 2017, 2018, 2019, 2020, 2021, 2022, 2023, 2024, 2025, 2026, 2027, 2028, 2029, 2030, 2031, 2032, 2033, 2034, 2035, 2036, 2037, 2038, 2039, 2040, 2041, 2042, 2043, 2044, 2045, 2046, 2047, 2048, 2049, 2050, 2051, 2052, 2053, 2054, 2055, 2056, 2057, 2058, 2059, 2060, 2061, 2062, 2063, 2064, 2065, 2066, 2067, 2068, 2069, 2070, 2071, 2072, 2073, 2074, 2075, 2076, 2077, 2078, 2079, 2080, 2081, 2082, 2083, 2084, 2085, 2086, 2087, 2088, 2089, 2090, 2091, 2092, 2093, 2094, 2095, 2096, 2097, 2098, 2099, 2100, 2101, 2102, 2103, 2104, 2105, 2106, 2107, 2108, 2109, 2110, 2111, 2112, 2113, 2114, 2115, 2116, 2117, 2118, 2119, 2120, 2121, 2122, 2123, 2124, 2125, 2126, 2127, 2128, 2129, 2130, 2131, 2132, 2133, 2134, 2135, 2136, 2137, 2138, 2139, 2140, 2141, 2142, 2143, 2144, 2145, 2146, 2147, 2148, 2149, 2150, 2151, 2152, 2153, 2154, 2155, 2156, 2157, 2158, 2159, 2160, 2161, 2162, 2163, 2164, 2165, 2166, 2167, 2168, 2169, 2170, 2171, 2172, 2173, 2174, 2175, 2176, 2177, 2178, 2179, 2180, 2181, 2182, 2183, 2184, 2185, 2186, 2187, 2188, 2189, 2190, 2191, 2192, 2193, 2194, 2195, 2196, 2197, 2198, 2199, 2200, 2201, 2202, 2203, 2204, 2205, 2206, 2207, 2208, 2209, 2210, 2211, 2212, 2213, 2214, 2215, 2216, 2217, 2218, 2219, 2220, 2221, 2222, 2223, 2224, 2225, 2226, 2227, 2228, 2229, 2230, 2231, 2232, 2233, 2234, 2235, 2236, 2237, 2238, 2239, 2240, 2241, 2242, 2243, 2244, 2245, 2246, 2247, 2248, 2249, 2250, 2251, 2252, 2253, 2254, 2255, 2256, 2257, 2258, 2259, 2260, 2261, 2262, 2263, 2264, 2265, 2266, 2267, 2268, 2269, 2270, 2271, 2272, 2273, 2274, 2275, 2276, 2277, 2278, 2279, 2280, 2281, 2282, 2283, 2284, 2285, 2286, 2287, 2288, 2289, 2290, 2291, 2292, 2293, 2294, 2295, 2296, 2297, 2298, 2299, 2300, 2301, 2302, 2303, 2304, 2305, 2306, 2307, 2308, 2309, 2310, 2311, 2312, 2313, 2314, 2315, 2316, 2317, 2318, 2319, 2320, 2321, 2322, 2323, 2324, 2325, 2326, 2327, 2328, 2329, 2330, 2331, 2332, 2333, 2334, 2335, 2336, 2337, 2338, 2339, 2340, 2341, 2342, 2343, 2344, 2345, 2346, 2347, 2348, 2349, 2350, 2351, 2352, 2353, 2354, 2355, 2356, 2357, 2358, 2359, 2360, 2361, 2362, 2363, 2364, 2365, 2366, 2367, 2368, 2369, 2370, 2371, 2372, 2373, 2374, 2375, 2376, 2377, 2378, 2379, 2380, 2381, 2382, 2383, 2384, 2385, 2386, 2387, 2388, 2389, 2390, 2391, 2392, 2393, 2394, 2395, 2396, 2397, 2398, 2399, 2400, 2401, 2402, 2403, 2404, 2405, 2406, 2407, 2408, 2409, 2410, 2411, 2412, 2413, 2414, 2415, 2416, 2417, 2418, 2419, 2420, 2421, 2422, 2423, 2424, 2425, 2426, 2427, 2428, 2429, 2430, 2431, 2432, 2433, 2434, 2435, 2436, 2437, 2438, 2439, 2440, 2441, 2442, 2443, 2444, 2445, 2446, 2447, 2448, 2449, 2450, 2451, 2452, 2453, 2454, 2455, 2456, 2457, 2458, 2459, 2460, 2461, 2462, 2463, 2464, 2465, 2466, 2467, 2468, 2469, 2470, 2471, 2472, 2473, 2474, 2475, 2476, 2477, 2478, 2479, 2480, 2481, 2482, 2483, 2484, 2485, 2486, 2487, 2488, 2489, 2490, 2491, 2492, 2493, 2494, 2495, 2496, 2497, 2498, 2499, 2500, 2501, 2502, 2503, 2504, 2505, 2506, 2507, 2508, 2509, 2510, 2511, 2512, 2513, 2514, 2515, 2516, 2517, 2518, 2519, 2520, 2521, 2522, 2523, 2524, 2525, 2526, 2527, 2528, 2529, 2530, 2531, 2532, 2533, 2534, 2535, 2536, 2537, 2538, 2539, 2540, 2541, 2542, 2543, 2544, 2545, 2546, 2547, 2548, 2549, 2550, 2551, 2552, 2553, 2554, 2555, 2556, 2557, 2558, 2559, 2560, 2561, 2562, 2563, 2564, 2565, 2566, 2567, 2568, 2569, 2570, 2571, 2572, 2573, 2574, 2575, 2576, 2577, 2578, 2579, 2580, 2581, 2582, 2583, 2584, 2585, 2586, 2587, 2588, 2589, 2590, 2591, 2592, 2593, 2594, 2595, 2596, 2597, 2598, 2599, 2600, 2601, 2602, 2603, 2604, 2605, 2606, 2607, 2608, 2609, 2610, 2611, 2612, 2613, 2614, 2615, 2616, 2617, 2618, 2619, 2620, 2621, 2622, 2623, 2624, 2625, 2626, 2627, 2628, 2629, 2630, 2631, 2632, 2633, 2634, 2635, 2636, 2637, 2638, 2639, 2640, 2641, 2642, 2643, 2644, 2645, 2646, 2647, 2648, 2649, 2650, 2651, 2652, 2653, 2654, 2655, 2656, 2657, 2658, 2659, 2660, 2661, 2662, 2663, 2664, 2665, 2666, 2667, 2668, 2669, 2670, 2671, 2672, 2673, 2674, 2675, 2676, 2677, 2678, 26

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...and the other is the fact that the ...

Fine Aggregates in Bituminous Mixtures

Voids - Workability and Compressibility - Stability -

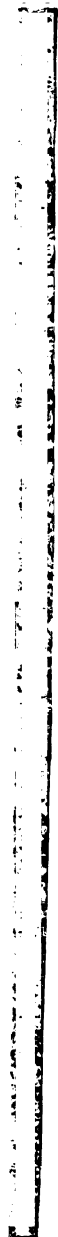
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