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PROPERTIES OF BANGLADESHI TRADITIONAL CERAMICS

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Abstract*-In this paper the effect of Bangladeshi traditional ceramics as a raw material on the physical and mechanical properties as well as on microstructure was observed. Mymensingh clay and Savar clay was taken as raw materials. A fast single stage sintering cycle was performed. Hand pressed (uniaxial loading) green samples were sintered at a temperature range 800-1200°C for 4 hours. Drying & firing shrinkage along with different properties such as density, cold crushing strength (CCS) and percent water absorption were measured. Finally the microstructure was observed by Scanning electron microscope (SEM). The microstructure revealed the presence of both amorphous and crystalline structure. Higher sintering temperature caused grain growth. The other properties of the materials appeared to be related to the type and quantity of crystalline phases in the sintered bodies.*

Keywords: Amorphous, Sintering, Grains,CCS, Water absorptivity

1. INTRODUCTION

The art of making pottery by forming and burning clay has been practiced from the earliest civilizations. Burnt clayware has been dating from about 6500 B.C. and was well developed as a commercial product by about 4000 B.C. The two main categories of ceramics are traditional and engineering. Traditional ceramics have been served humanity well for at least the past ten millennia. Traditional ceramics are characterized by mostly silicate based porous microstructure that is quite coarse, non-uniform and multiphase. Among them clays are the most widely used raw material for structural ceramics such as bricks & tiles. Different properties of ceramic product are not only related to its mineralogical composition of raw material but also to the different variables in production operation such as, drying and shaping techniques, firing temperature etc. This experiment was conducted in a manner similar to the traditional practice of making brick, which includes raw material collection, processing, shaping, drying and finally firing or sintering [2].

Traditional ceramics are made from natural materials such as clay. The oldest ceramic raw material is undoubtedly clay. Clay has been defined as an earth that forms a coherent, sticky mass when mixed with water; when wet, this mass is readily moldable, but if dried it becomes hard and brittle and retains its shape. Moreover, if heated to redness, it becomes still harder and is no longer susceptible to the action of water. Such a material clearly lends to the making of articles of all shapes [3].

Clay consists of a large number of very tiny flat plates, stacked together but separated by thin layers of water. The water allows the plates to cling together, but also acts as a lubricant, allowing the plates to slide past one another. As a result, clay is easily molded into shapes. High temperatures drive out water and allow bonds to form between plates, holding them in place and promoting the formation of a hard solid [4].

Geological studies reveal clay to be of two different types based on the way they were deposited. The type of clays which are found to be at the place of their origin is called Residual Clay. Typically these types of clays are deposited along the igneous rocks from which they were formed and are obtained in relatively pure state. Based on their in-situ nature, they are found to have coarse particle size with a wide particle size distribution. Due to this, these clays show lower plasticity. China clay is an example of residual clay, which is highly pure, has larger particle size and lower plasticity. The other type is Sedimentary Clays which are deposited by transportation from their origin by natural agencies like water, wind etc. Sedimentary clays are seldom obtained in pure state, due to impurities that are picked up during transportation and are retained in the deposits. The grinding action of clay particles in water, wind and ice results in very fine particle sizes, giving the sedimentary clay very high plasticity [1].

Geological surveys indicated that Bangladesh has deposits of both Residual and Sedimentary types of clays. A number of places across the country have been identified as the sources of various types of clay. Notable locations are Savar, Bijoypur in Mymensingh, Barapukuria and Maddhyapara in Dinajpur etc. [1].

2. EXPERIMENTAL PROCEDURE

2.1Raw Materials

Mymensingh clay and Savar clay were used as raw material containing 15-20% moisture. Mymensingh Clays were fine grained containing small percentage of moisture, while Saver clays were coarser grained with higherpercentage of moisture. About 0.20Kg of clay was taken. No extra binder was needed as clay itself worked as binder. The clay and water was mixed thoroughly. It was done just before shape forming to avoid natural drying.

2.2 Sample Preparation

The specimens were made using a steel mold by hand mixing, molding and ramming with the help of hammer. The samples prepared were more or less rectangular in shape. The dimension was measured carefully to calculate the volume of samples.

2.3 Drying and Firing

Natural drying was done for three days. It was done to remove moisture naturally as more as possible. Then the samples were heated in a drying oven for 86400 seconds at a temperature of 110^0C and after that, all the dimensions of the samples were measured again.
After drying the samples were placed in a box type muffle furnace for sintering. The blocks were fired at temperature 800-1200^0C for almost 14400 seconds. Then the dimension and weight of the bricks were measured again.

2.4 Measurement of Drying & Firing shrinkage

From the dimensions measured before and after drying and firing the initial and final volume of blocks were measured.Equation 1 shows the calculation of drying & firing shrinkages.

$$\%\ \text{Volume Shrinkage} = \frac{(\text{initial vol.} - \text{final vol.})}{\text{initial vol.}} \times 100\% \qquad (1)$$

2.5 Measurement of Water Absorptivity

Absorptivity or apparent porosity was measured by using Archimedes method which involved boiling the test samples in water for 14400 seconds. The difference in density before and after boiling indicates the amount of water absorbed as well as apparent porosity or open porosity. Equation 2 shows the calculation of percent water absorption.

$$\%\ \text{Water Absorptivity} = \frac{(\text{initial wt} - \text{final wt.})}{\text{initial wt.}} \times 100\% \qquad (2)$$

2.6 Measurement of Cold Crushing Strength

The bricks were put under compressive load in a Universal Testing Machine (UTM) at a fixed strain rate of 250 N/second. Then when the bricks started to crack readings were taken which reflects the value of CCS. The unit of CCS was calculated in Newton.

2.7 SEM Analysis

SEM analysis was carried out on selected sintered sample by scanning electron microscopy. Sample was prepared by rubbing both sides of it on emery paper (4/0) and finally on the velvet clothe along with alumina powder.

3. RESULTS AND DISCUSSIONS

3.1Effect on Drying Shrinkage

Drying shrinkage of both Mymensingh clay and Savar clay samples were measured. Mymensingh clay made samples showed little drying shrinkage than the Savar clay samples. Figure 1 shows the variation of percent drying shrinkage for both clays. It can be seen from the figure that, the percent drying shrinkage was almost double in some cases for Savar clay compared to Mymensingh clay.

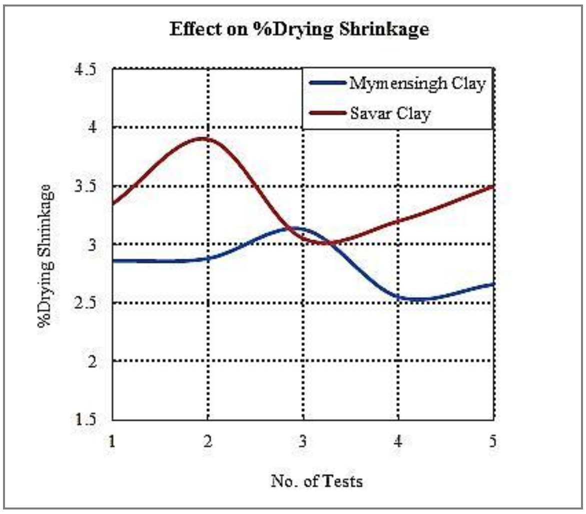

Fig.1: Variation of %Drying shrinkage of different clay

3.2 Effect on Firing Shrinkage

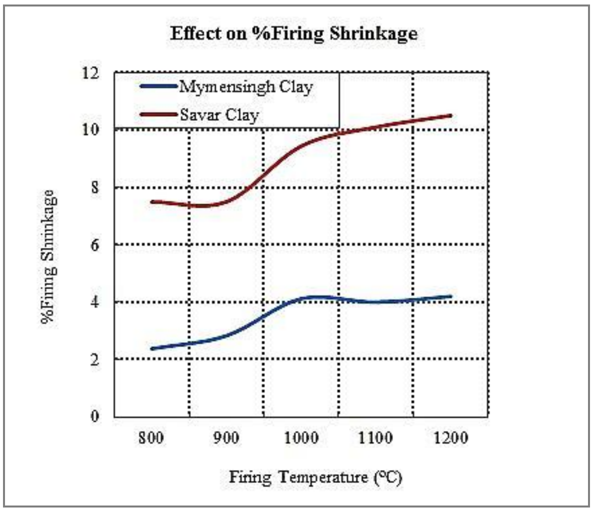

Fig.2: Variation of % Firing shrinkage with temperature

Figure 2 shows the variation of percent firing shrinkage with sintering or firing temperature. Again

Savar clay showed higher percent firing shrinkage than that of Mymensingh clay. The amount of shrinkage increased with firing temperature.

3.3 Effect on Water Absorptivity

Sintered samples were taken for water absorption test. Percent water absorption decreased with increasing sintering temperature (Fig. 3). This was true for both Mymensingh and Savar clay. It can be seen that, both curves showed almost same pattern.

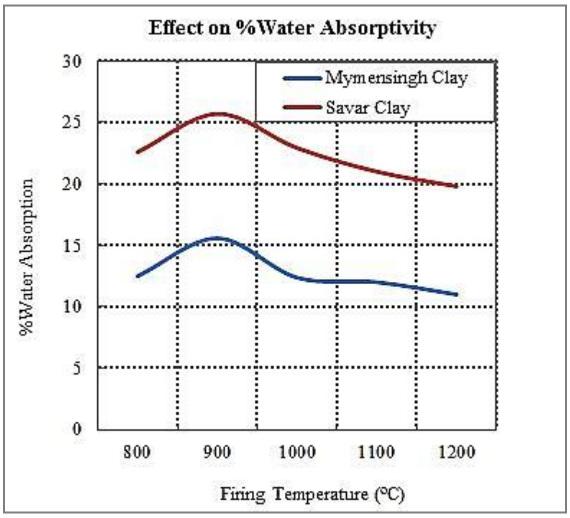

Fig.3: Variation of % Water shrinkage with temperature

3.4 Effect on Cold Crushing Strength (CCS)

Figure 4 shows the effect of sintering temperature on cold crushing strength. Cold crushing strength was seen to remain more or less constant with firing temperature. The CCS value was much higher for Mymensingh clay than the Savar clay. The finer particle size of Mymensingh clay resulted higher cold crushing strength.

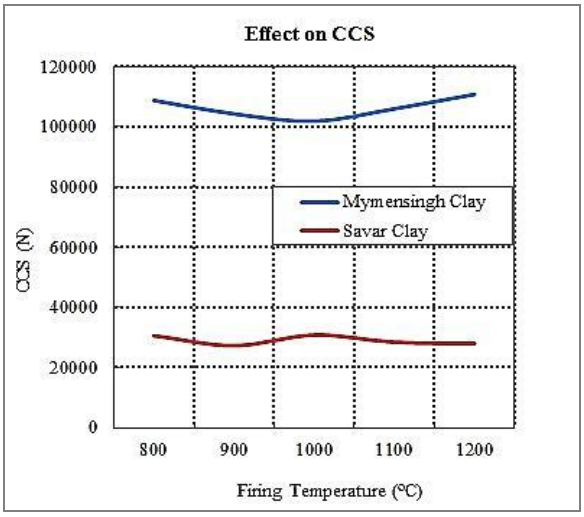

Fig.4:Cold crushing strength Vs Firing temperature

3.5 SEM Analysis

SEM analysis revealed the microstructure of thefired samples (Fig. 5-6). It was found that, with firing temperature the presence of dense structure increased while porosity decreased. But at higher firing temperature, glassy or amorphous phases appeared. Moreover, the grain growth was seen to occur at that corresponding temperature.

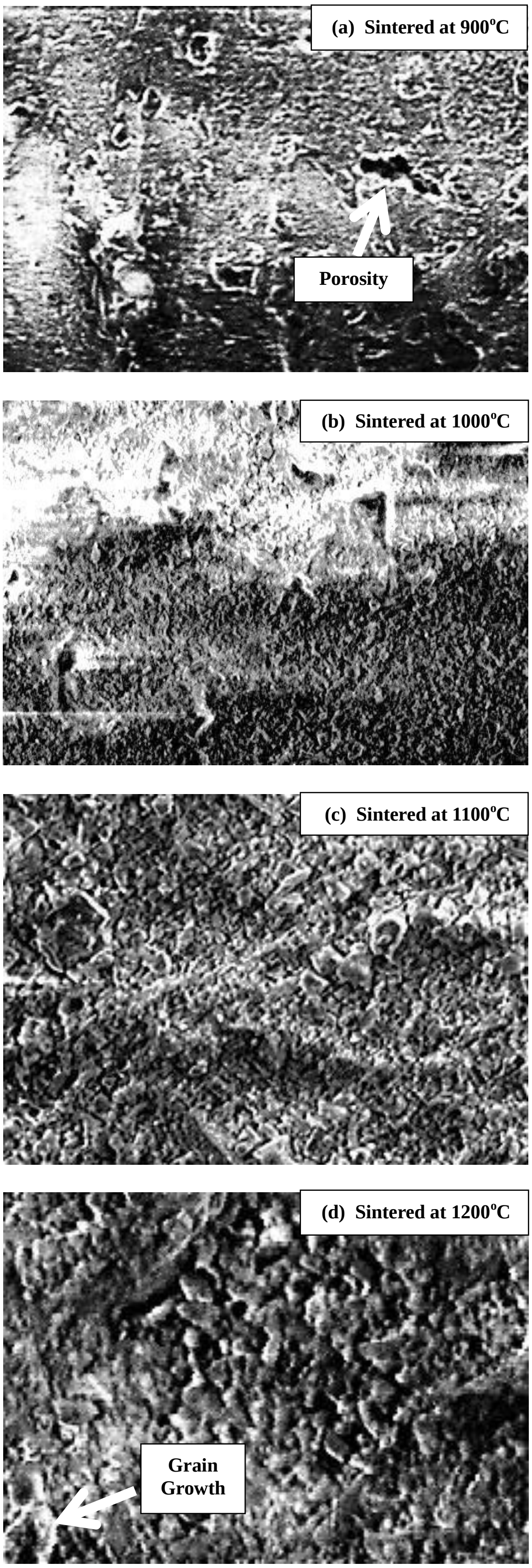

Fig.5: SEM micrographs of Mymensingh Clay

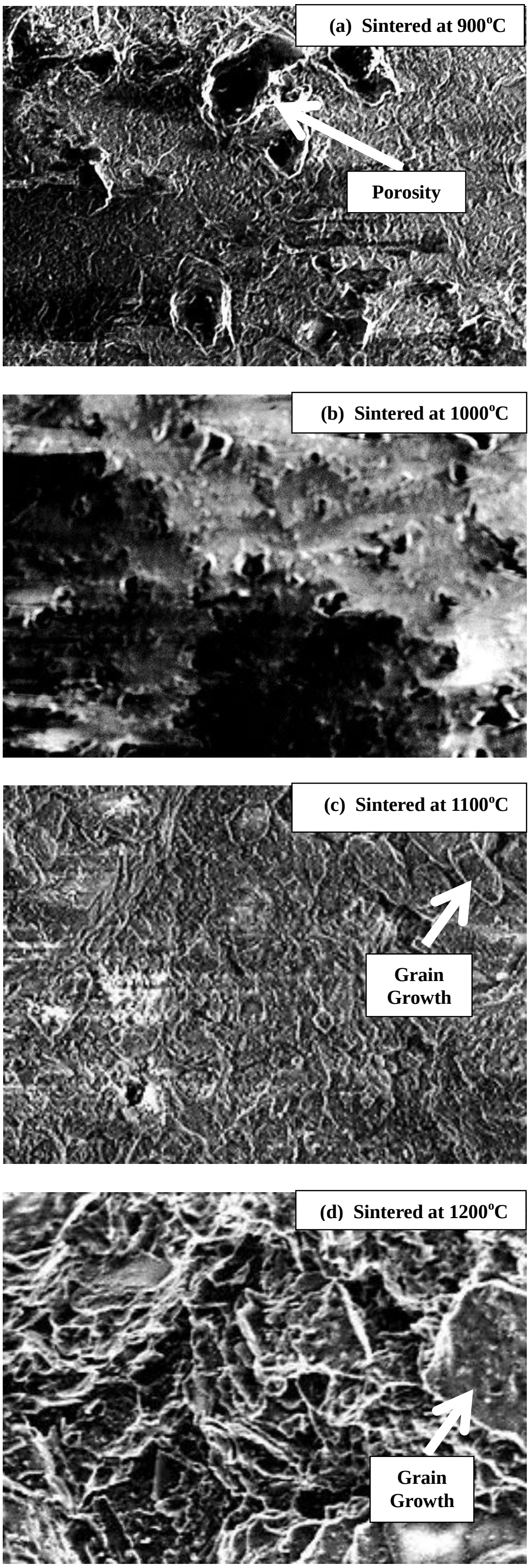

Fig.6:SEM micrographs of Savar Clay

4. CONCLUSIONS

The particle size of Mymensingh clay was finer than the Savar clay. So the packing of particles of Savar clay was poor. The green or unsintered Savar clay samples contained higher porosity. This large particle size and higher porosity resulted the following conclusions:

(1) Ceramic bodies shrink on drying. Because of water removal from the body during drying period the inter-particle distance decreases which consequently cause the volume to shrink. The volume shrinkage of drying is proportional to amount of moisture removed. Savar clay contained higher moisture content than the Mymensingh clay. This resulted a higher percentage of shrinkage during drying.

(2) During sintering removal of porosity between the particles is accompanied by shrinkage of the component. Sintering temperature greatly affect the total densification of the sintered component.At higher sintering temperature the formation of glassy phase becomes easier, which create bonding between the particles, fills up the pores and causes densification. Generally, with increase in sintering temperature degree of densification also increases which reflected by firing shrinkage.

(3) Percent firing shrinkage increased with increase in sintering temperature for both Mymensingh and Savar clay. For Savar clay it became constant at higher sintering temperature.

(4) Normally with increase in firing temperature densification also increases so amount of apparent porosity as well as absorptivity decreases. It was true for both claysamples. As Savar clay had higher porosity so it showed higher water absorptivity than Mymensingh clay.

(5) Sinteringcause densification and bond formation, which results higher cold crushing strength (CCS). The CCS value also depends on particle size. As Mymensingh clay had fine particles it showed higher crushing strength.

5. ACKOWLEDGEMENT

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6. REFERENCES

[1] A. Mousharraf, M.S. Hossain and M.F. Islam, “Potential of Locally Available Clay as Raw Material”, *Journal of Chemical Engineering, IEB,* vol. ChE. 26, no. 1, pp. 34-79, 2011.

[2] W.D. Kingery, H.K. Bowmen, and D.R. Uhlman, *Introduction to Ceramics*, John Wiley & Sons, 1975.

[3] W.E. Worrall, *Clays and Ceramic Raw Materials*, Elsevier Applied Science, 1986.

[4] J.F. Shackelford, R.H. Doremus, *Ceramic and Glass Materials Structure, Properties and Processing*, Springer, 2008.

7. NOMENCLATURE

Symbol	Meaning	Unit
Initial Vol.	Initial Volume	(m^3)
Final Vol.	Final Volume	(m^3)

Initial wt.	Initial Weight	(Kg)
Final wt.	Final Weight	(Kg)
CCS	Cold crushing strength	(N)