

Drying Phase of Soil-Asphalt Construction

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A laboratory study was made of the rate of drying of water and hydrocarbon volatiles from a soil-asphalt mixture and the effect on the stability and other basic properties of the compacted mixture.

The soil was a sandy loam with a liquid limit of 21, a PI of 5, and a fluff point range from 6 to 12 percent. The asphalt used as the stabilizing agent was MC-3 cutback.

The results of this study indicate that soils stabilized with cutbacks need to be dried out before compaction to provide high initial strength. After compaction, additional curing results in even more strength. The indications are that soil stabilized with cutback cannot be compacted to a density requirement.

● **AMONG** the highway fields in which important advancements have been made recently is the field of stabilization of soils with asphalt. Most of the achievements in this field have been primarily in the development of chemical additives for certain unsuitable soils so that they can be stabilized with asphalt. Although this type of development is important, there is always a continuing need for adding to the basic knowledge of all highway materials, as well as the stabilization of soils with asphalt. Much is still to be learned about the basic actions of soil-asphalt mixtures. Until these basic actions are understood, especially that action concerned with the drying phase, adequate construction controls of this material cannot be developed.

In the Southwest, many miles of roads have been successfully constructed of soils stabilized with asphalt. This has been done primarily by using a medium curing cutback and limiting the soil type to sandy loams with liquid limits less than 30 and plastic indices less than 10. After the roadbed has been prepared, the construction of the soil-asphalt road progresses as follows:

The specified type of soil to be stabilized is obtained on the roadbed. Existing soils may be used if suitable, or other soils may be added and blended if need be. This material is controlled by the sieve analysis and the Atterberg limits tests.

Proper mixing of the cutback with the soil can be accomplished only if the soil is moist. Accordingly, the water content of the soil is adjusted to bring it to the amount desirable for mixing. Although the fluff point test indicates a range of moisture suitable for mixing (1), it is not normally used in actual construction but primarily as a research tool. Usually, the exact amount of water needed is left to the discretion of the engineer (2,6). Some specifications indicate only that the amount of water shall be "what is needed for a uniform workable mixture."

When the proper amount of water is present, the correct amount of asphaltic cutback is added and mixing takes place. Accurate control of this phase is obtained through laboratory design, asphalt metering devices and extraction tests.

Before compaction, this mixture of soil, water and cutback must be manipulated to reduce the amount of water and hydrocarbon volatiles present. Specifications are vague about control of this phase and often read "the mixture must be dried to the moisture and volatile content needed for proper compaction." The control of this phase then is also at the discretion of the engineer, usually through a "trial and error" method. One engineer does say that the liquid content of the mixture should be adjusted to be slightly less than the optimum liquid content as determined by the proper compaction tests (2).

When the mixture is dry enough, it is spread over the entire roadway in lifts and compacted. No controls are usually specified for this important phase either, except that "the mixture be rolled until the material is firmly compacted."

The last phase is the final grading of the soil-asphalt road surface and the placing of some type of abrasive-resistance wearing surface, if needed.

Even though all of these phases are necessary for soil-asphalt construction, drying of the mixture before compaction is perhaps one of the most important phases. The proper amount of drying is difficult to control and is hard to determine. If drying is improper, not only considerable time and effort must be spent to correct the defect, but detrimental effects on the desirable physical properties of the mixture will also exist. The significance of this phase is well recognized among certain engineers. Some authorities in this field even believe that curing of the mixture before compaction is the most important phase in soil-asphalt stabilization.

No criteria nor tests have been established for the control of such an important construction phase as the drying of the mixture before compaction. As previously noted, specifications are vague about any control of this phase. Many engineers have found the best method for determining the amount of drying was a "trial and error" method. In this case, the dried soil-asphalt mixture is compacted and is checked to find out whether any soft or failed areas developed during or after compaction. If there are no indications of surface failures, then it is assumed that the mixture was adequately dried before actual compaction was done. If, however, soft or failed areas do develop during or after compaction, the mixture was not dried enough and must be dug up, dried out more and recompactd into a strong, stable road.

A scientifically controlled method is definitely needed for such an important phase as this. Naturally, no tests nor criteria can be established until a basic knowledge of the action of this material is known. It was the purpose of this investigation, then, to determine the rate of evaporation of the water and hydrocarbon volatiles from a soil-asphalt mixture and the resulting effects on the stability and other basic properties of the mixture. Four important variables were considered: (1) the amount of initial mixing water, (2) the amount of initial cutback, (3) the amount of drying time in the loose state before compaction, and (4) the time of curing after compaction. The amount of initial mixing water and the amount of initial cutback were each varied from dry to wet mixtures. Both the drying time in the oven before compaction and the time of curing after compaction were continued until the rate of evaporation of the water and hydrocarbon volatiles became practically zero. In this study, the influence of various types of soils and of different types of cutbacks, other than MC-3 was not investigated.

MATERIALS AND TESTING PROCEDURES

Materials

The basic materials used in this soil-asphalt research were a silty sand and an asphaltic cutback. The soil was classified pedologically as a Dougherty, with sieve analysis as shown in Table 1. It had a liquid limit of 21, a plastic index of 5, and a fluff point range from 6 to 12 percent. The standard proctor dry unit weight of this soil was 126.0 pcf and the optimum moisture content was 12.7 percent. It met the requirements specified by the Oklahoma State Highway Department for soils to be used for soil-asphalt bases (6).

The asphalt used in this investigation was a medium curing cutback, grade MC-3, that met ASTM specifications. It was obtained from Allied Materials Corporation's refinery at Stroud, Oklahoma, and contained 14.5 percent volatiles by total weight. These volatiles had a specific gravity of 0.78.

The water used in moistening the soil to the fluff point was tap water, free of excessive amounts of alkali or acid.

Testing Procedures

There were three basic testing procedures generally followed in this investigation.

TABLE 1
GRADATION OF SOIL

Sieve Size No.	10	40	80	200
Percent Passing	100	96	64	37

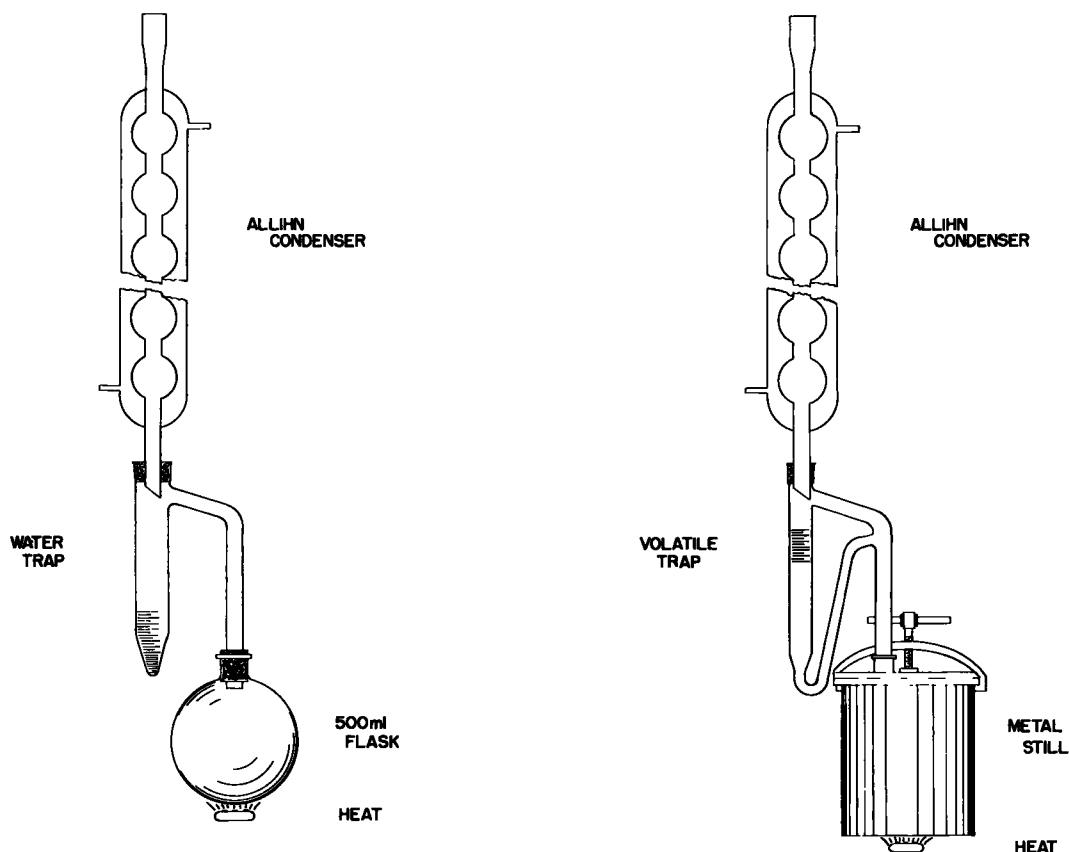


Figure 1. Apparatus for determining percent of water and volatiles.

Preparation and Drying of Soil-Asphalt Mixtures. After the soil was brought to the laboratory, it was allowed to dry out at room temperature. It was then passed through a No. 10 sieve with clods being broken up when necessary. Shortly before needed, the soil was placed in sealed cans and the moisture content determined. When the amount of moisture existing in the soil was known, the desired amount of water to be added was quickly calculated. This water was mixed thoroughly with the soil. The moist soil was then passed through a No. 8 sieve and placed at once in a sealed container. In order to allow the water to disperse uniformly throughout the soil, the mixture was allowed to stand at least 15 hours before being used.

Approximately 3,000 grams of the moist soil were weighed into the mixing container and the desired amount of cutback added. These ingredients were thoroughly mixed for two minutes by a mechanical mixer. Since some balling of the mixture occurred, the soil was passed through a No. 6 sieve. Immediately this mixture was spread in shallow pans in approximately $\frac{3}{4}$ - in. layers and was placed in a constant temperature oven of 110 F for the desired drying. At frequent intervals, the mixture was stirred.

Strength Test. When drying was completed, the soil-asphalt mixture was removed from the oven and three specimens molded at once, using the Hveem-Gyratory method (7). These specimens were weighed for determination of their unit weight and air voids content. Also, representative samples of the mixture were obtained for determination of water and hydrocarbon volatile contents of the mixture. In one phase of the study, the specimens were tested immediately in the Hveem Stabilometer (7).

In another phase, the compacted specimens were allowed to cure at room temperature for various numbers of days before being tested and their water and hydrocarbon volatile content determined.

Determination of Water and Hydrocarbon Volatiles Content. The procedures for determining the amount of water and hydrocarbon volatiles in the soil-asphalt mixture were similar and, in fact, required similar equipment. Primarily, a liquid was added to bring the asphalt mixture to a "liquid state". The liquid used had a specific gravity different from that of the material for which the test was being conducted. After distillation, the two liquids were separated (since they were of different specific gravities) and measurement on a volume basis was made.

Essentially, the procedure for determining the percent of water was to add zylene to the soil-asphalt mixture to bring it to a "liquid state". (About 200 ml were used with a 100 gm sample of soil-asphalt.) The mixture was distilled in an apparatus as shown in Figure 1. Water was collected in the bottom of a calibrated trap while the lighter zylene and hydrocarbon volatiles remained on top of the water. The volume of water in the trap was measured at the completion of the test.

When the amount of hydrocarbon volatiles present was determined, a 50-50 solution of glycerine and water was added to the soil-asphalt mixture to bring it to the "liquid state". During distillation, the volatile trap, as shown in Figure 1, allowed the heavier condensed solution of glycerine and water to return to the still. The small amount of hydrocarbon volatiles that collected on top of the heavier solution in the calibrated trap was measured at the end of the test.

RESULTS

In the construction of soil-asphalt roads, the evaporation of water and hydrocarbon volatiles takes place not only from the mixture when it is in the loose state before compaction, but also from the mixture after it is rolled into a dense, solid mass. For this study, evaporation data were obtained on two separate phases: soil-asphalt mixtures that were dried before compaction and mixtures that were cured after molding into specimens.¹

Variability was provided in the mixtures that were dried before molding by using various amounts of mixing water and various asphalt cutback content. Initial water contents of 6, 8, and 10 percent and 4, 5-1/2, and 7 percent asphalt cutback were used. These amounts covered the range normally used in soil-asphalt construction for this type of soil. The time of curing in the oven varied from approximately 2-1/2 hours to more than 18 hours when the mixtures were dried to approximately constant weight. The data from these series of tests are given in Tables 2 and 3.

For those mixtures that were allowed to cure after being molded into specimens, variability was induced through different times of drying in the oven before compaction: 0, 2-1/2, and 5 hours were used. The time of curing of the compacted specimens varied from 0 to 28 days. All mixtures used in this series of tests contained 8 percent initial moisture and 5-1/2 percent initial cutback. Results obtained are shown in Table 4.

Compacted specimens were formed from the same mixtures used in obtaining the evaporation data. After the unit weights of these specimens were determined, they were tested in an unsoaked condition. Their average unit weight and stability are also given in Tables 2, 3, and 4.

Rate of Evaporation

The amounts of water and hydrocarbon volatiles remaining in the loose mixture after various drying times in the oven are presented in Figures 2 and 3. These figures indicate that the same general trend exists in the rate of evaporation regardless of the initial amount of cutback (Fig. 2) or the initial amount of mixing water (Fig. 3). The

¹In this paper, the term drying is used to mean the evaporation that takes place from the loose mixture before compaction; curing refers to the evaporation that progresses from the compacted specimens.

results discussed in relation to drying before compaction are applicable regardless of the amount of mixing water or initial cutback.

The rates of evaporation of water and of hydrocarbon volatiles from the mixture are shown in the upper and lower parts, respectively, of these figures. In the beginning, the water tended to dry out of the mixture quite rapidly and then leveled off after a period of drying time until the rate of evaporation was practically zero. The rate of evaporation of the hydrocarbon volatiles was similar to that of the water. Initially, the volatiles evaporated rapidly and then slacked off until little change in the amount of volatiles in the mixture was obtained by longer periods of drying.

The water dried out of the mixture at a faster rate than did the hydrocarbon volatiles. The initial slopes of the water content curves are greater than those of the hydrocarbon volatile curves. Also the difference in these rates is more pronounced than it first appears, for the ordinate scale of the water content is ten times that of the volatiles scale. The rate of evaporation of water was more than ten times that of the hydrocarbon volatiles.

A small amount of both the hydrocarbon volatiles and water remained in the mixture even after it dried so that the rate of evaporation was practically zero. Drying at the test temperature did not remove all of the water and volatiles from the mixture during the drying time studied.

The data presented in Figure 4 show the rate of evaporation of water and hydrocarbon volatiles from mixtures that were compacted and allowed to cure for various periods of time. Initially, all mixtures contained 8 percent water and 5½ percent cutback.

TABLE 2
EVAPORATION BEFORE COMPACTION
CONSTANT WATER CONTENT, 8 PERCENT

Initial Cutback Content, percent	Drying Time, hr	Water Content, percent	Volatile Content, percent	Unit Weight, pcf	Hveem Stability, percent
4	0	7.08	0.58	137.2	24.1
	2	4.38	0.45	130.0	42.0
	5	2.39	0.38	121.5	46.5
	10	1.19	0.28	116.9	50.1
	22½	0.73	0.25	112.9	51.7
	26½	0.63	0.21	112.5	52.2
5½	0	7.08	0.80	135.5	18.5
	2½	4.59	0.54	131.1	43.0
	4½	2.64	0.42	127.2	49.5
	10½	1.09	0.22	119.2	49.0
	18	1.06	0.19	117.2	48.5
	28½	0.85	0.21	116.4	-
7	0	7.08	1.02	136.2	11.1
	2½	4.74	0.70	132.6	28.3
	5	2.42	0.53	129.1	41.8
	10½	1.24	0.30	123.7	51.2
	19½	0.80	0.26	117.7	49.1
	28½	0.67	0.25	117.4	49.1

TABLE 3
EVAPORATION BEFORE COMPACTION
CONSTANT CUTBACK CONTENT, 5½ PERCENT

Initial Water Content, percent	Drying Time, hr	Water Content, percent	Volatile Content, percent	Unit Weight, pcf	Hveem Stability, percent
6	0	5.19	0.80	134.2	30.4
	2½	1.76	0.63	123.3	39.4
	5	0.96	0.49	119.1	41.4
	10½	0.67	0.35	117.2	45.5
	16	0.48	0.31	114.7	43.7
	26	0.41	0.30	115.1	44.2
8	0	7.08	0.80	135.5	18.5
	2½	4.59	0.54	131.1	43.0
	4½	2.64	0.42	127.2	49.6
	10½	1.09	0.22	119.2	49.0
	18	1.06	0.19	117.2	48.5
	28½	0.85	0.21	116.4	-
10	0	8.94	0.80	134.4	5.0
	2	5.67	0.56	131.3	25.6
	4½	3.28	0.54	123.9	41.1
	10½	0.74	0.37	117.0	49.6
	19½	0.38	0.32	113.0	48.7
	26	0.53	0.33	113.4	50.7

TABLE 4
EVAPORATION AFTER MOLDING INTO SPECIMENS

Drying Time, hr	Curing Time, days	Water Content, percent	Volatile Content, percent	Unit Weight, pcf	Hveem Stability, percent
0	0	7.08	0.80	135.5	18.5
	3	3.48	0.66	132.5	36.3
	7	1.50	0.60	130.4	54.9
	14	1.17	0.54	129.4	62.3
	28	0.55	0.53	128.6	64.8
2½	0	4.59	0.54	131.1	43.0
	3	1.79	0.52	127.1	52.7
	7	0.85	0.49	125.8	59.2
	14	0.96	0.41	124.2	60.5
	28	0.51	0.40	123.8	62.4
5	0	2.64	0.42	127.2	49.5
	3	0.96	0.43	122.4	49.6
	7	0.79	0.40	121.0	50.5
	14	0.97	0.40	118.5	52.1
	28	0.65	0.39	119.3	55.9

The shapes of the curves in Figure 4 are similar to the curves of the two previous figures. Water tended to dry out more rapidly right after molding and then tapered off until practically no additional water evaporated from the specimens. Even so, not all of the water was removed from the specimens. The final amount of water remaining in the compaction mixtures—approximately 1 percent—was about the same as the minimum amount of water remaining in the mixtures after they were

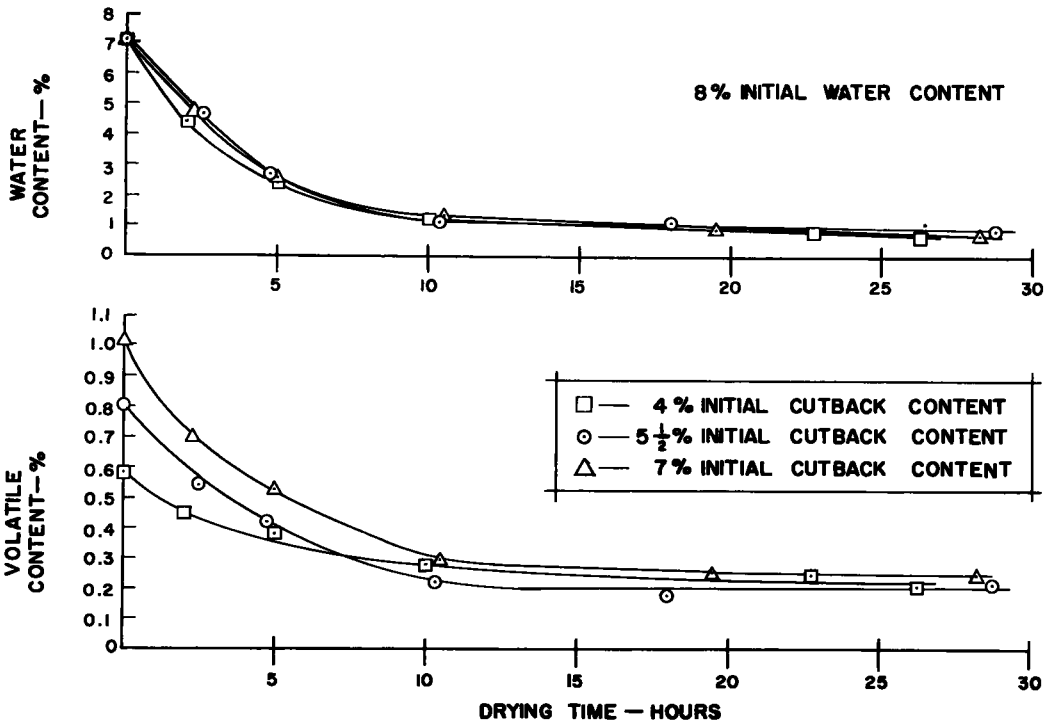


Figure 2. Variation in water and volatile content with drying time (variable-initial cutback content).

dried in the oven, as shown in Figures 2 and 3. Although a longer period of evaporation time was needed, approximately the same amount of water dried out of the compacted soil-asphalt mixture as evaporated out of mixtures that were dried in the loose state.

These same relationships did not exist for the hydrocarbon volatile, as shown in the lower portion of Figure 4. With it, the rate of evaporation quickly became zero and little change in the volatile content took place as the specimens were allowed to cure for longer periods of time. The amount of the volatiles remaining in the compacted specimen at the end of the desired curing time was about one-half of one percent (0.5 percent). This was greater than the amount of volatiles remaining in the mixture after prolonged drying in the oven. Apparently longer periods of time are needed for the evaporation of hydrocarbon volatiles from compacted mixtures than from mixtures dried in the loose condition.

From this data, it appears that regardless of the amount of initial water used for mixing or the amount of cutback used, water evaporated out at a much faster rate than did the hydrocarbon volatiles. This relationship existed after the mixture was compacted into specimens as well as when it was in the loose state. The rate of evaporation of both water and hydrocarbon volatiles was slower from compacted specimens than from the mixture in the loose state.

INFLUENCE OF EVAPORATION ON STABILITY

In Figures 5 and 6 is shown the Hveem stability of specimens containing 5½ percent initial cutback and 8 percent initial water content, respectively. The general trend is similar in both figures. As the mixtures were dried before compaction, the stability increased fairly rapidly but soon leveled off at a maximum so that little change occurred with additional drying. The mixtures with the least amount of water and cutback

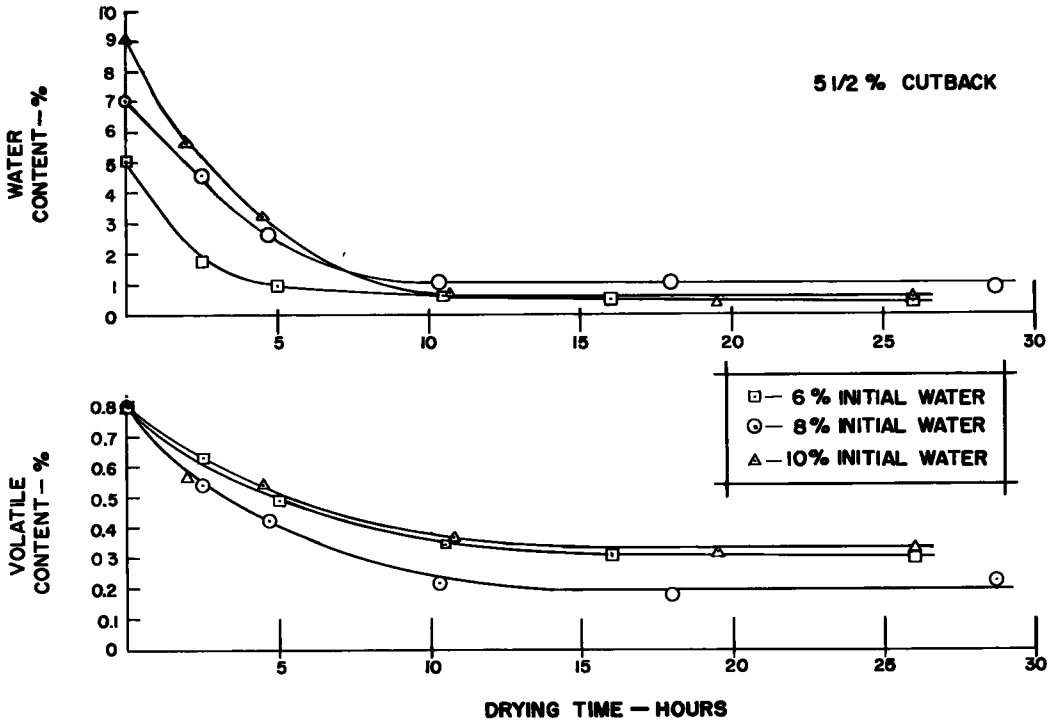


Figure 3. Variation in water and volatile content with drying time (variable-initial water content).

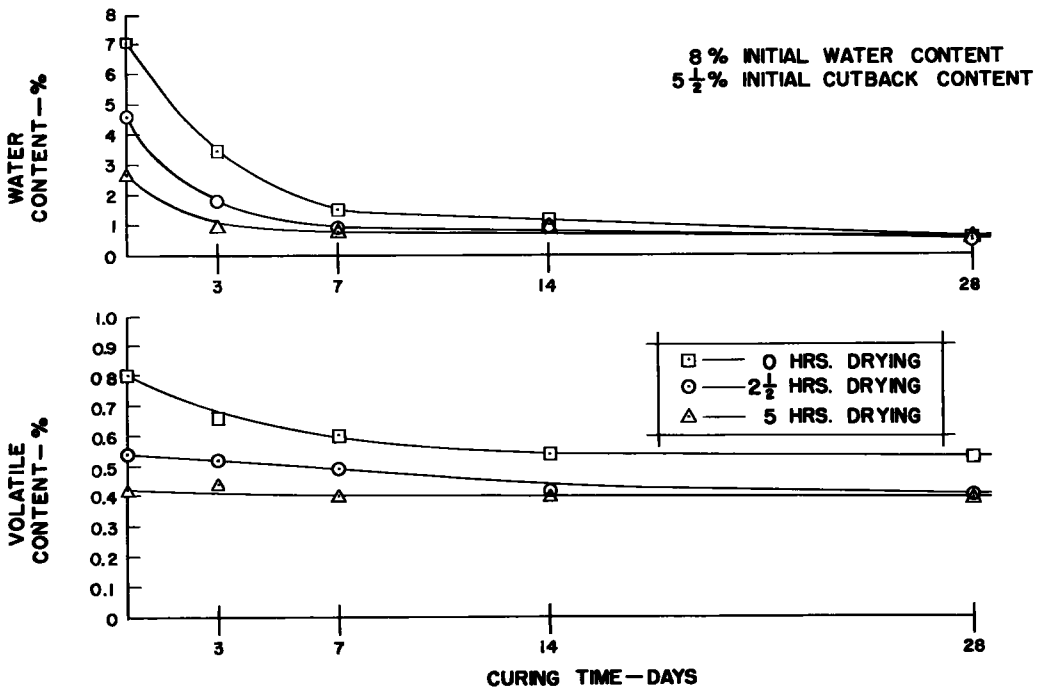


Figure 4. Variation in water and volatile content with time of curing after molding specimen (variable-time of drying before molding specimen).

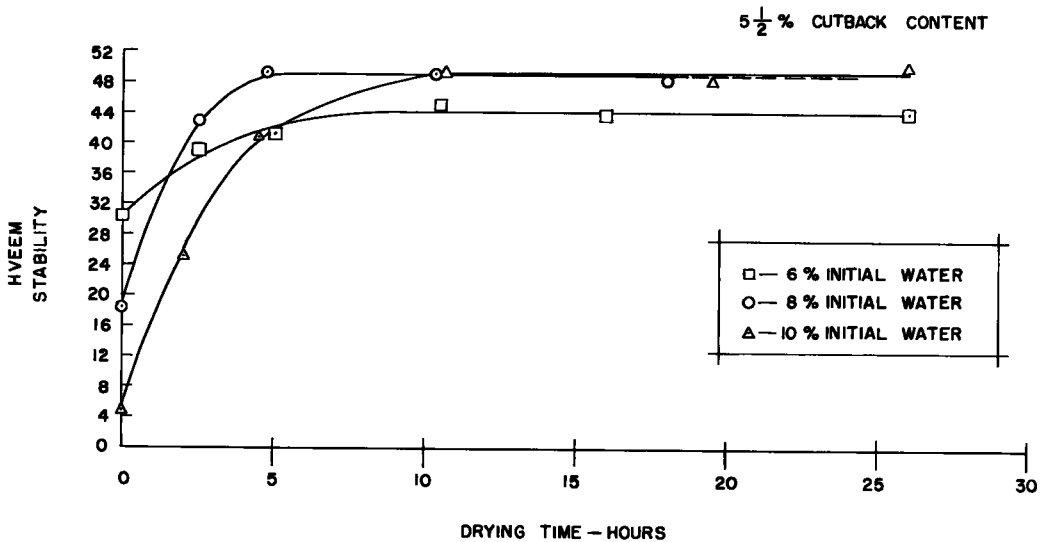


Figure 5. Variation in stability with drying time (variable-initial water content).

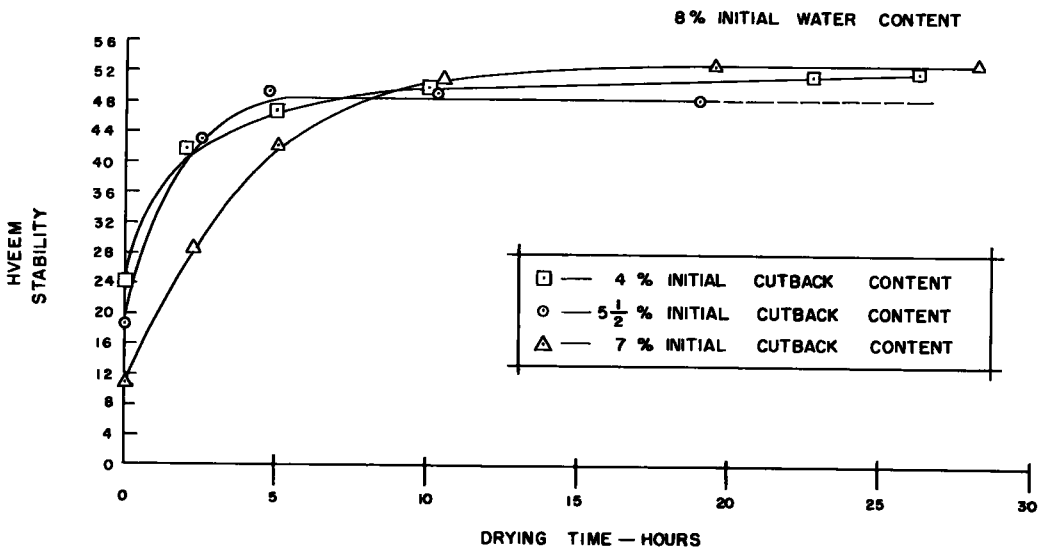


Figure 6. Variation in stability with drying time (variable-initial cutback content). increased materially in stability when dried out for even a short period of time before compaction.

When these two figures are compared with Figures 2 and 3, the relationship between the stability and the evaporation of the water and hydrocarbon volatiles is obtained. In general, the stability of these mixtures was increased as the amount of water and hydrocarbon volatiles decreased. Maximum stability was reached at approximately the same amount of elapsed drying time as was needed for the rate of evaporation to become practically zero. Additional drying of the mixtures in the oven did not increase the stability of the mixture nor did it dry out any more appreciable amounts of water and hydrocarbon volatiles.

The stability of the mixture after various periods of curing of the compacted specimens is shown in Figure 7. In general, the compacted specimens gained stability initially as they were allowed to dry out. The rate of gain, however, soon

decreased to practically zero and little increase in stability was obtained with additional curing. This trend is related to the evaporation of water and hydrocarbon volatiles from the mixture (Fig. 4). As long as there was a decrease in the amount of hydrocarbon volatiles and water an increase in the stability of the specimens occurred. Even the mixture that was fairly dry at the time of compaction gained some strength as it was cured. When the rate of evaporation was reduced to practically zero, however, the stability of the mixtures was increased almost none at all.

Stability of this soil-asphalt mixture, then, was related to the amount of water and hydrocarbon volatiles present in the mixture. As the water and volatiles evaporated, the stability of the compacted specimens increased until the rate of evaporation decreased to almost zero. After this, little change in stability was obtained by additional drying. This increase in stability occurred as additional amounts of water and hydrocarbon volatiles evaporated, both before and after compaction into specimens.

INFLUENCE OF EVAPORATION ON THE UNIT WEIGHT OF COMPACTION SPECIMENS

The variation in the unit weight of compacted specimens, as the loose mixtures were dried before molding, is shown in Figure 8. This figure shows only the data obtained from specimens with $5\frac{1}{2}$ percent initial cutback but with variable amounts of mixing water. Data obtained from specimens with other amounts of cutback were similar to the data in this figure and are not repeated here.

As the mixture dried out, the unit weight of the specimens tended to decrease fairly rapidly and then reached minimum values, after which little change occurred with additional drying. This trend is similar to the rate of evaporation of water and hydrocarbon volatiles (Fig. 3). All tended to decrease and then level off until little change occurred as the drying time became greater.

Drying of these mixtures did not adjust the "liquid content" (asphalt, water and hydrocarbon volatiles) to an optimum for compaction. The greatest unit weight of these specimens occurred when they were compacted immediately after mixing. Since they had not been dried out, they contained the maximum amount of water and hydrocarbon volatiles. Any reduction in the amount of water and hydrocarbon volatiles through drying brought about a decrease, not an increase, in unit weight. Also note that at the time of mixing the specimens containing $5\frac{1}{2}$ percent asphalt and 8

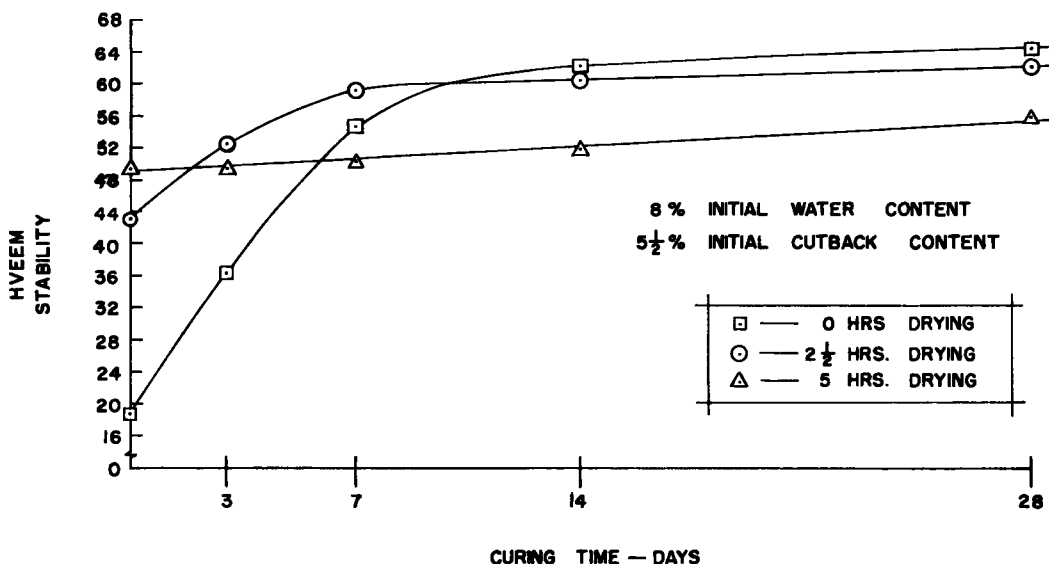


Figure 7. Variation in stability with time of curing after molding specimen (variable-time of drying before molding specimen).

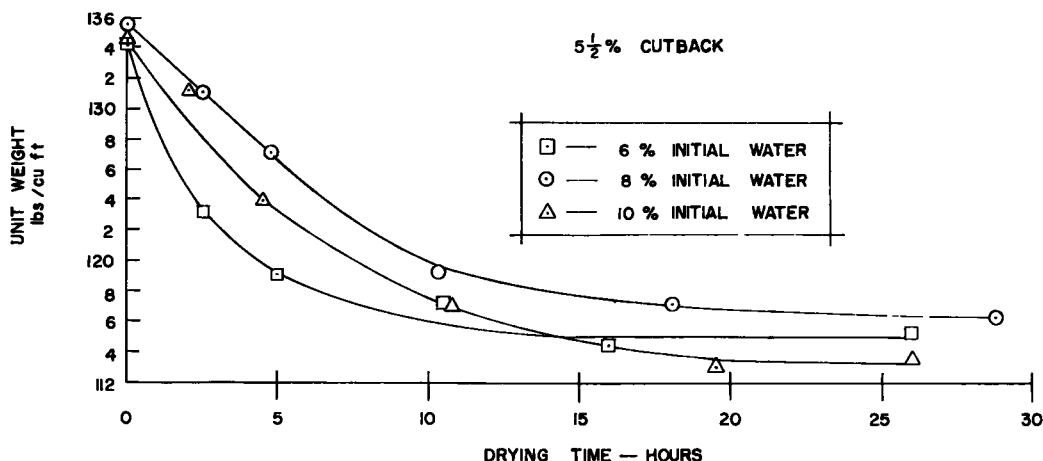


Figure 8. Variation in unit weight with drying time (variable-initial water content).

percent water had a total liquid content of 12.6 percent. This was slightly less than the optimum moisture content as determined by the standard Proctor compaction test of 12.7 percent. A drier mixture originally containing 6 percent mixing water has even less "liquid content". Any drying would increase the difference between the liquid content of these mixtures and the standard Proctor optimum mixture content. Drying of the water and hydrocarbon volatiles out of this soil-asphalt mixture did not adjust the "liquid content" to an optimum value at which maximum density could be obtained.

It appears from these data that high specimen density when obtained by adjusting the water and volatile content in the mixture is not accompanied by high mixture stability. Most construction materials which need to be compacted for satisfactory use do have high stability when compacted at optimum moisture content to maximum density. The maximum stability of asphaltic concrete mixtures occurs at approximately the same asphalt content at which maximum weight occurs (5). Cohesive soils, such as clays, have high strength when compacted at the optimum moisture content, producing maximum density. For most cohesive soils, though, this is not the maximum strength (4). As the amount of water in these soils is reduced, the strength is increased. In most instances, the stability of the drier mixture is not much greater than the stability of the mixture at optimum moisture content. For this reason and a few minor ones, such as reduction in permeability, compaction at optimum moisture content to high density produces the desired results of a soil with high strength. This phenomenon does not exist in the soil-asphalt mixture of this investigation, for at maximum unit weight, with large amounts of water and volatiles, it has very low stability. As the water and hydrocarbon volatiles are reduced in amounts by drying, the unit weight decreases and the stability of the mixture increases. To obtain the desired high stability, the mixture had to be compacted with smaller amounts of water and hydrocarbon volatiles and reduced density.

For controlling the compaction of soil-asphalt mixtures, a density requirement, per se, cannot be used. If this were the only requirement, high density could easily be obtained by compacting the mixture without any drying. Such compaction would result in very low initial stability. High strength was obtained only after the mixture was dried. Any control of the compaction of soil-asphalt mixture by a density requirement must be accompanied by a limitation in the amount of water and hydrocarbon volatiles in the mixture. In this manner, high density obtained by additional compactive effort will result in the desired high strength.

INFLUENCE OF EVAPORATION ON AIR VOID CONTENT

The evaporation of water and hydrocarbon volatiles from the mixture influenced the air void content of the compacted specimen as shown in Figure 9. These results, pertaining only to those mixtures containing $5\frac{1}{2}$ percent initial asphalt content and 8 percent mixing water, were computed from the data given in Tables 2 and 4. The upper portion of Figure 9 shows the air void content of the compacted specimens as related to the drying of the loose mixtures in the oven before compaction. In the lower portion of this figure are shown the air void contents of specimens as they were allowed to cure after molding. The three lines indicate the results obtained from specimens that were allowed to dry out in the oven for various periods of time before compaction into specimens. The curves in this figure are all of similar shape. As the water and hydrocarbon volatiles evaporated, whether from the loose mixture in the oven or from the specimens after compaction, the air void content of the compacted specimens increased at a fairly rapid rate. Gradually, a change occurred until the air void content did not vary much with additional evaporation. As previously seen, this trend is similar to the change in other characteristics of the mixture with evaporation.

The final air void content of the compacted mixture was influenced by the length of time the loose mixtures were dried in the oven before being molded into specimens. As water and hydrocarbon volatiles evaporated from the loose mixture, the air void content of the compacted specimens was increased, that is, drier mixes at the time of compaction resulted in larger amounts of air voids in the compacted specimens.

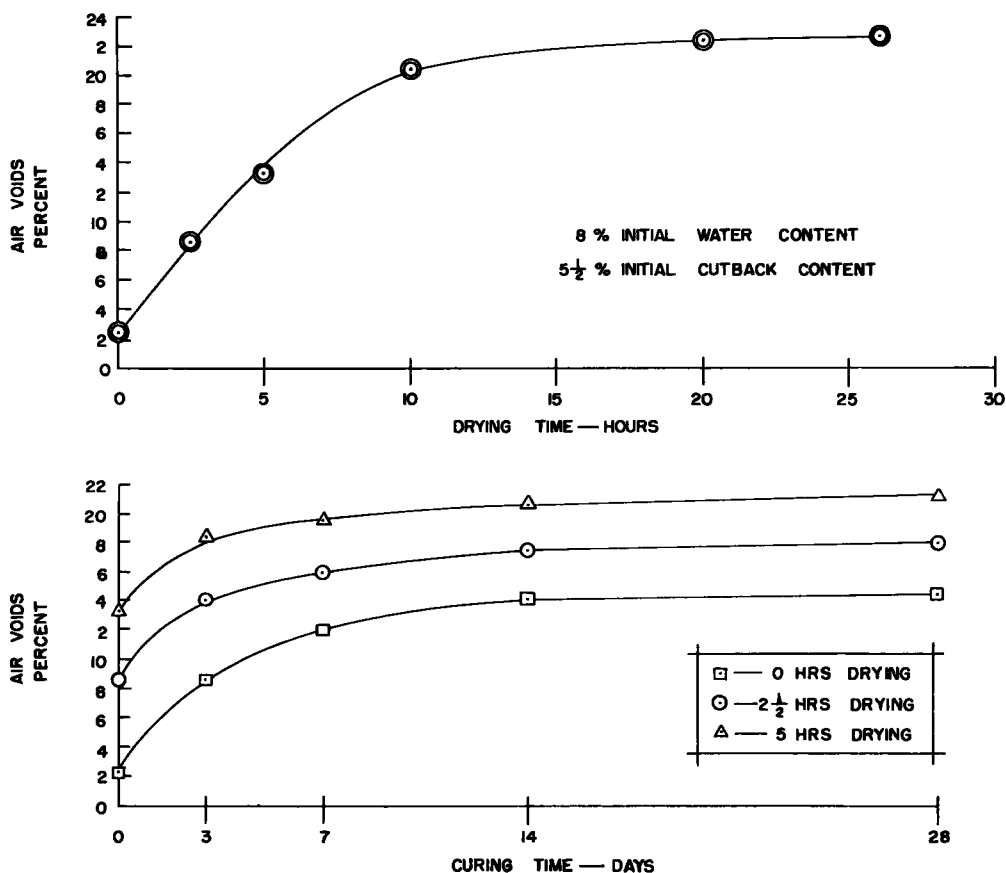


Figure 9. Variation in air void content with time of evaporation before and after molding specimen.

When the mix was molded immediately after mixing (zero hours drying) and was allowed to cure in the compacted state, the compacted specimens not only had a small amount of air voids initially but also had a relatively low air void content all during the time the specimens were curing (see lower portion of Fig. 9). On the other hand, specimens produced from mixtures that were dried for longer periods of time in the oven had a higher air void content at the time of compaction and also had larger air void content as the water and volatiles evaporated from the compacted specimens. The air void content in specimens after being cured for some days in the compacted state was largest for those mixtures that were the driest at the time of compaction.

Many characteristics of a compacted mixture are related to its air void content. The durability of asphaltic concrete decreases with increased amounts of air void (5). As the air void content becomes greater in clay soils, the shear strength tends to decrease, but the permeability tends to increase (3). Soils that are more permeable are more susceptible to soaking up water, a characteristic that results in lower strength. Soil-asphalt mixtures which contain larger amounts of air void are also more susceptible to absorbing water. This fact was borne out in a series of tests conducted on the soil-asphalt mixture containing 5½ percent initial cutback and 8 percent mixing water. The loose mixture was dried for various periods of time and compacted. Immediately after being molded, the specimens were completely immersed in water for seven days. The final water content of these soaked specimens is given in Table 5. Drier soil-asphalt specimens which contained larger amounts of air voids at the time of molding absorbed more water. This phenomenon exists also in sandy clay soils, such as that used in this study, when not stabilized with asphalt (4). Susceptibility of the soil-asphalt mixture to absorbing water, then, was greatly increased as the air void content was also increased.

Since there existed a relationship between the amount of evaporated water and hydrocarbon volatiles and the susceptibility of the compacted mixture to absorb water, it appeared that the mixture should not be compacted in too dry a condition lest it be quite susceptible to absorption of water. Soil-asphalt mixtures should be dried out just enough to obtain the desired initial stability and then compacted. Any additional drying is detrimental to the compacted mixture.

SUMMARY OF RESULTS

The results obtained in this study were acquired entirely by a laboratory investigation, using the Hveem-Gyratory method of measuring stability. Only one type of asphalt and one type of soil were used throughout. The results have not been checked by other test methods nor correlated with other types of soils and cutbacks. This evaluation of the effect of the drying phase on the various properties of the mixture is definitely limited in this respect. Cognizance of these facts must be considered in drawing any conclusions from the results.

1. The variation in the rate of evaporation of the water and volatiles from both the loose mixture and the compacted specimens was similar. Initially, the evaporation was quite rapid. It leveled off at a minimum value and changed little with additional drying at the oven's constant temperature.

2. Regardless of the amount of initial water used for mixing or the amount of cutback used, water evaporated out at a much faster rate than did the hydrocarbon volatiles. This relationship existed after the mixture was compacted into specimens as well as before when it was in the loose state. However, the rate of evaporation of both the water and hydrocarbon volatiles was much slower from the compacted specimens than from the mixture in the loose state.

3. The stability of the soil-asphalt mixtures was inversely related to the

TABLE 5
MOISTURE CONTENT OF SOIL-ASPHALT SPECIMENS
AFTER SOAKING FOR 7 DAYS
(ORIGINAL MOISTURE CONTENT - 7.08%)

Drying Time - Hr	0	2½	5	10	20
Moisture Content - percent	8.25	8.55	9.25	11.70	a

^aDisintegrated in water, before end of 7-day period.

amount of water and hydrocarbon volatiles present in the mixture. As the water and volatiles were dried from the uncompacted mixture, the stability of the compacted specimens increased until the rate of evaporation decreased to almost zero. After this, little change in stability was obtained by additional drying. An increase in the stability was obtained, however, in those compacted specimens in which additional amounts of water and hydrocarbon volatiles evaporated after compaction.

4. The unit weight of the compacted soil-asphalt specimens tended to decrease as the water and hydrocarbon volatiles evaporated from the mixture. The air void content, on the other hand, increased as evaporation took place. When evaporation was practically stopped, the unit weight was at a minimum value and the air void content was at a maximum.

The results of this study indicate that soils stabilized with cutbacks need to be dried out before compaction, not to adjust the "liquid content" for optimum compaction but to provide high initial stability. After compaction, additional curing results in even more stability. Although this drying is needed before the mixture is compacted, too dry a mixture is not desirable. The drier the mixture is at the time of compaction, the greater the air void content. Consequently, the mixture is more susceptible to soaking up water. Also, the indications are that soil stabilized with cutback is a material which cannot be compacted to a density requirement, per se, for high strength is not related to high unit weight in soil-asphalt mixtures. Thus, any control of the stability of these mixtures by a density requirement should be accompanied by a limitation in the amount of water and hydrocarbon volatiles in the mixture.

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