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SUBJECT

Application of Petrographic Methods to a Study of Canadian Cements and Aggregates for Concrete

NOTE

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APPLICATION OF PETROGRAPHIC METHODS TO A STUDY OF CANADIAN CEMENTS AND AGGREGATES FOR CONCRETE

by V. Chaly

I would like to tell you in a few words about the petrographic examination of aggregate, determination of its qualitative and quantitative composition, detection of reactive or dangerous minerals, and the possibilities for direct visual observation offered by the petrographical methods in the studies of concrete, its structure and phenomena due to various conditions of treatment.

We have started a long-term study of Canadian aggregates and cements which is intended to provide basic information relative to the durability of concrete. It is hoped that this work will, in time, reveal the various causes of concrete deterioration and suggest preventive measures that may be applied.

For the moment we are at the first stage of this study consisting of:-

1. Examination of aggregates from different parts of Canada, analysis of aggregates used in our experiments, documentation of the distribution and occurrence of different types of aggregates employed in concrete.

2. Mixing of preliminary selected and examined aggregate with different types of cement.

3. Study of changes in samples prepared as above and treated under different temperature and humidity conditions (wetting and drying, and freezing and thawing tests).

The samples of aggregate are submitted to the granulometrical test, organic test, and petrographical analysis of each granulometrical fraction so as to determine the exact mineralogical composition of each fraction and distribution of different minerals present in granulometrical fractions.

The specific procedures employed in the petrographic examination of any sample will depend to a large extent on the purpose of the examination and the nature of the sample. Petrographic examinations are made:

1. To determine the physical and chemical properties of the material that may be observed by petrographic methods and that bear on the quality of the material for its intended use.

2. To describe and classify the constituents of the sample, and

3. To determine the relative amounts of the constituents of the samples: this is essential for proper evaluation of the sample when the constituents differ significantly in properties that bear on the quality of the material for its intended use.

Identification of the constituents of a sample is usually a necessary step towards the recognition of the properties which may be expected to influence the behaviour of the aggregate in its intended use. The value of any petrographic examination depends to a large extent on the representativeness of the samples examined and the completeness and accuracy of the information provided to the petrographer concerning the source and proposed use of the material. Such a method will be used for the recognition of the characteristic properties of rocks and minerals and to describe and classify the constituents of an aggregate sample. It is intended to outline the extent to which such techniques should be used, the selection of properties which should be looked for, and the manner in which such techniques may best be employed in the examination of samples of aggregate.

The simplest methods are given by Geikie in his "Textbook of Geology" in 1893. It uses a combination of simple physical and chemical determinations to identify the rock. In some cases the individual minerals can be identified and the rock can be named from a knowledge of its component minerals, their abundance, and the relative amount of each. In other cases the minerals may be too small to identify with the hand lens, and recourse must be had to the general distribution of the minerals and to the structure of the rock. The equipment needed consists only of a knife blade of good steel, a small magnifying glass of 6x to 10x power, and a bottle of dilute hydrochloric acid with a dropper. It should not be expected that this method will permit the identification of any and all rocks, but it is able to identify the more common rocks used as aggregate.

In those cases where the rock cannot positively be identified, the more complicated technique will be used:

1. Determination under the stereoscopic microscope using higher magnifications (from 6x to 180x), or

2. Determination in thin sections or polished surfaces with special petrographic microscope under polarized, transmitted, or reflected light (magnification from 20x to 2200x) and using special methods and techniques.

With the help of a magnifying glass and a knife blade or using stereoscopic or petrographic microscopes and applying all its numerous accessories and more or less complicated techniques, we are in a position to determine with certainty all mineralogical constituents and the type of rock composing the sample. Knowing the mineralogical constituents and their individual qualities we can easily determine the behaviour of this particular sample as aggregate in concrete, and, consequently, the physical and chemical properties of the concrete containing the above-mentioned aggregate.

Over 100 samples of gravel and natural sand are sieved according to A.S.T.M. Method of Test for Sieve Analysis of Fine and Coarse Aggregate (C 136 Test) to provide samples of each sieve size. The results of the sieve analysis of each sample are used in calculating results of the petrographic examination. Each sieve fraction is examined separately, starting with the largest size available. 300 or more particles of each sieve fraction are identified and counted using the stereoscopic microscope for the particles of larger size, and the petrographic microscope for the particles of smaller size sieve fraction.

The composition of each sieve fraction of a sample is calculated in percentage so as to be able to deduct the globular composition of samples.

During the petrographic examination of samples, our attention was particularly drawn to the presence of minerals or materials which may produce destructive effects in concrete, as for example, provoking expansion, cracks, change of colour, etc. (extensive premature alteration). The following particles were considered with more attention than ordinary constituents of aggregates:

1. Reactive minerals and rocks

2. Organic materials (coal, lignite, wood fibres, etc.)

3. Colouring materials as iron oxide, for example.

In selecting aggregate materials for these studies, rocks were primarily chosen which had been suggested as being susceptible to attack by alkalies of cement. Other materials were chosen whose behaviour was doubtful or unknown.

Then, the samples of natural sand and gravel were used in their natural state as aggregate for a series of tests, such as compressive strength test on 2"x2" cubes, mortar bar expansion test, freezing and thawing test, and wetting and drying test.

All bars and cubes are prepared with two different types of cement which differ essentially in their alkali content.

Chemical analyses of these cements are as follows:

Chem. comp.	SiO_2	Al_2O_3	Fe_2O_3	AgO	SO_3	Na_2O	K_2O	MgO	Alkali calcul. as Na_2O
Belleville	21.2	6.9	3.0	63.0	1.9	0.54	0.96	1.8	1.19
Exshaw	21.3	5.3	2.9	63.1	1.9	0.09	0.54	3.2	0.45

One set of bars is prepared for each of the high and low alkali cements, and using the high and low alkali cements two sets of bars and cubes are prepared under the same conditions of flow and cement aggregate ratio from each previously examined and selected aggregate.

The bars and cubes are moulded the same day and after 22-24 hours are removed and placed in high humidity and constant temperature curing chamber.

The cubes are tested at the usual age of 28 days. At the same time the 11" bars start their freezing and thawing and wetting and drying tests, while the mortar bar expansion test starts with bars 7 days old.

The tests consist of the following:

1. Standard mortar bar expansion test-treatment of bars at 100°F in high humidity air conditions.

2. Freezing and thawing test - freezing at 10°F for 16 hours in air and thawing in water at room temperature for 8 hours.

3. Wetting and drying test - wetting at 75°F in water for 16 hours and drying in air at 130°F for 8 hours.

Appropriate testing equipment was constructed in our own laboratory.

All bars are measured on the standard comparator regularly and the results recorded.

In order to reduce the number of factors affecting the results, tests were made also on a number of the pure minerals and rocks. These include, quartz, opal, chert, chalcedony, obsidian and pumice.

The grading of these pure artificial aggregates is concordant with A.S.T.M. methods for testing fine aggregate and is as follows:

retained on sieve No.	8	-	19%
"	16	-	19%
"	30	-	19%
"	50	-	19%
"	100	-	19%
passing sieve	No.100	-	5%

The 5" bars are prepared and treated under the same conditions as samples of natural aggregate.

On the other hand, we propose to add these reactive minerals in different percentages and of different grain sizes to the normally inactive aggregate previously examined, in order to see the effect of their presence on the behaviour of concrete.

A representative part of each mixture is reserved for microscopical study. These specimens are treated under the same conditions, i.e., mortar bar expansion test, wetting and drying, and freezing and thawing tests. The thin sections or polished surfaces can be prepared and examined with the petrographical microscope.

Parallel to the study of natural aggregate and special samples a test is being conducted for determining the solubility of salts present in concrete.

This test consists of immersing bars containing high alkali cement in water for 16 hours and drying at 130°F in an oven for 8 hours. The test is repeated 2 - 4 - 8 and 16 times. Water samples are periodically analysed in order to determine the ph of the solution and amount and nature of the dissolved salts.

Other tests have been undertaken in order to study the effect of admixtures in concrete made with Canadian materials. Air-entraining agents, fly ash, pozzolanic materials, and other admixtures are used in conjunction with ordinary sands or specially prepared aggregates.

In conclusion, I would like to outline generally our programme of study for the immediate future:

1. Study of Canadian aggregates, their physical and chemical properties and behaviour in concrete.

2. Study of the properties of Canadian cements.

3. Study of the most satisfactory combination of a particular cement and aggregate and its application for a special type of construction.

4. Theoretical studies on durability of aggregate and concrete. This includes: porosity and capillary effects, freezing and wetting effects, chemical reactions between aggregates and cements, etc.