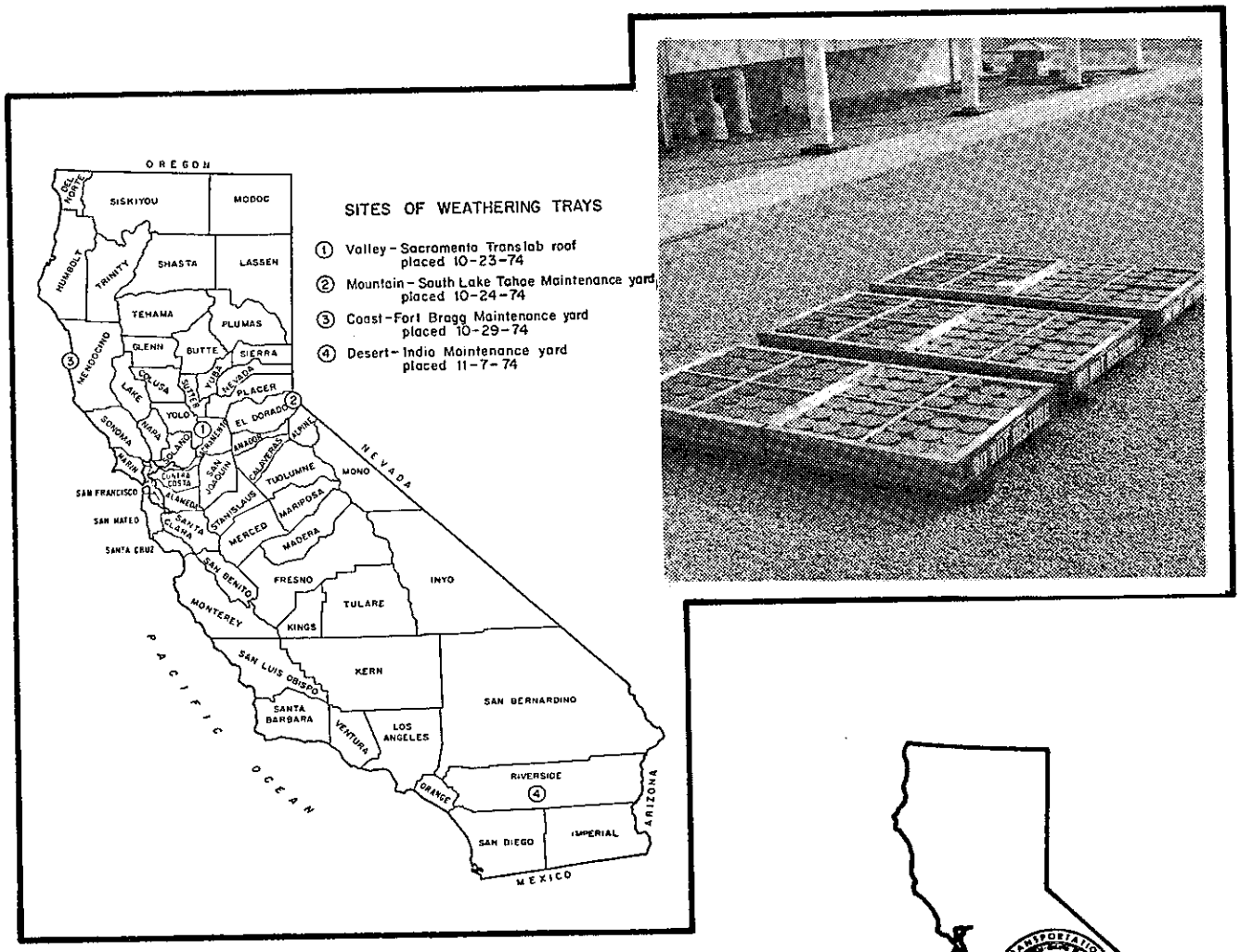
REPORT NO. FHWA/CA/TL-80/14

AN INVESTIGATION OF THE EFFECTIVENESS OF ASPHALT DURABILITY TESTS-FINAL REPORT



FINAL REPORT

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16. ABSTRACT

This is the final report of an asphalt durability project which involved weathering laboratory fabricated briquettes at four different climatic weathering sites within California and subsequent comparison of the effect of this weathering with the results of several laboratory tests of the asphalts used for the briquettes.

The analysis of the test results presents a startling picture of extreme weathering at a hot desert site and the realization that thermal oxidation is the most significant factor affecting asphalt durability. Included are analyses which show that the effects of voids and aggregate porosity are less severe than the thermal oxidation effect in hot desert climates.

A comparison of the results of laboratory tests for predicting asphalt hardening with the results for the field weathered briquettes show that none of the procedures is capable of adequately predicting asphalt weathering in a hot weathering site such as Indio.

A new procedure (California Tilt-oven Asphalt Durability Test) was developed to approximate the effect produced at Indio in two years. Some correlation to briquette results was obtained.

A climatic specification to control asphalt hardening in the hot climatic areas is proposed.

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DEPARTMENT OF TRANSPORTATION
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OFFICE OF TRANSPORTATION LABORATORY

May 1980

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AN INVESTIGATION OF THE EFFECTIVENESS OF ASPHALT DURABILITY TESTS

Final Report

Study Made by ..... Soil Mechanics and Pavement Branch

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Appreciation is also extended to those involved with the typing, drafting, and editing, viz, Darla Bailey, Marion Ivester, and Eileen Howe.

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quanity	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic yards (yd^3)	3.785 .02832 .7646	litres (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time			
(Flow)	cubic feet per second (ft^3/s)	28.317	litres per second (l/s)
	gallons per minute (gal/min)	.06309	litres per second (l/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour(mph) feet per second(fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity(G)	9.807	metres per second squared (m/s^2)
Weight Density	pounds per cubic (lb/ft^3)	16.02	kilograms per cubic metre (kg/m^2)
Force	pounds (lbs) kips (1000 lbs)	4.448 4448	newtons(N) newtons (N)
Thermal Energy	British thermal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds(ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds(ft-lbs) foot-pounds(ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi $\sqrt{in}$)	1.0988	mega pascals $\sqrt{metre}$ (MPa $\sqrt{m}$)
	pounds per square inch square root inch (psi $\sqrt{in}$)	1.0988	kilo pascals $\sqrt{metre}$ (KPa $\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{tF - 32}{1.8} = tC$	degrees celsius (°C)

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INTRODUCTION

Studies to improve and measure asphalt durability have been underway for many years. Since late 1973, the California Department of Transportation has been engaged in a research project to establish asphalt durability criteria. Carefully controlled and fabricated laboratory briquettes were weathered in four distinctly different field environments for four years prior to testing.

This report presents the results of tests on the weathered briquettes at different intervals as well as an analysis of those results in comparison to values derived from various laboratory procedures for predicting asphalt durability. Additionally, a new laboratory procedure for predicting asphalt durability, developed by Caltrans Laboratory, is presented. Correlating evidence from a field test section is also included to "calibrate" the field weathering procedure used. New specifications are proposed relating to findings obtained from this study. These new specifications should provide assurance that the asphalts used in a given climate area are those most capable of providing satisfactory performance.

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FINDINGS AND CONCLUSIONS

Findings and conclusions determined from this study are as follows:

1. High average air temperature (thermal oxidation) is the most significant factor affecting the rate and amount of asphalt hardening in hot climates. Voids and aggregate porosity are also contributing factors but are dependent upon the asphalt's susceptibility to these factors.

2. The effect of excess voids and aggregate porosity does appear to affect asphalt hardening significantly at cooler pavement sites.

3. The effect of voids is similar among all asphalts.

4. The effect of aggregate porosity varies among the more volatile asphalts.

5. Results from the Calipatria Test Road indicate that briquette weathering per unit time is slightly more severe than actual road weathering in the Indio climate. These results indicate that 24 months of briquette weathering at Indio is approximately equal to 32 months of road weathering.

6. It is apparent that the effects on asphalt hardening produced by the Indio site would serve as an excellent model for a hot climate asphalt specification.

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7. It appears that the California Tilt-oven Asphalt Durability Test could be used to predict the asphalt hardening caused in two years at the Indio site and that the results of tests on the residue from this test could be used with a hot climate specification to control asphalt durability.

8. In addition to improved asphalt from a durability procedure, it is believed that the following factors will improve asphalt durability: 1. Adherence to specification compaction requirements to reduce voids, 2. The selective use of asphalts which are most suited to the quality of the aggregate available, 3. The avoidance of the use of absorbent aggregate wherever possible in hot areas, 4. The use of the softest grade of asphalt consistent with curing and stability constraints, and 5. The insulating of the asphalt concrete mat with a cover such as a reflective chip seal in hot areas.

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IMPLEMENTATION

To implement the findings of this study, it would be necessary to adopt asphalt specifications based on climatic differences in California. Specifically, a specification is needed to lessen the effect of hot climates on asphalt hardening. Such a specification is offered in this report.

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SYNOPSIS OF PROJECT

I. Plan

The laboratory fabricated briquettes which were installed in four environmentally different weathering sites were designed to have both controlled variables and constants. These included:

A. Three asphalts - high, high moderate, and low temperature susceptibility.

B. Two aggregates - absorbent and nonabsorbent.

C. Mix design - Standard California Type B, 3/4 inch maximum, medium grading with optimum bitumen content for each aggregate.

D. Mixing - conditions were the same for each batch. A mixing temperature of approximately 325° was used.

E. Fabrication and voids - 1500 gram briquettes - 4-inch diameter - fabricated to three void ranges (3 to 5%, 7 to 9%, 10 to 12%).

F. Weathering:

1. Four climatic sites - (coastal, valley, high mountain, desert).

2. Weathering periods - initial, 1 year, 2 years, 4 years.

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Complete details regarding the design, fabrication and installation of the briquettes can be found in an initial report for this project(1).

II. Field Weathering Conditions

The four weathering sites all had significantly different climates which represented the various regions of California. Figures 1 and 2 show the location of these sites and the trays of briquettes as arranged for weathering. Climatological data for the four sites is presented in Table 1. During the four year weathering period, the average temperatures corresponded closely with the normal average temperatures. During this period a two year drought occurred in northern California which is reflected in the below normal precipitation averages for the weathering period. In contrast, the southern California desert site at Indio experienced unusual storms for two of the four years, thus causing an above normal average precipitation.

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FIELD TEST RESULTS

I. Laboratory Fabricated Briquettes

Laboratory testing of the briquettes was programmed to occur on original, 1 year, 2 year, and 4 year old specimens. Recovery of the asphalt was accomplished using the Abson recovery procedure (AASHTO-T170) prior to testing. Some of the briquettes were tested to determine their Resilient Modulus (M_R) value when this procedure became available. Also, a portion of some of the briquettes was sawed into slices to determine hardening with depth. The Micro-Recovery Procedure (California Test 365) was used to recover the small samples of asphalt.

A. Abson Recovered Asphalt: Each Abson recovery sample consisted of two 1500 gram briquettes (1250 grams for briquettes containing 10-12% voids and absorbent aggregate). Since there were four briquettes for each variable, Abson recoveries were run in duplicate. Tables 2A and B, 3A and B, 4A and B and 5A and B present the results of tests performed on the recovered asphalts for each weathering period and site.

B. Micro-Recovery of Sawn Slices: Micro-recoveries were performed on one half of one of the briquettes from selected samples. The briquettes were sawn in half vertically. Each half was then divided into four equal slices with depth. Normally the slices were approximately 3/4-inch thick. This size sample provided sufficient asphalt after recovery to perform microviscosity and microductility tests. Tables 6 and 7 contain these results.

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C. Resilient Modulus (M_R): When the Resilient Modulus (M_R) procedure became available approximately two years after the beginning of this project, it was decided to measure this mix property for the remaining samples. In addition, an extra set of original briquettes which had been stored in a dark cool location was tested at that time. Several of the briquettes containing LA Basin and Santa Maria asphalt that had other briquettes stacked upon them had begun to disintegrate during this storage period due to lack of lateral support and thus were not tested. All the 4-year briquettes were tested. Table 8 presents the "original" and four-year test results.

II. Calipatria Field Test Section

In November 1977, the Transportation Laboratory was involved in a study of asphalt rubber interlayers on a road in the same climatic area as the Indio test site (at Calipatria, about 60 miles south of Indio in the Imperial Valley). As part of the Calipatria study, thick AC overlays (0.20' and 0.35') were placed over control and interlayer sections using one of the asphalts (LA Basin) used in this asphalt durability study. Since approximately two years remained for this study, samples of the asphalt and mix were obtained during paving operations at Calipatria and cores were taken two years later in the same sections. The test results for the asphalt recovered from these cores was then compared to the two year Indio test results to verify the authenticity of the field weathering procedure used in this durability study.

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A. Testing of Original Asphalt and Mix: Tests were performed on the original asphalts sampled the day of paving and on AC mix samples taken from the paver. The results are shown by Table 9. A comparison of the test results for the LA Basin asphalt used in this study and the LA Basin asphalt from Calipatria indicates that they are probably from the same crude source (Table 10).

B. Abson Recovered Samples: Four 4-inch diameter cores were removed from several separate locations after 26 months. To minimize the effect of any underlying layers and the "tack" coat and to study a uniform pavement depth representative of most overlays, only the top 2 inches of each core was used for this study. The four cores (top 2") from each location were then broken up and combined thoroughly prior to apportioning a 3000 gram sample for Abson recovery. Table 11 presents the results of tests on the recovered asphalt.

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ANALYSIS OF FIELD TEST RESULTS

I. Preface

It is generally accepted that asphalt hardening is a good relative measure of asphalt concrete durability, other factors such as pavement base stability and structural integrity being equal. Because asphalt concrete void contents influence the rate at which asphalt hardens, a primary intent of this study was to determine if a useful critical void content range could be ascertained that could be related to various pavement environments and to asphalt durability. When the "first year" test results became available from the four weathering sites, it became apparent that factors other than void content were equally or more important to asphalt durability. As the study progressed, it became increasingly apparent that asphalt hardening in hot climates is most influenced by thermal oxidation with voids and aggregate characteristics contributing in varying degrees depending upon the character of the individual asphalts. Dickenson(2) reports that the rate of thermal oxidation is approximately doubled for every 10°C (18°F) rise in temperature. Thus the rate of hardening in service depends, to a large extent, on the pavement temperature system.

As mentioned earlier, the four weathering sites have distinctive climates representing major portions of California. The average yearly temperature for each site ranged from 41.6°F at South Lake Tahoe to 73°F at Indio. Table 1 presents this information plus data showing that the Indio site had a high percentage of days in which the "high"

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temperature exceeded 90°F and 100°F. The temperature data would indicate that according to Dickenson's(2) formula, the rate of thermal hardening at the Indio site should have been about three times that of the South Lake Tahoe and Fort Bragg sites. Similarly, the Sacramento site should show an increase in thermal oxidation or hardening of about two times that of South Lake Tahoe and Fort Bragg sites.

II. Weathering Factors

Analysis of the field test results from the recovered briquettes was based on three main factors which influence asphalt hardening. These factors are: A. - Site climate, B. - Voids, and C. - Aggregate porosity (Km value). Charts showing the effects of these hardening factors were prepared for 77°F and 140°F temperatures to show the significant differences in temperature and shear susceptibility of the three asphalts.

A. Site Climate: Figures 3 and 4 and Table 12 show the total effect of the various climatic differences. The hardening pattern appears to fall in line quite well with the predictions based on average temperatures even though the Sacramento curves do not quite measure up to the prediction. A similar relationship of temperature to hardening is exhibited when a comparison is made between the number of 90°F+ and 100°F+ maximum temperature days/year and the viscosity measurements at 77°F (25°C) and 140°F (60°C) on the graphs. Figures 5 through 10 show how climate affected the hardening rates of each asphalt at 77°F and 140°F. As can be seen, all of the asphalts reacted similarly to the Indio (desert) climate. However, the valley asphalt showed little effect from the warm Sacramento (valley) climate.

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B. Voids [Calculated from the Theoretical Maximum Density and the Compacted Sample Density(1)]: The effect of void content on hardening is portrayed on Figures 11 through 18. Figures 11 and 12 present the void effects from a view of combined sites, aggregates, and asphalts. The effects of voids, as shown on these figures, indicates a definite increase in hardening as the void percentage increases, particularly when the viscosity is measured at 140°F (60°C) (Figure 12). Each of the asphalts appears to react similarly to the differences in voids. The apparent discrepancy with the valley asphalt (Figures 13 and 16) can be explained by the fact that the 10 to 12% void briquettes for the valley asphalt were actually about 9%(1). Thus, the 10 to 12% curve and the 7 to 9% curve are almost identical.

C. Aggregate Porosity [Km Value(1)]: The effect of aggregate porosity on hardening apparently is a function of the volatility of the asphalt. Figures 19 through 26 show the effects of aggregate porosity on asphalt hardening as determined from this study. It appears that the hardening characteristics of the relatively volatile Santa Maria asphalt are more sensitive to aggregate porosity than are those of the Valley and LA Basin asphalts. When the Santa Maria asphalt is used with a nonabsorbent aggregate, it compares favorably with the less volatile asphalts in regard to asphalt hardening (Figures 27 through 30).

D. Combining Factors: The data obtained for this project suggests that climate affects asphalt hardening considerably more than mix void content or aggregate porosity in hot areas. The data suggest that the effect of voids and aggregate porosity become more significant as the temperature increases, however. In addition, the

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effect of porosity is noticeably dependent upon the nature of the asphalt. It appears that in the cooler climates, asphalt hardening rates are considerably slower and that the cause of this hardening is more equally divided among climatic factors, voids, and aggregate porosity. Figures 27 through 30 show these relationships.

E. Hardening With Depth: Part of the durability study dealt with a minor study of hardening with depth. The selected briquettes through the first three samplings included only those containing Santa Maria asphalt and having void contents of 3 to 5% and 10 to 12%. These samples were chosen for this limited study because it appeared they would provide the most significant results. At the last sampling (four years), 7 to 9% briquettes containing the valley (Kern) and LA Basin asphalts were also included. Figures 31 and 32 illustrate the relationships between asphalt hardening and depth, time, aggregate porosity, and mix void content. Generally, the surface slice showed the effect of actinic hardening. Figures 33 through 36 display the fourth year picture of hardening with depth for each site. Generally, they are all quite similar except for the hardening which was considerably greater at the Indio site and somewhat greater at Sacramento.

F. Weathering Effects on Other Asphalt Properties: The results of asphalt weathering can also be seen by examining the effect of time on several other properties. These include temperature and shear susceptibility and ductility. The effects of temperature susceptibility can be seen by comparing the viscosity data at 77°F and 140°F shown on Figures 3 and 4. Other tests which measure temperature susceptibility are the softening point and, to a

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degree, the ductility determination. Tables 2A and B through 5A and B contain softening point and ductility test results from all of the test sections. Figure 37 portrays how the effects of climate and time affected the ductility of the different asphalts. The greatest effect was again evident at Indio. Ductility measurements may also indicate changes or degrees of shear susceptibility. The effects of climate and time on shear susceptibility are portrayed on Figure 38.

G. Resilient Modulus (M_R): Graphs of the Resilient Modulus (M_R) values found on Table 8 are presented as Figures 39 and 40. Resilient Modulus (M_R) primarily indicates the degree of rigidity of the core or briquette being tested or the pavement from which a core was taken. As the values increase, an increase in rigidity is indicated. The results shown on these graphs indicate that originally there was considerable variation in rigidity between the briquettes fabricated from the different asphalts at the different void contents. The mix containing the Santa Maria asphalt is more sensitive to void content than the valley mix as indicated by M_R. However, the effect of aggregate porosity is the opposite of that shown by the valley mix. The fourth-year results show that the briquettes from the sites with the most hardening exhibit Resilient Modulus (M_R) results which are the most uniform and similar. Also, none of the values are extremely high.

III. Comparison of Briquette Results to Road Results

Since Indio and Calipatria have approximately the same climate, a comparison of rate of hardening results for

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the Indio briquettes and the Calipatria overlay was accomplished. Table 11 contains a comparison of the road results with 24-month Indio results taken from Figures 6, 9, and 41. It can be seen that there is a fairly good correlation between the results. The "Road" average results are slightly softer, indicating that the briquette weathering medium is slightly more severe than that of an actual overlay. The data from Figures 6, 9, and 41 suggests that 26 months of road weathering is equivalent to approximately 20 months of briquette weathering time.

Using these figures, 24 months of briquette weathering time represents approximately 32 months of road weathering time. This correlation is for only the LA Basin asphalt although it is believed that the other asphalts would react similarly.

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COMPARISON OF FIELD BRIQUETTE TEST RESULTS WITH LABORATORY ASPHALT TEST RESULTS

I. Synopsis of Laboratory Asphalt Test Procedures

Several laboratory procedures for predicting asphalt hardening have been studied and their results have been compared to previous field test section results(3). These procedures were again performed on the asphalts used in this study at the beginning of the project. Procedural details and the test results for each procedure can be found in the initial report of this project(1). Following is a list of the procedures:

A. Compositional Tests

1. Rostler Fingerprinting Procedure - Rostler Ratio $(N+A_1)/(P+A_2)$ - Generally considered the most predictive relationship.

2. Characterization of Asphaltene Dispersions (Heithaus Method) - State of Peptization "P" considered most significant.

3. Vanadium Content Determination - Indicates PPM of vanadium.

B. Accelerated Weathering Procedures

1. RTF Durability Test (5 hrs at 325°F [163°C]) - The size of recovered sample allows numerous tests on residue.

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2. Rolling Microfilm Circulating Oven Durability Test (RMF-C at 210°F [98.9°C] for 48 hours) - Provides only enough residue to perform micro-tests, also has potential of being quite dangerous to run.

3. Ottawa Sand Mix Weathering in Planetary Oven at 140°F (60°C) - Various time periods of up to 1200 hours have been tried. The most appropriate time seems to be 400 to 800 hours. The test generally provides only enough residue for micro-tests.

4. Weathering Plate Durability Test (Calif. Test 347; 210°F [98.9°C] for 24 hours) - Provides only enough residue for micro-tests.

5. Actinic Light Weathering Test (95°F [35°C], 18 hours, 1000 MW/cm^2 of 3660 angstrom [$M^{1x10^{-10}}$] actinic radiation). Results of tests run at different thicknesses indicate this test only measures the effect of actinic light hardening within the outer 5μ of the asphalt film.

II. New Durability Test Procedure (California Tilt-oven Asphalt Durability Test)

After completing the testing of the two year sampling of weathered briquettes, it became apparent that none of the laboratory asphalt test procedures listed above adequately predicted the effect of asphalt weathering at the field sites. In addition, none of the results from previous Caltrans research on asphalt durability indicated the profound changes in asphalt that were occurring at Indio. These changes brought about a new awareness of the effect

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of thermal hardening upon asphalt. Thus, it was decided that a new procedure should be developed which simulates to a reasonable degree, what is apparently the most severe California weathering condition, a desert climate. Thus the two year results from Indio were used as a target for a new procedure.

While the same oven is used in both the RMF-C and RTF procedures(1), the RMF-C procedure requires additional apparatus. The RMF-C procedure gave better results than most of the prediction procedures. It was, however, difficult to run, produced a very small amount of residue, and, probably most important, was potentially quite dangerous because of the presence of volatile fumes in the oven. Although the RTF procedure was relatively simple and produced the largest quantity of residue of any of the prediction procedures, the resulting data did not correlate well with field results. The RTF and RTF-C (AASHTO T240) require identical apparatus. Thus, the development of a new test was based primarily on the RTF procedure.

In the process of developing a procedure which would more accurately predict the hardening pattern of asphalts which had different temperature susceptibilities and volatilities, it was necessary to lower the temperature which then required a longer weathering period. Lowering of the temperature caused the asphalt to build up in the bottles, which were horizontal in the RTF and RMF-C procedures, and drip out of some of the bottles. This problem was addressed by tilting the oven so that the front was slightly higher. While the test procedure was being evolved, an effort was made to keep the oven as horizontal as possible, the temperature as low as possible, and the weathering period as short as possible. The new test procedure is presented in Appendix A.

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The following conditions were selected to approximate the asphalt hardening occurring at Indio. Temperature - 113°C (235.4°F); weathering period - 168 hours (7 days); oven tilt - 1 cm rise in 54 cm (1.06°) measured from the back of the oven.

III. Comparison of Laboratory Asphalt Test Results and Briquette Test Results

Table 13 presents comparisons of the results from the testing of the field weathered briquettes with the results from the various laboratory prediction procedures. An analysis of the results indicates that the California Tilt-oven procedure resulted in the best prediction of change in asphalt properties occurring during the 24-month test period at Indio. This is particularly evident when comparing the penetration results. The tilt-oven procedure is the only procedure besides the RTF Durability Procedure (325°F-5 hrs) which provides sufficient residue to perform a penetration test. It would, therefore, appear that the California Tilt-oven Procedure could be used successfully in a specification to control asphalt hardening in a climate where thermal hardening is the most significant weathering factor.

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CLIMATIC SPECIFICATIONS

It has become apparent that different asphalt specifications are needed for different climatic conditions, particularly in California which has the following major climatic categories: 1. Coastal, 2. High Mountain, 3. Great Valley, 4. Desert, plus many subclimates. Figure 42 shows a delineation of these climates. The major categories include the following areas from the figure: 1. Coastal-1,2,3, & 6; 2, Mountains-4,7,8, & part of 9; 3. Great Valley-part of 3, & 5; 4. Desert-9.

Approximately 1/3 of the land area in California is subjected to what might be termed an excess of thermal oxidation potential. We note on Table 1 that the Sacramento and Indio sites have 75 or more days per year on the average which have maximum temperatures of 90°F or above. On Figure 42 these areas would include the great valley and desert regions. Figure 43 outlines the prevalence of 90°F maximum temperature days in California.

In order to utilize climatic specifications most efficiently, it is necessary to categorize the state into three climatic areas: 1. - Hot desert and great valley areas - maximum temperature of at least 90°F for over 60 days/year. 2. - Cold mountainous areas -minimum temperature of 32°F or less at least 90 days/years (see Figure 44), and 3. - Temperate areas - all other areas.

Asphalt specifications for use in each of these climatic areas would then include the following:

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1. Hot desert(4) and great valley areas: Use the existing California Paving Asphalt specification as modified below and prohibit the use of AR 8000 and AR 16000 grades for road or street paving.

Test on Residue*	AASHTO Test Method	Minimum	Maximum
Penetration at 77°F (25°C)	T49	15	
Absolute Viscosity at 140°F (60°C),(Kilopoise)	T202		100
Ductility at 77°F (25°C) 5 cm/minute, (cm)	T51	20	

*From the California Tilt-oven durability test.

2. Cold mountainous areas: Add a penetration requirement at 39.2°F (4°C) to the current requirements for paving grade asphalt and, again, prohibit the use of AR 8000 and AR 16000 grades.

3. All other areas: Use the current California Paving Asphalt specification.

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REFERENCES

1. Predoehl, N. H. and Kemp, G. R., "An Investigation of the Effectiveness of Asphalt Durability Tests - Initial Phase," FHWA-CA-78-26, August 1978.

2. Dickinson, E. J., "The Hardening of Middle East Petroleum Asphalts in Pavement Surfacings," Personal informational paper - Australian Road Research Bd. 1979. Submitted for presentation to the annual meeting of AAPT, February 1980.

3. Predoehl, N. H. and Kemp, G. R., "Durability of Paving Asphalts, Laboratory Test and Field Data Comparison," State of California, Department of Transportation, Division of Highways, Transportation Laboratory, Research Report CA-DOT-TL-3134-17-74-11, March 1974.

4. Asphalt Concrete Overlay Design Manual, California Department of Transportation, January 1979, p. 23*.

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Table 1

Durability Site Weather Data (U.S. Weather records)

Weathering Site	Average Temperatures°F			Average Days* Maximum Temperature		Precipitation (inches)		
	Avg. During 4 yr cure	Normal Avg/yr	Departure	(32.2°C) 90°F and over/yr	(37.8°C) 100°F and over/yr	Avg. During 4 yr cure	Normal Avg/yr	Departure %
Fort Bragg (coastal)	52.1	52.9	-.8	0	0	31.7	39.9	-8.2 (-20.5%)
Sacramento (valley)	63.0	61.4	+1.6	75	16.6	14.2	18.2	-4.0 (-22%)
So Lake Tahoe (high mountain)	41.6	-	-	***0	0	**19.7	**33.1	-13.4 (-40.5%)
Indio (low desert)	73.0	73.0	0	171	95.5	5.4	3.0	+2.4 (+80%)

* For 1975 thru 1978 cure period)
**Tahoe City (No precipitation records at So. Lake Tahoe FAA - this site in same area

***One day in the 4-year period was over 90°F.

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FIELD WEATHERED BRIQUETTE TEST RESULTS-A

(ABSON RECOVERED AASHTO T 170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Fort Bragg

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate					Absorbent Aggregate				
			Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)	Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)
AASHTO Test Method			T 49	T 53	T 51	T 202	T 201	T 49	T 53	T 51	T 202	T 201
0	Valley (Kern)	3-5	36	126	150+	3.7	327	37	132	150+	3.6	348
0	"	7-9	34	126	150+	3.9	333	35	133	150+	3.9	371
0	"	10-12	34	126	150+	3.8	333	35	133	150+	3.7	335
0	LA Basin	3-5	37	126	150+	3.5	338	38	131	150+	3.6	354
0	"	7-9	37	125	150+	3.4	332	37	132	150+	3.6	375
0	"	10-12	40	124	150+	3.4	338	41	130	150+	3.2	335
0	Santa Maria	3-5	84	118	150+	2.2	413	74	129	141+	3.0	495
0	"	7-9	89	118	150+	2.1	423	76	130	150+	3.2	497
0	"	10-12	87	119	150+	2.2	411	80	126	150+	2.6	464
13	Valley (Kern)	3-5	18	139	150+	9.9	485	22	138	150+	7.2	429
13	"	7-9	14	143	150+	14.9	558	19	137	150+	8.0	458
13	"	10-12	13	145	150+	14.6	569	20	138	150+	8.2	452
13	LA Basin	3-5	26	136	150+	5.5	417	24	138	150+	6.1	431
13	"	7-9	20	138	150+	7.8	486	22	138	150+	7.6	473
13	"	10-12	20	141	150+	8.4	509	22	138	150+	7.0	473
13	Santa Maria	3-5	56	136	150+	5.3	597	47	134	150+	6.3	693
13	"	7-9	54	134	150+	5.3	597	47	135	150+	5.7	620
13	"	10-12	50	134	150+	6.0	642	49	133	147	7.1	692
24	Valley (Kern)	3-5	16	140	100+	12.8	540	20	139	100+	8.6	452
24	"	7-9	12	143	100+	23.6	696	21	141	100+	8.8	561
24	"	10-12	16	143	100+	15.5	726	21	140	100+	8.6	494
24	LA Basin	3-5	25	136	100+	6.8	462	28	138	100+	7.0	495
24	"	7-9	21	140	100+	8.7	513	23	141	100+	8.0	510
24	"	10-12	17	140	100+	11.2	531	21	142	100+	10.6	606
24	Santa Maria	3-5	51	133	100+	6.2	702	45	135	100+	8.3	764
24	"	7-9	45	137	99	8.0	749	42	140	93	10.2	842
24	"	10-12	47	141	100+	9.1	797	40	147	100+	10.3	795
53	Valley (Kern)	3-5	12	144	100+	17.2	618	15	140	100+	13.0	560
53	"	7-9	11	150	25.5	38.3	868	14	143	100+	17.0	622
53	"	10-12	8	148	64.7	31.5	781	14	142	100+	15.9	625
53	LA Basin	3-5	22	136	100+	8.6	504	17	138	100+	11.9	611
53	"	7-9	19	140	100+	12.2	622	22	133	100+	8.8	526
53	"	10-12	18	142	100+	15.9	630	18	140	100+	13.5	600
53	Santa Maria	3-5	43	138	79.1	10.8	801	31	141	44.2	20.3	1074
53	"	7-9	36	142	60.0	16.3	995	29	145	45.9	25.0	1321
53	"	10-12	35	141	49.4	17.2	1010	30	142	59.6	20.2	1107

77°F = 25°C, 140°F = 60°C, 275°F = 135°C

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TABLE 2B

FIELD WEATHERED BRIQUETTE TEST RESULTS – B

(ABSON RECOVERED AASHTO T 170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Fort Bragg

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate				Absorbent Aggregate			
			Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)	Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)
California Test Method No.			348		348	349	348		348	349
0	Valley (Kern)	3–5	12.1	12.1	.0	113	7.9	7.9	.0	118
0	"	7–9	12.5	12.5	.0	96	9.5	10.2	.02	110
0	"	10–12	10.5	10.5	.0	106	9.2	9.2	.0	121
0	LA Basin	3–5	8.65	8.65	.0	125	8.1	8.5	.02	124
0	"	7–9	9.58	9.58	.0	126	8.0	8.0	.0	121
0	"	0–12	10.8	10.8	.0	128	7.07	7.07	.0	123
0	Santa Maria	3–5	2.19	3.35	.11	63	2.83	4.49	.12	44
0	"	7–9	2.52	3.9	.11	49	3.36	6.1	.15	45
0	"	10–12	1.82	2.87	.11	46	3.15	4.98	.11	44
13	Valley (Kern)	3–5	29.7	31.0	.01	88	18.2	18.2	.0	105
13	"	7–9	51.5	63.5	.06	31	22.1	22.1	.0	114
13	"	10–12	52.4	58.6	.03	57	23.2	23.2	.0	110
13	LA Basin	3–5	11.1	11.1	.0	112	14.3	14.3	.0	134
13	"	7–9	19.6	21.3	.03	122	18.6	18.6	.0	116
13	"	10–12	23.1	23.1	.0	112	18.6	18.6	.0	137
13	Santa Maria	3–5	3.4	7.1	.18	47	5.5	9.4	.14	34
13	"	7–9	3.8	6.7	.15	46	5.8	8.6	.11	43
13	"	10–12	5.1	7.5	.10	43	6.3	11.0	.14	44
24	Valley (Kern)	3–5	37.4	44.9	.05	80	22.8	22.8	.0	126
24	"	7–9	84.0	113.0	.08	22	21.6	21.6	.0	120
24	"	10–12	43.9	62.0	.07	26	22.1	25.6	.04	97
24	LA Basin	3–5	14.0	14.7	.02	101	14.6	15.5	.02	93
24	"	7–9	23.1	23.2	.0	130	19.5	20.2	.01	87
24	"	10–12	29.9	36.7	.06	74	24.1	31.2	.06	68
24	Santa Maria	3–5	5.0	7.9	.12	39	6.5	10.5	.13	39
24	"	7–9	6.3	10.0	.12	41	7.5	13.7	.15	16
24	"	10–12	6.6	11.8	.15	29	8.35	15.7	.16	42
53	Valley (Kern)	3–5	58.1	81.0	.09	40	38.5	46.9	.04	67
53	"	7–9	134.0	236.0	.15	0	48.7	65.5	.07	26
53	"	10–12	115.0	227.0	.12	0	48.2	55.7	.04	18
53	LA Basin	3–5	18.8	21.1	.03	89	30.8	34.8	.03	82
53	"	7–9	31.2	40.9	.07	46	23.6	30.7	.06	36
53	"	10–12	39.0	59.4	.07	45	35.0	48.0	.08	47
53	Santa Maria	3–5	8.3	18.5	.20	22	12.9	27.8	.20	14
53	"	7–9	9.9	23.7	.23	13	14.0	34.4	.23	12
53	"	10–12	11.5	25.8	.21	13	14.1	24.3	.14	11

77° F = 25° C

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FIELD WEATHERED BRIQUETTE TEST RESULTS-A

(ABSON RECOVERED AASHTO T 170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Sacramento

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate					Absorbent Aggregate				
			Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)	Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)
AASHTO Test Method			T 49	T 53	T 51	T 202	T 201	T 49	T 53	T 51	T 202	T 201
0	Valley (Kern)	3 – 5	36	126	150+	3.7	327	37	132	150+	3.6	348
0	"	7 – 9	34	126	150+	3.9	333	35	133	150+	3.9	371
0	"	10 – 12	34	126	150+	3.8	333	35	133	150+	3.7	335
0	LA Basin	3 – 5	37	126	150+	3.5	338	38	131	150+	3.6	354
0	"	7 – 9	37	125	150+	3.4	332	37	132	150+	3.6	375
0	"	10 – 12	40	124	150+	3.4	338	41	130	150+	3.2	335
0	Santa Maria	3 – 5	84	118	150+	2.2	413	74	129	141+	3.0	495
0	"	7 – 9	89	118	150+	2.1	423	76	130	150+	3.2	497
0	"	10 – 12	87	119	150+	2.2	411	80	126	150+	2.6	464
16	Valley (Kern)	3 – 5	15	143	150+	11.7	519	17	140	150+	10.2	494
16	"	7 – 9	13	147	150+	17.4	603	16	140	150+	11.0	503
16	"	10 – 12	13	145	150+	13.2	558	16	144	150+	11.9	522
16	LA Basin	3 – 5	20	138	150+	7.9	477	18	139	150+	10.8	536
16	"	7 – 9	18	141	150+	11.6	562	19	138	150+	10.9	543
16	"	10 – 12	14	145	150+	14.2	597	16	145	150+	13.0	577
16	Santa Maria	3 – 5	46	137	150+	7.0	683	35	143	150+	11.7	855
16	"	7 – 9	38	141	150+	11.3	812	38	140	150+	12.0	849
16	"	10 – 12	40	139	150+	10.2	797	39	141	150+	11.0	866
28	Valley (Kern)	3 – 5	15	143	100+	12.9	530	15	145	100+	13.3	586
28	"	7 – 9	10	154	80	27.0	735	13	145	100+	15.1	565
28	"	10 – 12	13	148	100+	16.8	600	16	148	100+	14.5	545
28	LA Basin	3 – 5	17	148	100+	12.9	560	18	145	100+	13.4	624
28	"	7 – 9	14	149	100+	15.9	600	14	147	100+	17.0	640
28	"	10 – 12	11	153	100+	19.6	680	12	148	100+	21.0	675
28	Santa Maria	3 – 5	35	142	92	13.3	803	25	150	49	22.4	1138
28	"	7 – 9	31	147	59	19.8	1211	27	151	59	23.8	1178
28	"	10 – 12	27	152	48	20.9	1090	27	154	43	24.8	1251
51	Valley (Kern)	3 – 5	16	141	100+	15.1	578	13	143	100+	19.9	669
51	"	7 – 9	14	146	64	28.8	758	15	143	100+	17.0	639
51	"	10 – 12	15	144	100+	21.0	681	12	146	100+	26.3	811
51	LA Basin	3 – 5	17	142	100+	14.0	605	12	146	100+	24.3	789
51	"	7 – 9	14	145	100+	21.6	749	14	145	100+	21.2	780
51	"	10 – 12	13	146	100+	24.1	804	18	141	100+	15.5	668
51	Santa Maria	3 – 5	41	140	58	17.6	1015	22	152	26	53.1	1746
51	"	7 – 9	28	151	34	38.7	1551	25	154	38	43.5	1584
51	"	10 – 12	26	153	25	56.3	1794	21	155	18	68.6	2016

77°F = 25°C, 140°F = 60°C, 275°F = 135°C

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TABLE 3B

FIELD WEATHERED BRIQUETTE TEST RESULTS – B

(ABSON RECOVERED AASHTO T170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Sacramento

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate				Absorbent Aggregate			
			Micro-Viscosity (megapoise)		Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)	Micro-Viscosity (megapoise)		Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)
			at 0.05 sec^{-1} Shear rate	at 0.001 sec^{-1} Shear rate			at 0.05 sec^{-1} Shear rate	at 0.001 sec^{-1} Shear rate		
California Test Method No.			348		348	349	348		348	349
0	Valley (Kern)	3–5	12.1	12.1	.0	113	7.9	7.9	.0	118
0	"	7–9	12.5	12.5	.0	96	9.5	10.2	.02	110
0	"	10–12	10.5	10.5	.0	106	9.2	9.2	.0	121
0	LA Basin	3–5	8.65	8.65	.0	125	8.1	8.5	.02	124
0	"	7–9	9.58	9.58	.0	126	8.0	8.0	.0	121
0	"	0–12	10.8	10.8	.0	128	7.07	7.07	.0	123
0	Santa Maria	3–5	2.19	3.35	.11	63	2.83	4.49	.12	44
0	"	7–9	2.52	3.9	.11	49	3.36	6.1	.15	45
0	"	10–12	1.82	2.87	.11	46	3.15	4.98	.11	44
16	Valley (Kern)	3–5	37.0	37.8	.0	102	28.9	32.4	.03	112
16	"	7–9	64.0	79.0	.06	19	31.6	35.0	.03	97
16	"	10–12	44.4	69.8	.12	59	34.3	37.6	.03	16
16	LA Basin	3–5	18.6	20.6	.03	111	26.2	28.9	.02	115
16	"	7–9	29.3	33.9	.04	64	32.5	36.8	.03	58
16	"	10–12	39.9	48.6	.04	40	37.4	49.7	.08	83
16	Santa Maria	3–5	5.5	9.6	.14	45	9.2	16.9	.16	37
16	"	7–9	9.2	17.5	.17	28	9.5	19.1	.18	33
16	"	10–12	8.5	14.7	.14	28	8.5	17.3	.18	30
28	Valley (Kern)	3–5	36.3	41.1	.04	93	47.8	52.8	.03	50
28	"	7–9	97.5	144.0	.11	7	41.7	52.8	.06	48
28	"	10–12	50.3	61.0	.05	44	45.7	57.5	.06	20
28	LA Basin	3–5	33.8	39.0	.04	101	35.3	42.3	.05	66
28	"	7–9	44.3	56.4	.06	40	47.6	64.0	.08	25
28	"	10–12	63.3	90.0	.09	12	65.8	91.5	.09	18
28	Santa Maria	3–5	8.8	15.8	.15	24	16.8	36.9	.21	12
28	"	7–9	14.2	32.1	.21	12	18.8	40.3	.19	13
28	"	10–12	14.3	31.0	.20	13	17.0	36.8	.20	12
51	Valley (Kern)	3–5	49.0	62.5	.06	37	65.5	85.5	.07	23
51	"	7–9	110.0	175.0	.12	0	54.5	79.5	.10	20
51	"	10–12	59.0	108.0	.14	4	93.0	144.0	.11	2
51	LA Basin	3–5	39.1	53.5	.09	66	73.0	114.0	.11	20
51	"	7–9	66.2	99.0	.11	2	60.5	107.0	.15	21
51	"	10–12	119.0	371.0	.22	2	47.0	81.5	.15	16
51	Santa Maria	3–5	10.4	25.9	.23	12	31.7	84.8	.25	5
51	"	7–9	18.3	50.6	.26	8	24.1	75.0	.29	5
51	"	10–12	17.4	59.0	.31	5	33.3	117.0	.31	4

77° F = 25° C

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FIELD WEATHERED BRIQUETTE TEST RESULTS-A

(ABSON-RECOVERED AASHTO T 170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site South Lake Tahoe

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate					Absorbent Aggregate				
			Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)	Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)
AASHTO Test Method			T 49	T 53	T 51	T 202	T 201	T 49	T 53	T 51	T 202	T 201
0	Valley (Kern)	3-5	36	126	150+	3.7	327	37	132	150+	3.6	348
0	"	7-9	34	126	150+	3.9	333	35	133	150+	3.9	371
0	"	10-12	34	126	150+	3.8	333	35	133	150+	3.7	335
0	LA Basin	3-5	37	126	150+	3.5	338	38	131	150+	3.6	354
0	"	7-9	37	125	150+	3.4	332	37	132	150+	3.6	375
0	"	10-12	40	124	150+	3.4	338	41	130	150+	3.2	335
0	Santa Maria	3-5	84	118	150+	2.2	413	74	129	141+	3.0	495
0	"	7-9	89	118	150+	2.1	423	76	130	150+	3.2	497
0	"	10-12	87	119	150+	2.2	411	80	126	150+	2.6	464
11	Valley (Kern)	3-5	21	138	150+	7.7	429	23	135	150+	5.7	419
11	"	7-9	18	141	150+	10.0	514	22	137	150+	7.2	383
11	"	10-12	20	140	150+	9.3	457	23	139	150+	7.1	422
11	LA Basin	3-5	26	137	150+	5.9	419	26	137	150+	6.3	444
11	"	7-9	21	140	150+	7.6	471	24	139	150+	7.4	465
11	"	10-12	20	137	150+	7.8	504	22	140	150+	7.7	485
11	Santa Maria	3-5	56	134	150+	5.8	596	46	133	150+	7.6	731
11	"	7-9	52	137	150+	5.3	595	48	138	150+	6.8	689
11	"	10-12	50	135	150+	5.8	617	46	132	150+	7.4	725
23	Valley (Kern)	3-5	21	138	100+	8.7	461	25	134	100+	6.7	455
23	"	7-9	17	138	100+	11.0	500	19	139	100+	9.1	462
23	"	10-12	15	142	100+	13.9	495	19	137	100+	9.8	482
23	LA Basin	3-5	26	134	100+	7.2	530	26	130	100+	6.7	449
23	"	7-9	20	135	100+	9.2	492	26	133	100+	6.8	477
23	"	10-12	20	134	100+	10.6	527	19	137	100+	10.7	518
23	Santa Maria	3-5	53	133	100+	5.4	590	38	137	100+	10.8	833
23	"	7-9	44	136	100+	8.3	705	43	138	100+	10.3	815
23	"	10-12	44	133	100+	7.5	687	40	140	100+	9.9	825
48	Valley (Kern)	3-5	17	139	100+	10.8	522	15	143	100+	13.3	546
48	"	7-9	14	144	100+	20.1	626	23	136	100+	7.6	448
48	"	10-12	12	146	100+	18.2	639	14	142	100+	16.2	607
48	LA Basin	3-5	17	139	100+	11.0	594	14	145	100+	15.9	627
48	"	7-9	14	143	100+	16.4	657	15	142	100+	16.4	639
48	"	10-12	12	144	55.8	22.0	704	13	144	100+	18.6	717
48	Santa Maria	3-5	38	138	81.5	11.4	839	28	147	44.9	24.7	1218
48	"	7-9	32	144	52.4	17.2	1090	27	146	61.1	24.9	1216
48	"	10-12	32	143	55.2	17.7	981	26	147	57.5	27.6	1575

77°F = 25°C, 140°F = 60°C, 275°F = 135°C

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TABLE 4B

FIELD WEATHERED BRIQUETTE TEST RESULTS – B

(ABSON RECOVERED AASHTO T170 – AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site South Lake Tahoe

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate				Absorbent Aggregate			
			Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)	Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)
California Test Method No.			348		348	349	348		348	349
0	Valley (Kern)	3–5	12.1	12.1	.0	113	7.9	7.9	.0	118
0	"	7–9	12.5	12.5	.0	96	9.5	10.2	.02	110
0	"	10–12	10.5	10.5	.0	106	9.2	9.2	.0	121
0	LA Basin	3–5	8.65	8.65	.0	125	8.1	8.5	.02	124
0	"	7–9	9.58	9.58	.0	126	8.0	8.0	.0	121
0	"	0–12	10.8	10.8	.0	128	7.07	7.07	.0	123
0	Santa Maria	3–5	2.19	3.35	.11	63	2.83	4.49	.12	44
0	"	7–9	2.52	3.9	.11	49	3.36	6.1	.15	45
0	"	10–12	1.82	2.87	.11	46	3.15	4.98	.11	44
11	Valley (Kern)	3–5	21.8	21.8	.0	126	13.2	13.2	.0	128
11	"	7–9	30.8	34.6	.03	66	17.8	17.8	.0	130
11	"	10–12	28.5	29.4	.01	109	19.4	19.7	.01	114
11	LA Basin	3–5	13.4	13.4	.0	130	14.2	14.2	.0	132
11	"	7–9	20.0	20.8	.01	108	18.3	19.3	.02	139
11	"	10–12	20.0	21.3	.02	116	18.9	19.8	.02	120
11	Santa Maria	3–5	4.0	6.5	.13	47	5.9	9.7	.12	35
11	"	7–9	4.2	7.6	.16	41	5.3	10.1	.15	38
11	"	10–12	4.2	8.5	.17	39	6.1	10.5	.11	49
23	Valley (Kern)	3–5	23.8	23.8	.0	120	13.8	13.8	.0	136
23	"	7–9	30.4	34.4	.03	124	24.1	24.1	.0	127
23	"	10–12	42.2	50.0	.05	52	25.4	25.4	.0	97
23	LA Basin	3–5	16.4	17.4	.02	135	15.6	16.9	.04	73
23	"	7–9	22.6	23.9	.01	84	15.8	15.8	.0	106
23	"	10–12	27.1	32.9	.05	113	28.4	31.9	.03	119
23	Santa Maria	3–5	3.96	7.7	.17	38	8.72	18.0	.18	27
23	"	7–9	6.35	10.1	.12	30	7.45	13.7	.15	41
23	"	10–12	5.88	10.5	.15	38	8.55	14.4	.14	40
48	Valley (Kern)	3–5	31.1	40.5	.07	86	41.1	51.3	.06	71
48	"	7–9	62.8	78.8	.07	22	27.5	29.0	.01	64
48	"	10–12	65.0	89.7	.08	7	50.0	56.2	.04	15
48	LA Basin	3–5	27.9	30.6	.03	74	40.1	52.7	.07	49
48	"	7–9	45.0	70.2	.12	11	41.4	56.6	.08	33
48	"	10–12	71.2	107.0	.11	4	53.0	79.2	.11	17
48	Santa Maria	3–5	8.8	17.7	.18	17	17.6	38.4	.20	12
48	"	7–9	13.0	29.2	.21	15	17.1	39.2	.21	14
48	"	10–12	10.0	22.0	.19	20	17.3	40.4	.22	9

77°F = 25°C

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TABLE 5A

FIELD WEATHERED BRIQUETTE TEST RESULTS-A

(ABSON RECOVERED AASHTO T 170 - AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Indio

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate					Absorbent Aggregate				
			Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)	Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (cm)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)
AASHTO Test Method			T 49	T 53	T 51	T 202	T 201	T 49	T 53	T 51	T 202	T 201
0	Valley (Kern)	3-5	36	126	150+	3.7	327	37	132	150+	3.6	348
0	"	7-9	34	126	150+	3.9	333	35	133	150+	3.9	371
0	"	10-12	34	126	150+	3.8	333	35	133	150+	3.7	335
0	LA Basin	3-5	37	126	150+	3.5	338	38	131	150+	3.6	354
0	"	7-9	37	125	150+	3.4	332	37	132	150+	3.6	375
0	"	10-12	40	124	150+	3.4	338	41	130	150+	3.2	335
0	Santa Maria	3-5	84	118	150+	2.2	413	74	129	141+	3.0	495
0	"	7-9	89	118	150+	2.1	423	76	130	150+	3.2	497
0	"	10-12	87	119	150+	2.2	411	80	126	150+	2.6	464
14	Valley (Kern)	3-5	12	148	150+	19.0	642	13	145	150+	18.4	600
14	"	7-9	13	150	150+	23.1	711	12	149	150+	23.0	702
14	"	10-12	13	147	150+	23.4	681	13	150	150+	21.2	767
14	LA Basin	3-5	17	140	150+	11.6	534	12	150	150+	23.4	746
14	"	7-9	19	141	150+	10.3	536	12	150	150+	23.7	738
14	"	10-12	17	147	150+	13.4	624	10	152	150+	28.3	827
14	Santa Maria	3-5	34	142	105	14.0	908	24	151	55	35.4	1391
14	"	7-9	28	148	96	21.4	1100	19	155	29	41.2	1535
14	"	10-12	28	150	81	22.9	1092	20	156	26	48.4	1611
27	Valley (Kern)	3-5	12	151	100+	23.2	715	11	155	80	28.0	768
27	"	7-9	10	153	30	34.7	825	9	152	40	34.1	855
27	"	10-12	10	160	23	38.7	835	10	153	24	33.6	810
27	LA Basin	3-5	10	157	38	20.9	680	8	164	21	37.0	915
27	"	7-9	10	156	56	41.0	945	9	165	6	47.3	1035
27	"	10-12	9	157	12	72.6	1200	9	161	11	57.9	1150
27	Santa Maria	3-5	22	154	18	46.4	1519	17	168	13	82.0	1972
27	"	7-9	22	171	12	60.2	1660	19	164	12	80.5	1980
27	"	10-12	20	168	20	70.4	1905	14	167	9	106.9	2265
49	Valley (Kern)	3-5	10	151	60	38.3	852	10	150	57	40.2	918
49	"	7-9	7	158	5.5	99.5	1215	8	156	7.9	67.1	1077
49	"	10-12	8	157	6.8	74.6	1122	8	155	7.5	72.0	1130
49	LA Basin	3-5	13	148	100+	26.4	830	8	155	8.6	69.3	1178
49	"	7-9	8	155	8.6	75.7	1241	8	156	14.1	58.9	1148
49	"	10-12	7	159	6.3	102.9	1427	7	156	7.6	88.3	1306
49	Santa Maria	3-5	21	155	8.8	89.4	2118	14	174	5.4	460.2	5445
49	"	7-9	19	163	8.9	115.5	2471	13	177	5.0	796.5	7184
49	"	10-12	17	163	5.9	193.7	3066	13	182	4.2	1815	10720

77°F = 25°C, 140°F = 60°C, 275°F = 135°C

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TABLE 5B

FIELD WEATHERED BRIQUETTE TEST RESULTS—B

(ABSON RECOVERED AASHTO T170—AVERAGE OF 2 SAMPLES [4 BRIQUETTES])

Test Site Indio

Weathering Period (Months)	Asphalt Source	% Voids	Non-Absorbent Aggregate				Absorbent Aggregate			
			Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)	Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)
California Test Method No.			348		348	349	348		348	349
0	Valley (Kern)	3-5	12.1	12.1	.0	113	7.9	7.9	.0	118
0	"	7-9	12.5	12.5	.0	96	9.5	10.2	.02	110
0	"	10-12	10.5	10.5	.0	106	9.2	9.2	.0	121
0	LA Basin	3-5	8.65	8.65	.0	125	8.1	8.5	.02	124
0	"	7-9	9.58	9.58	.0	126	8.0	8.0	.0	121
0	"	0-12	10.8	10.8	.0	128	7.07	7.07	.0	123
0	Santa Maria	3-5	2.19	3.35	.11	63	2.83	4.49	.12	44
0	"	7-9	2.52	3.9	.11	49	3.36	6.1	.15	45
0	"	10-12	1.82	2.87	.11	46	3.15	4.98	.11	44
14	Valley (Kern)	3-5	66.8	85.5	.07	12	63.3	86.0	.08	23
14	"	7-9	86.8	119.0	.08	10	88.5	107.0	.05	9
14	"	10-12	97.5	118.0	.06	16	77.5	102.0	.07	2
14	LA Basin	3-5	32.5	36.4	.03	121	83.3	109.0	.07	27
14	"	7-9	26.9	31.5	.04	126	85.0	115.0	.08	6
14	"	10-12	60.4	80.8	.07	12	108.0	206.0	.09	3
14	Santa Maria	3-5	9.9	21.7	.20	20	21.2	52.5	.23	11
14	"	7-9	15.4	33.6	.20	15	27.2	64.0	.22	9
14	"	10-12	16.5	35.8	.20	14	26.7	84.5	.29	7
27	Valley (Kern)	3-5	71.0	98.8	.09	10	96.0	125.0	.07	7
27	"	7-9	128.0	201.0	.12	1	111.0	167.0	.11	2
27	"	10-12	131.0	213.0	.12	3	126.0	188.0	.11	2
27	LA Basin	3-5	59.5	86.3	.10	45	130.0	187.0	.10	2
27	"	7-9	107.0	174.0	.12	4	186.0	287.0	.11	3
27	"	10-12	221.0	423.0	.17	1	153.0	296.0	.19	1
27	Santa Maria	3-5	21.8	63.8	.28	7	37.3	138.0	.34	4
27	"	7-9	23.8	75.8	.30	6	36.3	116.0	.30	3
27	"	10-12	30.5	108.0	.32	5	53.0	197.0	.34	2
49	Valley (Kern)	3-5	157.0	272.0	.18	3	168.0	248.0	.11	2
49	"	7-9	435.0	847.0	.17	0	305.0	505.0	.13	0
49	"	10-12	364.0	622.0	.14	0	296.0	550.0	.16	0
49	LA Basin	3-5	96.0	150.0	.12	7	272.0	470.0	.15	1
49	"	7-9	348.0	610.0	.14	0	231.0	360.0	.12	0
49	"	10-12	350.0	755.0	.20	0	279.0	640.0	.21	0
49	Santa Maria	3-5	40.6	144.0	.32	2	71.5	313.0	.38	1
49	"	7-9	36.2	129.0	.33	2	111.0	461.0	.37	0
49	"	10-12	51.8	215.0	.37	2	117.0	600.0	.43	0

77°F = 25°C

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MICRO-RECOVERED ASPHALT FROM SLICES (CALIFORNIA T.M. 365) TABLE 6

Age (Mo)	Weathering Site & Aggregate*	Asphalt Source	% Voids	Slice 1 – 0 To 3/4" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 1 – 0 To 3/4" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 1 – 0 To 3/4" Approx. Shear Susceptibility (Slope)	Slice 1 – 0 To 3/4" Approx. Micro-Ductility at 77°F (mm)	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 2 – 7/8" To 1 5/8" Approx. Shear Susceptibility (Slope)	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Ductility at 77°F (mm)	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 3 – 1 3/4" To 2 1/2" Approx. Shear Susceptibility (Slope)	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Ductility at 77°F (mm)	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 4 – 2 5/8" To 3 3/8" Approx. Shear Susceptibility (Slope)	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Ductility at 77°F (mm)
-1st yr-				California Test Method No. 348		348	349	348		348	349	348		348	349	348		348	349
11	SoLake NA	Santa	3-5	6.7	12.0	.15	30	2.7	5.2	.17	51	2.6	4.5	.14	40	2.9	4.9	.14	38
	TahoeNA	Maria	10-12	7.4	13.8	.16	37	2.6	3.6	.09	61	2.1	3.1	.11	47	2.1	2.9	.09	44
	" A	"	3-5	8.6	16.0	.15	25	3.6	5.9	.13	46	3.5	6.5	.16	45	3.9	7.3	.16	30
	" A	"	10-12	10.9	22.2	.18	25	3.9	5.8	.10	43	5.2	7.6	.10	52	3.3	4.1	.06	50
13	FortBragg NA	"	3-5	6.9	9.7	.09	33	3.2	5.2	.13	40	2.6	4.2	.12	54	2.9	4.1	.09	28
	NA	"	10-12	9.4	18.2	.17	28	3.2	4.9	.11	46	3.4	5.6	.13	41	3.5	5.5	.11	49
	" A	"	3-5	10.2	15.2	.10	28	5.3	10.0	.16	29	6.2	9.0	.10	23	6.5	9.6	.10	27
	" A	"	10-12	7.8	14.8	.17	42	6.1	8.1	.07	51	5.0	7.1	.09	44	5.3	9.0	.13	37
14	IndioNA	"	3-5	28.5	92.0	.30	9	10.5	19.6	.16	23	4.0	6.2	.11	29	9.2	18.4	.18	25
	" NA	"	10-12	32.0	105.0	.30	3	15.8	33.4	.19	14	12.9	25.8	.18	10	13.3	28.0	.19	14
	" A	"	3-5	63.0	225.0	.33	1	24.3	62.5	.24	4	20.0	56.0	.27	9	23.4	53.0	.21	7
	" A	"	10-12	77.0	295.0	.34	1	28.0	73.0	.24	3	22.4	54.5	.23	4	20.0	45.0	.21	8
16	Sacto NA	"	3-5	12.7	22.7	.15	14	5.0	8.0	.12	36	3.8	4.8	.06	41	3.0	4.7	.12	47
	" NA	"	10-12	19.2	51.0	.25	9	6.7	10.4	.11	30	7.8	10.5	.08	38	8.5	14.8	.14	23
	" A	"	3-5	13.7	27.0	.17	17	6.6	10.8	.13	40	4.9	8.1	.13	43	4.6	7.4	.12	42
	" A	"	10-12	19.4	41.5	.19	10	8.5	12.9	.11	39	8.2	13.9	.14	39	7.2	9.8	.08	40
	-2nd Year-																		
23	So Lake NA	Santa	3-5	15.9	34.8	.20	9	3.8	6.3	.13	34	2.5	3.9	.11	48	2.4	4.3	.15	40
	Tahoe NA	Maria	10-12	16.7	44.5	.26	10	4.0	6.9	.14	39	3.8	5.9	.11	52	3.3	4.7	.09	38
	" A	"	3-5	12.0	17.8	.10	18	5.2	7.9	.11	45	4.7	6.9	.10	37	3.8	6.1	.12	47
	" A	"	10-12	12.1	21.3	.15	31	6.4	8.9	.09	41	5.4	9.5	.15	28	4.6	7.1	.11	49
24	FortBragg NA	"	3-5	10.4	16.3	.11	25	4.4	6.1	.08	43	2.1	3.0	.09	52	3.3	5.4	.13	50
	" NA	"	10-12	11.8	22.9	.17	18	5.5	8.2	.11	48	4.7	8.7	.16	44	6.2	9.3	.11	39
	" A	"	3-5	12.6	22.0	.14	25	6.4	11.7	.15	46	6.7	11.9	.15	42	6.0	10.0	.13	40
	" A	"	10-12	14.4	29.0	.18	31	6.5	9.6	.10	47	6.7	9.9	.10	50	7.3	12.3	.13	45
27	Indio NA	"	3-5	68.0	272.0	.35	0	29.3	107.0	.33	2	20.3	36.8	.15	7	23.5	62.0	.25	9
	" NA	"	10-12	69.0	305.0	.38	0	30.0	99.5	.31	2	19.8	53.0	.25	3	24.5	71.0	.27	5
	" A	"	3-5	93.0	510.0	.43	0	45.5	123.0	.25	2	35.2	97.0	.26	4	44.2	128.0	.27	1
	" A	"	10-12	97.0	425.0	.38	0	43.3	136.0	.30	1	45.0	167.0	.33	2	38.2	104.0	.30	3
28	Sacto NA	"	3-5	22.2	63.0	.27	6	8.1	14.3	.14	35	4.4	7.3	.13	42	5.2	8.2	.11	37
	" NA	"	10-12	31.4	93.5	.28	3	12.8	24.8	.17	16	10.2	20.4	.18	20	12.2	20.4	.13	17
	" A	"	3-5	25.3	75.0	.28	7	14.3	29.3	.18	15	10.7	22.0	.19	14	15.3	36.8	.22	20
	" A	"	10-12	29.0	79.5	.26	3	16.1	23.9	.10	13	14.5	26.9	.16	23	16.8	29.4	.14	19

* NA = Non Absorbent Aggregate, A = Absorbent Aggregate, 77°F = 25°C

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MICRO-RECOVERED ASPHALT FROM SLICES (CALIFORNIA T.M. 365) TABLE 7

Age (Mo)	Weathering Site & Aggregate*	Asphalt Source	% Voids	Slice 1 – 0 To 3/4" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 1 – 0 To 3/4" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 1 – 0 To 3/4" Approx. Shear Susceptibility (Slope)	Slice 1 – 0 To 3/4" Approx. Micro-Ductility at 77°F (mm)	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 2 – 7/8" To 1 5/8" Approx. Shear Susceptibility (Slope)	Slice 2 – 7/8" To 1 5/8" Approx. Micro-Ductility at 77°F (mm)	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 3 – 1 3/4" To 2 1/2" Approx. Shear Susceptibility (Slope)	Slice 3 – 1 3/4" To 2 1/2" Approx. Micro-Ductility at 77°F (mm)	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Viscosity (megapoise) at 0.05 sec⁻¹ Shear rate	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Viscosity (megapoise) at 0.001 sec⁻¹ Shear rate	Slice 4 – 2 5/8" To 3 3/8" Approx. Shear Susceptibility (Slope)	Slice 4 – 2 5/8" To 3 3/8" Approx. Micro-Ductility at 77°F (mm)
-4th Yea		California Test Method No.		348		348	349	348		348	349	348		348	349	348		348	349
48	SoLakeNA	Valley	7-9	234.0	407.0	.14	2	108.0	137.0	.06	2	79.5	79.5	.0	0	120.0	120.0	.0	2
	TahoeNA	LABasin	7-9	190.0	274.0	.09	1	66.0	88.0	.08	7	54.0	65.5	.05	23	59.5	66.0	.03	18
	" NA	Santa	3-5	20.0	62.5	.29	6	8.4	16.3	.17	32	6.7	13.5	.18	32	6.3	12.8	.18	25
	" NA	Maria	10-12	33.5	106.0	.29	3	9.3	14.5	.11	23	7.1	10.4	.10	29	7.7	12.8	.13	14
	" A	Valley	7-9	90.0	132.0	.10	5	53.7	54.0	.0	15	50.0	54.0	.02	0	45.5	58.0	.06	6
	" A	LABasin	7-9	119.0	180.0	.11	3	48.0	66.5	.09	11	38.7	40.2	.01	57	38.7	47.0	.05	20
	" A	Santa	3-5	21.5	61.0	.27	6	11.5	23.8	.19	36	10.3	15.2	.10	36	9.8	10.6	.04	17
	" A	Maria	10-12	33.0	103.0	.29	2	17.0	38.0	.21	17	19.2	31.3	.13	14	18.7	43.0	.21	8
49	IndioNA	Valley	7-9	1270.	3100.	.23	0	400.0	1230.	.29	0	465.0	1050.	.21	0	425.0	850.0	.18	0
	" NA	LABasin	7-9	1100.	2200.	.18	0	480.0	990.0	.18	0	365.0	670.0	.15	0	330.0	690.0	.19	1
	" NA	Santa	3-5	720.0	1470.	.19	0	57.0	200.0	.32	0	17.7	37.5	.19	6	17.8	59.0	.31	8
	" NA	Maria	10-12	445.0	1570.	.32	0	84.0	365.0	.37	0	80.0	355.0	.38	0	77.5	233.0	.28	1
	" A	Valley	7-9	380.0	1780.	.40	0	397.0	645.0	.12	0	281.0	472.0	.13	0	535.0	745.0	.09	0
	" A	LABasin	7-9	510.0	2450.	.40	0	490.0	1270.	.25	0	650.0	1000.	.11	0	585.0	850.0	.10	0
	" A	Santa	3-5	605.0	2140.	.32	0	238.0	800.0	.31	0	140.0	535.0	.35	0	238.0	760.0	.30	0
	" A	Maria	10-12	3300.	5750.	.14	0	220.0	745.0	.31	0	110.0	425.0	.35	0	123.0	510.0	.36	0
51	SactoNA	Valley	7-9	530.0	930.0	.14	0	270.0	430.0	.12	2	243.0	370.0	.11	0	255.0	440.0	.14	0
	" NA	LABasin	7-9	300.0	530.0	.15	0	184.0	282.0	.11	1	156.0	220.0	.09	1	138.0	210.0	.11	0
	" NA	Santa	3-5	40.7	136.0	.31	1	18.9	44.5	.22	5	18.8	38.4	.19	7	13.4	29.3	.20	7
	" NA	Maria	10-12	55.5	232.0	.36	0	23.5	75.0	.30	4	25.5	51.5	.18	4	28.4	79.0	.26	3
	" A	Valley	7-9	235.0	422.0	.15	1	143.0	168.0	.04	3	105.0	149.0	.09	2	100.0	155.0	.11	3
	" A	LABasin	7-9	300.0	620.0	.19	0	218.0	318.0	.10	0	202.0	297.0	.10	0	166.0	226.0	.08	1
	" A	Santa	3-5	152.0	530.0	.32	0	32.8	97.5	.28	2	32.3	86.5	.25	3	28.0	68.5	.23	4
	" A	Maria	10-12	109.0	357.0	.30	1	38.7	99.5	.24	4	45.5	132.0	.28	5	39.5	127.0	.30	6
53	Fort NA	Valley	7-9	242.0	545.0	.21	0	209.0	273.0	.07	2	186.0	252.0	.08	0	209.0	327.0	.12	1
	Bragg NA	LABasin	7-9	143.0	209.0	.10	5	70.0	96.0	.08	2	61.0	70.0	.04	4	50.0	50.0	.0	10
	" NA	Santa	3-5	18.3	42.5	.22	6	5.4	9.5	.15	21	2.7	5.5	.19	32	3.8	7.8	.19	35
	" NA	Maria	10-12	16.4	29.0	.15	7	8.0	11.3	.09	29	7.7	12.1	.11	33	10.2	18.2	.15	40
	" A	Valley	7-9	96.0	142.0	.10	3	84.0	97.0	.04	9	98.5	137.0	.08	1	74.0	95.0	.06	3
	" A	LABasin	7-9	96.5	128.0	.08	5	53.5	53.5	.0	26	50.0	63.5	.06	27	50.0	67.5	.08	12
	" A	Santa	3-5	23.0	61.0	.25	4	22.2	49.0	.20	5	17.0	34.6	.18	18	15.5	27.5	.14	14
	" A	Maria	10-12	20.4	40.5	.18	8	15.3	30.1	.17	25	14.8	21.8	.10	17	16.5	25.4	.11	13

*NA = Non Absorbent Aggregate, A = Absorbent Aggregate, 77°F = 25°C

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Table 8

Resilient Modulus (M_R) Test Results
(Original and Four Year Weathering)
(Average of 2 Samples)

Weathering Site	Asphalt Source	Voids %	Resilient Modulus (M_R) P.S.I. Non-Absorbent Aggregate	Absorbent Aggregate
Original	Valley(Kern)	3-5	9.5×10^5	8.1×10^5
"	"	7-9	8.8×10^5	5.9×10^5
"	"	10-12	1.0×10^6	7.3×10^5
"	LA Basin	7-9	7.4×10^5	-
"	Santa Maria	3-5	3.3×10^5	4.3×10^5
"	"	7-9	1.6×10^5	-
"	"	10-12	1.5×10^5	2.7×10^5
Fort Bragg (Coastal)	Valley(Kern)	3-5	8.2×10^5	6.4×10^5
	"	7-9	7.5×10^5	6.4×10^5
"	"	10-12	7.3×10^5	6.7×10^5
"	LA Basin	3-5	6.5×10^5	7.4×10^5
"	"	7-9	5.8×10^5	6.6×10^5
"	"	10-12	5.6×10^5	7.6×10^5
"	Santa Maria	3-5	4.0×10^5	5.5×10^5
"	"	7-9	3.7×10^5	4.0×10^5
"	"	10-12	2.9×10^5	3.7×10^5
Sacramento (Valley)	Valley(Kern)	3-5	7.2×10^5	6.5×10^5
	"	7-9	7.3×10^5	4.9×10^5
"	"	10-12	7.6×10^5	5.1×10^5
"	LA Basin	3-5	5.3×10^5	5.9×10^5
"	"	7-9	5.4×10^5	4.5×10^5
"	"	10-12	5.6×10^5	5.0×10^5
"	Santa Maria	3-5	4.0×10^5	4.3×10^5
"	"	7-9	3.4×10^5	3.9×10^5
"	"	10-12	3.7×10^5	3.9×10^5
SoLake Tahoe (Mountain)	Valley(Kern)	3-5	1.1×10^6	9.1×10^5
	"	7-9	9.2×10^5	7.1×10^5
"	"	10-12	8.1×10^5	8.1×10^5
"	LA Basin	3-5	8.9×10^5	8.9×10^5
"	"	7-9	8.2×10^5	7.2×10^5
"	"	10-12	9.2×10^5	6.7×10^5
"	Santa Maria	3-5	4.1×10^5	5.5×10^5
"	"	7-9	3.9×10^5	4.5×10^5
"	"	10-12	3.2×10^5	4.4×10^5
Indio (Desert)	Valley(Kern)	3-5	7.7×10^5	7.0×10^5
	"	7-9	7.2×10^5	6.3×10^5
"	"	10-12	6.2×10^5	6.9×10^5
"	LA Basin	3-5	7.3×10^5	7.4×10^5
"	"	7-9	7.1×10^5	5.6×10^5
"	"	10-12	7.2×10^5	6.4×10^5
"	Santa Maria	3-5	5.5×10^5	6.9×10^5
"	"	7-9	5.0×10^5	4.7×10^5
"	"	10-12	5.1×10^5	5.6×10^5

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Table 9

Calipatria Test Section
(Contract 11-166914-Rd. 11-IMP-111-33.0/38.0)
ORIGINAL ASPHALT TEST RESULTS
(Sampled 11-30-77)

Asphalt Source L.A. Basin Grade AR4000		Section 5	Section 4	Section 6	Section 7
Tests on Original Asphalt	AASHTO Designation	R4940	R4941	R4942	R4943
Penetration at 77F (25C) (0.1mm)	T 49	52	52	53	53
at 39.2F (4C)(0.1mm)	T 49	12	12	11	11
Penetration Ratio $\frac{39.2F Pen.}{77F Pen} \times 100$		23.1	23.1	20.8	20.8
Flash Point C.O.C. (°F)	T 48	545	535	535	540
Softening Point (°F)	T 53	123	123	124	124
Solubilityin Trichloroethylene(%)	T 44	99.98	99.99	99.99	99.99
Spot Test (heptane-Xylene Equivalent)	T102	20-30	20-30	20-30	20-30
Specific Gravity at 77F	T228	1.0199	1.0205	1.0201	1.0206
at 60F	T228	1.0259	1.0265	1.0261	1.0267
Absolute Viscosity at 140F(60C)(Poise)	T202	2166	2089	2056	2091
Thin Film Loss (325F,5hr.)(% Loss)	T179	0.117	0.13	0.128	0.116
Rolling Thin Film Test (325F,85min)	T240				
Tests on RTF Residue					
Absolute Viscosity at 140F(60C)(poise)	T202	4375	4166	4164	4220
Kinematic Viscosity at 275F(135C) cSt	T201	363	348	363	383
Penetration at 77F(25C)(0.1mm)	T 49	34	34	33	32
% original penetration at 77F.	T 49	65.4	65.4	62.3	60.4
Ductility at 77F, 4cm/min. (cm)	T 51	100+	100+	100+	100+
at 39.2F, 1 cm/min. (cm)	T 51	0.25	0.25	0.25	0.5

Tests on AC Mix Samples from Road		Section 4	Section 5	Section 6	Section 7
Penetration at 77F (25C) (0.1mm)	T 49	28	29	28	26
Softening Point, (°F)	T 53	136	137	136	137
Ductility at 77°F (25C)5cm/min. (cm)	T 51	100+	100+	100+	100+
Absolute Viscosity at 140°F(60C)(poise)	T202	5926	6097	5280	5872
Kinematic Viscosity at 275°F(135C)(cSt)	T201	453	465	468	468

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Table 10

Comparison of Original Propertities
of LA Basin Asphalts used in Durability Study
and LA Basin asphalt from Calipatria Test Section

(Average Results)

Common Tests	AASHTO Method	Durability Study	Calipatria Test Section
Test on Original Asphalt			
Penetration at 77F (25C)(0.1mm)	T 49	58	53
Flash Point, COC (°F)	T 48	525	539
Solubility in Trichloroethylene (%)	T 44	99.96	99.99
Specific Gravity (77F/77F)	T228	1.019	1.0203
Absolute Viscosity at 140F(60C)(poise)	T202	1816	2100
Rolling Thin Film Procedure	T240		
Tests on RTFC Residue			
Absolute Viscosity at 140F(60C)(poise)	T202	3509	4231
Kinematic Viscosity at 275F(135C)(cSt)	T201	339	364
Penetration at 77F (25C)(0.1mm)	T 49	41	33
% Original Penetration at 77F (%)	T 49	71	63
Ductility at 77F (25C)(5cm/min)(cm)	T 51	150+	100+
Test on Residue from "California Tilt-oven Durability Test."			
Absolute Viscosity at 140°F(60°C) (Kilopoise)	T202	50.2	56.6
Kinematic Viscosity 275°F(135C)(cSt)	T201	1038	1044
Penetration at 77°F(25°C)(0.1mm)	T 49	11	10
Ductility at 77°F(25C)5cm/min.(cm)	T 51	12	12

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Table II
Road Test Results - Road 11-IMP-111
[Each sample represents average of four(4 inch)cores-Top 2"]

Test Site Calipatria

Weathering Period (Months)	Asphalt Source	SAMPLE No	AASHTO Test Method					California Test Method No.			
			Pen. at 77°F (0.1 mm)	S.P. °F	Ductility at 77°F (c m)	A.Viscosity at 140°F (Kilopoise)	Kinematic Viscosity at 275°F (CST)	Micro-Viscosity (megapoise) at 0.05 sec^{-1} Shear rate	Micro-Viscosity (megapoise) at 0.001 sec^{-1} Shear rate	Shear Susceptibility (Slope)	Micro-Ductility at 77°F (mm)
ABSON RECOVERED AASHTO T 170			T49	T53	T51	T 202	T 201	348		348	349
26	LA Basin	80260	12	148	96	31.5	974	59.8	108.0	.15	16
26	LA Basin	80261	11	148	55	31.4	890	79.5	124.0	.11	0
26	LA Basin	80262	11	146	30	39.7	1006	120.0	163.0	.08	4
26	LA Basin	80263	13	145	82	29.9	926	64.5	107.0	.13	16
26	LA Basin	80264	13	147	95	28.6	857	76.0	103.0	.08	11
26	LA Basin	80265	11	149	68	34.8	936	103.0	166.0	.12	4
26	LA Basin	80266	10	150	31	39.1	1075	118.0	177.0	.10	0
AVERAGE			12	148	65	33.6	952	88.7	135.0	.11	7
* 24Mo.Briq.AVG.from Charts			11			39		120			

*For Indio location.

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Table 12

Relationship of Hardening To Temperature

Weathering Site	Viscosity Micro-Viscosity at 77°F(25°c) at 0.05 sec^{-1} Shear Rate (megapoise) From Fig. 3	(48 months) Absolute Viscosity at 140°F(60°c) (Kilopoise)from Fig. 4	Days/year of High Temperatures 90°F(32.2°c) and over days/year	100°F(37.8°c) and over days/year
So. Lake Tahoe	36	18	0	0
Fort Bragg	35	16	0	0
Sacramento	52	28	75	16.6
Indio	200	220	171	95.5

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Table 13

Comparison of Briquette Test Results
to Predictions of Various Laboratory Predictor Procedures
(description of procedures and complete test results in Initial Report (1))
(combined voids & aggregates at Indio site for Briquette test results)

Name of Procedure		Asphalts Valley(Kern)	LA Basin	Santa Maria
1. Comparison to Micro Viscosity at 77°F(25°C) Calif Test 348				
Briquette Test Results(Indio)				
Microviscosity at 77°F(megapoise)				
at 0.05 sec^{-1} S.R.	12 mo.	62	62	16
	24 mo.	114	122	32
	48 mo.	280	255	69
RTF Durability Test				
at .05 sec^{-1} S.R. (5 hrs - 325°F[163°C])		25	31	20
RMFC (48 hrs-210°F[98.9C])				
at .05 sec^{-1} S.R.		38	54	10
at .001 sec^{-1} S.R.		53	91	26
at Constant Shear 16g/cm^2		44	93	23
Planetary Weathering oven - Ottawa Sand Mix cured at 140°F(60°C)				
at 0.05 sec^{-1} S.R.	400 hrs	34	40	20
	800 hrs	68	98	40
	1200 hrs	96	165	83
Weathering Plates at (210°F(98.9°C), 24 hrs., 20μ)				
at 0.05 sec^{-1} S.R.		39	55	21
California Tilt-oven Durability Test (113°C-168 hrs)				
at 0.05 sec^{-1} S.R.		60	110	23

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Table 13 (Continued)

Name of Procedure		Asphalts Valley(Kern)	LA Basin	Santa Maria
2. Comparison to Absolute Viscosity at 140°F(60°C) AASHTO T202				
Briquette Test Results (Indio) absolute Vis. 140°F(60°C)				
(Kilopoise) (From graph)	12 mo.	18	15	24
	24 mo.	31	40	64
	48 mo.	63	70	530
RTF Durability Test				
(Kilopoise) 5hr-325°F(163°C)		11	15	87
California Tilt-oven Durability Test (113C-168h) (Kilopoise)		24	49	95
3. Comparison to Penetration at 77°F(25°C)				
Briquette Test Results Pen at 77°F(25°C)	12 mo.	14	15	29
	24 mo.	11	11	20
	48 mo.	9	8	16
RTF Durability Test (325°F(163C)-5 hrs)		20	19	26
California Tilt-oven durability Test (113C-168 hrs)		12	11	23
4. Other methods which have no direct comparisons.				
Rostler Ratio $(N+A_1)/(P+A_2)$		1.64	1.78	1.65
Characterization of Asphaltene Dispersions (Heithaus Method)				
Peptizability of Asphaltenes "Pa"		.773	.698	.642
Peptizing power of Maltenes "Po"		1.307	1.312	1.180
State of Peptization of the Asphaltenes "P"		5.76	4.38	3.29
Vanadium Content Determination (PPM)		41	81	110

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Table 13 (Continued)

Name of Procedure		Asphalts Valley(Kern)	LA Basin	Santa Maria
5-A. Comparison to Micro-Ductility at 77°F (5mm/min)mm Calif Test 349				
Briquette Test Results (Indio)				
(From Fig. 37)	12 mo.	18	53	17
	24 mo.	6	17	7
	48 mo.	1	1	1
RTF Durability Test (325°F - 5 hrs.) mm		60	43	4
California Tilt-oven Durability Test (113°C- 168 hrs.)mm		12	3	3
B. Comparison to Ductility at 77°F (5 cm/min) cm. (AASHTO-T51)				
Briquette Test Results (Indio) (From Table 5A) (Averages)				
	14 mo.	150+	150+	65
	27 mo.	50	24	14
	49 mo.	24	24	6
RTF Durability Test (525°F - 5 hours) cm		150+	150+	13
California Tilt-oven Durability Test (113°C - 168 hours) cm		12	14	10

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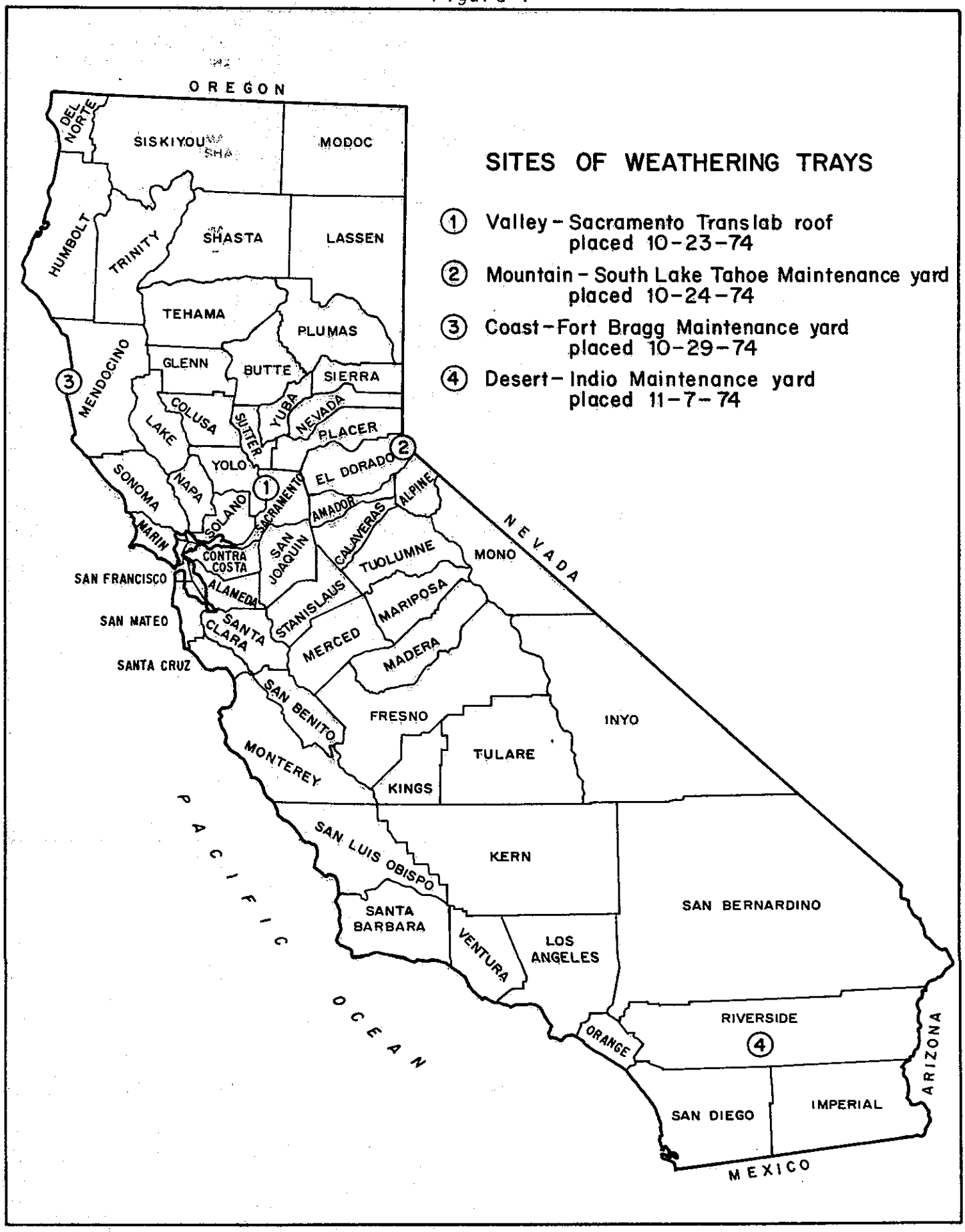

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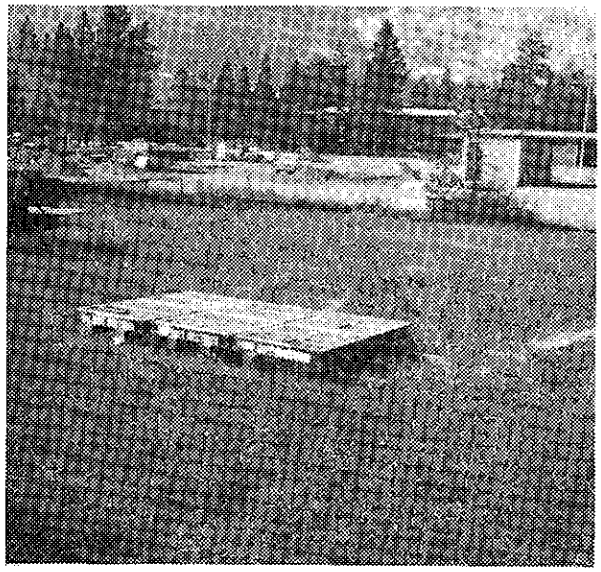
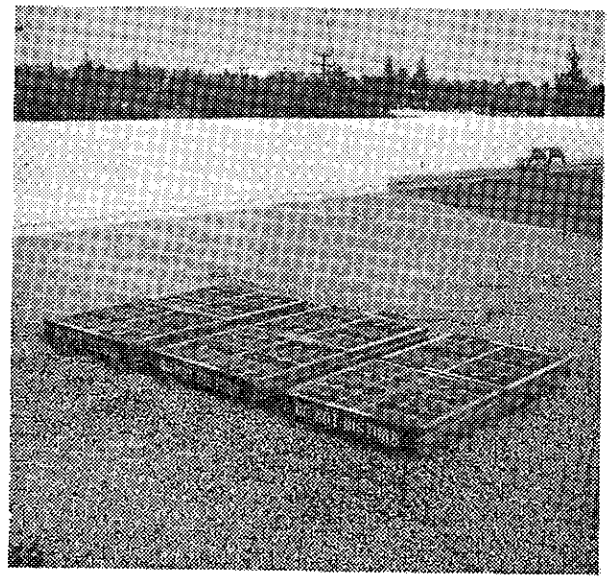
Figure 2

Weathering Sites

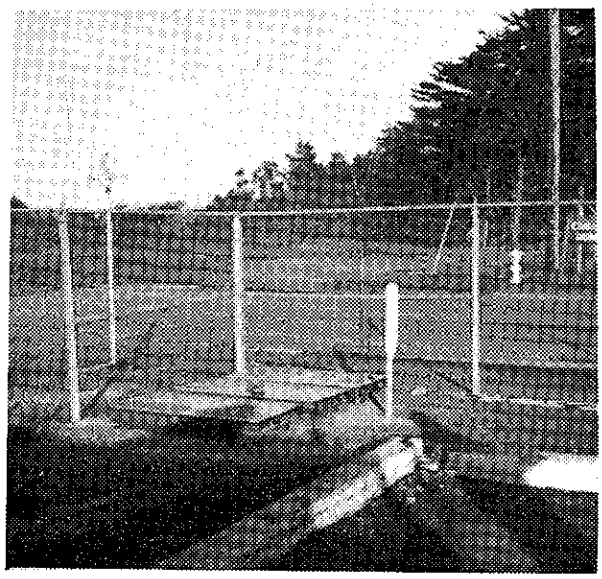
Oct.-Nov. 1974-Newly Installed



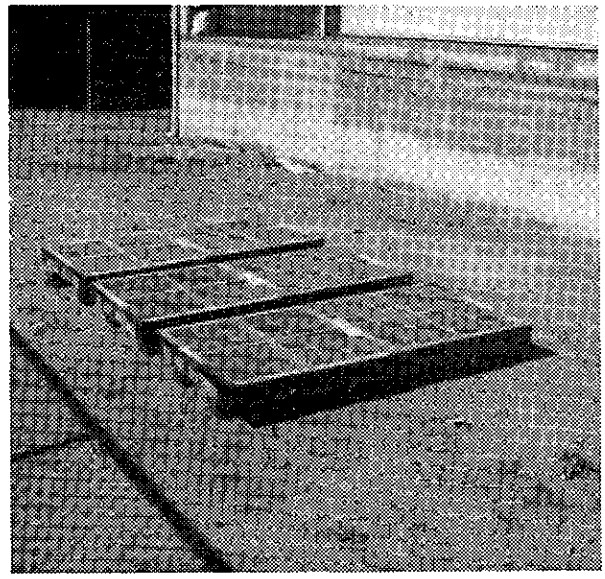
Mountain
South Lake Tahoe, CA



Valley
Roof-TransLab
Sacramento, CA



Coastal
Fort Bragg, CA



Desert
Indio, CA

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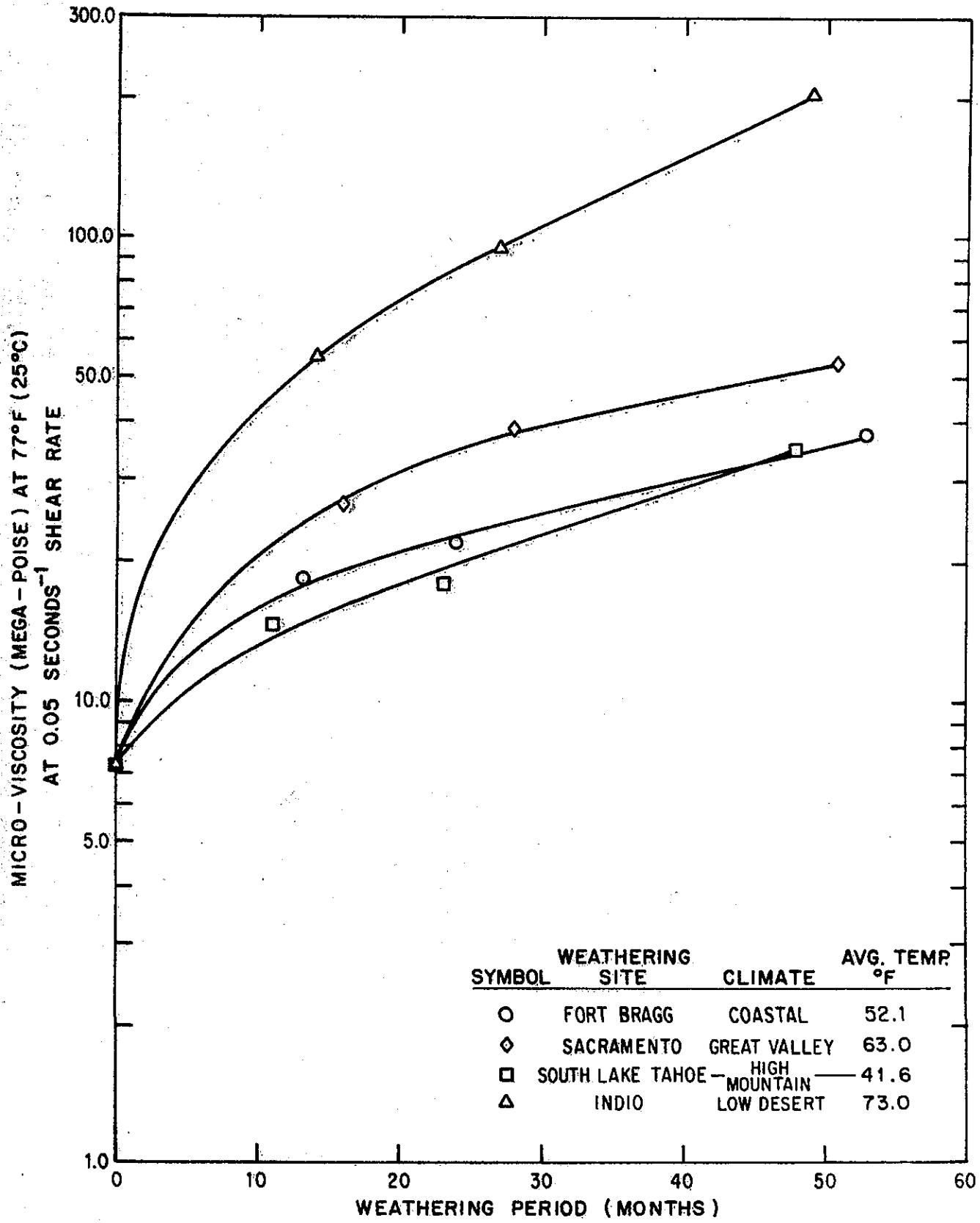

EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED ASPHALTS, AGGREGATES & VOIDS AT 77°F (25°C)

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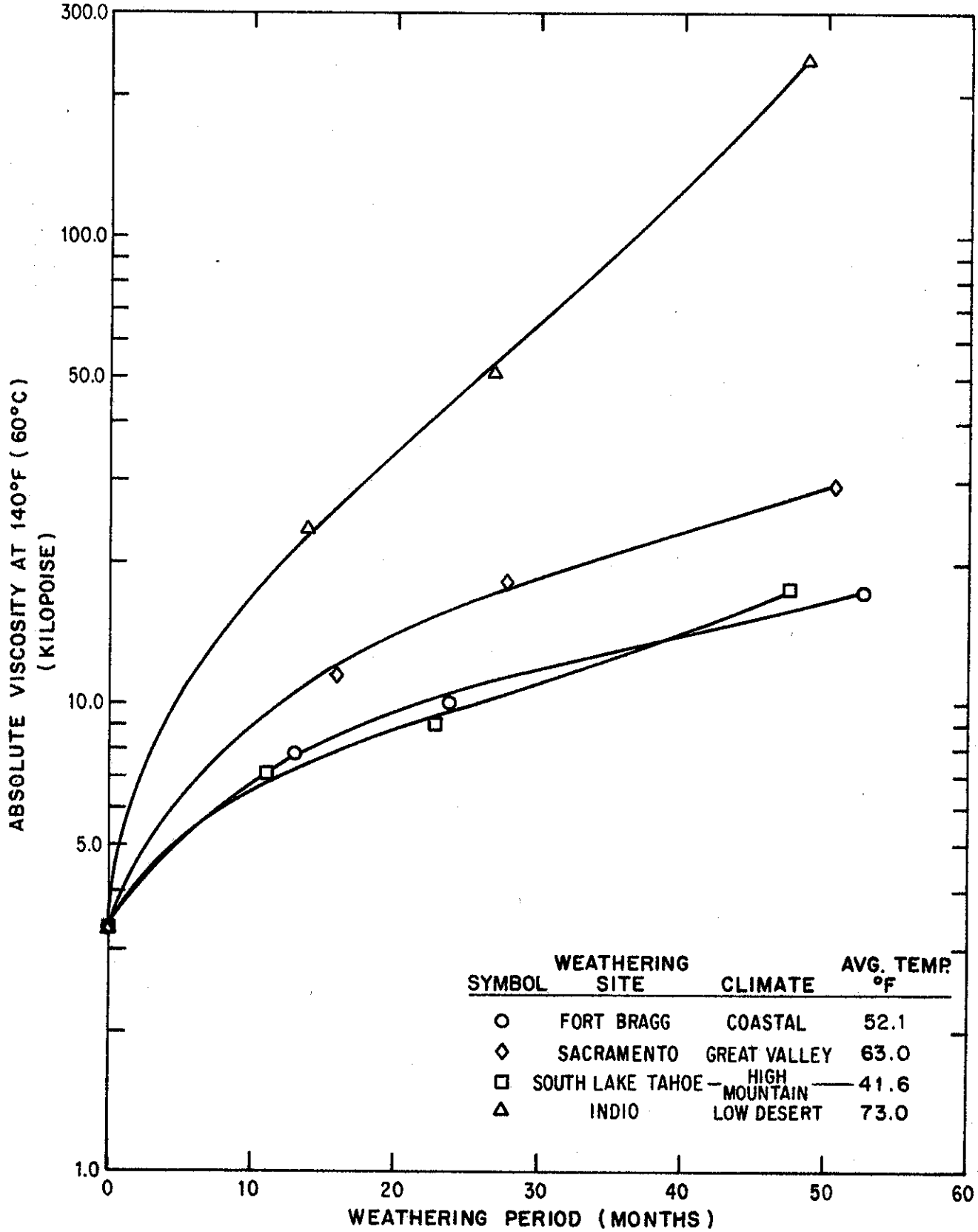
Figure 4



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED ASPHALTS, AGGREGATES & VOIDS AT 140°F (60°C)

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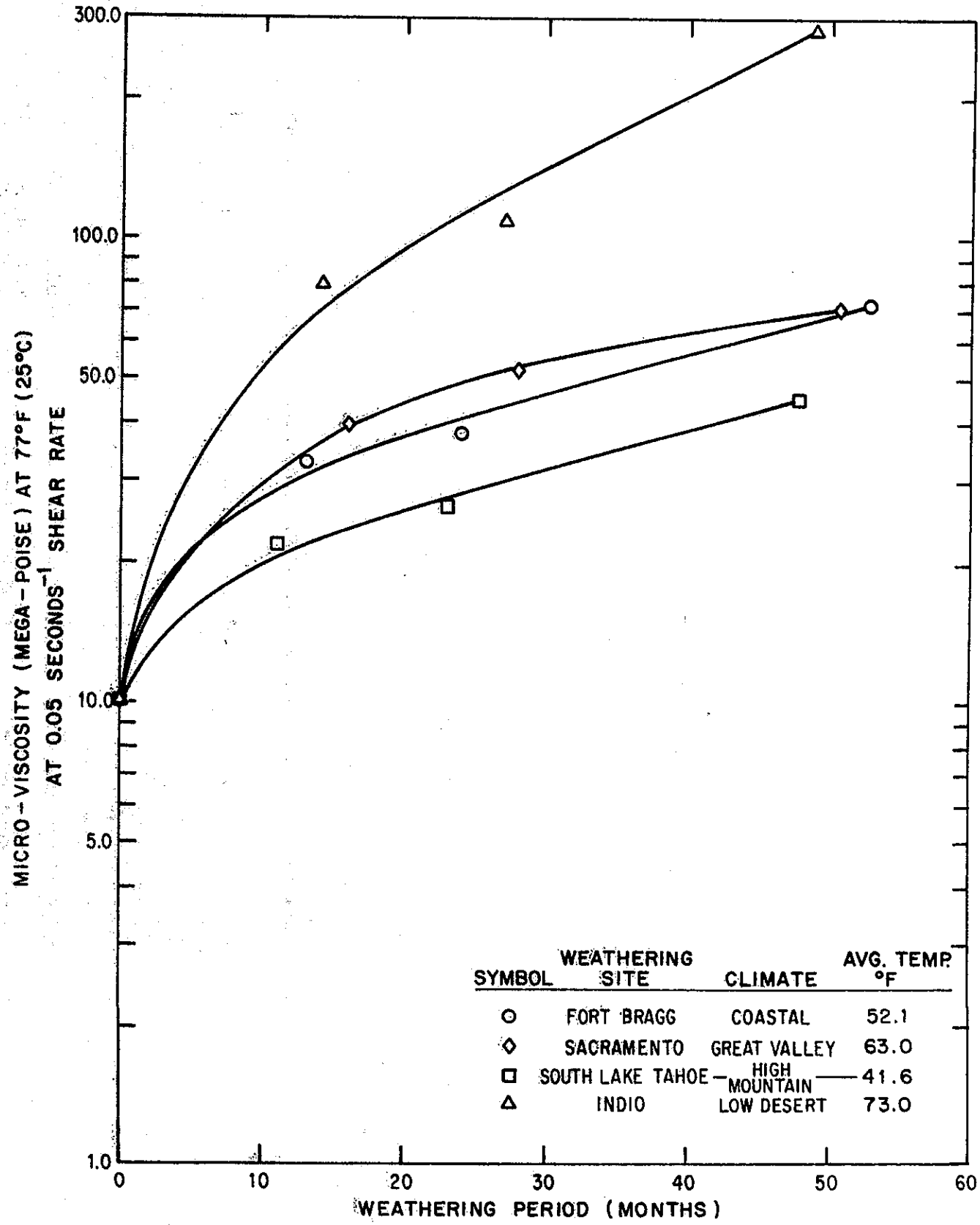
Figure 5



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATES & VOIDS – (VALLEY ASPHALT)

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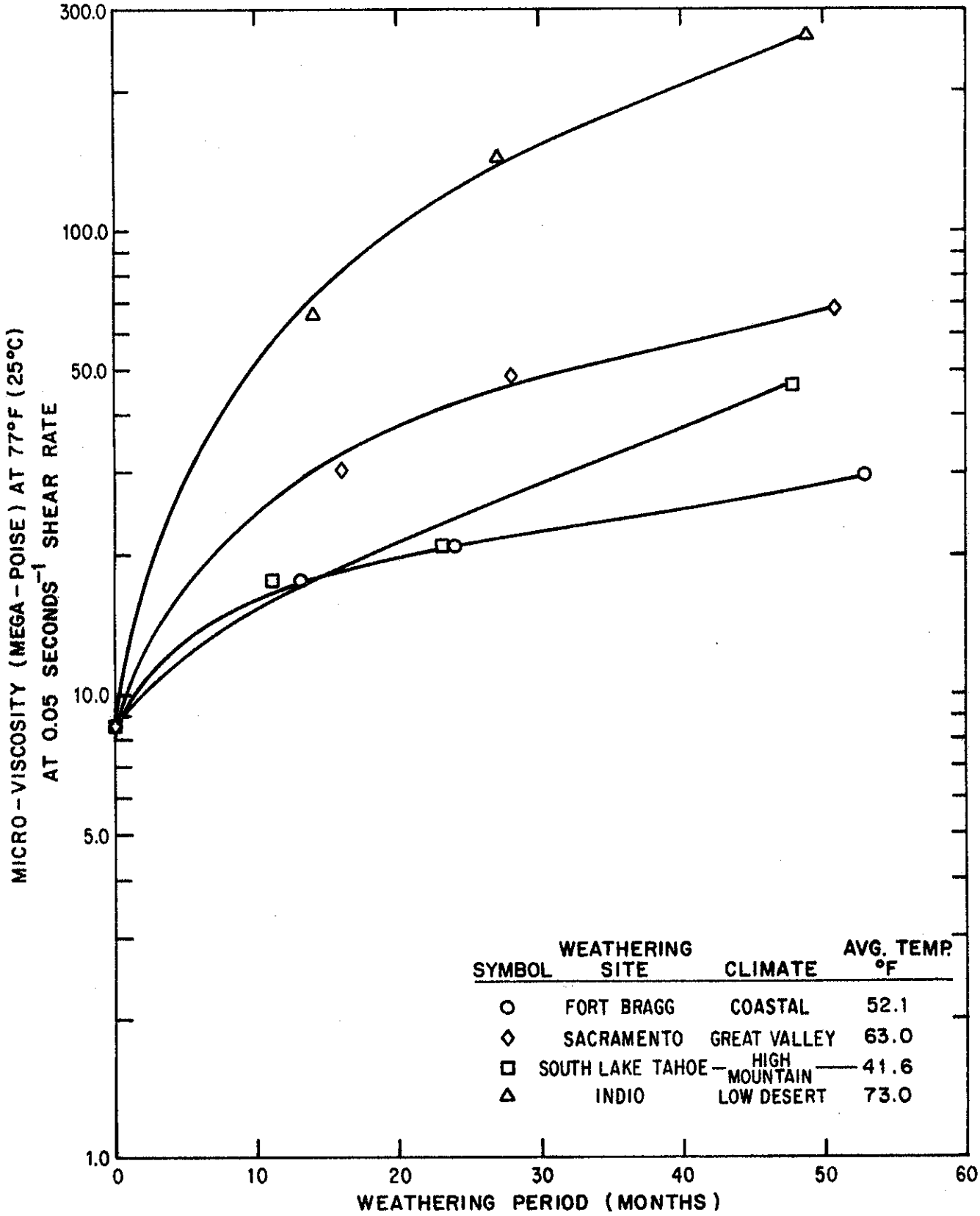
Figure 6



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATE & VOIDS — (LA BASIN ASPHALT)

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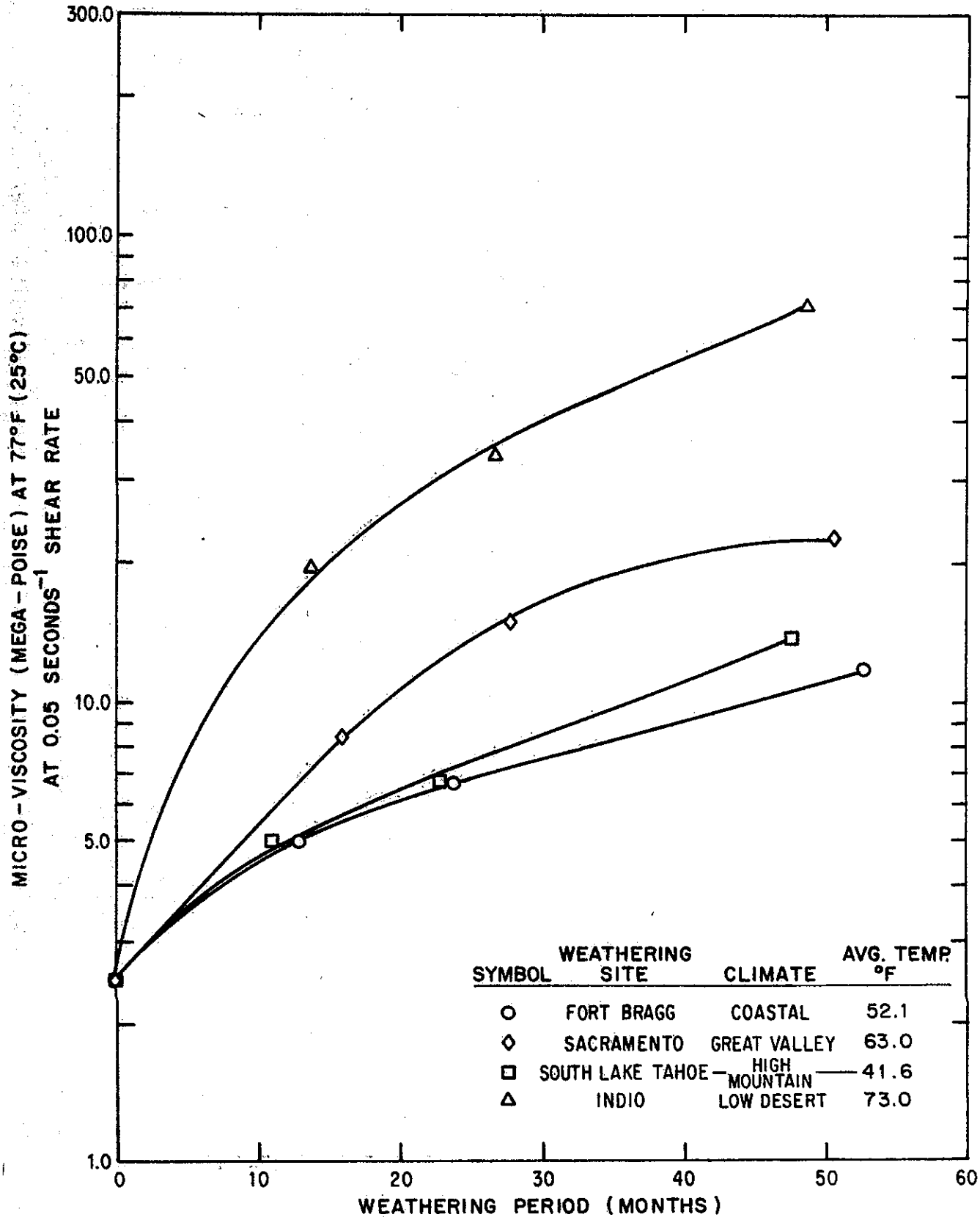
Figure 7



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATES & VOIDS - (SANTA MARIA ASPHALT)

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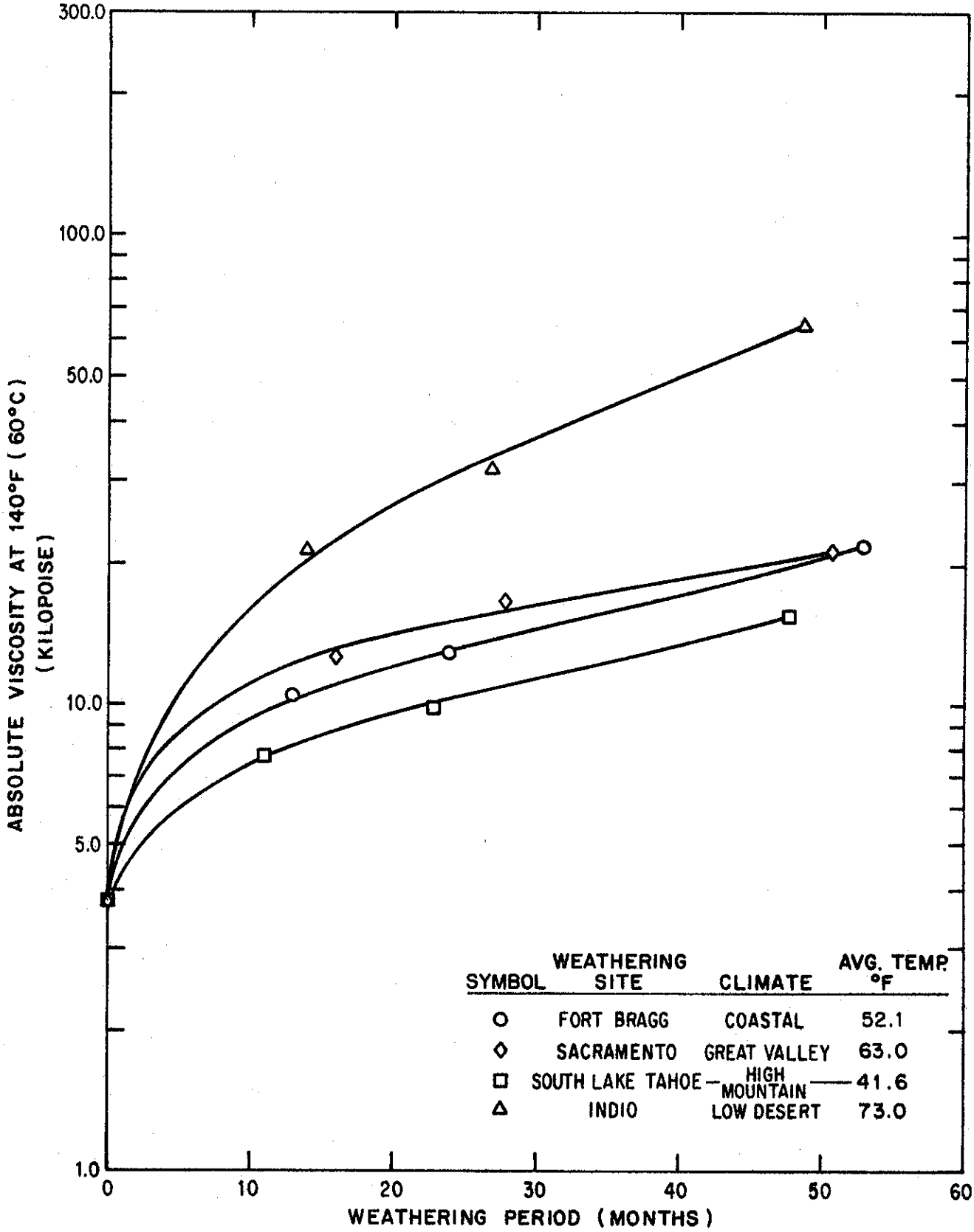
Figure 8



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATES & VOIDS — (VALLEY ASPHALT)

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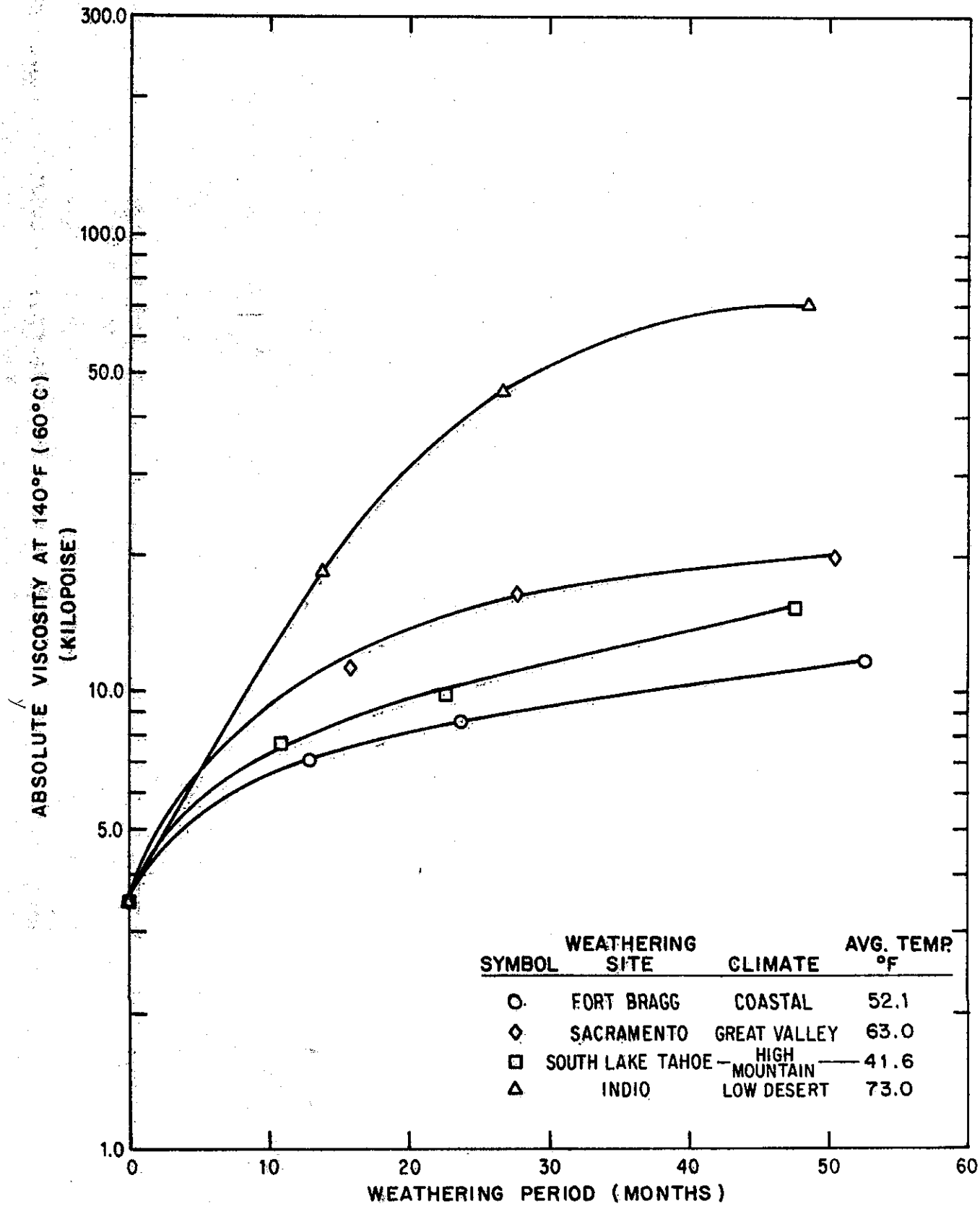

EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATES & VOIDS – (LA BASIN ASPHALT)

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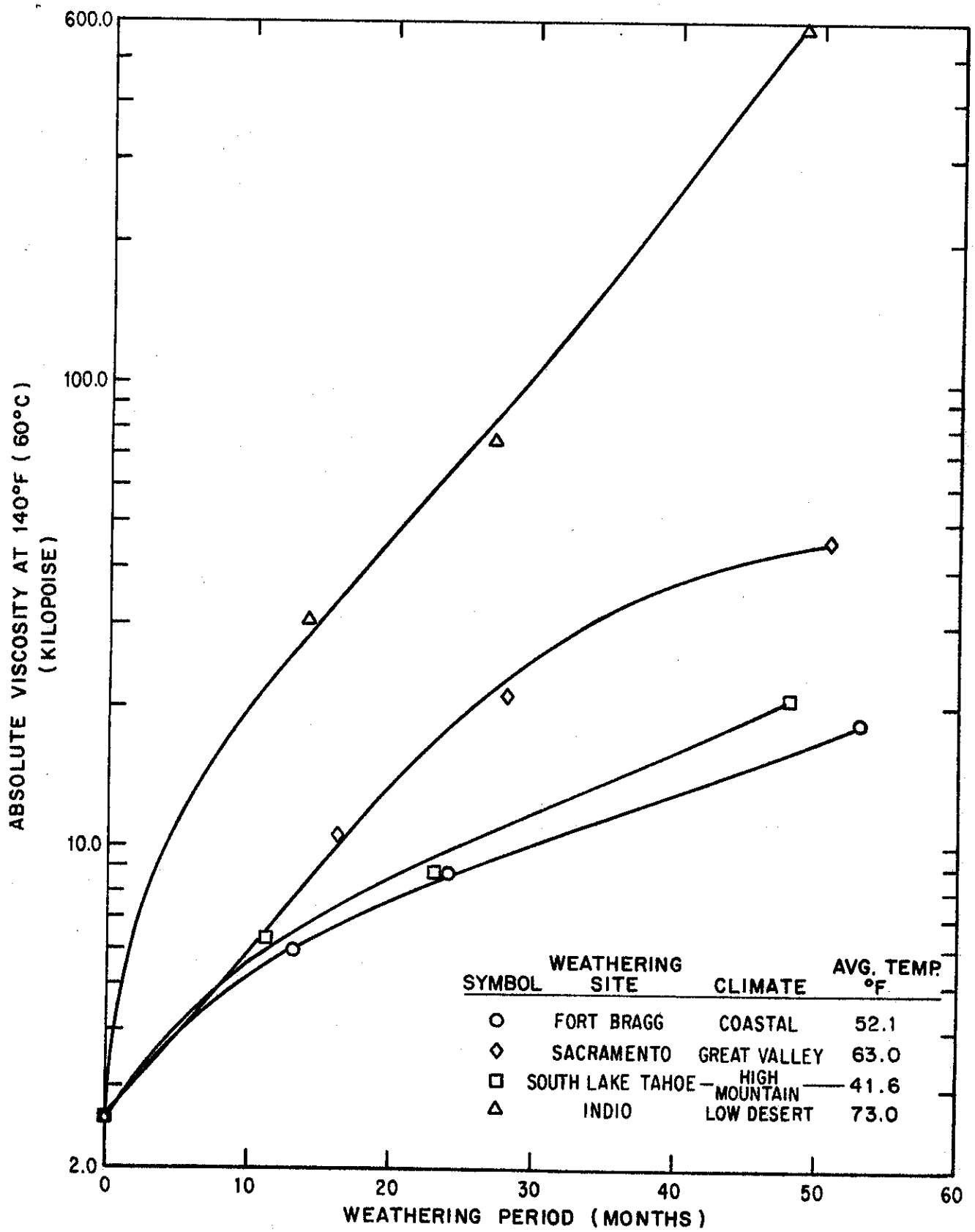
Figure 10



EFFECT OF CLIMATE ON HARDENING (4 CLIMATIC SITES)

COMBINED AGGREGATES & VOIDS – (SANTA MARIA ASPHALT)

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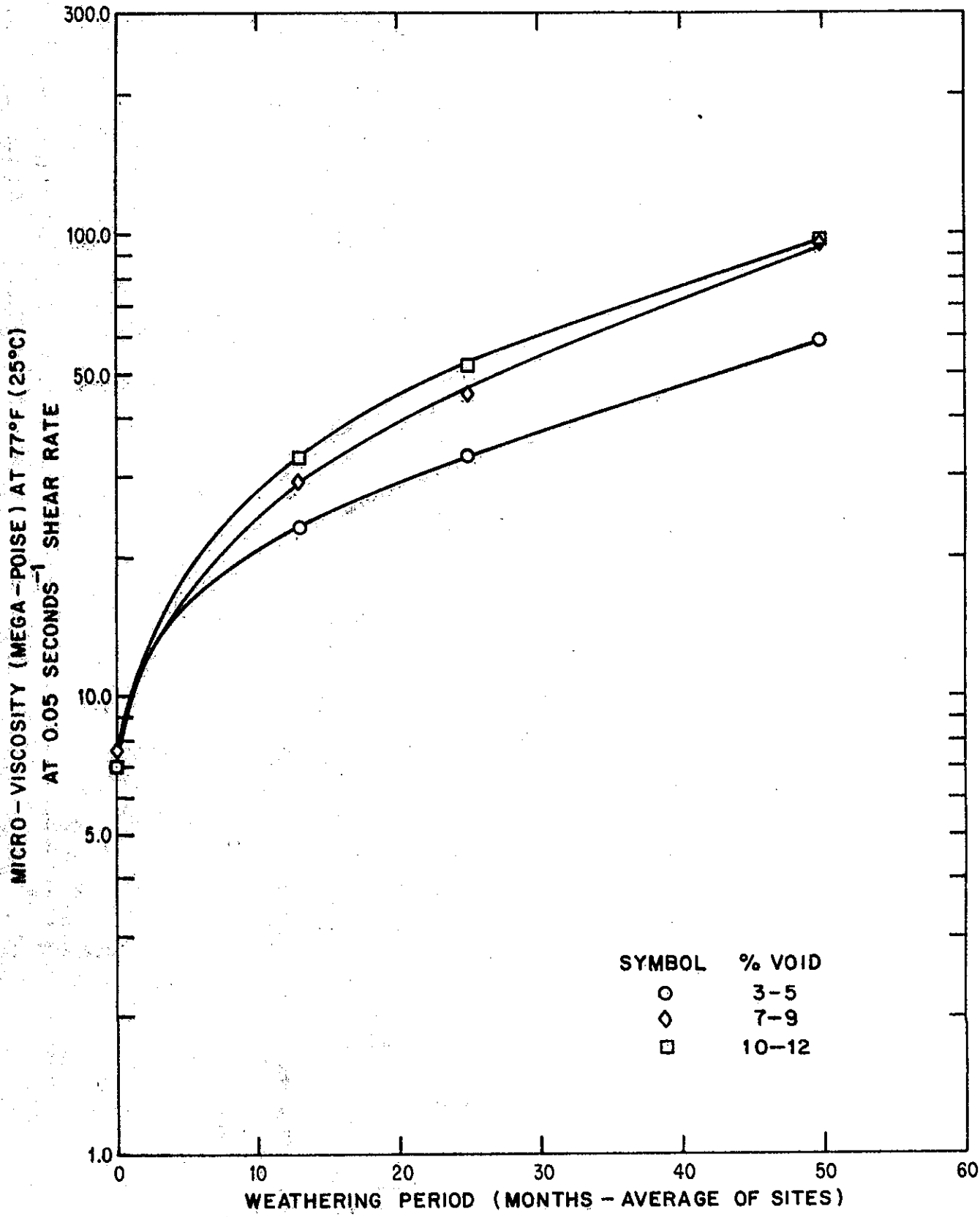

EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE & ASPHALTS

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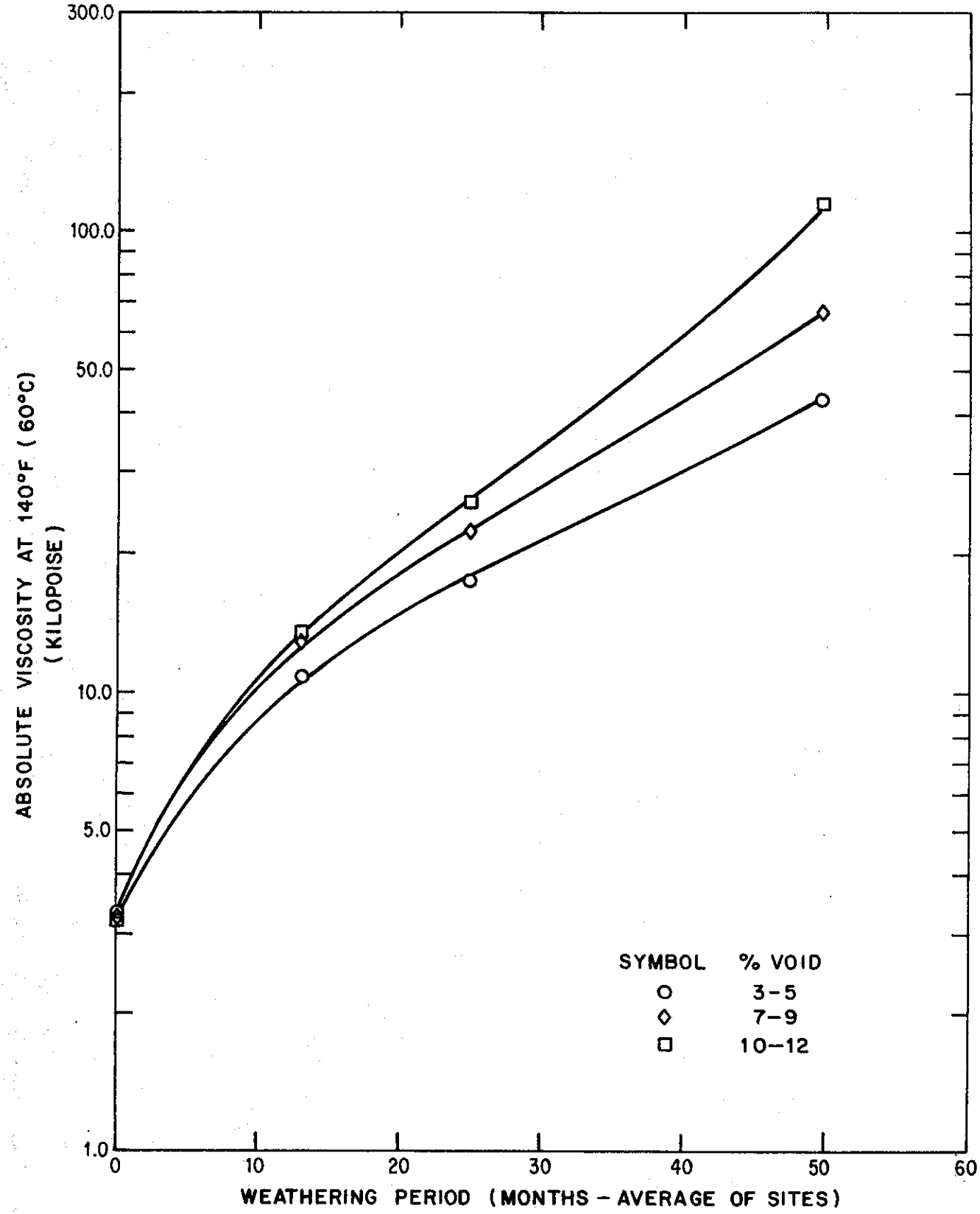
Figure 12



EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE & ASPHALTS

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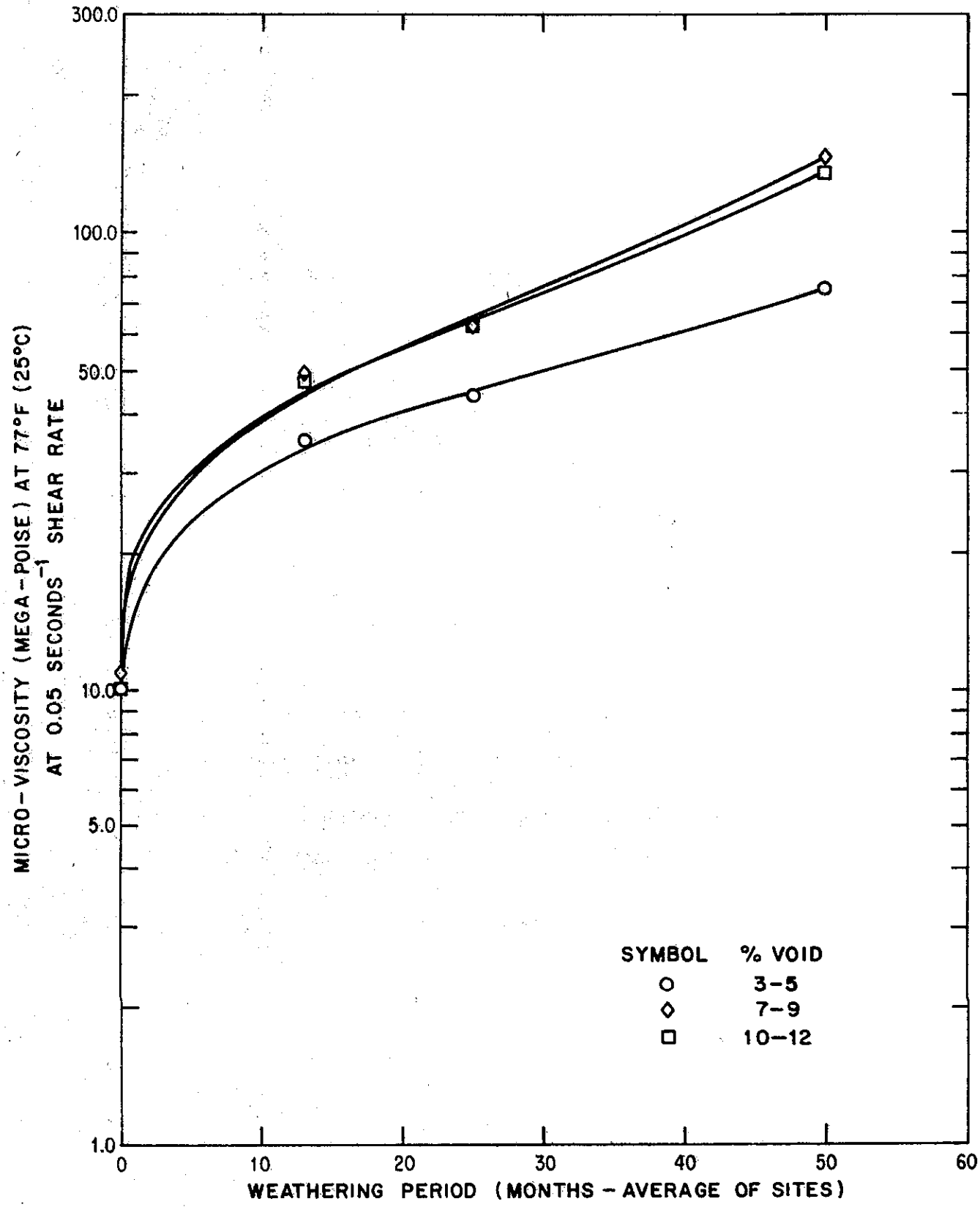
Figure 13



EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE - (VALLEY ASPHALT)

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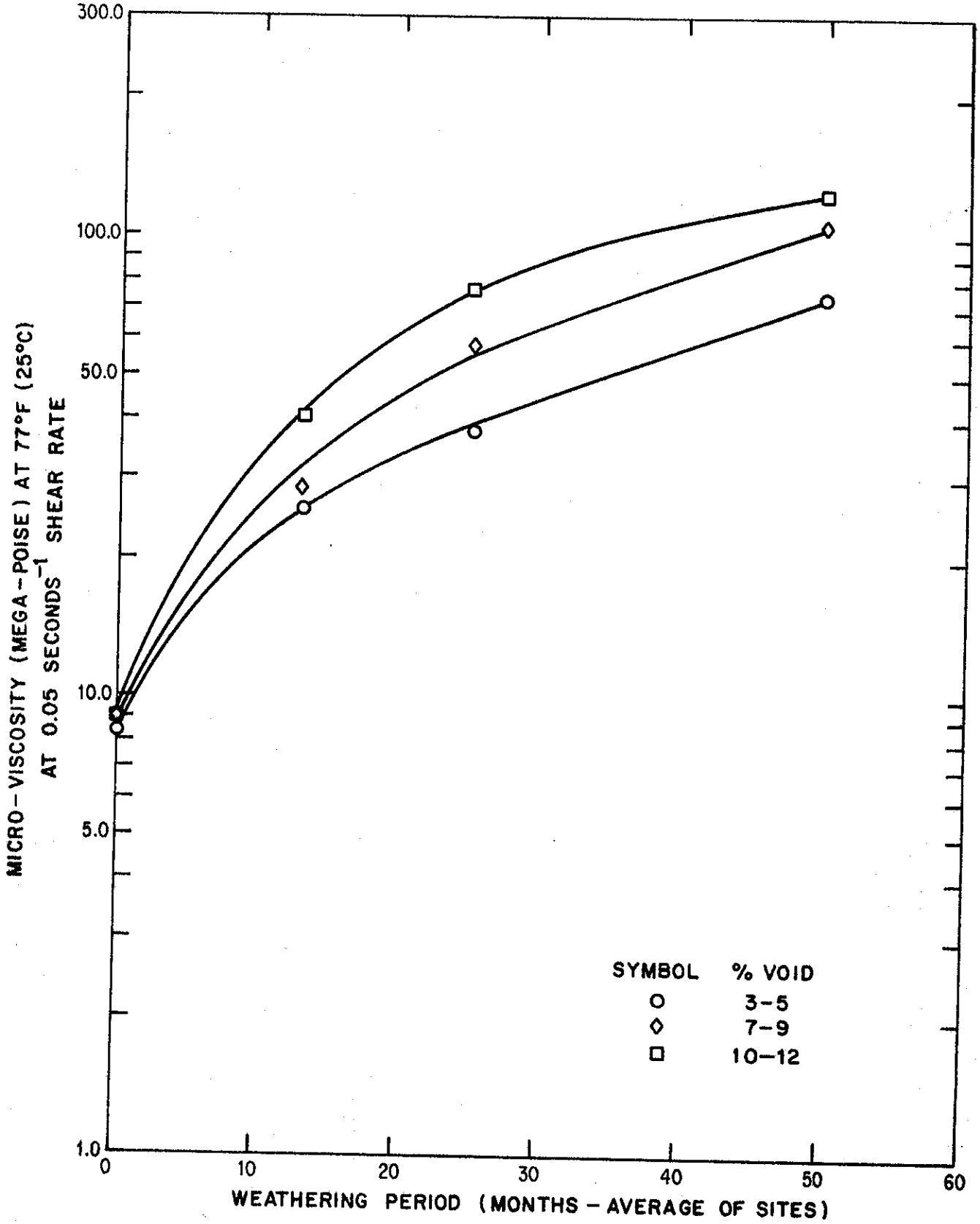
Figure 14



EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE - (L A BASIN ASPHALT)

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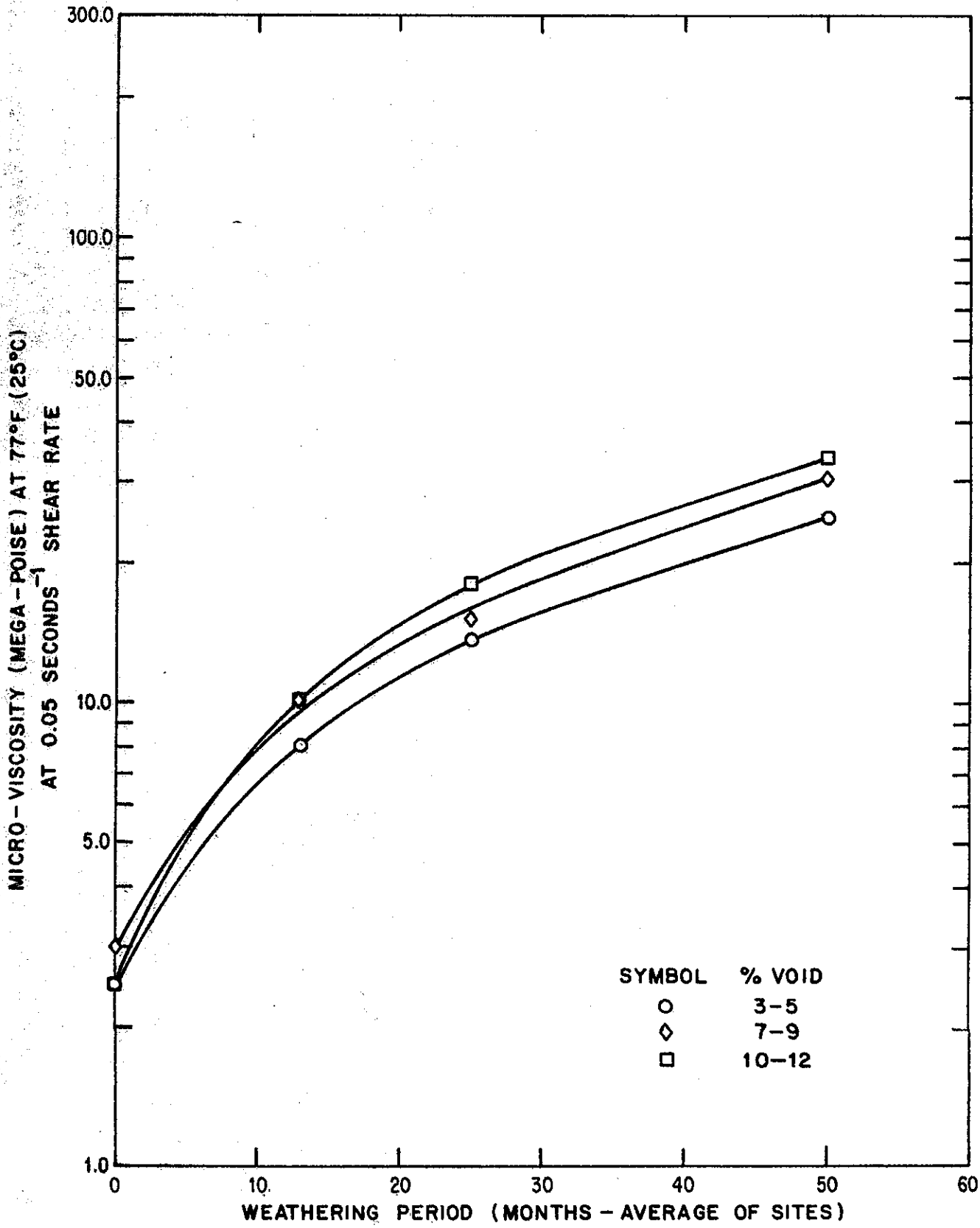

EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE - (SANTA MARIA ASPHALT)

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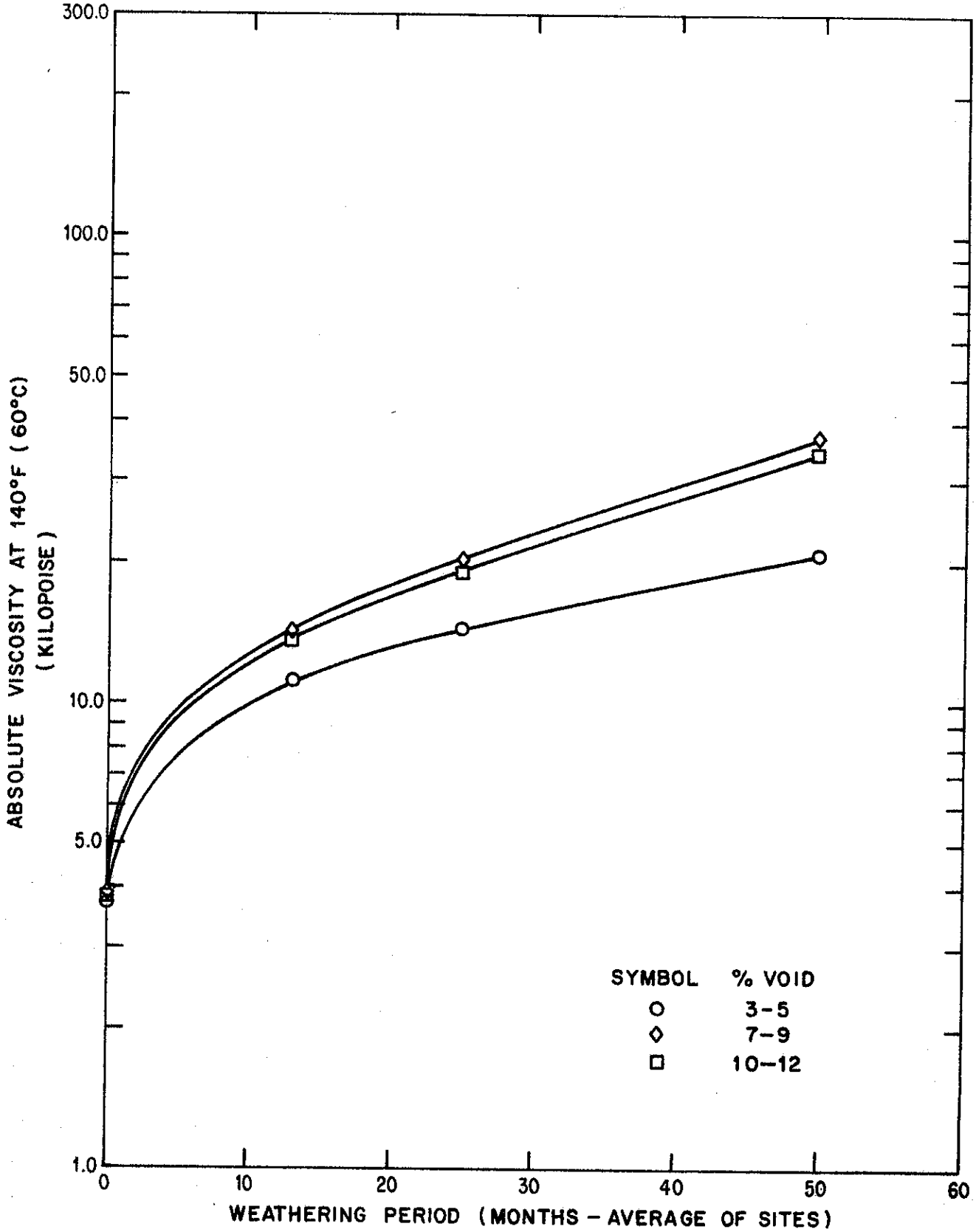
Figure 16



EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE – (VALLEY ASPHALT)

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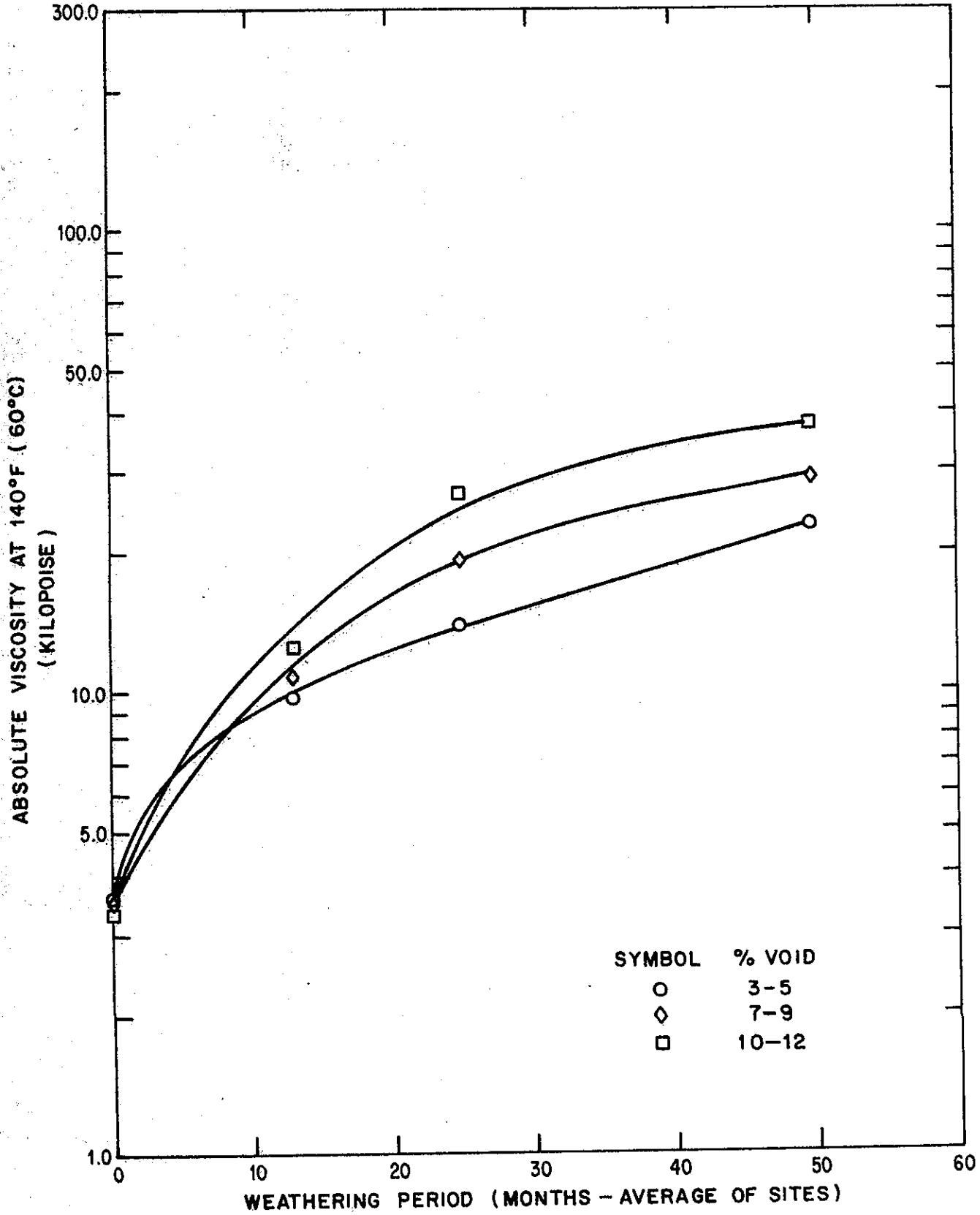

EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE – (LA BASIN ASPHALT)

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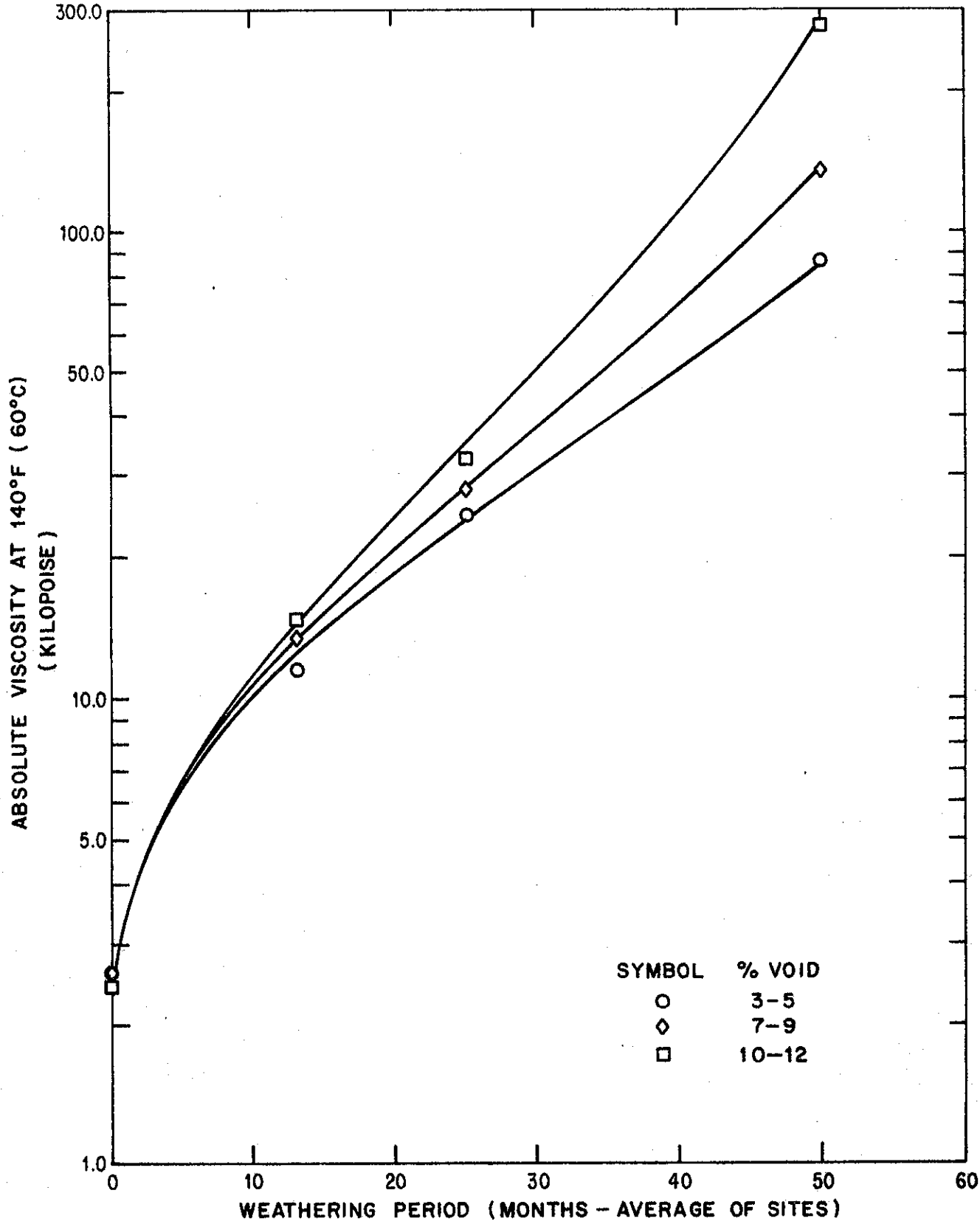
Figure 18



EFFECTS OF VOIDS ON HARDENING

COMBINED SITES, AGGREGATE – (SANTA MARIA ASPHALT)

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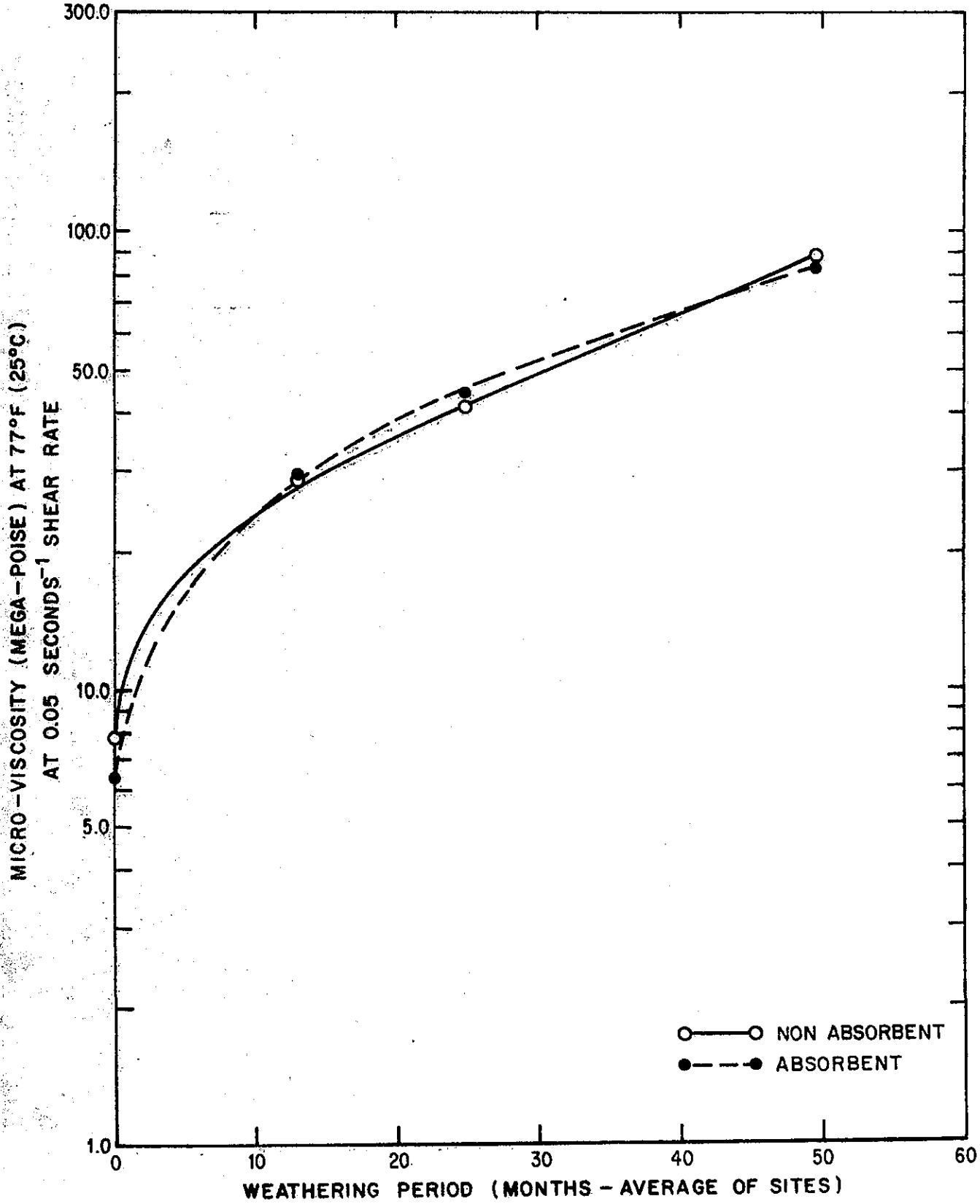
Figure 19



EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES, VOIDS & ASPHALTS

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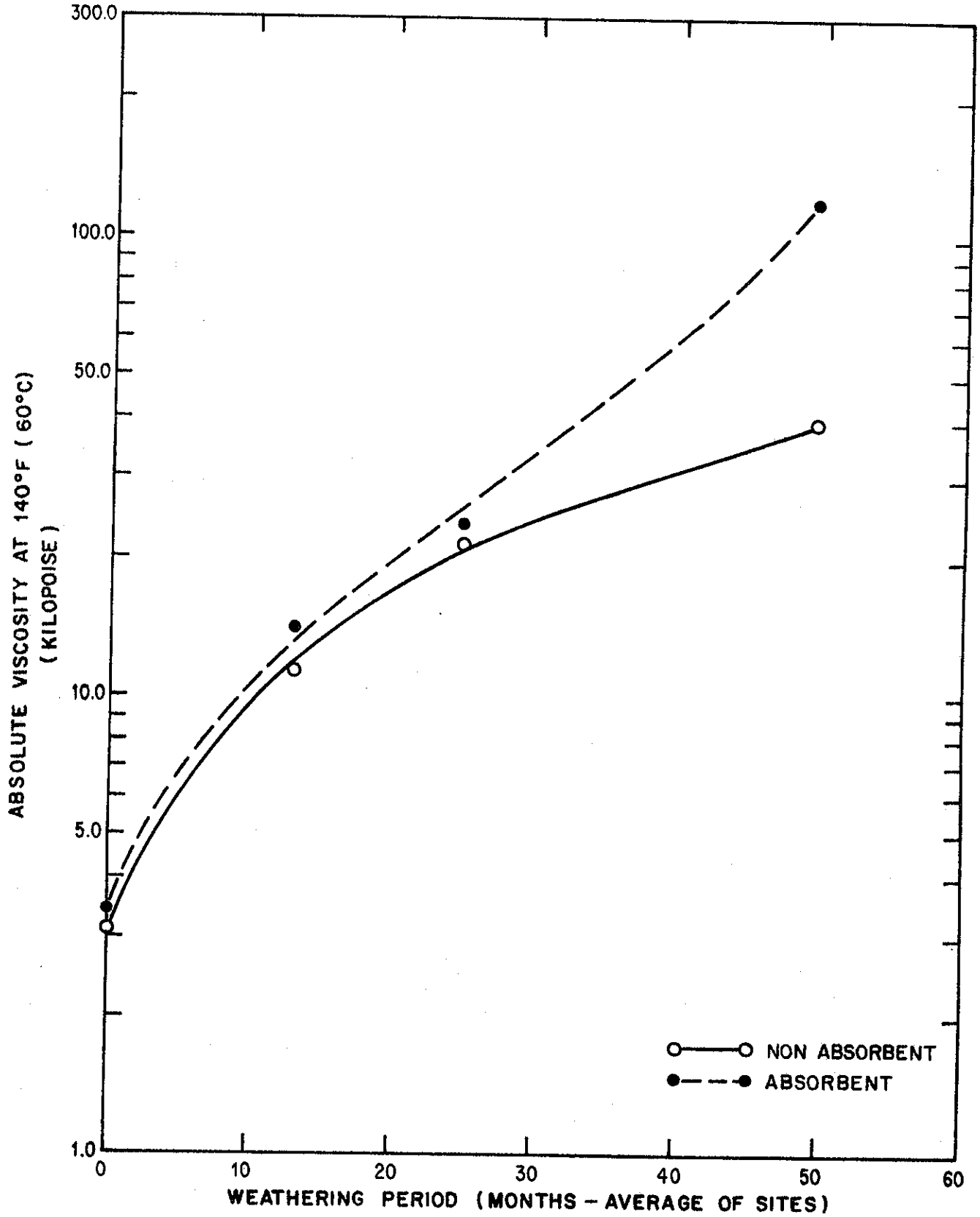
Figure 20



EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES, VOIDS & ASPHALTS

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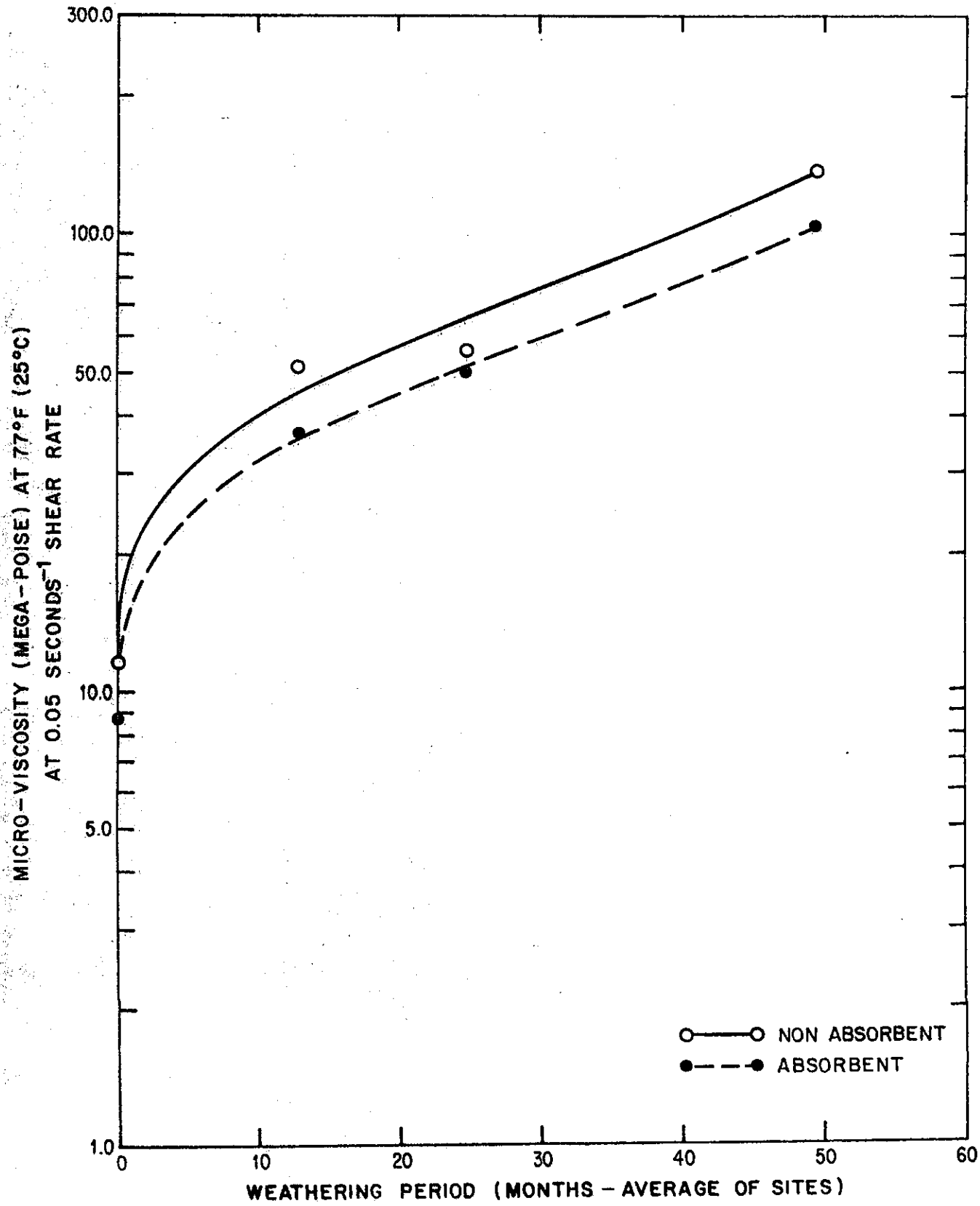

EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS - (VALLEY ASPHALT)

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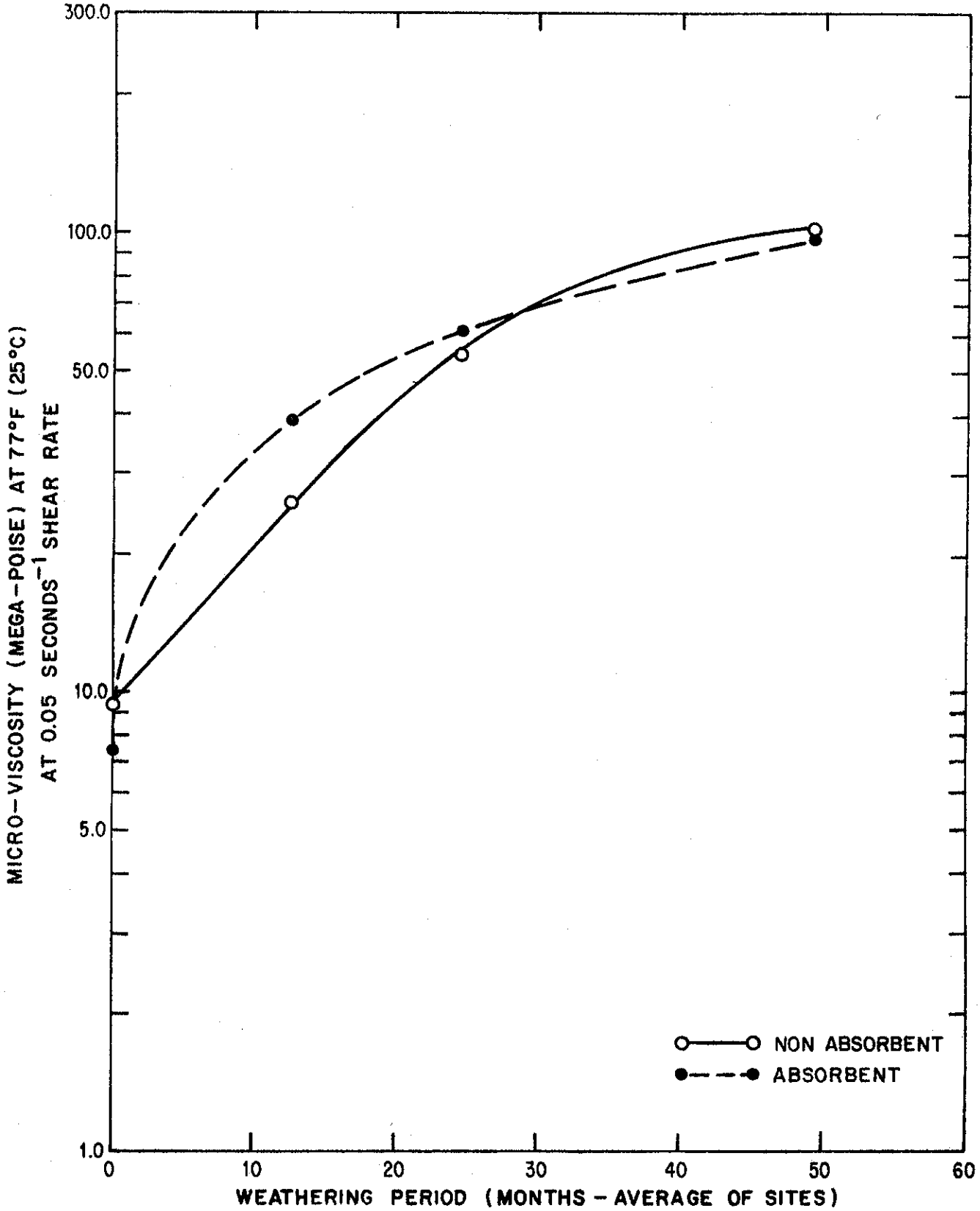
Figure 22



EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS (LA BASIN ASPHALT)

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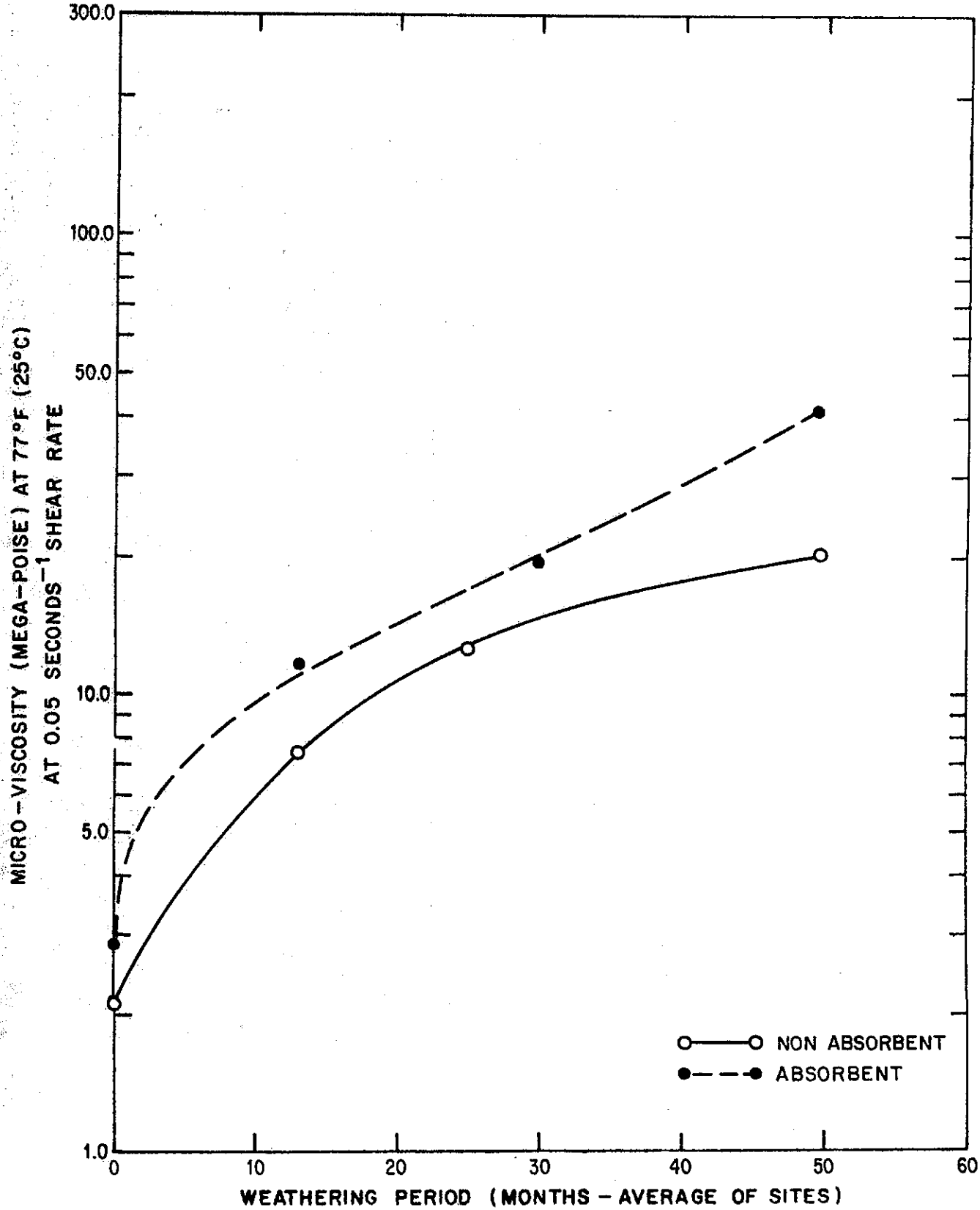

EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS (SANTA MARIA ASPHALT)

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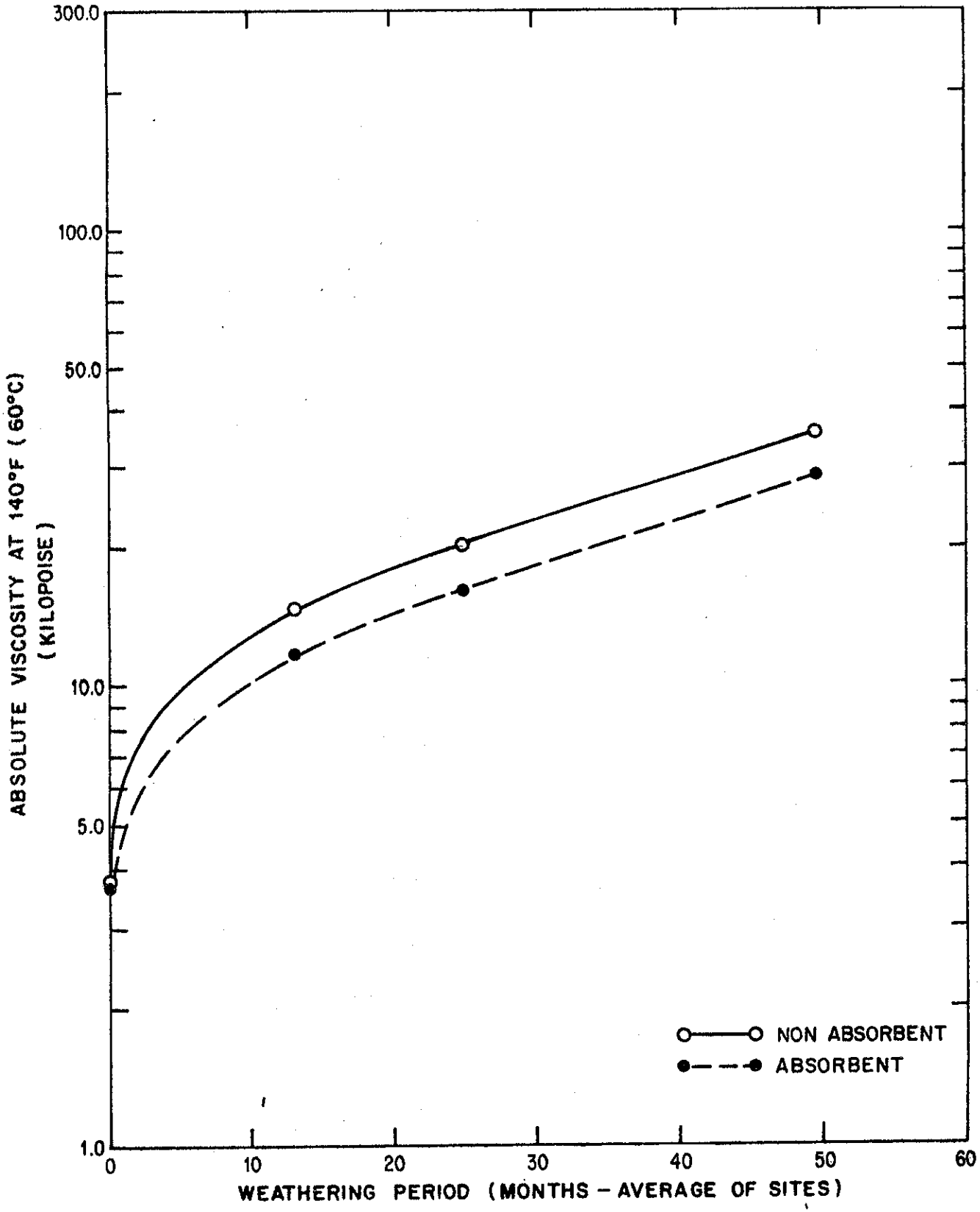
Figure 24



EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS (VALLEY (KERN) ASPHALT)

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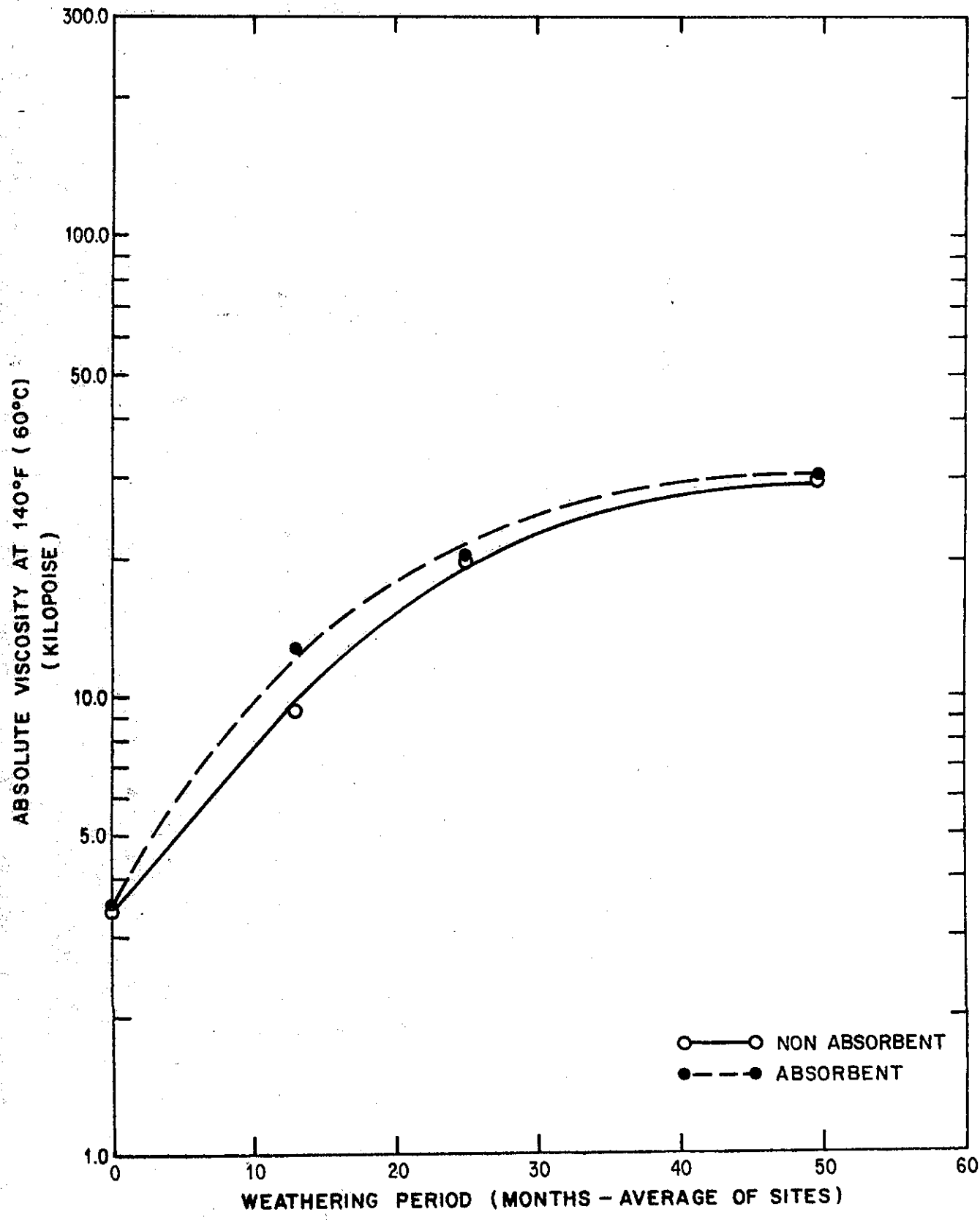

EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS (LA BASIN ASPHALT)

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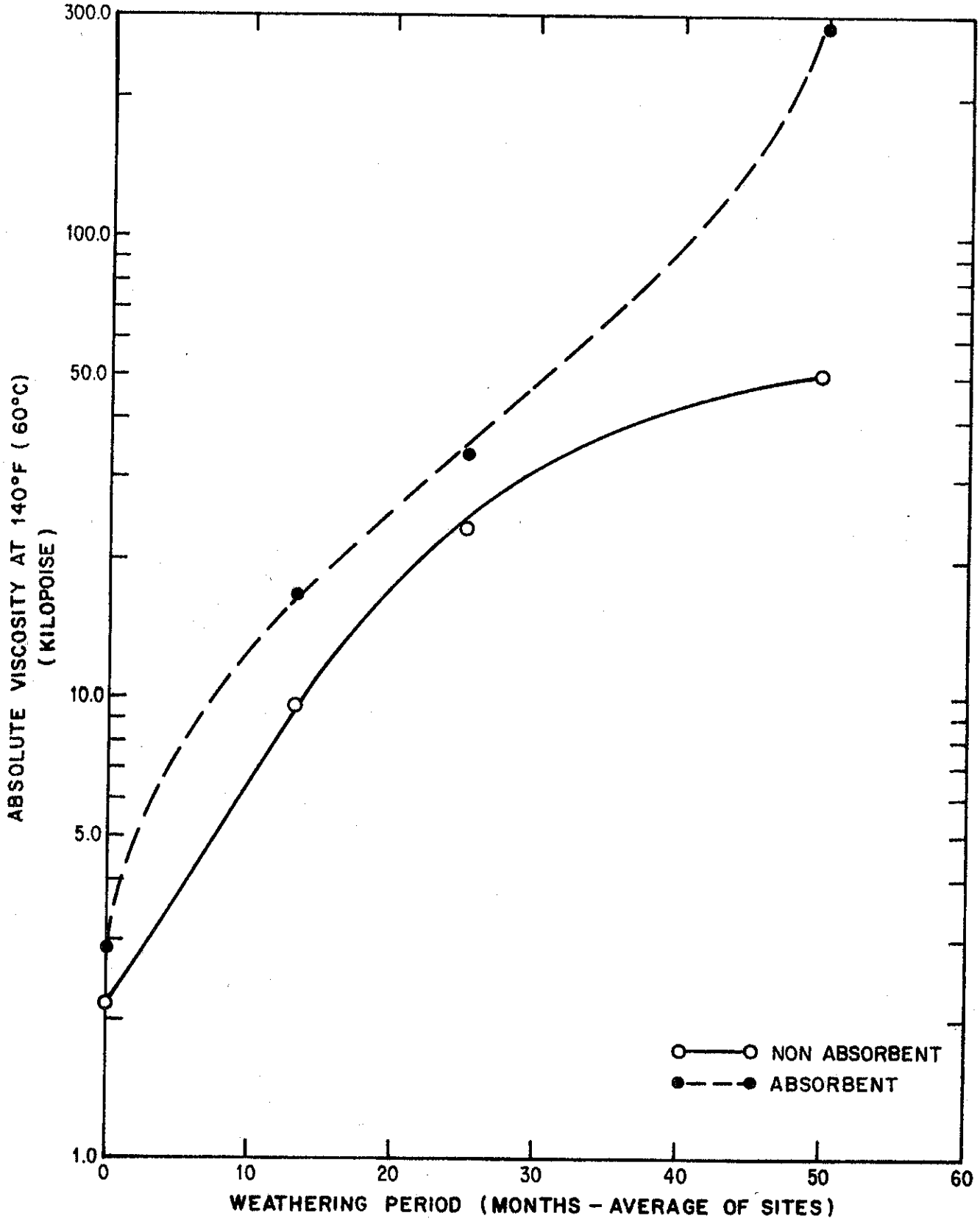
Figure 26



EFFECTS OF AGGREGATES ON HARDENING

COMBINED SITES & VOIDS (SANTA MARIA ASPHALT)

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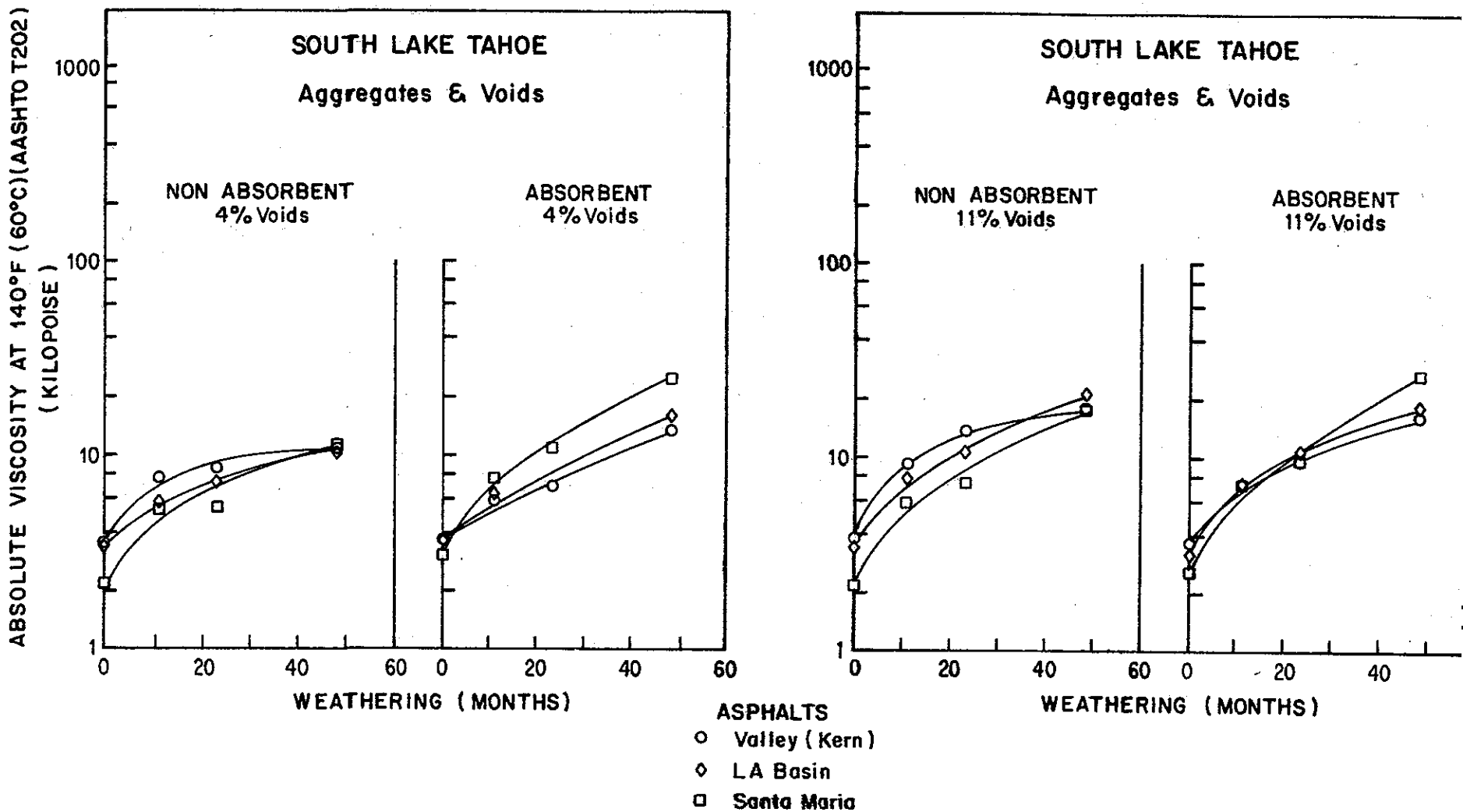
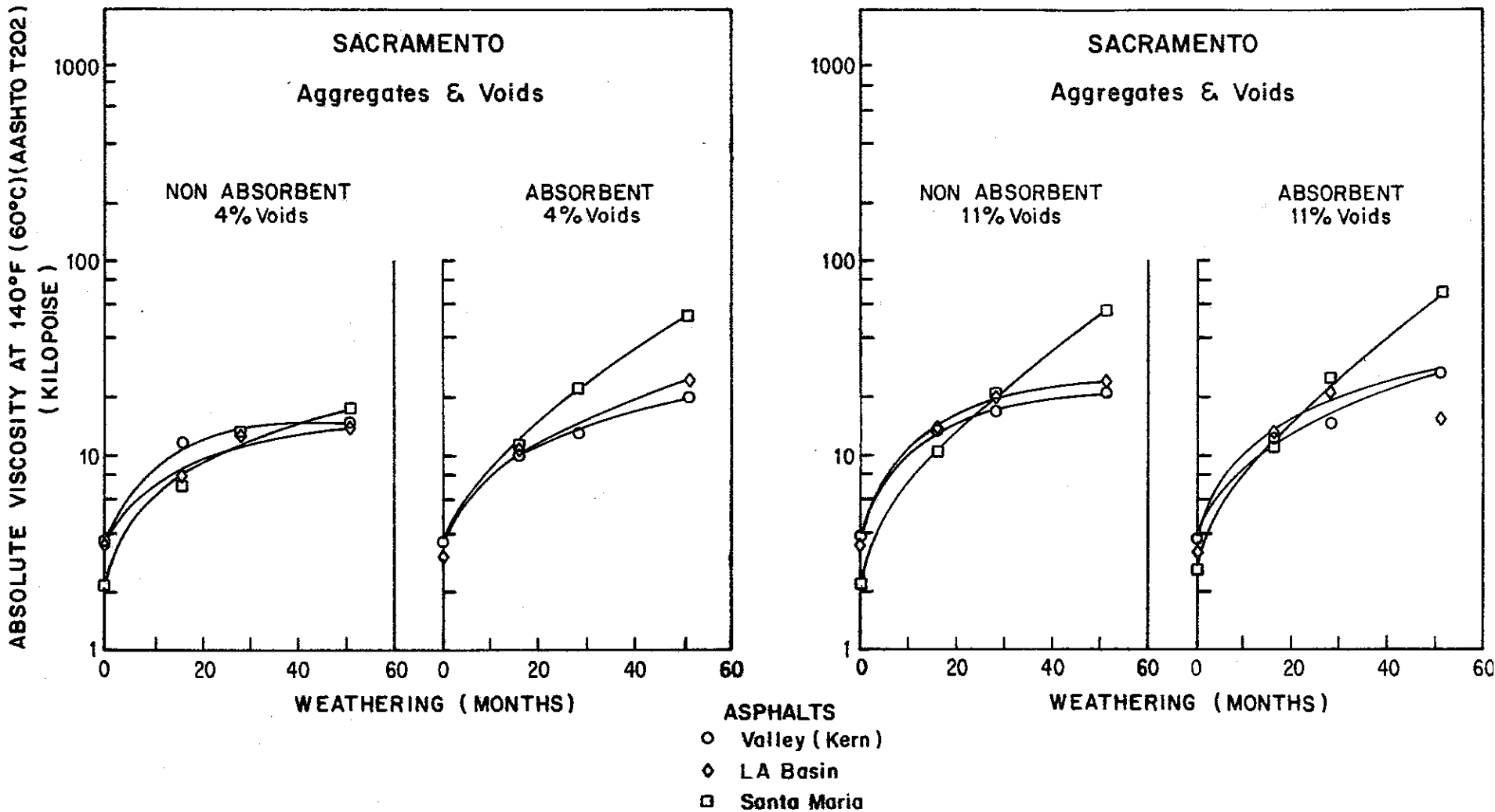


EFFECTS OF VOIDS & AGGREGATES ON HARDENING BY SITE

Figure 27



EFFECTS OF VOIDS & AGGREGATES ON HARDENING BY SITE

Figure 28

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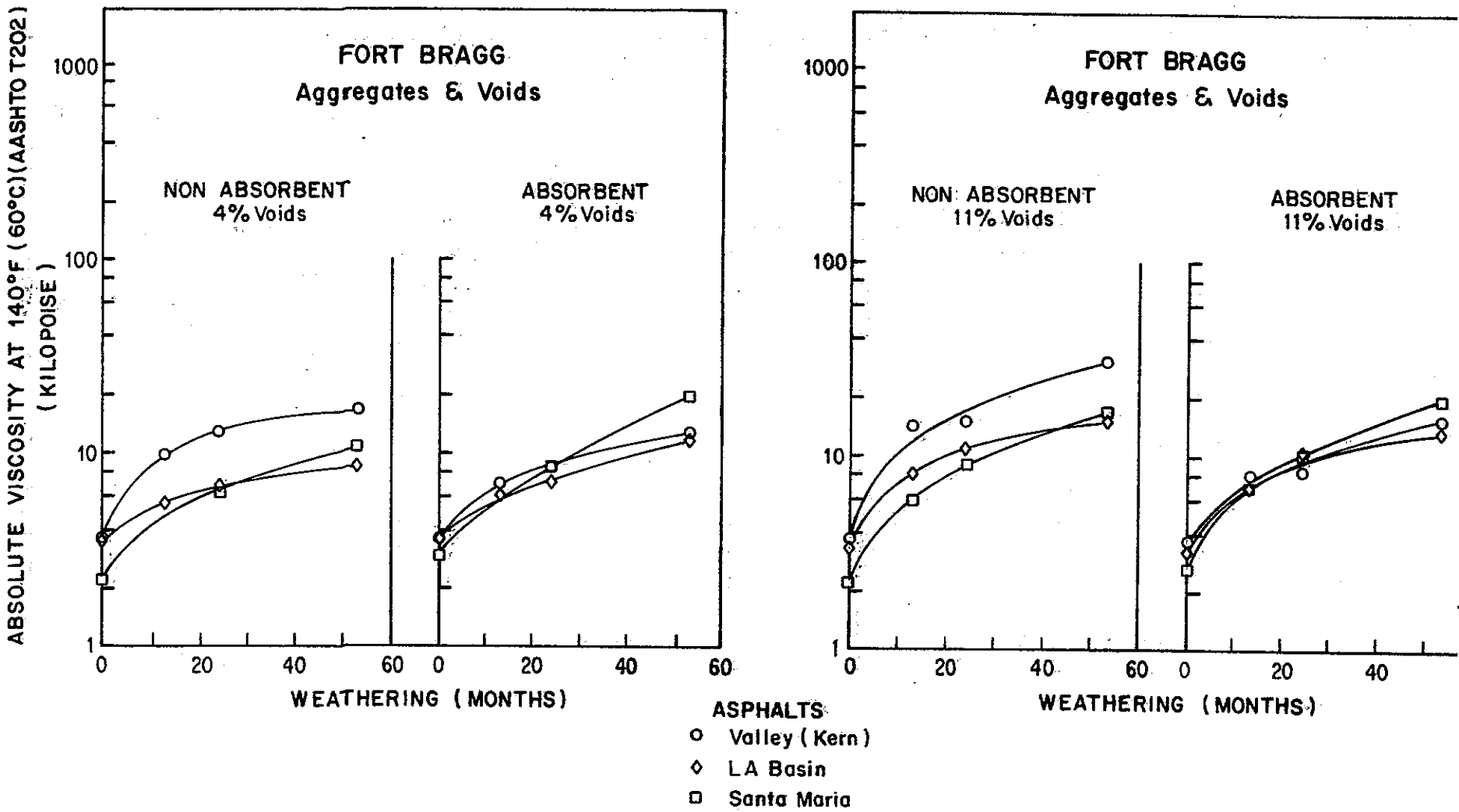

EFFECTS OF VOIDS & AGGREGATES ON HARDENING BY SITE

Figure 29

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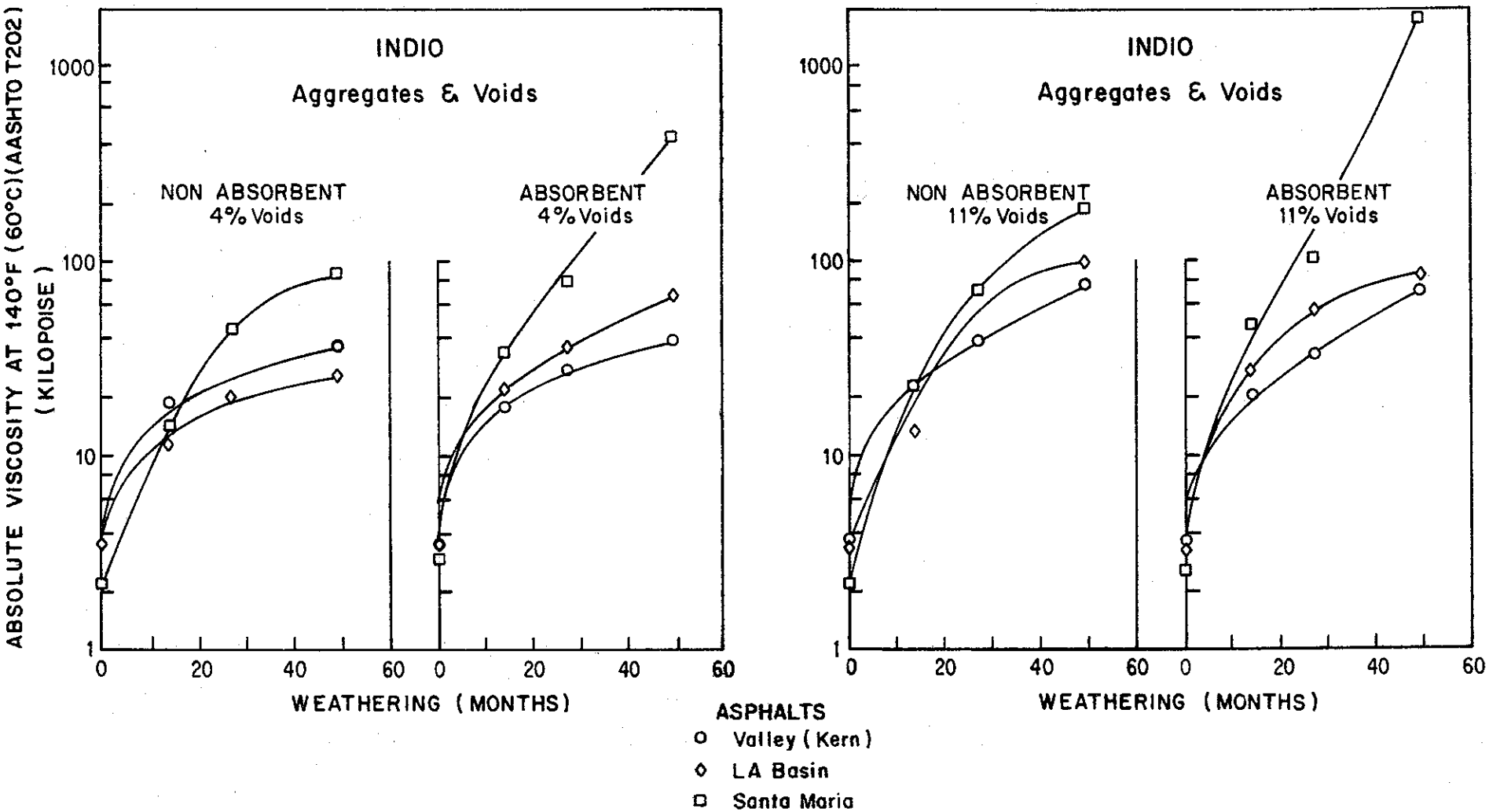

EFFECTS OF VOIDS & AGGREGATES ON HARDENING BY SITE

Figure 30

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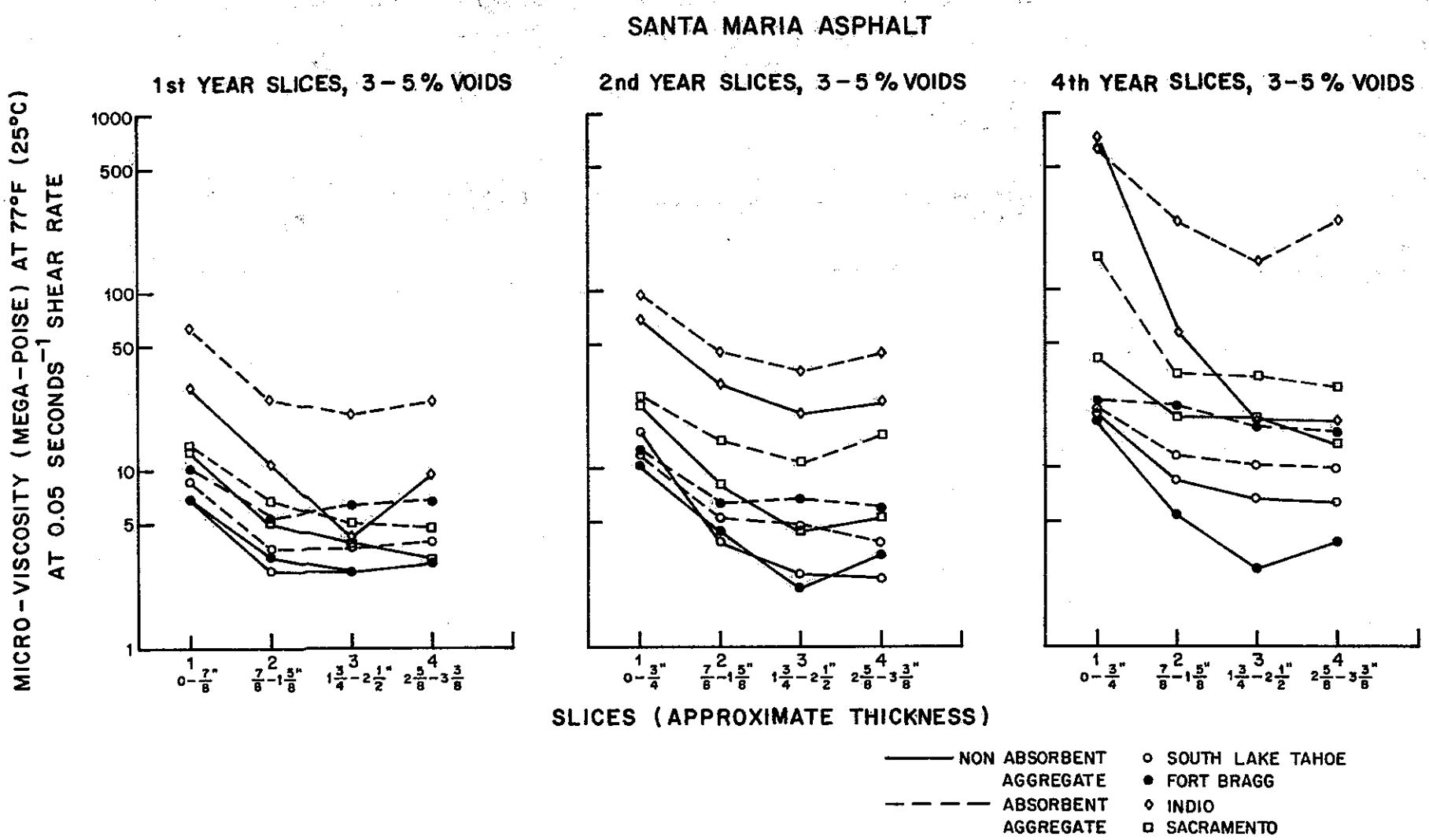
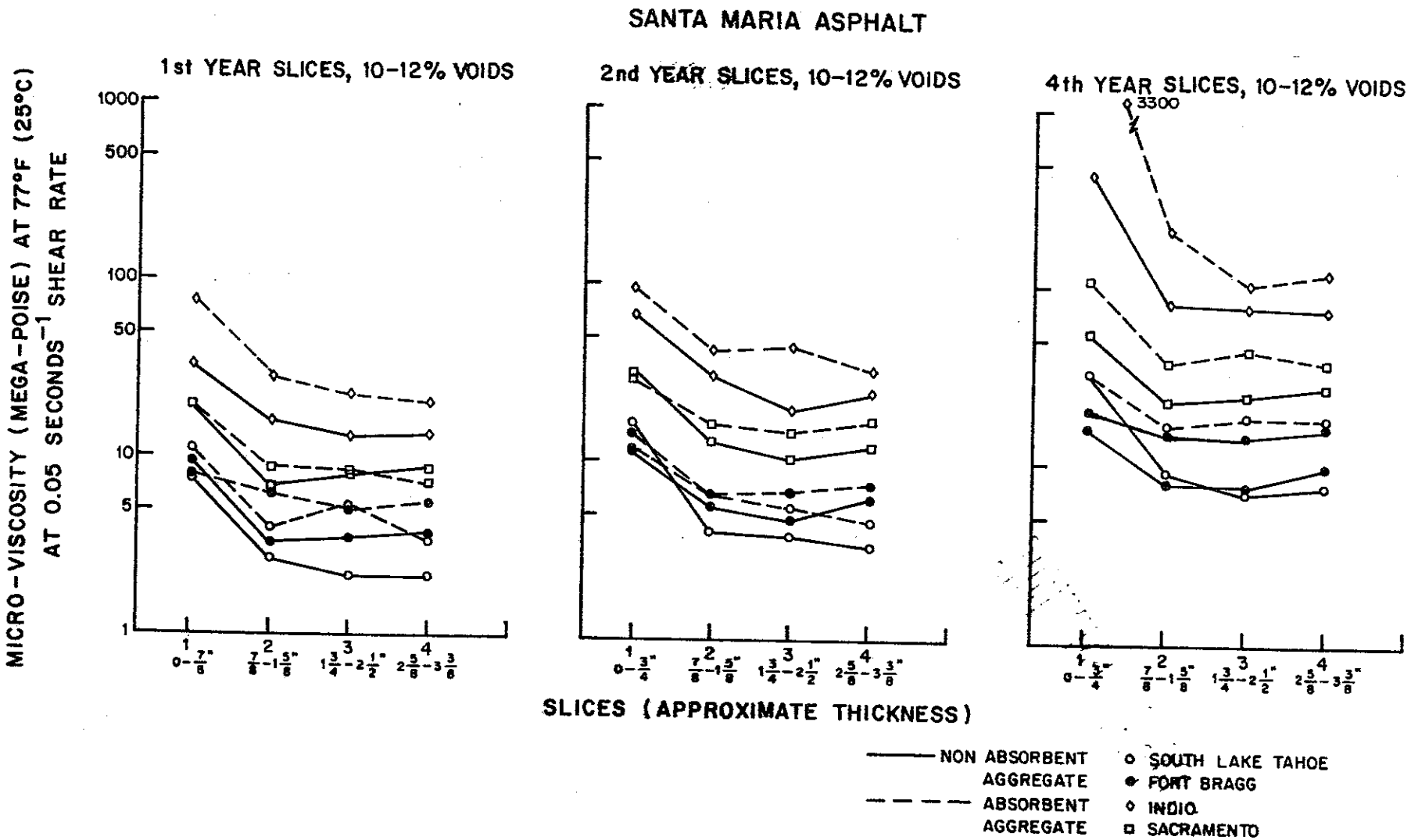


EFFECTS OF AGING ON HARDENING WITH DEPTH – 3 TO 5 % VOIDS

Figure 31



EFFECTS OF AGING ON HARDENING WITH DEPTH - 10 TO 12% VOIDS

Figure 32

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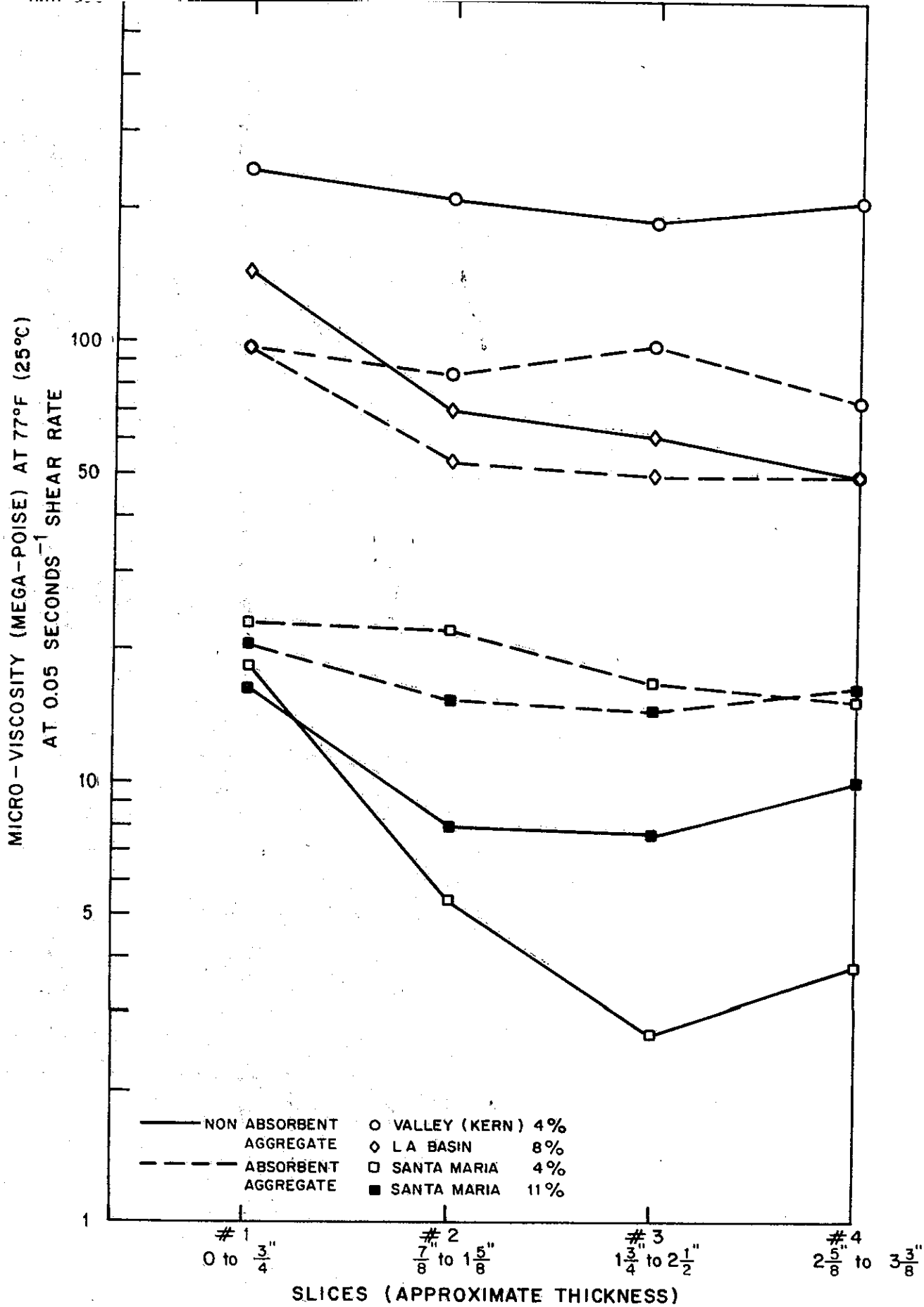

4th YEAR—SLICES—WEATHERING SITE, Fort Bragg

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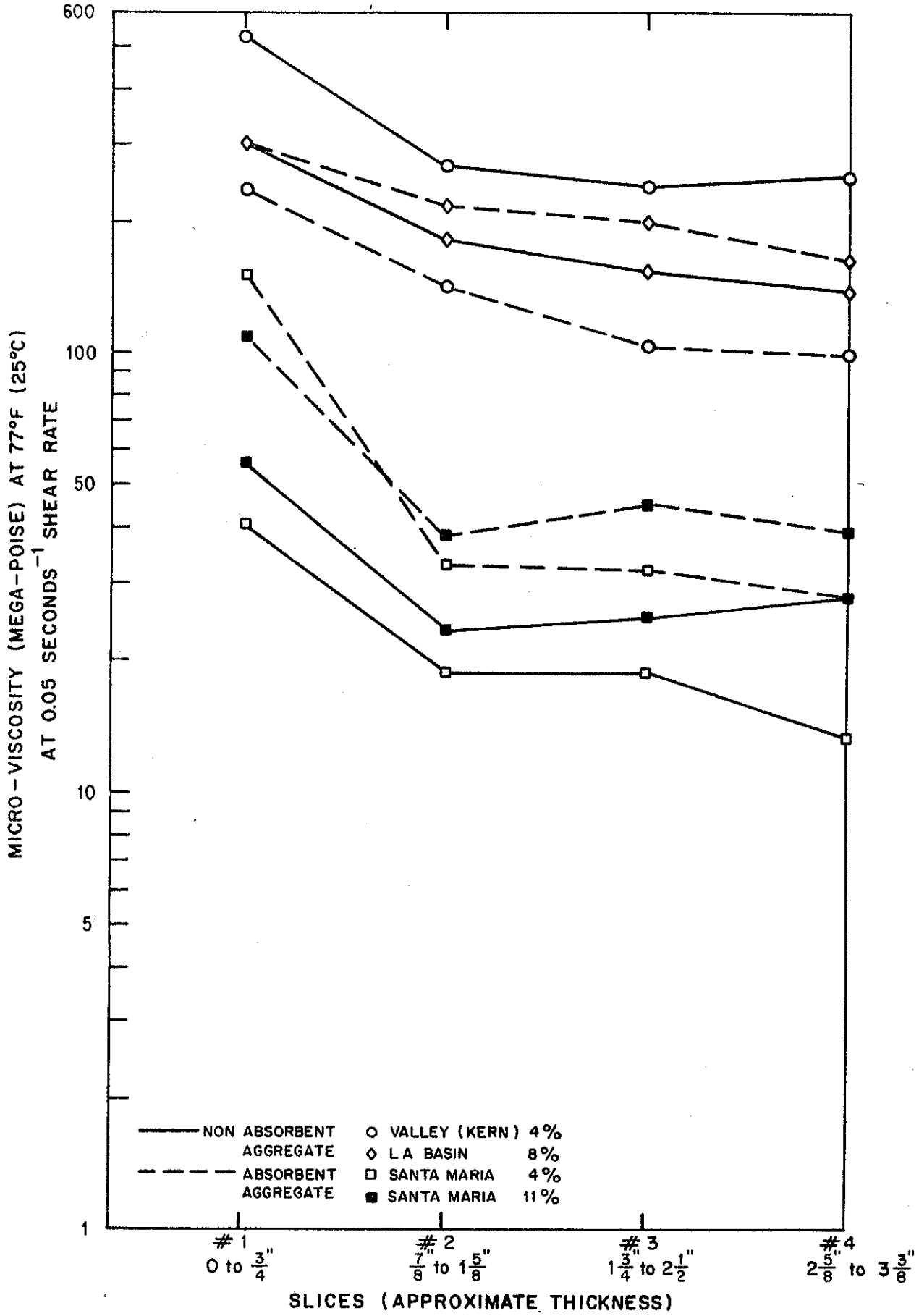
Figure 34



4th YEAR—SLICES—WEATHERING SITE, Sacramento

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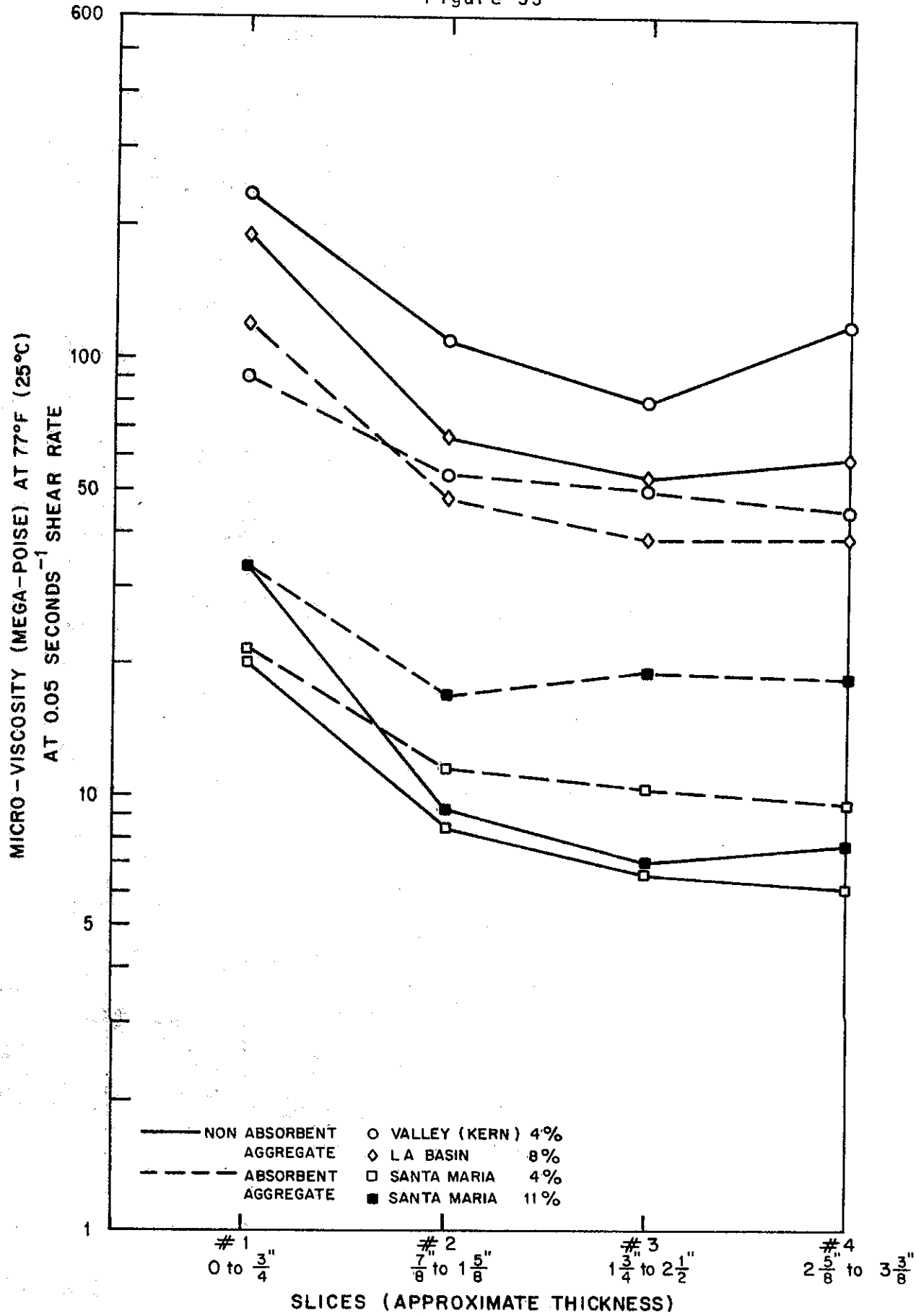
Figure 35



4th YEAR—SLICES—WEATHERING SITE, S. Lake Tahoe

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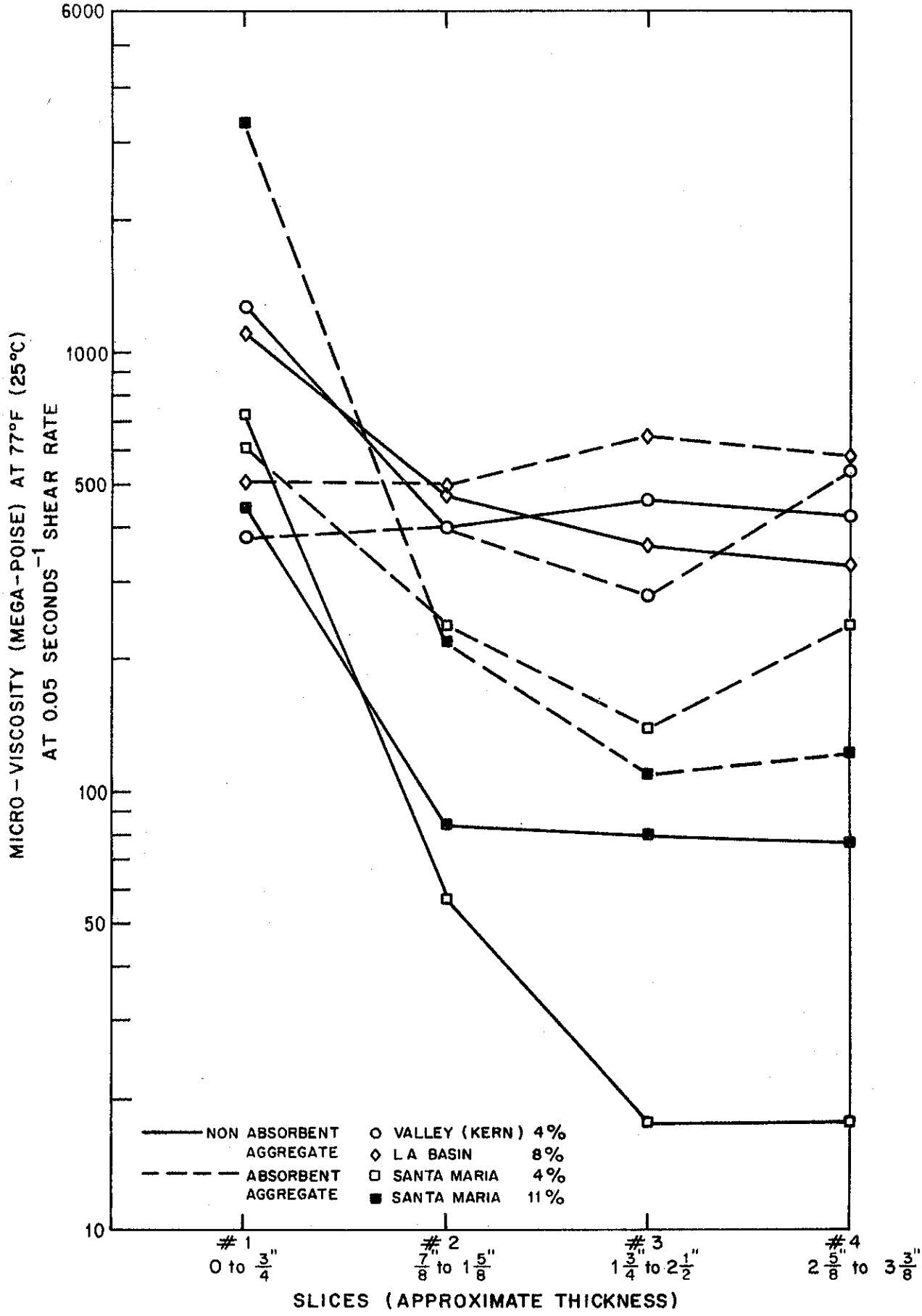
Figure 36



4th YEAR—SLICES—WEATHERING SITE, Indio

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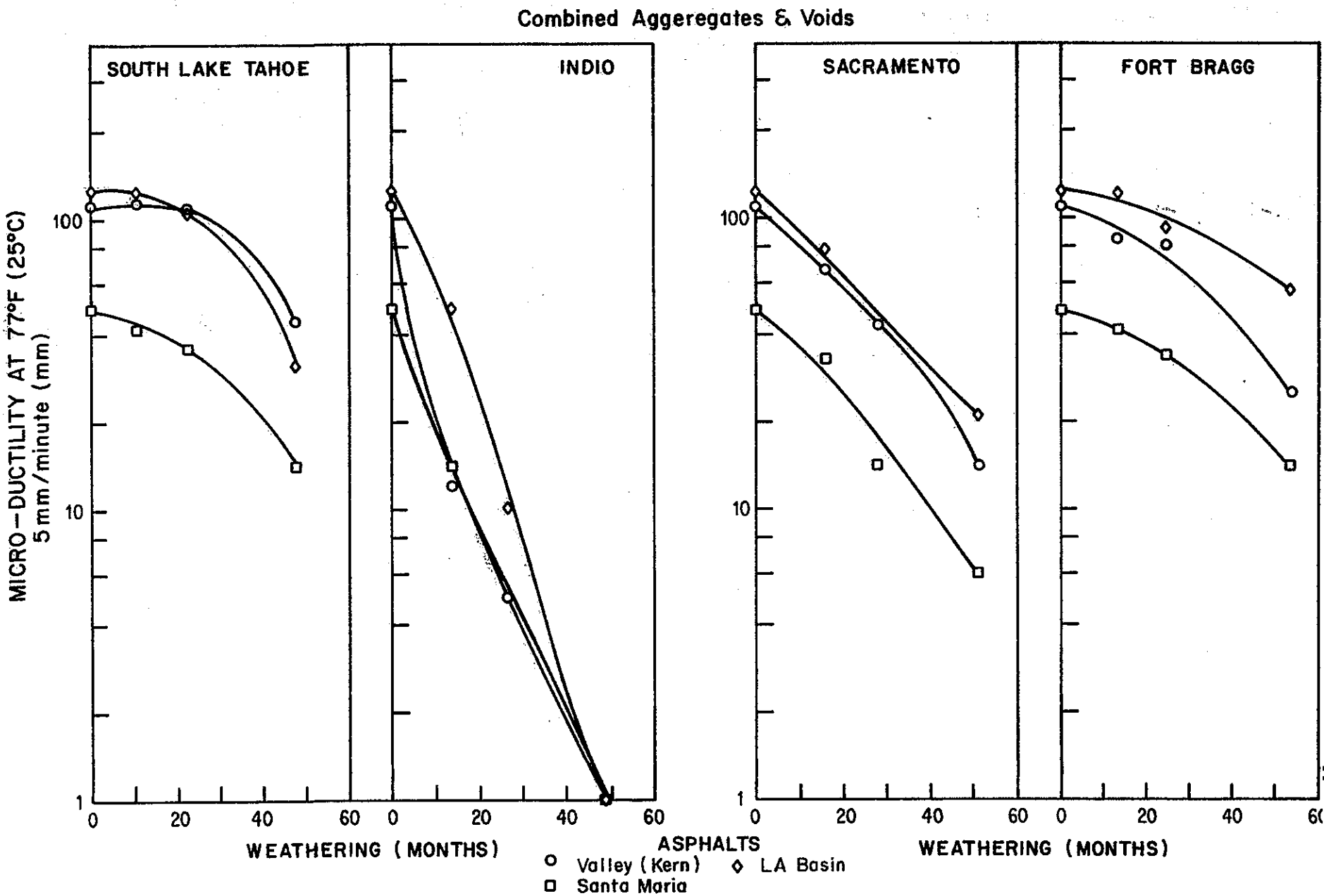

EFFECTS OF CLIMATE ON MICRO-DUCTILITY

Figure 37

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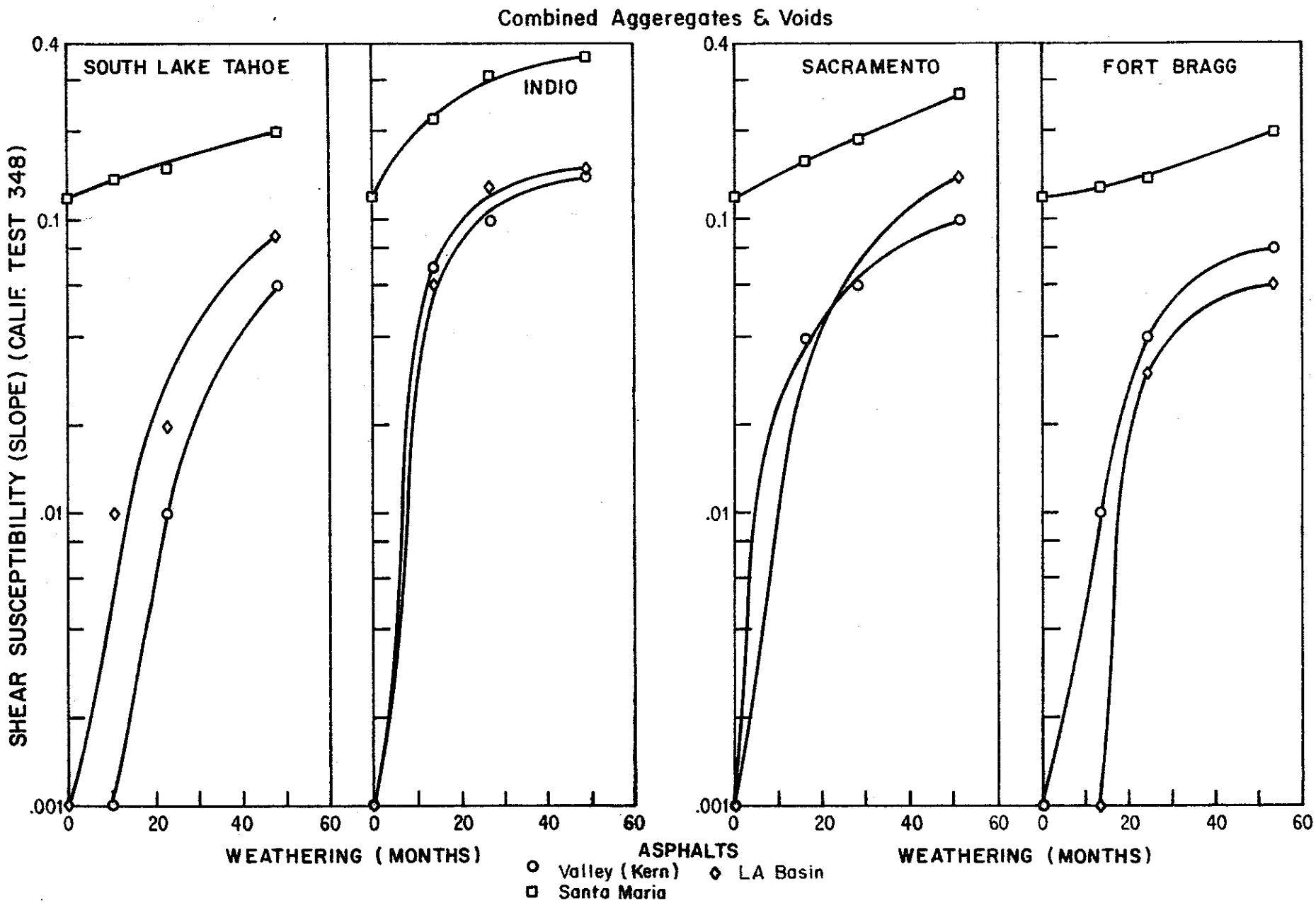
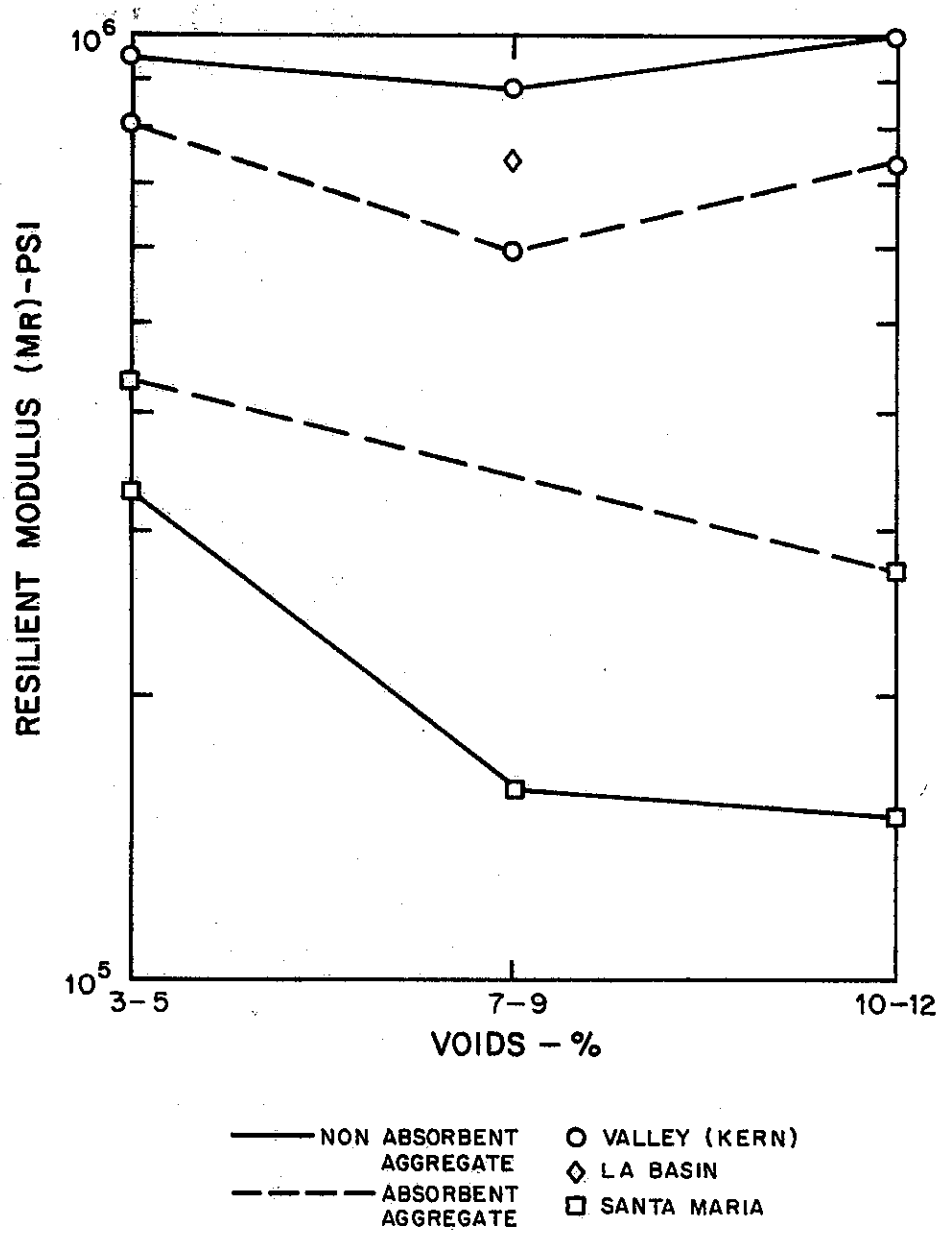


EFFECTS OF CLIMATE ON SHEAR SUSCEPTIBILITY

Figure 38

Figure 39



ORIGINAL RESILIENT MODULUS (M_R) TEST RESULTS

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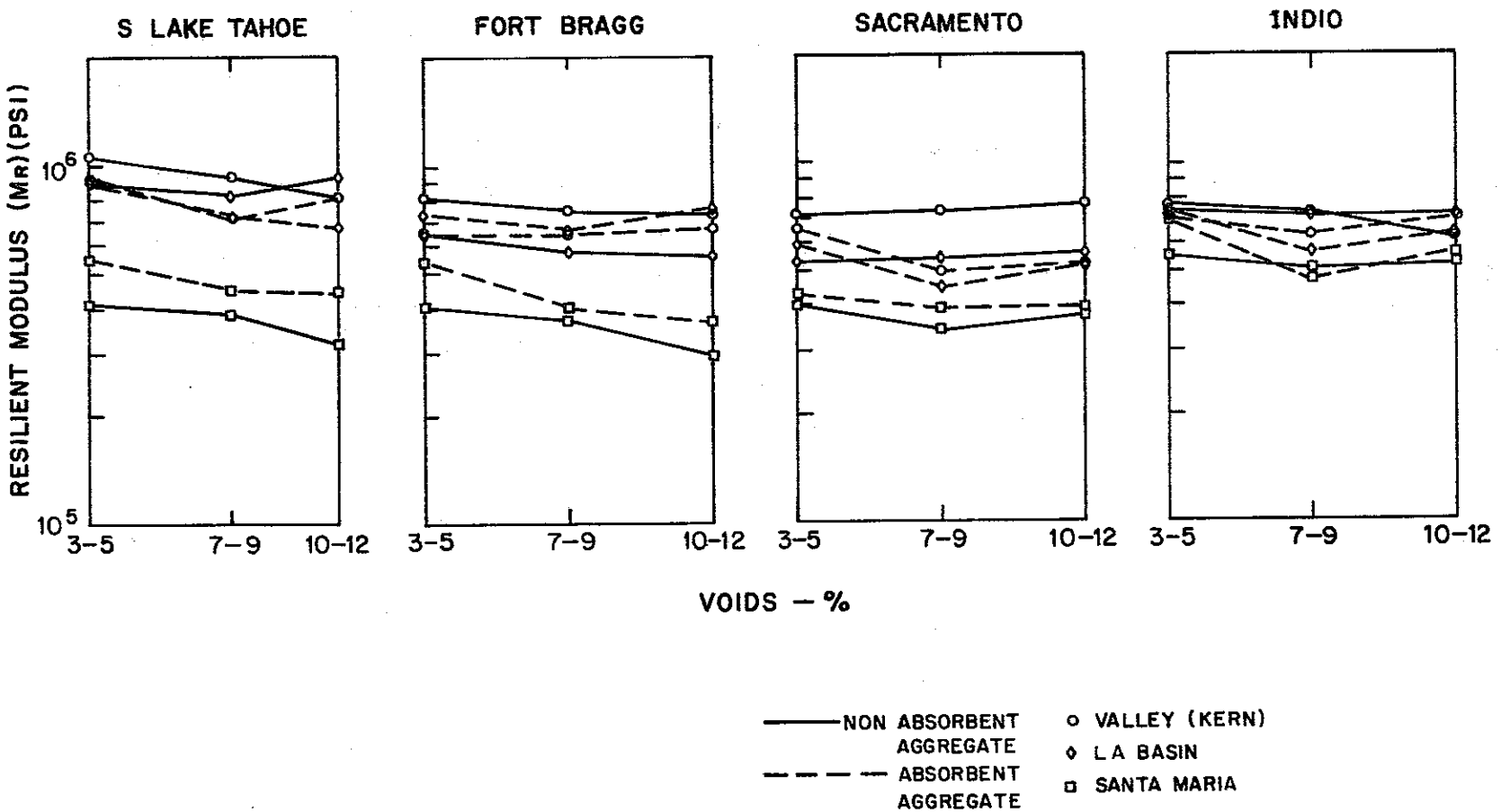

RESILIENT MODULUS (MR) ON 4th YEAR BRIQUETTES

Figure 40

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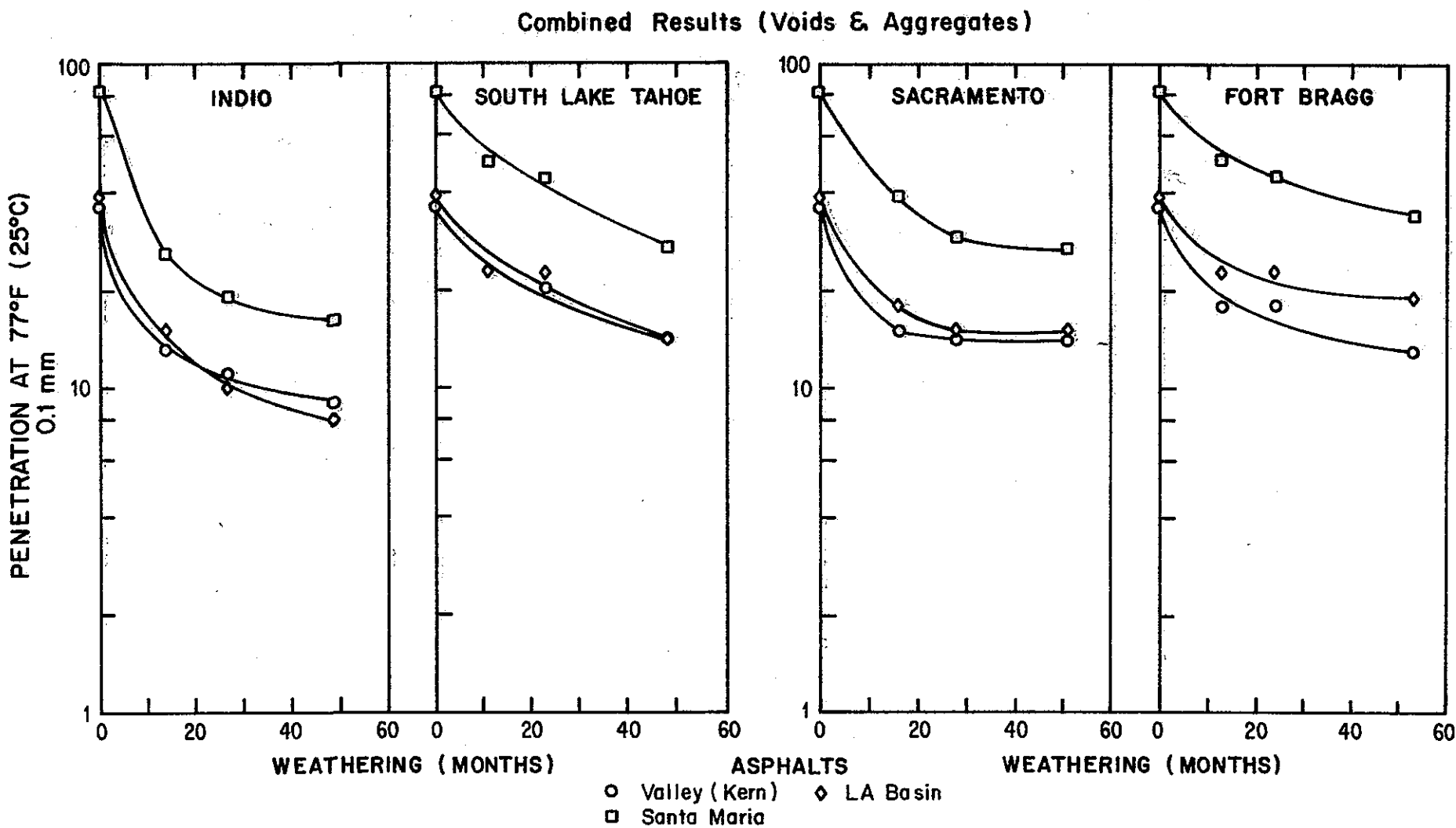
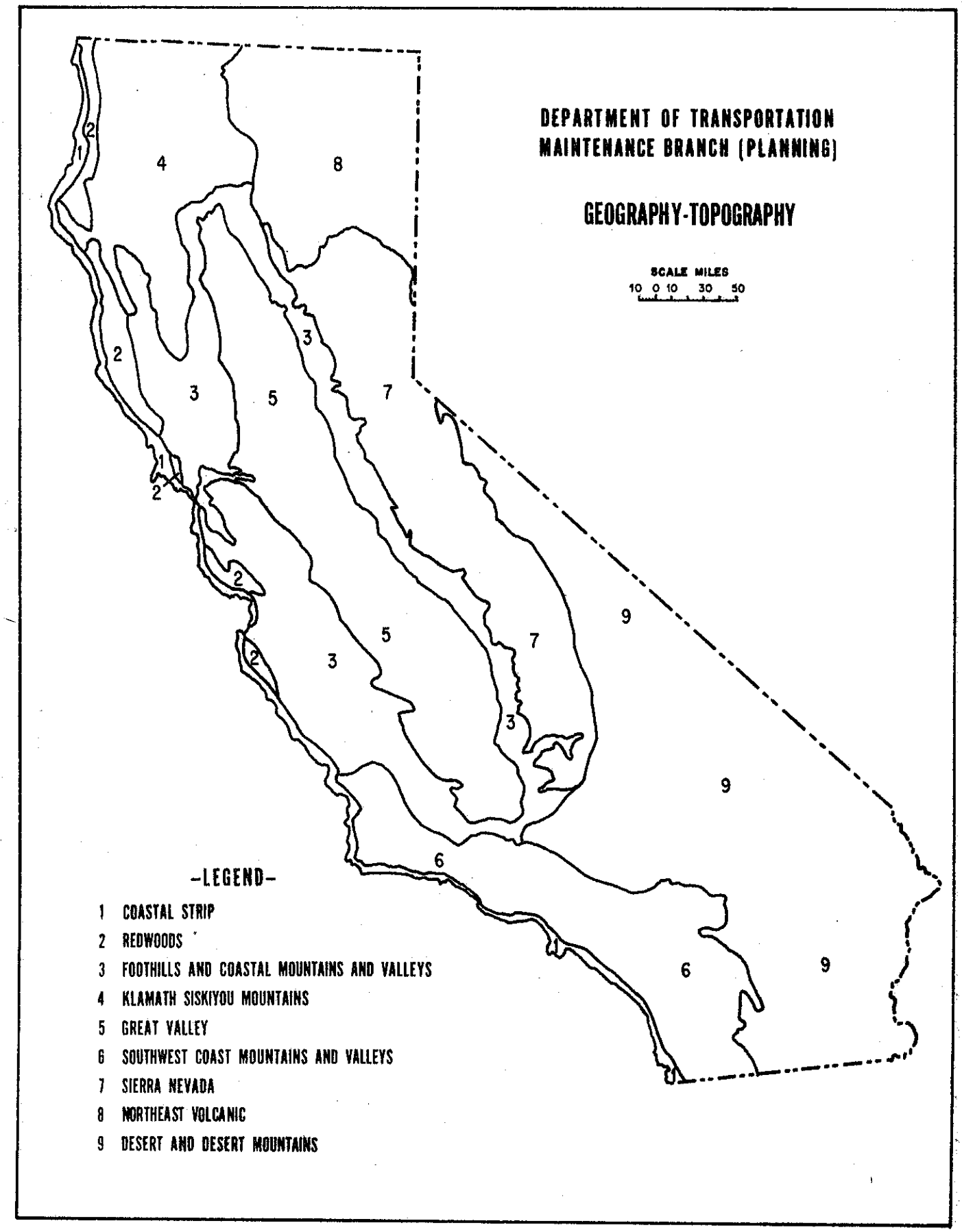


COMBINED PENETRATION RESULTS

Figure 41



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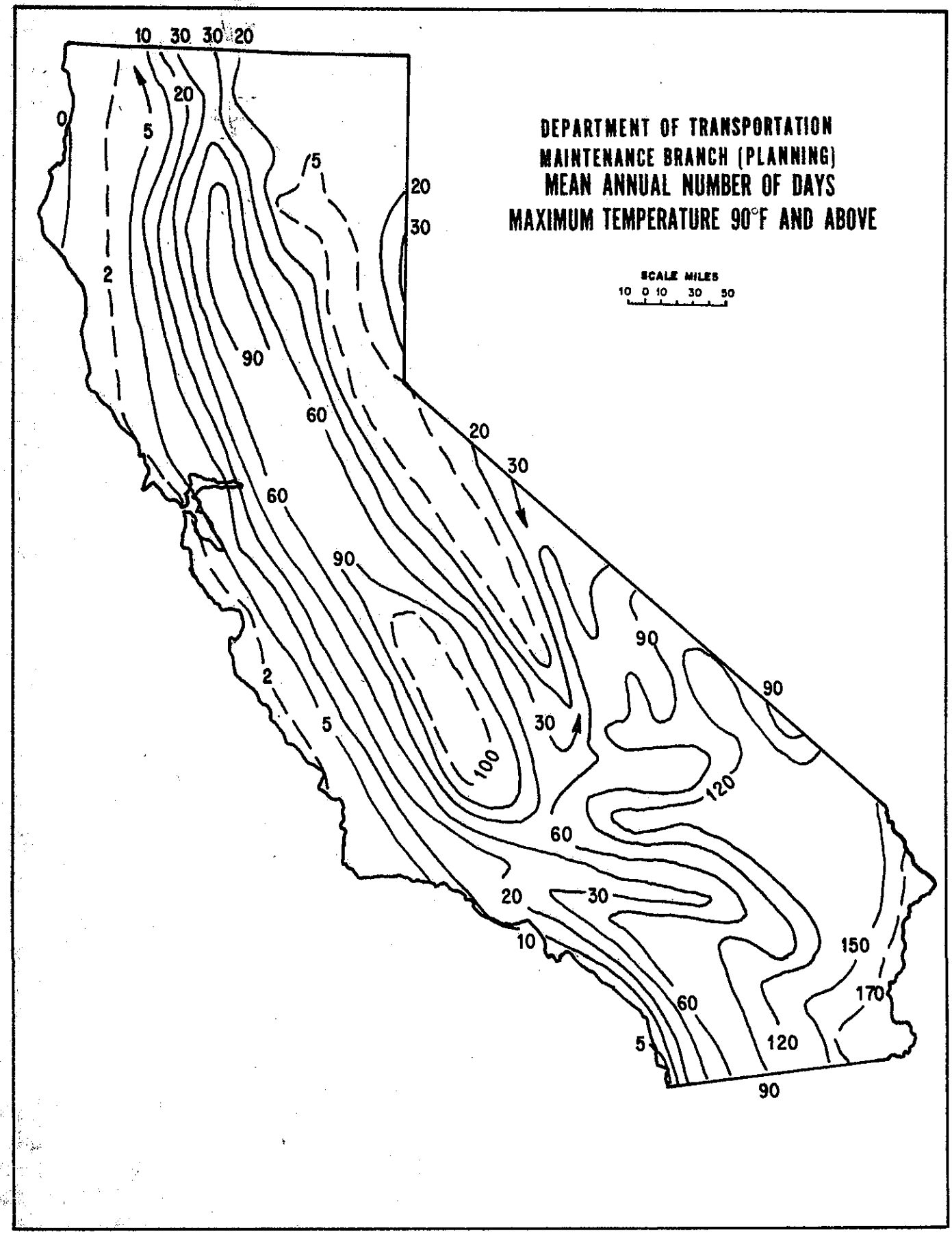

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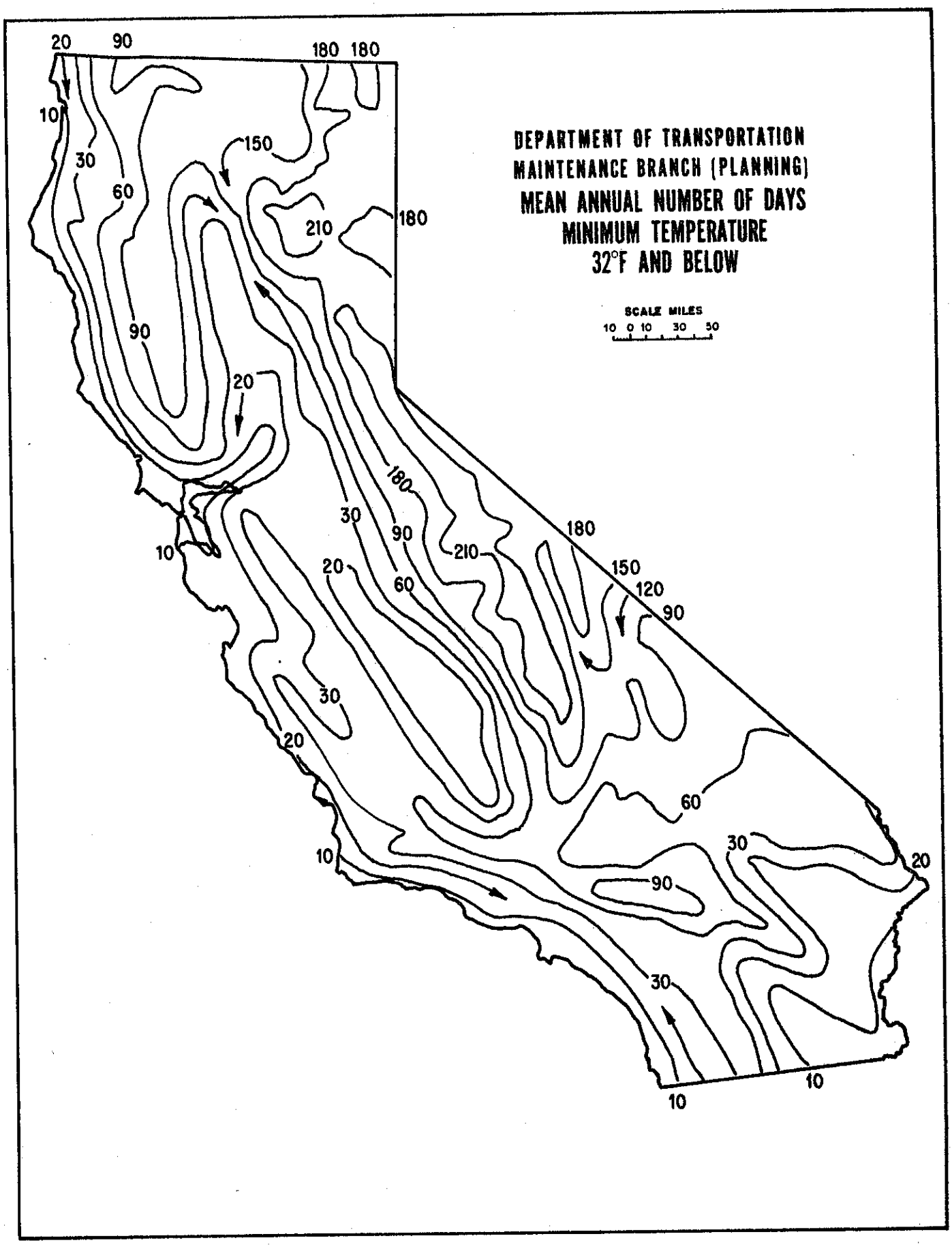

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Appendix A

PROPOSED

CALIFORNIA TILT-OVEN ASPHALT DURABILITY TEST

SCOPE

This method utilizes the apparatus required for AASHTO T240 (Rolling Thin Film Test) with slight modifications to weather semi-solid asphalt at 113C (235.4F) for 168 hours. These conditions simulate the effect of field weathering for two (2) years in a hot desert site model. The effects of this weathering are determined from measurements made on the residue.

APPARATUS

Oven - This shall be a double-walled electrically heated convection type. Its inside dimensions are: height 15 in. (381 mm) and depth (with door closed) 17-1/2± 1/2 in. (445 ± 13 mm). The door shall contain a symmetrically located window with dimensions of 12 in. (305 mm) to 13 in. (330 mm) wide by 8 in. (203 mm) to 9 in. (229 mm) high. The window shall contain two sheets of heat resistant glass separated by an air space. The window should permit an unobstructed view of the interior of the oven. The top of the upper heating element shall be 1 ± 1/8 in. (25 ± 3 mm) below the oven floor. The oven shall be vented top and bottom. The bottom vents shall be located symmetrically to supply incoming air around the heating elements. They shall have an open area of 2.31 ± 0.11 sq in. (14.9 ± 0.07 sq in. (9.4 ± 0.45 cm^2).

The oven shall have an air plenum covering the side walls and ceiling; the air space being 1 1/2 in. (38 mm) deep from the walls and ceiling. At a midpoint in the width of the oven and 6 in. (152 mm) from the face of the circular metal carriage to its axis, a squirrel cage type fan 5 1/4 in. (133.4 mm) O.D. by 2 7/8 in. (73 mm) wide shall be

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turned at 1725 RPM by an externally mounted motor. The squirrel cage fan shall be set so that the fan turns in an opposite direction to its vanes. The air flow characteristics of the fan-plenum system shall be suction from the floor of the oven through the wall plenums and existing of the air through the fan. Figures 1 and 2 show details of this plenum system.

The oven shall be equipped with a proportional control thermostat capable of maintaining 113 C (235.4 F) temperature within ± 0.5 C (± 1.0 F). The sensing element of the thermostat shall be placed 1 in. (25 mm) from the left side and approximately 1-1/2 in. (38 mm) from the ceiling of the interior of the plenum enclosed oven so that the end of the sensing element is at a point approximately 8 in. (203 mm) from the rear interior wall of the oven. The thermometer shall be hung or affixed to a mounting in the ceiling which is 2 in. (51 mm) from the right side at a midpoint in the depth of the oven so that the bottom of the bulb of the specified thermometer is approximately 1 in. (25 mm) above the coiled copper tubing on the floor of the oven. It should be adjusted so that it can be easily read through the window in the door. The heating controls shall be capable of bringing the fully loaded oven back to the test temperature within a 10 minute period after insertion of the samples in a preheated oven.

The oven shall be provided with a 12 in. (305 mm) diameter vertical circular carriage - see Figure 2 for details. This carriage shall be provided with suitable openings and clips for firmly holding eight glass containers - see Figure 3 - in a horizontal position. The vertical carriage shall be mechanically driven through a 3/4 in. (19 mm) diameter shaft at a speed of 15 ± 0.2 RPM.

The oven shall be equipped with an air jet positioned to blow heated air into each bottle at its lowest point of travel. The air jet shall have an outlet orifice 0.04 in. (1.02 mm) in diameter (No. 60

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drill) connected to a 25 ft (7.6 m) length of 5/16 in. (7.9 mm) O.D. copper tubing. This tubing shall be coiled to lie flat on the bottom of the oven and lead to a source of fresh dried, dust-free regulated air.

Note 1 - Activated Silica Gel treated with an indicator is a satisfactory desiccant for the dried air.

Flow Meter - The flowmeter may be any suitable type capable of accurately measuring the air flow at a rate of 4000 ml per minute at the outlet of the copper tube.

Thermometer - This thermometer shall meet the following specifications; range, 70 to 120°C; length 12 in.; graduation, 1/5°C divisions; Total immersion.

Note 2 - A thermometer for the "Distillation of Benzol and Toluol" from Van Water and Rogers, Catalog No. VWR 61088-005 meets these specifications.

Container - The container in which the sample is to be tested shall be of heat resistant glass conforming to the dimensions shown in Figure 3.

PREPARATION OF OVEN

Position the air outlet orifice so that it is 1/4 in. (6.4 mm) from the opening of the glass container. The orifice shall also be so positioned that the jet blows horizontally into the central arc of the opening of the circling glass container.

Position the thermometer so that the end of the bulb of the thermometer is within approximately 1 in. (25 mm) of the copper tubing.

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Level the oven so that the horizontal axes of the glass containers is tilted 1.06° (approximately 1 cm rise in 54 cm) higher in the front (door opening) of the oven when in position in the carriage.

Preheat the oven for a minimum of 16 hours prior to testing with the controls on the setting which will be used during the operation of the oven. The control thermostat shall be adjusted so that when the oven is fully loaded and the air is on, it will return to 113 ± 0.5 C (235.4 ± 1.0 F).

PROCEDURE

The sample as received shall be free of water. Heat the sample in its container with a loosely fitted cover in an oven not to exceed 163 C (325 F) for the minimum time necessary to insure that the sample is completely fluid. Manually stir the sample but avoid incorporating air bubbles.

Pour 35 ± 0.5 grams of the sample into each of the required glass containers providing sufficient material for characterizing tests which are to be run on the residue. Cool to room temperature.

Note 3 - A minimum of two test bottles will be required per sample if only the Penetration, Viscosity at 140 F, and Ductility are performed. Perform the Penetration initially, then reheat to pour the Viscosity and Ductility.

With the oven at operating temperature, arrange the containers holding the asphalt in the carriage so that the carriage is balanced. Fill any unused spaces in the carriage with empty containers. Close the door and rotate the carriage assembly at a rate of 15 ± 0.2 RPM. Start the air flow at a set rate of 4000 ± 200 ml per minute. Maintain the samples in the oven with the air flowing and the carriage

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rotating for 168 hours ± 10 minutes. The test temperature 113 ± 0.5 C (235.4 ± 1.0 F) should be reached within the first 10 minutes. At the conclusion of the testing period, remove the containers from the oven.

Immediately place the containers, in an upright (vertical) position, in an oven at 163 ± 3 C (325 ± 5 F) for 15 to 20 minutes. Remove and pour all of the residue without scraping into a metal container and cover if no test are performed immediately.

Note 4 - Normally all testing of the residue should be completed within 72 hours.

TESTING

Perform the Penetration at 25 C (77 F) AASHTO T49, Absolute Viscosity at 60 C (140 F) AASHTO T202, and Ductility at 25 C (77 F) AASHTO T51 on the weathered residue to determine the predicted "Two Year Hot Desert" durability characteristics of the asphalt.

REPORT

Report the results of the Penetration at 25 C (77 F) AASHTO T49, the Absolute Viscosity at 60 C (140 F) AASHTO T202, and the Ductility at 25 C (77 F) AASHTO T51 as the predicted "Two Year Hot Desert" durability characteristics of the asphalt.

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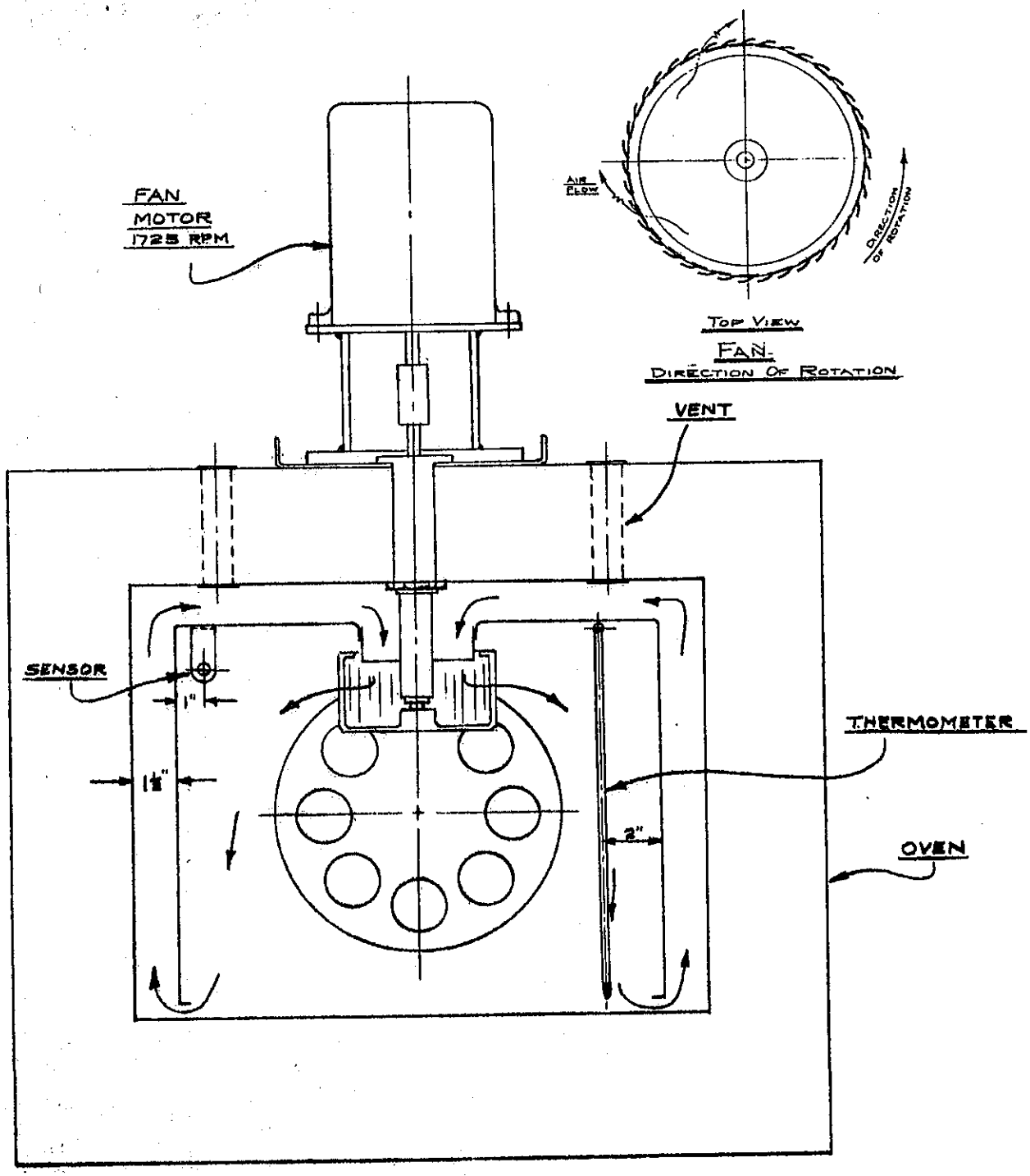

SCHEMATIC OF AIR FLOW
FRONT VIEW

FIGURE 1

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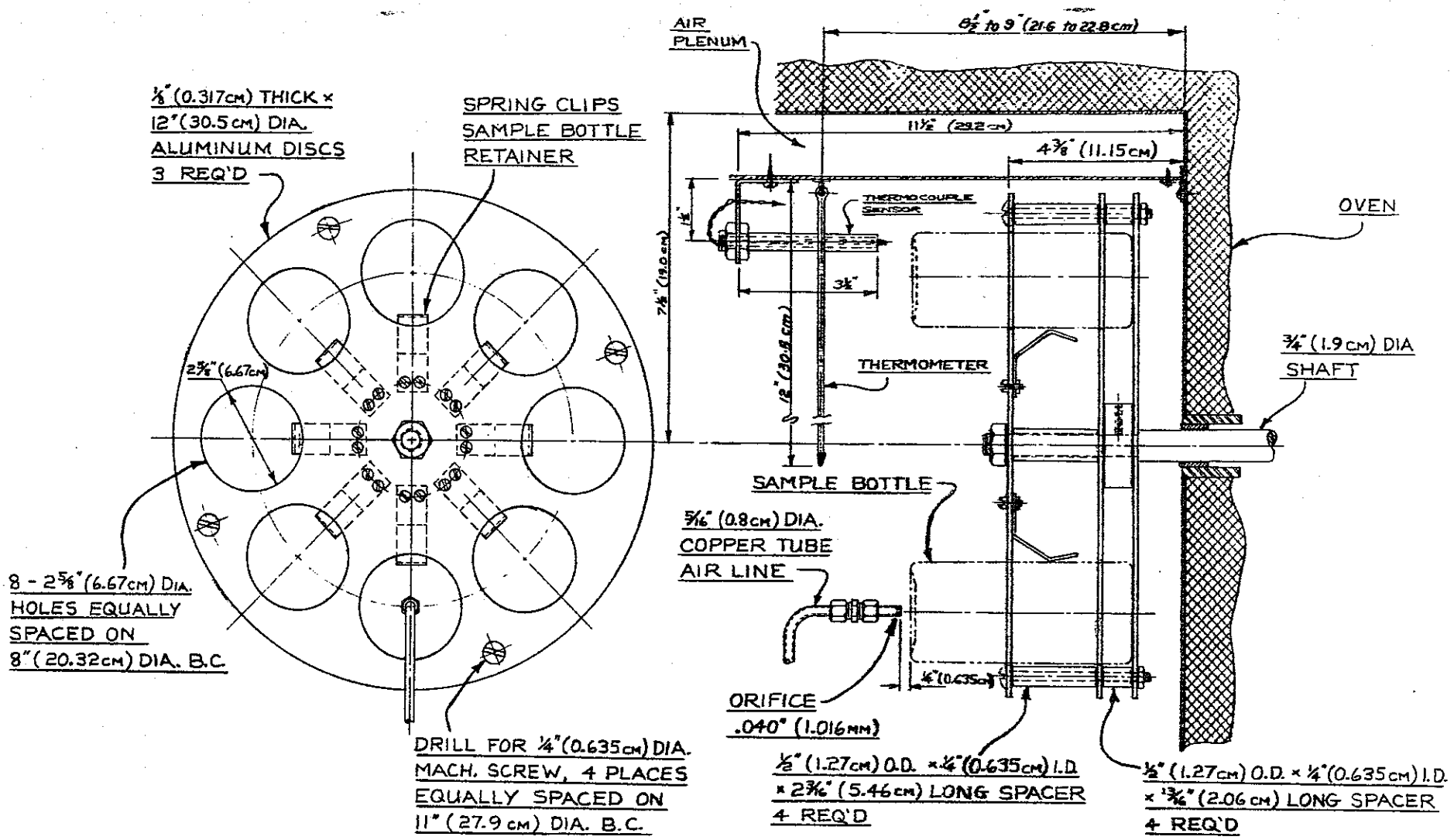

CIRCULAR METAL CARRIAGE

FIGURE 2

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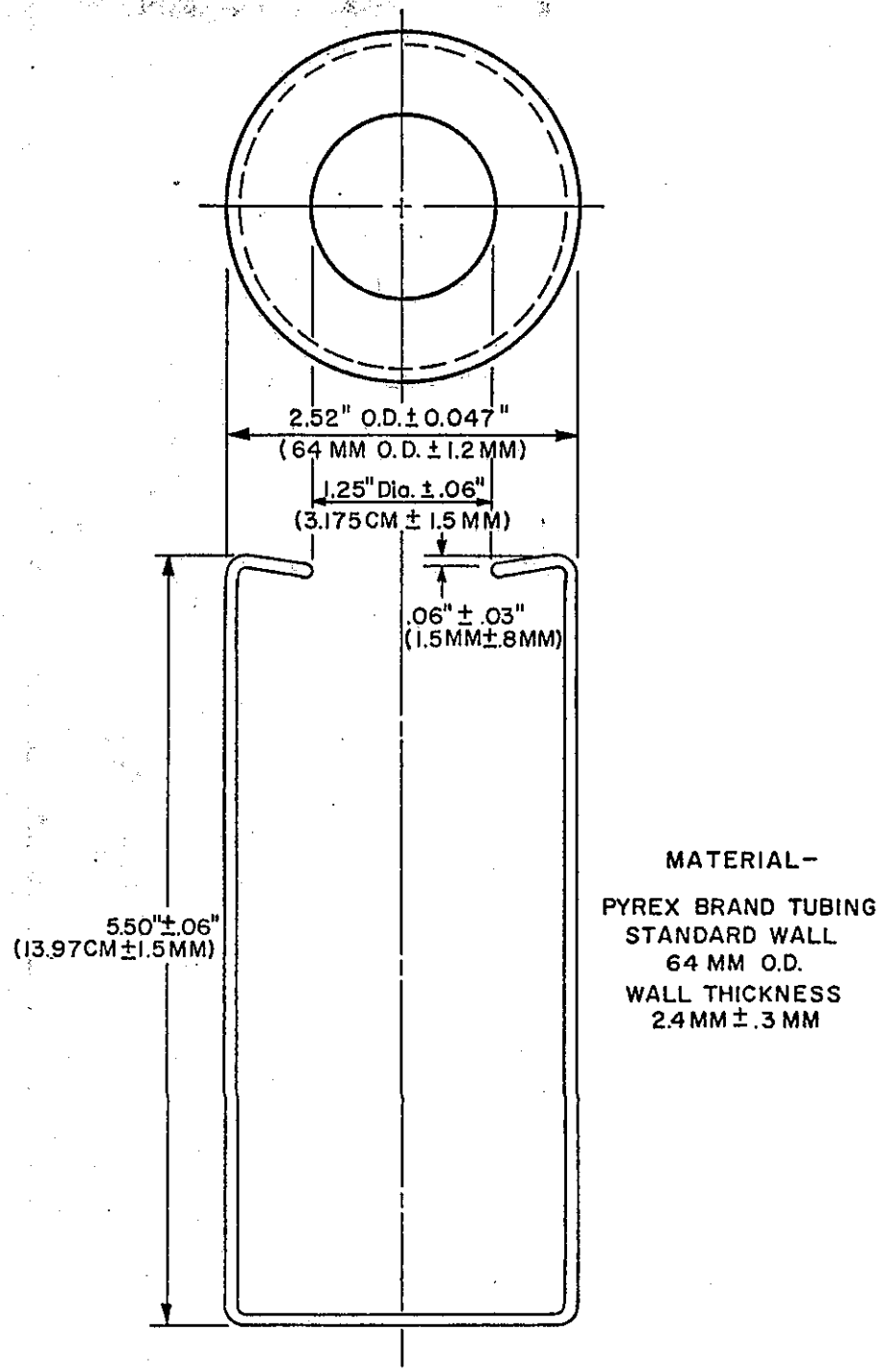

FIGURE 3 - SAMPLE BOTTLE

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