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A SURVEY OF SOME ILLINOIS MATERIALS POSSIBLY USEFUL AS POZZOLANS

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SUMMARY

Because of the current interest in pozzolans as addivitives to portland cement to modify its properties in certain desirable ways and because Illinois has no known deposits of the usual natural pozzolans, the Illinois State Geological Survey has made a preliminary study of four samples of Illinois shales, eight samples of various types of clays, and two samples of silica, one each from northern and southern Illinois. In their natural state most of the samples had little pozzolanic reactivity. When heated at various temperatures up to 1300° C, four samples - kaolin near Anna, fireclay near Hadley, an absorptive clay near Olmsted, and a residual clay at Mermet - gave results suggesting that they merit further investigation as pozzolans. All four of these samples except that from Hadley came from extreme southern Illinois.

INTRODUCTION

Mielenz et al. (1952b) have defined pozzolans as "natural or artificial siliceous and aluminous substances which are not cementitious in themselves, but which contain substances that react with lime at atmospheric temperatures in the presence of water to form cementitious compounds." This definition includes natural pozzolans, meaning naturally occurring materials that display pozzolanic activity in the raw state or that may have such activity induced in them by heating. Some of the more commonly used pozzolans are volcanic ash and pumicite. The use of fly ash from large coal-burning installations also has been proposed.

In recent years interest has revived in the use of pozzolanic materials, due largely to the need for cements with special properties for use in situations in which the characteristics of ordinary portland cement are in some respects inadequate.

Pozzolans are used in two ways - to replace a portion of the portland cement used in the preparation of concrete and to modify the properties of mortar or concrete in such ways as to improve it for use in general or special situations. For example, pozzolanic materials are used to control the generation of heat in large masses of concrete during the setting period, to minimize the effects of reactive aggregates, or to reduce expansion of concrete during setting. The pozzolan may be introduced at some suitable stage in the cement manufacturing process or may be added during the concrete mixing process, depending on the situation and on the effect desired.

The current interest in pozzolans and the lack of information about possible natural pozzolanic materials in Illinois led to a preliminary study of twelve samples of clays and shales and two samples of silica from Illinois. Four samples of out-of-state materials also were tested for comparative purposes because they represented fairly pure clay mineral types. The Illinois samples were chosen as typical of those materials in the state that might be expected to have pozzolanic properties. No volcanic ash or pumice deposits are known in Illinois. The source and brief mineralogical and geological descriptions of the samples are listed at the end of this paper.

TESTS

The samples were evaluated by means of a chemical test proposed by Mielenz et al. (1952a) who believed it would indicate the ability of a pozzolan to control expansion of mortar resulting from reaction between cement alkalies and susceptible aggregates. They showed that results of the test correlated reasonably well with the Pyrex mortar bar expansion test for 63 pozzolanic materials. The test involves heating a mixture of the sample with a standard solution of sodium hydroxide in the presence of lime and determining the amount of alkali neutralized during the test.

The results are expressed in milliequivalents per liter of sodium hydroxide neutralized. The details of the test are set forth in the reference given. A "reduction in alkalinity" of 210 milliequivalents or more per liter is considered a criterion of a satisfactory pozzolan from the standpoint of control of alkali-aggregate expansion.

The samples, collected from the sources and/or locations described under "Materials," were air-dried and ground in a small laboratory hammer mill, using a screen with holes one-eighth inch in diameter. The material thus ranged from fine dust to particles about one millimeter in diameter. The silicas were ground at the supplier's plant and were considerably finer.

Portions of each sample were heated in an electric furnace to the temperatures indicated at the tops of the various columns in the accompanying table. The numbers in the first column serve to identify the raw material as described in the section "Materials." The numbers in the columns are the "reduction in alkalinity" expressed in milliequivalents per liter. The higher this number, the greater is the probability that the material may be useful as a pozzolan.

DISCUSSION

On the basis of the results set forth in table 1, four of the 14 Illinois samples studied may merit further consideration as pozzolans - sample 996N, a kaolinitic clay from near Hadley in western Illinois; sample 869, a kaolin clay from near Anna in extreme southern Illinois; sample Fe 101, a montmorillonite clay (Porters' Creek Clay) from Olmsted, and 1520B, a residual clay with a kaolinite content of about 50 percent.

Sample Fe 101 (principally montmorillonite) exhibited good alkali reduction even in the raw state and continued to do so until the calcination was carried above 900° C.

The Anna kaolin (sample 869) was nearly as good as sample Fe 101 through the lower temperatures, and samples heated to 1100° C were still active.

Sample 996N, a kaolinitic clay from near Hadley, was a borderline material, but it developed quite good alkali reduction capacity when heated to temperatures in the range 900° to 1100° C.

None of the shales tested gave promise.

Samples SIS, a southern Illinois silica, and 1520B, a residual clay, may be of questionable worth as prospective pozzolans.

The four out-of-state samples - 877, 868, DB, and 882 - as well as the Illinois sample 410 were included because they represent a very high, well crystallized kaolinite content (877), a western type montmorillonite (868), a southern type montmorillonite (DB), a quite pure illite (410), and an attapulgite (882).

Because most common clays and shales contain kaolinite, montmorillonite, illite, and silica in varying proportions, it is to be expected that, qualitatively at least, their properties (pozzolanic properties included) will be more or less directly influenced by the amount and kind of minerals of which they are constituted. Sample 410, which has high illite content, gave low alkali reduction values. Therefore is is not surprising that sample 866, similar in clay mineral content to sample 410 but containing less illite, gives somewhat higher alkali reduction values. Sample NIS, almost pure quartz, gave very low alkali reduction values. Therefore clays or shales with high quartz and high illite content may be expected to give low alkali reduction values. Conversely, high-kaolinite or high-montmorillonite contents tend to increase the probability that the material will be useful as a pozzolan.

REFERENCES

Mielenz, R. C., Greene, K. T., Benton, E. J., and Geier, F. H., 1952a, Chemical test for alkali reactivity of pozzolans: ASTM Proc., v. 52, p. 1128-1144.

Mielenz, R. C., Witte, L. P., and Glantz, O. J., 1952b, Effect of calcination on natural pozzolans: ASTM Spec. Tech. Pub. No. 99.

TABLE 1 - RESULTS OF TESTS ON POTENTIAL POZZOLANS*

Numbers indicate reduction in alkalinity

Sample No.	Raw	500° C	570° C	600° C	700° C	800° C	900° C	1000° C	1100° C	1200° C	1300° C
Clays											
410	53	59	57			95	46	0	6		
866		85			92	112	155	34	17	11	
936N	27	178	212		176	209	222	305	264	36	100
869	30	234	232		239	246	328	361	323	195	125
877		238	220			235	248	351	365	245	244
Fe 101	279	279	248		300	276	333	0	105	43	64
868	140	152			114	207	183	62		9	
DB	200	205		124	134	254	203	218	23	26	
882	188	286	284		328	335	310	83		59	
1423	13	8		45	23	28	78	24	14	19	65
1321A	12	24			26	80	33	11	10	75	
1520B		216			136	173	107	75	31	68	
Silicas											
NIS	15	12		14		24	21	24	21	29	83
SIS	125	112			100	84	79	40	77	102	258
Shales											
1325A	21	4			18	4	2	14	8	33	
1337	15	11		6		18	56	6	15	10	
1427	18	62			20	31	54	21	25	9	
1425		67			69	69	34	17	54	62	

*Procedure from Mielenz, Greene, et al., p. 1143.

Materials

Clays

410 Near S½ SW¼ sec. 31, T. 19 N., R. 13 W., Vermilion County, Illinois, about two miles south of Fithian along each cut bank of Salt Fork Creek, west of farm house and south of bridge over creek. This clay is Fithian illite that comes from beneath the coal in the Fithian Cyclothem (Pennsylvanian age). The clay contains quartz, pyrite, gypsum, illite, and mixed-lattice clay minerals.

866 N½ sec. 11, T. 33 N., R. 8 E., Grundy County, Illinois, about six miles east of Morris. This clay is probably from the Seahorn Cyclothem (Pennsylvanian age). It contains quartz, gypsum, pyrite, illite, and mixed-lattice clay minerals, the latter in higher proportion to illite than sample 410.

996N NW¼ SW¼ NW¼ sec. 10, T. 4 S., R. 5 W., Pike County, Illinois, about two and a half miles north of Hadley on north of old road just before it turns north (east of new part of road in south valley wall of Hadley Creek). This clay is the lowest Pennsylvanian age deposit in the area. The mineral composition is kaolinite, quartz, and illite. About half of the kaolinite is well crystallized and half approaches halloysite.

869 SE¼ SW¼ sec. 35, T. 11 S., R. 2 W., Union County, Illinois, about three miles west of Cobden, southwest of Clear Creek, along west side of county road. The clay, known as Anna kaolin, is a poorly crystalline kaolinite and quartz (Cretaceous age).

877 Dry Branch, Georgia, from the pits of the Georgia Kaolin Company. The kaolinite is a well crystallized variety. The clay is of Cretaceous age.

Fe 101 SW¼ SW¼ sec. 26, T. 15 S., R. 1 E., Pulaski County, Illinois, at the Star Enterprise pit south of Olmsted on the west bank of the Ohio River. This is Porters Creek Clay (Tertiary age). The mineralogy is montmorillonite, quartz, and illite. The clay is principally montmorillonite which has the natural properties of a fullers earth.

868 Belle Fourche, South Dakota, supplied by the American Colloid Company. The mineralogy is montmorillonite (low iron), cristobalite, and gypsum. The clay is of Cretaceous age.

DB Pontotoc, Mississippi, supplied by International Minerals and Chemical Corporation. The mineralogy is montmorillonite (high iron), cristobalite, and limonite. The clay is of Cretaceous age.

882 Quincy, Florida, supplied by the Floridin Company. The mineralogy is attapulgite, quartz, and montmorillonite. The clay is of Miocene age.

1423 NW¼ NW¼ sec. 21, T. 15 S., R. 3 W., Alexander County, Illinois, about one and a half miles south of Thebes along the east Mississippi River bluff, east of the Missouri Pacific Railroad, back of farmhouse in the clay pit of Illinois Mineral Company. The clay is of Cretaceous age. The mineralogy is kaolinite, halloysite, illite, and quartz.

1520B SE¼ NE¼ sec. 22, T. 14 S., R. 3 E., Massac County, Illinois. Residual clay about one mile northwest of Mermet, west of U. S. Highway 45 and C. B. & Q Railroad. The clay, a residual clay over Mississippian age limestone, is probably pre-Pleistocene.

1321A SW¼ SW¼ sec. 34, T. 27 N., R. 8 E., Livingston County, Illinois, north of Chatsworth. The clay is Wisconsinan glacial till. The mineralogical composition is chlorite, illite, mixed-layer clay minerals, quartz, dolomite, and calcite.

Silicas

NIS Ground quartz produced by grinding St. Peter Sandstone from La Salle County, Illinois. Mineralogy is quartz. The sample is from St. Peter Sandstone which is of Ordovician age.

SIS "Amorphous" silica or tripoli from Alexander County, Illinois. The mineralogy is quartz. The deposit is of Devonian age.

Shales

1325A SE¼ NE¼ sec. 12, T. 5 N., R. 4 W., McDonough County, Illinois, north of Colchester. The material is the Francis Creek Shale (Pennsylvanian age). The mineralogy is illite, chlorite, quartz, mixed-lattice clay minerals, and kaolinite.

1337 SE¼ SE¼ NW¼ sec. 24, T. 1 S., R. 4 W., Brown County, Illinois, north of gravel road in west cut bank of Dry Fork Creek about three miles southwest of Mt. Sterling. The shale is the Purington and is of Pennsylvanian age. The mineralogy is illite, quartz, chlorite, and mixed-lattice clay minerals.

1427 NE¼ NE¼ sec. 28, T. 7 N., R. 3 E., Rayette County, Illinois, about a fourth of a mile west of St. Elms, north of Pennsylvania Railroad and south of county road. The material is a shale from the Mattoon Formation of Pennsylvanian age. The mineralogy is illite, chlorite, quartz, mixed-layer clay minerals and siderite.

1425 SW¼ NW¼ SE¼ sec. 14, T. 12 S., R. 2 W., Union County, Illinois, about two miles west of Anna-Jonesboro, west of State Pond dam on south valley wall of creek below dam. Clay is from New Albany Shale of Devonian age. The mineralogy is illite, chlorite, and quartz.