INVESTIGATIONS ON PHYSICO–CHEMICAL AND BRICKS MAKING CHARACTERISTICS OF BRAHMAPUTRA ALLUVIUM AND RED SOILS OF NORTH EASTERN STATES OF INDIA.

by

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Abstract

The feasibility of utilising the soils of northeastern states of India comprising of Brahmaputra alluvium and red soils of Shillong plateau, which are generally acidic and sandy to clayey loam in texture have been examined for the production of vitrified and common building bricks. Traditionally red soils are considered inferior for brick making and the bricks manufactured from these soils are invariably porous, posses low strength and crack on firing. It has been found that the clay mineral associated with these soils are a mixture of kaolinite, mica; iron bearing minerals as hematite, goethite and gibbsite are present as accessory minerals. Bricks of compressive strength 50 to 150 kg/cm² and water absorption 11 to 21 per cent from red soils while bricks of higher strength up to 350 kg/cm² and water absorption 5 to 10 present from Brahmaputra alluvium can be manufactured at an optimum temperature range of 1000° to 1100°C. Slow rate of firing checks the cracks of bricks during firing.

At the request of Engineer-in-Chief, Army Head Quarters, New Delhi and Chief Engineer, North East ern Zone, Shillong; the Brahamputra Alluvium and red soils occurring in the north eastern region of India were examined for their physico-chemical and brick making characteristics to manufacture common building bricks, vitrified and paving bricks. The green bricks manufactured in this area crack on firing and invariably yield low strength porous bricks when fired in conventional clamps or continous types of kilns.

Soil characteristics

The soils from New Missamari and Chabua towns (Brahamputra alluvium, Assam); Shillong in red soil zone of Khasi and Jaintia Hills (Meghalaya) and Dimapur in red soil region of Nagaland were selected for the study. The soils of Brahamaputra alluvium are partly new and partly old, sandy loam in texture and are mostly acidic[1]. The red soils of Shillong plateau are acidic red loams rich in organic carbon and have been formed as a result of weathering of gneisses, magnetite, schists, quartizites, granite rocks etc. occurring underneath the soil profiles[1].

The Brahamaputra alluvium from New Missamari and Chabua are predominantly silty and free from coarser particles. The coarser particles are mostly quartzitic. The red soils of Dimapur and Shillong are mostly free from coarser particles, a few concretions ferruginous and siliceous in nature occure. The mechanical analysis results (Table 1) show the higher proportions of silt in all the soils and the texture varying from loamy to clayey loam[2]. The exception being Shillong—B soil which is sandy loam. The plastic characteristics of the soils are given in table 1., which show that all these soils are inorganic clays of low to medium plasticity (C L group as per casagrande's plasticity chart[3]). Shillong—B soil is typical having low plastic index.

The results of pH, soluble solids, organic carbon and chemical composition of the soils are given in table 2, which confirm that the soils are acidic, rich in organic carbon and the water solubles present in alluvial soils are slightly in higher proportions than the red soils.

All the soils, irrespective of colour, are mostly rich in ferric iron and show molar silica: allumina ratio varying in the range of 2 to 3.3 and molar silica: sesquioxide ratio 1.8 to 2.7 excepting in the case of Shillong—B wherein both the ratio are abnormally high. The base exchange capacity of the soils vary in the range of 24 to 31 me/100g of clay suggesting the presence of mica, disordered Kaolin group of clay minerals[4] (table 2).

The mineralogical analysis carried out by Differential Thermal and X-ray techniques (table 3) and petrographic analysis of coarser particles (passing I.S. 18 mesh and retained on I.S. 8 mesh) show the presence of a mixture of mica and kaolinitic group of clay

minerals. Geothite and gibbsite exist in low proportions in all the soils. The presence of vermiculite and chlorite minerals has also been detected in the alluvium. The red soils of Shillong are particularly rich in goethite and iron bearing minerals as haematite and magnetite. The presence of zircon in traces in almost all the soils have been observed.

Brick Making Characteristics:

Briquettes of size 7.6 × 5.04 × 3.75 cms and full size bricks (22.86 × 11.43 × 7.62 cms) were hand moulded after processing the soil to remove coarser modules above 1 mm size, wetting the clay mass for 24 hours with sufficient water and manually kneading it to develop uniform consistency suitable for slop moulding. The bricks were dried in the sun and did not show excessive drying shrinkage to cause drying losses.

The briquettes were fired at temperatures varying from 800° to 1100°C in an electric furnace and the fired briquettes were tested for compressive strength, water absorption and bulk density as specified in IS 3495:1973[5]. The shrinkage behaviour of the soils at various temperatures was determined using Malkins Thermal Expansion apparatus on bars of size 7.25 × 1.25 × 1.25 cms and dried at 105°C. To investigate the reversible and irreversible shrinkage occurring in the fired clay body the bars prefired at 1000°C were refired after a fortnight exposure to the atmosphere, and the shrinkage/expansion measurements occurring at various temperatures were recorded.

The results on strength development, water absorption and bulk density of briquettes show that the compressive strength and bulk density increase while the water absorption decreases with the increase in firing temperature irrespective of the red, black or alluvial nature of the soil occurring in this region. However, there is no appreciable improvement in strength or decrease in water absorption when briquettes are fired at temperatures below 950°C, abrupt strength development takes place when briquettes are fired beyond 1000°C (Fig. 1-3). This is a characteristic similar to that reported earlier for soils of Indo-Gangetic plains[6], Tripura[7], Imphal regions[8].

The results of expansion and shrinkage characteristics occurring in the brick body during firing are given in fig.4. It may be noted that the brick bodies from all the soils show an over all linear expansion varying form 0.1 to 1.2 percent when fired upto 1000°C, it is found to increase upto 1.9 percent in the case of Shillong-B soil. However, the tendency for gradual shrinkage in brick body is initiated at about 900°C. The above behaviour is characteristic of soils which contain high proportions of siliceous and non clay minerals as gibbsite, goethite etc. Similar observations have been reported by Lepingle[9] for common brick clay and some clays containing kaolin, halloysite, gibbsite minerals. Hyslop and McMurdo[10] have also reported similar results for china clay, halloysite sericitic clays. Bigot[11] has concluded from similar studies that clays containing no free silica do not expand below 1000°C.

The thermal expansion contraction curve for all these soils (fig.4) show an over all expansion upto 700°C. A sharp expansion occurs at 573°C in the temperature range of 500° to 600°C. This is attributed to dehydroxylation of kaolinite, halloysite disordered kaolinand mica minerals associated with soils and reversible α-β quartz inversion[12]. The reversible expansion at 870°C is more marked in siliceous soils from Dimapur and New Messamari which could be attributed to reversible quartz/tridymite transformations[12]. The shrinkage in all the samples is initiated at temperatures beyond 800°C and tends to become rapid upto 950°C showing loss of mineral structure and the tendency for the formation of crystalline phases. However, the tendency for shrinkage in the temperature range of 950° to 1000°C is retarded showing the initiation of the formation of stable crystallites as λ-Al_2O_3/ primary mullite/spinel, contributing to gradual increase in strength development and decrease in porosity [13,16] (Fig.1to 3). Since the shrinkage data could not be determined beyond 1000°C, the various stages at which the formation of high temperature crystallites and glassy matrix is occurhing could not be ascertained.

The results of compressive strength, water absorption and bulk density of full size bricks when tested as per I.S. 3495 (pt 1 to IV): 1973, are given in tabie 4. The resuls show that the strength in bricks fired at 1060°C from all the soils is doubled compared to the strength developed at 1000°C. This can be attributed due to the formation of stable crystallities as secondary mullite from kaolinitic group of clays, [14 16] spinel from mica mnierals [2,13] and insitu bonding with the glassy matrix. [13,16] Vitrified and common building bricks of strength 75 to 350 kg/cm² and water absorption 5 to 20 percent can be manufactured from Brahmaputra alluvium at a firing temperature range of 1000° to 1060°C, while in the case of red soils common building bricks of strength 50-150 kg/cm² and water absorption 11 to 21 percent can be manufactured at firing temperatures 1020°-1060°C.

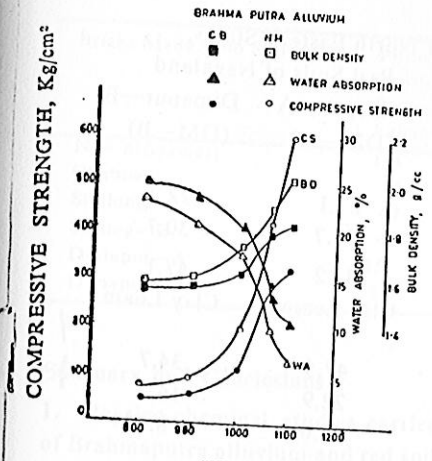

FIG. 1 PLOT SHOWING FIRING PROPERTIES OF BRIQUETTES FROM SOILS OF BRAHMAPUTRA VALLEY.

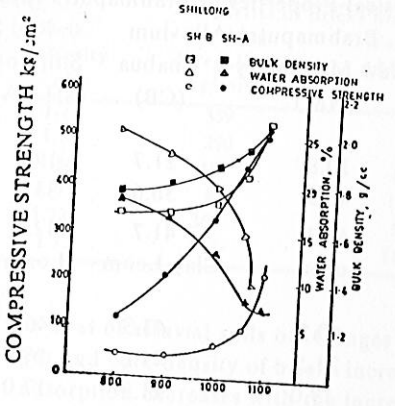

FIG. 2: PLOT SHOWING FIRING PROPERTIES OF BRIQUETTES FROM RED SOILS OF SHILLONG (MEGHALAYA)

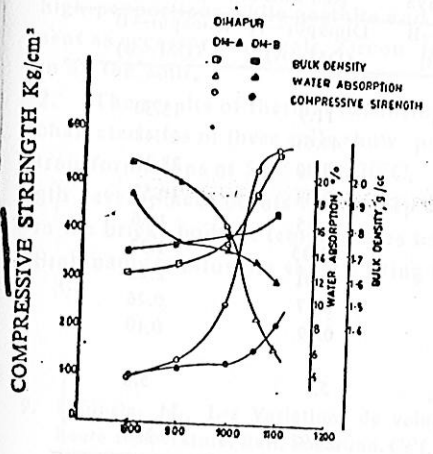

FIG. 3: PLOT SHOWING FIRING PROPERTIES OF BRIQUETTES FROM RED SOILS OF DIMAPUR (NAGALAND)

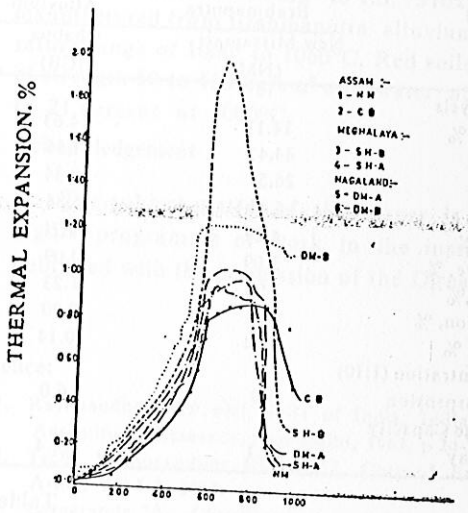

FIG. 4: PLOT SHOWING THERMAL EXPANSION BEHAVIOUR OF SOILS FROM ASSAM, NAGALAND AND MEGHALAYA.

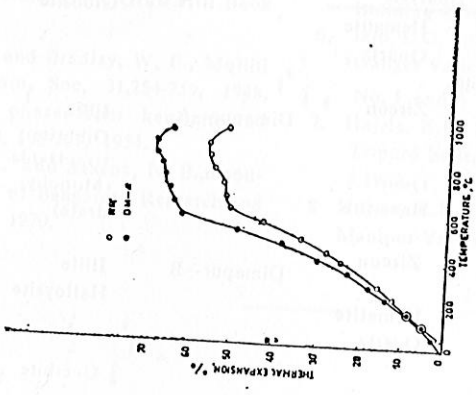

FIG. 5, PLOT SHOWING THERMAL EXPASINON BEHAVIOUR ©F FIRED SAMPLES FROM SOILS OF ASSAM AND NAGALAND.

Table—1

Physical Properties of Brahmaputra Alluvium and Red Soils of North Eastern States.

Properties	Brahmaputra Alluvium		Red Soils of Meghalaya		Red Soils of Nagaland	
	New Missamary (NM)	Chabua (CB)	Shillong—A (SH—A)	Shillong—B (SH—B)	Dimapur—A (DM—A)	Dimapur—B (DM—B)
A. Mechanical Analysis						
Clay, %	10.8	21.7	19.2	9.2	27.1	22.2
Silt, %	45.9	36.6	38.2	19.8	39.7	30.7
Sand, %	43.3	41.7	42.6	71.0	33.2	47.1
Texture	Loam	Clay Loam	Loam	Sandy Loam	Clay Loam	Clay Loam
B. Atterberg Limits						
Liquid Limit	40.5	43.3	46.0	28.0	47.5	34.7
Plastic Limit	21.5	21.6	29.0	20.0	22.9	16.3
Plasticity Index	19.0	21.7	17.0	8.0	24.6	18.4
Soil Group (As per Casagrande's Plasticity chart)	CL	CL	CL	CL-ML	CL	CL

Table-2

Chemical Properties of Brahmaputra Alluvium and Red Soils of North Eastern States.

Properties	Brahmaputra Alluvium		Red Soils of Meghalaya		Red Soils of Nagaland	
	New Missamari (NM)	Chabua (CB)	Shillong—A (SH—A)	Shillong—B (SH—B)	Dimapur—A (DM—A)	Dimapur—B (DM—B)
A— Chemical Analysis						
Loss on Ignition, %	14.11	14.63	12.10	17.43	11.9	13.30
Silica, %	44.47	37.16	48.35	54.38	44.61	42.48
Alumina, %	26.57	30.34	24.70	15.50	27.30	28.21
Iron Oxide, %	6.44	6.84	8.60	5.26	12.08	10.55
Calcium Oxide, %	4.29	5.71	3.20	4.06	1.75	1.86
Magnesium Oxide, %	3.09	4.09	2.50	2.18	1 35	1.37
Alkali Oxide etc,%	1.03	1.23	0.55	1.19	1.01	2.23
B. Organic Carbon, %	0.23	0.30	0.22	0.32	0.17	0.26
C. Soluble Salts, %	0.12	0.14	0.05	0.07	0.09	0.10
D. H+ion Concentration (1:10) Soil Water suspension	5.8	6.0	6.1	6.0	5.7	5.8
E. Base Exchange Capacity meq 100 of clay	25.1	24.4	31.0	32.7	29.92	25.1

Table—3

Mineralogical Composition of Different Soils

Soil Samples from	Minerals Identified by		
	DTA	X—Ray	Petrographic Analysis
New Missamary	Illite Kaolinite Goethite Gibbsite	Muscovite Kaolinite/ Disordered Kaolin Chlorite Vermiculite Quartz	Hematite Quartz Zircon
Chabua	Illite Kaolinite (disordered) Gibbsite Goethite	Muscovite Kaolinite (disordered) Quartz	Quartz Hematite Zircon
Shillong—A	Illite Kaolinite Goethite	Illite Kaolinite Halloysite/ disordered Kaolin	Hematite Quartz
Shillong—B	Illite Goethite Gibbsite	Illite Quartz Kaolinite/ Disordered Kaolin	Hematite Magnetite Garnet Corundum Ziicon
Dimapur—A	Illite Gibbsite Iron Oxide (Monohydrate)	Illite Muscovite Kaolinite Kaolin (disordered)	Hematite Magnetite Muscovite
Dimapur—B	Illite Halloysite Goethite	Kaolinite Halloysite/ disordered Kaolin Illite	Quartz Quartz Magnetite orthoclase

Table—4

Firing properties of Bricks (22.86×11.43×7.62 cms)

Bricks Made from Soils of	Properties of Bricks Fired at 1000°C			Properties of Bricks fired at 1060°C		
	Crushing Strength kg/cm²	Water Absorption %	Bulk Density g/cc	Crushing Strength kg/cm²	Water Absorption %	Bulk Density g/cc
New Missamari	125	17.0	1.71	359	4.6	1.86
Chibua	85	19.0	1.63	290	10.8	1.88
Shillong—A	67	20.6	1.86	187	14.5	1.92
Shillog—B	42	17.5	1.63	82	11.6	1.66
Dimapur—A	154	20.7	1.72	368	5.9	1.84
Dimapur—B	58	21.0	1.72	147	11.5	1.80

Summary and Conclusions:

1. Physico chemical studies carried out on the soils of Brahmaputra alluvium and red soils of Shillong plateau and Nagaland are acidic in nature, rich in organic matter and are sandy to clayey loam in texture. Mineralogical studies show the presence of Kaolinite and mica group of clay minerals. Hematite exists in high proportions while goethite and gibbsite are present as accessory minerals, Zircon is invariably present in all the soils.

2. The results of thermal expansion and contraction characteristics of these soils show polymorphic quartz transformations at 573° and 870°C, appreciable strength development occurs when steep shrinkage initiates in the bricks body at temperatures beyond 950°C. The Brahmaputra alluvium show a firing behaviour, similar to that of alluvial soils of Ganges valley as the strength and bulk density of bricks increase while the water absorption decreases with the increase in firing temperature.

3. Vitrified and common building bricks of compressive strength 75 to 350 kg/cm² and water absorption 5 to 20 percent conforming to I.S. 3102;1977, can be manufactured from Brahmaputra alluvium at a temperature range of 1000° to 1060°C. Red soils yield bricks of strength 50 to 150 kg/cm² and water absorption 11 to 21 percent at 1000°C.

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