A CASE STUDY OF BRICK PROPERTIES MANUFACTURE IN BHAKTAPUR

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Abstract

Bricks are commonly used for construction of buildings structures. The main objective of this article is to present the case study on different properties of the bricks manufactured in Bhaktapur city. Sample specimens were collected and tested for crushing strength, water absorption, specific gravity, density, porosity, impact test, dimension test, hardness test, soundness test and color appearance test of bricks in the laboratory. The overall aim of this study is to determine, through extensive experimental investigation, the effect of different brick on strength, water absorption, density, hardness, impact, porosity, and crushing strength. After multiple tests, results regarding the properties of bricks included – water absorption varies from 8.80% to 23.93%, porosity varying from 19.28% to 53.99%, specific gravity varying from 2.19 to 4.00, density varying from 1549.77 kg/m^3 to 2816.6kg/m^3, and crushing strength varying from 7.83 MPa to 22.10 MPa. In hardness test,15 out of 33 were found to be hard; while 13 out of 33 passed the impact test; and 18 out of 33 has metallic sound. For the good quality of brick, the brick should have bright color appearance but only 15 out of 33 samples carry bright color appearance. Regarding the dimensions, length varies from 212.00mm to 242.00mm, breadth varies from 96.00mm to 115.00 mm and thickness varies from 48.80 mm to 63.00mm.From this research, properties of almost all bricks are not as per Nepal Building Code. The bricks manufactured at present are being commercialized rather than maintaining the standards as per the code.

Keywords: Brick, Water absorption, Porosity, Crushing strength, Bulk density, Specific gravity, Impact test.

1. Introduction

1.1. Background

Brick is considered as one of the most important raw material for construction purpose. There are about 1000 brick kilns in Nepal where annually six billion bricks are produced (Baum E., 2012).In Nepal, major brick industries are located in Kathmandu valley and Terai region. It is estimated that 110 brick kilnsare in operation in Kathmandu valley. Among 110 kilns operated in Kathmandu valley, 15 are present in Kathmandu district, 32 and 63 in Lalitpur and Bhaktapur respectively (Vista et al., 2018).

Bricks are essential construction materials in structural field. Quality of bricks defines the strength of the bricks. If the quality of brick used in the structure is not good then it can lead to serious damages to the structure. Therefore, it is essential to check the quality of brick before using it in any construction activities. Quality of bricks is determined by knowing the properties of bricks. The properties of bricks depend on their mineralogical compositions, manufacturing process and firing temperature.

Physical properties are the quantitative characteristics of brick and its behavior to external influences other than applied forces. Observing physical properties is important because they can significantly influence the performance and strength of bricks used in structural purposes. Mechanical properties are the characteristics of different materials in response to externally applied loads. They consist of different properties including elastic properties, which describe resistance to deformation and distortion, and strength properties, which describe resistance to any applied loads.

Kaushik et al., (2007) had investigated

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experimentally the uniaxial monotonic compressive stress-strain behavior and other characteristics of unreinforced masonry and its constituents, i.e. solid clay bricks and mortar. It was experimentally analyzed to determine the uniaxial compressive stress strain curves of brick units, mortar cubes, and masonry prisms constructed with different combinations of bricks and mortar grades. They performed test for water absorption for bricks concluding water absorption by 12.30%. For different bricks used in the study, mean values of compressive strength varied from 16.10 MPa to 28.90 MPa.

Phaiju et al., (2018) had tested experimentally for mechanical properties of bricks and masonry panel. The test results for brick compression suggested that the full brick samples chosen had the compression strength of 11.12 MPa and that of scaled down brick had 13.73 MPa. The handmade bricks had been found to have density of 17 kN/m^3 in dry state.

Paulo et al., (2009) did a research on a large sample of clay brick specimens (new and old bricks) collected from the 12^{th} to 19^{th} centuries from six Portuguese monasteries and were characterized chemically, physically, and mechanically. The results showed that the sample bricks had mechanical properties of the same order of magnitude and indicated that the new bricks were more durable than the old ones tested, and have similar compressive strength. The compatibility within chemical, physical and mechanical properties can be possibly established by several aspects, namely geometrical aspects, manufacturing aspects and building technology, vulnerability towards degradation and compressive strength.

Bhattarai et al., (2018) conducted series of test for physical and mechanical properties of seven ancient clay brick samples of Kathmandu valley using ASTM standards. All the brick samples used in this study had the water absorption, apparent porosity and bulk density in the range of 10-28 percent, 17-33 percent and 1.20 g/cm^3-1.80 g/cm^3 respectively; while the compressive strength of all the brick samples was found to be in the range of 5-23 MPa. The compressive strength of all the clay brick samples had been correlated with their physical properties.

2. Material and Method

2.1. Material

Samples of bricks were collected from brick kilns located in different manufacturing area of Bhaktapur. Selected manufacturing areas include Sudal, Suryabinayak, Chhaling, Jagati, Tathali, Sipadole, Changu Narayan, Duwakot, and Ithuli. The collected specimens were brought to the testing laboratory of Khwopa Engineering College, Bhaktapur for conducting tests to evaluate their quality.

2.2. Method

The objective of these tests was to analyze and investigate the physical properties and mechanical properties of the manufactured bricks.

Based on 33 samples collection from different places, testing of bricks was carried out in the laboratories. Physical and mechanical tests were done for the determination of these properties in laboratory according to different standard codes. Using IS 1528(part 15): 2007, ISO 5017:1998, density and porosity were determined. Using IS 3495 (Parts 1 to 4):1992, crushing strength and water absorption of different bricks were determined.

2.2.1 Mechanical Properties

Mechanical test conducted on the brick sample include crushing strength of brick. Crushing strength helps to determine the quality and durability of brick to be used in the construction of structure. As per IS 3495 (Parts 1 to 4):1992, the crushing strength/compressive strength of the brick can be determined by using following formula,

$$\text{Crushing strength or Compressive strength } \left(\frac{\text{N}}{\text{mm}^2}\right) = \frac{\text{Maximum load at failure}}{\text{Average net area of two faces under compression}} \quad (1)$$

2.2.2 Physical Properties

Physical test conducted on the brick sample include porosity, specific gravity, dimensions, density, hardness test, impact test, soundness test, color test, and water absorption test.

The physical properties are determined using following relation:

$$\text{Water absorption} = \frac{(\text{Saturated weight of brick} - \text{Dry weight of brick})}{\text{Dry weight of brick}} \text{X } 100\% \quad (2)$$

Apparent porosity, P

$$(\%)=\frac{(\text{Saturated weight of brick}-\text{Dry weight of brick})}{\text{Volume of the brick}}\text{X } 100\% \quad (3)$$

Specific gravity =

$$\frac{\text{Dry weight of brick}}{\text{Dry weight of brick}-\text{Suspended weight of brick}} \quad (4)$$

$$\text{Density} = \frac{\text{Dry weight of brick}}{\text{Volume of the brick}} \quad (5)$$

3. Results and Discussions

3.1. Mechanical properties of brick sample

3.1.1. Crushing strength

The crushing strength of thirty-three brick samples has been tested under mechanical test of brick. The crushing strength of thirty-three brick samples are shown in Fig. 1.

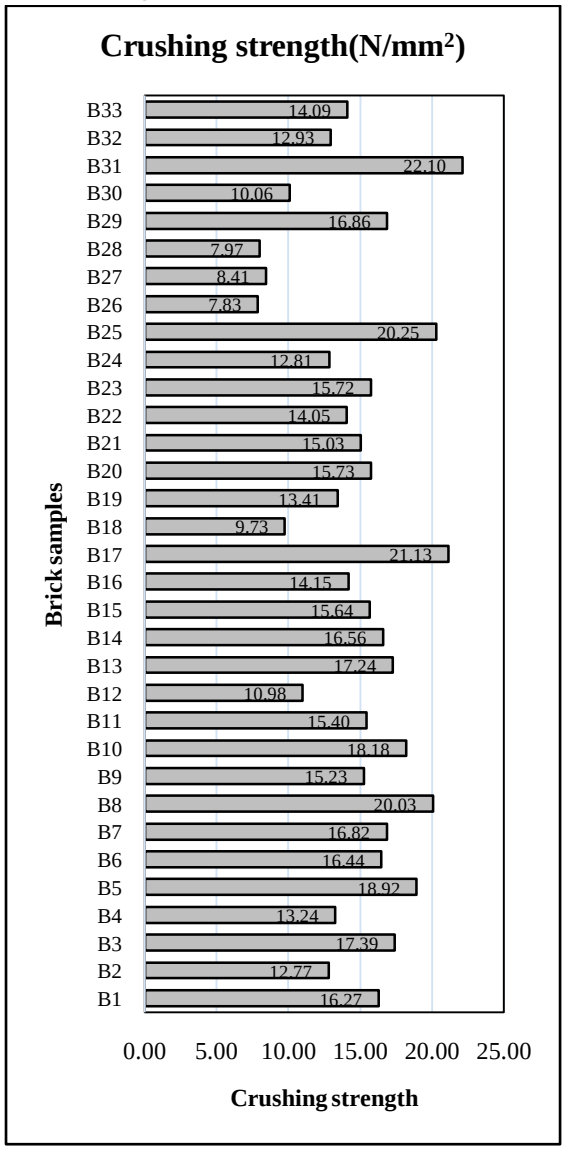

Fig. 1.Crushing strength of brick sample

It is clear from the Fig. 1, that thirty-three brick samples have the crushing strength in the range of 7.83 MPa to 22.10 MPa. The crushing strength of the brick should not be less than 3.50 MPa as provided in NBC 109-1994. But from the findings, crushing strength of brick is more than 3.50 MPa, which showed the satisfactory result.

3.2. Physical Properties of Brick Sample

3.2.1. Water Absorption test on brick and porosity

Water absorption test on brick is conducted to find out the amount of moisture content absorbed by brick under excessive conditions. Low water absorption is the representation for high compressive strength, durability and good quality of bricks. Number of brick samples count with water absorption property in the range difference of 5% is shown in Fig. 2 and the number of brick samples count with Porosity Property in the range difference of 5% is shown in Fig. 3.

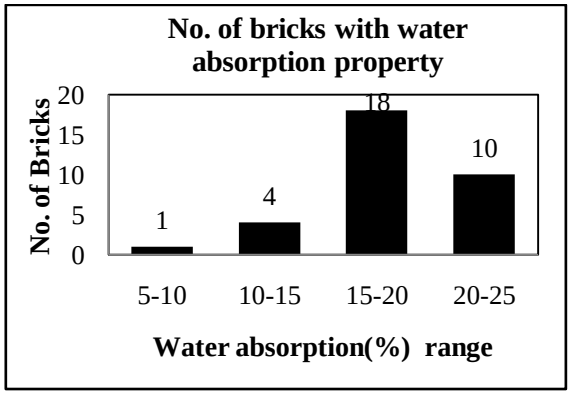

Fig. 2. Number of brick samples count with water absorption property in the range difference of 5%

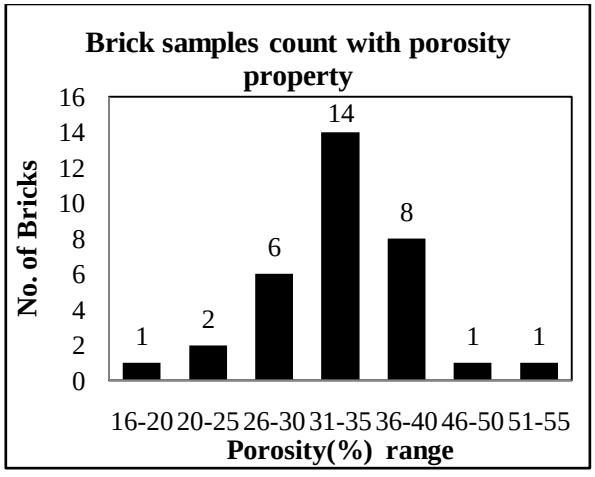

Fig. 3. Number of brick samples count with porosity property in the range difference of 5%

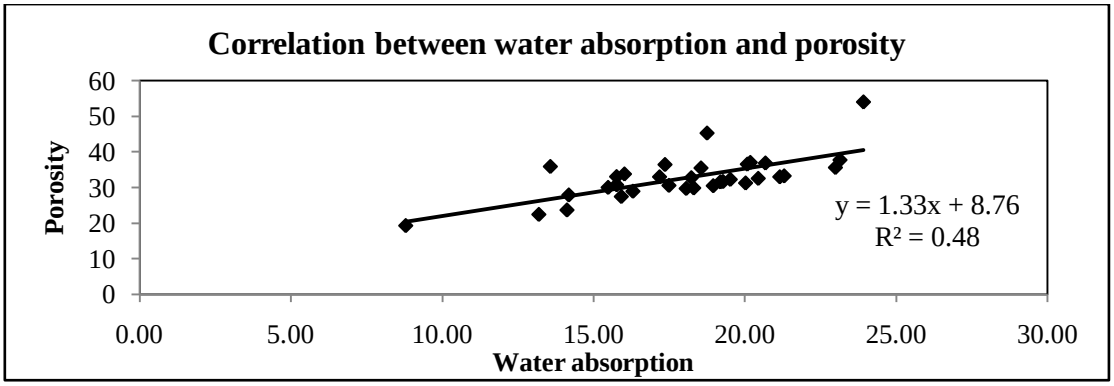

Fig.4. Correlation between water absorption and porosity of brick samples

Although the bricks were manufactured in different locations, though rather close geographically, it can be observed that the most frequent range of porosity values for the sample bricks is about 26%– 40%, which is about 85% of the total brick specimens. Similarly, 28 out of 33 brick samples have the most frequent range of water absorption value i.e. 15% - 25%, which is also 85% of the total brick specimens. It indicates homogeneous manufacturing samples in case of water absorption and porosity properties.From Fig. 4, it is observed that the correlation coefficient (R) has the value of 0.69.Thecorrelation coefficient between water absorption property and porosity property is found to be of higher value i.e. the brick samples have good relationship between water absorption property and porosity property. It shows that if the brick sample has higher porosity value, then the sample absorbs sufficient amount of water.

3.2.2. Specific Gravity Test on Brick

Specific gravity test for brick samples shows that there is not large variation in specific gravity from sample collected from various manufacturers. From Fig. 5, it can be observed that most of the brick samples (32 out of 33) frequently range values between 2 and 4 for the specific gravity.

3.2.3. Density

Density varies from country to country as standard sizes of the bricks vary; depend upon the dimension of the bricks. As per IS 875 (Part 1) – 1987, density of bricks should normally lie between 1600.00 kg/m^3 to 1920.00kg/m^3.From Fig. 6, it is found that 26 brick samples lie in the range frequency of 1500.01kg/m^3 – 2000.00 kg/m^{3}which shows that 79% of the brick specimens is within the range provided as in IS 875 (Part 1) - 1987.

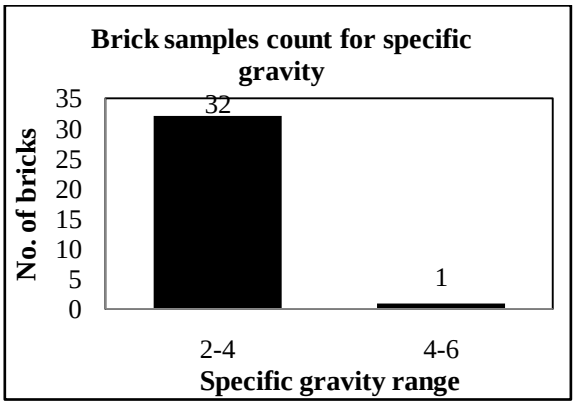

Fig. 5. Brick samples count on specific gravity of brick samples in the range difference of 2.

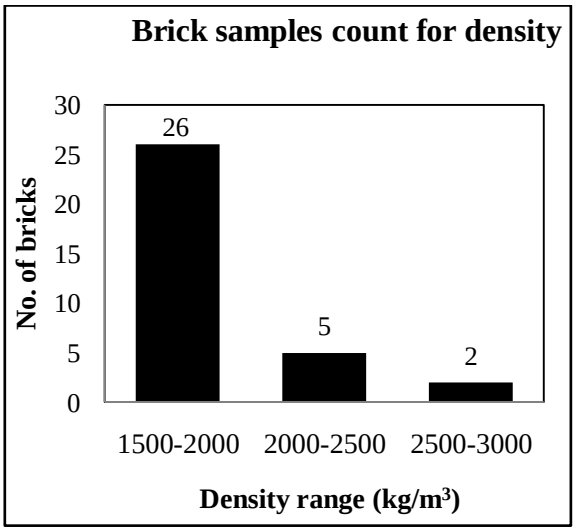

Fig. 6. Brick count for density of brick samples in the range difference of 500kg/m^3.

3.2.4. Dimension

Various sizes of bricks are available in the market but according to the national building code of Nepal (NBC 109-1994), the standard size of brick used in Nepal is 240mm x 115mm x 57mm.Among 33 samples only 1 (B28) is of standard size whereas dimensions of the 32 brick samples do not meet as per the code.

Table 1: Dimension of brick sample

S.No.	Brick Samples	Length, mm	Width, mm	Thickness, mm
1	B1	218.80	100.90	53.42
2	B2	226.10	103.80	52.76
3	B3	227.50	105.00	52.30
4	B4	217.00	102.00	50.00
5	B5	228.50	104.50	51.00
6	B6	225.00	102.00	48.80
7	B7	224.50	102.00	53.50
8	B8	219.00	106.50	50.30
9	B9	216.50	102.30	54.34
10	B10	219.40	102.20	53.16
11	B11	215.00	99.00	50.00
12	B12	226.50	101.80	54.50
13	B13	220.00	103.50	55.40
14	B14	232.00	112.30	52.60
15	B15	223.50	102.00	53.50
16	B16	212.00	100.00	57.00
17	B17	213.00	100.00	56.00
18	B18	235.00	105.00	60.00
19	B19	240.00	115.00	58.00
20	B20	220.00	104.00	55.00
21	B21	230.00	107.00	50.00
22	B22	235.00	103.00	55.00
23	B23	228.00	106.00	58.00
24	B24	223.00	105.00	55.00
25	B25	216.00	96.00	56.00
26	B26	221.00	104.00	54.00
27	B27	214.00	100.00	54.00
28	B28	242.00	114.00	59.00
29	B29	213.00	103.00	59.00
30	B30	213.00	98.00	63.00
31	B31	215.00	101.00	54.00
32	B32	221.00	105.00	53.00
33	B33	215.00	99.00	54.00

3.2.5. Hardness

Bricks are generally hard because of baking in kiln and if you scratch the brick with nails it should not produce any nail impression. This is one of the important properties of brick as it defined the durability of brick.

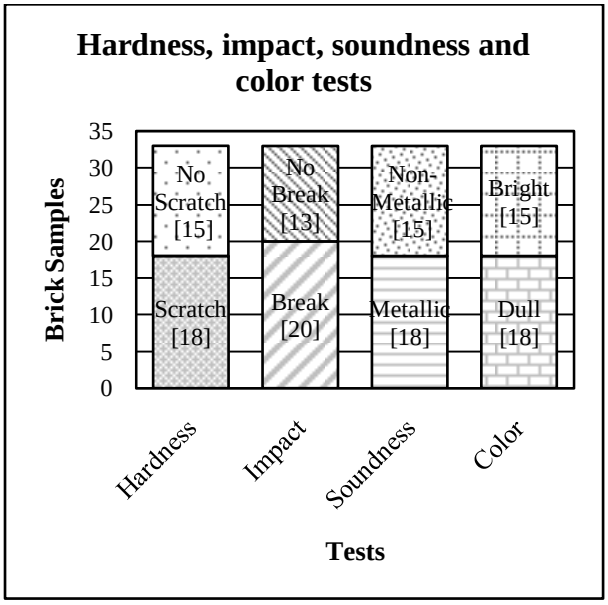

Fig. 7. Hardness, impact, soundness and color test of brick sample

3.2.6. Impact test

In this test the bricks are allowed to fall from a height of 1 meter on ground. Good quality brick shouldn't break. In case it breaks, it should not be used for construction. The impact test results for 33 sample bricks are shown in Fig.7.

3.2.7. Soundness

Soundness test of a brick is performed to understand the quality of bricks. In this test, two bricks are struck with each other. Good quality bricks usually don't break and should produce a metallic sound when struck with each other. 18 brick samples are found to produce a metallic sound when struck with each other. The soundness test results for 33 sample bricks are shown in Fig. 7.

3.2.8. Color

Well burnt clay brick are of uniform and bright appearance and red in color throughout its section. Out of 33 samples, only 15 samples show the brick is of good color. The color test results for 33 sample bricks are shown in Fig. 7.

4. Conclusion

The present research work was focused to study the physical and mechanical properties of 33bricks of Bhaktapur for their quality assessments using standards codes and the following conclusions are drawn from above results and discussion. From the laboratory work, the dimensions of the brick samples are comparatively less than the standard dimension provided in NBC 109-1994. The water absorption, apparent porosity and bulk density are related for the improvement of the mechanical property of crushing strength of the brick samples used in this study. After the conduction of water absorption test, the observed results show water absorption by the bricks comparatively satisfied with the result of Bhattarai et al., (2018).The minimum crushing strength of bricks provided in NBC 109-1994 is 3.50 MPa. But from the test of research work, the sample bricks had higher minimum crushing strength value than that given in NBC 109-1994.Similarly, porosity was found varying from 19.28% to 53.99%, specific gravity varying from 2.19 to 4.00, density varying from 1549.77 kg/m^3(1.55 g/cm^3) to 2816.60 kg/m^3(2.82 g/cm^3)respectively. There is a good correlation between the water absorption capacity, and porosity. It shows, higher the value of water absorption and porosity, lower the value of density of analyzed bricks samples whereas physical tests for impact, hardness, soundness, color do not show satisfactory results.

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