AN ANALYTICAL STUDY OF COLONIAL AND CONTEMPORARY BRICKS FROM THE BUILDINGS OF LAHORE, PAKISTAN

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ABSTRACT

The British colonial buildings in the city of Lahore were mainly constructed with fair face bricks. The different forms and decorative styles of bricks were used in the building façade that formed the characteristic British Colonial Style. This study focuses on the comparative analysis of the contemporary and colonial bricks for their durability and salt deposits in the present scenario. The representative brick samples have been collected from the selected buildings for their physical, mechanical and chemical testing, to generate data for comparative analysis in addition to the visual examination of buildings for the study of deterioration factors. The results clearly depict that the contemporary bricks composition and manufacturing techniques are different from the colonial bricks. The high content of soluble salts in the contemporary bricks was found to be responsible for salt deposits in contemporary bricks and one of the main cause of failure in the restoration works of the colonial buildings.

Keywords: Colonial, Contemporary, Bricks, Lahore, Pakistan.

INTRODUCTION

The clay brick is the main and oldest material used in every era of the world history in building construction, like construction of defense city walls, culverts, bridges, brick soling on roads, building façade and streets, arches etc. Initially the sun dried brickwork was used and with the passage of time, new ideas of burnt bricks were developed which were found to be more durable and weather resistance in harsh climate state (Kornmann, 1986).

The history of ancient civilization and its architecture shows the significance of brick. In ancient civilization, such as Egyptian civilization, sun dried brick was used, as a building material, and the Mesopotamians used sundried bricks in their Ziggurats due to easy availability of mud / clay along the banks of Rivers Tigris, Euphrates and Nile. Ancient Indus civilizations used fire burnt bricks in their single and double story houses, in granaries, for sewerage channels, public baths, and other public places. Evidence is available in the remains of Indus civilization of Harappa and Mohenjo-Daro in Pakistan (Hassan,1980, 1984 and 1988). The Egyptians used sun dried mud bricks in house construction because this ancient civilization was established along the River Nile and mud was easily available on both banks of the river. The people of ancient Roman civilization further refined those sun dried bricks into burnt bricks, fired in a specific kiln. They mostly preferred to make bricks in the spring. They prepared their burnt bricks two years before using them in construction. The Ancient Greeks were well aware that the perpendicular fire burnt brick walls were more durable than stone walls.

City of Lahore, Pakistan

Lahore is an old urban epicenter. Lahore was one of the foremost cities in the 17th century during the Mughal era. The city has a rich architectural heritage that reflects the

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administrative fortunes of the conquerors of the city. Modern Lahore is planned along the lines set typically by the British, during their one hundred years of colonial rule over the sub-continent.

The Mughal ruler also left a strong and permanent stylistic imprint on the city. The buildings built during early Mughal rule used burnt clay brick and polychromatic materials, whereas late Mughal architectural works used pink white marble and red sandstone. In both cases the architecture maintained a critical balance between the massive structure and the light and transparent screen partitions. Proportion, balance and symmetry were three very important organizing factors in the Mughal architecture.

The British post-colonial period perceived two main styles of colonial architecture. The first was international architectural style, greatly penetrated by the architectural work's of Master Architect Le-Corbusier and afterwards the Brutalistic architectural style. The second one sustained the colonial style and tradition of modern planning and was concerned with orientalized building façades.

Lahore also has vernacular style and traditions, that try to repeat certain local ideas and styles, using contemporary construction materials. The colonial buildings also reflect a traditional style of buildings with blend of Mughal building styles and British colonial styles. The exposed brickwork is freely used in the colonial buildings, but in the Mughal buildings the brickwork is hiden by lime plaster. The maximum use of exposed brickwork in colonial building tends to promote different forms and styles of bricks very tactfully (Bonnel and Butteworth,1950).The use of fairface brick was promoted in the colonial period. In spite of this the standard common clay brick, rectangular in shape, was used. Another form of brick used was half round corner brick, with chamfered corner of the brick. Corner pointed arch shaped brick and many other shapes were also used in construction of buildings during the colonial period.

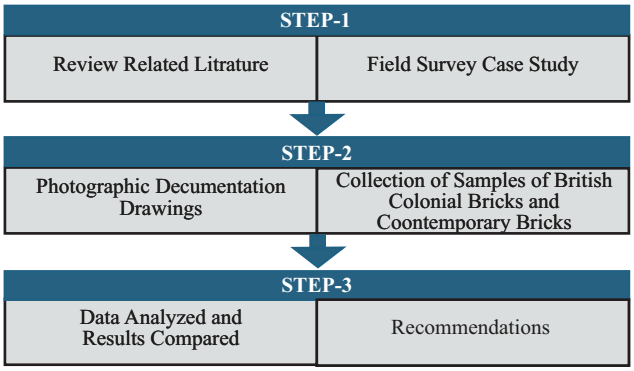

Figure-1: The schematic layout of research methodology.

Research Method

This research was divided into three major phases (Figure 1). In the first phase the related literature was reviewed which was focused on the study of brick in the British colonial period in Lahore city. The second phase involved the field survey of colonial and contemporary buildings in Lahore. The next phase included collection of proper samples of the colonial and contemporary building bricks from various buildings constructed during different times. The collected samples were tested in the laboratory to generate the required data. The buildings were also physically examined to identify various causes of deterioration. These were further supported by photographic evidence and drawings. After collection of the data, it was analyzed and compared with respect to chemical composition, clay quality, clay selection, shapes, strength, manufacturing process, burning process and uses in the buildings, and then the conclusion were drawn from the comparative analysis.

Buildings selected to collect brick samples: Case Study-1: Aitchison College Lahore

The Aitchison College has a strong historical background and rich architectural edifices belonging to British colonial period. The old building of Aitchison College is the best example of brick structure of colonial construction (Figures 2 and 3). Completed in 1886, seven colonial buildings which were constructed with common clay bricks with exposed bricks on building façades are scattered at the site of Aitchison College.

Case Study-2: Lahore Railway Station

The Railway station of Lahore (Figure 4) is another example of British colonial building in the city of Lahore. The main construction materials of the building are commonly available clay brick and steel trusses with wooden doors/windows. The façade of the railway station is artistically developed, creating a balance with conical minarets which erect on an octagonal base and round shape minarets. This building was constructed by British colonists' architects between 1859-1860 at the cost of half a million Rupees. It is located at the junction of Lahore-Amritsar railway line. The railway network of the subcontinent was developed by the British and is one of their long-lasting contributions to the culture and infrastructure of this region (Chopra and Patwardhan, 1954).

Case Study-3: Alhamra Art Council Lahore

The Alhamra Arts Council Lahore (Figure 5) is the main complex for cultural activities for the people of Lahore city and its vicinity and for people from all over Pakistan. It is situated on the Mall Road, now known as Shahrah Quiad-e-Azam (after the founder of Pakistan). The Arts Complex was designed by Architect Nayyar Ali Dada. The Alhamra Hall-1 is the single cultural theater visible from the Mall Road and the access of this portion is directly from the Mall Road. The form of the blocks used in its construction are mostly octagonal in shape. The architectural style of the complex is unique and distinctive, reflecting modern architecture. It is a good example of a building in Lahore which is constructed with common clay bricks locally produced. The architect used a local building material and very artfully exposed bricks on the façades of all the building blocks in the complex. The thick and huge structure with exposed common clay brick walls represents Mughal architectural forms.

Figure-2: The elevation of old building of Aitchison College Lahore.

Figure-4: Front view of railway station of Lahore.

Case Study-4: Lahore University, Raiwind Road, Lahore

The 2nd campus of the University of Lahore is (Figures 6 and 7) located on Defense Road, near the Raiwind Road Lahore. The University houses Medical Engineering and Architecture Departments, and locally produced clay brick is predominantly used as a construction material.

Sampling of Bricks

For evaluation of the bricks, different samples were collected from Aitchison College and other colonial buildings such as Lahore Railway Station and Railway Quarters. The size

Figure-3: Main dome decorated with mini domes of Aitchison College.

Figure-5: Alhmra Arts Council Hall No.1.

Figure-6: Main gate of Lahore University, Raiwind Road, Lahore with brick pillars.

Figure-7: Internal view of Lahore University.

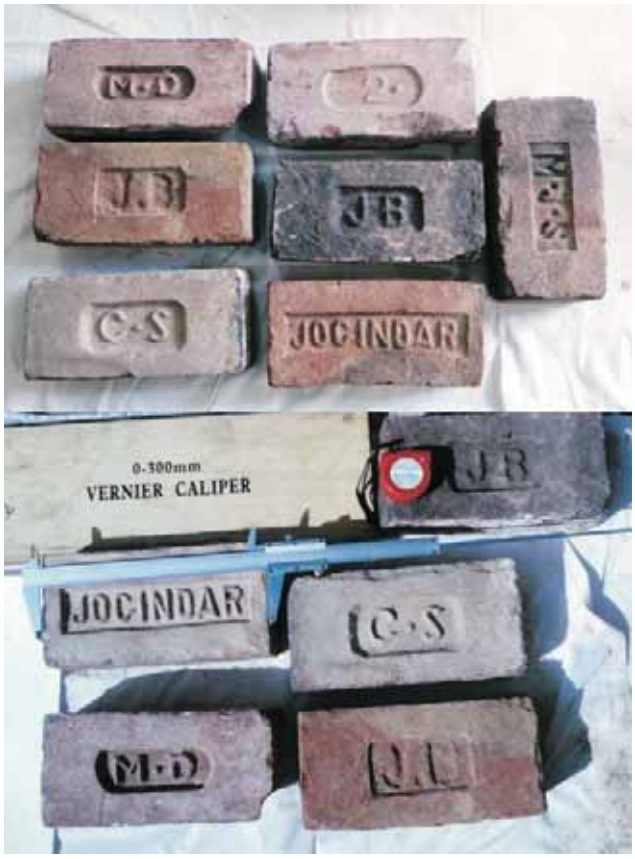

Figure-8: The samples of bricks used in British colonial buildings (With Marks: M. D, 2., J. B. K. J S., C. S., JOCINDAR).

Figure-9: Samples of contemporary bricks used in building construction.

Figure-10: Samples of bricks used in contemporary building.

of the colonial bricks was found to be 9.0" in length 4.5" width and 2.9" thickness (Figure 8). Most of the colonial buildings were built at the end of 19th century.

A comparison of the colonial bricks was done with the contemporary bricks available in the market. It was found that different sizes of contemporary bricks are available in the brick market (Figures 9 and 10). Mostly available bricks were under sized and only some brick kilns manufactured a special quality of brick and produced standard sized bricks.

The standard sized bricks were available at higher prices than economical class which were under sized. The special quality bricks which met the standard size were not used in ordinary building construction due to high cost. Other economical class bricks, which were introduced as first class brick by the kiln owners, were mostly used in the construction. These under sized bricks increased the cost of construction in the form of excessive use of cement in mortar and plaster.

RESULTS AND DISCUSSIONS

A comparison was made between contemporary bricks and the colonial bricks (Tables 1, 2 and 3) with respect to size, colour, form, strength, weight, water absorption, chemical composition and efflorescence appearance on the faces of brickwork.

Table-1: Comparative analysis physical properties of colonial and contemporary bricks.

Sr. No.	Bricks	Sample No.	Mark (Frog)	Size (Inch)	S-Section Area (Sq. Inch)	Ultimate Load KN	Ultimate Stress Psi
1.	COLONIAL	T. B-1	JOCINDAR	8.9 x 4.4 x 3.1	39.16	522.40	2998.0
2.		T. B-2	M. J. S	8.8 x 4.4 x 3.1	38.72	446.70	2592.0
3.		T. B-3	M. J. S	9.0 x 4.5 x 2.9	40.50	478.50	2630.0
4.		T. B-4	C. S	8.9 x 4.5 x 3.0	40.05	436.00	2530.0
5.		T. B-5	M. D	8.8 x 4.3 x 2.9	37.84	669.00	4214.0
6.		T. B-6	J. B	8.9 x 4.5 x 3.1	40.05	385.20	2137.0
7.	CONTEMPORARY	T. C-1	FB	8.8 x 4.2 x 3.0	36.54	431.00	2650.0
8.		T. C-2	FB	8.9 x 4.3 x 2.8	38.27	420.90	2471.0
9.		T. C-3	ABC	8.1 x 3.8 x 2.6	30.78	165.40	1129.0
10.		T. C-4	ABC	8.2 x 4.0 x 2.6	32.80	209.00	1520.0
11.		T. C-5	T T	8.2 x 4.0 x 2.7	32.80	208.00	1420.0
12.		T. C-6	T T	8.2 x 4.0 x 2.5	32.80	317.20	2166.0

Table-2: Comparative analysis of physical properties of colonial and contemporary bricks.

Sr. No.	Bricks	Sample No.	Mark (Frog)	Weight (Kg)		Water Absorption (%)
				Wet	Dry	
1.	COLONIAL	T. B-1	JOCINDAR	3.942	3.510	12.31%
2.		T. B-2	M. J. S	3.872	3.415	13.24%
3.		T. B-3	M. J. S	3.783	3.335	11.53%
4.		T. B-4	C. S	4.020	3.551	13.21%
5.		T. B-5	M. D	3.664	3.420	12.14%
6.		T. B-6	J. B	4.033	3.516	13.74%
7.	CONTEMPORARY	T. C-1	FB	3.691	3.337	10.61%
8.		T. C-2	FB	3.529	3.079	14.62%
9.		T. C-3	ABC	2.52	2.607	07.43%
10.		T. C-4	ABC	2.587	2.639	08.05%
11.		T. C-5	T T	2.522	2.658	05.38%
12.		T. C-6	T T	2.572	2.669	09.72%

Table-3: Chemical composition of colonial and contemporary bricks: Calcium Oxide (CaO), Silica (SiO_2), Magnesium Oxide (MgO), Sulphate (SO_4), Chloride Contents (Cl^-), Alumina (AL_2O_3), Iron Oxide (Fe_2O_3), M. C. Moisture Content.

Sr. No.	Elemental Composition	Sample T. B-1	Sample T. B-2	Sample T. C-1	Sample T. C-1	Sample T. C-1	Sample T. C-1
1.	CaO	4.48%	3.36%	3.64%	03.20%	03.39%	2.35%
2.	SiO_2	92.25%	94.6%	91.10%	92.00%	91.4%	93.14%
3.	MgO	1.12%	0.89%	00.52%	00.55%	00.49%	0.61%
4.	SO_4	0.08%	0.08%	1.31%	1.28%	1.50%	1.22%
5.	Cl^-	0.78%	0.17%	0.0461%	0.0496%	0.049%	0.0533%
6.	AL_2O_3	0.66%	0.42%	01.11%	01.14%	01.12%	1.06%
7.	Fe_2O_3	0.02%	0.01%	00.86%	0.75%	0.58%	0.78%
8.	M. C	2.75%	2.83%	3.10%	2.85%	3.21%	2.60%

The size of British colonial bricks were mostly standardized, but the size of contemporary bricks was under sized except for some special quality bricks. The smooth and regular colour of colonial bricks showed its standard firing on its required temperature. The standard required temperature is 1000ºC which dissolves all the organic compound and soluble salts. The colour of the colonial bricks was reddish with offwhite texture. Some of them had yellow and red shade and some of them had claret colour. The variations of colours showed that most of these bricks were burnt on 1000º C. These bricks were fired at 600º C to 750º C. The heat control at 1000º C is required for good quaility but mostly contemporary brick makers are using substandard fuel such as rice husk, rubber, motor bike tyres, wooden waste, other plastic waste and low quality coal in kiln for firing bricks. These substandard firing materials produce low temperature of about 600ºC to 800º C which is not enough for first class brick baking. Due to low temperature, most of the organic matters, soluble salts, and other chemicals in the clay are not completely disposed off and produce efflorescence and destruction of bricks after construction.

The bricks which were manufactured in the vicinity of Lahore, such as *Daroghewala, Herbanaspura* and *Baipheroo* have had good crushing strength and fell in special categories bricks but economical first class brick samples had less crushing strength as per standard. The bricks manufactured in district Narrowal and Sheikhupura had less crushing strength due to the hard soil and disbalanced soil particles. The strength of all the samples of colonial bricks was more than 2000 psi. The result showed that these bricks had good bearing capacity as compared to the contemporary bricks (Table 1).

The contemporary bricks varied in weight also. Mostly common bricks had a lesser volume and weight. Some makes of special bricks had proper volume and weight according to standard. The weight of the British colonial bricks was according to the standard, because of compact soil particles and solidness (Table 2).

The water absorption test of contemporary bricks gave great variation in the results. The common economical class bricks manufactured in the district Narrowal and Sheikhupura had less water absorption percentage than the bricks manufactured in the Lahore district. The first class special bricks had water absorption percentage according to the standard 12% to 15% with respect to their weight, which was excellent. Absorption of bricks used in British colonial period was about 12% to 13% (Table 2). This result showed that the water absorption of these bricks was excellent. It was observed that these samples of bricks were more than handred years old and bore a lot of climatic change and variation of temperature, but presently it showed durability upto the standard.

The chemical analysis reflected that the quantity of sulphates and calcium was excessive as per standard in the contemporary bricks, which caused the efflorescence on the face of brick work. This also led to fast decomposition due to climate and temperature variation. The chemical analysis of colonial bricks showed the quantities of sulphates and chlorides was minimized due to the passage of time and proper soil selection during manufacturing state and the continuous climatic change reduced the soluble salts in these bricks (Table 3).

The contemporary bricks analysis showed that different sizes of bricks were available and mostly contemporary bricks were under sized and did not meet the standards. Some brick makers used standard size mouldes for brick moulding but the brick size was reduced due to shrinkage

during drying and baking (Table 1).

The contemporary bricks were available in the market in different forms and styles. The strength of contemporary bricks as mentioned in Table 1, showed that some special brick maker companies were producing good strength bricks, but mostly brick makers were producing low standard bricks due to lack of knowledge of the raw materials selection.

It was perceived from the visits to different brick kilns that there was no check and balance by the government to maintain the quality of the bricks. This huge industry had no proper recognition and no appropriate rules and regulation. Thus, it is suggested that needful measures should be taken in this regard, by the local government, to ensure the standardized bricks production. It should be the duty of the quality control department of the local government authority to ensure the soil quality, firing materials and temperature control devices at the kiln. The chemical test showed (Table 3) that proper soil selection criteria was not followed by the bricks manufacturers. Due to the improper clay selection, the ultimate result in the form of substandard bricks was produced. The soil containing more than 0.25% soluble salts was not considered suitable for brick making. If bases responsible for forming soluble sulphates of Mg, Na & K are present in excess i.e. 0.05%, the brick is more prone to efflorescence (Hassan, 1980, 1984). The reasons of efflorescence in the contemporary bricks was the excessive quantity of soluble salts in the soil. To protect the bricks from efflorescence correct soil for brick making should be selected which should not have aforesaid chemicals in excessive quantities.

It was also observed in the tests of colonial bricks that there was great variation in strengths of bricks samples. The sample on serial No.3 showed strength 1638 psi, which did not meet the required standard, and the same quality of bricks was under burnt. The sample on serial No. 5 showed extra strength of 4214 psi which was double the strength, as compared to the standard strength, according to the British Standard (2000 psi). This indicated that the same quality bricks were over burnt. The result of water absorption of this brick (6.55%) also reflected that these bricks were over burnt, because the actual required standard of water absorption is 12%. The aforesaid facts provide a strong ground that the temperature of brick baking in the kiln could not be completely maintained at the time of colonial period, but the ratio of standard bricks produced was maintained at 68%, under burnt bricks were 16.5% and over burnt bricks were 16.5% also. This variation of strength was also observed in the contemporary bricks.

CONCLUSIONS AND RECOMMENDATIONS

It is concluded that the bricks used in the British colonial buildings are more durable as the lab results show that the average compression strength of colonial bricks is 2266 psi, which is more than the required standard compression strength of 2000 psi and the water absorption of colonial brick is 12.33% - 14.7% with respect to its weight, which is according to the standard required for first class bricks. The British combined local techniques coupled with their native observation to form an international standardized brick that now stands as an example of sustainable heritage.

It is also concluded that the main reason of excessive salts appearance on the face of the brick masonry is the selection of improper soil. The proper soil selection is very important for durable and sustainable bricks manufacturing. It also reduces the possibility of efflorescence. The research also revealed that the use of appropriate soil produced a more economical and sustainable brick. The suitable ratio of soil particles is very crucial for producing first class durable bricks and the temperature of brick kiln should be 1000^{o} C, to dissolve the unnecessary salts which are naturally present in the soil ingredients. The harmful effect of the excessive soluble salts can be controlled by adding appropriate quantity of barium carbonate, which combines with CaSO4 to form calcium carbonate. This process is very costly and highly skilled technicians are required to execute this.

Furthermore, the brick manufacturers are mostly unfamiliar with the modern techniques and technology of brick manufacturing process, which causes a great variation in the sizes, bearing capacity, water absorption and quality of contemporary bricks. It is also concluded that the contemporary buildings brickworks are impaired by efflorescence crystallization which appear on the face of brickwork after an effect of dampness. The bricks used in the colonial buildings have also been impaired badly by influence of moisture inside the bricks cross section, which causes the appearance of efflorescence on the old brick work. The reason behind efflorescence is dampness, which can be controlled and protected by eliminating the sources of dampness. Additionally, there is a great variation of brick quality and prices. The sizes of bricks available in the market are not meeting the standard size and are mostly undersized or are reduced in size and are sold at less price, at about Rs. 7500 / 1000 bricks. The special size and quality bricks are available in higher prices, at about Rs. 10500 / 1000 bricks in the vicinity of Lahore city (irrigated areas). In Narowal district (non-irrigated areas) mostly bricks are under sized and available in prices about Rs. 6500 / 1000 bricks.

It is recommended that the bricks used in the colonial buildings. may be reused for restoration work of these buildings, due to their durability. The contemporary bricks can also be used, which are especially manufactured with appropriate clay as per standard requirements and are durable and sustainable for first class brickwork in building construction.

The standard temperature of bricks firing in the kiln is also recommended which should be maintained at 1000^{o} C. This helps to decompose the appropriate quantity of salts during firing. The causes of efflorescence should be explored further and research for proper rectification of this continuous deterioration of brickwork should be undertaken.

Further, it is recommended that the contemporary brick manufacturers' should be educated about the importance of suitable soil selection, chemical composition and ratio of soil ingredients. They should adopt the factors which matter in producing quality brick, such as to maintain the kiln temperature during the bricks firing for the first class bricks hiring expert and experienced labor, using salt free water for clay preparation and using good quality of fuel for firing the bricks.

It is also recommended that the government should recognize the brick manufacturing as an industry and arrange training programs for their workers, in technical education and vocational training authority institutions, and include "Brick Manufacturing Techniques" courses as part of industry demand driven courses. Awareness workshops should be conducted for standardized brick manufacturing for brick manufacturers on district level and lab testing facilities for soil quality should be provided. The need of the hour is to openly take up immediate measures and follow ups for the implementation of brick standards to transfer long-lasting and safe building structures to the future generations.

REFERENCES

Bonnel.R. D. G. & Butterworth, B., 1950, *Clay Building Bricks of UK*, HMSO, London.

Chopra S. K. and Patwardhan, 1954, "A survey of bricks production in India", *Bulletin of CBRI*, Vol. 2 No. 1.

Hassan A., 1980, "Questions & Answers about Modular Bricks", *Pakistan Engineer* Vol. VI, No.7.

Hassan A., 1984, "Development of New Bricks and their Influence on Economy", *Tans. Of Modular Soc.* London, Modular Quarterly MQ 1964/2

Hassan A., 1988, *The Art and Science of Brickmaking*, Combine Printer, Lahore, Pakistan.

Kornmann, M., 1986, *Clay Bricks and Roof Tiles, Manufacturing and Properties*, USA.