An Experimental Study on Properties of Burnt Clay Bricks using Industrial Waste

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Abstract— There is over million tons of industrial wastes are being produced by mining industrial process per annual in India. The problem is to dispose these waste materials which are arising from continuous technological and industrial development. If some of these waste materials produced by industrial processes are found suitable and utilized in construction field, then the disposal of such waste materials can be achieved and thereby cost of construction can also be cut down. Kaolin waste (china clay waste) is one of such materials which is being generated by industries abundantly. Since kaolin gains strength on heating, an attempt is made in this investigation to utilize the kaolin waste in burnt clay bricks and results are studied. In the present work, burnt clay bricks are prepared with kaolin waste as a replacement of traditional clay in different proportions i.e. 5%, 10%, 15%, 20% and 25%. These bricks are tested for its basic properties and the results are compared with conventional burnt clay bricks. Masonry compressive strength test and flexural strength tests had been conducted on the masonry samples of optimum percentage. Finally it is concluded that industrial waste replaced burnt clay bricks can be successfully used in construction field since it has achieved more strength than traditional clay bricks and hence in turn disposal of some industrial waste found suitable way of utilization.

Key words: Kaolin Waste, Burnt Clay Brick, Conventional Clay Bricks, Compressive Strength, Water Absorption, Flexural Strength.

I. INTRODUCTION

Burnt clay Bricks are the one of the substantial basic material required in the construction activities. Clay bricks are the one of the oldest artificial building material and its wide spread use due to properties like fire resistant and durability against various weathering actions. Manufacturing process of burnt clay bricks is simple, it involves preparation of wet clay mix, conferring wet mix to the desired shape, drying and burning. Firing temperature, production method and properties of clay mix are the key components in deciding the various properties of burnt bricks, however compressive strength and water absorption are the major properties. Quality of burnt clay bricks made its application in the construction of load and non load bearing structure. Construction of masonry structure with burnt clay bricks as a masonry units gained more popularity than the concrete block masonry. Adequate masonry bond strength can be established with usage of appropriate combination of bricks and masonry mortar.

Masonry wall are one of the low cost building material, having good heat insulation properties, easy availability and locally available material. Masonry is a consistently an anisotropic, non-elastic and non-homogeneous material and it is very weak in tension force this is because masonry structure is made of a two elements i.e. bricks and mortar therefore masonry normally provided to resist the compressive forces. The strength and stiffness of masonry depends on the bricks and mortar strength respectively and it usually lies between the strength of bricks and mortar and this fact may be true when one component of masonry is weaker and softer than other. The main aspect of this study is to achieve higher strength in burnt clay bricks by using the waste materials from kaolin processing industry as kaolin undergoes thermal activation on heating which has an influence on the increase in compressive strength of bricks.

Kaolin (china clay) is mainly composed of kaolinite which is a clay mineral formed by the hydrothermal decomposition of granite rocks over many millions of years. It is a hydrated aluminium silicate crystalline mineral and its chemical composition is $Al_2Si_2O_5(OH)_4$. Kaolin mining is done by three different processes such as opencast mining, refining and drying. Kaolin is the soft white clay generally used in the production of porcelain, paper, paint, rubber and other products. Kaolin becomes plastic when it is mixed with water of 25 to 35 percent, can be molded under pressure and even retain its shape after removal of pressure. Quantity of water required for the plasticity of kaolin mainly depends on the size and chemical composition of kaolin particles, with the increase of water amount kaolin turns into slurry form. Mainly, kaolin industry produces two kinds of wastes while processing primary kaolin. Separation of sand from ore constitutes the first type which is the first processing step and second processing step gives rise to second type of waste where the process of wet sieving is indulged to separate the finer fraction and thereby purifying the kaolin. However, large quantity of waste is generated during the mining and processing of kaolin which leads to the disposal problem.

II. METHODOLOGY

A. Clay:

The base clay used in this current research study is collected from three different sites which suits some specific properties and characteristics for brick manufacturing. This clay is tested to determine its various properties and results are tabulated in table-1.

Fig. 1: Clay Mix

Tests	Results	Unit
Specific Gravity	2.579	-
Sand fraction (4.75mm-75µ)	2.583	%
Moisture Content	1.25	%
Liquid limit	41.0	%
Plastic limit	26.7	%

Table 1: Physical properties of clay

B. Kaolin Waste:

The kaolin waste was brought from Mysore Minerals Ltd (MML) near Bhageshpur, Arasikere Taluk. This waste was sieved through 90µ sieve to remove any coarser and organic impurities, also to avoid voids in the bricks and to get appropriately mixed with the base clay while brick manufacturing. Chemical and physical properties of kaolin waste are analyzed and tabulated in table 2 and table 3.

Fig. 2: industrial waste (kaolin waste)

Chemical Composition %	Kaolin waste
Sio_2	53
Al_2O_3	29
Fe	1.2
CaO	1.0
MgO	0.9
TiO_2	0.4
LOI	9.0
P^H	6.8

Table 2: Chemical properties of kaolin waste

Tests	Results	Unit
Specific Gravity	2.583	-
Fineness Modulus	3.268	%
Moisture content	0.65	%
Liquid Limit	49	%
Plastic Limit	23	%

Table 3: Physical Properties of Kaolin waste

III. Experimental Results and Discussions

The kaolin waste is replaced with the basic clay material with different percentages i.e. 5, 10, 15, 20 & 25% and bricks are prepared with the process of hand molding. By knowing the volume of brick mould (220×100×75) and density (1.83g/cc), the total weight (i.e. 3040grams) of the clay required to prepare one single brick is found. Five different percentages are made according to different percentage replacement of kaolin waste with the basic clay and water is added to every proportion until the mix becomes plastic in stage. These prepared bricks are then allowed to dry in a shaded area for 15 days and the dried bricks are burnt in a kiln for about 20 days using rice husk as a fuel. Then the bricks are subjected to test different physical and mechanical properties such as dimensionality, initial rate of absorption, water absorption, dry density, hardness, efflorescence, soundness, shape & size, dry & wet compressive strengths, expansion on saturation, alternative wetting & drying and masonry prism strength. Major properties are discussed below:

A. Water Absorption

The water absorption test is performed as per the guidelines of IS code. The below table shows the percentage of water absorption of different percentage replacements.

Replacement of kaolin waste (%)	Dry Weight (Kg)	Wet Weight (Kg)	Water Absorption (%)
0	2.85	3.35	17.54
5	2.88	3.26	13.19
10	2.87	3.26	13.58
15	2.86	3.24	13.28
20	2.81	3.19	13.52
25	2.84	3.20	12.67

Table 4: Results of Water Absorption

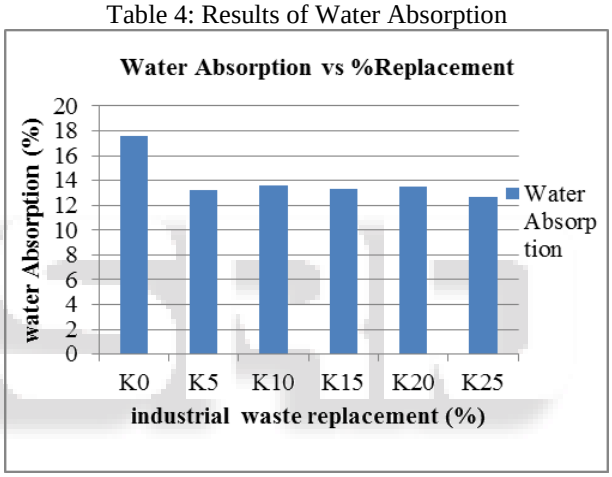

Fig. 3: Water Absorption Vs % Replacement

From the above figure it can be seen that the water absorption is maximum for the bricks with 0% kaolin waste. For 5% and 25% of kaolin waste, water absorption found to be minimum i.e., 13.19 & 12.67% respectively. There is an about 23% of difference in water absorption between bricks with and without kaolin waste.

B. Compressive Strength

Compressive strength of the prepared samples was determined according to guidelines and specifications of IS code. The below table shows average dry compressive strength.

% Of Industrial Waste Replaced	Length (mm)	Breadth (mm)	Depth (mm)	Load (KN)	Dry Compressive Strength (N/mm^2)
0	218	97	73	70	3.31
5	219	98	74	140	6.52
10	219	96	73	150	7.18
15	218	97	73	160	7.56
20	219	98	74	140	6.52
25	217	97	72	120	5.70

Table 5: Test results of dry compressive strength

From the above table it can be note that as the percentage of industrial waste increases there will be increase in compressive strength of bricks. Later the strength deceases with the further increment in the industrial waste replacement beyond 15% and hence 15% replacement is found out to be optimum value.

Below fig. shows the graphical representation in variation of compressive strength of bricks with different percentage replacement of industrial waste and it was found that there is a drastically increase in a compressive strength for each 5% replacement of clay by kaolin waste and 15% replacement was found to be optimum value.

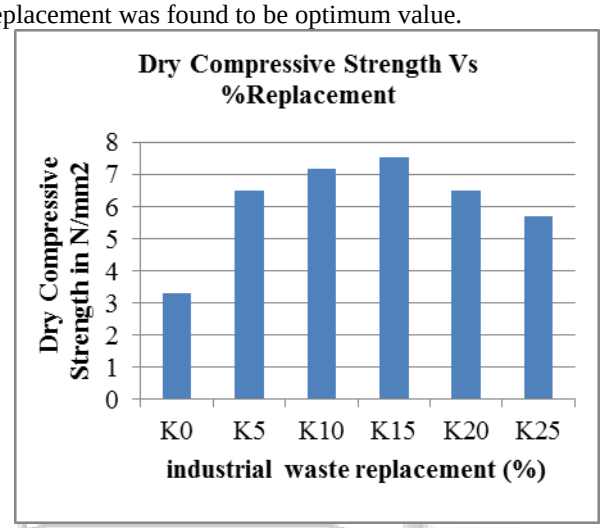

Fig. 4: dry compressive strength Vs % replacement

– The wet compressive strength test has been carried out in surface dry condition on bricks saturated for 24hours in water. However, the load is applied only in the direction parallel to the thickness of the brick. Three specimens from the each series have been tested for wet compressive strength. The test is performed as per the specifications of IS code, same procedure adopted as in the case of dry compressive strength test.

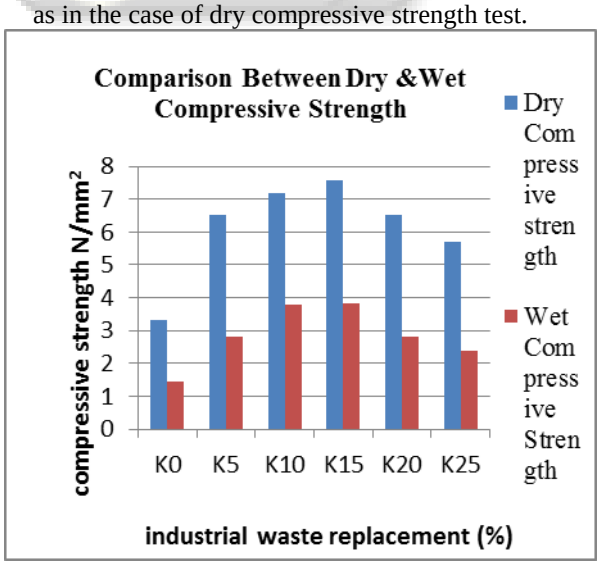

Fig. 5: comparison between wet and dry compressive Strengths

The above graph shows the comparison between wet and dry compressive strengths of different percentage replacements.

C. Masonry Prism Test

Testing on masonry prism strength is done according to IS standards. 1:6 cement sand mortar are used as a bonding agent to bind the masonry bricks. The properties of masonry prism are as shown in the below table.

Parameters	**Masonry With Normal Bricks**	**Masonry With Industrial Waste Replacement (15%)**
Compressive Strength By Prism Test(N/mm^2)	0.8	1.462
Masonry Efficiency (%)	55.55	38.07
Flexural Bond Strength By Bond Wrench Test (N/mm^2)	0.16	0.201

Table 6: Properties Masonry Prism

Bond wrench testing is done according to ASTM C 1072. According to standards, lever arm used to create a moment in the mortar joint. Calculation of flexural bond strength is done according to the below mentioned formula.

$$f_b = 6PL/bt2$$

Where,

f_b = Flexural bond strength of masonry

P = Failure Load

L = Distance between the point of application of the load and centre of prism

b = Width of the prism at the plane of failure

d = Thickness of the prism at the plane of failure

Below fig. shows the experimental set up for prism strength tests i.e., compressive strength test and flexural bond wrench strength tests of masonry prisms

Fig. 6: Compressive Strength and Flexural Strength of Prism

IV. CONCLUSIONS

Based on the physical and mechanical test results 15% replacement of basic clay by industrial waste (kaolin) is considered as an optimum replacement for basic clay.

From IRA test conclusion can be drawn that the rate of absorption for regular bricks are less compare to the bricks with 15% industrial waste.

Water absorption for regular bricks are 15% more compare with bricks with industrial waste and water absorption decreases with increase in percentage of industrial waste.

Dry density varies for each series of bricks and compare to normal bricks density of bricks with 15% industrial waste are found to be higher.

Wet compressive strength of bricks with 15% industrial waste satisfies the requirements of class 30 grade bricks.

Wet compressive strength of bricks is almost 0.5 times the dry compressive strength for all series of bricks.

Finally it is concluded that industrial waste (i.e. Kaolin) can be effectively used in the production of masonry bricks with 15% Kaolin as an optimum percentage.

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