EXPERIMENTAL ANALYSIS OF COMPRESSIVE STRENGTH AND BLOCK DENSITY OF BRICKS UTILIZING WASTE MATERIALS

Subodh Khatkar

Designation Department of Civil Engineering, MRIEM, Rohtak, Haryana, India
Email - khatkarsubodh@gmail.com

Abstract: *Bricks will always be the necessity of building materials but in future clay will not be available in plenty for the making of bricks, as the use of land is rapidly increasing. At this time industrial as well agricultural as wastes enriched in silica e.g. rice husk ash and fly ash will fulfil the demand of clay so as to make bricks. Moreover the building structures are getting heavier with time, the use of fly ash bricks would be more efficient as its strength is more than that of clay bricks. At the same time this strategy serves two important purposes i.e. maximum disposal of wastes and conservation of scarce resources and materials. Keeping this in mind, the present research aims to investigate the effects of addition of fly ash and rice husk ash to clay to manufacture good quality of bricks. The bricks comprising fly ash and rice husk ash are studied for compressive strength and block density.*

Key Words: Compressive Strength, Block Density, Bricks, Waste materials

1. INTRODUCTION:

In India, brick is one of the most important building materials being extensively used in construction activities. Bricks are made of a mixture of clay from ancient times [1-4]. The entire clay consumed in this brick making process is taken out from the fields, this unlimited use of agricultural land is very harmful to society as it will gradually finish the top fertile agricultural land. This made the researchers to realize the urgent need of new and economical building materials. The use of industrial as well as agricultural wastes instead of clay provides one of the practical solutions to this problem [5]. These wastes have chemical composition almost identical to brick clay [6] and are easily available. So, ashes from industries and agricultural land are potential substitutes for clay in brick making industry. In this research work all attempts were made to use these alternative construction materials for brick production i.e. fly ash [15] and rice husk ash. These bricks are investigated for compressive strength and block density. This brick making technology recently has become a big money making business too all over the world. As compared to conventional clay bricks, these bricks are stronger, durable, lighter and economical. Being less permeable, dampness related issues are far lesser in these bricks than their clayey counterparts [14]. The use of ash fly ash and rice husk bricks will undoubtedly decrease the cost of construction therefore will encourage the engineers to build low cost safe infrastructures. Nowadays, people of India are steadily constructing houses using these ash bricks, which are going to be a saviour of environment for years to come.

2. EXPERIMENTAL:

This research work, involves the utilization of industrial waste (fly ash) [7] as well as agricultural (rice husk ash; RSH) material as a replacement of the cement for the manufacturing of the desired bricks. The manufactured bricks have been tested for their quality through compressive strength test and block density test.

2.1 Materials

The fly ash [9] and rice husk ash are utilized in the production of eco-friendly bricks [8], which are used as alternative construction materials. In the present study, 0, 10, 20, 30 and 40 percentage of fly ash/rice husk are added to conventional clay bricks designated as M0, F1/R1, F2/R2, F3/R3, F4/R4, respectively to form brick samples. Then the comprehensive strength and block density are investigated.

2.2 Methods

The compressive strength of the samples prepared was determined in a compression testing machine. This test was done to know the compressive strength of brick [2]. It is also called crushing strength of brick. Generally 5 specimens of bricks are taken to laboratory for testing and tested one by one. In this test a brick specimen is put on crushing machine and then pressure is applied pressure till it breaks. The ultimate pressure at which brick is crushed is taken into account. All five brick specimens are tested one by one and average result is taken as brick's compressive/crushing strength. Apparatus used were compression testing machine, measuring tape, surface grinder and plywood sheets.

Block Density is also called as unit weight of substance. Density represents the degree of compactness of material. If the material is of more density, it is more compacted material. If two different materials are same in weight, but the density of both may be different. Lower dense material occupies more volume than higher dense material.

2.3 Compressive Strength Test of Fly ash and Rice husk ash bricks

In order to carry out the test, the sample was first prepared by following a series of steps. Any unevenness observed in the bed faces was removed to provide two smooth and parallel faces by grinding. Then the sample was immersed in water at room temperature for 24 hours. The cement mortar (1:1) mixture was prepared and filled the frog and all voids in bed faces with it. The prepared sample was stored under damp jute bag for 3 days in clean water. Moisture content was removed and wiped out. The area of two horizontal faces was measured. The comprehensive strength was measured by using formula mentioned beow:

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

Using the above mentioned procedure initially the sample designated M0 (Clay brick) was tested by taking its 5 samples on compression testing machine. The results are tabulated in Table 1.

Table 1 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

In similar manner, 5 samples of brick from each type of brick manufactured were tested and the average of the results was taken, the results are tabulated in Table 2 to Table 9.

Table 2 Test for Compressive Strength of Sample F1

Sr. No.	Sample F1	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	F1-1	233×103×70	23999	101	4.21
2	F1-2	233×103×70	23999	103	4.29
3	F1-3	232×104×70	24128	100	4.14
4	F1-4	235×105×70	24675	102	4.13
5	F1-5	232×105×70	24360	99	4.06
Average					4.16

Table 3 Test for Compressive Strength of Sample F2

Sr. No.	Sample F2	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	F2-1	233×103×70	23999	118	4.92
2	F2-2	233×103×70	23999	113	4.71
3	F2-3	232×104×70	24128	117	4.85
4	F2-4	235×105×70	24675	117	4.74
5	F2-5	232×105×70	24360	117	4.80
Average					4.80

Table 4 Test for Compressive Strength of Sample F3

Sr. No.	Sample F3	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	F3-1	233×103×70	23999	129	5.38
2	F3-2	235×103×70	24205	125	5.16
3	F3-3	232×104×70	24128	128	5.31
4	F3-4	235×105×70	24675	129	5.23
5	F3-5	232×105×70	24360	128	5.25
Average					5.26

Table 5 Test for Compressive Strength of Sample F4

Sr. No.	Sample F4	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	F4-1	233×103×70	23999	142	5.92
2	F4-2	235×103×70	24205	137	5.66
3	F4-3	232×104×70	24128	141	5.84
4	F4-4	236×105×70	24780	141	5.69
5	F4-5	232×105×70	24360	142	5.83
Average					5.78

Table 6 Test for Compressive Strength of Sample R1

Sr. No.	Sample R1	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	R1-1	235×103×70	24205	91	3.76
2	R1-2	232×102×70	23664	87	3.68
3	R1-3	232×104×70	24128	91	3.77
4	R1-4	236×103×70	24308	89	3.66
5	R1-5	232×105×70	24360	90	3.69
Average					3.71

Table 7 Test for Compressive Strength of Sample R2

Sr. No.	Sample R2	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	R2-1	235×103×70	24205	74	3.06
2	R2-2	232×102×70	23664	69	2.92
3	R2-3	232×104×70	24128	73	3.03
4	R2-4	236×103×70	24308	73	3.00
5	R2-5	232×105×70	24360	73	3.00
Average					2.99

Table 8 Test for Compressive Strength of Sample R3

Sr. No.	Sample R3	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	R3-1	235×103×70	24205	69	2.85
2	R3-2	232×103×70	23896	64	2.67
3	R3-3	235×104×70	24440	68	2.78
4	R3-4	235×103×70	24205	68	2.81
5	R3-5	233×105×70	24465	68	2.78
Average					2.77

Table 9 Test for Compressive Strength of Sample R4

Sr. No.	Sample R4	Specimen Size (mm)	Average Area of bed surface (mm^2)	Maximum load at failure (kN)	Compressive Strength (N/mm^2)
1	R4-1	235×103×70	24205	66	2.71
2	R4-2	232×103×70	23896	61	2.54
3	R4-3	235×104×70	24440	65	2.65
4	R4-4	235×103×70	24205	65	2.67
5	R4-5	233×105×70	24465	65	2.64
Average					2.64

2.4 Block Density Test of Fly ash and Rice husk ash bricks

To determine the density of the block, first the brick was heated in the oven to 100^{o}C and then it was cooled to room temperature. Now the dimensions of bricks were noted down and from that the volume of the brick sample was found and finally the brick sample was weighed. The density of block was determined from relation given below and the average density of 5 bricks was taken as the final brick density and the average of the results are as tabulated in Table 10. Density of block = mass/volume (kg/m^3).

The block density of the samples prepared was found by considering the dry weight and overall volume of 5 samples.

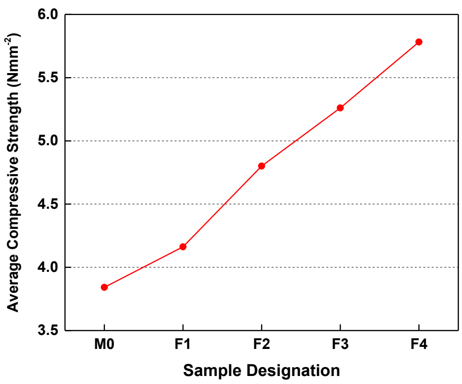
Table 10 Block Density Test results of all samples

Sr.No.	Sample Designation	Average Block Density ($kg\ m^{-3}$)
1.	M0	1826.998
2.	F1	1824.812
3.	F2	1758.392
4.	F3	1701.982
5.	F4	1690.001
6.	R1	1798.058
7.	R2	1765.612
8.	R3	1711.252
9.	R4	1698.128

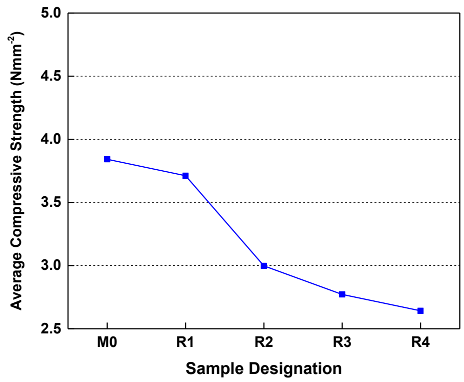
3. RESULTS AND DISCUSSION:

3.1 Average Compressive Strength of Bricks

Initially testing was done on normal clay bricks. Then to compare the results with the bricks with added fly ash and rice husk ash, similar tests were performed on these bricks. Figure 1 a) presents the comparative plot of average compressive strength of normal clay bricks and fly ash bricks with varied proportion of fly ash.



a)



b)

Figure 1 Average Compressive Strength a) Fly Ash Bricks b) Rice Husk Ash Bricks

This figure clearly illustrates that with the addition of fly ash in normal clay bricks the average compressive strength of the manufactured bricks increases and also with the increase in the percentage of added fly ash the average compressive strength of the bricks is seen to increase. This can be accounted to the fact that fly ash being a pozollan increases the compressive strength of the product [11].

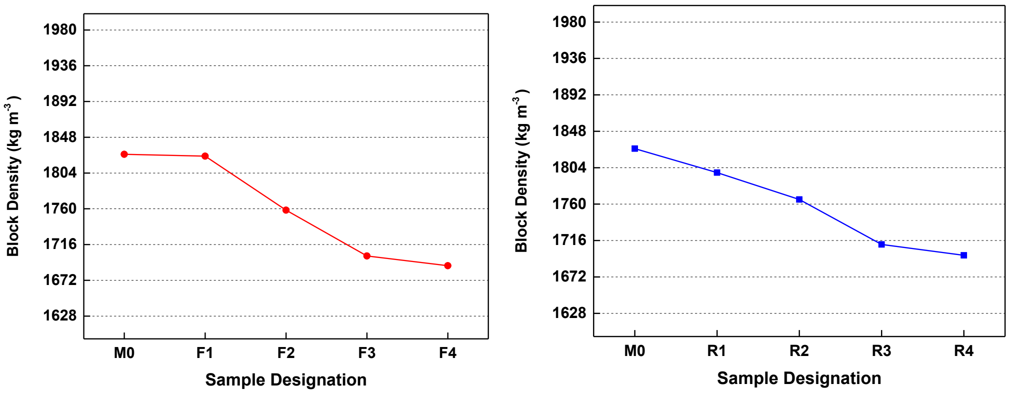
Figure 1 b) gives the plot for the average compressive strength of normal clay bricks and rice husk ash bricks with varied proportion of rice husk ash in the bricks. It can be clearly seen from the plot that with the increase in percentage of added rice husk ash the average compressive strength of the brick is reduced. The average comprehensive strength result of the fly ash and rice husk ash samples have been summarized in Table 11.

Table 11 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.	F1	24232.2	101	4.16
3.	F2	24232.2	116.4	4.80
4.	F3	24273.4	127.8	5.26
5.	F4	24294.4	140.6	5.78
6.	R1	24133	89.6	3.71
7.	R2	24133	72.4	2.99
8.	R3	24242.2	67.4	2.77
9.	R4	24242.2	64.4	2.64

3.2 Block Density of bricks

Clay bricks and two more types of bricks were manufactured having different proportions of admixtures. Initially testing was done on normal clay bricks. Then to compare the results with the bricks with added fly ash and rice husk ash, similar tests were performed on these bricks. Figure 2 a) presents the comparative plot of block density test [13] results in case of normal clay bricks and fly ash bricks with varied proportion of fly ash.



a) b)

Figure 2 Block Density a) Fly Ash Bricks b) Rice Husk Ash Bricks

Figure 2 b) compares the block density test results in case of normal clay bricks and rice husk ash bricks with varied proportion of rice husk ash. The results clearly depict that with the addition of fly ash and rice husk ash the block density of the bricks is reduced as compared to normal clay bricks which is shown clearly in comparative plots of figure 2 a) and b).

4. CONCLUSIONS:

The present work investigate the effects of addition of fly ash [9] and rice husk ash to clay and the exact optimal percentage of fly ash and rice husk ash required for manufacturing superior quality of bricks [10]. Compressive strength and block density analysis of the manufactured bricks reveal the satisfactory performance of manufactured fly ash bricks and rice husk ash bricks as load bearing elements [12]. The average compressive strength of clay bricks was found to be 3.839 N/mm^2. A gain in the average compressive strength of bricks containing fly ash was observed as the percentage of fly ash increased while a decrease was noticed in case of rice husk ash bricks with increase in rice husk ash percentage. The F4 and R4 designated bricks with 40% fly ash and rice husk ash possessed average compressive strength 5.782 N/mm^2 and 2.642 N/mm^2 respectively. The block density test results reveal a reducing trend in density of all the bricks manufactured by addition of admixtures. Addition of both the rice husk ash and fly ash make the brick light in weight as compared to conventional red brick due to this the dead load of the construction is considerably reduced . These eco-friendly bricks are very beneficial in construction industry.

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