Factors Influencing Strengths of Structural Clay Products from Montmorillonitic Clays*

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Introduction

A clay containing large proportions of montmorillonitic clay mineral (50-60%) and nodular lime (20-30%) is unsuitable for brick making. Bricks made out of such clays exhibit drying cracks, fusion at comparatively low temperature, short vitrification range, tendency to bloat and lime blowing.

Many of the deleterious effects mentioned above are minimized to a great extent by several processes applied either singly or in combination. For instance plasticity can be reduced and workability of the clay improved by the addition of grog. Drying cracks are also reduced by the addition of grog. Lime blowing is prevented by docking [1, 2] i.e. by immersion of the brick in water for a short time after withdrawal from the kiln. By these treatments fairly durable bricks are obtained and attempts to develop stronger bricks have not met with much success. Jain & Coworkers [3, 4] showed the possibility of improving the strengths of structural clay products by wet grinding but these are shown to be applicable only for clays containing low fractions.

Although each of the above processes is claimed to improve the clay for the production of good structural products, a systematic investigation on the effect of various factors, viz. particle size distribution lime, sodium chloride and grog contents, and temperature of firing on strength development is lacking. The paper pertains to investigations on the optimum conditions for maximum strength development and also discusses the inhibitive influence of various factors in obtaining suitable bricks. These studies, it is hoped, will provide a basis for suggesting a suitable treatment for obtaining a brick of desirable strength from montmorillonitic clays.

Experimental

For the purpose of the present investigation

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a montmorillonitic clay of the following composition and properties was chosen (Table-I).

Table-I

Properties of the Clay

	Clay	Silt	Sand
Composition :	(0.002 mm) 53.3	(0.02 mm) 19.8	(0.02 mm) 26.9

Cation exchange capacity 98.6 m.e./100g (Clay fraction)

Differntial Thermal Analysis

Endothermic peaks; 150°C(large) 550°C(medium) 800°C (small)

Exothermic peaks; 350°C(large) 900°C (small)

Chemical Composition :	Per cent
SiO_2	48.65
Al_2O_3	12.83
Fe_2O_3	9.35
CaO	7.87
MgO	2.26
Insolubles	1.49
Loss on ignition	17.33
SiO_2/Al_2O_3	6 42
$SiO_2/Al_2O_3+Fe_2O_3$	4.39

Without any treatment bricks made out of this clay exhibit large shrinkage and cracking during drying. After firing, the bricks disintegrate within 4-5 days due to lime blowing.

Calcium carbonate and Sodium chloride A. R. quality) ground to 200 mesh (ASTM) were mixed with the clay for a study on the effect of varying amounts of calcium carbonate and sodium chloride on strength development. Grog was obtained by firing the clay at 600°C for 3 hrs. Grinding of the clay was carried out in a mortar mill without or with water for varying periods. Briquettes 3″x2″x1½″ were moulded at a suitable moisture content and fired in an electric muffle furnace at 1000°C for five hours unless otherwise stated.

Discussion

Drying cracks in highly plastic clays can be eliminated by the addition of certain electrolytes or an opening material. Calcined clay or sand is generally mixed with the clay to stop drying cracks. Effect of addition of various percentages of grog shows that the drying cracks fail to develop with an addition of 20 per cent or more of grog. In order to determine the optimum amount of grog required to realise maximum crushing strength, several briquettes were prepared by mixing 20, 25, 30, 40, 50, and 60 per cent of grog. The results are plotted in Fig. 1. No visible

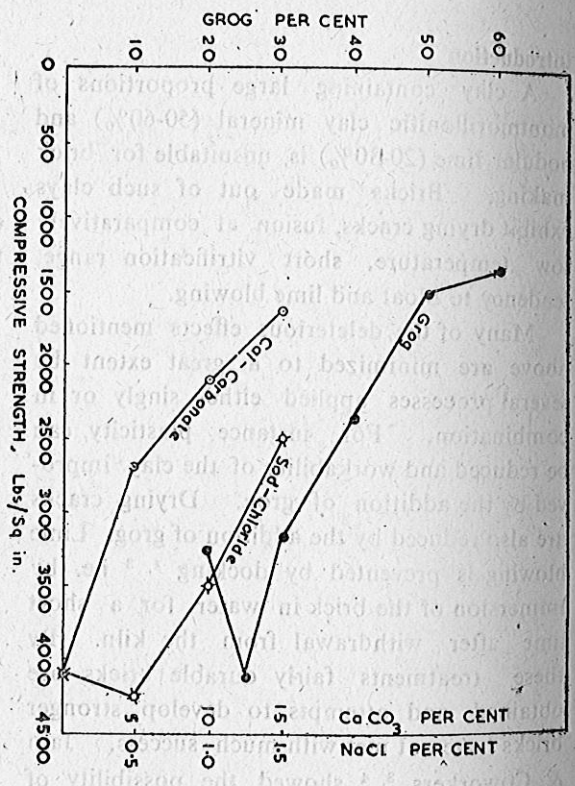

Fig. 1. Effect of Addition of Grog, NaCl & $CaCO_3$ on Strength Development in Montmorillonitic Clays.

drying cracks are observed with 20 per cent grog but fired briquettes exhibited hair cracks. The mixture containing 25 per cent grog and wet ground develops a maximum strength of 4115 lb/sq.in. and this value is about 100 per cent more than the unground mixture. Further increase in grog content results in lower crushing strengths. This is perhaps due to the fact that in a mixture containing low clay fraction the particles of grog and other non-plastic constituents are not held together very closely and rigidly, causing less compaction and strength in the fired products.

It is known that strength develoment of a fired clay depends on particle size distribution of its constituents [5]. A few experiments were carried out to investigate the effect of dry or wet grinding the clay and/or grog portion in the mixture and the results are presented in Table II.

Table II- Effect of grinding on strength development

No.	Method of preparation	Crushing strength lbs/sq.in.
1.	Grog + Clay (both unground)	987
2.	Grog (D G.) + Clay	1322
3.	Grog + Clay (D.G.)	1241
4.	Grog (W.G.) + Clay	1287
5.	Grog + Clay (W.G.)	1131
6.	Grog (D.G.) + Clay (D.G.)	1455
7.	Grog (W.G.) + Clay (W.G.)	1528

D.G: Dry ground, W.G. : Wet ground. The studies pertain to a mixture containing Clay : Grog = 50: 50

The wet ground mixture develops a maximum strength of 1528 lbs/sq.in. and is more than 60 per cent of the strength developed by un-ground mixture. This shows that the method of wetgrinding can be applied to clays having higher clay fractions.

For further experiments, a mixture containing clay : grog in the ratio 75:25 was chosen since this proportion exhibited maximum crushing strength. For a grinding period of one hour a maximum strength of 4115 lbs/sq. in. is obtained but this drops to 3527 lbs/sq.in. and 2157 lbs/sq. in after two and three hours of grinding respectively. Wet grinding results in increased compaction and strength. Excessive grinding will cause enormous reduction in particle size and increased plasticity. This will result in drying cracks and low strengths in the fired briquettes.

Studies on the effect of varying amounts of lime on strength development (Fig.1) shows that with increasing amounts of lime from 5 to 15 per cent the strength drops from 2704 to 1643 lbs. per sq, in. This may be due to the sudden fluxing effect, low vitrification range and development of vesicular structure.

The effect of varying amounts of sodium chloride from 0.5 to 1.5 per cent (Fig.1) shows that strength increase to 4278 lbs/sq in. with 0.5 per cent NaCl. and reduces to 2517 lbs/sq in with 1.5 per cent NaCl The decrease in strength is possibly due to increased fusion of the mass with higher amounts of NaCl.

The effect of temperature of firing from 800 to 1050°C shows that the strengths developed are 2602, 3010, and 4115 lbs/sq. in at 800, 900 and 1000°C respectively. At higher temperatures the briquettes are deformed, due to vitrification.

Acknowledgement

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