A STUDY OF THE WATERTIGHTNESS OF CONCRETE WITH AN ADMIXTURE OF CELITE

Thesis for the Degree of B. S.

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A STUDY OF THE WATERTIGHTNESS OF CONCRETE WITH AN ADMIXTURE OF CELITE

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CONTENTS

I. INTRODUCTION

Watertightness or permeability cannot in any sense be underestimated as to importance in concrete construction. The ability to retain or rather the flexibility with which water permeates through some concrete is indeed a big question. In such structure as concrete pipes, concrete ships, drydocks, canals, dams, swimming pools and many others, this then is an important item.

Theoretically, and it has been proven practical, it is possible to get a concrete which will be absolutely watertight and which furthermore will hold water under very high pressures. If an exact design according to the Portland Cement Company is made and used, a concrete with the minimum amount of voids and maximum amount of strength and watertightness can be obtained.

This theoretical concrete, however, does not, as most engineers know, hold absolutely on every job, especially those of a smaller nature. On a job where a good mix is not designed the water can easily seep through. For such mixtures various admixtures have been tried, one of which I have attempted to experiment with. I will then in the following consider only a crude and rough mix, and with this mix, by adding the given admixture, attempt to get the desired result of watertightness.

The admixture which I will consider goes under the commercial name of Celite. It is claimed that by adding this to the mix, a denser concrete giving greater strength, work-

ability, less segregation, and watertightness is obtained. I will at this time confine all my attentions to the permeability and watertightness with a few minor observations on some other points.

The problem then is to test a concrete with this admixture as to its watertightness. I will first discuss the materials used, then the mixes, then the apparatus, and finally the tests and results obtained. Finally, I will attempt to draw suitable conclusions from them.

II. MATERIALS

The cement used in all the mixes was Petoskey Portland Cement. No tests regarding it were made. Rather, it was used just as it came from the factory where it was manufactures.

The fine aggregate which was used was obtained from the bins in the concrete laboratory and was used just as it came out of the bin without any tests being made upon it.

The coarse aggregate was also obtained from the bins in the concrete laboratory. It was very roughly graded as to size and also as to cleanliness, the extremely large pieces being rejected and the dirty pieces being also thrown out.

The Celite in composition is but a very finely ground silica SiO_2. In the mixture it is inert and is not acted on or does not act on any of the substances in the mix. It was obtained from the Celite Products Company, New York. It is through their courtesy and willingness to cooperate that we were able to obtain this admixture so as to be able to experiment with it. No tests were performed with the Celite other than using it in the various experiments as it came from the company.

The water used in the mixes was obtained from the college mains.

III. MIXES

Three mixes, only one being standard, were used. A 1-2-4, 1-3-5, 1-3-6, mixes were used, the 1-2-4 mix being a rather common one, while the other mixes, the 1-2-5 and 1-3-6, are very rare and in being rare are extremely high in coarse aggregate. The Celite if acting in its proper capacity is assumed to fill the voids in the mix and in the case of the 1-2-5 and 1-3-6 mixes an excellent opportunity to observe this could be had by noticing their relative watertightness in the tests. A mix of this nature could also then show us just how coarse a mix could be before it became pervious and also through the addition of Celite it might be made impervious.

I first decided that two slumps, they being a 3" and 4", would determine the water content but this was not followed out throughout the work. Discs were made for both a 3-inch and 4-inch slump in the 1-2-4 mix, but due to the coarseness of the 1-2-5 and 1-3-6 mixes, I decided to use only the 4-inch slump in them, and attempt to get the results with it. From each mix I made five discs with varying percentages of Celite in proportion to the weight of cement.

Number 1 with 0% Celite
" 2 " 1% "
" 3 " 1½% "
" 4 " 6% "
" 5 " 8% "

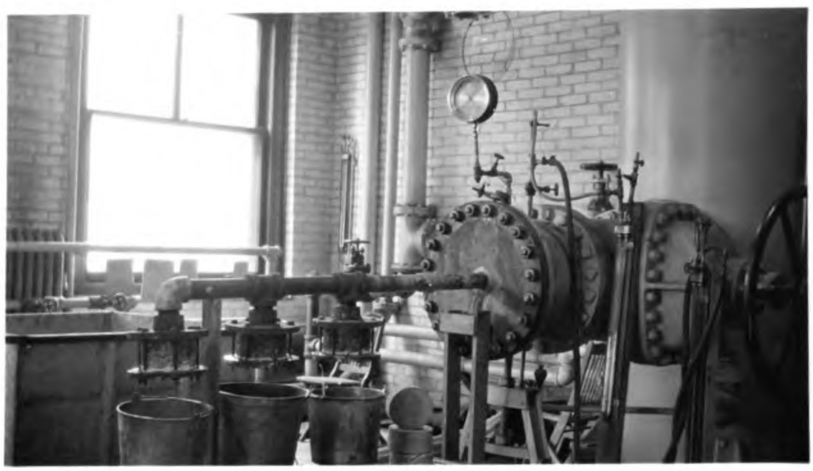
To obtain the required amount of Celite in the mix I had to weigh the amount of concrete in each successive disc and then find by proportion the weight of cement in the diso or rather that remaining in the mix and also the weight of Celite remaining in the mix. This then gave me a figure for the weight of cement remaining in the mix from which I could compute the amount of Celite necessary to add each time. A simple proportion is all that is necessary to determine this and there is no need at this time to demonstrate it. The following table will show the quantities and system of numbering used as the discs were made in the concrete laboratory.

Disc No.	Mix	Slump	% Celite	Date Poured
1	1-2-4	2"	0	April 14
2	"	"	1	"
3	"	"	1½	"
4	"	"	6	"
5	"	"	8	April 18
6	1-2-6	4	0	"
7	"	"	1	"
8	"	"	6	"
9	"	"	1½	April 19
10	"	"	8	"
11	1-2-5	"	0	"
12	"	"	1	"
13	"	"	6	April 21
14	"	"	1½	"
15	"	"	8	"
16	1-2-4	"	0	"
17	"	"	1	"
18	"	"	6	"
19	"	"	1½	"
20	"	"	8	"

IV. APPARATUS

The suggestion or idea on apparatus was brought to me through a series of tests conducted by C. F. Meanwell and C. J. McLean on their thesis work in 1930. A detailed drawing and sketch of the apparatus may be obtained by referring to the thesis by these two men. I accepted their principles and have made a few slight revisions which I thought would better accomplish the results hoped for. From the sketch which you see on the following page, the disc three inches thick and seven inches in diameter is placed between two flanges and then firmly clamped down by the bolts around the edge of the flanges. The apparatus seemed to be very satisfactory except for one detail which I think it best to explain; then if further work is to be done along this line, a better and more efficient method could probably be found.

The biggest question which I had to contend with and which spoiled my results the most was the question of making the joint between the iron flange and the concrete watertight. The disc was made with an even surface on top and with a rather rough surface on the bottom. To make a watertight connection, it was first thought that just a small rubber gasket would do but this failed miserably. Larger gaskets were then used which worked much better but



not to satisfaction. Then the same larger gaskets were used with a filler beneath them and with a thick layer of putty around them which gave about the best results but which still did not prevent leaking. It was found also that the discs cracked because they were not brought up even all around so plaster of Paris was placed on the under side and in this manner an even surface was obtained all around the face of the disc. This last combination of gaskets and leak preventatives worked out the best but they were far from perfect since even after they had been put into use the water nevertheless leaked over the edges between the flange and disc.

It was thought best at first to catch just the water which came on down through the discs and then through the two-inch hole in the bottom flange but since the pressure of the water in the disc would be exerted equally in all directions it would then be expected to find the water seeping out of all sides of the disc as well as out of the bottom. The discs were therefore placed horizontal and all the water which permeated out of the sides as well as through the bottom was caught in the pails placed on a platform beneath the discs.

The water pressure was obtained from the college and was registered by a gauge shown in the accompanying

photograph. Although I at first expected to use different pressures ranging from approximately 10 to 70 pounds per square inch, this was not carried out, and the maximum pressure of 70 pounds per square inch was used throughout every test. I thought that this maximum pressure would give the most practical results, it being similar to those in concrete pipe and other structures needing to be absolutely watertight.

No apparatus was available to obtain a reduced pressure so that seepage and other small pressure heads similar to seepage could not be used.

V. TESTS AND RESULTS

Each disc was mixed and formed in a metal mould coated with oil on the inside to allow it to be easily disconnected from the concrete. The discs were then placed in a damp chamber and allowed to set for fourteen days.

It was hoped that results of a very accurate nature could have been obtained so that graphs and charts of the flow through the discs might be made indicating the time it took for the water to permeate through; the amount through each disc; and the relative efficiency of varying percentages of Celite as added to the mixtures in the discs. Due to leakage in almost every case caused by a bad joint, and cracks, it was found that accurate quantities of water could not be obtained. The combination of bad joints and cracks in the concrete allowed an excessive amount of water to drip into the pails so that only a rough account of quantities was obtained and written up rather than being placed in tabulated form or in graphical form. Following is a list of the trials as they were observed:

Disc 1. A 1-3-4 mix with 3 inch slump and 0% of Celite. Cracked and considerable water permeated through cracks. A considerable amount also ran outside between flange and disc through gasket. From close observation

the water was noticed oozing out the side and bottom and more water came through from this disc than any of the other three on at that time.

Disc 2. A 1-3-4 mix; 2 inch slump; 1% Celite. Did not crack but water did get by the gasket. Water also permeated through sides and bottom as in all of the other discs by the beads noticeably forming on the sides.

Disc 3. A 1-3-4 mix; 2 inch slump; 1½% Celite. Did not crack but gasket leaked. Considerable amount of water came through.

Disc 4. A 1-3-4 mix; 2 inch slump; 6% Celite. Cracked and no accurate results could be obtained.

Disc 5. A 1-3-4 mix; 2 inch slump; 8% Celite. Did not crack but gasket leaked. Water permeated through but it was not as outstanding as in the other tests.

Disc 6. A 1-3-6 mix; 4 inch slump; 9% Celite. Did not crack but was very porous. It was extremely more porous than any other disc made. Indications from the amount of water which came through the sides and out of the bottom showed that this disc was very porous.

Disc 7. A 1-3-6 mix; 4 inch slump; 1% Celite. This sample cracked but nevertheless considerable water did come through other than the cracks.

Disc 8. A 1-2-6 mix; 4 inch slump; 6% Celite. This sample did not crack but quantities of water similar to that through the others came through this one.

Discs 9-10. 1-2-6 mix; 4 inch slump; 1½ and 8% Celite. Both these discs cracked but water permeated through them as much as through any of the others of this series.

Disc 11. A 1-2-5 mix; 4 inch slump; 0% Celite. Did not crack but very porous.

Discs 12-14. 1-2-5 mix; 4 inch slump; 1 and 1½% Celite. Number 12 cracked but nevertheless it was very porous in the uncracked part, similar to No. 14.

Discs 13-15. 1-2-5 mix; 4 inch slump; 6 and 8% Celite. Neither of these cracked but water did permeate through them shortly after the full force was turned on. After allowing the water to remain on for four hours, considerable water did permeate through but not of such a large quantity as through those of a smaller percentage of Celite or in any of those in the 1-2-6 mix.

Disc 16. 1-2-4 mix; 4 inch slump; 0% Celite. Cracked but very little water permeated through the cracks. Some, however, did come through the sides and bottom although in not such large quantities.

Discs 17-18. 1-2-4 mix; 4 inch slump; 1 and 1½% Celite. Number 17 cracked and water permeated through the cracks. In Number 19, which did not crack, the water permeated very slowly through the fissures and irregularities on the sides of the disc. That which did appear, however, seemed only to wet the surface, none getting through due to evaporation.

Discs 18-20. 1-2-4 mix; 4 inch slump; 6 and 8% Celite. Neither of these discs cracked. Due to their high content of Celite they were supposedly more watertight, but did not however prove such. The water seemed to permeate through these much faster after the pressure was turned on than through the others of this same series.

VI. CONCLUSION

It is rather a hard proposition to draw conclusions from the data and results presented, due to the great inaccuracy experienced on account of improper gaskets to keep the water from flowing between the disc and flange and also due to the cracking of some of the discs. I had hoped to obtain graphs and more accurate data from which proper results and conclusions could have been easily obtained. If the time would have allowed I would have deemed it more advisable to have disregarded my tests and would have gone about making more which I am sure would have been more accurate and safe to draw conclusions from.

However, from the results obtained I will attempt to give my conclusions. It can very easily be seen that the leaner mixes, as the 1-3-6 and 1-3-5, thrown together as roughly as these were, are not satisfactory. In these mixes it appeared to be rather an apparent fact, however, that the more Celite added to the mix, the more impervious the mix became. It is my contention that if the correct amount of Celite be added to these mixes, they can then be made somewhat impervious. I say somewhat impervious because the leaner mixes would have the greatest amount of voids and it is almost an impossibility to fill all these voids and do it properly.

My next point in conclusion is that to get an absolutely watertight concrete the mix must be accurately and thoroughly designed and worked out. In the 1-2-4 mixes, both the 2 inch and 4 inch slump, it was found that the water permeated through regardless of the varying amounts of Celite added, although it was noticed that in the mix where only 1 and 1½% of Celite was added, the water did not appear to get through as quickly or in such large quantities.

Celite as an admixture I would say should be used in very small quantities principally as a safety factor in a well-designed mix. It should not be relied upon to make a mix which lacks thorough design meet the requirements of a well-designed mix.

In summarizing I will quote from a chapter in Hool's "Reinforced Concrete", Volume II, which will and does explain my two points very thoroughly.

> "The addition of so-called 'integral' water-proofing compounds will not compensate for lean mixtures, nor for poor materials, nor for poor workmanship in the fabrication of the concrete. Since in practice the inert integral compounds (acting simply as void filling material) are added in small quantities, they have very little or no

effect on the permeability of the concrete. If the same care be taken in making the concrete impermeable without the addition of waterproofing materials as is ordinarily taken when waterproofing materials are added, an impermeable concrete can be obtained."

APPENDIX I

The following is a list of books and references from which valuable information on concrete was obtained in the preparation of this thesis:

I. Thesis of 1930 by C. F. Meanwell and C. J. McLean - "Study of the Permeability of Concrete"

II. Hool - "Reinforced Concrete Construction"
Volume II, Chapter XXIII
"Waterproofing of Concrete"

III. Hool and Johnson -
Concrete Engineers' Handbook

APPENDIX II

Watertightness or Permeability of Concrete With An Admixture of Celite

Outline

Materials:

1. Celite obtained from the Celite Company.
2. Gravels of various grades obtainable from the college.
3. A slow and rapid setting cement to be used.
4. Sands of various grades.
5. Water to be obtained from the college mains.

Mixtures:

1. Mixes to be graded as to quality by
   (a) Kind of materials used.
   (b) Workability.
   (c) Carefulness in preparation.
2. Three standard mixes will be used:
   (a) 1-2-4
   (b) 1-2-5
   (c) 1-2-6
3. Percentage of additional Celite will be varied - 0-1-1½-6-8.

Tests:

1. All discs to be tested under water pressures of varying amounts.
2. Mix to be tested by the slump test.