

# **A Visual Study on Motifs and Patterns of Ahom's Brick Monuments**

Thesis submission in partial fulfilment  
of the requirements for the degree of  
Doctor of Philosophy

**Saurav Khuttiya Deori**  
Roll no. 156105012

Under the supervision of  
**Professor Utpal Barua**

Department of Design




Indian Institute of Technology Guwahati  
Guwahati-781039, Assam, India  
April, 2022



## DECLARATION

“I, Saurav Khuttiya Deori, declare that the Ph.D. thesis titled, “**A Visual Study on Motifs and Patterns of Ahom’s Brick Monuments**” contains no material that has been submitted previously, in whole or in part, for the award of any other academic degree or diploma. Except where otherwise indicated, this thesis is my own work”.

**Saurav Khuttiya Deori,**  
Research Scholar,  
Department of Design,  
Indian Institute of Technology Guwahati  
Guwahati, Assam -781039

Signature:.....

Date: 22/04/2022 Place: IIT Guwahati



## CERTIFICATE OF AUTHENTICATION

This thesis entitled “**A Visual Study on Motifs and Patterns of Ahom’s Brick Monuments**” submitted in partial fulfillment of the requirements for the Degree of Doctor of Philosophy at Indian Institute of Technology Guwahati has been carried out under my supervision and is a bonified work of Mr. Saurav Khuttiya Deori.

I confirm that this thesis is an original work of Mr. Saurav Khuttiya Deori except where due acknowledgement has been made and has not been submitted previously, in whole or in part, to qualify for any academic award within or outside this institution.

I also confirm that Mr. Saurav Khuttiya Deori has fulfilled all the mandatory requirements as per as the rules and regulations necessary for the award of the degree of Doctor of Philosophy at Indian Institute of Technology.

**Dr. Utpal Barua**

Thesis Supervisor,  
Professor, Department of Design,  
Indian Institute of Technology Guwahati  
Guwahati, Assam-781039

Signature:.....

Date: 22/04/2022 Place: IIT Guwahati



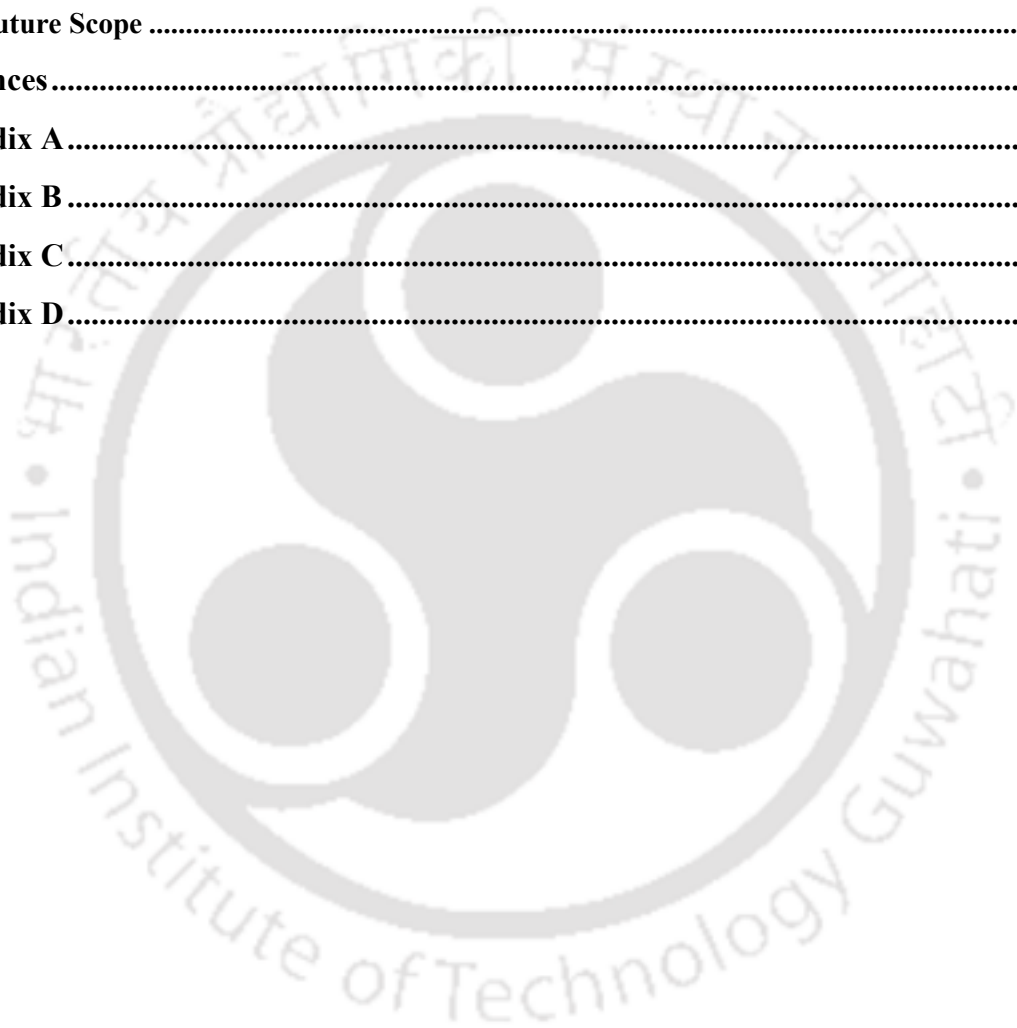
## Table of Contents

### Acknowledgment

Abstract.....	13
Overall thesis structure .....	17
List of Tables .....	19
List of Figures.....	22
<b>CHAPTER ONE: Introduction .....</b>	<b>27</b>
1.1 Architectural Ornamentation.....	27
1.2 Ahom Brick monuments .....	28
1.3 Research Justification. ....	29
1.4 Research Problem.....	30
1.5 Research Questions.....	31
1.6 Research Aim & Objectives.....	31
1.7 Research Methodology .....	31
1. 8 Conclusion .....	32
<b>CHAPTER TWO: Literature Review.....</b>	<b>33</b>
2.1 Ornamentation.....	33
2.1.1 Indian architectural ornamentation.....	35
2.1.2 Architectural ornamentations during Gupta Age in Assam.....	42
2.1.3 Architectural ornamentations post Gupta age in Assam .....	44
2.1.4 Architectural ornamentations during Pala dynasty of Assam .....	47
2.2 Mediaeval Era of Assam .....	49
2.2.1 The Ahoms .....	50
2.2.2 Ahom Art and Architecture.....	51
2.3 Bengal temple Architecture .....	56
2.5 Insight of the study .....	58
<b>CHAPTER THREE: Methodology .....</b>	<b>61</b>
3.1 Data Collections .....	62
3.2 Categorization of motifs and patterns .....	64
3.4 Coding Data.....	65
3.5 Data Sorting and Variation analysis .....	66
3.5.1 Visual Analysis .....	67
3.5.2 Symmetry Analysis. ....	67
3.6. Material Study from Bricks and Mortar samples .....	71
3.6.1 Characterization of materials .....	72
3.7 Discussions.....	73

<b>CHAPTER FOUR: Data collection and Variation Analysis .....</b>	<b>75</b>
<b>4.1 Data Collection and categorisation .....</b>	<b>77</b>
<b>4.2 Terracotta Ornamentation .....</b>	<b>78</b>
4.2.1 Variation analysis of Motifs and Patterns – Ghanasyam House.....	80
4.2.2 Variation analysis of motifs and patterns – Namath Kali Temple.....	82
<b>4.3 Stucco Ornamentations.....</b>	<b>83</b>
4.3.1 Variation analysis of motifs and patterns – Rang Ghar.....	83
4.3.2 Variation analysis of motifs and patterns – Talatal Ghar.....	85
4.3.3 Variation analysis of motifs and patterns – Kareng Ghar .....	86
<b>4.3 Findings .....</b>	<b>87</b>
Interview and discussion findings.....	87
Ghanasyam House.....	87
Namath Kali.....	88
Rang Ghar .....	88
Talatal Ghar .....	88
Kareng Ghar.....	89
<b>CHAPTER FIVE: Visual analysis.....</b>	<b>91</b>
<b>5.1 Form extractions from terracotta ornamentations.....</b>	<b>92</b>
5.1.1 Ghanasyam House form extractions.....	93
5.1.2 Namath Kali Temple- form extractions.....	99
<b>5.2 Results– terracotta ornamentation .....</b>	<b>103</b>
5.2.1 Shape and form- Ghanasyam House. ....	103
5.2.2 Shape and form- Namath Kali.....	104
5.2.3 Color and Texture- Ghanasyam House & Namath Kali.....	105
5.2.4 Symmetry Analysis of terracotta monuments. ....	106
<b>5.3. Form extractions from Stucco ornamentations .....</b>	<b>111</b>
5.3.1 Form extractions – Rang Ghar .....	112
5.3.2 Form extractions – Talatal Ghar.....	127
5.3.3 Form extractions – Kareng Ghar .....	134
<b>5.4 Results– Stucco ornamentation .....</b>	<b>137</b>
5.4.1 Shapes and forms- Rang Ghar, Talatal and Kareng Ghar .....	137
5.4.2. Color and Texture- Rang Ghar, Talatal and Kareng Ghar.....	139
5.4.3 Symmetry Analysis .....	139
<b>CHAPTER SIX: Material Study.....</b>	<b>145</b>
<b>6.1 Early construction materials of the monuments.....</b>	<b>145</b>
<b>6.2 Terracotta type Monuments .....</b>	<b>146</b>
6.2.1 Elemental composition of bricks and mortar (wt%).....	146
6.2.2. FTIR analysis of bricks and mortar .....	149
6.2.3. Powder X-ray diffraction of bricks and mortar .....	150
<b>6.3 Stucco type Monuments .....</b>	<b>152</b>
6.3.1 Elemental composition of bricks and mortar (wt%).....	152
6.3.2. Powder X-ray diffraction of bricks and mortar .....	153
6.3.3 FTIR analysis of bricks and mortar.....	155
<b>6.4 Discussions.....</b>	<b>157</b>

<b>CHAPTER SEVEN: Discussions and Conclusion .....</b>	<b>159</b>
<b>7.1 Discussions.....</b>	<b>159</b>
7.1.1 Similarities in ornamentations.....	160
7.1.2 Visual forms in the ornamentation .....	163
7.1.3 Visual Characteristics of ornamentation .....	167
7.1.4 Material considerations .....	173
<b>7.2 Conclusion .....</b>	<b>174</b>
7.2.1 Research Questions. ....	175
7.2.2 Major Contribution.....	177
7.2.3 Limitation.....	178
<b>7.3 Future Scope .....</b>	<b>178</b>
<b>References.....</b>	<b>185</b>
<b>Appendix A.....</b>	<b>189</b>
<b>Appendix B.....</b>	<b>194</b>
<b>Appendix C.....</b>	<b>195</b>
<b>Appendix D.....</b>	<b>196</b>





## Acknowledgement

This thesis is the outcome of my interest in visual art and design. This journey has provided me with in-depth insights and appreciation to the heritage and art of Assam.

I would like to thank my esteemed supervisor – Prof. Utpal Barua for his invaluable supervision, support and tutelage during the course of my Ph.D. degree. My gratitude extends to my doctoral committee members, Dr. Sougata Karmakar, Prof. Pradip K. Das, Prof. Sukanya Sharma and Dr. Manoj Majhi for the valuable suggestions, guidance and evaluations on my research works. I would also like to express my gratitude to **Design Innovation Center, IIT Guwahati** for the funding opportunity (initial four years) to undertake my Ph.D. research at the Department of Design, IIT Guwahati, Assam.

Additionally, I would like to express my gratitude to Dr. Manjil Hazarika, Department of Archaeology, Cotton University; Sri. Nabajit Deori, Deputy Director (Exploration & Excavation), Directorate of Archaeology, Assam; Shri Bikash Chandra Das, Senior Conservation Assistant, Sibsagar Circle, Archaeology Survey of India (ASI) for giving me valuable time for discussions and archeological information of Assam and Department of Historical and Antiquarian Studies, Guwahati, Assam.

I want to thank Dr. Chiranjib Gogoi and Mr. Deep Bora for helping me to conduct my experiments in Central Instruments Facility, IIT Guwahati. I extend my gratitude to Mr. Ayushman Gogoi and his family for unconditional support during my field visits.

I would like to extend my gratitude to my friends, lab mates, colleagues and research participants for a cherished time spent together in the lab and social settings. My appreciation goes out to my parents and dearest Pebi for their encouragement, patience and support throughout my Ph.D.



## Abstract

Assam is located in the North-eastern part of India; it is blessed with its rich and diverse culture and heritage. One of the most influential aspects of heritage is the reign of Ahoms in Assam for nearly 600 years (A.D. 1228–1826). Historically, Ahoms are from a group of Tai people and most historians mention that the descendants of Tai people are from Yunnan province. The Ahoms came to Assam by crossing the Patkai Hills on the northern- eastern border of Myanmar. They settled over the Brahmaputra valley and extended their kingdom over the upper and lower part of Assam. With the leadership of the first Ahom King *Sukapha* (A.D. 1228–1268), they set up their first capital in the Charaideu district of Assam. The initial phase of the Ahom dynasty was unstable as they were expanding the kingdom subjugating the Brahmaputra valley of Assam. By the 17th century, art and architecture flourished prosperously. Literature states that during the reign of Ahom King Rudra Singha (A.D. 1698-1714), the masonry architecture flourished.

The pilot study discloses that there are more than 30 Ahom masonry architectures all over Assam. These architectures are mostly temples and only a few non-religious architectures are able to subsist. Out of these 30 monuments, most of them are preserved under the Archaeological Survey of India (ASI), Guwahati Circle, Assam and Directorate of Archaeology, Guwahati, Assam. The Ahoms in the late mediaeval period used stone cuts, stucco reliefs and terracotta moulds in their ornamentations. The stone cuts have managed to survive the geographic conditions, but the terracotta and the stucco ornamentations are fragmented. The study moreover reveals that out of all these monuments, the Namath kali temple of Nilachal Hills, Ghanasyam House, Rang Ghar, Talatal Ghar of Sivasagar district and Kareng Ghar of Charaideu district of Assam have managed to retain their original structure and ornamentations. Few sections include renovated ornamentation, but it lacks early aesthetics, as the renovated forms are unable to unify with the ancient forms. This not only dilutes the early essence but also ignores the early artisans' values and the underlying design principles of the ornamentation. Literature shows that there is significantly less study on the architectural ornamentation of the Ahom monuments, resulting in the absence of systematic documentation of these architectural ornaments. It also discloses that the Namath kali and Ghanasyam House display similar architectural styles, yet the Namath kali construction period is indefinite. This gives a solid consideration to study the visual and material aspects of the Ahom Brick ornamentation.

Based on the pilot and literature studies, the following objectives are considered:

- To study the art and architecture of the Ahom dynasty.
- To identify the visual characteristics of the ornamentations of the Ahom brick monuments.
- To study the construction materials of Ahom brick masonry architectures.

There are two phases- **A & B** in data collection. Phase **A** includes collecting photo and video data of the ornamentation in monuments and semi-structured interviews with locals and experts; **B** includes the collection of material data of Bricks sample and mortar samples. The material study has provided information related to early construction raw materials and the connections with similar types of architecture with respect to its construction dates. The secondary data are collected from journals, magazines, libraries and the internet.

As the data was in large numbers, the categorization theory of Athavankar (1989) was adopted. This includes segmentation of the motifs and patterns into the following types: Floral motifs, Compound motifs, Animal motifs, Symbolic motifs, Organic patterns and Geometric patterns. The motifs and patterns are coded to reduce data redundancy based on the categorization. Variation analysis, visual analysis and symmetry analysis are conducted with the coded data. The symmetry analysis considers the one-dimensional and two-dimensional pattern classes. The method to classify the pattern classes is adopted from Washburn & Crowe (1988). In Phase B, multiple site visits were done to study the brick dimensions and sample collection of brick and mortars. For the analysis of materials, samples of bricks and mortar were collected from the monuments. Three testing phases are conducted with the collected brick and mortar samples- Energy Dispersive X-Ray Analysis (EDX) to study morphology and elemental compositions of the brick and mortar samples, Power X-Ray diffraction (PXRD) helps to identify mineral presents in bricks and mortar samples and Fourier Transform Infrared Spectroscopy (FT-IR) identifies the chemical bonds in a molecule.

The results of variation and visual analysis display the visual characteristics of the motifs and patterns and the underlying design principles followed in the visual compositions and spatial arrangements. The results display quantitative data of predominant symmetry operations of the motifs and pattern classes. It also discloses that vegetal forms are predominant in the overall Ahom brick-masonry ornamentations. The use of singular floral motifs like Lotus flower is prominent in all the monuments. Although the ornamentations radiate influences from the Gupta style, Indo-Islamic arts and exotic Southeast Asian styles, the artisans have managed

to develop and inculcate traditional and local styles in masonry constructions. The overall study discloses the underlying structure and visual characteristics of Ahom architectural ornamentations with insights into early bricks and mortars used in the constructions of these majestic architectures.

The thesis provides significant contributions to understanding the Ahom architectural ornamentations of Assam by systematically documenting them. The study provides in-depth insights into the early Ahom ornamentation styles, elements and forms used to embellish the brick architectures. It provides a reference source for the art and archaeology of Assam and India for the conservation and preservation of the traditional architectural art of Assam. The studied data unlocks the integration of multidisciplinary domains like Artificial Intelligence (Deep learning), Augmented Reality (AR), etc. for digital preservation and digital exploration with concern for the tangible heritage of Assam.





## Overall thesis structure

**Chapter One:** The Chapter One provides introduction to the Assam state of Northeast India and the impact of the Ahom dynasty on the culture and heritage of Assam. It introduces the Architectures of Ahom and the importance of Architectural ornamentations. The chapter talks briefly about the motivation of the research, the research area and the problems. Considering the above, the research methods are briefly mentioned. The aim and objectives of the research are also mentioned.

**Chapter Two:** This chapter explores and studies the scenario of the Indian architectural ornamentation from early stone cuts to masonry architecture. It discusses the art and architecture scenario of Assam before and during the Ahom reign. The influences and the artisans of the masonry buildings of the Ahoms are being mentioned. To understand the early construction technology, its raw materials and manufacturing process are studied. The research insights are discussed.

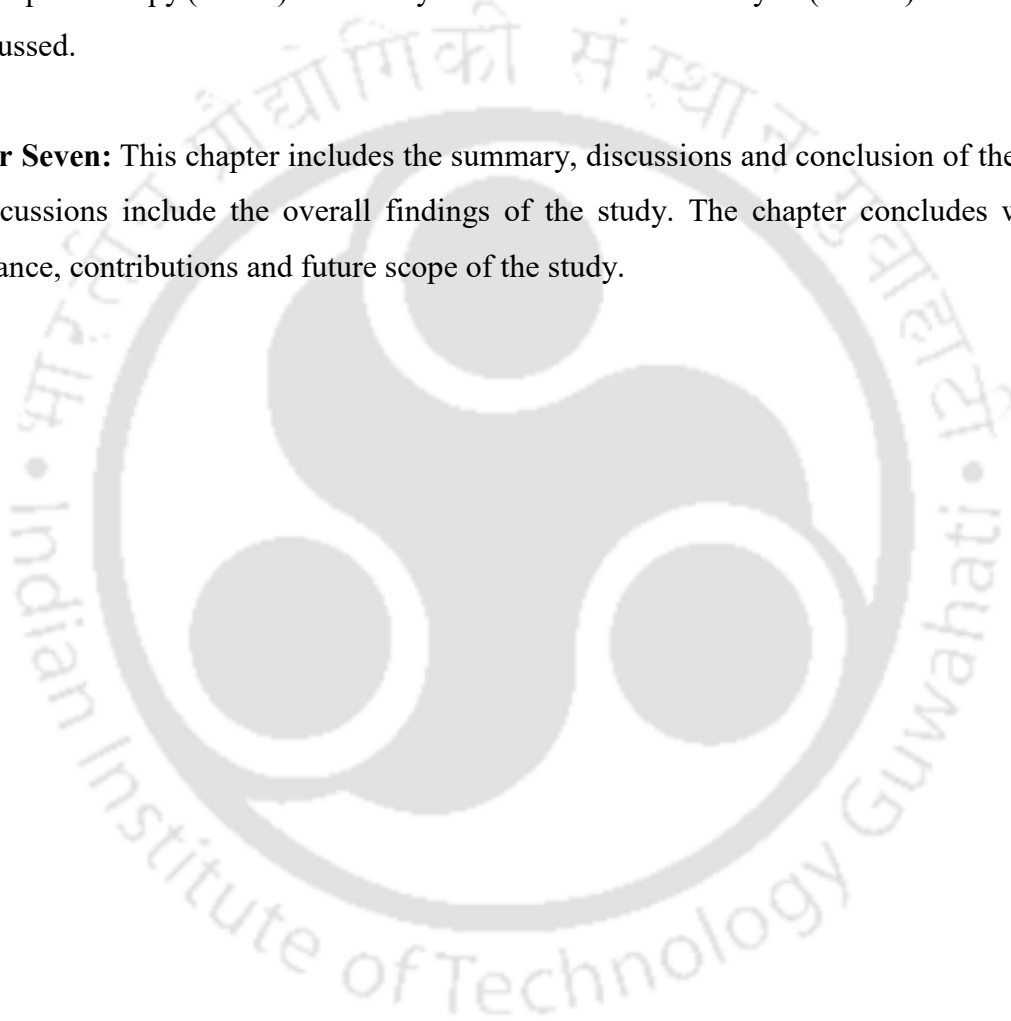
**Chapter Three:** This chapter provides details about the research methodology adopted for the study. The data collected are from only brick architecture monuments of Ahoms with ornamentation. Details of data collection and data sorting using categorization theory are being discussed. The data coding into motifs and pattern types are discussed. The process of variation, visual and symmetry analysis is disclosed. Another section of the data collection is related to material study, where small portions of brick and mortar samples of the selected monuments are collected. The collection process and the testing process like Energy Dispersive X-Ray Analysis (EDX), Fourier Transform Infrared Spectroscopy (FT-IR), X-Ray Powder Diffraction Analysis (PXRD) of the samples along with its purpose are discussed in this chapter.

**Chapter Four:** The process of data sorted and variation analysis based on the shapes and structure of motifs and patterns are discussed in this chapter. With a brief introduction of the selected monuments, each variant of the motifs and patterns is coded with linear extractions and the quantitative data is revealed. The overall analysis is divided into two parts, the terracotta plaques and the stucco ornaments of the monuments. Furthermore, the quantitative results of the variant types are discussed.

**Chapter Five:** Visual analysis of the extracted motifs and patterns are discussed in this chapter. The analysis considers the shapes, forms, colours and textures discussed in this chapter. Along with symmetry, variations of the motifs and patterns are discussed. The dominating symmetry types and pattern classes are highlighted.

**Chapter Six:** The material study of the collected mortar and brick samples are discussed in this chapter. The results of Energy Dispersive X-Ray Analysis (EDX), Fourier Transform Infrared Spectroscopy (FT-IR) and X-Ray Powder Diffraction Analysis (PXRD) of the samples are discussed.

**Chapter Seven:** This chapter includes the summary, discussions and conclusion of the study. The discussions include the overall findings of the study. The chapter concludes with its significance, contributions and future scope of the study.

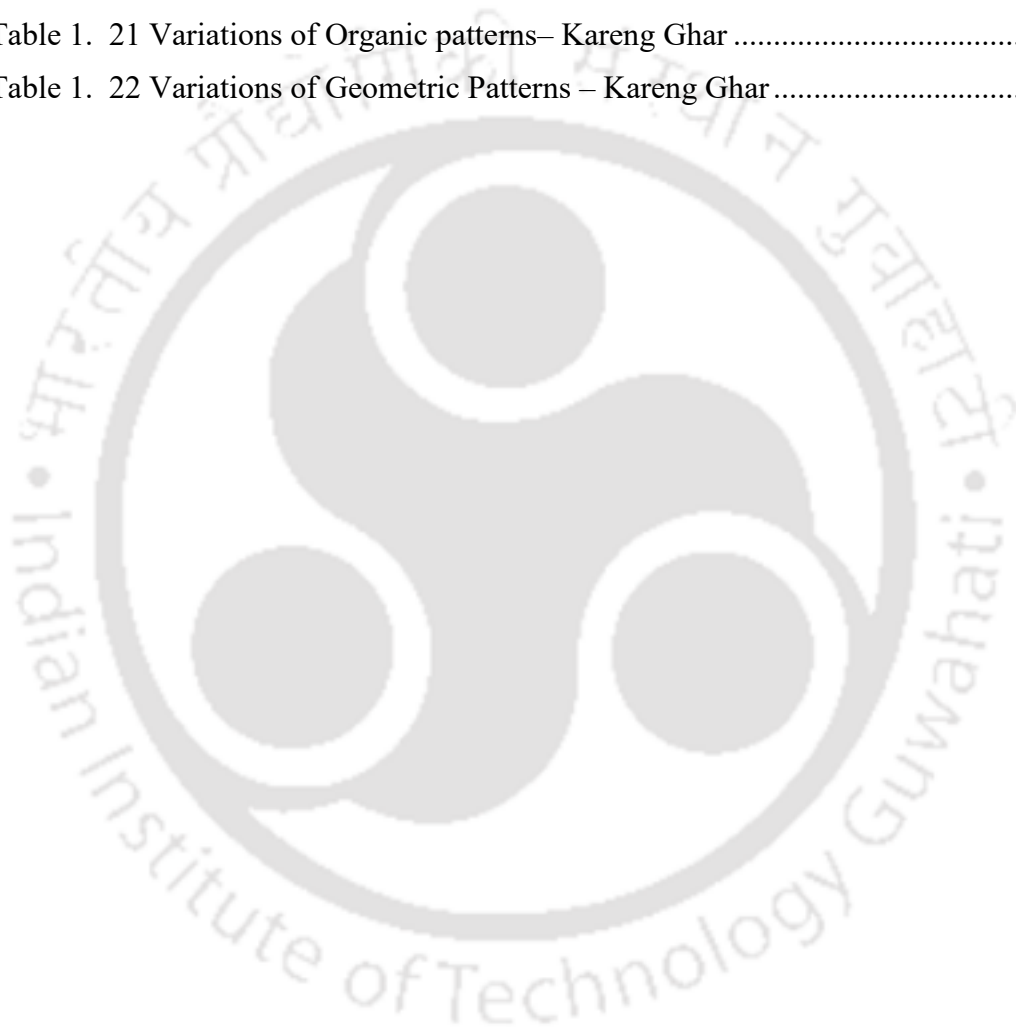


## List of Tables

Table 3. 1 Coding on Motif and pattern type based on the superordinate, Basic and subordinate level .....	66
Table 4. 1 Visited sites of Ahom monuments with architecture and material information, Assam.....	75
Table 4. 2 Sample table of variations of Floral Motifs – Ghanasyam House.....	90
Table 5. 1 Ghanasyam House – Elements of floral motifs .....	93
Table 5. 2 Ghanasyam House – Elements of Compound motifs.....	94
Table 5. 3 Ghanasyam House – Elements of animal motifs .....	95
Table 5. 4 Ghanasyam House Elements of organic patterns .....	96
Table 5. 5 Ghanasyam House – Elements of geometric patterns .....	98
Table 5. 6 Namath Kali – Elements of floral motifs.....	99
Table 5. 7 Namath Kali – Elements of animal motifs.....	100
Table 5. 8 Namath Kali – Elements of organic & geometric patterns.....	100
Table 5. 9 Symmetry association of Motifs in Ghanasyam House.....	108
Table 5. 10 Symmetry association of Motifs in Namath Kali Temple .....	108
Table 5. 11 Pattern class association of Ghanasyam House .....	110
Table 5. 12 Pattern class association of Namath Kali Temple (Change the <i>pmm2</i> ).....	110
Table 5. 13 Rang Ghar– Elements of floral motifs.....	112
Table 5. 14 Rang Ghar– Elements of Compound motifs.....	113
Table 5. 15 Rang Ghar– Elements of organic patterns .....	124
Table 5. 16 Talatal Ghar– Elements of flora motifs .....	127
Table 5. 17 Talatal Ghar– Elements of compound motifs.....	127
Table 5. 18 Talatal Ghar– Elements of organic patterns. ....	129
Table 5. 19 Talatal Ghar– Elements of geometric patterns. ....	132
Table 5. 20 Kareng Ghar– Elements of motifs .....	134
Table 5. 21 Kareng Ghar– Elements of organic patterns.....	135
Table 5. 22 Kareng Ghar– Elements of Geometric patterns.....	136
Table 5. 23 Symmetry association of Rang Ghar motifs.....	141
Table 5. 24 Symmetry association of Talatal Ghar motifs .....	141
Table 5. 25 Symmetry association of Kareng Ghar motifs.....	141
Table 5. 26 Pattern class association of Rang Ghar patterns .....	142
Table 5. 27 Pattern class association of Talatal Ghar patterns .....	143

Table 5. 28 Pattern class association of Kareng Ghar patterns.....	143
Table 6. 1 Elemental analysis of bricks and mortar of Ghanasyam House and Namath Kali using Energy Dispersive X-ray Spectroscopy (EDX). .....	148
Table 6. 2 Mineral identification of (a) Ghanasyam House brick and (b) Namath Kali Temple brick .....	151
Table 6. 3 Mineral identification of (c) Ghanasyam House mortar and (d) Namath Kali Temple mortar.....	152
Table 6. 4 Elemental analysis of bricks and mortar of Kareng Ghar, Rang Ghar and Talatal Ghar using Energy Dispersive X-ray Spectroscopy (EDX) .....	153
Table 6. 5 Mineral identification of (a) Kareng Ghar brick, (b) Rang Ghar brick and (c) Talatal Ghar brick .....	154
Table 6. 6 Mineral identification of (d) Kareng Ghar mortar, (e) Rang Ghar mortar and (f) Talatal Ghar mortar.....	155
Table 6. 7 The IR spectra and probable vibrational assignments of brick and mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar. ....	156
Table 7. 1 Variations of floral forms used in Ahom brick monuments ornamentation.....	164
Table 7. 2 Variations of leaves used in Ahom brick monuments ornamentation.....	165
Table 7. 3 Variations of Branching used in Ahom brick monuments ornamentation. ....	165
Table 7. 4 Animal forms used in Ahom brick monuments ornamentation.....	166
Table 7. 5 Human figures used in Ahom brick monuments ornamentation. ....	166
Table 7. 6 Man-made forms used in Ahom brick monuments ornamentation. ....	166
Appx. Table 1. 1 Variations of Floral Motifs – Ghanasyam House .....	196
Appx. Table 1. 2 Variations of Animal Motifs – Ghanasyam House.....	197
Appx. Table 1. 3 Variations of Compound Motifs – Ghanasyam House.....	199
Appx. Table 1. 4 Variations of Symbolic Motifs – Ghanasyam House .....	199
Appx. Table 1. 5 Variations of Patterns – Ghanasyam House.....	199
Appx. Table 1. 6 Variations of Floral Motifs – Namath Kali.....	201
Appx. Table 1. 7 Variations of Animal Motifs – Namath Kali .....	201
Appx. Table 1. 8 Variations of symbolic Motifs – Namath Kali.....	202
Appx. Table 1. 9 Variations of patterns – Namath Kali .....	202
Appx. Table 1. 10 Variations of Floral Motifs – Rang Ghar.....	202
Appx. Table 1. 11 Variations of Compound Motifs – Rang Ghar.....	203
Appx. Table 1. 12 Variations of Symbolic Motifs – Rang Ghar .....	207

Appx. Table 1. 13 Variations of Patterns – Rang Ghar .....	207
Appx. Table 1. 14 Variations of Floral Motifs – Talata Ghar .....	208
Appx. Table 1. 15 Variations of Compound Motifs – Talatal Ghar .....	208
Appx. Table 1. 16 Variations of Animal Motifs – Talatal Ghar.....	209
Appx. Table 1. 17 Variations of Organic patterns – Talatal Ghar.....	209
Appx. Table 1. 18 Variations of Geometric patterns – Talatal Ghar.....	211
Appx. Table 1. 19 Variations of Floral Motifs – Kareng Ghar.....	211
Appx. Table 1. 20 Variation of Animal Motifs – Kareng Ghar.....	212
Appx. Table 1. 21 Variations of Organic patterns– Kareng Ghar .....	212
Appx. Table 1. 22 Variations of Geometric Patterns – Kareng Ghar .....	213



## List of Figures

<b>Fig 2. 1</b> The Great Stupa at Sanchi .....	36
<b>Fig 2. 2</b> Floral and geometric ornamentation of Dhamek Stupa, Uttar Pradesh, India. ....	37
<b>Fig 2. 3</b> Ajanta cave number 26.....	38
<b>Fig 2. 4</b> Entrance arches of Qutb Mosque of Delhi (1192) .....	38
<b>Fig 2. 5</b> (a) <i>Ramayana</i> and b) <i>Mahabharata</i> sculting in Kailasa Temple Ellora.....	39
<b>Fig 2. 6</b> Ceiling (shallow dome) of Khajuraho temples.....	40
<b>Fig 2. 7</b> Calligraphy with vegetal and geometric ornamentations of Qutb Minar, Delhi. ....	42
<b>Fig 2. 8</b> The Dah-parbatiya temple stone door, Tezpur, Assam. ....	44
<b>Fig 2. 9</b> Bamini Hills, Cole park Stone ornamented ruins, Tezpur. ....	45
<b>Fig 2. 10</b> <i>Kirtimukha</i> on stone slabs, Rajbari, c.11th century CE. (Saikia and Das, 2021).....	46
<b>Fig 2. 11</b> Stone remains of Madan Kamdev, archeological site. ....	48
<b>Fig 2. 12</b> Assam Map displaying Charaideo district near Sivasagar, Assam, India. ....	50
<b>Fig 2. 13</b> Stone sculpture of Joy dol of Joysagar Tank, Sivasagar. (AD 1696–14).....	52
<b>Fig 2. 14</b> Front section of Ghanasyam House, Sivasagar. ....	54
<b>Fig 2. 15</b> Front section of Namath Kali, Nilachal Hills, Guwahati. ....	54
<b>Fig 2. 16</b> a) Rang Ghar b) Talatal Ghar of Sivsagar area and c) Kareng Ghar of Charaideu area of Assam.....	55
<b>Fig 2. 17</b> Front view of the <i>Jor-Bangla</i> Gangeshwar Shiva temple, Murshidabad, West Bengal (Mangaonkar, 2012). 18 <sup>th</sup> century. ....	57
<b>Fig 2. 18</b> Front view of the <i>Jor-Bangla</i> Gopinath temple, Pabna, Bangladesh.(Ray, 2012)...	58
<b>Fig. 3. 1</b> Assam map showing districts of the considered brick monuments for the study. ....	61
<b>Fig. 3. 2</b> a) Normal lighting inside the Talatal Ghar, Sivasagar; b) Lightning setup for visibility; c)Photo enhancement for details using editing software. ....	63
<b>Fig. 3. 3</b> Brick and mortar samples collected form the selected monuments. ....	63
<b>Fig. 3. 4</b> a) Rang Ghar old photograph (1922-23), Source- ASI; b) Photograph of Rang Ghar after renovation (2016) .....	64
<b>Fig. 3. 5</b> Systematic categorization chart for the motif types and pattern types.....	64
<b>Fig. 3. 6</b> Schematic representations of symmetry operations .....	67
<b>Fig. 3. 7</b> variations of reflection axis in motifs exhibiting reflection symmetry. ....	68
<b>Fig. 3. 8</b> variations of rotations in motifs exhibiting rotational symmetry.....	68
<b>Fig. 3. 9</b> Seven variations of one-dimensional or frieze patterns. ....	69
<b>Fig. 3. 10</b> Seventeen variations of Two-dimensional patterns.....	70
<b>Fig. 3. 11</b> flowchart for analysing the one-dimensional(Seven classes) with one colour patterns.....	71

**Fig. 3. 12** Displaying the material study process of bricks and mortars of the monuments.... 72

**Fig. 4. 1** Variations of terracotta plaques on the side wall, Ghanasyam House, Sivasagar, Assam..... 76

**Fig. 4. 2** Floral stucco pattern on the wall of Rang Ghar, Sivasagar, Assam. .... 76

**Fig. 4. 3** Assam map showing districts of the considered brick monuments for the study. .... 77

**Fig. 4. 4** Systematic categorization chart for the motif types and pattern types , (Deori and Barua, 2021)..... 78

**Fig. 4. 5** Ghanasyam House with the key plan and structural study..... 80

**Fig. 4. 6** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Ghanasyam House. .... 81

**Fig. 4. 7** Namath Kali Temple of Nilachal Hills, Assam..... 81

**Fig. 4. 8** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Namath Kali temple..... 82

**Fig. 4. 9** (a)Font side of Rang Ghar with key plan (b)- source ASI ..... 83

**Fig. 4. 10** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Rang Ghar..... 84

**Fig. 4. 11** (a)Font side of Talatal Ghar with key plan (b)- source ASI..... 84

**Fig. 4. 12** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Talatal Ghar..... 85

**Fig. 4. 13** (a)Font side of Kareng Ghar with key plan (b)- source ASI..... 86

**Fig. 4. 14** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Kareng Ghar..... 86

**Fig. 5. 1** Terracotta monuments colours Ghansyam House and Namath Kali Temple ..... 105

**Fig. 5. 2** Comparison of *bada* section of Ghansyam House and Namath Kali Temple..... 106

**Fig. 5. 3** Percentage of pattern class in the pattern plaques of Ghanasyam House (a) and Namath Kali Temple(b) ..... 110

**Fig. 5. 4** Pie chart of percentage of pattern class variants of (a) Rang Ghar (b) Talatal Ghar and (c) Kareng Ghar..... 143

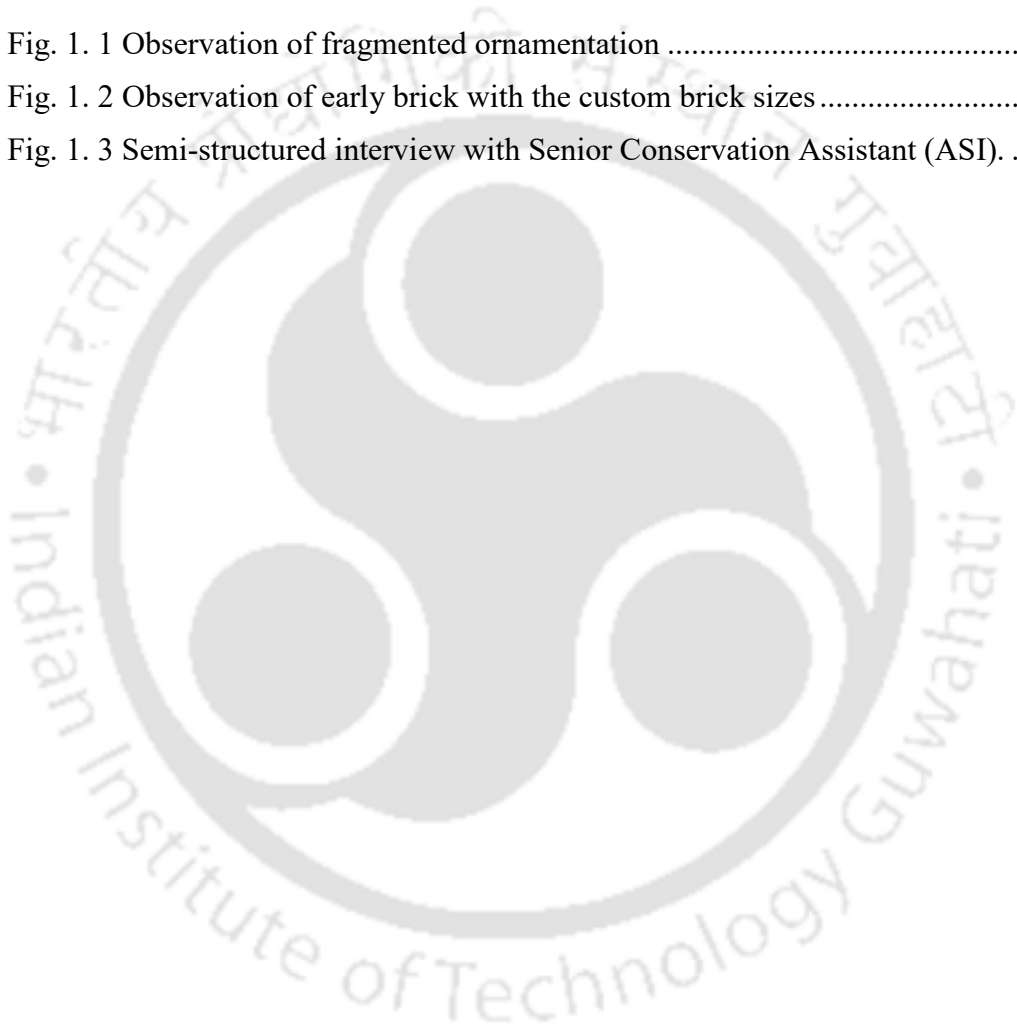
**Fig. 6. 1** Screenshot of Google Map displaying the geographical distance of Namath kali temple of Nilachal Hills and Ghanasyam House of Sivasagar by road. .... 145

**Fig. 6. 2** Zoomed in photo displaying particles of snail shells: Ghanasyam Mortar (left), Namath Kali Mortar (Right) ..... 146

**Fig. 6. 3** Electron micrograph (left) and EDX spectrum (right) of Ghanasyam House brick 147

<b>Fig. 6. 4</b> Electron micrograph (left) and EDX spectrum (right) of Namath Kali Temple brick .....	147
<b>Fig. 6. 5</b> Electron micrograph (left) and EDX spectrum (right) of Ghanasyam House mortar .....	147
<b>Fig. 6. 6</b> Electron micrograph (left) and EDX spectrum (right) of Namath Kali Temple mortar .....	147
<b>Fig. 6. 7</b> FTIR spectra of Bricks of Ghanasyam House and Namath Kali .....	149
<b>Fig. 6. 8</b> FTIR spectra of Mortar of Ghanasyam House and Namath Kali .....	150
<b>Fig. 6. 9</b> PXRD pattern of Bricks of Ghanasyam House and Namath Kali Temple. ....	150
<b>Fig. 6. 10</b> PXRD pattern of Mortar of Ghanasyam House and Namath Kali Temple .....	151
<b>Fig. 6. 11</b> PXRD pattern of Bricks of Kareng Ghar, Rang Ghar and Talatal Ghar .....	154
<b>Fig. 6. 12</b> PXRD pattern of Mortar of Kareng Ghar, Rang Ghar and Talatal Ghar .....	154
<b>Fig. 6. 13</b> FTIR spectra of Bricks of Kareng Ghar, Rang Ghar and Talatal Ghar .....	157
<b>Fig. 6. 14</b> FTIR spectra of Mortar of Kareng Ghar, Rang Ghar and Talatal Ghar .....	157
<b>Fig. 7. 1</b> a) pattern plaques of Gopinath Jor-Bangla Temple, Pabna, Bangladesh b) Pattern plaques of Ghanasyam House, Sivsagar, India .....	160
<b>Fig. 7. 2</b> a) Manjushri sculpture from 11th century, Bengal or Bangladesh   source: <a href="https://www.metmuseum.org/art/collection/search/38124">https://www.metmuseum.org/art/collection/search/38124</a> ; b) and c) entrance arches of Gangeswar Shiva Temple of 18th century, West Bengal, India; d) Entrance arches of Ghanasyam House of 16th-17th century, Assam, India. ....	161
<b>Fig. 7. 3</b> Panswé Belu (orge) found in Manuha Temple (1067 A.D.), Myanmar .....	162
<b>Fig. 7. 4</b> Rang Ghar horizontal panel compound motifs (Ran-M-Wa-C-05, 19, 26). ....	163
<b>Fig. 7. 5</b> Display of underlying design characteristic of the motifs used in terracotta-type monuments. ....	168
<b>Fig. 7. 6</b> Display of underlying design characteristic of the patterns used in terracotta-type monuments. ....	169
<b>Fig. 7. 7</b> Display of underlying design characteristic of the motifs used in stucco-type monuments. ....	172
<b>Fig. 7. 8</b> Display of underlying design characteristic of the patterns used in stucco-type monuments. ....	173
<b>Fig. 7. 9</b> Example of object detection (left) and semantic segmentation (right) .....	178
<b>Fig. 7. 10</b> The difference between machine learning and deep learning algorithms .....	179
<b>Fig. 7. 11</b> (a) is the original motif and (b) is a damaged motif. ....	181
<b>Fig. 7. 12</b> Two-stage model to restore a damaged image .....	181
Appx A Fig. 1. 1 Ghanasyam House, Sivasagar- Photographs of various sections of the monuments .....	189

Appx A Fig. 1. 2 Namath Kali Temple, Guwahati- Photographs of various sections of the monuments.....	190
Appx A Fig. 1. 3 Rang Ghar, Sivsagar- Photographs of various sections of the monuments .....	191
Appx A Fig. 1. 4 Talatal Ghar, Sivsagar- Photographs of various sections of the monuments .....	192
Appx A Fig. 1. 5 Talatal Ghar, Sivsagar- Photographs of various sections of the monuments .....	193
Appx B Fig. 1. 1 Observation of fragmented ornamentation .....	194
Appx B Fig. 1. 2 Observation of early brick with the custom brick sizes.....	194
Appx B Fig. 1. 3 Semi-structured interview with Senior Conservation Assistant (ASI). ....	194





## CHAPTER ONE: Introduction

The state of Assam falls in the easternmost part of India, its lies between latitudes 28° 18' and 24° North and longitudes 90° 46' and 94° 4' East. It is bounded on the North by the sub-Himalayan ranges of Bhutan and the state of Arunachal Pradesh; to the West lies the state of Meghalaya, West Bengal and Bangladesh. Towards the East, Assam is surrounded by Patkai range, which defines the Western boundary of Myanmar (Burma). To the Southern part, lies the states of Nagaland, Manipur, Mizoram and Tripura. Choudhury (2013) mentions that the plains area of Assam can be divided into two valleys, these are the Brahmaputra Valley and the Surma Valley, named after two principal rivers flowing in these areas. The Brahmaputra valley includes the middle portion of Assam with the districts of Dhuburi, Barpeta, Kamrup, Nalbari, Goalpara, Kokrajhar, Sonitpur, Darrang, Lakhimpur, Dibrugarh, Sivasagar, Charaideu, Jorhat, Nagaon and Kamrup.

Assam has a rich history of around 600 years of the Ahom dynasty. They ruled Assam from the 13<sup>th</sup> to 19<sup>th</sup> century. According to the Ahom chronicles, the Ahoms came from *Mong-Mao*, a *Tai*<sup>1</sup> state in South-Western Yunnan, in 1215 A.D., then migrated to Northern Burma crossing Patkai Hills. The Ahom settled in the Brahmaputra valley of Assam. Under the Ahom kingdom, the art and architecture flourished remarkably during the late medieval era (Barpujari, 2007). They built many buildings, temples and houses using stones and bricks. Initially, the constructions were made of timber and bamboo, but the buildings did not sustain for long durations; hence stones and bricks were used for construction purposes (R. Gupta, 1982). Today, the Ahom architectures are part of the Assamese culture as religious buildings like temples or *Dols* and non-religious buildings like heritage monuments. These buildings are the pride of Assamese culture, as it endorses the admiration for Ahom dynasty. With the support of the Archaeological Survey of India (ASI), Guwahati Circle, Assam and Directorate of Archaeology, Guwahati, Assam most of the Ahom monuments are preserved.

### 1.1 Architectural Ornamentation

In architecture, the ornamentations are part of embellishments to the buildings to display distinctiveness. Literature mentions the use of architectural ornamentations from the Egyptian age. Architectural ornamentation in India is distinguishable from 274 B.C. during the Mauryan

---

<sup>1</sup> *Tai* people are a subgroup of *Tai* language speakers who are widely distributed in Southeast Asia and the Yunnan Province of Southwest China.

ruler of Magadha, *Ashoka* (Verma, 2014). With time and the advent of various dynasties, India's ornamentation evolved with cultural diffusion, adaptation and adoption. In the context of architectural evolution, Assam had the advent of dynasties like Guptas, Varmans, Palas; with them, new styles and ornamentations were inculcated in architecture (Ahmed, 1994; Barpujari, 2007; Das, 2007, 2019; R. Gupta, 1982; Sarma, 1988). The Ahom architecture flourished during the late mediaeval era. These architectures include stone cuts, stucco reliefs and terracotta moulds as part of ornamentations in brick masonry buildings. The ornamentations are rich with religious sculptures, human figures, vegetal and geometric forms.

## 1.2 Ahom Brick monuments

Today, the heritage of the Ahom architecture can be observed in many stone and masonry monuments. Many stone and brick monuments are in the Guwahati, Tezpur, Jorhat, Sivasagar and Charaideu area (ASI, n.d.). However, with due course of time, the brick monuments have survived in fragments. This is due to the clay material type with environmental conditions and natural causes. The pilot study reveals that, the **Namath Kali Temple** of Nilachal Hills, **Ghanasyam House**, **Rang Ghar**, **Talatal Ghar** of Sivasagar district and **Kareng Ghar** of Charaideu district of Assam are the only brick monuments with survived ornamentations. Intriguingly, the Ghanasyam House of Sivasagar and Namath Kali Temple of Nilachal Hills, display similarities in architectural style, although they are geographically (363 km approx.) far away from each other. Both these monuments have terracotta ornamentations with similar tiling styles. Stucco ornamentation is the other type of ornamentation observed in the Ahom brick monuments. This type of ornamentation is commonly observed in the Rang Ghar, Talatal Ghar and Kareng Ghar monuments. The overall visual study of these brick monuments distinctly categorizes these two variations of ornamentations- i) the **terracotta ornamentations** and ii) the **stucco ornamentations** as both require a different craftsmanship. The terracotta includes brunt clay to create various decorative moulds; these moulds or plaques are tiled to achieve a unified ornamented structure. The stucco ornaments or stuccowork in architecture includes refined exterior or interior plasterwork used as three-dimensional ornamentation that considers sculpting to create various forms and shapes for architectural embellishments.

It was observed that refurbishment of some stucco ornaments lacks the early aesthetics and essence, resulting in disharmony in the overall ornamentation. To date, multiple studies related to monument sculptures and iconographies are undertaken and are primarily descriptive. The visual study on the ornamentation of the Ahom brick architecture is still yet

to be explored and documented. To understand the brick architectural ornamentations of the Ahom dynasty, the study focuses on the visual characteristics of the motifs and patterns used in the monuments mentioned above. The material study of the construction materials is considered to understand the early construction technology.

### **1.3 Research Justification.**

Assam is blessed with rich culture and heritage. The Ahoms had a remarkable influence on its development in art and architecture. Rich with various imprints of early masonry architecture, the development of the tourism industry had a significant impact on these tangible heritage sites. With the rapid increase in tourism infrastructure, these tangible heritage sites are a great source of economic development. With consideration of development comes the pressure to increase footfalls in these heritage sites. Henceforth, the refurbishments of the heritage sites are initiated to create awareness and bring a sense of pride to the native individuals. With the increase in renovations in various sites, the consideration of early ornamentation and its aesthetic sense gets diluted due to a lack of research and systematic visual documentation. The visual forms and shapes are distinctly different from the original ornamentation. This not only dilutes the initial quintessence of the ornamentation but ignores the early artisans' craftsmanship values and idioms in terms of art and architecture. The reformed shapes wipe the underlying structural forms and shapes of the ornamentation. Gradually, these new forms will be considered part of history, resulting in tampering with the ancient art and architecture of Assam. This sudden change in lieu of development fades the ornamentation aesthetics of the fragmented monuments. To create awareness and sensitivity and conserve the traditional art and architecture of these monuments, in-depth visual study and systematic documentation of these ornamentations are much needed.

For a building to be an architecture, the context, functionality and aesthetic sense should cater simultaneously. The means of expression in architecture lies in materiality. As William Morris, a renowned English textile designer and architectural conservationist, quotes, "Material is clearly the foundation of architecture and perhaps one would not go very far wrong if one defined architecture as the art of building suitably with suitable material. There are certainly many other things which are considered architectural and yet not nearly so intimately and essentially a part of architecture, as a consideration of material". The inclusion of material study provides insights on the architect's choices in terms of building form and structure. During the Ahom reign, the concept of masonry architecture was established by considering burnt bricks and mortar. The inclusion of these materials in architecture has motivated the

architects to develop structures that establishes relationship between visual quality and structural ability. This also highlights their vision of eternal glorification of rulers with the engineering capabilities of that era. The use of bricks and mortars in architecture stimulated the artisans to explore the materials to develop design styles and structures. This is evidently seen in the form of Architectural ornamentation. The development architectural ornamentations are best displayed because of the choice of construction materials. The artisans had the leverage to curve and mould organic and geometric forms as ornamentation.

Hence, to provide a holistic approach to the study, the understanding of materials and the visual significance of Ahom ornamentation specific to brick masonry architecture is considered. Considering both factors, it provides a good scope and opportunity to study the brick ornamentations of the Ahom dynasty. Works of literature on the material study of these monuments are significantly rare; to understand the early constructions, the material study will provide information on early constructions techniques and compositions.

#### **1.4 Research Problem**

To date, most scholars and historians undertake studies related to monument sculptures and iconographies. (Ahmed, 1994; Barpujari, 2007; Choudhury, 2013; Gupta, 1982; Sarma, 1988) have studied extensively of early temple architectures, Ahom architectures and iconography. These studies are primarily descriptive. However, the study on architectural ornamentations is sporadic.

Verma (2014) highlights the details of ornamentations styles with materials in Indian Architectures. Nevertheless, the inclusion of architectural styles and ornamentations of the North-eastern part of India was not to be seen. This may be due to a lack of early documentation.

As early monuments are in bricks, these monuments have survived in fragments over time. This is due to the clay material type with environmental conditions and natural causes. During the pilot study, it was also observed that refurbishment of some ornaments lacks ancient aesthetics in some monuments, resulting in disharmony in the overall ornamentation. Considering both the factors, it provides a good scope and opportunity to study the brick ornamentations of the Ahom dynasty. Works of literature on the material study of these monuments are rare. In order to understand the early constructions, the material study will provide information on early constructions techniques and compositions.

## 1.5 Research Questions.

1. What are the visual characteristics of the Ahom brick architectural ornamentations?
2. What visual forms are used in motifs and patterns of brick monuments?
3. Who were the artisans of the Ahom monuments? What were their inspirations?
4. What were the early material considerations of Ahom brick architectures?

## 1.6 Research Aim & Objectives

**Aim:** To study the visual elements of ornamentations of Ahom brick monuments.

**Objectives:**

1. To study and identify the visual characteristic of Ahom brick Ornamentations.
2. To study and analyse the visual forms used in motifs and patterns of the brick monuments.
3. To study and understand the art and architecture of the Ahom dynasty.
4. To study the early construction material and technology of Ahom brick monuments.

## 1.7 Research Methodology

The initial study embraces historical and descriptive approach to understand the background of Ahom in Assam. Photo, video documentations and semi-structured interviews are adopted for data collection. Details of data collection and sorting of data using categorization theory of Athavankar (1989) are being discussed. The categorisation theory divides the data into three levels: *superordinate, basic and subordinate levels*. The subordinate level segregates the data into various motif and pattern types. With the categorised data; Variation, Visual and Symmetry analysis are considered. The variation analysis includes the studying the motifs and pattern variants based on motif and pattern types and its structural compositions. The visual analysis considers the analysis of shapes, forms, colour and textures used in the motifs and pattern compositions. The symmetry analysis includes the basic symmetry operations- *rotational, reflectional, translation and glide reflection*. It also considers pattern classes to study the variations in structural arrangements. These pattern classes include one-dimensional and two-dimensional pattern classes. There are seven variants of these one-dimensional pattern variants and seventeen variants of two-dimensional pattern variants. The flowchart to analyse the one-dimensional pattern classes is adopted from Washburn and Crowe (1988). Another section of the data collection was related to material study, where small portions of brick and mortar samples of the selected monuments are collected. The collection process and the testing

process like Energy Dispersive X-Ray Analysis (EDX), Fourier Transform Infrared Spectroscopy (FT-IR), X-Ray Powder Diffraction Analysis (PXRD) are considered to understand the early construction technology.

## **1. 8 Conclusion**

This chapter provides a brief outline of the thesis. It explains the research background, the research justification and the research problems. Based on it, the research questions and objectives are generated. These objectives provide the scope to study the visual characteristics of the architectural ornamentations of the Ahom dynasty of Assam.

The next chapter includes the literature study on the Indian architectural ornamentations and the Ahom art and architecture and its influences.



## CHAPTER TWO: Literature Review

### 2.1 Ornamentation

Since prehistoric times, people have searched for ways to give visual form to ideas and concepts, store knowledge in visual form and bring order and clarity to information. Meggs & Purvis (2012) mentions, “Speech—the ability to make sounds in order to communicate—was an early skill developed by the species (humans) on the long evolutionary trail from its archaic beginnings. Writing is the visual counterpart of speech”. If we consider the prehistoric cave drawings, these cave drawings were made for survival and for utilitarian and ritualistic purposes. The abstract geometric sign including dots, squares and fusion with natural habitats like animals, are seen from early cave paintings. Inclusion of imagery and patterns from ancient times helps to express their belief system and artistic taste and fundamentally it was always a medium of communication. The use of ornamentation in different cultures has always been an intention to create value that can be incorporated in textiles, pottery, weapons, architectures, paintings, manuscripts etc. This was attempted by applying abstract or representational forms with symbolic meanings. Although developing the ornamentations takes time, the vital purpose is communication. It portrays the artisan’s intention to connect the nature, spiritual worlds or the mythical world, which may go beyond the materialistic world.

From the age of early Indian armours, which dates from the Vedic period (c. 1500 – c. 500 BCE), we can see the use of crest, flags and armours of various dynasties or kingdoms to identify themselves to be part of a community or kingdom. The inclusion of these symbols or patterns defines the survival of their race. It is the proclamation of a particular tribe, kingdom, its culture or beliefs. Architectural ornaments act in the same way. The manifestation of imagery, patterns and configurations help to define their existence in terms of rulers, dynasty, culture, beliefs and philosophy.

According to the Oxford dictionary, 2020, “an ornament is a thing used or serving to make something look more attractive but usually having no practical purpose”. Its origin is from Old French *ournement* and from Latin *ornamentum* which means equipment. The Latin verb is *ornare* ‘adorn’. The verb dates from the early 18<sup>th</sup> century. Ornamentation are decorative elements added to something to enhance its appearance. *Ornare* which means - to confer honour or grace; to dress; to equip; to decorate, furnish, adorn, garnish, trim, embellish or to beautify.

Stevens W. Semes (2004) in his book ‘*The Architecture of Classical Interior*’ mentions that- it may be defined as the architecture of the near view. For example, Ajanta Ellora caves

of India, where the overall structure adorns visual elements with patterns and details of each composition could be distinguished. Another way that we might define ornaments “is an enrichment of a building in order to reveal a building’s purpose or use”. Whereas decoration “is an enrichment of architecture that adds beauty by making the structural systems at work more legible ... it is a poetic expression of structure” (McNamara, 2009). According to Kent Bloomer one of the renown American sculptor, professor and author who is a well-known proponent and creator of architectural ornament, “ornament is a system of figuration which must absolutely must connect to and become embodied with the thing being ornamented. Achieving that union is the absolute property”. The ornaments cannot be autonomous, it is the union with the holder, that brings the soul of ornamentation. Ornaments can be elements of decoration, but it is not fundamentally decoration, it is something that are put inside the system of a decoration. Verma (2014) in his book ‘*Ornamentation in Indian Architecture*’ states that, “For a building to become architecture, it must be thematically essentialized through a process of ornamentation. The product of this proceeds is ‘ornament’- something employed to adorn, beautifully, or embellish, or that naturally does this”.

Most ornamentation manifests into **motifs** and **patterns**. The motif in architecture is structural designs, especially found repeated in buildings and the patterns are designed in repetition on shapes, forms, lines and colours. Hann (2013) states that “motifs are generally considered to be visual building blocks, found in regularly repeating compositions. They may be free-standing, may form a repeating unit in a regular pattern or may form a component of a larger nonrepeating composition.” He also adds that using representational forms like flowers as motifs or geometrical forms like swastika may have inherited symbolism or be used just for ornamental purposes. Architectural patterns play an essential role in influencing culture. Washburn and Crowe (1988) observed that the titles of the renowned works by Owen Jones (*The Grammar of Ornament*, 1987 [1856]) and Flinders Petrie (*Decorative Patterns of the Ancient World*, 1974 [1930]) implied that surface patterns served the purpose of embellishment and decoration rather than communication. Further to this, they stated that “non-representational patterns not only decorate but also act as visual voices that communicate important cultural information in conjunction with verbalized speech and song”. A very good example in non-representational design in India, is the Hindu temple architecture. In Hindu beliefs, number is considered an expression of the structure of the universe and a means of effecting the interplay between the universe and man (Michell, 1988). The construction of Hindu temples is based on the geometry of *Vastu purasha mandala*; where the concept of *Purasha* was made to the abstract idea of a square as the highest geometric form. In the

foundation of any Hindu temple, cosmos is embodied by laying down the diagram of *Vastu purasha mandala* on a selected ground. This divine diagram reflects the image of cosmos through its fractal qualities (Md Rian et al., 2007). The Mandala can be considered an ideogram, while the temple is the material manifestation of the concepts it embodies (Trivedi, 1993). To be able to convey these meanings through form, a strong relationship had to be developed between form and meanings in a decipherable language. This relationship that develops between forms and their meanings within the Hindu temple is essential to its function as a link between the gods and man (Michell, 1988). In the foundation of any Hindu temple, cosmos is embodied by laying down the diagram of *Vastu purasha mandala* on a selected ground. This divine diagram reflects the image of cosmos through its fractal qualities (Md Rian et al., 2007).

With the intention to understand the underlying structure of ornamentation, this thesis primarily focuses on the architectural motifs and patterns of the brick architecture of Ahom dynasty of Assam, India. To understand and analyse the ornamentation of a specific time period, geography and culture of Assam, the broader context of architectural ornamentation needs to be considered. As India has a diverse geography, the background study includes the pivotal phases starting from the early discerned ornamentation with varied styles amended with different dynasties and periods.

### **2.1.1 Indian architectural ornamentation**

The Indian architectural ornamentations are assumed to have emerged during the 3<sup>rd</sup> century B.C. with *Ashoka*, the third Mauryan ruler of Magadha, who conquered the throne in 274 BC. With his ascendancy, the illustrated Buddhist art came into the art and architecture of that era. These arts are witnessed in monolithic pillars, stupas, groups of rock-cut chambers and shrines. In due course of time, it had a prodigious influence on early Indian art and architecture.

The early form of expression is mostly observed in woods. Henceforth, finding another material like dressed stone is a pivotal step in the cultural evolution of the people. The emergence of Buddhism during the reign of Ashoka manifest the development of arts in India. Inspirations from Greek, Persian and perhaps Egyptian shapes and decorative forms are seen in the extractions. Brown (2021) mentions that the development of the stonework which Ashoka introduced represents an Indian offshoot of that forceful Greco-Persian culture that flourished with vigor in Western Asia.

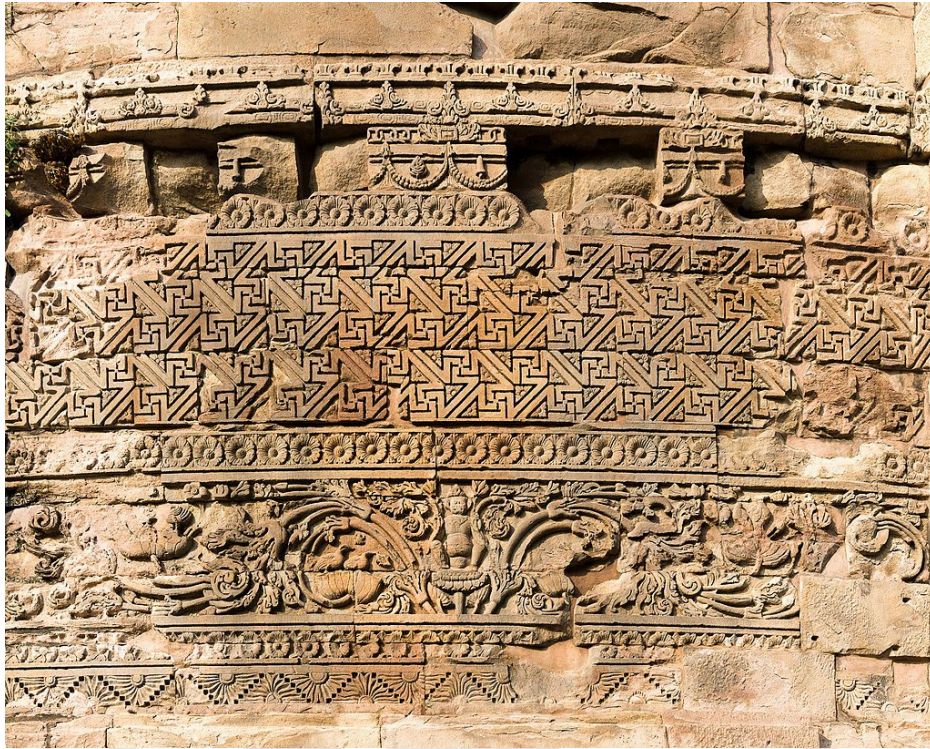
The influences of Hellenic, Pharaonic and Iranian elements are witnessed in Buddhist ornamentations of India. The architectural synthesis of Indian traditional art is described in

*Sanchi toranas* (Fig. 2.1) during the *Sungas* and *Andhras* dynasties (185 BC-AD 150). The immersion of Indian symbolic motifs of Vedic times like the *trisula* (Trident), the wheel, the lotus, the tree of life and many other motifs were part of the Buddhist art and reproduced as architectural ornamentation. The use of ornaments in Buddhist architecture unravelled the aesthetic exquisiteness, grace and relevance in architectural magnificence in India.



**Fig 2. 1** The Great Stupa at Sanchi

Source-<https://en.wikipedia.org/wiki/Sanchi>



**Fig 2. 2** Floral and geometric ornamentation of Dhamek Stupa, Uttar Pradesh, India.

Source- [https://en.wikipedia.org/wiki/Dhamek\\_Stupa](https://en.wikipedia.org/wiki/Dhamek_Stupa)

The varied opulence of ornamentation flourished in the Dhamek Stupa (**Fig. 2.2**) at Sarnath (c. AD 600) with various organic and geometric forms. The usage of vegetal scrolls with diaper patterns on the stone demonstrates the skills and considerations of striking designs for architectural ornamentation by the rulers. Another marvel of stone cut ornamentation of the Buddhist art is observed in Ajanta caves of India, which is declared a UNESCO World Heritage site. The cave is located 107 kilometres from Aurangabad, Maharashtra. Historians and archaeologists state that the first Buddhist cave monuments at Ajanta date from the 2<sup>nd</sup> and 1<sup>st</sup> centuries B.C. Many more ornately ornamented caves were added to the original group during the Gupta period (5<sup>th</sup> and 6<sup>th</sup> centuries A.D.). There are thirty rock-cut caves divided into *Viharas* (monasteries) and these are filled with brilliant wall paintings and rock-cut sculptures of Buddhist art (**Fig. 2.3**).



**Fig 2. 3** Ajanta cave number 26

Source: [https://en.wikipedia.org/wiki/Ajanta\\_Caves](https://en.wikipedia.org/wiki/Ajanta_Caves)

Some essence of Gupta style ornamentations is seen with spiral motifs, a combination of wave-like curves with proliferated flowers and vines visible in the massive fragmented entrance arches of Qutb Mosque of Delhi (1192). Near to that, the Iron pillar of the 4<sup>th</sup> – 5<sup>th</sup> century is seen (**Fig. 2.4**). This demonstrates the considerations of the Gupta ornamentation style by the Delhi sultanate ruler.



**Fig 2. 4** Entrance arches of Qutb Mosque of Delhi (1192)

Source- <https://smarthistory.org/qutb-delhi-sultanate/>

With the Gupta style of ornamentations in architecture comes the *Chalukyan*<sup>2</sup> Architecture (c. AD 450-650). The Chalukyan architecture reveals similarities with the Gupta style with detailed use of vegetal patterns, motifs and sculpting are part of the temple ornamentation. The exhibition of the refined work is observed in most of the early Hindu and Jain temple architecture. One of the refined works of Chalukyan architecture is the *Kailasha* Temple of Ellora. This temple displays exemplary works in rock-cut sculpting. It is considered one of the most remarkable cave temples of the world in terms of architectural type, size and sculpting techniques. Rock cut visual narratives of *Ramayana* and *Mahabharata* are observed as panels in the temple (Fig. 2.5).

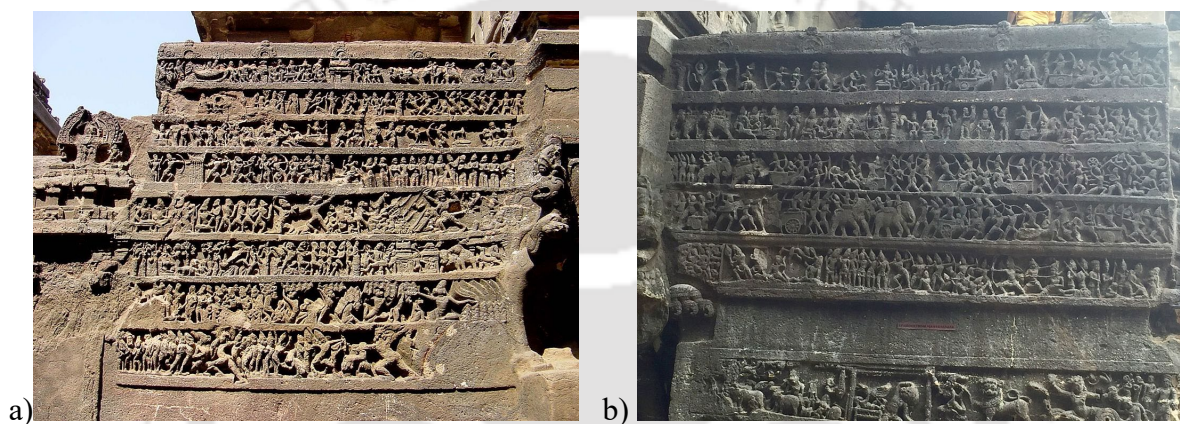


Fig 2. 5 (a) *Ramayana* and b) *Mahabharata* sculpting in Kailasa Temple Ellora

Source: [https://en.wikipedia.org/wiki/Kailasa\\_Temple,\\_Ellora](https://en.wikipedia.org/wiki/Kailasa_Temple,_Ellora)

The *mandapas*<sup>3</sup> and *rathas*<sup>4</sup> of the Pallava dynasty (c. AD 600-900) exhibit beautiful architectural ornamentation along with sculptures in them. The *Badami* and *Pattadakal* temples of the Cholas (AD 900-1150) include figurative forms and animal motifs in architecture. The Chola showcase the prodigious richness in designs of ornamental compositions in architecture. One of the finest examples is the “tree of knowledge” motif found in the temple of Tanjore.

The *gopurams*<sup>5</sup> under the Pandayas (c. AD 1100-1350), the earliest of their kind, are of the more superficial and conventional variety and their decoration is mainly of the architectural

<sup>2</sup> The *Chalukya* dynasty was a Classical Indian dynasty that ruled large parts of southern and central India between the 6th and the 12th centuries.

<sup>3</sup> *Mandapa* in Indian architecture, especially Hindu temple architecture, is a pillared hall or pavilion for public rituals.

<sup>4</sup> In Hindu temple architecture, *ratha* is a facet or vertical offset projection on the plan of the sanctum and *shikhara* above, or other structure. The *shikhara*, a Sanskrit word translating literally to "mountain peak", refers to the rising tower in the Hindu temple architecture of North India,

<sup>5</sup> A *gopuram* or *gopura* is a monumental entrance tower, usually ornate, at the entrance of a Hindu temple, in the Dravidian architecture of the Southern India.

type. During the Vijayanagar dynasty (AD 1350-1565), the religious building includes diverse groups of structures and forms with plastic embellishment in the ornamentation. These temples follow mostly the Dravidian-style temple architecture.

Towards the north, the temples of Orissa, particularly in Bhubaneswar, Puri and Konar follow the Indo-Aryan style of temple architecture. This group of temples has highly ornamented walls with surfaces filled with abundant patterns and figurative forms. The figurative forms in the temples exhibit multifarious details and varied posture spread all over the walls of the temples. This emphasizes the sincere considerations of figurative forms and patterns as an integral part of the Orissan temple ornamentation. The use of geometrical, vegetal, mythical and animal forms is prominent as ornamentation. The Khajuraho temples (AD 950-1050) has one of the finest and admirable display of ornamentation in Orissan style. (Verma, 2014) states that the Khajuraho temples display commendable results in implementing sculptures carved in high relief, motifs and parallel friezes with ornate interiors. The ceiling (shallow dome) of Khajuraho temples produces the detailed ornamentation compositions. The design selected is usually a geometrical one comprising intersecting circles that form a series of semi-spherical recesses with a long, richly carved pendant dropping from the center of each (Fig. 2.6).



**Fig 2. 6** Ceiling (shallow dome) of Khajuraho temples

Source- [https://en.wikipedia.org/wiki/Khajuraho\\_Group\\_of\\_Monuments](https://en.wikipedia.org/wiki/Khajuraho_Group_of_Monuments)

Considering all the evolutions of the early architectural monuments from Buddhist art to Hindu art, vegetal and figurative forms are embellished in walls, pillars, roofs and entrances of the architecture. The floral motifs are inspired by botanical forms such as lotus, rosettes and stylized branches with complex compositions that include animal figurative forms. The extravagant foliage and mythical animals such as *makara*<sup>6</sup>, the fish-tailed elephant (*matangunarka*) and numerous motifs, including trident, the railing motif, wheels, bell shapes, vases (*ghatapallava*), winged lions (*sapaksha-singha*), griffin (*syena-vyala*) and "Tree of Life" are the sacrosanct elements of the early Indian ornamentation which are reproduced extensively. The figurative forms like humans, mythical humans, deities and demons are part of the temple structures.

Bosham (2004) precisely observes that most Hindu, Buddhist and Jain-like temple structures use human female form as ornamental motifs. He further mentions, 'the form is always scantily dressed and nearly always in accordance with Indian standards of beauty'. Apart from the organic forms and structures, the consideration of geometric forms is also part of the Buddhist Hindu and Jain architectural ornamentation. Motifs ranged from simple concentric circles and pointed ovals; some symbolic motifs with geometrical forms include the lozenge and *Swastika* motif.

Indian architecture acknowledged a new dimension of art after the advent of Muhammadans. The interior and exterior of the buildings were designed with flamboyant and vibrant stones. Painted plasters and tiles were segments of the architectural ornamentation. With these evolvments of the material, visual art and composition, it was an era of transition and adaptation. This phase of coloration of architectural art in Indian is the phase of 'Indo-Islamic art'. The Indo-Islamic art propagated the use of white marble and red sandstones with geometrical design and patterns of subtle curves in architecture. Another significant addition to this art is the inscription of calligraphy as ornamentation in architecture; one of the finest examples is the Qutb Minar of Delhi (**Fig. 2.7**). In Islam, calligraphy is bestowed as prestige superior to any other art form. It is considered a visual expression of the highest art of all; the art of the spoken world. One of the main characteristics of Islamic art is the paramount importance of calligraphy. Apart from calligraphy in architecture, the use of extensive scrollwork, arabesques, geometric motifs and interlace patterns, friezes with palmettes and

---

<sup>6</sup> *Makara* is a water monster of Hindu religious myth that is represented in religious art. It is mythical sea creature. It is usually described as a half terrestrial animal such as an elephant, crocodile, or deer in the frontal part and half-aquatic animal in the other part, usually of a fish or a seal.

leaves, medallions, cartouches, pendants, crescents, stars and latticework are observed in Indo-Islamic architecture.

(Verma, 2014) mentions that the geometric patterns are used repeatedly in the ornamentation. These have developed over the centuries. Most of these are derived from various cultures: Greek, Roman, Byzantine, Central Asian and Persian. They are usually distinguished from the arabesque term in Islamic art based on curving and branching vegetal forms.



Fig 2. 7 Calligraphy with vegetal and geometric ornamentations of Qutb Minar, Delhi.

Source-<https://lighteddream.wordpress.com/2016/05/04/whispering-stones-of-qutb-complex-forgotten-calligraphy-and-hidden-symbols/>

### 2.1.2 Architectural ornamentations during Gupta Age in Assam

With these evolutions of ornamentations with details of stone cuts to plaques in masonry architecture, the explorations of art and architecture in various places of mainstream India were discernable. These works of art and architecture were noticeably spreading in the North-eastern part of India, in the State of Assam.

The early phase of the architecture of Assam is still not known distinctly. It is not known what type of architecture was originally developed in Assam. Sarma (1988) states 'Brown, (2021) has primarily studied the genesis of Indian architecture, but Assam lacks sources that could help us in assessing how the original architecture of this land looked like; instead, the existing primitive monuments of the State such as *dolmen*, *megalith*, *menhir*, etc., both in hills as well as in plains and simultaneous survival of many tribal usages to this date make us believe

that whatever methodical and scientific architecture developed in this region was basically exotic.’ Most of the early architectural ruins, specifically the rock-cut sculptures, are in fragments. This is due to natural causes like the earthquake of 1950, which almost destroyed the early evidence of the era. Apart from that, the effect of vegetal growth, human encroachments and weather conditions has catalyzed the impact.

With the existing ruins and archeological excavations, the architectures showcase the advent of the Gupta style and are considered the vigor stage of the architectural development in Assam. The development of this architecture was so influential that its effects and outcomes can be traced from the Gupta period till the end of the early mediaeval period. According to history, the early mediaeval ruling dynasties of Assam documents were the *Varmana dynasty* from 4<sup>th</sup> to 7<sup>th</sup> century A.D., then came the *Salastambha dynasty* (7<sup>th</sup>- 10<sup>th</sup> century A.D.) and the *Pala dynasty* (11<sup>th</sup> -12<sup>th</sup> century A.D.). During the Varmana Dynasty, the influence of the Gupta art is visible in most of the remains and ruins of Brahmaputra valley. Sarma (1988) mentions that these records are so meagre and irregular that it is almost impossible to trace the early roots of architecture. However, despite vacant interspaces and missing links among them, the gradual propagation of the Gupta ideas to this region appears to be almost synchronal.

Some of the survived remains of the Gupta influence can be seen in the cave temple *Umachala* (5<sup>th</sup> century A.D.) in Guwahati, with stone inscriptions. This inscription is essential not only because it is the earliest historical record discovered within the State so far but because it records the establishment of the first temple ever built in the Brahmaputra valley (Agarwal, 1965). Incised on the northern face of a rock, this inscription informs us about a cave temple caused to be constructed by *Maharajadhiraja Sri Surendravarmana*. The temple of Barganga, of Nowgong (currently Nagoan) district of Assam, also reflects the influence of the Gupta style in Architecture. The passage of the temple displays two human figures, holding *trisula* (trident) sculpted in stone. Along with it several other sculptures are also observed.

The *Da-Parvatiya* temple (**Fig. 2.8**) of Tezpur in the Darang district of Assam is one of the remarkable surviving stone structures of 5<sup>th</sup> – 6<sup>th</sup> centuries. Many historians and scholars have done extensive research on it. The structure resonances as one of the refined art styles of the Gupta idioms. The structure is a stone door frame highly ornamented with floral motifs, vegetal scrolls, human figures with complex posture and deities. The ornamental work exhibits the exceptional artistry of the artificer. According to (Agarwal, 1965), the door-frame of the Gupta period may contain the following features that projects an image in the center of the lintel, attendant figures, auspicious birds on wings, stylized swastika, full vase, amorous couples, foliated scrolls, rosettes and the figures of Ganga and Yamuna. The arrangement of

the lintel always overshoots the outer span of the two jambs. The *Da Parvatiya* door-frame possesses most of these elements. Its *lalāta bimba*<sup>7</sup> contains a figure with prominent wings which has been identified with *Garuda*<sup>8</sup>, the vehicle of the god *Viṣṇu*. The temple appears to have been dedicated to *Viṣṇu*.



Fig 2. 8 The Dah-parvatiya temple stone door, Tezpur, Assam.

### 2.1.3 Architectural ornamentations post Gupta age in Assam

The cultural influence of the Gupta Age did not end abruptly, though it is mentioned that the political essence diminished by 5<sup>th</sup> century A.D.; the cultural impact lasted for another century till 6<sup>th</sup> century A.D. The Varman came under the influence of the Gupta empire in the 4<sup>th</sup> century. Hence, they continue with the similar art of the Guptas from 6<sup>th</sup> to 7<sup>th</sup> century A.D. The archeological remains and the history remind us that the Gupta influenced the traditional plastic art of Assam, which continued until the Varmana period 650 A.D. The Gupta architecture underwent further experimentation and improvement till standardization of procedure was arrived at by the middle of the 8<sup>th</sup> century A.D.

<sup>7</sup> *lalāta bimba* is a block in the centre of a lintel to be carved into an image.

<sup>8</sup> *Garuda* is a mythical bird or bird-like creature in Hindu, Buddhist and Jain faith.

The post-Gupta period showcased the evolution of art activities in Assam. The *Salastambha* Period (7<sup>th</sup> – 10<sup>th</sup> Century A.D.) advent after the *Varmana* Period. During this period, traces of an attempt to establish a local school are unmistakably discernible in the remains of art ascribed to the period. This trend continued throughout the sculptural activities till the 12<sup>th</sup> century A.D. Ahmed (1994) mentions that this attempt was, to some extent, effective in instituting an independent school of art which would be termed as '*Kamarupa school*.' The attempt to founding such a school was partially prosperous as it is evident from the archaeological remains of the pre-Ahom art of Assam that they exhibit a diverse form of Orissa or Kalinga school, a later form of the Gupta tradition. The theme and technique of the art objects of the pre-Ahom Assam are almost in the same idiom as the art movement prevalent in Central India. However, the physiognomic and anatomical depiction is solely local.



Fig 2. 9 Bamini Hills, Cole park Stone ornamented ruins, Tezpur.

Most of the remains of the *Salastambha* period comes from Tezpur, the Head Quarters of the modern Sonitpur district. The Cole park of Tezpur (Fig. 2.9) has the most refined works of rock cuts and rock sculpting in fragments. According to R.D. Banerji, a renowned Archeologist, the Cole Park ruins belong to three different periods of history and therefore the ruins belong to three separate building. The remains signify the richness in stone sculpting of that particular era. These ruins exhibit varied ornamentation styles with the amalgamation of figurative, vegetal and geometric forms. It moreover unveils that the fragments are part of stone temple architecture of *Pancaratha*<sup>9</sup> style, depicting Orissan temple motifs. Diamond shaped

<sup>9</sup> A Hindu temple is a *pancharatha* when there are five *ratha* (on plan) or *paga* (on elevation) on the tower of the temple (generally a shikhara). The *rathas* are vertical offset projection or facets. The name comes from the sanskrit *Pancha* (five) and *Ratha* (chariot), but the link with the concept of chariot is not clear.

rosettes, *Kriittimukha*<sup>10</sup> (Fig 2. 10) motifs, human figures, varied floral motifs and patterns, animal and birds, arabesque designs with sculpture of Hindu God *Visnu*, *Brahma*.

The Ruins of *Mikirati* near *Doboka* display the architectural traditions from 6<sup>th</sup> to 12<sup>th</sup> Century A.D. Use of brick-masonry with stone in architecture is observed with the remains of rock-cut door lintel. These remains have a similar style of ornamentations with the Cole Park rock lintels of Tezpur. Towards the west, within four kilometers, lies *Gachatal*. The ruins here are ornamented with figurative forms, vegetal and geometric patterns. The sculptures of Hindu gods and goddesses are observed, with motifs of elephants, flowers, foliage, animals and birds.



**Fig 2. 10** *Kirtimukha* on stone slabs, Rajbari, c.11th century CE. (Saikia and Das, 2021)

Source: <https://www.ancient-asia-journal.com/article/10.5334/aa.211/>

In the Nagaon district of Assam, the *Rajbari* group of temples of the Jogijan Mauza is the only site with the biggest architectural attempts and the optimum stone carving. The place showcases brick–masonry architectures, which are constructed in the later phase. The combination of brick and stone construction displays the exceptional craftsmanship of the

---

<sup>10</sup> *Kirtimukha* is the name of a swallowing fierce monster face with huge fangs and gaping mouth, very common in the iconography of Hindu temple architecture in India and Southeast Asia and often also found in Buddhist architecture.

artisans. The temple number four amongst the *Rajbari* group temple exhibits the finest sculptures. The stone pieces bear number of design forms such as temple motifs, scroll, arabesques, floral, leafy, geometrical patterns with symbolic motifs like *Kritimukha* friezes (Fig. 2.10) and human form with intricate posture (Saikia & Das, 2021). Although the Temple group has variations in ornamentation, the overall structure resembles the 9<sup>th</sup> – 11<sup>th</sup> century architectural style.

#### 2.1.4 Architectural ornamentations during Pala dynasty of Assam

The with the diffusion of the *Varmana* dynasty came the advent of the *Pala* dynasty (11<sup>th</sup> – 12<sup>th</sup> Century A.D.) of Assam. During the Pala dynasty, the art and architecture of the era progressed prolifically. The early architectures showcased the exceptional skills of Rock-cut and sculpting; with the beginning of the Pala dynasty, the blend of stone and brick-masonry works emerged profoundly. Barpujari (2007) mentions that the remains of this period became the basis of the architectural activities of the late-mediaeval Assam. He further adds, “it can further be said with confidence that though the building tradition of the early mediaeval Assam did not continue in the later mediaeval times, it served as a prime source of inspiration and a guide for at least the starting of a new phase of temple building in late-mediaeval Assam.” Sarma (1988) identifies the artistic evolution of Pala in terms of architectural features: i) the temples became more diminutive in stature but increased in their number and ii) the temples became more ornamental.

The *Madan-Kamdeva Pahar* was observed as one of the busiest centres of architectural activities during the Pala period. The area is located on a small hill approximately 20 km from Guwahati, Assam. Stone cut blocks ruins are ornamented with human figures, animals, *Kritimukha* motif and vegetal patterns. Near to Guwahati, the *Pingalesvara* ruins date to the Pala period. The temple of this place has depictions of elephants in rows, a series of circles containing figures with their limbs moving in centripetal order. Some ruins are ornamented with frieze of bracket figures. Sarma (1988) states this temple may be placed in the 11<sup>th</sup> – 12<sup>th</sup> century.

The temple ruins at Baman, under Darrang District near Guwahati, include stone blocks with temple architecture. The use of *Kritimukha* motifs along with floral patterns and *Kalpavriksha*<sup>11</sup> are observed as ornamentation. The survival of ceiling slab with a double-

---

<sup>11</sup> *Kalpavriksha* also known as *kalpataru*, *kalpadruma* or *kalpapādapa*, is a wish-fulfilling divine tree in Indian-origin religions, namely Hinduism, Jainism, Buddhism and Sikhism. It is mentioned in Sanskrit literature from the earliest sources.

petaled lotus known as *Visvapadama*<sup>12</sup> reflects the skillsets of the artisan. The ruins are dated from the 11<sup>th</sup> -12<sup>th</sup> century A.D. In the *Na-Nath* Group of Temples (11<sup>th</sup>- 12<sup>th</sup> Century A.D.) Kenduguri of Assam, the use of both stone and bricks are observed in the temple architecture. The use of terracotta plaques is observed in the ornamentation. This includes human figures, animals and trees and *Kalpavriksha* motifs.



**Fig 2. 11** Stone remains of Madan Kamdev, archeological site.

Source: By Bhaskarbhagawati - Own work, CC BY-SA 3.0,  
<https://commons.wikimedia.org/w/index.php?curid=33709280>

The *Deoparvat* ruins near Numaligarh, Assam, are remarkable evidence of Architectural excellence during the Pala period. The stone temple is more prominent in dimension, with remains of ceiling slab like *Visvapadama*; seed vessel with the figure of *Vidyadhara*<sup>13</sup> resembling late Gupta art style. There are terracotta sculptures depicting humans, birds and vegetal forms. Some stone blocks are ornamented with friezes of bracket figures, tiaras and lotus buds. The depiction of *Kritimukha* motifs is also observed in ruins. This motif plays a very intriguing role in signifying the cultural adoption in art. The face of the motifs is not similar to that found in the early ruins of Assam. Sarma (1988) highlights that the motif

---

<sup>12</sup> *Visvapadama* is a large two layer petal lotus motif curved with stone placed in ceiling. This motifs is observed in most of stone temples of Assam as ruins.

<sup>13</sup> *Vidyadhara* are a group of supernatural beings in Indian religions who possess magical powers. In Hinduism, they also attend Shiva, who lives in the Himalayas.

has horn-like eyes displaying Javanese influence. This influence contemplates probable influence as cultural diffusion and adoption of south-east Asian style.

The *Gupteswara* temple at Singri, Darrang District of Assam, is the only surviving temple from the mediaeval period of Assam. The overall architecture provides an impression of Ahom age architecture. This architecture has a similarity with the 17<sup>th</sup>-18<sup>th</sup> century temple architecture of Assam. The fusion of stone and brick-masonry is seen in the architecture. The *do-chala*<sup>14</sup> architecture is prominent in *mandapa* section (pavilion for public rituals) of the temple. The use of figurative, vegetal and symbolic forms is observed as ornamentation. The use of *Kritimukha* motifs is seen in the walls of the monument. Although the architecture has an impression of the Ahom period style of construction, the interior depicts the style of the Pala period.

By the end of the Pala period (A.D. 990-A.D. 1138), the early mediaeval period of building activities came to an end. The period appears to have produced not only the most significant number of temples ever built in this State, but it introduced certain special ornamental features also. The ornamentations are distinctly visible in the Pala architecture. The constructions materials inclined toward bricks which were rare earlier. The incorporation of local styles with Indo-Aryan elements are observed, along with some Southeast Asian exotic styles. With the end of the Palas, the architectural activities of the State also faced a phase of decadence (Gupta, 1982). Shreds of evidence show that the building trend continued somehow up to the close of the 12<sup>th</sup> century A.D. or a few decades more but not with the original temple or splendor. With the Palas of the Assam, the long building tradition initiated by the Varmanas ended.

## 2.2 Mediaeval Era of Assam

With the end of Pala rule in Assam by the second quarter of the 12<sup>th</sup> century, the ancient period of the history of Assam came to an end and the mediaeval period of Assam ushered. The 13<sup>th</sup> and 14<sup>th</sup> centuries of Assam mostly went through wars and political strifes in the Brahmaputra valley. With the invasion and expansion of the Ahom kingdom from the early 13<sup>th</sup> century in the Brahmaputra valley of Assam, the native kingdoms like Chutiya and Kacharis were undergoing frequent battles and skirmishes. This period of uncertainty continued till the Ahoms vanquished the whole valley. The Ambari archeological excavation in Guwahati discloses the

---

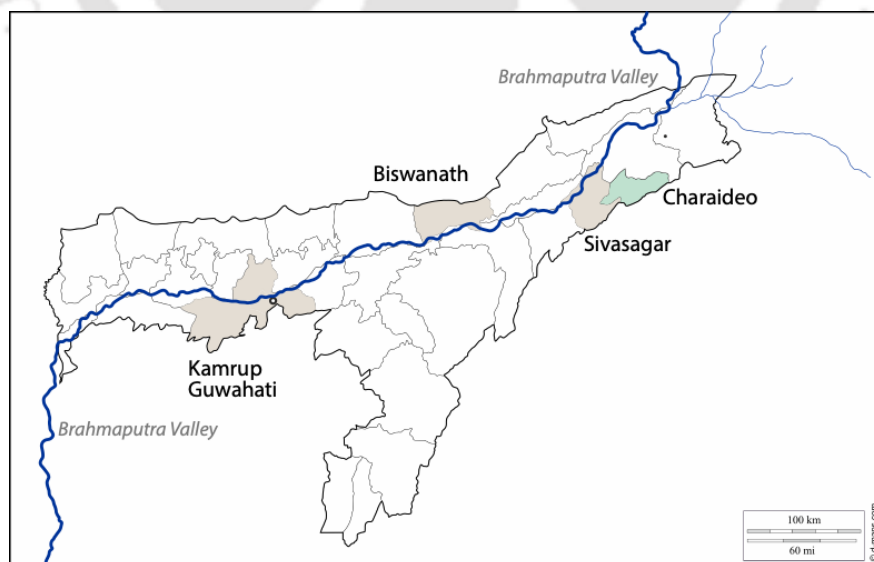
<sup>14</sup> *Do-chala* means double roofed structure of a traditional hut or houses that came into popularity during the 17th century tomb type architecture of Assam and Bengal.

plastic art activities during the 13<sup>th</sup> century A.D. Historians, archeologists and scholars are still in search of building activities of 14<sup>th</sup> century – 15<sup>th</sup> century. However, to date, it is entirely unknown. By the 16<sup>th</sup> century, the Chutiya Kingdom got annihilated by the Ahom rulers followed by the Kacharis and the Kamata kingdom, which are said to be the most vigorous opponents for the Ahom kingdom. With the dispersed control over the Brahmaputra valley, the Ahom gained complete supremacy by the 17<sup>th</sup> century. During their reign, architecture flourished all over the Brahmaputra valley of Assam. Most of their constructions are preserved under the Archeological Survey of India (ASI), Guwahati circle and Directorate of Archaeology, Guwahati, Assam.

With the advent of the Ahom dynasty, the architectural scenario flourished. Assam is blessed to have most of the heritage buildings of this era. These architectures are spread all over the Brahmaputra valley of Assam.

### 2.2.1 The Ahoms

Assam has a rich history of 600 years of the Ahom dynasty. They ruled Assam from 13<sup>th</sup> century to 19<sup>th</sup> century. According to the Ahom chronicles or *Buranji*, they came from Mong-Mao, a Tai state in South-Western Yunnan, in 1215 A.D., then migrated to northern Burma crossing Patkai Hills. According to historians, the Ahoms are traditionally from the Great *Tai*<sup>15</sup> group of peoples. *Sukapha* became the first king of the Ahom dynasty in Assam. He established his first capital in Charaideo, which is currently a district near the Sivasagar area of Assam, India (Fig. 2.12).



**Fig 2. 12** Assam Map displaying Charaideo district near Sivasagar, Assam, India.

<sup>15</sup> *Tai* people are a subgroup of *Tai* language speakers who are widely distributed in Southeast Asia and the Yunnan Province of Southwest China.

By the end of the 17<sup>th</sup> century, the Ahom dynasty has expanded its kingdom all over the Brahmaputra valley of Assam. Under the Ahom kingdom, art and architecture flourished remarkably. Initially, the constructions were made of wood and bamboo, but the buildings did not sustain for long durations. Hence stones and bricks were used for construction purposes. The Ahoms built many brick buildings and temples and the ornamentation mostly includes vegetal and figurative motifs, sculptures and patterns with organic and geometric forms.

### 2.2.2 Ahom Art and Architecture

**Stone Sculpture.** The sculpting during the Ahom period was influenced by the traditional national woodwork (Gupta, 1982). The sculptures of the Ahom dynasty ranges from woodwork, metal coins, stone, terracotta and stucco reliefs. According to (R. . Gupta, 1982) the main centers of sculptural activities were at Kamakya, Hajo, Gosanimari, Garhgaon, Rangpur, Joysagar, Kulagaon and Sivasagar of Assam.

Ahom sculptures started with rock-cut figures. The Ahom chronicles or *Buranjis* mention the activities of rock-cut sculpting of Ahom rulers from 1401 A.D (Gogoi, n.d.). Sculpting in stone pillars with inscriptions are found in some parts of upper Assam; this includes places like Sivasagar, Sadiya and Tinsukia. With a gradual inclination of the Ahom rulers towards Hindu religions, the expression of art changed to religious figures and shrines. The inclusion of Hindu gods, goddesses and deities was common in stone sculpting. These works are sumptuously highlighted in many temples or *Dols* of Sivasagar area. The Gauri Sagar group of temples, Siva Dol of Sivasagar, Joysagar Group of temples all embellishes the opulence of stone reliefs.

Along with the stone relief of Hindu gods and goddesses, human figures are also sculpted in these reliefs (Sarma, 1988). Most of these compositions are within a multifoil arch with pillars on each side as an entrance (**Fig. 2.13**). Gupta (1982) mentions ‘the human figures have the feet are oriented inside view, the body in front view and the faces usually in profile. The faces are large, a local ethnic characteristic feature as we also see in the Khmer reliefs from Angkor in Cambodia. The profile faces are sometimes remarkably similar to similar faces from Angkor.’ He further raises questions in connections with the stone carver of Assam with Cambodia, as history does not provide any evidence of such associations. There Ahom stone sculpting also includes animal, birds forms and vegetal patterns. Sculptures of Peacock, lotus, horses are commonly seen in temples exteriors.



**Fig 2. 13** Stone sculpture of Joy dol of Joysagar Tank, Sivasagar. (AD 1696–14).

**Terracotta.** Terracotta has been part of Assam history as a utilitarian, expression and ritual medium. Terracotta in Assam is dated to *Shunga* Dynasty, the earliest terracotta sculpture found in Ambari, Guwahati. The tradition of using terracotta is from the early Gupta period (5<sup>th</sup> Century A.D.) till the late mediaeval era.

The terracotta sculptures during the Ahom period are primarily in ornamental form. It includes bricks, flat tiles and terracotta pilasters and molded brick sculptures (Das, 2019). Gupta (1982) mentions ‘during the Ahom period (13<sup>th</sup> – 19<sup>th</sup> century A.D), the art of terracotta was further developed to make pinkish tile-like bricks for building and paving royal roads, drainage pipes, refuse bins and soak-pits and rings for pucca-wells’.

Das (2019) highlights that the early terracotta architectures are the *Thaora Dol*, of Sivsagar, constructed during 1683-85 C.E and *Biswanath Temple* of Biswanath District. Both these monuments are fully renovated as the early structure were in dilapidated condition. The walls of these monuments include the early terracotta sculptures of vegetal and animal forms. Some of the most delicate embellishments in architecture is seen in the Ghanasyam House of Sivasagar and Namath Kali Temple of Guwahati (Ahmed, 1994; Barpujari, 2007; Das, 2019; Gupta, 1982). The traces of terracotta plaques are found in temples walls and some during excavations. Some of them are kept in Assam State Museum, Guwahati. These plaques have rich floral forms, figurative forms and floral patterns. Some excavated panels have the

reminiscence of the Mughal hunting scene, as for which Das raises questions regarding the artisan's intentions and where was the artisan from?

Dolls and toys were also made in terracotta and grouped under general *Putala* or *Puteli*. These were sometimes specially made for semi-religious folk ceremonies like doll's Wedding in Kamrup (Gupta, 1982). The terracotta dolls and toys also made their way to fairs and festivals for selling purposes during the late mediaeval era of Assam.

With the gradual decline of the Ahom Kingdom by the end of the 18th century due to court machinations, internal conflict and weak rulers; the political revolt came into play. During this unstable phase emerged the intervention of English East India, Anglo-Burmese war of 1824 broke out. This resulted in the decline of *Tungkhungia* dynasty leading to a setback in the terracotta industry of Assam.

**Architecture.** The history mentions that the architectures of late mediaeval era after the advent of Ahom dynasty flourished remarkably. With the rise of the Ahom dynasty came a new era of innovation in architectural style. This style initially started with the renovation and reproduction of the early existing style of Assam by amending with own styles and designs. These innovations in construction highly show their versatility in terms of cultural diffusion, adaptation and adoption. One of the examples was mentioned earlier, the *Gupteswara* temple at Singri. The *mandapa* sections are covered with the Ahom *do-chala* roof style. This style is mostly observed in the late mediaeval architectural styles of Assam. Two similar terracotta *do-chala* architecture styles are observed in Sivasagar and Guwahati area. The Ghanasyam House (**Fig. 2.14**) of Sivasagar and Namath Kali Temple (**Fig. 2.15**) of Nilachal Hills, Guwahati. According to historians and scholars, both monuments resemble similar architectural styles. (S. Deori et al., 2020) in his article titled '*Architectural and Comparative Material Study of Brick and Mortar of Ahom monuments*' has studied the construction style and material elements and found that these two monuments follow similar construction styles and raw materials for construction. Another vital discovery was the construction period of the Namath kali temple, as it was unknown. Deori's study provides strong indications that both monuments were constructed in the same era.



**Fig 2. 14** Front section of Ghanasyam House, Sivasagar.



**Fig 2. 15** Front section of Namath Kali, Nilachal Hills, Guwahati.

Barpujari, (2007) mentions that ‘whether the renovation of the earlier structure or a fresh one, the buildings of the late-mediaeval period were mostly traditional in outlook but they became comparatively simple and dull in outline.’ This is because the Ahom temple architecture considered any conceivable shapes for its plan right from quadrilateral to a polygon, even round and reformed at their own will. This resulted in a utilitarian structure suitable for its use with no strict design guidelines. Barpujari further states that the late mediaeval architectural styles largely accumulated various other styles; the probable construction styles and technology are from the Hindu, Islamic, indigenous or exotic.

(Ahmed, 1994; Barpujari, 2007; Gait, 1926; R. . Gupta, 1982; Sarma, 1988) states that the early construction of the Assam includes timbers and woods as construction which were non-permanent in material quality. The permanent material in constructions is considered to evolve from the Gupta period, as there is no early evidence before that.



**Fig 2. 16** a) Rang Ghar b) Talatal Ghar of Sivasagar area and c) Kareng Ghar of Charaideu area of Assam

The Ahoms first set up their Kingdom in Charaideu, a newly formed district of Assam was the first capital of the Ahoms, under the power of King *Sukhapha*. Most of the Ahom constructions are observed in the Charaideu area, Sivasagar Area and nearby areas. The Ahom architecture can be divided into two sections; non-religious architecture and religious architecture. The non-religious includes the constructions of buildings, Palaces, roads, bridges, *Maidams* (Ahom burial places) etc. Furthermore, the religious architecture mostly includes temples or *dols* known locally. The contribution of Ahom in civil works are varied but limited. (Barpujari, 2007) The permanent phase of the non-religious architecture is mostly observed during Ahom King *Rudra Singha* (A.D 1698-1714). Many buildings and temples are constructed during his reign. Gait (1926) states, “It is also mentioned that he was anxious to build Palaces and city of bricks, but there was no one in his kingdom who knows how to do this. He, therefore, imported from Koch Bihar an artisan named *Ghanasyam*, under whose supervision numerous brick buildings were erected at *Rangpur*<sup>16</sup>, close to Sivasagar and also Charaideo.” The Ahom masonry architecture is spread in most of the areas of Brahmaputra valley. The preserved monuments are mostly located in the Sivasagar area that includes Joysagar, Gaurisagar and Charaideo. Some of the iconic non-religious buildings are in these areas; the Rang Ghar (**Fig. 2.16, a**), Talatal Ghar (**Fig. 2.16, b**) and Kareng Ghar (**Fig. 2.16, c**) exhibit unique architectural structures that are not commonly seen in Ahom architecture. The other places of Assam include Negheriting, Jorhat, Guwahati, Dhuburi, Goalpara and

<sup>16</sup> Rangpur, one of the capitals of the Ahom kingdom, was established by the Swargadeo Rudra Singha in 1707. It is currently a part of Sivasagar town.

Biswanath. These built are mostly in the form of temples. Gupta (1982) highlights that most of the masonry works of Ahom were under the superintendent named *Chang Rung Phukan*. His details of material consideration are documented in a book in the Assamese version named "*Chang Rung Phukanar Buranji*", (Barua, 1992). The book includes the details of early construction materials with composition ratio in local Assamese measuring units. The book mentions the use of burnt bricks and lime mortars to construct houses, temples, buildings and *maidam*<sup>17</sup>. Lime mortar was used to cement the bricks. The *buranji* mentions mixtures of many organic and inorganic raw materials for the mortar mixture. Some of the raw materials in the mortar composition include snail shells, limestones, oil, quick lime, *borali* fish (helicopter catfish or wallago catfish), molasses, duck eggs and brick powders. Most of the construction materials of the Ahom include stones, bricks, mortars and terracotta plaques. The Ahom architecture have displayed varied styles yet outstanding construction craftsmanship with artistic skills in rock sculpting, terracotta mouldings and stucco reliefs on brick walls. The **Table 4.1** list in **Chapter four** displays the variations in architecture types with material types. Preservation and conservation measures are taken by ASI, Guwahati Circle and Directorate of Archaeology, Guwahati Assam (ASI, n.d.; Dir. of archae., n.d.).

### 2.3 Bengal temple Architecture

The literature study of the late mediaeval architecture of Assam discloses that most of the Ahom architecture includes amalgamations of styles from the Gupta period, Pala period, Orissan and the Indo-Islamic style. There were two types of ornamentation in the Ahom period: i) Terracotta plaques and ii) Stucco reliefs. It was interesting to witness that the terracotta-style architecture *do-chala* of the Ahom has similarities with the Bengal terracotta temples. This similarity has been highlighted by (Ahmed, 1994). The front façade of the *do-chala* monuments has distinct similarities with the tiling styles, pillar placements and visual narratives with the inclusion of the elements.

During the late mediaeval period in Bengal, most of the temple-building activities occurred. According to the prevalent periodization, this period is contemporary with the Mughal and Colonial periods in Bengal. The Bengal terracotta architecture advent during the late mediaeval era. This tradition lasted for 400 years from the 15<sup>th</sup> century till the 19<sup>th</sup> century CE. With the rise of terracotta temple architecture, the development of a vernacular idiom of

---

<sup>17</sup> *Maidams* are tumulus built during Ahom reign for the Royals and the aristocrats.

this art style was observed (Ray, 2013). This new development of style was stated as ‘appertaining to folk architecture’ by (Bhattacharya, 2016).

According to (Mangaonkar, 2012; Ray, 2012), the main temples that appeared were *Chala*, *Ratna* and *Dalan* styles. The *Chala* was mostly reproduced style by the architects of that era. Similar to Assamese *do-chala*, style influences the traditional hut styles of that era. With the rising recognition of this style, the architects have explored and experimented with the form and shapes of the temples, resulting in many variations of the *Chala* style. These are *Do-Chala*, *Char-Chala*, *At-Chala*, *Baro-Chala* and *Jor-Bangla*. *Do-Chala* and *Char-Chala* temples have two and four-sided roofs, respectively. Whereas a *Char-Chala* temple with one additional tier becomes *At-Chala*, i.e. eight-sided and the one with a two-tiered roof becomes *baro-chala* or twelve-sided. *Jor-Bangla* is an entirely different variant of the *Chala* type where two *do-Chala* temples are joined together in such a fashion that the structure becomes one. However, it retains two separate roofs and the two chambers beneath it where the front one acts as the assembly hall or the *mandapa* and the later one becomes the *garbhagriha*. (Guha & Bandyopadhyay, 2017; Ray, 2012)



**Fig 2. 17** Front view of the *Jor-Bangla* Gangeshwar Shiva temple, Murshidabad, West Bengal (Mangaonkar, 2012). 18<sup>th</sup> century.



**Fig 2. 18** Front view of the *Jor-Bangla* Gopinath temple, Pabna, Bangladesh.(Ray, 2012)

The façade of Ghanasyam House of Sivasagar and Namath Kali Temple of Guwahati shares similarities with the façades *Jor-Bangla* Gangeshwar Shiva temple, Murshidabad, West Bengal (**Fig. 2.17**). These similar façade (**Fig. 2.18**) is also observed in Bangladesh, as they were part of India before the Bengal partition (Goldberg, n.d.). One similar façade is observed with the *Jor-Bangla* Gopinath Temple, Pabana, West Bengal. The architectural styles share similarity in tiling, façade, pillar placement and ornamentation. The use of three entrance pillar before *garvagriha*, visual narratives in the wall of the entrances provides substantial similarity to the terracotta monuments of Assam. It is evident that there are similarities with the mediaeval architecture of Assam. (Ahmed, 1994; Sarma, 1988) has mentioned its resemblances with the Bengal *chala* style architectures.

## 2.5 Insight of the study

The literature shows how ornamentation is a significant consideration in Indian architecture, from early stone sculpting to brick masonry. Religious beliefs of every culture or dynasty has proliferated the way of expression through art and architecture. The architectural evolution in the Indian context provides substantial information of cultural diffusion, adaptation and adoption. With this, the considerations of ornamentations in the form of motifs, sculptures and

patterns are observed. These use of visual forms and construction materials have evolved together, but the philosophy has always remained the same.

The literature also highlights a parallel evolution that was proceeding in the North-eastern part of India in the state of Assam. The artefacts of stone and rock cuts provide strong influences on mainstream India. These influences are substantiated by many scholars and experts. With due course of time, evolution in architecture and ornamentation are significantly discernible from the Guptas, Palas, Orissan style till the pre-advent of the Ahom dynasty.

With the advent of the Ahom dynasty, the Brick-masonry flourished all over the Brahmaputra Valley of Assam. The rise of the Ahom dynasty stipulated a new era of innovation in architectural style. This style initially started with the renovation and reproduction of the early existing style of Assam by amending with its own styles and designs. The construction styles and technology are from the Hindu and Indo-Islamic and some are assumed to be connected to exotic south-east Asian styles. The study shows that the terracotta monuments in Assam share similarities with the Bengal Terracotta temples. Nevertheless, it has managed to radiate its unique local designs and forms.

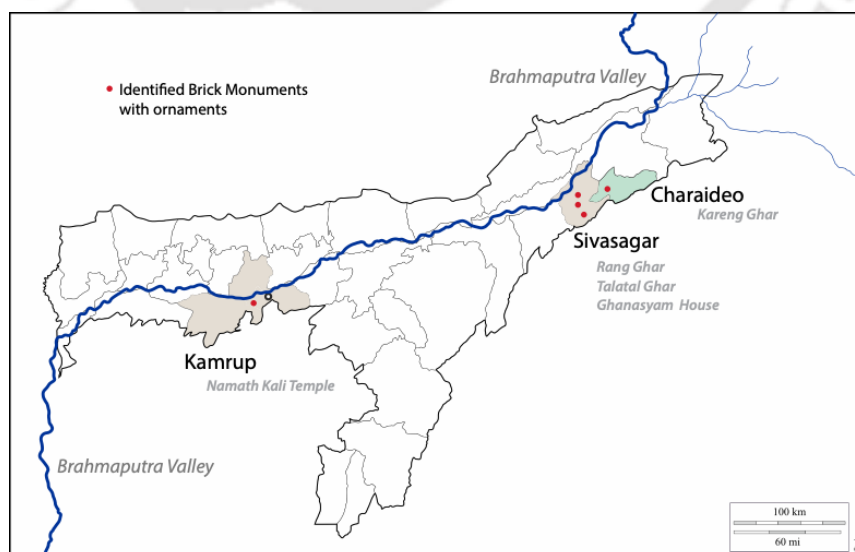
Most of the studies are on temple architecture and the iconography, arts and sculptures of Assam. Not many studies are pondered into Ahom architectural ornamentations and materials, specifically the Brick-masonry of Assam. It provides a tremendous opportunity to consider the visual and material aspects of Ahom brick architectural ornamentations of Assam.



## CHAPTER THREE: Methodology

The overall research is based on the ornamentation of Ahom bricks monuments; to understand the background of these monuments qualitative approach is considered. To understand the context of Ahom and their art and architecture broadly, historical approach was undertaken. Based on the literature reviews, a pilot study was considered to determine the total number of Ahom monuments in Assam. The initial study also considered identifying the architecture types with the unscathed, semi refurbished and fully refurbished monuments. The results show that some brick monuments are fragmented and some are semi-refurbished or fully refurbished. This is because of the natural causes like earthquakes, vegetation and weather condition. The earthquake of 1950 has destroyed most of the early architectures of Assam, including stone and Brick-masonry buildings (Sharma & Zaman, 2019). Assam falls under Zone V of the seismic map, considered a “very high damage risk zone”. Assam witnessed several massive earthquakes, including the one in 1950, whose magnitude was 8.7 on the Richter scale (FPJ Bureau, 2019). However, it is astounding to notice some massive masonry architectures survive in the past quakes. The stone ornamentations can subsist the geographical conditions, as the endurance of stones compared to bricks is longer. The brick ornamentations have survived in fragments.

Out of 31 monuments, only four brick monuments, namely **Ghanasyam House**, **Rang Ghar**, **Talatal Ghar** of Sivasagar area, **Kareng Ghar** of Charaideo area and **Namath Kali Temple** of Nilachal Hills, Guwahati are in unscathed structure with survived motifs and patterns. Hence the data collection is done from these places (**Fig.3.1**).



**Fig. 3. 1** Assam map showing districts of the considered brick monuments for the study.

The ornamentation varies into two types in terms of construction and architectural styles. These are a) **terracotta** and b) **stucco**. The terracotta ornamentation styles include the use of multiple terracotta plaques by tiling all over the façade, near the roof section and pillars of the monuments. The pilot study reveals that the Ghanasyam House and Namath Kali Temple have similar architecture with the same tiling structures. The stucco ornamentation includes plastering the wall and curving the ornamentations. This technique is observed in Rang Ghar, Talatal Ghar and Kareng Ghar. Considering these two styles of ornamentations, further analysis has been conducted.

Multiple site visits were considered to study architecture type and the ornamentation in it. Although the selected monument's ornamentations are abundant with various motifs, patterns and sculptures of Hindu gods and deities, only motifs and patterns were considered for visual analysis of the ornamentation, as many authors and scholars have extensively studied Ahom's art and iconography of sculptures. Descriptive approach was chosen for the analysis of the ornamentation.

### **3.1 Data Collections**

Two phases **A** & **B** are considered for the data collection. Phase **A** includes collecting photo data of the monuments and semi-structured interviews with Archaeologists of Guwahati, Conservation officers (ASI), Sivasagar circle and local museum owner of Sivasagar phase; **B** includes the collection of material data of Bricks sample and mortar sample. The material study has provided information related to early construction raw materials and the connections with similar types of architecture with respect to its construction dates.

The data collection includes high-resolution photo data of each selected monument. Close-up shots of the ornamentations are taken for proper identifications and for later extractions. The photographs are taken from all angles to understand the contour and outline of the ornamentation. Some of the interior sections of the monuments have low lighting leading to low details of the ornamentations. To enhance the visibility, proper lightning setup is considered with photo enhancements using various software tools in Adobe photoshop (**Fig. 3.2, c**). Videography of the monuments are considered to generate reference points of the motif and pattern placements.



**Fig. 3. 2** a) Normal lighting inside the Talatal Ghar, Sivasagar; b) Lightning setup for visibility; c)Photo enhancement for details using editing software.

To study early constructions raw materials, early bricks and mortar samples are taken from selected monuments to analyse the compositions and early techniques of productions (**Fig, 3.3**). Brick shape and sizes are also taken into considerations for comparison purposes.



**Fig. 3. 3** Brick and mortar samples collected form the selected monuments.

Semi-structured interviews are conducted with the renovation experts of ASI (Guwahati Circle) to understand early raw materials used in the construction of brick architecture and the current consideration of raw materials in refurbishing these monuments and the stucco ornamentation. Another semi-structured interview of a local renowned museum owner was considered to identify and understand the influence of the Ahom dynasty on the culture of Assam. Multiple discussions with an archaeologist of Assam, academicians, researchers and archaeology officers to understand the current scenario of the conservations and findings related to Ahom monuments.

Early photographs of the selected monuments are collected from ASI, Guwahati Circle, Assam to distinguish the early and recent conditions of the monuments focusing on the ornamentation, to reduce the chances of considering the fully renovated motifs and patterns (Fig. 3.4).



Fig. 3. 4 a) Rang Ghar old photograph (1922-23), Source- ASI; b) Photograph of Rang Ghar after renovation (2016)

### 3.2 Categorization of motifs and patterns

As mentioned earlier, in **Chapter Two**, the Ahom dynasty has been concomitant with art and architecture in Assam. The selected monuments are massive in size and have a unique architecture type of their own. Multiple site visits are conducted for video and photo data focusing on the architectural ornamentations.

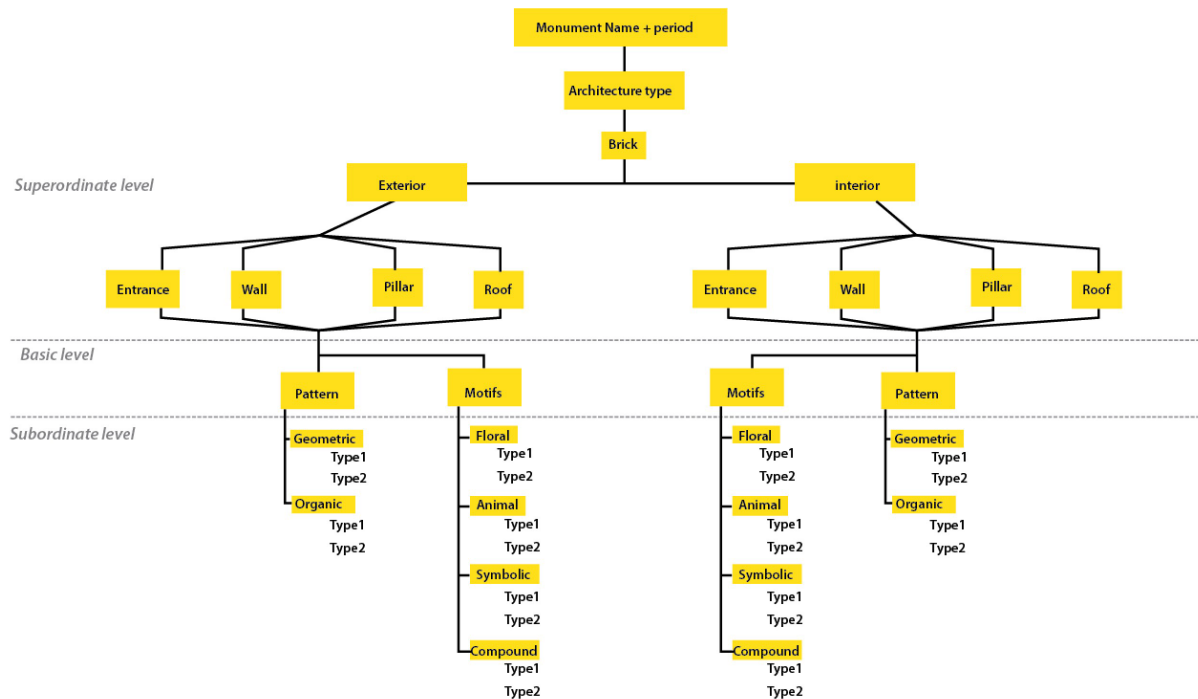


Fig. 3. 5 Systematic categorization chart for the motif types and pattern types

As the data was in large number, categorization theory of Athavankar (1989) is considered. His study '*Categorization..Natural Language and Design*' states that organized categorization can lead to concepts and with that visual information can be controlled. In principles of categorization; Rosch (1978) states that 'instead of categorizing objects into large numbers of finely discriminate and tightly organized concepts, the mind automatically selects the cognitively economical option of neglecting the infinite differences among objects to behaviorally and cognitively usable proportions. The categorization process treats nonidentical objects as equivalent, when differences are irrelevant to the human response'. Monga (2019) has applied this theory to her Ph.D. thesis to classify the elements of Assamese *Naamghar*<sup>18</sup>.

With relevance to the data sorting, (Deori & Barua, 2021) have adopted this theory to sort the data based on motifs and patterns on a terracotta ornamented monument. There are three levels in considerations of categorization – *Superordinate level*, *Basic Level* and *Subordinate level* (**Fig. 3.5**). The motifs and patterns are mostly observed in the walls, pillars, roof and the entrance sections of the selected monument. Hence, in Superordinate level, the exterior and interior sections of the monuments have been considered. This includes photo data from the entrance, wall, pillars and roof of the monuments. The Basic level has two sections; it includes segregating the data to Motifs and Patterns from the superordinate level. In the third level, i.e., the Subordinate level, the motifs and patterns are sorted into various types. These motifs types are divided into *floral*, *compound*, *animal* and *symbolic type*; the patterns types are *organic* and *geometric types*. The floral motif includes single or multiple flowers; the Compound type includes motifs compositions with flowers, animals, mythical creatures, humans, birds, man-made and abstract forms. The symbolic motif includes mythical creatures and religious symbols. The animal motif includes humans, wild and domestic animals and birds. Using this categorization chart (**Fig. 3.5**), the data are easily traceable with the source, reducing the chances of data redundancy.

### 3.4 Coding Data

Motifs are subdivided to -*Floral* (includes various shapes of flowers), *Compound motif* (motif united with multiple elements like flowers, creepers, creatures, animals, human or branching plants within a frame), *Symbolic* (includes Mythical animals or religious symbol) and *Animal* (includes birds, fish, human, wilds animals and domestic animals). Patterns are

---

<sup>18</sup> The *Naamghar* (literally Name-House) is a prayer-house where the devotees, present as the congregation, sing the Names of God. In the Satras, the main feature is the *Naamghar* It is in fact the permanent feature of every village, town and city of Assam. This has made *Sankaradeva's* religion a living religion.

divided into two groups- *Organic patterns* (includes floral or abstract organic forms) and *Geometric Patterns* (includes geometric lines, curves and circular forms). The motifs and patterns are observed in the Entrance (En), Pillar(Pi), Wall(Wa) and Roof(Ro) of the monument. To reduce the complexity of the data sorting and analysis, the photo data is being coded with designated alphabets and numbers. For example, a floral motif from a wall of Rang Ghar is coded as: *Ran-M-Wa-F-01*. *Ran* for Rang Ghar, *M* for Motif, *Wa* for the section i.e. Wall, *F* for floral motif and *01* is the serial number of the motif type. (Table 3.1).

**Table 3. 1 Coding on Motif and pattern type based on the superordinate, Basic and subordinate level**

Sr No.	Sections	Motif Type	Code
1.	Entrance (En) Pillar (Pi) Wall (Wa) Roof (Ro)	1. Floral	<i>M-En-F-01</i>
		2. Compound	<i>M-En-C-01</i>
		3. Symbolic	<i>M-En-S-01</i>
		4. Animal	<i>M-En-A-01</i>

Sr No.	Sections	Pattern Type	Code
1.	Entrance (En) Pillar (Pi) Wall (Wa) Roof (Ro)	1. Organic	<i>P-En-O-01</i>
		2. Geometric	<i>P-En-G-01</i>

With the coding of the data, linear extraction of the motifs and patterns is done using vector software Adobe Illustrator 2021 to study the shape and form in the composition. Considering the linear extraction, variation analysis of the extracted motifs and pattern is done. The quantitative data showcases the dominating motif and pattern types. Further, the study considers visual analysis based on shape, form, colour and texture. The study helps to understand the nuances in the visual compositions of the motifs and patterns.

### 3.5 Data Sorting and Variation analysis

The variation analysis of motifs and patterns are done by segregating the data based on the categorization theory. Each of the sorted data are coded and the variations are counted with information about the motifs and patterns with brief description about it. The motifs and patterns are sorted with its Code, Reference image and Quantity of variants. With the complexity of these large data, five designers were asked to categorize the photo data using the mentioned categorization process. The categorization done by each designer is then compared to refine the taxonomical structure based on commonalities.

The data were sorted based on the variation type and quantity of the motifs used in the ornamentation of the monument along with its structural descriptions. The results provide quantitative data of the variants and predominant motifs and patterns types.

### 3.5.1 Visual Analysis

With the data categorised and coded, each linear extracted motifs and pattern has undergone visual analysis based on shape, form, colour and texture. As Wong (1993) talks about characteristics of *Unit forms*, *Subunit forms* and *Superunit forms* in his book '*Principles of Form and Design*'. The element extraction process considers these characteristics in the ornamental compositions. The motifs and patterns are further analysed based on spatial arrangements in a confined composition. Most of the compound motifs include branching in their composition. The variations of these branching are studied to understand its visual idioms. The visual analysis also includes the orientations of the elements of vegetal and figurative forms. Symmetry has always been part of architecture and its ornamentations. Symmetry analysis adds another layer of information about the ornaments. It helps to understand the underlying structure while considering the motifs and patterns.

The analysis provides the details of shapes, forms and characteristics of the Ahom ornamentations. It also provides the underlying design principles of the Ahom ornamentations.

### 3.5.2 Symmetry Analysis.

Hann (2013) that the symmetry implies a balance of physical form and, in everyday usage, can be applied to an image, figure, or object with two equal parts, each of the same size, shape and content, one a reflection (like a mirror) of the other. Symmetry is observed in most natural and man-made forms; Washburn and Crowe (1988) have provided an extensive study on how a culture uses pattern symmetry to encode meaning; how it communicates messages related to societal structure the culture that created the object. Hann (2013) considers the above encoding and suggests that symmetry is capable of encoding meaning, but that other geometrical features (such as root rectangles) may also act as encoders of the meaning of a culture.

With the intention to understand and explore the cultural meaning, symmetry analysis is considered. The four-symmetry operations *translation*, *rotation*, *reflection* and *glide reflection* are taken to analyze the motifs and patterns. (Fig.3.6)

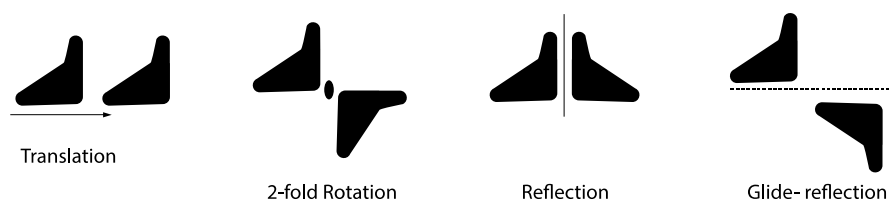


Fig. 3. 6 Schematic representations of symmetry operations

The patterns consist of the repetition of similar elements in a structured way. To analyze the repetition elements, the patterns are primarily divided into one-dimensional and two-dimensional patterns. Washburn and Crowe (1988) mentions that if a design admits translations in only one direction (and its “opposite direction”), the design is called one-dimensional or *frieze* patterns (also known as border or strip patterns) (Fig. 3.9). Besides, if a plane figure admits translation in two or more directions, it is a two-dimensional pattern. (Fig. 3.10)

Hann (2013) explains that motifs may be either asymmetrical or symmetrical. An asymmetrical motif does not possess any symmetry characteristics. Specific motifs exhibit either reflection symmetry or rotational symmetry. In the reflection category, the motif consists of two or more component segments of the same size, shape and content and each of these component segments reflects an adjacent part. Fig. 3.7 display the variations of the reflection axis in reflection symmetry motifs. These variations can be attained by creating imaginary reflection axes that pass through the centre of the imaginary circle surrounding the motif.



Fig. 3. 7 variations of reflection axis in motifs exhibiting reflection symmetry.

In rotational motifs, two or more similar component segments are reproduced in a circular movement rather than reflection. Variations of rotations can be attained by reproducing the component segments. Fig. 3.8 shows the different extensions of rotations.



Fig. 3. 8 variations of rotations in motifs exhibiting rotational symmetry.

When all the four symmetry operations (translation, rotation, reflection and glide reflection) are combined in designs that repeat or translate in one direction within two parallel lines, a total of seven specific friezes or one-dimensional pattern classes can be produced. Similarly, combining the four symmetry operations in two distinct directions across a plane, a total of seventeen distinct two-dimensional patterns can be attained.

(Hann, 2013; Washburn and Crowe, 1988) have extensively explained and studied these pattern classes. The variations of these classes have specific notation that is adopted from *International Tables for X-Ray Crystallography*, Vol. 1 (Pauling, 1954). The seven frieze-design or one-dimensional pattern classes are as follows:  $p111$ ,  $p1a1$ ,  $pm11$ ,  $p1m1$ ,  $p112$ ,  $pma2$  and  $pmm2$  (Fig. 3.9). The letter and number components of the notation denote the presence or absence of the four symmetry operations.

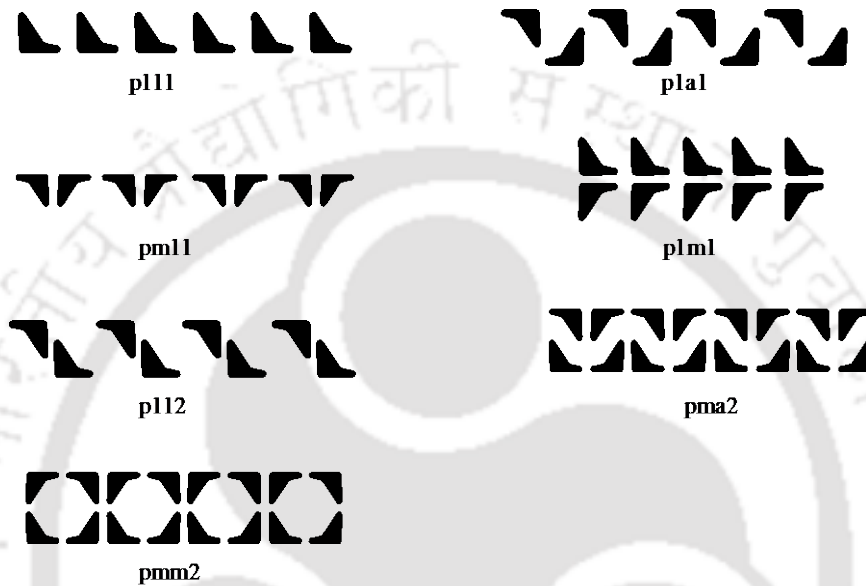
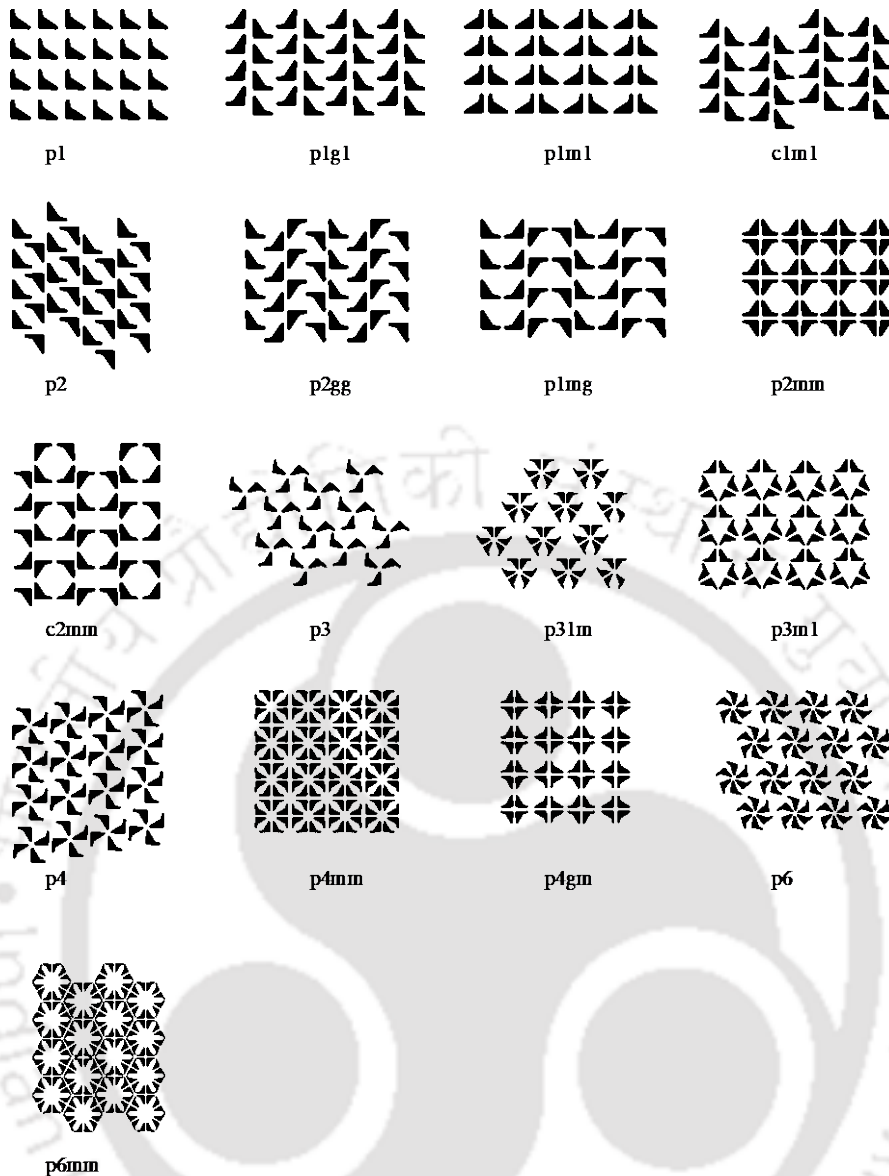


Fig. 3. 9 Seven variations of one-dimensional or frieze patterns.

As noted earlier, combinations of the four symmetry operations yield a total of seventeen all-over pattern classes. In describing these (Fig. 3.10), it is best to group them by referring to the absence or presence of rotational symmetry (and, if present, the highest order of rotational symmetry): pattern classes  $p111$  (or  $p1$ ),  $plg1$ ,  $p1m1$  and  $c1m1$ , which do not include rotation of any kind among their constituent symmetries; pattern classes  $p211$  (or  $p2$ ),  $p2gg$ ,  $p2mg$ ,  $p2mm$  and  $c2mm$ , which exhibit twofold rotation; classes  $p311$  (or  $p3$ ),  $p3m1$  and  $p31m$ , which exhibit threefold rotational symmetry; classes  $p411$  (or  $p4$ ),  $p4gm$  and  $p4mm$ , which exhibit four-fold rotation; classes  $p611$  (or  $p6$ ) and  $p6mm$ , which have a highest order of rotation of six. Although complicated, the notation used for each of the seventeen classes of all-over patterns simply indicates the relevant combination of symmetry operation from the seventeen possibilities



**Fig. 3.10** Seventeen variations of Two-dimensional patterns.

(Washburn and Crowe, 1988) further creates a flowchart for analysing the one-dimensional (Seven classes) with one colour patterns and one-dimensional patterns with two colours. As our data extraction reveals that only single colour motif and patterns are observed. To classify and to analysis the seven one dimensional pattern classes, (Washburn and Crowe, 1988) flowchart (**Fig. 3.11**) has been adopted.

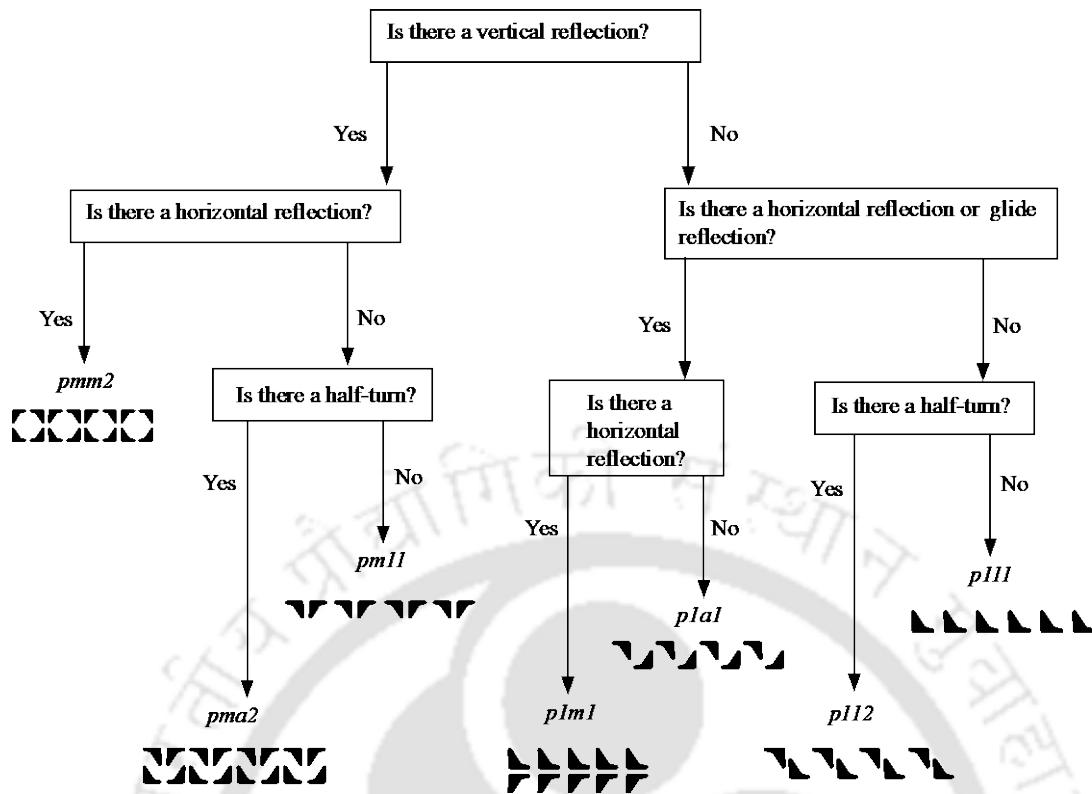


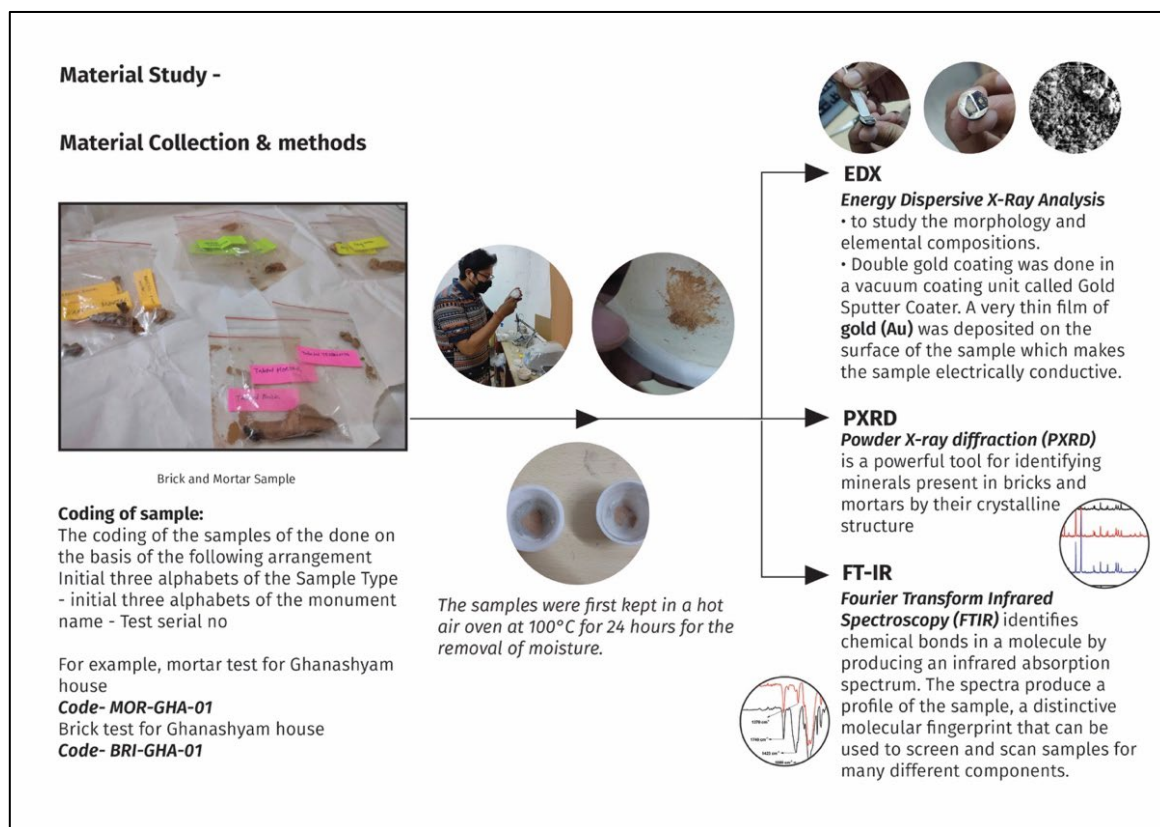
Fig. 3. 11 flowchart for analysing the One-dimensional (Seven classes) with one colour patterns.

(Washburn and Crowe, 1988)

### 3.6. Material Study from Bricks and Mortar samples

The primary data was collected using semi-structured interviews with the Archaeological conservation officer of Sivasagar area, ASI, to understand the early composition and modern-day compositions of brick and mortar used in conservation. Multiple site visits were done to study the brick dimensions and sample collection of brick and mortars. For the analysis of brick and mortar, samples of each were collected from the monuments. Sealing and coding of the samples are done to reduce the chances of intermixing samples. They were scrubbed to free from any contaminants and kept in a hot air oven at 100°C for 24 hours to remove moisture. This made the materials dry and easy to grind. The dried materials were pulverized in a grinder into powder form for further analysis.

Three testing phases are conducted with the collected brick and mortar samples (Fig. 3.12.). Energy Dispersive X-Ray Analysis (EDX) to study the morphology and elemental compositions of the brick and mortar samples, Power X-Ray diffraction (PXRD) helps to identify mineral presents in bricks and mortar samples and Fourier Transform Infrared Spectroscopy (FT-IR) identifies the chemical bonds in a molecule. The results are compared and analysed with similar types of ornamented monuments.



**Fig. 3. 12** Displaying the material study process of bricks and mortars of the monuments.

### 3.6.1 Characterization of materials

#### Elemental analysis

The sample of bricks and mortar of the brick monuments were characterized for elemental composition by Energy Dispersive X- Ray Analysis (EDX) (Make: Zeiss, Model: Sigma). The materials were dried again before analysis in a hot air oven at 100°C for 8 hours and were kept in a desiccator to cool to room temperature. The samples were first dispersed in ethanol, dried and then dropped the mixture onto a clean substrate. Later they are mounted on the stub using double-sided conductive carbon tapes for analysis.

#### Fourier transform infrared (FT-IR) Spectroscopy

Fourier transform infrared (FT-IR) spectra of the materials were recorded on a PerkinElmer Spectrum Two FT-IR spectrometer ( $\lambda_{\max}$  in  $\text{cm}^{-1}$ ) on KBr pellets in the range of 4000-400  $\text{cm}^{-1}$ .

### **Powder X- ray diffraction (PXRD)**

Powder X-ray diffraction (PXRD) is another powerful tool for brick and mortar characterisation. The application of X-ray diffraction in the above materials is likely through the Bragg equation;  $n\lambda=2d\sin\theta$ . Using this equation, the angles for the coherent scattering of X-rays (by diffraction) and the distance between adjacent planes is determined. By convention,  $n$  is equal to unity and  $\lambda$  is the wavelength of the material used as the X-ray source. PXRD measurements of the materials were carried out using a Bruker D2 Phaser X-ray diffractometer which was employed at 30 kV, 10 mA, using Cu-K $\alpha$  radiation at  $\lambda = 1.5406 \text{ \AA}$ .

### **3.7 Discussions**

The cumulative results of variation analysis, visual analysis and the material study provide in-depth information on the terracotta and stucco types of ornamentation found in the brick architecture monuments of the Ahom dynasty, Assam. The variation analysis results highlight the variations of floral motifs, compound motifs, animal motifs, symbolic motifs, organic patterns and geometric patterns. The quantitative data provides the predominant types of variations with motifs and pattern types. These results, in general, highlight the range of overall ornamentations used in the monuments.

The visual analysis considers the shape, forms, colour and texture of the motifs and patterns. The inclusion of symmetry analysis in it provides the range of one-dimensional and two-dimensional pattern classes considered in the compositions of the patterns. This analysis brings thorough insights into vegetal, figurative and geometric shapes considerations and visual associations with man-made and natural forms. The methodology provides information on the unit forms, subunit forms and superunit forms used to compose the ornamentations. The symmetry analysis provides the quantitative data of predominant symmetry operations used in ornamentation. The inclusion of analysis of pattern classes gives insights into the pattern characteristics and classes used as ornamentation.

The material study provides information of the early brick and mortar making technology with the elemental compositions and the artisans' considerations. The material analysis supports the early construction raw materials and discusses and highlights the connections with terracotta types and stucco types of ornamentation. These findings provide insights to cultural diffusion, adoptions and adaptation of the Ahom dynasty.



## CHAPTER FOUR: Data collection and Variation Analysis

The preliminary pilot study was conducted to locate all the Ahom monuments of Assam. The results show that there more than 31 Ahom monuments dispersed all over Assam. The data was segregated in terms of monument's name, locations, architecture types and construction material.

**Table 4. 1 Visited sites of Ahom monuments with architecture and material information, Assam.**

Sr. No.	Monument Name	Location/ Area	Architecture Type	Construction Material
1	Ghanashyam House	Sivasagar	Non-religious	Terracotta + Brick
2	Gulaghar	Rangpur	Non-religious	Brick
3	Joy Dol, joysagar Tank	Joysagar	Religious	Brick + Stone
4	Kareng ghar	Garhgaon	Non-religious	Brick
5	Rang Ghar	Joysagar	Non-religious	Brick
6	Talatal Ghar	Rangpur	Non-religious	Brick
7	Devi dol Gaurisagar	Gaurisagar	Religious	Brick + Stone
8	Laxmisagar Tank, Vishnu Dol	Laxmisagar	Religious	Brick + Stone
9	Laxmisagar Jagadhatri Dol Durga	Laxmisagar	Religious	Brick
10	Vishnu Dol Gaurisagar	Gaurisagar	Religious	Brick
11	Shiva Dol Gaurisagar	Gaurisagar	Religious	Brick + Stone
12	Haragauri Dol	Rangpur	Religious	Brick
13	Shiva Dol	Sivasagar	Religious	Brick + Stone
14	Na-Pukhuri Siva Dol, Joysagar	Joysagar	Religious	Brick
15	Hilesawar Temple	Tezpur	Religious	Brick + Stone
16	Umatumuni Island	Biswanath Ghat	Non-religious	Stone
17	Bordol	Biswanath Ghat	Religious	Brick
18	Bishwanath Temple	Biswanath Ghat	Religious	Terracotta + Brick
19	Ganesh temple	Hajo	Religious	Brick + Stone
20	Kedar temple	Hajo	Religious	Stone
21	Madhav temple	Hajo	Religious	Brick + Stone
22	Aswaklanta Temple	North Guwahati	Religious	Brick + Stone
23	Manikarnewswar Devalaya	North Guwahati	Religious	Brick + Stone
24	Baisitha Temple	Guwahati	Religious	Brick + Stone
25	Namath Kali Temple	Nilachal Hills	Religious	Terracotta + Brick
26	Sidheswar Temple	Nilachal Hills	Religious	Brick + Stone
27	Kameshwar Temple	Nilachal Hills	Religious	Brick + Stone
28	Ugratara Temple	Guwahati	Religious	Brick + Stone
29	Umananda Temple	Umananda Island	Religious	Brick + Stone

The **Table 4.1** shows the places visited and the Ahom monument's name with the architecture type and the construction materials used. It was observed that there are two distinct variations in ornamentation in the monuments: i) **Terracotta plaques (Fig. 4.1)** and ii) **Stucco. (Fig. 4.2)** Terracotta plaques include moulded plaques of burnt clay and are tiled for ornamental purposes. The stucco is the process of creating decorative forms by hand using mortar on walls, bricks, or other surfaces.

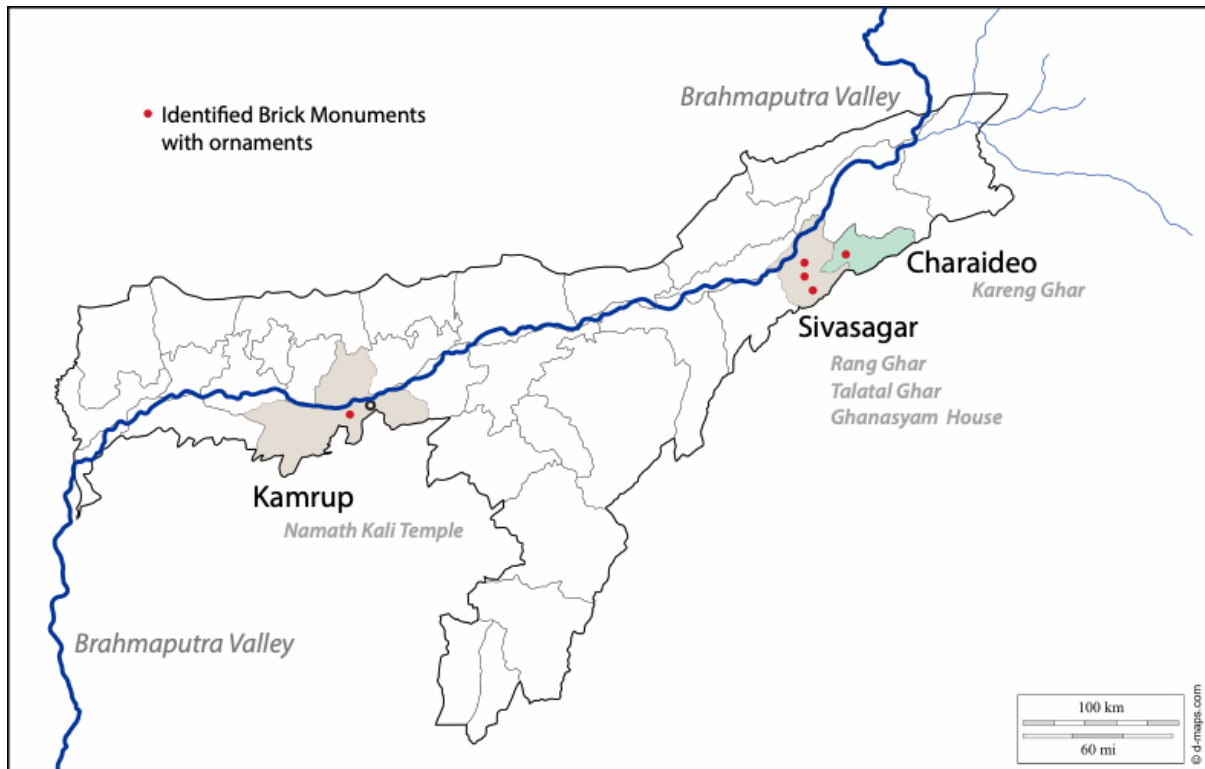


**Fig. 4.1** Variations of terracotta plaques on the side wall, Ghanasyam House, Sivasagar, Assam.



**Fig. 4.2** Floral stucco pattern on the wall of Rang Ghar, Sivasagar, Assam.

The study reveals that only five brick architecture has been able to survive its ornamentation; these are: **Namath kali Temple** of Nilachal Hills, Guwahati, **Ghanasyam House**, **Rang Ghar**, **Talatal Ghar** of Sivasagar district and **Kareng Ghar** of Charaideo District (**Fig. 4.3**). The **Biswanath Temple** of Biswanath Ghat, has its ornamentation intact. However, while asking the locals, it was found that the overall structure of the temple has been renovated as the temple was found in dilapidated condition. Hence, considering the authenticity of the study, ornamentations of the Biswanath temple is not considered.



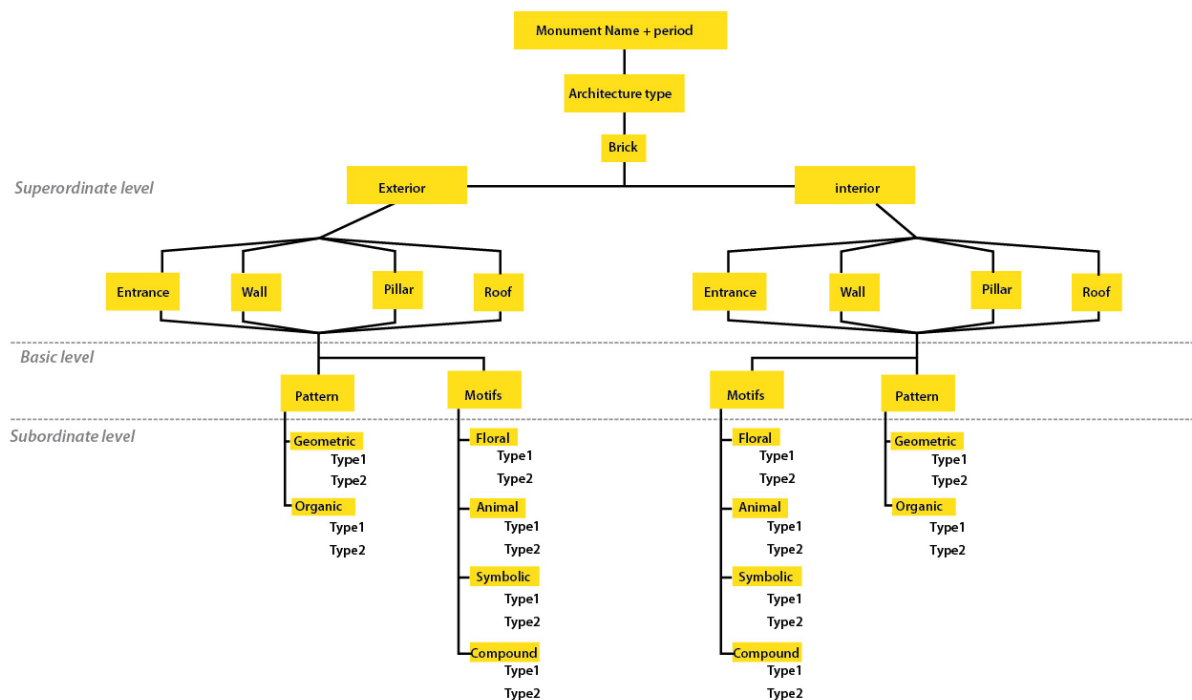
**Fig. 4.3** Assam map showing districts of the considered brick monuments for the study.

#### 4.1 Data Collection and categorisation

As mentioned in **Chapter 3** in the data collection section, there are two phases- **A** & **B** for data collection. Phase **A** includes collecting photo data of the monuments and semi-structured interviews with Archaeologists, Conservation officers (ASI) and a local museum owner. Phase **B** includes the collection of material data of the Bricks sample and mortar sample. The photo data is collected to analyse the underlying design principles of the ornamentations. The material study has provided information related to early construction raw materials and the connections with similar types of architecture concerning its construction dates.

With the photo data collected semi structured interview with the Conservation officer (ASI) Sivasagar circle has been conducted. The interview questions were open ended questions related to the early construction materials of the brick masonry architecture and current

consideration of raw materials for renovations. Discussions with Archaeologist included current scenario of ornamentation study, influences of Ahom ornamentation and material study of the brick monuments.



**Fig. 4. 4** Systematic categorization chart for the motif types and pattern types , (Deori and Barua, 2021)

The variation analysis of motifs and patterns are done by segregating the data based on the categorization chart (Fig. 4.4). Each of the sorted data are coded and the variations of motifs and patterns are counted. The motifs and patterns are sorted with its Code, reference Image and Quantity (Appendix D). With the complexity of these large data, five designers were asked to categorize the photo data using the mentioned categorization process. The categorization done by each designer is then compared to refine the taxonomical structure based on commonalities. The data were sorted based on the variation type and quantity of the motifs used in the monument's ornamentation and its structural descriptions.

## 4.2 Terracotta Ornamentation

**Ghanasyam House** or *Dol* (Temple) Fig. 4.5 is on the southern end of the west bank of the Joysagar tank in the Sivasagar district of Assam. According to ASI, this monument is constructed during the reign of Rudra Singha (CE 1696-1714). The monument measures 7m 23cm X 6m 35 cm (Das, 2019). The architecture is constructed using bricks and terracotta plaques with sculptures, motifs and patterns. The architecture of the house or *Dol* has

resemblance with the contemporary temple architectures of West Bengal and Bangladesh (Das, 2019). The style of architecture is known as the *chala* structure. There are different types of *chalas*. The *do-chala* type has only two hanging roof tips on each side of a roof divided in the middle by a ridge-line; *char-chala* type, four roof corners and have a dome-like shape; the double-storey has *at-chala* type and has eight roof corners. Considering the roof corners and the double-storey, the Ghanasyam House falls under *atchala* architecture **Fig. 4.5** (Front view, roof). According to the Archaeological Survey of India (S. Gupta & Panda, 2011), the monument reflects the influence of Islamic architecture because of the 3 arch-type of the door entrance **Fig. 4.5** (Key Plan) and in inside the north wall contains a *Mihrab*. The edges of arches are ornamented with decorative terracotta tiles with multiple zigzag patterns. The monument is rich with detailed terracotta sculptures, various floral motifs, patterns, mythical creatures and visual narratives. 'The mosaic over the central arch depicts a lively scene of a number of monkeys that appear frolicking, but a closer study reveals that is a kaleidoscopic scene from the *Ramayana*<sup>19</sup> in which the monkeys are actually engaged in constructing the stone bridge to Lanka. In the upper left-hand side, two monkeys are carrying a stone block while others are giving directions. In the upper right-hand side *Sita* is seated in the *Asokavana*<sup>20</sup> while another tile shows a crude representation of *Ravana* in meditation' (Das, 2019). The monument radiates cultural and religious fusion with the craftsmanship of the artisan.

---

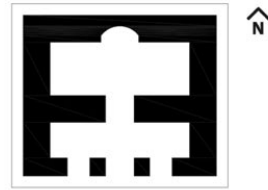
<sup>19</sup> *Ramayana* is an ancient Sanskrit epic which follows Prince *Rama's* quest to rescue his beloved wife *Sita* from the clutches of *Ravana* with the help of an army of monkeys.

<sup>20</sup> The name of tree under which *Sita* Devi spent one year while she is in Lanka. That garden is called '*Ashokavanam*'

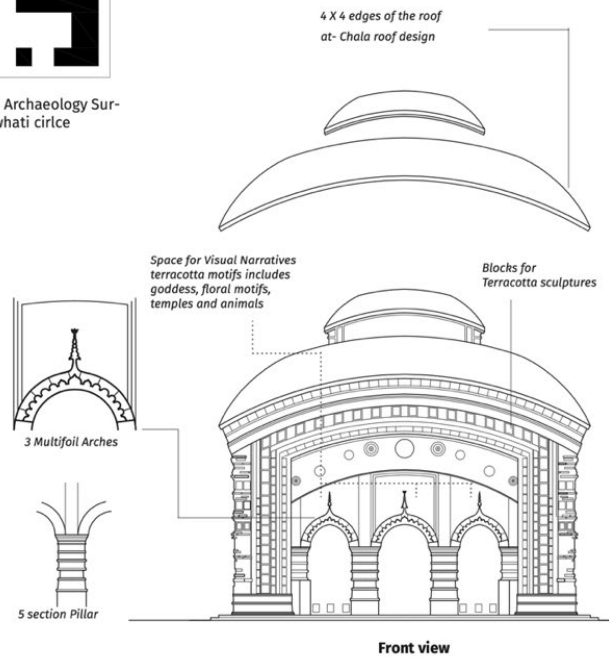
**Name: Ghanashyam House**  
**Location: Joysagar**  
**Year: 1696-1714**



**Ghanashyam house (1946-47)**  
 Source: ASI, Guwhati cirlice



Key plan: Source Archaeology Survey of India, Guwhati cirlice



**Fig. 4. 5** Ghanasyam House with the key plan and structural study.

#### 4.2.1 Variation analysis of Motifs and Patterns – Ghanasyam House

The data were sorted based on the variation type and quantity of the motifs used in the ornamentation of the monument along with its structural descriptions. The quantified results of the (**Appendix D, Appx. Table 1.1**) indicate that there are seven different types of floral motifs with variations in shapes and sizes. It was observed that out of 248 motifs, 73% are floral motifs, 4% are Compound motifs, 17% are animal motifs and 7% are symbolic. The variation analysis of the floral motifs indicates that the Lotus motif is the predominant floral motifs of all.

On the exterior surface of the monument, there are more than 709 motifs plaques, out of which 63% are organic patterns and 37 % are geometric. Out of 89 pattern plaques in the interior, 69% are organic patterns and 31% are geometrical. Both the data indicate that the organic patterns are more commonly used patterns in the monument (**Fig. 4.6**). In the analysis, it is observed that consideration of seamless design is visible in the patterns.

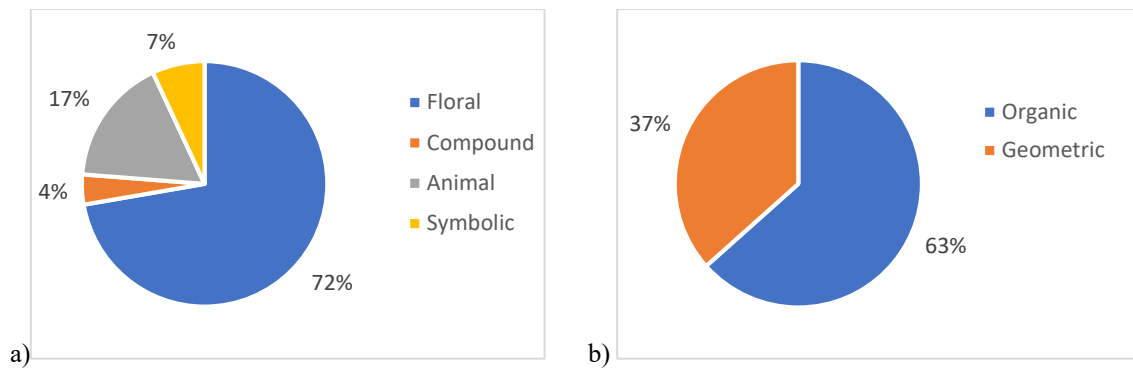


Fig. 4. 6 Pie chart displaying the percentage of a) Motif and b) Pattern types used in Ghanasyam House.

**Namath Kali Temple (Fig. 4.7)** is located near the northwest side of the famous Kamakhya Temple in Nilachal Hills, Guwahati Assam. According to the Directorate of Archaeology, Guwahati, Assam, the Ahom king *Siva Singha* (1714 - 1744 CE) became a disciple of *Krishnaram Bhattacharyya*, who was given the management of the temple of Kamakhya. Krishnaram and his successors, generally known as *Parbatiya Gosain*, were assigned large land estates to maintain this temple. Considering the literatures, it is evident that the temple was constructed and maintained by descendants of *Parbatiya Gosain*, known as *Na-Gosain*. However, the exact period of the construction is still unknown.



Fig. 4. 7 Namath Kali Temple of Nilachal Hills, Assam

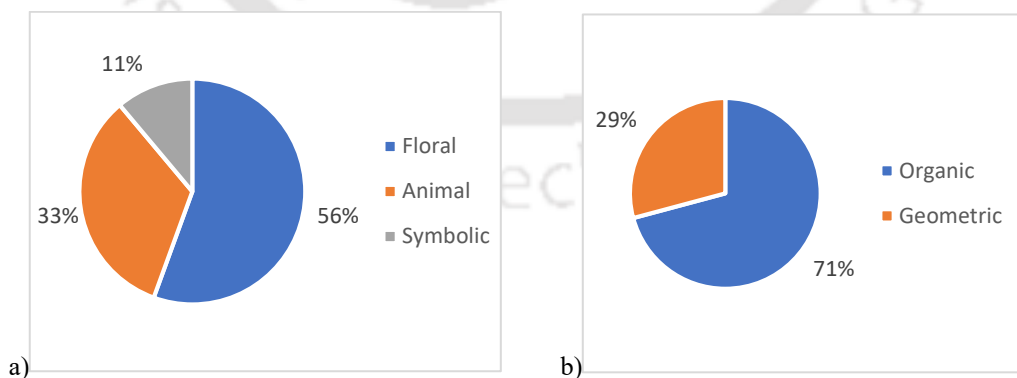
Though few portions of the monument retain its early structures (Fig. 4.6), the left section of the façade has retained its details in ornamentation. The monument is constructed

over a raised rectangular platform and some ornamentations are visible in the doorway pillars of the temple. Multiple decorated terracotta plaques are aligned all over it. The upper section of the wall consists of floral pattern plaques with floral motifs placed within parallelogram and rectangular borders. Some of the terracotta sculptures of humans in acrobatic postures, gargoyles and monkeys at corners of walls are extended like fins and are aligned vertically. The existing remains of the temple reflect the essence of the Ghanasyam house of Sivasagar with roof style, terracotta plaques and similar construction materials like terracotta bricks and lime mortars. Considering the overall structure, it is fair to assume that Namath kali Temple had the *Chouchala* roof type as Ghanasyam House. The decoration moulds of both the monuments have their own identity in the compositions of sculptures, motifs and patterns.

#### 4.2.2 Variation analysis of motifs and patterns – Namath Kali Temple

The data collected from the Namath kali is comparatively very less; this is due to the fragmentation of the monument. There are only a few plaques attached to the façade of the structure.

With the collected data, it was observed that there were no survived compound motifs; only floral, animal and symbolic motifs were present. The collected data disclose variations in floral motifs and animal motifs. Out of 37 motifs and patterns, 56 % floral motif, 33 % animal motif and 11% symbolic motif. The organic patterns are more in percentage, with 71% and 29% of geometric patterns. The results disclose floral motifs and organic patterns to be predominantly used in the ornamentation of Namath Kali Temple (**Fig. 4.8**)

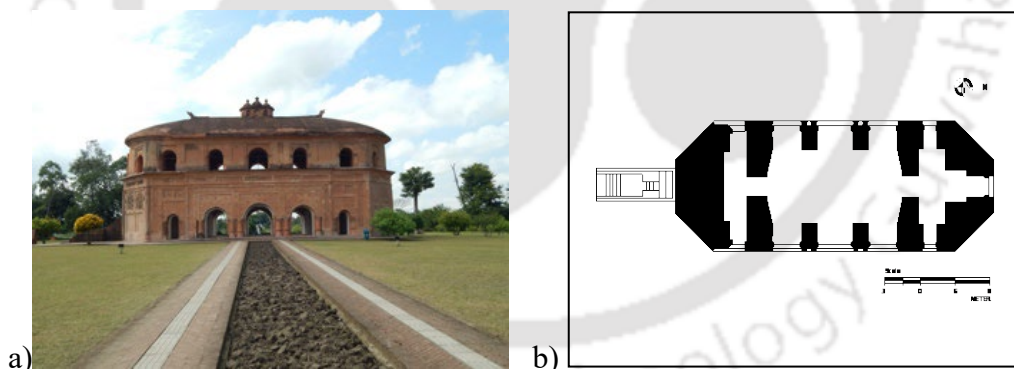


**Fig. 4. 8** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Namath Kali temple.

### 4.3 Stucco Ornamentations

**Rang Ghar** This monument was built by Ahom King *Pramatta Singha* (1744-1751). The building has a unique shell-roof style that leads to a parabolic roof structure (**Fig. 4.9, a**). A similar roof style is observed in *Mandapa*<sup>21</sup> of Kamakhya temple in Nilachal Hills, Guwahati, Assam. The ground-plan is a rectangle with trapezoidal ends (**Fig. 4.9, b**).

There are multiple entrances and openings with multifoil arches on both floors, which resembles the *Indo-Islamic* architecture of India. The monument is ornamented with many beautiful floral motifs, creepers, compound motifs with flowers, animals and mythical creatures. The ornamentation also includes the representation of Hindu symbolic forms like *Makara*. The monument is constructed as a royal grandeur for witnessing outdoor games, such as buffalo-fight, falconry, outdoor games etc. (Gupta and Panda, 2011). The raw construction materials are brick and mortar. Some remains of decorative terracotta bricks are observed in the monument's entrance pillars, which resembles the terracotta bricks of Ghanasyam House of Joysagar area, Assam. The monument exhibits the exceptional craftsmanship skills of the artisans in brick architecture and ornamentations. With due course of time, it has successfully survived many earthquakes as it sits on the high prone earthquake zone-V (FPJ Bureau, 2019).



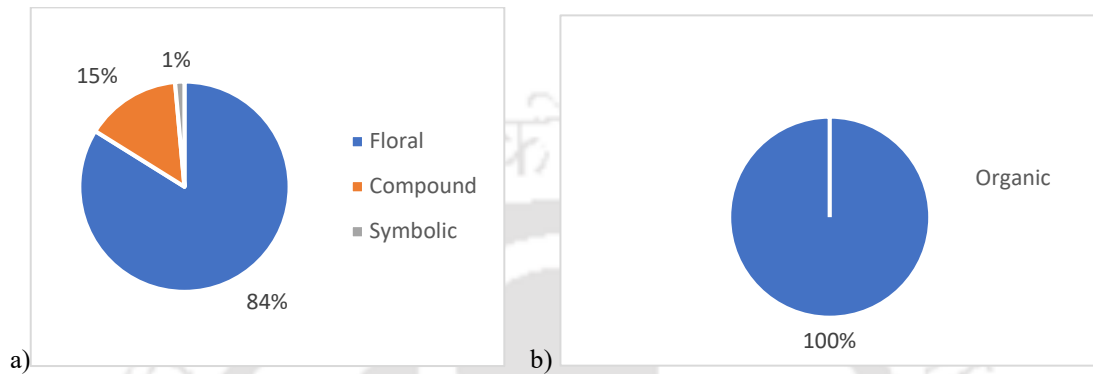
**Fig. 4.9** (a)Front side of Rang Ghar with key plan (b)- source ASI

#### 4.3.1 Variation analysis of motifs and patterns – Rang Ghar

The ornamentation variation analysis of Rang Ghar discloses the usage of a variety of motifs and patterns covered in walls and entrances. There is repetitive use of singular floral motifs all over the walls of the monument. All the compound motifs are different in compositions, but similar shapes and forms are seen amongst them. There are no significant animal motifs in the

<sup>21</sup> A pillared hall or porch fronting a Hindu temple. It may be attached or detached from the building.

walls of the monument, but figurative forms of animals are found in compound motifs with vegetal forms and branches in composition. The quantitative data discloses 84% use of floral motifs, 15% compound motifs and only 1% symbolic motifs (**Fig. 4.10, a**). From the extracted data, it was observed that only organic patterns are part of the ornamentation. Each organic pattern has varied flowers and leaves in its compositions.



**Fig. 4.10** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Rang Ghar.

**The Talatal Ghar** monument (**Fig. 4.11, a**) is one of the largest and extended secular buildings built by the Ahom dynasty, in one of the Ahom's capital city *Rangpur*. The building was initially constructed using woods and locally available ephemeral materials. Later it was rebuilt by Ahom king *Rajeshwar Singha* in 1765 using bricks and mortars (Gupta, 1982).



**Fig. 4.11** (a)Front side of Talatal Ghar with key plan (b)- source ASI

The architecture consists of multiple floors and openings in multifoil curve arches. The ground floor of the monument has many chambers inside; the exterior consists of multiple openings with stylobate pillars and entrance arches. Some ornamentation remains are visible

in the building walls with floral motifs, compound motifs with humans, animals and plants. Stairs are built inside the building directing to the terrace. The structure has a small octagonal temple attached to it. According to Barpujari (2007), the monument was originally a three-storey building with a sub-terranean storey. The upper storey has almost disappeared only few sections and fragments are present as remains. The present ground floor is almost filled up with soil. The overall structure defines exceptional engineering in brick architecture.

#### 4.3.2 Variation analysis of motifs and patterns – Talatal Ghar

The variation analysis of the ornamentation of Talatal Ghar displays the use of floral, animal motifs and compound motifs in walls of the monuments. Unfortunately, most of the motifs are in derelict conditions. However, the author tried to extract as many elements out of the survived motifs and patterns using various software by changing the exposure values of the original photo data. The results show 17% of floral motifs, 33% animal motifs and 50% animal motifs in fragmented conditions. The patterns include 89% organic patterns and 11% geometric patterns (Fig. 4.12). The variation analysis of the pattern shows multiple asymmetric patterns with complex compositions in the interior entrances of the monument. These details are not visible in normal lighting conditions; the data collection included arrangements of good lighting conditions to extract maximum details of the ornamentation.

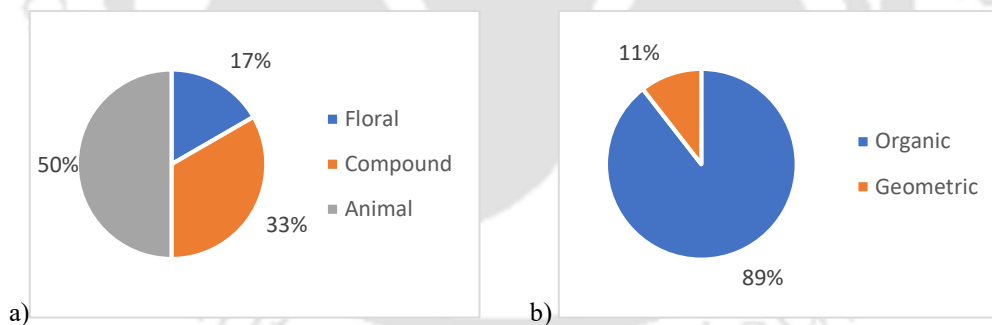
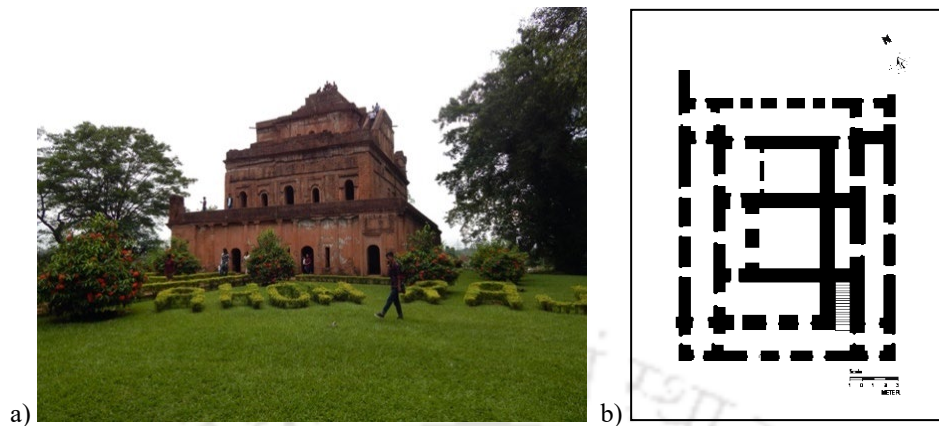


Fig. 4. 12 Pie chart displaying the percentage of a) Motif and b) Pattern types used in Talatal Ghar.

**The Kareng Ghar (Fig. 4.13, a)** is also tagged as *Ahom Raja's (King's) Palace* by ASI, Guwahati circle, Assam. The monument is considered to be the royal palace of the Ahom. It was built during the reign of Ahom king *Rajeshwar Singha* (1751-1768) (Gupta and Panda, 2011). The brick architecture monument has four storeys, with spaces for an open terrace on each floor. The building is elevated with proportionately smaller storeys one above the other thus, giving a pyramidal effect to the whole elevation. The structure consists of multiple openings, with room-like chambers for each storey. The construction consists of multiple

pillars with different shapes and sizes. In the ground floor's exterior, the façade consists of multiple pillars and columns supporting the monument.

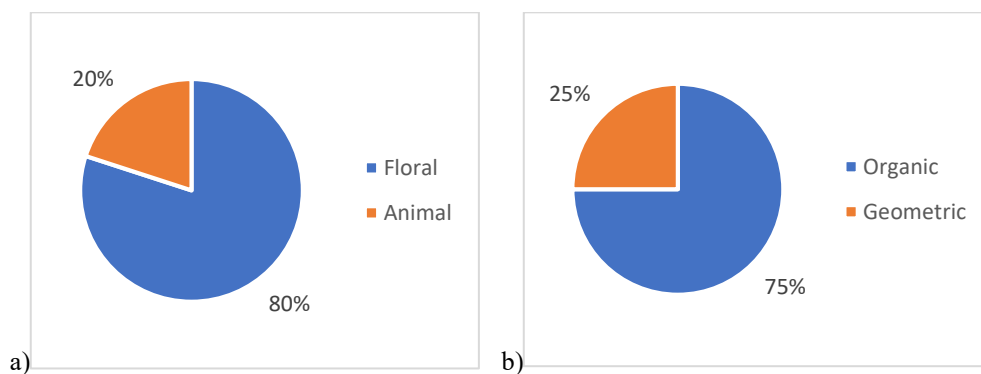


**Fig. 4.13** (a)Front side of Kareng Ghar with key plan (b)- source ASI

Most of the pillars designed with stylobate. The building is almost square in plan. Some of the ornamentation remains are visible in the pillars, walls and ceilings of the floors. This monument uses bricks and mortar as the construction materials. Variations of brick structures are observed in the pillars and columns of the building. Most of the upper section of the monument disappeared due to natural causes. The preserved portion radiates the artisan’s skillset and profound understanding of construction on brick.

#### 4.3.3 Variation analysis of motifs and patterns – Kareng Ghar

With the same condition as Talatal Ghar, the Kareng Ghar motifs and patterns are very less in quantity. Most of the sections of the monuments are refurbished. The data discloses only two types of survived motifs- floral motifs with 80% and animal motifs with 20%. In the case of patterns, quantitative data highlights 75% organic and 25% geometric. These results show the floral motifs and organic patterns to be predominant types of architectural ornaments (Fig. 4.14.).



**Fig. 4.14** Pie chart displaying the percentage of a) Motif and b) Pattern types used in Kareng Ghar.

## 4.3 Findings

### Interview and discussion findings

- The materials used in renovations includes bricks, unslaked lime, brick surkhi, brick aggregate. The organic materials include molasses, Indian bael gum, *methi* (fenugreek seeds), *hilikha* (*Terminalia Chebula*), *katha* (*Catechu*), black lentils. The material they use for renovations includes custom size bricks replicating the early bricks.
- Early brick replicas are custom-made for the refurbishment of the architecture which not easy to manufacture as the brick kiln has to create custom moulds of early bricks.
- Ornamentation works includes visual observation and replicating the existing form.
- Stucco relief artisans are significantly scarcer in Assam. Hence, artisans from West Bengal are hired to do the refurbishment work.
- Ahom architectural ornamentation study is rare.
- The Assam *Chala* brick monuments has similarities with West Bengal *Jor Bangla* Temples. Similarity of west Bengal terracotta are mentioned in the literatures, but the comparison is yet to be studied.

With the overall variation analysis, based on the quantitative data, here are the following findings of each of the monuments.

### Ghanasyam House

- The lotus motif is the most dominating motif, with six variations in motif style.
- The *Gha-M-Ro-F-05*(**Appendix D**) is the most repeated single floral motif; these floral motifs are placed near the roofline.
- There are multiple animal motifs, with humans, birds like parrots and peacocks and animals including monkeys.
- Visual narratives of Ramayana are observed in the upper section of the three entrance arches of the façade.
- There is no repetition of human terracotta plaques; all the compositions are unique.
- Compound motifs primarily include branching of vegetal forms.
- Symbolic motifs include Hindu symbolic forms. The motif of Temple with *Shiva Linga* inside it has the highest replications all over the front three entrance arches.
- The pattern block code *Gha-P-Wa-O-03* (**Appendix D**) has two different flowers that touches each other in alternate positions with highest repetitions.
- The use of geometric pattern blocks is observed in the pillars and wall sections.

- There is total of 9 pattern variations in the Ghanasyam House. The repetition of the pattern plaques is more compared to motifs.

### **Namath Kali**

- The structure of Namath kali is in dilapidated condition. There is less surviving ornamentation compared to the Ghanasyam House.
- There are four variants of single floral motifs.
- Lotus motifs are common with six and eight-petal variants.
- Human figures with various postures are observed.
- *Makara* motif is observed in the upper section of the façade.
- The patterns blocks are geometric and organic in shapes, with the organic patterns being predominant.

### **Rang Ghar**

- The single floral motifs have three variants. With three-layered petals, two-layered petals.
- The single floral motif Lotus is the predominant motif.
- The single floral motifs have the highest repetitions compared to other motif types.
- The compound motifs have a total of 41 variants, with the highest number of diverse compositions. Some of the compound motifs are semi-refurbished and a few of them is fully refurbished motifs. The fully refurbished compound motifs are not considered as they lack in early aesthetics.
- The compound motifs include horizontal and vertical panel compositions.
- The *Ran-M-En-S-01*(**Appendix D**) *symbolic* motif has only one variant; this motif is mostly placed over the interior and exterior entrance arches.
- The Pattens has seven variants; all of them are organic with vegetal forms.

### **Talatal Ghar**

- Most of the surviving ornaments are in fragments.
- Only 1 variant of a single floral motif is observed. This variant shares similarities with the Ghanasyam House and Rang Ghar single lotus motifs.
- Two variants of compound motifs have survived.
- The compound motifs include horizontal and vertical panel compositions.

- The animal motif includes human forms, with three variants.
- Talatal Ghar shows the highest number of organic pattern variants in stucco reliefs. The interior section has most of the variants.
- The inclusion of geometrical patterns are observed in the pillars of the monuments.
- Organic patterns are the predominant patterns compared to geometric.

### **Kareng Ghar**

- Most of the surviving ornaments are in fragments.
- Two variants of single floral motifs are observed.
- Animal motifs include birds with only one variant.
- The Organic patterns have nine variants. These variants are observed on walls and pillar sections of the monuments
- The geometric pattern has three variants.
- The floral motifs and Organic patterns are predominant in overall ornamentation

The variation analysis intends to identify the visual forms used in the ornamentation. Based on the identifications, the variations are identified. This helped to understand the variations within a motif and pattern category. Quantitative data showcases the predominant types of motifs and patterns, their variations and repetitions. With the cumulative data analysis, the results disclose that the use of floral motifs and organic motifs is significantly more than other motif types.

The **Table 4.2**, display the data coding and linear extractions of floral motifs of the Ghanasyam House, similar structure is followed in data categorization and linear extraction of motifs and patterns. The details are in **Appendix D**.

**Table 4. 2 Sample table of variations of Floral Motifs – Ghanasyam House**

Code	Image	Linear Extraction	Quantity
<i>Gha-M-En-F-01</i>			4
<i>Gha-M-Wa-F-02</i>			3
<i>Gha-M-Wa-F-03</i>		 Reconstructed	3
<i>Gha-M-Wa-F-04</i>			5
<i>Gha-M-Ro-F-05</i>			160
<i>Gha-M-Ro-F-06</i>			5
<i>Gha-M-Wa-F-07</i>			1

## CHAPTER FIVE: Visual analysis

In the last **Chapter 4**, the variation of the coded motifs and patterns are analysed based on the adopted categorization theory of the coded data (Athavankar, 1989). Visual analysis is considered to study the underlying structure of the motifs and patterns used in ornamentations of the monuments. It considers the terracotta ornamentation and stucco ornaments as distinctive categories, as the terracotta process includes burning clay and molding techniques converted into motifs and patterns plaques. However, the stucco includes sculpting on plain surfaces using mortar, forming reliefs of motifs and patterns.

The primary phase of visual analysis includes linear extraction of the coded motifs and patterns. The linear extractions succor in distinguishing the outline of the shapes and elements used in the ornamentations. These linear extractions are then dichotomized into unit forms, subunit forms and superunit forms. The process helps to cognize the elemental compositions of the ornamentation. Wong (1993) explains that when a design is composed of a number of forms, those of identical or similar shapes are ‘unit forms’ which appear more than once in a design. The presence of unit forms helps to unify a design. Wong further explains that a unit form can be composed of smaller elements that are used in repetition; such elements are called subunit forms. Furthermore, if the unit forms in the process of being organized in design are grouped together to become a bigger form which is then used in repetition, are called superunit forms. The dissection of the linear extractions is done considering unit forms, subunit and superunit forms. These considerations helped to navigate the various elemental compositions in motifs and patterns. With the segmentation of motifs and patterns composition, each form is studied based on its shapes, branching and spatial arrangement.

Symmetry analysis is a significant consideration for this study. Washburn and Crowe (1988) has considered extensive studies in symmetry and patterns. Hann (2013) in his book, ‘*Symbol, Pattern and Symmetry*’, he explains the importance of structural characteristics of ornamentations to study cultural diffusion, adoption and adaptation. The author stretches the importance of *style*- it is the sum of aesthetic attributes which place an object within a particular range of types. He states that the most significant aesthetic attributes are the shape and form of the object itself and its surface patterning, texture and coloration. The cultural changes in society are expressed in subtle ways through changes in the structural characteristics of visual art.

(Washburn and Crowe, 1988) They highlights that symmetry classifications of bodies of data from ethnographic groups have revealed that cultural groups (i.e., interacting peoples who share a standard life system) have preferential ways of arranging design elements. A cultural group will constantly use its specific types of seven one-dimensional and seventeen two dimensional patterns rather than randomly using them in their design. The nonrandomness of design structure, as measured by symmetry analysis, in any given cultural group is fundamentally significant.

As explained in Chapter 3; the symmetry analysis considers four symmetry operations – *rotation, reflection, translation and glide reflection*. These operations consist of seven one-dimensional patterns and seventeen two-dimensional patterns. The linear extracted patterns are analysed based on these pattern classes.

Considering the shapes, forms, colours, textures & symmetries, the visual composition of each motif and pattern is studied to find the underlying ornamentation design structure of these monuments. This chapter studies the mentioned attributes from each of the monuments. The analysis considers two distinctive categories, i.e., the terracotta and stucco types; the Ghanasyam House and Namath kali Temple are considered in the terracotta type category and Rang Ghar, Talatal Ghar and Kareng Ghar are considered in the stucco type category.

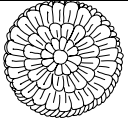





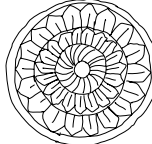


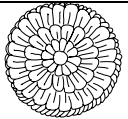


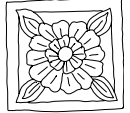



### **5.1 Form extractions from terracotta ornamentations**










The Ghanasyam House and Namath Kali Temple motif and pattern have been extracted based on unit forms, as shown in **Table 5.1 to 5.8**. The compound motifs of the Ghanasyam House include floral extensions displaying branching in the compositions. The analysis extracts the rudimentary elements like the petal shapes, core, base, extension type in branching, abstract shapes and repetition of shapes. The table sections are divided into codes, elements and descriptions. The element section is subdivided into unit forms and subunit forms of various shapes, flowers, leaves, branching and base or border types, with codes and descriptions of each motif and pattern. The animal motif and symbolic motif's compositions are considered a whole unit; this includes body parts and the associated elements. The results of this analysis disclose the predominant shapes, symmetry and pattern classes.

### 5.1.1 Ghanasyam House form extractions












The table below showcase the unit forms, subunit forms and superunit forms of the motifs and patterns.




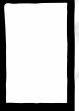
**Table 5. 1 Ghanasyam House – Elements of floral motifs**

Code	Floral	Elements			Description
		Centre	Shape types	Base	
<i>Gha-M-En-F-01</i>		●	3 layered  Rounded petals		The lotus motif has a circular base with three layers of petals arranged in a circle, with a core in its centre. The shape of the petals is a rounded type. The border of the base has a texture of twinning wire all around. The petals are arranged in radial composition.
<i>Gha-M-Wa-F-02</i>		●	 Pointed petals		The lotus motif has a circular base with petals. The arranged petals display affinity, with a core in its center. The shape of the petals is a pointed type with in-lines. The border of the base is a thick circular stroke. The arrangement of the petals is in affinity leading to unity in the composition.
<i>Gha-M-Wa-F-03</i>		●	 Pointed Petals		The lotus motif has a circular base with a border and three layers of petals arranged in a circle, with a core in its center. The first layer from the core has arc lines in place of petals. The arc follows the radiation pattern in clock wise direction. The petals are pointed type.
<i>Gha-M-Wa-F-04</i>		●	3 layered  Rounded		The lotus motif has a circular base with three layers of petals arranged in a circle, with a core in its centre. The shape of the petals is a rounded type. The border of the base has a texture of twinning wire all around. The petals of the motifs arranged in radiation composition.
<i>Gha-M-Ro-F-05</i>		●	  Rounded Petals & Pointed Sepals		The floral motif has a square border, the floral motif has two layers of petal and the sepals are diagonally placed in each corner between the


					flower and the border. The petals have rounded tips and the sepals have a pointed tip with in-lines.	
<i>Gha-M-Ro-F-06</i>		●	2 layered  Rounded Petals		Lotus motif near the top roof. The lotus has a circular base with 2 step petal expansion. The petal shape is rounded. The petals are arranged in radial composition.	
<i>Gha-M-Wa-F-07</i>		●	  Rounded & Pointed petals	  Abstract Shape		The floral motif has a square base; it has two layers of petals. The first layer petals are having rounded tip and the second layer has a pointed tip with in-lines. Each corner of the base has two curved abstract shapes to complement the overall motif.

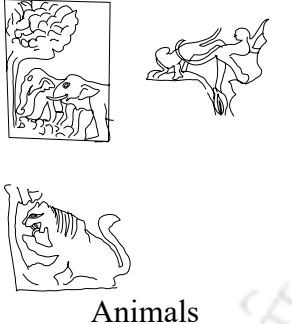
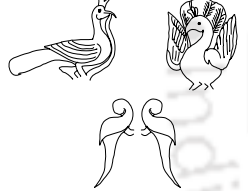
**Table 5. 2 Ghanasyam House – Elements of Compound motifs**

Code	Compound	Elements				Description
		Flower	Leaves	Base	Branching	
<i>Gha-M-Wa-C-01</i>		 				The compound motif follows symmetrical branching with flowers and leaves. It has two branch extensions with flowers and leaves on each side. The branching ends with a larger flower with two leaves extended on both side from the top of it. Two of the flowers includes buds with them. The floral motif has a rectangle border
<i>Gha-M-Wa-C-02</i>						The compound motif follows symmetrical branching with flowers and leaves. It has two branch extensions. The branching starts from the base with flowers and leaves on both the sides. The larger flower at the top





						extends the other branch with pointed tip leaves. This motif has a rectangle border
<i>Gha-M-Wa-C-03</i>						The floral motif has a rectangle border. The central floral motif has two layers of petals with rounded tip. There are two flowers on top and bottom of the motifs which are half cut from the center. The central flower has sepals extended towards each corners of the rectangle border. The sepal tips are pointed in shape. Proliferation is seen on the petals.














**Table 5. 3 Ghanasyam House – Elements of animal motifs**

Code	Animal Motifs	Elements			Description
		Body Parts	Man Made	Natural	
<i>Gha-M-Wa-A-(6 to 9)</i> <i>Gha-M-Wa-A-(11 to 16, 18,19)</i>	 Humans	Head Legs Hands Body Eyes Hair Mouth	Basket Bow Arrow Stick Dress Ornaments Crown Hat Palanquin	Flower Bird Dog Tree Fruits	Most of the human motifs are representational forms with full human body. Natural and man-made forms are included to express the cultural and environmental aspect of that era. The postures display movement in compositions. These are obtained by shifting hands and legs and leaning angles with the body.










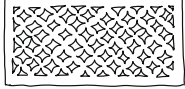


<p><i>Gha-M-Wa-A-4,10,17</i></p>	 <p>Animals</p>	<p><b>Elephant</b> eyes, Trunk, head, ears, legs, Tusk. <b>Tiger</b> eyes, Teeth, ears, legs, Tail, Body, head <b>Monkey</b> eyes, ears, legs, Tail, Body, Head</p>		<p>Tree Plant Branch Food</p>	<p>Depiction of animals are seen in motifs, including the anatomy of the respective animals. The animals are composed with natural forms like tree, branch, food and plants. The postures display movements in compositions. These are obtained by shifting hands, legs, tusk, trunk, tail and leaning angles with the body.</p>
<p><i>Gha-M-Wa-A-1,2,3</i></p>	 <p>Birds</p>	<p>Head Wings Beak Crown Legs Body Tail</p>		<p>Snake</p>	<p>Depiction of Plants are seen in Motifs, including the full anatomy of the respective birds. The peacock holds a snake in its beak, the details like crown of the peacock and its feathers are displayed. Birds like parrots are also included. The postures display movements and still compositions.</p>

**Table 5. 4 Ghanasyam House Elements of organic patterns**

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<p><i>Gha-P-Wa-O-03</i></p>			 <p>Rounded petals and pointed sepals</p>		<p>The pattern two different floral forms which are aligned together with one after another. The petal shape of one motif is rounded and the other is pointed. Each of it has a core.</p>

<p><i>Gha-P-Wa-O-04</i></p>			 <p>Rounded petals</p>	 <p>Spiral and angular lines</p>		<p>The pattern follows spiral curve, connecting the next spiral which is just the inverse of it. The design ends with half cut spiral which if added another block displays a seamless design. Angular line groves are seen all over the spiral curve including the edges of the base in multi direction. The centre of the spiral has a floral motif with rounded petals.</p>
<p><i>Gha-P-Wa-O-01</i></p>			 <p>Rounded and pointed petals</p>	 <p>Rounded tip leaves</p>		<p>The pattern includes repetition of an abstract image in two-way continuance, within the border. The shape consists of metamorphose leaf like shape extended to pointed tip. The pattern follows seamless design.</p>
<p><i>Gha-P-Wa-O-02</i></p>			<p><b>Abstract</b></p>  <p>Rounded proliferation with Pointed tip</p>		<p>The pattern includes repetition of an abstract image in two-way continuance, within the border. The shape consists of metamorphose leaf like shape extended to pointed tip. The pattern follows seamless design.</p>	

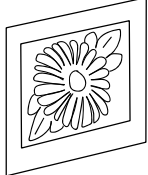

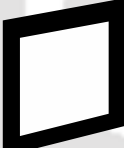
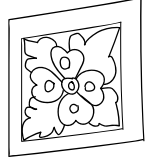

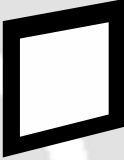
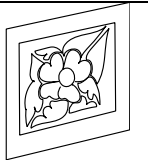

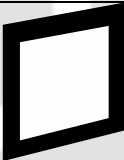
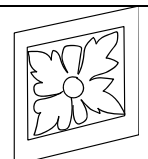

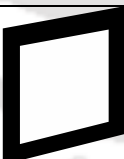
**Table 5. 5 Ghanasyam House – Elements of geometric patterns**

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<i>Gha-P-Wa-G-04</i>					The pattern plaque includes compound geometric forms, petals and rectangle with lines. The petals have pointed tips and each plaque has two geometric floral on each corner of it.
<i>Gha-P-Wa-G-05</i>					The pattern plaque include pentagon with two adjacent right angles. The pentagon follows two-way continuance, supported by a thick line on the top. The base is rectangle in shape.
<i>Gha-P-Wa-G-03</i>					The pattern plaque include triangle as a basic shape with Reflection on two-way continuance. There are two strips of triangles facing each other horizontally.
<i>Gha-P-Wa-G-01,02</i>					The pattern plaque includes triangles and squares with the lines curved inwards. The squares are placed diagonally and the triangles are placed on the edges of the plaques.


### 5.1.2 Namath Kali Temple- form extractions

In the last chapter the variation analysis results indicate that the ornamentation of Namath kali has able to survive in fragmented condition. The survive motifs and patterns are analysed in the table below.





**Table 5. 6 Namath Kali – Elements of floral motifs**




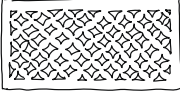
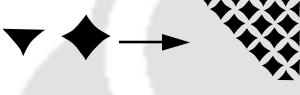

Code	Floral Motif	Elements			Description
		Centre	Shape types	Base	
<i>Nam-M-En-F-01</i>		●			The floral motif has a parallelogram base with thick boarder. Inside it has a circular flower with core in it. The petals are arrangements exhibit radial symmetry. The base has leaves pointing in each corner of the parallelogram.
<i>Nam-M-En-F-02</i>		●			The floral motif has a parallelogram base with thick boarder. The flower has four petals with rounded corner with hollow in it. The base has leaves pointing towards each corner of the parallelogram. The leaves are both pointed and rounded in shapes
<i>Nam-M-En-F-03</i>		●			The base geometry is common with both the above motifs. The motif exhibits similarity with <i>Nam-M-En-O-02</i> , the leaves are comparatively larger than the other mentioned motif. The petals have similar rounder shapes.
<i>Nam-M-En-F-04</i>		●			This floral motif has four petals with a central core. The composition has petals with rounded corners. The motif has a parallelogram base and is placed on the front wall of the monument.

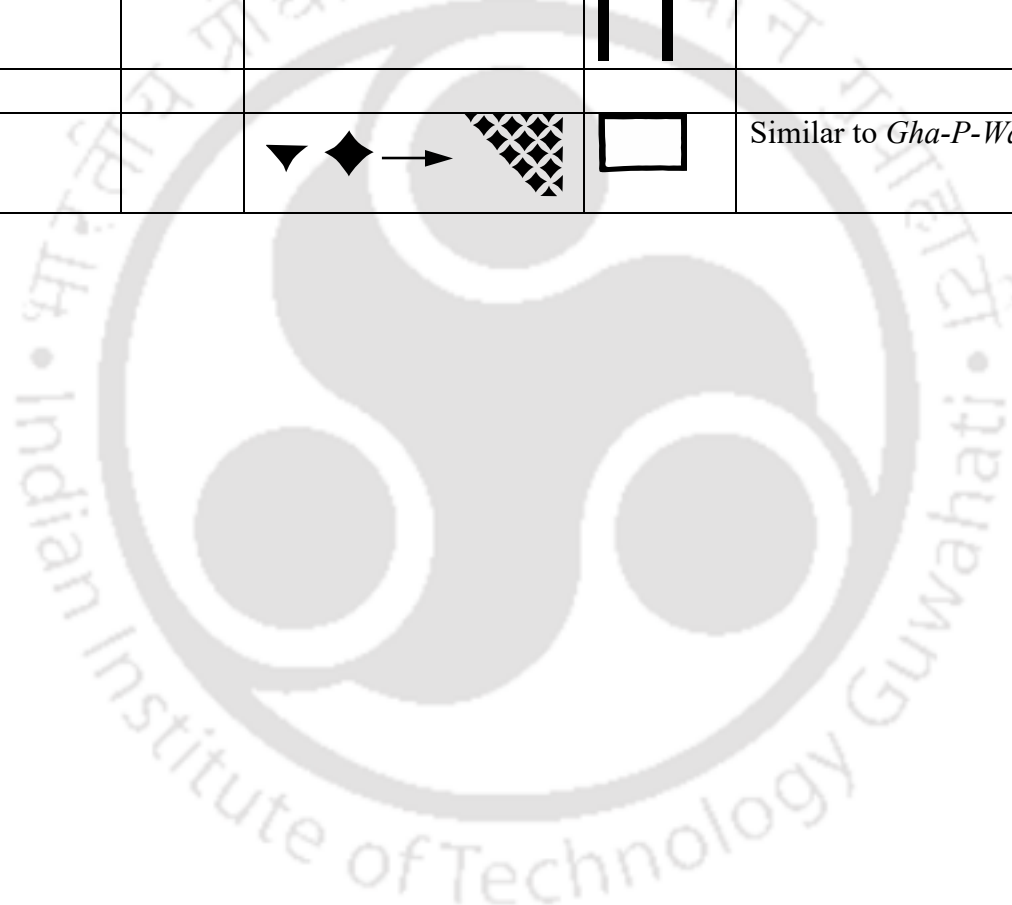
**Table 5. 7 Namath Kali – Elements of animal motifs**

Code	Animal Motifs	Elements			Description
		Body Parts	Man Made	Natural	
<i>Nam-M-En-A-01 to 04</i>		Head Legs Hands Body Eyes Mouth	<i>Doba</i> Drum Stick Dress Hat Shoes Sword Shield Trumpet	NA	Most of the human motifs are representational forms with full human body. Natural and man-made forms are included to express the cultural and environmental aspect of that era. The postures display movements in composition. These are obtained by shifting hands and legs and leaning angles with the body. The use of man-made things is observed in the compositions, depicting movement.

**Table 5. 8 Namath Kali – Elements of organic & geometric patterns**

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<i>Nam-P-En-O-01</i>					This organic pattern has a complex composition in terms of elements. The pattern plaques is placed in a vertical layout. The composition includes four petal flowers with pointed edges, vines intertwining and overlapping to connect each other in a repeated order. The motif is observed in the front wall of the monument.

<i>Nam-P-En-O-01</i>						The Organic pattern is seen in the front wall of the monument. The pattern plaque consists of curved leaves with multiple proliferation in it. The composition displays glide-reflection symmetry.
<b>Geometric</b>						
<i>Nam-P-En-G-01</i>						Similar to <i>Gha-P-Wa-G-01,02</i>





## 5.2 Results– terracotta ornamentation

### 5.2.1 Shape and form- Ghanasyam House.

The dismemberment of the motifs and patterns discloses a variety of shapes and forms considered in its composition. **Table 5.1 to 5.5**, study the elemental composition of the varied motifs and pattern types. With analysis of the visual attributes, it is observed that in most floral motifs, the petals of the flowers are rounded in shape compared to pointed petals. The repetition of the petal is arranged radially. In some floral motifs, the arrangement of the petals does not follow a strict repetition pattern but varies individually or progressively to conform to the overall shape and structure, which according to (Wong, 1993) in his book 'Principles of Form and Design' describes as Affinity, leading to unity in the composition.

The Compound motifs (**Table 5.2**) consist of an amalgamation of multiple organic shapes and forms. Some of the motifs follow branching with flowers and leaves. The petals and leaves are pointed and rounded in shape. Few leaves follow metamorphosis and deformation in shapes and some display proliferations within the shapes. Interestingly all the compound motifs are composed within a rectangular bordered frame. The branching includes curved upward and downward leaves with characteristics of splitting during extension.

In animal motifs (**Table 5.3**), the analysis considers the visual anatomy of the animals. Most of the animal motifs are represented in the form of humans, animals and birds. Head, eyes, body, legs and hands are distinctly visible in human forms. Apart from that, man-made and natural forms are placed within the frame. The animal form consists of head, legs, limbs, body, tail, tusk, trunk and ears based on animal species. The representation of birds includes the head, beak, legs and feathers. Both the animal and bird compositions are associated with natural forms like trees, plants and reptiles (**Table 5.3** displays the linear extraction of Animal motifs). It is observed that most of the compositions of the animal motifs display movement in the living beings' forms and posture. The artisans attain it by aligning the shoulders, legs, hands and heads in their preferred positions.

The ornamentation patterns exhibit the repetition of the unit forms (**Table 5.4** and **Table 5.5** display the linear extraction of pattern types). The organic pattern consists primarily of flowers and leaves. The petals are rounded and pointed in shapes. One pattern (*Gha-P-Wa-0-04*) follows a spiral curve connecting the next spiral, which is just the inverse of it. The design ends with a half-cut spiral, which, if added, another block displays a seamless design. This design plaque is also observed in one of the terracotta *Jor-Bangla* temples of Bangladesh. Angular line grooves are seen all over the spiral curve, including the base's edges in multi-

direction. Translation symmetry is observed in most of the pattern compositions. The visual elements of the motifs and patterns inherit design principles like Symmetry, Repetition, Radiation, Affinity and Unity. The ornamentation's composition analysis highlights the underlying principles like Repetition, Gradation, Similarity, Contrast, Concentration and Anomaly ( Deori & Barua, 2021). The use of seamless design in the pattern plaques discloses the expertise and conscious decision in design consideration and development of the ornamentation by the artisans.

### **5.2.2 Shape and form- Namath Kali.**

Although the architectural style resembles Ghanasyam House, the motifs have their unique representation. The tiling structure of these decorative plaques of the monument has similarities with the terracotta *Jor-Bangla* temples of West Bengal and Bangladesh. Nevertheless, the Namath Kali temple has lost most of its ornaments; the survived motifs exhibit beautiful details of the motifs and patterns.

The floral motifs have petals with pointed and rounded edges with parallelogram-shaped border frames. Most of the survived have floral motifs composed of four-petal types and are arranged diagonally. The animal motifs primarily include human figures in dynamic posture displaying movement in the compositions. The compositions are associated with man-made elements, like a man playing a locally made drum known as *the Doba* drum with drumsticks and another one playing a trumpet-shaped musical instrument. The human compositions also include holding a sword and shield. These figurative arts have details of humans wearing dresses, hats & shoes. The compositions are confined to a boarded frame of rectangle or parallelogram. It is done to attain the ornamentation's tiling pattern, providing the form and functionality.

There are no survived compound motifs; a symbolic motif is observed in the top section of the façade. This symbolic motif (*Nam-M-En-S-01*, Chapter 3) has substantial similarity with the *Makara* motif in Hindu mythology and interestingly, a similar form has been observed in a West Bengal *Jor- Bangla* Terracotta temple. The tusk extension has similar details to the Namath kali temple symbolic motif. These indicate that there is cultural diffusion, adaptation and adoption. The artisan had a similar understanding of developing the moulds for the ornamentations and the skills were shared within the geographical area. This may led the rulers to appreciate and adapt the visual art that emerged during that era.

The pattern plaques are also available in bits and pieces. The existing patterns display complex compositions of the structured intertwining of floral vines and some pattern plaques

display repeated curved and proliferated leaves following glide reflection symmetry. One of the geometric pattern plaques (*Nam-P-En-G-01*) has substantial similarity with the Ghanasyam House pattern plaques (*Gha-P-Wa-G-02*). The shapes and sizes of these pattern plaques are the same; these pattern plaques are placed in similar ways on both walls and pillars of the monument.

### 5.2.3 Color and Texture- Ghanasyam House & Namath Kali.

The color of the Ghanasyam House and Namath Kali (Fig. 5.1) radiates a tint of red due to terracotta plaques, bricks and mortar compositions. The terracotta process includes baking of clay; this creates a brown & reddish tone in the brick plaques. According to ASI, the composition of the early mortar includes the mixing of lime (limestone and snail shell), pulses, resin, hemp (*canarium resiniferum*), molasses, fish, etc. Again the fusion of molasses and limestone leads to the creation of red tint. (Saurav Khuttiya Deori et al., 2021)



Fig. 5. 1 Terracotta monuments colours Ghansyam House and Namath Kali Temple

In the ornamentation of the monument, the decorative texture is used for contrast in the composition. On the entrance arches of Ghanasyam House, near the Ramayana's visual narratives, the zig-zag texture is observed on the edges of each composition. The composition of the texture decorates the surface and remains subordinate to the shape. Though the zig-zag lines of the texture have irregularity, the composition of the texture plaques maintains a degree of uniformity with overall ornamentation. It highlights the artisan's design consideration with the elemental composition of each form and shape of the ornamentation leading to a harmonious design.

## 5.2.4 Symmetry Analysis of terracotta monuments.

### 5.2.4.1 Architecture- Ghanasyam House and Namath kali.

The architecture of the Ghanasyam House itself retains reflection or bilateral symmetry. Suppose an imaginary vertical line is drawn from the center of the middle multifoil arch. In that case, most of the elements of the ornaments present in the front wall exhibit bilateral symmetry (Figure Fig.5.2). Considering the vertical axis, it can be termed as one-directional reflection symmetry (Hann, 2013). The similarity in motifs placement can be observed on both sides of the front wall. Animal motifs like a peacock with a snake in its beak are placed on both the front wall's top corners facing each other. Similarly, the symmetry in the arches and the visual narratives over the smaller multifoil arches on each side supports bilateral symmetry. The floral motifs like the lotus motifs present in the front wall are also placed to support the reflectional symmetry.

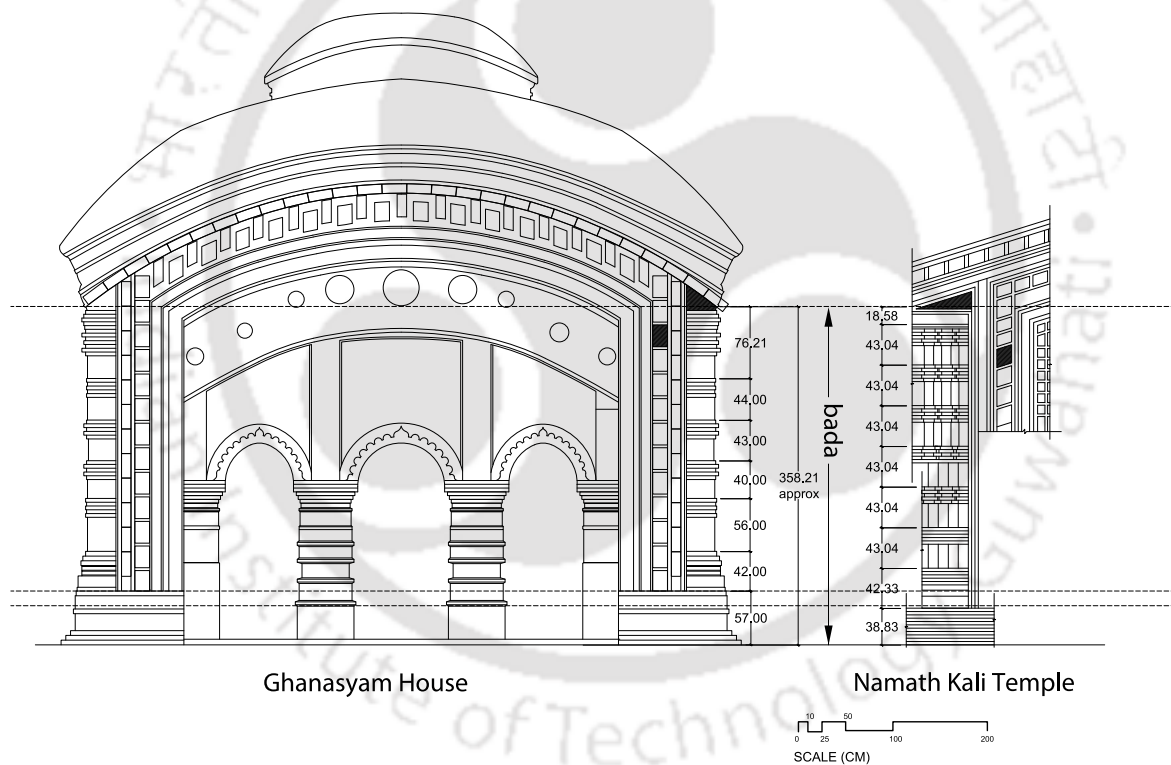


Fig. 5. 2 Comparison of *bada* section of Ghanasyam House and Namath Kali Temple.

Although most of the Namath Kali temple façade structure got damaged due to natural causes, the outline of the façade has a convincing similarity with Ghanasyam House. Considering this similarity in tilpattern and the architecture of both the terracotta monuments,

the study further includes comparison of *bada*<sup>22</sup> sections in terms of height and brick arrangements.

The comparison was analysed considering the primary data like photographs, brick dimensions and measurement. Using the AutoCAD software (2018 version), the monument's linear extraction is modeled. Both the models are then placed side by side to study the variations and similarities. The results (**Fig.5.2**) display similarity in height (approx.) from *jagati*<sup>23</sup> (platform) to the top portion of *bada*, but the difference in the brick arrangements and plaque moulds are noticed. The brick layouts in the *bada* are in horizontal and vertical arrangements. The horizontal bricks are arranged in a group of five layers of thin decorative bricks in both the monuments. These horizontal bricks groups divide the *bada* into multiple sections. The alternate sections are arranging with vertical bricks which are mostly wider and thicker than the horizontal bricks. Some of them are floral decorative plaques in Ghanasyam House, whereas only the brick remains are visible in Namath kali Temple. Although there is a similarity in the decoration style, both monuments retain their unique arrangements of the terracotta plaques. **Fig.5.2** also displays the variation of plaque moulds (highlighted with dark color). Near the *bada* of Ghanasyam House, decorative terracotta plaques are rectangular, whereas the Namath kali shapes of plaques are parallelogram. It is noteworthy that, in both the monuments upper section of *bada* forms a scalene triangle with a 90° angle (highlighted with dark color). The plaques display similarity in framing, including shapes like vertical rectangles and parallelograms.

#### 5.2.4.2 Symmetry in motifs.





























**Table 5.10** displays the linear extraction of various motifs in Ghanasyam House. The symmetry analysis shows that the single floral motifs follow rotational symmetry and two of the types follow four-fold rotation symmetry. The compound motif has one-directional and two-directional reflection symmetry. Most animal motifs are asymmetric with 360-degrees of rotation; there are only two types with one-directional reflection symmetry. The symbolic motifs are asymmetric with 360-degree rotation symmetry. The data analysis shows that out of 284 motifs, 73% follow rotation symmetry, only 4% follow bilateral symmetry and 23% are asymmetric with 360 degrees of rotation symmetry. The analysis shows that rotational symmetry is predominant, including some floral motifs variations with fourfold symmetry.

---










<sup>22</sup> The *bada* is the vertical wall portion of a temple, typically considered in Orissa temple architecture

<sup>23</sup> It is a raised platform for sitting and praying and is common in North Indian temples.

**Table 5. 9 Symmetry association of Motifs in Ghanasyam House**

Motif Types	Rotation Symmetry					Reflection Symmetry	
	4 fold Symmetry						
<i>Floral</i>							
<i>Compound</i>						Two-direction 	One-direction 
<i>Animal</i>	Asymmetric type with 360 degree rotation						
							
							
							
<i>Symbolic</i>							

**Table 5. 10 Symmetry association of Motifs in Namath Kali Temple**

Motif Types	Rotation Symmetry				Reflection Symmetry	
	2 fold Symmetry					
<i>Floral</i>						
<i>Compound</i>					Two-direction	One-direction
<i>Animal</i>	Asymmetric type with 360 degree rotation					
						
						
<i>Symbolic</i>						

**Table 5.11** displays the symmetry variations in the motifs of the Namath Kali temple. All the existing floral motifs display two-fold rotational symmetry. The compositions are in the parallelogram and rhombus-shaped border with a diagonal line of symmetry. Like the Ghanasyam House, the animal motifs are asymmetric with 360- degrees of rotation. The surviving motifs are comparatively less in number to determine the exact dominating symmetry. However, with consideration of existing floral motifs, the two-fold rotational symmetry is dominant in the façade of the monument.

#### 5.2.4.3 Pattern Analysis.

**Table 5.12** analyses the pattern classes of the plaques of Ghanasyam House. Terracotta pattern plaques are placed to provide transitional symmetry, i.e., one after another. In both organic and geometric pattern plaques, it is observed that the motifs plaques are grouped with more than one element. The compositions are analysed using systematic classification. The extracted linear data is analysed with the symmetry operations, considering the one-dimensional and two-dimensional pattern classes. It is interesting to observe that the patterns of Ghanasyam have both dimensions of classes. The one-dimensional classes of  $p111$ ,  $pmm2$ ,  $plal$  and  $plm1$  are observed in the organic patterns. In the geometric patterns, one-dimensional classes of  $pm1$ ,  $pmm2$  and a two-dimensional class of  $c2mm$  is observed. The class of  $pmm2$  pattern type is common in both geometric and organic pattern plaques. The pie chart results indicate the  $p111$  class to be the predominant pattern plaques, with the  $pmm2$  and two-dimensional class of  $c2mm$ . (Fig. 5.3, a)

**Table 5.13** of pattern class are extracted from Namath Kali temple. Transitional symmetry is also observed in the patterns. Both organic and geometric patterns plaques are placed on the façade of the monuments. One-dimensional patterns like  $pmm2$  &  $plal$  are observed and two-dimensional pattern  $c2mm$  is observed. This class of frieze pattern is also observed in one of the Ghanasyam House pattern plaques. The use of  $plal$  is predominant in the Namath Kali temple. (Fig. 5.3, b)

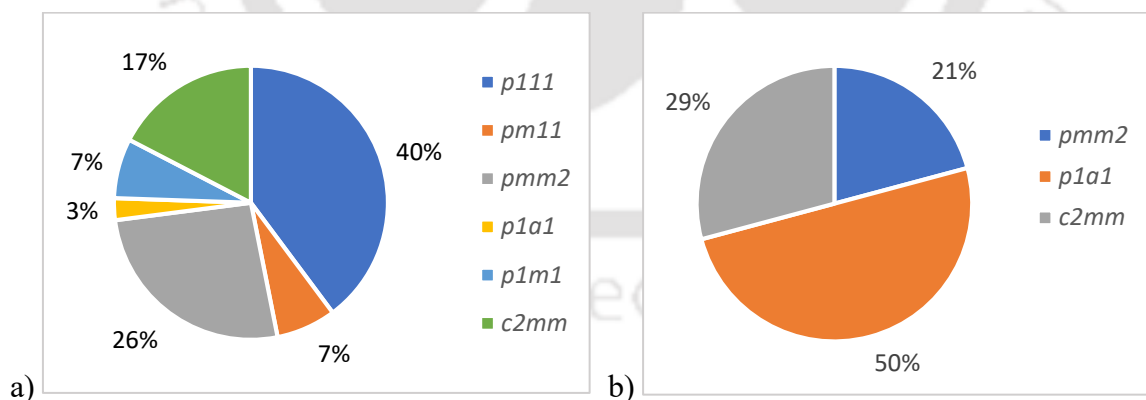
With the comparison of pattern classes of both the monuments, it is evident that patterns classes of  $pmm2$ ,  $plal$  and  $c2mm$  are standard in both the monuments.

**Table 5. 11 Pattern class association of Ghanasyam House**

Pattern Class	<i>p111</i> ▲▲▲▲	<i>pm11</i> ▼▼▼▼	<i>p112</i> ▲▼▲▼	<i>pmm2</i> □□□□	<i>plal</i> ▲▼▲▼	<i>p1m1</i> ▶▶▶▶	<i>pma2</i> ▲▼▲▼
<i>Organic</i>							
<i>Geometric</i>							<i>c2mm</i> 

**Table 5. 12 Pattern class association of Namath Kali Temple (Change the *pmm2*)**

Pattern Class	<i>p111</i> ▲▲▲▲	<i>pm11</i> ▼▼▼▼	<i>p112</i> ▲▼▲▼	<i>pmm2</i> □□□□	<i>plal</i> ▲▼▲▼	<i>p1m1</i> ▶▶▶▶	<i>pma2</i> ▲▼▲▼
<i>Organic</i>							
<i>Geometric</i>							<i>c2mm</i> 



**Fig. 5. 3 Percentage of pattern class in the pattern plaques of Ghanasyam House (a) and Namath Kali Temple(b)**

### 5.3. Form extractions from Stucco ornamentations

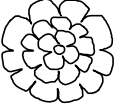

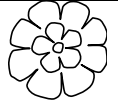

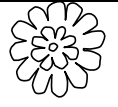

The Rang Ghar Talatal Ghar and Kareng Ghar are the only surviving massive brick architecture with stucco walls. The linear extraction from each monument discloses a variety of motifs and patterns. These decorations are rich in vegetal, figurative, organic, geometric and abstract forms. Following the similar analysis structure of terracotta plaque visual analysis, the stucco walls of the monuments are considered. The compositions are dismembered from the linear extraction to acquire the unit, subunit and superunit forms. These extractions are converted in solid two-dimensional shapes to analyze the aesthetics. **Table 5.13 to 5.22** display the visual attributes of motifs and patterns of Rang Ghar, Talatal Ghar and Kareng Ghar. The table includes the variation codes coded during variation analysis in the last chapter for easy referencing of the actual photograph. The element section is sub-divided into shapes, borders, center and branching with the description of each motif.

With each analysis of motifs in terms of shapes, form, colour and texture, these motifs and patterns have undergone symmetry analysis similar to the terracotta plaques. The analysis includes the formerly mentioned symmetry operations and pattern classes.








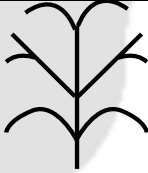




### 5.3.1 Form extractions – Rang Ghar



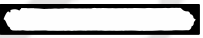









The table below showcase the unit forms, subunit forms and superunit forms of the motifs and patterns.



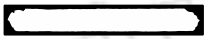



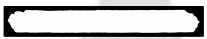




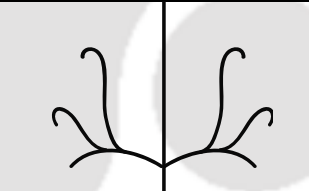

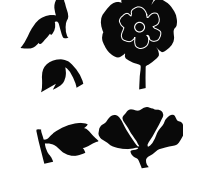


**Table 5. 13 Rang Ghar– Elements of floral motifs**



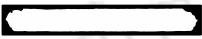
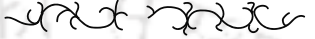



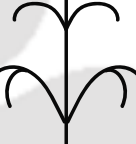



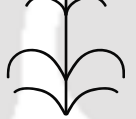




Code	Floral Motif	Elements			Description
		Centre	Shape types	Base	
<i>Ran-M-Wa-F-01</i>					The floral motif has 3-layer petals, with rotational symmetry. The petals are rounded in shape. These motifs are the largest amongst all the singular floral motifs. These motifs are used over the walls of the entrance pillars of the monument. The composition of these motifs is organic in nature.
<i>Ran-M-Wa-F-02</i>					The floral motif has 2-layer petals with rotational symmetry. The petals are rounded in shape. These motifs are systematically placed all over the lower section walls of the monument. The motifs are also seen over each multi-foil arches. The composition of the motifs is organic in nature.
<i>Ran-M-Wa-F-03</i>					The floral motif has 2-layer petals, with rotational symmetry. The petals are rounded in shape and the lower petal layer has more petal counts if compared to other single floral motifs. These motifs are systematically placed on the Right-side Arch entrance of the ground floor. The composition of the motifs is organic in nature.

















**Table 5. 14 Rang Ghar– Elements of Compound motifs**

















Code	Compound	Elements			Description
		Shapes	Base	Branching	
Ran- M- Wa-C- 01					This compound motif placed in the front walls of the lower section, towards the left portion of the monument. The motifs follow branching with three flowers extending from below, with leaves extending to floral buds. The motif exhibits bilateral symmetry. The petals are rounded in shape, with pointed leaves. The motif is placed inside a multi-foil arch frame. These types of composition are similar to some of the niche-and-flower design of the Indian carpets of the Mughal era.
Ran- M- Wa-C- 02					Considering the compositions, this motif has similarity with the (M-Wa-C-01) motif. It also displays bilateral similarity. The top flower has distinct petal cuts with extension to two buds on both directions. Interestingly the composition is more of a floral portrait rather than fusion with other elements like creepers or animals.
Ran- M-					This panel motif is placed just below the cornice of the monument towards the left side. The panel motif has been semi restored. It is observed considering remains of the panel's







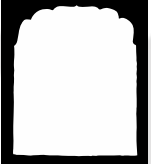
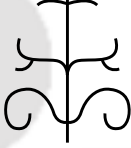


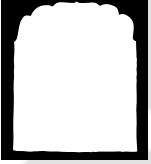





<p>Wa-C-03</p>					<p>mid-section the rest of the restoration is done. The panel composition displays bilateral symmetry. The mid-section consists of a vase or a pot like shape, where the floral creepers extends in both directions with flowers, buds and leaves. The creepers have smooth curve with wavy flow.</p>
<p>Ran-M-Wa-C-04</p>					<p>This panel motif is placed just below the cornice of the monument in the mid-section. The panel motif has been semi restored. The panel composition includes a mouse or squirrel like creature with extension of floral creepers from the mouth and torso part. The extended creepers include flowers, buds and leaves. The creepers have smooth curve with wavy flow.</p>
<p>Ran-M-Wa-C-05</p>					<p>This panel motif is placed just below the cornice of the monument towards the central section. The panel motif has been semi restored. The panel composition includes a face of mythical creature with front limbs. The creepers extension is from the mouth of the creature. The extended creepers includes flowers, buds and leaves. The composition follows bilateral symmetry.</p>
<p>Ran-M-Wa-C-06</p>					<p>This panel motif is placed just below the cornice of the monument in the mid-section. The composition includes a face of dragon like creature from the left with its fangs out. The</p>



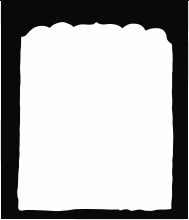
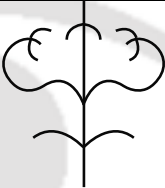

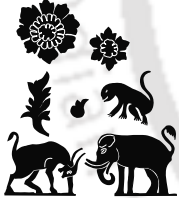
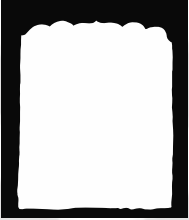
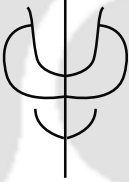
					creepers extend from its mouth to the other end of the panel. The creepers include flowers, leaves and buds.
Ran-M-Wa-C-07					This panel motif is placed just below the cornice of the monument in the mid-section. The motif has similarity with the elements of the (M-Wa-C-04) motif. The panel composition has a mirror reflection of the M-Wa-C-04 motif.
Ran-M-Wa-C-08					This panel motif is placed just below the cornice of the monument in the mid-section. The composition consists of creepers with multiple flowers, buds and leaves. The extension of the vines is seen from the flower petals. Asymmetry in composition is observed.
Ran-M-Wa-C-09					Considering the compositions, this motif has similarity with the (M-Wa-C-01, 02) motifs. It also displays bilateral similarity. The composition includes a branch out stem with 3 flowers, 4 buds and 3 leaves. The lower flowers have similar petal structure as compared to the top flower petals. The composition includes niche and flower design.
Ran-M-Wa-C-10					Considering the compositions, this motif has similarity with the (M-Wa-C-01, 02, 09) motifs. It also displays bilateral similarity. The composition includes a branch out stem with 3 flowers, 1 bud and 8 leaves. The lower flowers



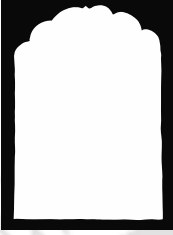



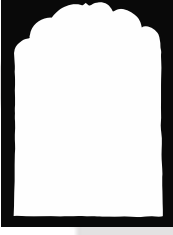





					have similar petal structure as compared to the top flower petals. The composition includes niche and flower design.
Ran-M-Wa-C-11					This panel motif consists of creepers with flowers, buds and leaves. The composition is asymmetric in nature. Each flower has eight petals. The vines branch out in curve shape and ends with a flower. The vines emerge from both the corners of the panel.
Ran-M-Wa-C-12					Considering the compositions, this motif has similarity with the (M-Wa-C-01, 02, 09) motifs. It also displays bilateral similarity. The composition includes a branch out stem with 4 flowers, which are composed as bend-neck. Branching in the composition is visible, with the stems and leaves.
Ran-M-Wa-C-13					Considering the compositions, this motif has similarity with the (M-Wa-C-01, 02, 09, 12) motifs. It also displays bilateral similarity. The composition includes a branch out stem with 3 flowers, where two lower flowers are composed as bend-neck. Branching in the composition is visible, with the stems and leaves.
Ran-M-Wa-C-14					This panel has some similarity with the M-Wa-C-06 motif. The panel follows bilateral symmetry. There are two faces of dragon like creature at both ends. The creature has sharp



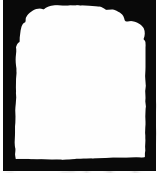
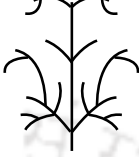


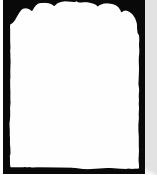
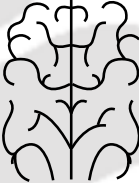








					teeth, where the vines emerges with a wavy flow. The vines include 5 flowers with leaves.
Ran-M-Wa-C-15					The panel consist of multiple flowers with leaves and vines. The vines extend from one end to another in wave formation. The panel is observed in the central back wall of the monument below the cornice.
Ran-M-Wa-C-16					This panel composed with the same level of the above panel. The composition includes bilateral symmetry. The composition includes vines with distinct tendrils, flowers and leaves. The vine branches out horizontally from the central stem towards both the end. The composition is very unique considering the other panel motifs.
Ran-M-Wa-C-17					This panel composed with flowers, stems, tendrils, flowers and vines. The vines emerge horizontally from the central stem in opposite direction. The vines follow wave like formation.
Ran-M-Wa-C-18					This panel is found to be fully restored. The composition includes a central vase/ bell like shape out of which the vines emerges in opposite direction horizontally. Multiple Flowers and leaves are observed in the panel composition.




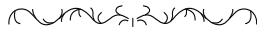
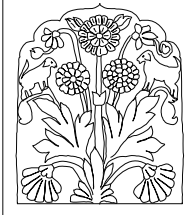









Ran- M- Wa-C- 19					This panel resembles <i>M-Wa-C-05</i> motif panel of the front wall. This motif is placed just below the cornice of the monument towards the central section of the back wall. The panel motif has been semi restored. The composition includes a face of a mythical / lion creature with front limbs holding the extended vines horizontally. The creepers extension is from the mouth of the creature. The extended creepers include flowers, buds and leaves. The composition follows bilateral symmetry.
Ran- M- Wa-C- 20					This panel composition has similarity with <i>M-Wa-C-18</i> panel motif. The vines emerged from the stems of the vase following bilateral symmetry branching. The composition includes multiple flowers and leaves extended from a vase.
Ran- M- Wa-C- 21					Considering the compositions, this motif has similarity with the ( <i>M-Wa-C-01, 02, 09, 12, 13</i> ) motifs. It also displays bilateral similarity. The composition includes a branch out stem with 5 flowers and multiple leaves.
Ran- M- Wa-C- 22					This motif has similarity with the ( <i>M-Wa-C-01, 02, 09, 12, 13, 21</i> ) motifs. Compared with other similar compositions, this composition is asymmetric. It includes a branch out stem with 3 flowers and multiple leaves.

<p>Ran- M- Wa-C- 23</p>					<p>The panel motif is composed using branching of a central stem in opposite direction horizontally. The composition reflects bilateral symmetry. It includes a central stem, multiple flowers, vines and leaves. The vines are follows wavy path in the composition.</p>
<p>Ran- M- Wa-C- 24</p>					<p>The composition reflects bilateral symmetry. The composition includes 7 flowers with variation in shapes and sizes, multiple leaves and a branching stem and vines.</p>
<p>Ran- M- Wa-C- 25</p>					<p>The composition reflects bilateral symmetry. The composition includes 9 flowers with variation in shapes and sizes, multiple leaves, 2 monkeys holding the branch extensions in the upper section of the compound motif. The branching of stem is observed. Six flowers are composed as bend-neck. Overall the composition is unique in nature with amalgamation of animal and flowers.</p>
<p>Ran- M- Wa-C- 26</p>					<p>This panel resembles (<i>M-Wa-C-05, 19</i>) motif of the front and back wall. This motif is placed just below the cornice of the monument towards the trapezoid section of the back wall. The composition includes a face of a mythical / lion creature with front limbs holding the extended vines horizontally. The creepers</p>

					extension is from the mouth of the creature / lion. The extended creepers includes flowers, buds and leaves. The composition follows bilateral symmetry.
Ran- M- Wa-C- 27					The composition has similarity with (M-Wa-C-26) motif. It reflects bilateral symmetry. The composition includes 6 flowers with variation in sizes, multiple leaves, 2 adult monkeys, 1 younger, hanging the branch extensions of the stem. In the lower section of the composition; on the left is a Rhino and a Lion/ tiger on the right facing each other. The multiple branching of stem is observed.
Ran- M- Wa-C- 28					The composition has similarity with (M-Wa-C-26, 28) motif. It reflects bilateral symmetry. The composition includes 6 flowers with variation in sizes, multiple leaves, 2 monkeys in the upper section, sitting over the branch extensions of the stem. In the lower section on the left is a raging bull and a elephant facing each other. The multiple branching of stem is observed.

<p>Ran- M- Wa-C- 29</p>					<p>The composition includes multiple branching. The motif displays bilateral symmetry. The motifs includes 7 flowers with multiple leaves and buds. Two survived headless birds are observed on the upper section of the motif.</p>
<p>Ran- M- Wa-C- 30</p>					<p>The motif has similarity with (M-Wa-C-30) motif. The composition includes multiple branching. The motif displays bilateral symmetry. The motifs include 7 flowers with multiple leaves and buds. Two birds are observed on the upper section and one bird on the lower section of the motif.</p>
<p>Ran- M- Wa-C- 31</p>					<p>This panel motif has a indiscernible form of a creature same where the vines of the creepers extends horizontally towards both the ends. The composition also includes multiple flowers with leaves. The vines have a wavy flow to it. The composition exhibits bilateral symmetry.</p>

<p>Ran- M- Wa-C- 32</p>					<p>The wall motif has similarities with <i>M-Wa-C-26, 28, 29</i> motifs. The composition includes two birds in the top portion, the lower portion includes animals in shape of dogs stretching upwards and resting the front paws on the stem of the plant. 10 flowers including buds and leaves are observed in the composition. Bilateral symmetry is observed in the composition.</p>
<p>Ran- M- Wa-C- 33</p>					<p>This wall motif has much detailed smaller flowers compared to rest of the motifs. The composition has branches of the stems which are more of vines with curve path. The composition exhibits bilateral symmetry. The composition includes multiple flowers and leaves.</p>
<p>Ran- M- Wa-C- 34</p>					<p>The remains of this motif exhibits branching of the composition, probably it had the same bilateral stem composition with multiple flowers and leaves.</p>
<p>Ran- M- Wa-C- 35</p>					<p>The remains of this motif have similarity with <i>M-Wa-C-34</i> in terms of the composition, floral design and branching remains.</p>

Ran- M- Wa-C- 36					The panel motif has similarity with the <i>M-Wa-C-24</i> motif. Both the motifs are placed below the cornice of the monument. The composition includes extension of the vines in horizontal from the central stem towards opposite directions. Multiple flowers and leaves are in the composition.
Ran- M- Wa-C- 37		Fully Refurbished			This motif composition includes both flowers and animals. Bilateral symmetry is observed. There are 7 flowers and two dogs like animal standing over the branch out leaves facing each other.
Ran- M- Wa-C- 38		Fully Refurbished			This motif includes 11 flowers with multiple leaves. There is variation in the floral types. The composition includes bilateral symmetry.
Ran- M- Wa-C- 39					This motif has similarities with the <i>M-Wa-C-11</i> Motif. The composition includes extension floral vine in horizontal direction. The vines include 10 flowers aligned in adjacent way over the wavy vine.




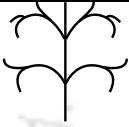















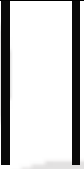





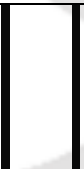



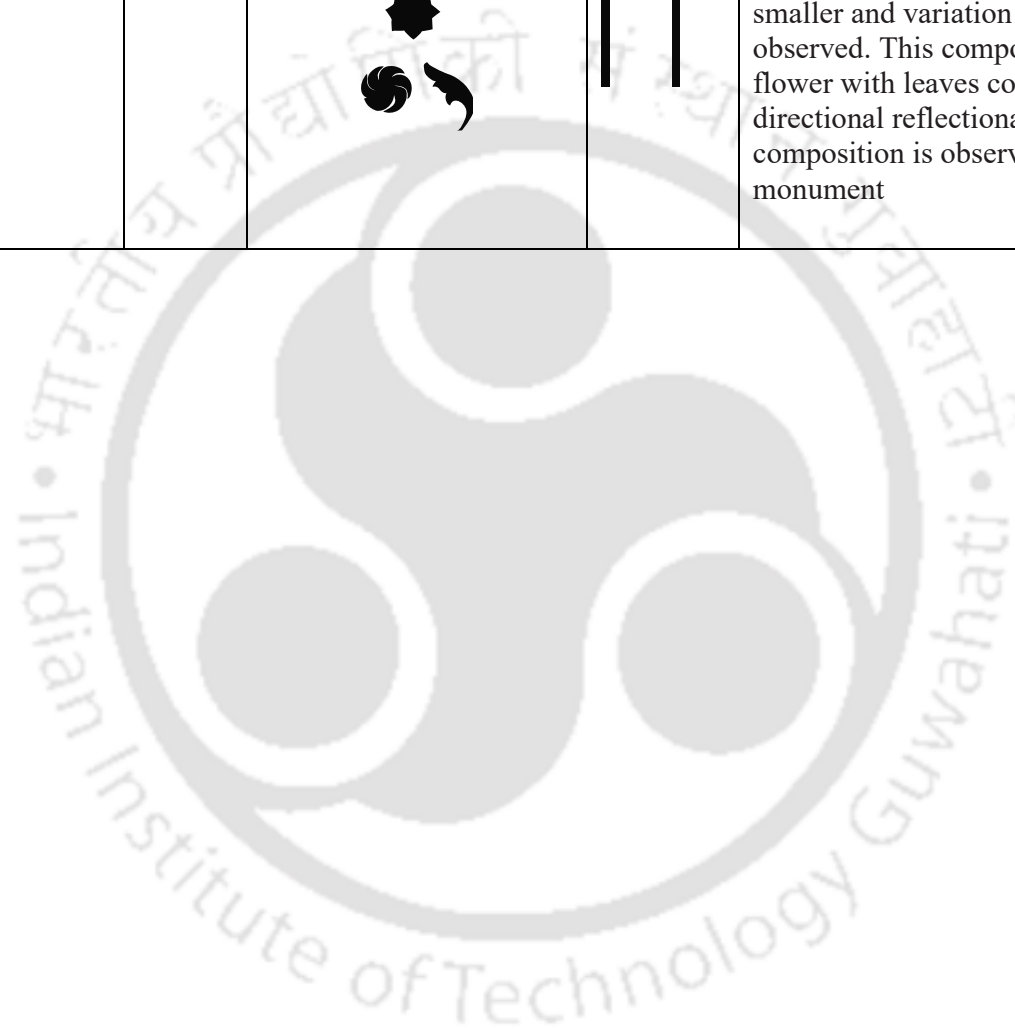
Ran-M-Wa-C-40					The motif has similarity with the <i>M-Wa-C-12</i> motif. The composition displays bilateral symmetry. Four bend-neck flowers are branching out of the central stem.
Ran-M-Wa-C-41					Complex branching is observed and extension of the vines over the flowers are displayed. 3 flowers with leaves and buds are seen in the composition.

Table 5. 15 Rang Ghar– Elements of organic patterns

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
Ran-P-Wa-O-01					The organic pattern follows bilateral symmetry. The composition includes repetitive use of two curve shaped vegetal leaf covering a flower. This pattern is repeated wall over the walls of the monument.
Ran-P-Wa-O-02					There is similarity with the <i>P-Wa-O-01</i> motif. Here, the composition exhibits more detail strokes in flowers and leaves arranged one after another. This panel is observed in the front, side and the back walls of the monument.

<p>Ran-P-Wa-O-03</p>					<p>There is similarity with the <i>P-Wa-O-01</i>, 2 motifs. Here, the composition exhibits more detail strokes in flowers and leaves arranged one after another, emerging of additional leaves from the lower section of the flower is noticed. The composition exhibits bilateral symmetry. The repetition of pattern is one-directional.</p>
<p>Ran-P-Wa-O-04</p>					<p>This composition includes extended vines from a multi petal flower vertically. The composition exhibits seamless design with leaves and vines with two directional reflectional symmetry. This panel is observed in the front walls covering the three multi-foil arches in the central section.</p>
<p>Ran-P-Wa-O-05</p>					<p>This composition repetition of a multi petal flower with leaves covered each side. This pattern two directional reflectional symmetry. This panel pattern composition is observed in the walls of the monument</p>
<p>Ran-P-Wa-O-06</p>					<p>This composition has similarity with the <i>P-Wa-O-05</i> motif, but the central flower is comparatively smaller. This composition repetition of a multi petal flower with leaves covered each side. This pattern two directional reflectional symmetry. This panel pattern composition is observed in the walls of the monument</p>

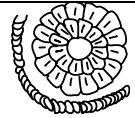



<p>Ran-P-Wa-O-07</p>						<p>his composition has similarity with the <i>P-Wa-O-05</i>, <i>06</i> motif, but the central flower is comparatively smaller and variation in the flower petal design is observed. This composition repetition of a multi petal flower with leaves covered each side. This pattern two directional reflectional symmetry. This panel pattern composition is observed in the side walls of the monument</p>
----------------------	---	--	--	--	---	---



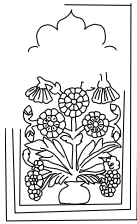



### 5.3.2 Form extractions – Talatal Ghar














The table below showcase the unit forms, subunit forms and superunit forms of the motifs and patterns.

**Table 5. 16 Talatal Ghar– Elements of flora motifs**













Code	Floral Motif	Elements			Description
		Centre	Shape types	Base	
<i>Tal-M-En-F-01</i>			2 layered petals  Rounded		The lotus motif has two layered petals and the petals are rounded in shape. Similar types of motifs are observed in other monuments of Sivasagar and Charaideo area. The motifs exhibit rotational symmetry. The 2 of these motifs is placed on the left exterior walls of Talatal Ghar near the roofed stairs and one on the back wall of the monument.



















**Table 5. 17 Talatal Ghar– Elements of compound motifs**




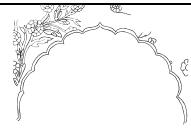








Code	Compound	Elements			Description
		Shapes	Base	Branching	
<i>Tal-M-Wa-F-01</i>					This compound motif has multiple flowers with petals in rounded shape. The flowers exhibit rotational symmetry. The overall composition includes a rounded pot with emerging floral stems with leaves, flowers and buds. The composition exhibits bilateral symmetry. The motif seemed to be placed inside a multi-foil arch - frame. These types of composition similar are to some of the niche-and-flower design of the Indian carpets of the Mughal era. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs.









<p>Tal-M-Wa-F-02</p>					<p>This compound motif seemed to have lower section of human figure. The figure shape resembles the costumes of Mughals during 17th century - 'Jama coat' and 'Juti'. Near the figure a plant can be observed. The composition is inside a mutli-foil arch. Although most of the composition is deteriorated due to natural causes and time, the shapes and form in the composition leads to human and a plant. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs.</p>
<p>Tal-M-Wa-C-03</p>					<p>This compound motif has seemed to capture deer hunting in a forest by a royal human figure riding a horse. The composition has details of the garments use by the hunter, a tree can be observed in the background of the composition. The motif displays dynamism in overall composition. Like others, this motif is placed inside a multi-foil arched frame. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs.</p>
<p>Tal-M-Wa-C-04</p>					<p>The motif has a human form, standing with a raised hand. The form looks like the human figure is wearing Mughal outfit, like <i>Jama coat</i>, <i>Paijama</i>, <i>Juti</i> and <i>turban</i>. The human figure is composed inside a multi-foil arched frame. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs.</p>
<p>Tal-M-Wa-C-05</p>					<p>This panel motif placed on the left exterior walls of Talatal Ghar near the roofed stairs. The composition includes multiple flowers extended with vines and leaves. The petals are both rounded and pointed in shapes. The compositions display branching, it is placed insided a rectangular panel vertically.</p>

**Table 5. 18 Talatal Ghar– Elements of organic patterns.**



Code	Pattern	Elements			Description
		Centre	Shapes	Base	
Tal-P-Wa-O-01					The panel motif consists of <i>bipinnately compound leaf</i> , stacked one pair after another. The leaves are pointed in shape. The composition displays bilateral symmetry. The branch of the compound leaves curves towards the tip of it. The composition is vertical and it is inside a rectangular panel. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs.
Tal-P-Wa-O-02					The panel consist of repetition of alternate flowers stacked one after another, the sepals of the flowers connects the sepals of the flower above it. The petals consist of both rounded and pointed shapes. The motif is placed on the left exterior walls of Talatal Ghar near the roofed stairs. The pattern exhibits one directional reflection symmetry.
Tal-P-Wa-O-03					The pattern panel consist of two layered petals flowers. The petals are rounded in shape. Each of the flowers are extended with compound leaves branching out in opposite direction continuing the flow. The pattern exhibits two directional reflection symmetry. The patterns are placed vertically.
Tal-P-Wa-O-04					The pattern panel consist of two layered petals flowers. The petals are rounded in shape. Each of the flowers are extended with curved vines with extended leaves branching out in opposite direction continuing the flow. The pattern exhibits two directional reflection symmetry with vertical placement.



<i>Tal-P-Wa-O-05</i>					The pattern panel consist of two layered petals flowers. The petals are rounded in shape. Each of the flowers are extended with curved leaves branching out in opposite direction continuing the flow. The flowers have 4 sepals in the base, directed in different directions. The pattern exhibits two directional reflection symmetry and are placed vertically.
<i>Tal-P-Wa-O-06</i>					The patterns include curved vines extending the inward flowers which are place alternatively. The pattern is placed just below the parapet of the building. The flower petals are rounded in shape. The composition is horizontally extended.
<i>Tal-P-Wa-O-07</i>					The patterns include curved lines depicting the sepals of a flower. The shapes are rounded and are repeated below the parapet of the building. The composition includes horizontal line in both the sides of the repeating sepals. It displays two directional reflection symmetry.
<i>Tal-P-Wa-O-08</i>					These patterns reflect bilateral symmetry as a composition. There are three 3 flowers with petals and leaves. The central flower is different the other two in both the sides. The composition displays anomaly.
<i>Tal-P-Wa-O-09</i>					The pattern is observed in back section in the walls of the monument. The pattern is composed considering linear repetition of a single unit form. The unit form consists of four petal flowers with rounded petal corner and a core. The leaves are expanded in opposite directions from the upper and lower section of the flower.
<i>Tal-P-En-O-10</i>					The pattern consists of flowers with vines and leaves. The unit-form consist of a flower with curve petals. The lower

					section of the flower extends with vines extend in two opposite direction joining another upper section of flower.
<i>Tal-P-En-O-11</i>					The pattern has complex extension of vines along with flowers and leaves. These types of beautiful patterns are only showcased in the interior entrance arches of the Talatal Ghar. The unit-forms exhibits bilateral symmetry, repetition of unit forms leads to pattern.
<i>Tal-P-En-O-12</i>					The pattern has complex extension of vines along with flowers and leaves. Similar to the above pattern, the composition is in the interior section, above the entrance arch. The unit-forms exhibits bilateral symmetry, repetition of unit forms leads to pattern.
<i>Tal-P-En-O-13</i>					The pattern displays scroll patterns, with wavy vines extending with leaves, buds and flowers. The arrangement is one directional. The pattern is observed above the entrance arch. The arrangement of flower is upward and downward directions.
<i>Tal-P-En-O-14</i>					The pattern is observed over the multi-foil arch entrance in a interior section of the monument. The pattern is unique of its own, it consists of larger leaves of extended from a flower which connects another section of flower. The overlapping of vines and leaves in developing the pattern is observed. Leaves, vines and flowers with various shapes is observed in the composition of pattern.

<i>Tal-P-En-O-15</i>					The pattern is largely in fragmented state. The composition includes multiple shaped flowers, leaves and vines in curve shape. The flowers are having circular and pointed petals.
<i>Tal-P-En-O-16</i>					The pattern is largely in fragmented state. The composition includes multiple shaped flowers, leaves and vines in curve shape. The flowers are having circular petals, the vines are extended to connect the other set of flowers.
<i>Tal-P-Pi-O-17</i>					This pattern is observed in one of the interior entrance pillars of the monument. The organic pattern covers the overall shaft section of the pillar. It includes extension vines multiple flowers and buds. The composition displays extension of vines in four direction from a single flower connecting to another flower from each extended vine, resulting in pattern by repetition of arrangements.

**Table 5. 19 Talatal Ghar– Elements of geometric patterns.**

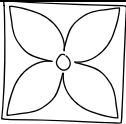



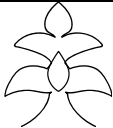



Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<i>Tal-P-En-G-01</i>					The Geometric pattern is observed in the interior entrance pillar in one of the monument's chamber. The pattern exists on the base of the pillar. The shape forms downward pointed convex pentagon shape. The convex

					pentagon is placed repeatedly with a rhombus shape between each of it.
<i>Tal-P-En-G-02</i>					The Geometric pattern is observed in the interior entrance pillar in one of the monument's chamber. The pattern exists on the base of the pillar just below the shaft section. Repeated used of rhombus shape is used in linear direction. The composition is supported by two borders in upper and lower section.







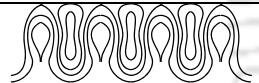







### 5.3.3 Form extractions – Kareng Ghar

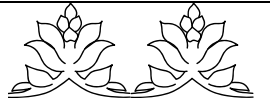



The table below showcase the unit forms, subunit forms and superunit forms of the motifs and patterns.

**Table 5. 20 Kareng Ghar– Elements of motifs**





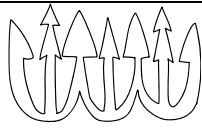

Code	Floral Motif	Elements			Description
		Centre	Shape types	Base	
<i>Kar-M-Pi-F-01</i>					This Motif variant is observed on the left section pillar of the monument. There are total of 3 visible floral motifs on the mid-section of the shaft. Each motif has four petals pointed in each direction of the square base, displaying reflection symmetry
					This motif is observed in on the top section of the entrance arch section. The motif uses shape of leaves, with bilateral symmetry. The composition is overlapped with a single shapes leaf on the central position of the composition.
	<b>Animal Motif</b>				
<i>Kar-M-Pi-A-01</i>					This motif is present same pillar where the <i>Kar-M-Pi-F-01</i> is present. This animal motif is present in capital section, of the pillar. The motif includes two peacocks facing each other displaying bilateral symmetry with a floral bud in the center of the composition.

**Table 5. 21 Kareng Ghar– Elements of organic patterns**

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<i>Kar-P-Pi-O-01</i>					These organic patterns are observed in the right section pillars of the monument. The composition reflects bilateral symmetry. It includes three flowers extending its leaves that joins each of it. The upper section includes 3 petal flowers filling the empty spaces of the composition.
<i>Kar-P-Pi-O-02</i>					These organic patterns are observed in the right section pillars of the monument (near to <i>Kar-P-Pi-O-01</i> ). It includes three lotus flowers extending its vines that joins each of it. The composition exhibits glide reflection symmetry.
<i>Kar-P-Pi-O-03</i>					These organic patterns are observed in the right section pillars of the monument (near to <i>Kar-P-Pi-O-01,2</i> ). The composition includes 5 leaves with curves with S shapes and exhibits glide reflection symmetry.
<i>Kar-P-Pi-O-04</i>					These organic patterns are observed in the right section pillars of the monument (near to <i>Kar-P-Pi-O-01,2,3</i> ). The composition includes multiple wavy lines, forming water droplet shape in the centre.
<i>Kar-P-Wa-O-05</i>					This scroll design is observed in the walls interior section of the monument. The pattern includes used of flowers and leaves connecting the repeated elements. The flowers have four petals in rugged shapes. The composition exhibits glide-reflection symmetry
<i>Kar-P-Wa-O-06</i>					This scroll design is observed in the walls interior section of the monument (above the <i>Kar-P-Wa-O-05</i> ). The pattern includes used of flowers and leaves connecting the repeated elements. The flowers have four petals in rounded shape. The composition exhibits glide-reflection symmetry
<i>Kar-P-Wa-O-07</i>					This scroll motif is observed in the walls interior section of the monument. The pattern includes used larger and smaller flowers with

				leaves connecting the repeated elements. The flowers have multiple petals with two layers with a core.
<i>Kar-P-Wa-O-08</i>				This scroll motif is observed in the walls interior section of the monument just above the <i>Kar-P-Wa-O-07</i> . The pattern includes flower with pointed petals with vines/stem connecting the repeated elements.
<i>Kar-P-Wa-O-09</i>				This scroll motif is observed in the walls interior section of the monument. The pattern includes used flower which is similar to <i>Kar-P-Pi-O-01</i> , vines/stem connecting the repeated elements.

**Table 5. 22 Kareng Ghar– Elements of Geometric patterns**

Code	Pattern	Elements			Description
		Centre	Shapes	Base	
<i>Kar-P-Wa-G-01</i>					The vertical geometric pattern is observed near the wall of entrance in one of the interior chambers of the monument. The composition uses curve lines forming leaf shape in repetition.
<i>Kar-P-Pi-G-02</i>					This geometric pattern is observed on of the shaft section of a pillar. The pattern includes curve scales similar to fish scales. The composition includes multiple curve lines one over another.
<i>Kar-P-Pi-G-03</i>					This geometric pattern is in the capital of the pillar. It is present in left section pillar of the monument. The composition display bilateral symmetry. There are multiple upward extension in the shape of an arrow or spear. The lower section connects each shape with a curve line.

## 5.4 Results– Stucco ornamentation

For visual analysis of the ornamentation, the shapes, form, color and texture of the extracted motifs and patterns are considered. Each motif and pattern have undergone linear extraction after the variation analysis. Primarily the shapes and forms in the composition of motifs and patterns are studied using formal analysis. The composition is dissected to identify its elements.

### 5.4.1 Shapes and forms- Rang Ghar, Talatal and Kareng Ghar

*Floral motifs.* In Rang Ghar, the floral motifs are in large number. They have multiple petals with variations in petal counts, shape and petal layers. The singular floral motifs are more in numbers compared to other motif types. These motifs are arranged in structures all over the entrance arches, wall, near pillars and columns. Most of the existing single floral petals are rounded in shape rather than pointed. The motifs have two-layer petals with a circular core. Repetition of petal shapes creates unit forms; some unit forms display affinity<sup>24</sup> and rotational symmetry. Union of two or more layers of petals are observed in the floral compositions.

Comparatively, Talatal Ghar has significantly fewer singular floral motifs. The existing lotus motif has strong similarities with some of the front wall singular lotus motifs of Ghanasyam House, as it has a circular base. The rounded petal types have similarities with most of the ornamented flowers of all the selected monuments.

Kareng Ghar, on the contrary, had lost most of the ornamentations due to natural causes. The collected data displays a four-petal singular floral motif. The motif has a flower inside a square border, with each petal pointed towards every corner of the square border. The petals have a pointed edge.

*Compound motifs.* The compositions of compound motifs in Rang Ghar are a mixture of flowers, vines, leaves, animals, mythical creatures and man-made forms. Most of the compound motifs display bilateral symmetry in branching. Affinity in compositions are observed in the motifs with floral types and branching of buds and vines. This leads to unity in overall compositions. Man-made forms like framed multi-foil arches are observed in most. Representational forms of wild animals, plants, flowers, birds, creatures and vases are included in compound motifs. Repetition of shape, size, direction and position of the elements are observed and most of the composition displays bilateral symmetry.

---

<sup>24</sup> Elements within a particular natural form- cells, section or layers that make up a surface. These elements are not strict repetitions, but vary individually or progressively to conform an overall shape or structure (Wong, 1993)

In Talatal Ghar, compound motifs have multiple flowers with petals in both rounded and pointed shapes. Man-made forms like a rounded pot with emerging floral stems. Most of the motif seemed to be placed inside a multi-foil arch frame. These types of composition similar to some of the *niche-and-flower*<sup>25</sup> designs of the Indian carpets of the Mughal era. Some compound motifs seemed to have fragmented human figures with hunting, standing and resting postures. The human figure shape is similar to Mughals' costumes during the 17<sup>th</sup> century - '*Jama coat*' and '*Juti*' (shoes). Although most of the composition is deteriorated due to natural causes, the shapes and form in the composition lead to humans displaying movement and static postures, branching stems with proliferated pointed leaves and inclusion of animals like horses and deer. Some panel motifs are placed on the left exterior walls of Talatal Ghar near the roofed stairs. It has multiple flowers extended with vines and leaves. The floral petals are both rounded and pointed in shapes. Most of the existing motifs display asymmetry.

Kareng Ghar's compound motifs are in fragments. Hence, it was not easy to extract precise forms. The existing forms and shapes display flowers with curved leaves with pointed edges repeated with varied shaped flowers.

*Animal & Symbolic motifs.* In Rang Ghar, the symbolic creature is placed in the interior entrance arches of the ground floor facing each other. There is a total of six of these symbolic motifs. The motifs have a closer resemblance to the face of *Makara* and the body of *Yali*<sup>26</sup>. This same motif has been emphasized as Ahom royal insignia dragon by the locals.

A motif of the human form, standing with a raised hand, is seen in Talatal Ghar. The form looks like the human figure is wearing an outfit resembling the king's outfits, like *Jama coat*, *Pajama*, *Juti* and *turban*. The human figure is composed inside a multi-foil arched frame. It is placed on the left exterior walls of Talatal Ghar near the roofed stairs. The collected data of Kareng Ghar do not show any survived animal and symbolic motifs.

*Patterns.* Most of the organic pattern follows bilateral symmetry in Rang Ghar. The composition includes repetitive use of two curve-shaped proliferated vegetal leaves surrounding a flower with curved edged petals. This pattern is repeated all over the walls of the monument. The composition includes extended vines from a multi petal flower vertically. It exhibits a seamless design with leaves and vines with two-directional reflectional symmetry.

---

<sup>25</sup> <https://www.metmuseum.org/art/collection/search/452554>

<sup>26</sup> *Yali* is a mythical creature seen in many South Indian temples, often sculpted onto the pillars.

The floral petals are rounded in shape and the leaves have a pointed edge. Repetition in shape, size, colour and directions is observed. Directional variations like alternate directions are observed in some patterns (Wong, 1993).

In Talatal Ghar, some panel patterns consist of a bipinnately compound leaf stacked one pair after another. The leaves are pointed in shape. The compositions display bilateral symmetry, one-directional reflection symmetry and asymmetry. In some panel, it consists of the repetition of alternate flowers stacked one after another, the sepals of the flowers connect the sepals of the flower above it. The floral petals consist of both rounded and pointed shapes. The interior section of the monument has many fragments of organic patterns over the entrance arches and some of the walls. The compositions of the patterns display details of flowers intertwined leaves with branching out of vines in structured and repetitive patterns.

The existing patterns of Kareng Ghar are a mix of organic and geometric patterns. In some of the pillars, vertical line strips, crisscross patterns are observed. As compared to geometric patterns, organic patterns are more dominant. The use of flowers with pointed and round petals is standard, with pointed edge leaves. Man-made forms with wave patterns are seen in the compositions.

#### **5.4.2. Color and Texture- Rang Ghar, Talatal and Kareng Ghar**

All the masonry buildings of the Ahoms radiates a tint of red colour due to mixtures of bricks and mortars. According to ASI, the early mortar composition includes mixing lime (limestone and snail shell), pulses, resin, hemp (*canarium resiniferum*), molasses, fish, etc. Again, the fusion of molasses and limestone leads to the creation of red tint. Texture development in the walls and pillars of the monuments are observed. Tactile texture has a distinct kind known as organized texture, where the mortars are striped into small bits in the shape of overlapped leaves on the ceiling walls, lines and parallelogram-shaped strips in pillars. The use of organized texture leads to a new ornamented surface as a whole.

#### **5.4.3 Symmetry Analysis**

##### *5.4.3.1 Architecture.*

Rang Ghar's architecture evidently reveals bilateral symmetry, with an equal balance of entrance arches with similar shapes and sizes from the façade. The meticulous details in terms of motifs and patterns placement and balanced postures of human and animal sculptures in the roof in a symmetrical way visibly depict the early artisan's craftsmanship.

On the other hand, the architecture of the Talatal Ghar is not symmetrical. But the structures like a temple-like dome to the left and to the right chambers with traditional hut-like rooms have visually balanced the monument's overall façade. There are multiple entrances from each side of the monument that complements the overall structure.

The Kareng Ghar, with its three-storey structure, reflects bilateral symmetry. The structure has pyramidal progression, with each floor gradually extended, narrowing to the top. Visible pilaster columns have been placed on all sides of the monument.

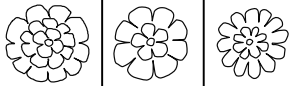

#### *5.4.3.2 Symmetry in motifs.*

The Rang Ghar is the only highly ornamented stucco-type monument of brick architecture in Assam. The singular floral motifs have been an integral part of the ornamentation. These singular floral motifs have been repeatedly used in all the sections of the wall. The compound motifs are the next prominent motif type used in ornamentation. These motifs are composed within a beautiful milfoil arch resembling some of the niche-and-flower designs of the Indian carpets of the Mughal era. Some of these compound motifs are composed in the horizontal panel-type sections. The **Table 5.23** of symmetry types discloses all the singular floral motifs discloses rotational symmetry. Most of the compound motif has bilateral reflection symmetry and a few of them are asymmetric with 360-degree rotation. There was no specific animal motif, but symbolic motifs over the interior and second floors are observed with reflection symmetry in Rang Ghar.





The Talatal Ghar has very few survived motifs. The **Table 5.24**, discloses that only a single floral motif variant is observed with rotational symmetry in its composition. The compound motifs observed are asymmetric and some possess reflection symmetry with branching. The compositions are similar to the Rang Ghar compound motifs with similar floral branching structures. The animal motif found in the data extractions is in a fragmented state. However, the linear extraction of these motifs discloses asymmetric composition, with **dynamic symmetry**, resulting in a visual balance in the composition.

The Kareng Ghar (**Table 5.24**) has the most petite survived motif compared to the Rang Ghar and Talatal Ghar. The only existing singular floral motif is observed in one of the front pillars. The floral motif exhibits four-fold symmetry with a four-petal count, with each petal pointing to each corner of the square base. Both the compound and animal motifs follow reflection symmetry due to its composition.




**Table 5. 23 Symmetry association of Rang Ghar motifs**

Motif Types	Rotation Symmetry	Reflection Symmetry	
Floral			
Compound	Asymmetric type with 360 degree rotation <b>Motif Code</b> Ran-M-Wa-C-04,06,07,08, 11,15,17,22,39.	Two-direction	One-direction
Animal			
Symbolic			

**Table 5. 24 Symmetry association of Talatal Ghar motifs**

Motif Types	Rotation Symmetry	Reflection Symmetry	
Floral			
Compound	Asymmetric type with 360 degree rotation 	Two-direction	One-direction 
Animal	Asymmetric type with 360 degree rotation 		
Symbolic			

**Table 5. 25 Symmetry association of Kareng Ghar motifs**

Motif Types	Rotation Symmetry	Reflection Symmetry	
Floral	4 fold Symmetry 		
Compound		Two-direction	One-direction 
Animal			
Symbolic			






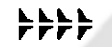


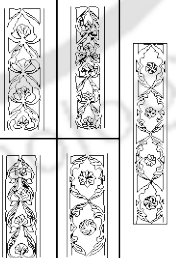

### 5.4.3.3 Symmetry in Patterns.

Although Rang Ghar is highly ornamented, it is noteworthy to see that only a few pattern classes are used in organic pattern ornamentation. All the pattern classes (Table 5.26) are one-dimensional patterns; these are *pmm2*, *p1m1* and *pma2*. The quantitative data also discloses that the pattern class of *p1m1* is predominant and has multiple variants (Fig. 5.4, a).

The Talatal Ghar, has more pattern variations compared to motifs. The interior section entrance is mostly ornamented with asymmetric patterns. Hence, only the symmetric patterns are displayed in the table to analyze the classes. Both one-dimensional and two-dimensional pattern classes are observed in the linear extracted patterns. These classes (Table 5.27) are *p111*, *pm11*, *plal*, *p1m1* and frieze pattern class *cm1m* are observed in organic patterns. The pattern class *pm11* & *pmm2* are found in geometric patterns. The quantitative data discloses the *pm11* class to be the predominant class (Fig. 5.4, b).

In Kareng Ghar, the survived patterns are comparatively more than the motifs. The organic and geometric patterns are observed in four different pattern classes. One dimension and two-dimensional pattern include classes (Table 5.28) of *p111*, *pm11*, *plal*, *pma2* in organic patterns and pattern classes of *pm11* and *p1m1* in a geometric pattern. The *pm11* is the predominant pattern class in the monument (Fig. 5.4, c)

**Table 5. 26 Pattern class association of Rang Ghar patterns**

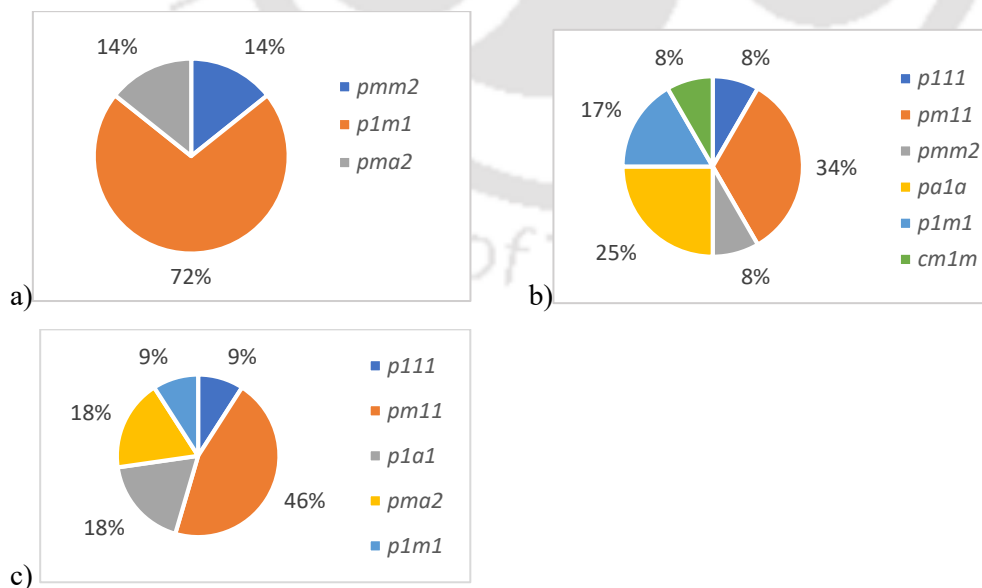
Pattern Class	<i>p111</i> 	<i>pm11</i> 	<i>p112</i> 	<i>pmm2</i> 	<i>plal</i> 	<i>p1m1</i> 	<i>pma2</i> 
<i>Organic</i>							
<i>Geometric</i>							

**Table 5. 27 Pattern class association of Talatal Ghar patterns**

Pattern Class	<i>p111</i> ▲▲▲▲	<i>pm11</i> ▼▼▼▼	<i>p112</i> ▲▲▲▲	<i>pmm2</i> □□□□	<i>plal</i> ▼▼▼▼	<i>p1m1</i> ▶▶▶▶	<i>pma2</i> ▲▲▲▲
<i>Organic</i>							<i>cm1m</i> 
<i>Geometric</i>							

**Table 5. 28 Pattern class association of Kareng Ghar patterns**

Pattern Class	<i>p111</i> ▲▲▲▲	<i>pm11</i> ▼▼▼▼	<i>p112</i> ▲▲▲▲	<i>pmm2</i> □□□□	<i>plal</i> ▼▼▼▼	<i>p1m1</i> ▶▶▶▶	<i>pma2</i> ▲▲▲▲
<i>Organic</i>							
<i>Geometric</i>							<i>p1m1</i> 

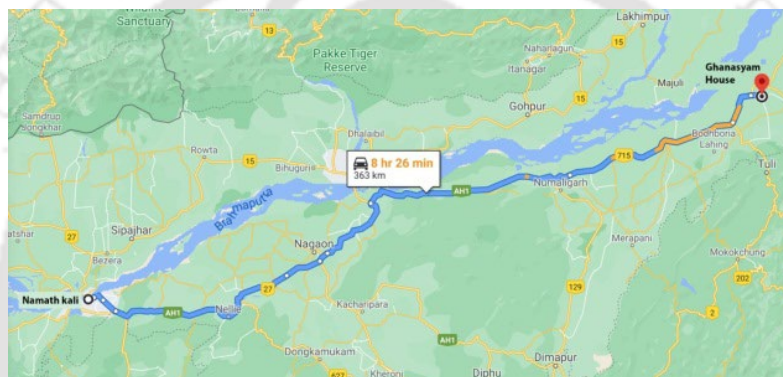


**Fig. 5. 4** Pie chart of percentage of pattern class variants of (a) Rang Ghar (b) Talatal Ghar and (c) Kareng Ghar.



## CHAPTER SIX: Material Study

To study the early construction materials of the Ahom brick monuments; brick and mortar samples from all the considered monuments are collected. The variation analysis and visual analysis provide strong evidence that the Ghanasyam House of Sivsagar and Namath Kali Temple of Guwahati shares similar architectural and structural similarities. Moreover, geographically, they are located approx. 363 km far from each other (**Fig. 6.1**). However, the construction period of Namath Kali is unknown and not yet documented. When asked to locals regarding the construction period, the response was ambiguous. The comparative material study on both these monuments provides conclusive results on the construction time.



**Fig. 6. 1** Screenshot of Google Map displaying the geographical distance of Namath kali temple of Nilachal Hills and Ghanasyam House of Sivasagar by road.

Literature on Rang Ghar, Talatal Ghar and Kareng Ghar provides information on architecture styles and their architectural key plan. However, minimal resources are on construction materials. These are massive structures that survive the harsh geographic conditions with earthquakes. The comparative materials study provides information on the early compositions process and techniques.

### 6.1 Early construction materials of the monuments

The early construction materials for Houses and buildings of Ahom dynasty was in woods and bamboo. As with due course the materials decay, hence they shifted their construction materials to stone and bricks. R. Gupta (1982) states, ‘according to Eric T.D Lambert the bricks of Ahom era are similar to those used in Siam in the *Ayuthia* period. The bricks were square, rectangular, triangular, round, perforated and fluted’. The *Chung Rung Phukanor Buranji* mentions, Ahom during the late medieval era used burnt bricks and lime mortars for construction of houses,

temples, buildings and *maidams*<sup>27</sup>(Barua, 1992). They used lime mortar to cement the bricks. The *buranji* states mixture of many organic and inorganic raw materials for the mortar mixture. Some of the raw materials in the mortar composition includes molasses, duck eggs, *borali* fish (helicopter catfish or wallago catfish), snail shells, limestones, oil, quick lime, brick powder (Ahmed, 1994; Barpujari, 2007; Barua, 1992). Its noteworthy that particles of snail shells are still visible in the mortars of the monuments. (Fig. 6.2)



**Fig. 6. 2** Zoomed in photo displaying particles of snail shells: Ghanasyam Mortar (left), Namath Kali Mortar (Right)

The details of materials and methods were mentioned in **Chapter 3.**; Three phases of testing are conducted with the collected brick and mortar samples. Energy Dispersive X-Ray Analysis (EDX) to study the morphology and elemental compositions of the brick and mortar samples, Power X-Ray diffraction (PXRD) helps to identify mineral presents in bricks and mortar samples and Fourier Transform Infrared Spectroscopy (FT-IR) identifies the chemical bonds in a molecule.

The results are compared and analysed with similar types of ornamented monuments.

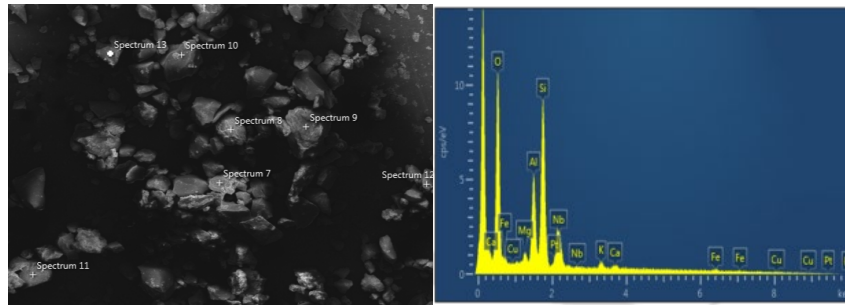
## 6.2 Terracotta type Monuments

### 6.2.1 Elemental composition of bricks and mortar (wt%)

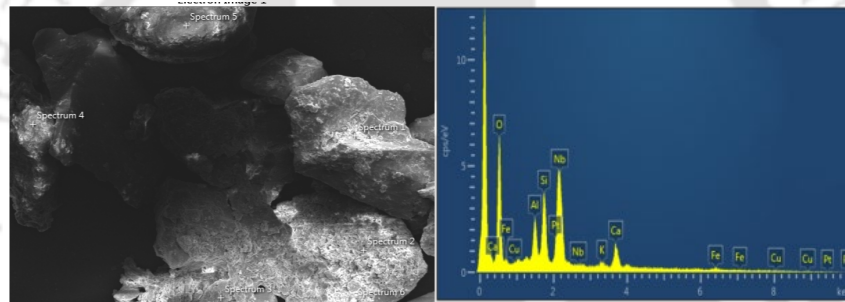
The elemental compositions present in the bricks and mortar of Ghanasyam House and Namath Kali Temple were determined with the help of Energy Dispersive X-ray Spectroscopy (EDX). The results of the EDX are summarized in Table 1. **Figure 6.3-6.6** shows the electron micrographs and EDX spectrum of bricks and mortar of Ghanasyam House and Namath Kali

<sup>27</sup> A *maidam* is a tumulus of the royalty and aristocracy of the medieval Ahom Kingdom in Assam, India.

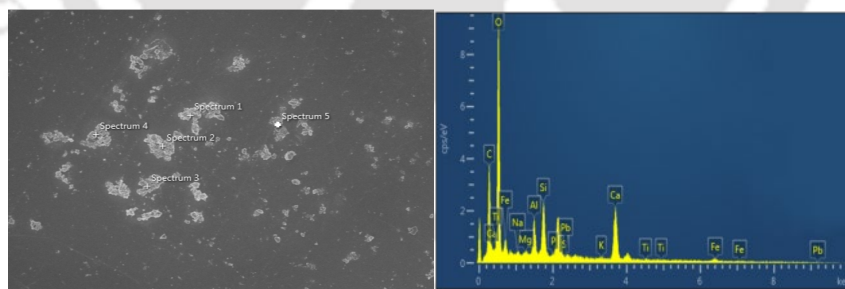
Temple. The Ghanasyam and Namath Kali Temple brick sample analysis revealed the presence of silicon, aluminium and iron in high percentages and calcium, potassium, magnesium, niobium, platinum, copper and sodium in low percentages (**Table 6.1**). Out of all elements present in the brick samples, the percentage of calcium and iron is higher in Namath Kali brick, whereas the percentage of silica and aluminium is found more in Ghanasyam brick.



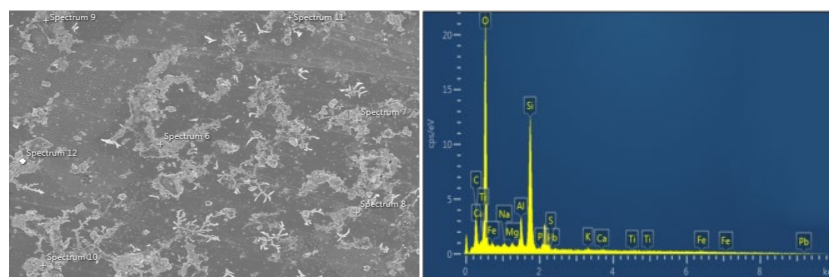
**Fig. 6. 3** Electron micrograph (left) and EDX spectrum (right) of Ghanasyam House brick



**Fig. 6. 4** Electron micrograph (left) and EDX spectrum (right) of Namath Kali Temple brick



**Fig. 6. 5** Electron micrograph (left) and EDX spectrum (right) of Ghanasyam House mortar



**Fig. 6. 6** Electron micrograph (left) and EDX spectrum (right) of Namath Kali Temple mortar

In Ghanasyam and Namath Kali mortar samples, silicon and calcium are present in high percentages and aluminium, iron, sodium and potassium in low percentages. The other elements magnesium, titanium, phosphorous, lead and sulphur are also present but in trace amounts. From the results, it is seen that bricks contained a higher percentage of iron than mortars. Theoretically, it can be explained that bricks contained more clay, which leads to a high percentage of iron oxide. Though reportedly, the construction of Ghanasyam House and Namath Kali Temple were of a different time period, the results of the elemental study pointed out in **Table 6.1** display that the raw materials were taken from the same sources.

**Table 6. 1 Elemental analysis of bricks and mortar of Ghanasyam House and Namath Kali using Energy Dispersive X-ray Spectroscopy (EDX).**

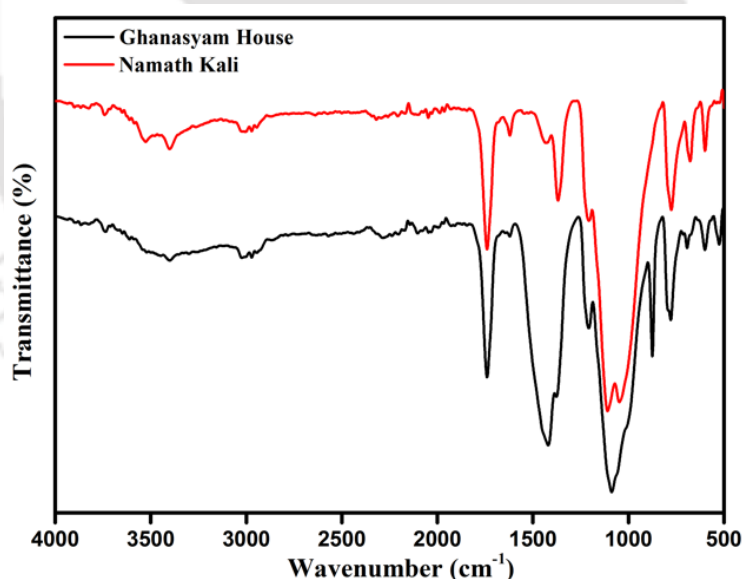
Component	Ghanasyam Brick (wt%)	Namath Kali Brick (wt%)	Ghanasyam Mortar (wt%)	Namath Kali Mortar (wt%)
O	41.5	45.5	37.7	44.3
C	5.7	0	27.6	24.3
Si	21.3	16.9	10.3	11.9
Al	14.2	11	5.4	2.9
Na	1.4	-	0.9	0.4
Fe	9.2	10.6	6.3	2.5
K	1.4	1.5	1.5	0.4
Ca	2.5	5.7	9.2	11.9
Mg	1.2	0.7	0.2	0.3
Nb	1.2	5	-	-
Pt	0.4	2.7	-	-
Cu	0.1	0.7	-	-
Ti	-	-	0.2	0.03
P	-	-	0.1	0.2
Pb	-	-	0.2	0.6
S	-	-	0.1	0.2

The percentage of calcium in the mortar is comparatively higher than the bricks of Ghanasyam House and Namath Kali Temple. The finding is very encouraging as the *buranji*

states mixture of many organic raw materials for the mortar mixture as mentioned above. Construction with these mixtures of products, in the form of interlocking crystals, increases the strength of the mortars which in turn, vindicates their use as construction materials of many ancient buildings across the globe (Moropoulou et al., 2002).

### 6.2.2. FTIR analysis of bricks and mortar

FTIR was done for study of surface functional groups on brick and mortar samples. A comparative FTIR spectrum of bricks and mortar of Ghanasyam House and Namath Kali Temple were shown in **Fig. 6.7 and 6.8** The bands at 1080 and 1040  $\text{cm}^{-1}$  of bricks samples of Ghanasyam House and Namath Kali Temple represents the Si-O-Si stretching vibrations of Kaolinite (Bakolas et al., 2008; Ece et al., 2003). In the FTIR spectra of Bricks of Ghanasyam House and Namath Kali the bands at 599 and 593  $\text{cm}^{-1}$  attributed to the presence of Fe-O of hematite. The bands at 785 and 760  $\text{cm}^{-1}$  of Ghanasyam House and Namath Kali bricks are related to the stretching vibrations mode of Al-O bonds. The IR bands around 683 and 671  $\text{cm}^{-1}$  of Ghanasyam and Namath Kali brick and 694 and 693  $\text{cm}^{-1}$  of Ghanasyam and Namath Kali mortar respectively are due to the presence of Si-O bond of quartz (Venkatachalapathy et al., 2006). It indicates that all the brick and mortar samples have quartz in their compositions.



**Fig. 6. 7** FTIR spectra of Bricks of Ghanasyam House and Namath Kali

The interpretation of the OH stretching region (3700-3400  $\text{cm}^{-1}$ ) has received special attention as these peaks are absent in case of bricks of Ghanasyam House and Namath Kali Temple which suggests that the clay materials in the bricks must had been fired during their processing at about 650°C. Further the structural pattern of the spectra of both the places is

found to be similar indicating the manufacturing process of the bricks and mortars were almost same.

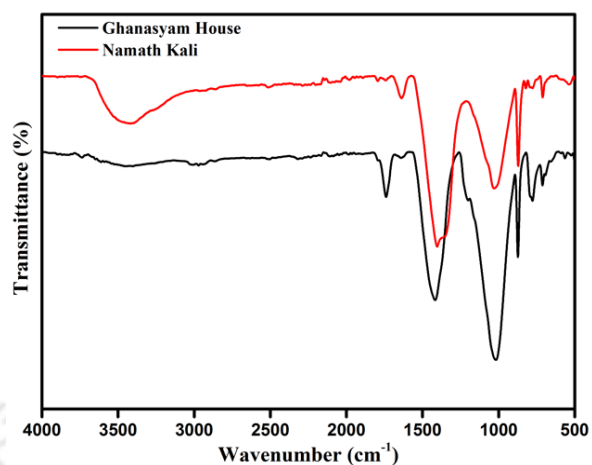


Fig. 6. 8 FTIR spectra of Mortar of Ghanasyam House and Namath Kali

### 6.2.3. Powder X-ray diffraction of bricks and mortar

PXRD analysis was done to study the structural changes of bricks and mortar of Ghanasyam House and Namath Kali Temple and their respective comparison are shown in **Fig. 6.9 and 6.10**. The minerals identified by PXRD of bricks and mortar are shown in **Table 6.2 and 6.3**. PXRD pattern of bricks of Ghanasyam House and Namath Kali Temple shows that they were mainly composed of quartz ( $\text{SiO}_2$ ), hematite ( $\text{Fe}_2\text{O}_3$ ) and kaolinite ( $\text{Al}_2\text{O}_3(\text{SiO}_2)_2(\text{H}_2\text{O})_2$ ). Apart from the common minerals, albite ( $\text{NaAlSi}_3\text{O}_8$ ) in Ghanasyam brick and orthoclase ( $\text{KAlSi}_3\text{O}_8$ ) in Namath Kali brick are also detected. May be small amount of these feldspars are present as most of these minerals are common in clay composition of this geographical region, which also showed in elemental composition of EDX.

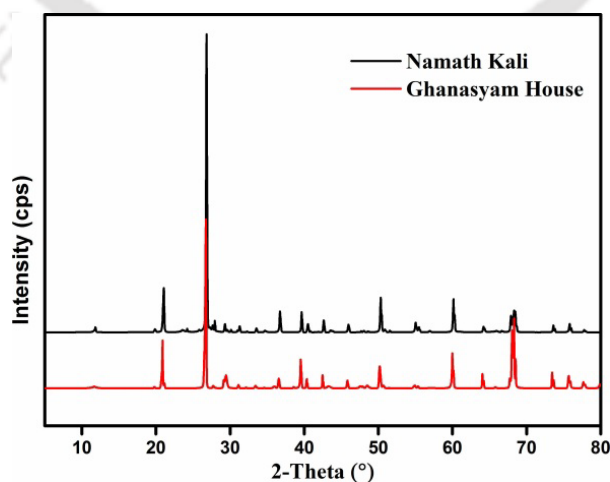


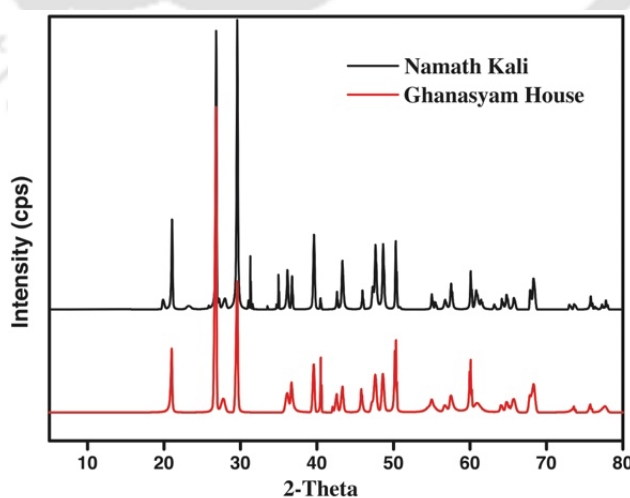
Fig. 6. 9 PXRD pattern of Bricks of Ghanasyam House and Namath Kali Temple.

**Table 6. 2 Mineral identification of (a) Ghanasyam House brick and (b) Namath Kali Temple brick**

a) Ghanasyam Brick			b) Namath Kali Brick		
2θ	d[Å]	Mineral identification	2θ	d[Å]	Mineral identification
20.8860	4.2497	Quartz	21.0292	4.2211	Orthoclase
26.6139	3.3466	Quartz	26.8237	3.3209	Quartz
36.5629	2.4556	Albite	45.9768	1.9723	Kaolinite
39.6498	2.2712	Quartz	50.3305	1.8114	Quartz
45.9769	1.9723	Kaolinite	55.1124	1.6650	Hematite
55.0658	1.6663	Hematite	21.0292	4.2211	Orthoclase

The results suggested that the bricks were manufactured by using materials of high clay content. Quartz is a major mineral which makes the brick self-tempered and hematite is considered as a concentrated coloring material which presence makes the bricks reddish (Pankaj et al., n.d.).

Whereas the PXRD patterns of mortars of Ghanasyam House and Namath Kali showed that they were mainly composed of quartz and calcite with a mixture of albite and hematite. It was assumed that the calcite was derived from carbonated lime, while quartz, hematite and albite were from brick powders (Böke et al., 2006). The results indicated that the source of raw materials or the method of preparation of bricks and mortars might result in similar products manufactured in two different places.



**Fig. 6. 10** PXRD pattern of Mortar of Ghanasyam House and Namath Kali Temple.

**Table 6. 3 Mineral identification of (c) Ghanasyam House mortar and (d) Namath Kali Temple mortar**

a) Ghanasyam Mortar			b) Namath Kali Mortar		
2 $\theta$	d[Å]	Mineral identification	2 $\theta$	d[Å]	Mineral identification
21.0446	4.2180	Quartz	21.0446	4.2180	Quartz
29.5734	3.0181	Calcite	26.8132	3.3222	Quartz
36.6104	2.4525	Albite	29.5733	3.0181	Calcite
36.7346	2.4445	Quartz	36.6104	2.4525	Albite
40.5499	2.2229	Quartz	39.6066	2.2736	Quartz
48.6670	1.8694	Quartz	47.6590	1.9066	Quartz
55.0303	1.6673	Hematite	55.0310	1.6673	Hematite

### 6.3 Stucco type Monuments

#### 6.3.1 Elemental composition of bricks and mortar (wt%)

**Table 6.4** depicts the elemental compositions of bricks and mortar of Kareng Ghar, Rang Ghar and Talatal Ghar using Energy Dispersive X-ray Spectroscopy (EDX). EDX analyses of brick samples of Kareng Ghar and Talatal Ghar revealed silicon, aluminum and iron in high percentages and potassium, magnesium, sodium and calcium in low percentages. It has been noticed that in case of Rang Ghar brick, the percentage of calcium is found higher and silicon, aluminum and iron percentages are quite lower than Kareng Ghar and Talatal Ghar bricks. The higher percentage of silicon in Kareng Ghar and Talatal Ghar bricks indicates quartz as the major component of the clay material.

On the other hand, mortars used in Kareng Ghar, Rang Ghar and Talatal Ghar contain highest percentage of calcium followed by silicon, aluminium and iron with trace amount of potassium, magnesium and sodium. The high percentage of calcium exhibits that pure lime was used in the preparation of mortar (Oguz et al., 2014). No sodium is traced in Talatal Ghar mortar. The silicon content in Rang Ghar mortar is quite higher than the Kareng Ghar and Talatal Ghar mortar. From the components it could be assumed that the mortar mainly composed of calcite and quartz minerals. Calcite mineral shows that lime was used as a binding material and quartz mineral shows that the aggregates used generally contained silicon mineral.

**Table 6. 4 Elemental analysis of bricks and mortar of Kareng Ghar, Rang Ghar and Talatal Ghar using Energy Dispersive X-ray Spectroscopy (EDX)**

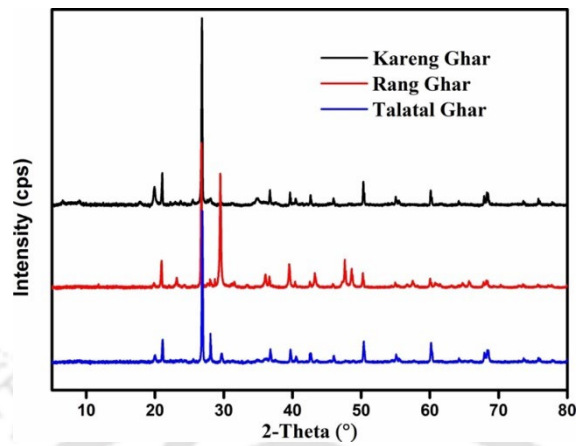
Components	Kareng Ghar Brick (wt%)	Rang Ghar Brick (wt%)	Talatal Ghar Brick (wt%)	Kareng Ghar Mortar (wt%)	Rang Ghar Mortar (wt%)	Talatal Ghar Mortar (wt%)
O	48.7	45.1	41.6	45.5	41	47.3
C	9	23.2	33.2	21.5	16.1	18.3
Si	22.2	8.3	12.6	4.5	9.7	6.2
Al	9.8	4.2	5.3	1.5	5.7	2.5
Fe	5.2	1.9	3.6	1.1	5.3	1.9
K	2.3	0.7	1.2	0.5	0.7	0.8
Mg	1.2	0.3	0.8	0.4	0.8	0.3
Na	0.8	0.5	0.7	0.03	0.2	0
Ca	0.5	15.5	0.8	24.7	20.4	22.3

### 6.3.2. Powder X-ray diffraction of bricks and mortar

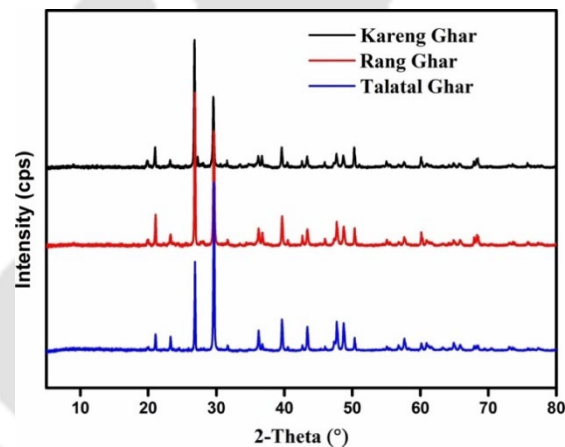
Figure 6.11 and 6.12 shows the comparative PXRD pattern of bricks and mortar of Kareng Ghar, Rang Ghar and Talatal Ghar. The mineral identification was done on the basis of d spacing value and is represented in Table 6.5 and 6.6 for bricks and mortars of Kareng Ghar, Rang Ghar and Talatal Ghar. The table and PXRD pattern show that the Kareng Ghar and Talatal Ghar bricks composed of quartz ( $\text{SiO}_2$ ), being the main component, kaolinite ( $\text{Al}_2\text{O}_3(\text{SiO}_2)_2(\text{H}_2\text{O})_2$ ) and hematite ( $\text{Fe}_2\text{O}_3$ ) whereas the Rang Ghar brick composed of mainly quartz, calcite ( $\text{CaCO}_3$ ) and hematite. Based on the results it could be anticipated that the bricks were made using materials of clay content which was rich in quartz and hematite. The reddish color of the bricks can be attributed due to the presence of hematite as small amount of its presence can make the brick reddish (Singh and Sharma, 2016a).

PXRD patterns of mortars of Kareng Ghar, Rang Ghar and Talatal Ghar revealed that they were composed of mainly calcite and quartz with a blend of hematite, kaolinite and orthoclase ( $\text{KAlSi}_3\text{O}_8$ ). It is assumed that the blended aggregates quartz, hematite, kaolinite and orthoclase were taken from brick powders and the main compound calcite from pure carbonated lime (Böke et al., 2006). The cohesion between brick aggregates and carbonated lime was found strong and diffuse indicating uniform blending in all mortars. The similar

compositions of all the mortars indicated that the raw materials source or the method of preparation of mortars might be the same irrespective of different places.



**Fig. 6. 11** PXRD pattern of Bricks of Kareng Ghar, Rang Ghar and Talatal Ghar



**Fig. 6. 12** PXRD pattern of Mortar of Kareng Ghar, Rang Ghar and Talatal Ghar

**Table 6. 5** Mineral identification of (a) Kareng Ghar brick, (b) Rang Ghar brick and (c) Talatal Ghar brick

(a) Kareng Ghar brick		(b) Rang Ghar brick		(c) Talatal Ghar brick	
d[Å]	Mineral identification	d[Å]	Mineral identification	d[Å]	Mineral identification
4.2197	Quartz	4.2195	Quartz	4.2197	Quartz
3.3214	Quartz	3.2981	Quartz	3.3214	Quartz
2.4449	Quartz	3.0112	Calcite	2.4449	Quartz
2.2710	Quartz	2.2270	Quartz	2.2710	Quartz
2.2268	Quartz	1.8119	Quartz	2.2268	Quartz

2.1187	Quartz	1.8115	Quartz	2.1187	Quartz
1.9725	Quartz/Kaolinite	1.6642	Hematite	1.9724	Quartz/Kaolinite
1.8115	Quartz	1.5363	Quartz	1.8115	Quartz
1.6661	Hematite	-	-	1.6660	Hematite
1.5373	Quartz	-	-	1.5373	Quartz

**Table 6. 6 Mineral identification of (d) Kareng Ghar mortar, (e) Rang Ghar mortar and (f) Talatal Ghar mortar**

(d) Kareng Ghar mortar		(e) Rang Ghar mortar		(f) Talatal Ghar mortar	
d[Å]	Mineral identification	d[Å]	Mineral identification	d[Å]	Mineral identification
4.2264	Orthoclase	4.4414	Kaolinite	4.2264	Orthoclase
3.3248	Quartz	4.2264	Orthoclase	3.3248	Quartz
3.0181	Calcite	3.3248	Quartz	3.0181	Calcite
2.4464	Quartz	3.0181	Calcite	2.4709	Quartz
2.2732	Quartz	2.4464	Quartz	2.2732	Quartz
2.2282	Quartz	2.2732	Quartz	1.9734	Quartz/Kaolinite
2.1202	Quartz	2.2282	Quartz	1.8127	Quartz
1.9734	Quartz/Kaolinite	2.1202	Quartz	1.6673	Hematite
1.8127	Quartz	1.9734	Quartz/Kaolinite	1.5366	Quartz
1.6673	Hematite	1.8127	Quartz	-	-
1.5379	Quartz	1.6673	Hematite	-	-
-	-	1.5379	Quartz	-	-

### 6.3.3 FTIR analysis of bricks and mortar

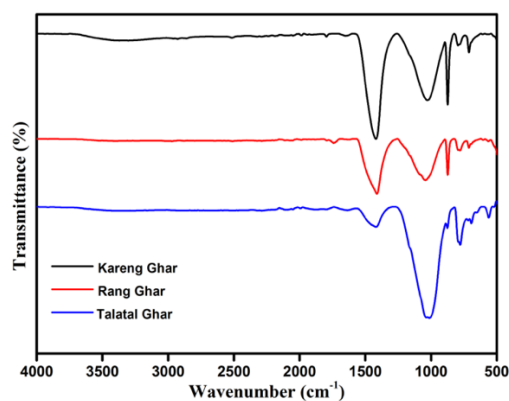
FTIR analysis was done to study the surface functional groups on bricks and mortars of Kareng Ghar, Rang Ghar and Talatal Ghar. **Fig. 6.13** and **6.14** shows the comparative FTIR spectrum of brick and mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar. **Table 6.7** shows the IR spectra and probable vibrational assignments of brick and mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar.

The bands at 1028, 1038 and 1022  $\text{cm}^{-1}$  of bricks samples and 1040, 1036 and 1029  $\text{cm}^{-1}$  of mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar signifies the Si-O-Si stretching vibrations of kaolinite. The following bands at 795, 794 and 780  $\text{cm}^{-1}$  of bricks samples and 790 781 and 783  $\text{cm}^{-1}$  of mortar samples represents Si-O of quartz (Schroeder, 2002; Singh and Sharma, 2016b). This indicates the presence of quartz and kaolinite in both brick and mortar samples. The IR band appears at around 709, 710 and 712  $\text{cm}^{-1}$  confirms the presence of calcite in all mortar samples (FB et al., 2002). The bands at 562, 560 and 562  $\text{cm}^{-1}$  of mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar and 564 and 556  $\text{cm}^{-1}$  of brick samples of Rang Ghar and Talatal Ghar are related to the stretching vibrations mode of Fe-O of hematite.

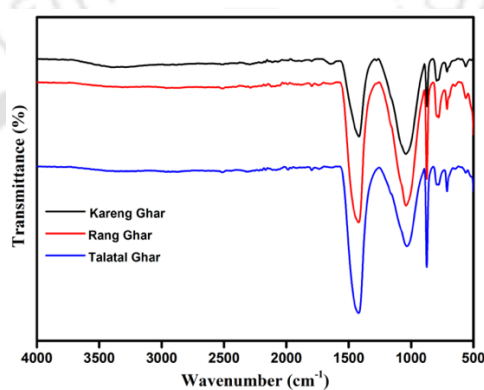
No peak is observed in the OH stretching region (3700-3400  $\text{cm}^{-1}$ ) and H-O-H bending of water (1650-1600  $\text{cm}^{-1}$ ) in both the brick and mortar samples which indicates that the clay materials must had been baked at about 550-650°C during the manufacturing process in the brick kiln. The structural pattern of all the mortar samples is found to be similar signifying the brick material processing and preparation of mortars were almost same.

**Table 6. 7 The IR spectra and probable vibrational assignments of brick and mortar samples of Kareng Ghar, Rang Ghar and Talatal Ghar.**

Peak position range ( $\text{cm}^{-1}$ )	Kareng Ghar Brick	Rang Ghar Brick	Talatal Ghar Brick	Kareng Ghar Mortar	Rang Ghar Mortar	Talatal Ghar Mortar	Tentative vibrational assignments
1040–1020	1028	1038	1022	1040	1036	1029	Si–O–Si (kaolinite)
798–764	795	794	780	790	781	783	Si–O of quartz
694–664	-	-	690	-	-	-	Si–O of quartz
720-700	-	711	-	709	710	712	Calcite
580–535	-	564	556	562	560	562	Fe–O of hematite
485–450	454	464	476	457	468	467	Si–O–Si bending (microcline)



**Fig. 6. 13** FTIR spectra of Bricks of Kareng Ghar, Rang Ghar and Talatal Ghar



**Fig. 6. 14** FTIR spectra of Mortar of Kareng Ghar, Rang Ghar and Talatal Ghar

## 6.4 Discussions

The Ghanasyam House of Sivasagar and Namath kali of Nilachal Hills, Guwahati, is the most unique and ornamented monuments of the Ahom dynasty, Assam. Although Namath kali Temple has retained only a few portions of its original architecture due to natural causes and vegetation, the remains still display detailed ornamentation. Irrespective of the geographical differences, both the monuments display the same *do-chala* architectural style. Also, the comparative study of both *bada* provides an in-depth insight into the similarity in *bada* height (approx.), variations in arrangement styles of the bricks and the shapes of terracotta plaques used in ornamentation. The results display a definite aesthetic similarity. The architectural style purely defines the exceptional skills of the artisans and their knowledge of terracotta mouldings. As both the monuments are constructed using Bricks and Mortar, it is observed that the architectural features are fading away due to the climatic condition and vegetation with due time. The elemental compositions of bricks and mortar of each monument were studied and compared the composition and structural pattern using Energy Dispersive X-Ray Analysis (EDX), Fourier transform infrared (FT-IR) and Powder X-ray diffraction

(PXR). The material test and comparison results also provide similarities in brick and mortar elemental compositions. The PXR and FT-IR graphs also show similar structural patterns. With the above analysis and findings, it can be assumed that the monuments' construction could be done during the same time period.

Rang Ghar, Talatal Ghar and Kareng Ghar are some of the most iconic buildings preserved under ASI. These monuments were constructed within the 1744 - 1768 time period and are some of the most important tourist attractions in the Sivasagar and Charaideo districts. The bricks and mortars used in the Kareng Ghar, Rang Ghar and Talatal Ghar have survived without significant deterioration. The early construction materials were investigated and compared by analyzing the structural composition and patterns of bricks and mortars of the three monuments. The collected brick and mortar samples were studied for structural and elemental compositions using FT-IR, EDX and PXR. The EDX result displays the same periodic elements in bricks and mortars with varying weight percentages. The FT-IR spectra and PXR patterns of bricks of Kareng Ghar and Talatal Ghar are found to be similar, whereas the Rang Ghar displays a slightly different spectrum and pattern. In the case of mortar samples, the FT-IR and PXR analyses showed similar structural patterns. This indicated that the brick and mortar compositions were ideal and perfect cementing materials. The result shows that the brick of Kareng Ghar and Talatal Ghar contains quartz, kaolinite and hematite, whereas the Rang Ghar brick contains quartz, calcite and hematite. Kaolinite is a soft, earthy, usually white mineral with low shrink-swell and low cation-exchange capacity, making the brick long-lasting.

The results provide solid probable indications that Kareng Ghar and Talatal Ghar bricks were made under the same firing condition, using similar raw materials sources; this lets us know that the artisan followed the same manufacturing techniques during that era. At the same time, a different source of raw materials and techniques was used to manufacture Rang Ghar bricks.

The mortars of all three monuments are mostly made of calcite with combination of quartz, hematite, kaolinite and orthoclase, indicating a similar source of raw materials and a similar manufacturing process. These results furthermore satisfy the early Ahom *buranji* (cornicles), which mentions mixtures of many organic and inorganic raw materials such as snail shells, limestones, oil, quick lime, *borali* (helicopter catfish or wallago catfish) fish, molasses, duck eggs and brick powders. The similar compositions of all the mortars indicated that the raw materials source or the method of preparation of mortars might be the same irrespective of different places.

## CHAPTER SEVEN: Discussions and Conclusion

### 7.1 Discussions

The ornamentations in architecture are a vital part of embellishing the overall structure. The use of ornamentation provides complementary characteristics to a building or structure. There is unified communication amongst the structure and ornaments. Like a song enhances its expressions by adding notes or by modifying rhythms, it is the ornamentation that sprouts the eccentricity of a song. According to Kent Bloomer, one of the renowned American sculptor, professor and author who is also a well-known proponent and creator of architectural ornament quotes, “ornament is a system of figuration which must absolutely must connect to and become embodied with the thing being ornamented. Achieving that union is the absolute property”. The ornaments cannot be autonomous, it is the notion of union with the holder, that brings the soul of ornamentation. Ornaments can be elements of decoration, but it is not fundamentally decoration. It is something that is put inside the system of decoration.

From literature reviews, nearly all temple architectures have followed an architectural style based on the era of rulers and the cultures. The ornamentation style provides architectural uniqueness and unconventionality, giving soul to the overall structure. In the context of Ahom brick monuments, the conservation of ornamentation is observed with cleaning and renovations of some fragmented sections. However, without considering the early aesthetics, these new renovations fail to rejuvenate the soul of the ancient Ahom architecture. Understanding the visual characteristics of the forms and visual elements considered by the early artisans and patrons is a must to preserve the early aesthetic of Ahom brick ornamentations.

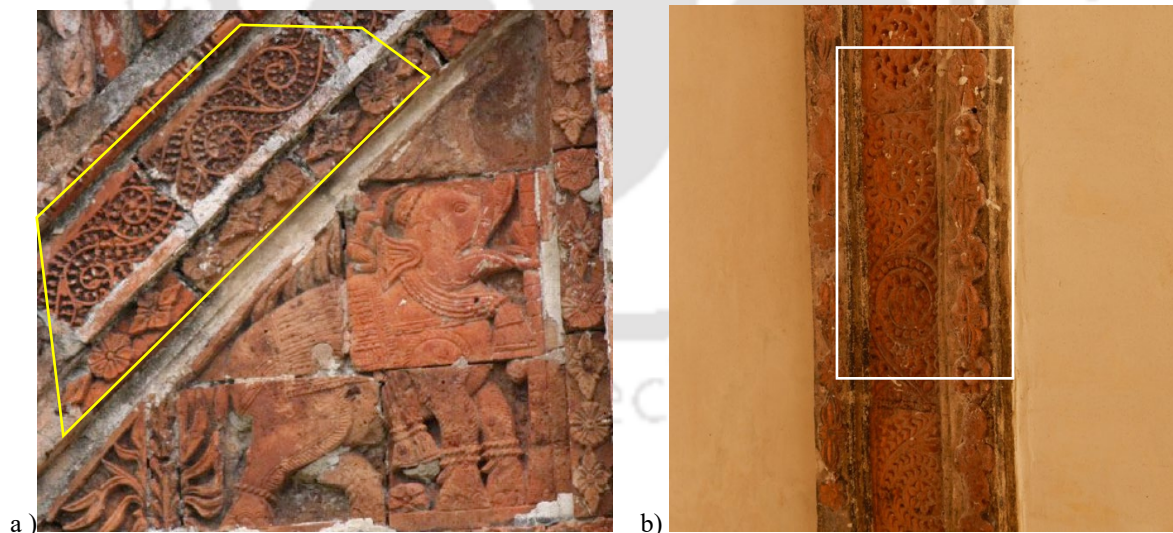
The literature study sheds light on how the late mediaeval era of Assam has artistic assimilation from the Gupta, Orissan, Indo-Islamic and southeast Asian elements. The study also shows that the terracotta monuments in Assam reflect influences from Hindu and Indo-Islamic architectures, sharing architectural similarities with the West Bengal *Jor-Bangla* Terracotta temples retaining the local style. There are three types of ornamentation used in Ahom architecture: stone cut, terracotta and stucco. The architectural sculptures and iconography of Assam have been studied extensively, but Ahom brick architectural ornamentation studies are significantly rare.

The pilot study reveals that the stone cut ornamentation has survived successfully considering the natural calamities like the earthquake of 1950 and various climatic conditions of the geography. It reveals that the terracotta and stucco ornamentations have survived in fragments compared to stone cut ornamentations of the late mediaeval era. With the initiative

of the Archaeological Survey of India (ASI), Guwahati Circle, Assam and Directorate of Archaeology, Guwahati, some of them have been conserved and some are renovated to early structural forms. According to the Conservation officer (ASI) of Guwahati Circle, their process of ornamental renovations includes inspiration from the surviving ornamentations. It is best tried to replicate the existing ornamental forms. He further mentions a lack of artisans specializing in late medieval stucco works. Henceforth, they need to hire artisans from West Bengal for stucco ornamentation. The materials used in renovations include bricks, unslaked lime, brick surkhi and brick aggregate. Furthermore, organic materials include molasses, Indian bael gum, *methi* (fenugreek seeds), *hilikha* (*Terminalia Chebula*), *katha* (*Catechu*) and black lentils. The material they use for renovations includes custom-sized bricks replicating the early bricks.

The visual study of the ornaments provides underlying structural information about the ornamental elements used in Ahom brick masonry. The study includes the visual details, variations in visual compositions, symmetrical properties and the range of the elements used in architectural ornamentation. The in-depth analysis provides the structural framework for the composition of the motifs and patterns and underlying design principles considered by the early artisans.

### 7.1.1 Similarities in ornamentations



**Fig. 7.1** a) pattern plaques of Gopinath Jor-Bangla Temple, Pabna, Bangladesh b) Pattern plaques of Ghanasyam House, Sivsagar, India

The terracotta ornamentation provides strong similarities with the West Bengal and Bangladesh *Jor-Bangla* Temples. The figure of Gopinath *Jor-Bangla* Temple and Ghanasyam House discloses similar pattern compositions and pattern choices. The **Fig. 7.1** (a) is a section

on the wall of Gopinath *Jor-Bangla* Temple. The spiral pattern plaques are arranged with other floral pattern plaques of rounded and pointed petals, continuing rhombus-shaped composition. These similar arrangements are observed in Ghanasyam House’s interior section. Similarly, the ornamentation of entrance arches of **Fig. 7.2** (b), (c) and (d) has strong similarities. The use of the temple motif is common in both entrances. In another section **Fig. 7.2** (c); the organic curved side panel of entrance arches has a similar design structure to **Fig. 7.2** (d). It indicates that the specific moulds and shapes were considered based on the structure and sections of the monument.

In **Fig.7.2** (a), the use of temple motifs over the arches has similarities with one of the sculptures found during the Pala dynasty of Bengal. This sculpture represents an esoteric form of *Manjushri*<sup>28</sup>, the Bodhisattva of Transcendent Wisdom. The sculpture includes multiple stupas over the arches. These similar arrangements can be seen in both the monument’s entrance arches.

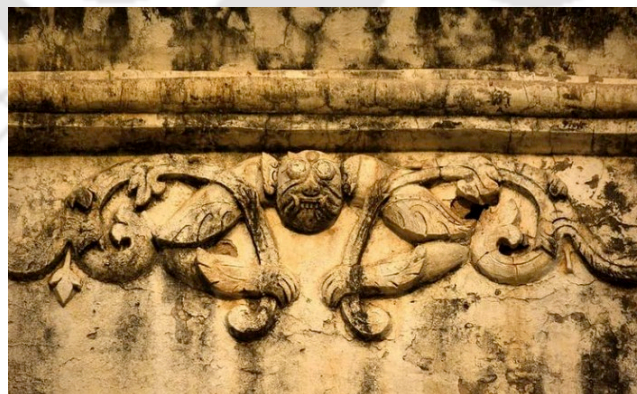


**Fig. 7. 2** a) Manjushri sculpture from 11th century, Bengal or Bangladesh | source: <https://www.metmuseum.org/art/collection/search/38124> ; b) and c) entrance arches of Gangeswar Shiva Temple of 18th century, West Bengal, India; d) Entrance arches of Ghanasyam House of 16th-17th century, Assam, India.

<sup>28</sup> *Manjushri*, in Mahayana Buddhism, the bodhisattva (“Buddha-to-be”) personify supreme wisdom. His name in Sanskrit means “gentle, or sweet, glory”.

The inclusion of these underlying designs leading to linear concentrations in compositions is fascinating to observe, considering that the sculpture was dated to the Pala period of West Bengal. The adoption of this style in the late mediaeval terracotta structure is pretty evident, signifying the cultural diffusion and adoption in terms of ornamentation. Considering the construction time period, it is evident that the Ghanasyam House initially used these plaques and probably a part of Assam was the center of terracotta mould making. It also signifies that artisans have been following the same skillset of terracotta plaque making with a similar philosophy and design considerations irrespective of geographical differences. The use of local elements is observed in both the monuments; this also strongly reflects the consideration and fusion of art based on geography, culture, patron, or rulers.

In the stucco ornamentation, the analysis discloses new visual similarities with Burmese folklores in ornamentations, like *Panswé Belu* (ogre)- (lit flower dangles) *Belu*<sup>29</sup> has curved or hooked fangs that eat flowers and fruits. The ogre possesses a similar posture to Rang Ghar horizontal panel compound motifs (*Ran-M-Wa-C-05, 19, 26, 31*), with the extended vegetal vines held with both hands. The similarity needs to be pondered as the historians trace the Ahom race to be migrated from Norther Burma to the Brahmaputra valley of Assam in the first centuries. The inclusion of this motif with the creature has not been mentioned in works of literature. This demonstrates potential linkage with the early roots of the Ahoms. The similarities and influences disclose strong indications of cultural diffusion and adoption in Ahom brick ornamentations.



**Fig. 7. 3** Panswé Belu (ogre) found in Manuha Temple (1067 A.D.), Myanmar.

Source: by indiastretched(Own Work), [https://www.instagram.com/p/B\\_ACxyNBNC0/](https://www.instagram.com/p/B_ACxyNBNC0/)

---

<sup>29</sup> *Belu* is a mythical creature in Burmese mythology, the *Panswé Belu*, literally "flower dangles". *Belu* with curved or hooked fangs that eat flowers and fruits. Generally benevolent.



**Fig. 7. 4** Rang Ghar horizontal panel compound motifs (Ran-M-Wa-C-05, 19, 26).

### 7.1.2 Visual forms in the ornamentation






























The visual analysis of the motifs and patterns of the Ahom brick monuments provides a range of organic and geometric forms. The inclusion of figurative, vegetal and geometrical forms is commonly observed during the analysis. The terracotta moulds and stucco reliefs have varied forms of expression. The terracotta monuments include arrangement or tiling in structural patterns to accomplish harmonious compositions. These plaques vary in shape and size based on the structural requirements.

The motifs used in the terracotta and brick monuments include floral, animal, compound and symbolic motifs. The most predominant single floral motif is the lotus motif. From the early Buddhist art to Hindu and Indo-Islamic art, the lotus motif has been part of Indian ornamentation. The results show that the Ahoms have an intense fascination with the lotus flower. The early remains of stones cuts and stone plates showcase the repeated use of the Lotus flower motif in religious and non-religious buildings. The terracotta ornaments disclose multiple variants of Lotus motifs with different shapes, sizes, forms and styles. This includes petal shapes with rounded and pointed petals and variations in compositions with rotational structure and display of affinity (Wong, 1993). In addition to the lotus motif, many other floral forms are observed with variations in petal counts, shapes and sizes. The petal shapes mostly have pointed, rounded and wavy ends. The inclusion of flowers and buds is observed in animal, compound and organic patterns in most compound motifs. The copious consideration of floral forms in ornamentation are showcased in the quantitative data of the variation analysis. **Table 7.1** shows the range of floral shapes used in Ahom brick ornamentation.






































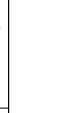







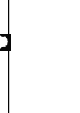
**Table 7. 4 Animal forms(a) and Creatures (b) used in Ahom brick monuments ornamentation.**

**Table 7. 5 Human figures used in Ahom brick monuments ornamentation.**

**Table 7. 6 Man-made forms used in Ahom brick monuments ornamentation.**

### 7.1.3 Visual Characteristics of ornamentation

#### 7.1.3.1 Terracotta ornamentations

With the visual analysis of the terracotta and stucco brick ornamented monuments, it is evident that the ornamentations are rich with varied floral and patterns. The cultural diffusion and adaptation are distinctly showcased in the design structures of the ornamentation. The rich simple and complex motifs and patterns plaques of Ghanasyam House and Namath kali show the underlying design and technological scenario of the late medieval era. With the compilation of variation, visual and symmetry analysis, **Figure 7.5** has been established to highlight the underlying design characteristic of the ornamentations used in terracotta-type monuments.

The single floral motifs are composed of a border frame or a base. There are three variations of the border frames; these are circular, square and rhombus shapes. The petal shapes have both rounded and pointed, displaying rotational symmetry. The floral motifs vary in shape and size. Repetition of these variants can be seen in overall ornamentations.

Most of the compound motifs are composed with a rectangular border frame; the compositions include three basic types of branching: curved upward, curved downward extensions and upward diagonal extensions. The flowers and leaves used in the compound motifs vary in shape and size. Similar types of flowers and leaves are repeated in composition to develop unity and harmonious design. The shapes include the use of rounded and pointed petals and leaves. Proliferated leaves in the curved extension are part of the compositions. The overall composition displays vertical branching with reflection symmetry.

The constructions of animal motifs are in parallelogram and square types of borders frames. The animal motifs are mostly asymmetric due to the dynamic compositions of the motifs to display movement. The motif structures display movements in the compositions. Most of the animal motifs are composed of interacting with natural or man-made elements. The associated elements are showcased in detail in **Table 7.5** and **7.6**. These associations with natural and man-made elements in the case of humans illustrate the artisans' intentions to display the day-to-day lifestyle of that era.

These adoption and adaptation of culture are prominent when symbolic motifs like *Makara*, *Gajavyala*<sup>30</sup>, *Shiva Linga*<sup>31</sup> and human motifs of the tribal person caring food in a bamboo basket, a human figure playing local drum *Doba* are used as a part of architectural ornamentations.

---

<sup>30</sup> Mythical creature with Lion-bodied Animal with Elephant Head, often seen in South Indian Temples.

<sup>31</sup> *Shiva linga*, is an abstract or aniconic representation of the Hindu god *Shiva* in Shaivism

The patterns analysis also discloses the use of both organic and geometric patterns in plaques. These pattern plaques are constructed considering seamless design in overall ornamentations. Varied patterns plaques are tiled adjacent to each other, yet the compositions display unity and harmonious design. The organic patterns are predominant; these motifs are composed of flowers, leaves, vines and abstract organic shapes. The organic and geometric pattern consists of three frames: vertical frames that extend upward and downwards, horizontal frames extending both sideways and closed rectangle border frames. The flowers used in the pattern display rotational symmetry with repetition and variation in shapes and sizes. The unit forms extraction also displays petals with both pointed and rounded shapes. The leaves used in the ornamentation display reflection symmetry. The intertwined floral vine pattern of Namath Kali displays complex patterns with S and C type curves. The use of abstract organic form is unique, considering the frequent use of vegetal forms in ornamentations of Ahom monuments. These abstract organic shapes with multiple structure proliferation are repeated in ornamentation. (Fig. 5.4)

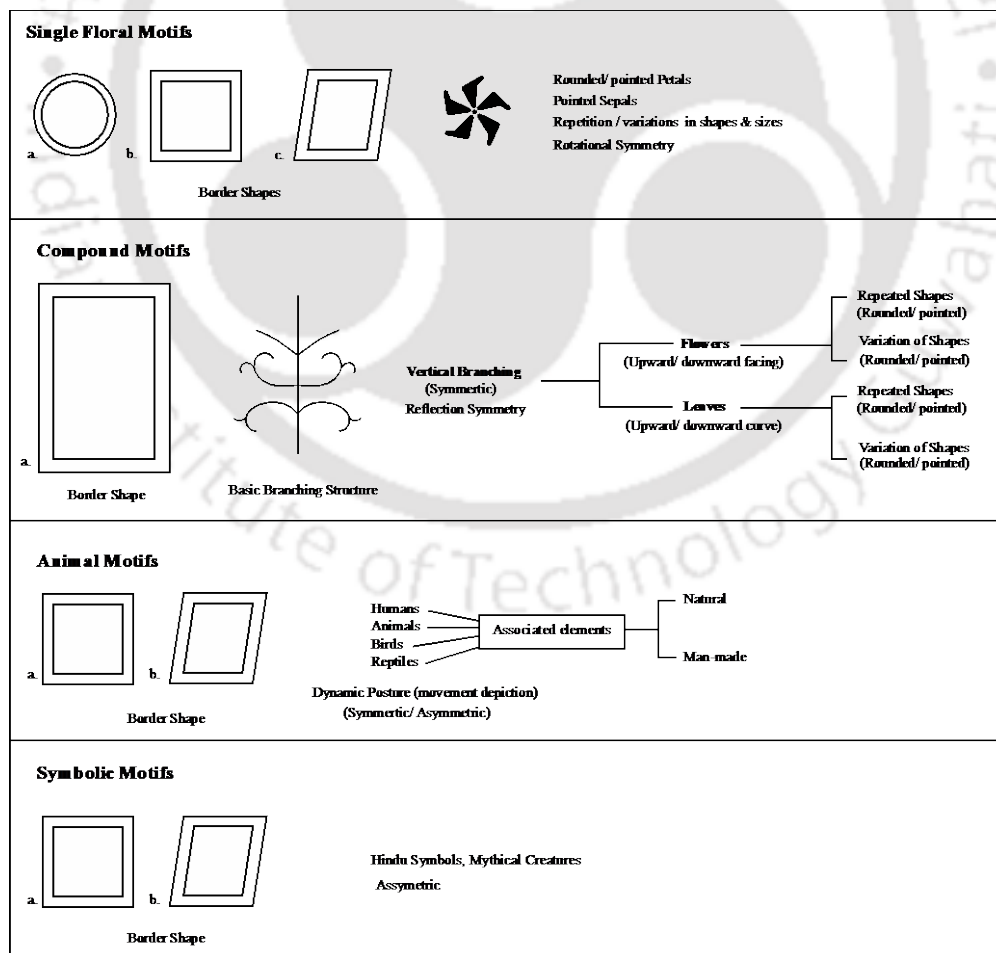


Fig. 7. 5 Display of underlying design characteristic of the motifs used in terracotta-type monuments.

These organic patterns use four one-dimensional classes out of the seven pattern classes. These include pattern class of *p111*, *pmm2*, *p1a1*, *p1m1*. The geometric patterns are composed of closed and open border frames. The composition includes the use of geometric shapes like curved rhombus, triangles, irregular pentagons and lines. These are arranged with pattern classes of *pmm2*, *p1m1* and a two-dimensional pattern class of *c2mm*. (Fig. 5.4)

The class of *p111* and *p1m1* discloses no rotation of any kind among their constituent symmetry, but repetition of unit forms is displayed. The *pmm2* class exhibits horizontal reflection with the unit forms and the *p1a1* class exhibits glide reflection. The *c2mm* class found in the geometric pattern display twofold rotation in its pattern composition.

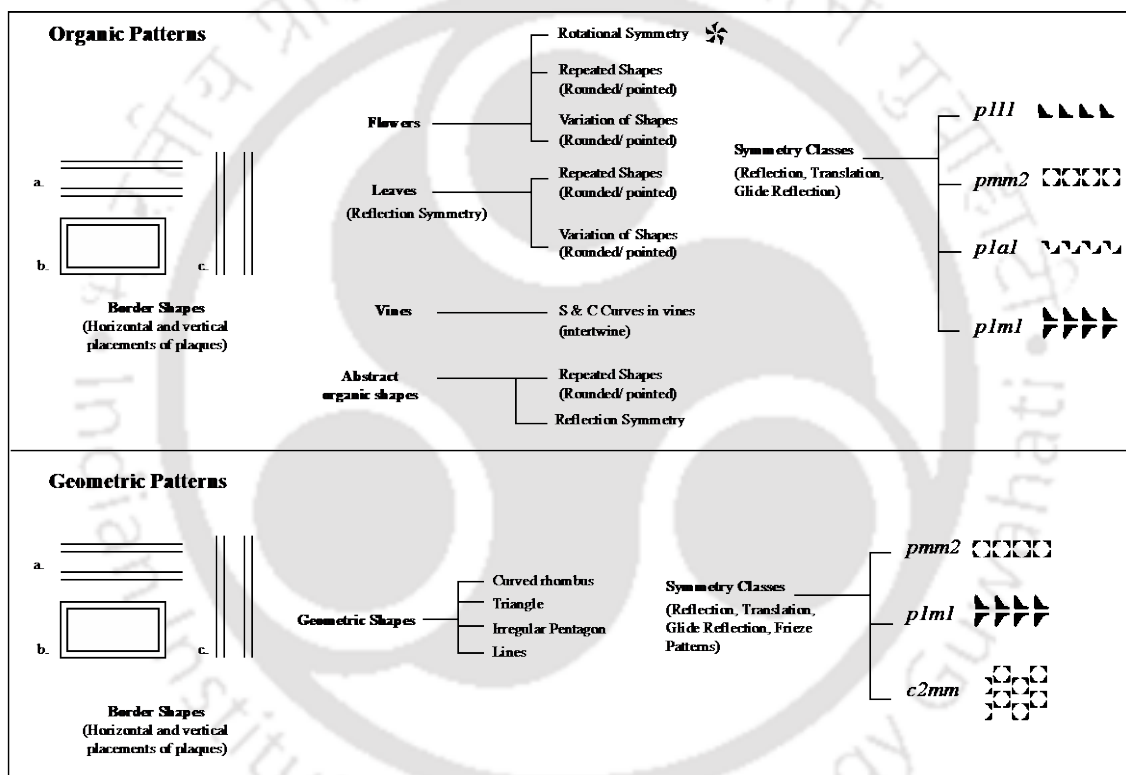


Fig. 7. 6 Display of underlying design characteristic of the patterns used in terracotta-type monuments.

The details of the ornamentation highly showcase the craftsmanship of the architects. The variations analysis indicates that the ornamentation of the monument is more inclined towards organic floral designs and patterns than geometric designs and patterns. The visual elements of the motifs and patterns embody design principles like symmetry, repetition, radiation, affinity and unity. The ornamentation's composition analysis highlights the underlying principles like Repetition, Gradation, Similarity, Contrast, Concentration and Anomaly (Deori & Barua, 2021). The use of seamless design in the pattern plaques discloses

the expert and conscious decision in design consideration and development of the ornamentation by the artisans. The monument structure, including the ornamentation, follows symmetrical properties. The study highlights the design considerations with elemental compositions to maintain visual balance, retaining the sense of unity in the overall ornamentation. The symmetry analysis gives a new perspective to cultural integration in terms of visual art and design. With the analysis of the motifs, it is clear that the rotational symmetry is the predominant symmetry. This is because of the repetitive use of floral motifs as a part of the ornamentation.

With all the gathered data, **Fig. 7.5** and **7.6** showcases the design characteristics motifs and patterns of the terracotta ornamentation of Ahom brick monuments.

#### *7.1.3.1 Stucco ornamentations*

The stucco ornamentation of Rang Ghar, Talatal Ghar and Kareng Ghar has its representations based on vegetal, figurative and abstract forms. The literature provides minimal information regarding the stucco ornamentations of Ahom brick monuments. Most of the literature mentions these ornamentations to be related to Indo-Islamic architecture. Visual analysis of Ahom brick ornamentation opens a new door to research. The shape and form analysis disclose the richness in compositions of these motifs and patterns. The single floral motifs are circular in shape and consist of pointed and rounded petal shapes. Repetition and variations of shapes and sizes are considered in construction. The compound motifs are highest in number in Rang Ghar compared to Talatal Ghar and Kareng Ghar.

The stucco single floral motifs primarily exhibits rotational symmetry. Some are symmetrical in composition and some display affinity. The petals are rounded and pointed in shape; some floral compositions include sepals with pointed ends. Repetition of these floral forms is observed in most of the building walls.

The compound motifs are composed of three horizontal border frames variants and three vertical border frames variants. The vertical border frame comprises multifoil arches; the composition includes vegetal forms branching upward. The branching displays symmetrical and asymmetrical properties. Bilateral symmetry is primarily considered in motif composition. Floral forms like flowers, buds and leaves are considered; these shapes are repeated in overall composition to display balance, unity and harmony. The shapes of flower petals and leaves vary with rounded and pointed ends. The orientation of flowers and leaves faces upward and downward. Figurative forms are also included in the compound motifs; these figurative forms mainly depict animals, birds and man-made objects like a vase. The animal and birds display

movement and static postures in compositions. The horizontal border compound motifs consider branching extending mirror direction horizontally. This branching exhibits bilateral symmetry and asymmetry composition. The composition includes flowers and buds, leaves and vines extensions, mythical creatures and man-made shapes. The flowers and leaves are oriented in upward and downward directions. The composition includes vines that follow S and C curves extensions. The flowers and leaves are pointed and rounded in shape.

The animal motifs are composed within a multifoil arched frame. The composition primarily includes figurative forms like humans, animals and birds. The composition of figurative forms may include interacting with natural and man-made forms. Compared with other motif types, the symbolic motif is the less considered motif in stucco-type ornamentations. The use of *Makara*, also represented locally as the Ahom insignia dragon, is repeatedly used at the entrance of the Rang Ghar.

The patterns analysis also discloses the use of organic and geometric types in stucco ornamentation. These patterns are composed considering seamless design in overall ornamentations. The compositions display unity and harmonious design with repetitions. The organic patterns are predominant; the patterns are composed of flowers, leaves, vines and abstract organic shapes. The organic pattern consists of vertical frames that extend upward and downwards, closed rectangle border frames and closed vertical frames with arches inside. The flowers used in the pattern display rotational and reflection symmetry with repetition and variation in shapes and sizes. The unit forms extraction also displays petals with both pointed and rounded shapes. The leaves mostly display reflection symmetry. The floral vine pattern displays with S and C type curves extension. The use of abstract organic form is unique, considering the frequent use of vegetal forms in ornamentations of Ahom monuments.

The Geometric patterns are composed with and without borders. The borders are primarily in horizontal layouts extending sideways. The geometric shapes used in stucco patterns are arches, triangles, irregular pentagons, curves and straight lines. These shapes are repeated and reflected to attain pattern variants.

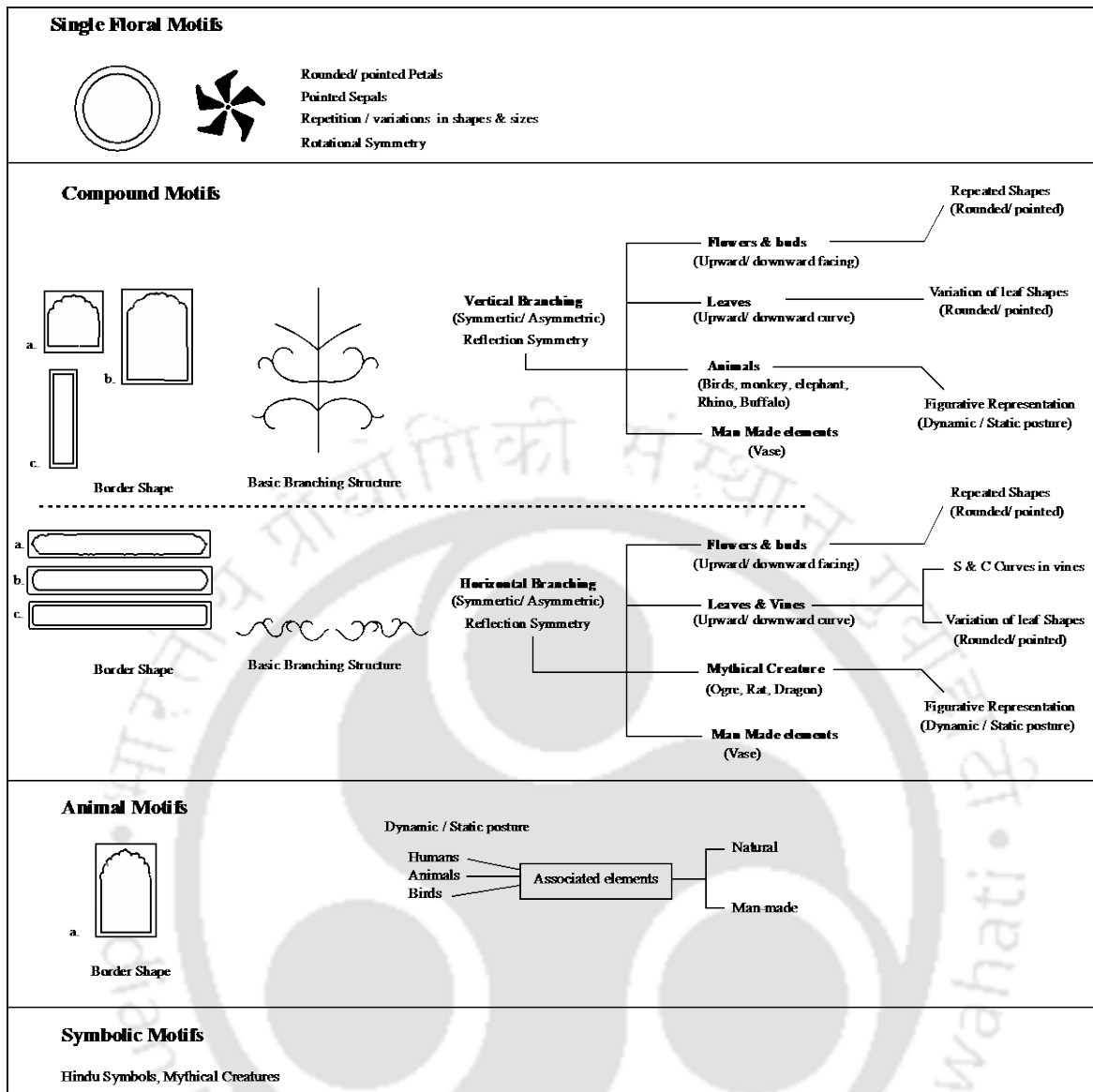


Fig. 7. 7 Display of underlying design characteristic of the motifs used in stucco-type monuments.

The patterns classes of  $p111$ ,  $pmm2$ ,  $plal$ ,  $plml$ ,  $pma2$ ,  $pm11$  and two-dimensional pattern  $cm1m$  are followed in the composition. The geometric patterns include shapes of Arch, triangle, irregular pentagon and lines and curves in its composition. The symmetry class includes  $pmm2$  and  $pm11$  and  $plml$ . Similar to the terracotta patterns, the stucco patterns display classes  $p111$ ,  $plml$  that exhibit no rotation among their constituent symmetry. The  $plml$  in the geometric pattern class is of two-dimensional pattern. The  $pmm2$  class exhibits horizontal reflection with the unit forms with the  $plal$  class displaying glide reflection. The  $pma2$  class display rotation and vertical reflection with consistent incrementation.

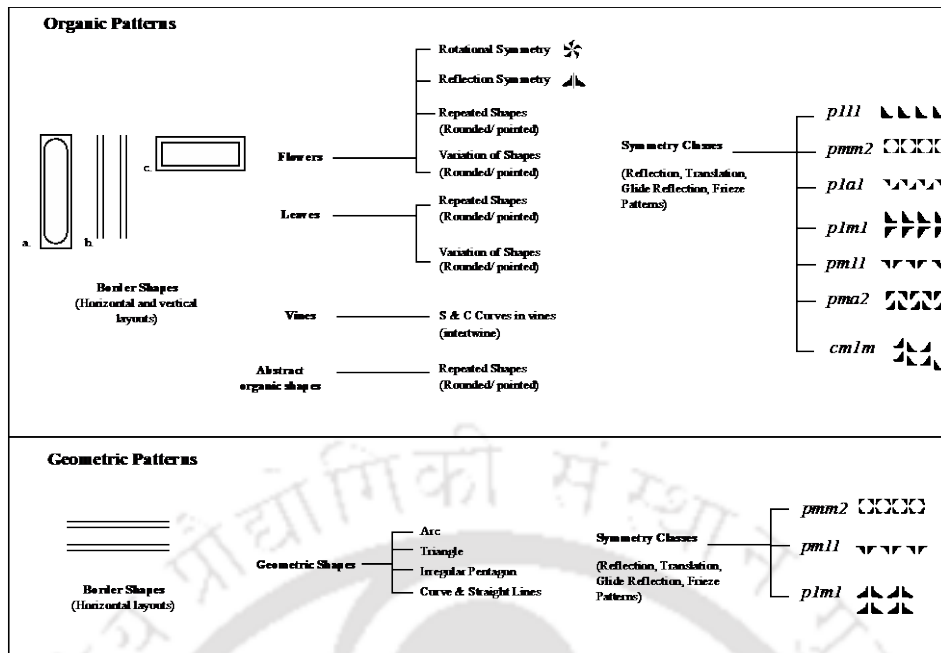


Fig. 7. 8 Display of underlying design characteristic of the patterns used in stucco-type monuments.

The study sheds light on bilateral symmetry in most compositions and visual distribution with spatial arrangements. Repetition in shape, size and form are also observed. Design principles like repetition, gradation, anomaly, contrast, similarity, radiation and concentration are in the compositions. The comprehensive study provides a handful of information on the underlying design considerations in the compositions of motifs and patterns of the monuments. In the context of the refurbishment of the early fragmented ornamentation of the Ahoms, it provides contextual information regarding the aesthetics, shapes, forms and symmetry considerations of that era.

With all the gathered data, Fig. 7.7 and 7.8 showcases the design characteristics motifs and patterns of the Stucco ornamentation of Ahom brick monuments.

#### 7.1.4 Material considerations

The experts and scholars rarely ponder the study of the early construction material of the Ahom monuments. The architecture of these monuments is thoroughly studied and evaluated, but the study of bricks and mortar compositions is rare. Along with the ornamentation, it was vital to understand the material consideration for the ornaments. Hence Chapter Six provides details of the materials and the elemental compositions. The results provide similarities between the terracotta monuments and the stucco monuments. This is a significant finding in understanding the early construction techniques and technology. The mortars of all three monuments are mostly of calcite with combination of quartz, hematite,

kaolinite and orthoclase; indicating that same source of raw materials and a similar manufacturing process. These results also satisfy the early Ahom *buranji* (cornices), which mentions mixtures of many organic and inorganic raw materials such as snail shells, limestones, oil, quick lime, *borali* fish (helicopter catfish or wallago catfish), molasses, duck eggs and brick powders. The similar compositions of all the mortars indicated that the raw materials source or the method of preparation of mortars might be the same irrespective of different places.

The photo data and the analysis shows the calcium to be present in most of the samples, justifies the early compositions. Another vital finding is the connection of Namath Kali and Ghanasyam House with the construction date. The study considered three vital comparison analyses architecture, ornamentations and material. The analyses of the all there strongly indicates that the Namath Kali temple and Ghanasyam has been constructed in the same period and with the Ghanasyam House recorded constriction period in 17th Century by ASI, the results Namath kali temple strongly indicates that it has similar construction timeframe.

## 7.2 Conclusion

Literature has discussed details of architecture type with materials. From the Gupta period until the Pala period of Assam, scholars and historians have discussed and documented most architectural features with ornamentation details. The inclusion of the Gupta style and similarities with the Northern style and the resemblances with Orissan temple motifs show the cultural diffusion and adoption of the ornamental style from the early architecture of Assam till the Pala period.

Most of the studies are on temple architecture and the iconography, arts and sculptures of Assam. Not many studies are pondered into Ahom architectural ornamentations, specifically the Brick-masonry of Assam. There is no systematic documentation available of architectural ornamentation of the Ahom brick monuments; this leads to a lack of renovation outputs in ornamentations and patterns, henceforth diluting the ancient ornamental aesthetic. It provides a tremendous opportunity to consider the visual aspect of Ahom brick architectural ornamentations of Assam to conserve the Ahom traditional art of terracotta plaques and stucco reliefs. Based on the above factors, these following research questions are considered:

### 7.2.1 Research Questions.

1. What are the visual characteristics of the Ahom brick architecture ornamentations?

**Objective:** To study and identify the visual characteristic of Ahom brick Ornamentations.

#### Results

- The Ahom architectural ornamentations include mostly motifs and patterns. The shapes of petals have rounded and pointed edges. The petal layers ranges from single to three layered petal combinations. The terracotta single floral motif has border or base with circular, square and rhombus shapes. Some flowers display affinity. Most of the flowers exhibits rotational symmetry.
- The compound motifs mostly display branching with bilateral symmetry and asymmetry. The branching includes upward and downward curved extension and splitting and proliferations of branch leaves.
- The human postures mostly display movements in overall compositions.
- The patterns exhibit repetition in one-dimensional and two-dimensional. This mostly includes symmetry operation like translation, reflection and glide reflection.
- The patterns composition exhibits pattern classes like-  $p111$ ,  $pmm2$ ,  $plal$ ,  $plm1$ ,  $pma2$ ,  $cm1m$ ,  $pm11$  and  $c2mm$ .

2. What visual forms are used in Motifs and patterns of brick monuments?

**Objective:** To study and analyse the visual forms used in motifs and patterns of the brick monuments.

#### Results:

- The singular floral motifs are mostly Lotus flower. With rounded and pointed petal shapes.
- The animal, birds, creatures, flowers, buds, leaves, vines, stems and man-made objects like vase are part of compositions.
- The animal motifs display figurative human, animal and birds.
- The human forms are found to be associated with natural and man-made forms.
- Symbolic motifs showcase the use of Hindu symbolic forms. (eg *Makara*, *Temple*, *Siva linga*, *gajavyala*.)

3. Who were the artisans of the Ahom monuments? What were their inspirations?

**Objective:** To study and understand the art and architecture of the Ahom dynasty.

Results:

- Literature provides strong indications that the artisans were imported from West Bengal during the reign of King Rudra Singha (A.D 1698-1714) for brick masonry architectures. Yet, the book *Chang Rung Phukanar Buranji*, highlights his supervisions in constructions of city buildings and roads. There is an amalgamation of local and Bengal artisans, as for local elements in the architectures and ornamentation styles are observed.
- The site visits and literatures indicate the architectural inspirations dates from the Gupta age, most of the architecture evolve during the Pala dynasty. These include sculpting and stone cuts. The influence of Indo-Islamic architecture is prominent in most of the monuments. The brick masonry ornamentations are mostly inspired from botanical forms. This includes flowers, vines, animals, humans, mythical creatures and Hindu symbolic forms. Stucco works display influence of Hindu, Indo-Islamic styles and exotic Southeast Asian styles with inclusion of local designs.
- The Terracotta architectures of Assam has similarities with the West Bengal and Bangladesh *Jor Bangla* Temples. All the temples display similarities in structural designs of the front façades. The use similar motifs and patterns are observed. This discloses the cultural diffusion and fusion of the visual arts of within these different geographical locations. Although there is similarity in design philosophy, the native designs overpower the overall ornamentations.

4. What was the early material considerations of Ahom brick architectures?

**Objective:** To study and understand the material technology of Ahom brick Monuments

Results:

- In terracotta monuments, the material test and comparison result also provide similarity in brick and mortars' elemental compositions. The PXRD and FT-IR graphs also show similar structural patterns. With the analysis and findings, it strongly indicates that Ghanasyam House and Namath Kali temple construction could be done during the same time period; as the construction period of Namath Kali temple was unknown.

- The stucco ornamented monuments, the result shows that the brick of Kareng Ghar and Talatal Ghar contains quartz, kaolinite and hematite whereas the Rang Ghar brick contains quartz, calcite and hematite. Kaolinite is a soft, earthy, usually white mineral having low shrink–swell and low cation-exchange capacity which makes the brick long-lasting.
- It shows that presumably, Kareng Ghar and Talatal Ghar bricks were made under same firing condition, using same sources of raw materials following the same process of manufacturing by the artisans of that era while different source of raw materials and techniques was used for the manufacturing of Rang Ghar bricks. The mortar of all the three monuments composed of mainly calcite with a combination of quartz, hematite, kaolinite and orthoclase indicates the same source of raw materials and similar process of manufacturing.
- The mortars of all three monuments are mostly of calcite with combination of quartz, hematite, kaolinite and orthoclase; indicating that same source of raw materials and a similar manufacturing process. These results also satisfy the early Ahom *buranji* (cornicles), which mentions mixtures of many organic and inorganic raw materials such as snail shells, limestones, oil, quick lime, *borali* fish (helicopter catfish or wallago catfish), molasses, duck eggs and brick powders. The similar compositions of all the mortars indicated that the raw materials source or the method of preparation of mortars might be the same irrespective of different places.

### 7.2.2 Major Contribution.

- There was no systematic archive or documentation of Ahom brick ornamentation. The study provides important source of information to understand the Ahom brick ornamentation. Along with that, the study provides a beneficial source to understand the shapes and forms used in ornamentation leading to conservation and preservation of traditional visual art forms. This documentation provides a visual source to restore or to renovate the early Ahom brick ornamentation.
- The material study of the Ahom ornamentation is rare. The comparative study provides an in-depth scientific information of early bricks and mortar. The results of Ghanasyam House and Namath kali temple comparisons in architectural and material study provides a significant contribution to historical and archaeological areas of Assam and India.

### 7.2.3 Limitation

- The study is conducted only with the limited number of survived brick ornamentalations, as the early documentation of the architectural ornamentation is very rare and most of the ornamentation are in dilapidated condition.
- The study on the Ahom brick ornaments is very limited. There is less literature source on the ornamentation details and documentation. This motivated the overall study of the Ahom brick ornamentation.

### 7.3 Future Scope

Over the last two decades, the research and development on Artificial Intelligence (AI) algorithms has accelerated in such a way that almost every aspect of human life has applications of AI today. It has become a highly useful tool that can help people and organizations to gain greater insights from data and make better decisions on a personal or collective basis. The objective behind any AI application is to mimic the human intelligence by mathematically modelling the cognitive processes that occur inside a human brain. In the beginning, the application of AI was focused on individual tasks, such as *object detection* (Zhao et al., 2018) in Fig 7.9 (left), *semantic segmentation* (Lateef & Ruichek, 2019) in Fig 7.9(right) , *speech recognition* (Zhang & LeCun, 2015), *text understanding* (Kamath et al., 2019) etc. and these tasks mostly try to model how, we human see, hear, experience and understand the world around us.

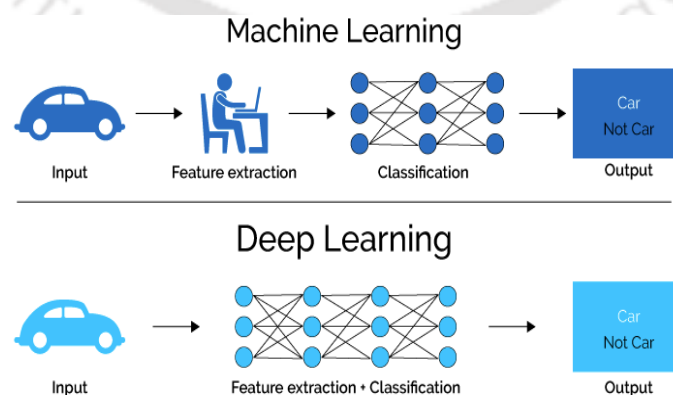


Fig. 7. 9 Example of object detection (left) and semantic segmentation (right)

As the performances of these tasks became better to an extent that it can challenge human performance and, in some cases, can even beat human, more complex tasks were designed for AI, such as caption generation, autonomous chatbot etc. For the caption generation task, in its simplest form, the AI needs to recognize the objects in an image, understand the surrounding of the objects and actions (if any) the objects are performing and then form a caption using a

trained model for text generation in a specific language like English. The wide-spread uses of that AI encompasses monitoring and diagnosis of health, recommendation systems, security and surveillance, robotics, autonomous driving, drug discovery, augmented and virtual reality (AR & VR) and more. Every business organization uses AI to deliver more value to their customers by making better policies based on the analysis provided by AI systems that uses a large amount of data to run complex algorithms within small amount of time. Gaining insights from such large collection of data in a small time is practically impossible for a human mind. The optimistic and interesting thing is that the advancements till now are considered to be the initial phase of the amalgamation of AI and humankind and the future AI will help us to solve deeper issues and lift human society on many levels.

Any state-of-the-art AI system uses *deep learning* algorithms to learn directly from a large collection of digital data. Deep learning algorithms are subset to a larger set of algorithms called *machine learning* algorithms. In traditional machine learning algorithms, some features need to be extracted first manually and then these features are used to perform different tasks. Thus, when we have large and complex collection of data, such manual feature extraction is not favorable in terms of effort, time and ability to learn complex data. However, in deep learning algorithms, the features required will be directly extracted from the data and simultaneously the AI-based task will also be performed. Deep learning algorithms are based on the neural information processing mechanism that is present in a human brain. The human brain is composed of a network of neurons that has connections with each other and specific neurons fire while performing specific tasks and learning process. With an appropriate training methodology to train such deep learning algorithms using data, the AI can effectively learn the underlying complex and relevant features of the data specific to the task at hand.



**Fig. 7. 10** The difference between machine learning and deep learning algorithms

Along with the vast pool of applications, AI can be a useful tool for digital preservation of architectural designs in heritage sites from decay due to natural conditions and human activities. The architectural designs present in various structures built during a historical time period under the reign of a dynasty, such as the *Ahoms* in Assam, will always have certain unique characteristics that people with expertise in history, architecture and design will be able to understand through data collection and visual analysis. However, understanding and modelling these designs from digital data like images using AI-based systems will be advantageous for many purposes. Such AI systems will help in promoting digital applications such as AR, VR and Holographic interactions for visual education on these designs and as a whole on the cultural heritage to non-domain experts, students, tourists. A step forward in the digitization of historical education and tourism. For example, a student who visits a cultural heritage site and observes a damaged design will be able to generate an approximate design of the original design through a smart application just by pointing his or her smart phone camera to it. This digitization using modern technologies will also be helpful to create a sense of importance of our heritage among general population which is central to the idea of preservation of any cultural heritage.

One work in the direction of digital preservation of heritage site is done for the Bishnupur heritage site, situated about 132 kilometers away from Kolkata (*BHID: Bishnupur Heritage Image Database*, n.d.). The team of researchers created an image database from different temples present at Bishnupur and performed several computer vision tasks such as reconstructing 3D model of the temples, inserting visual information into damaged region, texture classification, searching for multiple occurrences of a sub-image or a figure in an image. In these applications, manual feature extraction-based machine-learning models are used and are not completely data-driven as in today's AI applications which is useful for creating a higher-performance, UI-based application. One advantage of applying deep learning algorithms is that it is more capable of modelling complex data than manual feature extraction resulting in much better performance, provided we have large amount of data and the designs that we are present in any historical structure are quite complex by their nature.

To demonstrate one effective application of deep learning-based AI system using the data collected in this research work, a methodology to train an AI which will be able to restore a possibly damaged design using its own understanding of the designs during Ahom time period is described. In the figure below, **Fig 7.11** (a) is the original motif and (b) is a damaged motif.



Fig. 7.11 (a) is the original motif and (b) is a damaged motif.

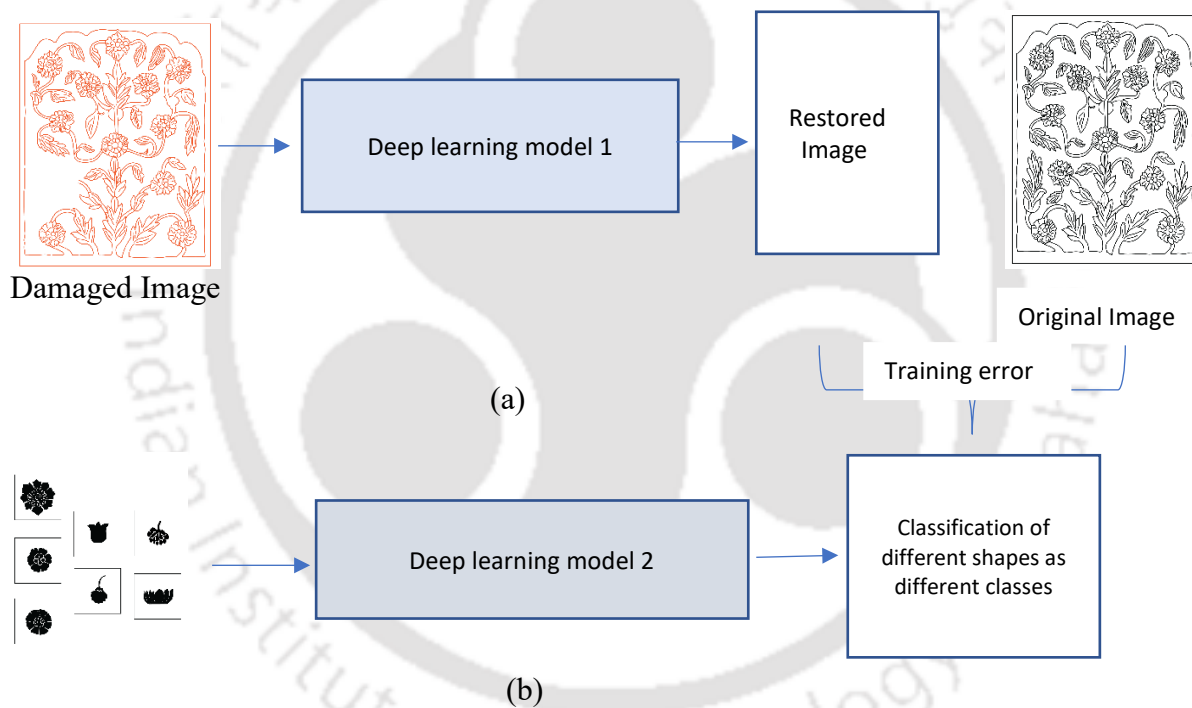


Fig. 7.12 Two-stage model to restore a damaged image

The AI system should be able to understand two aspects for such an application: the global design aspects and the local detail aspects. The global design aspects are the symmetries, detection of flowers, leaves, animals and any other elements etc. The local detail aspects are the details and patterns present in the flowers, leaves, animals etc. Therefore, there will be two deep-learning based models specific for each task. In the first stage, the model to understand global design aspects will be trained using data-pairs of original design and the corresponding damaged design as shown in Fig 7.12 (a). An original design can be deformed in many different

regions and ways to create different data-pairs from a single design itself. During a particular iteration of training, the input to the AI system will be the damaged design and output will be an estimated restored version of it. This restored version will be compared against the original design to calculate a training error. With more iterations and many such restored-original pair comparisons, the AI will try to minimize the training error and lower training errors will mean that the AI is able to understand the design aspects present in those images leading to better restoration of images.

In the second stage, the model to learn about the details present in different elements of the design, as shown in **Fig 7.12 (b)**. For this, a deep-learning based model will be trained to classify different patterns of an element, such as flowers, as different classes. A properly trained model will be able to classify different patterns as different classes, which will mean that the model is able to understand the different shapes and patterns in those flower types. The restored image that will be obtained from the first model may lack details in certain elements. Therefore, having another model that is trained to understand such patterns will help enhance the restored version for better visual appeal. As it is desired to obtain an AI which will be able to interact with common people, the design and training will certainly contain many stages (two for the provided methodology) and of high complexity to obtain better visual results and extensive experimentation will be required to obtain the optimal AI system. However, the development of such an AI system will not only be helpful for visual understanding of people but also other features can be included to develop a digital application for smart devices.

The data and insights gained from the research work will be helpful to develop different AI systems that will help in digital preservation and promotion of the heritage sites.

## List of Publications

### Book Chapters

- Deori, Saurav Khuttiya, & Barua, U. (2021). A Visual Analysis of Motifs and Patterns of Ghanasyam House Sivasagar, Assam, India. *Smart Innovation, Systems and Technologies*, 221, 579–591. [https://doi.org/10.1007/978-981-16-0041-8\\_48](https://doi.org/10.1007/978-981-16-0041-8_48)
- Deori, Saurav K., & Barua, U. (2021). Comparative visual analysis of brick architecture ornamentations of the Ahom monuments in Sivasagar, Assam, India. *Ergonomics for Design and Innovation*. <https://doi.org/10.1007/978-3-030-94277-9>

### Conference proceedings

- Deori, S., Sharma, S., Bora, D., & Barua, U. (2020). Architectural and Comparative Material Study of Brick and Mortar of Ahom monuments. *IVCSAMSEA2020: International Virtual Conference on Smart Advanced Material Science and Engineering Applications*.
- Deori, Saurav Khuttiya, Sharma, S., Bora, D., & Barua, U. (2021). Comparative material study of ancient bricks and mortars of Sivasagar and Charaideo area, Assam, India. *AIP Conference Proceedings*, 2358(1), 090017. <https://doi.org/10.1063/5.0059055>



## References

- Agarwal, V. S. (1965). *Studies in Indian Art* (1st ed.). Vishwavidyalaya Prakashan.
- Ahmed, K. (1994). *The Art and Architecture of Assam* (First). Spectrum Publications.
- ASI. (n.d.). *Archaeological Survey of India(ASI), Guwahati Circle, Assam*. Retrieved October 28, 2021, from <http://asiguwahaticircle.gov.in/publications.html>
- Athavankar, U. A. (1989). Categorization... Natural Language and Design. *Source: Design Issues*, 5(2), 100–111. <https://www.jstor.org/stable/1511517>
- Bakolas, A., Aggelakopoulou, E., & Moropoulou, A. (2008). Evaluation of pozzolanic activity and physico-mechanical characteristics in ceramic powder-lime pastes. *Journal of Thermal Analysis and Calorimetry 2008 92:1*, 92(1), 345–351. <https://doi.org/10.1007/S10973-007-8858-1>
- Barpujari, H. . (2007). *The Comprehensive History of Assam : Vol. III* (3rd ed.). Publication Board Assam.
- Barua, B. (1992). *Chang Rung Phukanar Buranji* (K. D. Hazarika (Ed.); First). Department of Assamese Dibrugarh University.
- Bhattacharya, S. (2016). Book Reviews : HITESRANJAN SANYAL, Social Mobility in Bengal, Calcutta, 1981, pp. x+145, Rs 50: <Http://Dx.Doi.Org/10.1177/001946468201900111>, 19(1), 97–99. <https://doi.org/10.1177/001946468201900111>
- BHID: *Bishnupur Heritage Image Database*. (n.d.). Retrieved November 3, 2021, from <https://www.isical.ac.in/~bsnpr/bishnupur.php>
- Böke, H., Akkurt, S., Ipekoğlu, B., & Uğurlu, E. (2006). Characteristics of brick used as aggregate in historic brick-lime mortars and plasters. *Cement and Concrete Research*, 36(6), 1115–1122. <https://doi.org/10.1016/J.CEMCONRES.2006.03.011>
- Bosham, A. . (2004). *The Wonder That Was India* (3rd Revised Edition).
- Brown, P. (2021). *Indian Architecture* (Vol. 1).
- Choudhury, R. D. (2013). *Art and Archaeology of The Brahmaputra Valley of Assam* (second). Spectrum Publications.
- Das, P. (2007). *History And Achaeology of North-East India* (First). Agam Kala Prakashan.
- Das, P. (2019). *Terracotta Sculptures of Assam* (First). Research India Press.
- Deori, S., Sharma, S., Bora, D., & Barua, U. (2020). Architectural and Comparative Material Study of Brick and Mortar of Ahom monuments . *IVCSAMSEA2020: International Virtual Conference on Smart Advanced Material Science and Engineering Applications*.

- Deori, Saurav K., & Barua, U. (2021). Comparative visual analysis of brick architecture ornamentations of the Ahom monuments in Sivasagar, Assam, India. *Ergonomics for Design and Innovation*. <https://doi.org/10.1007/978-3-030-94277-9>
- Deori, Saurav Khuttiya, & Barua, U. (2021). A Visual Analysis of Motifs and Patterns of Ghanasyam House Sivasagar, Assam, India. *Smart Innovation, Systems and Technologies*, 221, 579–591. [https://doi.org/10.1007/978-981-16-0041-8\\_48](https://doi.org/10.1007/978-981-16-0041-8_48)
- Deori, Saurav Khuttiya, Sharma, S., Bora, D., & Barua, U. (2021). Comparative material study of ancient bricks and mortars of Sivasagar and Charaideo area, Assam, India. *AIP Conference Proceedings*, 2358(1), 090017. <https://doi.org/10.1063/5.0059055>
- Dir. of archae. (n.d.). *Protected Archaeological Sites and Monuments* | Directorate of Archaeology | Government Of Assam, India. Retrieved October 28, 2021, from <https://archaeology.assam.gov.in/information-services/detail/list-of-protected-archaeological-sites-and-monuments>
- Ece, O. I., Nakagawa, Z.-E., & Schroeder, P. A. (2003). Alteration of Volcanic Rocks and Genesis of Kaolin Deposits in the Şile Region, Northern Istanbul, Turkey. I: Clay mineralogy. *Clays and Clay Minerals* 2003 51:6, 51(6), 675–688. <https://doi.org/10.1346/CCMN.2003.0510610>
- FB, R., JV, A., & MC, M. M. (2002). FTIR quantitative analysis of calcium carbonate (calcite) and silica (quartz) mixtures using the constant ratio method. Application to geological samples. *Talanta*, 58(4), 811–821. [https://doi.org/10.1016/S0039-9140\(02\)00372-7](https://doi.org/10.1016/S0039-9140(02)00372-7)
- FPJ Bureau. (2019, May 31). *Standing tall in earthquakes*. <https://www.freepressjournal.in/weekend/standing-tall-in-earthquakes>
- Gait, E. (1926). *History of Assam* (Second). Thacker, Spink & Co.
- Gogoi, L. (n.d.). *Buranjiye Parasha Nagar*.
- Goldberg, M. (n.d.). *partition of Bengal* | Indian history | Britannica. Retrieved October 27, 2021, from <https://www.britannica.com/event/Partition-of-Bengal>
- Guha, S., & Bandyopadhyay, A. (2017). Terracotta Temples of Bengal: A Culmination of Pre-existing Architectural Styles. <https://dx.doi.org/10.21659/Cjad.V1n1.V1n105>, 1(1). doi: <https://dx.doi.org/10.21659/cjad.v1n1.v1n10>
- Gupta, R. . (1982). *Art of Mediaeval Assam* (First). Cosmo Publications.
- Gupta, S., & Panda, S. (2011). *Centrally Protected Monuments of North-East India*.
- Hann, M. (2013). *Symbol, Pattern & Symmetry* (1st ed.). Bloomsbury.
- Kamath, U., Liu, J., & Whitaker, J. (2019). Deep Learning for NLP and Speech Recognition.

- Deep Learning for NLP and Speech Recognition*. <https://doi.org/10.1007/978-3-030-14596-5>
- Lateef, F., & Ruichek, Y. (2019). Survey on semantic segmentation using deep learning techniques. *Neurocomputing*, 338, 321–348.  
<https://doi.org/10.1016/J.NEUCOM.2019.02.003>
- Mangaonkar, P. (2012). Temples of Bengal: Material Style and Technological Evolution. *Chitrolekha International Magazine on Art and Design*, 2(1).  
[www.chitrolekha.com/v2n1.php](http://www.chitrolekha.com/v2n1.php) Available at [www.chitrolekha.com/V2/n1/01\\_Temples\\_Bengal\\_Style\\_Technology.pdf](http://www.chitrolekha.com/V2/n1/01_Temples_Bengal_Style_Technology.pdf)
- McNamara, D. R. (2009). *Catholic Church Architecture and the Spirit of the Liturgy* (first). Hillenbrand Books.
- Md Rian, I., Park, J. H., Uk Ahn, H., & Chang, D. (2007). Fractal geometry as the synthesis of Hindu cosmology in Kandariya Mahadev temple, Khajuraho. *Building and Environment*, 42(12), 4093–4107. <https://doi.org/10.1016/j.buildenv.2007.01.028>
- Meggs, P. B., & Purvis, A. W. (2012). *History of Graphic*.
- Michell, G. (1988). *The Hindu temple*. University of Chicago Press.
- Monga, C. (2019). *Identification of Design Elements in Naamghar of Assam*. Indian Institution of Technology Guwahati.
- Moropoulou, A., Cakmak, A. S., Biscontin, G., Bakolas, A., & Zendri, E. (2002). Advanced Byzantine cement based composites resisting earthquake stresses: the crushed brick/lime mortars of Justinian's Hagia Sophia. *Construction and Building Materials*, 16(8).  
<https://www.infona.pl/resource/bwmeta1.element.elsevier-08c7edd1-ae10-343f-9bd6-5be861940504>
- Oguz, C., Turker, F., & Kockal, N. U. (2014). Construction materials used in the historical roman era bath in Myra. *Scientific World Journal*, 2014.  
<https://doi.org/10.1155/2014/536105>
- Pankaj, S., Tamta, P., Bueno, L., Machado, J. S., Oлару, M., Bodi, G., Singh, P., & Sharma, S. (n.d.). *Exploring the Bamuni Hill Remains: An Archaeometric Study of Pottery Multi-analytical characterization of Cucuteni pottery* *Exploring the Bamuni Hill Remains: An Archaeometric Study of Pottery*.
- Pauling, L. (1954). International Tables for X-ray Crystallography. Volume I. Symmetry Groups edited by N. F. M. Henry and K. Lonsdale. *Acta Crystallographica*, 7(3), 304–304. <https://doi.org/10.1107/S0365110X54000874>
- Ray, M. (2012). Representation in Monument Building and Schematic of Terracotta

- Narratives: Delving into Some Aspects of Gopinath Jor-Bangla Temple, Pabna, Bangladesh. *Chitrolekha International Magazine on Art and Design*, 2(1).  
[www.chitrolekha.com/v2n1.php](http://www.chitrolekha.com/v2n1.php)
- Rosch, E. (1978). Principles of Categorization. *Readings in Cognitive Science: A Perspective from Psychology and Artificial Intelligence*, 312–322. <https://doi.org/10.1016/B978-1-4832-1446-7.50028-5>
- Saikia, M., & Das, P. (2021). Kīrtimukha in the Art of the Kapili-Jamuna Valley of Assam: An Artistic Survey. *Ancient Asia*, 12(0), 1–15. <https://doi.org/10.5334/AA.211>
- Sarma, P. C. (1988). *Architecture of Assam* (First). Agam Kala Prakasn.
- Sharma, A., & Zaman, F. (2019). Senhri Journal of Multidisciplinary Studies THE GREAT ASSAM EARTHQUAKE OF 1950: A HISTORICAL REVIEW. *Senhri Journal of Multidisciplinary Studies*, 4(1), 1–10. <https://doi.org/10.36110/sjms.2019.04.01.001>
- Trivedi, K. (1993). Hindu Temple: Models of a Fractal Universe. *International Seminar on Mayonic Science and Technology*, 243–258.
- Venkatachalapathy, R., Sridharan, T., Dhanapandian, S., & Manoharan, C. (2006). DETERMINATION OF FIRING TEMPERATURE OF ANCIENT POTTERIES BY MEANS OF INFRARED AND MOSSBAUER STUDIES. <Http://Dx.Doi.Org/10.1081/SL-120016279>, 35(6), 769–779. <https://doi.org/10.1081/SL-120016279>
- Verma, S. . (2014). *Ornamentation in Indian Architecture* (First). Aryan Books International .
- Washburn, D. K., & Crowe, D. W. (1988). *Symmetries of Culture* (First). University of Washington Press.
- Wong, W. (1993). *Principles of Form and Design* (First). John Wiley & Sons, Inc.
- Zhang, X., & LeCun, Y. (2015). *Text Understanding from Scratch*.  
<https://arxiv.org/abs/1502.01710v5>
- Zhao, Z.-Q., Zheng, P., Xu, S., & Wu, X. (2018). Object Detection with Deep Learning: A Review. *IEEE Transactions on Neural Networks and Learning Systems*, 30(11), 3212–3232. <https://arxiv.org/abs/1807.05511v2>

## Appendix A

Photographs of the selected monuments, to study the architecture type and trace the ornaments.



Appx A Fig. 1. 1 Ghanasyam House, Sivasagar- Photographs of various sections of the monuments



Appx A Fig. 1. 2 Namath Kali Temple, Guwahati- Photographs of various sections of the monuments



Appx A Fig. 1. 3 Rang Ghar, Sivasagar- Photographs of various sections of the monuments



Appx A Fig. 1. 4 Talatal Ghar, Sivsagar- Photographs of various sections of the monuments



Appx A Fig. 1. 5 Talatal Ghar, Sivisagar- Photographs of various sections of the monuments

## Appendix B

### Photographs of field visits and data collection



Appx B Fig. 1. 1 Observation of fragmented ornamentation



Appx B Fig. 1. 2 Observation of early brick with the custom brick sizes



Appx B Fig. 1. 3 Semi-structured interview with Senior Conservation Assistant (ASI).

## Appendix C

### Questionnaire (Semi-structured interview)

Senior Conservation Assistant, ASI, Sivasagar Circle.

- What is your role in Archaeological survey of India, Assam? How many centrally protected monuments are there in Assam?
- Is there any ongoing renovation projects? What are the projects about?
- What is the primary consideration for renovations?
- What are the material consideration for renovation?
- How do you renovate the ornaments of the monuments?
- Do ASI train workers for renovation?

### Major Interview findings

- Worked under two renovation projects under Sivasagar Circle.
- Renovation of **Rang Ghar, Talatal Ghar and Kareng Ghar** - on Progress. (under his supervision)
- Renovation process on the damage area are tried to replicate by observing and studying the form visually.
- Construction of the heritage sites are done using binder & filler. They also include organic substance in the composition. They use latex polymer for plastering sometimes.
- The materials used in renovations includes bricks, unslaked lime, brick surkhi, brick aggregate. And organic materials includes molasses, Indian bael gum, *methi* (fenugreek seeds), *hilikha* (Terminalia Chebula), *katha* (Catechu), black lentils. The material they use for renovations includes custom size bricks replicating the early bricks.


### Limitations

- There are no expert craftsman for the renovation of the heritage sites in Assam, hence they hire experts from West Bengal for the construction and renovation. The experts works under his supervision.
- There are limitation on the structure of the bricks as the brick-yards has difficulty to manufacture the same replica of the ancient bricks.





















## Appendix D



















Variations of coded motifs and patterns with linear extractions with quantity.

**Appx. Table 1. 1 Variations of Floral Motifs – Ghanasyam House**


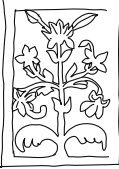

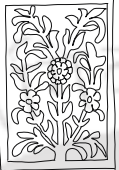


Code	Image	Linear Extraction	Quantity
<i>Gha-M-En-F-01</i>			4
<i>Gha-M-Wa-F-02</i>			3
<i>Gha-M-Wa-F-03</i>		 Reconstructed	3
<i>Gha-M-Wa-F-04</i>			5
<i>Gha-M-Ro-F-05</i>			160
<i>Gha-M-Ro-F-06</i>			5
<i>Gha-M-Wa-F-07</i>			1

**Appx. Table 1. 2 Variations of Animal Motifs – Ghanasyam House**

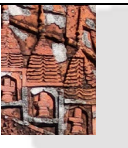

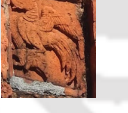



Code	Image	Linear Extraction	Quantity
<i>Gha-M-En-A-01</i>			4
<i>Gha-M-Wa-A-02</i>			2
<i>Gha-M-Wa-A-03</i>			1
<i>Gha-M-En-A-04</i>			6
<i>Gha-M-En-A-05</i>			13
<i>Gha-M-Wa-A-06</i>			1
<i>Gha-M-Wa-A-07</i>			1
<i>Gha-M-Wa-A-08</i>			1
<i>Gha-M-Wa-A-09</i>			1
<i>Gha-M-Wa-A-10</i>			1

<i>Gha-M-Wa-A-11</i>			1
<i>Gha-M-Wa-A-12</i>			1
<i>Gha-M-Wa-A-13</i>			1
<i>Gha-M-Wa-A-14</i>			1
<i>Gha-M-En-A-15</i>			1
<i>Gha-M-En-A-16</i>			1
<i>Gha-M-Wa-A-17</i>			1
<i>Gha-M-Wa-A-18</i>			1
<i>Gha-M-Wa-A-19</i>			1


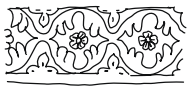
**Appx. Table 1. 3 Variations of Compound Motifs – Ghanasyam House**








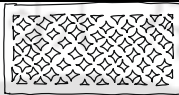




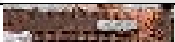



Code	Image	Linear Extraction	Quantity
<i>Gha-M-Wa-C-01</i>			1
<i>Gha-M-Wa-C-02</i>			1
<i>Gha-M-Wa-C-03</i>			7







**Appx. Table 1. 4 Variations of Symbolic Motifs – Ghanasyam House**

Code	Image	Linear Extraction	Quantity
<i>Gha-M-En-S-01</i>			15
<i>Gha-M-Wa-S-02</i>			1
<i>Gha-M-Wa-S-03</i>			1


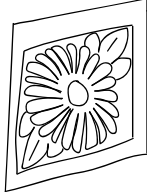

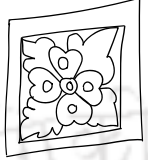

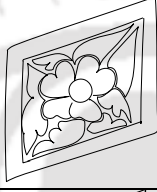

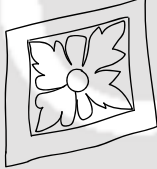
**Appx. Table 1. 5 Variations of Patterns – Ghanasyam House**

Code (Exterior Section)	Image	Linear Extraction	Quantity
<i>Gha-P-Wa-O-01</i>			56 (F) + 25(ls)+ 27(rs)









			+34(b)+ = 142
<i>Gha-P-Wa-O-02</i>			52
<i>Gha-P-Wa-O-03</i>			250 and above
<i>Gha-P-Wa-0-04</i>			1
<i>Gha-P-Pi-G-01</i>			48
<i>Gha-P-Wa-G-02</i>			80
<i>Gha-P-Wa-G-03</i>			50
<i>Gha-P-Wa-G-04</i>			34
<i>Gha-P-Wa-G-05</i>			52

Code (Interior)	Image	Linear Extraction	Quantity
<i>Gha-P-En-O-01</i>			18
<i>Gha-P-En-O-02</i>			43
<i>Gha-P-En-G-01</i>			28



**Appx. Table 1. 6 Variations of Floral Motifs – Namath Kali**

Code	Image	Linear extraction	Quantity
<i>Nam-M-En-F-01</i>			1
<i>Nam-M-En-F-02</i>			1
<i>Nam-M-En-F-03</i>			1
<i>Nam-M-En-F-04</i>			2





**Appx. Table 1. 7 Variations of Animal Motifs – Namath Kali**



Code	Image	Linear extraction	Quantity
<i>Nam-M-En-A-01</i>			1
<i>Nam-M-En-A-02</i>			1
<i>Nam-M-En-A-03</i>			1
<i>Nam-M-En-A-04</i>			1

**Appx. Table 1. 8 Variations of Symbolic Motifs – Namath Kali**

Code	Image	Linear extraction	Quantity
<i>Nam-M-En-S-01</i>			1


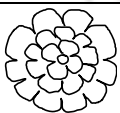

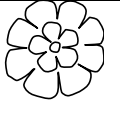


**Appx. Table 1. 9 Variations of Patterns – Namath Kali**

Code	Image	Linear extraction	Quantity
<i>Nam-P-En-O-01</i>			5
<i>Nam-P-En-O-02</i>			12


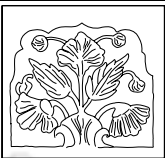


















Code	Image	Linear extraction	Quantity
<i>Nam-P-En-G-01</i>			7




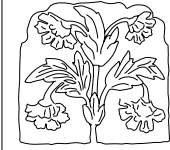



















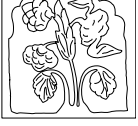
**Stucco ornamentation**



















**Appx. Table 1. 10 Variations of Floral Motifs – Rang Ghar**





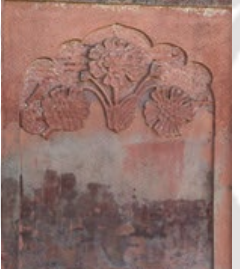








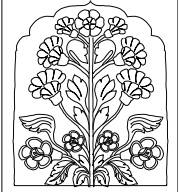


Code	Image	Linear extraction	Quantity
<i>Ran-M-Wa-F-01</i>			3
<i>Ran-M-Wa-F-02</i>			222
<i>Ran-M-Wa-F-03</i>			9





**Appx. Table 1. 11 Variations of Compound Motifs – Rang Ghar**

Code	Image	Linear extraction	Quantity
<i>Ran-M-Wa-C-01</i>			1
<i>Ran-M-Wa-C-02</i>			1
<i>Ran-M-Wa-C-03</i>			1
<i>Ran-M-Wa-C-04</i>			1
<i>Ran-M-Wa-C-05</i>			1
<i>Ran-M-Wa-C-06</i>			1
<i>Ran-M-Wa-C-07</i>			1
<i>Ran-M-Wa-C-08</i>			1
<i>Ran-M-Wa-C-09</i>			1
<i>Ran-M-Wa-C-10</i>			1





<i>Ran-M-Wa-C-11</i>			1
<i>Ran-M-Wa-C-12</i>			1
<i>Ran-M-Wa-C-13</i>			1
<i>Ran-M-Wa-C-14</i>			1
<i>Ran-M-Wa-C-15</i>			1
<i>Ran-M-Wa-C-16</i>			1
<i>Ran-M-Wa-C-17</i>			1
<i>Ran-M-Wa-C-18</i>			1
<i>Ran-M-Wa-C-19</i>			1
<i>Ran-M-Wa-C-20</i>			1
<i>Ran-M-Wa-C-21</i>			1
<i>Ran-M-Wa-C-22</i>			1

<i>Ran-M-Wa-C-23</i>			1
<i>Ran-M-Wa-C-24</i>			1
<i>Ran-M-Wa-C-25</i>			1
<i>Ran-M-Wa-C-26</i>			1
<i>Ran-M-Wa-C-27</i>			1
<i>Ran-M-Wa-C-28</i>			1
<i>Ran-M-Wa-C-29</i>			1
<i>Ran-M-Wa-C-30</i>			1
<i>Ran-M-Wa-C-31</i>			1

Ran-M-Wa-C-32			1
Ran-M-Wa-C-33			1
Ran-M-Wa-C-34			1
Ran-M-Wa-C-35			1
Ran-M-Wa-C-36			1
Ran-M-Wa-C-37			1
Ran-M-Wa-C-38			1
Ran-M-Wa-C-39			1







<i>Ran-M-Wa-C-40</i>			1
<i>Ran-M-Wa-C-41</i>			1









**Appx. Table 1. 12 Variations of Symbolic Motifs – Rang Ghar**

Code	Image	Linear extraction	Quantity
<i>Ran-M-En-S-01</i>			4
<i>Ran-M-En-S-02</i>			2



**Appx. Table 1. 13 Variations of Patterns – Rang Ghar**

Organic Patterns


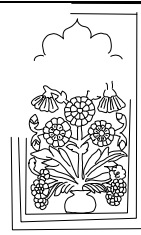
Code	Image	Linear extraction	Quantity
<i>Ran-P-Wa-O-01</i>			1
<i>Ran-P-Wa-O-02</i>			1
<i>Ran-P-Wa-O-03</i>			1

<i>Ran-P-Wa-O-04</i>			1
<i>Ran-P-Wa-O-05</i>			1
<i>Ran-P-Wa-O-06</i>			1
<i>Ran-P-Wa-O-07</i>			1

**Appx. Table 1. 14 Variations of Floral Motifs – Talata Ghar**







Code	Image	Linear extraction	Quantity
<i>Tal-M-En-F-01</i>			3

**Appx. Table 1. 15 Variations of Compound Motifs – Talatal Ghar**







Code	Image	Linear extraction	Quantity
<i>Tal-M-Wa-C-01</i>			1





<i>Tal-M-Wa-C-02</i>			1
----------------------	---	---	---

**Appx. Table 1. 16 Variations of Animal Motifs – Talatal Ghar**

Code	Image	Linear extraction	Quantity
<i>Tal-M-Wa-A-01</i>			1
<i>Tal-M-Wa-A-02</i>			1
<i>Tal-M-Wa-A-03</i>			1





**Appx. Table 1. 17 Variations of Organic patterns – Talatal Ghar**

Code	Image	Linear extraction	Quantity
<i>Tal-P-Wa-O-01</i>			1
<i>Tal-P-Wa-O-02</i>			1
<i>Tal-P-Wa-O-03</i>			1


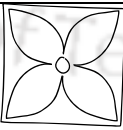

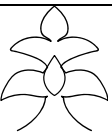
<i>Tal-P-Wa-O-04</i>			1
<i>Tal-P-Wa-O-05</i>			1
<i>Tal-P-Wa-O-06</i>			1
<i>Tal-P-Wa-O-07</i>			1
<i>Tal-P-Wa-O-08</i>			1
<i>Tal-P-Wa-O-09</i>			1
<i>Tal-P-En-O-10</i>			1
<i>Tal-P-En-O-11</i>			1
<i>Tal-P-En-O-12</i>			1
<i>Tal-P-En-O-13</i>			1
<i>Tal-P-En-O-14</i>			1

<i>Tal-P-En-O-15</i>			1
<i>Tal-P-En-O-16</i>			1
<i>Tal-P-Pi-O-17</i>			1


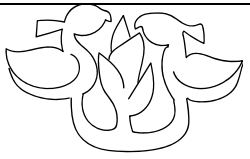
**Appx. Table 1. 18 Variations of Geometric patterns – Talatal Ghar**

Code	Image	Linear extraction	Quantity
<i>Tal-P-En-G-01</i>			1
<i>Tal-P-En-G-01</i>			1

**Appx. Table 1. 19 Variations of Floral Motifs – Kareng Ghar**



Code	Image	Linear extraction	Quantity
<i>Kar-M-Pi-F-01</i>			3
<i>Kar-M-En-F-02</i>			1

**Appx. Table 1. 20 Variation of Animal Motifs – Kareng Ghar**







Code	Image	Linear extraction	Quantity
<i>Kar-M-Pi-A-01</i>			1

**Appx. Table 1. 21 Variations of Organic patterns– Kareng Ghar**

Code	Image	Linear extraction	Quantity
<i>Kar-P-Pi-O-01</i>			2
<i>Kar-P-Pi-O-02</i>			2
<i>Kar-P-Pi-O-03</i>			2
<i>Kar-P-Pi-O-04</i>			1
<i>Kar-P-Wa-O-05</i>			1
<i>Kar-P-Wa-O-06</i>			1
<i>Kar-P-Wa-O-07</i>			2
<i>Kar-P-Wa-O-08</i>			1

<i>Kar-P-Wa-O-09</i>			1
----------------------	---	--	---

**Appx. Table 1. 22 Variations of Geometric Patterns – Kareng Ghar**

Code	Image	Linear extraction	Quantity
<i>Kar-P-Wa-G-01</i>			1
<i>Kar-P-Pi-G-02</i>			1
<i>Kar-P-Pi-G-03</i>			1

