BRICK AS A CONSTRUCTION MATERIAL IN INDIA : HISTORICAL PERSPECTIVES

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Abstract

In ancient time, India sub-continent has witnessed a high level of scientific and technological progress in diverse fields. Many excavations, carried out in the last centuries have substantiated this fact. The excavations at Mohan-jo-daro, Harappa, Lothal, Dholaveer and many others places present an envious picture in relation to scientific and technological developments in ancient India. In medieval times also, such developments continued, though at a lower pace. Certain marvels erected in this time stand as testimony to the creative genius of Indians in this era. This paper discusses in brief about certain characteristics of bricks as a construction material used in ancient and medieval times in India.

1. INTRODUCTION

Various types of structures serve definite and different ends, but express in their constructions the social, economic, political and technological capabilities of their time. Masonry is one of the primitive arts and was carried to perfection quite early in ancient times in Indian subcontinent. On the basis of available evidences, the history of brick masonry may be traced back to the proto-Harappan age, datable to around 6000 B. C. During the proto-Harappan age, only unburnt bricks had been used in building constructions and the bricks were not good in shape due to probable absence of brick-casting moulds. By the Harappan times, brick casting and firing technology could be well developed. Since then down the historical ages, both burnt and unburnt bricks, depending upon requirements, fuel and economic conditions had been used for erecting structures. The proto-Harappan technology has been found to be capable of erecting only temporary and small structures, not exceeding two storeys in height.

The Harappan period mark a qualitative evolution in building technology, which could be capable of making structures ranging from small houses to multi-storeyed public and domestic buildings. Mohenjodarian building-models have ranged from small houses to multistoreyed magnificent public and domestic structures, in contrast to the small and temporary structures found at Harappa, which might have been incapable of accommodating the public business of a supposed capital. This has led to an understanding that Harappa might have not been a capital metropolis.

Indus Valley Civilization represents a distinct identity in comparison to the plastering and binding agents used in the subsequent cultures. According to Encyclopedia of Indian Archaeology, "Plaster is defined as a material used for coating walls and mortar. It may also be defined as a plastic building material, generally made by mixing lime with sand and water". Webster's Encyclopedic Dictionary describes cement as a 'binding element or agent; a substance to make objects adhere to each other or a powder of alumina, silica, lime, iron oxide and magnesia burned together in a kiln and pulverized and used as an ingredient of mortar and concrete'.

By the middle of the first millennium BC, structures of more permanent nature started

appearing in the Gangetic plains. It is closely linked with the 'second urbanization' and a true beginning of 'Iron Age' in this region. A regular use of baked bricks is supposed to start with certain amount of development of pyrotechnology at this stage with terracotta, cementing materials and metallurgy. In Gangetic plains, the use of cementing material made its appearance with the baked brick structures around the middle of first millennium BC and it remained quite popular almost upto the advent of modern Portland cement, which is being used at a very large scale now. It is still in practice to some extent in these plains. The mortar composition appears to have undergone changes at different stages, i.e., Mauryan, Shunga-Kushan and Gupta periods. The masonry units on which the plaster was applied (brick, stone, etc.) and the purpose of the plaster also appears to have influenced its composition. In subsequent period, the material from a site near Ashokan piller at Sarnath has been found to contain higher percentage of $CaCO_3$ in comparison to other mortars of much later periods like those from Chetsingh Quila and Ramnagar fort of Varanasi (India).

Bricks are found to be more durable than many other building materials. Many good quality brick structures have survived several hundred years of exposure to the environment. However, in certain cases, some brick structures fail to survive even for a few decades due to use of less durable bricks along with other factors. India is a subcontinent with various and varied climatic conditions and thus requires specifications for brick in accordance with her regional conditions and requirements. To improve the longevity of brick masonry, several attempts have been made to prepare specifications, to exclude brick of poor durability from the use.

A study has been carried out using eighteen brick samples, covering a long span of historical time, i.e., from 1990 – 5 yrs B.P. (before present). These brick samples have been clay burnt bricks, which were prepared manually. Of these brick-samples, five have been from Hulaskhera (H1-H5), an archaeological site situated at Mohanlalganj in Lucknow district of Uttar Pradesh, India. These samples pertain to Kushana and the Gupta periods and fall in a time-span of 1900 to 1100 years B.P.

Rests of the samples were taken from various ancient structures at different locations of Varanasi city and the area around it. Of these samples obtained from Varanasi and around, one belongs to an old well situated at Shankaracharya Colony within Banaras Hindu University (B.H.U.) campus and is datable to 900 years B.P.; two to Shiva temple at Panchakoshi Marg (ST1 and ST2), belonging to a period around 800 years B.P.; one to an old structure at Naria, near B.H.U., of around 600 years B.P.; three to Pitter House (P1-P3), about 400 years B.P.; two to Tagore House (T1 and T2), approximately 400 years B.P.; two to old structures near Kachahari (K1 and K2), about 200 years B.P. and 100 years B.P. respectively; and two modern brick samples (B1 and B2), about 5 years B.P.. The dates of Varanasi samples are based on the historical evidences and the local information available. These samples along-with their characteristic features are presented in Tables 1 and 2 (Kumar and Rai, 1992).

As shown in Table 1, there is no trend observed in case of thickness of bricks with age. However, it is evident that modern bricks are comparatively thicker than the older ones. This indicates that from ancient to modern times, no size specification was followed and these variations may

be attributed to local practices in time and space. The studies have further showed that use of frog came into prevalence around 200 years B.P. and prior to this; its importance was perhaps not realized in India.

Table 1: Physical Characteristics of Various Brick Samples

Recovery Site	Probable age in years (B.P.)	Thickness (mm)	Degree of Burning	Frog
Hullaskhera	—-	—-	—-	—-
Period (Pd II)	1900	65.00	Under Burnt	No
Pd II	1700	50.00	—do—	No
Pd III	1400	52.50	—do—	No
Pd III	1300	60.00	——do——	No
Pd III	1100	56.00	——do——	No
Well	900	40.00	Over Burnt	No
Shiva Temple	800	30.00	Full Burnt	No
Shiva Temple	800	35.00	Full Burnt	No
Naria	600	20.00	Under Burnt	No
Pitter House	400	35.00	——do——	No
Pitter House	400	35.00	Full Burnt	No
Pitter House	400	36.00	Over Burnt	No
Tagore House	400	30.00	——do——	No
Tagore House	400	30.00	Under Burnt	No
Kachahari	200	82.00	Full Burnt	Yes
Kachahari	100	72.50	Under Burnt	Yes
B.H.U.	5	68.50	——do——	Yes
B.H.U.	5	71.00	Full Burnt	Yes

The minerals in these brick samples have been found in highly weathered and altered state. The mineralogy and texture of the samples have showed (in Table 2) that these are hand-made clay- burnt bricks. These are not following the specification-requirements in terms of their material composition. Texturally, most samples have been inhomogenous and Hulaskhera samples contained plant-materials and also, particularly rice husk etc. as ingredients of brick. As per the current Indian specifications, a good and durable brick must be homogeneous in texture, made of 20-35% clay, 20-35% silt and 35-45% sand and should not have free lime etc. (Kumar and Rai, 1992). The brick-samples investigated have shown a marked deviation from these specifications and thus, these can be called to be of poor durability. On the contrary, these samples are in fairly good condition in spite of their prolonged exposure to environment. Thus, compositional standards of Indian specifications do not seem to hold strong ground related to durability (Kumar and Rai, 1992). In Table 2, the abbreviations used are - I = Illite; K = Kaolinite; F = Feldspar; M = Micas; Gl = Glauconite; Ca = Calcite; Ch = Chlorite; S = Sericite; H = Hematite; Gr = Grunner; V = Vermiculite and Q = Quartz. Further, P means 'Present" and A means 'Absent'.

The hues/colours and sound-testing of these brick samples have showed that before 110 years B.P., bricks were generally fired under low temperature conditions. Differentiation between under-full and over-burnt brick samples appeared after 900 years B.P.. This implies that after 900 years B.P., manufacturers could attain control over kiln temperature and developed the process to produce bricks of various qualities. Since all the sampled brick successfully stood the age long test of the environmental exposure, it seems that the apparent range of firing may not be considered to be an important factor in ascertaining the durability of bricks (Kumar and Rai, 1992).

2. BRICKS IN ANCIENT TIME

There seems to be no reference to bricks in the Rigveda. Though the use of bricks finds its mention at the cremation grounds in the Yajurveda,

nothing can be concluded with regard to its advent. The brick making techniques, their types and various uses clearly appear in the Brâhmanas (Sat. Br. 6.1.2.22; 10.4.2.19; 6.2.1.10; 6.2.1.20; 10.4.1.7; 10.4.1.78). In the same Brâhmana (8.7.2.17), the length of brick has also been mentioned equal to thigh-bones. In the later texts, there are ample evidences for use of bricks.

Table 2: Mineral Composition of Brick-Samples Observed

Labelled	I	K	F	M	G	l	Ca	Ch	S	H	Cr	V	Q
H1	P	P	P	P	A		A	A	P	A	A	A	P
H2	P	P	P	P	P		A	P	A	A	P	A	P
H3	P	P	P	P	P		A	P	A	A	A	A	P
H4	P	P	P	P	A		A	A	A	A	A	A	P
H5	P	P	P	A	A		P	P	A	A	A	A	P
SC	P	P	P	P	P		A	P	A	A	A	A	P
ST1	P	P	A	P	P		A	P	P	A	P	P	A
ST2	P	P	A	P	P		A	P	P	A	P	P	P
N	P	P	P	P	P		A	A	P	A	P	A	P
P1	P	P	P	P	A		A	P	P	A	A	A	P
P2	P	P	P	P	A		A	P	P	A	A	A	P
P3	P	P	P	P	A		A	P	A	A	A	A	P
T1	P	P	P	P	A		A	A	A	A	A	A	P
T2	P	P	P	P	A		A	A	P	A	P	A	P
K1	P	P	P	P	A		A	A	A	A	A	A	P
K2	P	P	P	P	A		A	P	A	A	A	A	P
B1	P	P	P	P	P		P	P	P	A	P	P	P
B2	P	P	A	P	A		A	A	A	P	A	A	P

Surveys of building materials show that proto-Harappans mostly used unburnt brick in their masonry structures. These bricks were not good in shape, perhaps due to lack of brick casting-moulds (Ind. Arch. Rev. 1961-62; Ind. Arch. Rev. 1962-63). The first evidence for the brick casting-moulds have came from the Nal-Samadhi area, datable to 3000 B.C.. The Harappan civilization marks the beginning of burnt brick masonry structures. Barring the examples of Harappa, Kalibangan and Lothal, at other Harappan sites mostly burnt bricks had been used in masonry structures (Ind. Arch. Rev. 1954-51; Rao, 1973; Sankalia, 1962).

The evidences indicate that during the post-Harappan times, the use of burnt brick declined and most structure were made of unburnt bricks. The Ahar culture presented evidence for the use of both burnt and unburnt brick structures. In the Sunga period, Shujava type of burnt and unburnt bricks had also been introduced for epigraphic traditions. In the Kushana period, shinning bricks were introduced, which reappeared again during the time of Mughals (Rai and Kumar, 1989).

3. SOME PHYSICAL PARAMETERS

As Table 3 (Rai and Kumar, 1989) shows, bricks used all through the historical periods have been of various types and varied largely in size. These bricks have been comparatively much larger in size than those of the modern/modular bricks. Inconsistency in co-efficient of variances for their above-mentioned measures (as presented in Table 3) suggests lack of experience-based technological evolution or improvements over the time. In case of the evolution had occurred in brick-manufacturing technology, the coefficient of variances for brick dimensions should have gradually decreased. Thus, each historical period may be characterized by its own brick-manufacturing technology. As compared with other measures, the thickness of ancient bricks is comparatively very small, which may indicate a lack or imperfect development of temperature control device for firing of thicker bricks during these periods (Rai and Kumar, 1989).

The ratio between length and width has always been found to be less than two; which indicates that the historical bricks in walls were technically unsuitable and might have posed problems

in their laying and bonding. Because, for the bricks to be bonded properly the length should be at least 1/4" more than twice the width, so that one brick laid lengthwise along the wall would just cover two bricks laid crosswise with very thin joint of mortar between them (Khanna, 1984).

There is ample of data available on this aspect. Wall thickness of some structures at the Harappan sites was found above two bricks (Marshall, 1931) and that of some historical periods at Rajghat (Narain and Singh, 1968) varying in the range of one to two bricks. As the width of historical bricks was more than half the length, length and crosswise laying and bonding of these for stable construction of one-brick-thick wall could not possible.

Although crushing strength of historical bricks could not be known, this parameter might have been varying in the range corresponding to these of burnt and unburnt Indian bricks. The crushing strength of Indian bricks have been much variable and was found to vary from 30 kg/sq. cm. to 150 kg/sq. cm. for the hand-made burnt bricks (Chowdhuri, 1956). The crushing strengths of bricks from historical structures have been found varying in the range of second to first class bricks as per Indian Standards being applied now (Kumar and Rai, 1992).

Table 3: Bricks Used in Various Historical Periods

Periods	Time	N	L (inch)			W (inch)			T (inch)		
			M	S.D	C.V	M	S.D	C.V	M	S.D	C.V
Proto Harappan (Unburnt Bricks)	3500-2417	4116	.624	.760	.28	9	.233	.050	.333	.591	.230 .34
Harappan(UnburntBricks)	2500-1500 1300 BC	17	14.10	2.78		0.19	7.47	1.38	0.18	3.70	0.73 0.19
Harappan(BurntBricks)	2500-1500 BC	93	11.52	2.41		0.20	5.96	1.77	0.29	2.60	0.50 0.19
Post-Harappan	1800-500 BC	29	15.52	3.39	0.22	10.44	2.38	0.23	2.88	0.64	0.22
Mauryan	400-300 BC	121	16.18	3.74	0.23	10.25	2.43	0.23	3.03	0.92	0.33
Sunga	200 BC-50 AD	92	13.22		5.16	0.39	9.06	3.39	0.37	3.15	1.78 0.56
SungaSatvahana	200 BC	22	11.71	2.78	0.23	10.13	2.58	0.25	3.37	0.69	0.20
Kushana	50 BC300 AD	88	14.64	2.20	0.15	9.75	1.49	0.15	2.52	0.77	0.30
Saka-Kshatrapa	300 AD	80	15.06	2.90	0.19	9.22	1.50	0.16	3.11	0.87	0.27
Gupta and Post-Gupta	400-1000 AD	200	13.30	3.43	0.25	9.09	1.84	0.20	2.60	1.06	0.57

In Table 3, N = number of samples; L = Length; W = Width; T = Thickness; M = Mean; S.D. = Standard Deviation; C.V. = Coefficient of Variance.

4. CONCLUSIONS

From the facts mentioned above, it becomes amply clear that each of the historical periods had their characteristic brick-manufacturing technology and there does not seem to be much impact of earlier experiences over the technology of brick manufacture in different ages.

The study has also confirmed that there has been no marked difference in the brick-manufacturing techniques from ancient till modern times, except introduction of 'frog' mark and improvement in firing process during the later times. It is also interesting to note that every age had its own characteristic size of bricks and local practices of production seem to

govern the quality and technique of brick-manufacturing. Indian standard developed in modern time appear to be of the least significance for application even for classification of the bricks. These do not seem also to hold a strong ground even in the durability-determination of bricks of different ages. Bivariant parameters have showed very clearly that certain physical properties have continued to remain independent and there could be observed no significant correlation with the quality and durability of the brick-samples concerned to different historical time periods.

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