DEVELOPMENT OF A QUICK AND THOROUGH METHOD OF SOAKING SOIL-ASPHALT SPECIMENS

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CHAPTER I

INTRODUCTION AND REVIEW OF LITERATURE

At present there is no one universal standard method of bituminous stabilized soil design and construction. Many satisfactory methods, having widely different procedures and apparatus have been followed in different parts of the United States, making use of different bituminous mixtures, types of soil, and subject to different climatic conditions. Because of these widely diversified methods, the necessity of the development of a single, quick and thorough procedure is highly desirable.

All these methods of design use laboratory procedures in which some type of stability or strength value of a compacted soil bituminous specimen is measured. In this connection, stability of soil-asphaltic mix may be defined as its property by which the mix is able to resist permanent displacement under the imposed traffic loads. This property is of great concern to the Highway Engineer in as much as a lack of stability causes shoving, rutting, pushing, corrugating, etc. In order to have a true design of the mix, stability tests should be made on specimens which have been subjected to conditions similar to those which the actual soil-asphaltic mix is expected to be exposed to. A high moisture content causes a drop in the strength of soil-bitumen mixture. Hence, a study of the effect of soaking the specimens under various methods, is highly desirable.

The basic assumptions in the evaluation of strength in soils, subjected to stress, are that the mass of the soil is isotrophic, homogeneous and semi-infinite in extent. The same assumptions are also made in the theories dealing with stresses in any material. Hence, it is essential that in the study of soil-bituminous mixtures, the moisture content in the specimens is kept uniform throughout the specimen. Any variation of moisture content in the mass of one specimen such as from top to bottom or from outside to inside will result in erroneous evaluation of its strength. In the same way, any difference in moisture content between the different specimens tested would also cause errors in strength evaluation. Thus, it is of utmost importance in all of these tests that the moisture content of the specimens be kept constant.

On a review of the literature on the subject, it has been found that there are various methods of soaking soil-bitumen specimens. Of these, the three basic ones which have been more commonly proposed are: (1) The Total Immersion Method, (2) The One-Half Immersion Method, and (3) The Vacuum Saturation Method.

Rhodes (6) and Anderton (1) propose the Total Immersion Method for soaking specimens in their work on tar-soil mixtures. Incidentally, this is also the method used by the Oklahoma State Highway Department for its Soil-Asphalt-Design (8). This method consists of immersing the specimens completely in water at room temperature to a depth of one inch above the top of the specimen and keeping them soaked for various durations of time. Rhodes uses an 18 hour soaking time, while Anderton uses a 14 day soaking time. The Oklahoma State Highway Department recommends a 7 day soaking period.

Roediger and Klinger (7) and later Benson and Becker (2) have adopted the one-half immersion method, by which, the specimens are immersed in water to one-half their height and allowed to soak for various periods of time. While the former soaked their specimens for 7 days, the latter used a five day period.

The Vacuum Saturation Method has been used by Holmes and Klinger (4) in their "Suggested Methods of Field Procedure for the Design of Cutback Asphaltic-Soil Mixtures" and also by Thurston in his testing of Soil and Asphalt Mixtures. This method consists of placing the specimens in a water absorption box connected to a water reservoir. A vacuum is applied to the box and the system brought to varying absolute pressures and maintained as such for various periods of time. Water is then allowed to enter the chamber without increasing the pressure beyond that due to the vapor tension of the water. When enough water to cover the specimens has been delivered to the box, the clamp admitting the water is closed and the reduced pressure maintained for a specified time after which the box is brought to atmospheric pressure. The specimens are then removed from the box and immediately are totally immersed in water, flat-side down for a period of 24 hours.

There are various other methods of soaking specimens, such as the "Capillary Absorption Test" by McKesson, Hovis and Anderton (5) and a variation of the one-half immersion method by Heriot (3) in which the specimens are immersed to a depth of one-fourth their height.

From the present study, only the three aforementioned methods have been exclusively tested as they are more commonly used and since the latter only appear to be variation of the one-half immersion method.

This paper is an attempt to develop a quick and thorough method of soaking soil-asphalt specimens with a view to find a procedure which is less time consuming and at the same time might perhaps be more efficient than the other methods. A detailed study of the Vacuum Saturation Method of soaking specimens has been made with respect to the following conditions: (1) varying the duration of absolute pressure with time of soaking and amount of vacuum constant, (2) varying the time of soaking with the absolute pressure and time of applied pressure remaining constant, and (3) varying the amount of absolute pressure with the time of soaking and time of applying vacuum constant.

CHAPTER II

MATERIALS AND LABORATORY PROCEDURE MATERIALS

Materials

The materials used in this invesitgation is referred to as a "Soil-Asphalt" mixture and is obtained when an asphaltic material is incorporated in a soil. So, basically, there are two materials, viz: soil and asphalt, which are of concern in this study. The soil has to be in a moist condition to effect uniform mixing and so the presence of water in the mixture has also to be recognized.

Soil

The soil used in this test was an A.A.S.H.O. classification A-6 which was obtained from the roadside bank, 9 miles South and 1 mile East of Stillwater, Oklahoma. It was a combination of two soil horizons and was mixed in the laboratory on 1:3 proportion such that 25% of "A" horizon and 75% of "B" horizon soils were mixed on a dry weight basis. The "A" soil was an ash colored silty clay, while the "B" soil was a sandy, red clay. The resulting mixture was typical of the soil usually stabilized with asphalt in the State of Oklahoma and met the requirements of the Oklahoma State Highway Specification, Section 313 (8) for soil asphalt base.

The wet sieve analysis of this mixture is shown in Table I and the other engineering properties are listed in Table II.

TABLE I

SIEVE ANALYSIS OF SOIL MIXTURE

(25% "A" Horizon -- 75% "B" Horizon)

Sieve Size	#10	#40	#80	#200	Pan
% Passing	100	96.7	64.1	37.3	0

TABLE II

PROPERTIES OF SOIL MIXTURE

(25% "A" Horizon -- 75% "B" Horizon)

Atterberg Limits:	Liquid Limit	21%
	Plastic Limit	16%
	Plasticity Index	5%
Fluff Point Range:	Upper	13.0%
	Lower	5.5%
Max. Density (Standard Proctor)		125.5 lb. per cu. ft.
Optimum Moisture Content		11.0%

Asphalt

The asphalt used in all of these tests was a medium curing cutback meeting the A.S.T.M. Specification MC-3 and was obtained from the Allied Materials Corporation in Stroud, Oklahoma. It contained 14.5% hydrocarbon volatiles by weight. In the preparation of these specimens, a 5.5% (dry weight basis) of the MC-3 asphalt cutback was incorporated in the soil.

Procedure

The moisture content of soil "A" and "B" was independently determined. After this, the soils were mixed together in the 1:3 proportion on dry weight basis. Enough water was added to the mixture to make up 8% of moisture on dry weight basis. It was noticed that at this moisture content, the soil was neither wet nor dry, but produced certain optimum mixing characteristics that was called the "fluffy" condition of the fluff point. The soil was sieved through a No. 10 sieve to break down the balled up pieces and was then sealed in airtight containers. After 24 hours, the moisture was thoroughly dispersed throughout the mass.

Some evaporation from the mixture was inevitable in the mixing, but was not considered as seriously affecting the test, as this loss was fairly constant for all the batches of mix.

After the lapse of 24 hours, the soil was removed from the container and 5-1/2% (dry weight basis) of MC-3 cutback was added. The soil and asphalt cutback were then mixed for a period of two minutes in a Hobart Model C-100 mixer. The mixture was passed through a No. 4 sieve, to break down any large sized particles and then placed in an electric oven at 110 F for various drying periods. Care was taken to see that the mixture was stirred frequently at suitable intervals.

At the end of the drying period, the mixture was removed from the oven and about 400 grams were taken out for molding each specimen. The amount of mixture needed for each specimen varied with the length of the drying period so that a 4-1/2 inch specimen could be formed. Mixtures, which were cured for longer periods of time in the oven, required lesser amounts for molding than those which were cured for shorter periods of time. The size of the specimens throughout was 1.86 inches in diameter and 4.5 inches in height and about 2800 grams of moist soil was required to mold six specimens.

The mold used in preparing the specimens was made of steel and cylindrical in shape with an internal diameter of 1.86 inches. It had detachable ends and a plunger with a brass head which filled smoothly into the mold. Compaction of the mixture was effected in a Universal Hydraulic Testing Machine at a constant pressure of 2032 pounds per square inch for one minute.

After molding, each specimen was numbered, weighed and average height measured and recorded. They were then soaked immediately in the respective manners.

Soaking Methods

As mentioned already, three soaking methods were used in this study, viz., the total immersion, the one-half immersion, and the vacuum saturation method.

Total Immersion Method

For this method, a copper tank measuring 18 inches by 12 inches by 8-1/2 inches was used. It had a thin gray inside, with close-spaced perforations in it, that was mounted about three inches above the bottom of the tank. By this, the bottom of the specimens could be held above the bottom of the tank, thus enabling better access of the water to all sides of the specimens. The pan was levelled with the tray set-up, specimens were placed sufficiently apart and water level maintained at one-half inch above the top of the specimens.

Soaking was allowed at room temperature for two days, four days and seven days for each of two specimens. At the end of the soaking period, the specimens were taken out and surface dried with paper towels. Each of the two specimens was cut in such a way that the outer portion was separated from the inner core in the longitudinal direction. The two portions were each crumbled and 100 grams of each sample was taken for determination of moisture content. The procedure for determining the moisture content is described in Appendix A.

Since the difference in hydrostatic pressure at top and bottom of the specimen was negligible, it was considered that there could not have been a serious difference in the amount of water absorbed at the top and bottom of the specimen.

The One-Half Immersion Method

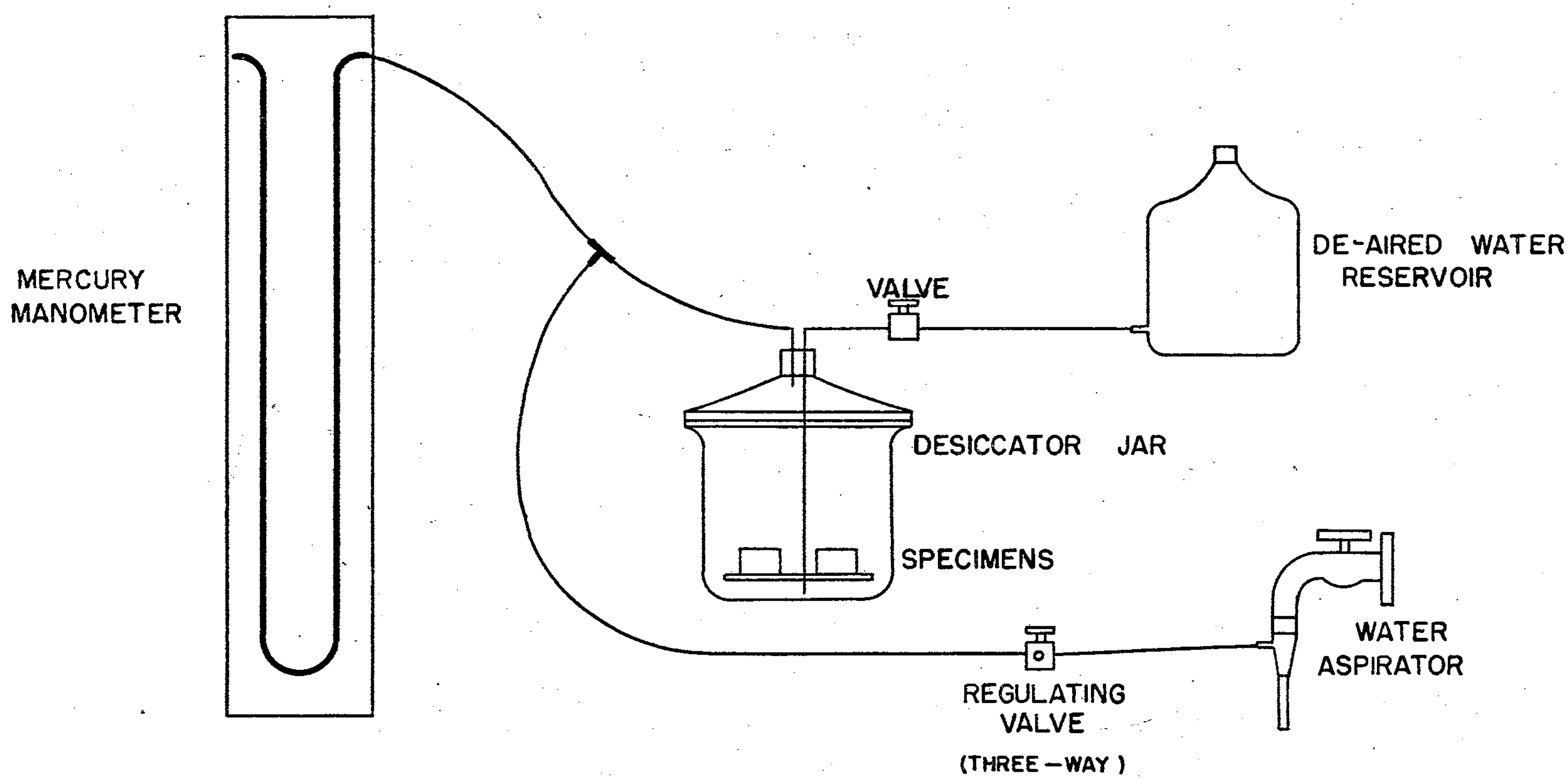
In this method, the specimens were placed in a shallow steel tank with a tray having perforations. The height of water was maintained at half the height of the specimens and the tank was kept in a humid room. As with the total Immersion Specimens, two specimens were allowed to soak for two days, two for four days and two for seven days.

After the respective soaking periods, the samples were taken out and free moisture was removed from the surface by wiping with paper towels. Each was laid flat and cut into three equal lengths. The outer portions of the bottom and top portions were used, while the inner core of the middle section was carefully separated by a knife and used. 100 grams of each of the three samples were crumbled into flasks and the moisture content determined.

Vacuum Saturation Method

The molded specimens were placed in a desiccator jar (Fig. 1), which was connected through a three-way plug one way to an aspirator for producing a vacuum, another to a manometer and the third to a jar containing de-aired water. With the connection to the de-aired water cut off, a vacuum was applied to the desiccator by means of the aspirator. The absolute pressure, as shown by the manometer, was noted. After the desired period of pressure time, the de-aired water was admitted to the jar and allowed to cover the specimens. During this time, the vacuum pressure was kept steady. Immediately after this, the jar was brought to atmospheric pressure and the specimens were allowed to soak for varying periods of time.

Of the three variables, viz., the amount of absolute pressure, the pressure-time, and the duration of soaking period, one item was varied, keeping the other two constant. First, the test was made with various pressure times and con-



SCHEMATIC DIAGRAM OF

APPARATUS FOR VACUUM SATURATION METHOD

Figure 1

stant soaking time and constant amounts of absolute pressure. The second series of test was made for various soaking time with constant pressure time and absolute pressure. The third tests covered varying absolute pressures with constant pressure time and periods of soaking.

Immediately after the soaking was complete, the specimens were taken out, their specimens wiped dry by paper towels and samples for outside and inside moisture contents were removed as in Total Immersion Method. These samples were tested to determine the amount of water absorbed.

CHAPTER III

RESULTS

The moisture content determination was made on 100 grams, 75 grams or 50 grams samples depending upon the amount of water in the sample. For the Total Immersion and Vacuum Saturation Methods, representative samples were taken from the outside and the inside middle third of the soaked specimens. For the case of the One-Half Immersion Method, the outer top one-third, the inner middle one-third and the outer bottom one-third, were used as representative samples. The percent by weight of water content on a dry weight basis was calculated and are shown in Tables 3 to 5.

TABLE 3

Showing the Percent of Moisture Content (Dry Weight Basis) in Specimens Soaked By The Total Immersion Method

Hours of Drying in Oven		0		
Days of Soaking	0	2	4	7
Outside	7.08	8.92	9.96	10.14
Inside	7.08	7.93	8.55	8.48

TABLE 3 (Cont'd)

Hours of Drying in Oven		2-1/2		
Days of Soaking	0	2	4	7
Outside	5.32	13.42	13.03	16.03
Inside	5.32	5.66	8.79	12.90

Hours of Drying in Oven		5		
Days of Soaking	0	2	4	7
Outside	3.42	15.43	16.56	17.68
Inside	3.42	4.38	5.31	10.05

Hours of Drying in Oven		10		
Days of Soaking	0	2	4	7
Outside	1.92	19.65	19.65	19.95
Inside	1.92	2.42	5.34	6.34

TABLE 4

Showing the Percent of Moisture Content (Dry Weight Basis) in Specimens Soaked By The One-Half Immersion Method

Hours of Drying in Oven		0		
Days of Soaking	0	2	4	7
Top	7.08	8.18	8.45	9.43
Middle	7.08	7.96	8.94	9.44
Bottom	7.08	9.18	9.68	9.68

TABLE 4 (Cont'd)

Hours of Drying in Oven		2-1/2		
Days of Soaking	0	2	4	7
Top	5.32	10.40	12.78	13.83
Middle	5.32	9.68	10.65	11.17
Bottom	5.32	16.60	20.03	22.15

Hours of Drying in Oven		5		
Days of Soaking	0	2	4	7
Top	3.48	14.1	17.12	20.30
Middle	3.48	12.45	15.41	19.10
Bottom	3.48	18.25	22.77	23.38

Hours of Drying in Oven		10		
Days of Soaking	0	2	4	7
Top	1.92	11.65	14.30	17.35
Middle	1.92	7.41	9.87	12.69
Bottom	1.92	20.00	23.00	25.85

TABLE 5

Showing the Percent of Moisture Content (Dry Weight Basis) in Specimens Soaked By The Vacuum Saturation Method

Soaking Time 10 Minutes and Absolute Pressure 100 MN.						
Pressure Time in Minutes	0	2	4	8	12	16
Outside	12.35	13.20	15.75	18.57	19.16	19.76
Inside	11.70	12.22	14.10	15.46	16.58	16.28

Pressure Time 12 Minutes and Absolute Pressure 100 MN.						
Soaking Time in Minutes	0	2	4	8	12	16
Outside	15.50	16.30	16.90	17.42	18.30	18.30
Inside	11.80	12.20	13.70	14.38	14.64	14.36

Pressure Time 12 Minutes and Soaking Time 10 Minutes				
Absolute Pressure in Millimeters	100	200	300	400
Outside	17.86	17.70	14.94	10.18
Inside	14.57	9.66	6.64	1.61

CHAPTER IV

DISCUSSION OF RESULTS

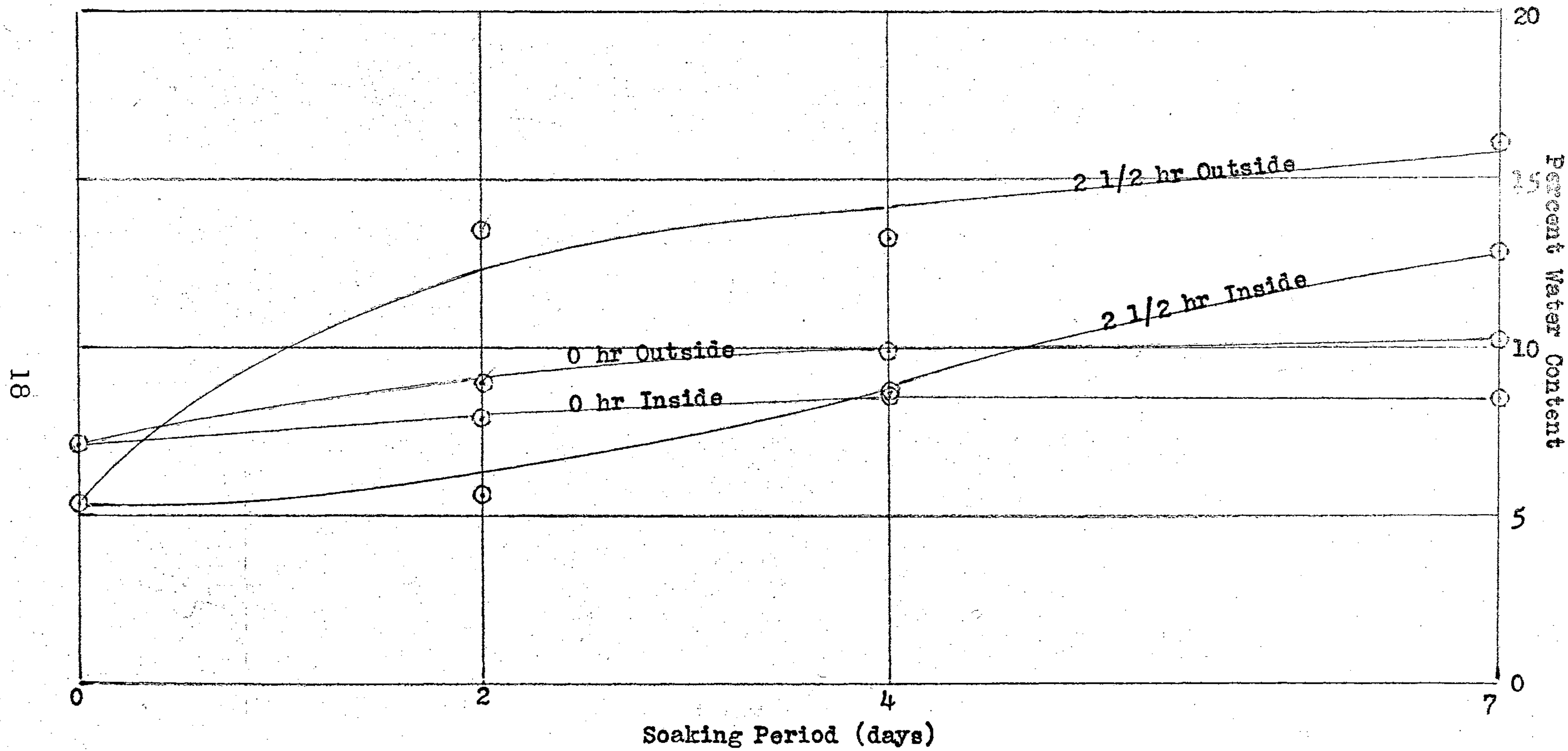
The results of the moisture content determination tests on different samples taken from the specimens, are discussed according to the various methods of soaking.

Total Immersion Method

The results obtained from soaking the specimens in the total immersion method are shown in Figures 2 and 3. There is a tendency for the curves for the outer portion to level off as the time of soaking increases. This suggests the possibility of a saturation point after which any further period of soaking has no effect on increasing the amount of water absorbed.

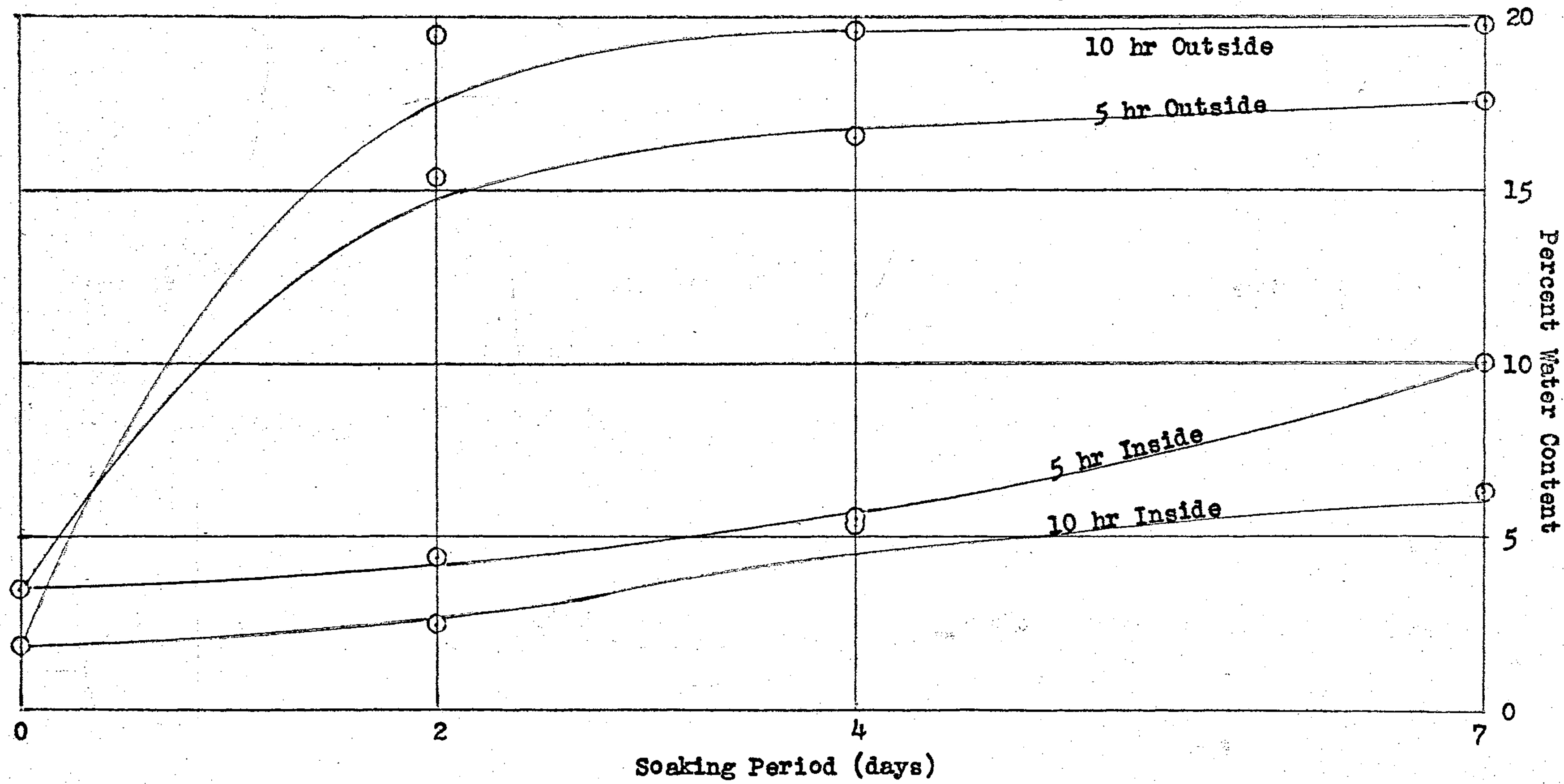
The rate of absorption of water by the inside core with respect to soaking time does not show a marked increase in the first few days as in the case of the outside core. A prolonged period of total immersion soaking seems to be necessary for the inside to absorb water in appreciable quantities, and when this is done, the outside has been well over-soaked. The difference in moisture content in the outside and inside portion of the specimens for 10-hour curing and 7 days soaking is about 13 percent.

In the early stages of their work, Roediger and Klinger



VARIATION IN WATER CONTENT WITH SOAKING PERIOD
IN SPECIMENS CURED FOR 0 HOURS AND 2 1/2 HOURS
BY TOTAL IMMERSION METHOD

Figure 2



VARIATION IN WATER CONTENT WITH SOAKING PERIOD
IN SPECIMENS CURED FOR 5 HOURS AND 10 HOURS
BY TOTAL IMMERSION METHOD

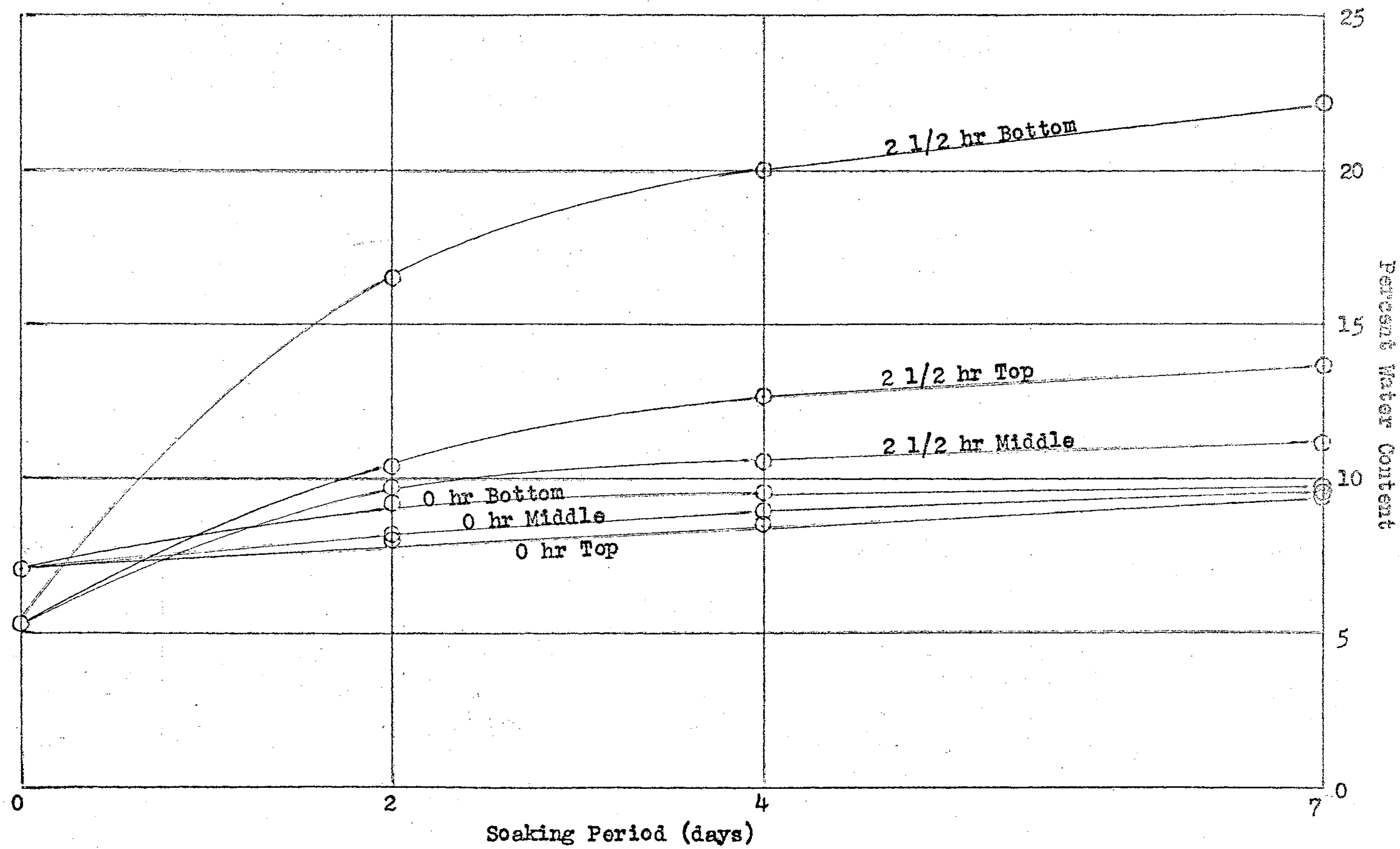
Figure 3

obtained "air-blocking" in samples soaked by total immersion method. Air-blocking occurs where the air is trapped and held in the voids of specimens by water pressure. Since the air cannot escape, the water cannot displace it and the soaking is retarded. The lack of increased amounts of water in the inner portions may be attributed to this effect.

One-Half Immersion Method

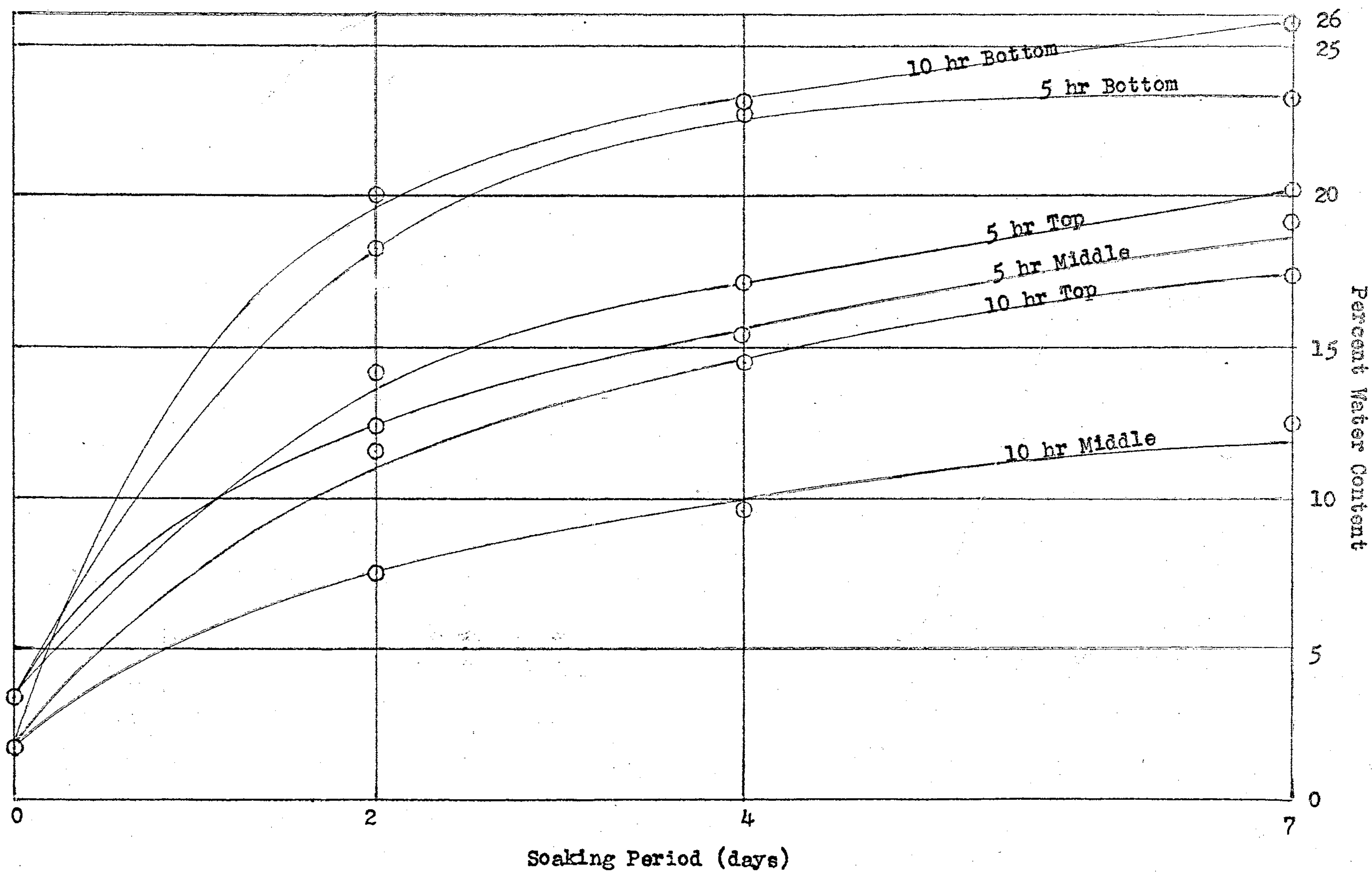
This method of soaking was devised with a view to investigate the possibility of variation in moisture content from top to bottom of the specimen. Hence, the moisture content determinations were made on the top, the outside, the middle inside and the bottom outside portions of the specimens. Results are graphically shown in Figures 4 and 5.

It may be seen from Figure No. 4 that for the 0 hour and 2-1/2 hour drying periods, there was no pronounced increase in absorption over a 7 day soaking time in the upper portion of the specimens. As might be expected, the bottom portions absorbed the greatest amount of water and the inside middle portions, the least. The top portions absorbed more than the inside, but less than the bottom portions. This property was exhibited in more pronounced manner in specimens dried for longer periods in the oven and also for the longer periods of soaking. Observations made at the time of separating the samples from different sections of the specimens showed that the outer portions, into which water could penetrate, had turned darker in color, than the



VARIATION IN WATER CONTENT WITH SOAKING PERIOD
IN SPECIMENS CURED FOR 0 HOURS AND 2 1/2 HOURS
BY ONE-HALF IMMERSION METHOD

Figure 4



VARIATION IN WATER CONTENT WITH SOAKING PERIOD
IN SPECIMENS CURED FOR 5 HOURS AND 10 HOURS
BY ONE-HALF IMMERSION METHOD

Figure 5

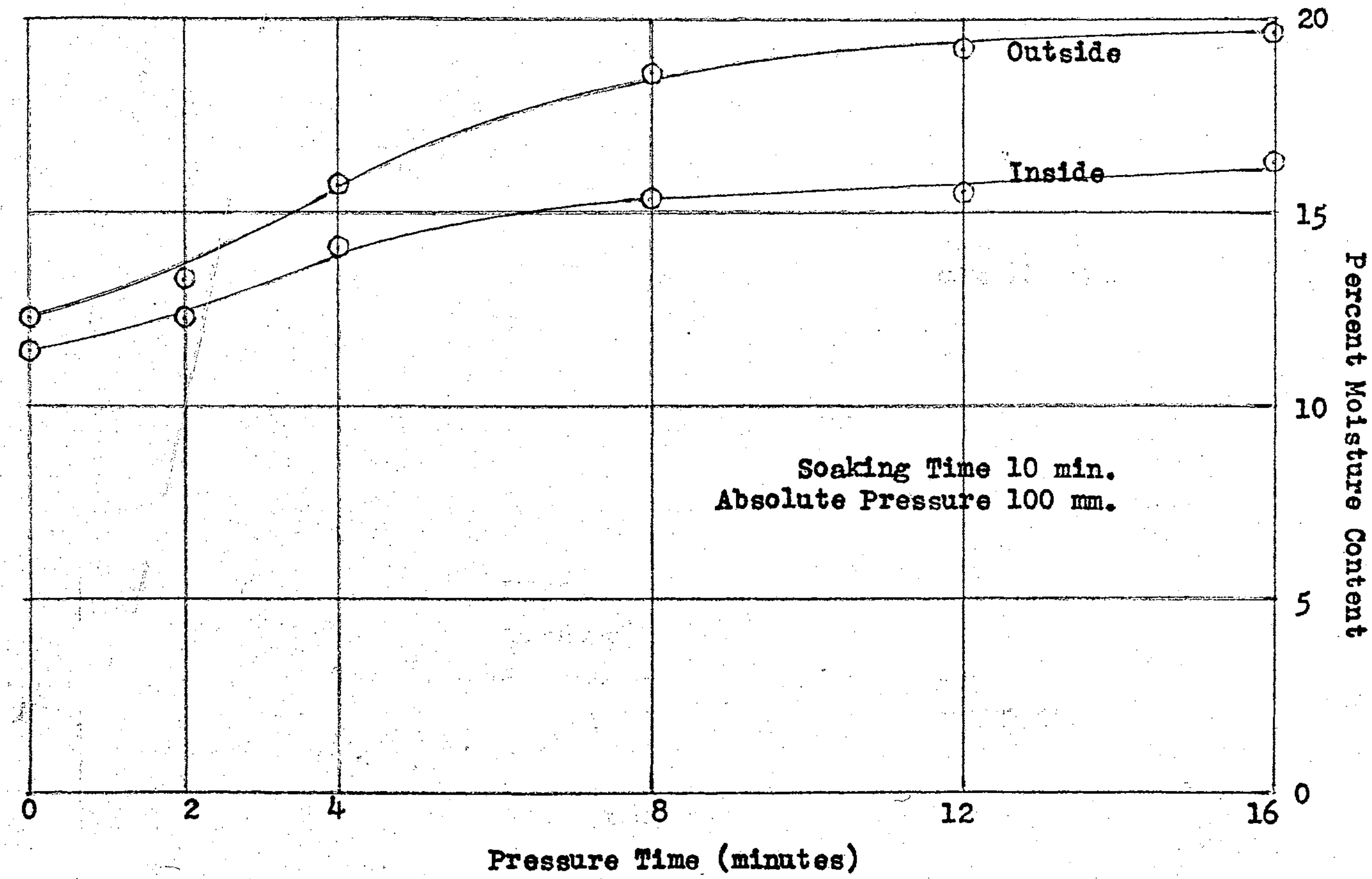
unsoaked interior portions. The extent of the color change gave an indication of the height to which absorption had progressed in the specimens. The change in color was not too much higher than half way up. From these observations, it is believed that a major share of the increased moisture in the top portions of the specimens was obtained from the moist atmosphere of the humid room and only a little from the water that was absorbed from the bottom of the specimens.

The difference in moisture content in the outside and inside portions of the specimens varied considerably with the period of drying the mixture in the oven, and also with the days of soaking. This difference for 10 hour curing and 7 days soaking period is about 13 percent.

Vacuum Saturation Method

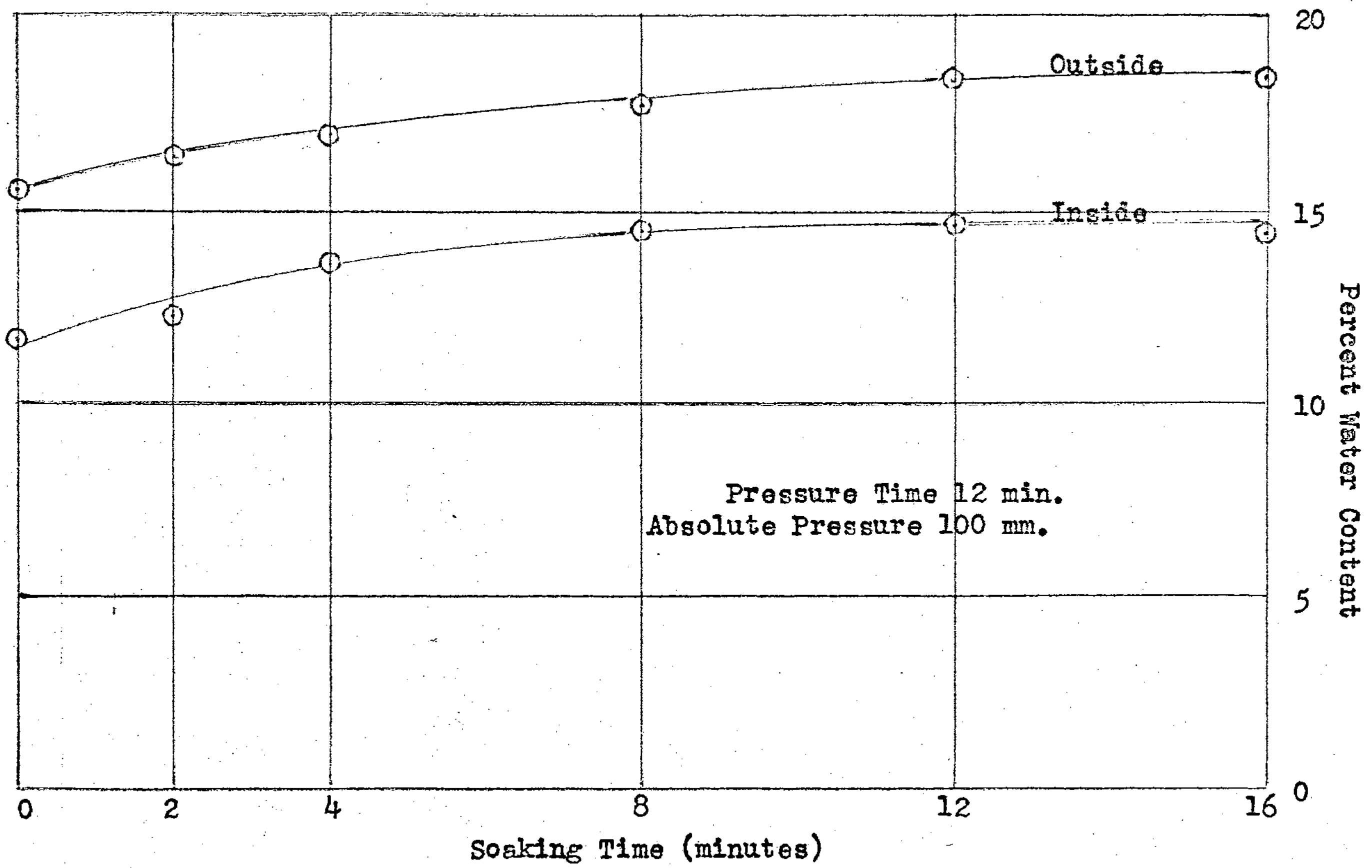
The specimens used in this method were molded only from mixtures dried in the oven for 2-1/2 hours. The results are graphically shown in Figures 6, 7, and 8.

With respect to the tests on varying pressure time and constant soaking period and constant absolute pressure (Figure 6), it was found that both the inside and outside portions of the specimens exhibited no appreciable increase in moisture content beyond a pressure time of twelve minutes. It was also noted that the difference in amount of water absorbed by outside and inside was smaller in the initial periods such as 2 and 4 minutes, but this difference tended to increase with increase in pres-



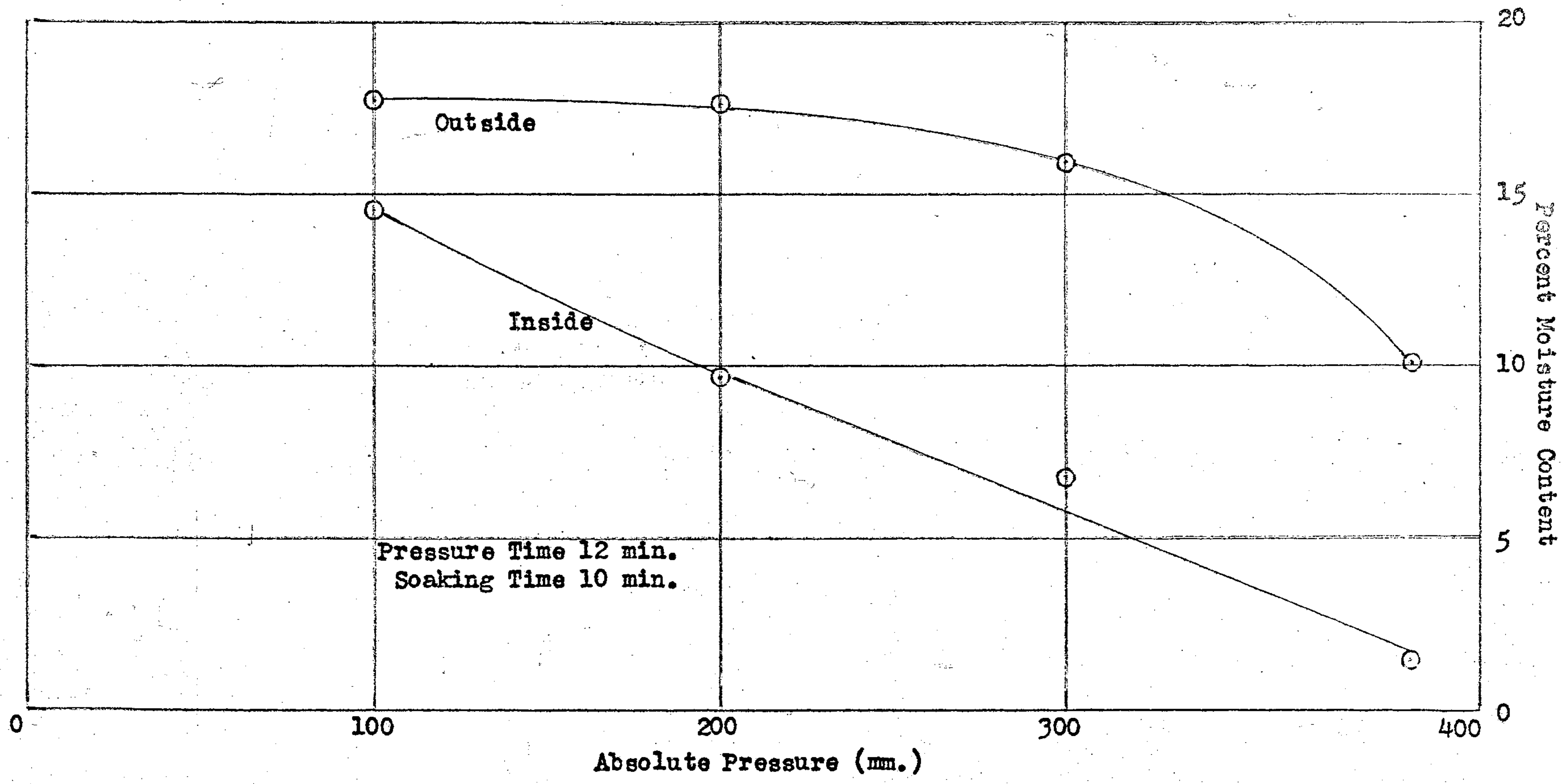
VARIATION IN WATER CONTENT WITH PRESSURE TIME
IN SPECIMENS SOAKED BY THE VACUUM SATURATION METHOD

Figure 6



VARIATION IN WATER CONTENT WITH SOAKING TIME
IN SPECIMENS SOAKED BY THE VACUUM SATURATION METHOD

Figure 7



VARIATION IN WATER CONTENT WITH ABSOLUTE PRESSURE
IN SPECIMENS SOAKED BY THE VACUUM SATURATION METHOD

Figure 8

sure time, though not in any appreciable manners.

The curves for constant pressure time and constant absolute pressure and varying soaking time (Figure 7), also tended to level off after a soaking time of between 8 and 10 minutes, but the difference in water absorbed by outside and inside portions was proportionately more in the shorter soaking periods than in longer periods.

The effect of varying the absolute pressure at constant pressure time with constant soaking time may be seen from the curves in Figure 8. The outside portions tended to absorb water at a decreasing rate with increase in absolute pressure, yet levelled off at or around twenty Cm absolute pressure. The inside portions also exhibited the same kind of behavior, i.e., they absorbed less moisture at increased absolute pressure. However, the rate at which the absorption took place in the inner core showed a more uniform rate with respect to change in absolute pressure. In the outer samples, the rate of absorption was more rapid during the initial stages of the application of vacuum pressure, than during the latter stages. This suggested that below a certain value of absolute pressure, viz., between two hundred and three hundred millimeters of absolute pressure, the rate of absorption of moisture by the outer portions did not cause any appreciable variation, corresponding to the other factors, namely, a specific soaking period of 10 minutes and a fixed pressure time of twelve minutes.

The mechanics of the vacuum saturation method was exhibited through a "blotter effect" by the specimens. When a vacuum was applied to the specimens, a portion of the air occupying the void spaces was drawn out, creating partial vacuums in them. When this vacuum pressure was maintained after the specimens were covered with water, the force pulling the air out of the pores in the specimens, caused a hinderance to the flow of water into the pores produced by capillary action and the small hydrostatic pressure. The amount of soaking was thereby retarded. However, when the specimens were brought back to atmospheric pressure, the water was forced into the voids by suction effect from the partial vacuums and in a few minutes, the specimens were thoroughly saturated. It was also observed that on removal of the specimens from the water after soaking, the surface moisture was very rapidly absorbed by the specimens like a blotter. In addition, the surface exhibited a spongy feeling when pressed with the finger.

From the foregoing, it was evident that both the total and one-half immersion methods of soaking specimens resulted in a large variation in moisture content across the cross-section of the specimens. In the vacuum saturation method, however, this variation was the least and consequently is better for adaption as a list procedure for soaking soil-asphalt specimens in the laboratory.

CHAPTER V

CONCLUSIONS

Total Immersion Method

1. In the outer portions of the specimens, the amount of water absorbed increased with an increase in drying time of the original mixture.

2. The inner portions of the specimens absorbed much lesser quantity of water than the outer portions.

3. The difference in amount of water absorbed by different portions of the specimens indicated that "air blocking" occurred in specimens that were totally immersed.

One-Half Immersion Method

1. There was a wide variation in the water absorbed by portions of specimens at different levels, such as the top, the middle and the bottom.

2. The bottom portions of the specimens absorbed the greatest amount of water and the inside portion the least amount.

Vacuum Saturation Method

1. This method required only a very short period of soaking, compared to the other two methods, to attain saturation.

2. Variation in water content throughout the mass of the specimen was less marked in this method than in the other two methods.

3. The amount of water absorbed with varying absolute pressures showed a levelling off between one hundred and two hundred millimeters absolute pressure.

4. The amount of water absorbed at constant absolute pressure and constant soaking time showed a levelling off at a pressure time between eight and twelve minutes.

5. The amount of water absorbed at constant absolute pressure and constant pressure time showed a levelling off at a soaking period of between eight and ten minutes.

Of the three different methods of soaking soil-asphalt specimens, it was found that the Vacuum Saturation Method was the quickest and most efficient method, as it was less time consuming and at the same time a more thorough method.

CHAPTER VI

A SUGGESTED METHOD OF SOAKING SOIL-ASPHALT SPECIMENS BY THE VACUUM SATURATION METHOD

The Vacuum Saturation Method, by virtue of being a quick and thorough method of soaking soil-asphalt specimens, affords a suitable method of laboratory test procedure. From the data available from the foregoing tests, the following procedure is tentatively suggested.

Procedure

1. The apparatus as shown in Figure 1 is set up with two test specimens placed flat on the tray of the desiccator.

2. A vacuum is applied to the desiccator by means of the aspirator so that the manometer registers an absolute pressure of one hundred millimeters. This absolute pressure is maintained for a period of twelve minutes.

3. Immediately after this, de-aired water is admitted into the desiccator and allowed to cover the specimen for at least one-half inch above their top surfaces. During this time, the vacuum pressure is kept steady throughout.

4. A stop watch is started immediately and air is let into the desiccator simultaneously. Soaking is allowed to continue 10 minutes.

5. After soaking, the specimens are taken out and the

surface moisture wiped off with a paper towel. Strength tests should be run immediately.

BIBLIOGRAPHY

1. Anderton, B.A., "Suggested Methods of Test for Water Absorption, Volume Change, and Stability of Mixtures of Tar and Soil", Procedures for Testing Soils, American Society for Testing Materials, (July 1950), p. 372.

2. Benson, J.R. and Becker, D.J., "Exploratory Research in Bituminous Soil Stabilization", Proceedings Association of Asphalt Paving Technologists, (Jan. 1942), Vol. 13, p. 120.

3. Heriot, L.W., "Suggested Method of Test for Quantity of Cut-Back Asphalt for Stabilising Sand Soils", Procedures for Testing Soils, American Society for Testing Materials, (July 1950), p. 367.

4. Holmes, A. and Klinger, E.W., "Suggested Methods of Field Procedure for the Design of Cut-Back Asphalt-Soil Mixtures", Procedures for Testing Soils, American Society for Testing Materials, (July 1950), p. 346.

5. McKesson, C.L., "Soil Stabilization With Emulsified Asphalt", Proceedings Highway Research Board, (Dec. 1935), p. 357.

6. Rhodes, E.O., "Suggested Method of Test for Evaluating Tar-Soil Mixtures", Procedures for Testing Soils, American Society for Testing Materials, (July 1950), p. 360.

7. Roediger, J.C. and Klinger, E.W., "Soil Stabilization Using Asphalt Cut-Backs as Biners", Proceedings Highway Research Board, (Dec. 1938), p. 299.

8. Standard Specifications for Highway Construction, Oklahoma State Highway Commission, (1954), p. 313.02.

APPENDIX A

MOISTURE DETERMINATION TEST

1. A 100 gram or 50 gram sample of the soaked soil-asphalt specimen, according to convenience, was placed in a five hundred millilliter round bottom flask.

2. Approximately two hundred milliliters of purified xylene was added to the sample in the flask and the mixture agitated.

3. The flask and its contents were then clamped to a ring-stand with a water trap and an Allihn condenser. A source of water supply was connected to the bottom of the condenser and an overflow tube attached at the top.

4. A gas burner was placed beneath the flask and the condenser allowed to boil at a moderate rate for a period of about 5 hours. The condensed liquid collected in the water trap with the water at the bottom and xylene at the top.

5. The bottom portion of the water trap was graduated in milliliters and at the end of the boing period, the amount of water present in the original sample was read directly from the trap.

APPENDIX B

CALCULATIONS OF WATER CONTENT ON DRY WEIGHT BASIS

The amount of water in grams per 100 grams of soil-asphalt sample was converted to percent water content on a dry weight basis by the following formula:

$$w = \frac{W_w \left(100 + b + v \right)}{100 - W_w}$$

in which w = % water (dry soil weight basis)

b = % bitumens (dry soil weight basis)

v = % hydrocarbon volatiles (dry soil weight basis)

W_w = % water (total weight basis = $\frac{\text{wt. of water} \times 100}{\text{total wt. of sample}}$

The percent of bitumens (b) was determined from a distillation test of the MC-3 asphalt cutback and amounted to 4.7% when using 5-1/2% cutback (dry weight basis) in soil asphalt mixture. The hydrocarbon volatiles (v) present in the soil-asphalt mixture after the various drying periods were 0.8% for 0 hour drying, 0.57% for 2-1/2 hours, 0.41% for 5 hours, and 0.26% for 10 hours. These values were obtained from distillation lists by Dr. Moreland Herrin.

VITA

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