Investigation of compressive strength and block density of bricks containing admixtures

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Abstract: *There has been a rapid growth in various building materials for the construction of building. Along with it, there is a multifold increase in demand for various building materials like bricks manufactured by using different admixtures. To meet the growing demand and provide better services, there has been a lot of research in the field of manufacturing of various construction bricks using industrial as well as agricultural waste materials like fly ash and rice husk ash. Conventional building bricks are made of a mixture of clay which are moulded to the desired shape and subjected to a number of processes, differing according to the nature of the material, the method of manufacture and the character of the finished product. As this construction field is emerging and maturing, many researchers from all across the globe are focusing on proper use of fly ash and rice husk ash for the manufacturing of bricks. These ashes are potential substitutes for clay in brick making industry. These bricks have chemical composition almost identical to clay brick. In the present report, the bricks consisting of different proportions of fly ash and rice husk ash together were prepared in order to make light weight bricks. The primary engineering properties such as compressive strength and block density were investigated.*

1. INTRODUCTION:

In early times dried bricks were made from clay containing earth or mud and finally dried by keeping in sun for several days till they acquired requisite strength so that they could used in construction works. The oldest bricks dates back to 7500 BC and were known to exist in the upper Tigris region i.e. Tell Aswad, as well as in southeast Anatolia, which is very near to Diyarbakirm [1]. Some reports dates between 7,000 and 6,395 BC, come from a city Jericho in the Palestinian Territories located near the Jordan River in the West Bank, city of Konya (in ancient times called as Iconium) in Turkey, Buhen an ancient Egyptian settlement situated on the West bank of the Nile and Mohenjo-daro, Harappa [2] and Mehrgarh [3] cities of the Indus Valley. Generally, bricks are of many types, which vary region wise and with time period. Two basic types of bricks are non-fired and fired bricks. Among these the fired bricks have also been used since ancient time and these are the strongest and durable construction materials. Fired bricks are burned in a kiln which makes them durable. Modern, fired, clay bricks are formed in one of three processes – soft mud, dry press or extruded. Production of bricks increased greatly with the onset of the Industrial Revolution and the rise in factory building. For reasons of speed and economy, bricks were increasingly preferred as building material to stone, even in areas where the stone was readily available. The color chosen for brick production was bright red in order to make the buildings more visible in the heavy fog and to help prevent traffic accidents [4]. In recent years, there has been a rapid growth in various building materials for the construction of building. Along with it, there is a multifold increase in demand for various building materials like bricks manufactured by using different admixtures [5]. To meet the growing demand and provide better services, there has been a lot of research in the field of manufacturing of various construction bricks using agricultural as well as industrial waste materials. As this construction field is emerging and maturing, these issues have been addressed by many researchers from all across the globe. Conventional building bricks are made of a mixture of clay which are moulded to the desired shape and subjected to a number of processes, differing according to the nature of the material, the method of manufacture and the character of the finished product. In this study, the bricks comprising of varying proportions of fly ash and rice husk ash added together were made and investigated for compressive strength and block density the fundamental engineering parameters.

2. EXPERIMENTAL:

2.1 Materials

Fly ash and rice husk ash were used as admixtures in the preparation of brick samples. Fly ash is the fine residue obtained from thermal power stations using ground or powered coal as boiler fuel. It is also known as pulverized fuel ash and is a glassy material and its main constituents are silica, alumina, iron and calcium [6]. The flying fine particles of ash from the chimneys of thermal power plants, cause great nuisance to the people living near the plants, corrode the structural surfaces and often cause respiratory deceases among the residents living in the neighborhood of thermal power plant.

RHA is an agricultural waste material, approximately twenty percent of rice husk are obtained from one quintal of rice, and rice husk is the outer covering of the grain of rice plant with a high concentration of silica, more than 80-85%. RHA is like fly ash with regards to its strength and durability but with a higher pozzolonic activity, it helps the pozzolonic reaction to occur at early ages rather than later as is the case with other replacement cementing materials [7-8]. Different amount of fly ash and rice husk ash were added together in addition to clay and tested for compressive strength and block density the fundamental engineering properties. Also the exact optimal percentage of fly ash and rice husk ash required for manufacturing superior quality of bricks was determined. The varying percentages of fly ash and rice husk ash were added to perform the experimental analysis. The different samples designated as M0, FR1-4 prepared for present study contain different proportions of fly ash [9] and rice husk as depicted in Table 1. These samples bricks are further used to carry out the performance analysis test.

Table 1 Various proportions used for experimental analysis

Sr.No.	Designation	Percentage of Clay	Percentage of Fly Ash	Percentage of Rice Husk Ash
1	M0	100	0	0
2	FR1	90	5	5
3	FR2	80	10	10
4	FR3	70	15	15
5	FR4	60	20	20

2.2 Methods

The compressive strength of normal clay bricks (M0) and bricks comprising of admixtures (FR1- FR4) was measured with compression testing machine [2]. Measuring tape, surface grinder and plywood sheets are necessary tools for the experiment. Five specimens of bricks were taken to laboratory for testing and tested one by one. The pressure was applied on the brick specimen through crushing machine till the specimen breaks. Average compressive/crushing strength is calculated by testing all five specimens one by one. Block Density refers to unit weight of substance. Degree of compactness of a material is shown in terms of density. More compact is the material; more will be the density of substance.

2.3 Compressive Strength Test of Bricks

A number of steps have been followed to prepare the sample for measuring the comprehensive strength. The sample was first ground for the formation of two smooth and parallel faces, thus removing any unevenness. The resulting material was immersed in water for 24 hours at room temperature. The cement mortar was prepared in 1:1 ratio and filled the frog and all voids in bed faces with it. The sample thus prepared was stored in damp jute bag for 3 days in clean water. The moisture content of the resultant sample was removed. Five samples M0 (Clay brick) were tested on compression testing machine by following the above described procedure and the results are listed in Table 2. The average area of horizontal faces was calculated and the comprehensive strength was estimated by employing the formula:

$$\text{Compressive Strength (N/mm}^2\text{)} = \frac{\text{Maximum load at failure in N}}{\text{Average area of bed faces in mm 2}}$$

Table 2 Test for Compressive Strength of Sample M0 (Clay Brick)

Sr. No.	Sample M0	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	M0-1	232×103×70	23896	94	3.93
2	M0-2	232×103×70	23896	89	3.72
3	M0-3	234×104×70	24336	94	3.86
4	M0-4	233×104×70	24232	93	3.83
5	M0-5	232×105×70	24360	93	3.81
Average					3.83

Similarly, 5 samples (FR) of brick comprising the admixtures of fly ash and rice husk ash are tested and the results are tabulated in Table 3 to Table 6.

Table 3 Test for Compressive Strength of Sample FR1

Sr. No.	Sample FR1	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	FR1-1	235×104×70	24440	99	4.06
2	FR1-2	233×103×70	23999	96	4.00
3	FR1-3	235×104×70	24440	98	4.01
4	FR1-4	234×103×70	24102	99	4.11
5	FR1-5	233×105×70	24465	98	4.02
Average					4.03

Table 4 Test for Compressive Strength of Sample FR2

Sr. No.	Sample FR2	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	FR2-1	233×104×70	24232	111	4.57
2	FR2-2	233×103×70	23999	106	4.40
3	FR2-3	235×104×70	24440	110	4.49
4	FR2-4	234×103×70	24102	110	4.55
5	FR2-5	233×105×70	24465	110	4.48
Average					4.50

Table 5 Test for Compressive Strength of Sample FR3

Sr. No.	Sample FR3	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	FR3-1	233×104×70	24232	115	4.75
2	FR3-2	233×103×70	23999	110	4.58
3	FR3-3	235×104×70	24440	113	4.62
4	FR3-4	234×103×70	24102	116	4.81
5	FR3-5	233×105×70	24465	114	4.66
Average					4.68

Table 6 Test for Compressive Strength of Sample FR4

Sr. No.	Sample FR4	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	FR4-1	232×104×70	24128	123	5.10
2	FR4-2	233×103×70	23999	118	4.92
3	FR4-3	235×104×70	24440	123	5.03
4	FR4-4	234×103×70	24102	122	5.06
5	FR4-5	233×105×70	24465	121	4.95
Average					5.01

2.4 Block Density Test of Bricks

Block density decides the sinking property of material. It is decided by knowing the density of liquid. If the material has lower density than liquid, then it will float on the surface of liquid. If it has more density than liquid, it will sink. Density value of construction material will also help to find out the quantity of material needed for particular space. The brick was heated in the oven to 100°C and then cooled at room temperature. The brick sample was weighed and volume of the brick sample is calculated by measuring the dimensions of bricks. The density of block was determined from the equation given below and the average results are as tabulated in Table 7. Density of block = mass/volume (kg/m^3).

Table 7 Block Density Test results of all samples

Sr.No.	Sample Designation	Average Block Density

		(kg m^{-3})
1.	M0	1826.998
2.	FR1	1801.058
3.	FR2	1771.512
4.	FR3	1721.126
5.	FR4	1701.298

3. RESULTS AND DISCUSSION:

3.1 Average Compressive Strength of Bricks

The compressive strength of normal clay bricks is measured at first and then these results are utilized to draw the comparative analysis of the strengths of the bricks comprising different proportions of fly ash and rice husk ash. Figure 1 demonstrates the graphical representation of average compressive strength of conventional clay bricks and bricks containing fly ash and rice husk ash. The figure suggests that with the addition of both fly ash and rice husk ash the compressive strength increases as compared to normal clay bricks. The average compressive strength of all the samples is tabulated in Table 8. This table demonstrates and compares the average compressive strength of all the manufactured samples. The exact optimal percentage of fly ash and rice husk is found to be 20% each and 60% clay i.e. in FR4 sample. The average compressive strength of clay bricks was found to be 3.839 N/mm^2 (M0 sample) while the average compressive strength for FR4 sample bricks is 5.012 N/mm^2. Thus, a net increase of 30.55% was found in average compressive strength as compared to clay bricks.

Table 8 Average Compressive Strength of all samples

Sr. No.	Sample Designation	Average Area of bed surface (mm^2)	Average Maximum load at failure (kN)	Average Compressive Strength (N mm^{-2})
1.	M0	24144	92.6	3.83
2.	FR1	24289.2	98	4.03
3.	FR2	24247.6	109.4	4.50
4.	FR3	24247.6	113.6	4.68
5.	FR4	24226.8	121.4	5.01

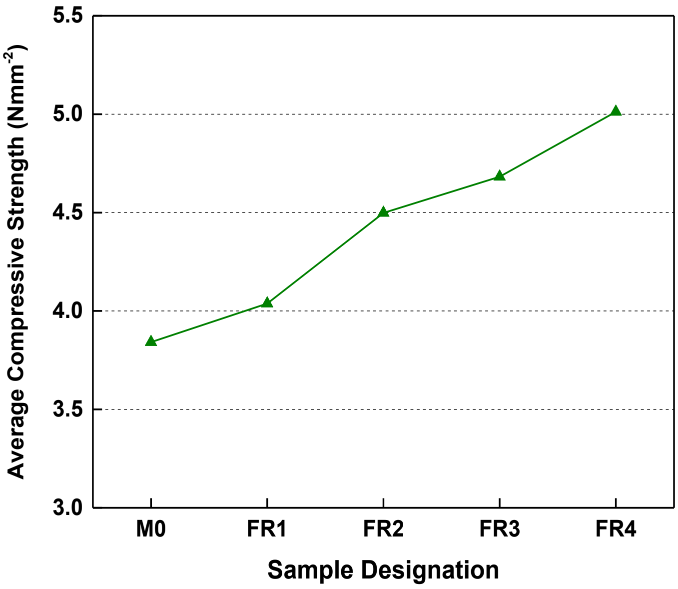

Figure 1 Average Compressive Strength of Fly Ash and Rice Husk Ash Bricks

3.2 Block Density Test Results

The block density of different types of bricks i.e. conventional clay bricks and bricks comprising admixtures has been measured and it is observed that with the addition of fly ash and rice husk ash together, the block density of the bricks is reduced as compared to normal clay bricks. The comparative analysis is shown in Figure 2. The average block density of clay bricks was found to be 1826.998 kg m^{-3} (M0 sample) while the average block density for FR4 sample bricks is 1701.298 kg m^{-3}. Thus, a net decrease of 6.88% was found in average block density as compared to clay bricks. Addition of both the rice husk ash and fly ash together make the brick light in weight as compared to conventional red brick due to this the dead load of the construction is considerably reduced.

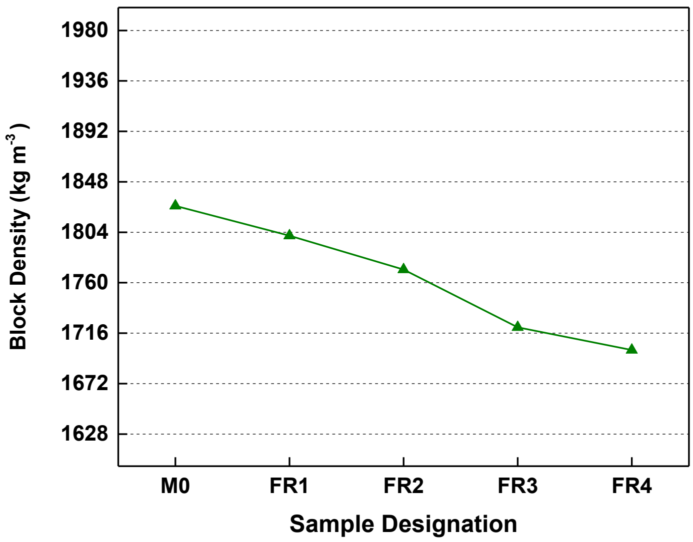

Figure 2 Block Density of Fly Ash and Rice Husk Ash Bricks

4. CONCLUSION:

In the present work the effect of addition of fly ash and rice husk ash together in different compositions to clay was investigated. Also, the exact optimal percentage of fly ash and rice husk ash required for manufacturing superior quality of bricks was estimated. The compressive strength and block density analysis was done of the manufactured bricks. The exact optimal percentage of fly ash and rice husk endorsed is 20% each and 60% clay i.e. in FR4 sample. The clay bricks and FR4 sample bricks possessed average compressive strength 3.839 N/mm2 and 5.012 N/mm2 while average block density was found to be 1826.998 kg m-3 and 1701.298 kg m-3 respectively. Thus, a net increase of 30.55% in average compressive strength was observed while a net decrease of 6.88% was found in average block density as compared to clay bricks. Hence, the mixed design FR4 sample containing both the admixture is highly recommended in terms of compressive strength and low brick weight. Finally it can be concluded that the utilization of these industrial as well as agricultural waste materials will lead to improved construction practices in the coming future globally [10].

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