THESIS

THE EFFECTS OF CHEMICAL SALTS ON CONCRETE

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THE EFFECTS OF CHEMICAL SALTS ON CONCRETE.

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THESIS

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PREFACE.

For valued aid and advice on the work involved in this thesis, I am greatly indebted to Professor H. K. Vedder and C. Allen.

W. K. Willman.

THE EFFECT OF CHEMICAL SALTS ON CONCRETE BRIQUETTES.

INTRODUCTION.

Engineers are continually seeking the economical construction. The present construction age is an age of concrete and steel, the design meeting practically all conditions that arise in building work. Among the countless advantages of the present day concrete construction, strength, durability, beauty and simplicity of construction are highly important. The long life of the structure makes it economical, even tho the size of the members required to meet the stresses makes it a massive, heavy work.

If it were possible to increase the strength of concrete by the addition of a cheap chemical salt, the massive structures of today could be lightened in weight and correspondingly beautified.

It might also be possible to cheapen the cost of construction by a reduction in quantities. Experiments to date in concrete have singularly failed to disclose any such salt and it is my intention in this thesis to conduct and discuss a series of tests on concrete briquettes using solutions of the more common and cheapest salts in the mixtures.

SPECIFICATIONS.

(The specifications cited below are essentially those of the American Society for Testing materials.)

1. Peninsular cement was used thru-out the tests,
2. The residue on a No. 200 sieve shall not exceed 22% by weight,
3. The mix shall be 1:2 for the mortar briquettes, that is, one part of cement to two of sand,
4. Due to lack of Ottawa sand, bank sand was used in the mortars. Tests carried on proved that bank sand contained 0.68% moisture and Ottawa sand .037% moisture which called for reducing the water .7%. Tests on the tensile strength of mortars proved the tensile strength of bank sand to be 12% greater than Ottawa sand mortar.
5. All cement used in this thesis shall be passed thru a No. 30 mesh,
6. The chemical salt solution shall be a 10% solution and this solution shall be 10% by volume of the water used.
7. The following chemical salts shall be used and eight briquettes, (4 neat and 4 mortar) for the seven and twenty eight day tests shall be made.

Sodium chloride,

Sodium nitrate,

Sodium sulphate,

Potassium chloride,

Potassium nitrate,

Potassium bichromate,

Magnesium chloride,

Magnesium sulphate,

Magnesium nitrate,

Calcium sulphate,

Calcium chloride,

Calcium nitrate,

Barium sulphate

Barium chloride,

Barium nitrate,

METHOD OF PROCEDURE.

I. NORMAL CONSISTENCY.

I used Peninsular cement thru-out the tests, first getting its normal consistency by means of the Vicat needle. In this test various mixes of neat cement were made, mixing approximately 1 1/2 minutes. This mix was formed into a ball and tossed between the hands six times. It was then placed in the Vicat needle base and the surface flushed. The needle was quickly released and allowed to press into the concrete. When the needle drops 10 mm. in 1/2 a minute, we have attained the normal consistency. If it drops more than 10 mm. the mix is too wet; if less than 10 mm. the mix is too dry. The amount of water required is expressed in percentage by weight of the dry cement.

Results 500 gms. of cement

$\underline{135}$ cc. H_2O

$\frac{135}{500}$ = 27% normal consistency for neat briquettes.

For the mortar briquettes of standard 1:2 mix, it was found by comparing a mix with the sand used to a mix with standard Ottawa sand that a normal consistency of about 12.5% was right.

II. MANUFACTURE OF BRIQUETTES.

I decided to give the manufactured briquettes seven and twenty eight day comparison tests with briquettes not containing chemical salts, said test to consist of breaking in the Rhiele tension testing machine for any comparative changes in strength.

The mixes used were as follows:

Neat cement briquettes 700 gms. Peninsular cement 170.1 cc H_2O	27.5% Normal consistency.
17.01 cc H_2O 1.89 gms. Chem. Salt	In solution.
Mortar briquettes 467 gms. sand 233 gms. Peninsular cement, 78.75 cc. H_2O	1:2 mix.
7.85 cc. H_2O .875 gms. Chem. salt	In solution.

I mixed four neat briquettes and four mortar briquettes, each containing the proper proportion of the chemical solution for comparison with the ordinary cement and mortar briquette in a seven day test and the same number for a twenty-eight day test. These were allowed to set in the gang molds for twenty-four hours and then placed in chambers and covered with water.

At the end of the respective time periods, the briquettes were broken in a Rhiele tension machine. The results were tabulated and the average strength of each batch of briquettes computed and tabulated. The results are in pounds per square inch.

RESULTS - 7 DAY TEST.

NEAT

Salt	1	2	3	4	Av.
Standard Br.	490	490	505	475	490
Sod. Chloride	470	500	515	530	503
Sod. Nitrate	515	500	500	470	497
Sod. Sulphate	595	550	620	500	567
Pot. Chloride	530	550	550	530	532
Pot. Nitrate	450	500	460	510	480
Pot. Bichromate	500	490	540	535	514
Mag. Chloride	590	550	490	500	526
Mag. Sulphate	480	500	510	530	518
Mag. Nitrate	500	490	550	490	508
Cal. Sulphate	520	585	590	550	561
Cal. Chloride	485	470	450	500	476
Cal. Nitrate	550	570	520	440	530
Bar. Sulphate	590	585	470	530	544
Bar. Chloride	470	560	500	510	510
Bar. Nitrate	580	520	510	525	534

RESULTS - 7 DAY TEST.

MORTAR

Salt	1	2	3	4	Av.
Standard Br.	310	320	335	330	324
Sod. Chloride	320	315	345	310	323
Sod. Nitrate	335	345	355	320	344
Sod. Sulphate	400	385	350	375	378
Pot. Chloride	325	330	375	340	343
Pot. Nitrate	300	305	290	310	301
Pot. Bichromate	410	370	340	390	378
Mag. Chloride	390	320	350	380	360
Mag. Culphate	290	300	330	315	309
Mag. Nitrate	310	330	330	320	323
Cal. Sulphate	360	350	370	385	388
Cal. Chloride	390	350	360	360	365
Cal. Nitrate	310	330	300	320	315
Bar. Sulphate	260	310	300	315	297
Bar. Chloride	290	320	300	295	301
Bar. Nitrate	280	310	320	340	315

RESULTS - 28 DAY TEST

NEAT

Salt	1	2	3	4	5
Standard Br.	610	660	615	690	644
Sod. Chloride	550	650	530	540	568
Sod. Nitrate	550	620	555	600	565
Sod. Sulphate	550	620	670	650	623
Pot. Chloride	620	550	730	500	600
Pot. Nitrate	560	600	650	655	617
Pot. Bichromate	730	640	710	740	705
Mag. Chloride	680	630	590	610	627
Mag. Sulphate	750	660	760	700	718
Mag. Nitrate	590	600	560	630	570
Cal. Sulphate	560	635n	710	600	601
Cal. Chloride	610	560	590	580	588
Cal. Nitrate	605	610	650	620	621
Bar. Sulphate	640	600	710	670	655
Bar. Chloride	720	700	640	670	683
Bar. Nitrate	710	640	740	720	703

RESULTS - 28 DAY TEST

MORTAR

Salt	1	2	3	4	Av.
Standard Br.	500	460	450	470	470
Sod. Chloride	400	400	380	440	405
Sod. Nitrate	420	400	440	440	425
Sod. Sulphate	500	510	460	440	478
Pot. Chloride	440	380	400	500	430
Pot. Nitrate	390	380	380	420	393
Pot. Bichromate	490	480	500	450	480
Mag. Chloride	500	430	530	480	485
Mag. Sulphate	430	420	510	430	443
Mag. Nitrate	400	540	450	470	465
Cal. Sulphate	530	420	430	400	443
Cal. Chloride	500	510	460	450	480
Cal Nitrate	430	420	430	400	420
Bar. Sulphate	450	450	390	430	430
Bar. Chloride	380	430	400	360	393
Bar. Nitrate	400	400	410	400	402

DISCUSSION OF RESULTS

7 day test.

The comparison of breaking strength of the standard neat briquette and the Sod. sulphate briquette showed the greatest increase, the neat sod. sul. briquette breaking for an average of 567 pounds per square inch as compared to the average of 490 for the standard neat briquette. The sod. sulphate mortar briquette broke at 378 as compared to 324 for the standard mortar briquette.

The barium sulphate neat showed an increase of 54 pounds per square inch while the mortar showed a decrease of 27 pounds per square inch. Such a discrepancy is hard to explain satisfactorily unless it be improper mixing or handling of the testing machine, which would occur should the revolving jaws stick.

The other notable neat briquette increases were in those treated with Barium nitrate, pottasium chloride, said increases ranging from 20 to 40 pounds per square inch. The mortar briquettes treated with these same chemicals increased approximately in proportion except in very few instances.

It is my opinion that the only chemicals that had an increasing effect on the briquettes were sodium sulphate and pottasium bichromate. This opinion is

based on the fact that both the neat and mortar briquettes increased in strength and the briquettes broke at nearly the same pull thru-out.

DISCUSSION OF RESULTS

28 Day Test.

In the 28 day test, the only chemical that seemed to increase the briquette's strength was potassium bichromate, the neat briquette having an average increase of 61 pounds per square inch and the mortar an average increase of 10 pounds per square inch. In other cases the strength of the neat treated briquettes would increase slightly while the strength of the mortar bricks would decrease and vice versa.

In conclusion I would say that the results I obtained would hardly make it worth while to treat cement or concrete with a chemical salt. The salts are not at all readily soluble and the only one, potassium bichromate, that seemed to affect the briquette strength steadily is an orange colored salt and its use colored the briquette. I do not think this is desirable. The increases in strength were not pronounced enough in any case to make the treatment an economy. However, were it possible to run a larger number of tests, the wider range of results would tend to give a closer and more accurate average of comparative strengths and might prove conclusively that treatment with a certain chemical salt would increase the strength

of the concrete. Insofar as the quantity of calcium, magnesium and sulphates in cement is limited now according to the A. S. of Testing Materials, it is clear that their use would be detrimental.