THE RELATION BETWEEN SOILS AND THE PENETRATING ABILITY OF ROAD SURFACING MATERIALS

THESIS FOR THE DEGREE OF B. S.

W. H. Yost

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THESIS

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THE RELATION BETWEEN SOILS AND THE PENETRATING ABILITY OF ROAD SURFACING MATERIALS

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THESIS

CONTENTS

ACKNOWLEDGMENT

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W. H. Yost

OBJECT OF THESIS

The object of this thesis is to determine the penetrating ability, and the binding properties of road surfacing material after maximum penetration through compact and cohesive soil.

PROCEDURE AND DATA

The soil to be used in the experiment was obtained by Mr. Rothgery from a gravel road that was subject to traffic. This type of soil was used to get a soil mixture that would pack in boxes without experimenting. A sieve analysis of the soil was made, so more soil of the same texture could be made if needed.

Seven boxes were made three feet in length, one foot in width, and three inches in depth. The boxes were then divided into sections one foot square. In order to keep the bituminous material and water from penetrating into the wood of the box, the boxes were painted.

The soil was placed in the experimental boxes and water applied in small quantity. If water is applied in excess quantities, the silt in the soil will be washed out, and the binding properties of the soil spoiled. When the soil was saturated with water, a tamp was used to pack it in the boxes. The soil was placed in a temperature of 90 degrees Fahrenheit for two hours in order to evaporate the water. The soil was then exposed to water again until saturated. Again the soil was tamped to be sure of a compact mass as though it were in a road subject to traffic. The soil was allowed to dry for four days in a temperature of 90 degrees Fahrenheit in order to extract all the water.

While the soil was drying, glass tubes six inches in length were filled with the same soil as in the boxes. The soil in the tubes was packed to the same degree of hardness as the soil in the boxes. This was also done with water and a tamp. The tubes were filled with soil within an inch of the top. The inch at the top being left to apply an excess of bitumous material. While the soil in the tubes were drying, the specific viscosity of the materials to be used in the experiment was determined.

To determine the specific viscosity of a material by the Engler Viscosimeter the following procedure is required. Two hundred and forty cubic centimeters of water at 44½ degrees Centigrade or 122 degrees Fahrenheit was placed in the Viscosimeter. The time required for the passing of 100 cc through the orifice in the viscosimeter was recorded by a stop watch. The material to be tested was placed in the viscosimeter and the same procedure was followed. The time it took the test material to flow through the orifice divided by the time it took the water to flow through the same orifice gave the viscosity of the material. After the viscosity of the materials was obtained, the application of the materials to the soil was next.

The quantity of material to be applied to the soil was taken from the State specifications which requires one-half gallon of bituminous material--first application. To be sure that none of the material would penetrate into the wood of the box, the quantity of material to be applied was figured for a ten inch square instead of a twelve inch square.

One half gallon per square yard equals 1.45 cc per square inch; therefore the quantity of material to be applied to one hundred square inches equals 145 cc.

The state specifications also require tar products to be at a temperature that will cause the material to flow freely. This temperature was obtained from specifications published by the American Tar Products Company which gave the temperature ranging from 125-150 degrees Fahrenheit.

The asphaltic material was applied cold or at room temperature which was 90 degrees Fahrenheit. After all the material was applied to the soil, it was allowed to stand for seventy-two hours to insure complete penetration.

Tarvia "B" Heavy viscosity 18-25 penetrated the soil in the box three-quarter of an inch. The maximum soil penetration was seven-eighths of an inch. The penetration was uniform throughout with a dull black color at the top and bottom. The particles were cemented together well throughout.

Tarvia "B" Medium viscosity 13-18 penetrated the soil in the box to a depth of one inch. The maximum soil penetration was also one inch. The color remained constant from top to bottom showing good tar deposits on the particles of gravel. The binding quality of the material was better than that of Tarvia "B" Heavy.

Tarvia "B" Light viscosity 8-13 penetrated the soil in the box seven-eighths of an inch. The maximum soil penetration was one and three quarter inches. The particles of gravel showed small tar deposits, and medium brown color throughout. The binding quality was not as good as the two Tarvia materials already mentioned.

Tarvia "A" float 100-150 @ 32 degrees Centigrade showed one-quarter of an inch maximum soil penetration, and no penetration in the box. The material formed in a semi-hard mass on the surface of the gravel.

Tarvia Retread viscosity 25-40 penetrated the soil in the box one-half inch. The maximum soil penetration was one and three-quarter inches. The color was uniform throughout showing bright shiny particles of gravel at the bottom and top. The binding quality was good.

Tarvia Retread (heavy) viscosity 60-65 penetrated the soil in the box one-quarter of an inch. The maximum soil penetration was one and one-quarter inches. The binding quality of the material was good, and the particles showed good tar deposits on the top and bottom.

Protectar Seal Coat viscosity 40-45 penetrated the soil in the box three-sixteenths of an inch. The maximum soil penetration was five-eighths inches. The material formed a solid mass on the top of the gravel.

Tarmac "P" Grade 1 viscosity 7-10 penetrated the soil in the box one inch. The maximum soil penetration was two inches. The color of the penetrated material was medium brown and the binding quality was fair.

Refined Water Gas Tar viscosity 7-10 penetrated the soil in the box one inch. The maximum soil penetration was two and one-half inches. The binding quality of the material was good with bright shiny deposits of tar at the top and bottom.

Stanolind Cut-Back for Cold Mix. viscosity 60-65 penetrated the soil in the box one-sixteenth of an inch. The maximum soil penetration was five-eighths of an inch. The binding quality of the material was hardly nothing because of the lack of penetration.

Stanolind Cut-Back Asphalt "AC" specific viscosity 50-100 penetrated the soil in the box one-sixteenth of an inch.

The maximum soil penetration was three-quarters of an inch. The binding quality was nothing due to no penetration.

Protectar Primer viscosity 2-3 penetrated through the soil in the box. The maximum soil penetration was greater than the depth of the tube. The binding quality of the material was almost nothing. The color was a medium brown throughout with small deposits of tar on the particles of gravel.

Bitumuls Primer viscosity 2-3 penetrated the soil in the box one-quarter of an inch. The maximum soil penetration was one inch. The binding quality of the material could not be considered because of the minimum penetration of the material.

Col-Pen Dust Cure viscosity 4-5 penetrated the soil in the box five-eighths of an inch. The maximum soil penetration was three-quarters of an inch. The binding properties were good with bright shiny particles throughout.

Col-Pen Dust Cure 1:1 mix viscosity 3-4 penetrated the soil in the box three-eighths of an inch. The maximum soil penetration was three-quarter inches. The color was dark dull brown throughout, showing very little deposits of tar on the particles.

Col-Pen Dust Cure 1:2 mix viscosity 3-4 was the same as the 1:1 mix.

HEA No. 3 viscosity 3-4 showed no penetration at all.

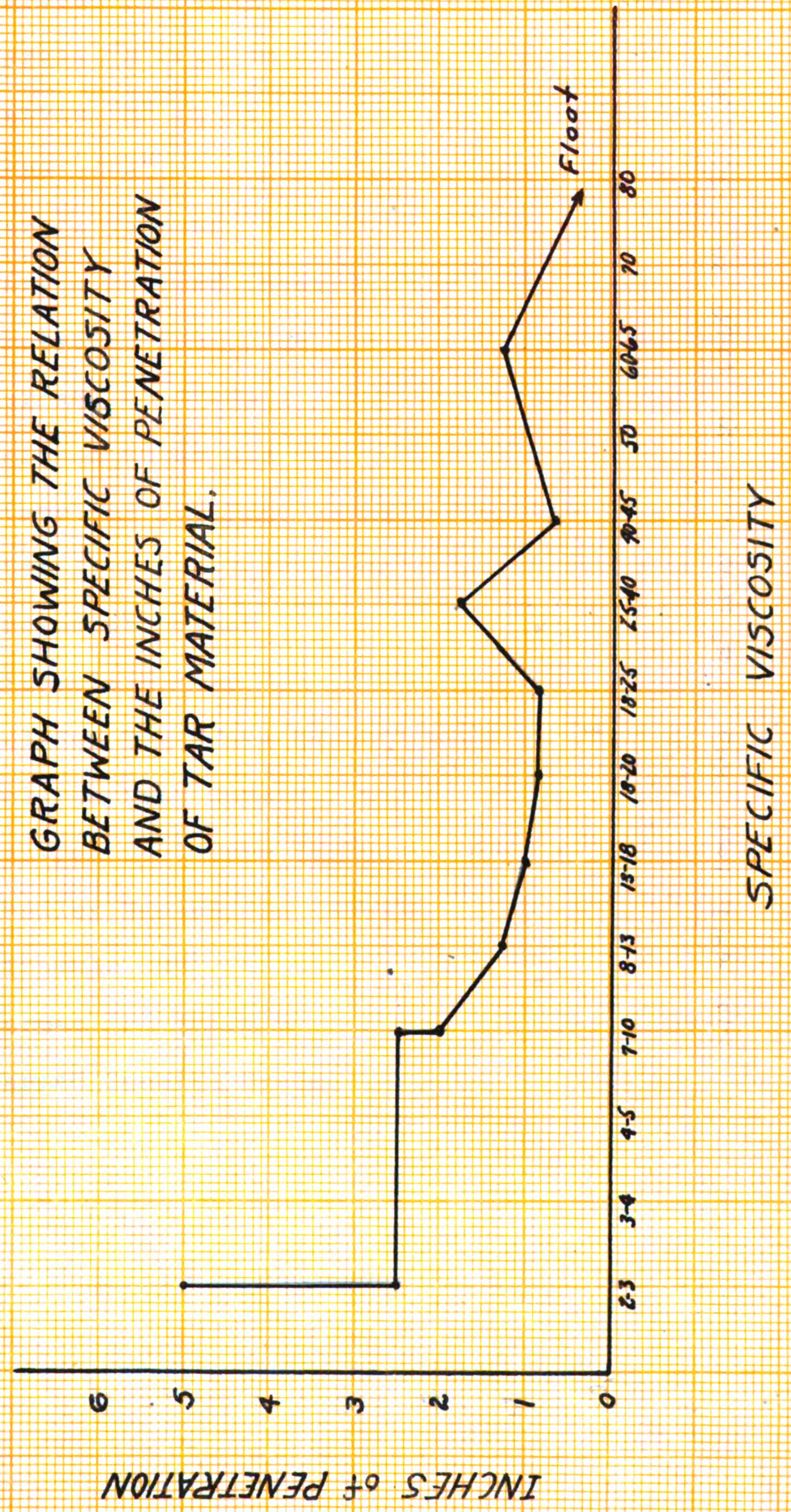
Bitumuls H R M Viscosity 4-5 did not penetrate the soil in either one of the tests.

Tarmac "P" Grade 4 viscosity 4-5 penetrated the soil in the box three-eighths of an inch. The maximum soil penetration was seven-eighths of an inch. The binding quality of the material was good and the particles of gravel showed bright and shiny throughout.

Tarmac Special viscosity 2-3 penetrated the soil in the box one and one-quarter inches. The maximum soil penetration was two and one-quarter inches. The color was uniform throughout with very small tar deposits on the particles of gravel. The binding quality of the material was almost nothing.

Sieve Analysis of Soil.

Retained on	1½ "	sieve	0	grams
" "	3/4 "	sieve	36.35	grams
" "	3/8 "	sieve	81.45	Grams
" "	No. 4	sieve	88.85	grams
" "	No. 8	sieve	55.95	grams
" "	No. 14	sieve	54.15	grams
" "	No. 28	sieve	44.70	grams
" "	No. 48	sieve	63.46	grams
" "	No.100	sieve	47.79	grams
" "	Pan		25.60	grams
	Total		499.30	


GRAPH SHOWING THE RELATION
BETWEEN SPECIFIC VISCOSITY
AND THE INCHES OF PENETRATION
OF TAR MATERIAL.
INCHES of PENETRATION
0
1
2
3
4
5
6
SPECIFIC VISCOSITY
2-3
3-4
4-5
7-10
8-13
13-18
18-20
18-25
25-40
40-45
50
60-6.5
70
80
Float

MATERIAL	PEN. IN BOX	MAX. SOIL PEN.
1. Tarvia "B" Heavy	3/4 in.	7/8 in.
2. Tarvia "B" Medium	1 "	1 "
3. Tarvia "B" Light	7/8 "	1 1/4 "
4. Tarvia "A"	0 "	1/4 "
5. Tarvia Retread	1/2 "	1 3/4 "
6. Tarvia Retread (heavy)	1/4 "	1 1/4 "
7. Protectar Seal Coat	3/16 "	5/8 "
8. Tarmac "P" Grade 1	3/4 "	2 "
9. Refined Water Gas Tar	1 "	2 1/2 "
10. Stanolind Cut-Back Asphalt Cold Mix	1/16 "	5/8 "
11. Stanolind Cut-Back Asphalt "AC"	3/8 "	3/4 "
12. Protectar Primer	2 1/2 "	5 "
13. Bitumuls Primer	1/4 "	1 "
14. Col-Pen Dust Cure concentrated	5/8 "	3/4 "
15. Col-Pen Dust Cure 1:1 mix	3/8 "	3/4 "
16. Col-Pen Dust Cure 1:2 mix	1/2 "	7/8 "
18. Headley Emulsified Asphalt	0 "	0 "
19. Bitumuls HRM	0 "	0 "
20. Tarmac "P" Grade 4	3/8 "	7/8 "
21. Tarmac Special Grade	1 1/4 "	2 1/2 "

CONCLUSION

In comparing the tar used in this experiment, it can be seen from the graph (page 11A) that as the specific viscosity increases the soil penetration decreases with the exception of the two Tarvia Retread materials with viscosities of 25-40 and 60-65. The two Retread materials show a large increase over the other materials with practically the same viscosity. In the picture graph (page 26) this fact can also be seen. Tube five represents Tarvia Retread viscosity 25-40 which shows an increase in soil penetration over the other materials with practically the same viscosity. The graph also shows a decrease in soil penetration as the viscosity increases until tube six is reached. When tube six is reached an increase in penetration is seen because of the Tarvia Retread material viscosity 60-65. The penetration is not as great as in the first case although it shows an increase in penetration over the other materials of a lower viscosity. Although the two Retread materials show an increase in soil penetration over the other materials of lower viscosity, the graph also shows a decrease in soil penetration as their viscosity increases. Therefore, I believe, it can be said that soil penetration varies with the viscosity of the material. A decrease in soil penetration shows an increase in viscosity and vice versa.

The binding quality of tar materials vary with the soil penetration. Some of the materials show good binding properties as they start to penetrate the soil, but as penetration increases the tar is filtered out by the soil and at the end of penetration there is nothing left of the original material but the fluxing compound.

The Protectar Primer penetrated through the box when applied according to the state specifications. The penetration was also through the tube in the maximum soil penetration test. Although the soil penetration of the material was good, the binding properties of the material was almost nothing. The material could be used as a dust layer, but for a binding compound something else would have to be used if good results are to be obtained.

Tarmac Special Grade showed good penetration in the box, but the binding quality was very little. The material on the top of the box was a dark brown in color, but as penetration increased the material changed in color to a light brown which showed some filtration of the tar. The material could be used to some extent as a dust layer, but where binding of the soil is required some other material should be used.

Refined Water Gas Tar showed good binding properties in the box. The material did not penetrate to a very great depth when applied according to state specifications, but when an excess of the material was used, good penetration was found. (See picture graph page 26). As the penetration increased it covered the particles with a good coating of tar which was bright and shiny. In breaking the material out of the box it could be noticed that the tar made a good binder because the particles of soil cohered and broke off in chunks. I believe that the material could be used as a binding compound if applied in excess quantity.

Tarmac "P" Grade 1 showed good penetration when applied in excess quantity, but when applied according to state specifications the penetration was medium as compared with the rest of the material used. The material covered the particles of soil well, and the color was uniform throughout penetration but the binding properties of the material were not very good. When samples of the soil were broken after penetration, the particles did not hold together as was expected but fell away from each other as though it were plain soil.

Tarvia "B" Light showed good uniform penetration in the box. The color was constant, and the particles showed good tar deposits at the bottom as well as at the top where the material was applied. The binding quality of the material was not very good because the particles of soil fell apart when touched. The material showed about the same binding qualities as Tarmac "P" Grade 1. The penetration of the two materials was about the same when applied in excess amounts.

and when applied according to state specifications.

Tarvia "B" Medium showed good uniform penetration with the color remaining the same throughout the test. The binding properties of the material was better than that of Tarvia "B" Light although the penetration was about the same when applied according to state specifications. When the material was applied in excess amounts the penetration was not as great as in the case of the Tarvia "B" Light. The soil covered with Tarvia "B" Medium cohered better than it did when covered with Tarvia "B" Light. The coating of tar on the particles was also better when Tarvia "B" Medium was used. I believe that Tarvia "B" Medium could be used to some extent as a good penetration binding material.

Tarmac "P" Grade 4 showed about the same binding properties as Tarvia "B" Medium. The color of the penetrated material was blacker and more shiny at the bottom than it was when Tarvia "B" Medium was used. The particles of soil showed more tar deposits than the particles of soil did in the preceding example. When the soil was broken out of the box after penetration, the unpentrated soil could be easily broken away from the tar covered soil without the tar covered soil crumbling. When pressure was applied to the tar covered soil, it took considerable pressure between the fingers to break the particles apart. The penetrating ability of the two materials, Tarmac "P" Grade 4 and Tarvia "B" Medium, was about the same when applied in excess amounts, but when applied according to state specifications the penetrating ability of the Travia "B" Medium was much greater then the Tarmac material.

Tarvia "B" Heavy showed good penetration. The color was uniform throughout the penetrated soil, but the particles of soil did not show the bright and shiny color as in the case of the Tarmac "P" Grade 4. The binding quality of the material was good, and the particles of soil cohe red when the sample was broken out of the box. The penetrating ability of the two materials was about the same when applied in excess amounts and when applied according to state specifications.

Tarvia Retread showed good penetration when applied in excess amounts, but when applied according to state specifications the penetration was not as good as Tarvia "B" Medium. The color after penetration was uniform throughout with bright shiny particles of tar covered soil. The binding property was stronger than that of Tarvia "B" Heavy, and it also had about the same binding qualities as Tarmac "P" Grade 4.

Protectar Seal Coat is not the kind of a material to be used where penetration is required. When the material was applied according to state specifications, it hardened on the top of the soil and could be pealed off with very little difficulty. The penetration when applied in an excess amount was very little.

Tarvia Retread (heavy) viscosity 60-65 showed good penetration when applied in excess amounts, but when applied according to state specifications the penetration was very small. The binding properties of the material were good with uniform color throughout which showed good deposits of tar on the particles of soil.

Tarvia "A" showed very little penetration in either case. This material should not be used where penetration is required.

The asphalic material showed very little penetration in all but two cases. The material when applied according to state specifications hardened on the surface of the soil and penetrated very little. The maximum soil penetration was very little; ranging from zero as a minimum to one inch as a maximum. The binding properties were good in most cases where penetration occurred with the exception of the 1:1 mix and the 1:2 mix of the Col-Pen material. In these two cases, the material was a medium brown in color after penetration had reached a maximum, and the binding properties were very little.

Bitumuls Primer showed very little penetration with most of the material staying on the top of the soil. The binding properties of the material were good as far as the material penetrated, but it did not penetrate far enough to be considered as a penetrating binding material.

Col-Pen Dust Cure mixed one part material and one part water showed good penetration when applied according to state specifications, but the binding quality was very little.

Col-Pen Dust Cure mixed one part of material to two parts water showed the same reaction as the 1:1 mix.

Headley Emulsified Asphalt No. 3 showed no penetration in either the maximum soil penetration test or in the boxes.

Col-Pen Dust Cure concentrated showed good binding properties, forming a bright shiny mixture at the end of penetration. Although the binding properties were good the material did not penetrate far enough to be of any value as a penetrating binding material.

Bitumuls HRM showed no penetration in either of the two tests.

Stanolind Cut-Back Asphalt for Cold Mix showed very little penetration in either of the two tests. The material formed on the top of the soil in a solid mass.

Stanolind Cut-Back Asphalt "AC" performed the same as the Cold Mix Asphalt.

In comparing the two kinds of material, tar and asphalt, tar is the material to be used where penetration is needed.

The asphalt material will not penetrate the soil to a depth that will cause good binding of the particles. Therefore, soil penetrating ability as compared to an asphaltic material is almost zero while the soil penetrating ability of a tar product depends upon the viscosity of the material.

1- Tarvia "B" Heavy maximum soil penetration 7/8 in.

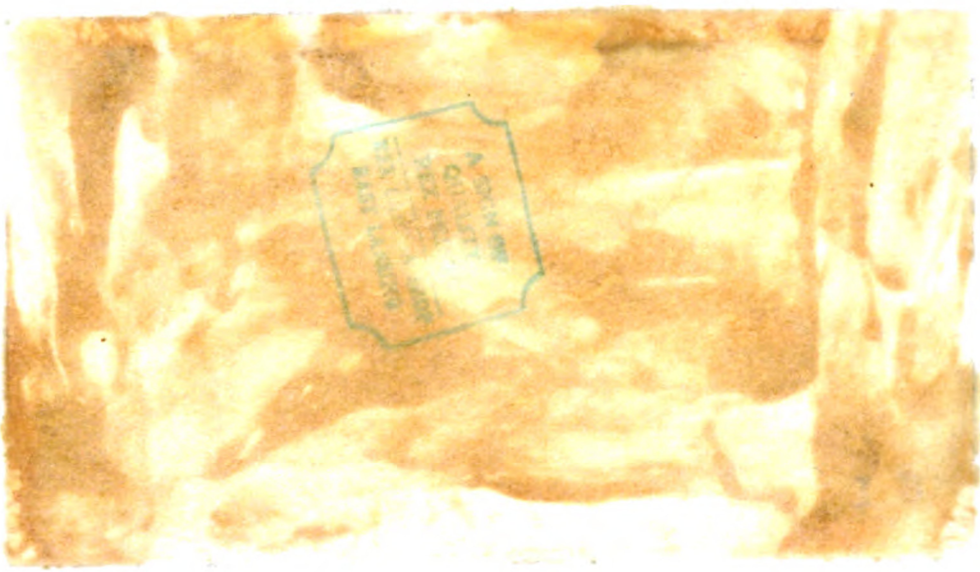
2- Tarvia "B" Medium " " " 1 in.

3- Tarvia "B" Light " " " 1 1/4 in.

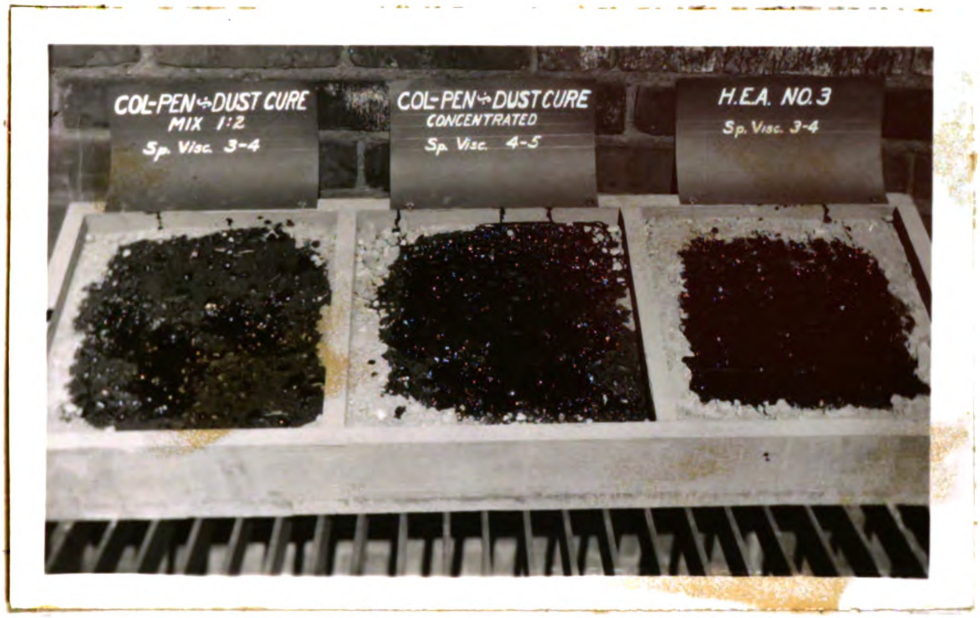
Tarvia "A" maximum soil penetration		1/4 in.
Tarvia Retread " " "		1 3/4 in.
Tarvia Retread " " "		1 1/4 in.

Protectar Seal Coat maximum	soil	penetration		5/8 in.
Tarmac "P" Grade 1	"	"	"	2 in.
Refined Water Gas Tar	"	"	"	2 1/2 in.

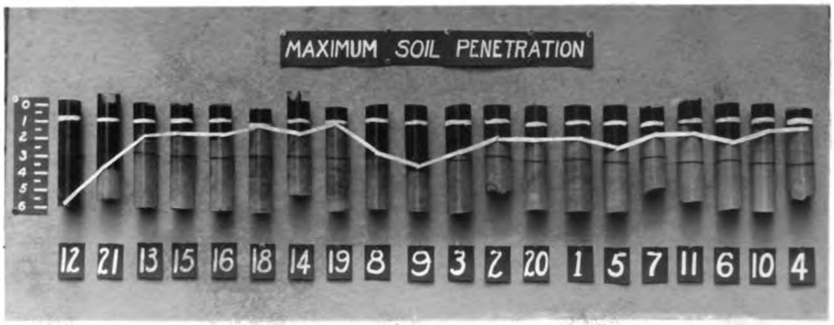
Stanolind Cut-Back Asphalt for Cold Mix maximum soil penetration	5/8 in.
Stanolind Cut-Back Asphalt "AC" maximun soil penetration	3/4 in.
Protectar Primer maximum soil penetration	5 1/2 in.
Tarmac Special " " "	2 1/2 in.
Tarmac "P" Grade 4 " " "	7/8 in.
Bitumuls HRM " " "	0 in.



Bitumuls Primer maximun soil penetration	1 in.
Col-Pen Dust Cure conc. maximum soil penetration	3/4 in.
Col-Pen Dust Cure 1:1 mix " " "	3/4 in.



Col-Pen Dust Cure 1:2 mix	maximum	soil	penetration	7/8	in.
Col-Pen Dust Cure conc.	"	"	"	3/4	in.
Headley Emulsified Asphalt	"	"	"	0	in.



		Penetration
1.	Tarvia "B" Heavy	7/8 in.
2.	Tarvia "B" Medium	1 in.
3.	Tarvia "B" Light	1 1/4 in.
4.	Tarvia "A"	1/4 in.
5.	Tarvia Retread	1 3/4 in.
6.	Tarvia Retread (heavy)	1 1/4 in.
7.	Protectar Seal Coat	5/8 in.
8.	Tarmac "P" Grade 1	2 in.
9.	Refined Water Gas Tar	2 1/2 in.
10.	Stanolind Cut-Back Asphalt Cold Mix	5/8 in.
11.	Stanolind Cut-Back Asphalt "AC"	3/4 in.
12.	Protectar Primer	5 1/2 in.
13.	Bitumuls Primer	1 in.
14.	Col-Pen Dust Cure conc.	3/4 in.
15.	Col-Pen Dust Cure 1:1 mix	3/4 in.
16.	Col-Pen Dust Cure 1:2 mix	7/8 in.
18.	Headley Emulsified Asphalt No. 3	0 in.
19.	Bitumuls HRM	0 in.
20.	Tarmac "P" Grade 4	7/8 in.
21.	Tarmac Special Grade	2 1/2 in.

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18

[redacted]

Pocket empty as of
4/2011