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Bricks from the Soils of Kandla Port

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Summary.

Bricks with a strength of about 1500 to 2000 lbs/sq. in. can be manufactured from soils at Kandla Port provided they are fired to a temperature of about 1000°C. Bricks made with untreated soil burst during firing owing to the presence of nitrogenous organic matter and its reaction with soluble salts like chlorides to form ammonium salts. It has been found that the addition of sand, grog or powdered coal overcomes this defect.

Introduction.

It was reported by the Port Authorites at Kandla that the local soil did not yield good bricks as it became deformed during drying. The problem of making good bricks from such soil was investigated and the results are recorded in this paper.

Experimental

Two soil samples K_1 and K_2 were taken for the investigation. Sample K_1 represents the soil of the top 3′, and sample K_2 the soil from a depth lower than 3 feet. International method A was used for the mechanical analysis of the soils. The soluble salts were determined by extracting the salts present in the soils with water and estimating then gravimetrically. The results of the analysis are given in table I and II.

TABLE I.

Mechanical Composition of the Soils.

Soil	Mechanical Analysis Clay	Silt	Sand	CaO in Soil%	Soluble Salts%
K_1	30.5	29.9	39.6	6.98	4.23
K_1	39.5	32.5	27.9	6.62	6.30

TABLE II.

Analysis of Soluble Salts in Soil K_1.

	%
Al_2O_3	0.76
CaO	0.71
MgO	0.36
Na_2O	1.77
Cl	1.87
So_3	0.36

Briquettes (3″×2″×1½″) were moulded from the two soils at a moisture content of 40% and dried slowly in the shade as too rapid drying was liable to produce cracking and warping. Surface efflorescence due to high soluble salts content was removed by brushing. Briquettes were also made incorporating sand, grog and powdered coal in the soils.

Grog was prepared by burning the soils at a temperature of 300° to 400°C and powderlng the calcined product to pass through B. S. Sieve 10. Two types of sand are available in the vicinity of the port area. One of the two samples was coarse and obviously unsuitable for brick making. The other sample contained more fines, but had to be seived through B. S. 10 to separate lime nodules. The briquettes were burnt in an electric furnace at temperatures of 950°C and 1000°C. Their compressive strength and other properties were then determined according to Indian Standard Specifications and are given in table III.

Results and Discussions.

The two soils tested in the present experiments contain a high percentage of clay and a large amount of soluble salts (see table I and II). Both soils behaved abnormally during firing.

TABLE III.

Showing the effect of the addition of sand, Grog And powdered coal on the Physical Properties of Bricks.

Composition	Water absorption 950°C	Water absorption 1000°C	Bulk density 950°C	Bulk density 1000°C	Compressive Strength (p. si.) 950°C	Compressive Strength (p. si.) 1000°C	Remarks
Soil K_1—10% grog.	—	—	—	—	—	—	Burst between 200°C—300°C
Soil K_1—15% grog.	24.1	20.6	1.52	1.54	2105	2396	
Soil K_1—20% grog.	25.7	20.7	1.50	1.61	1993	2800	
Soil K_2—10% grog.	—	—	—	—	—	—	Burst between 200 to 300°C
Soil K_2—15% grog.	24.6	24 4	1.52	1.52	2333	2343	
Soil K_2—20% grog.	21.1	20.8	1.60	1.61	3142	2900	
Soil K_1—10% sand.	—	—	—	—	—	—	Burst between 200°C to 300
Soil K_1—15% sand.	17.4	18.4	1.61	1.67	2984	3199	
Soil K_1—20% sand.	17.4	17.7	1.67	1.66	2721	2912	
Soil K_2—10% sand.	—	—	—	—	—	—	Burst between 200 to 300°C
Soil K_2—15% sand.	20.7	19.4	1.68	1.68	2788	2794	
Soil K_2—20% sand.	18.6	17.5	1.67	1.67	2648	3021	
Soil K_1—1% powd. coal.	—	21.9	—	1 58	—	2386	
Soil K_1—2% powd. coa .	—	23.2	—	1.52	—	2463	
Soil K_1—3% powd. coal,	—	24.20	—	1 50	—	2818	o riquettes burst between 200 to 300°C
Soil K_1—4% powd. coal.	—	24.80	—	1.49	—	2860	
Soil K_2—1% powd. coal.	—	24.50	—	1.68	—	1856	
Soil K_2—2% powd. coal.	—	23.40	—	1.68	—	2239	
Soil K_2—3% powd. coal.	—	23.30	—	1.70	—	2075	Two briquettes burst between 200 to 300°C.
Soil K_2—4% powd. coal.	—	24.30	—	1.73	—	2698	

Violent bursting with the evolution of ammonium chloride was observed between 200 to 300°C. As the soils contain a high percentage of clay, the pores in the briquette are small and the ammonium chloride is not able to pass through them as quickly as it is formed. As a result pressure is developed within the briquettes and this causes bursting.

Leaching the soil with normal potassium sulphate, washing it with water, and treating it with hydrogen peroxide overcame the bursting. When the soils were leached with sulphate solution, ammonium salts could be detected in the leachate. The amount of ammonia recovered by this process was found to be 0.85%. The water extracts of the two soils gave a negative test for ammonium salts, as apparently these were not leached out with the water, indicating that ammonium chloride is not present in a free state in the soils. The addition of 0.5% to 1% ammonium chloride to the leached soil again produced bursting.

The above observations indicate that ammonium salts which are responsible for the bursting of the bricks, exists as nitrogenous organic matter capable of reacting at temperatures of about 200° to 300°C with the soluble salts present in the soil and forming ammonium chloride. This type of reaction appears to take place at ordinary temperature also in the presence of normal sulphate solution which explains the efficacy of leaching out with that solution.

Having established the cause of bursting, investigations were carried out to find a workable method for stopping it. The problem could be attacked in two ways, either the reaction between the soluble salts and organic matter could be inhibited by removing the reactants or the size of the pores could be increased by adding some coarse material, so that the chloride formed as a result of reaction between the reactants could escape through the pores. The organic matter in the soil could be destroyed by treatment with hydrogen peroxide or decomposed by leaching with potassium sulphate. However, these methods are expensive and cannot be used on a commercial scale. The removal of inorganic salts by washing the soil would be another method but this may or may not be practical on commercial scale

The second line of attack involved the adding of grog and sand. It was observed that the addition of more than 15% sand or grog did away with bursting and gave fired bricks of sufficient strength. As both the soils are sticky the addition of coarser materials improves their workability considerably. The use of sand in preference to grog is recommended as it gives a slightly better brick than that obtained by adding an equivalent quantity of grog. Further, the addition of sand (containing 0.2% salts) to a soil containing a high percentage of total soluble salts would decrease the corresponding amount of salt in the total admixture, whereas the quantity of salt would be unaffected by the addition of grog.

In another experiment 1 to 4% powdered coal passing 100 mesh sieve was added to the two soils. It was observed that the addition of 1 to 2% coal was effective in checking bursting whereas with 3 to 4% coal bursting recurred. It is not known whether the small quantity of coal powder causes soil aggregation or inhibits the reaction between the reactants. Further work is needed to elucidate this point.

The physical properties of the two soils as given in table 1, show that soil K_1 should be preferred to K_2 for brick manufacture, as the former contains a lesser percentage of clay and a smaller amount of soluble salts.

Briquettes obtained by adding 20% sand to soil K_1 (an admixture recommended for brick making at Kandla Port) and firing at about 1000°C give a compressive strength of 2912 lb./sq. in. and the corresponding figure for full size bricks ($9'' \times 4\frac{1}{2}'' \times 3''$) as obtained by dividing the above figure by 1.6 is 1812 lb/sq. in., a value very nearly the same as prescribed in the Indian Standard Specifications (IS : 1077—1957) for a grade AA brick.

Burning of Bricks.

The burning of bricks on a commercial scale may present certain difficulties. It was observed that a good deal of chlorine and other gasses are evolved when these bricks are fired to a temperature of above 800°C. Consequently during commercial manufacture metal chimneys are likely to corrode more severely than with normal soils. Bricks should if possible be fired in a continuous kiln connected to a brick chimney.

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