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LIGHTWEIGHT BRICKS MADE WITH CLAY AND EXPANDED PLASTIC

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A B S T R A C T

Lightweight bricks can be made from Illinois brick clay combined with expanded plastic. The bricks have an attractive texture, weigh half as much as ordinary bricks, have insulating and accoustical advantages, and can be made by conventional extrusion means at a reasonable cost.

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INTRODUCTION

Before and after World War II, the Illinois State Geological Survey investigated the possibility of making lightweight brick from clay mixed with a filler of peat or shredded corncobs. The results were described by Lamar (1955) in Illinois Industrial Minerals Notes 2. The bricks had an interesting pitted texture and were light in weight. Those made with peat weighed from 40 to 100 pounds per cubic foot and those made with corncobs weighed from 55 to 95 pounds per cubic foot. However, both peat and corncob bricks showed too much linear shrinkage during the drying and burning cycles, and the fired bricks were not of uniform size.

As sources of peat and corncobs are fast disappearing because of urban expansion and modern harvesting techniques, a new filler that could be used to make satisfactory lightweight bricks is needed. A recent Survey investigation into the field of lightweight ceramic products is described by White and O'Brien (1964), who showed how a completely ceramic lightweight block could be made with aggregate derived from bloated shale and a clay matrix. These all-ceramic blocks were shown to be better than lightweight concrete blocks for many purposes.

A recent news release (Chem. Age, 1966) indicated that a patent had been issued in Sweden for building bricks of high mechanical strength, light weight, and excellent insulating properties. The bricks were made of clay and prefoamed polystyrene beads. The beads, which have diameters of 1 to 3 millimeters, weigh about 1 pound per cubic foot when bloated. When they are fired they evaporate, leaving fine, almost spherical holes in the finished brick. There is no ash or residue. The United States rights to this process are held by Johns-Manville and cover the production of this particular type of expanded plastic (called "Flamingo Foam") and its incorporation into clay products*. Another patent (U. S. 3,258,349) bearing closely on this subject was issued June 28, 1966, to G. F. Scott and assigned to the Norton Company. It covers the manufacture of insulating refractories from alumina and polystyrene beads.

* Personal communication from Paul V. Johnson, Deputy Director of Research, Structural Clay Products Research Foundation, Geneva, Illinois, 1967.

MATERIALS USED IN TESTS

Polystyrene resins are available from a number of companies. For the tests reported here, Pelaspan 222M, a spherical form of expandable polystyrene, was donated by the Dow Chemical Company, Midland, Michigan.

The clays, one red-burning and one buff-burning, were obtained from the Western Brick Company, Danville, Illinois. The red-burning clay is a marine shale of Pennsylvanian age that occurs above the No. 6 Coal at Western's pit near Danville. During the stripping operations, some of the Pleistocene till overlying the shale is probably mined with the shale. The buff-burning clay is purchased by Western Brick from a supplier in Indiana. It is undoubtedly a Pennsylvanian underclay, and is similar in composition and properties to many Pennsylvanian buff-burning underclays that occur in Illinois.

The purpose of the investigation by the Geological Survey was to determine whether or not Illinois clays could be used with polystyrene beads to make lightweight brick. The results are presented to producers of structural clay products as evidence that such products could open an interesting field. Any commercial application of this work should, of course, be preceded by a more complete review of the patent literature.

LABORATORY PROCEDURES

The polystyrene was bloated by one of two methods. In the first, live steam was passed through the material; in the second, steam heat was applied externally to the vessel that contained the polystyrene. The live steam technique produced beads in a wide range of sizes, which had to be dried before sizing or other treatment. The dry heat procedure produced beads of more uniform size, perhaps 10 percent oversize and 10 percent undersize when screened in the range from -6 mesh to +10 mesh. The undersized spheres were cycled into the next bloating process.

The clays were mixed with various amounts of expanded polystyrene spheres. The volume ratios of clay to plastic appear in tables 1 and 2. The dry clay and polystyrene were hand mixed; water was then added until the mixture was plastic. The bricks were made in a conventional laboratory model extruding machine manufactured by the International Clay Machinery Company. The mixture was extruded through a die 1 inch square and was cut into briquettes 4.5 inches long. These were air dried and fired at various temperatures in an electric kiln for 24 hours, a schedule similar to that used in the brick industry. Briquettes were made with red-burning and with buff-burning clays. The temperatures used were selected to cover the range commonly employed for commercial firing of these types of clays.

Specimens were cut from the briquettes and tested for compressive (crushing) strength, modulus of rupture, cross-sectional shrinkage, water absorption, saturation coefficient, and porosity.

TABLE 1—PHYSICAL AND MECHANICAL PROPERTIES OF MIXTURES OF RED-BURNING CLAY AND POLYSTYRENE BEADS

Volume ratio (clay/ plastic)	Firing temp. (°F)	Poros- ity (%)	Den- sity lb/ cu ft	Cross- sectional shrinkage (%)	Crushing strength (psi)	Modulus of rupture (psi)	Water absorp- tion (%)	Satu- ration coeffi- cient	ASTM grade
100% clay	1832	23.6	113	+1.0	9280	1090	12	.77	SW
3:1	1832	37.7	93	+0.6	3070	...	23	.56	MW
2:1	1832	49.6	82	+0.3	4175	...	35	.63	NW
1:1	1832	49.7	76	+0.1	1390	...	34	.50	NW
0.5:1	1832	58.5	64	0.0	1130	...	54	.38	NW
0.35:1	1832	59.3	60	-2.2*	1030	422	54	.39	‡
100% clay	1922	21.5	113	+2.0	5250	2290	10	.84	SW
3:1	1922	31.1	95	+0.2	3795	1420	18	.57	SW
2:1	1922	35.2	88	+0.2	2665	1090	21	.50	SW
1:1	1922	41.1	73	+0.6	1390	608	31	.49	NW
0.5:1	1922	57.1	62	+0.1	725	205†	51	.36	‡
0.35:1	1922	56.3	57	-2.2*	1300	718†	53	.38	NW
100% clay	2012	7.6	116	+9.2	17030	4785	0.4	.57	SW
3:1	2012	15.2	92	+8.0	2875	1735	7	.31	SW
2:1	2012	18.5	88	+9.5	3500	1710	9	.19	SW
1:1	2012	25.8	74	+9.5	2000	1705	15	.20	MW
0.5:1	2012	45.5	62	+5.0	640	816	34	.30	‡
0.35:1	2012	56.8	61	+7.0	907	757	42	.19	‡

* Negative shrinkage indicates actual expansion over die size.

† Data from single sample only.

‡ Does not meet minimum compressive strength for NW grade.

RESULTS

The results of the tests are shown in tables 1 and 2. The standard testing procedures described by ASTM C-67-62 were followed as closely as was practicable. The specimens were limited to 1-inch cubes, instead of the sizes of test pieces specified by ASTM. The specimen cubes were not capped for compressive strength measurements, except in one series of clay/plastic mixtures, in which it was found that capping did not influence the measured results in any regular or predictable manner. Instead of being capped, the sawed ends of each cube used in the measurements were carefully ground to give smooth parallel faces.

Linear fired shrinkage was not determined directly. Instead, the dimensions of the fired cubes used for the porosity test were measured prior to any wetting and these values were then compared to the nominal dimensions

TABLE 2—PHYSICAL AND MECHANICAL PROPERTIES OF MIXTURES OF BUFF-BURNING CLAY AND POLYSTYRENE BEADS

Volume ratio (clay/ plastic)	Firing temp. (°F)	Porosity (%)	Density lb/ cu ft	Cross-sectional shrinkage (%)	Crushing strength (psi)	Modulus of rupture (psi)	Water absorption (%)	Saturation coefficient	ASTM grade
100% clay	1832	23.5	110	+4.3	4060	1955	12	.87	MW
2:1	1832	31.4	82	+2.7	1545	603	21	.70	NW
1:1	1832	56.5	66	+1.2	668	370	48	.42	*
0.5:1	1832	49.8	63	0.0	400	464	41	.41	*
0.35:1	1832	61.9	58	+0.3	548	292	61	.37	*
100% clay	2012	14.5	104	+8.2	12750	2690	6	.90	SW
2:1	2012	22.6	80	+5.0	1880	1175	14	.65	NW
1:1	2012	54.5	66	+4.5	1580	628	32	.47	NW
0.5:1	2012	47.5	59	+0.8	870	558	36	.36	*
0.35:1	2012	57.8	56	+0.3	375	404	54	.30	*
100% clay	2192	4.2	108	+4.3	9900	2050	2	.69	SW
2:1	2192	16.4	83	+3.0	2920	1235	9	.27	SW
1:1	2192	49.4	64	+2.5	1740	725	31	.43	NW
0.5:1	2192	37.2	58	+2.0	1315	562	27	.23	NW
0.35:1	2192	52.1	56	+2.0	1412	477	48	.32	NW

* Does not meet minimum compressive strength for NW grade.

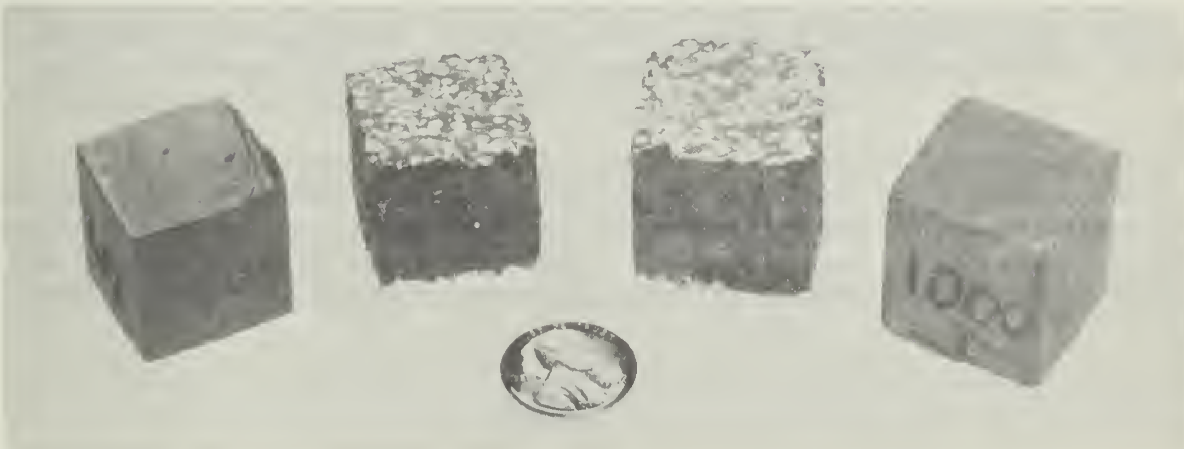
of the extrusion die. These data (called cross-sectional shrinkage in tables 1 and 2) show a decreasing amount of fired shrinkage as the proportion of expanded polystyrene in the body increases, being highest in the pure clay briquettes. In other words, shrinkage is inversely proportional to the percentage of plastic added.

The fired color depends on the clay used and the temperature attained. The red-burning clay turned light red at 1832° F (1000° C), medium red at 1922° F (1050° C), and dark red at 2012° F (1100° C). The buff-burning clay was off-white at 1832° F (1000° C), ivory at 2012° F (1100° C), and yellow-buff at 2192° F (1200° C).

Plate 1 shows specimen cubes of the briquettes made in this study. The top photograph displays cubes of buff brick made with various proportions of clay and polystyrene and fired at 2012° F (1100° C). The lower picture shows samples of red brick fired to two different temperatures; both sets include a sample made with a 0.35:1 clay/plastic ratio and one that was 100 percent clay. The titles and data on the plate are self explanatory.

BRICK SPECIMENS MADE WITH BUFF-BURNING CLAY AND POLYSTYRENE BEADS
(Voids in specimens appear dark because of shadows cast by lighting.)

Vol. % polystyrene	(left to right)	0	33	50	67	74
Firing temp. °F	(left to right)	2012	2012	2012	2012	2012



BRICK SPECIMENS MADE WITH RED-BURNING CLAY AND POLYSTYRENE BEADS
(Holes in top surface of center pair of blocks have been filled with plaster of paris.)

Vol. % polystyrene	(left to right)	0	74	74	0
Firing temp. °F	(left to right)	2012	2012	1832	1832

Plate 1 - Test bricks made with various Illinois clays and polystyrene beads.

USES FOR LIGHTWEIGHT CERAMIC BRICKS

Bricks of attractive texture with light weight, good insulative and accoustical properties, and good strength, such as those produced in this investigation, could be used in many ways. As construction bricks for homes, schools, and light industrial buildings, they would provide not only an attractive appearance but lighter wall weight (requiring less massive foundations), better insulation than solid brick in masonry construction (greater temperature-control efficiency at lower cost both summer and winter), and easier lay-up in the wall. However, because of the rather high moisture absorption of this product, exterior use of such bricks would be restricted to either protected areas or to warm climates. Although the thermal conductivity and accoustical absorption of this type of brick were not measured, the presence of voids in the body would obviously result in superior insulating qualities. This would be desirable in a fireplace wall, or as walls in dens, family rooms, or other parts of homes or office buildings where a low-maintenance, permanent, attractive finish is required. Filling the surface voids with a suitable material of contrasting color would add to its decorative appeal.

The last columns in tables 1 and 2 show the relative ASTM designation described in ASTM Standards (Am. Soc. Testing and Materials, 1964) under standards for building bricks. Grade SW includes bricks intended to be highly resistant to frost action and exposure to freezing when completely water saturated. Grade MW is the designation for bricks subjected to intermittent freezing, but never while completely saturated with water. Grade NW bricks are intended for use as backup or interior masonry and are characterized only by a minimum compressive strength. Some of the lower clay/plastic ratio briquettes do not meet the crushing strength specifications for ASTM grade NW, but it is unlikely that this type of lightweight product would ever be used as a structural backup brick. These lower compressive strength bricks, however, may be satisfactory for many applications, since the lighter weight of the individual bricks would result in lower wall loadings.

Clay-polystyrene mixtures, subject to extensive field testing, also should produce marketable interior patio blocks and floor tile. Wear characteristics should be as good as those of conventional bricks or cement blocks, and the texture would be more attractive. They would have the same advantages when used in patterned masonry screening walls for patios, yards, and interiors.

SUMMARY

Bricks and other shapes of fired products made from Illinois brick clays mixed with bloated polystyrene beads have light weight, good strength, good insulating properties, and a very attractive and unique texture. They can be made at a cost that approximates that of conventional decorative bricks, and could be used whenever light weight or interesting texture is desired.

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