IJCRT.ORG ISSN : 2320-2882

INTERNATIONAL JOURNAL OF CREATIVE RESEARCH THOUGHTS (IJCRT)

An International Open Access, Peer-reviewed, Refereed Journal

Assessment of the Quality of Burnt Clay Bricks of Different Industries in Jorhat District, Assam

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Abstract: The aim of this study work presented in this paper is to assess the quality of 1st class burnt clay bricks manufactured in 5 (five) different clay brick manufacturing industry in the Jorhat district of Assam. This study also attempts to understand the entire manufacturing process that is followed in clay brick manufacturing. 20 bricks samples were randomly collected from each of the 5 (five) clay brick manufacturing industries namely NBF, BBB, SBI, MAYUR and MAK to determine their physical and mechanical properties. In this regard, four principal quality tests such as Water absorption test, Efflorescence test, Compressive strength test and Dimension test was conducted and the test results were compared with IS recommended values. From the water absorption test, it was found that NBF, SBI and MAYUR met the IS requirement. The efflorescence test results for all the brick brands were found satisfactory as per IS Code of clay burnt bricks. The compressive strength of (14.72 – 17.82 N/mm^2) were within the class designation of burnt clay brick. The brick samples were observed to have length, width and height within the tolerance level. This study will be helpful to the researchers, policy makers and concerned authorities to perform the quality analysis test of 2nd and 3rd class clay bricks in future.

Keywords: *Burnt Clay Bricks, Brick Manufacturing Industry, Quality Tests, Water absorption test, Efflorescence test, Compressive strength test and Dimension test, IS code.*

1. Introduction: The common building bricks are not only one of the oldest but also the most extensively used building material in construction work. It is essentially a local building material and consequently there exist considerable variations in the quality of raw material. the process of manufacture and the quality of the finished product. Rapid building activity, to be on rational lines, needs a certain degree of uniformity in the construction materials. Standardization of the common building brick with regard to its quality and dimensions would substantially help in raising the quality of construction work and its speed.

The brick industry plays an important role in the construction sector and an important part of the Indian economy. Clay fired bricks are considered as a backbone of this sector contributing 10 % of the Gross Domestic Product (GDP), registering an annual growth of about 9 %. The brick industry of India is mainly an un-organized sector and second largest manufacturer of bricks behind China which has a 54% share as per the 2015. There are about 1, 40,000 brick-making enterprises, which produce about 250 billion bricks every year. About 65% of India's brick production comes from the country's major brick-producing states. Punjab, Haryana, Uttar Pradesh, Bihar, and West Bengal are the Indian states that produce the most bricks. Over 2–10 million bricks are produced annually by the brick kilns, which are clustered around major cities and towns in India. In Fig.-1, India's share is given which is approx. 11% of the world brick production whereas China's share is approx. 54%.

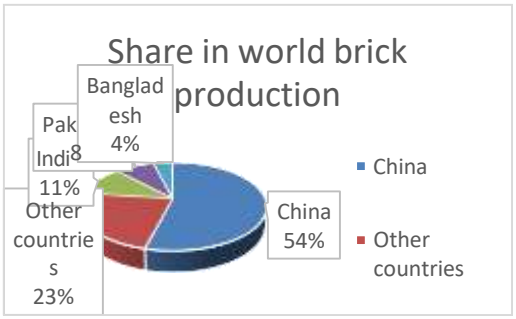

Fig.-1: Share in world brick production

Assam is also one of the most important states for producing bricks like other major brick-producing states of India. The demand of burnt clay bricks in Assam is around 4000-5000 million pieces in 2013-15 periods and is gradually increasing. In Assam burnt clay bricks are mainly used as important building material in housing and other construction purposes mainly due to economic as well as its environmental friendly reasons. These bricks also produces a superior, and comfortable physical living environment than other type of building and walling materials such as earth block, concrete block, stone concrete, stone block, fly ash brick etc.

There is a vast gap between supply and demand of these clay bricks in Assam. The traditional brick making process is still used in Assam and rest of India. The states that are highlighted are typically the primary locations for the brick manufacturing process as shown in Fig.-2.

Fig.-2: Brick making in India

This study has focused on the Jorhat District, where the brick manufacturing is very much active. Numerous firms are situated in and around the place. Gradually the number of such firms has increased, making them a viable investment option for startups. For this purpose, many workers from Bihar and West Bengal travel to Assam each year.

2. Objectives of the study: The major objectives of this study are:

a. To study the manufacturing process involved in the clay brick manufacturing.

b. To carry out quality test of burnt clay bricks of five different brick manufacturing industry.

2.1. Significance of the study: The study gives an insight into four principal quality test carried out on 1st class burnt clay bricks manufactured in five different brick manufacturing industries in Jorhat, Assam. Apart from this, collection of raw materials and steps involved in the clay brick manufacturing are also examined in this study. In addition, it reveals the specifics of whether the manufacturing facilities are adhering to the industry standards for high-quality bricks or merely compromising on quality in order to remain relevant in this competitive market. The data and information presented in this study will be helpful for determining the quality of 2nd and 3rd class burnt clay bricks in future research.

2.2. Profile of the firms: The profile of the five different brick manufacturing firms that has been used in this research work is shown in Table-1:

Table-1: Profile of the firms used in the thesis

Sl. No.	Brand	Industry Name	Production Capacity (lakhs/Year)
1	NBF	Nargish Brick Field	3.0
2	SBI	Swarna Brick Industry	2.5
3	BBB	B. Baruah Bricks	3.0
4	MAYUR	Mayur Brick Field	3.5
5	MAK	MAK Brick Industry	3.0

3. Research methodology: The methodology of the present research work is as follows:

3.1. Area of the Study: The State Assam is situated in the north-eastern part of India. Jorhat is an administrative district of the Indian state of Assam situated in the central part of the Brahmaputra Valley. The district is bounded by Lakhimpur on north, Nagaland state on the south, Sibsagar on the east and Golaghat on the west. On the north of the district, the river Brahmaputra forms the largest riverine island of the world. Map of Jorhat district is given below:

Fig.-3: Map of Jorhat

3.2. Source of data: The primary data information used for the study is mostly collected from proprietors and labourers working at the brick manufacturing industries in Jorhat district Assam. The Secondary data sources such as various research publications, websites and other related publications are also used to gather information for the study. In addition to the primary and secondary data sources, field observation and personal experience were also helped for the preparation of this paper. So, the study is based on both the primary and secondary sources of information.

3.3. Population of study: There are 45 (approx) numbers of burnt clay brick manufacturing industries at Jorhat district and all of them have been taken as the universe or population of this study.

3.4. Sample of study: In this study, random sampling method has been applied in two stages. Out of 45 numbers of clay brick manufacturing industries, only 5 (five) numbers of industries namely BBB, NBF, SBI, MAYUR, and MAK have been selected by random sampling method. Again from these 5 brick manufacturing industries, 20 numbers of 1st class burnt clay brick has been selected randomly.

3.5. Tools and Machinery used in the study: The tools and equipment used were steel tape, digital weighing balance and Compression Testing Machine to perform four quality tests on 1st class burnt clay bricks.

3.6. Analysis and interpretation of experimental data: For making better analysis**, t**he experimental and observed data were tabulated for data interpretation.

4. Limitations of the Study: The following are the limitations of this study:

a. The study is restricted to 1st class Burnt Clay bricks only. Other classes of bricks are excluded from this study.
b. The study is only confined to Jorhat district only.
c. Unwillingness of labourers' to disclose information.

5. Manufacturing process of bricks: The following steps are involved in the clay brick manufacturing in Assam and rest of India:

5.1. Material procurement 5.2. Tempering 5.3. Molding 5.4. Drying 5.5. Burning 5.6. Sorting

5.1. Material procurement: In Assam, the basic raw material for making clay brick is ground clay.

5.2. Tempering: In this stage, ground clay is mixed with water by manually or with pug mill to get plastic quality which is suitable for molding.

5.3. Molding: In this process, prepared clay is mold into required shape to the brick (generally rectangular). There are two types of molding according to scale of production:

5.3.1. Hand molding (for small scale)
5.3.2. Machine molding (for large scale)

5.3.1. Hand molding: If manufacturing of bricks is on a small scale and manpower is also cheap then we can go for hand molding. The molds are in rectangular shape made of wood or steel which are opened at the top and bottom.

5.3.2. Machine molding: This brick molding technique is required when there is a demand in large quantity, and then machine molding is economical and also saves more time. Here, we have two types of machines through which molding can be done:

(a) Plastic clay machines
(b) Dry clay machines

5.4. Drying: After molding process, the drying of raw bricks is done to reduce moisture by natural process (i.e. sun drying) for 3-10 days depending upon the weather conditions. Otherwise they may crack while burning.

5.5. Burning: In the process of burning, the sun dried bricks are burned in the kilns about 1100°C to impart hardness and strength to the bricks and makes them dense and durable.

5.6. Sorting: The sorting is done on basis of coloration which is an indication of level of burning.

6. Quality Analysis on Burnt Clay Bricks: In this study, four principal quality tests such as water absorption test, efflorescence test, compressive strength test, and dimension test was carried out in order to get an idea about quality of 1st class burnt clay bricks of five different Brick manufacturing industry.

6.1. Water absorption test: Water absorption test is carried out to ascertain the percentage of water absorbed by the brick when it is soaked in cold water for 24 hours. For determining water absorption test of bricks, 3 (three) numbers of 1st class burnt clay bricks were taken randomly from each of the 5 (five) different brick manufacturing industry. The bricks were tested in accordance with the procedure laid down in IS 3495 (Part 2): 1992 after immersion in cold water for 24 hours, water absorption shall not be more than 20 percent by weight up to class 12.5 and 15 percent by weight for higher classes. Water absorption, percent by mass, after 24-hour immersion in cold water is given by the following formula:

$$\frac{M2-M1}{M1} \times 100$$

Where, M_1 = Dry mass of brick and M_2 = Wet mass of brick after 24-hour immersion in cold water.

Water absorption of 1st class clay brick should not exceed 12 - 15% of its dry weight. Table-2 illustrates the water absorption test results of the 1st class burnt clay bricks.

Table-2**:** Water absorption test results for burnt bricks.

Brick Brand	Sample No	Dry Weight	Wet weight	Water absorption	Average water absorption
NBF	1	2.810	3.055	8.71%	15.80%
	2	2.582	3.178	23.08%	
	3	2.855	3.381	15.62%	
SBI	1	2.927	3.376	15.3%	11.62%
	2	2.790	3.057	9.56%	
	3	2.785	3.064	10.01%	
BBB	1	2.903	3.140	8.16%	7.61%
	2	2.610	2.786	6.74%	
	3	2.700	2.902	7.48%	
MAYUR	1	2.703	3.141	16.20%	14.59%
	2	2.773	3.258	17.49%	
	3	2.646	2.913	10.09%	
MAK	1	2.502	2.761	10.35%	9.35%
	2	2.862	3.015	5.34%	
	3	2.925	3.287	12.37%	

From the Table-2, it is found that NBF site bricks recorded the highest water absorption of 15.80%, followed by MAYUR site bricks (14.59%) and the least was 7.61% from BBB site bricks. It is also clear that NBF, SBI and MAYUR brick brands satisfies the IS recommended values whereas BBB and MAK brands produces brick lower than IS recommended values. As a result, the brick will not stick with mortar properly.

6.2. Efflorescence test: Efflorescence means the appearance of white-coloured powder material on the surface on the brick. In most cases, efflorescence is caused by salts from the external sources such as ground water, contaminated atmosphere, mortar ingredients and other materials in contacts with the bricks. It can be serious; causing unsightly permanent discoloration or even the failure of plaster, paint work or face finishes. The efflorescence test on bricks is carried out to check the presence of alkaline substances. Only bricks with "nil" or "slight" efflorescence are recommended for any high-quality brickwork. Anything more than that should only be used on low-quality projects where efflorescence won't be a big problem. For this test, 3 numbers of 1st class burnt clay bricks were taken randomly from each of the five brick industry and tests were performed as per IS 3495 (Part 3): 1992. The tests results were tabulated in Table no-3.

Table no.-3: Test results of efflorescence test for bricks.

Industry Name	Sample number	Efflorescence	Remarks
NBF	1	NIL	Pass
	2	NIL	Pass
	3	NIL	Pass
SBI	1	SLIGHT	Pass
	2	NIL	Pass
	3	SLIGHT	Pass
BBB	1	NIL	Pass
	2	NIL	Pass
	3	NIL	Pass
MAYUR	1	SLIGHT	Pass
	2	SLIGHT	Pass
	3	NIL	Pass
MAK	1	NIL	Pass
	2	NIL	Pass
	3	NIL	Pass

Source: Material Testing Laboratory Results

From the Table no-3, it is seen that all the fifteen samples coming from five brick industry were safe when compared with standard values as per IS 3495 (Parts 3): 1992.

6.3. Compressive strength test: Compressive strength test or crushing strength test was carried out on Compression Testing Machine following IS 3495 (Part 1): 1992 to determine the load carrying capacity of bricks when subjected to a compressive load. Compressive strength is the ratio of maximum load at failure in N to the average area of the bed faces in mm^2. The compressive strength of first class clay brick should not be less than 10.5 N/mm² as per IS 3495 (Parts 1): 1992. For this test, 3 numbers of 1st class clay bricks were taken randomly from each of the five brick industry and tests results were tabulated in Table no-4.

Table no.-4: Test results of Compressive strength test of brick

Industry Name	Sample number	Volume in mm^3	Surface area in mm^2	Load at failure (N)	Compressive strength N/mm^2	Average Compressive strength N/mm^2	Remarks
NBF	1	1662080	23744	390000	16.4	16.25	1st class
	2	1612800	25200	380000	15.07		
	3	1578785	24289	420000	17.29		
BBB	1	1524600	24200	480000	19.83	17.68	1st class
	2	1546980	26220	430000	16.39		
	3	1634432	25538	430000	16.83		
SBI	1	1475600	21700	440000	20.27	17.82	1st class
	2	1694000	24200	350000	14.46		
	3	1741630	24530	460000	18.75		
MAYUR	1	1606500	23625	340000	14.39	14.72	1st class
	2	1579955	24307	210000	8.63		
	3	1559250	23625	500000	21.16		
MAK	1	1621400	24200	440000	18.18	17.16	1st class
	2	1720400	25300	440000	17.39		
	3	1545840	25764	410000	15.91		

Source: Compression Testing Machine results

From Table-4, it is found that the average values of Compressive strength for all the samples are more than 10.5 N/mm². All the five brick industry showed relatively better trend with the values of Compressive strength.

6.4. Dimension test of brick: This test is performed to check whether the bricks are of required dimensions or not. According to IS 1077:1992, the dimensions of bricks when tests shall be within the following limits per 20 bricks:

For non-modular size
Length 4680 to 4520 mm (4600±80 * mm)
Width 2240 to 2160mm (2200 ±40 * mm
Height 1440 to 1360 mm (1400 ±40 * mm)

For this test, 6 Bricks were taken randomly from each of the five brick industry to check measurement of length, width and height. The bricks were arranged upon a level surface successively as indicated in Fig.-4. The overall length, width and height of the assembled bricks were measured with the help of a steel tape and the measured values were noted in Table no-5.

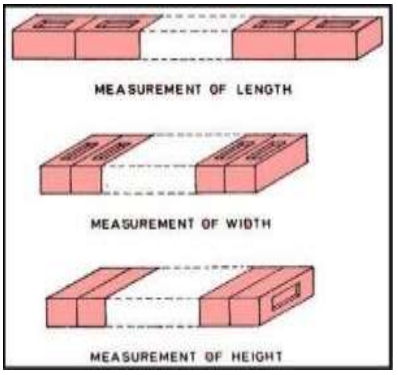

Fig.-4: Dimension Test on bricks

Table no-5: Dimension Test results

Name of brick Industry	Parameter	Observed Value (mm)	Tolerable limits (mm)	Remarks
NBF	Total Length of 6 bricks	1364	1404 to 1356	1st class
	Total Width of 6 bricks	680	672 to 648	1st class
	Total Height of 6 bricks	406	432 to 408	1st class
SBI	Total Length of 6 bricks	1355	1404 to 1356	1st class
	Total Width of 6 bricks	665	672 to 648	1st class
	Total Height of 6 bricks	423	432 to 408	1st class
BBB	Total Length of 6 bricks	1360	1404 to 1356	1st class
	Total Width of 6 bricks	674	672 to 648	1st class
	Total Height of 6 bricks	398	432 to 408	1st class
MAYUR	Total Length of 6 bricks	1380	1404 to 1356	1st class
	Total Width of 6 bricks	675	672 to 648	1st class
	Total Height of 6 bricks	420	432 to 408	1st class
MAK	Total Length of 6 bricks	1362	1404 to 1356	1st class
	Total Width of 6 bricks	683	672 to 648	1st class
	Total Height of 6 bricks	415	432 to 408	1st class

Source: Field Survey

As per Table-5; it is seen that all the samples taken from 5 (five) different bricks manufacturing industries are within the tolerable limits in accordance with IS 1077: 1992.

7.0. Future Scope: This research work was solely focused on the manufacturing process and quality test of 1st class burnt clay bricks. The future scopes that can be done through this study are:

(i) The quality analysis tests for 2nd class and 3rd class bricks will be the research work for further study as this sort of work have been left untouched.

(ii) Quality tests for the raw materials used in the manufacturing process of bricks will be another research work which can be used for further study.

(iii) Additional research can be conducted only to find ways to improve on the brick manufacturing industries methods.

(iv) The quality tests can be done on other types of bricks such as un-burnt clay bricks, fly ash bricks, concrete bricks, engineering bricks, and calcium silicate bricks.

8.0. Conclusion: In this study, there were two main objectives that needed to be addressed: Manufacturing process of burnt clay bricks and Quality tests on bricks. From the study it can be concluded that

(i) The traditional manufacturing process is still followed in the 5 (five) brick making industries of Jorhat district.

(ii) The average values of water absorption of NBF, BBB, and MAYUR were met with reference to IS 3495 (Part 2): 1992. But average values of water absorption of SBI and MAK brands were found less standard IS Code.

(iii) The standard limit was met by all the samples from five different bricks manufacturing industries used in this study. The usual limit is none or very little efflorescence. All 3 (three) brick industries, namely, NBF, BBB and MAK had "nil" efflorescence, with the exception of MAYUR & SBI, which had a slight efflorescence.

(iv) The average values of compressive strength for all the samples were more than 10.5 N/mm² which satisfied IS 3495 (Parts 1): 1992. All the five brick industry showed relatively better trend with the values of Compressive strength.

(v) All of the bricks used in this study were within the prescribed standard limit in accordance with IS: 1077:1992.

At the end we can say that the burnt clay brick manufacturing industries should introduce new technologies to maximize their production, improve quality of bricks, reduce carbon emission and also take necessary steps for the growth as well as development of the industry which enhances the economy as a whole.

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