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MINES BRANCH INVESTIGATION REPORT IR 66-25

EVALUATION OF THREE MATERIALS FROM BRITISH COLUMBIA FOR USE AS NATURAL POZZOLANS

by

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MINERAL PROCESSING DIVISION

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SUMMARY OF RESULTS

Petrographic examination showed that samples P1 and P3 are fine and medium grained micaceous sand derived from an igneous or metamorphic rock of granite origin. The mineralogical compositions of the materials indicate that they have no value as pozzolans. They also have no commercial value as sand for use as fine aggregate in concrete or mortar mixes.

Tests carried out on sample P2 show that in the natural state the material has little value for use as a pozzolan. However, when calcined at about 1900° F. and then finely ground, the material showed excellent pozzolanic properties. Its pozzolanic activity index with Portland cement was 134 per cent of control, and that with lime showed 1025 psi, which is well above the minimum requirements for pozzolan.

The drying shrinkage of mortar bars containing the calcined material at 28 days was 0.057%, which is more than the permissable 0.03% specified by the ASTM.

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INTRODUCTION

Three different samples of material from British Columbia were submitted by Mr. James A. Rutherford, a prospector from Vancouver, B. C., for examination and evaluation for use as pozzolan.

Pozzolans may be defined as siliceous materials that in themselves possess little or no cementitious value, but will, in finely divided form and in the presence of moisture, chemically react with calcium hydroxide at ordinary temperatures to form stable, insoluble compounds possessing cementitious properties.

Pozzolans are used principally to supplement or partially replace Portland cement to obtain specific properties such as: reduction in the heat of hydration of mass concrete; reduction in bleeding and permeability; and improved concrete workability.

TEST SAMPLES

The following samples (Lab. No. CM 205) were submitted for evaluation:

P1 - Very fine grained micaceous sand;
P2 - Very fine grained consolidated mudstone;
P3 - Fine grained micaceous sand.

These samples originated from the area near the Columbia River dam project. Samples P1 and P3 have no commercial value. Sample P2 was taken exactly at the railroad station of Tete Jaune, B. C. on the main C.N.R. line between Jasper and Prince George. This deposit is extensive, and has been formed as a Pleistocene lake accumulation.

TEST PROCEDURES

Each sample was examined by a petrologist using a stereo-microscope. Mineral compositions of the samples were determined by approximate grain counts. Sample P2 was studied in more detail using X-ray diffraction and chemical analysis. This sample was tested also for its pozzolanic properties in accordance with ASTM C 402-65T.

The particle size distribution of all test samples was determined by sieve analysis.

TEST RESULTS

Petrographic Description*

A. Samples P1 and P3 are tan coloured, fine and medium grained micaceous sands. They were split into two fractions at specific gravity 2.70 for study. Approximate grain count analyses gave the following mineralogical compositions:

TABLE 1

MINERALOGICAL COMPOSITION

Mineral Constituents	Composition, per cent	
	P1	P3
Muscovite	22	15
Biotite	8	8
Quartz	35	45
K-feldspar	6	1.5
Na-feldspar	20	20
Hornblende	2	2
Garnet	1	3
Apatite	1	Negl.
Epidote	1	0.5
Carbonate	1	Negl.
Sphene	Negl.	Negl.
Tourmaline	Negl.	Negl.
Miscellaneous	2	5
	99	100

Both sand samples P1 and P3 could have been derived from an igneous or metamorphic rock of granitic composition.

* Petrographic examination and X-ray diffraction by J. A. Soles, Divisional Petrologist.

Sand P1 is very fine grained, with percentage passing sieves Nos. 200 and 325 being 57 and 34 respectively. Sand P3 is somewhat coarser. Both are contaminated by muscovite and biotite in amounts ranging from 23 per cent in sand P3, to 30 per cent in sand P1. Benefication of the sand by removal of mica would be a costly procedure. It must be mentioned that this mica is not of the type which is being used for production of expanded vermiculite.

B. Sample P2 is a greyish tan, fissile, thinly laminated, porous mudstone (shale) having a conchoidal fracture.

Microscopic study of a thin section (TS-18-64) revealed that the sample was an aphanitic mass containing minute oriented flakes and particles of less than 10 microns in diameter. Occasional lamellae contain larger flakes (1 mm) of mica.

An X-ray diffractogram showed that the following minerals are present:

Hydrous mica (e.g.Muscovite): Major constituent
Mixed-layer chlorite montmorillonite: Major constituent
Quartz: Minor constituent
Kaolinite: Small amount

The material is a semi-consolidated sediment.

Chemical Analysis

The results obtained from the chemical analysis of the sample P2 are given in Table 2. Also shown are the chemical requirements for pozzolan as specified in ASTM C 402-65T

TABLE 2

CHEMICAL COMPOSITION

Chemical Constituents	Test Sample CM 205 - P2* per cent	ASTM Specification C 402-65T, per cent
Silicon dioxide (SiO_2) plus aluminum oxide (Al_2O_3) plus iron oxide (Fe_2O_3)	75.64	Min. 70.0
Magnesium oxide (MgO)	3.95	Max. 5.0
Sulphur trioxide (SO_3)	0.06	Max. 3.0
Loss on Ignition (L.O.I.)	7.00	Max. 10.0
Moisture content	2.48	Max. 3.0

* Chemical analysis from Mines Branch Internal Report MS-AC 64-377.

Physical Tests

Tests were carried out in accordance with the ASTM specifications for "Raw or Calcined Natural Pozzolans for Use As Admixtures in Portland Cement Concrete". (ASTM Designation C 402-65T).

Sample P2 was crushed in a laboratory jaw crusher to minus four mesh size and then ground in a laboratory porcelain pebble mill for $5\frac{1}{2}$ hrs.

Another sample of the same material was calcined at 1900° F. prior to grinding. The raw and calcined samples of the finely ground material were tested for fineness and pozzolanic properties. The percentages retained on a No. 325 sieve, pozzolanic indices with Portland cement and lime, as well as the shrinkage values are shown in Table 3, both for raw and calcined material. Also shown are the ASTM specification requirements for pozzolans.

TABLE 3

PHYSICAL PROPERTIES AND SPECIFICATION REQUIREMENTS

Physical Properties	Test Sample CM 205-P2		ASTM SPECIFICATION C 402 - 65 T
	Raw	Calcined	
Amount retained when wet sieved* on No. 325 sieve, per cent	10.0	4.0	Max. 12.0
Pozzolanic activity index:			
With Portland cement, at 28 days (per cent of control)	53	134	Min. 75
With lime, at 7 days (psi)	115	1025	Min. 800
Change of drying shrinkage of mortar bars at 28 days, per cent	0.02	0.057	0.03

* Sieve analysis made on Alpine Jet Sieve apparatus (See Ref. 1)

DISCUSSION

The mineralogical compositions of samples P1 and P3 indicate that their silica content is too low to meet the minimum requirement of ASTM C 402 for pozzolans.

Although the results of the chemical analysis indicate possible pozzolanic properties of sample P2, the physical tests carried out on the sample show that in the natural raw state the material has little value for use as a pozzolan in Portland cement concrete.

However, if the same material is properly heat treated, its pozzolanic properties can be increased appreciably. Tests carried out on this material, calcined at about 1900° F. produced excellent pozzolanic activity indices both with Portland cement and with lime.

A drawback of the calcined material, as shown in the tests, is the excessive shrinkage, which is nearly double the permissable amount specified by ASTM C 402. If this material is to be produced on a commercial basis the shrinkage property should be further investigated.

CONCLUSIONS

Samples P1 and P3 do not have suitable pozzolanic properties.

Material represented by sample P2, however, may be used as a pozzolanic additive in concrete, provided it is calcined at a temperature ranging from 1800 to 1900° F. and ground to pass a No. 325 sieve.

The optimum amount of the pozzolan to be used should be determined by making a series of concrete test mixes incorporating different amounts of the above material. It is considered that such a program can be satisfactorily carried out by a commercial testing laboratory.