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Determination of the hydraulicity of local lime-stone

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THESIS.

DETERMINATION

of the

HYDRAULICITY

of

LOCAL LIME-STONE

By

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Hydraulic Cement.

I took as the subject of my thesis the hydraulic properties of the Lime Stone of this vicinity and confined my researches to two of the larger Lime Stone Quarries about one mile South West of Rolla.

The Lime Stone of this region is very variable as to texture as well as chemical constitution and even in the same specimens parts are compact and firmly cemented while other portions are loose and chalky, capable of being easily disintegrated. This is especially noticeable in Surface Stone and for this reason of appearance such Stone is unfit for building except in the case of foundations.

as the surface would soon become uneven no matter how carefully dressed.

This stone not only contains many little pockets of lime and alumina from which the CO_2 has been expelled, but in many cases small pieces of chert, flint, compact silicious sand, and often even granular sand that can easily be removed by the finger nail. Such stone as this would be unfit for good lime, so it would be very desirable to have some method of utilizing these large deposits by some profitable means.

The stones vary also largely in the amount of Magnesia present, from a mere trace in some of the Onyx regions to

Lenite. The Silica is also a variable quantity, but its varying disposition depends more on the minute individual deposits in the Lime Stone, than when combined Chemically or intimately mixed.

All the Specimens I have seen contain some Ferric Oxide and Alumina. These constituents seem to vary less than any other parts of the Stone, but are small.

The Calcium Carbonate of course varies with the Magnesium Carbonate as the Lime is simply displaced by Magnesia.

The Carbon dioxide varies inversely with the sum of the impurities. Silica, Alumina and Ferric Oxide.

For the method of my work I have

drawn from the following Authors:

Heath on Lime and Cement.

Reid on Portland Cement

Bakers Masonry

Chemical Review

Thorpes Dictionary of Chemistry.

Watts "

Transactions Am Inst Mining Engineers

and Missouri Geological Survey.

I have taken as Standards to work from the Portland and Rosendale Cements.

The Authors all agree approximately on the Chemical composition necessary to make good cement and Baker goes so far as to question whether Hydraulic Cement may not be made from any lime stone

It probably could if the proper constituents were added to make the chemical formulae agree to the needs. But my work was with local products and was to be cheap so that it could be of a practical advantage. However I question if it were ever possible to make good cement from any Lime Stone as I think the hydraulicity of Lime Stone does not depend entirely on its chemical composition at least on such composition as we are capable of performing. It may be due to some relation to great pressure or great lengths of time. At any rate there are records of many failures to make good Hydraulic Cement by careful workmen and good machinery

It is supposed by some that Magnesia is inert in Cement, others say it is unimportant when not exceeding 2 or 3 % but in large quantities causes the Cement to expand after some time thus injuring the masonry by cracking and loosening the joints.

Ferric Oxide is thought by some to be advantageous, by others of no consequence, but all agree that it should not exceed 5 or 6 %

The Alkalies are generally considered as beneficial as they assist in forming Potash and Soda Silicate when heated, which aids in cementing the particles firmly together on the addition of water

They are never in such quantity as to be considered detrimental.

The Lime is the essential ingredient assisted by the Silica, this forms Silicate of Lime on fusing that give the product the cementing power.

Alumina acts as Basic, Acid or Neutral, Combining with Silica forming Silicate of Alumina or with Lime, forming Aluminate of Lime. When in excess it appears to be neutral and would then only be an adulterant the same as would be the case if sifted in after the cement is made.

The amount of Alumina needed evidently depends on the excess of Silica over

Lime or Magnesia, or the Converse

The essentials to a good Hydraulic Cement as has been determined by experiment is Lime and Silica all others being Subordinate

Hydraulic Lime Stone is generally of a Dark Grey color, or Dark Blue or Drab.

It is of Compact texture, massive with even or chonchoidal fracture, and a Clayey smell and taste.

The following are analyses of Lime Stone and Clay which may well represent Portland and Rosendale Cement

Analyses of Lime Stone for Portland Cement

Calcium Carbonate - $CaCO_3$	57.35 to 96.52%
Silica - SiO_2	1.67 to 6.54
Alumina - Al_2O_3	.114 to .93
Magnesium Carbonate - $MgCO_3$	.10 to .50
Ferric Oxide - Fe_2O_3	.38 to .46
Potash and Soda - K_2O, Na_2O	.42 to .417

Analysis of Clay for Portland Cement

Silica - SiO_2	55 to 70%
Alumina - Al_2O_3	11 to 24
Lime - CaO	4 to 8
Magnesia - MgO	1 to 2
Iron Oxide - Fe_2O_3	3 to 5
Potash and Soda - K_2O, Na_2O	3 to 5
Carbon Dioxide - CO_2	4 to 5

Analyses of Lime Stone for Rosendale Cement

Calcium Carbonate - $CaCO_3$	68. to 80.%
Silica - SiO_2	20. to 10.%
Magnesia - MgO about	15 - 15 "
Alumina - Al_2O_3	3. to 4.

I have give for comparison two analyses of mine of the Lime Stone of this vicinity. They are as follows:-

Lime - CaO	28.67%	28.60%
Magnesia - MgO	9.47	11.80
Silica - SiO_2	9.28	10.30
Carbon Dioxide - CO_2	43.62	39.60
Alumina and Ferric Oxide - Al_2O_3, Fe_2O_3	3.64	.50
Alkalies, Na_2O & K_2O	3.62	not det.
Water, H_2O	1.22	1.50
	99.52	98.70

My Experiment.

I first attempted to burn the Quinn lime in series as in burning lime and also cement sometime, but soon found that this was impractical by the method I had on hand. I then ground the stone so that all would pass a 2500 mesh sieve and burned it at a high heat, (about 1100°C). It failed to give any hydraulic properties by this means so I concluded to grind it finer so as to offer more chances of its being exposed entirely to the heat.

The rest of my work was on stone ground so that it would all pass a 6400 mesh screen. I fused the stuff in a Wind Furnace, stirred to expell all moisture and Carbonic Acid, One lot I heated to about Cherry redness and kept it at that heat for three hours (In none of my fusions were there more than 1½ % CO_2 remaining.) It failed to develope any marked degree of hydraulicity, So I next tried it at a heat as high as the furnace would give and nearly to vitrification. It was heated so high that some of the pulp in the bottom of the crucible was vitrified. The vitrified mass I rejected and tested the other which gave stronger properties of hydraulicity than any before, but not altering sufficiently to permit of being moulded.

Finding my efforts futile to make good Hydraulic Cement from the Lime Stone above

I next tried fusing it with Clay consisting chiefly of alumina but containing some Silica and Iron Oxide

I mixed the Lime Stone Pulp intimately with the fine Clay (Made to pass 6400 mesh) in the proportions of 5-10-20-25 and 50 % Clay. These fusions failed to produce hydraulicity so I next tried the Lime stone Pulp with ground Silicious Sand (6400 mesh screen) in the same proportions as the Clay: 5-10-20-25 & 50 % Sand This increased the hydraulicity some but could be easily broken by the fingers even after three weeks setting.

I next tried the Lime Stone Pulp with both Clay and Silica together and the difference of the hydraulicity with that of the Clay alone was inappreciable

I next tried (For the sake of experiment only) 5% of Ferric Oxide with the same stone I could however detect no difference in its setting capacity. I then considered my work at a close as I could conceive of no better way to ~~perform~~ the experiments and of no other rational mixture where Local material could be used that was plentifull and cheap.

I allowed all these Cements to stand under water three weeks and some of them seven weeks as they had not set then it was pretty good evidence they never would and even if they should after such a length of time they

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would be unfit for work for time is always a consideration.

As I have tried in every way I can conceive of to make a cement from local materials that can be obtained cheaply and plentifully and failed in each case to get a Hydraulic cement that would answer the specifications of any good piece of masonry, in fact not as strong as common lime cement I have concluded that from a practical stand point, Hydraulic cement cannot be made of the Lime Stones of this vicinity.

Respectfully Submitted

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