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A fire clay cement study

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A FIRE CLAY CEMENT STUDY

by

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A

THESIS

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Table of Contents

Introduction

The purpose of this investigation was to develop a satisfactory boiler setting cement from a semi-flint fire clay. This clay is now being mined and used to make refractory ware by the Wellsville Fire Brick Company, Wellsville, Missouri. It has been my intention of using only those materials which have been used by this company and following the same preparation of the clay, that is, using the machinery which is at present available in the plant.

Preliminary Study

A study of the cement now manufactured by this company revealed that it had a fairly low shrinkage and spalled quite readily when subjected to sudden temperature changes. This cement has a composition of:

35% semi-flint fire clay
50% grog
15% gannister
10% (by volume) sodium silicate

It is evident that the shrinkage produced in firing by the clay content was in excess to the expansion produced by the allotropic modification of the gannister. The body appeared to have good strength and its adhering qualities were fair. The P.C.E. value was between cone 29-30. This cement had been used at high temperatures but did give satisfactory results due to its shrinkage in service.

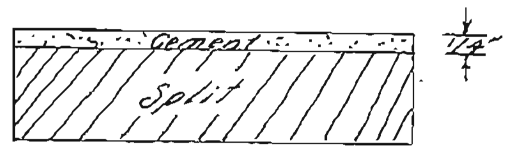
Procedure

The materials were thoroughly dried in an electric oven at 200°F, ground in a set of rolls and a pulverizer then screened thru sixty mesh so that the product varied from 60 to approximately 200 mesh.

The following mixes were made up, by weight, and dry mixed in a sail cloth: To each mix, 10% by volume of sodium silicate was added with the pugging water. Enough water was added to meet practical conditions and the mass was kneaded and worked with the hands.

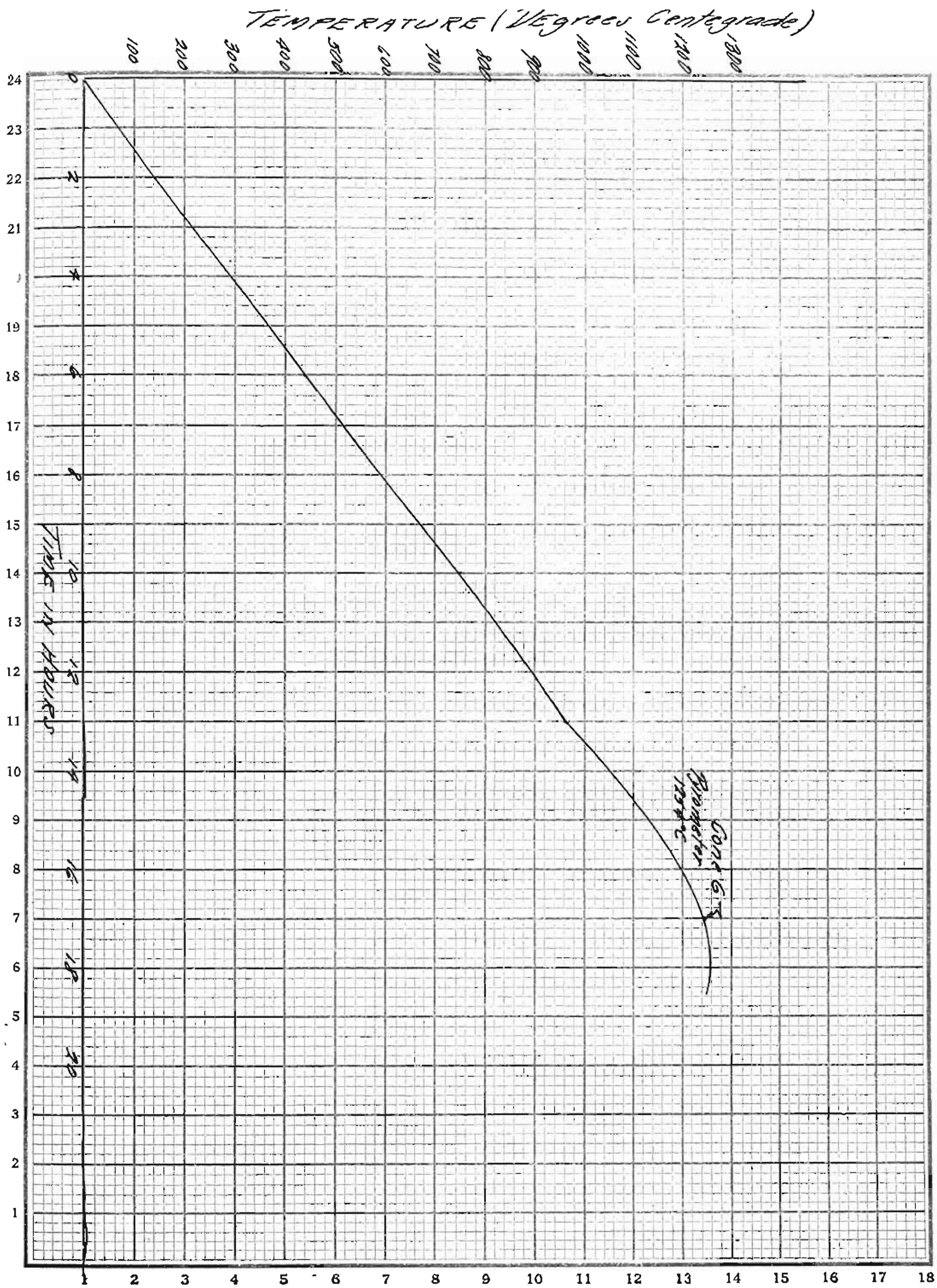
Specimen No.	%Clay	%Grog	%Gannister
1	45	45	10
2	45	40	15
3	45	35	20
4	45	30	25
5	45	25	30
6	40	50	10
7	40	45	15
8	40	40	20
9	40	35	25
10	40	30	30
11	35	55	10
12	35	50	15
13	35	45	20
14	35	40	25
15	35	35	30
16	30	60	10
17	30	55	15
18	30	50	20
19	30	45	25
20	30	40	30

The specimen consisted of one-half of a nine-inch split upon which the cement was spread over to a depth of one-quarter of an inch; great care was taken to maintain a uniform depth of the cement.



The drying was done in the closed room of the laboratory with a damp cloth covering the specimen to insure slow drying so that the cement would not crack and draw away from the split.

The firing was done with oil in a down draft test kiln in the laboratory. The specimens were placed so that the flames would impinge directly upon them, thus suffering the severest conditions to which they could be subjected during the burn. The temperature to which these specimens were fired was 2282°F. Immediately after the firing was completed the kiln was subjected to a rapid cooling and the specimens were taken out and examined.



TEMPERATURE (Degrees Centegrade)
TIME IN HOURS
Cone 6
Biotite
Start

Data

Specimen	Remarks
No. 1	High shrinkage, badly cracked, fair adhesion.
No. 2	Same as No. 1
No. 3	Medium shrinkage, cracked and spalled.
No. 4	Fairly low shrinkage, cracked, good adhesion.
No. 5	Same as No. 4 spalled.
No. 6	Medium shrinkage, cracked, good adhesion.
No. 7	Medium shrinkage, cracked.
No. 8	Low shrinkage, slightly cracked, good adhesion.
No. 9	Low shrinkage, evidence of spalling.
No. 10	Low shrinkage, cracked and spalled.
No. 11	Low shrinkage, commercial possibility, no cracking evidenced. P.C.E. value cone 29.
No. 12	Low shrinkage, cracked, fair adhesion qualities. P.C.E. value cone 29-30.
No. 13	Low shrinkage, cracked, fair adhesion.
No. 14	Same as No. 13.
No. 15.	Cracked and spalled.
No. 16	Low shrinkage, slightly cracked.
No. 17	No shrinkage evidenced, but slightly cracked.

Data

Specimen	Remarks
No. 18	No shrinkage or cracking evidenced, good adhesion, commercial possibility, P.C.E. value cone 29.
No. 19	No shrinkage, slightly cracked.
No. 20	Cracked and spalled.

Interpretation of Results

From the data obtained it is evident that a high clay content produces a high shrinkage, which may to a certain extent be counteracted by the use of grog, at the expense of the adhering quality of the cement. The use of gannister will counteract the shrinkage produced by the clay, however if used in excess it tends to cause cracking and spalling.

Specimens, numbers 11, 12 and 18, revealed the best commercial possibilities of the series. Of these three specimens, number 18 gave evidence of being the best. It was fairly dense and seemed quite hard burned; no cracking or spalling , no shrinkage could be noticed and its P.C.E. value was high enough to insure its use at high temperatures.

The method used to determine the results was crude because it was not possible to accurately measure the shrinkage which took place other than with the eye. All cracked and spalled specimens were considered as unsatisfactory and those which were not in this condition were examined carefully.

Some percentage of error may have been introduced into the work thru a slight variation in the water content of each specimen; although extreme care was taken to maintain the same consistency thru out. Again some cracking may have occurred during the drying period as it was necessary to dry the cement from its base outward, otherwise it would draw away from the split.

Abstract

Industrial survey of High Temperature Cements.

From a questionnaire which had been submitted to some 200 plants, the Sub-Committee of the A.S.T.M. has drawn the following conclusions:

a. Refractoriness.- Shrinkage and vitrification of boiler operating temperatures are important. The refractoriness determined from the P.C.E. value only, is not sufficient.

b. Tightness of Joints.- Satisfactory cement reduces spalling by preventing heat penetration and falling out of pieces of brick when cracking takes place.

c. Workability and ability to stay in suspension.- These properties are important since they affect the labor cost for construction work, as well as the uniformity in thickness of the joints.

d. Air Setting.- Cold setting cements can be heated up more readily than when fire clay alone is used and the former have less drying shrinkage.

e. Ability to Carry Loads.- This is considered so unimportant that it need have no consideration

in specifications.

Abstract.

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Refractory Cements for the Non-Furrous.

Foundry: By Harold E. White.

A good refractory cement should have the following properties:

a. Elasticity or ability to adapt itself and cling to unlike materials having different coefficients of expansion.

b. Mechanical strength to maintain loads at high temperatures and not crumble or bloat.

c. High P.C.E. value.

d. Resistance to abrasion.

e. Low shrinkage.

f. Resistance to disintegration (low porosity to prevent dissociation by gases.)

g. Chemical resistance (slagging.)

h. Resistance to spalling.

i. Long vitrification range.

j. Workability.

A smooth working and easily used mortar is desired,and it should spread like fat clay.

The ability of a cement to allow unequal expansion between its own structure and the parent refractory, is a valuable characteristic.

The use of super-refractory cements seems to have expanded beyond the field of super-refractory fired shapes, as the life of fire clay refractories is being increased by installing new work and maintaining old ones with these materials.