NATIONAL BUREAU OF STANDARDS REPORT

5432

WATER ABSORPTION OF ASPHALT-ADDITIVE COATINGS

by

Sidney H. Greenfeld

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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WATER ABSORPTION OF ASPHALT-ADDITIVE COATINGS

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ABSTRACT

Forty-nine specimens of asphalt and additive coatings, the durability and characteristics of which were reported in BMS-147 (1)[1], were immersed in distilled water, and water-absorption characteristics were determined over a period of 2100 days. All of the specimens absorbed water progressively and approximately logarithmically with time, the additive coatings more rapidly than the asphalt coatings. The absorption seemed to be controlled by the diffusion of the water into the specimens. The specific gravities of the asphalt coatings increased during absorption, indicating the displacement of a light material, while those of the additive coatings decreased.

Several months were required to dry the specimens to constant weight at 120°F. Most of the coatings retained a permanent gain of somewhat less than one percent, while twelve, all with California asphalt, lost some weight. Like the absorption, the drying was controlled by the diffusion of the water through the specimens.

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1. INTRODUCTION

In the course of the investigation of the "Effects of Mineral Additives on the Durability of Coating-Grade Roofing Asphalts" (1), the water-absorption characteristics of the coatings were determined. As coatings on shingles these materials would ordinarily not be maintained in a continuously wet condition for more than about two weeks at a time. After a relatively short period of

[1] Numbers in parentheses refer to references tabulated in the Bibliography section of this report.

exposure to the weather, the coatings would become somewhat more porous and it is expected that the water absorption would increase. However, there is the possibility of using asphalt coatings such as these for waterproofing tanks or vats. Then the long-term water-absorption characteristics would be of interest.

2. MATERIALS AND METHODS

The asphalts and mineral additives are the same as those reported in BMS-147 (1). Half-way through the exposure-panel making procedure reported in BMS-147, a water-absorption test specimen (a disk 3 inches in diameter and 3/16 inch thick) was made in a brass mold.[2/] This specimen was submerged under 1/4 inch of distilled water with 48 others, representing the three asphalts and additive coatings containing 35, 50 and 60 percent blue black slate, Niagara dolomite, low carbon fly ash and Lake Erie silica, 35 and 50 percent Florida clay and 35% Tennessee mica. The specimens were all weighed periodically in a surface-dry condition. Specific gravity determinations were made before exposure and at approximately 600 and 2100 days of submersion.

After the final specific gravity measurements were made, the specimens were permitted to dry in front of an electric fan. They lost weight very slowly, and after a week, were placed in a vacuum desiccator at about 10 mm. pressure and room

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[2/] The detailed procedure is in the Appendix.

temperature. The rate of weight loss increased for a short period, but then dropped back to almost nothing. After six weeks the specimens were placed in an air oven at 100°F. Three weeks later the temperature was raised to 120°F. The specimens were removed as they attained constant weight.

3. RESULTS AND DISCUSSION

The experimental data on the absorption of water by 51 coatings are presented in Table 1, expressed as weight of water absorbed per square foot of surface area. Specific gravity and volume change data are also included. The drying data and the appearance of the specimens at the conclusion of the study are presented in Table 2. The water-absorption data have been plotted on logarithmic graph paper and the graphs are appended to this report.

When asphalt or additive coatings are submerged in water they gain weight. The rate at which they absorb water is related to the size and shape of the specimen as well as to the source of the asphalt and kind of additive present. Pfeiffer (2) reported that water may be absorbed by bitumen in three ways:

1. By normal solubility, which is of the order of about 0.001 to 0.01 percent.
2. By osmotic pressure cell formation, resulting from the presence of small pockets of inorganic, water-soluble salts. The water absorbed by this mechanism is theoretically infinite.

3. By the presence of hydrophilic additives. The absorption is limited by the nature of the additive.

Close study of Table 1 and the water-absorption curves in the Appendix shows that all of the coatings absorbed water progressively with time. In all instances, the water absorption was far in excess of 0.01 percent, eliminating mechanism 1. as the dominant procedure by which the water was absorbed.

In some specimens it was quite evident that disproportionately large quantities of water were absorbed locally because blisters and spongy spots formed in the disk. In others, little change was noted in appearance. Thus, mechanism 2. is probably functioning. In those coatings containing additives, there was a wide variation of absorption with both type and quantity of additive.

The gain in weight of all of the coatings was approximately logarithmic over a long period of time. After several hundred days of submersion the absorption in many of the coatings continued in a rather haphazard and unpredictable manner.

About half of these coatings, as indicated in Table 1, were accidentally partially uncovered for short periods of time on one or more occasions during the course of this study.

Once resubmerged, however, the specimens rapidly regained any loss that might have occurred. Since coating grade asphalts are rarely submerged for relatively long periods of time, when used in roofing, the lower portions of the curves are of most interest.

Of the three asphalts, two have logarithmic absorptions indicating that the rate of absorption is controlled by the diffusion of the moisture into the specimen. Similarly, many of the additive coatings exhibit absorption of this type. However, the absorptions of the Mid-Continent asphalt and the other additive coatings are not linear with time on logarithmic graph paper and, therefore, are not entirely controlled by diffusion into the specimen.

Pfeiffer (2) reported that the moisture content of bitumen layers decreases rapidly from the surface into the coating. He quotes concentrations of 6 percent in the surface 1.5 mm. of a specimen, 2 percent in the next 1.5 mm., and 1.5 percent in the third 1.5 mm. strata of a blown asphalt that had absorbed between 3 and 4 percent of water. This may be taken as confirmation of the dependence of absorption on diffusion into the specimens.

With but one exception the additive coatings absorbed at a more rapid rate than their corresponding asphalt coatings. The absorption usually increased with concentration for each

type of mineral matter once the variations produced by small imperfections in the coatings were filled. (Because the coatings containing mica or the higher concentrations of some of the other minerals were very viscous it was not possible to eliminate all of the air pockets in the specimens. In some cases, this condition produced a high initial absorption. However, especially in this specimens containing mica, the rate of absorption soon changed to what might be considered normal.)

The increased absorption produced by the presence of mineral matter may be the result of the greater ease of movement of water along the mineral-asphalt interface than through the asphalt or, as Pfieffer (2) suggests, of the nature of the mineral itself.

The order of absorption of the various coatings is recorded in Table 3, both at 28 days of immersion and at the time the study was discontinued. While there were differences in the coatings that could be attributed to the asphalts, the asphalts themselves were always the lowest absorbers. The specimen containing 35 percent mica in California asphalt obviously had air pockets that were displaced by water soon after immersion, for by the end of the study its absorption was next to the lowest, as in the cases of the other asphalts.

Before immersion and at 600 and about 2100 days, specific gravity determinations were made of all of the specimens. In all instances the specific gravities of the asphalts increased and those of the additive coatings decreased with the time of immersion. Because of the additive nature of the density function, the latter is readily understood, but it is difficult to explain how addition of water to asphalt can increase the specific gravity of the specimen above unity, except by the displacement of some less-dense material. If this material were permanently displaced, it would become apparent when the specimens were dried.

On the assumption that there are no voids or soluble components in the specimens, the change in weight of each specimen would be paralleled by a like change in volume. Comparison of the corresponding weight and volume increases at 600 and about 2100 days, in Table 1, shows that this correspondence is not always present. As a matter of fact, within experimental error, it exists in only about 40 percent of the specimens. In about 30 percent of the specimens, the volume increase is less than the weight increase, indicating that the water displaced a lighter material. In the other instances, the coatings swelled more than expected. These variances were distributed among the coatings irrespective of the asphalts.

When the specimens were removed from the water after about 2100 days of immersion, they had absorbed up to 25 percent of their original weight of water. Many of them had blistered and cracked to relieve the strains set up by this absorption.

The specimens were dried in front of an electric fan for four days. Because the rate of weight loss dropped off rapidly after the second day, the specimens were placed in a vacuum desiccator. The rate increased to about its initial value, but again declined rapidly. It became obvious that changing these ambient conditions only affected the moisture near the surface, and the drying, like the absorption, was controlled by the diffusion of the moisture through the specimens. Since the only variable that influences diffusion that can be readily varied is temperature, the specimens were placed in an air oven at 100-120°F. and dried over a period of several months to constant weight or until the specimens began to gain weight. The minimum weight was recorded as the final weight.

Twelve of the 49 specimens underwent a net loss in weight of between 0.01 and 0.99 percent. All of these were made with California asphalt. Five of the California specimens and all of the others had a permanent increase in weight of up to 1.07 percent. The largest permanent gains in coatings from each

asphalt were in the specimens containing blue black slate. However, there was no relation between concentration and permanent gain.

Many of the specimens were apparently unchanged by the long periods of immersion and drying. However, others were changed appreciably and were obviously in bad condition. Several lost their surface luster and had many cracks. A few continued to show the blisters that had formed during immersion. Many of the specimens shrunk from their original diameters, but only two expanded. Thus, while the coatings returned to nearly their original weight, in many cases the water did permanent damage to them.

4. BIBLIOGRAPHY

(1) Greenfeld, S. H., "Effects of Mineral Additives on the Durability of Coating-Grade Roofing Asphalts", B.M.S. Report No. 147, National Bureau of Standards, September 1956.

(2) Pfeiffer, J. P., "The Properties of Asphaltic Bitumen", pp. 107, 270-272, Elsevier Publishing Company, New York, 1950.

5. APPENDIX

5.1 Water-Absorption Procedure

Application:

This method is applicable to all asphalts having softening points (ring and ball) of 170°F. or over.

Apparatus and Materials Required:

1. Brass mold, 3/16-in.-thick, 3-in.-diameter hole.
2. Brass plate, 4 by 4 in.
3. Glycerine.
4. Hotplate.
5. 100 g of asphalt to be tested.
6. Pyrex-glass tray, 1-1/2 in. deep, any convenient length and width.
7. Distilled water.

Preparation of Specimen:

Apply glycerine to the surfaces of the clean brass plate and mold, which will come in contact with the asphalt. Assemble the mold and place it on the brass plate. Heat the sample of asphalt to be tested until fluid and free from air bubbles. If the sample contains mineral matter, it should be stirred slowly with a piece of stiff wire to keep the matter properly suspended without incorporating air bubbles.

Pour a sufficient amount of the sample to fill the mold. The pouring must be done in a manner such that air bubbles are not occluded. The surface may be flamed lightly to remove a few that might form. Not more than 1/16 in. of the sample should show above the top of the mold. After the specimen has cooled thoroughly, remove it from the mold and wash it to remove the attached glycerine. Allow the specimen to dry and mark identification on both sides.

Procedure:

Weigh the specimen to 0.001 g and record the weight. Place the specimen in the glass tray and fill it with sufficient distilled water to submerge the specimen at least 1/4 in. Place the glass tray and specimen in a dark cabinet at room temperature.

Make periodic weighings in the following manner to determine the amount of water absorbed:

Remove the specimen from the water at the end of each specified period. Do not wipe, but blot both sides and edges carefully until each surface is an uniformly dry as possible. Weigh the specimen and record the weight. Return the specimen to the distilled water tray. Renew with fresh water at each weighing.

Compute the water absorbed, and convert the result to grams of water absorbed per square foot of asphalt surface exposed, including the edges of the disk.

5.2 Water-Absorption Graphs

Following are graphs of the water absorptions of the 49 asphalt and additive coatings.

The Project gratefully acknowledges the drawing of the water-absorption graphs by Mr. J. L. Strahan, Technical Director of the Asphalt Roofing Industry Bureau.

Coati Descrip
California A
35% BBS
50% BBS
60% BBS
35% Clay
50% Clay
60% Clay
35% Dolomi
50% Dolomi
60% Dolomi
35% Fly As
50% Fly As
60% Fly As
35% Mica
35% Silica
50% Silica
60% Silica
Mid-Contine
35% BBS
50% BBS
60% BBS
35% Clay
50% Clay
35% Dolomi
50% Dolomi
60% Dolomi
35% Fly As
50% Fly As
60% Fly As
35% Mica
35% Silica
50% Silica
60% Silica

TABLE 1. WATER ABSORPTION DATA

Coating Description	Water Absorbed at, Days												Specific Gravity			Volume Change at	
	7	14	28	100	200	400	600	1000	1350	1700	Final	Time	Initial	600 Days	Final	600 Days	Final**
	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	Days				cc/ft²	cc/ft²
California Asphalt	0.285	0.475	0.670	1.43	2.35	3.58	4.62	6.55	8.30	9.15*	10.9	2113	1.015	1.017	1.025	4.11	8.78
35% BBS	0.372	0.529	0.773	1.86	3.30	5.55	6.43	9.40	12.8	13.1*	16.4	2105	1.32	1.304	1.296	7.07	16.00
50% BBS	0.407	0.607	0.920	2.46	5.00	8.54	11.9	18.8	25.5	25.9*	32.3	2113	1.51	1.481	1.451	12.37	31.27
60% BBS	0.410	0.613	0.923	2.64	5.49	9.22	13.0	20.0	27.0	24.0*	30.1	2113	1.68	1.634	1.597	13.72	29.39
35% Clay	0.517	0.847	1.323	2.80	5.01	7.20	7.50	10.4	17.3	23.2	28.8	2079	1.30	1.295	1.272	5.83	22.71
50% Clay	0.585	1.006	1.378	3.82	6.43	9.12	11.9	19.0	27.4	24.3*	31.4	2086	1.47	1.455	1.425	10.44	28.73
60% Clay	0.674	1.181	2.038	4.92	8.71	11.9	11.8*	18.3	25.4	29.5	33.6	2079	1.61	1.591	1.548	12.53	30.78
35% Dolomite	0.430	0.622	0.882	2.25	4.30	7.01	9.27	11.8	14.7	15.3	18.3	2100	1.31	1.288	1.279	10.03	18.40
50% Dolomite	0.396	0.661	1.068	2.86	5.53	8.41	11.0	14.8	18.1	19.1*	22.8	2092	1.50	1.459	1.435	12.11	23.32
60% Dolomite	0.502	0.838	1.297	3.36	6.95	10.8	14.5	18.6	23.1	25.6*	31.0	2092	1.66	1.602	1.554	8.94	25.11
35% Fly Ash	0.448	0.662	0.952	6.00	28.9	55.0	68.8	73.5	78.3	77.9*	87.5	2113	1.29	1.201	1.194	73.1	90.20
50% Fly Ash	0.503	0.743	1.115	6.90	37.2	61.4	72.0	72.5*	77.7	75.4*	87.0	2113	1.46	1.316	1.304	75.4	87.79
60% Fly Ash	0.493	0.739	1.139	7.40	27.0	45.3	52.5	56.5	63.9	71.7*	64.9	2092	1.60	1.457	1.442	55.8	66.99
35% Mica	1.670	1.883	2.047	3.00	4.26	5.40	6.32	7.50	9.77	9.96*	12.2	2086	1.33	1.308	1.309	8.58	12.23
35% Silica	0.267	0.391	0.639	1.50	2.80	7.00	8.30*	9.50	10.3	16.0	24.4	2079	1.30	1.299	1.275	2.94	22.81
50% Silica	0.278	0.447	0.726	1.70	3.40	3.90	3.80*	23.1	35.5	44.3	54.1	2079	1.47	1.464	1.435	6.52	42.38
60% Silica	0.289	0.446	0.726	1.80	5.00	12.7	14.5*	26.5	37.5	44.0	52.3	2072	1.62	1.578	1.495	14.02	50.23
Mid-Continent Asphalt	0.131	0.262	0.432	1.01	1.70	2.58	2.93	3.34	4.00	4.19*	4.99	2155	0.999	1.006	1.011	1.63	2.79
35% BBS	0.238	0.475	0.697	1.56	2.68	4.52	5.58	7.42	9.80	11.2*	14.9	2155	1.30	1.288	1.281	6.28	14.59
50% BBS	0.513	0.630	0.913	1.94	3.46	5.86	7.46	11.3	16.4*	19.7*	26.8	2134	1.49	1.483	1.449	6.10	24.17
60% BBS	0.293	0.612	0.994	2.40	4.62	8.63	12.0	21.0	33.0*	38.8*	51.1	2141	1.66	1.611	1.529	14.34	51.97
35% Clay	0.575	0.869	1.421	2.82	4.05	4.98	5.68	6.90	7.80*	9.00*	10.3	2072	1.28	1.275	1.274	5.27	8.92
50% Clay	0.874	1.329	2.176	4.30	6.23	7.70	7.75*	12.3	16.9	21.0	24.2	2072	1.45	1.436	1.414	10.12	24.99
35% Dolomite	0.300	0.541	0.855	1.95	3.45	5.13	6.09	7.10	8.90	10.1	12.2	2127	1.29	1.269	1.267	7.99	13.28
50% Dolomite	0.480	0.731	1.152	2.54	4.57	6.56	8.12	8.90	11.7	12.7	16.5	2120	1.48	1.451	1.438	9.59	17.31
60% Dolomite	0.593	0.881	1.412	3.17	5.70	8.20	10.2	13.1	16.4*	19.1*	23.7	2120	1.64	1.596	1.561	11.75	24.96
35% Fly Ash	0.414	0.586	0.883	2.00	4.25	8.25	12.7	20.6	28.1	34.2*	43.1	2134	1.27	1.226	1.199	16.61	46.06
50% Fly Ash	0.492	0.718	1.076	2.58	6.55	16.6	27.0	37.1	46.6	55.3*	65.3	2134	1.44	1.355	1.306	31.68	68.80
60% Fly Ash	0.516	0.852	1.232	2.80	8.75	26.1	34.4	40.6	47.4	54.6*	63.6	2127	1.58	1.474	1.432	39.97	68.43
35% Mica	0.425	0.593	0.827	1.54	2.33	3.30	3.92	4.83	5.32*	5.65	6.68	2127	1.31	1.285	1.285	7.02	9.20
35% Silica	0.232	0.348	0.556	1.18	2.03	2.90	3.28	4.24	5.42*	6.43*	8.41	2120	1.28	1.266	1.265	4.85	8.96
50% Silica	0.274	0.401	0.620	1.30	2.23	3.12	3.75	5.56	9.90*	12.1*	15.6	2120	1.45	1.446	1.428	3.22	14.18
60% Silica	0.247	0.424	0.652	1.38	2.52	3.59	4.43	8.35	14.7*	16.8	22.8	2120	1.60	1.605	1.546	8.26	21.91

(Continued on next page)

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TABLE 1. WATER ABSORPTION DATA (Continued)

Coating Description	Water Absorbed at, Days												Specific Gravity			Volume Change at	
	7	14	28	100	200	400	600	1000	1350	1700	Final	Time	Initial	600 Days	Final	600 Days	Final**
	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	g/ft²	Days				cc/ft²	cc/ft²
Venezuela Asphalt	0.160	0.222	0.327	0.68	1.13	1.72	2.05	2.45	3.02	3.46	4.06	2176	1.018	1.025	1.031	0.852	1.94
35% BBS	0.214	0.346	0.534	1.30	2.22	3.91	4.77	6.82	9.11	11.4	14.9	2176	1.32	1.303	1.293	5.34	15.04
50% BBS	0.238	0.447	0.662	1.73	3.15	5.74	7.45	11.8	16.9	22.0	30.8	2176	1.51	1.485	1.435	7.68	30.15
60% BBS	0.235	0.379	0.704	1.95	3.71	7.20	10.1	18.8	28.5	37.7	51.1	2169	1.68	1.638	1.549	11.69	51.25
35% Clay	0.754	1.508	1.875	3.01	4.20	5.13	8.18	14.1	17.9	22.5	26.2	2065	1.30	1.290	1.271	7.60	24.63
50% Clay	0.650	1.298	1.910	4.00	5.90	7.08	9.07	11.4	16.0	18.7	21.2	2065	1.47	1.464	1.439	7.32	19.31
35% Dolomite	0.173	0.420	0.906	1.80	2.92	3.46	5.27	6.80	8.20	9.50	11.2	2155	1.31	1.284	1.279	7.91	13.04
50% Dolomite	0.357	0.607	1.147	2.31	3.86	5.77	7.00	9.30	11.2	13.0	15.7	2155	1.50	1.472	1.454	8.66	16.77
60% Dolomite	0.403	0.805	1.260	2.72	4.70	7.30	8.96	11.8	14.5	17.2	21.0	2155	1.66	1.620	1.586	10.16	21.87
35% Fly Ash	0.294	0.437	0.699	1.65	3.00	6.60	9.40	21.7	35.3	42.5	51.2	2169	1.29	1.257	1.214	12.00	52.78
50% Fly Ash	0.376	0.525	0.929	2.10	4.75	11.9	16.4	28.8	40.3	49.0	59.1	2169	1.46	1.394	1.336	21.64	63.09
60% Fly Ash	0.398	0.665	1.078	2.20	4.90	13.2	19.3	29.3	40.4	48.4	56.3	2162	1.60	1.522	1.451	22.70	58.35
35% Mica	0.185	0.369	0.515	1.19	1.72	2.55	3.03	3.86	4.67	5.35	6.17	2155	1.33	1.306	1.308	5.38	8.12
35% Silica	0.240	0.480	0.630	1.21	1.92	2.56	3.00	8.30	13.8	18.6	23.3	2065	1.30	1.302	1.272	1.93	22.40
50% Silica	0.318	0.424	0.593	1.28	2.03	2.75	2.75*	7.00	12.1	16.4	20.9	2051	1.47	1.463	1.423	2.76	20.19
60% Silica	0.280	0.381	0.594	1.36	2.15	3.11	4.33	10.6	17.2	23.0	28.7	2051	1.62	1.616	1.555	2.90	27.05

*Specimens were not completely submerged during entire period between weighings.
**See column 13 for number of days of submersion.

TABLE 2. DRYING DATA*

Coating	Orig. Wt.	Final Wt.	Change	% Change	Description
California Asphalt	20.678	20.672	-0.006	-0.03	Unchanged.
35% BBS	25.837	25.943	+0.106	+0.41	Slight shrinkage.
50% BBS	37.416	37.523	+0.107	+0.29	Few cracks.
60% BBS	38.185	38.313	+0.128	+0.34	Few cracks, shrinkage.
35% Clay	28.357	28.297	-0.060	-0.21	Shrinkage.
50% Clay	35.355	35.344	-0.011	-0.04	Unchanged.
60% Clay	41.060	40.971	-0.089	-0.22	Slight shrinkage.
35% Dolomite	23.993	23.908	-0.085	-0.35	Slight shrinkage.
50% Dolomite	26.478	26.380	-0.098	-0.37	Slight shrinkage.
60% Dolomite	30.338	30.158	-0.180	-0.59	Shrinkage.
35% Fly Ash	30.333	30.111	-0.222	-0.73	Blistered, expanded.
50% Fly Ash	30.360	30.060	-0.300	-0.99	Blistered.
60% Fly Ash	36.182	36.025	-0.157	-0.43	Shrinkage, cracked.
35% Mica	34.375	34.602	+0.227	+0.66	Slight shrinkage.
35% Silica	27.014	27.016	+0.002	+0.01	Slight shrinkage.
50% Silica	31.332	31.245	-0.087	-0.28	Unchanged.
60% Silica	32.644	32.546	-0.098	-0.30	Slight shrinkage.
Mid-Continent Asphalt	19.387	19.537	+0.150	+0.78	Slight shrinkage.
35% BBS	28.890	29.120	+0.230	+0.80	Fine cracks.
50% BBS	33.447	33.742	+0.295	+0.88	Fine cracks.
60% BBS	40.742	41.102	+0.360	+0.88	Cracked, dull.
35% Clay	25.915	26.117	+0.202	+0.78	Unchanged.
50% Clay	32.321	32.450	+0.129	+0.40	Slight shrinkage.
35% Dolomite	27.877	27.986	+0.109	+0.39	Fine cracks.
50% Dolomite	32.563	32.616	+0.053	+0.16	Unchanged.
60% Dolomite	35.236	35.277	+0.041	+0.12	Fine cracks.
35% Fly Ash	23.620	23.775	+0.155	+0.66	Shrinkage, cracked.
50% Fly Ash	29.066	29.242	+0.176	+0.61	Fine cracks, dull.
60% Fly Ash	42.065	42.109	+0.044	+0.10	Cracked, shrinkage, dull.
35% Mica	30.376	30.550	+0.174	+0.57	Unchanged.
35% Silica	26.731	26.897	+0.166	+0.62	Unchanged.
50% Silica	33.616	33.820	+0.204	+0.61	Unchanged.
60% Silica	36.250	36.306	+0.056	+0.15	Unchanged.

(Continued on next page)

TABLE 2. DRYING DATA* (Continued)

Coating	Orig.	Final	Change	% Change	Description
Venezuela Asphalt	17.708	17.866	+0.158	+0.89	Unchanged.
35% BBS	24.348	24.544	+0.196	+0.80	Unchanged.
50% BBS	27.161	27.453	+0.292	+1.07	Many fine cracks.
60% BBS	41.218	41.514	+0.296	+0.72	Cracked, shrinkage, dull.
35% Clay	25.131	25.312	+0.181	+0.72	Slight shrinkage.
50% Clay	35.501	35.631	+0.130	+0.37	Unchanged.
35% Dolomite	25.717	28.832	+0.115	+0.45	Unchanged.
50% Dolomite	31.244	31.290	+0.046	+0.15	Slight shrinkage.
60% Dolomite	33.751	33.770	+0.019	+0.06	Unchanged.
35% Fly Ash	23.892	23.997	+0.105	+0.44	Few cracks, shrinkage.
50% Fly Ash	32.974	33.063	+0.089	+0.28	Cracked, slight shrinkage, dull.
60% Fly Ash	33.542	33.696	+0.154	+0.46	Cracked, shrinkage, dull.
35% Mica	30.917	31.089	+0.172	+0.56	Unchanged.
35% Silica	26.668	26.805	+0.137	+0.51	Fine cracks.
50% Silica	27.007	27.073	+0.067	+0.25	Slight shrinkage.
60% Silica	37.150	37.232	+0.082	+0.22	Slight expansion.

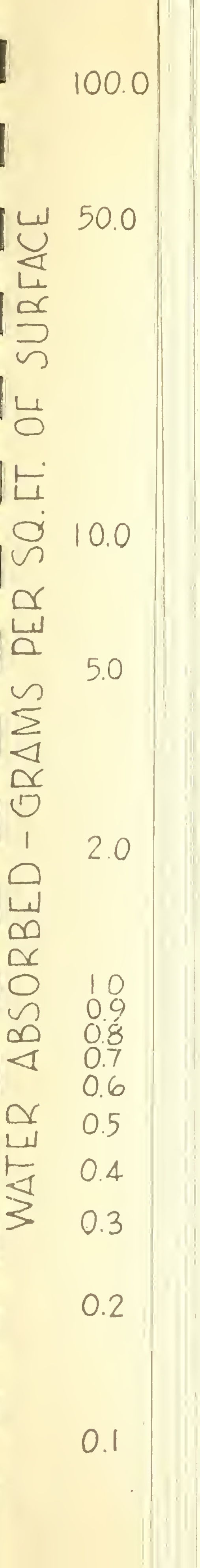
*After over 2100 days of immersion in distilled water and being dried to constant weight.

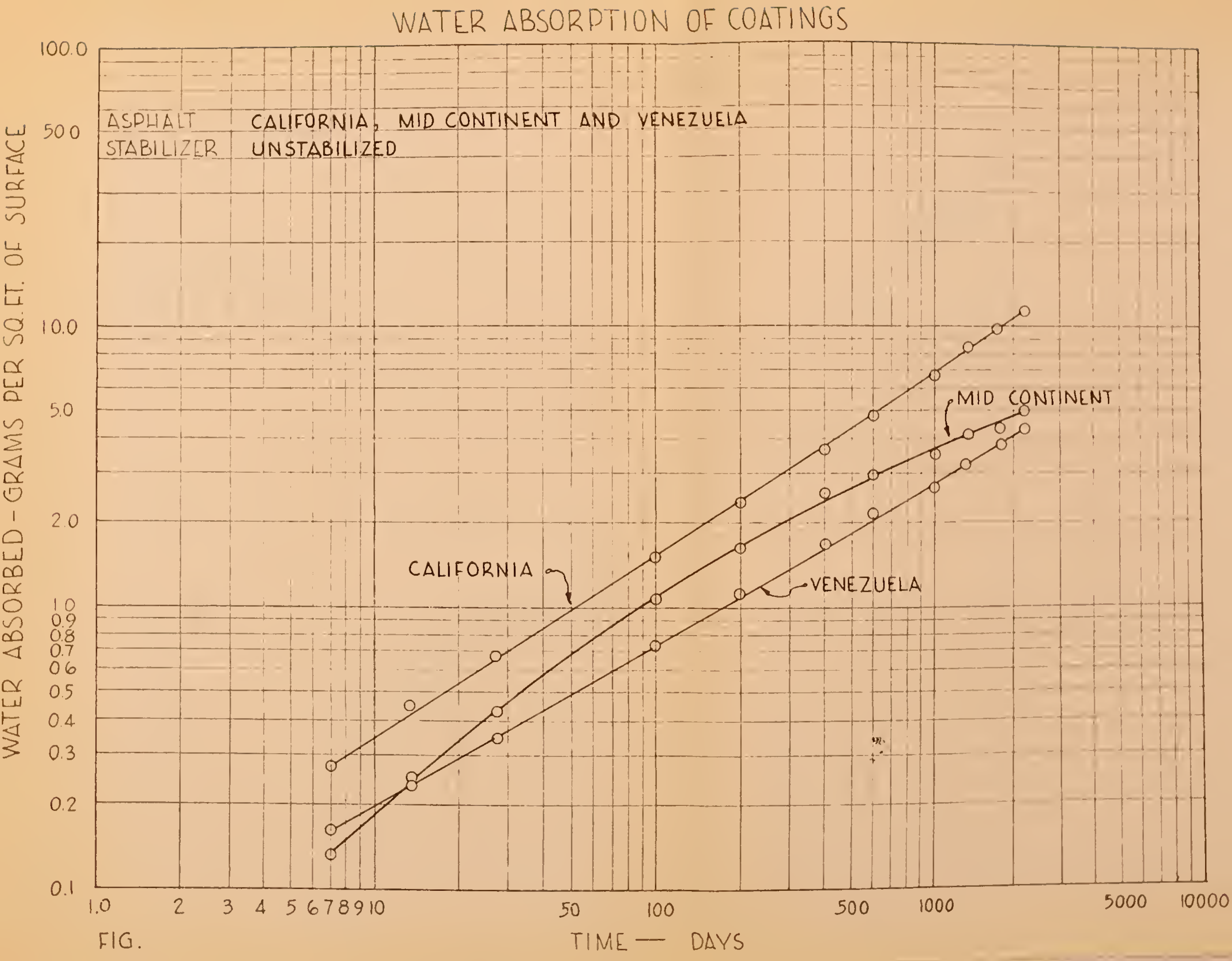
TABLE 3. ORDER OF INCREASING WATER ABSORPTION*

ASPHALT:	California		Mid-Continent		Venezuela	
IMMERSION TIME, Day	28	2100**	28	2100**	28	2100**
Order						
1	35F	Asph.	Asph.	Asph.	Asph.	Asph.
2	Asph.	35E	35F	35E	35E	35E
3	50F	35A	50F	35F	35A	35C
4	60F	35C	60F	35B	50F	35A
5	35A	50C	35A	35C	60F	50C
6	35C	35F	35E	35A	35F	50F
7	50A	35B	35C	50F	50A	60C
8	60A	60A	35D	50C	35D	50B
9	35D	60C	50A	60F	60A	35F
10	50C	50B	60A	60C	35C	35B
11	50D	50A	50D	50B	50D	60F
12	60D	60B	50C	50A	60D	50A
13	60C	60F	60D	35D	50C	60A
14	35B	50F	60C	60A	60C	35D
15	50B	60D	35B	60D	35B	60D
16	60B	50D	50B	50D	50B	50D
17	35E	35D				

*A = Blue Black Slate.
B = Florida Clay.
C = Niagara Dolomite.
D = Low Carbon Fly Ash.
E = Tennessee Mica.
F = Lake Erie Silica.

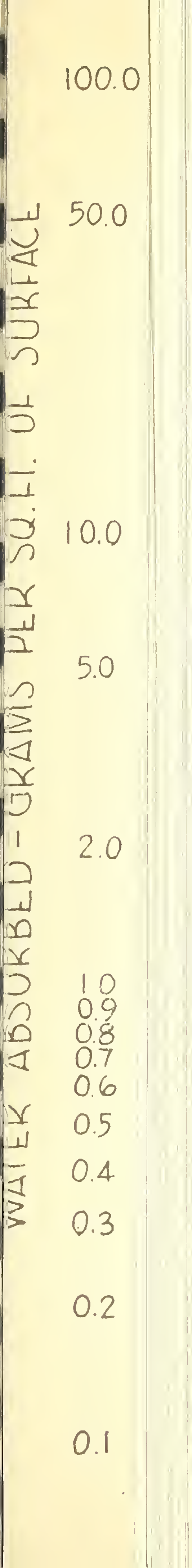
**Approximate time of immersion at end of study. See Table 1 for true time.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

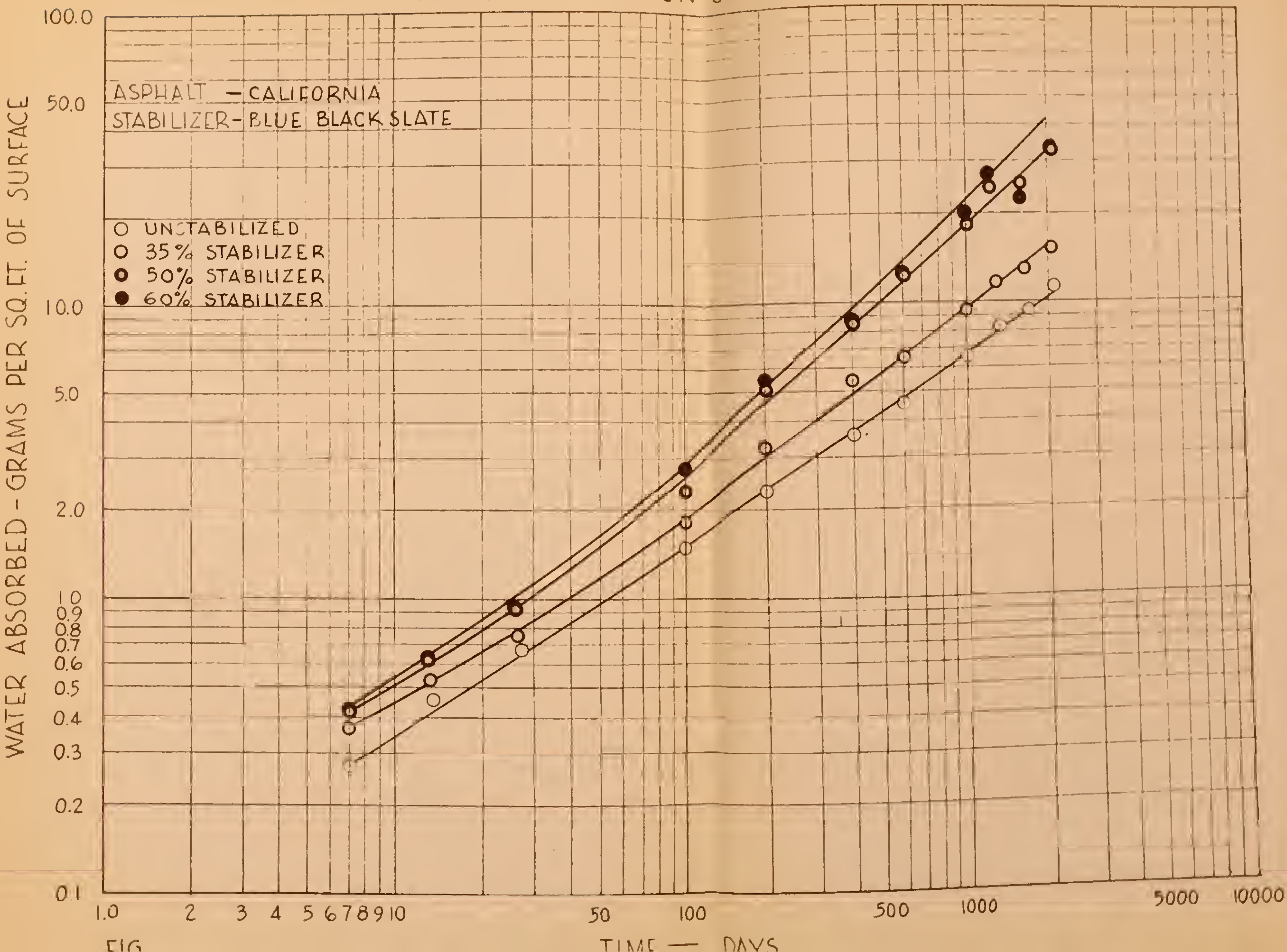


WATER ABSORPTION OF COATINGS
ASPHALT CALIFORNIA, MID CONTINENT AND VENEZUELA
STABILIZER UNSTABILIZED
WATER ABSORBED - GRAMS PER SQ. FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
MID CONTINENT
CALIFORNIA
VENEZUELA
1.0
2
3
4
5
6
7
8
9
10
50
100
500
1000
5000
10000
TIME — DAYS

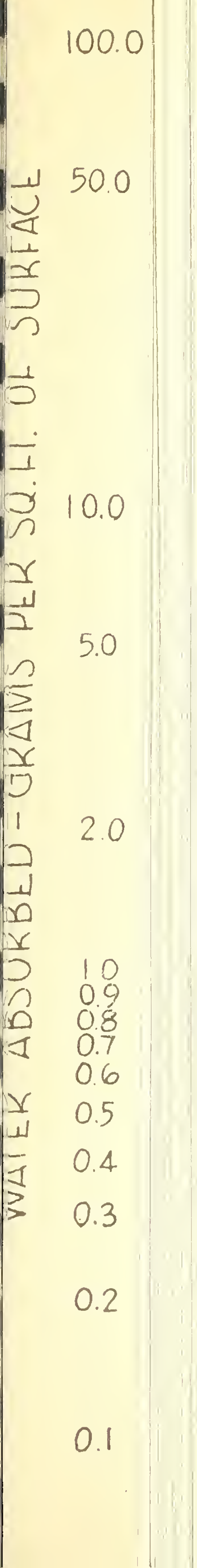
FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS



FIG


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

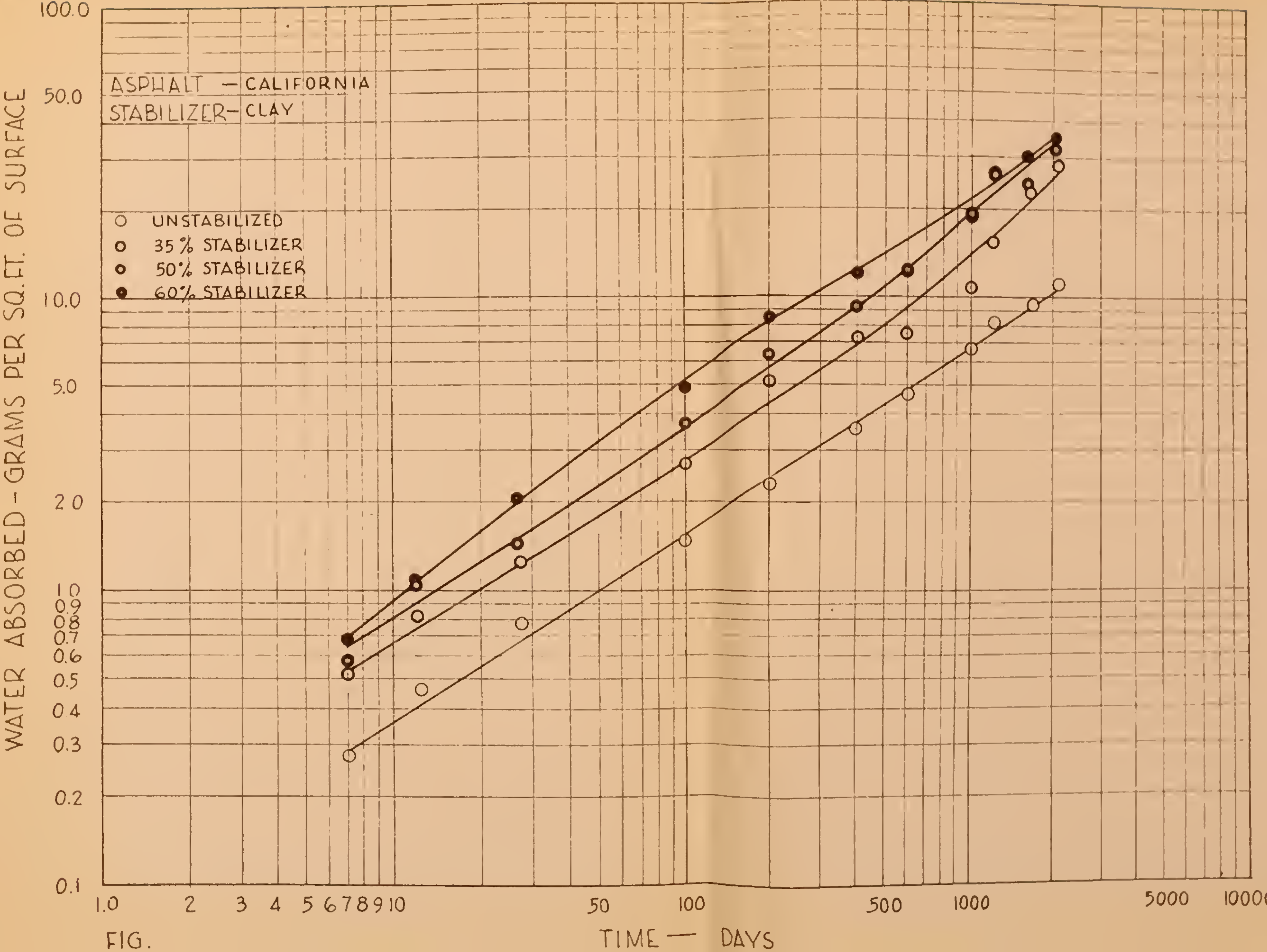
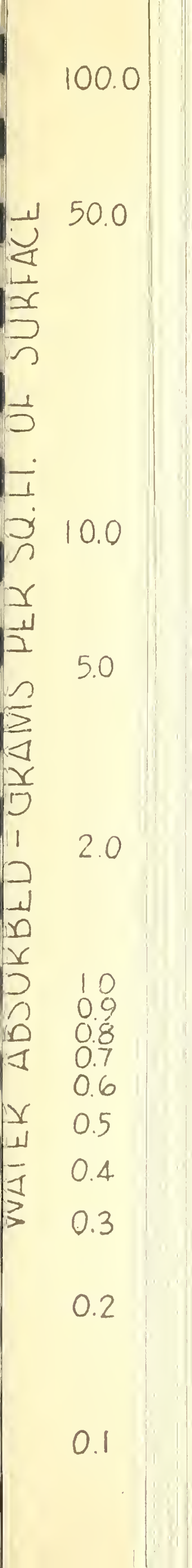


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

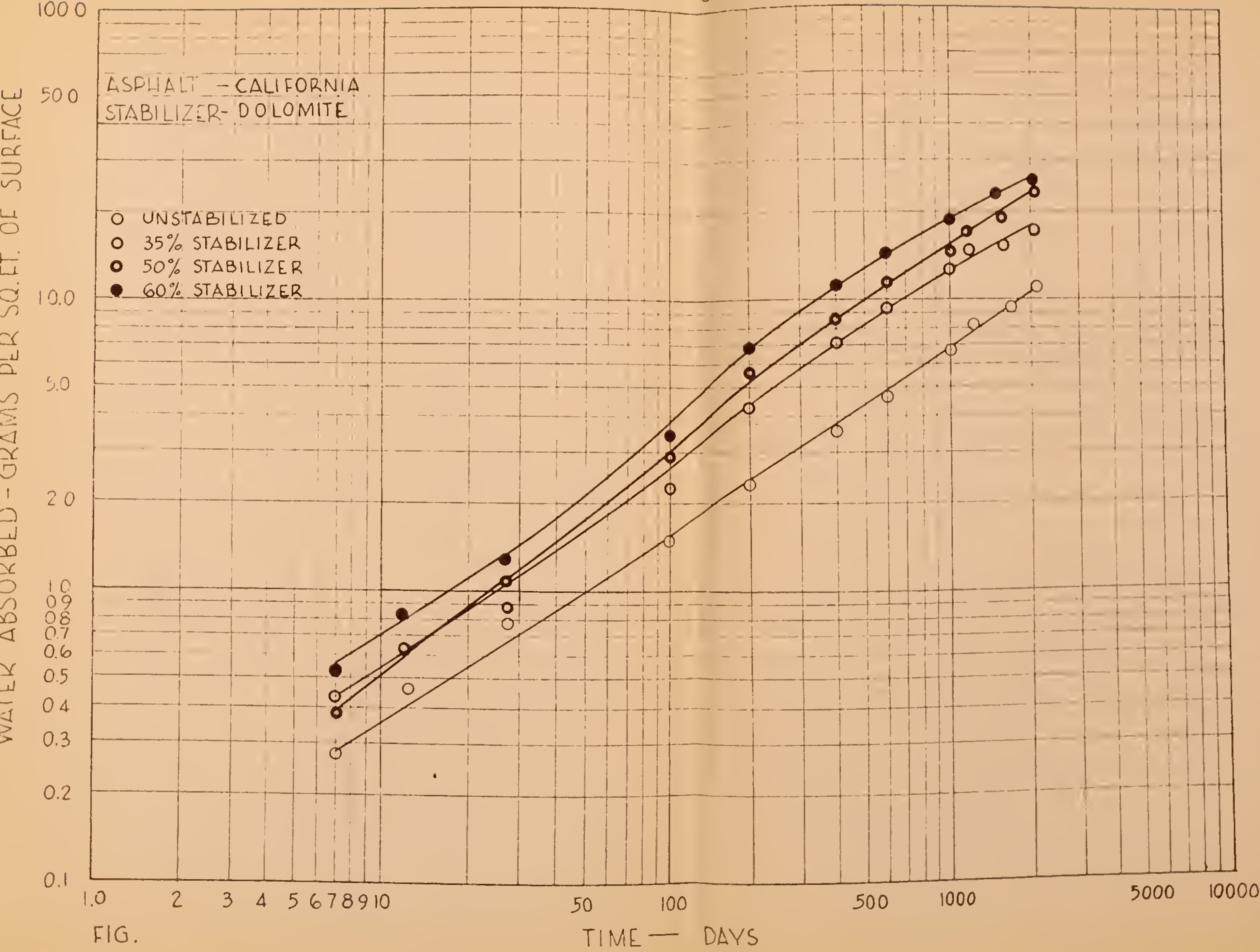
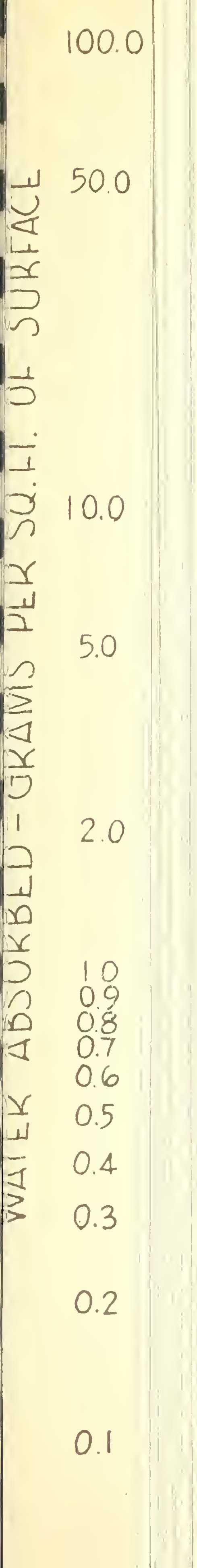


FIG.


WATER ABSORBED - GRAMS PER SQ. FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

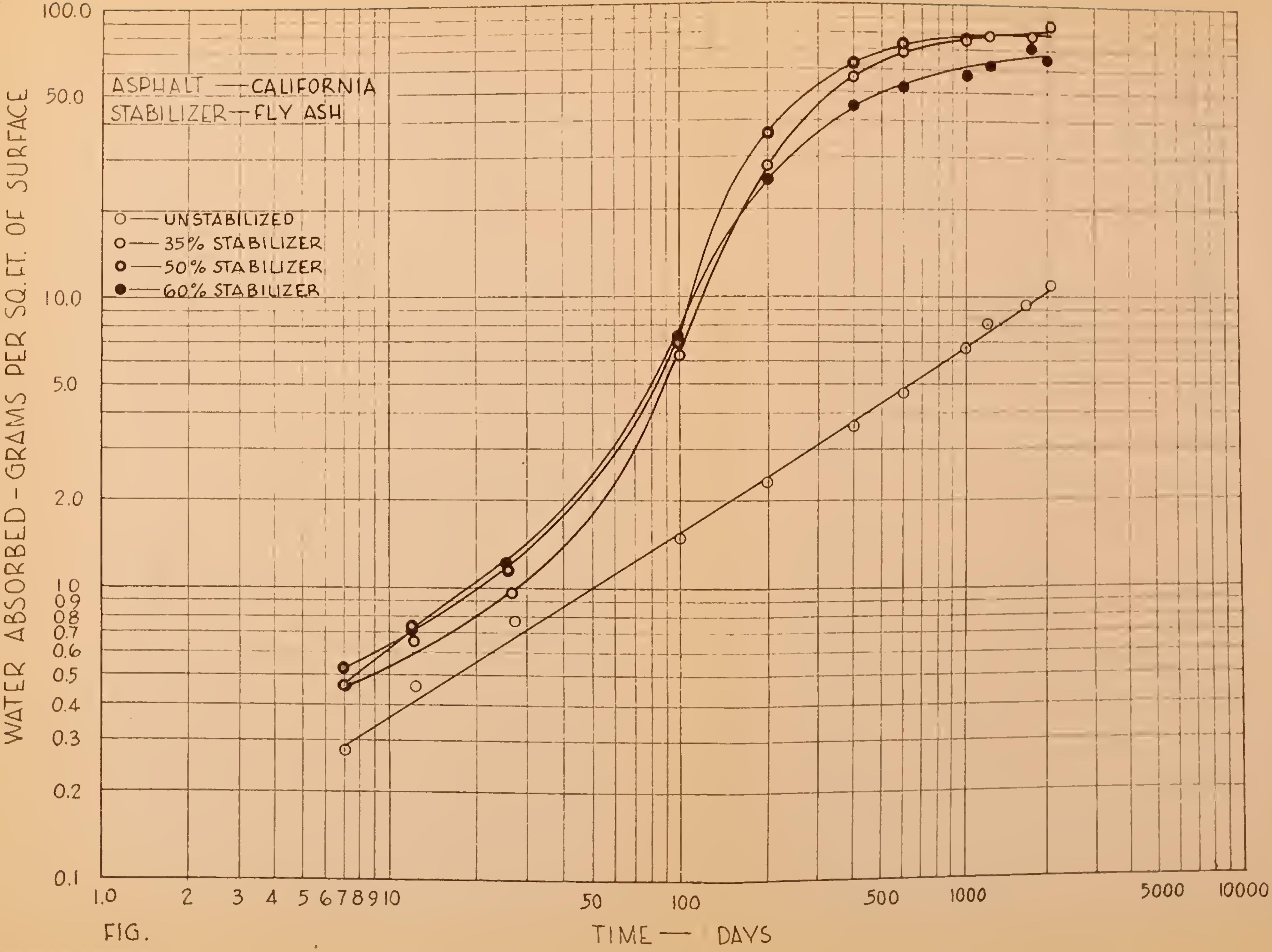
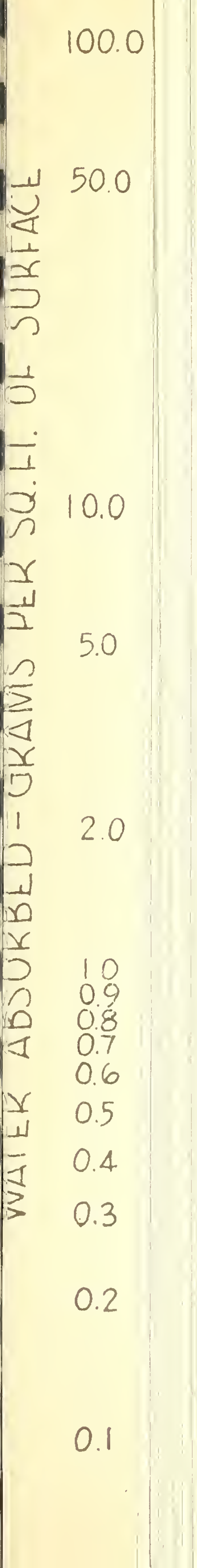


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

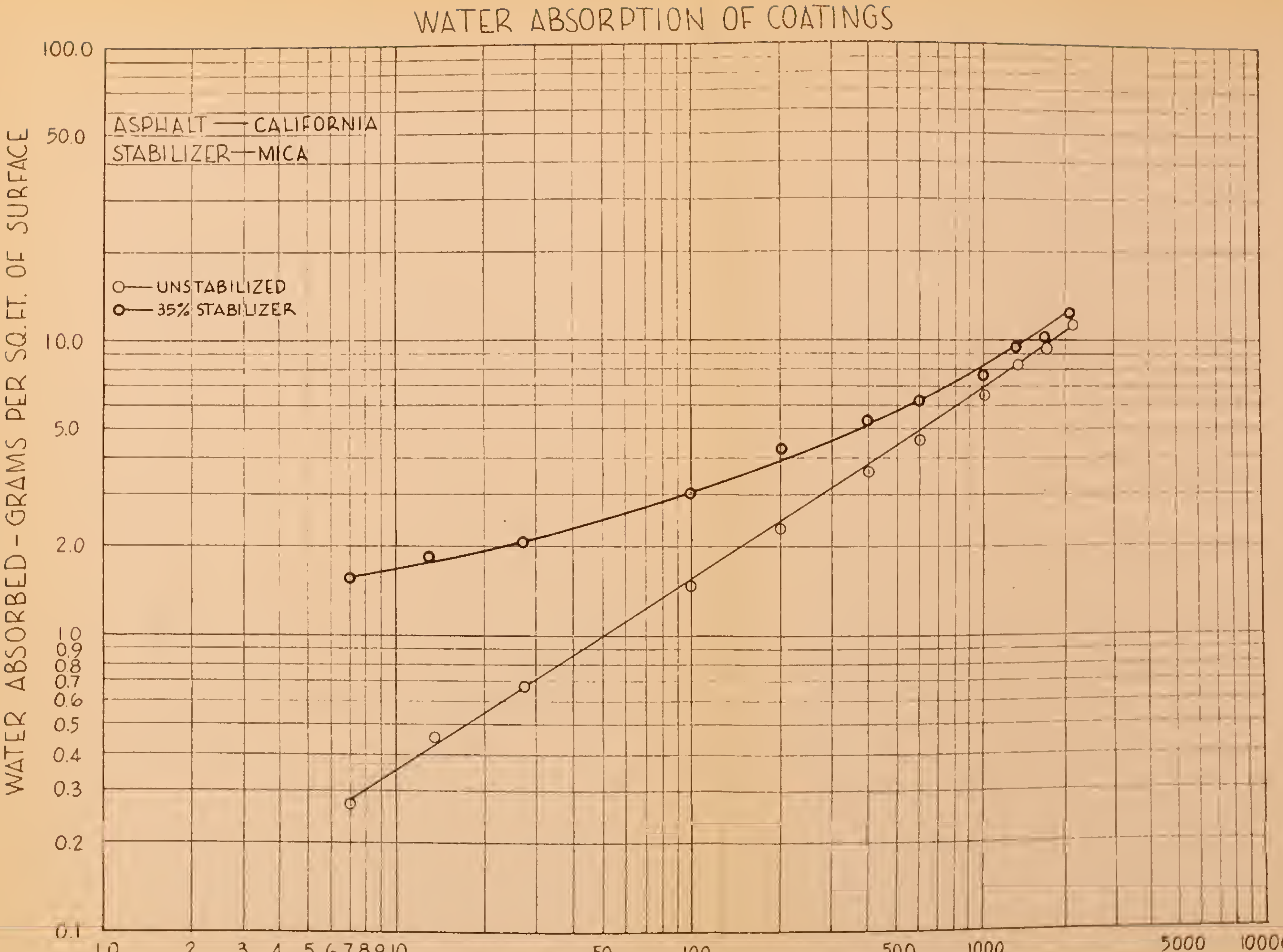
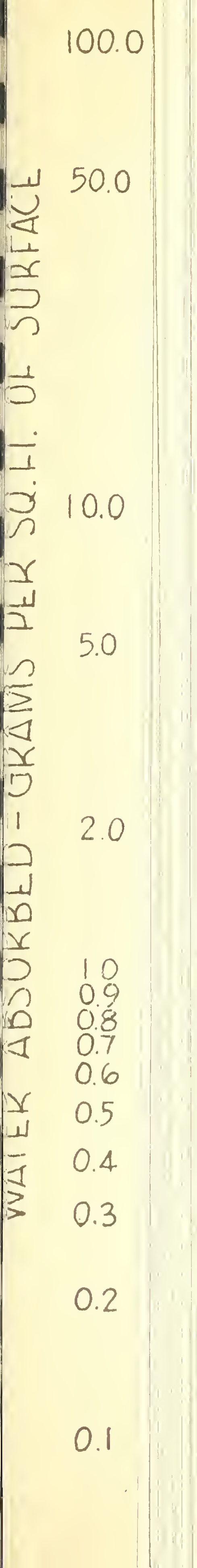

WATER ABSORPTION OF COATINGS
ASPHALT — CALIFORNIA
STABILIZER — MICA
○— UNSTABILIZED
○— 35% STABILIZER
WATER ABSORBED - GRAMS PER SQ. FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0
2
3
4
5
6 7 8 9 10
50
100
500
1000
5000
10000
TIME — DAYS

FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

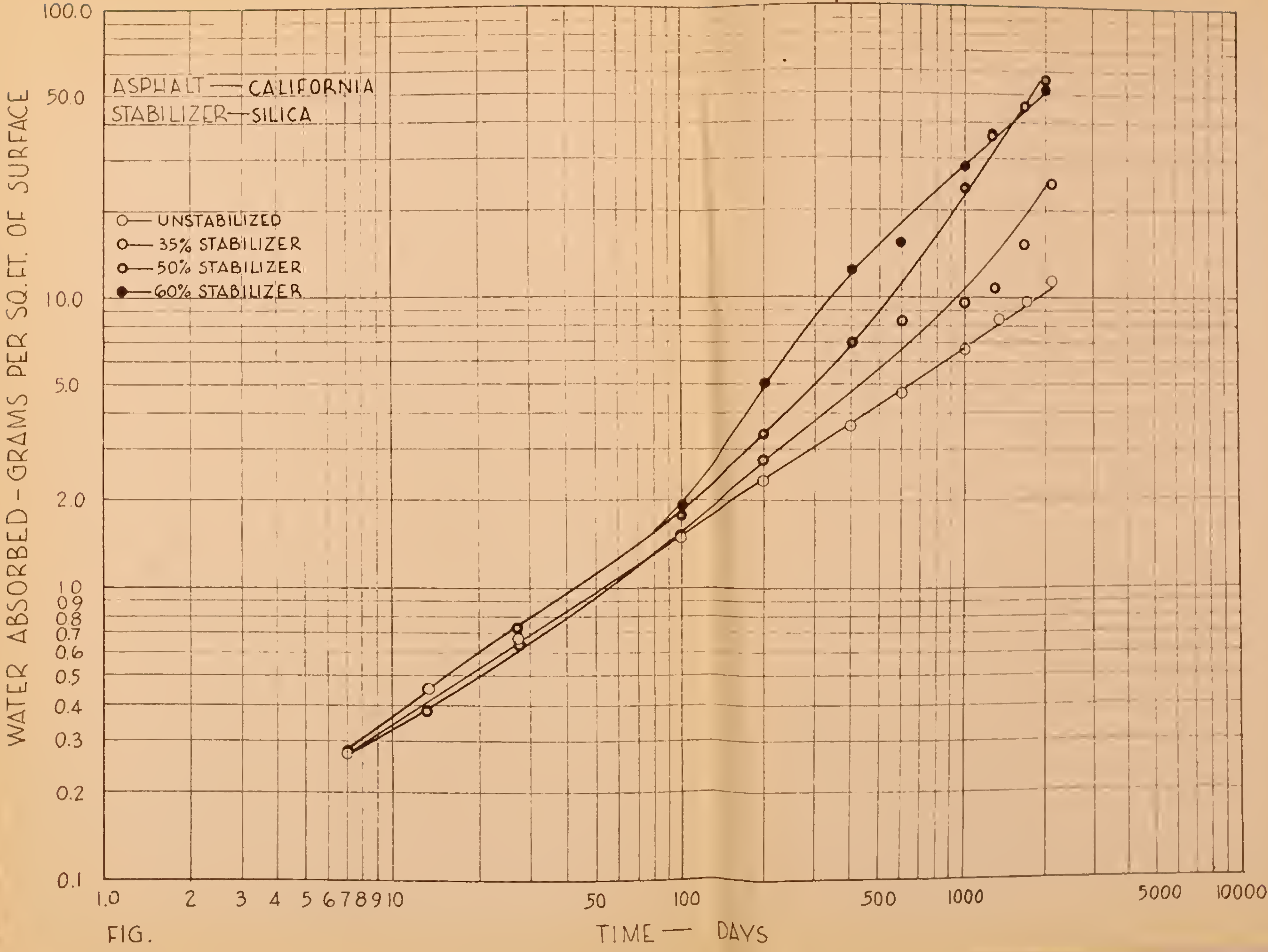
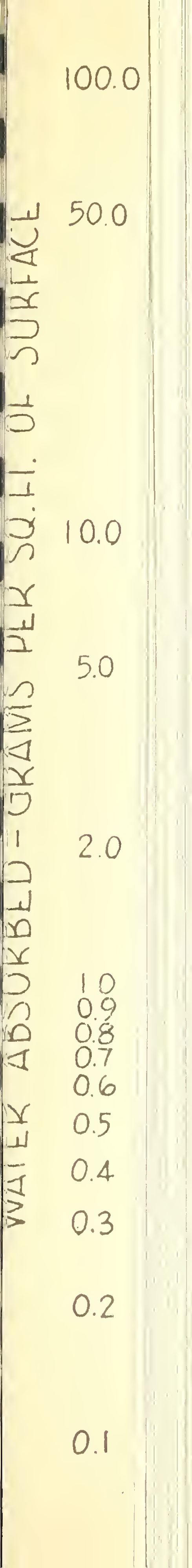


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

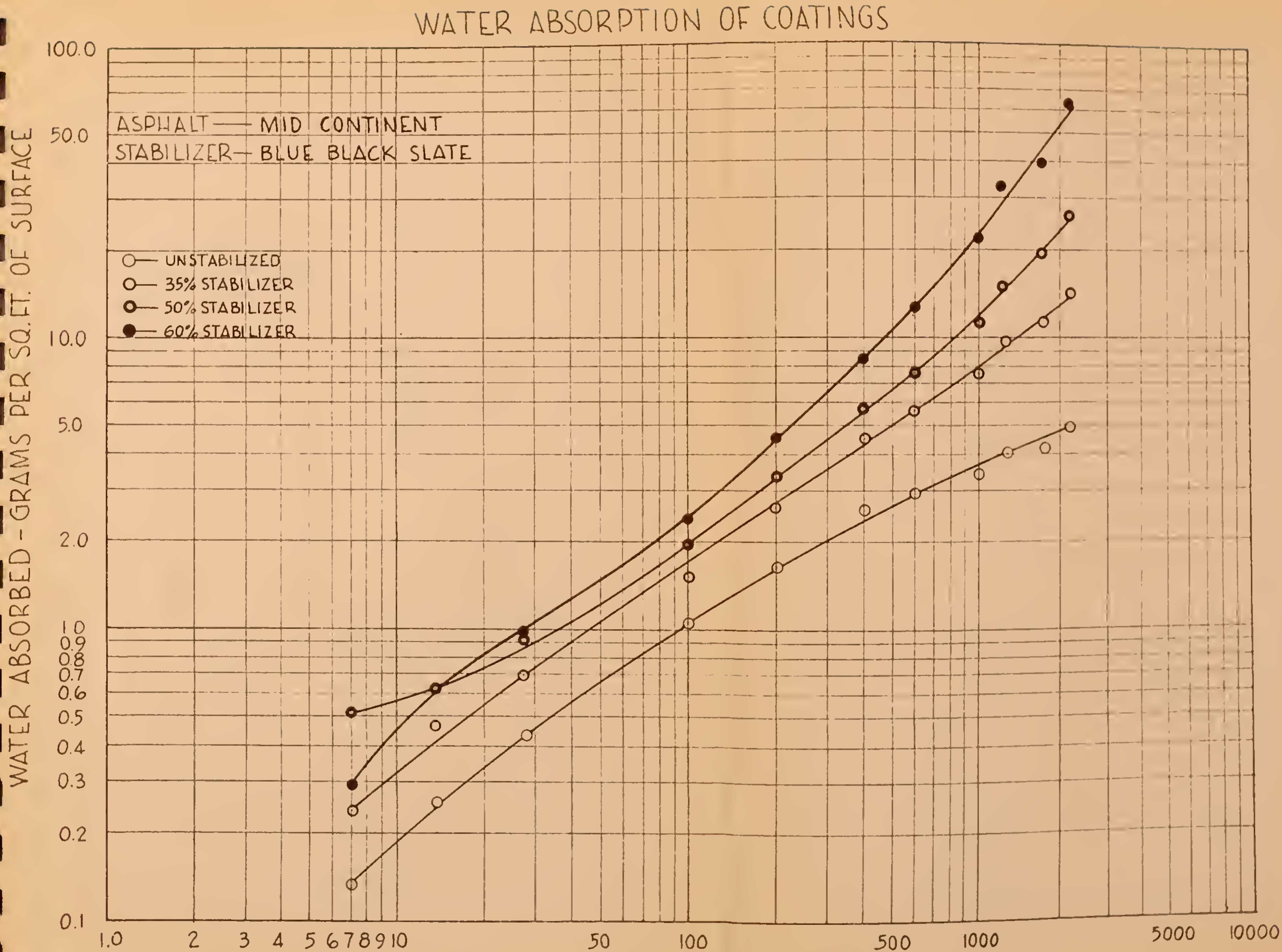
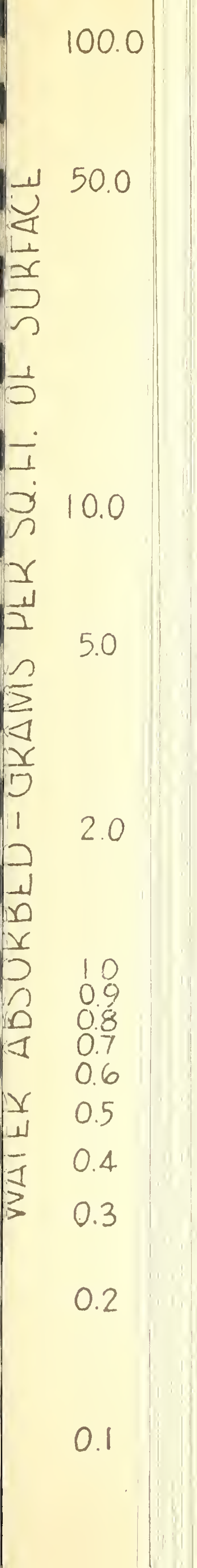

WATER ABSORPTION OF COATINGS
ASPHALT — MID CONTINENT
STABILIZER — BLUE BLACK SLATE
UNSTABILIZED
35% STABILIZER
50% STABILIZER
60% STABILIZER
WATER ABSORBED - GRAMS PER SQ. FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0
2
3
4
5
6
7
8
9
10
50
100
500
1000
5000
10000
TIME — DAYS

FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

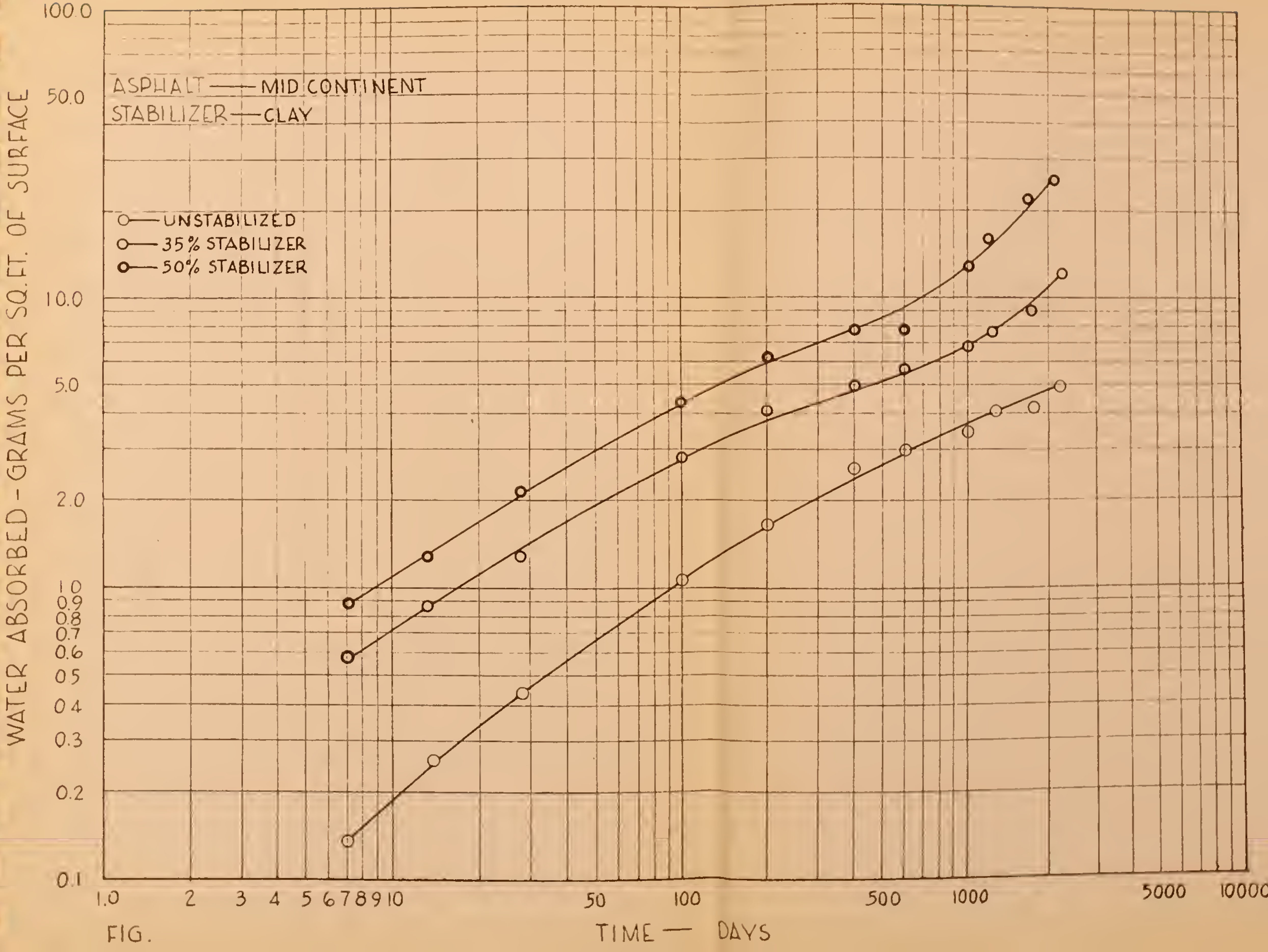
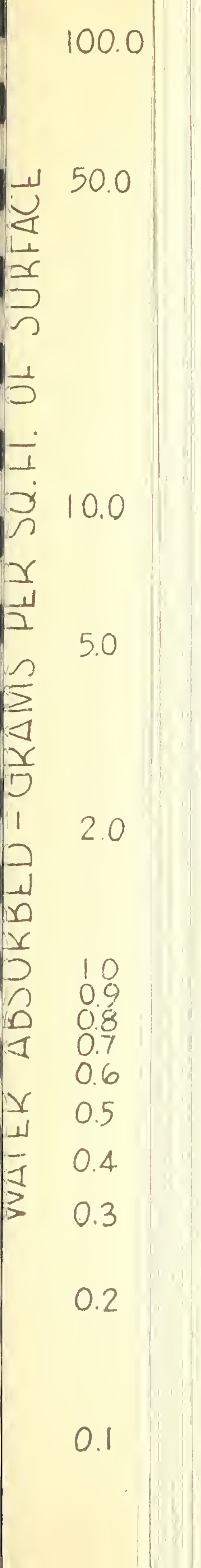


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

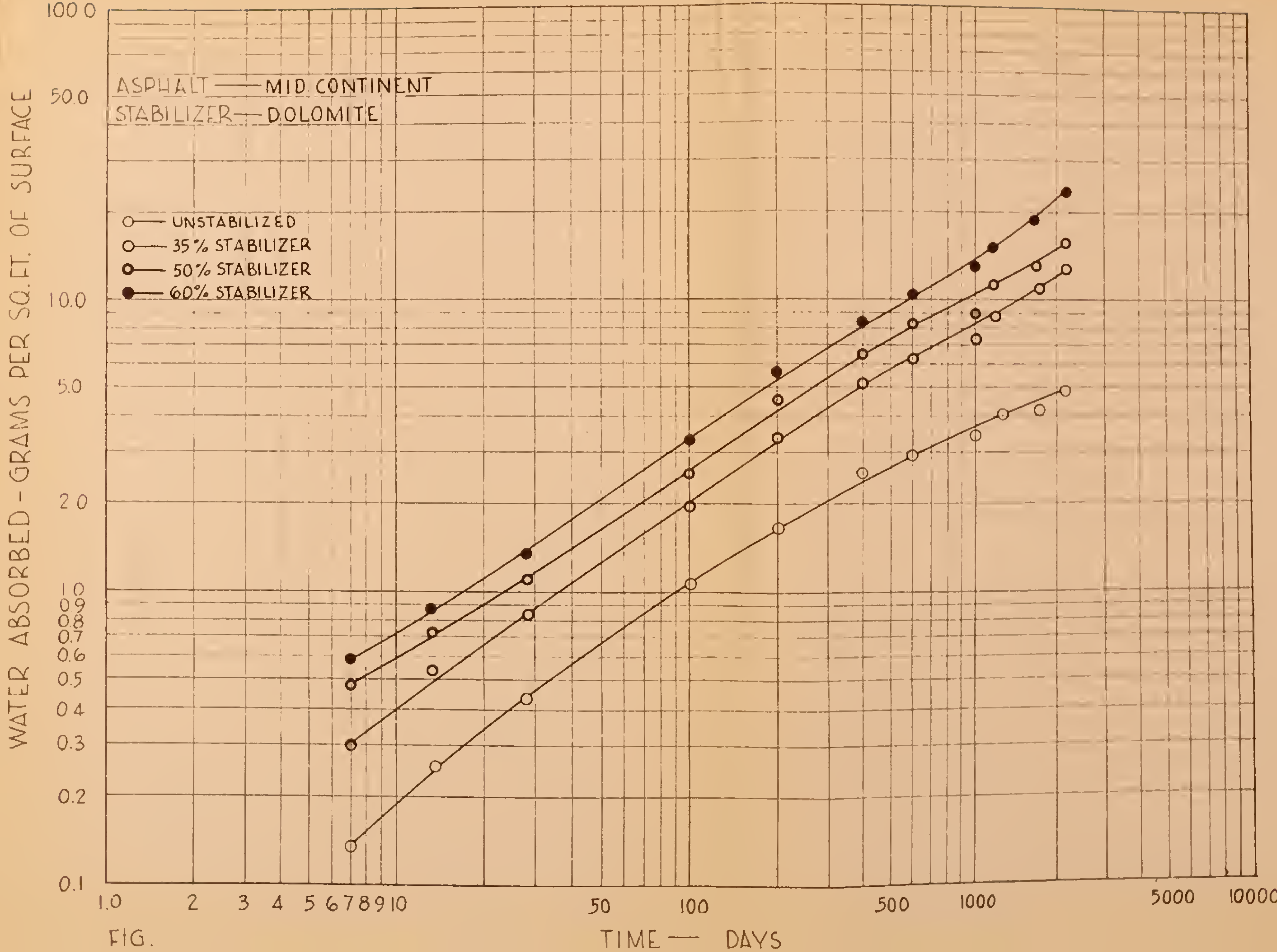
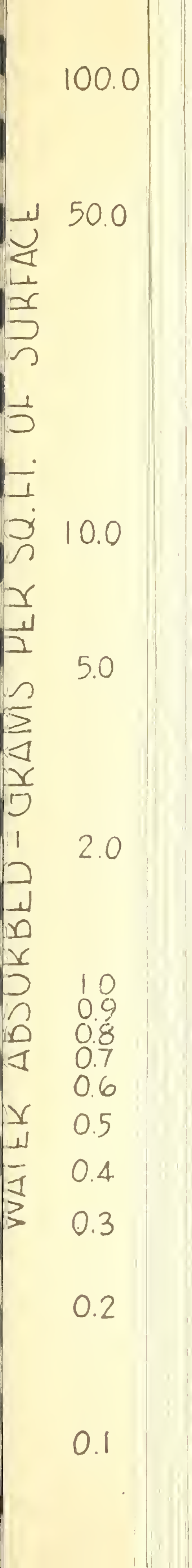
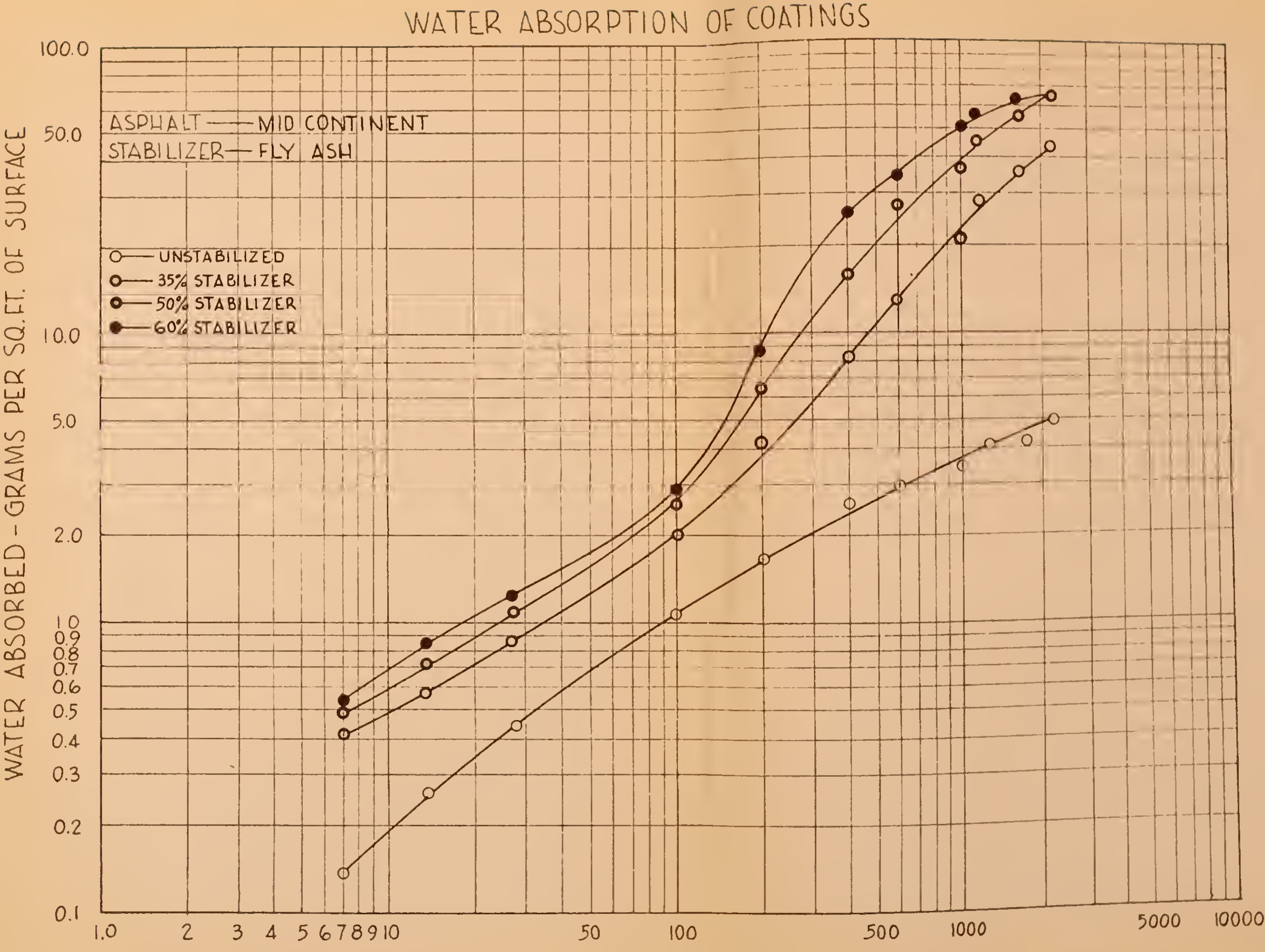
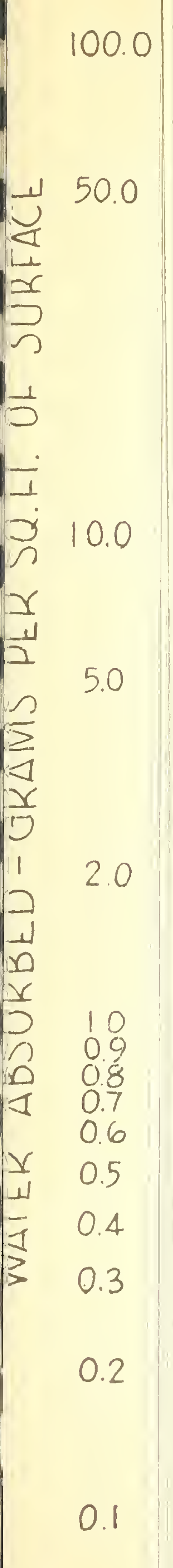


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1


WATER ABSORPTION OF COATINGS
ASPHALT — MID CONTINENT
STABILIZER — FLY ASH
UNSTABILIZED
35% STABILIZER
50% STABILIZER
60% STABILIZER
WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
TIME — DAYS
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0
2
3
4
5
6
7
8
9
10
50
100
500
1000
5000
10000
FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

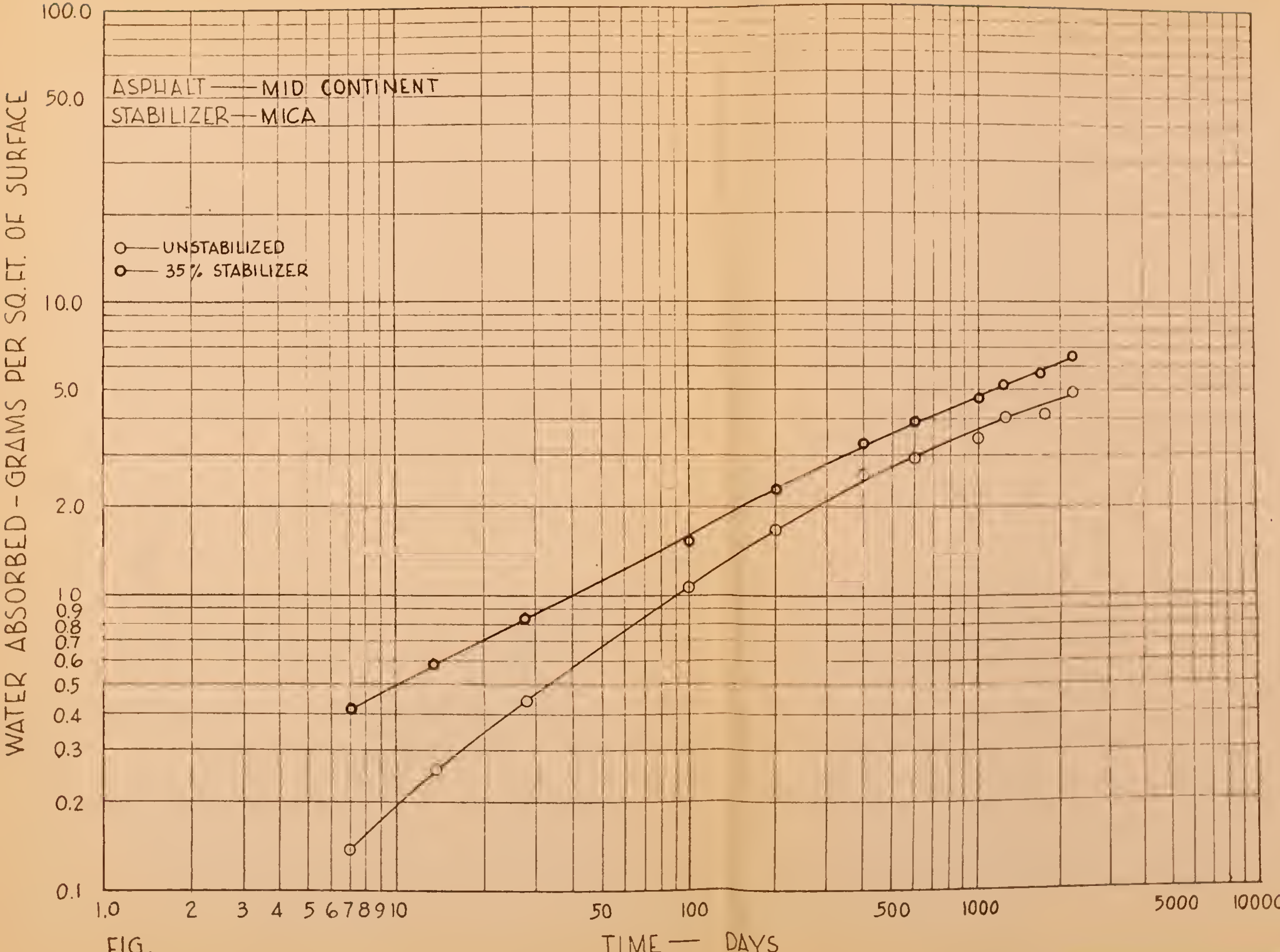
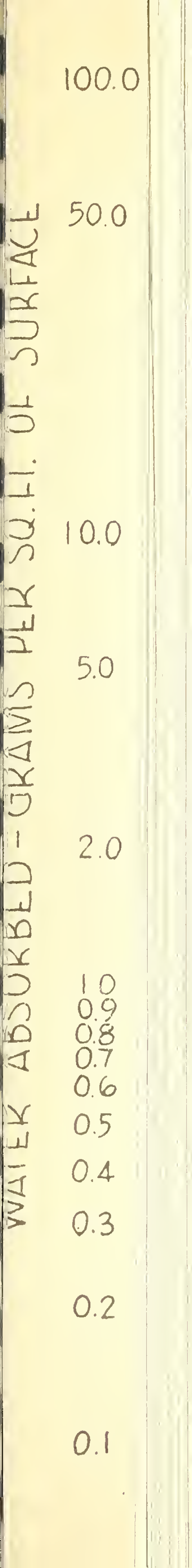
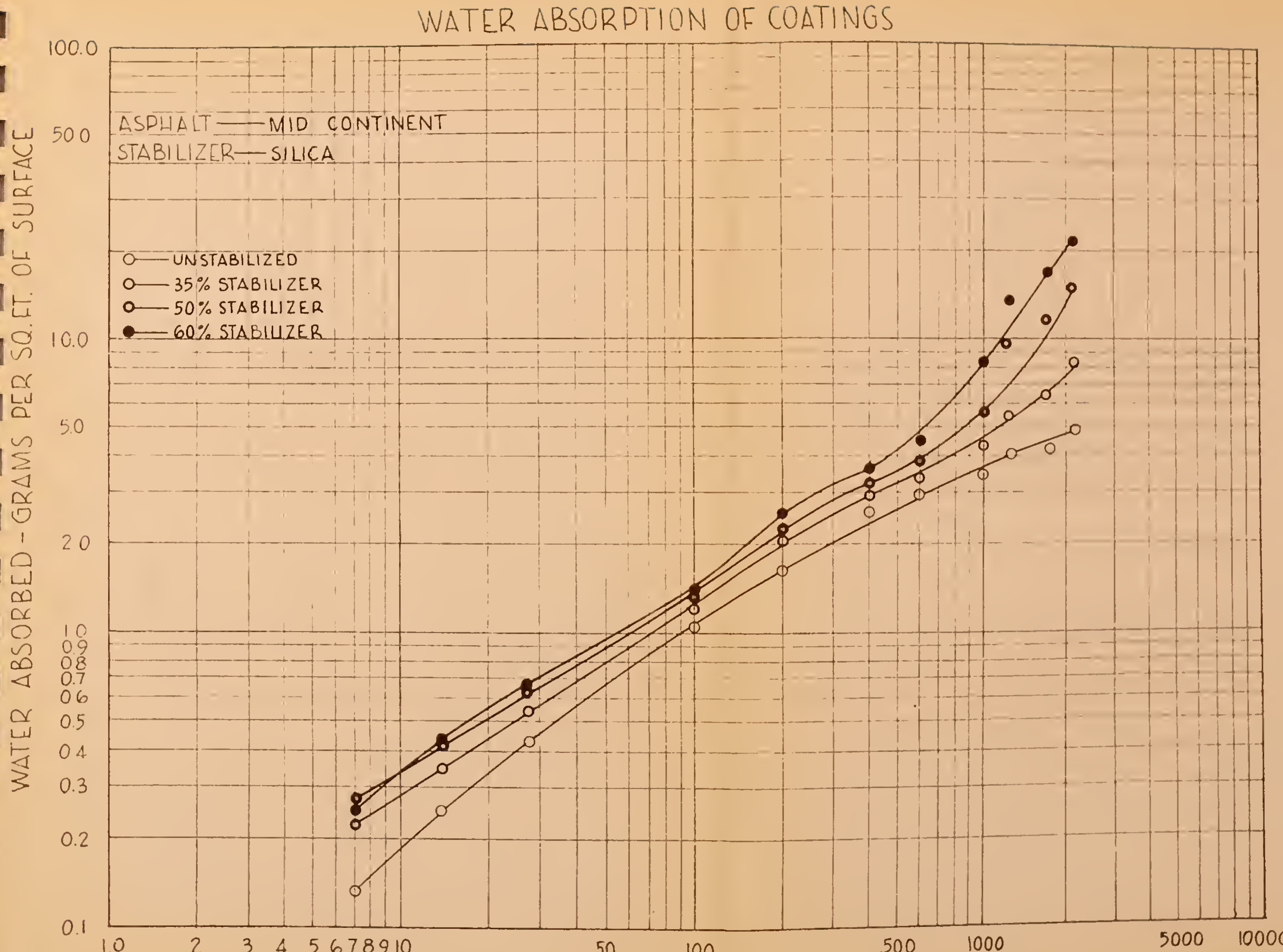


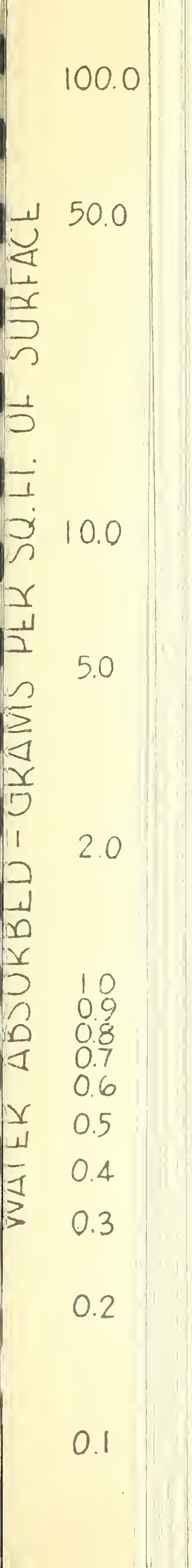
FIG.

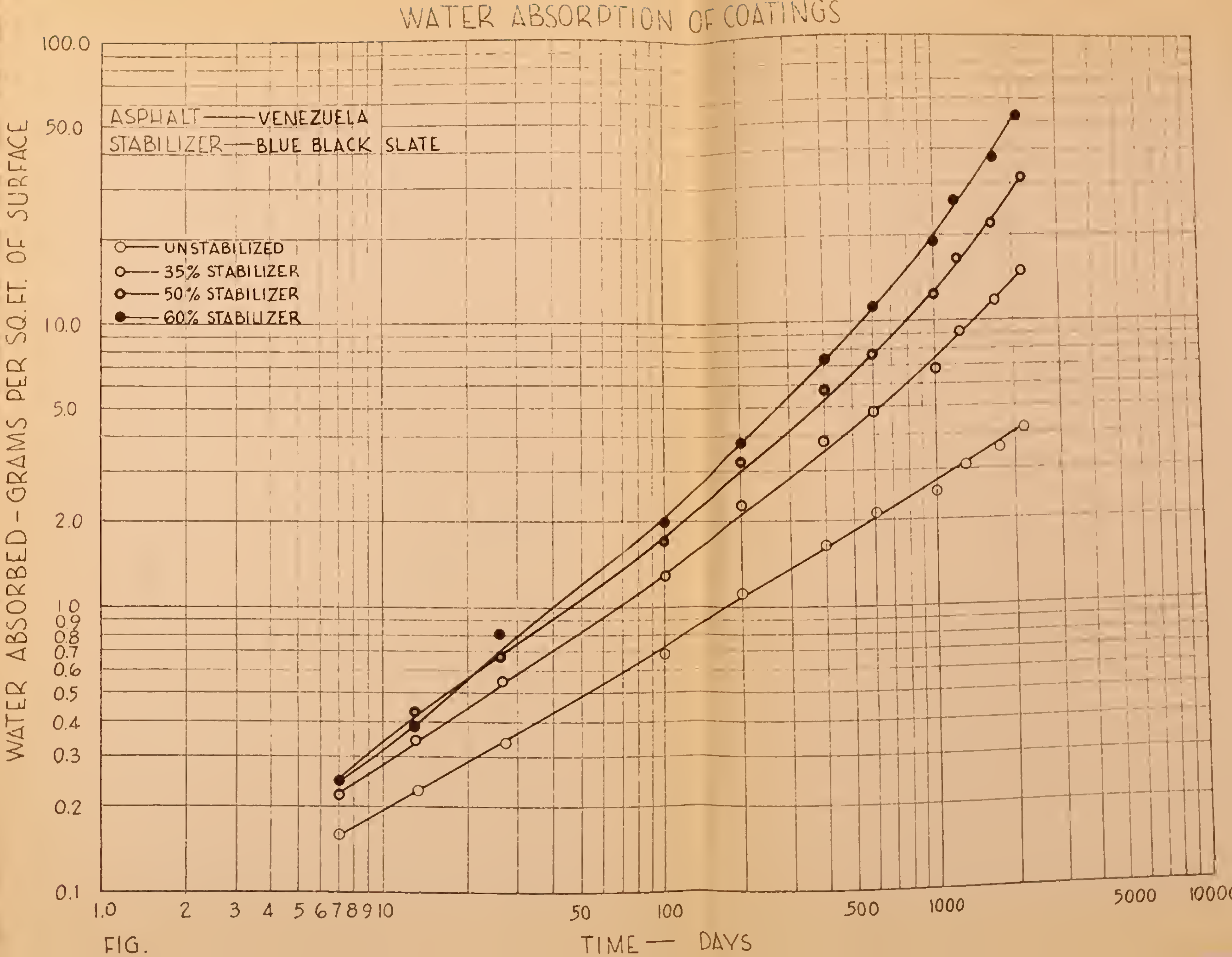

WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1



WATER ABSORPTION OF COATINGS
ASPHALT —— MID CONTINENT
STABILIZER —— SILICA
UNSTABILIZED
35% STABILIZER
50% STABILIZER
60% STABILIZER
WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0 2 3 4 5 6 7 8 9 10 50 100 500 1000 5000 10000
TIME — DAYS

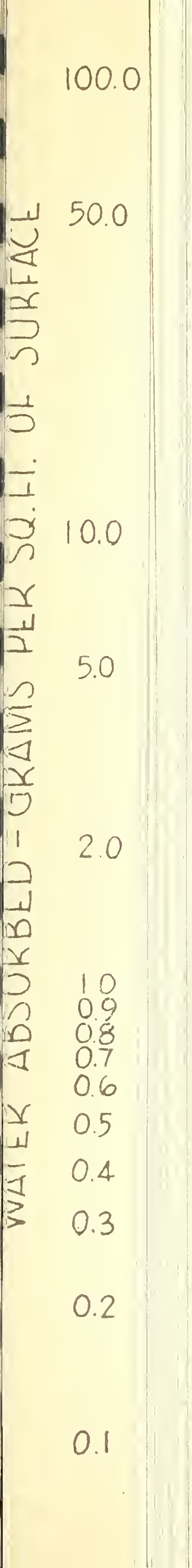
FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1



WATER ABSORPTION OF COATINGS
ASPHALT —— VENEZUELA
STABILIZER —— BLUE BLACK SLATE
UNSTABILIZED
35% STABILIZER
50% STABILIZER
60% STABILIZER
WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0
2
3
4
5
6
7
8
9
10
50
100
500
1000
5000
10000
TIME — DAYS

FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

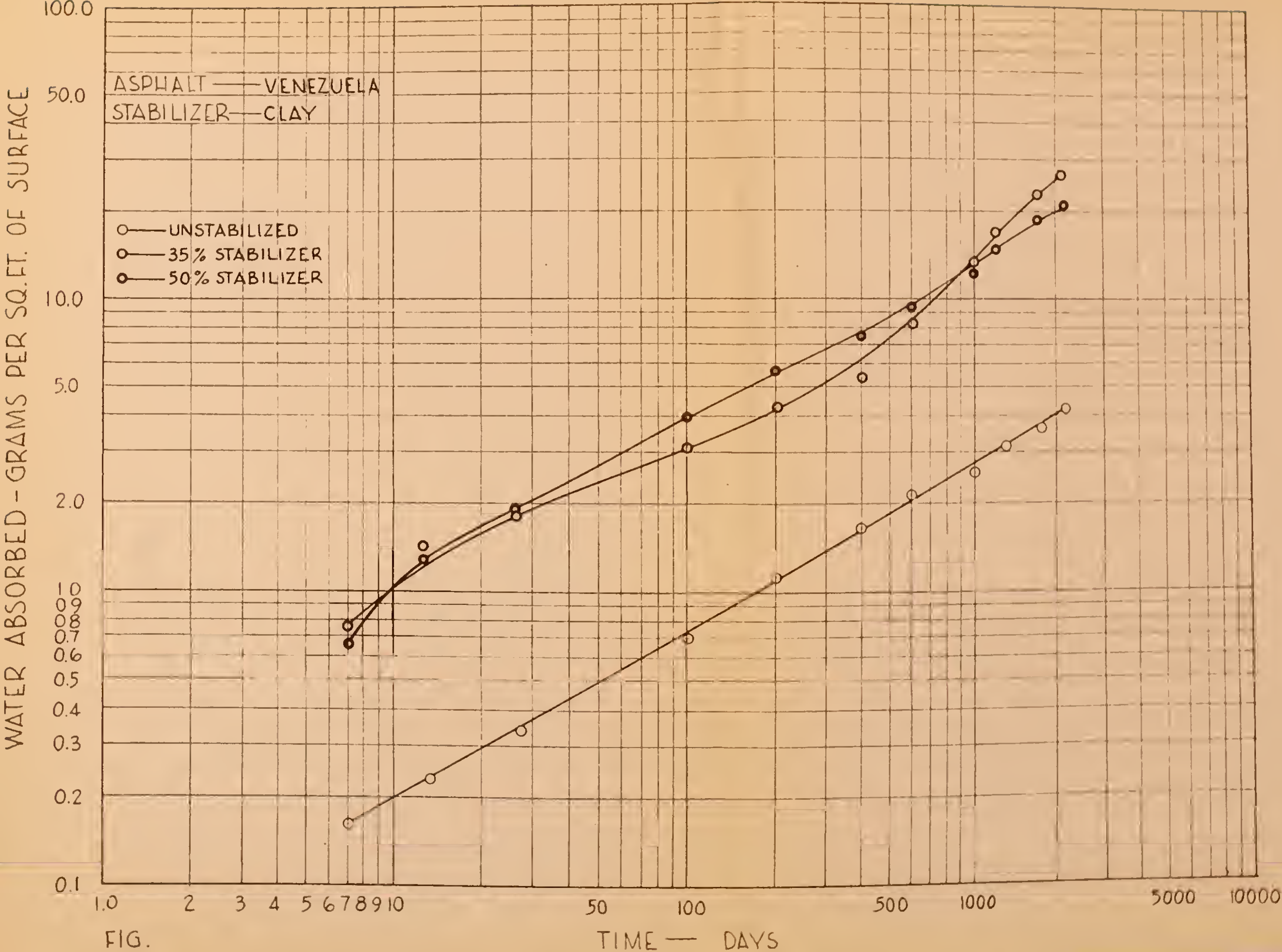
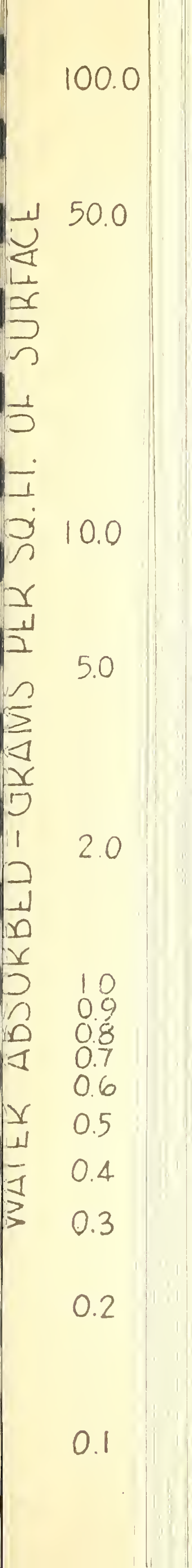


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

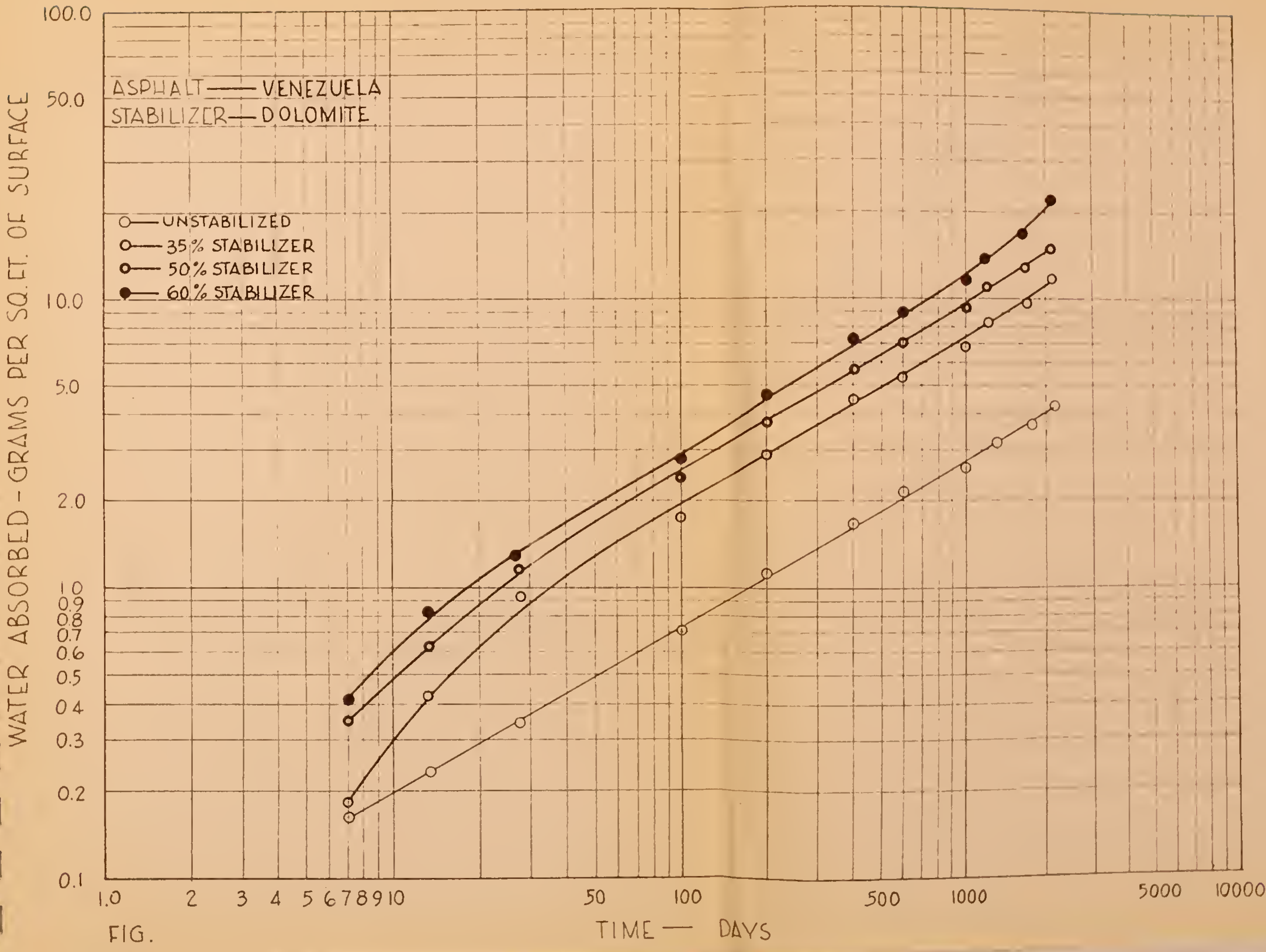
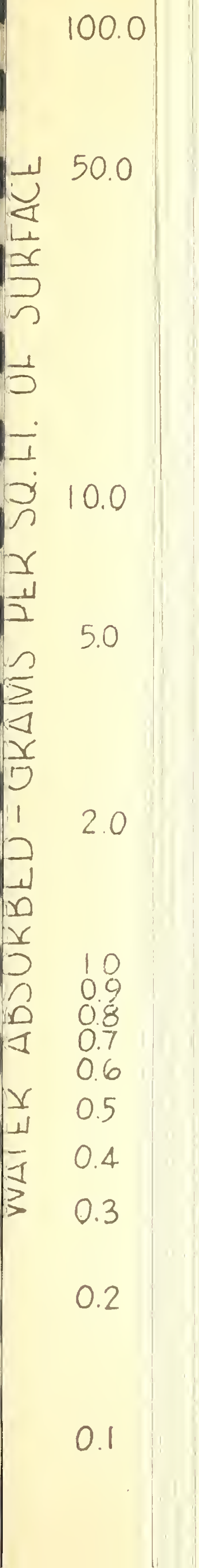


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

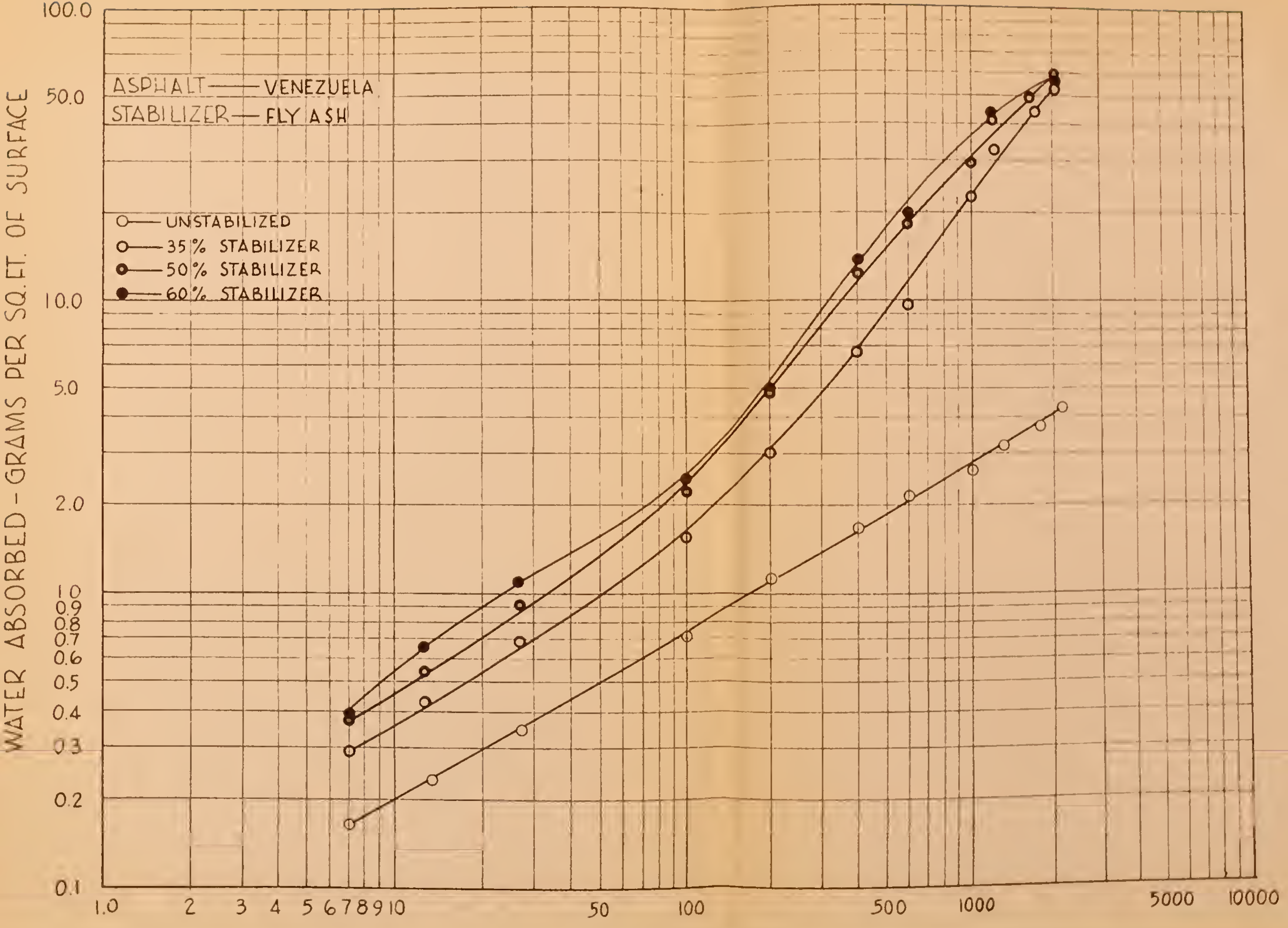
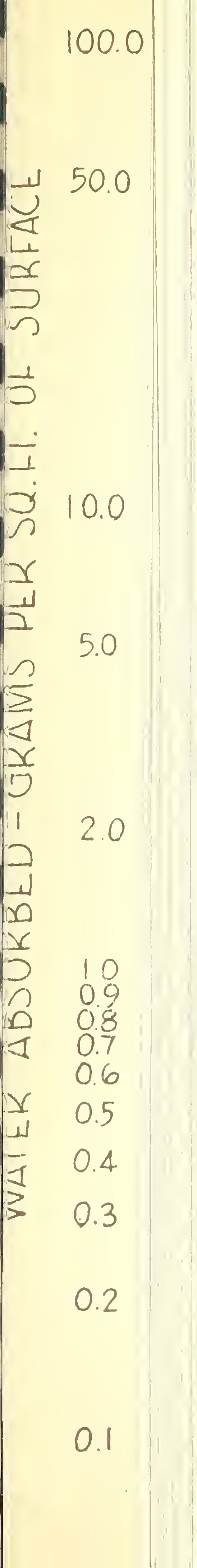


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

WATER ABSORPTION OF COATINGS

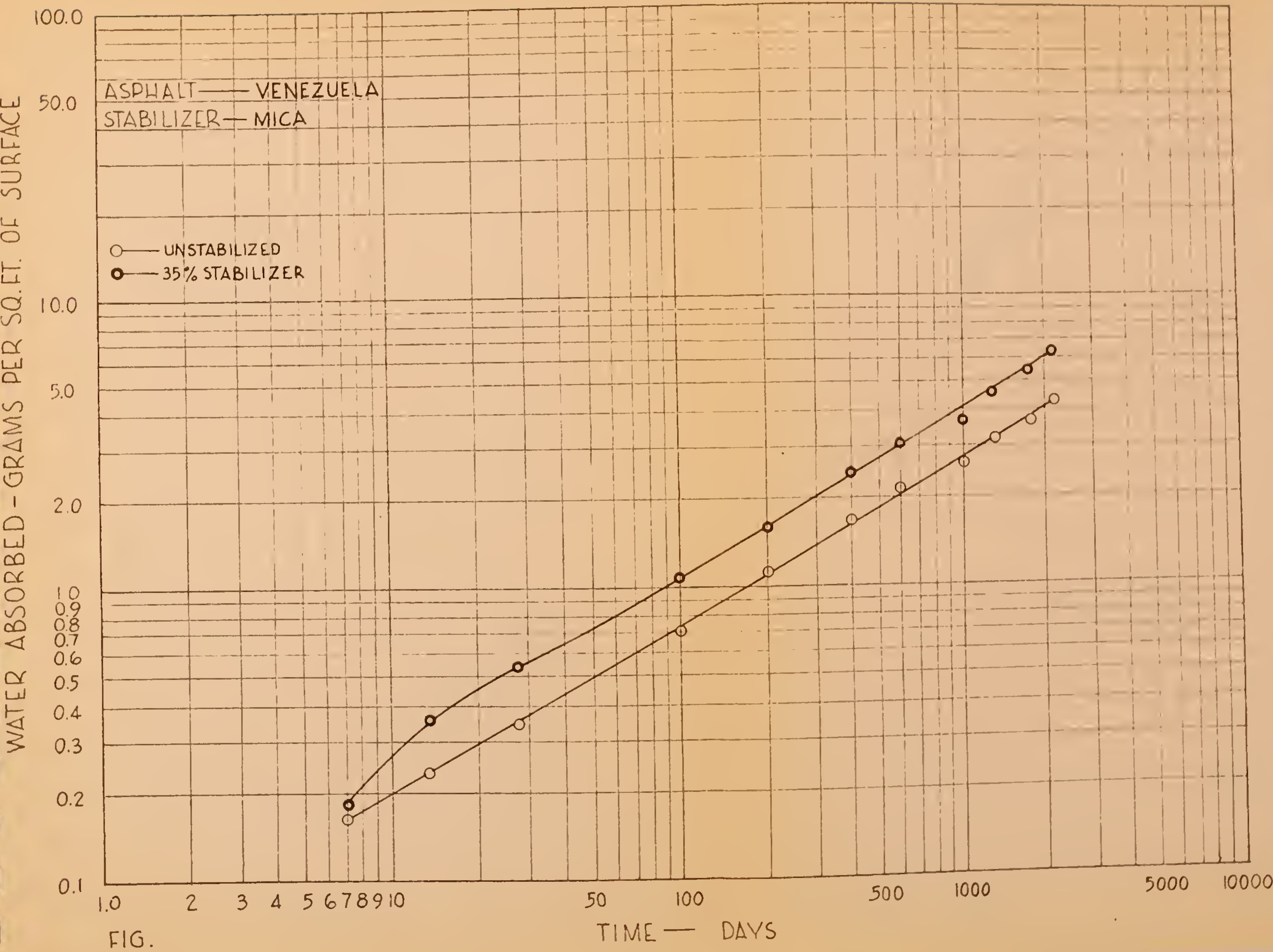
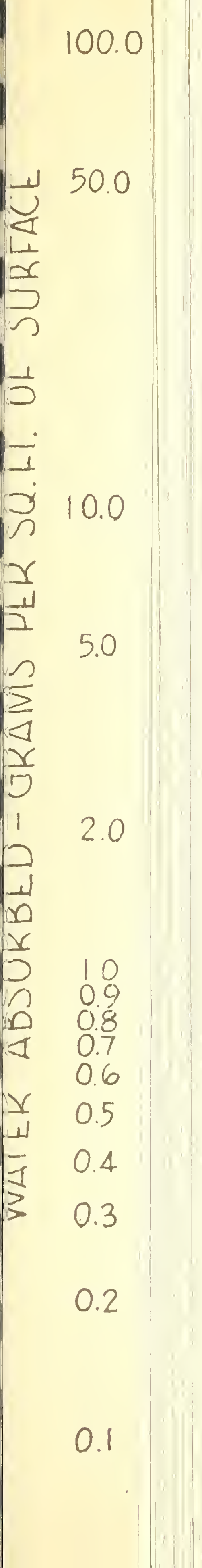


FIG.


WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

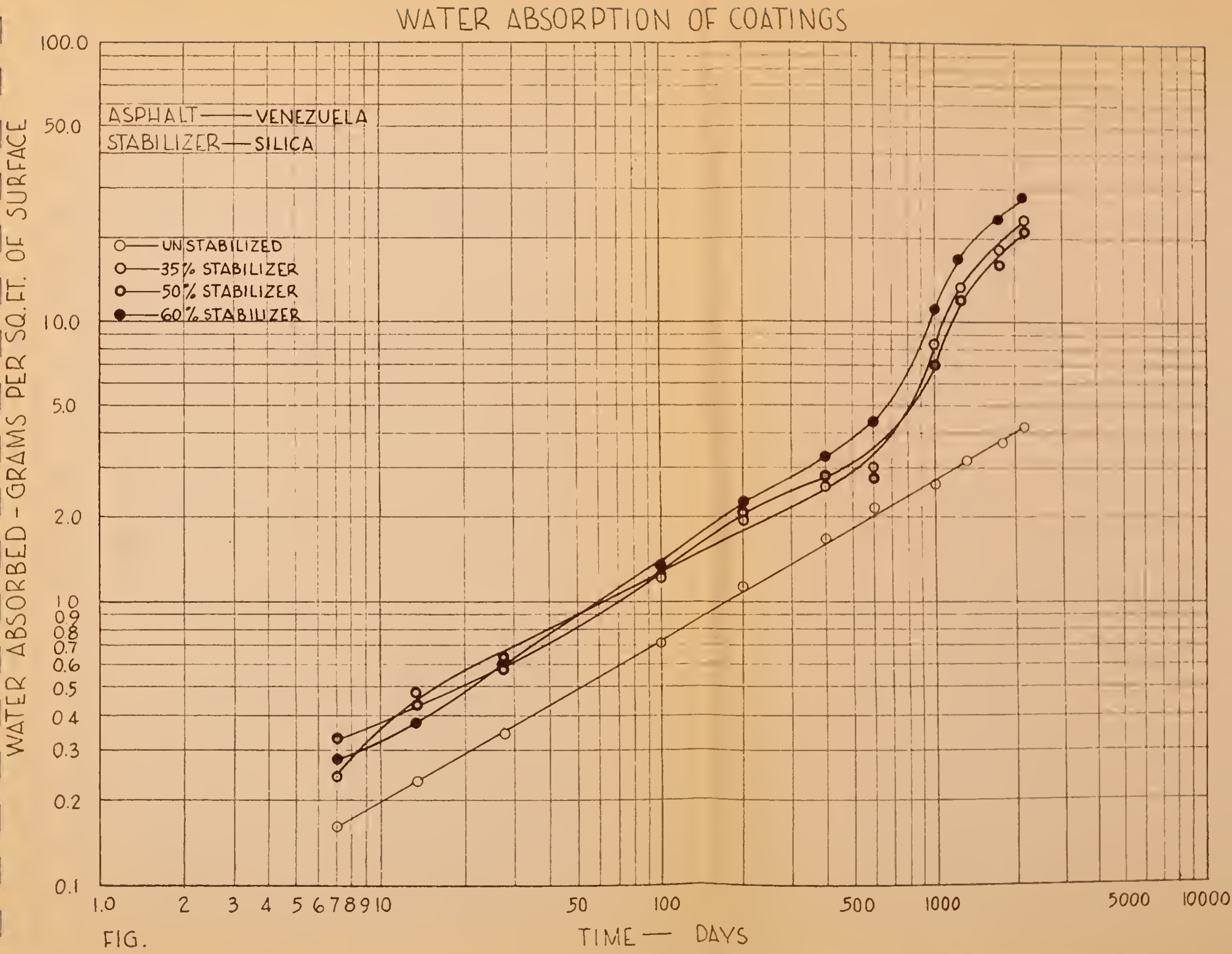
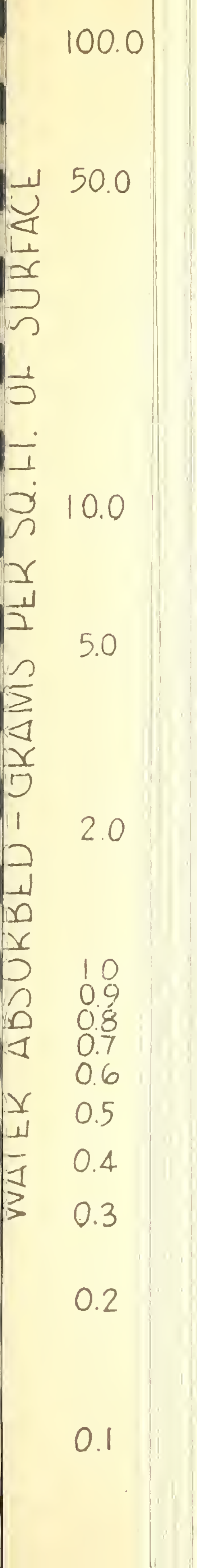

WATER ABSORPTION OF COATINGS
ASPHALT——VENEZUELA
STABILIZER——SILICA
UNSTABILIZED
35% STABILIZER
50% STABILIZER
60% STABILIZER
WATER ABSORBED - GRAMS PER SQ.FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
1.0
2
3
4
5
6
7
8
9
10
50
100
500
1000
5000
10000
TIME — DAYS

FIG.



WATER ABSORBED - GRAMS PER SQ. FT. OF SURFACE
100.0
50.0
10.0
5.0
2.0
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1

U. S. DEPARTMENT OF COMMERCE
Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS
A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity. Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

Mineral Products. Engineering Ceramics. Glass. Refractories. Enameled Metals. Concreting Materials. Constitution and Microstructure.

Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

Data Processing Systems. SEAC Engineering Group. Components and Techniques. Digital Circuitry. Digital Systems. Analogue Systems. Application Engineering.

- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

Radio Propagation Engineering. Data Reduction Instrumentation. Modulation Systems. Navigation Systems. Radio Noise. Tropospheric Measurements. Tropospheric Analysis. Radio Systems Application Engineering.

Radio Standards. Radio Frequencies. Microwave Frequencies. High Frequency Electrical Standards. Radio Broadcast Service. High Frequency Impedance Standards. Calibration Center. Microwave Physics. Microwave Circuit Standards.

NBS