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Thermoluminescence (TL)Studies of the Ancient Monuments of the Ahom Civilizations in Sivasagar, Assam, India

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Abstract:
The ancient bricks samples collected from the ancient Capital of the Ahom Civilizations at Sivsagar District of Assam have been studied by Physical Techniques such as XRD, FTIR, TL etc. The bricks from the famous Kamakhya Temple have also been dated by TL Techniques. The studies show that part of the temple in all probability was reconstructed around 800 A.D. while the older one was built around 500 A.D. The constitutional analysis of the bricks sample by XRD, FTIR, XRF etc. techniques shows that the materials by which the monuments were constructed during the Ahom Kings were found to be almost similar to that of the Kamakhya Temple in Guwahati, Assam. The dates of the Ahom Civilization by TL were also found to be almost contemporary with the dates of the bricks of the Kamakhya Temple which readily suggests that the temple would have been reconstructed by the Ahom Kings during the Ahom Civilization around 800 A.D.

Keyword:Ahoms, Rong Ghar, TL, OSL, Quartz, XRF, XRD, FTIR

1. Introduction:

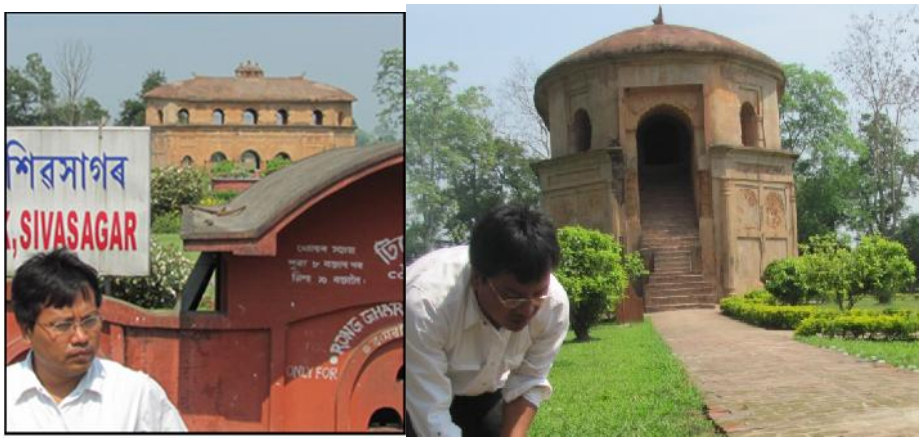

Photo: The Author at the Rong Ghar a part of the Ahom Cicilisation in Sivasagar(left) and the famous Kamakhya Temple (right)

Bricks are one of the oldest building materials known to man [1]. The use of sub- soil materials in building was a large subject along eras [2]. The brickwork has attracted considerable interest over the years, through using different types of bricks that have been divided according to different criteria depending on fabric, dimensions, regularity of shape and appearances [3]. Fired or burned bricks have been used on a large scale in buildings from the very beginning of the third millennium B.C. [4].

During the last two decades, architectural heritage preservation has reached a rising interest for scientists, architects, engineers and archaeologists, this subject being an interdisciplinary research area. When damaged historical masonry needs to be restored with substitution bricks, a good characterization of both, new and old

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material forecasts us both physical and the chemical behavior of the system. In addition to the necessary aesthetic aspect, the familiarity with physico-chemical properties is crucial to maintain chemical equilibrium with adjoining materials. The historical understanding is not just to analyze and preserve objects but also to investigate the knowledge and skills used to produce and use them [5].

The main objective of this study is to evaluate the different Physical characteristics of brick used in the construction of ancient capital of Ahoms in Sibsagar and the ancient monument of the famous Kamakhya Temple near Guwahati in Assam. The main goals of the building material characterization are preservation and restoration, aiding archaeological studies which include: Origin of historical raw materials, Processes and changes in archaeological artifacts undergone during burial, Determination of original firing temperature and Reconstruction of firing techniques and manufacturing technologies [6].

1.1. The Kamakhya Temple

Situated on the Nilachal Hill at an atitude of 800m above mean sea level and extended from 26°10′7″N to 91°47′12″E in western part of Guwahati city in Assam, India, the Kamakhya Temple is an important pilgrimage destination for general Hindu and Tantric worshipers [7].The current temple structure was constructed in 1565 by Chilarai of the Koch dynasty in the style of medieval temples [8]. The form of the earlier structure, destroyed by the Kala Pahar, is not exactly known.

1.2. Ahom Civilization and the Kamakhya Temple

By the end of 1658, the Ahoms under King Jayadhvaj Singha conquered the Lower Assam and their interests in the temple grew. In the decades that followed the Ahom kings continued to support the Kamakhya temple by rebuilding and renovating [9].The present work intends to support the historical and archaeological accounts of these two cultural heritage sites of Assam.

2. Experimental

The ancient bricks samples collected from two famous cultural heritage sites of Assam have been studied by applying physical methods of X-Ray Diffraction (XRD), Thermoluminescence (TL) and Fourrier Transform Infrared (FTIR) techniques. The XRD analysis of all the brick samples has been carried out under the Xpert Pro PANalytical X-Ray Diffractometer at the Physics Department of Manipur University. FTIR analysis of the Kamakhya bricks have been recorded at IIT, Guwahati in a Nicolet Impact 410 (Perkin-Elmer Corporation, Norwalk, Connecticut, USA), with Nichrome as the reference and KBr pallet as the sample. The FTIR of the Ahom building and sculpture bricks have been recorded in SHUMADZU FTIR-800S (KYOTO, JAPAN) analyzer at the Chemistry Department of Manipur University.

Table I: *Peaks corresponding to XRD of Ahom bricks*

Pos[°2Th.]	Height Int[cts]	FWHM[°2Th.]	d-spacing[Å]	Rel.[%]	Phases/ Sign
20.8257	337.74	0.2400	4.26193	16.33	(Quartz)
26.6229	2068.67	0.2400	3.34558	100.00	(Quartz)
36.5181	213.65	0.2400	2.45856	10.33	(Quartz)
38.3444	157.73	0.1800	2.34555	7.62	(Silicate)
39.4373	135.31	0.2400	2.28303	6.54	(Quartz)
40.2745	86.52	0.2400	2.23748	4.18	(Quartz)
42.4132	105.91	0.2400	2.12947	5.12	(Quartz)
44.6457	687.88	0.2400	2.02804	33.25	(Fe, C)
45.8105	71.32	0.3000	1.97914	3.45	(Quartz)
50.1143	277.23	0.2400	1.81879	13.40	(Quartz)
51.1417	93.20	0.1800	1.78464	4.51	(Quartz)
54.8327	68.79	0.2400	1.67292	3.33	(Quartz)
59.9322	198.19	0.2400	1.54218	9.58	(Quartz)
65.0122	99.54	0.2400	1.43341	4.81	(Quartz)
67.7153	110.18	0.1800	1.38262	5.33	(Quartz)

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Table II: FTIR of the Ahom Bricks

Sl. No.	Frequency (cm^{-1})	Assignment
1	2510	CO_3
2	1787	Silicates
3	1611	Silicates
4	1484	Ca CO_3, CH, CO_3
5	1000	Ca Al Silicates, H_2O

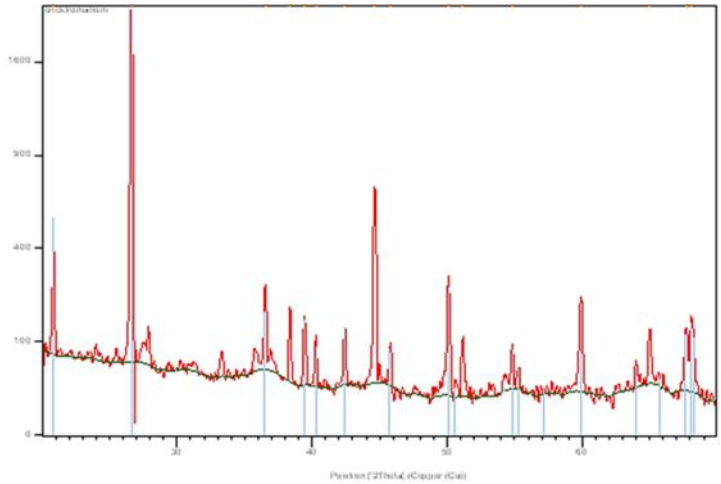

Fig. 1. *XRD Spectra of the Ahom brick with copper target*

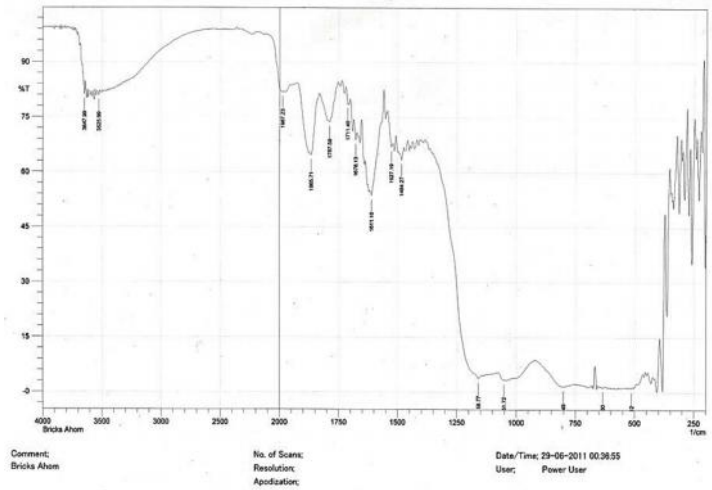

Fig. 2 : FTIR Spectra of Ahom Bricks

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2.1. Ahom Civilization

X-ray diffraction of normal brick of the Ahom civilization shows the presence of silica (α- quartz) as the major phase and silicate of Ca, Al, as minor phases. But, the brick from the ancient monumental sculpture of the Ahom civilization shows the presence of other phases like Iron phosphate and gypsum as minor phases along with the silica phase [Table I and II].

The strong band at 3645 cm^{-1} in the FTIR analysis of the Ahom sculpture brick and at 3647 cm^{-1} from the Ahom building brick represents OH stretching vibration. Aliphatic CH_2 (i.e. C-H stretching vibration) gives rise to the doublet at 2980/2874 cm^{-1} in Ahom sculpture brick is not appeared in the case of Ahom building bricks. This is due to the fact that the sculpture bricks contain some other elemental composition to make it suitable for the work of the sculpture. SH stretching vibration could be the reason for the band around 2400 i.e. C-H stretching vibration. To the band at 2510 cm^{-1}, of the sculpture bricks, we could assign H-O-H bending vibration while it could not be observed in the building bricks. The 1484 cm^{-1} band in the sample from the Ahom building brick could be due to CH_2 scissors deformation or C-CH_3. Si-O-Si stretching vibration gives rise to the strong band at 1158 cm^{-1}. The 820 cm^{-1} in the sculpture brick could be Si-O of quartz and the 554 cm^{-1} in the building brick could be Fe-O of magnetite. The 450 /420cm^{-1} of the both the bricks could be due to C-H in-plane bending [10-15]. More number of carbonate and Carbon bands appears in the Sculpture bricks. The carbonates (CO_3) associated with several other elements have been observed.

Table III: Comparative analysis of the bricks of Ahom civilizations and the Kamakhya Temple

Sample	Phases observed by XRD	Assignments by FTIR
Ahom (Bricks)	Quartz, Sillicates, Iron, Carbon	Calcium Aluminium Silicates, Water, Calcium Carbonate, $CaCO_3CHCO_3$
Ahom (Sculpture)	Quartz, Iron Phosphates, Gypsum, Fluorite	CaAlSiO, H_2O, $CHCO_3$, $MgCO_3$, CO_3
Kamakhya (Old)	Calcium Aluminium Silicates, Quartz	OH, CH_2, CO_3, SH, H_2O (vib.), Silicates, Quartz, Si-O-Si
Kamakhya (New)	Silicate, Quartz, Iron Phosphates,	CH_2, CO_3, SH, H_2O (vib.), Silicates, Quartz, Si-O-Si bending

2.2. Kamakhya Temple

Similarly, the bricks obtained from the Kamakhya Temple, both new and old sites, were analyzed by XRD, FTIR and TL techniques. XRD pattern of the old brick shows the presence of a-quartz as the major constituents with minor amount of Calcium Aluminium silicate phases; whereas the new brick shows the presence of other minor phases of Calcium Aluminium silicate and Iron phosphate hydrates. The presence of Iron phosphates in the new brick shows the advancement of brick manufacturing skills in response to the deterioration caused by natural hazards like earthquakes and any other impacts.

3. Conclusion

The study proved that though the main constituent of the brick samples are found to be Quartz, there is still a noticeable difficulty in discussing the different chemical characteristics and physical properties of the structure. This difficulty is essentially due to the effects of several deterioration forms that are attributed to the effects of deterioration cycles dominating in the study area, as well as the effects of manufacturing processes. In addition to the diversity of the inorganic and organic material used to produce the brick. Calcite($CaCO_3$) is a major mineral resulted from adding limestone fragments during the brick making processes as a flux, or from using lime as sticking mortar, or as a direct result of water migration [16]. It may be also due to the carbonation cycle affected lime mortar layers.

The deterioration phenomena affecting the brick units owing essentially to some physical and chemical events such as air temperature, windblown and rain off moisture, leaching out, salt crystallization and thermal

changes, in addition to the properties of brick itself. All of these mechanisms led to the creation different deterioration forms such as unequal settlement, collapsing of internal architectural features, sap root staining, bees burrowing, bird accumulations, poor carbonation of mortars, wearing out of mortar components and water saturation.

On the other hand, the presence of Quartz (SiO_2) is ascribed to the use of some sand particles as an additive material in brick manufacturing. It may be also formed by rising the temperature, which leads to the driven off water of crystallization and carbonization of some organic compounds in an exothermic reaction. Consequently aluminium silicate will be dehydrated leading to the formation of SiO_2. Meanwhile, clays convert to amorphous metakaolin [17].

Finally, the presence of amorphous structures in the investigated samples is due to the clay minerals themselves and is particularly difficult to analyze. Imperfections in crystalline structure affect their diffraction characteristics [18].

4. Acknowledgement:

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