Effect of Clay-Sand ratio on the Properties of Clay Bodies prepared from Local Clays

A THESIS SUBMITTED IN THE PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF

BACHELOR OF TECHNOLOGY

IN

CERAMIC ENGINEERING

By

Lucky Goyal

111CR0095

DEPARTMENT OF CERAMIC ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

ROURKELA

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Under the guidance of

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ROURKELA

CERTIFICATE

This is to certify that the project work entitled **"Effect of Clay-Sand ratio on the Properties of Clay Bodies prepared from Local Clays"** submitted by **Lucky Goyal (111cr0507)** is an authentic work carried out by him under my supervision and guidance for the partial fulfillment of the requirement for the award of Bachelor of Technology Degree in Ceramic Engineering at National Institute of Technology, Rourkela.

To the best of my knowledge, the matter embodied in the project has not been submitted to any other University / Institute for the award of any Degree or Diploma.

Date:

(Prof. Santanu Bhattacharyya)

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An assemblage of this nature could never have been attempted without reference to and inspiration from the works of others whose details are mentioned in the reference section. I acknowledge my indebtedness to all of them.

Last but not the least; I am thankful to God and my parents, who kept me for the necessary work during my thesis work.

Date:

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ABSTRACT

Common clay bricks were prepared by mixing sand in different proportions (10, 20, 30, 40 wt. %) with clay. Local clay from two different sources, viz. Koel River and Naga Pond were used as the clay source. The clay – sand mixture was characterized for liquid limit, Plastic Limit and plasticity index. The brick samples were made by hand moulding and fired at 1000°C, 1100°C, 1200°C and 1300°C. Apparent porosity, Bulk density, Water absorption and Bending Strength of the samples were measured. The highest strength was 103.80 kg/cm^2 for bricks prepared from Koel River Clay – Sand mixture(90% Clay - 10% Sand) and sintered at 1300°C, apparent porosity was 22.95% and water absorption 11.78%. In Naga Pond Clay, the strength was 120.02 Kg/cm^2, apparent porosity 22.40% and water absorption 11.45% for 90% Clay – 10% Sand composition .

The porosity increased with increase in sand content. The results show that both the clay can be suitable for common roofing tile and water pitchers.

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INTRODUCTION

1.1 Introduction

Clay brick has been present since the beginning of civilization nearly in form of sun dried or burnt clay brick. It was used because its easy production process, light weight and were resistant to fire. Burnt clay bricks are being used as important building construction material in India. These bricks are used in construction due to its high compressive strength and durability against natural weathering. These bricks also possess reasonable acid-alkali resistance. [1]

Most of the clays exhibit plasticity properties when water is mixed with it. Depending on the amount of water, clay-water system shows four different consistency states granular, plastic, paste and slurry. [2]

The consistency states do affect the properties of green and fired bodies. The important properties of clay based bodies are apparent porosity, water absorption and bending strength. Apparent porosity, bulk density and water absorption are affected by clay properties, method of manufacturing and firing temperature. It also depends on composition - 1.e. the ratio clay to non-clay, material in the batch. The chemical reactions and the shrinkage/expansion occurring at the sintering temperature can also affect the above physical properties. The porosity and water absorption of green bricks are affected by particle size, size distribution and packing density of the green body. In the fired body, these above properties are decided by the mineral phases (crystalline/amorphous), their nature and the bonding with the particles or grains. [3, 4]

In this work, clay based bodies were prepared using local clay and sand mixture. Two types of local clay were used. The clays were collected from Koel River, Koel Nagar Rourkela (Orissa) and from Naga Pond, NIT Rourkela, Rourkela (Orissa). Sand sample was collected from NIT Rourkela campus, Rourkela (Orissa). The justification for this work is to try to utilize the local common clays for brick and roofing tile making and also to try to fix the composition for porous material to be used for water pitchers.

In order to achieve the above objectives, Clay-Sand mix was mixed with suitable amount of water and bricks were prepared by hand moulding method, dried and sintered at different temperatures. The physical and mechanical properties of the bricks were measured as a function of sintering temperature.

Chapter - 2

LITERATURE REVIEW

Only a few literatures are available on the normal clay-sand body making. The following are the summary of the available literatures.

Sedat analyzed the effect of firing temperature on the physical properties and mechanical properties of fired clay bricks. The Plastic Limit, liquid limit and plasticity index were 24.65%, 33.23% and 8.64% respectively. The clay brick samples were fired at different temperature (700°C-1100°C) and apparent porosity, bulk density, water absorption and compressive strength were determined. The results show that firing temperature affects physical properties and mechanical properties of fired brick. The crushing strength increased water absorption decreased with increase in firing temperature. [5]

R. Alonso-Santurde et al. investigated effect of sand addition in clay bricks on the physical and mineralogical properties of clay-sand bricks. Two types of sand were used in this investigation, viz. Green Sand (GS) and Core Sand (CS). 0%-50% of Sand is mixed with clay and fired at 850°C-1050°C to produce bricks. It was observed that Clay-Green Sand brick fired at 1050°C have improved physical properties. Sand content increases the water absorption and decreased at lower sand content and the firing shrinkage increases. This led to decrease in flexural strength and bulk density. At higher firing temperature, the water absorption decreases and the flexural strength increases. Thus Clay- Green Sand brick fired at 1050°C had better properties. It was also concluded that foundry sand industrial waste could be used as raw material for manufacturing ceramic products. [6]

Johari et al. investigated effect of firing temperature on microstructure, phase composition, water absorption, compressive strength and porosity of brick collected from Beruas (Malaysia). The Bricks were fired at 850°C -1250°C. In the fired bricks, the porosity decreased from 39.33% to5.87% on increasing the firing temperature from 1000°C to 1250°C. Brick fired at 1000°C or higher temperature showed good compressive strength and improved physical properties. Brick fired below 1000°C had high water absorption > 25% whereas the brick fired at 1200°C and 1250°C had water absorption value 6.63% and 2.71% respectively. It was concluded that economically cheap brick (porosity <29%) could be made by firing at 1100°C. Such bricks also had low water absorption (25%) and high strength value about 40-70N/mm2. [7]

The above literature reviews show that common clay and sand mixture could be shaped and fired at different temperatures to produce common brick and tile. The water absorption, porosity and strength were dependent on clay-sand ratio and firing temperature.

In view of the above, the following has been decided for investigation in the present study:

1. Preparation of different clay-sand mixture using clays from two local sources.
2. Determination of plastic and flow property of the clay-sand mixtures as a function of sand content.
3. Determination of drying and firing shrinkage of the fired bricks.
4. Determination of firing shrinkage, porosity, water absorption and strength of the fired Clay-Sand bricks as a function of
    a. clay- sand ratio
    b. Firing temperature.
5. To decide the optimum composition and firing temperature for use as common roofing tile.

Chapter – 3

EXPERIMENTAL PROCEDURE

The Experimental Procedure consisted of following steps:

3.1 Clay collection and processing of clay

Clay sample used for making clay-sand bricks were collected from Koel River, Rourkela (Orissa) and Naga Pond, Rourkela (Orissa). The collected Clay samples were dried in open air for 2-3 days followed by oven drying at a temperature 120ºC. The dried clay was crushed and ground to a fine powder. This powder was then passed through a 150μm sieve to remove the coarse fraction.

3.2 Sand collection and processing of sand

The collected sand sample was washed with water to remove dust. After water washing the sand was treated with1:1 diluted HCl and the whole system was boiled for 10-15 minutes and then stirred for 30 to 40 minutes. After this step the color of acid solution turned to brownish yellow. This change in colour was due to dissolution of Fe-Oxide in acidic solution. Process was repeated more 2 or 3 times followed by water washing. The dried powder was treated with magnet by passing the magnet over the sand to remove iron particles. Finally the sand was sieved through 180μm sieve to obtain fine sand powder.

3.3 Determination of liquid limit, Plastic Limit and plasticity index

3.3.1 Method for determining Plastic Limit of soil:

Plastic Limit is defined as minimum water content at which behavior of clay changes to plastic. Plastic Limit is calculated by Rolling Thread Method and if clay is plastic then it can be thread rolled into small diameter. Plastic Limit is water content where this thread breaks apart at a diameter of 3.2nm. [8]

Apparatus required:

- Petri dishes
- Balance
- Glass plate
- Spatula or knife
- Measuring cylinder
- Beaker, Drying oven

Procedure:

Four empty petri dishes were weighed and noted. Some amount of Koel River or Naga Pond Clay was taken in a beaker and water was added till clay behaved such that could be easily rolled without sticking to the hands. This consistency clay mixture was taken and rolled between fingers and glass plate to make a thread of 3.2mm.If thread diameter reached 3.2 mm without crumbling then the process was continued till the rolled thread was no longer able to reach 3.2 mm without crumbling. The crumbled thread was placed in the petri dish and weight was noted and kept in a drying oven for at least 24 hours. After drying the weight of petri dishes containing dried clay were measured and noted.

The moisture content was calculated for each sample according to the formula:

Moisture content (%) = (M2-M3)/ (M1-M2) ………………….. (1)

Where,

M1 = weight of empty Petri dish

M2 = weight of Petri dish + Clay before drying

M3 = weight of Petri dish + Clay after drying

Average of five moisture contents was taken which gave us the Plastic Limit for Koel River/Naga Pond Clay.

3.3.2 Method for determining liquid limit of clay:

Liquid limit of clay is defined as water content at which it changes its consistency from plastic to liquid. Liquid limit is calculated by Liquid Limit Test defined by ASTM standard test method. Liquid limit is also defined as water content at which it takes 25 taps of bowl to close a groove of 13.5mm. [8]

Apparatus required:

- Liquid limit device
- Petri dishes
- Flat grooving tool with gage
- Plastic beaker
- Weighing Balance
- knife
- Water cylinder
- Drying oven.

Procedure:

Four empty petri dishes were weighed. Some amount (nearly 100gm) of Koel River or Naga Pond Clay was taken in a plastic beaker and mixed with small amount of water just to make it smooth paste. Liquid limit device was adjusted to make sure that point where the distance between the cup base and the height during bumping should be 10 mm. The clay paste was placed into the cup of liquid limit device and was spread equally. Grooving tool was used to cut a straight groove from the center of cup and separate into two halves. The device was rotated at a rate of 2 tapping per second and number of tapping was counted till two parts of clay paste meet at bottom part of groove at least up to a distance of 13.5mm.A small portion of clay paste was taken in a petri dish with help of knife and weight of petri dish with clay was taken in weighing balance. The clay samples were dried in an oven for at least 24 hours. The weight of petri dishes was noted.

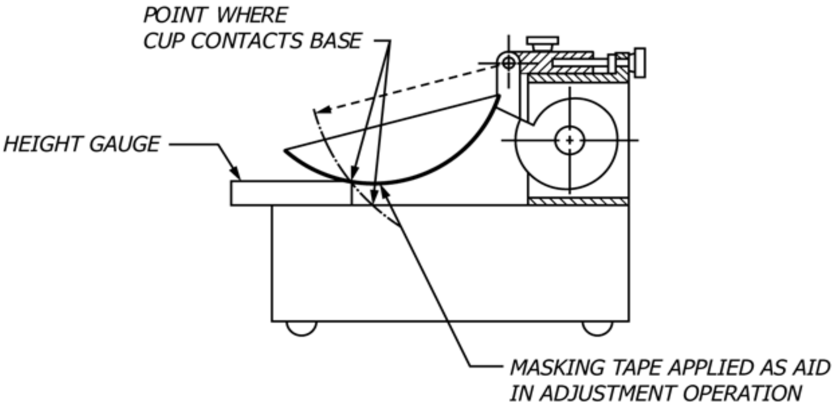

Figure 1 Liquid limit device [8]

Moisture content was calculated for all samples according to the formula:

Moisture content (%) = (M2-M3)/ (M1-M2) ……………… (2)

Where,

M1 = weight of empty Petri dish

M2 = weight of Petri dish + Clay before drying

M3 = weight of Petri dish + Clay after drying

No. of tapping (N) was plotted against moisture content (%) and from the graph moisture content was determined for 25 no. of tapping. This value of moisture content is liquid limit of Koel river/Naga Pond Clay.

3.4 Batch composition and mixing

3.4.1 For Naga Pond Clay sample

The preparation of test samples involved mixing of clay with varying amount of sand from 10% to 40% by weight in an agate mortar.

Table 1 1Amount of clay and sand mixed for different composition of Naga Pond Clay and sand mix

Clay-sand mix	Amount of clay(gm)	Amount of sand(gm)
90% clay-10% sand mix	108	12
80% clay-20% sand mix	104	26
70% clay-30% sand mix	98	42
60% clay-40% sand mix	90	60

3.4.2 For Koel River Clay sample

The preparation of test samples involved mixing of clay with varying amount of sand from 10% to 40% by weight in an agate mortar for homogeneous mixing as shown in table.

Table 2Amount of clay and sand mixed for different composition of Koel River Clay and sand mix

Clay-sand mix	Amount of clay(gm)	Amount of sand(gm)
90% clay-10% sand mix	108	12
80% clay-20% sand mix	104	26
70% clay-30% sand mix	98	42
60% clay-40% sand mix	90	60

3.5 Shaping

The clay-sand mixes thus prepared were mixed with suitable amount of water to make a paste that can be rolled easily on a plane glass plate. Now this paste was rolled between my hand and plane glass plate to get a ball type shape. After that it was pressed by some plane heavy object. After pressing it up to the required width brick samples of required dimension were cut of it using knife and scale. Bricks made were then kept for drying in oven for minimum of 48 hours at temperature 50ºC - 120ºC.after drying firing is done in muffle furnace and total 111 fired clay-sand bricks were prepared .

3.6 Drying and Firing

The green shaped brick was dried at a temperature in between 50ºC-120ºC for 48 hours. During drying of brick, the moisture evaporates leading to the shrinkage of brick. After drying of these bricks, firing was done at 1000ºC, 1100ºC, 1200ºC and 1300ºC with a holding time of 2 hours at the peak temperature.

Figure 2 Brick samples fired at 1000ºC

Figure 3 Naga Pond Clay-Sand bricks fired at 1100ºC, 1200ºC and 1300ºC

Figure 4 Koel River Clay-Sand bricks fired at 1100ºC, 1200ºC and 1300ºC

3.7 Determination of Firing Shrinkage

Firing shrinkage was measured making two marks on the surface of bars 2cm apart just after shaping and measuring the distance after drying and again after firing. Firing shrinkage was measured by measuring the length of the sample after firing. Hence firing shrinkage can be formulated as follows:

$$\text{Firing shrinkage (\%)} = ((l_0 - l_1)/l_0) \times 100 \ldots\ldots\ldots\ldots\ldots\ldots \text{(3)}$$

Where,

l_0 = initial distance between holes after drying

l_1 = final distance between holes after firing

3.8 Determination of Apparent porosity, Bulk Density and Water Absorption

Apparent porosity, Bulk density and Water absorption of fired clay-sand bricks were measured by boiling water method. [9]

Apparatus required:

Balance, glass beaker (suspended mass container), glass beaker (boiling container), wire loop, wet cloth, heater

Procedure:

Dry weight of clay-sand bricks were measured and noted. Sometimes test samples breaks during saturation or boiling so dry weight can be taken after process completes. Distilled water was filled in glass beaker and clay-sand bricks were placed carefully inside it. Whole system was kept on heater for boiling it.it should be noted that bricks should be completely immersed in water throughout the boiling period and further water can be added if water level goes down. Boiling was done for 2 hours.

After boiling samples were kept for soaking in the same water they were boiled for a period of 24 hours .it was made sure that samples were completely immersed in water. Suspended weight was measured for each brick after the soaking of bricks and noted. Suspended weight was calculated by keeping the brick sample on wire loop suspended in water and attached to balance by other end.

Saturated weight (soaked weight) was measured after removing all the visible water droplets present on surface of brick sample using a wet cloth. You should take care during removing droplets as it can introduce error if water present in pores goes out. After this brick sample was weighed using balance and weight sample noted. Similarly all brick samples were weighed. Weight measurement should be done immediately to avoid errors.

Apparent porosity = [(M – D) / (M – S)] x 100 ……………………… (4)

Bulk density = D / (M – S) …………………...…... (5)

Water absorption = [(M – D) / D] x 100 ………………………. (6)

Where,

M = Soaked weight

S = Suspended weight

D = Dry weight

3.9 Determination of Bending Strength

The bending strength of the sintered bars was measured by 3 point bending method using a Universal Tensile Machine (H10KS Tinius Olsen). Width and height of the samples were measured using a Vernier caliper. Bars were placed in 3 point bend fixture as shown in Figure 5. Span length was set to 35mm and test speed was set 0.5mm/minute. Flexural strength was measured. Flexural strength can be calculated according to the formula:

Flexural strength = $1.5Pl/bd^2$ ……………………….. (7)

Where,

P = corrected load on bar

L = Span length

b = Breadth of sample

d = Height of sample

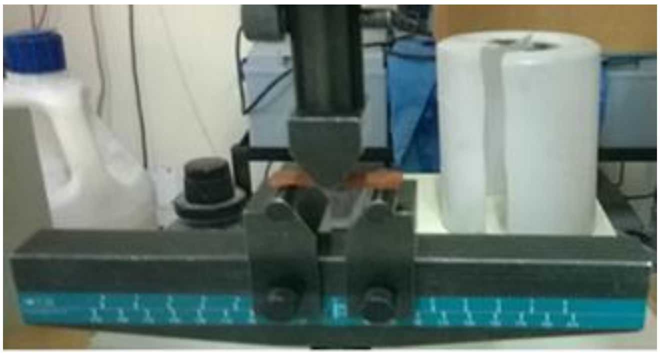

Figure 5 3 Point Bend Test fixture

Figure 6 H10KS Tinius Olsen Universal Testing Machine (UTM)

Chapter – 4

Results and Discussion

4.1 Liquid limit, Plastic Limit and Plasticity Index

Liquid limit, Plastic Limit and Plasticity Index were calculated for both types of clays. Liquid limit test results are shown in Table 3 for Naga Pond Clay sample and in Table 4 for Koel River Clay. Liquid limits were calculated by plotting no. of tapings vs water content shown in Figure 7 for Naga Pond Clay and in Figure 8 for Koel River Clay for Naga Pond Clay respectively. Liquid limit for Koel River Clay was found to be more than from Naga Pond Clay. Liquid limit for Naga Pond Clay was found to be 55.6 and for Koel River Clay it was 61.8.

Table 3 Liquid limit test results for Naga Pond Clay

Sample	M1	M2	M3	Water content(w)	No. of taping
1	27.589	30.781	29.490	40.44	38
2	27.821	30.118	28.887	53.59	27
3	27.935	28.955	28.337	60.58	22

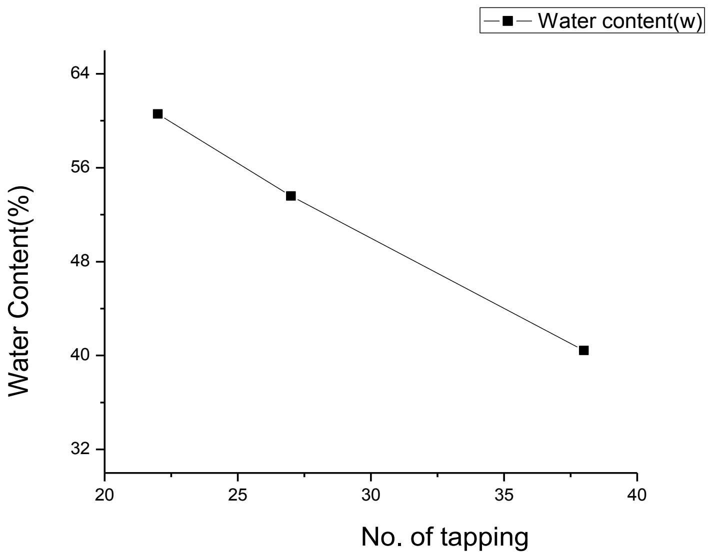

Figure 7 No. of tapping vs water content for Naga Pond Clay

Table 4 Liquid limit test results for Koel River Clay

Sample	M1	M2	M3	Water content(w)	No. of taping
1	28.051	30.058	29.763	30.32	49
2	27.642	28.625	28.175	45.77	38
3	26.728	28.965	27.757	54.00	32

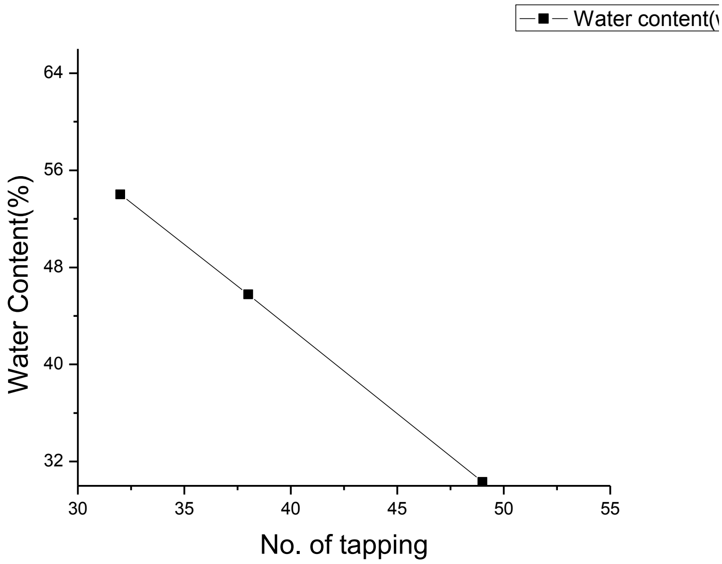

Figure 7 No. of tapping vs water content for Koel River Clay

Plastic Limit test results are shown in Table 5 for Naga Pond Clay and Table 6 for Koel River Clay respectively Plastic Limit value for naga pond was found to be 46.43 and for Koel River it was 50.03. It can be seen that Plastic Limit of clay from Koel River is more than the clay from Naga Pond.

Table 5 Plastic Limit test results for Naga Pond Clay

Sample	M1	M2	M3	Water content(W)
1	26.728	27.624	27.206	49.47
2	27.819	28.701	28.302	45.23
3	28.043	29.114	28.637	44.53
4	30.024	30.869	30.476	46.50

Table 6 Plastic Limit test results for Koel River Clay

Sample	M1	M2	M3	Water content(W)
1	27.642	27.884	27.765	49.17
2	28.051	28.385	28.212	51.79
3	27.710	27.965	27.842	48.23
4	29.645	29.899	29.769	51.18

Plasticity index was calculated for both types of clays. Plasticity Index for Koel River Clay sample and for Naga Pond Clay sample is found to be 11.71 and 9.17 respectively.

4.2 Firing shrinkage

Table 7 Firing shrinkage vs sand content for Naga Pond Clay-sand brick fired at 1000ºC

Percent Sand	10	20	30	40
Percent Firing shrinkage	1.90	1.78	1.74	1.39

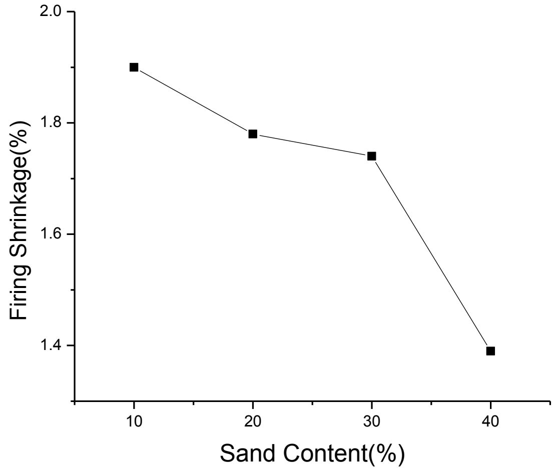

Figure 8 Sand Content vs Firing Shrinkage for Naga Pond Clay/sand brick fired at 1000ºC

Table 8 Firing Shrinkage vs Sand Content for Koel River Clay/sand brick fired at 1000ºC

Percent Sand	10	20	30	40
Percent Firing shrinkage	2.08	1.67	1.38	1.43

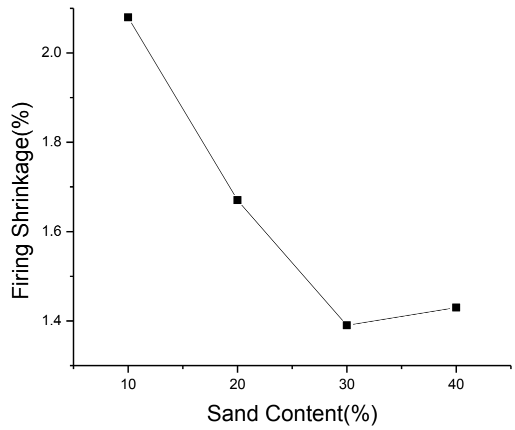

Figure 9 Firing Shrinkage vs Sand Content for Koel River Clay/sand bar fired at 1000ºC

Variation of firing shrinkage with sand content for clay-sand bar is shown in Figure 9 and Figure 10. Firing shrinkage decreases with sand addition due to reduction in pore removal and decrease densification.

4.3 Apparent porosity, Bulk Density, Water Absorption and Flexural Strength

Apparent porosity, bulk density and water absorption of clay-sand bar were calculated for different sand percentage by weight for different firing temperatures ranging from 1000ºC -1300ºC.As we can see from results apparent porosity increases with increase in sand percentage and also it decreases with increase in firing temperature. Flexural strength was also calculated for each sample for varying sand content and at different firing temperature.

According to this study, water absorption and apparent porosity increases and bulk density decreases with addition of sand for bricks fired at 1000ºC can be seen from Table 9 and Table 10. Maximum porosity for Koel River Clay-sand brick was measured for 60% clay-40%sand bar fired at 1000 ºC and minimum porosity for 90%clay-

10%sand brick composition fired at 1300 ºC. Porosity value for Koel River Clay brick fired at 1000 ºC are 30.312% and 33.85% for 10% sand addition and for 40% sand addition respectively. Similarly for Naga Pond Clay-sand brick fired at 1000 ºC apparent porosity value ranges from 30.22% and 33.45% for 10% sand addition and 40% sand addition respectively.

Table 9 Porosity, Density, Water Absorption and Strength for Naga Pond Clay-Sand bars fired at 1000ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	30.22	32.29	32.94	33.45
Bulk density(g/cm^3)	1.833	1.821	1.807	1.8005
Water absorption (%)	16.2075	17.23	17.43	18.12
Bending strength(Kg/cm^2)	59.44	52.71	22.56	19.17

Table 10 Porosity, Density, Water Absorption and Strength for Koel River Clay-Sand bars fired at 1000ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	30.312	32.72	33.06	33.85
Bulk density(g/cm^3)	1.832	1.81	1.804	1.801
Water absorption (%)	16.256	17.48	17.99	18.205
Bending strength(Kg/cm^2)	35.31	23.50	19.51	11.01

Table 11 Porosity, Density, Water Absorption and Strength for Naga Pond Clay-Sand bars fired at 1100ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	28.04	29.10	30.03	31.48
Bulk density(g/cm^3)	1.923	1.8836	1.850	1.817
Water absorption (%)	14.58	15.44	16.22	17.31
Bending strength(Kg/cm^2)	70.46	47.31	38.41	19.86

Table 12 Porosity, Density, Water Absorption and Strength for Koel River Clay-Sand bars fired at 1100ºC

Properties	Weight Percent Sand			
	10%	20%	30%	40%
Apparent porosity (%)	28.04	29.10	30.03	31.48
Bulk density(g/cm^3)	1.923	1.8836	1.850	1.817
Water absorption (%)	14.58	15.44	16.22	17.31
Bending strength (Kg/cm^2)	70.46	47.31	38.41	19.86

Table 13 Porosity, Density, Water Absorption and Strength for Naga Pond Clay-Sand bars fired at 1200ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	27.90	28.373	29.16	30.43
Bulk density(g/cm^3)	1.935	1.9075	1.881	1.863
Water absorption (%)	14.41	14.81	15.52	16.326
Bending strength(Kg/cm^2)	87.28	74.64	66.89	57.61

Table 14 Porosity, Density, Water Absorption and Strength for Koel River Clay-Sand bars fired at 1200ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	27.99	28.93	29.77	31.026
Bulk density(g/cm^3)	1.924	1.893	1.878	1.826
Water absorption (%)	14.54	15.27	15.84	16.98
Bending strength(Kg/cm^2)	78.72	69.95	63.83	33.23

Table 15 Porosity, Density, Water Absorption and Strength for Naga Pond Clay-Sand bars fired at 1300ºC

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	22.40	23.405	23.47	26.22
Bulk density(g/cm^3)	1.955	1.951	1.946	1.937
Water absorption (%)	11.45	12.005	12.06	13.53
Bending strength(Kg/cm^2)	120.02	95.03	84.84	61.28

Table 16 Porosity, Density, Water Absorption and Strength for Koel River Clay-Sand bars fired at 1300°C

Properties	Weight Percent Sand			
	10	20	30	40
Apparent porosity (%)	22.95	23.44	23.98	26.833
Bulk density(g/cm^3)	1.947	1.936	1.928	1.924
Water absorption (%)	11.78	12.10	12.44	13.94
Bending strength(Kg/cm^2)	103.80	88.10	82.69	55.16

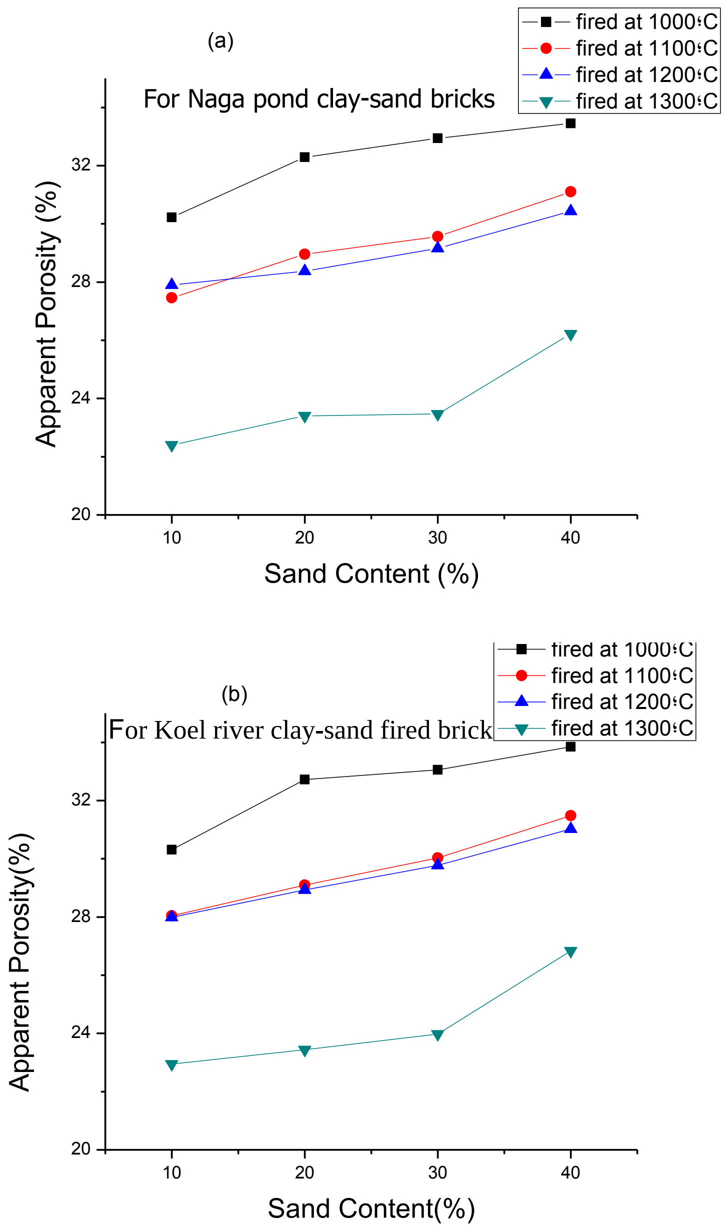

Figure 10 Sand Content vs Apparent Porosity (a) For Naga Pond Clay-Sand bars and (b) For Koel River Clay-Sand fired bars

The variation of Apparent Porosity of clay-sand bar samples with firing temperature and Sand Content for samples prepared with Naga Pond Clay is shown in Figure 11(a) and for samples prepared with Koel River Clay is shown in Figure 11(b). Apparent porosity increased with increasing sand content and decreased with increase in firing temperature. The increase in porosity with sand content is due to the increase in non-plastic fraction. Since sand is non-shrinkage hence the shrinkage of clay produces porosity. At higher sintering temperature, the decrease in porosity is due to higher densification and the resultant decrease in porosity.

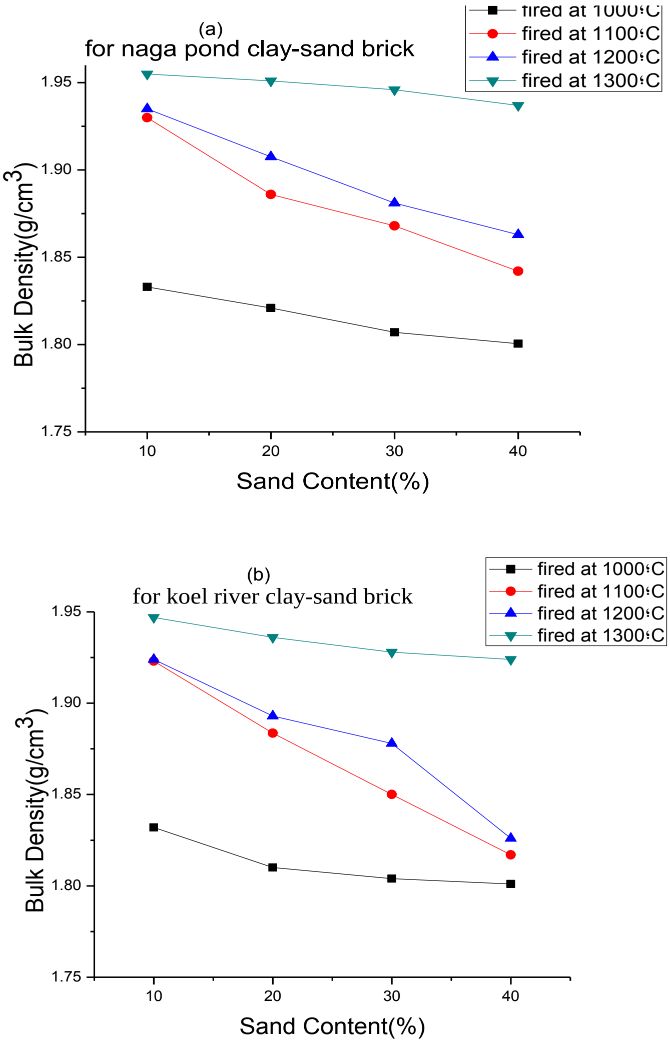

Figure 11 Sand Content vs Bulk Density (a) For Naga Pond Clay-sand bars and (b) For Koel River Clay-sand fired bars

The variation of Bulk density with firing temperature and Sand Content for samples prepared with Naga Pond Clay is shown in Figure 12(a) and for samples prepared with Koel River Clay is shown in Figure 12(b). Bulk density decreased with increasing sand content and increased with increase in firing temperature. Bulk density is related to densification and densification decreases with increase in sand content. Addition of sand increases voids. Thus density decreases at higher sand content. On increasing firing temperature density increases as also the bulk density due to higher densification.

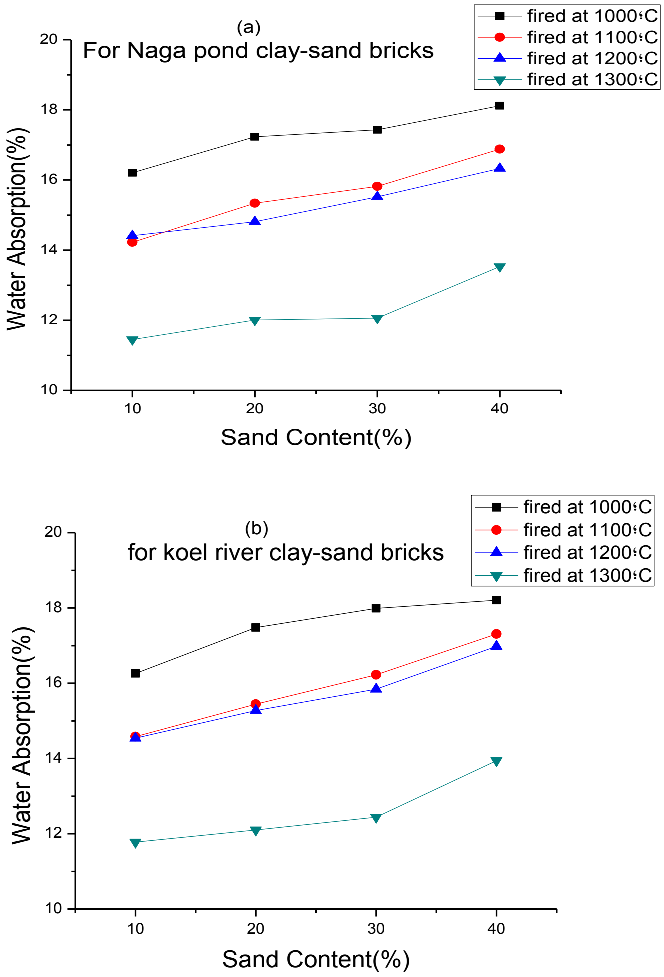

Figure 12 Sand Content vs Water Absorption (a) For Naga Pond Clay-sand bars and (b) For Koel River Clay-sand fired bars.

The variation of Water absorption with firing temperature and Sand Content for samples prepared with Naga Pond Clay is shown in Figure 13(a) and for samples prepared with Koel River Clay is shown in Figure 13(b). Water absorption increased with increase in sand content and decreased with increase in firing temperature. The increase in water absorption is due to increase in the non-plastic fraction. Since sand is non-shrinking hence the shrinkage of clay produces porosity. At higher sintering temperature, the decrease in water absorption is due to higher densification and the resultant decrease in water absorption.

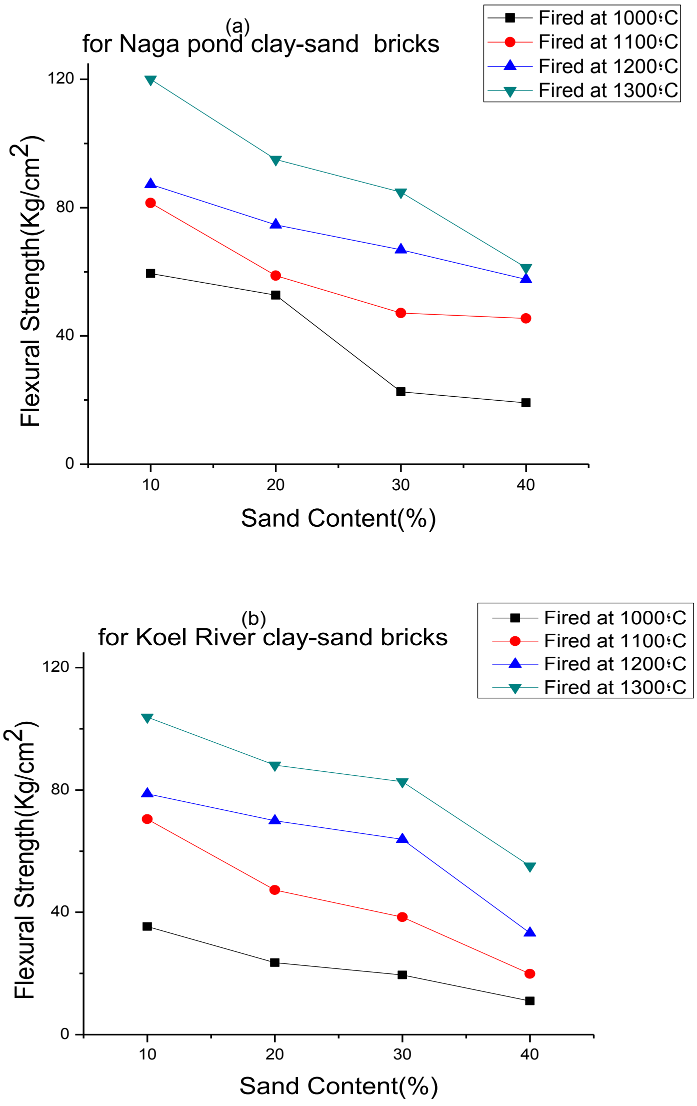

Figure 13 Sand Content vs Flexural Strength (a) For Naga Pond Clay-sand bars and (b) For Koel River Clay-sand fired bars.

The variation of Flexural strength with firing temperature and Sand Content for samples prepared with Naga Pond Clay is shown in Figure 18(a) and for samples prepared with Koel River Clay is shown in Figure 18(b). Flexural strength increased with increase in firing temperature and decreased with increase in sand content. The decrease in Flexural strength with sand content is due to the increase in non-plastic material which reduces shrinkage and also creates porosity. Higher porosity results in the decrease in bending strength.

Chapter – 5
Conclusions

- Plastic Limit of Koel River Clay was 50.03% and of Naga Pond Clay was 46.43%. Liquid Limit of Koel River Clay was 61.8% and of Naga Pond Clay was 55.6%. Plasticity index of Koel River Clay was 11.71 and of Naga Pond Clay was 9.17.
- Apparent porosity increased with the increase in sand content and decreased with an increase in firing temperature.
- Bulk density decreased with increasing sand content and increased with increase in firing temperature.
- Water absorption increased with increase in sand content and decreased with the increase in firing temperature.
- Bending Strength decreased with increasing sand content and increased with an increase in firing temperature.
- For Naga Pond Clay – Sand bar, the highest Bending Strength (120 Kg/cm^2) was achieved for 90% clay – 10% sand brick composition when sintered at 1300°C . The sample had Apparent Porosity 22.40% , Bulk Density 1.955 g/cm^3 and Water Absorption 11.45%.
- For Koel River Clay – Sand bar, the highest Bending Strength (103.8 Kg/cm^2) was obtained in 90% clay – 10% sand brick composition when sintered at 1300°C. The samples had apparent porosity 22.95%, bulk density 1.947 g/cm^3 and water absorption 11.78%.

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