Bricks from Acidic Soils of Manipur Valley

By

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ABSTRACT

The acidic red loam of Manipur valley, formed as a result of transported weathered fines from the rocks of Disarg series and shales, sandstone, siltstone and ferruginous materials of Arakan and Naga hills, contain muscovite, illite, kaolinite, goethite, chert (polycrystalline quartz), soda potash feldspar and chlorite clay minerals. The bricks manufactured from these soils turn porous, yield poor strength and crack on burning at temperatures 300-400°C, which has been attributed to clogging of pores in brick body due to the presence of 16-36% colloidal fines and rapid evolution of gases during oxidation of organic carbon, pyrite, ferruginous materials etc. present in the soil.

The bursting of bricks during firing can be checked by the addition of opening material as grog or local sand (10-30%) by weight and firing at a controlled rate not exceeding 50°C/hour. Bricks of strength 70-250kg/cm², water absorption 3 to 12% and bulk density 1.60 to 2.18 g/cc can be manufactured in the firing range of 1000 to 1050°C.

At the request of Industries Department, Manipur state, investigations on the suitability of acidic soils covering the central valley of Manipur state was undertaken for the manufacture of good quality building bricks. Ths brick industry in the state has been facing serious problems as (1) 40 to 55% of the moulded bricks crack during drying and burst during firing (2) high cost of firing bricks (3) efflorescence and salt retention in fired bricks obtained from kilns where Assam coal, generally known to contain high sulphur, is used as fuel. A process to develop bricks of strength 200/350 kg/cm² water absorption 5-10% and bulk density 1.80 to 2.10 g/cc and the results of investigations to establish the factors contributing to firing losses have been reported in the paper.

Soil Characteristics of Manipur Velley.

The soil of Mainpur valley has been broadly olassified as red loam containing very fine grained sand, silt and clay[1,2]. The deposits are of recent age and have been formed as a result of transported weathered fines from Naga and Arakan hills. Concealed beneath them are the rocks of Disang series and shales, which show spheroidal weathering in the form of compact sandstone, siltstone and ferruginous materials. The occurance of lignite seam associated with bluish grey clay is common around Imphal. This alluvium is plastic and is used for brick manufacturing.

The soils from 5 kiln sites from Canchipur village on Indo-Burma Road at 4th mile stone from Imphal were selected for the studies. The particle size distribution, Atterberg's limit, organic carbon, hydrogen ion concentration and chemical analysis of the soils are given in Table 1. The soils are acidic in nature, pH 6 to 6.8, rich in organic carbon, 0.11 to 0.8% and contain nodular concretions which disintegrate in sufficient wetting. It appears from Table 1 and 2 that the total fines in soils 1 & 2 is higher than that present in soil samples 3 & 5 but the liquid limit for all these four soils is comparable. It indicates that the proportion of non-clay fraction below 0.002 mm in soils 1 & 2 is greater than that of 3 & 5 and does not contribute to increase the liquid limit. The presence of high proportions of organic carbon in soils 1,2 and 5 (0.75 to 0.82%), however, improves the plastic properties and increases the acidity of the soil.

Mineralogical Studies :

The chemical analysis of hydrogen peroxide treated clay fraction from soils 2, 4 & 5 (Table 2) show a silica:alumina ratio 3.1, 2.3, 4.0 and silica-sesquioxide ratio 2.5, 1.2, 2.8 respectively. The activity coefficient varying from 0.57 to 1.17 (Table 1) for all the samples show that these clays can be classified as normal clays, which according to Skempton[3] are generally known to contain halloysite, illite and chlorite group of clay minerals. The soils are rich in organic carbon (0.11 to 0.82%) and the base exchange capacity vary between 41 to 55 m. eq./100 gm of clay (Table 2). This suggest that the clay mineral associated with the soil could be halloysite (kaolinitic)/illite (mica group). The observed values of base exchange capacity are slightly high, which could be attributed to the presence of organic matter/colloidal particles and the ferruginous matter present in the soil[4]. The soils 1 & 3 contain 0.27, 012% water solubles respectively mainly in the form of calcium sulphate and magnesium sulphate (Table 1), which may however contribute to the development of scum and efflorescence. The total sulphur in soil is high varying in the range of 0.098 to 0.136%, which may oxidise on burning to form soluble sulphates in fired brick bodies.

The result of petrographic analysis on soils (fraction retained on 150μ and passing 90μ IS sieve) show the presence of quartz, chert (Cryptocrystalline quartz), goethite, pyrite and minor amounts of feldspar and chlorite. Iron minerals occur as coatings and as an alteration product, covering silica grains fully or partially. These alteration products consist mainly of goethite. Pyrite grains occur independently. Quartz grains are generally rounded to sub-rounded in shape and show the presence of fissures and cracks filled up by ferruginous impurities indicating the effect of excessive weathering. Chert exists in considerable proportions. Amongst accessory constituents, feldspar as an inter-growth of potash-soda feldspar and chlorite as an alteration product are present.

The clay fraction free from organic mater was used for X-ray and differential thermal analsis. The thermograms obtained from samples 1 to 5 (Fig. 1) show endothermic peaks at 100-110°C in the temperature range of 100-200°C, 520-550°C and an exothermic peak at 960-980°C indicating the presence of kaolinitic and illitic group of clay minerals. The endothermic peak at 310°C and exothermic at 420-440°C suggest the presence of goethite/gibbsite and pyrite. The X-ray results for these samples show the characteristic lines 10.1, 4.49; 2.56 and 7.11; 3.57; 2.33; 1.49; indicating the presence of illite, muscovite and kaolinite respectively[5]. Goethite, magnetite, pyrite, quartz and a little amount of corundum is also present in all the soils.

Moulding and drying characteristics of bricks :

Briquettes of size 7.55 x 5.08 x 3.53 cms obtained by extrusion process and full size bricks (22.86x11.43 x 7.- cms) shaped by hand moulding process were dried under sun. The bricks did not show any deformation on moulding or warping and cracking during drying. However, all the bricks cracked on firing below 900°C while bricks from soils 1 & 2 burst into pieces at lower temperatures 300-400°C. A similar observation has been reported for bricks manufactured from marine clays of Kandla[6] and alluvial clays of Tripura[7] and Asansol[8].

The expansion and contraction characteristics of bricks during firing from soil samples 1 & 5 were therefore investigated using Malkins Thermal expansion apparatus. The extruted mass of clay body was used to mould the bars of size 7.62 x 1.27 x 1.27 cms for the study. The edges of the specimen were cut in such a way that the two end faces were plain and perpendicular to the length of the piece. The specimens were oven dried at 105°C. The green specimens were fired in the thermal expansion apparatus at a firing rate of 6°C/ minute. Similar study was also conducted on prefired specimens. The results of expansion and contraction occuring in the green and prefired specimens at various temperatures during firing cycle are given in fig. 5. The results show two inflections occuring in the temperature ranges of 150 to 250°C and 500 650°C These inflections also appear in prefired specimens indicating the reversible volume changes in the brick body due to transformation of α quarts to β quartz [8,9,10,11,12,13,14]. Further, the linear expansion occuring in the temperature range of 150 to 250°C is 0.1%. which increases to 0.64% in the temperature range of 500 to 650°C. This causes sufficient stresses in the brick body to crack during firing. The cracking may be further aggravated as a result of the gases formed in the bricks body during decomposition of organic matter, oxidation of pyrite and other ferruginous materials present in the soil.

The oxidation of organic matter depends on (1) the nature of clay organic complexes, (2) amount of oxygen available and (3) grain size of the clay body providing access to the ingress of oxygen as well as expulsion of gases (4) temperature. These reactions are time dependent. It is considered that the gases readily evolved at temperature 300-400°C/ 500-650°C and at faster rate of firing do not get easy access to flow out from the non-porous structure formed as a result of clogging of pores by colloidal particles present in the brick body (Table 1). These gases get entrapped and eventually expand to burst the brick body. Such results have been reported for porcelain bodies [9,14] marine soils rich in organic matter and some alluvial clays [7,8].

Based on these observations, the cracking during firing was checked by the addition of 10 to 30% grog (clay calcined at 700°C) or local sand and firing at a controlled rate not exceeding 50°C/hour. Full size bricks and briquettes were therefore moulded by the addition of grog and local sand in optimum proportions (Table 3) and were fired at the above rate in an electric furance. The results of strength development at various temperaturs of firing in briquettes are given in Fig. 2 and for the bricks in Table 3.

The strength and bulk density increases with the increase of firing temperature upto 1060°C. The bloating in briquettes from all the soils occurs at temperatures above 1060°C when bulk density and compressive strength decreases and water absorption increases slightly (Fig. 2,3,4). It may be noted from Fig. 5 that abrupt shrinkage in bricks occurs beyond 900°C. This explains the sharp increase in strength [15, 16, 17] occuring in the brick body as a result of the formation of glassy matrix bonding insitu the crystallites as spinel/mullite etc. formed from the clay minerals illite/kaolinite present in the soil.

Full size bricks from the soils containing grog and local sand in optimum proportions (Table 3) were fired at temperatures 950,1000 and 1060°C. The bricks of strength 80 to 350 kg/cm^2, water absorption 3 to 12% and bulk density 1.60 to 2.16 g/cc can be manufactured on the addition of grog from the soils at temperatures 1000 ± 50°C. On the addition of local sand the strength is slightly reduced (Table 4) and common building bricks of strength 70 to 150 kg/cm^2 and water absorption above 5% can be manufactured. The recommendations for the manufacture of such bricks have been adopted by the industry in the State of Manipur.

Conclusions :

1. The red loam of Manipur is highly weathered containing nodules of silt and sand stones. Mineralogical studies show the presence of illite. muscovite and kaolinite, goethite, chert, pyrite. Feldspar and chlorite are also present as accessory minerals.

2. Cracking of bricks during burning occurs at 300-400°C due to the presence of organic matter, pyrite and ferruginous materials in the soils and nonporous structure of the clay body containing 20 to 32% colloidal fines.

3. The cracking of bricks can be checked by the addition of opening material as grog and sand (10 to 30%) and controlled firing at a rate not exceeding 50°C/hour.

4. Bricks of strength 70 to 250 kg/cm^2, water absorption 3 to 12% and bulk density 1.6 to 2.18 g/cc can be manufactured from Manipur soils by the addition of 10 to 30% grog or local sand.

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TABLE—1

Physico Chemical Properties of Imphal Soils

Soil Samples	1	2	3	4	5
Mechanical Analysis					
Particles <1μ colloidal %	23.7	36.8	24.0	14.5	16.5
Particles <2μ clay %	40.6	43.6	30.6	18.6	30.1
Silt %	30.5	27.0	46.0	48.0	39.5
sand %	28.9	29.4	23.4	33.4	30.4
Atterberg's Limit					
Liquid Limit	59	57	60	43	59
Plastic Limit	31	32	25	24	31
Plasticity Index	28	25	35	19	28
Activity-Coefficient	0.69	0.57	1.17	1.02	0.93
Organic Carbon (%)	0.75	0.78	0.16	.11	0.82
Soluble Salt (%)	0.27	0.06	0.12	.06	0.09
Calcium Carbonate (%)	Nil	Nil	Nil	Nil	Nil
pH	6.1	6.1	6.7	6.8	6.2

TABLE—2

Chemical analysis of Imphal Soils

Soil Sample	2	4	5
Loss on Ignition %	10.04	10.14	9.04
Silica (SiO_2) %	51.55	43.76	53.82
Ferric Oxide (Fe_2O_3) %	7.08	9.57	8.92
Alumina (Al_2O_3) %	27.21	31.99	22.75
Calcium Oxide (CaO) %	1.26	1.38	0.77
Magnesium Oxide (MgO) %	1.55	1.64	1.76
Alkalies etc. (Na_2O+K_2O) %	1.31	1.26	2.94
Base exchange capacity, meg/ 100 gr. clay	41	51	55

TABLE—3

Firing characteristics of full size bricks

(A) Requirement of opening material.		Soils Samples				
		1	2	3	4	5
Grog or Sand		30	30	10	Nil	20
(B) Properties of Fired Bricks : Grog Addition		Bricks from Soil samples				
Properties	Firing Temp. 0°C	1	2	3	4	5
1. Compressive Strength Kg/cm²	950	86	91	100	97	100
	1000	178	210	254	246	266
	1060	270	324	385	355	325
2. Water absorption (Percent)	950	13.6	12.2	15.3	17.7	16.2
	1000	8.1	6.4	5.9	8.2	8.7
	1060	4.8	2.0	1.03	1.25	3.6
3. Bulk density (g/cc)	950	1.71	1.61	1.64	1.62	1.63
	1000	1.77	1.86	1.88	1.82	1.85
	1060	1.92	2.14	2.16	1.95	2.08
(C) Sand Addition						
1. Compressive Strength (Kg/cm²)	1000		130	—	—	—
	1060	196	198	—	—	—
2. Water absorption (Percent)	1000	—	8.7	—	—	—
	1060	5.7	5.2	—	—	—
3. Bulk density g/cc	1000	—	1.72	—	—	—
	1060	1.76	1.77	—	—	—

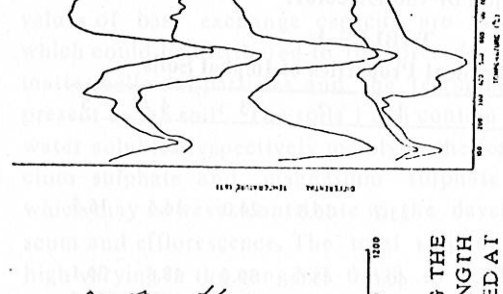

Fig. 1—DIFFERENTIAL THERMAL CURVES FOR IMPHAL SOILS

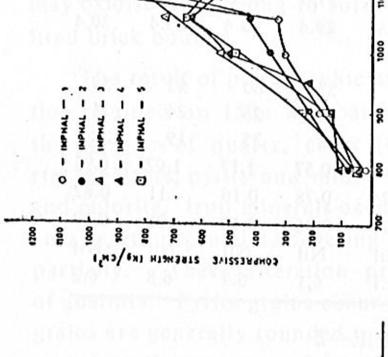

Fig. 2—GRAPH SHOWING THE COMPRESSIVE STRENGTH OF BRIQUETTES FIRED AT 800-1100°C

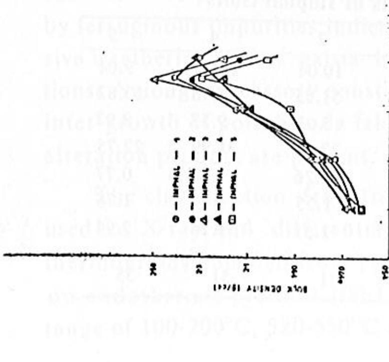

Fig. 3—GRAPH SHOWING THE BULK DENSITY OF BRIQUEITES FIRED AT 800-1100°C

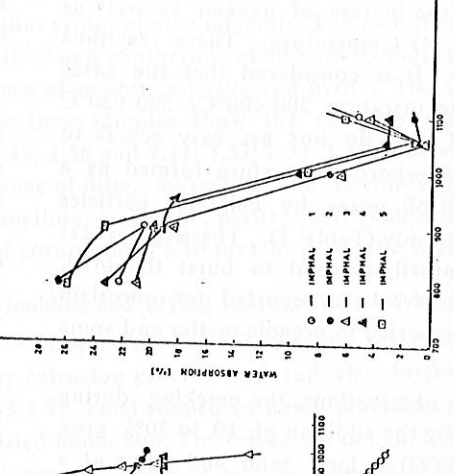

Fig. 4—GRAPH SHOWING THE WATER ABSORPTION OF BRIQUETTES FIRED AT 800-1100°C

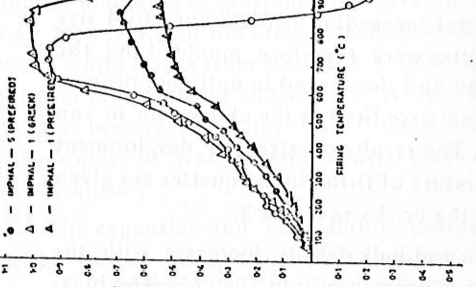

Fig. 5—GRAPH SHOWING EXPANSION AND CONTRACTION CHARACTERISTICS OF IMPHAL SOILS DURING FIRING UPTO 1000°C

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