HBRP PUBLICATION

Journal of Advances in Geotechnical Engineering
Volume 2 Issue 3

Investigation of Physical Properties of Locally (Rajshahi, Bangladesh) Available Clay

M.A. Kaiyum[1]*, S. Rahman[2]
[1]Lecturer, [2]Student
Department of Glass & Ceramic Engineering, Rajshahi University of Engineering & Technology (RUET), Rajshahi, Bangladesh.
****Corresponding Author***
E-Mail Id:-*kaiyum@gce.ruet.ac.bd*

ABSTRACT

All over the world metallic material is running out and their processing cost increasing day by day. This problem can be solved easily by using ceramic materials as a substitute of metallic materials. In ceramic sector clay is an abundant source for developing different materials. From the point of view in this research physical properties of clays were investigated. The clay samples were collected from different places of Rajshahi city of Bangladesh. Basic properties of clays like moisture content, impurities content, plasticity, drying weight loss, drying shrinkage, firing weight loss, firing shrinkage, water absorption of fired clay body etc. properties are determined preciously. The remarkable grit content, drying weight loss & drying shrinkage, firing shrinkage and plasticity index were determined as 1.8%, 3.35% & 2.82%, 1.61% and 3.64 respectively. For determining plasticity prefer corn plasticity tester was used. To determine the weight loss micro gram weight balance was used and digital slide calipers were used for calculating length and thickness. As like as physical test XRD analysis was carried out for determining the structural analysis. Mainly cubic and hexagonal phases are found and dominating planes were (011), (110) and (101) was determined. And crystalline size was 284.2 Armstrong.

Keywords:-*Drying shrinkage, plasticity, grit content, loss on ignition etc.*

INTRODUCTION

Clay is a hydrated aluminous silicate. It contains a lot of oxides like Al_2O_3, SiO_2, Na_2O, K_2O, MgO, CaO and very small amount of SO_3, TiO_2, Li_2O etc. clay has different composition and different structure according to geometrical position and it is a complex mineral mixture [1]. Clay contains different types of minerals as like as Keolinite, Halloysite, Smectite, Illite, Chrysotile, Palygorskite, Sepolite, Allophane and Imogolite [2]. Sometimes clay contains some organic ingredients and some bacteria which the causes of variation of plasticity of clay are. Clay contains water in their surface, interstitial site and into their atomic arrangement which is called chemically bonded water. The main structure of clay consists of tetrahedral and octahedral sheet of silicate. Between two sheets some ions exist like Ca^{+2}, Na^{+}, K^{+} and Mg^{+2}. However, this investigation does not deal with their chemical properties or structural properties. Here some physical properties are investigated which are very important to know as a ceramic engineer. For formation of clay products, it is very important to know this. Traditional ceramics are made from clay.

METHODOLOGY

The materials were at the very first collected from the different places of Rajshahi city of Bangladesh. Prefer Corn Plasticity Tester, Plastic Container, Furnace, Weight Machine, and Vibrating Sieve Shaker were the essentials

equipment used for this research. For determining of drying weight loss, drying shrinkage, firing weight loss, firing shrinkage and water absorption rectangular shaped clay samples were made (15 cm×10 cm×5 cm) and fired in an electric kiln furnace at 1250 C.

For determining the content of moisture the clay sample was collected. Wet weight with moisture was leisurely measured by the weight balance **(W_1)** then the trial materials were placed in a furnace at 110'C and the functional setup were hold down for a day long. After drying the weight **(W_2)** is measured. From equation (i) the percentages (%) of moisture content is measured. For determining grit similar process is applied. The impure materials are dried and sieved and using the equation percentages of grit is measured.

Percentages of moisture/grit = $\frac{(W1-W2)}{W1} \times 100$..... (i)

For determining the plasticity of our trail clay several cylindrical shape bar with predefined dimensions were made. By the help of the plasticity tester machine and comparing the values with specific standard we had measured the plasticity of our clay. Drying weight loss and firing weight loss, was determined by measuring the weight of green sample and after drying and firing using equation (i). Drying shrinkage and firing shrinkage also measured using the equation (ii) where L1=initial length, L2= length after drying or firing.

Percentages of Drying/Firing Shrinkage= $\frac{(L1-L2)}{L1} \times 100$.....(ii)

Plasticity of clay was determined using Prefercorn Plasticity Tester. Using the following equation plasticity was measured. Where a_0=plasticity index, h_1= final height of the bar, h_0= 40 mm; if a_0<2.5; it is hard materials; a_0=2.5 to 4.00; it is plastic materials and a_0>4.00; it is sticky materials.

$a_0=\frac{h_0}{h_1}$ .....(iii)

Above all the tests shows that a particular types of clay sample shows better physical properties and that sample was analyzed by X-ray diffraction method.

RESULTS AND DISCUSSION

The results that are found is discussed below.

Moisture Content and Grit Content

The moisture content and grit content are given in the following table. Using eqn. (i) the moisture and grit were calculated.

Table 1: *Percentages of moisture and grit content*

Sample Name	Percentages of moisture content (%)	Percentages of grit content (%)
A	21.25	3.39
B	**9.16**	**1.80**
C	13.56	8.18
D	12.52	4.61
E	15.34	7.15
F	12.59	2.15
G	13.19	3.34

All the samples show different types of moisture and grit content. The higher amount of moisture content indicates that the clay will consume more heat energy during processing. The grit content indicates the amount of impurity. The lowest value of grit content indicates good quality raw materials. Sample B shows better quality raw materials. Which contains comparatively low moisture and grit content. So, it can be concluded that B has better quality as a ceramic raw material.

Drying Weight Loss and Drying Shrinkage

The resultant drying weight loss and drying shrinkage is given in the following table. Naturally found clay may contain many waters like 25-40 percent or more.

Table 2: *Percentages of drying weight loss and drying shrinkage*

Sample Name	Percentages of drying weight loss (%)	Percentages of drying shrinkage (length) (%)	Percentages of drying shrinkage (volume) (%)
A	9.83	4	21.21
B	**3.35**	**2.82**	**8.9**
C	4.52	8.13	21.14
D	7.46	3.33	33.37
E	9.38	5	11.75
F	7.81	2.04	13.16
G	3.52	2.83	21.28

Sometimes some drying related problems may occur and that can be solved easily using different established method all over the world [3]. During drying in this experiment no problems are found.

The causes of drying weight loss are moisture. Surface, capillary and pore water are lost due to drying. Which creates shrink the clay body. It is time consuming process, because the water boiled, formed steam and removes gradually from clay body. Clay sample B shows low drying weight loss, very low length and volume shrinkage, which is very good for making good clay product [References].

Firing Weight Loss and Firing Shrinkage

The clay sample is dried at 1250^0C and the firing shrinkage and firing weight loss was measured. It is given in the following table. Physical and chemical changes during firing depends on various parameter like composition, particle sizes, heating and cooling rate, amount of water content, soaking time and temperature etc.

Table 3: *Percentages of firing weight loss and firing shrinkage*

Sample Name	Percentages of firing weight loss (%)	Percentages of firing shrinkage (length) (%)	Percentages of firing shrinkage (volume) (%)
A	1.78	2.1	8.65
B	**1.11**	**1.61**	**2.54**
C	2.38	7.69	7.88
D	1.55	6.67	4.38
E	5.09	5.2	3.52
F	7.86	2.04	8.51
G	4.97	2.83	9.76

Firing weight loss is the causes of evaporation of organic volatile materials from clay sample. During firing chemically bonded and mechanically bonded water removes so weight loss and shrinkage occurs during firing [4]. Some body get contract due to densification. Densification causes due to sintering which creates mass diffusion. Because of grain growth and mass transfer, porosity removed gradually, and reduction of porosity may be up to 31% [5]. At 500-700^0C decomposition of carbonates occurs [6] it is also a cause of firing weight loss.

Plasticity Testing

Plasticity is the properties of a material which indicates the formability of clay. Plasticity is a property which depends on the amount of water, organic materials, particle size and types of materials. Using eqn. (ii) the plasticity index was determined. The resultant plasticity is given in the following table.

Table 4: *Plasticity Index*

Sample Name	$a_0=\frac{h_0}{h_1}$	Remarks
A	2.5	Plastic
B	**2.10**	**Hard**
C	4.00	Plastic
D	3.64	Plastic
E	3.64	Plastic
F	3.64	Plastic
G	2	Hard

Sample B and G shows that they are not plastic for 20% of water. But others result for sample B is very good. It is possible to make it plastic. For that water can be increased.

XRD Analysis

Seven different types of clay samples were collected. But among of that sample only Sample shows a special result. So, this sample was analyzed by x-ray diffraction method. The curve is shown below. The curve shows a large number of peaks. The XRD curve is given below.

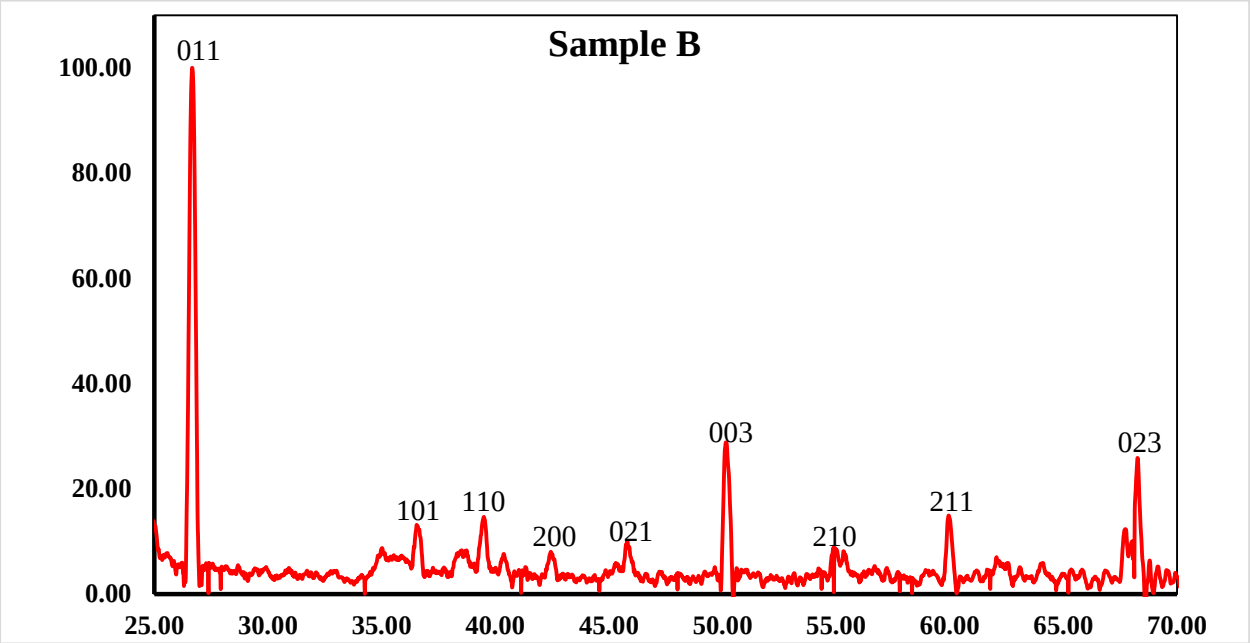

Fig.1: *XRD curve*

From the XRD curve analysis a large number of elements and oxides are found. Among of them the followings are major ingredients. These are given in the following table with their structure. The data was analyzed with Eva software. D8 advanced Brucker XRD machine was used.

Table 5: *XRD data analysis table [7, 8]*

S.L No.	Compound	Formula	Structure	(h,k,l)	d-Spacing	Lattice Parameter (Å)	Phase Percentage (%)
01.	Quartz	SiO_2	Hexagonal	(011)	3.343	a=b=4.914 c=5.406 z=3	79
02.	Sodium Oxide	Na_2O	Cubic	(110)	3.027	a=b=c=4.28	1.5
03.	Magnesium Oxide	MgO	Hexagonal	(101)	2.450	a=b=3.202 c=5.199 z= 2	19

From the Full Wave Half Maximum (FWHM) method the average crystalline size was measured 284.2 **Å**.

CONCLUSION

From the above study it is found that the available clays like sample A, B, C, D, E, F and G shows different properties at different tests. In plasticity testing Sample B and G are hard, if we use this clay sample the products will be cracked easily. For making products of desired specification sample F will be better because the firing shrinkage is very small for it. The single clay can't be used for making product, but these clays can be mixed with ball clay, china clay, quartz and feldspar. The clays can be used as a substitute for any clay composition.

REFERENCES

1. S. Hassan, V. Aigbodion, *Effect coal ash on some refractory properties of alumino-silicate* (Kankara) clay for furnace lining, Egypt. J. Basic Appl. Sci. 1 (2014) 107–114p.
2. S. Mukherjee, the Science of Clays: *Applications in Industry, Engineering and Environment.* DOI 10.1007/978-94-007-6683-9_5©2013.
3. G.W. Scherer, *Theory of drying*, J. Am. Ceram. Soc. 73 (1990) 3–14p.
4. Sedat Karaman, Sabit Ershahin and Hikmet Gunal, "*Firing Temperature and Firing Time Influence on Physical and Mechanical Properties of Clay Brick*", JSIR, vol. 65, Febuary 2006, 153-159p.
5. I. Johari, S. Said, B. Hisham, A. Bakar, Z. A. Ahmad, "*Effect of the Change of Firing Temperature on Microstructure and Physical Properties of Clay Bricks from Beruas (Malaysia)",* Science of Sintering, 42 (2010) 245-254p.
6. Venkatmani, "*Physical and Chemical Reaction during Firing of Sanitary ware*", Sanitary Ware. Org.
7. Hazen, R.M., Finger, L.W., Hemley, R.J., Mao, H.K., *solid state commun.* 1989.72:507p.
8. Hanawalt, J. "*Anal. Chem*",1938.10:475p.