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CHEMICAL TREATMENT OF BEAVERTON, ONT. CLAY TO REDUCE BANK MOISTURE CONTENT AND TO IMPROVE DRYING

by

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INTRODUCTION

A visit was made during a field trip by J.G. Brady and S. Matthews to the plant of the Beaverton Brick and Tile, Beaverton, Ontario. A discussion was held with Mr. Taylor, owner of the plant regarding the moisture content of the local clay used for the manufacture of drain tile. The clay used is a common buff burning, highly calcareous, surface clay which is worked to a depth of approximately eight feet from the surface. Considerable difficulty has been experienced during wet months with the high moisture content of the clay from the portion of the pit close to the river. No clay drying facilities are available and only small clay storage facilities are in use. Mr. Taylor was interested in the possibility of making a chemical addition to the clay so that the excess moisture in the clay would be taken up during pugging. In addition to the high moisture content care must be exercised in drying the clay from this part of the pit. Two samples of clay were taken, one from the pit close to the river and one adjacent to the railroad track well removed from the river. It was decided to investigate these samples in the laboratory and determine if a chemical additive might be used to take up some of the excess moisture in the river clay and at the same time aid drying.

BODY COMPOSITIONS

Evaluation tests were made on the two samples taken at the pit. In addition hydrated lime ($Ca(OH)_2$) and sodium carbonate (Na_2CO_3) were added in small percentages by weight to the river clay. The composition of the bodies are shown in Table 1.

TABLE 1. - Body Compositions

Laboratory No.	Body Composition
158	Pit clay from near river
159	Pit clay from near track
158-1	Clay 158 plus 0.1% $Ca(OH)_2$
158-2	Clay 158 plus 0.3% $Ca(OH)_2$
158-3	Clay 158 plus 0.6% $Ca(OH)_2$
158-4	Clay 158 plus 0.5% Na_2CO_3

PROCEDURE

The clay was dried and ground to pass a 16 mesh Tyler screen. Briquettes of the various bodies, 4½" x 1½" x 1¼" were hand moulded in steel moulds. The clay was tempered with water to a stiff plastic condition. The amount of water required was noted and the water of plasticity calculated. The workability and plasticity were observed. One briquette of each composition was placed immediately into a laboratory drier at 185°F and the effect of rapid drying noted. The balance of the briquettes were air dried for 24 hours and dried finally in a laboratory drier at 185°F. The drying shrinkage was measured. The briquettes were fired to cones 06 (1816°F), 04 (1922°F), 02 (2014°F), and 1 (2077°F) in an electric laboratory kiln under rapid firing conditions in an oxidizing atmosphere. The fired colour, hardness, shrinkage and water absorption after 24 hours in cold water were determined. The pyrometric cone equivalents (PCEs) or softening point of the two samples were determined. It was assumed that the small chemical additions to clay 158 would not affect the P.C.E.

An indication of the mineralogical composition was obtained by differential thermal analysis (DTA).

RESULTS

The results of the physical property tests are shown in Table 2.

Differential thermal analysis shows that samples 158 and 159 are principally a heterogeneous mixture of a micaceous clay mineral, calcium carbonate, ($CaCO_3$), and free quartz. In addition there is probably a small quantity of finely pulverized minerals such as feldspar etc. which do not give a thermal reaction in the differential thermal analysis method. The reaction due to the clay mineral in both samples is very small indicating that the clay mineral content is not higher than 35 to 50%. The clays each contain approximately 15% free quartz (SiO_2) which is normal for most clays. The calcium carbonate content is very high in both samples. Each one contains approximately 25% $CaCO_3$. There was no indication from the DTA curves of the cause of the difference in drying and moisture properties of the two samples.

DISCUSSION OF RESULTS

The test results indicate that samples 158 and 159 are common, fairly plastic, low fusion, highly calcareous, buff firing clays having a PCE of cone 3 (2106°F). The clays fire to a buff colour, expand up to cone 02, have a high absorption and are inclined to be soft up to this temperature because of the high calcium carbonate content. The short firing range is due in part to the presence of this mineral.

TABLE 2 - Physical Properties of Beaverton Clay Bodies

Clay No.	UNFIRED CHARACTERISTICS	P.C.E.	FIRED CHARACTERISTICS					REMARKS
			Cone No.	Fired Skg. % *	Abs. %	Colour	Hardness	
Lab. 158	Grey clay from pit close to river; very calcareous, very plastic, works well, water of plasticity 20%, cracks slightly with rapid drying, drying shrinkage 5.9%.	Cone 3	06 04 02 1	+1.0 +1.5 +1.0 0.6	20.8 20.0 16.5 10.1	cream " " light buff	very soft " " soft fairly hard	This is a common clay containing excessive calcium carbonate. It is inclined to be difficult to dry and the firing range is short.
Lab 159	Grey clay from pit close to railway very calcareous, good plasticity, works well, water of plasticity, 17.5%, safe drying, drying shrinkage 5.7%	Cone 3	06 04 02 1	+1.8 +1.7 +0.8 0	18.9 18.6 14.8 12.5	cream " creamy buff buff	very soft very soft soft fairly hard	This is a common clay containing excessive calcium carbonate. It dries safely and the firing range is short
Lab 158-1 (158 plus 0.10% $Ca(OH)_2$)	The mixture is fairly plastic and works well. It is safe drying, drying shrinkage 5.3%. The water of plasticity is 22%.		06 04 02 1	+0.8 +1.0 0.1 1.7	21.2 18.9 16.2 14.3	dark cream cream buff " " buff	very soft soft fairly soft fairly hard	The 0.1% $Ca(OH)_2$ improves the drying increases the water of plasticity and decreases the drying shrinkage. The firing range is short.
Lab 158-2 (158 plus 0.3% $Ca(OH)_2$	The mixture is fairly plastic and works well. It is safe drying, drying shrinkage 5.7%, water of plasticity 24.4%	Same as 158 (cone 3)	06 04 02 1	+1.1 +1.1 0.3 1.0	21.1 19.1 18.1 17.7	cream " creamy buff buff	very soft " " fairly soft fairly hard	Short firing range, higher absorption than 158, safe drying. The drying shrinkage is similar to 158 and the water of plasticity is greater than 158.
Lab 158-3 (158 plus 0.6% $Ca(OH)_2$	This mixture is fairly plastic and works well. It is safe drying, drying shrinkage 4.7%, water of plasticity 25.0%.	Cone 3	06 04 02 1	+1.0 +1.3 +0.5 2.2	23.4 21.7 19.6 17.8	cream " " buff	very soft " " " " fairly hard	Short firing range, higher absorption than 158, safe drying. Drying shrinkage is less and water of plasticity is greater than 158
Lab 158-4 (158 plus 0.5% Na_2CO_3	This mixture is inclined to be sticky and greasy. cracks in drying, drying shrinkage 5.0%, water of plasticity 17.2%	Cone 3	06 04 02 1	+2.1 +1.6 2.1 3.7	16.9 15.8 12.1 6.4	cream " light buff buff	soft " fairly hard hard	Short firing range, the addition of Na_2CO_3 makes clay 158 crack more than without the chemical. The absorption is reduced and the firing shrinkage increased

* a plus sign indicates expansion

Clay 159 is safe drying while number 158 tends to crack with rapid drying. The water of plasticity for 158 is slightly higher than for 159. This indicates that possibly 158 contains slightly more plastic material which might make it more sensitive to drying and moisutre conditions.

The addition of hydrated lime improves the drying characteristics of 158. A small addition of 0.1% $Ca(OH)_2$ makes this sample safe drying (body 158-1). The clay retains its plasticity with a hydrated lime addition of 0.6% and is safe drying. The water of plasticity increases as the hydrated lime percentage increases. Without hydrated lime the water of plasticity is 20%. For additions of 0.1, 0.3, and 0.6% to this material the water of plasticity is 22%, 24.4% and 25.0%. Thus it is apparent that if hydrated lime is added in small quantities the water required to produce a plastic mass from clay 158 is increased. Accordingly, if the clay initially contains a small amount of excess moisture at the pit for proper extruding, a small addition of hydrated lime would take up this excess water. In addition it will improve the drying charatteristics.

Sodium carbonate acts in just the reverse manner to hydrated lime. A 0.5% addition of sodium carbonate to sample 158 made drying more difficult and reduced the water of plasticity from 20% to 17.5%. Accordingly, it is not a suitable additive for this raw material.

Careful control of any addition of hydrated lime to the clay must be maintained. An excessive percentage will make the clay difficult to extrude and probably produce a white scum on the dried and fired ware. Indications are that from 0.1% to 0.3% is a satisfactory addition.

CONCLUSIONS

The results of the tests indicate that samples 158 and 159 are fairly plastic, common, buff firing, low fusion raw materials. The presence of excessive clacium carbonate tends to cause the product to be soft and porous. These clays tend to expand slightly during firing. This is also caused by the evolution of the carbon dioxide from the decomposition of calcium carbonate. Sample 158 tends to crack with rapid drying and is slightly more plastic than 159. Both samples have a short firing range in which a hard, dense, uniformly sized product such as face brick can be produced.

The addition of hydrated lime $Ca(OH)_2$ improves the drying characterisitcs of 158 and increases the amount of water required to produce a plastic mass from it. Thus a small addition of hydrated lime will tend to partially dry up this clay when it contains a slight moisture excess. The hydrated lime should be thoroughly pugged into the clay before extrusion. An addition of 0.1 to 0.3% should give satisfactory results. A carefully controlled plant trial should be carried out to determine the effect of the additions under plant conditions.

Sodium carbonate is not a suitable additive for use with clay 158.

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