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THE EFFECT OF AN ADMIXTURE
UPON WATER LOSS AND WATER
GAIN IN PORTLAND CEMENT
CONCRETE

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THESIS

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The Effect of an Admixture Upon Water Loss
and Water Gain in Portland Cement Concrete

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by

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PREFACE

The uses of concrete are gradually becoming more numerous, and with the introduction of new uses and new methods, many new problems confront the engineer.

Haphazard workmanship will not produce good concrete, and a haphazard design of a concrete mix will not produce the type of concrete necessary for any particular job. With the increase in the number of uses, the proper design of a mix is increasingly important. Details of the types and amounts of aggregate, cement, and water, are highly important, and as more details of theory concerning the action of these constituents are found, the greater is the probability and possibility of making good concrete. The subject of this paper is intended to add a little bit of information to the amount that has already been gathered from a field that has ever broadening possibilities.

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E. L. H.

The Effect of an Admixture Upon Water Loss and Water Gain in Portland Cement Concrete

The theory of hydration of portland cement concrete is that the hydration process begins immediately when the cement and water are mixed, and that it continues until all of the cement or water is used up. Strength curves show that concrete increases in strength rapidly after being placed, and that after a few days the increase diminishes until it reaches zero. From this it is shown that hydration is rapid at first and that it gradually decreases as the water is used up in the reaction. Strength of concrete is usually based upon strength after a period of twenty eight days of curing. Such strength is laboratory strength only because concrete is rarely cured more than fourteen days in the field. The most benefit is derived in the first three days during which period most of the water loss and regain takes place. This series of tests was conducted for the purpose of measuring the amount of water lost and replaced in portland cement concrete, and to show the effect of varying percentages of a silica admixture on the amount of water lost, and then to measure the amount that can be replaced.

There are two methods of adding an admixture to a concrete mixture. The first and most widely used is that of replacing the cement with the admixture and at the same time reducing the amount of water, thus preserving the water-cement ratio and retaining the original strength. The amounts of fine and coarse aggregate are kept constant. The second method is that of replacing the cement with the admixture, and keeping the amounts of water and aggregate constant. The last method was the one used in this investigation, the cement being reduced in quantities of 10% and being replaced by an equal volume of a pulverized silica admixture.

The tests show that with 10% of the cement replaced by an equal volume of admixture, the amount of water lost is increased. This water loss is known as bleeding, and is the quantity that rises to the top immediately after the concrete has been placed. An additional reduction in the amount of cement in quantities of 10% shows a corresponding increase in the amount of bleeding. A curve with values of the amount of bleeding plotted against the percentages of cement removed indicates the increase in the amount of water lost. This curve is not accurate beyond the point at which 40% of the cement has been replaced by admixture. A trial was made with 50% of the cement removed, but the results were so far out of conformity with the previous

teste that it was not accurate enough to warrant consideration. Instead of plotting all of the values for water lost in each group, the mean values were plotted to eliminate confusion in both plotting and reading the curve. In all cases, the values were close enough together to warrant the plotting of the mean point. In most of the tests, the loss of water occurred in about two hours, this process being followed immediately by absorption. The time necessary to absorb the water lost was about five hours. Similar tests were performed at the Toledo Vitrified Brick Co. of Toledo, Ohio, but they were performed by the method in which some of the water was removed when the cement was removed. They carried out only one comparison test in which they replaced 10% of the cement with the same volume of pulverized silica admixture. Their results show a considerable reduction in water loss when compared with the mixture containing no admixture. Their results lead to the same conclusions that were arrived at in this investigation.

The water loss takes place immediately. This bleeding action is due to the excess water rising to the surface by means of capillary action through the voids in the concrete. It was found that there was an increase in bleeding through the point at which 40% of the cement was removed, with the exception of the 30% point which yielded slightly more water than the 20% and 40% points. The water loss at the 30% point is considered high, and does not represent the

true tendency of the curve. As stated before, the 50% point is low and will not be given consideration. The tendency toward an increase in bleeding can be attributed to the fact that there was more water present in proportion to the active element (cement), and hence more was available for bleeding. Very little is absorbed by the admixture which is an inactive element in the concrete. The results also show that the increase in amount of water lost, with an increase in the amount of admixture, is small in comparison to the amount of water available, thus leading to the conclusion that the admixture in some way interferes with the passage of water through the concrete. The pulverized silica admixture is somewhat finer than cement, and tends to fill the voids in the mixture thus checking capillary action and reducing the amount of bleeding.

A glance at the slump tests shows a correlation between slump and water loss. It shows that the amount of water lost increases as the slump increases, and decreases as the mixture gets stiffer; and it also shows that, as a general rule, the slump increases as the cement is removed and the admixture added, the other factors being kept constant. Exceptions in this investigation were shown in one test with no admixture, the test with 30% admixture, and the test with 50% admixture. The first two exceptions had a higher slump, and their losses through bleeding are shown above the curve. The last exception had a low slump and a

corresponding low loss of water. It will be noted that the test with no admixture, which had a 4 inch slump, lost less water than the test containing 30% admixture by volume which had a slump of $3\frac{1}{2}$ inches. The conclusion drawn from this agrees with those drawn previously that the amount of bleeding will increase as the amount of cement replaced by the admixture is increased. In these two cases, the slumps were sufficiently close together in value, that the conclusions reached could be easily correlated with those previously arrived at.

Bleeding, as measured in this investigation, is not directly a measure of the loss through leakage. Leakage occurred in one of the cylinders, and the total water lost was collected. The loss through bleeding was less than that of the cylinders in the same test series, but the combination of water collected from bleeding and leakage was considerably more than that lost by the other cylinders. The indication is that loss through bleeding is limited in depth. With the occurrence of a leak, the head of water developed in the cylinder, and the weight of the concrete force the water through the opening, and some that would have risen through capillary action is forced from the cylinder.

After the water was removed, it was replaced and more was added as the other was absorbed. The tests were carried out to determine the amount of water that would be

absorbed, but the total amount absorbed was not determined because the concrete was still taking in moisture when the tests were concluded. The results show that concrete takes in more water than it loses in bleeding. In all cases, the total amount replaced, in addition to the amount lost, was over 100% of that lost. The results of the curing process are illustrated here. Proper curing can achieve two results: the elimination of loss through evaporation, and addition of water to that already present. The first result preserves the water-cement ratio, the second increases it and at the same time raises the strength. Strength tests were not run in this investigation, and so the increase in strength was not determined.

The investigation was carried out using pulverized silica as the admixture. The water-cement ratio used was 6 gallons of water to one sack of cement, and the mix used was a mix consisting of one part of cement, 2 parts of fine aggregate, and 3 parts of coarse aggregate by volume. Methods of determining the specific gravity of aggregate, unit weight of fine and coarse aggregate, and the percent of surface moisture in the fine aggregate were the standard tests as set up by the American Society of Testing Materials. The tests were made by substituting varying percentages of silica admixture for cement in the ratio of a cubic foot of admixture to a cubic foot of cement, or a ratio of 85 pounds of admixture to 94 pounds of cement, the other constituents

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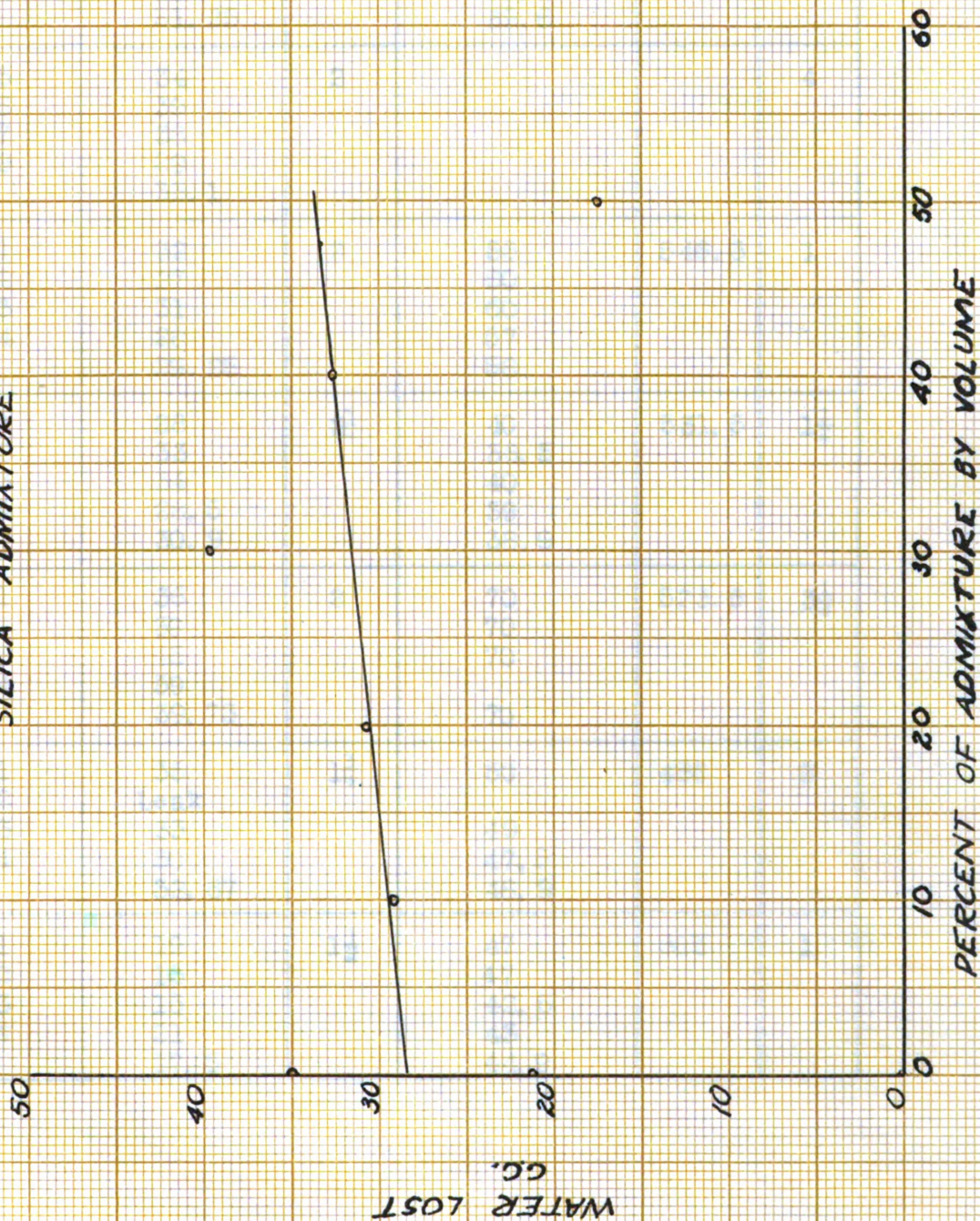
being kept constant. The percentages of cement replaced by the admixture were: zero, 10, 20, 30, 40, and 50, percent by volume. The volumes were converted to weights and the substitutions made on a weight basis. Four tests were made for each series.

The method was to place the concrete in a standard test mold 6 inches in diameter and 12 inches deep, allowing it to stand until all of the bleeding had taken place, removing the water at intervals, and then replacing it. Each sample was well rodded to eliminate air bubbles and to assure uniformity among all of the samples, and the surface was smoothed off and made slightly concave to facilitate the collection of the water. Water was removed from the sample by a pipette. After the water had been replaced and had been absorbed, further quantities were added in 10 cc. amounts as needed.

In the performance of the investigation, it was necessary to seal the bottom plate to the cylinder, and to seal the longitudinal seam to prevent leakage. A cover was also provided to prevent evaporation from the surface of the concrete. Providing an effective seal for the cylinder presented a major problem in getting the test under way, a number of methods being tried without success. The first seal attempted was that of wax; it failed because it was too weak and brittle to withstand the water pressure. Plastic wood also failed because of its brittleness.

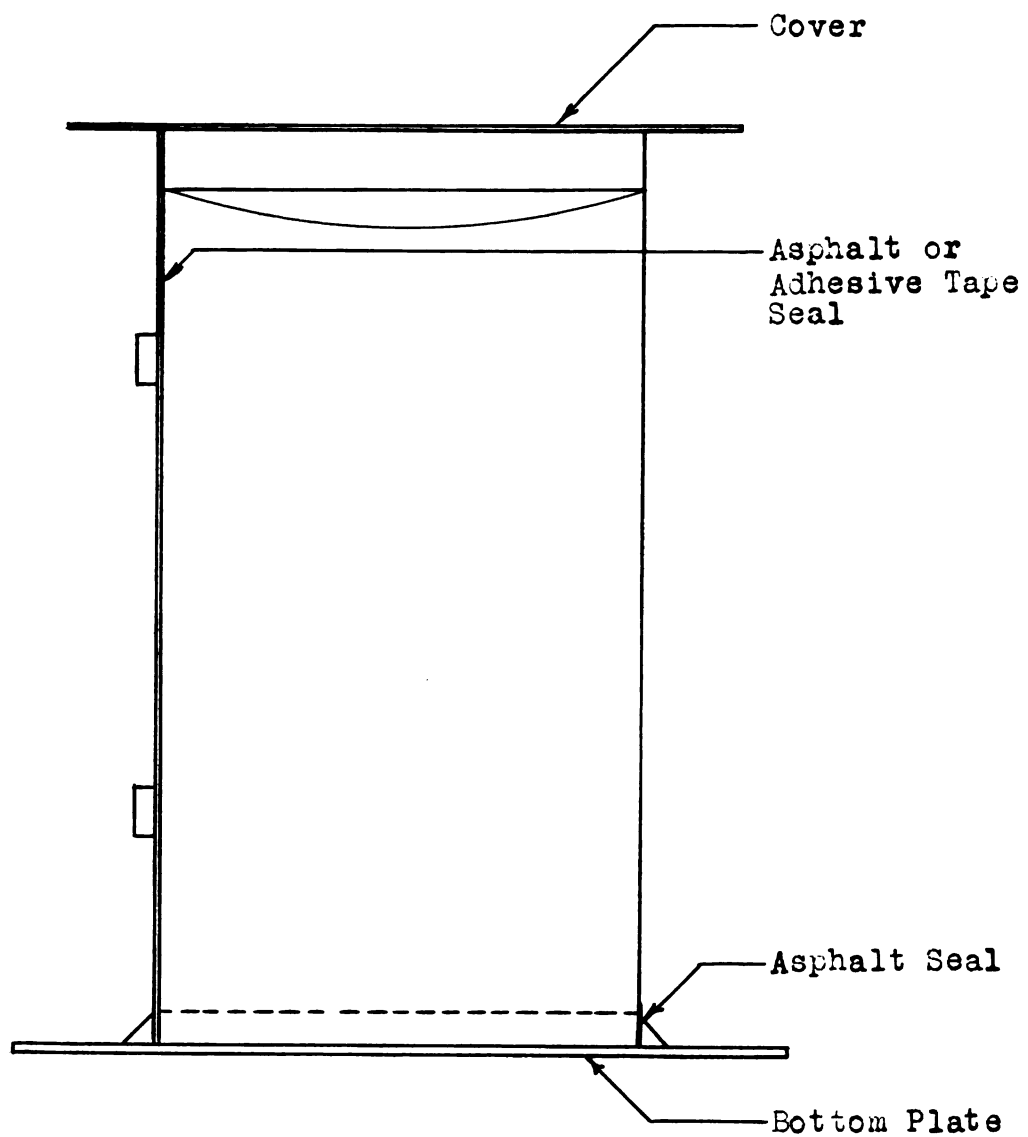
Waterproof adhesive tape proved to be satisfactory in sealing the longitudinal seam, but it could not effectively seal the bottom plate to the cylinder. Calking compound did not have the adhesive qualities to withstand the water pressure. Standard cardboard cylinder molds were tested. These cylinder molds are treated with wax and are, in themselves, waterproof, but when they were tested by filling them with water and allowing them to stand for a while, the seam around the bottom opened and the water evaporated. An asphalt seal that did not harden to the point of brittleness was tried and found to be acceptable. The result was that an asphalt seal was used exclusively between the cylinder and the bottom plate, and either asphalt or waterproof adhesive tape used on the longitudinal seam. Both methods were satisfactory. Each method of sealing was tested by filling the cylinder with water and noting the leakage after allowing it to stand for a few minutes. In like manner, each asphalt sealed cylinder was tested before being used in the investigation.

WATER LOSS IN PORTLAND CEMENT CONCRETE
WITH VARYING PERCENTAGES OF
SILICA ADMIXTURE



Test Sample		Water Lost	Time	Water Gained	Time	Slump
% Ad- mix.	No.	Cc.	Hrs.	Cc. Over Loss	Hrs.	In.
0 - 1		20	$1\frac{1}{2}$	40	173	1
0 - 2		26		40		
0 - 3		19		40		
0 - 4		20		38.25		
Mean		21.25		39.6		
0 - 5		34	2			4
0 - 6		39				
0 - 7		38				
0 - 8		29				
Mean		35.1				
10 - 1		32	2	55	546.5	1
10 - 2		27		60		
10 - 3		31		60		
10 - 4		28		57		
Mean		29.25		58		
20 - 1		28	$2\frac{3}{4}$	40	531.5	$1\frac{1}{2}$
20 - 2		33		36.5		
20 - 3		34		40		
20 - 4		28.5		39		
Mean		30.9		38.9		
30 - 1		36	2	70	523.5	$3\frac{1}{2}$
30 - 2		39		70		
30 - 3		45		70		
30 - 4		39		70		
Mean		39.75		70		
40 - 1		35	$1\frac{3}{4}$	50	456	2
40 - 2		Leak				
40 - 3		33		49		
40 - 4		30		47.5		
Mean		32.67		48.9		
50 - 1		19	$1\frac{1}{2}$	47	385	1
50 - 2		15		47		
50 - 3		15		42.5		
50 - 4		21		43		
Mean		17.5		44.9		

Water Loss and Water Gain Apparatus



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