

A Study on Typology of Bricks from Sri-Ksetra

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Abstract

Ancient structures are one of the most important evidences to study the cultures of the past. Bricks and terracotta plaques have been used to build and decorate structures since protohistoric time. Raw materials of bricks and terracotta plaques are usually made up of clay. Clay can be obtained abundantly. By firing clay, terracotta objects have been produced since ancient time. One of the most important terracotta objects found in the ancient civilization is brick of building material. Generally, the art of making brick had assisted to be urbanized. Moreover, bricks were extensively used to build town walls and fortresses for defense purposes in ancient time. Religious and ritual structures have also been built of bricks. Therefore, brick has played an important role in the civilization of a society. That is why bricks are noteworthy to study to reveal the past. This paper is dealt with bricks, finger-marked bricks, and bricks with inscriptions and relieves of Sri Ksetra. Chemical compositions and physical properties of bricks are also presented by using scientific physical test and other analytical methods including X-ray Fluorescence method (XRF) and X-ray Diffraction Method (XRD).

Keywords: Ancient Structures, Bricks, Finger-marked Bricks, Religious Monuments, Sri-Ksetra, Terracotta Plaques

Introduction

Throughout the long term history of civilization, one of the most remarkable innovations was brick. People have built various types of structure by using bricks since the protohistoric time. Brick is one of the most durable materials in archaeology. They can last for thousands of years.

Ancient bricks are different from modern bricks in terms of size and symbols which they bear. Archaeologists and historians are interested in studying bricks to reveal the past. In Myanmar, the earliest civilization was founded by Pyu and Pyu culture had flourished from the second century BCE to the ninth century CE. Bricks have been used since the beginning of Pyu period in Myanmar. Pyu had extensively used bricks to build city walls, moats, palace and palace enclosure walls, and religious and ritual structures. Brick structures of Pyu are standing until now.

Pyu period was followed by Bagan period. People of Bagan period had also built thousands of religious monuments in Bagan. Almost all these religious monuments were built of bricks. In later periods such as Pinya, Inn Wa, Taungoo, Nyaung Yan and Konbaung, bricks had played an important part in shaping the cultures of these periods. Study of ancient bricks is one of the important parts in investigating the history of Myanmar. Therefore, ancient bricks of Myanmar are noteworthy to study to reveal the history of Myanmar.

Historical Background

Sri Ksetra Ancient Pyu City, the largest and most elaborately constructed Pyu city, lies in the Nawin River Valley in Pyay Township, Pyay District, Bago Region. It is about 180 miles away from the northwest of Yangon. It is located between North Latitude 18° 39' and East Longitude 95° 17'.

It is roughly circular in shape, with a north-south diameter of 4.44 kilometers and east-west diameter of 3.96 kilometers. Its walled area embraces a vast area of 1880 hectares. The area of Sri Ksetra is wider than the other Pyu ancient cities such as Halin, near Shwe Bo, and Beikthano, near Taungdwingyi. It is encompassed by a high fortification wall constructed of large fired bricks, the circumference being 13.68 kilometers long, with triple walls on the

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southeast side. The city walls of Sri Ksetra are well preserved, some sections of the massive wall still stand to a height of 4.6 meters.

In the centre of the city lies the palace site, a rectangular enclosure, east to west 342.8 m by north to south 518 m. Both walled city and inner palace site were surrounded by moats. The northern half of the city is a low plain dominated by rice fields whereas the southern half is comparatively high, rising gradually beyond the fort wall towards the hill range to the south.¹

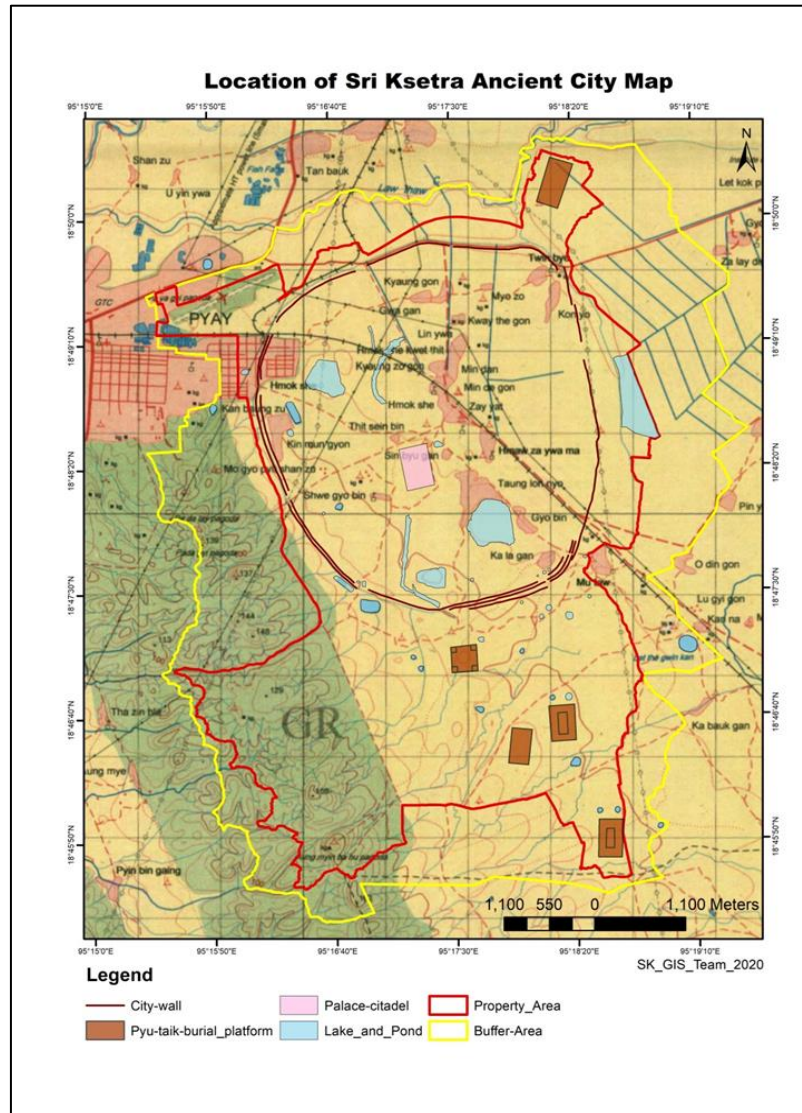


Fig.1 Map of Sri Ksetra, located between North Latitude 18° 39' and East Longitude 95° 17', the Nawin River Valley in Pyay Township, Pyay District, Bago Region. (Photo: Department of Archaeology and National Museum, GIS Team)

Some Myanmar chronicles described that the founding era of Sri Ksetra and its city planning were as follows: The Mon inscription of King Kyansittha (CE 1084-1113) of Bagan period mentioned that Sri Ksetra was founded by hermit called Vishnu associated with *Gavampati*, *Sakra* (Lord of the devas, Indra), *Viskyon* (Celestial Prince), *Naga* (Mythical Serpent), 100 years later of the great decease of Buddha.

¹ U Aung Thaw, *Historical Sites in Burma*. Yangon: Ministry of Union Culture. 1972. P.19

The Royal Horoscope Chronicle mentioned that sixty years after the death of Buddha, Sri Ksetra was founded by Maha Sambawa so called Prince of Tagaung. According to that chronicle, Sri Ksetra was founded sixty years after the death of Buddha.¹

According to the Great Chronicle (*Maha Razawin Gyi*) and *Glass Palace Chronicle* (*Mhannan Razawintaw Gyi*), ancient Sri Ksetra was founded by Hermit, *Sakra, Naga, Garuda, Gonbam, Candi* and *Parameswar* in the reign of King Duttabaung as early as the 101 years of Anno Buddha.²

Archaeological evidences from the excavations at Sri Ksetra revealed that this city had been founded since before third century CE. Archaeological evidence indicated that Sri Ksetra ancient city attained its height of prosperity between fourth and ninth century CE. According to Dr. Than Tun, one of the famous historians in Myanmar, Sri Ksetra had flourished since second century BCE and it declined at ninth century CE.³

Man Shu, one of the Chinese ancient chronicles, mentioned that the king of Nan-Chao invaded the Pyu kingdom in 832 CE. The invaders plundered the Pyu capital and took more than three thousand persons as prisoners and banished them into servitude.⁴ But it cannot be ascertained whether that capital was either Sri Ksetra or Halin, another contemporary Pyu city in the north.⁵

The earliest archaeological excavation had been carried out by French General Leyon De Beyleie in Sri-Ksetra. At that time, the Superintendent of Archaeology was Taw Sein Kho. Archaeological sites near Mg Kan Village and Khin Ba mound near Kala Kan Village had been excavated from 1907 to 1935. The excavation at the site near Mg Kan Village unearthed two gold leaves with inscriptions, inscribed in southern India script, and stone urns on which the lists of Vikrama Dynasty of Pyu period were inscribed and Buddha images. Excavation at Khin Ba Mound unearthed twenty gold leaves with inscription and silver objects. The style of script of those inscriptions was dated from the fifth century CE to the eighth century CE.⁶

Study on Typology of Bricks from Sri-Ksetra

Excavations at Pyu cities uncovered city-walls, gateways, palaces, religious and ritual structures, and potteries. City walls, gateways, palaces, and religious and ritual structures were built with bricks. Myanmar word ‘*aut*’ is derived from Pali word ‘*ishtaka*’ and Sanskrit word ‘*istika*’. The earliest brick structures can be found in Beikthano. Architecture styles of Beikthano are similar to those of the architecture styles of Southern India. The art of brick making was introduced to Myanmar from India in the first century CE.⁷

The excavations at Pyu ancient cities unearthed a good number of brick structures, gateways and city walls. These brick structures, gateways and city walls reveal about the brick lying system of Pyu and the use of bricks good ones and debris in building structures. The brick lying system of early structures was not so good but later structures were built with good brick lying system. Gadroon bricks were also used in some structures.

¹ U Hla Tin, (ed). *ဇာတာတော်ပုံရာဇဝင်*. (*The Royal Horoscope Chronicle*), Yangon: Department of Archaeology, Ministry of Union Culture, 1960.

² မှန်နန်းရာဇဝင်တော်ကြီး (*Glass Palace Chronicle*). Yangon: Thiha Yadanar Sarpay, 2008.

³ Than Tun. *Buddhist Art and Architecture*. Yangon: Sein Pan Myaing Sarpay. 2002. P.16

⁴ Thein Lwin . The Eight Miracles and the Seven Stations of the Buddha’s Life In Myanmar, Diploma Thesis., Archaeological Survey of India,2001. P.28

⁵ U Aung Thaw, *Historical Sites in Burma*. Yangon: Ministry of Union Culture, 1972. P.33

⁶ U Myint Aung, *တူးဖော်တွေ့ရှိသော သရေခေတ္တရာနှင့် သုတေသနဆောင်းပါးများ* (*The Works on Myanmar Archaeology*), Yangon: Yan Aung Sarpay, 2015. P.1

⁷ U Sein Maung Oo. “Ancient Sri Ksetra” (*Takkatho pyinyarpadether sarsaung. Volum (3),Part (1)*).Yangon: Ministry of Information, 1968. P.18

Pyu bricks were made of clay, sand and rice husks. In the first stage, the mixture of clay, sand and rice husks were soaked in water. After that, clay was kneaded thoroughly. And then, clay was pressed into the rectangular wooden mould. Pyus used to mark finger marks or press auspicious symbols or inscribe letter on the surface of bricks and let them dry under the sun shine. Rice husk and chopped straw are used as temper. Sand prevents sticky. Pyu used to add rice husk not to break and leak water.¹

According to the analysis husk impresses of bricks from Maingmaw, Beikthano, Halin, Sri Ksetra and Wadi reveal that the rice is predominantly rounded grains. In the mid's of 1970 by Kyoto University, tabulated the presence of three types of rice husks embedded in eighty-two samples of old bricks. The types were rounded grains found on early maturing paddy, large grain upland rice, and slender late-maturing paddy.²



Fig.2 Brick with rice husks from Lulinkyaw gateway. (Photo: Field School of Archaeology - Pyay)

Pyu bricks are even on both faces without dimple to hold mortar. Dimple on the face of brick is called '*thayo wit*', literally place for mortar. Present day brick has dimple on one face. However, some Pyu bricks bear fingermarks on their faces.

Pyu had made finger-marked by using finger(s). They scrubbed with single finger to get fingermarks on the surface of bricks before firing but sometimes they used two, three and even four fingers to get fingermarks. Designs of fingermarks were also vary. It is difficult to decipher the designs of fingermarks. Some suggest that they might be logos of brick makers or logos of production centers. Later, Pyu number and inscriptions were imprinted on the face of bricks. Bricks with imprinted number and inscriptions of Bagan period and later periods are also found in archaeological contexts.

Another interesting terracotta object of Pyu period is terracotta plaque with relief. Terracotta plaques are square or rectangular in shape. Relief designs on plaque vary from human and animal figures to floral designs. Some reliefs on plaques were depicted about the scene of 550 Jataka. These terracotta plaques were set up on the outer walls of temple or on the terraces of stupa.

¹ Khin Muiyar. ပျူခေတ်မှအုတ်ချပ်များလေ့လာချက် (Study on Pyu Bricks). Diploma Thesis, Department of Archaeology, Field School for Archaeology (Pyay), 2007. P.11

² U Aung Myint and Elizabeth Moore. Fingered-Marked Designs on Ancient Bricks in Myanmar. *The Pyu Landscape: collect articles*, Yangon: Ministry of Culture, (n.d). P.129



Fig.3 Jataka scene depicted on plaques. (Photo: Department of Archaeology and National Museum, Research and Training Session)

Most of the ancient religious monuments, residential buildings, city walls and town walls were built with bricks. Debris found at an ancient site are the remnants of the ancient structures which stand on the site. To build ancient city state like Sri Ksetra, it is needed millions of bricks. Bricks are different from other archaeological objects in terms of size and weight like coins and beads. Nature of building materials, bricks have to be made near or not far from the construction. Therefore, bricks are locally made material.¹

Town walls, moats, palace sites, palace enclosure walls, religious monuments including temples, stupas, monasteries, ordination halls and libraries, and water tanks can be found in archaeological sites which were belonged to different periods in Myanmar. These structures were built of bricks. Therefore, bricks have played an important role in different periods which were flourished in Myanmar. In studying bricks from different periods can be classified into three categories. They are finger-marked bricks, bricks born inscriptions and bricks born relief designs.

Finger-marked Bricks

The most remarkable points of Pyu bricks which were used to build town walls, gateways, palaces, palace enclosure walls and religious and ritual structures are large size and fingermarks on their faces. Dimension of the largest size of Pyu brick is 50.8 cm x 25.4 cm x 9 cm. The smallest one is 38 cm x 17.8 cm x 5 cm. Pyu used to scrub fingermarks on one face of bricks.²

Finger marked bricks are the earliest bricks in Myanmar archaeological context. Finger marked bricks are found at all Pyu cities and other Pyu settlements. Finger marked bricks are also discovered in Indian and Pakistan. Finger marked bricks are found among bricks of some ancient religious monuments from Buddha Gaya and Taxila of Sind State of India. These religious monuments are belonged to the first century BCE –the second century BCE. Finger marked bricks are also encountered in the relic chamber of Buddhist religious monument of Khapur Period (first century CE – ninth century CE). That religious monument is dated to the fourth century CE. Khapur Period is contemporary with Pyu Period.³

Finger marks on the finger marked bricks are not decoration because finger marks were marked only on the surfaces of the bricks. If bricks are laid, the marks cannot be seen.

¹ U Aung Myint. ကောင်းကင်ခါတံပုံမှ ရှေးဟောင်းမြန်မာ့မြို့တော်များ (Ancient Myanmar Cities in the Aerial photos). Yangon: Ministry of Culture, 1998. P.73

² Ibid. 31

³ Ibid. 75

Moreover, every brick does not bear finger marks. These marks might be the logos of brick makers or logos of brick production centers.

The earliest finger-marked bricks are found in Beikthano ancient city. Beikthano Pyu used two or three fingers to make fingermarks on bricks. Different patterns of fingermarks are also uncovered in Halin ancient city. One of the interesting points is that Sri Ksetra and other Pyu ancient cities bricks bear not only fingermarks but also Pyu number and inscriptions.



Fig.4 Fingered-marked brick. (Photo: Department of Archaeology and National Museum, Research and Training Session) Photo by U Sein Win

Bricks bearing inscriptions

Pyu inscription on bricks is one of the evidences which reveal that Pyu learned the art of writing. One of the most striking points of Sri Ksetra is that not only finger marked bricks but also bricks with auspicious symbols and Pyu characters and numbers are also encounter in Sri Ksetra. Some numbers say thousand. These numbers might be the quota of the production.¹

A broken part of brick which was found at the northeast corner of city wall bears Sanskrit inscription. The dimension of broken brick is 33 cm x 17.8 cm x 5cm. There are three lines of inscription written in Sanskrit with Northern India script but they are seriously damage. Some parts of the inscription can be deciphered, and the word in the middle of the first line says '*anurādha*', the word in the middle of the second line says '*catu*' and the word at the end of the third line says '*mān*'. Style of the script from that inscription is similar to the script inscribed on a bronze bell which was found Wanti Hill near ancient Vesali,-Mrauk U District, Rakhine State in 1922-23. The bell was dated to sixth century CE so the inscription on

¹ U Aung Myint. ကောင်းကင်ခါတံပုံမှ ရှေးဟောင်းမြန်မာ့မြို့တော်များ (Ancient Myanmar Cities in the Aerial photos). Yangon: Ministry of Culture, 1998. P.75-76

the brick of Sri Ksetra might be contemporary with the bell. Therefore, the brick of Sri Ksetra was belonged to the sixth century CE.¹

Shwe Phone Pwint Pagoda Museum, Pyay, houses a considerable number of bricks. These bricks were collected from Sri Ksetra. Some of these bricks bear imprinted Pyu numbers and inscriptions. The inscriptions were inscribed in Southern India script. The purpose of these Pyu numbers and inscriptions are difficult to interpret but the numbers might be telling of the number of bricks and the inscriptions might be the sign of brick makers. Such bricks are also found in Beikthano and other Pyu ancient cities.²



Fig.5 Bricks with Pyu inscriptions *Photo by U Sein Win*

Bricks with relief designs

Sri Ksetra Museum houses terracotta plaques with relief designs. These plaques are square in shape. They were set up on the outer walls of temples and on the terrace walls of stupas. They were intentionally made to decorate structures. The platform of Ma Thi Kya stupa, which is situated on the southern city wall, was adorned with terracotta plaques. The stupa was erected on the square platform. One side of the platform is 19 m long. The height of the platform is 2.3 m. Terracotta plaques were set up around the walls platform. Dimension of terracotta plaque is 38 cm x 35.6 cm x 7.6 cm. Most of the plaques are seriously damaged because of the weathering, and detail designs of the scene in plaque cannot be identified. In the scene, a man is riding a four-leg-creature like horse.³ Terracotta plaques which bear horse and

¹ ရှေးဟောင်းသုတေသနညွှန်ကြားရေးဝန်၏ ၁၉၅၉-၁၉၆၀ ခုနှစ်အတွက် နှစ်ချုပ်အစီရင်ခံစာ (Annual Report on Archaeology, 1959-60). Yangon: Baho Press, (1965). P.22

² Mg Yin Hlaing. ရွှေမီးဖိုတံပန်းအလက် (The Art of Firing Brick). Yangon: Sarpay Beikman, 2014. P.83

³ U Sein Maung Oo. "Ancient Sri Ksetra" (Takkatho pyinyarpadether sarsaung. Volum (3),Part (1).Yangon: Ministry of Information, 1968. P.171

rider of Sri Ksetra are similar to the design of terracotta plaques of Chansen, Central Thailand. The plaques of Thailand are belonged to the sixth century CE -the eighth century CE.¹



Fig.6 Brick with relief design from Ma Thi Kya stupa. (Photo: Field School of Archaeology - Pyay by U Win Kyaing, Principle)

Such terracotta plaques with relief are also found in other parts of Sri Ksetra. Another type of terracotta plaque with relief is also found in Sri Ksetra. That plaque bears dancing human figures. There are three human beings in the relief. The two on right side are man and woman. A hand of the man is putting on the woman shoulders. They are dancing cheerfully. The posture of relief is similar to those of Amaravati style.² A brick with dancing relief was also found at Myin Bhamu Pagoda. The relief is dancing man and woman. Their feet show that they are dancing lively.³ Moreover, Sri Ksetra Museum houses decorated terracotta reliefs with scrolling foliate motif.

¹ U Win Kyaing (trans). Fingered-Marked Designs on Ancient Bricks in Myanmar. *Health For All*, No.129.2016. P.176

² U Mya. ရှေးဟောင်းအုတ်ခွက်ရုပ်ပွားဆင်းတုတော်များ (*Ancient Votive Tablets*), Vol.2, Yangon: Retd. Superintendent Archaeological Survey, 1961. P.22




³ Ibid.23



Fig-(7) Decorated terracotta reliefs with scrolling foliate motif. (Photo: from Sri Ksetra Museum)

No.	Different size bricks
1.	Length (49.53)cm x Width (22.86) cm x Mass(7.62) cm
2.	Length (46.99) cm x Width (24.13) cm x Mass(7.62) cm
3.	Length (43.18) cm x Width (20.32) cm x Mass(7.62) cm
4.	Length (41.91) cm x Width (19.05) cm x Mass(6.35) cm
5.	Length (38.1) cm x Width (20.32) cm x Mass(7.62) cm
6.	Length (38.1) cm x Width (19.05) cm x Mass(6.35) cm
7.	Length (35.56) cm x Width (17.78) cm x Mass(6.35) cm
8.	Length (35.56) cm x Width (17.78) cm x Mass(5.08) cm
9.	Length (34.29) cm x Width (22.86) cm x Mass(6.35) cm
10.	Length (33.02) cm x Width (15.24) cm x Mass(6.35) cm
11.	Length (30.48) cm x Width (21.59) cm x Mass(7.62) cm
12.	Length (30.48) cm x Width (17.78) cm x Mass(7.62) cm

Fig.8 Different size bricks of Sri Ksetra. Photo by U Win Kyaing

No.	Types of Brick Design	Location	Sample illustration
1	Rectangular shaped bricks	Almost brick structures in Sri Ksetra	
2	B shaped bricks on one side	Khin Ba, Mathigyā, HMA 51, HMA 19	
3	Round bricks on one side	Khin Ba, Mathigyā, HMA 51, HMA 19	
4	Sharp bricks on one side	Mathigyā	
5	Wedge shaped bricks	HMA 51	
6	Finger –marked bricks	Numerous sites in Sri Ksetra	
7	Bricks bearing inscriptions	HMA 31 and so on	




8	Bricks bearing Pyu numeric	Numerous sites	
9	Bricks bearing relief designs	Khin Ba, Mathigyā, HMA 19, Yindaik-kwin Mound	
10	Bricks with footprint	Numerous sites	

Fig.9 Type of decoration design bricks of Sri Ksetra. Photo by U Win Kyaing

Scientific Analysis

Chemical composition and physical properties of a brick from Moat Htao Gateway, which is located on the southeast city wall of Sri Ksetra, was analyzed by using XRF (X-Ray Fluorescence Method) and XRD (X-Ray Diffraction Method). Mineralogical composition of the brick is potash feldspar (KF) 14.71 per cent, plagioclase (Pgl) 1.09 per cent, quartz (Qtz) 30.26 per cent, hematite (He) 12.97 per cent, calcite (Ca) 2.19 per cent, and clay minerals matrix (illite) 38.79 per cent.¹

According to the result of the test, density of the brick is 1.67 g/cm³. The density of the brick is fairly high and the absorption power of the brick is 10.9 per cent per day. Percentage of CaO (Calcium oxide) is only 0.94 per cent and so the amounts of interconnecting pores are much less. The brick is durable because of the less absorption power. (Tin Mg Oo, 2014:235) The amount of Al₂O₃ (Aluminium oxide) in the brick is 13.56 per cent so the resistance power is 18.2 N/mm². The resistance power of the brick is considerable high because of the high content of Al₂O₃ (Aluminium oxide) in the brick. Al₂O₃ (Aluminium oxide) is 13.56 per cent in the brick. The contents of Fe₂O₃ (Ferric oxide) and CaO (Calcium oxide) are 6.07 per cent and 0.94 per cent which give brick reddish-brown colour. The percentage of SiO₂ (Silicon Dioxide) is 70.31 per cent so the clay is rich in quartz. The percentage of CaO (Calcium oxide) in the clay is 0.94 per cent, and the type of clay is non-calcareous clay.²

Thin section of brick which is examined under microscope reveals that very fine quartz, illite, hematite and alkali feldspar include in the brick. Fine pale red clay are calcite and muscovite. The composition of minerals in the brick is feldspar, quartz (30.26 per cent), plagioclase (1.09 per cent), hematite (12.97 per cent) and illite (38.79 per cent). The firing temperature of brick is < 800°C because clay mineral like illite and calcite can be identified in the brick. Raw material of brick was obtained from a place away from the town wall because

¹ Tin Maung Oo (Shwe Pyi). မြန်မာ့ယဉ်ကျေးမှုသမိုင်းအတွက်အုတ်တစ်ချပ်သဲတစ်ပွင့်စာတမ်းများ (Little Papers for the History of Myanmar's Culture), Mandalay: Kyi Pway Sarpay, 2014. P.237

² Ibid. 236

basic elements and small amount of trace elements of brick and those of the earth beneath the town wall are different.¹

For my research paper, I have sent the sample of brick from HMA-64(Hmawza) to Department of Geology, Mandalay University. Chemical composition and physical properties of a brick from HMA-64 (Hmawza) which is located on the southeast of Sri Ksetra, was analyzed by using SQX (Semi Quantitative Analysis). Mineralogical composition of the brick is Na₂O (Sodium oxide) 2.33 per cent, MgO (Magnesium oxide) 1.01 per cent, Al₂O₃ (Aluminium oxide) 23.0 per cent, SiO₂ (Silicon Dioxide) 67.7 per cent, P₂O₅ (Phosphorus pentoxide) 1.06 per cent, Cl (Chloride iron) 0.0113 per cent, K₂O (Potassium oxide) 1.46 per cent, CaO (Calcium oxide) 0.664 per cent, TiO₂ (Titanium dioxide) 0.337 per cent, Cr₂O₃ (Chromium oxide) 0.0203 per cent, MnO (Manganese oxide) 0.0375 per cent, Fe₂O₃ (Ferric oxide) 2.20 per cent, NiO (Nickel oxide) 0.0075 per cent, ZnO (Zinc oxide) 0.0042 per cent, Rb₂O (Rubidium oxide) 0.0046 per cent, SrO (Strontium oxide) 0.0106 per cent, ZrO₂ (Zirconium oxide) 0.0142 per cent, BaO (Barium oxide) 0.0391 per cent. According to the result of the test, density of the brick is 99.9103 per cent.

The resistance power of the brick is considerably high because the high content of Al₂O₃(Aluminium oxide) in the brick is 23.0 per cent. The firing temperature of brick is > 900°C because Al₂O₃(Aluminium oxide) is 23.0 per cent. in the brick.

2019-11-29 14:54

SQX Calculation Result							
Sample : HMA-64		Date analyzed : 2019-11-29 14:20					
Application : F-U_Solid_S_827		Sample type : Oxide Powder		Balance :			
Sample film corr. : P.E.Film				Matching library :			
File : 201911291420				Impurity corr. :			
No.	Component	Result	Unit	Det. limit	El. line	Intensity	w/o normal
1	Na2O	2.33	mass%	0.49412	Na-KA	0.0204	3.3534
2	MgO	1.01	mass%	0.11055	Mg-KA	0.0892	1.4598
3	Al2O3	23.0	mass%	0.05807	Al-KA	18.0572	33.2134
4	SiO2	67.7	mass%	0.10315	Si-KA	57.1438	97.6036
5	P2O5	1.06	mass%	0.01666	P-KA	0.8300	1.5344
6	Cl	0.0113	mass%	0.00237	Cl-KA	0.0712	0.0162
7	K2O	1.46	mass%	0.00932	K-KA	4.2496	2.0996
8	CaO	0.664	mass%	0.00732	Ca-KA	2.7013	0.9564
9	TiO2	0.337	mass%	0.02059	Ti-KA	0.3730	0.4861
10	Cr2O3	0.0203	mass%	0.00575	Cr-KA	0.0660	0.0293
11	MnO	0.0375	mass%	0.00549	Mn-KA	0.2053	0.0540
12	Fe2O3	2.20	mass%	0.00717	Fe-KA	17.8090	3.1744
13	NiO	0.0075	mass%	0.00242	Ni-KA	0.1222	0.0109
14	ZnO	0.0042	mass%	0.00201	Zn-KA	0.1174	0.0060
15	Rb2O	0.0046	mass%	0.00138	Rb-KA	0.4334	0.0067
16	SrO	0.0106	mass%	0.00143	Sr-KA	1.0263	0.0152
17	ZrO2	0.0142	mass%	0.00155	Zr-KA	1.6591	0.0205
18	BaO	0.0391	mass%	0.02100	Ba-KA	0.4078	0.0564

Fig. 10 SQX Calculation Result of brick from HMA-64(HMAWZA).(Photo: Department of Geology, Mandalay University)

¹ Ibid. 237

Discussion

Urbanization founded by Pyu had appeared in Myanmar since the second century BCE. They built towns and cities with moats, town walls and gateways. Their town walls were high and thick. Moats, town walls and gateways were built of bricks. The area of Pyu cities were very large and it needed a large number of bricks to build walls. It cannot be denied that Pyu had learned the art of making brick before the second century BCE because they had founded towns since the second century BCE. Pyu used to build their structures with brick rows which were filled with brick debris. Two brick rows were laid first and then inner spaces between two brick rows were filled with brick debris. The works of brick laying at Sri Ksetra are better than those of other Pyu cities. In Sri Ksetra, brick structures were built not only of simple bricks but also of curved bricks. Curved bricks were made with special moulds. According to the result of the test, a brick from HMA-64 (Hmawza) contains more Al_2O_3 (Aluminium oxide) in the brick than a brick from Moat Htaw Gateway. So we can assume that the firing temperature of brick from HMA-64 (Hmawza) is higher.

Conclusion

The Myanmar word *aut*, literally brick, is derived from Sanskrit word. Pyu learned the art of making brick from India. Founding cities by using bricks was the progress of a society. During the Pyu period a large number of brick works can be found in Beikthano, Pinle, Halin and Sri Ksetra. Among these bricks, the bricks from Sri Ksetra are of the best quality because density and resistance of Sri Ksetra bricks are high and absorption power of the brick is low. High absorption power brick is not durable. Studying the chemical composition and physical properties of bricks assists to preserve the brick structures effectively. By knowing the physical properties of bricks, reasons of the damage of brick structures can be known.

Pyu culture is one of the most remarkable milestones in Myanmar history because Pyu founded the earliest civilization in Myanmar. Finger-marked, inscriptions and reliefs on bricks from Sri Ksetra Pyu ancient city can reveal the progress of Pyu civilization. Therefore, brick is one of the important artefacts in archaeology because it can give information about social, economic and political situation of ancient society. For those reasons, city wall, palace and palace enclosure walls, moats and religious and ritual structures which were built of bricks should be recorded systematically.

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