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Modern Engineering Studies on Ancient Building Materials of Sirpur (C.G)

R. K. Jain and A.M. Pande***

ABSTRACT

This paper presents results of various engineering tests conducted on some building materials collected from Sirpur (C.G). The tests on Bricks were conducted as per IS 1070:1992 & IS 3495(Part 1 to 4): 1992. The test such as chemical analysis was also conducted on binding material. The test results are interpreted in the context of modern technical specifications.

Keywords: *Heritage; Mortar; Rehabilitation; Monuments.*

1.0 Introduction

India‟s greatest assets are its cultural heritage. Many priceless treasures of our history and heritage are lying in ruins. In spite of this most of the structures are still in good condition because of the excellence in construction techniques and materials, used at that time. The technology and the materials adopted for these structures have proven its durability.

Some times for the rehabilitation of these monumental structures, it is expected that the materials like bricks, stones and the binding materials as stated in ancient literature may be used. The tasks of inspection and diagnosis of ancient buildings require obtaining a certain number of parameters, which provide information about the properties of the materials, the structural behavior, or possible defects.

We performed various tests on bricks and on binding material for brick as per the IS 1077: 1992 and IS 3495 (Part 1 to 4): 1992. Test on bricks was done in our college labs whereas the test on binding material was carried out at IBM Nagpur.

2.0 Case Study- Sirpur

Ancient Sirpur in Mahasamund district of Chhattisgarh State is located on the right bank of Mahanadi, 84 km from Raipur, Right from 5th cent, A.D. on wards up to 8th cent, A.D. it was the capital of Dakshin Kosala, first of Sarabhapriya rules and then of Somavamshis. As per archaeological evidences and copper plates inscription it was not only the political but also religious and cultural capital of the region. After it went into ruins due to floods of Mahanadi, centuries back, it came to live light in 1872, when Dr. Beglar and Sir John Marshall visited. Famous Lakshan temple was excavated during this time. Surang Teela situated in the centre of the village was partly excavated in 1872 A.D.

2.1 Anand prabh kuti vihara

Anand Prabhu Kuti Vihar was a place for worship related to the Buddhist monk named „Anand Prabhu‟ built in circa 7^{th}–8^{th} cent. A. D. Here, in main cell, a big sculpture of Lord Buddha is installed. All cells are made of bricks and the rooms are open.

Fig 1: Anand Prabh Kuti Vihara

**Corresponding Author: Department of Civil Engineering, Yeshwantrao Chavan College of Engineering, Wanadongri, Nagpur, India (E-mail: rveejain@yahoo.com)*
*** Department of Civil Engineering, Yeshwantrao Chavan College of Engineering, Wanadongri, Nagpur, India*

2.2 Swastika vihara

This monument is contemporary to Anand Prabhu Kuti Vihar at Sirpur situated at the distance of only 400 meters from the said monument. It is said that being in the shape of Swastika (a holy symbol) it was named as Swastika Vihar. A big sculpture of Lord Buddha is kept here in its sanctum. This beautiful Vihar was built just after the Anad Prbh Kuti Vihar in 7^{th}–8^{th} cent. A. D. This is a brick built Buddhist monastery smaller than Anand Prabhu-Kuti.

Fig 2: Swastika Vihara

3.0 Materials Used in Construction

The Main Building Block Of The Various Monuments Is Burnt Clay Brick. Bricks Have Been Laid With A Very Thin Mortar.

3.1 Bricks

It Is Logical To Assume That The Earliest Bricks Used in The Construction Were unburnt Sun Dried Mud Bricks.

4.0 Mechanical Properties of Bricks

Ancient Bricks From Various Structures Were Tested For Their Mechanical Properties.

4.1 Various tests performed on bricks

- Compressive Strength Test.
- Efflorescence Test.
- Water Absorption Test

Mortar

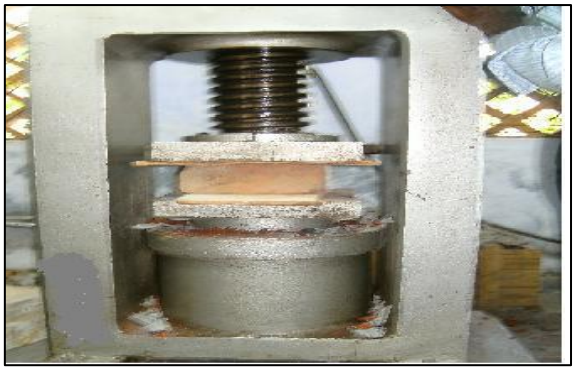
The Mortar Used In The Brickwork Of Ancient Structure Is A Clay-Slurry Type.

Fig 3: Collection of Mortar Sample

Burnt clay bricks

4.1.1 Compressive strength

Fig 4: Compressive Strength



Testing Procedure As Per Is 3495 (Part 1): 1992

Immerse the specimen in water at room temperature for 24 hours. Remove the specimen from water and drain out any surplus water. No mortar shall be filled in perforation and no mortar capping shall be provided.

Place the perforated faces of the brick between two 3-ply plywood sheets each of the testing machine. Apply the load axially at uniform rate of 14 N/mm^2 (140 kgf/cm^2) per minute till the failure occurs and note the maximum load at failure. The load at failure shall be maximum load at which the

specimen fails to produce any further increase in the indicator reading on the resting machine.

Formula

$$\text{Compression strength} = \frac{\text{Maximum load at failure in N (kgf)}}{\text{Average net area of the two faces Under compression in mm}^2\text{ (cm}^2\text{)}}$$

Table 1: Compressive Strength Analysis

Sr. No.	Site No	Brick Name	Size (Mm)	Load (Kg)	Compression Strength (N/Mm2)	Average Compressive Strength (N/Mm2)
1.	Site 1 Buddha Vihar (6thcentury Ad.)	B1 B2	200 X 180 180 X 150	42000 28000	11.67 10.37	11.02
2.	Site 2 Grain Area (12thcentury Ad.)	B 1 B2	180 × 150 180 X 150	20000 16000	7.40 5.92	6.66
3.	Site 4 Shiv Mandir (5th Century Ad.)	B 1 B2	180 × 130 200 X 150	19000 18000	8.12 6.0	7.06

Result

The average compressive strength is found to be 11.02, 6.66, 7.06 N/mm2.

This is Class Designation 12.5 for site 1 & 5 for site 2 and 4 as per IS 1077:1992

4.1.2 Water absorption

Determination of water absorption

Fig 5: Determination of Water Absorption

Testing procedure As per IS 3495 (Part 2): 1992

Dry the specimen in a ventilated oven at a temperature of 105 to 115 degree Celsius till it attains substantially constant mass. Cool the specimen to room temperature and obtain its weight (M1). Specimen warm to touch shall not be used for this purpose.

Immerse completely dried specimen in clean water at a room temperature of 27 + - 2 degree Celsius for 24 hours. Remove the specimen and wipe out any traces of water with a damp cloth and weigh the specimen. Complete the weighing 3 minutes after the specimen has been removed from water (M2).

Formula

$$\text{Water absorption} = \frac{\text{M2 --- M1}}{\text{M1}} \times 100$$

Table 2: Water Absorption Analysis

Sr. No	*Site No*	*Brick Name*	*M1 (Kg)*	*M2 (Kg)*	*Water Absorption %*	*Average Water Absorption %*
1.	*Site 1 Buddha Vihar (6thcentury Ad.)*	*B 1* *B2* *B3*	*4240* *3000* *2825*	*4985* *3550* *3260*	*17.57* *18.33* *15.39*	*17.10*
2.	*Site 2 Grain Area (12thcentury Ad.)*	*B 1* *B2* *B3*	*2300* *3340* *2640*	*2615* *3830* *3020*	*13.69* *14.67* *14.40*	*14.25*
3.	*Site 4 Shiv Mandir (5th Century Ad.)*	*B1* *B2* *B3*	*2130* *4230* *2470*	*2405* *4920* *2770*	*12.91* *16.31* *12.14*	*13.78*

As per IS 1077:1992, the permissible value is 20%.by weight up to Class Designation 12.5

4.1.3 Efflorescence

Fig 6: Efflorescence

Determination of efflorescence

Testing procedure: As per IS 3495 (Part 3):1992

Place the end of the bricks in the dish, the depth of immersion in water 25 mm. Place the whole arrangement in a warm (for example, 20 to 30 degree Celsius) well ventilated room until all the water in the dish is absorbed by the specimen and the surplus water evaporates. Cover the dish containing the brick with suitable glass cylinder so that excessive evaporation from the dish may not occur. When the water has been absorbed and bricks appear to be dry, place a similar quantity of water in the dish and allow it to evaporate as before. Examine the bricks for efflorescence after the second evaporation and report the results. The liability to efflorescence shall be reported as „nil", „slight„ „heavy„ or „serious" in accordance with the following definitions:

(i) **Nil** - When there is no perceptible of efflorescence.

(ii) **Slight** - When not more than 10 percent of the exposed area of the brick is covered with a thin deposit of salts.

(iii) **Moderate** - When there is a heavier deposits than under „slight" and covering up to 50 percent of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.

(iv) **Heavy** - When there is a heavy deposit of salts covering 50 percent or more of the exposed area of the brick surface but unaccompanied by powdering or flaking of the surface.

(iv) **Serious** - When there is a heavy deposit of salts accompanied by powdering and or flaking of the exposed surfaces.

Table 3: Effloresce Analysis

SR.NO	SITE NO	BRICK NAME	RESULT
1.	SITE 1 Buddhavihar (6th century AD.)	B 1 B2 B3	NIL
2.	SITE 2 Grainarea (12th century AD.)	B1 B2 B3	NIL
3.	SITE 4 Shiv Mandir (5th century AD.)	B1 B2 B3	NIL

Nil: There is no perceptible deposit of efflorescence. The bricks when tested in accordance with the procedure laid down in IS 3495 (Part 3):1992 the rating of efflorescence shall not be more than "moderate" up to class 12.5

XRF Scan report

Operator Indian Bureau of Mines Chemical Analysis of Mortar Sample -XRF Scan Report

Table 4: XRF Scan Report

SiO_2 %	Al_2O_3 %	Fe_2O_3 %	K_2O %	CaO %	P_2O_5 %	TiO_2 %	MgO %	Sr %
64.65	12.85	5.85	3.10	3.26	1.80	0.85	0.30	Trs
Na_2O %	MnO %	S %	Zr %	Ba %	Rb %	Pb %	Y %	
0.10	0.14	0.05	0.04	0.02	0.01	Trs	Trs	

5.0 Conclusions

From the tests conducted on brick, it appears that the ancient bricks are in no way inferior to modern bricks. From the table of scan report, it can be interpreted that the major constituents are Silica

(SiO2) and Alumina (Al2O3) followed by Fe2O3 and Cao. Inspite of low percentage of CaO, the mortar have good strength therefore this suggests that some natural polymers must have been added. More research is needed**.**

References

[1] IS 3495 (Parts 1 to 4): 1992 (Reaffirmed 2002)

[2] IS 1077: 1992 (Reaffirmed 2007)

[3] Puratatva Special volume 2007 published by Archaeological Society of India, New Delhi.