SHAPE AND GEOMETRY OF ORISSAN TEMPLE ARCHITECTURE

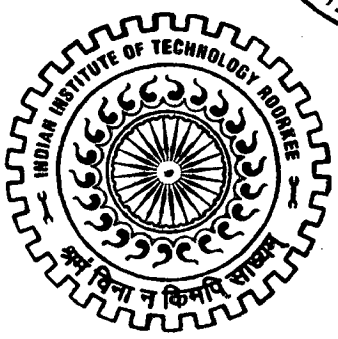
A DISSERTATION

Submitted in partial fulfillment of the requirements for the award of the degree of

MASTER OF ARCHITECTURE

By

PARTHA SARATHI MISHRA



DEPARTMENT OF ARCHITECTURE AND PLANNING
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CERTIFICATE

Certified that the report entitled **"Shape and Geometry of Orissan Temple Architecture"**, which has been submitted by **Mr. Partha Sarathi Mishra**, for partial fulfillment of the requirement for the award of the degree of **Master of Architecture**, submitted in the Department of Architecture and Planning, Indian Institute of Technology- Roorkee, is his own work done by him under my supervision and guidance. The matter embodied in this dissertation has not been submitted by him for the award of any other degree of this or any other institute.

Date: 07.06.2012
Place: Roorkee

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CANDIDATE'S DECLARATION

I hereby certify that this report entitled **"Shape and Geometry of Orissan Temple Architecture"**, which has been submitted in partial fulfillment of the requirement for the award of the degree of **Master of Architecture**, submitted in the Department of Architecture and Planning, Indian Institute of Technology- Roorkee, is an authentic record of my own work carried out during the period from July 2011 to June 2012, under the supervision and guidance of **DR. GAURAV RAHEJA,** Department of Architecture and Planning, Indian Institute of Technology, Roorkee, India.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree of this or any other institute.

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This is to certify that the above statement made by the candidate is correct to the best of my knowledge.

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(Partha Sarathi Mishra)

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ABBREVIATIONS

BBH	Bhogamandapa Bada Height
BGH	Bhogamandapa Gandi Height
BH	Bhogamandapa Height
BIA	Bhogamandapa Inner Area
BMH	Bhogamandapa Mastaka Height
BOA	Bhogamandapa Outer Area
BPH	Bhogamandapa Pitha Height
BPL	Bhogamandapa Plan Length
JBH	Jagamohana Bada Height
JGH	Jagamohana Gandi Height
JH	Jagamohana Height
JIA	Jagamohana Inner Area
JMH	Jagamohana Mastaka Height
JOA	Jagamohana Outer Area
JPDL	Jagamohana Plan Diagonal Length
JPH	Jagamohana Pitha Height
JPL	Jagamohana Plan Length
NBH	Natyamandapa Bada Height
NGH	Natyamandapa Gandi Height
NH	Natyamandapa Height
NIA	Natyamandapa Inner Area
NMH	Natyamandapa Mastaka Height
NOA	Natyamandapa Outer Area
NPDL	Natyamandapa Plan Diagonal Length
NPH	Natyamandapa Pitha Height
NPL	Natyamandapa Plan Length
OTA	Orissan Temple Architecture
RDBH	Rekha Deul Bada Height
RDGH	Rekha Deul Gandi Height
RDH	Rekha Deul Height
RDIA	Rekha Deul Inner Area
RDMH	Rekha Deul Mastaka Height
RDOA	Rekha Deul Outer Area
RDPDL	Rekha Deul Plan Diagonal Length
RDPH	Rekha Deul Pitha Height
RDPL	Rekha Deul Plan Length
TLT	Total Length of Temple
TWT	Total Width of Temple

EXECUTIVE SUMMARY

Introduction to the Topic

This dissertation focuses on the study of the Orissan Hindu Temple. There has been done a lot of research in Orissan Hindu Temple Architecture. Still many aspects of this subject are unexplored. This study has attempted to collect all the research that has been taking on in this field, and possibly contribute to the current knowledge through a shape and geometrical analysis of Orissan Hindu Temple architecture.

However the Indian temples are not only the abode of God and place of worship, but temples are also the cradle of knowledge, art, architecture and culture. The practices and traditions of temples exist not only in history but also in present time which greatly influence the sociocultural life of its people and gives continuity to traditional Indian values. However, unlike the western architecture, the evolution of Indian temple architecture is marked by a strict adherence to the original ancient models that were derived from religious consideration- and that continued over many centuries with the use of the basic proportion and rigid forms of the early temples.

Especially in Orissa, the temple architecture as also known as Kalingan Style or Orissan style of temple architecture. As these Orissan temples are considered as north indian style or the Nagara style but they have some unique features that separate from northern style. There built structures are considered as the devotional typr of architecture throughout the Orissa.

Hence this dissertation aims to present a dimensional study of Orissan temples taken from different time periods and their comparison with other Orissan styles of temples respectively for the various assessments of the temples.

To fulfill the main aim of this dissertation some objective has been employed as they are

1. To study the various phases of evolution of Orissan Temple Architecture.
2. To study the elements of Orissan Temple Architecture.
3. To conduct field/ visual Surveys to document the temple forms.
4. To analyses the Orissan Temple Architecture forms to identify its evolutionary process by conducting
    - Dimensional relationship between elements
    - With relation to vastu purusha mandala
    - Fractal geometry analysis
    - Visual analysis

The scope and Study of this dissertation is limited to shape and geometrical aspects of Orissan Temple Architecture.

For the entire thesis a methodology has been adopted which describe the entire thesis procedure and compilation. Form the very beginning it has been collected the literature from different sources which describe the geometrical aspects of temples and their inter-relationship. Various sources like Mansara, Mayamata & Orissan temple there are many treatise as Bhusan Pradipa, silpa Ratnakar, Vastu Sastra Upanishad, Silpa Sarini, Silpa Prakash, Padma Kesari, Deul Mapagunagara, Bhusana Prakash, Soudhkagama etc. and also some eminent temples books of Percy Brown and Stella Karmisch and many journals like Orissa Review etc. helped a lot for such kind of thesis. A visual and dimensional survey has been conducted and collected some drawing from archaeological survey of India Orissa chapter for the various analysis assessments. Analysis including dimensional analysis, relation with vastu purusha mandala, and some visual analysis has done as a part of methodology. After analysis major findings and scope for further research has included in the final report compilation.

Literature Study

The main elements of the typical Orissan temple are Rekha Deul, Jagamohana, the Natyamandapa and the Bhogamandapa which further divided into sub-parts that explains its shape and geometry.

The transformation of the Orissan Temple can be described through time periods like Formative Phase, Transitional Phase, Mature Phase and the Phase of Decadence. Different phases explained how the elements of Orissan temples have changed with respect to time.

The typical shape and geometry of Orissan temple architecture can be explained by temple forms, fractals geometry behind the temple elements, symbolism of basic geometrical forms and the cosmology behind the temple form and its elements.

Case Studies

All the temples have some geometrical rules and proportion. Since none of the Orissan temple has been analysed on the basis of shape and geometrical parameter hence, following temples has been studied from different styles of temple architecture.

In study of Chika Mahakut, it has been found that the elements of this temple are well arranged with the basis fundamental shapes like squares and its derivation of geometry and having inter-relation to each other with a certain proportion in different parts in plan form which inspire to study further on Orissan temple shape and geometry.

After study the simple geometry in the Chika Mahakut, the complex geometrical relationship has been studied in the Durga Temple Aihole. In this temple many complex derivation of squares to triangle and circles forms temples in different proportion has been found and its relationship with the different plan forms of the temple When there is no such

measured drawing available for analysis of temple form, then other methods are adopted. In Kandariya Mahadev temple, Khajuraho, Kiri Trivedi has tried to explain the geometry through box counting method and temple derivation from fractal geometry.

From the case study it has been found that, there are various methods to analyse the shape and geometry of temple architecture. So, author has tried to analyse the shape and geometry of Orissan temples through dimensional analysis, with vastu purusha Mandala and fractal geometry.

Research Design

After case study a research design forms which includes, the sampling procedure, design of survey schedule, primary and secondary data. The collection of data's through primary and secondary sources has been collected, finalised and the architectural characteristics has been inferred.

Selection of temple from a number of temples has been simplified by the arranging them through their date of construction. As from the literature it has been finalised that Orissan temple have distinguished four different phases and according to them elements of temples varies from time to time. There is another process has been conducted as the temples were built from different regions and have some different quality of appearance. When plotted the temples location on the physical map available it has been found that the major temples of Formative phase are found on the central Orissa, the Transition Phase in coastal Orissa region, the Mature Phase in southern and northern Orissa and the phase of decadence temples in eastern costal and western Orissa. That means present Orissa have all parts rich of Orissan temple architecture form and culture. It has been observed that many temple complexes have mixed phases due to time of construction from different kingdom to different.

Hence the selection of sample that has been collected in different phases are as three in number in formative phase, three in transition phase, two in mature phase and four from the phase of decadence, the uninformative of the analysis.

Shape and Geometrical Analysis

This dissertation covers mainly analysis of three kinds as they are

1. Analysis based on dimensional study
2. Analysis with vastu purusha mandala
3. Fractal geometrical analysis
4. Visual analysis

In the analysis based on dimensional analysis, it has been analyzed the different elements with respect to time period. They are like plan area ratio of the temples, means the total built-up area vs. Total wall area of the temple, temple height Vs. phases of Orissan

temple architecture and slenderness ratio vs. the phases of Orissan temple. All these three analyses explain the structural behavior of the temples which stand for centuries. Different analysis like the relationship between the areas and lengths of different halls explains the mass and proportion of the overall temple forms. Different analysis of elemental heights of different halls explains the proportion of the temples in its own parts with other parts of the halls.

All temples are generated from the vastu purusha mandala. This vastu purusha mandala are generally generated from the *Janampatri* (future forecast) of temples owner. According to that main deity size has been decided. And that is considered as 1 X 1 grid size among the 9 X 9 grid of vastu purusha mandala. When the dimensions of the temple have known, it is easy to find the location of each element of temples that were calculated at the time of temple construction. In particularly, this analysis has done to identify and relate with temple forms that were generated from vastu purusha mandala.

It is known that temples are generated from the fractal forms which are nature of fractalization, self-similar and repetition, super imposition & juxtaposition. Hence in the fractal geometrical analysis it has been tried to find out the different nature of fractal geometry lies in the temple forms. A visual survey and analysis has done to identify the nature, character and typical elements of Orissan temple form and geometry.

Major Findings

The finding of this dissertation on the basis of the above studies undertaken is that, the massive nature the stability of the temple structure depends mainly on the geometrical compatibility, with the elements with respect to the dimensions that varies from different phases of Orissan temple architecture. A dimensional analysis therefore constitutes an important step in shape and geometrical assessment of this kind of temple structures. The typical plan of a Hindu temple is an illustration of sacred geometry where the temple is representation of the mandala. The mandala is the sacred form consisting of the intersection of the circle and the square. In the Orissan Hindu architecture, temples were based on the geometry of the Vastu purusha mandala. Fractal elements are present in the temple forms and are directly or indirectly related to the vastu purusha mandala because of the astronomical movements and planetary positions.

Scope for Future Studies

The Hindu temples of India have been a subject of study for numerous historians, religious scholars, art historians, photo-journalists, archaeologists, architects and other professionals. There is scope for much study on Orissa as well as other Indian Hindu temples in different regions of India not just based on the iconography, form and transformation but

more on their building technology and structural analysis through shape and geometrical study on dimensional consideration. Some studies have been undertaken, For example it is known that numerous temples have fallen due to different calamities from time to time, yet there are even today examples of temple which haven't fallen either due to earthquake or cyclone or other natural calamity as because these temple were constructed in the form of an interlocking system as per laid out in the ancient manuals. Therefore these structures tend to vibrates along with the earth's vibrations, and will sway but not fall under any circumstances during earthquakes or cyclones. Therefore there is scope for further understanding of the structural aspects through understanding of shape grammar of Hindu temple

Conclusion

This dissertation is a research into the foundation of the Orissan Hindu temples and the development of temple architecture in Orissa. The distinctive architectural styles of Hindu temples have so developed due to its extended climatic, cultural, geographical, racial, historical and linguistic differences which are especially significant in the evolution of Orissan Hindu temple architecture i.e. form formative phase to phase decadence through Transitional phase and Mature Phase. The study of shape and geometry of Orissan temple tries to emphasis the hidden evolutionary process of temple build form by different analytical approach. The inter relationship of elements and their geometry are somehow interrelated with the planetary motion, vastu purusha mandala which gives birth to fractal elements and visually pleasing.

CHAPTER - 1

INTRODUCTION TO THE RESEARCH

1.1 Introduction

This dissertation focuses on the study of the Orissan Hindu Temple. There has been a lot of research into Orissan Hindu Temple Architecture. Still many aspects of this subject are unexplored. This study has attempted to collect all the research that has been taking on in this field, and possibly contribute to the current knowledge through a shape and geometrical analysis of Orissan Hindu Temple architecture.

This dissertation presents the philosophical and practical aspects that direct the shape and geometry of an Orissan Hindu temple building with the aim to understand how it influenced the form of the Orissan Hindu temple in its evolutionary process. The various periods of temple construction and its elements that have been employed in temple construction since ancient times has been studied not only through archival research but also through a comparative study of these important aspects and their relevance in modern day Orissan Hindu temple construction.

A study of history of architecture shows that the meaning of architecture and its relation to human experiences have been expressed in number of ways in the past. The intellectual and creative development of man manifested itself in the varied nature of architecture in different ages and across different civilizations. Thus, all over the world, various civilizations and cultures have contributed greatly to the art of building construction and which have been revealed in substantial form.

Every style of building construction reflects a clearly distinctive basic principle that represents a particular culture and era. For example, the strict and formulaic building design in Greek architecture exhibits a sophisticated suitability, whereas the Roman building design which are impressive even by modern standards, were based on their advanced technology (Brown, 1942). Similarly, a uniquely zealous French Gothic signifies a passionate culture and the Italian Renaissance reflects the artistic scholarship of its time. In the same way, the typical quality of early Indian architecture lies in the expression of spiritual contents through its temple architecture.

In India the temples are found everywhere varying from small villages to the metropolitan cities. The word 'temple' is derived from the Latin word templum means a sacred precinct. According to the definition, temple is a construction or builds form kept for religious or spiritual activities, like sacrifice and prayer or analogous rites. Traditionally,

temple is a sacred structure and also an indicative of abode of god or gods. However the Indian temples are not only the abode of God and place of worship, but temples are also the cradle of knowledge, art, architecture and culture. The practices and traditions of temples exist not only in history but also in present time which greatly influence the sociocultural life of its people and gives continuity to traditional Indian values. However, unlike the western architecture, the evolution of Indian temple architecture is marked by a strict adherence to the original ancient models that were derived from religious consideration- and that continued over many centuries with the use of the basic proportion and rigid forms of the early temples.

One of the most significant highlights of Indian architecture has been the evolution of the Hindu temple architecture. The Hindu temple architecture is distinguishable from the Jain and Buddhist temple architecture. Jain temples are seldom simple; the most elaborate of them a result from multiplication of the basic forms. The main difference between the Jain and Hindu temple is the lighter and more elegant character of the former. Buddhist shrines differed from those of the Hindus and Jains in two principal respects: these temples have been designed for congregational as well as devotional use by the monks and in their design decorative detail was used to emphasise rather than conceal the structure. By comparison to Buddhist and Jain structures, Brahmanical and Hindu buildings conformed to a rigidly prescribed plan form leading to a single focal point in the temple group.

1.2 Identification of the problem

In this present investigation, an attempt has been made to understand the architectural elements, how they ate relate to each other dimensionally through shape and geometry study.

The views of the Hindu philosophy say cosmos to be homogeneous and self-similar. And their relation with temple forms is a key feature to do this kind of dissertation.

Conferring to earliest architectural custom, Hindu temples are symbols of replicas of cosmos and their methods represent the cosmos characteristically. These may be viewed as three dimensional fractal models and that the use of fractal geometry produces has a symbolic sense in the regeneration of the form of Orissan Hindu temple.

1.3 Aim

This dissertation aims to present a dimensional study of Orissan temples taken from different time periods and their comparison with each other for the various assessments of the temples.

1.4 Objectives

5. To study the phases of evolution of Orissan Temple Architecture.
6. To study the various elements of Orissan Temple Architecture.
7. To conduct field/ visual Surveys to document the temple forms.
8. To analyses the Orissan Temple Architecture forms to identify its evolutionary process by conducting
   - Dimensional relationship between elements
   - With relation to vastu purusha mandala
   - Fractal geometry analysis
   - Visual analysis

1.5 Scope and Limitations

Study is limited to shape and geometrical aspects of Orissan Temple Architecture.

1.6 Methodology

In the process to continue the dissertation it has been important to identify its process. For that general research methodology has adapted for this kind of historical research. To find framing objectives and to achieve them following steps has been conducted.

- **Exploration**

  In this present investigation, an attempt has been made to understand the architectural characteristic of Orissan Temple through shape and geometry study.

- **Describe**

  To understand the typical character of Orissan Temple architecture during different phases through different dynasty ruled in Orissa.

- **Diagnose**

Subsequently a comparative analysis has been attempted between architectural styles of the deduced original form and geometry from different parts of Indian Hindu temples.

- **Deduction**

It has to be done, to analyse previous hypothesis and extract the theme and concept of Temple shape and geometry to understand its evolution process.

This dissertation is based on archival research and other documentary, literary works and theoretical investigation on ancient treatise and modern research works on the temple architecture of India. The archival research has helped to bring out the basic concept of Hinduism and how it influenced the design of Orissan Hindu temple architecture. The

Vastushastra and Shipshastra along with other general manuals on Hindu architecture have been referred to highlight the concepts that have been adopted since ancient times for the construction of the sacred Hindu temples.

This dissertation brings out the differences in the form and scale of the Orissan Hindu temple with the help of examples from the 'north Indian style' and the 'south Indian style' temples, highlighting that though the elements of Orissan temples may differ across regions they were all based on a single philosophy of design. The design philosophy of the Orissan Hindu temple is based on concepts of Hindu cosmology i.e. the divine 'Vastupurushamandala'. The influence of this basic divine concept on the layout of the temple plan and its external and internal forms and features is further explained with the examples of temples of the 'north Indian style 'and the south Indian style' from different time periods.

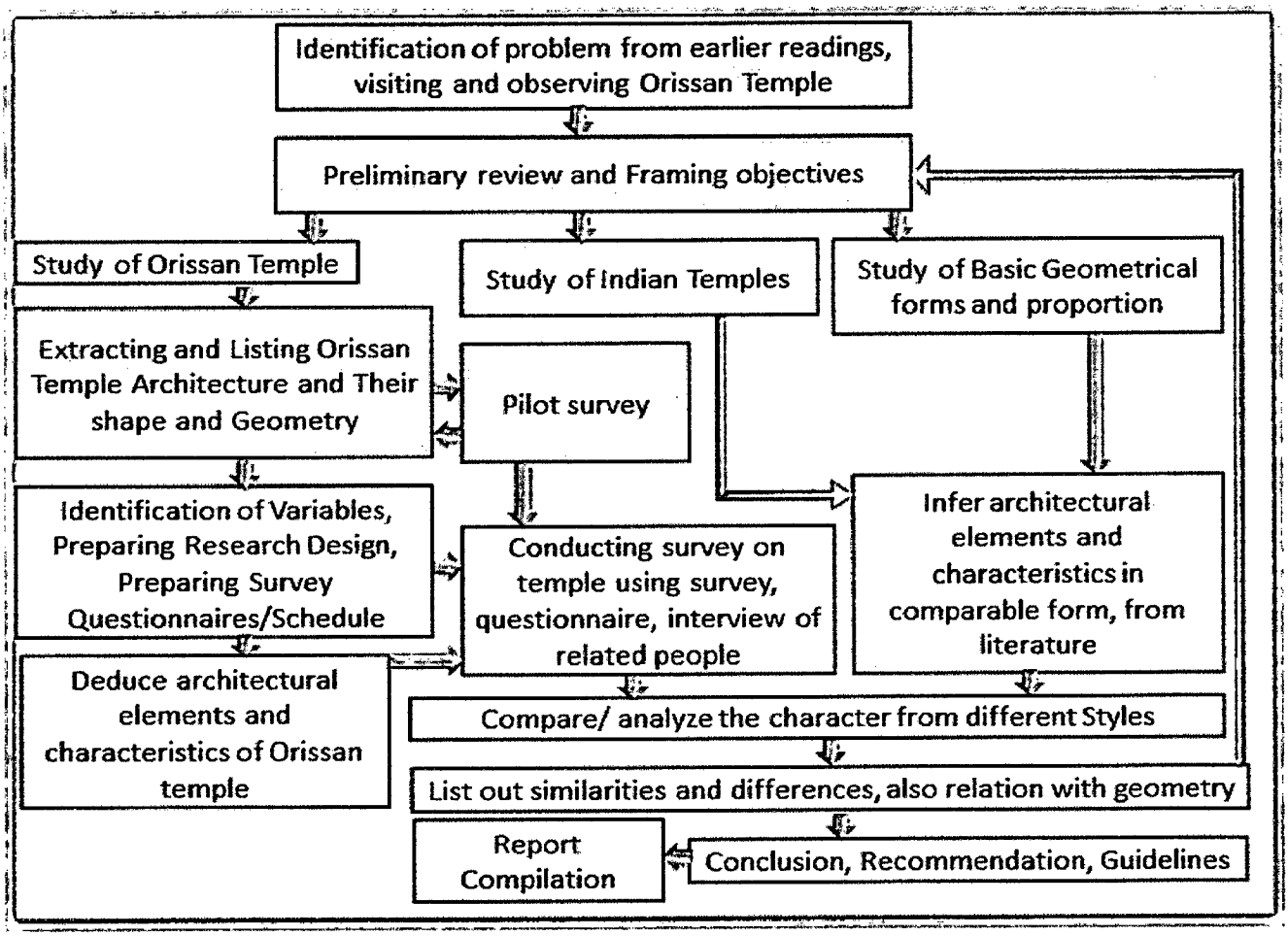


Figure 1.1 Methodology

1.7 Data

Both secondary and primary sources of data have been collected and employed in this investigation.

1.7.1 Secondary Sources of data

Literature relating to this investigation has to collect from different published and unpublished sources and employed.

The Published literature, such as related books (both written in English and Oriya), reports, and manuscripts are made use of. Another important source of data is souvenirs, journals, pamphlets published by various temple trusts during different occasions. The literature survey of north Indian temples and Dravidian temples was also done mostly based on available literature in the different sources.

1.7.2 Primary sources of data

The primary survey has to be conducted and employing a schedule, photographic survey and personal observation on temple buildings fully or partly. Discussions have to be conducted with experts and old local people. The main objective of this survey is to deduce the architectural characteristics through shape and geometry from its original form.

Further the major part of the primary survey is the architectural documentations of selected sample temples. For achieving this detail measure drawing is to be made of the selected samples buildings. They are has to be analysed for verifying the re-constructed architectural model.

1.8 Survey Tools and Techniques

An appropriate schedule has to be made to conduct the primary investigation. The schedule has to be develop based on the parameter that are required for the studying the architectural characteristics for deduce the shape and geometrical proportion of the Orissan temple architecture. Measurement Tapes, digital photographic tools, magnetic compass, etc. will be helpful for the use of data collection. Finally architectural documentation tools are used to document by selected sample buildings.

1.9 Analytical Tools and Techniques

1.9.1 Tools

Optimal softwares like MS Excel, SPSS has to be used for compiling and undertaking analytical work. For measured drawing and drawing purpose Auto CAD can be used.

1.9.2 Techniques

Comparative Analysis techniques have to be employed for this investigation.

1.10 Organization of the Thesis

Chapter 1 (Introduction to the Research) introduces the introduction of problem, Aim of the thesis dissertation, Objectives of the thesis, Scope and limitation of the thesis dissertation, Methodology followed by the kind of data expected and the probable outcome expectation of the thesis.

Chapter 2 (Literature Study) consists of a review of the 'state-of-the art' literature related to Orissan Temple Architecture. The areas covered under literature search include the elements of the Orissan temple like Rekha Deul, Jagamohana, The Natyamandapa and The Bhogamandapa. In the second half it explains the Transformation of the Orissan Temple through time periods like Formative Phase, Transitional Phase, Mature Phase and the Phase of Decadence. In the last part of this chapter explains the shape and geometrical study of Orissan temple architecture like the temple forms, fractals behind the elements, symbolism of basic geometrical forms and the cosmology behind the temple form and its elements.

Chapter 3 (Case Studies) carries an account of various case studies which reflects the ideas of shape and geometry of temple build form and methodological study to find out the appropriate shape and geometry of different temples. These studies were carried out to examine the probable outcome of the dissertation through shape and geometrical study. From the inferences and gaps identified from literature search the objectives of the thesis could be crystallized.

Chapter 4 (Research Design) forms the sampling procedure, design of survey schedule, primary and secondary data used in the present study. The collection of data's through primary and secondary sources are going to be collected, analysed and the architectural characteristics are going to be inferred.

Chapter 5(Shape and Geometrical Analysis) forms different probable outcomes of the shape and geometry of the Orissan Temples is going to be analysed. The inter-relation and comparison are going to be analysing through different softwares and techniques.

Chapter 6 (Conclusion) present the conclusions of the research with proposed criteria, Major Findings, Recommendation and focus the future scope for the further research.

CHAPTER - 2

LITERATURE STUDY

2.1 Elements of Orissan Temple Architecture

"Orissa has a long history during which Jainism, Buddhism, and Hinduism, all flourished for extended periods. Buddhist and Jain temples and caves predate Hindu architecture. The classic period for the Hindu Temple in Orissa is from perhaps the beginning of 8th century to around the middle of 13th century. Orissan Temple corresponds to an altogether different category." *(Karmisch, 1977)*

Orissa unique representations of temple forms are also known as Kalingan style of temple forms. As they are considered as the northern style but some identical features make them separate. Out of the five different types of architecture, that is: devotional, memorial, civil, military and domestic, one mainly come across the devotional type of architecture in Orissa. Others have disappeared with the ravages of time and power (Chand, July-2005). The Orissan Temple consists of four structures namely:

(a) The Vimana or Bada Deula or Rekha Deul (main shrine)

(b) The Jagamohana or Mukhasala (portico)

(c) The Natyamandapa (spectator's hall)

(d) The Bhogamandapa (hall for residuary donations) (Deheja, 1979)

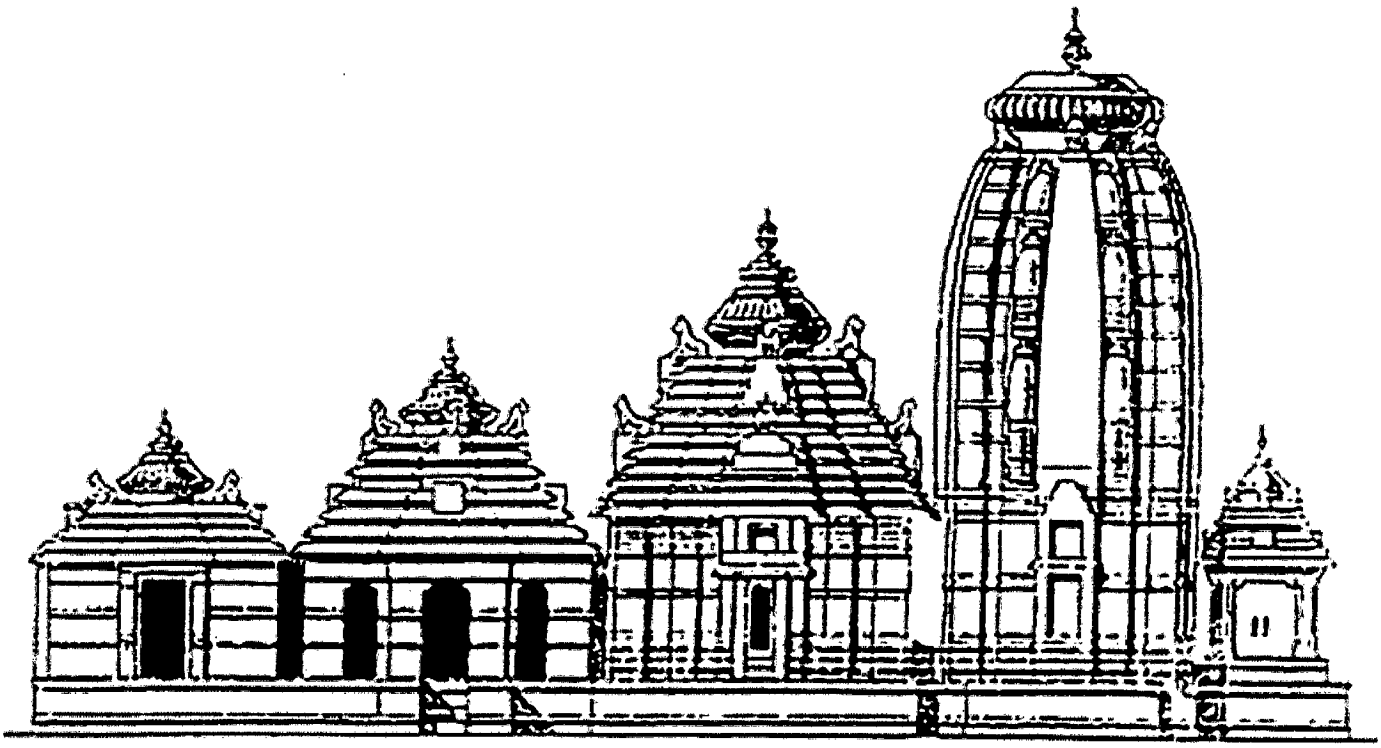


Figure 2.1 Typical Orissan Temple Elevation

Source: Deheja, V. (1979)

Due to separate regional development, some parts of the East Indian Temple use a different vocabulary than what is used somewhere else in India. For example, the part of the temple that contains the sanctuary is called a Deula in Orissa, but a Vimana all over the place else. Most of the Orissan Temple contains of a Rekha Deul and a Jagamohana. But in the later phases or time era many parts like the Natyamandapa and Bhogamandapa are added to the main build temple form. (Deheja, 1979).

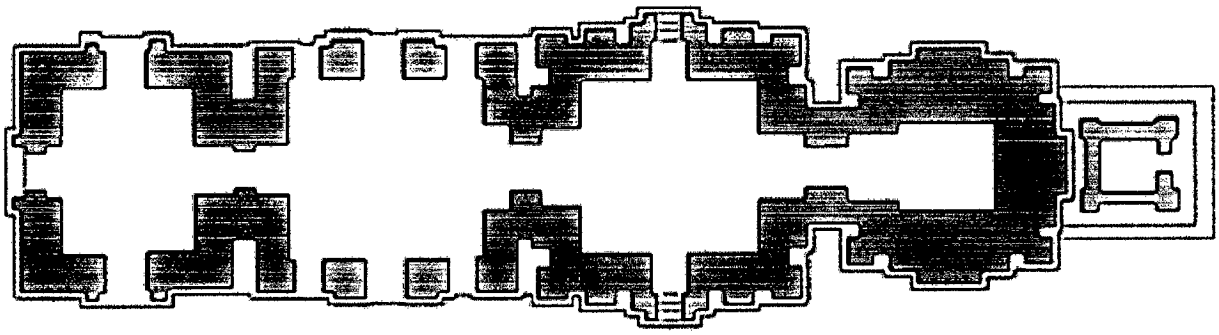


Figure 2.2 Typical Orissan Temple Plan

Source: Deheja, V. (1979)

2.1.1 The Vimana or Bada Deula (sanctum)

The 'Deula' is the sanctuary, containing the principal image of the temple surmounted by a curvilinear spire. One approaches the temple from the front structure, which is a prayer hall called Jagamohana. Behindhand this structure is the Vimana, which is comprised of the shrine of the temple (called garbha griha or "womb-house") that contains the idol of the deity, overwhelmed by a tower. This tower is called a shikhara and in Orissa, the structure is named as the rekha deula. (Deheja, 1979)

The elevation, of the temples shows interesting features. Both shrine (Bada/ Rekha Deula) and entranceway (Jagamohana) have four-fold vertical divisions as

- The Pitha (base)/ Pista
- The Bada (main structure or wall),
- The Gandi (stem) and
- The Mastaka (the crown or the head).

The architects perceived the temple in the structure of a human male character or purusha. From lowest to highest each part of the temple has a specific name conforming to that of members of the human parts.

The temple stances on a high base known as Pitha though maximum part are buried in the ground. The visible portion shows three mouldings, which are richly carved. The Bada or the vertical wall portion of the temple is divisible into pabhaga, jangha and baranda. This type

of three-fold division of Trianga bada is found in early temples. In later temples bada has five elements as

- Pabhaga (foot),
- lower Jangha (shin),
- Bandhana (bond),
- Upper Jangha
- Baranda. (Deheja, 1979)

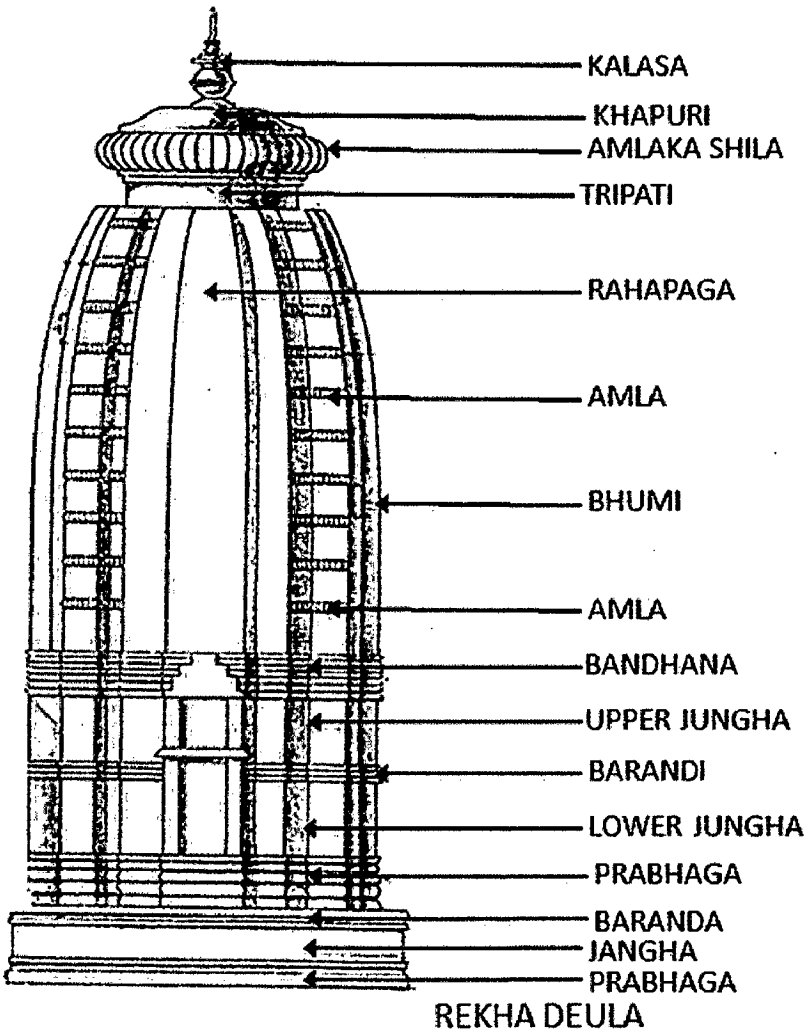


Figure 2.3 Typical Elevation of Orissan Rekha Deula

Source: Deheja, V. (1979)

The Pabhaga consists of five cornices one above another which is linked with perpendicular bands in all Paga of the Bada. These 5 mouldings are Khura, Kumbha, Pata, Kani and Basanta in climbing direction. The Khura is formed like a horse hoof and comprises upturned foliage schemes with scattered boundaries. The inferior part of Khura has been ornamented with Vanalata styles. The Kumbha is similar to a pitcher. The Kani is simple design, but the Pata and the Basanta are heavily decorated curves. (Chand, July-2005)

The inferior Jangha has Khakhramundis (small temples of Rekha Deul style) imitation of small temple.

The Bandhana contains of 3 cornices combined together at separate places by perpendicular bands ornamented with standing figures of Kanyas (maidens) confectioned with the inferior jangha and the upper jangha. It displays 5 divisions: Barani (khura), noli (kani), pata, noli, basanta respectively.

The upper Jangha portrays Pidhamundis (small temple forms of Jagamohana) comprising numerous goddesses. There is a near resemblance in the ornamental plan between inferior and superior Jangha, but in the presences of the Mundis and of the figures in the respites.

Baranda is the waist part, over the upper Jangha creating the top most part of the bada has a set of mouldings, initial with one moulding in the previous stage continuing into 7 and 10 mouldings which are khura, feni, noli, khura, pata, noli, pata, noli, basanta respectively.

The Gandi (trunk) of deula has a hyperbolic super-structure up to a flat top. The Orissan Temples are separated by vertical part projections known as rathas (on plan) or pagas (on elevation).

According to the number of rathas, the temples are classified as triratha, pancharatha, saptaratha and navaratha etc. Kanak rathas are the corner rathas, the Anuraha rathas are the intermediate rathas, and Raha rathas are the central. The vertical ribs of the tower is divided into horizontal courses called bhumi or storeys separated by amalas. In general bhumi are 3, 5,7,10 in numbers. On the Kanaka Paga of all Bhumi, there is a Bhumi Amla connected with Bhumi Barandis (sequence courses of stone). The Raha Paga contains places for the Parsva-devatas (side God) on different sides. The recesses between the Pagas contain figures of Kanyas in separate stances. Vajramastaka seen in Raha Paga is the usual feature in most of the Orissan Temples (Deheja, 1979). It is believed that temple is a place where the union or marriage between the believer and the divine god whom one love and believe takes place. It has been specified that the Rekha temple is the male and the Bhadra or Pidha is a female and their union is called Gainthala, which is a bond tied in the clothes of the bride and bridegroom at the time of marriage surmounted with a prominent Gajakranta, i.e., lion-on-elephant. (Chand, July-2005)

The mastaka (the head) is connected to Gandi by a recessed cylindrical portion known as beki (neck). Beki is connected to the mastaka by a threefold member known as Tripati. Mastaka consists of Amalaka sila (ribbed circular stone, resembling the amla, Khapuri (skull), Kalasa (auspicious pot) symbolizing a state of plenty or bounty and Ayudha (armament of the

preserved deity i.e., Chakra) in series. In the Beki, are implanted four figures of Dopichha lions at all angle, the interior of sanctum or Garbhagriha is generally smaller and darker than that of the porch. In the center of the room there is the simhasana on which the imageries of worship have been fitted.

It is used for a glimpse of the sacred image or rituals or individual worship under the watchful eye of the priest with path for circumambulation of the deity seat. There is only one doorway leading to Jagamohana. The porch is more public and used for group celebration, dancing, meditation, or reading. The Jagamohana is a Pidha temple, a structure with pyramidal rooftop laid in courses called pidha (also spelled "pida"). (Deheja, 1979)

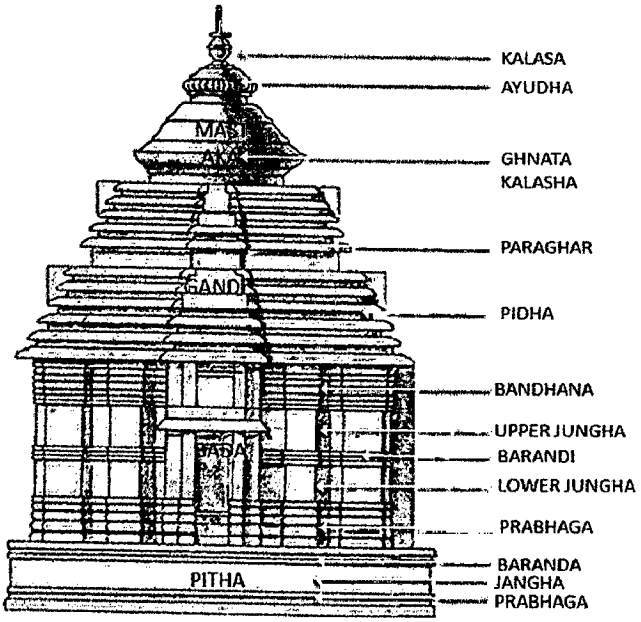


Figure 2.4 Typical Pidha Deula Elevation

Source: Deheja, V. (1979)

2.1.2 The Jagamohana or Mukhasala (porch)

The Jagamohana stands on a stage like the Rekha Duel, Bada is generally triratha or Pancharatha in plan form and contains of 5 parts of Vimana, which are richly carved with Mundis or miniature temples. The Gandi is formed of pidhas organized in two potalas or levels diminishing in size as these continue from lowest to highest. The Kanthi break in between the Potalas is also known as Para ghara (pigeon nest) decorated with Pidha-mundis, pillars and imageries of Mandiracharini. The Mastaka of the Pidha deula has the similar structures but for the adding of ghanta (bell). It contains of usual elements like Beki, Ghanta ("bell," named after its shape). Amalaka sila is supported by Deula charinis or seated divinities and Dopicha simhas being set in the beki. (Deheja, 1979).

2.1.3 The Natyamandapa (audience hall)

Natyamandapa seems to be a comparatively advanced structure. It is also a Pidha deula of pillared structure. Its roof is in much case flat consisting of strata of stone slabs. The inner of the gallery is healthy ornamented with separate types of stucco imageries and pictures. This area was intended for performing dances by the debdasis. (Deheja, 1979)

2.1.4 The Bhogamandapa (hall for residuary offerings)

The Bhogamandapa generally is as Jagamohana with a tall base but the parts do not conform to the provisions given in the architectural manuscripts of Orissa. The forecasts in the Bada part are not quite conspicuous, but its generous ornamentation enhances to the splendour of the construction. The Gandi is as Jagamohana style with Potalas. The Potalas contain of Pidhas figures of prominent lions in all Potal. The Gandi is also similar to Jagamohana. The Mastaka of Bhogamandapa is consists of the similar parts as others, but that a bold pot is located on the highest part of fit. The construction generally stances on four columns and the inner are left entirely plain in difference to the external decorations. (Deheja, 1979)

As temple is the adobe of God, for different day to day activity various interesting elements are seen in the bigger temple complexes. The temple inclusion contains of the galley, the Ananda Bazar or the marketplace for the Mahaprasada, and parks including the Koili Vaikuntha, Niladri Vihara along with few essential constructions like Snana Vedi (bathing platform) and limited shrines as well. Devotees circumambulation temple and seek 'Darsan' of the inconsequential deities in a set particular way. In case of Jagannath Temple Puri, a gangway is linking the galley with the Jagamohana through Bhogamandapa and Natyamandapa, to provide donations for the goddesses. (Bose, 1982)

The Khakhara Deula is altogether a different style of architecture closely appearing similar to the Dravidian Gopuram design. The word is derived from kakharu (pumpkin, gourd) as the crown looks like a barrel-vaulted. Elongated roof, The Gouri temple of Bhubaneswar is a glaring example of Khakhara temple. (Harle, 1986)

2.2 Transformation of the Orissan Temple

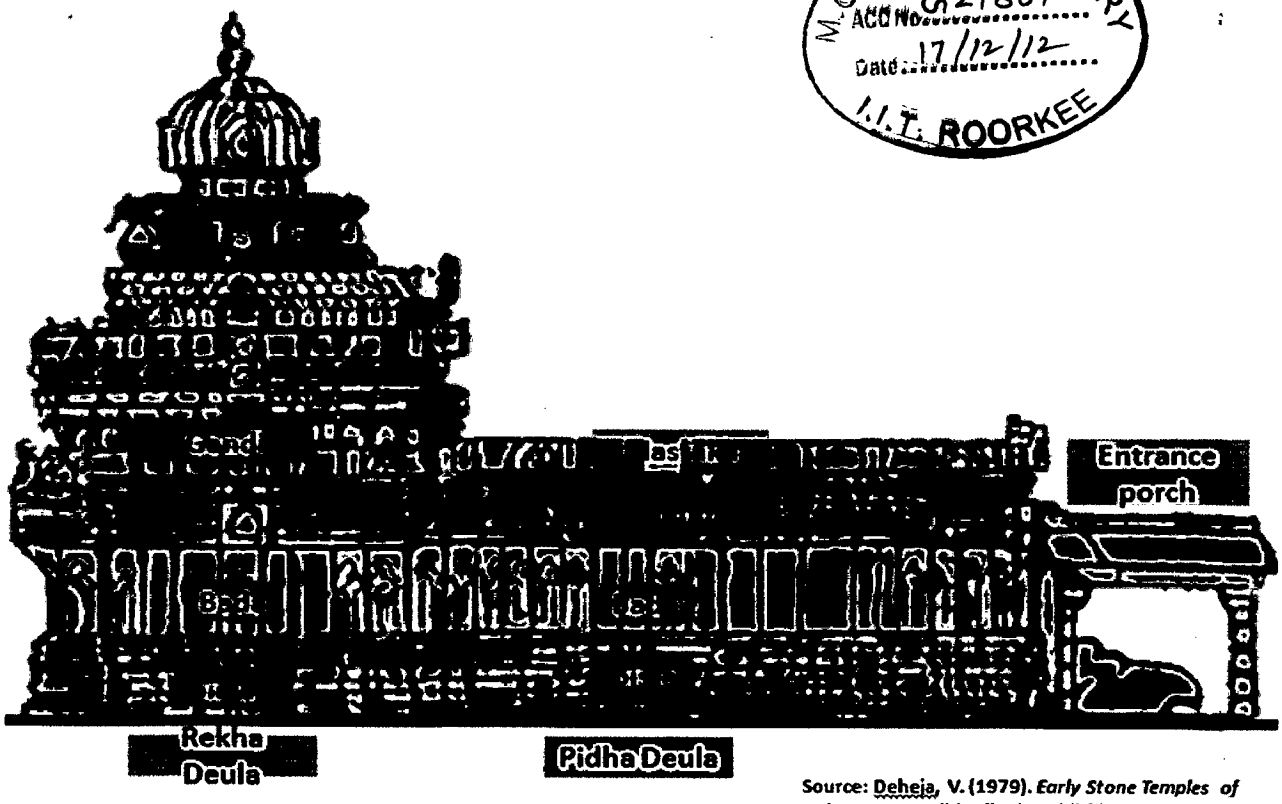
The archetypal phases for the Hindu Temple in Orissa is from the start of 8th century to about the central part of 13th century .The temples of Orissa give a picture of evolution from Parasurameswara to Lingaraj through Muktesvara and Vaital like other temples, which is eventually ended in Puri and with the greatest Konarak. The evolution can be classified into four distinctive phases of temple building,

- Formative phase,
- Transitional phase,
- Mature phase,
- Phase of decadence. (Karmisch, 1977)

2.2.1 Formative Phase

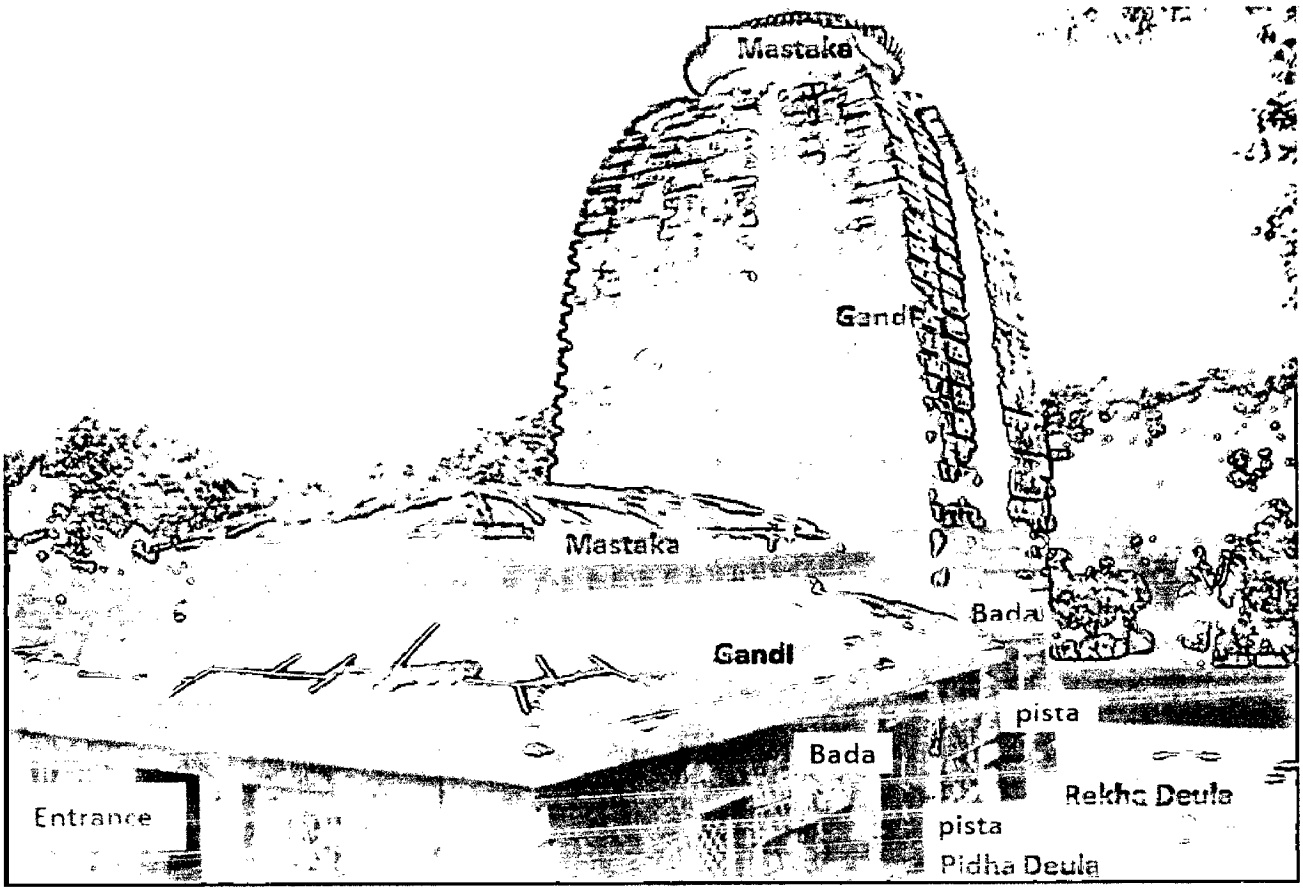
(6th century to the first half of the 9th century)

During this period there were only two structures of temples, Vimana or Bada Deula and Jagamohana or Mukhasala. Parsurameswar (7th century) is the best preserved specimen of the early phase. Vimana of Triratha has a rekha sikhara. The Jagamohana is a rectangular pillared hall with a terraced roof sloping in two tiers, with elevation Bada as tribhanga (with three divisions) Pabhaga and the foot portion consisting of three mouldings of khura, kumbha and pata. Gandi became a gradual curvature and started from the sikhara without any angasikhara. The temples are of small and moderate height. Baranda is terminating in a recessed kanthi. (Karmisch, 1977).



Source: Deheja, V. (1979). *Early Stone Temples of Orissa*. New Delhi: Vikash Publishing House Pvt. Ltd.

Figure 2.5 Typical Elevation of Formative Phase



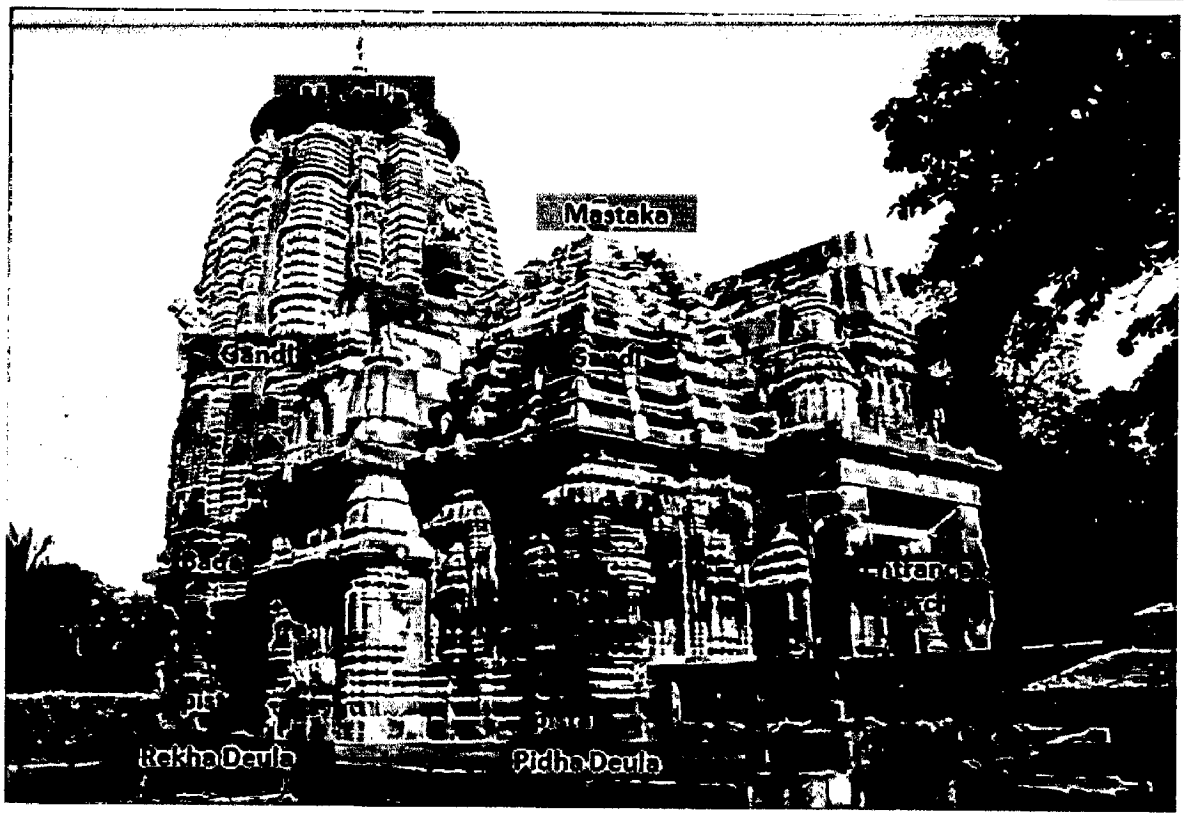
Parshurameswar at Old Town, Bhubaneswar Source: Photograph courtesy by Author

Figure 2.6 Parshurameswar Temple, Bhubaneswar

2.2.2 Transitional Phase

(2nd half of the 9th century to the first quarter of the 11th century)

The notable feature of the period was the introduction of ramp ant erotic sculptures due to the influence of Vajrayana philosophy. Mukteswar at Bhubaneswar was the last monument of this period. Mukhasala or the Jagamohana became an inseparable element with a perfect and natural joining of the Vimana with Jagamohana without the crude overlapping of the sanctum decoration conceived as a uniform complex in the original plan. Towards the end, the plan and elevation of the Mukhasala transformed from a rectangular flat roof to a square hall with a pyramidal superstructure. Parsvadevata images are carved out of single stones unlike the earlier tradition of blocks of stones that constituted a part of the temple wall. (Karmisch, 1977).



Shidheswar Temple, Bhubaneswar

Source: Photograph courtesy by Author

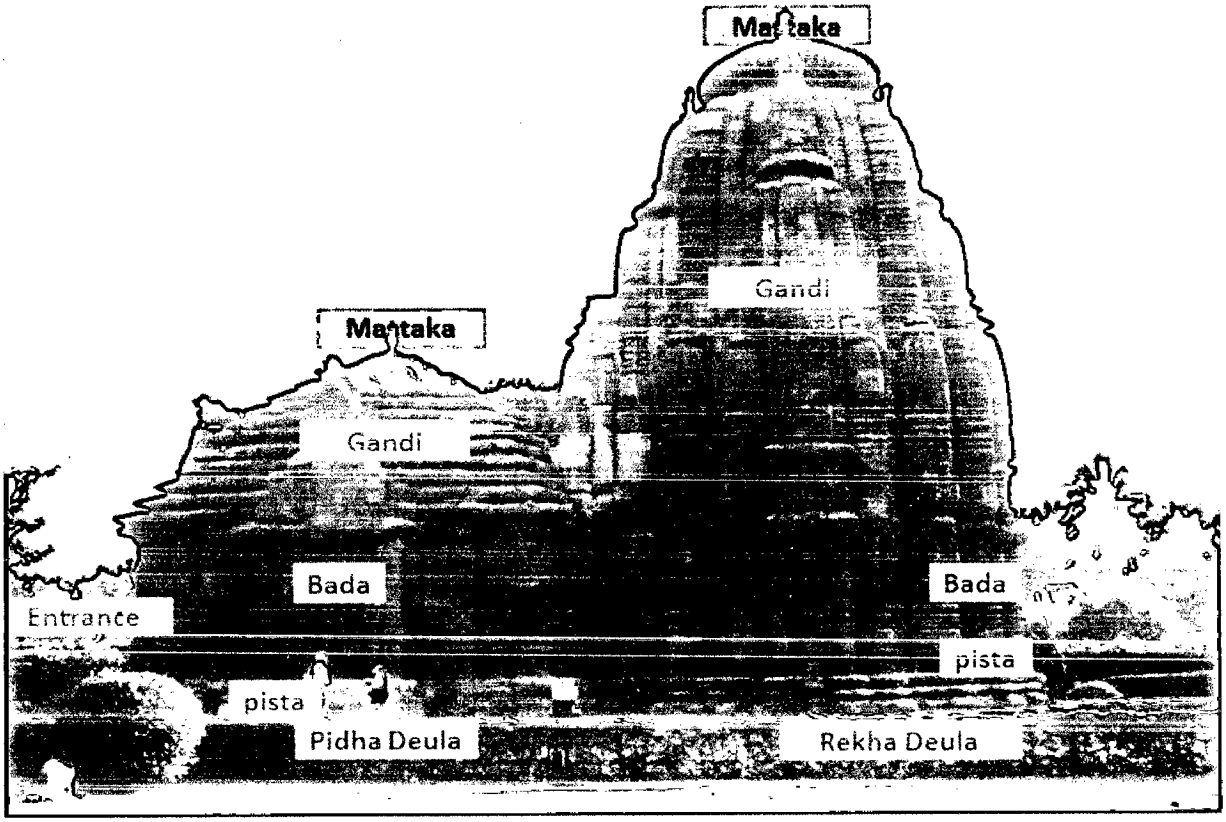
Figure 2.7 Shidheswar Temple, Bhubaneswar

2.2.3 Mature Phase

(From middle of the 11th century till the 13th century)

The building activity attained its maturity during this period which can be traced through a series of temples like Rajarani, Brahmeswar and finally the Lingaraj that presents the Orissan temple style at its best. The building tradition was continued by the Gangas who are credited with the construction of the great Jagannath Temple at Puri and the magnificent Konarak Temple, Puri. (Karmisch, 1977)

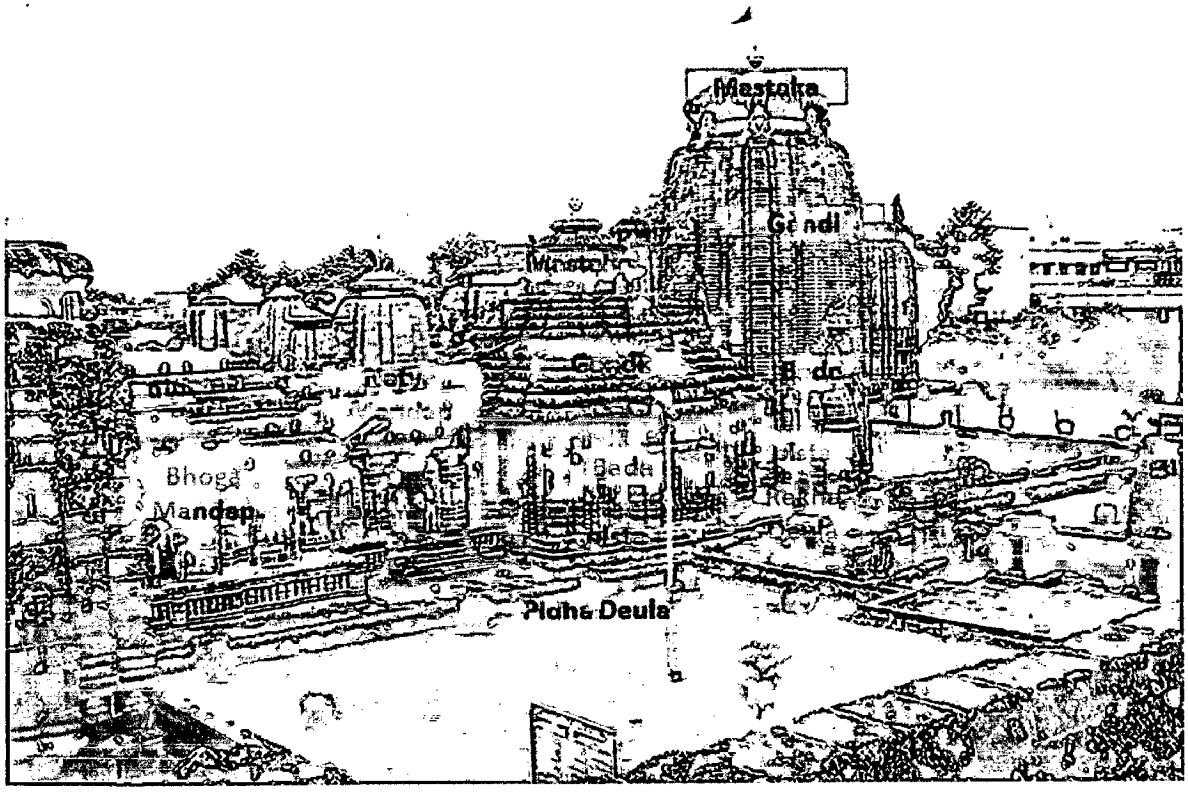
In this phase Bada is divided into five segments, Pabhaga has five mouldings; Gandi is embellished with Angasikharas (miniature temples) of diminishing size as they rise upwards. The Pagas projections are fully developed and prominently articulated. Amlaka sila is supported by Deula charinis or seated divinities and Dopicha simhas being set in the Beki. Introduction of the structural motifs like pidhamundi, khakharamundi and vajramundi are in the Jangha portion. The sculptures of this period are excellent in their plasticity and even include non-iconic female figures. In the iconography of the cult deities, new elements were introduced with profusion of female figures, projected lions (udyota simha) on the Rahapaga. Pista and platform became a regular feature. Natyamandapa and Bhogamandapa were added to the Jagamohana. Subsidiary shrines in front of the Parsvadevata niche were introduced. (Karmisch, 1977).



Rajarani temple at tankapani road, Bhubaneswar

Source: Photograph courtesy by Author

Figure 2.8 RajaRani Temple, Bhubaneswar



Lingaraj Temple Complex, Bhubaneswar

Source: Photograph courtesy by Author

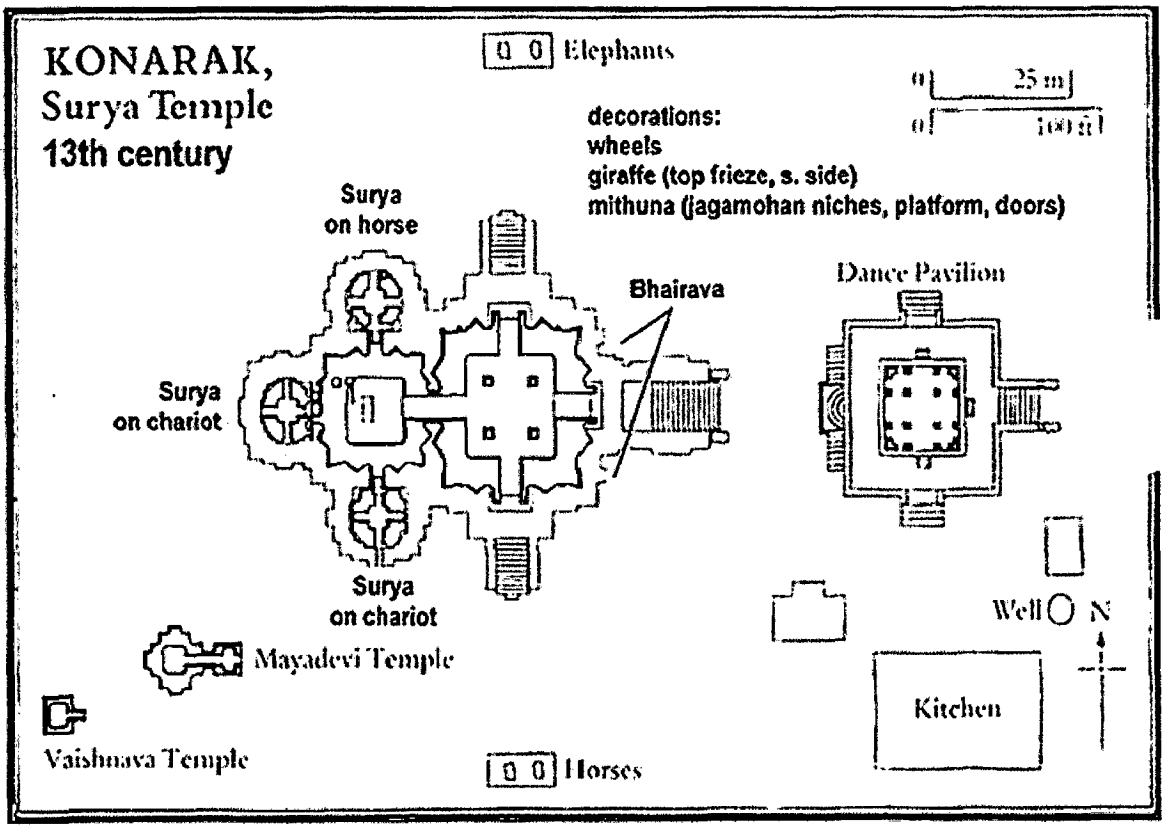
Figure 2.9 Lingaraj Temple, Bhubaneswar

2.2.4 Phase of decadence

(14th to 16th century)

The temple building activities that started during the 6th century reached its climax during the Ganga Period started declining during the Gajapati. The great period of Orissan Temple Architecture came to halt with the crowning achievement at Konark. Pidha deula became the choice for both Vimana and the Jagamohana. The walls of the temple are devoid of sculptural embellishment and decoration. Such insolvency was also noticed in the decoration of door jambs, which also largely remained plain. The temple building activities entered into a phase of decadence. The most important factors for the decline of temple building activities were the lack of royal patronage and decline of Hindu power.

A change was imitated in the prayer gallery's highest parts. Earlier period Jagamohana contains only with a kalasha (vase of plenty).at the end of this phase, the disk-shaped Amalaka and the Kalasha both existed at the Shikharas. Another development was that of the stable growth in the number of perpendicular ribs (bhumis) on the walls of the shikhara. But the base plan of the garbhagriha was square in nature; the Shikharas are up righted as height increases and the increase in the jaggedness make the form of the temple almost circular in shape. (Karmisch, 1977).



Source: Monuments of India, vol. 1

Figure 2.10 Plan of Konark Templ

2.3 Shape and geometrical study of Orissan Temple architecture

The architecture of Hindu temples is considered by certain typical official elements. The most established is a kind of jaggedness of each edges and surfaces. This sharpness results from splitting or breaking of forms into sub-forms. Hindu temple architecture is massive and needs an appreciative nature not only of Hindu philosophy but also the nature of rituals, religious practices and temple worship in Hinduism. This is to be neither comprehensive nor exhaustive in explaining these concepts and only describe, in a simplified manner, some of these concepts and how they affect the form of temple architecture. (Trivedi, K, 1989)

2.3.1 Self-similarity, fractals and temple forms

Taking into account many Orissan temple forms are based on factal forms and geometrical appearance. The idea of fractals characterises substances that display invariance underneath classification of scaling (Trivedi, K, 1989). A portion of such an substance, on existence enlarged, displays an arrival and belongings that are very alike to the entire. When each part is geometrically alike to the entire, such a form is known as self-similar. Self-similar forms overflow in trees, mountains, nature, clouds and lightning, river deltas and coastlines - all display self-similarity. Though the presence of the occurrences of self-similarity in the natural creation has been experiential and known for a time. Seemingly messy and formless shapes like islands and clouds were exposed to be based on a fractal order connecting replication on a continuously declining scale of a lone similar change. It has been projected that fractal geometry delivers a nearer mathematical ideal of numerous forms in nature than is likely with traditional geometry.

2.3.2 Basic geometrical forms as Symbolism

To show these proposals representatively in graphic form, elementary geometrical facts such as point, circle, triangle, square etc. were allocated different symbolic meaning in Indian holy art to signify the basic dynamisms of the cosmos. These representative geometrical facts were then joint in progressively compound facts to present specific potentials or forces embodied in some features of formation, development or ending.

In Indian holy art, the 'point' (bindu) is measured as the basis of all formation. It signifies focused energy, the primordial centre. From this centre create the numerous lines, angles and circles concluding in different shapes. A point can be measured as a circle with no radius. It can also be measured a triangle with no area, a point where the would-be three vertices agree, all shapes are possibly existent in the point. (Trivedi, K, 1989)

 The circle signifies the principle that has no starting, no ending and which is flawlessly regular. It specifies the realm of energies from the one centre. "The Circle is measured as all Universes, according to Vastusutra Upanishad. (Trivedi, K, 1989)

 The triangle is the elementary linear character of inclusion. Since space cannot be constrained by less than three lines, the triangle is considered as the 1st symbolic form to arise from the chaos previous formation. The descending pointing triangle is signifies of the female principle, while the rising pointing triangle signifies the male principle. The interpenetration of these two triangles signifies the idea of synthesis of polarities: the male and the female; matter and spirit; the static and the kinetic in a perfect state of unity. (Trivedi, K, 1989)

 A square represents the manifest world, the steady linear form signifying the earth. It is the important arrangement of the most of the holy structures, meaning the terrestrial world that must be exceeded. From these basic forms, many different geometrical diagrams signifying the various symmetries and energies of the cosmos are constructed. These diagrams are used as meditative instruments to wake in one these energies. The drawings are variously named Mandalas, Yantras, and Chakras. (Trivedi, K, 1989)

'Mandala' is a Sanskrit term sense polygon. In ritual drawings Mandalas mean 'Wholeness'. Their favoured forms are circles and squares. Traditionally, the circular mandalas are representative of the cosmos in its total and the square symbol of the earth and of the man-made world. 'Yantra' is also an intellectual geometrical design intended as a instrument for meditation.

The Sanskrit word 'Yantra' originates from the origin 'Yam' – sense to sustain, hold or bind. Yantra is an tool, a store-house of energy. Though mandala is cosmic, Yantra tells to a exact feature of cosmic power and may be the representation of a specific goddess, a exact yantra encompassing in it in a manageable form the uncontainable image of a deity. Every yantra is a sacred inclusion, a dwelling or a container of a selected deity. It is a alternative for an anthropomorphic copy of a divinity and is an intellectual conversion of the qualities and powers of the deity.

2.3.3 Temple plan cosmology

Permitting to Vastu-Shasta tradition, the ground plan of every Hindu temple must imitate to a mandala named the ' Vastu-purusha Mandala'. Countless importance is devoted to the founding of the Vastu-purusha Mandala, since it functions as a geometrical drawing of the

necessary construction of the universe, a symbol of the ordered cosmos. The Vastu-purusha Mandala is not an precise copy of the temple, but a 'forecast', a pattern of the potential within which a extensive range of options are implicit. The mandala is an ideogram while the temple is a physical manifestation of the ideas it symbolizes.

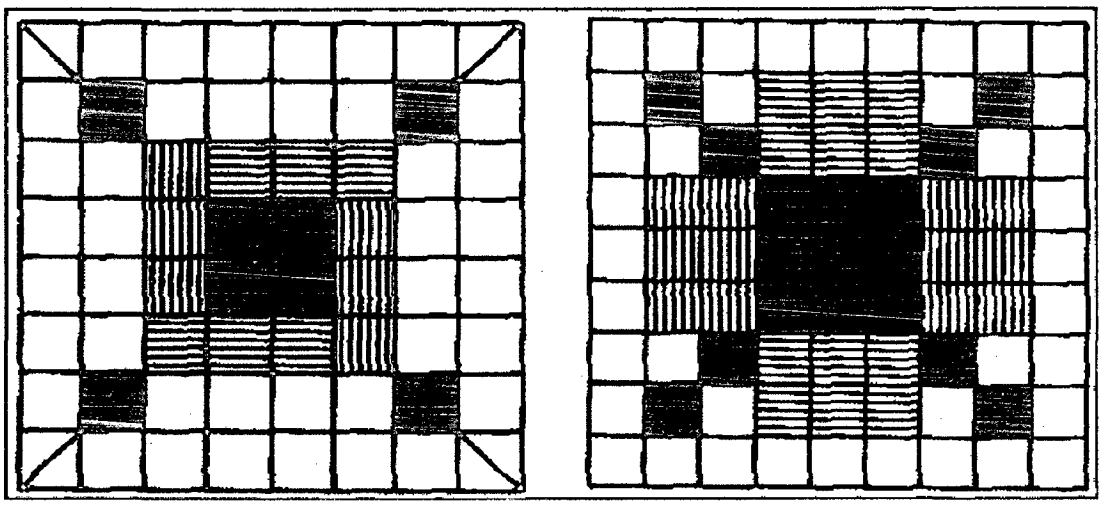


Figure 2.11 Vastupurasha mandalas of 8 x 8 (64) & 9 x 9 (81) squares

Source Trivedi, K, (1989)

Conferring to the agreements of Vastu-Shasta, all architectural structures should follow the square and the square grid, as the square symbolizes the manifest world. However, as the cosmos is signified by the circle representatively, the procedure of making an architectural model of the cosmos involves the represetation of a circle in a square grid in 2D structure and of an ellipsoid in a cubical network in 3-D construction. A procedure of discretization of all coiled methods is required by this need to signify them in a square grid, which results in the typical jaggedness of the temple plan. (Trivedi, K, 1989)

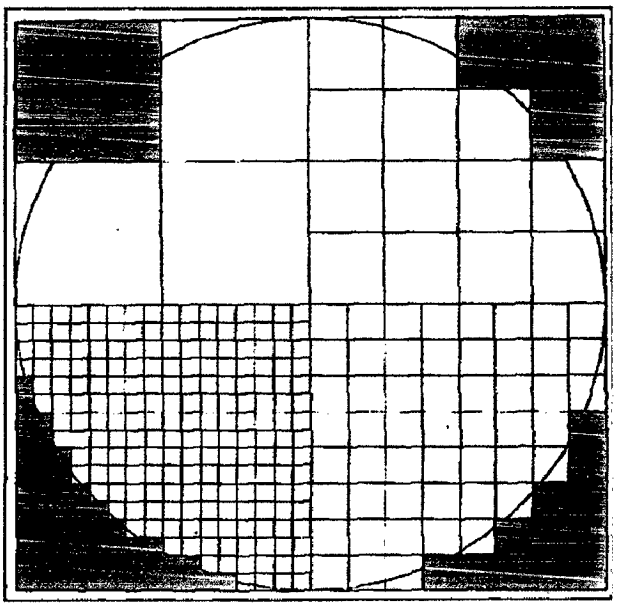


Figure 2.12 Circle in successively finer square grids and the resulting jaggedness

Source Trivedi, K, (1989)

Permitting to Vastu-Shasta manuscripts, a sequence of 32 kinds of Vastu-mandalas is supposed to be, continuing from a plan of one square to one (1 x 1) to one with 1024 (32 x 32) square portions, i.e. having a side length of 32 units. The two most usually used Vastu-purusha Mandalas are those having 64 (8x 8) and 81 (9x9) squares. The growing numbers of subdivisions are required to signify the gradually increasing complexity and details of an evolving cosmos. The simple, smaller temples based on the smaller mandalas signify the early stages of evolution, while the largest temple contains all the component parts and complexity of a fully evolved cosmos.

2.3.4 Fractal elements in Orissan Hindu Temple

In portraying an developing cosmos of rising difficulty, which is self-copying, self-formatting, self-look alike and self-motivated, several geometrical creation processes are followed in the architecture of Orissan Hindu temples. The development associated evolution cannot be spoken just by scaling; there is also a development in the complex structure of the developing shapes. The processes used are recursive and formative visually complicated forms from plain earlier forms through conjunctive presentation of making rules that are alike to the rules for producing fractals. Many other directions may be followed to create different portions of the temple the whole temple form results from a difficult connecting and grouping of these separate 3D forms in a combined entire.

Some major procedures to generate complex shapes and patterns, which can be identified, are:

1. Fractalization
2. Self-similar iteration in a decreasing scale
3. Repetition, superimposition and juxtaposition (Trivedi, K, 1989).

2.3.4.1 Fractalization

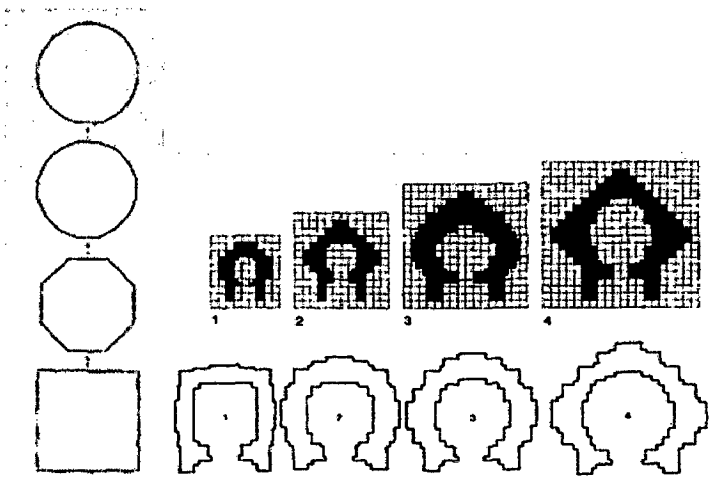


Figure 2.13 Transition from Square to Circle form of Garbhagriha

Source Trivedi, K, (1989)

Numerous other methods of fractalization to realize great visual stability to express the impression of multiplying and development are originate in current Orissan Temple. The plan shapes of vimana are changed from internal square shape to changed circular shape in the time change. Splitting or breaking up a motifs and restating it vertically, horizontally or radially around the unique theme. Such designs are usually originate in ceiling part of the temple.

2.3.4.2 Self-similar iteration in a decreasing scale

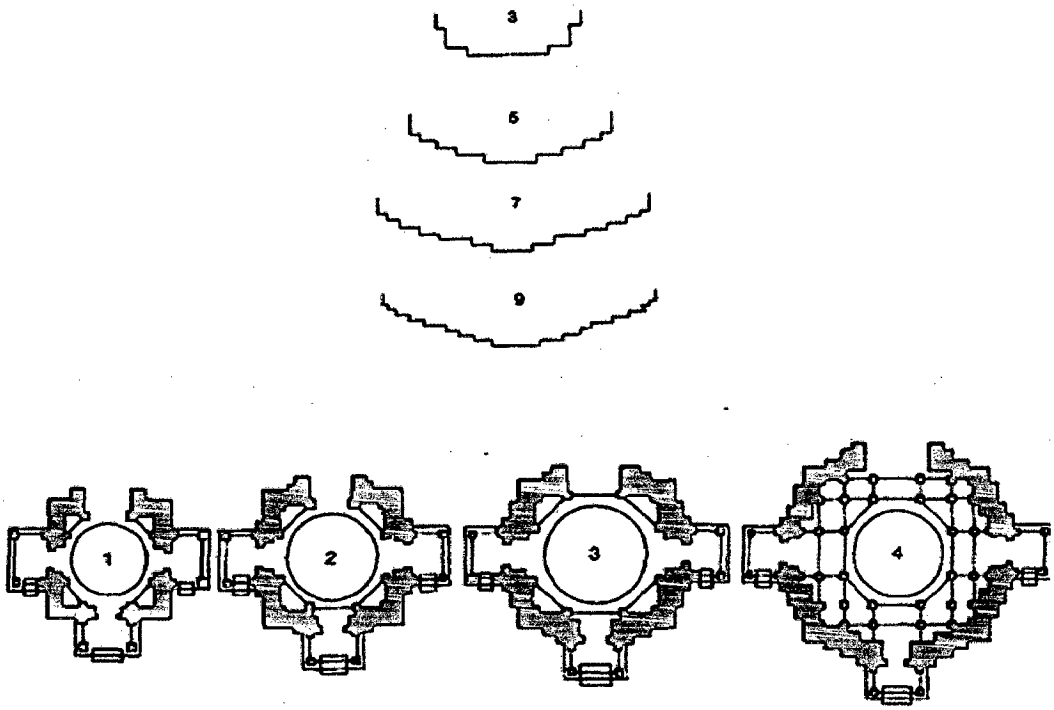


Figure 2.14 Increasing amount of Self similar projections in numerous types of base plans

Source Trivedi, K, (1989)

A recursive process connecting self-similar repetition in a progressively shrinking scale is often used to produce the shapes of different elements of the shrine. In its simplest shape, it could be dvi-Ratha, having only two propagations: bhadra also called ratha, (central offset) and kanaka or kona (corner). In the tri-anga temple, an additional member called pratiratha (companion of ratha) is inserted between the bhadra and karna. In the chaturanga plan, a nandika (half the size of pratiratha) is added between the bhadra and the pratiratha. In a panchanga plan, an additional nandika or its half- the konika is inserted between the karna and the pratiratha. (Trivedi, K, 1989)

A often seen subject on the external walls of temples is produced by fractal process on a triangle in three-dimension, and the subsequent shape is further overlaid with another ornamental design. The most complex and visually pleasing samples of self-similar repetition in 3D are originated in the shikhara element of the shrine.

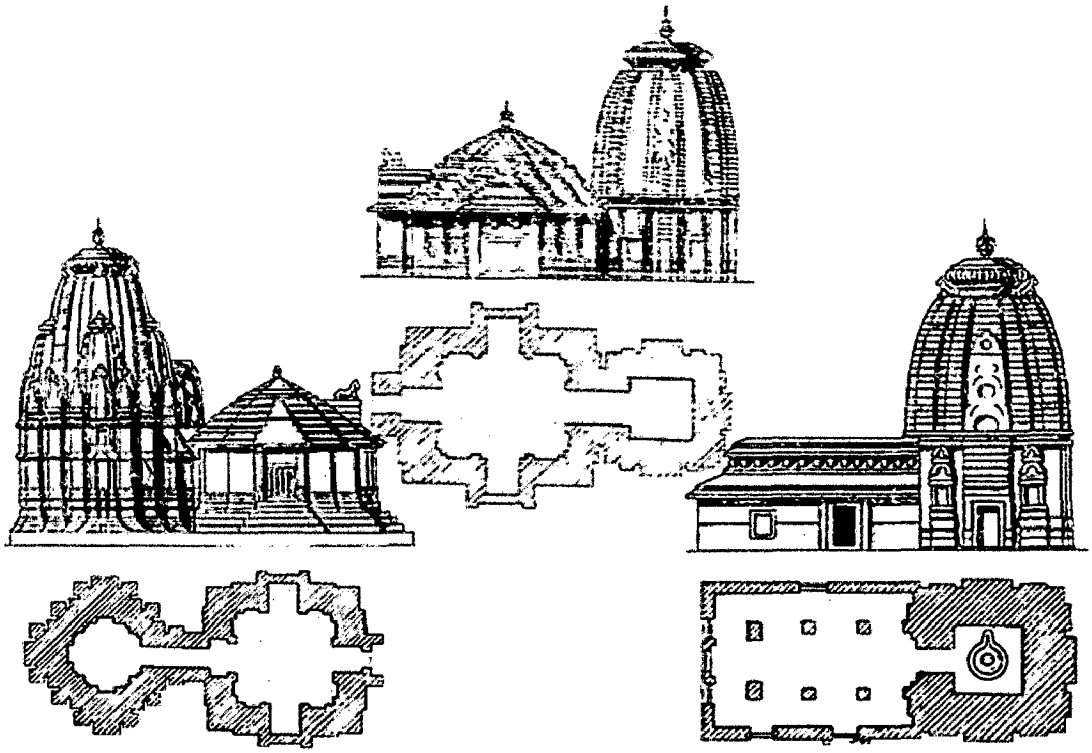


Figure 2.15 Orissan Temple showing Self similar repetition in a reducing Scale
Deheja, V. (1979)

2.3.4.3 Repetition, superimposition and juxtaposition

The replication of equal forms, either in the vertical or in the horizontal, or vertically as well as horizontally, is another frequently used procedure to add visual complexity to the temple form. The directions of replication and decrease act jointly. Stella Kramrisch describes the significance of these processes in her The Temple as Purusha: In addition to replication, dissimilar motifs are overlaid in 3D upon each other; motifs are emblazoned within dissimilar kinds of motifs and numerous other types of ideas and motifs are reduced and contrasted collected into one complex new object. Together, all these operations create the total temple form crawling with complex detail, vibrant, dynamic and self-similar like the cosmos it is supposed to signify. (Trivedi, K, 1989)

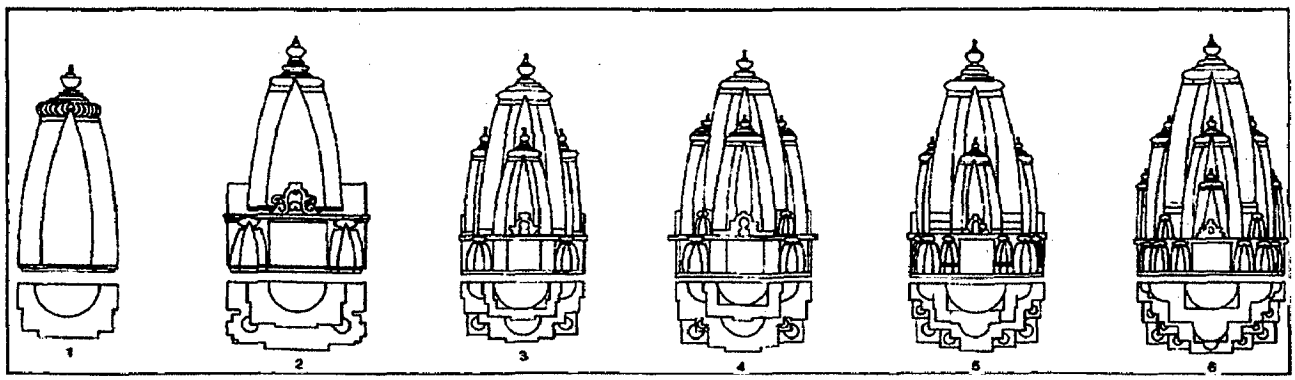


Figure 2.16 Different Shikharas increasingly of repetition, superimpose to each other
Source Trivedi, K, (1989),

CHAPTER - 3

CASE-STUDIES

"Embedded within the design of South Asian temples are multiple layers of cultural knowledge. Iconographic programmes to guide practitioners, messages of kingship and dynastic power, conceptions of the universe, and the dynamic processes of manifestation and dissolution, could all have a place in a temple design. Knowledge of geometry, both as an abstract science and part of a symbolic language, can also be found embedded in the design of a temple. How this came to be done can be difficult to determine. Most published plans lack the scale and precision to be of much use to the researcher, but when accurate measurements are available, the use of computer aided design tools can reveal a previously undiscovered, and perhaps unexpected, degree of geometric sophistication".

(Philip E. Harding)

The usage of the Vastupurushamandala, a ritual network generally containing of 64 or 81 squares boxes, and generally supposed to be fixed in the geometry of Vedic altars, was once taken as an archetypal element underlying all Hindu temples (Kramrisch 1946, p. 33).

This idea has recently been reconsidered. The prime proof for its usage came from the 5th century Brihatsamhita, an encyclopaedic effort whose primary theme is astrology. However, neither Vedic manuscripts nor architectural workings similar the Mayamatam or Manasara kind any reference to the vastu purusha mandala. It might yet to be argued that a ritual network was used in the design of certain temples, but its use was not ever universal. Furthermore, where evidence of its use is strong, its company does not prevent the use of other geometric procedures connecting opinions of connection among circles, squares, triangles, and designs of radiating lines (Volwahsen 1969, pp. 52-53)

The earliest Indian texts to deal with geometry directly are the Sulbasutras. Variously dated from as early as 800 B.C. to as late as the 4th century B.C. (Amma 1979, pp. 14-15), the Sulbasutras provides ended the geometric formulations necessary to build vedis, or altars and agnis, or fire pits. Though the Sulbasutras differ in plan and depth, they normally development in consecutive parts from abstract geometric values to the altars essential for precise ceremonies, with full images of the forms and sizes of the bricks required for altar creation. (Philip E. Harding, 2000)

Sulbasutras show how to found an east-west axis and intersect it with a north-south line, how to operate areas such as changing a provided rectangle into a square and vice-versa,

how to add and subtract squares of different areas, how to convert a square into a circle and vice-versa, and how to form various trapezoids out of squares or rectangles (Philip E. Harding, 2000). It has been known as the Pythagorean Theorem was understood by the Sulbasutras. They also understood the geometric significance of the square roots of two and three: if a square is constructing on the diagonal of another square, the second will be twice the area of the first. They therefore called the diagonal of a square the dvikarani, or "double maker". (Philip E. Harding, 2000)

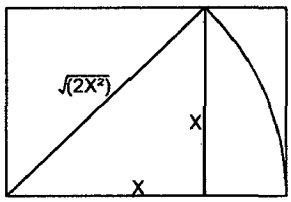


Figure 3.1 A rectangle with a ratio of 1:√2

Source: Philip E. Harding (2002)

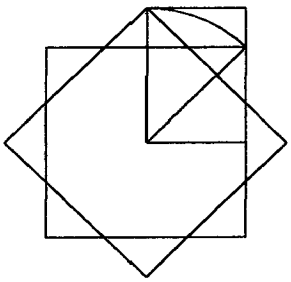


Figure 3.2 The ratio of 1: √2 in an Ad Quadratum construction

Source: Philip E. Harding (2002)

Moreover, Sulbasutras knew that, if a rectangle is formed with the proportion of one to the square root of two, its diagonal will be the trikarani, or "triple maker." (Philip E. Harding, 2000)

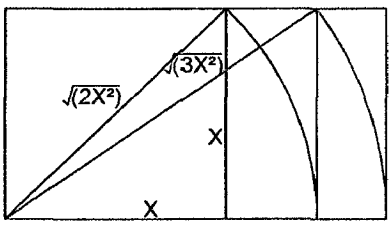


Figure 3.3 A rectangle in a ratio of 1: √3

Source: Philip E. Harding (2002)

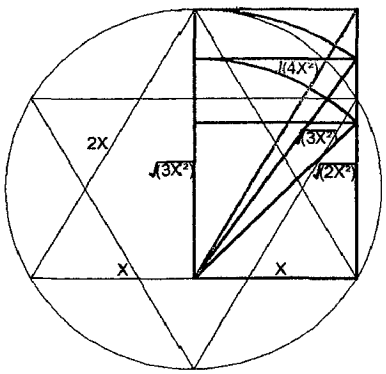


Figure 3.4 The ratio of 1: √3 in an Ad Triangulum

Source: Philip E. Harding (2002)

That is, a new square made on this diagonal has an area three times that of the original square. The dvikarani and trikarani are of even greater interest because their proportions are inherent in two common star polygons – the eight-pointed star (ad quadratum) and the six-pointed star (ad Triangulum). However it seems likely that the Early Western Chalukya builders, who did use these stars, were aware of at least some of the Sulbasutras, and their scheme of geometry should be understood as rising out of, and structure upon, the earlier Vedic tradition of altar structure. (Philip E. Harding, 2000)

3.1 Temple at Chika Mahakut

Philip E. Harding found the base plan of Chika Mahakut from the book "The Encyclopaedia of Indian Temple Architecture" which was drawn by Balon.

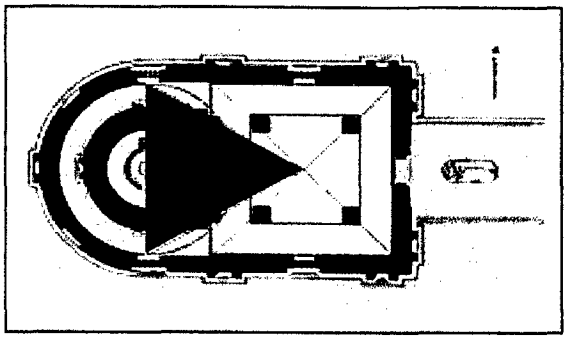


Figure 3.5 Base Plan of Chika Mahakut

(Philip E. Harding, 2000)

Mainly, it has been fitting a square into the Mandapa (gallery), and a circle along the inner face of the ambulatory's external wall as shown in Figure 3.5. Following, place an equilateral triangle into the circle of the pradikhina pathso that its base resembles to the diameter of the circle. The top of the triangle will then fall in the middle of the mandapa's square. They may have had a six pointed star, a simple triangle as given away, or other larger, as yet decided, creation. The lone object can be confirm of is that if the width of the gallery equals 2, then the space between the centre of the circle and the centre of the square equals $\sqrt{3}$. (Philip E. Harding, 2000)

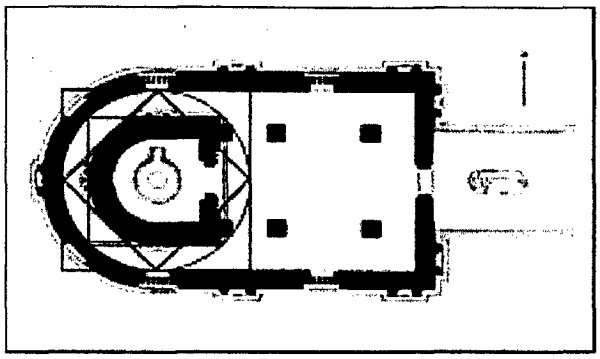


Figure 3.6 The usage of quadratum in Chika Mahakut

(Philip E. Harding, 2000)

Following, if an ad quadratum is made in the circle of the pradikhina path, it looks to find the external walls of the garbhagriha (Figure 3.6). The internal walls of the garbhagriha are a slightly complex. (Philip E. Harding, 2000)

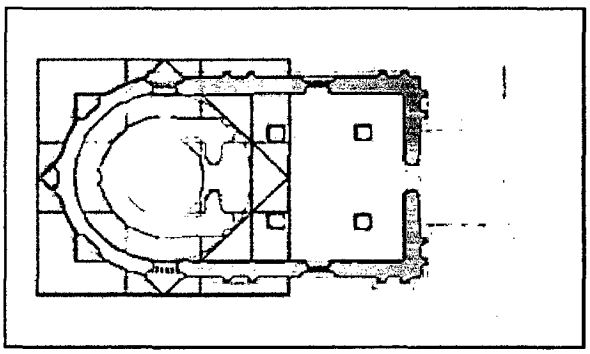


Figure 3.7 Way for finding the garbhagriha at Chika Mahakut

(Philip E. Harding, 2000)

Though, if additional ad quadratum is made on the external the preceding one, it can find a square that drops external the limits of the temple, which seems relevant. The central one third of this new square locates the inner walls of the garbhagriha (Figure 3.7). (Philip E. Harding, 2000)

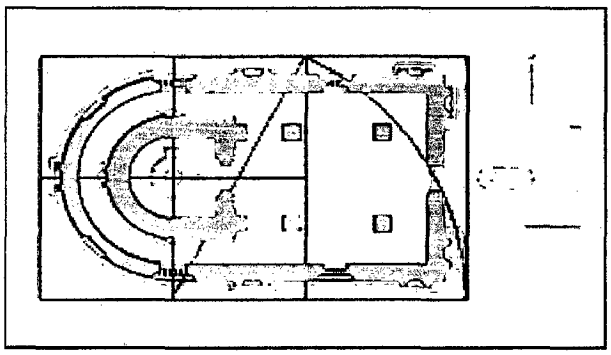


Figure 3.8 Chika Mahakut by a rectangle in the ratio of 1: Φ (golden section)

(Philip E. Harding, 2000)

Excitingly, if one divisions this new square in half, and takings the diagonal of one partial to draw an arc to the west, one can build a rectangle in the ratio of 1: Φ (the so-known as golden section), which looks to border, but not really touch, the temple walls (Figure 3.8). (Philip E. Harding, 2000)

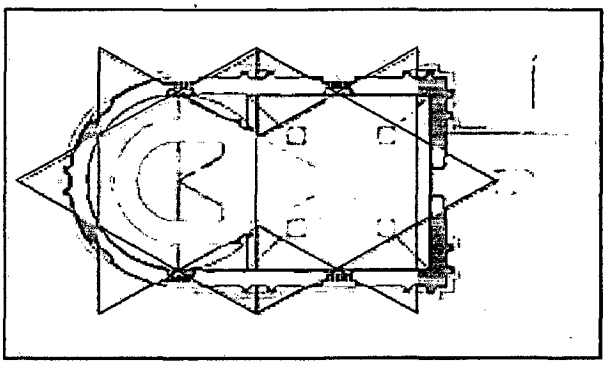


Figure 3.9 A triangular network on Chika Mahakut(Philip E. Harding, 2000)

One more structure of note at Chika Mahakut includes the apparent use of a triangular network. This is made off the first triangle it situated between the circle of the pradikhina pathand the middle of the mandapa and in results in two joining six-pointed stars (Figure 3.9). This network seems to find the middle-lines of both the windows and external places on the north and south sides of the sanctuary. Again, as before, it has probably observing after at an result of the creation the architects used rather than the construction itself. (Philip E. Harding, 2000)

3.2 The Durga Temple, Aihole

The so-known Durga temple at Aihole has been well considered over the years, and has even been the subject of a recent historiographical study (Tartakov 1997).

Its name does not come from being dedicated to the goddess Durga, but from its proximity to a fort or durga. There is no middle shrine image and many of the sculptures in the pradikhina pathare missing. However, based on inscriptions on an adjacent gate and some iconographic details, it is now generally considered to be an eighth-century, Early Western Chalukya temple dedicated to the god Aditya (Tartakov, 1997, p. 42).

It takes the form of an apsidal temple with inner and outer ambulatories a form early researcher's considered a derivative of Buddhist chaitya halls, but is now generally recognized as a traditional Brahmanical form. The northern-style shikhara looks a little incongruous, and some have speculated that it was a later addition, but it is now recognized as well within Early Western Chalukyan stylistic limits (Huntington 1985 p. 332).

The Durga temple is superior and more complex than Chika Mahakut but proves comparable kinds of relations. First, it will be valuable to start with some limits. It is researcher's doubt that the temple was really constructed with signs to ornamenting its geometry. Thus, some of the most important dimensions needed to start ornamenting its fundamental geometry are also some of the coolest to measure. (Philip E. Harding, 2000)

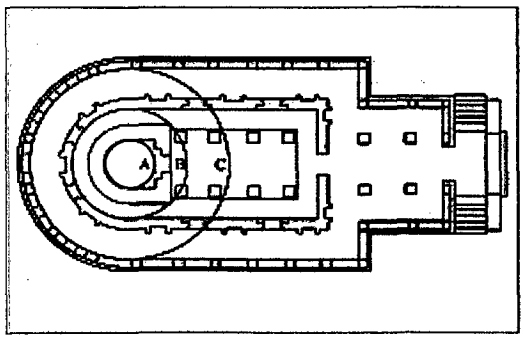


Figure 3.10 The three important circles of the Durga Temple.

(Philip E. Harding, 2000)

Inspection displays that certain of the Durga temple's walls are complex with base moldings, niche projections, and rests while others run conventional to the floor, imaginative by moldings or niches. It is just those wall sides deprived of moldings that are the most critical to the temple's sizes, and the coolest to amount. They are: the internal walls of the internal sanctum (and the diameter of the circle forming its western half), the interior width of the main hall (and the diameter of the circle forming the pradikhyana path continuous with the hall), and the width of the outer pradikhyana path (and the diameter of the circle of the outer pradikhyana path). When one has found the diameter of these three circles (identified in Figure 3.10 as A, B, and C), one can made the drawing to which the other part of the temple is calculated. (Philip E. Harding, 2000)

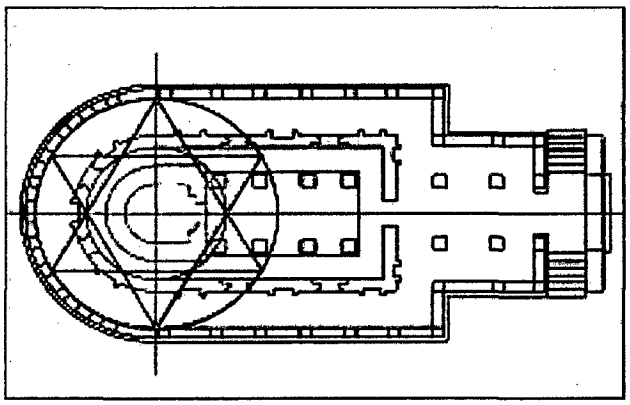


Figure 3.11 Ad Triangulum amongst the internal and outer ambulatories

(Philip E. Harding, 2000)

The easier fraction to locate is among internal and external ambulatory circles (Figure 3.11). If one made a six-pointed star, or ad Triangulum, in the outer circle then the point where the two triangles coincide finds circle B. This turns so flawlessly that the margin of error is less than one centimetre.

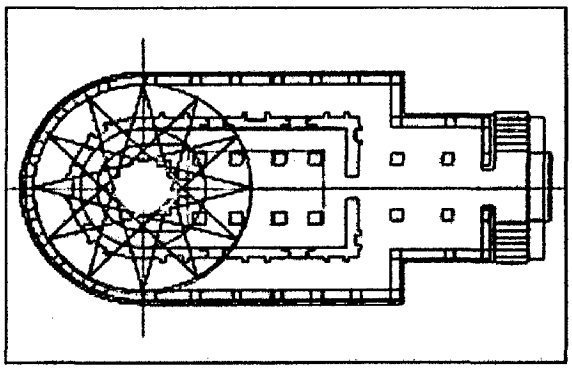


Figure 3.12 Twelve-pointed star located in the circle of the external ambulatory.

(Philip E. Harding, 2000)

Similarly, if one spaces a twelve-pointed star in between the circle of the external ambulatory, it will certain the circle of the internal sanctum with a margin of mistake of about one centimetre (Figure 3.12) and find simply the place of the garbhagriha. (Philip E. Harding, 2000)

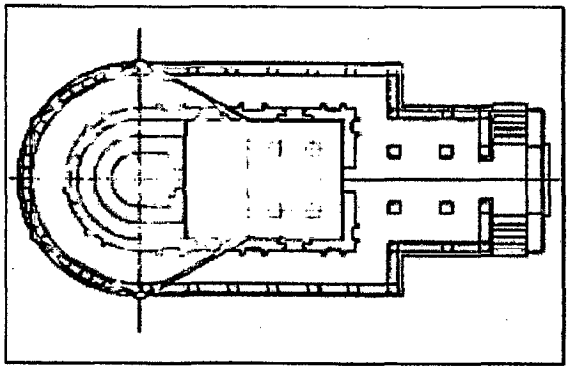


Figure 3.13 By means of a hexagon around the circle of the outer ambulatory

(Philip E. Harding, 2000)

If one places a hexagon about the outer pradikhyana path circle, then its eastern face divisions the hall at a point 3/5 from the entry. In fact, it found that the hall as a entire is in the ratio of 4x5 (Figure 3.13). (Philip E. Harding, 2000)

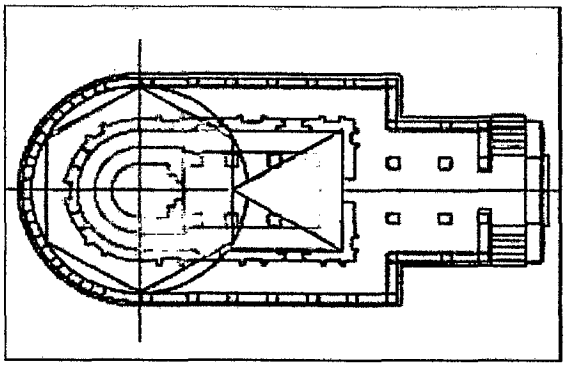


Figure 3.14 An equilateral triangle built-in between the main hall's internal east wall and a hexagon inside the circle of the external ambulatory.

(Philip E. Harding, 2000)

There is other method to locate the width of the hall that is even more precise than the 4x5 grid. If one pulls a hexagon inside the external pradikhyana path circle, then an equilateral triangle with sides of width of the hall each can be fitted with its top on the middle of the eastern face of the hexagon, and its base set on the internal eastern wall of the hall, as shown with a margin of error less than 1 cm. (Figure 3.14). (Philip E. Harding, 2000)

It seems unlikely that the builders actually used the constructions shown in Figures 3.13 and Figure 3.14, whereas they probably did use those shown in Figures 3.12 and Figure 3.13. Rather, researcher believes, they used some construction based on triangulation that produced the effects we can observe. (Philip E. Harding, 2000)

3.2.1 Conclusions

Though it would be filling to have the extra proof of a Sanskrit manuscript on temple geometry from the late 7th or early 8th centuries, this is not vital. The Durga temple exists as a well-construct main manuscript on the geometry of the Early Western Chalukyas. Their information of geometry was constructed into the construction in such a way that anybody

with a calculating rod and information of elementary geometric drawings could interpret. This type of geometry does not seem to be fixed in Vedic altars or the Vastupurushamandala. In its place, the geometry seems connected to the kind of geometric yantra used in tantric thought. Mandalas joining such yantra do not live from this period, and later mandalas that do join such instruments do not seem to be troubled with their geometric belongings in the similar method as the Durga temple.

However it is fairly likely whichever that the usage of geometric yantra in thought grew out of a form of geometric information established in this period, or else that the way taken by this scheme of geometry was determined by the usage of such yantra in thought. There is somewhat nearly worldwide about the usage of holy geometry in old-style holy architecture about the world, but the representative mass given to a six, eight, five or twelve-pointed star might differ.

3.3 Geometry and the Kandariya Mahadev temple, Khajuraho

3.3.1 Introduction

The belongings of self-similar replications, excess of textural particulars, and actions of form in architecture have been considered by fractal geometry. Conceived by Mandelbrot in 1970s, fractal theory has been widely adopted for the analysis and synthesis of architectural and urban designs. Mathematical features for the conception of fractal geometry have been called as iteration. Different rules of iteration create dissimilar fractal figures. The belongings of endlessness in the procedure of iteration make fractal character as the miniature of eternity. (Md Rain et al., 2007)

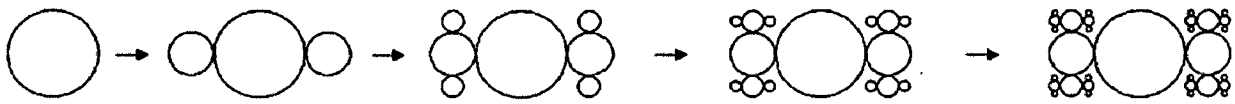


Figure 3.15 Changes of a fractal figure from a single circle by the iteration having some certain rule

Source: Md Rain et al., (2007)

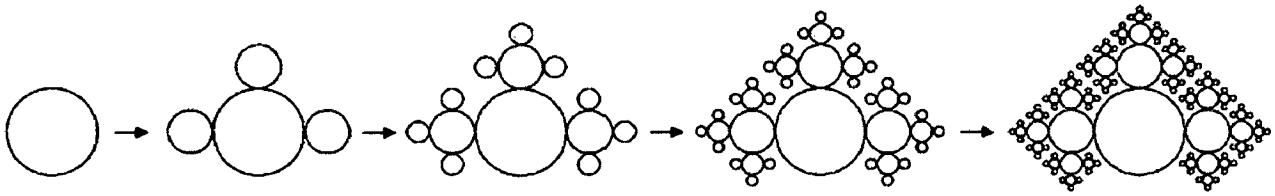


Figure 3.16 Changes of different fractal character from the same circle but by the iteration having changed rule

Source: Md Rain et al., (2007)

Though engaged in numerous arenas for changed roles fractal geometry has been messy particularly, in architecture as a linguistic which interprets the beauty of complication as well as the thoughts of architects. It also reproduces the process of universe and its vitality

decided the structures. Hindu temple is one of the best samples of those fractal buildings which were built in the past, far before than the birth of fractal theory and manifested the religious cosmic visions. Here it mainly deals with the fractal geometry that performs the main role for transforming or establishing the Hindu cosmology and philosophy into the divine diagrams (so-called vastu purusha mandala) and then to the structure. (Md Rain et al., 2007)

3.3.2 Elements of Kandariya Mahadev temple, Khajuraho

This temple was made in the central part of 11th century when Hindu temples had reached the uppermost part of mature phase design. Throughout the period, all types of Hindu fine art with music, sculpture and dance, were intermixed in temple designs. (Md Rain et al., 2007)

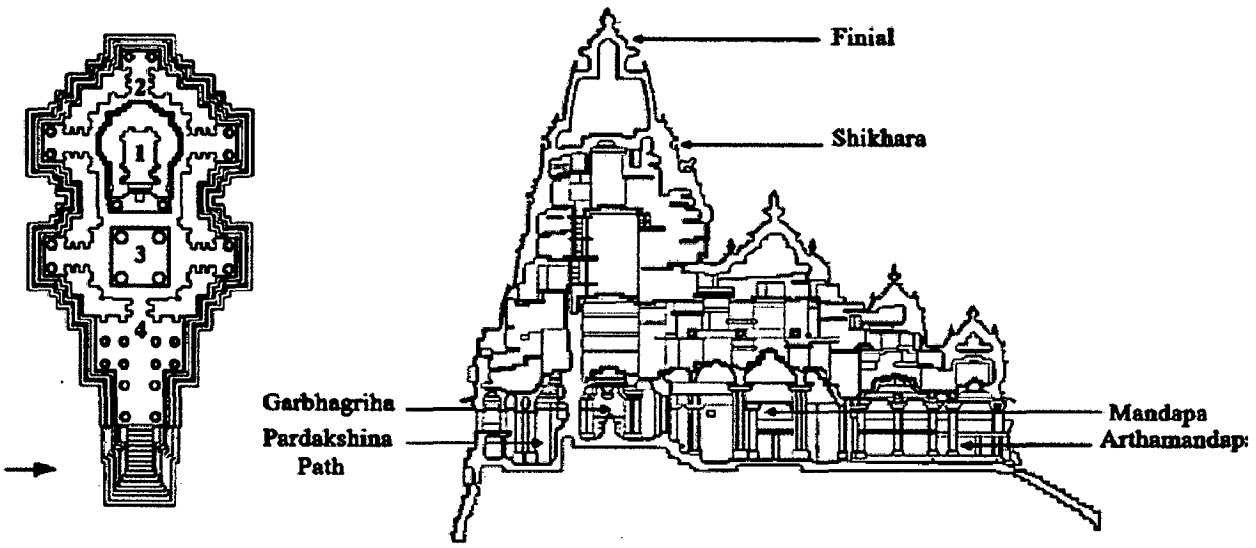
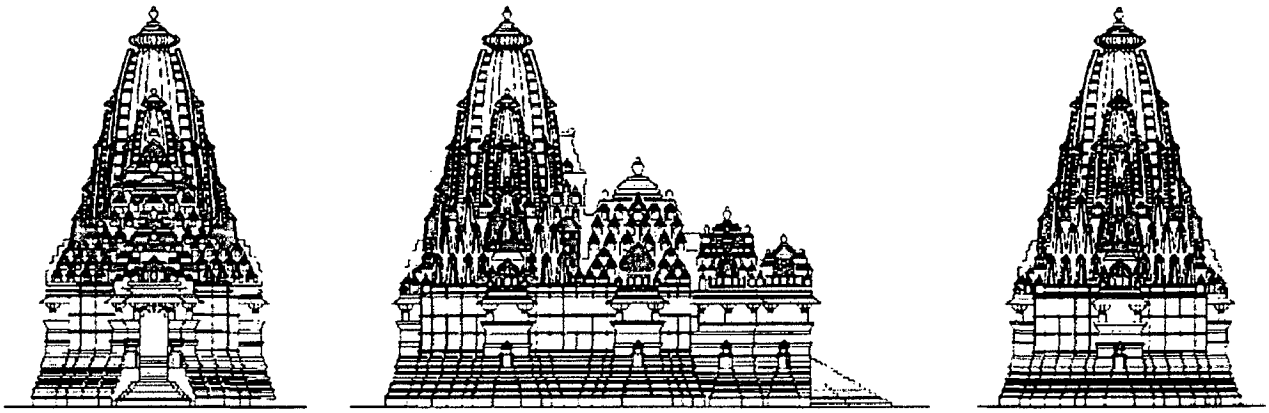


Figure 3.17 Plan and Section of Kandariya Mahadev temple, Khajuraho

Source: Md Rain et al., (2007)

Kandariya Mahadev temple has tallness of about 31 m. It is elevated above a plinth which made the temple build form holiness and colossal. The construction is 30.5m long and 20m wide, confronted to the east to greed the first sun rays. The entire construction contains of four major parts (Figure 3.17): as Garbhagriha, i.e., shrine where the main goddess has been retained, pradikhyana path, i.e., pradikhyana path having three sides' gallery carrying airing and bright to the inner hall, Mandapa, i.e., columned meeting hall having two sides gallery and Artha mandapa, i.e., incoming portico. (Md Rain et al., 2007)



(Front elevation) (North Elevation) (Back Elevation)

Figure 3.18 Different elevation of Kandariya Mahadev temple, Khajuraho.

Source: Md Rain et al., (2007)

The greatest prominent element of the temple is its haughty curved towers above the garbhagriha. It is recognized as shikhara. Shikhara is capped by an amalaka, 15 a ribbed circular theme, and a pot finial, familiar as the kalasha, a holy pot in which the most valuable solution amrita had been situated. Here in the shikhara, the union of the form of lotus blossom and that of foothill has been frozen into the form of many recursive models. Copies of the shikharas are the most separate features in the Kandariya Mahadev temple. Like external, internal of the Kandariya Mahadev temple is explained with decoration. At external it has more than 646 numbers of motives whereas 226 numbers of motives were carved in internal. There is no border between internal and external in terms of decoration and describing. (Md Rain et al., 2007)

3.3.3 The Foundation and the Floor Plans

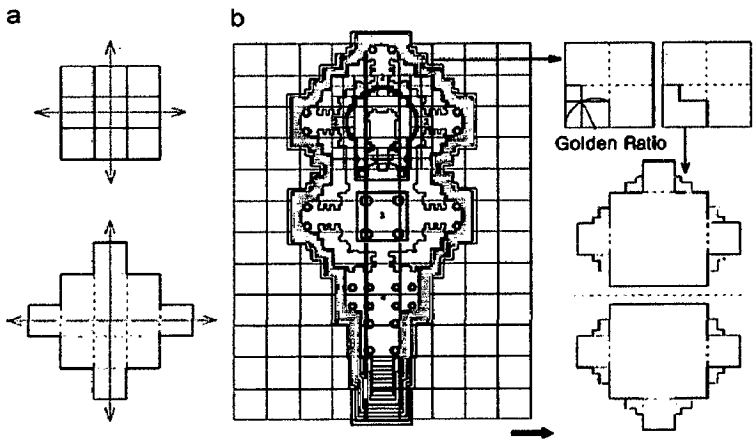


Figure 3.19 Plan and its derivation of Kandariya Mahadev temple, Khajuraho

Source: Md Rain et al., (2007)

Figure 3.19 shows:-

(a)- Top: Squares mandala. Bottom: sides of a 9-squares mandala are bumped up 1 pada along the cardinal directions.

(b)- Left: plan of Kandariya Mahadev temple. Right up: external corner of 1 pada and development of an element having golden proportion with a quarter of the pada. Right bottom: external corner of figure filled by the newly born element from a pada in its three sides and overlapped with the self-similar but opposite pattern to get final fractal patterned plan of the temple. (Md Rain et al., 2007)

Mahadev temple, in this symmetrical process one lesser square inside the network of mandala, i.e., one pada has been taken as one element. The external energies produced from the middle of mandala have bounced up the center of all side one unit along the four ways (Figure 3.19a) as the first iteration. Then all the anew instinctive external angles have been full with twisting parts which are advanced from the quarter of one pada. Each twisting part is the mixture of a golden rectangle and a square instinctive from the same rectangle. After satisfying the external corners, it has got the fractal design which is overlay with a self-similar design, planned for the mandapa, lengthways the axis of entry to the shrine. Lastly, by projecting the entering element along the same axis, it has achieved the final form (Figure 3.19b).

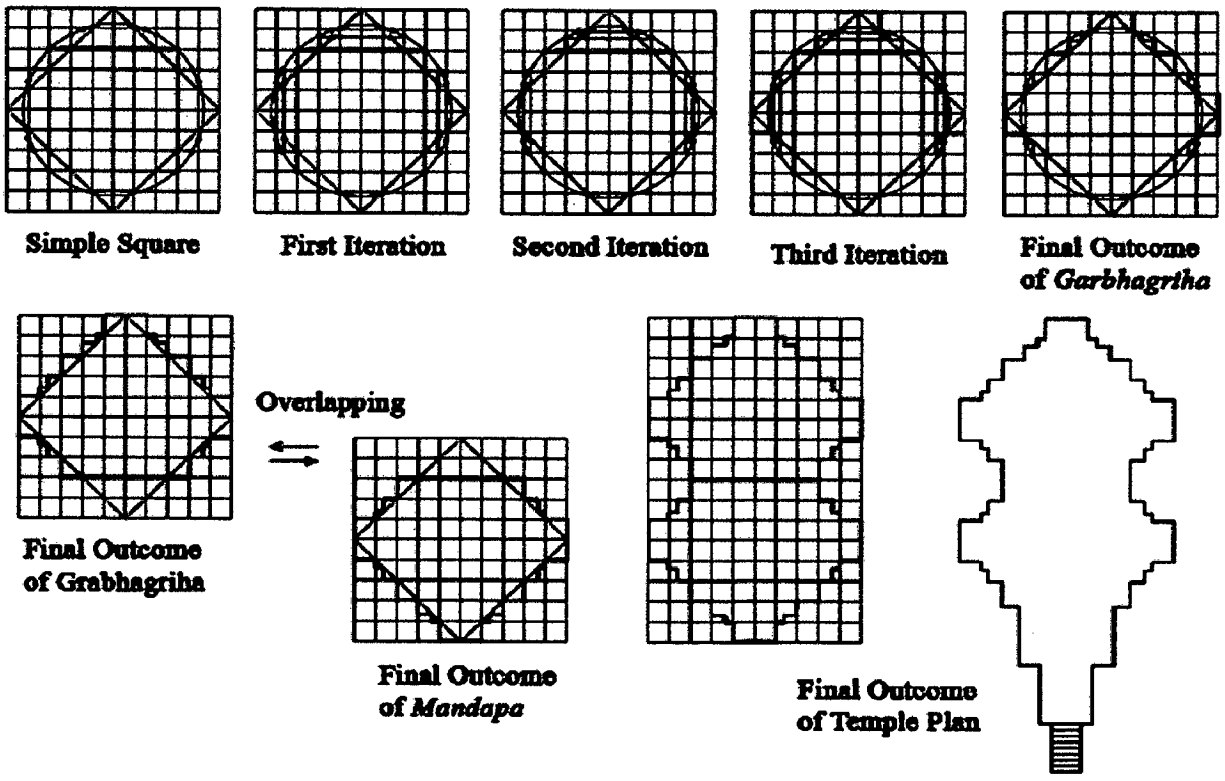


Figure 3.20 Symmetrical process of mandalas of Kandariya Mahadev temple.

Source: Md Rain et al., (2007)

Here every repetition has been started from the connection among a side of the diagonal square and the last repeated line, and stops at the connection among grid line and the circle. Lastly, the repetition stops at the junctions of the diagonal square (Figure 3.20). The

elongations of the previous repeated procedures portray the four fundamental directions. On the temple construction, these last likely fragments are exposed verandas, represents the fundamental directions. (Md Rain et al., 2007)

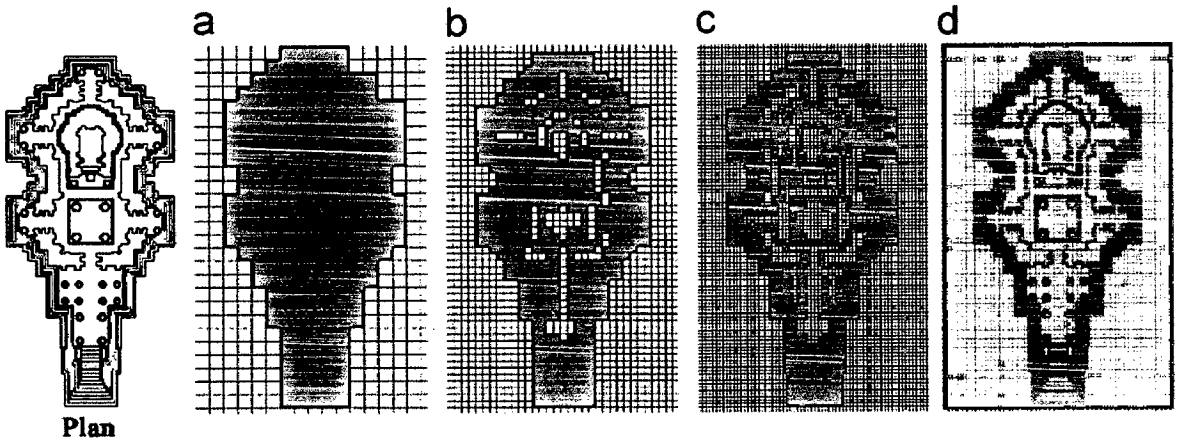


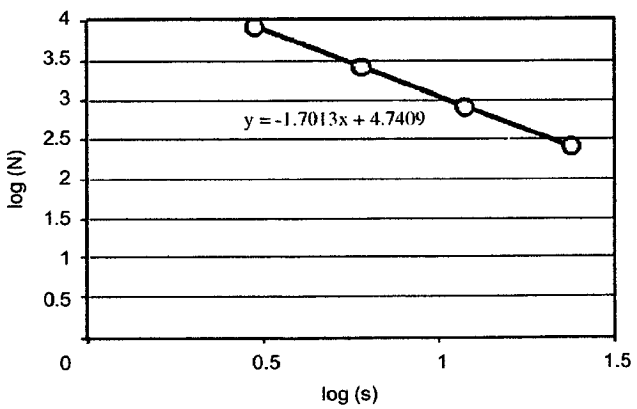
Figure 3.21 Box calculating process of the Kandariya Mahadev Temple

Source: Md Rain et al., (2007)

This fractal process of the plan of Kandariya Mahadev temple made it fractal in terms of unevenness and uneven form. Not only the external plan but also the plan of middle shrine is also the balance of external plan, which made entire the plan as fractal. For examining the unevenness of the plan of Kandariya Mahadev temple, **'Box-Counting Demonstration'** software has been established on the imageries of plan by having its size 50mmX70mm having resolution 80 pixels/ cm and grid sizes 24, 12, 6 and 3 (Figure 3.21). (Md Rain et al., 2007)

Table 3.1 Calculating Fractal Dimensions of plan through Box Counting Demonstration

Step	Grid size (*S*)	Marked boxes (*N*)	Log (*S*)	Log (*N*)
1	24	249	1.380	2.396
2	12	806	1.079	2.906
3	6	2554	0.778	3.407
4	3	8627	0.477	3.936



Graph 3.1 Between Log (S) and Log (N) for garbhagriha of Kandariya Mahadev temple, Khajuraho.

(Md Rain et al., 2007)

From the gradient, exposed in Graph 3.1, it is got that it has fractal measurement 1.70 which portrays its high degree of unevenness or particulars. The flat curve as a line in the graph defines the consistency of its unevenness. This degree of unevenness or particulars of plan has been emphasized in the construction to make the entire construction difficult and coarse. (Md Rain et al., 2007)

3.3.4 Elevations of Kandariya Mahadev temple, Khajuraho

In the structure of almost all Hindu temples, sthapati (Architect) took the mountain as a model of fractal object where self-similar mounts are repeated and recurred, pointing towards the sky. They made the rising towers, shikhara on the temple structure by copying the form of mountain which dominates on the earth, and the replicas of soaring towers on shikhara depict the series of repetitive universes. Even the accurate meaning of shikhara is also mountain. Besides, mythical mount meru was also the aim to adopt the form of a mountain in the structure of Hindu temples to manifest the cosmic events. (Md Rain et al., 2007)

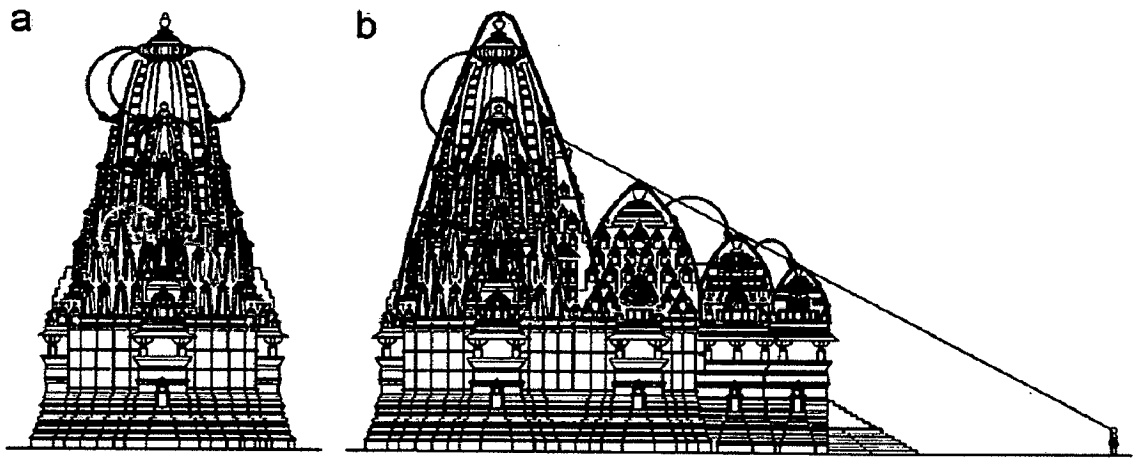


Figure 3.22 Elevations of Kandariya Mahadev temple, Khajuraho

Source: Md Rain et al., (2007)

Figure 3.22 shows:-

(a) Replications of Shikharas and their features in the shikhara; and

(b) Entire shape of shikhara is repetitive in a portion within another portion (noticeable by red colour). Replications of Shikharas above the mandapa (noticeable by green colour) make angle for rising eye measure to the main shikhara. (Md Rain et al., 2007)

In the case of Kandariya Mahadev temple, the main shikharas above the shrine is repetitive at its four edges and the similar procedure of replication is continuous in each recently born smaller shikharas, and once more this procedure repetitive in the previous newly born smaller shikharas (Figure 3.22). At the same time smaller shikharas are repetitive on the form of main shikhara in which the entire shikhara attains such an preparation where one can

simply feel the entire in a portion within another portion. Overhead the assembly gallery, i.e., mandapa the main shikhara is repetitive within its personal body and at the same time its entire body is repetitive along the axis of mandapa to the appearance. This procedure of repetitive shikharas overhead the mandapa (assembly gallery) and arthamandapa (arrival portico) is such that it made to change up one's eyes habitually to the main shikhara above shrine and from that mobile up through the summit of finial to the axis of cosmos. This highest point of the shikhara above sanctuary is believed as the ultimate point of deliverance from the somatic world. (Md Rain et al., 2007)

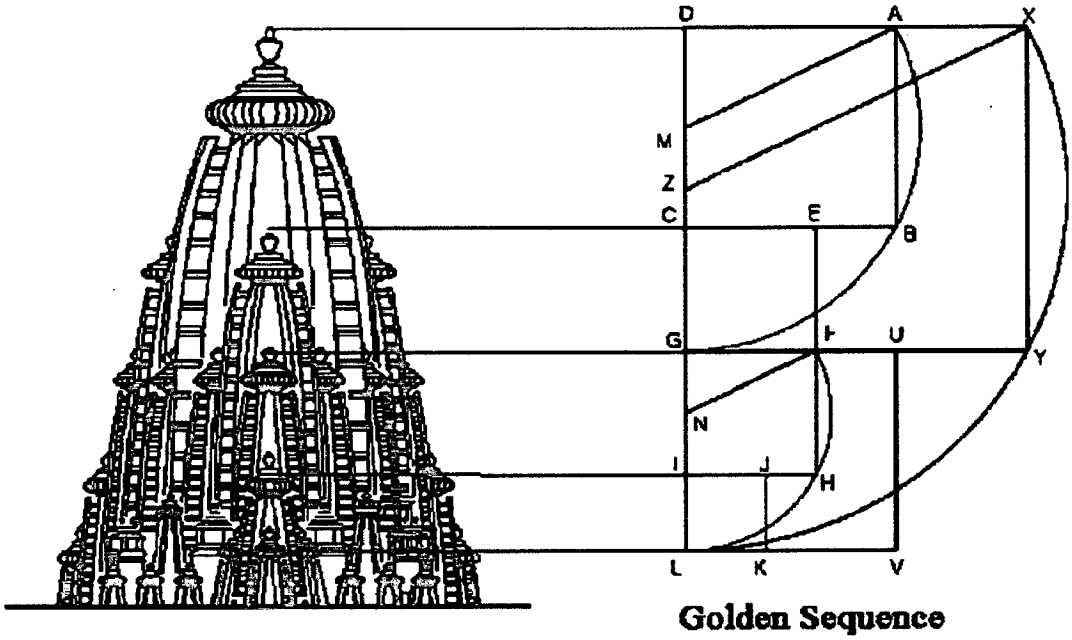


Figure 3.23 Shikharas of Kandariya Mahadev temple, Khajuraho follow the rule golden sequence.

Source: Md Rain et al., (2007)

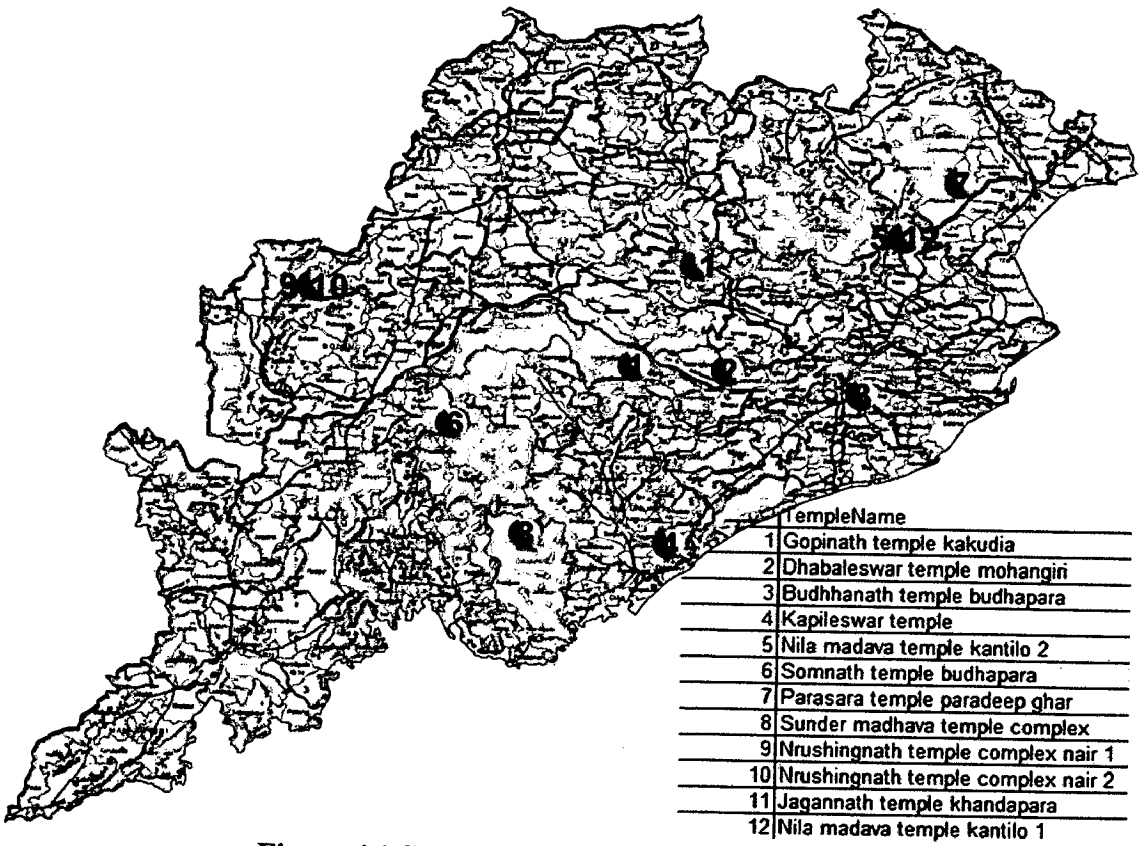
It goes out that the stratification of the shikharas above the shrine shadows the golden ratio as the fundamental law for procedure. Let's take the measurement between two tops of main shrine and second shrine as a side of a square (ABCD). Then, an arc is made whose middle is situated at M point and radius is MA (Figure 3.23). The arc traces the top of third tower and crosses the extension of a line DC at point G. Then, a square (EFGC) is made by having a line CG as a side. At the present the square (EFGC) is imitative as FHIG whose side GI regulates the measurement among third shikhara and fourth shikhara. Again a second arc is made from a point O by having the radius OF which touches the peak of fifth shikhara. It generates a new square (JKLI). Remarkably, the peaks of alternative shikharas, i.e., the peaks of first, third and fifth towers also follow the golden ratio, where the measurement among peaks of first and third shikharas regulates the square (XYGD) and that of third and fifth shikharas regulates the square (UVLG). . (Md Rain et al., 2007)

CHAPTER - 4

RESEARCH DESIGN

4.1 Introduction

As Orissa was also known as Kalinga and Utakal on later stage, its culture and heritage was famous from centuries. Orissa have thousands of temples existing on present date but some are officially conserved but others are still left due to some reasons like political reasons, mode of conservation evaluation etc. But each and every temple of Orissa has its own identity. To identify such quality and parameters this survey and questionnaires has been conducted. The main basis of conducting this survey was to identify the evolution process of Orissan temple architecture through shape and geometrical analysis. For that the archaeological survey of India, Orissa chapter has conducted many Orissan measured drawing in the year 1995-96 under the guidance of Ar. Akshya Behuria, he is presently having the post of IIA chairman, Orissa Chapter.



	TempleName
1	Gopinath temple kakudia
2	Dhabaleswar temple mohangiri
3	Budhhanath temple budhapara
4	Kapileswar temple
5	Nila madava temple kantilo 2
6	Somnath temple budhapara
7	Parasara temple paradeep ghar
8	Sunder madhava temple complex
9	Nrushingnath temple complex nair 1
10	Nrushingnath temple complex nair 2
11	Jagannath temple khandapara
12	Nila madava temple kantilo 1

Figure 4.1 Selected Temple from Orissan Map

Source: orissagov.in/portal, Author

4.2 Selection of Sample

Selection of temple from a number of temples has been simplified by the arranging them through their date of construction. As from the literature it has been finalised that

Orissan temple have distinguished four different phases and according to them elements of temples varies from time to time. There is another process has been conducted as the temples were built from different regions and have some different quality of appearance. When plotted the temples location on the physical map available it has been concluded that the major temples of Formative phase are found on the central Orissa, the Transition Phase are found in coastal Orissa region, the Mature Phase has been found in southern and northern Orissa and the phase of decadence temples has been found in eastern costal and western Orissa. That means present Orissa have all parts rich of Orissan temple architecture form and culture. It has been observed that many temple complexes have mixed phases due to time of construction from different kingdom to different. Many temples have either pond or river nearby. All the selected temples are described below with their location, description and some dimensional data which are available from the archaeological survey of India.

4.3 Design of Survey Schedule

A survey has been conducted for the selected temple. The necessary data has been extracted from the collected data from these sample temples. Datas which are required for the different kind of analysis has been collected for dimensional analysis, relation with vastu purusha mandala, relationship with fractal geometry and the visual analysis. For such kind of data collection a survey schedule has been designed to collection of data with an ease. In this schedule there has been inclusion of the location, age of construction, various temple elements' physical dimensions, necessary photographs, and data regarding significance of temples in the Historic, Cultural, Social & Associational data that are related to selected temple. Physical Description like Surrounding, Orientation Architectural features, Raha niche, and parsva devatas, Decorative features, Building materials, Construction techniques, Styles, Special features (if any) etc. has been collected to know the evolutionary process of the Orissan temple Architecture. The detailed schedule is attached in the annexure 1. And the detailed dimensional drawings are attached in annexure 2.

4.4 Data Collection

4.4.1 Gopinath temple, Kakudia

The Kshira Chora Gopinath temple is situated in Remuna. It is a little town located 9-km east of Balasore, about halfway between Calcutta and Puri. The name "Remuna" is resulting from the word "Ramaniya" which means very good-looking.

Figure 4.2 location of the Gopinath Temple

Source: Google earth

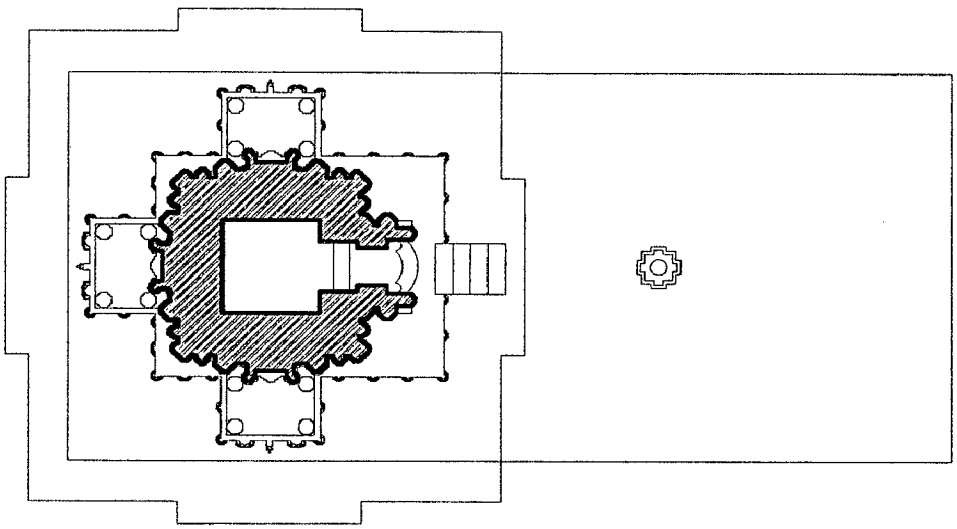


Figure 4.3 Plan of Gopinath Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Gopinath temple is located in the Puri district and the temple complex is very near to the Mahanadi River. The temple has only garbhagriha and it is predicted the temple is of near 5th century AD. As from the literature study it has been consider that the temple is coming under the formative phases (6th century to the first half of the 9th century) of Orissan temple architecture.

The temple has overall length of 35.419M and width of 20.170M. Total the built-up area of the temple is 68.9 Sq.M. and the wall area of the temple is 43.85 Sq.M.

The temple has only garbhagriha present and the internal length of garbhagriha is 3.660M and diagonal length is 5.175M. Hence the internal area of the garbhagriha is 13.39 Sq.M. the total height of the garbhagriha (Rekha Deul) is 20.615M. And the height further divided into four parts as Pitha, Bada, Gandi, Mastaka and their heights are 1.365M, 3.510M, 11.340M, and 4.440M respectively.

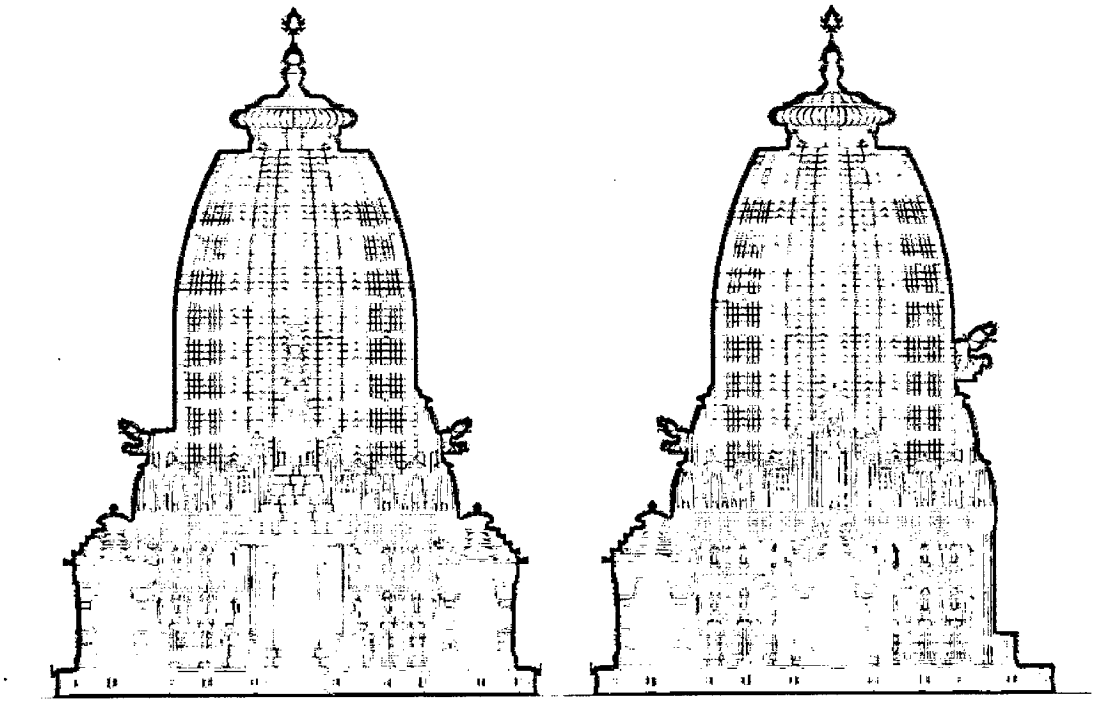


Figure 4.4 Elevations of Gopinath Temple
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

4.4.2 Dhabaleswar temple, Mohangiri

Dhabaleswar Temple is dedicated to the worship of Lord Shiva and stands on an island in the middle of the river Mahanadi at a distance of 37 kilometres from the city of Cuttack, in the exotic island of Dhabaleswar. It is believed that to save a devotee from disaster, Lord Shiva had turned a black bullock into white. On the full moon day of Kartika, lakhs of devotees gather here to observe Bada Osha festival.

The temple has only garbhagriha and it is predicted the temple is on nearly 6th century AD. As from the literature study it has been consider that the temple is coming under the formative phases (6th century to the first half of the 9th century) of Orissan temple architecture.

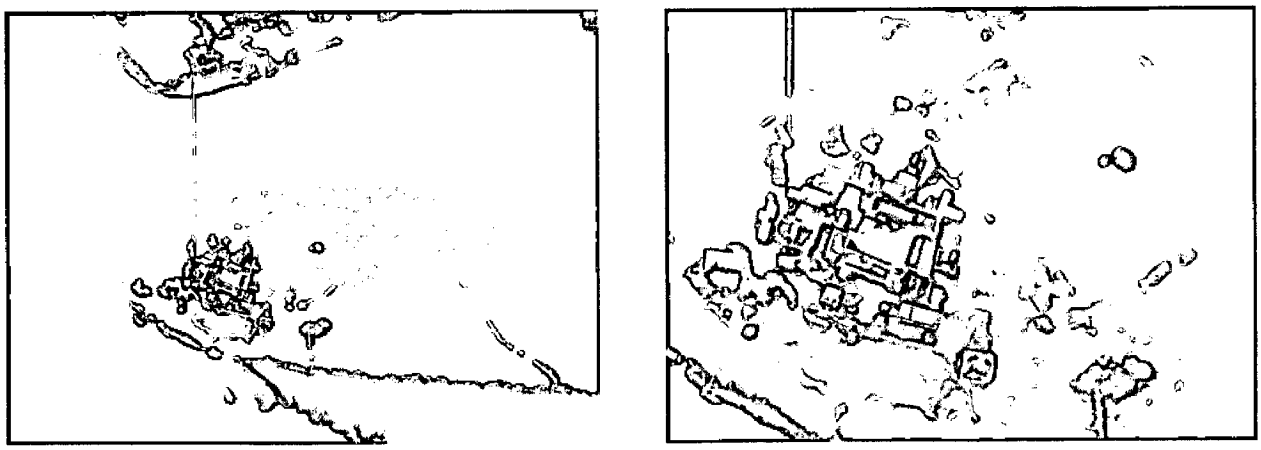


Figure 4.5 Location of the Bridge and the Dhabaleswar temple location
Source: Google earth

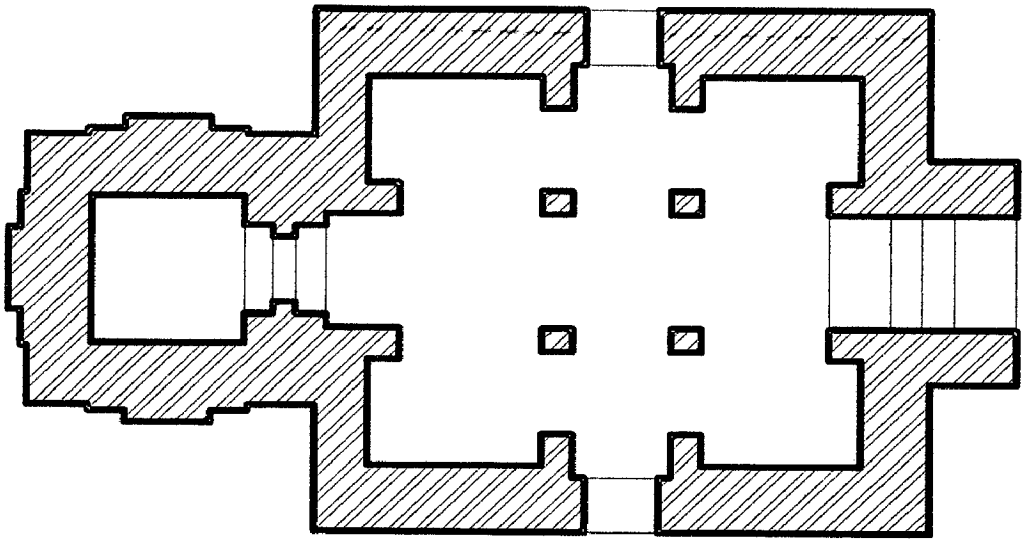


Figure 4.6 Plan of Dhabaleswar Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The temple has overall length of 12.495M and width of 6.75M. Total built-up area of the temple is 68.06 Sq.M. and the wall area of the temple is 23.64 Sq.M. The temple has only garbhagriha and Jagamohana present and the Natyamandapa and Bhogamandapa were not constructed.

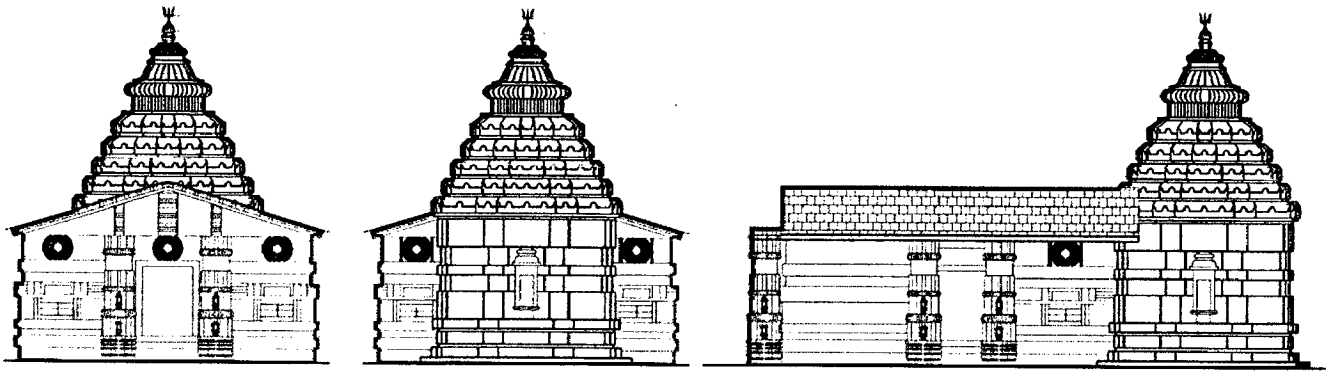


Figure 4.7 Front, Rear and Right Side Elevation of Dhabaleswar Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The internal length of garbhagriha is 1.905M and diagonal length is 2.695M. Hence the internal area of the garbhagriha is 3.62 Sq.M. the total height of the garbhagriha (Rekha Deul) is 8.610M. And the height further divided into four parts as Pitha, Bada, Gandi, Mastaka and their heights are 1.065M, 2.580M, 2.415M, and 2.550M respectively.

The Jagamohana has the inner length of 5.030M and diagonal length is 7.915M. Hence the inner area of the Jagamohana is 30.72 Sq. M. total height of the Jagamohana is 4.360M and it is divided into sub parts as Pitha, Bada, Gandi, Mastaka and their heights are 0.315M, 0.685M, 2.175M, 1.185M respectively.

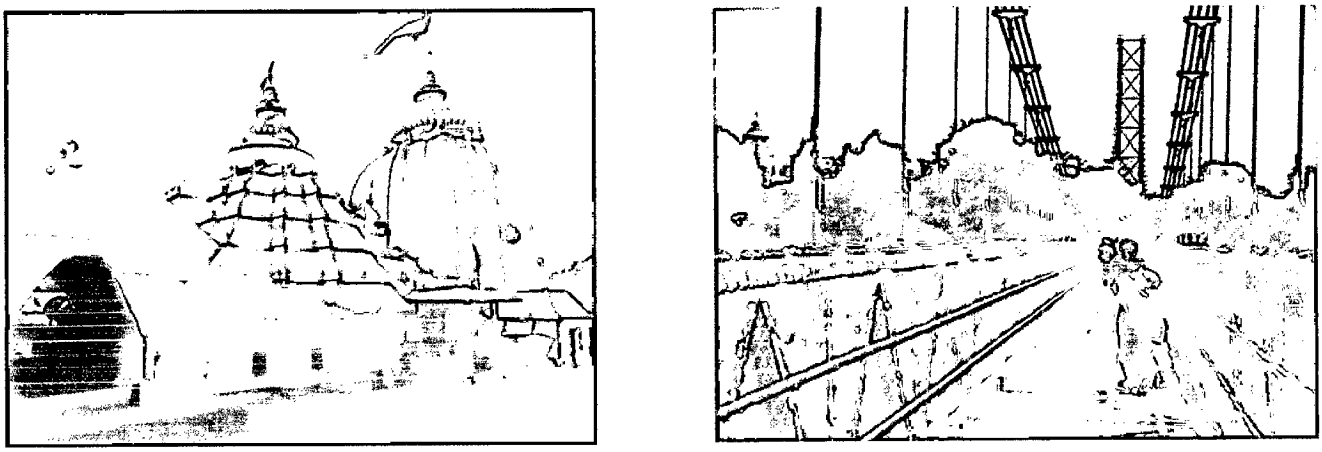


Figure 4.8 Existing Dhabaleswar Temple and connecting bridge to the temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The temple, located on the banks of the River Mahanadi, is blown up with stone carvings that date back to the early 6th century. The serene ambiance, in which the temple is situated, inspires spiritual feeling among one and all.

4.4.3 Budhhanath temple, Budhapara

Budhhanath temple, Budhapara is located in the district Sambalpur which had nearly constructed on the 8th century AD. Under the calculation of the phases of Orissan temple architecture it comes under Formative phase.

Figure 4.9 location of Budhhanath temple, Budhapara

Source: Google earth

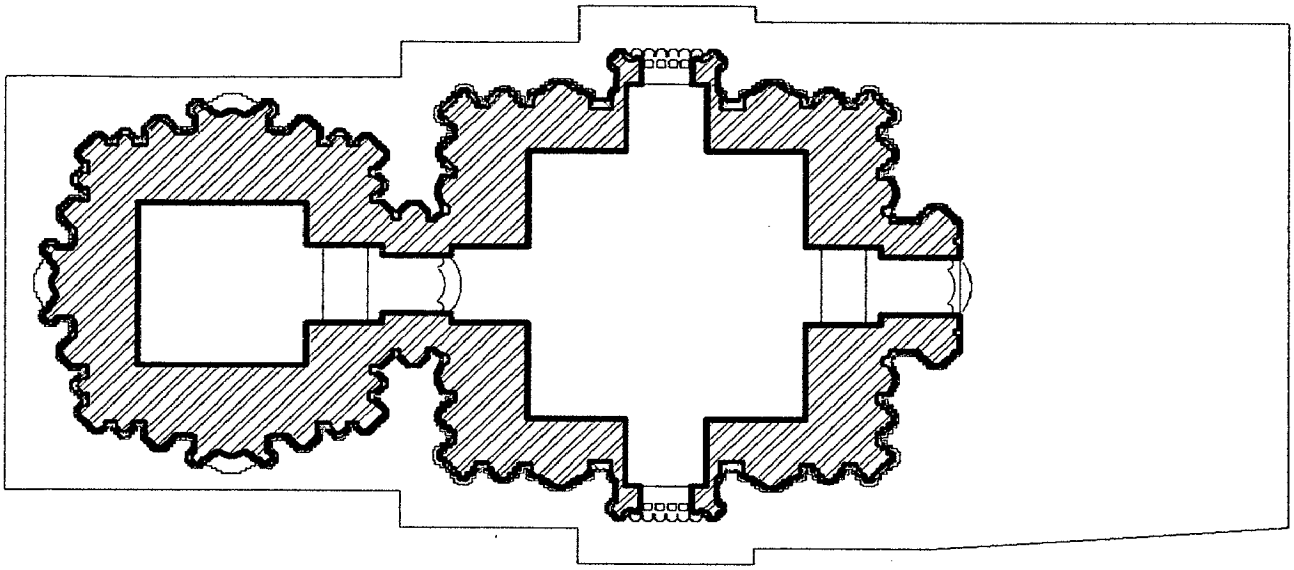


Figure 4.10 Plan of Budhhanath temple, Budhapara

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Temple is located in the Budhapara which is an artistic village from centuries. The main concept of the village is to produce temple oriented products. It's a worth seeing to the village and the temple complex. The temple has only garbhagriha and Jagamohana present

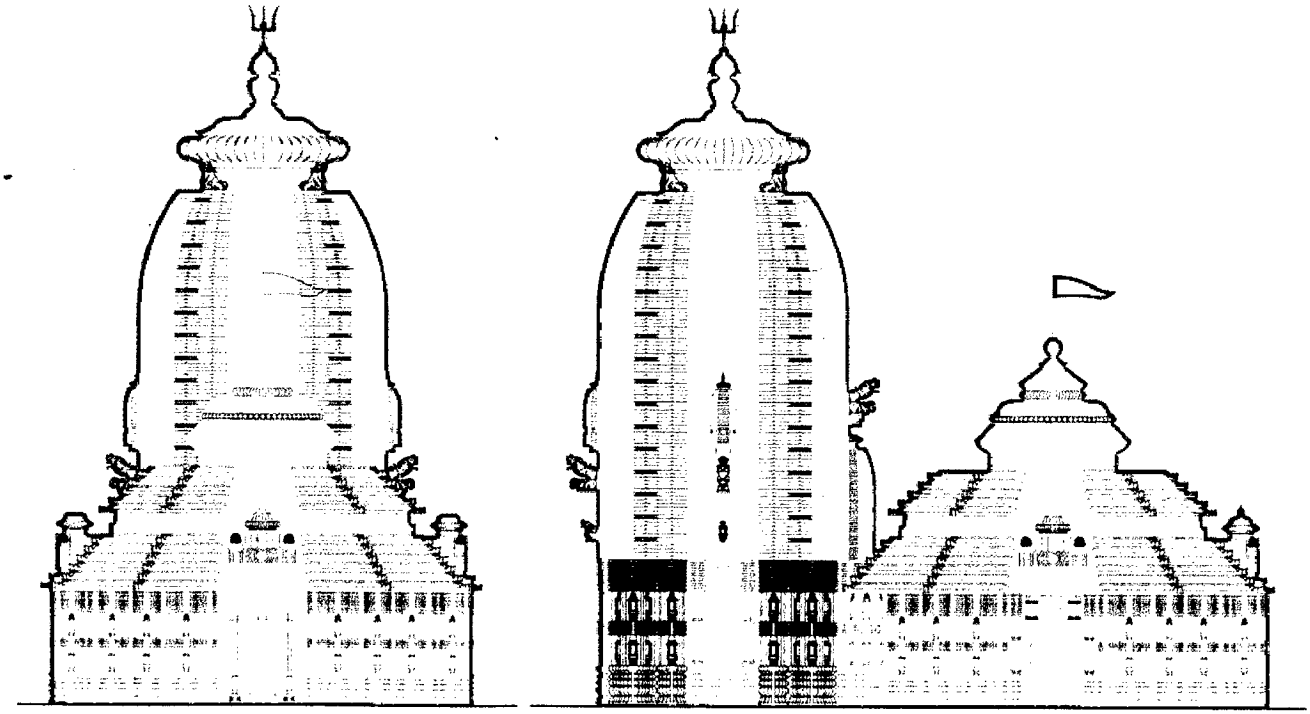


Figure 4.11 Front and rear Elevation of Budhhanath temple, Budhapara

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 12.170M and width is 6.755M. The overall built-up area of the temple is 68.06 Sq. M. and the wall area is 23.64 Sq. M.

The Rekha Deul has square shape ad its side dimension is 2.590M, the diagonal length is 3.665M and the inner area hence found to be 6.70 Sq. M. the total height of the Rekha Deul is found to be 15.575M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.910M, 2.335M, 8.210M and 4.120M respectively.

The Jagamohana has a square base and its side dimension is 4.265M, the diagonal length is 6.035M and hence the inner area of the Jagamohana is found to be 23.65 Sq. M. the height of the Jagamohana is found to be 9.185M. The total height is also divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.715M, 1.845M, 4.295M and 1.380M respectively.

4.4.4 Kapileswar temple

After the Gangas, the glorious period of temple- building activities in Orissa terminated, but the spirit lingered during the succeeding period of Suryavamsi ascendancy which also witnessed the erection of some notable temples in Orissa. The partly destroyed porch standing near the papanasini tank still bears an inscription referring to the reign of Kapileswar (10tn century AD). The striking female figures adorning the partly ruined porch purely represent the rudimentary imitations of their earlier prototypes. The inscribed slab that contains the elephant procession and an image of Nataraja carved on the northern wall of the structure, represent fine specimens of art of this period. In the close environs of Kapileswar is a pancharatha temple and is similar to the Mukteswar of Bhubaneswar. It niches, the Naga and Nagini columns, scroll works, Alasa-kanyas and half amalakas provide obvious evidence that the temple was built during the tenth century A.D. Hence according literature calculation it comes under the Mature Phase of Orissan temple architecture.

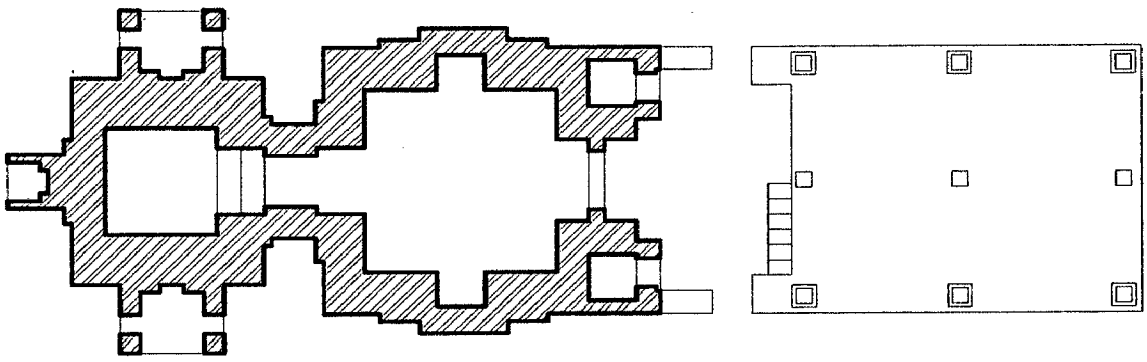


Figure 4.12 plan of 4.5 Kapileswar temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

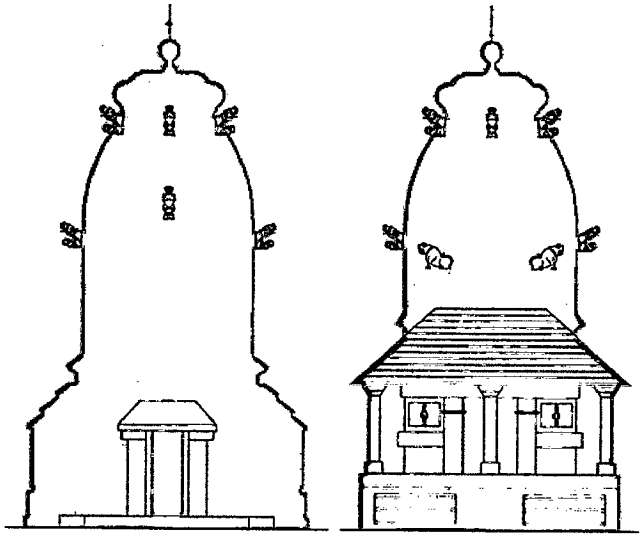


Figure 4.13 Front and Rear Elevation of Kapileswar temple
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

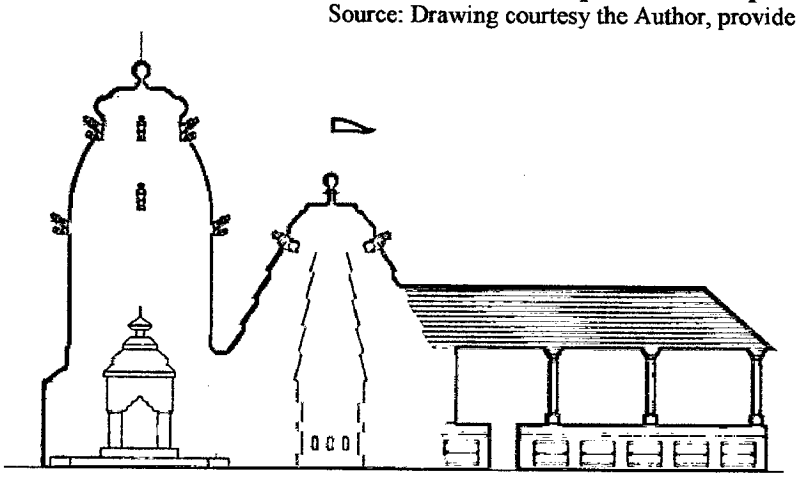


Figure 4.14 Right Side Elevation of Kapileswar temple
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

Figure 4.15 location of Kapileswar temple
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 21.665M and width is 6.860M. The overall built-up area of the temple is 58.59 Sq. M. and the wall area is 28.20 Sq. M.

The Rekha Deul has square shape ad its side dimension is 2.135M, the diagonal length is 3.015M and the inner area hence found to be 4.55 Sq. M. the total height of the Rekha Deul is found to be 13.535M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.760M, 2.970M, 6.400M and 3.405M respectively.

The Jagamohana has a square base and its side dimension is 3.660M, the diagonal length is 5.175M and hence the inner area of the Jagamohana is found to be 16.83 Sq. M. the height of the Jagamohana is found to be 9.185M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.455M, 2.360M, 3.910M and 2.460M respectively.

4.4.5 Nila Madava temple, Kantilo 1

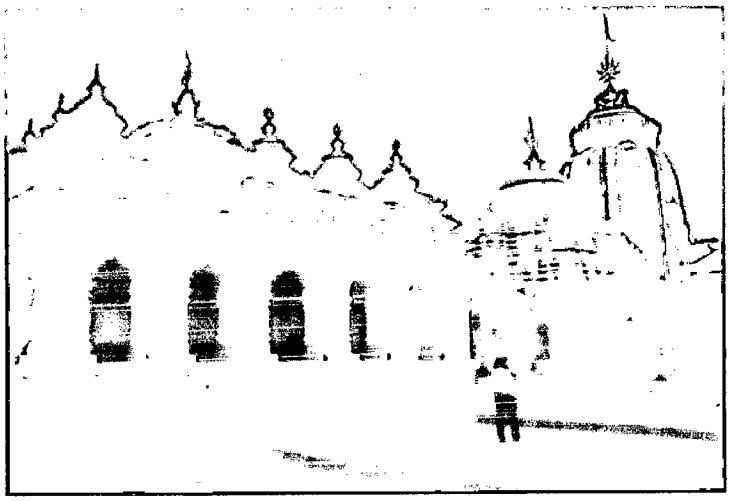


Figure 4.16 View of Nila Madava temple Kantilo

Source: Photograph courtesy the Author

Kantilo Nila Madhava Temple is standing elegantly on the banks of the river Mahanadi, Kantilo is famous for the temple of Lord Nila Madhava on top of the twin hills with a surrounding of green forests. Lord Nilama occupies a preeminent position in the cult of Lord Jagannath. A permanent flow of holy water from the feet of Lord Nila Madhava Lord Siddheswar is the highlight of the place. Kantilo has the most popular picnic spots in Orissa and is 100 km from Bhubaneswar.

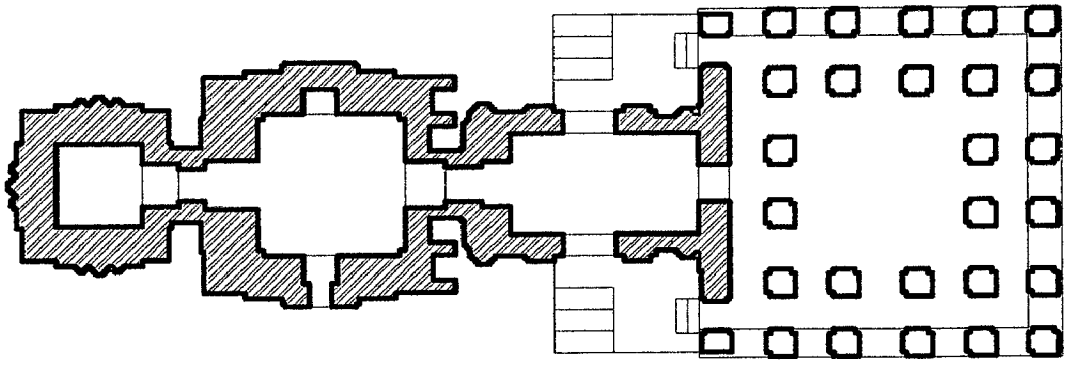


Figure 4.17 Plan of Nila Madava temple Kantilo 1

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

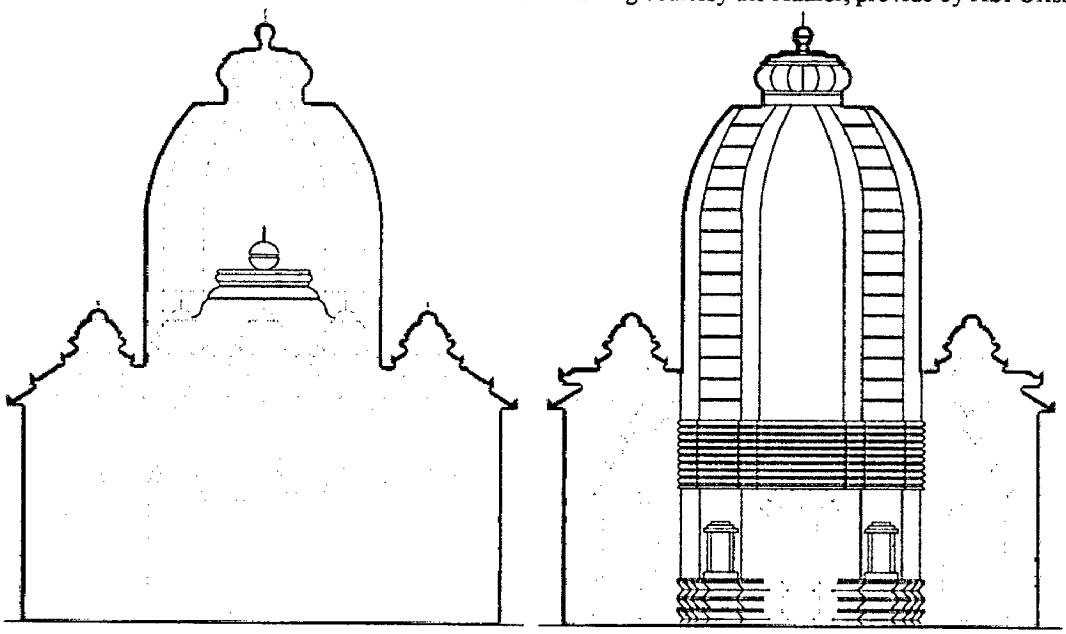


Figure 4.18 Front and Rear Elevations of Nila madava temple Kantilo

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

Nila Madava temple complex was built on the 10th century AD but later on some addition in the main temple has been done like Natyamandapa and Bhogamandapa are added in the later period i.e. in the 15th century. Hence the data collected and analysed from main temples is supposed to be at the phase of decadence but the other temples are considered as Transitional Phase of Orissan temple architecture. One can find each part like Rekha Deul, Jagamohana, Natyamandapa and Bhogamandapa in this temple.

The overall length of the temple is 28.450M and width is 9.755M. The overall built-up area of the temple is 183.93 Sq. M. and the wall area is 62.63 Sq. M.

The Rekha Deul has square shape ad its side dimension is 2.310M, the diagonal length is 3.270M and the inner area hence found to be 5.33 Sq. M. the total height of the Rekha Deul is found to be 13.945M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.990M, 4.345M, 6.630M and 1.980M respectively.

The Jagamohana has a square base and its side dimension is 3.960M, the diagonal length is 5.175M and hence the inner area of the Jagamohana is found to be 18.154 Sq. M. The height of the Jagamohana is found to be 8.885M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.990M, 1.980M, 4.140M and 1.775M respectively.

Figure 4.19 Location of Nila Madhava Temple Complex

Source: Google earth

The Natyamandapa has a rectangular base and its side dimension is 5.080M, the diagonal length is 5.810M and hence the inner area of the Natyamandapa is found to be 14.322' Sq. M. The height of the Jagamohana is found to be 8.020M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.725M, 1.905M, 2.090M and 3.300 respectively.

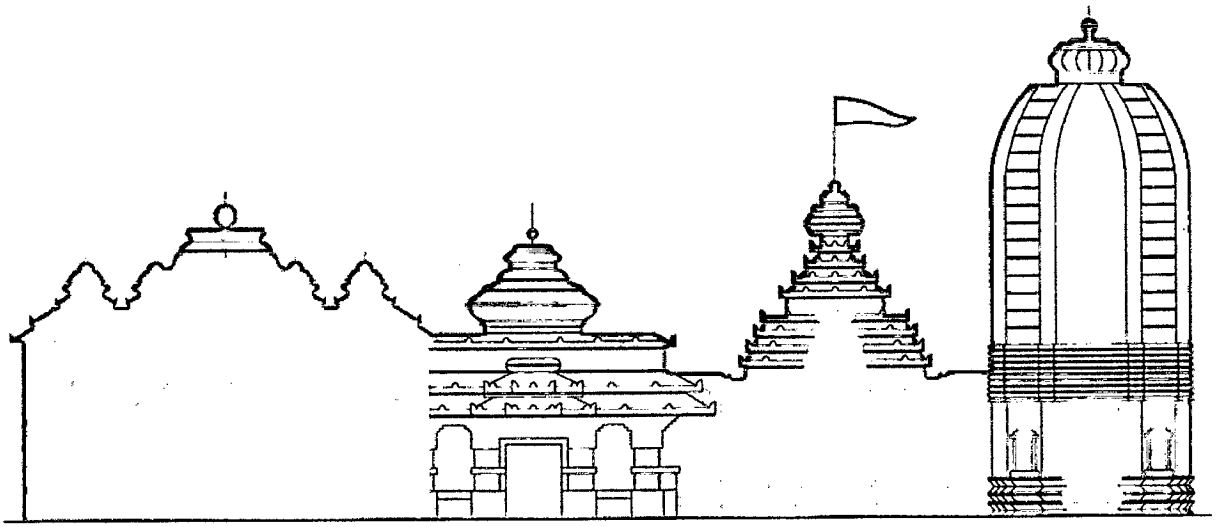


Figure 4.20 Left Side Elevation of Nila Madava temple Kantilo

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Bhogamandapa has a rectangular base and its side dimension is 8.090M, the diagonal length is 11.520M and hence the inner area of the Jagamohana is found to be 66.371

Sq. M. The height of the Jagamohana is found to be 6.810M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.030M, 3.480M, 1.170M and 1.130M respectively.

4.4.6 Nila Madava Temple, Kantilo 2

This temple is one of the sub-temple of Nila Madava temple complex, there are present of many such temple which are self-similar in nature. But the deity present inside the temple is different from each other. Kantilo Nila Madhava the temple was built on the latter half of 10^{th} century. Hence it has been concluded that the temple is coming under the Transitional phase of Orissan temple architecture.

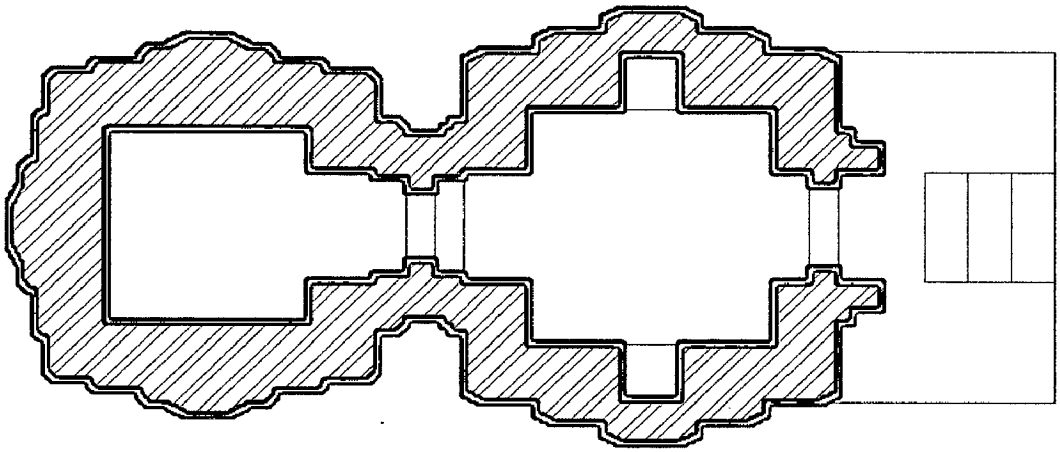


Figure 4.21 Plan of Sub Temple of Nila Madhava Temple Complex, Kantilo
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 11.060M and width is 4.800M. The overall built-up area of the temple is 41.56 Sq. M. and the wall area is 17.62 Sq. M.

The Rekha Deul has square shape ad its side dimension is 2.135M, the diagonal length is 3.015M and the inner area hence found to be 4.55 Sq. M. the total height of the Rekha Deul is found to be 9.480M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.990M, 2.555M, 4.245M, 1.690M respectively.

The Jagamohana has a square base and its side dimension is 2.590M, the diagonal length is 3.665M and hence the inner area of the Jagamohana is found to be 8.012 Sq. M. The height of the Jagamohana is found to be 7.070M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.990M, 1.980M, 1.755M and 2.345M respectively. This temple does not have Natyamandapa and Bhogamandapa as seen on the main temple.

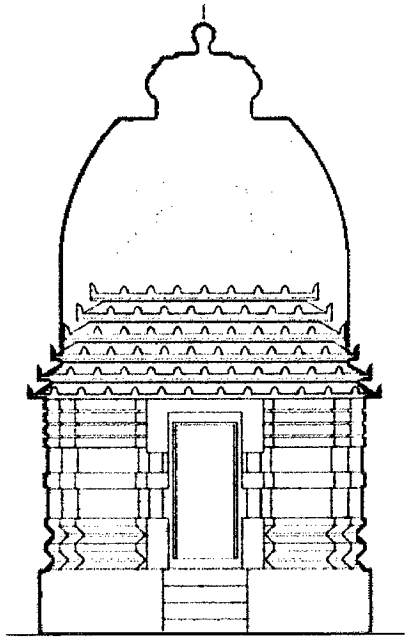


Figure 4.22 Front Elevation of Sub Temple of Nila Madhava Temple Complex, Kantilo

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

4.4.7 Somnath temple, Budhapara

This is another temple of Budhhanath temple complex, Budhapara. This temple is built on the period of 1st half of the 11th century, after the main temple Budhhanath was erected. As per the time of construction this temple is considered as in Transition Phase.

The overall length of the temple is 29.425 M and width is 19.660M. The overall built-up area of the temple is 132.41 Sq. M. and the wall area is 70.34 Sq. M.

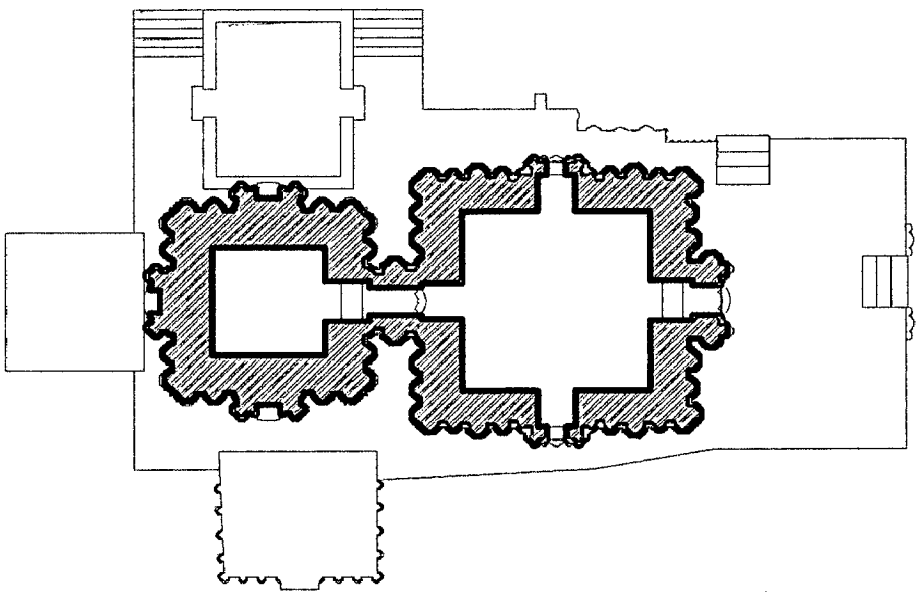


Figure 4.23 Plan of Somnath Temple, Budhapara

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Rekha Deul has square shape and its side dimension is 3.660M, the diagonal length is 5.175M and the inner area hence found to be 13.39Sq. M. the total height of the

Rekha Deul is found to be 26.190M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.490M, 3.830M, 13.460M and 7.410M respectively.

The Jagamohana has a square base and its side dimension is 6.095M, the diagonal length is 8.620M and hence the inner area of the Jagamohana is found to be 42.183 Sq. M. The height of the Jagamohana is found to be 15.055M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.175M, 3.025M, 4.515M and 6.340M respectively.

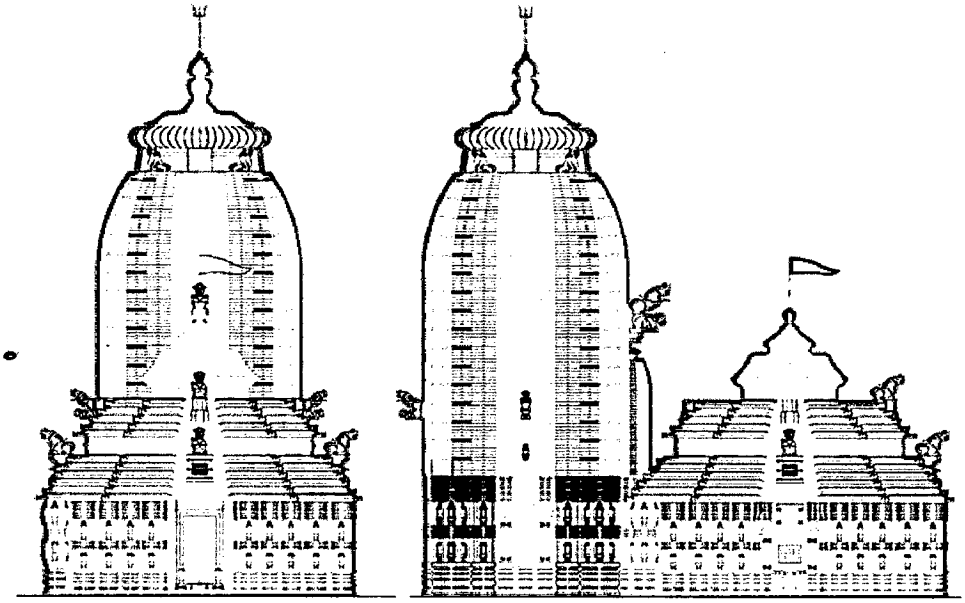


Figure 4.24 Elevation of Somnath Temple, Budhapara
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

4.4.8 Parasara temple, Paradeep ghar

The port city of Orissa Paradeep has this temple Parasara temple and was erected in the period of first half of 12th century. Due to the time of construction this temple can be classified as in the Mature phase of Orissan temple architecture.

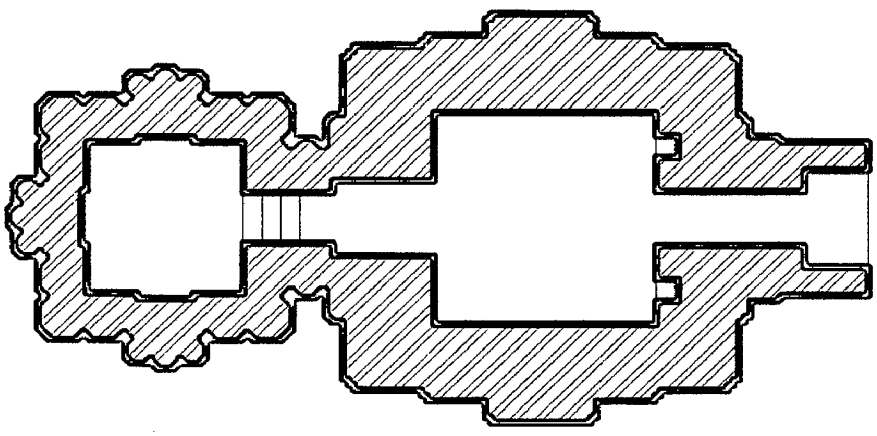


Figure 4.25 Plan of Parasara Temple, Paradeep
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

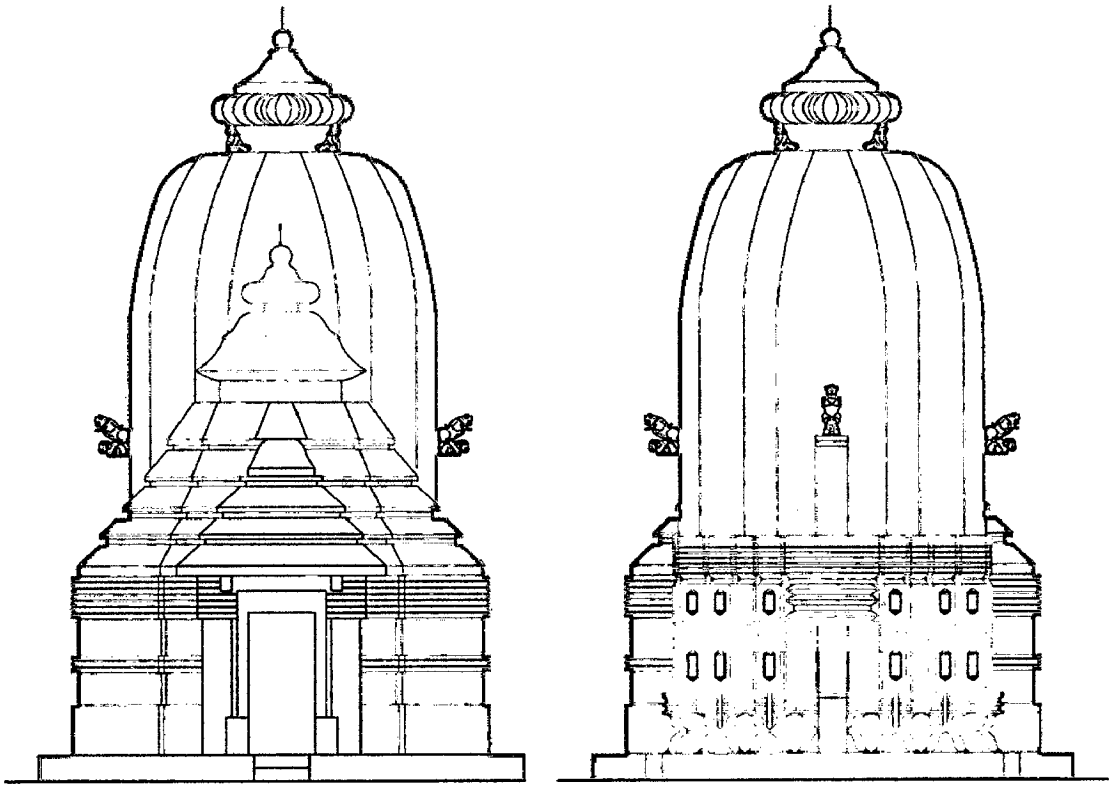


Figure 4.26 Front and Rear Elevation of Parasara Temple, Paradeep

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 11.660 M and width is 5.780M. The overall built-up area of the temple is 46.37 Sq. M. and the wall area is 27.01 Sq. M.

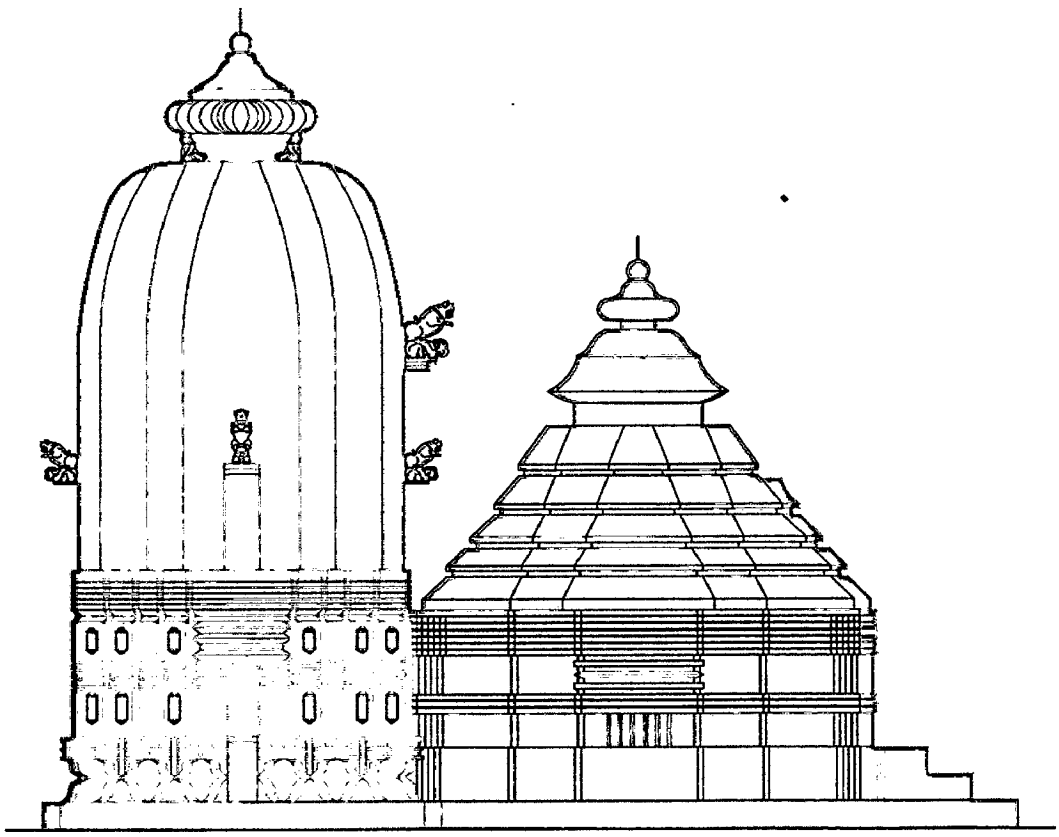


Figure 4.27 Right Side Elevation of Parasara Temple, Paradeep

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Rekha Deul has square shape and its side dimension is 2.135M, the diagonal length is 3.105M and the inner area hence found to be 4.72 Sq. M. the total height of the Rekha Deul is found to be 11.440M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.225M, 2.260M, 2.360M, 5.565M respectively.

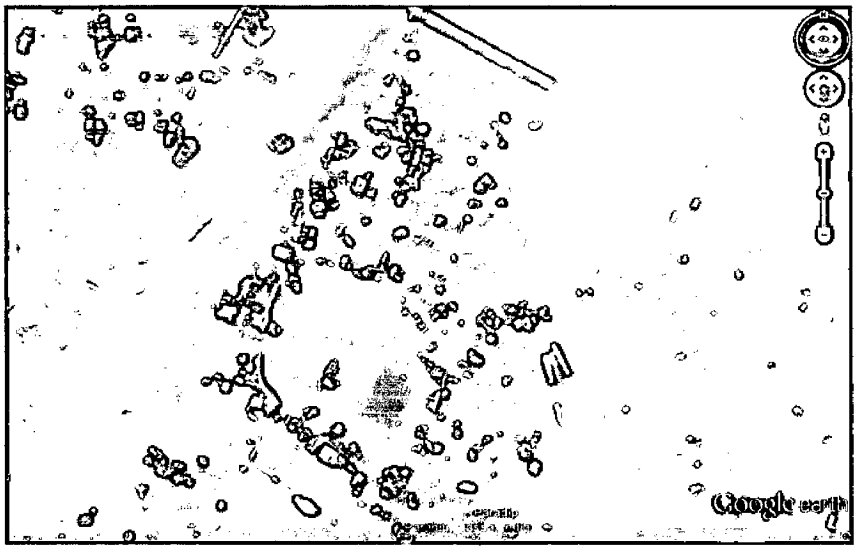


Figure 4.28 Location of the Parasara Temple, Paradeep

Source: Google earth

The Jagamohana has a square base and its side dimension is 3.200M, the diagonal length is 4.385M and hence the inner area of the Jagamohana is found to be 13.90 Sq. M. The height of the Jagamohana is found to be 8.050M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.105M, 2.005M, 2.360M, and 2.580M respectively. This temple does not have Natyamandapa and Bhogamandapa.

4.4.9 Sunder Madhava temple complex

Figure 4.29 Location of the Sunder Madhava Temple

Source: Google earth

The healthy economic condition and development of new religious structure gave birth to various cultural developments in the time of Ganga rulers. Temple became the main centre of entertainment during that period. The structure of the temple accommodated with variety of sculptures. The presiding deities were to be installed in the middle of the temple. An audience hail or Natyamandapa was the one important structure of temples.

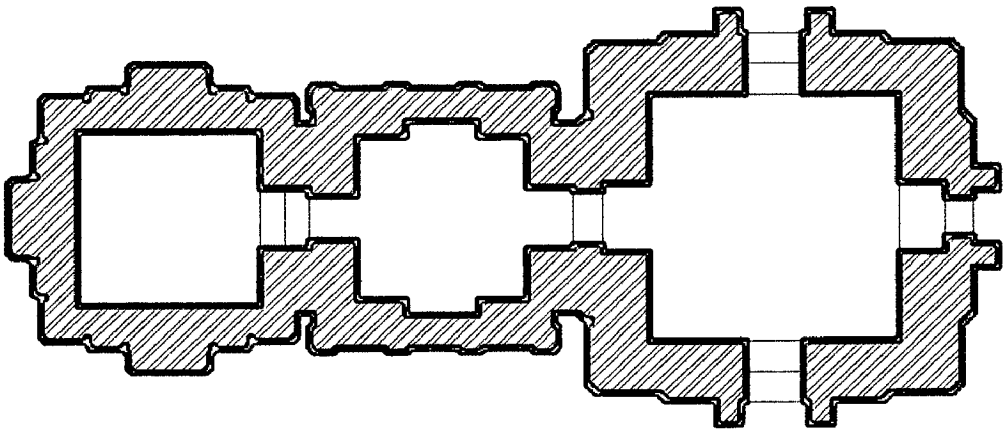


Figure 4.30 Plan of Sunder Madhava Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The customs of providing dancing girls, silk clothes, gold ornaments, elephants, musical parties, horses, cows and particularly big estates to the temple of Jagannath for its maintenance were some common events during the Ganga rule in Orissa. Sunder Madhava temple is of that era in which these things were introduced in the temple complex itself. This sunder Madhava temple was built on late 12th century AD. The constructions of temples were at the pick of this era. This period is also known as the golden era of Orissan temple architecture.

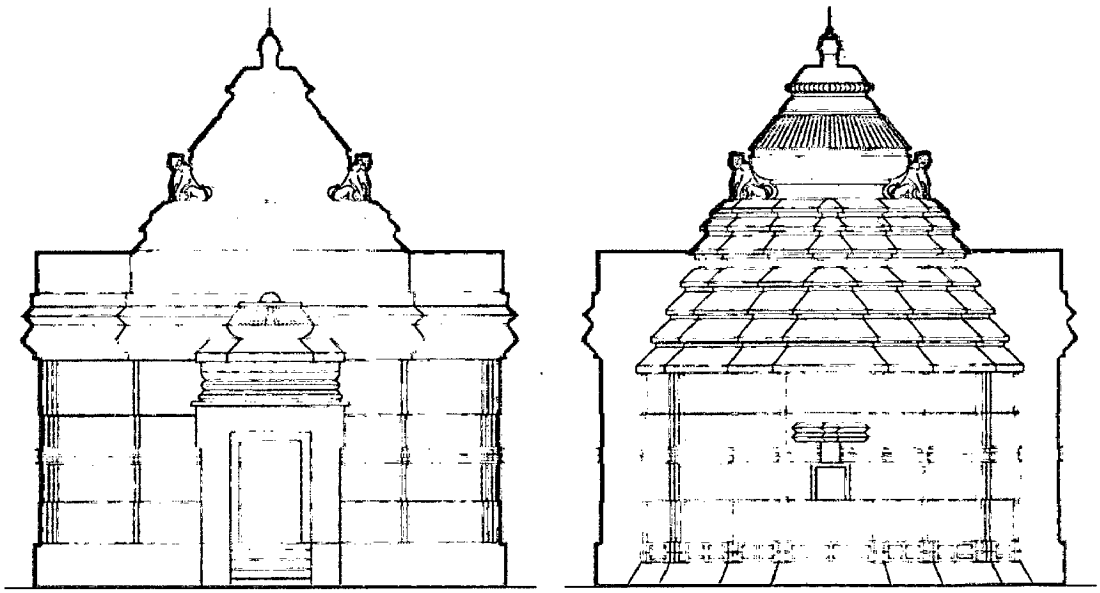


Figure 4.31 Front and Rear Elevations of Sunder Madhava Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 18.490 M and width is 8.050M. The overall built-up area of the temple is 104.03 Sq. M. and the wall area is 50.39 Sq. M.

The Rekha Deul has square shape and its side dimension is 3.405M, the diagonal length is 4.815M and the inner area hence found to be 11.594 Sq. M. the total height of the Rekha Deul is found to be 9.540M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.725M, 2.895M, 3.580M and 2.340M respectively.

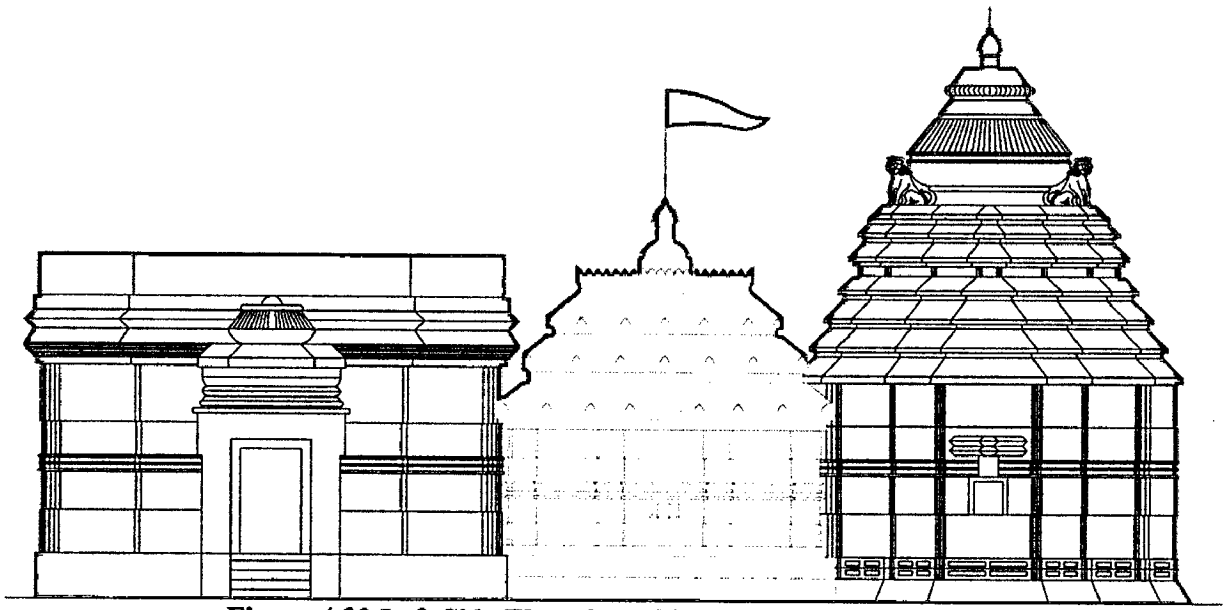


Figure 4.32 Left Side Elevation of Sunder Madhava Temple

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Jagamohana has a square base and its side dimension is 3.175M, the diagonal length is 4.490M and hence the inner area of the Jagamohana is found to be 12.670 Sq. M. The height of the Jagamohana is found to be 6.780M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.875M, 1.865M, 2.135M, and 1.905M respectively.

The Natyamandapa has a square base and its sides dimensions are 4.675M and 4.800M, the diagonal length is 6.700M and hence the inner area of the Natyamandapa is found to be 23.598 Sq. M. The height of the Natyamandapa is found to be 6.245M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.725M, 4.075M, 0.760M, and 0.685M respectively. This temple does not have any kind of Bhogamandapa.

4.4.10 Nrushingnath temple complex, Nair 1

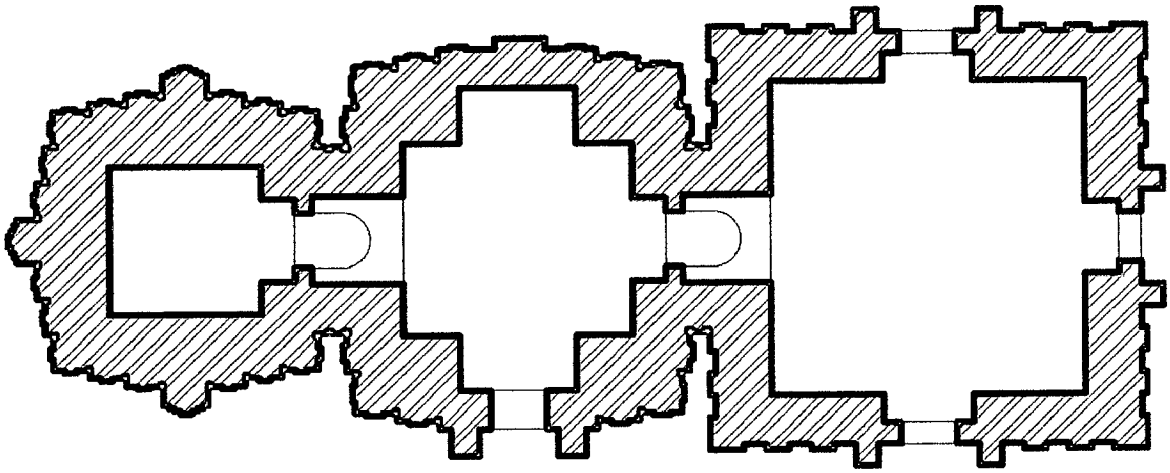


Figure 4.33 Plan of Nrushingnath Temple 1

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

In the Bargarh district of extreme western Orissa is the ancient temple of Lord Nrushingnath, also known as Bidala Nrusingha, Marjara Kesari, and Marjara Nrusingha. (In Oriya language, bidala and marjara mean "cat", and kesari means "lion". Also, Oriyas pronounce "Nrsimha" with a distinct "u" sound, hence the different spelling.) Situated about 300 kilometres from the famous temple of Lord Jagannath in Puri, the Nrushingnath temple is on northern foothills of the famous Gandhamadan Hill, where ancient rishis are said to have come to meditate. Some literatures say that Gandhamadan Hill was originally in the Himalayas, but a part of it fell down in this place when Hanuman was carrying it to Lanka with the herbs required to heal Lakshman. Gandhamadan Hill is also said to be one of the places where the Pandavas visited during their exile. The local tradition about this deity was compiled in the middle of the 18th century by the poet Yuga Das Kondh in his Nrsimha-charita. (These data has been collected from the local people conversation and interaction.)

There are two temples are presently situated the site where one of them was built on 13th century and 2nd one was built on 15th century.

The overall length of the temple is 15.660 M and width is 6.325M. The overall built-up area of the temple is 74.89 Sq. M. and the wall area is 34.64 Sq. M.

The Rekha Deul has square shape and its side dimension is 2.055M, the diagonal length is 2.910M and the inner area hence found to be 4.223 Sq. M. the total height of the Rekha Deul is found to be 11.320M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.800M, 2.860M, 5.525M and 2.135M respectively.

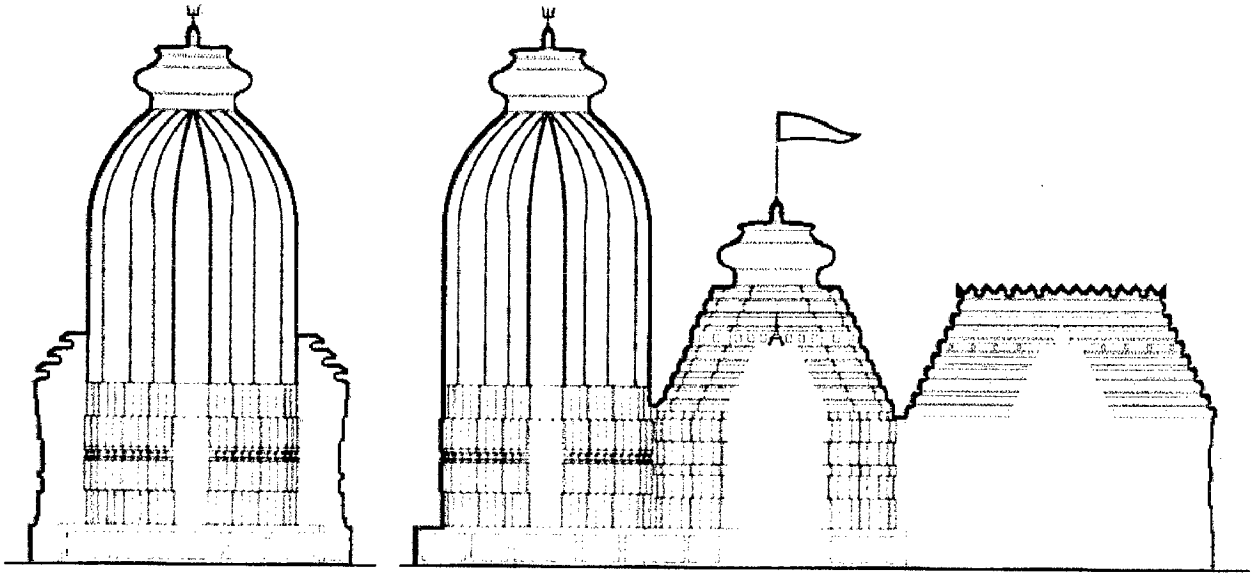


Figure 4.34 Elevation of Nrushingnath temple 1

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Jagamohana has a square base and its side dimension is 3.100M, the diagonal length is 4.090M and hence the inner area of the Jagamohana is found to be 11.870 Sq. M. The height of the Jagamohana is found to be 7.805M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.800M, 2.360M, 2.555M, and 2.090M respectively.

The Natyamandapa has a rectangular base and its sides dimensions are 4.265M and 4.365M, the diagonal length is 6.090M and hence the inner area of the Natyamandapa is found to be 19.916 Sq. M. The height of the Natyamandapa is found to be 5.785M. The total height is divided in to further three parts as Pitha, Bada, & Gandi and their heights are 0.800M, 2.285M and 2.700M, respectively. And Mastaka part is missing as the Natyamandapa has a flat roof structure.

4.4.11 Nrushingnath temple complex, Nair 2

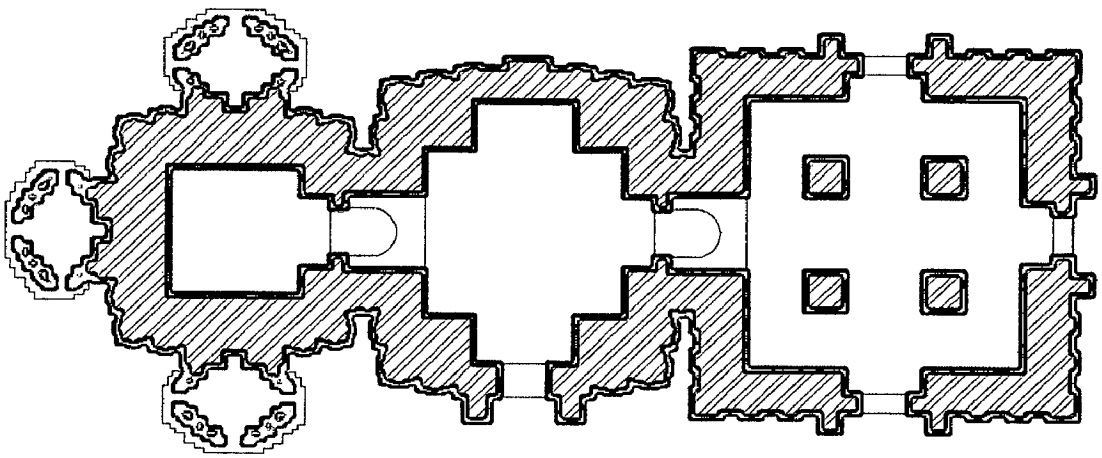


Figure 4.35 Plan of Nrushingnath Temple 2

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

This is another temple of Nrushingnath temple complex which was built on the 15th century. Hence as per the calculation it has come under the phase of Decadence. The main feature of this temple is that, it has three special projection on the Rekha Deul for paswa Debatas and they have equal importance to that of main deity inside the garbhagriha.

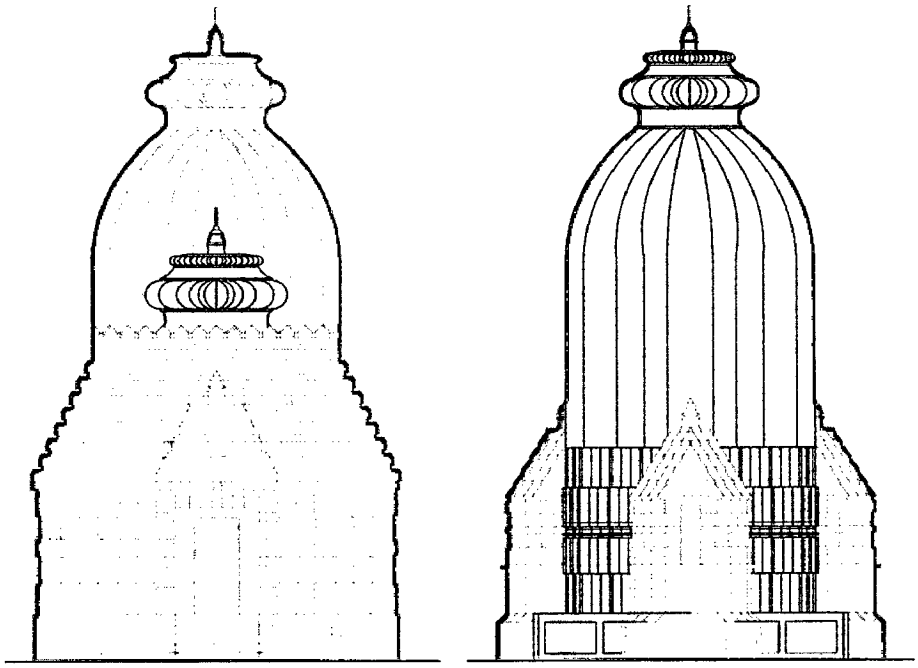


Figure 4.36 Front and rear Elevation of Nrushingnath Temple 2
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 16.800 M and width is 6.325M. The overall built-up area of the temple is 82.840 Sq. M. and the wall area is 37.430 Sq. M.

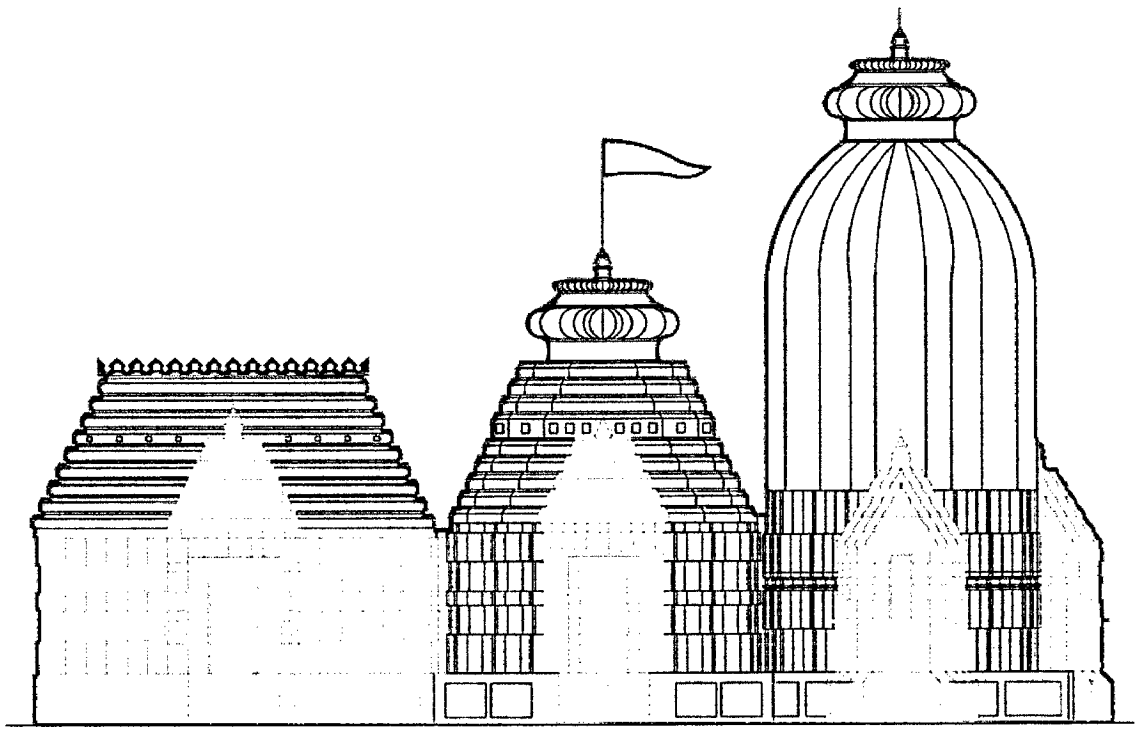


Figure 4.37 Left Side Elevation Of Nrushingnath Temple 2
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Rekha Deul has square shape and its side dimension is 2.055M, the diagonal length is 2.910M and the inner area hence found to be 4.223 Sq. M. the total height of the Rekha Deul is found to be 11.275M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.800M, 2.860M, 5.525M and 2.090M respectively.

Figure 4.38 Location of Nrushingnath Temple Complax

Source: Google earth

The Jagamohana has a square base and its side dimension is 3.100M, the diagonal length is 4.090M and hence the inner area of the Jagamohana is found to be 11.870 Sq. M. The height of the Jagamohana is found to be 7.805M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 0.800M, 2.360M, 2.555M, and 2.090M respectively.

The Natyamandapa has a rectangular base and its sides dimensions are 4.265M and 4.365M, the diagonal length is 6.090M and hence the inner area of the Natyamandapa is found to be 19.916 Sq. M. The height of the Natyamandapa is found to be 5.785M. The total height is divided in to further three parts as Pitha, Bada, & Gandi and their heights are 0.800M, 2.285M and 2.700M, respectively. And Mastaka part is missing as the Natyamandapa has a flat roof structure. This temple does not have any kind of Bhogamandapa.

Both the structures of these temples are so similar except the paswa debatas attached to the main garbhagriha part in both cases. These temples are located side by side and from the front both looks alike like twin brothers.

4.4.12 Jagannath temple, Khandapara

The Jagannath temple, Khandapara is located in the Ganjam district and is famous for its rituals. This temple has Rekha Deul, Jagamohana, and Natyamandapa but does not have any kind of Bhogamandapa. The wall of these temples is comparatively thicker than that of other Orissan temple architecture. It is found to be 750mm to 900mm thickness from parts to parts area.

Figure 4.39 Location of the Jagannath Temple, khandapara

Source: Google earth

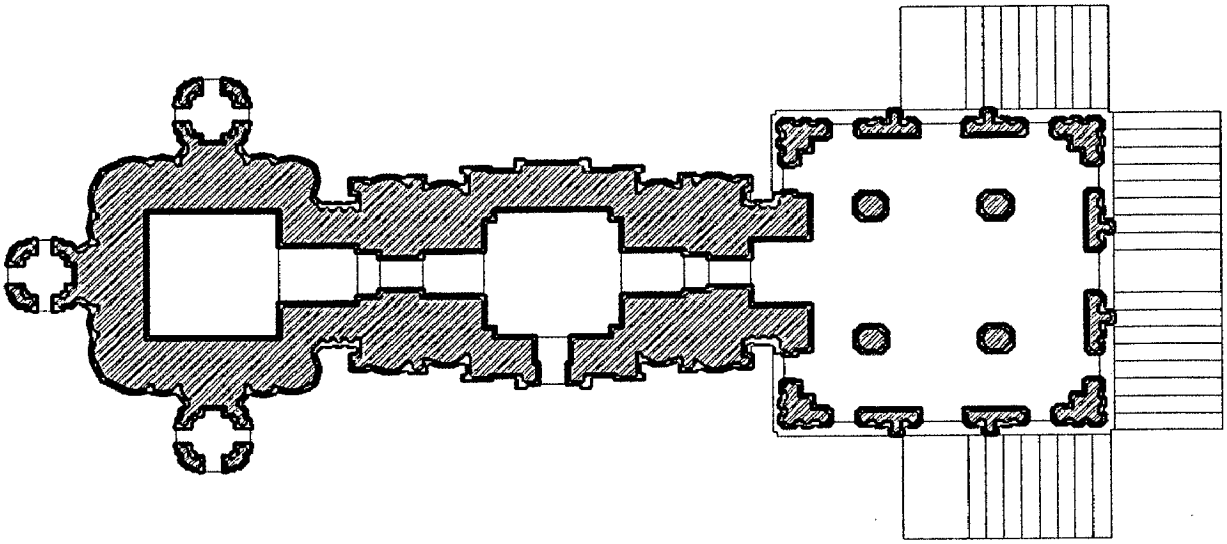


Figure 4.40 Plan of Jagannath Temple, khandapara

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The overall length of the temple is 41.275 M and width is 18.875M. The overall built-up area of the temple is 320.18 Sq. M. and the wall area is 132.060 Sq. M.

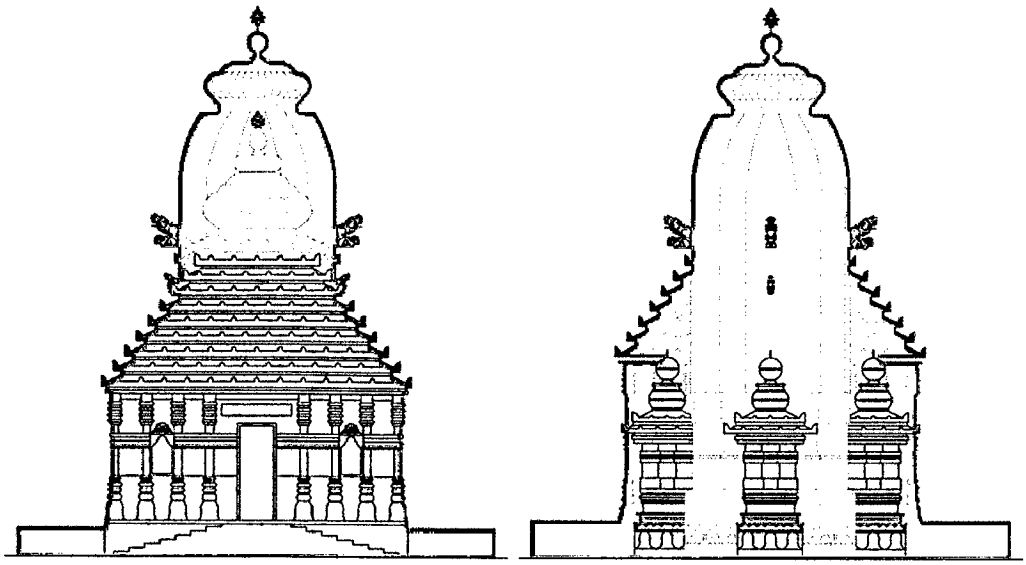


Figure 4.41 Front and Rear Elevation of Jagannath Temple, khandapara
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

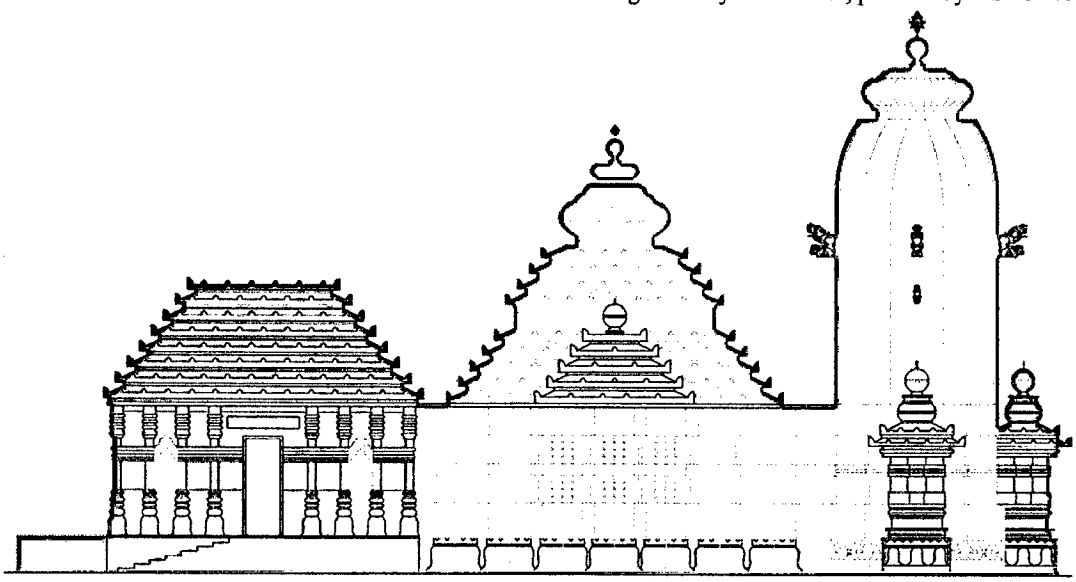


Figure 4.42 Right Side Elevation of Jagannath Temple, khandapara
Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

The Rekha Deul has square shape and its side dimension is 4.495M, the diagonal length is 6360M and the inner area hence found to be 20.205 Sq. M. the total height of the Rekha Deul is found to be 22.050M. And the Rekha Deul is divided into four major parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.450M, 5.220M, 11.125M and 4.255M respectively.

The Jagamohana has a rectangular base and its side dimensions are 4.675M and 1.495M, the diagonal length is 5.480M and hence the inner area of the Jagamohana is found to be 20.505 Sq. M. The height of the Jagamohana is found to be 17.830M. The total height is divided in to further four parts as Pitha, Bada, Gandi and Mastaka and their heights are 1.450M, 5.220M, 6.475M, and 4.685M respectively.

The Natyamandapa has a square base and its sides dimensions are 11.455M, the diagonal length is 12.395M and hence the inner area of the Natyamandapa is found to be 102.090 Sq. M. The height of the Natyamandapa is found to be 12.120M. The total height is divided in to further three parts as Pitha, Bada, & Gandi and their heights are 1.450M, 5.335M and 5.335M, respectively. And Mastaka part is missing as the Natyamandapa has a flat roof structure. This temple does not have any kind of Bhogamandapa.

CHAPTER - 5

SHAPE AND GEOMETRICAL ANALYSIS

"The vastu-purusha-mandala represents the manifest form of the Cosmic Being; upon which the temple is built and in whom the temple rests. The temple is situated in Him, comes from Him, and is a manifestation of Him. The vastu-purusha-mandala is both the body of the Cosmic Being and a bodily device by which those who have the requisite knowledge attain the best results in temple building." (Stella Kramrisch, The Hindu Temple, Vol. I)

This chapter discusses and analysis the results of the shape and geometrical study of the Orissan Hindu temple. It has divided into three main categories as the analysis based upon dimensional study, analysis based on Vastupurasha mandala and analysis based on fractal geometry. Here the following simplified methods of analysis and corresponding indexes are considered:

5.1 Analysis based on Dimensional Study

There has been following analysis done on the basis of dimensional study as they are -

1. In plan area ratio of the temple i.e. the total built-up area and the wall area of the temple.
2. Relation between the height and the time of construction.
3. Relation between the area and time of construction of the Orissan Hindu temple.
4. Comparison between the total build –up area and area of the main shrine i.e. the area of the garbhagriha.
5. Difference among the slenderness ratio and construction period of the temple.
6. Relation between the area and height of the main shrine (garbhagriha).
7. Relation between the different elements length of Orissan temple architecture in plan form.
8. Inter-relation between the length and width of the total temple in different phases.
9. Relation between the different halls areas.
10. Relation between the different halls heights.
11. Inter-relation between the different hall heights and the height of the garbhagriha.
12. Relation between the different parts height of the Garbhagriha.
13. Relation between the different parts height of the Jagamohana.
14. Relation between the different parts height of the Natyamandapa.

As the Orissan Hindu temple architecture has been classified into four major phases, The Formative phase, The Transitional Phase, The Mature Phase and The Phase of Decadence. The examples of temple for the analysis have been selected from the different parts of the Orissa. The main criteria for selection of these temples are their date of construction which ranges from the 5th century till the 15th century.

A sample size of 12 temples from the different locations of Orissa was selected. The selection was limited to 12 in number due to the limited availability of the basic drawings and information required for the analysis. The detailed drawings of each temple have been shown in the appendix.

5.1.1 In plan area ratio of the temple

Table 5.1: Orissan Hindu Temple for In Plan Area Ratio

Temple Name	period of Construction In Century	Phases	In Plan Area Ratio		
			Total Area of the Temple (Sq.M)	Total Wall Area of the Temple (Sq.M)	Total Wall Area / Total Area of Temple
Gopinath temple	5th	Formative Phase	68.9	43.85	63.64%
Dhabaleswar temple	6th	Formative Phase	68.06	23.64	34.73%
Budhhanath temple	8th	Formative Phase	75.96	36.81	48.46%
Kapileswar temple	10th	Transitional Phase	58.59	28.2	48.13%
Nila Madava temple 2	10th	Transitional Phase	41.56	17.62	42.40%
Somnath temple	11th	Transitional Phase	132.41	70.34	53.12%
Parasara temple	12th	Mature Phase	46.37	27.01	58.25%
Sunder Madhava temple	12th	Mature Phase	104.03	50.39	48.44%
Nrushingnath temple 1	15th	Phase of decadence	74.89	34.64	46.25%
Nrushingnath temple 2	13th	Phase of decadence	82.84	37.43	45.18%
Jagannath temple	14th	Phase of decadence	320.18	132.06	41.25%
Nila Madava temple 1	15th	Phase of decadence	183.93	62.63	34.05%

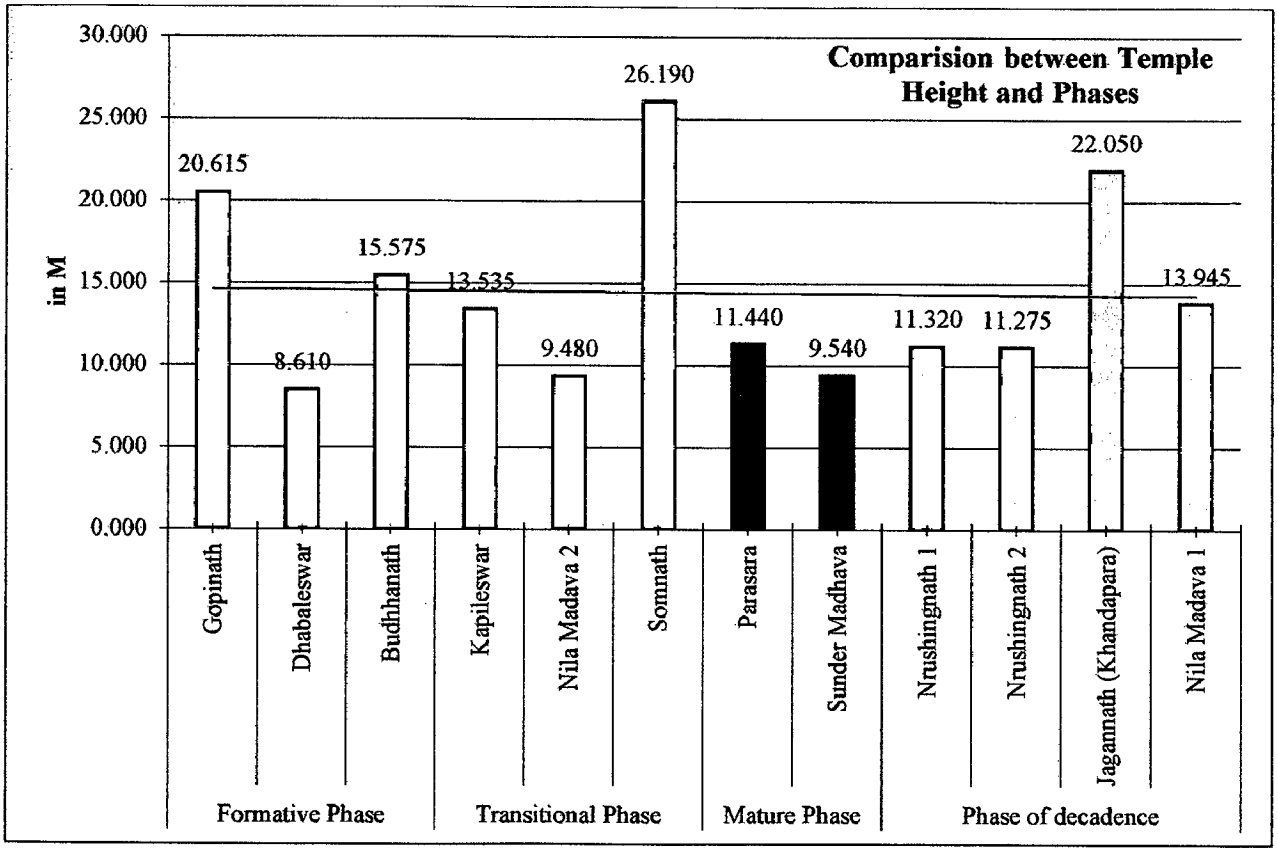
The safety of the ancient construction, namely with respect to earthquake actions, can be tentatively evaluated by calculating in plan ratio of the building (Lourenco, et al 2005). In plan area ratio is the ratio between the areas of the load bearing walls and the total in plan area of the temple. The ratio calculated for the samples of all four phases of Orissan Hindu Temples are shown in the above tables.

The calculations show the trend of construction of the Orissan Hindu temple was massive, heavy and piled up masonry, beams and corbelling. The strength and stability is obtained by the mass supporting mass method. The ratios obtained in the tables are four to five times higher than typically required for masonry buildings (5 to 10% in modern masonry, Euro code 8, and 10 to 20% in old churches (Lourenco, et al 2005)). The average value of in

plan area ratio for the Formative phase temple is 48.95% (with a range from 34.73 to 63.64%), while the average value for the Transitional Phases temple is 47.88% (with a range from 42.40 to 48.46%). And also the average value of mature phase and phase of decadence are 53.34% and 41.68%.

Thus, the Orissan Hindu temples seem relatively safe and stable structures for vertical and seismic actions. This is the key reason for a load bearing structure to stand for such long periods. The heavily ornamented and corbelling structure thus stands for long time.

5.1.2 : Relation between the Temple Height with Phases of the Hindu temple



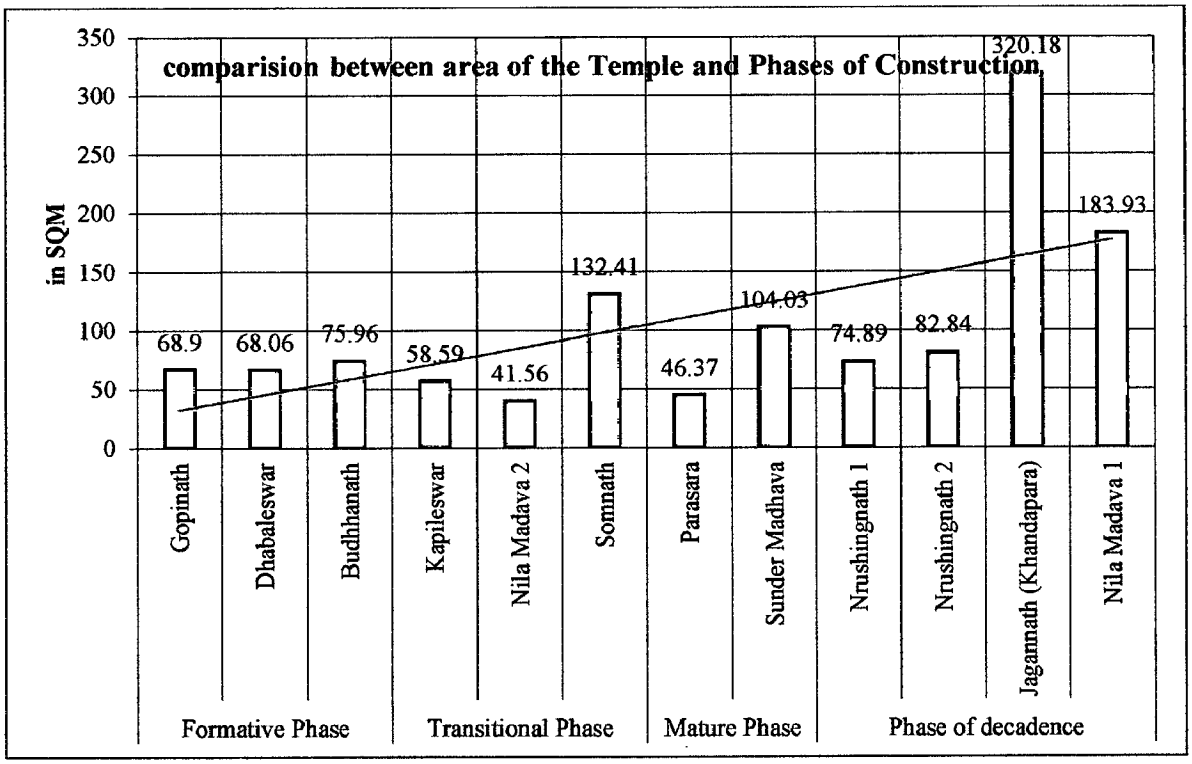
Graph 5.1 : Relation between the Temple Height with Phases of the Hindu temple

The almost parallel trend in the above graph shows that in the Orissan Hindu temples, the height of the shrine did not change their height with respect to the period of construction. The average height of the selected sample temples are 14.465m (with a range from 9 to 27m). It is noted that the values found are relatively low, when compared with masonry towers in Europe (up to 100 m in the Cremona Torrazo (Binda, 2008)) and even with other buildings in India (e.g. Qutub Minar in New Delhi, which totals 76 m). The Orissan Hindu temple the trend in the graph remains relatively constant which shows that the height of the temples does not increased with the time, probably due to religious reasons. In the collected sample temples

it is found that the height of the Somnath Temple, Budhapara has the highest height i.e. 26.190m which fall in the transitional phases.

And the lowest height is Dhabaleswar Temple i. e. 8.610m which comes under Formative phase. Thus it can be concluded that the height of the Orissan temple architecture did not depend upon the time era.

5.1.3 : Relation between the area and the time of construction



Graph 5.2 : Built-up area of Temples with Phases of OTA

The raised trend in the **Error! Reference source not found.** shows that the area of the shrine increased with respect to the period of construction. It has been observed that as the time increases the elements of Orissan temple architecture increases. The temples have been added with different halls with respect to time as they are Jagamohana, Natyamandapa and Bhogamandapa respectively. In the other hand it is possibly due to a combination of better building and material transportation techniques, wealth and size of the communities, and increasing workforce.

The raised trend in graph**Error! Reference source not found.** shows that the area of the shrine increased from Formative phase to the Phase of Decadence. In the above graph, it is concluded that the height of the temple is not related to the area of the total temple in different phases of Orissan Temple Architecture.

The average value of the built-up area for the selected temple is 104.81 (with a range from 40 to 320m^2). As seen in the primary data the different elements are added in due respect time the area of the whole temple increases but the height of the main shrine stands as it is. In

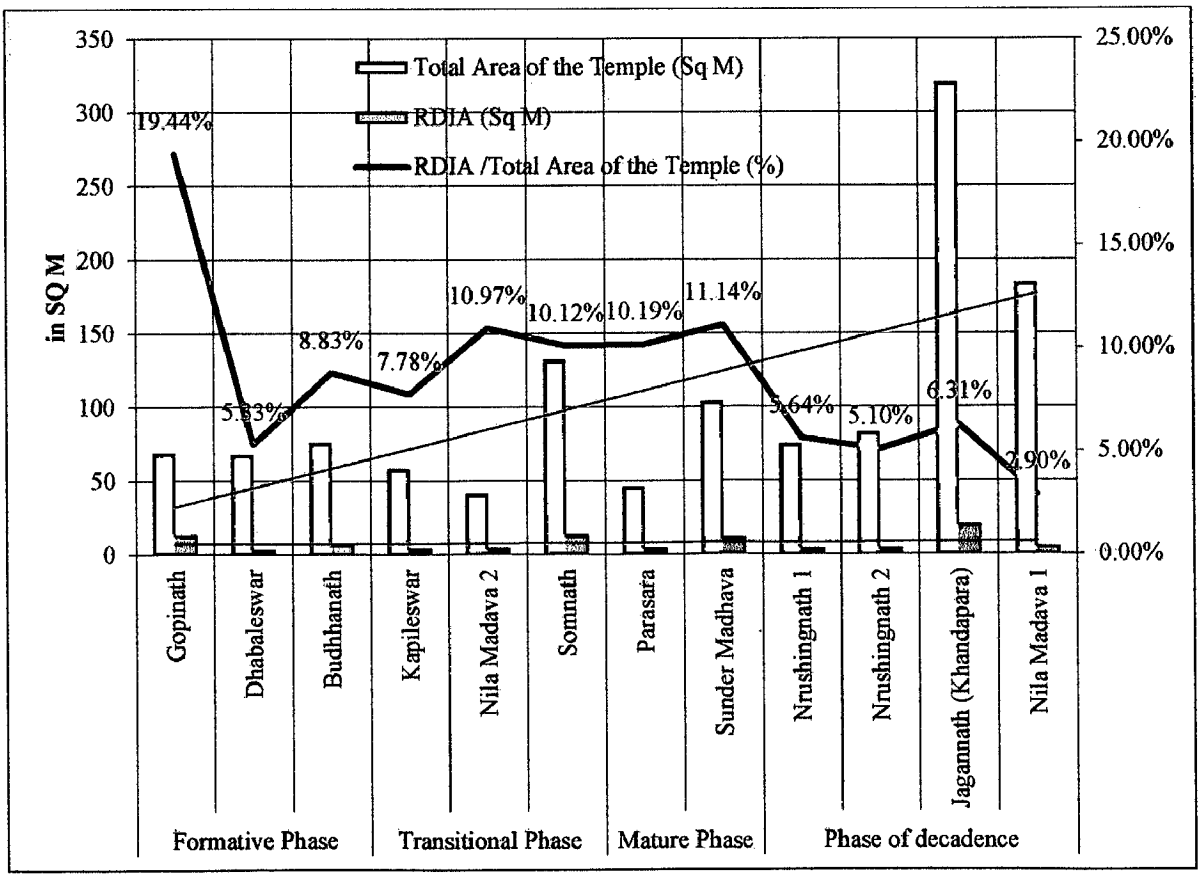
the selected sample temple the maximum area is Jagannath Temple, Khandapara i.e. 320. 18 Sq.M which is of phase of decadence era and the temple having minimum area is Nila Madhava Temple 2 which is a sub temple of Nila Madhava Temple complex, Kantilo which is categories in the Transitional phases.

5.1.4 Relation between Total Built-up Area and area of the Main Shrine

Table 5.2 : Showing Total area of the Temple and Rekha Deul Inner Length

Phases	Temple Name	Total Area of the Temple (Sq.M)	RDIA (Sq.M)	RDIA /Total Area of the Temple (%)
Formative Phase	Gopinath	68.9	13.40	19.44%
	Dhabaleswar	68.06	3.63	5.33%
	Budhhanath	75.96	6.71	8.83%
Transitional Phase	Kapileswar	58.59	4.56	7.78%
	Nila Madava 2	41.56	4.56	10.97%
	Somnath	132.41	13.40	10.12%
Mature Phase	Parasara	46.37	4.73	10.19%
	Sunder Madhava	104.03	11.59	11.14%
Phase of decadence	Nrushingnath 1	74.89	4.22	5.64%
	Nrushingnath 2	82.84	4.22	5.10%
	Jagannath (Khandapara)	320.18	20.21	6.31%
	Nila Madava 1	183.93	5.34	2.90%

RDIA= Rekha Deul Inner Area



Graph 5.3 : Showing Total Area and area of the Main Shrine

The Table 5.2 is showing area of the whole temple and the main shrine area and ratio between them. It is found that the total area verses main shrine area ratio, gradually decreases with progress of the time period. This is because the addition of the other major part in the plan of the temple as Jagamohana, Natyamandapa and Bhogamandapa later on.

The average the main temple built-up area is found to be 104.81 m^2 (with a range varies from 45m^2 to 320m^2). The average of the main shrine area of the selected sample temples is found to be 8.05 m^2 (with a range varies from 2 m^2 to 20 m^2).

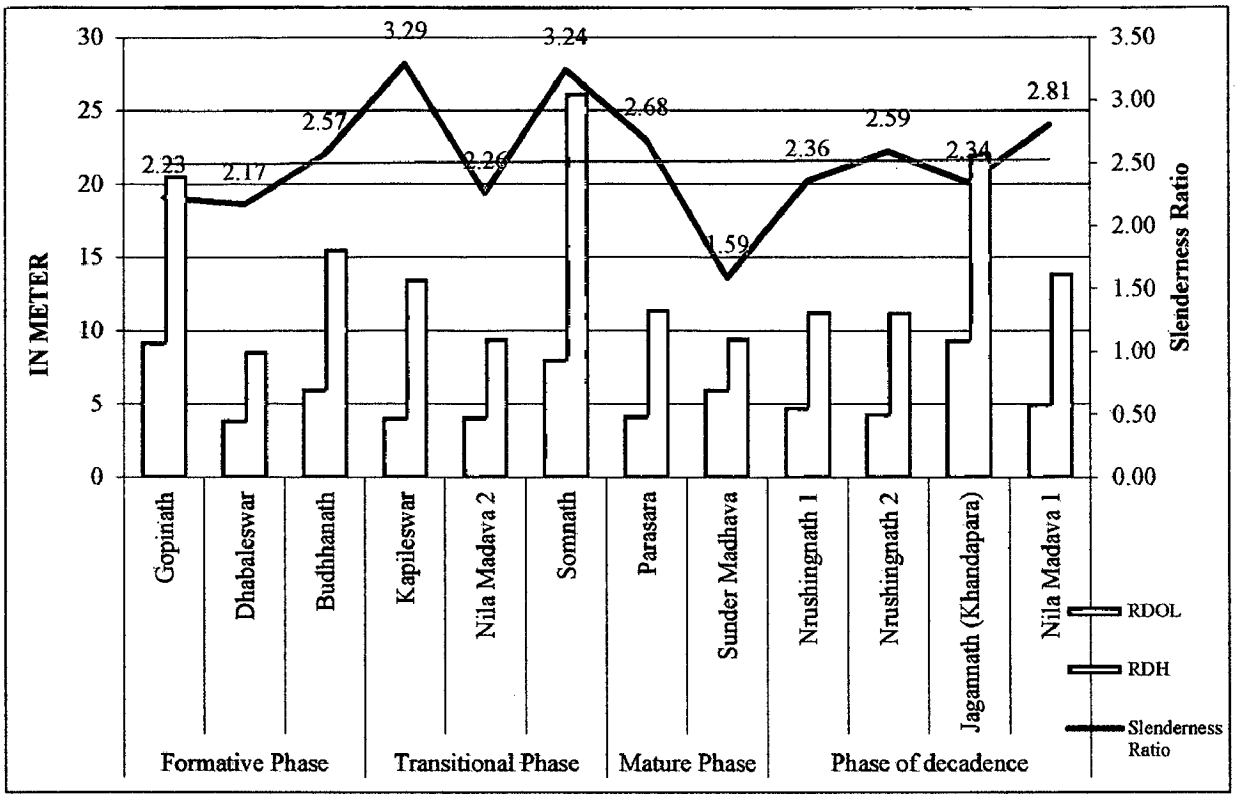
The raised trend in the Graph 5.3 shows that in the Orissan Hindu temples the area of the whole temple increases with respect to time but the area of the main garbhagriha did not change with time. This is due to the added elements to the main temple after onwards like Jagamohana, Natyamandapa and Bhogamandapa in different phases. The area, shape and geometry did not differ from phases to phases having a square plan.

5.1.5 Relation Between The Slenderness Ratio And Time of Construction

Slenderness ratio is the ratio between the height and the length of any object or the ratio between the length and the thickness of the same object, the most preferable among them is the lesser amounts between them. As the archaeological survey of India, Orissa chapter did not provide the thickness of the wall, hence the observation of the slenderness ratio is taken on the basis of the height and the external length of the garbhagriha has been taken into account. Below the table shows the phases of the Orissan Temple Architecture, Selected temple samples, Rekha Deul outer length (RDOL), Rekha Deul Height (RDH) and the slenderness ratio between them.

Table 5.3 slenderness ratio and phases of temples

Phases	Temple Name	RDOL (in M)	RDH (in M)	Slenderness Ratio
Formative Phase	Gopinath	9.245	20.615	2.23
	Dhabaleswar	3.96	8.610	2.17
	Budhhanath	6.06	15.575	2.57
Transitional Phase	Kapileswar	4.115	13.535	3.29
	Nila Madava 2	4.19	9.480	2.26
	Somnath	8.08	26.190	3.24
Mature Phase	Parasara	4.265	11.440	2.68
	Sunder Madhava	5.995	9.540	1.59
Phase of decadence	Nrushingnath 1	4.8	11.320	2.36
	Nrushingnath 2	4.345	11.275	2.59
	Jagannath (Khandapara)	9.41	22.050	2.34
	Nila Madava 1	4.965	13.945	2.81



Graph 5.4 Relation between the slenderness ratio and the phases of Orissan Temple Architecture

RDOL= Rekha Deul Outer Length

RDH= Rekha Deul height (Height of the Temple)

When plotted a graph, in the primary X-axis the height and the outer length of the garbhagriha in meter and in secondary X-axis taking the slenderness ratio between them, the observation has been found that in each era or the phases of the Orissan Temple architecture the slenderness ratio is coming in between 1.5 to 3.5. The maximum slenderness ratio found in the sample selected temple is the Kapileswar temple, Berhampur i.e. 3.29 and the minimum is the 1.59 i.e. the Sunder Mahadev Temple.

As the structure of temples having low slenderness ratio hence the build form the structure is very strong and stands for centuries. The parallel linear trend shows the slenderness ratio did not depend upon the time periods. The average value the slenderness ratio is 2.51 which is less as compare to NBC 2005 (National Building Code 2005) i.e. 27 for masonry load bearing structures.

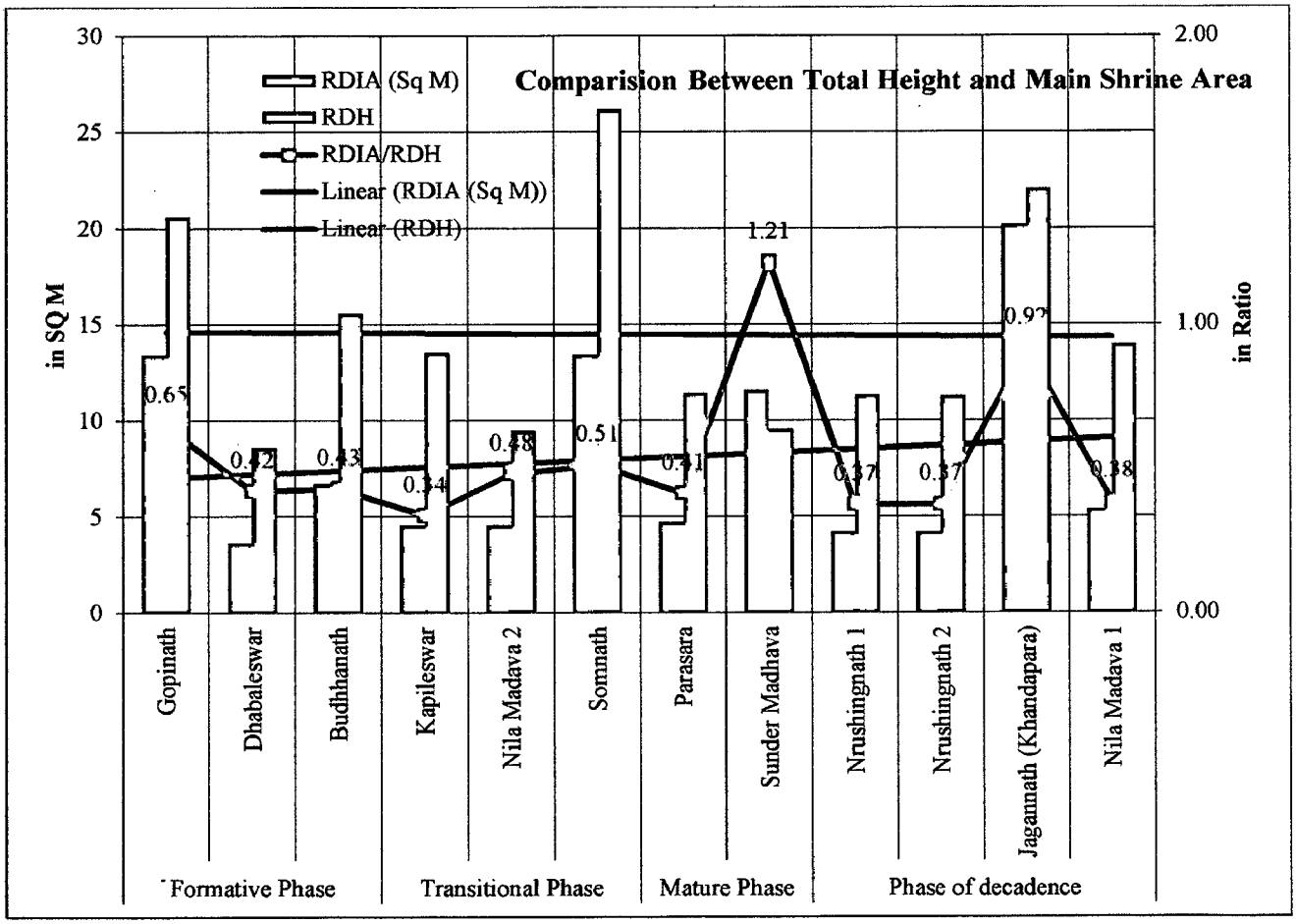
5.1.6 Relation between the area and height of the main shrine (garbhagriha)

Table 5.4 Relations between the Area and Height of the Garbhagriha

Phases	Temple Name	RDIA (Sq. M)	RDH (Sq. M)
Formative Phase	Gopinath	13.4	20.615
	Dhabaleswar	3.63	8.610
	Budhhanath	6.71	15.575
Transitional Phase	Kapileswar	4.56	13.535
	Nila Madava 2	4.56	9.480
	Somnath	13.4	26.190
Mature Phase	Parasara	4.73	11.440
	Sunder Madhava	11.59	9.540
Phase of decadence	Nrushingnath 1	4.22	11.320
	Nrushingnath 2	4.22	11.275
	Jagannath (Khandapara)	20.21	22.050
	Nila Madava 1	5.34	13.945

RDIA = Rekha Deul Inner Area

RDH= Rekha Deul Height



Graph 5.5 :Showing Relation between the Area and Height of the Garbhagriha

When plotted a line graph between the area of the garbhagriha and the height of the garbhagriha it has been found that they are almost parallel and gives a constant proportion with due course of time period. The average area of garbhagriha of the sample temples is 8.048m^2 and the average height of the main temple i.e. the height of the garbhagriha is found

to be 14.465m. When plotted a linear trend it has been observed that the area of the garbhagriha is increasing with respect to time but the linear trend line of the height is found to be almost parallel to the x-axis. The only contradiction is the Sunder Mahadev temple which height is very less i.e. 9.54m while are area of the inner core of the garbhagriha is found to be 11.59 m^2.

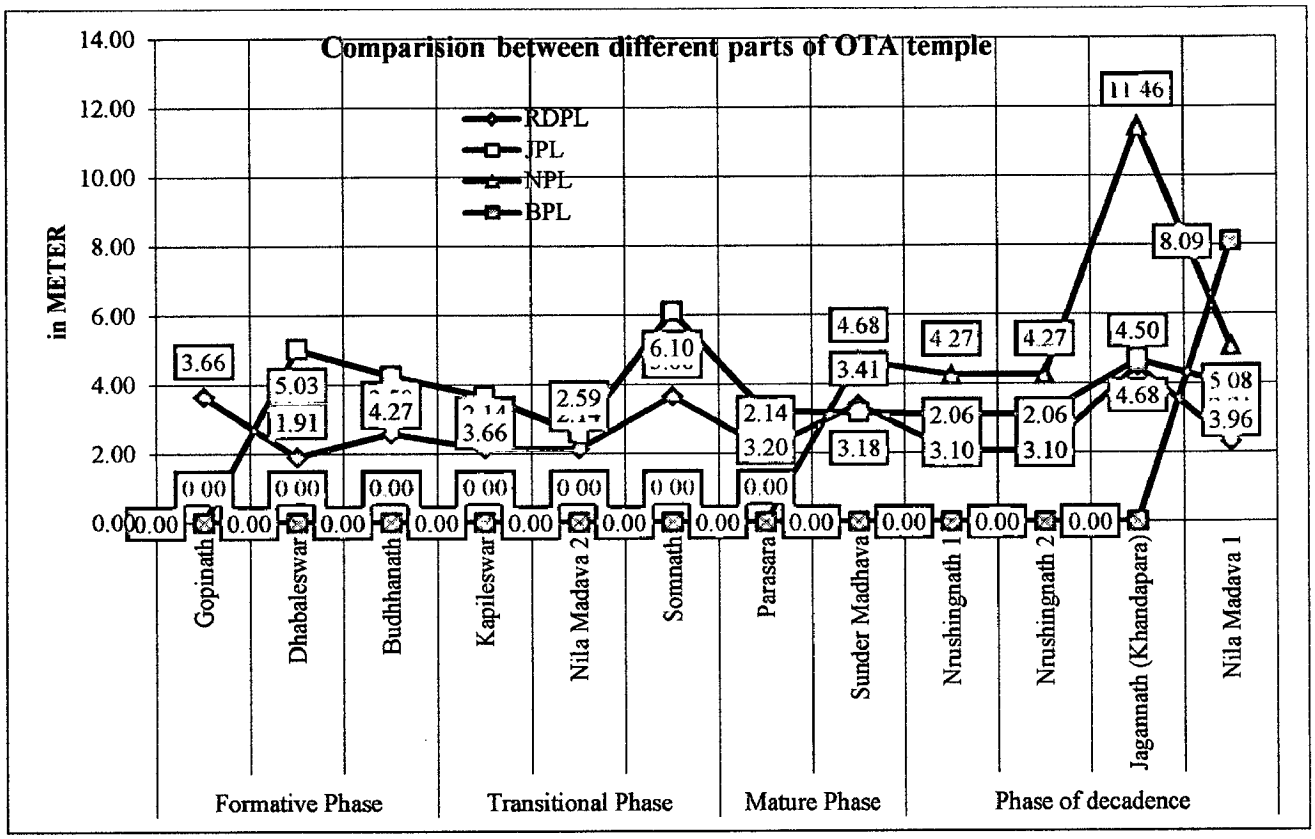
During the 10th and the 11th century due to the improvement in the construction technology, wealthy patrons and an impulse to extend upwards to create soaring heights, both in the coastal and western part of Orissa few temples reached to height of 60 m. for example: Jagannath Temple, Puri, Orissa and. It seems thus that, due to the difference in thoughts and different purpose of usage the temples in the Orissa grew vertically and expanded horizontally as well.

5.1.7 Relation between different Halls length in plans

From the primary data survey it has been observed that the formative phase had mainly garbhagriha, transition phases had both garbhagriha and Jagamohana but in the mature phase and the phase of decadence had gradually addition of Natyamandapa and the Bhogamandapa later on due course of time. Below the table shows the different plan length of the different hall length in meters.

Table 5.5 Length of different halls (chambers) of Orissan Temple Architecture

Phases	Temple Name	RDPL (in M)	JPL (in M)	NPL (in M)	BPL (in M)
Formative Phase	Gopinath	3.66	0.00	0.00	0.00
	Dhabaleswar	1.91	5.03	0.00	0.00
	Budhhanath	2.59	4.27	0.00	0.00
Transitional Phase	Kapileswar	2.14	3.66	0.00	0.00
	Nila Madava 2	2.14	2.59	0.00	0.00
	Somnath	3.66	6.10	0.00	0.00
Mature Phase	Parasara	2.14	3.20	0.00	0.00
	Sunder Madhava	3.41	3.18	4.68	0.00
Phase of decadence	Nrushingnath 1	2.06	3.10	4.27	0.00
	Nrushingnath 2	2.06	3.10	4.27	0.00
	Jagannath (Khandapara)	4.50	4.68	11.46	0.00
	Nila Madava 1	2.31	3.96	5.08	8.09



Graph 5.6 Comparison between the lengths of different halls of Orissan Temple Architecture

RDPL =Rekha Deul Plan Length
JPL = Jagamohana Plan Length
NPL = Natyamandapa Plan Length
BPL = Bhogamandapa Plan Length

From the above table and graph it has been observed that the different plan elements were added later on in due course of time. In the Formative Phase the Gopinath temple had only the Garbhagriha but in the Dhabaleswar temple and Budhhanath Temple had both Garbhagriha and Jagamohana. The transitional phase had both Garbhagriha and Jagamohana with added plinth for rituals excises. Mature phase had all main three elements in plans as garbhagriha, Jagamohana and Bhogamandapa had present. But the phase of decadence, due to the attack of Mughals many temples build in different styles and many goes in to dilapidated. It can be said that phase of decadence is the end part of the mature phase and the end era of the Orissan temple architecture.

Form the table and graph it is observed that the length of the added elements had more in dimensions like BPL> NPL > JPL > RDPL. Means the length of the Bhogamandapa is more than that of the Natyamandapa and Jagamohana and Rekha Deul and so on.

5.1.8 Relation between width and length of total build form

Different phases had different overall length increases as there had been addition of Jagamohana, Natyamandapa and Bhogamandapa as seen in the below table. And the width in

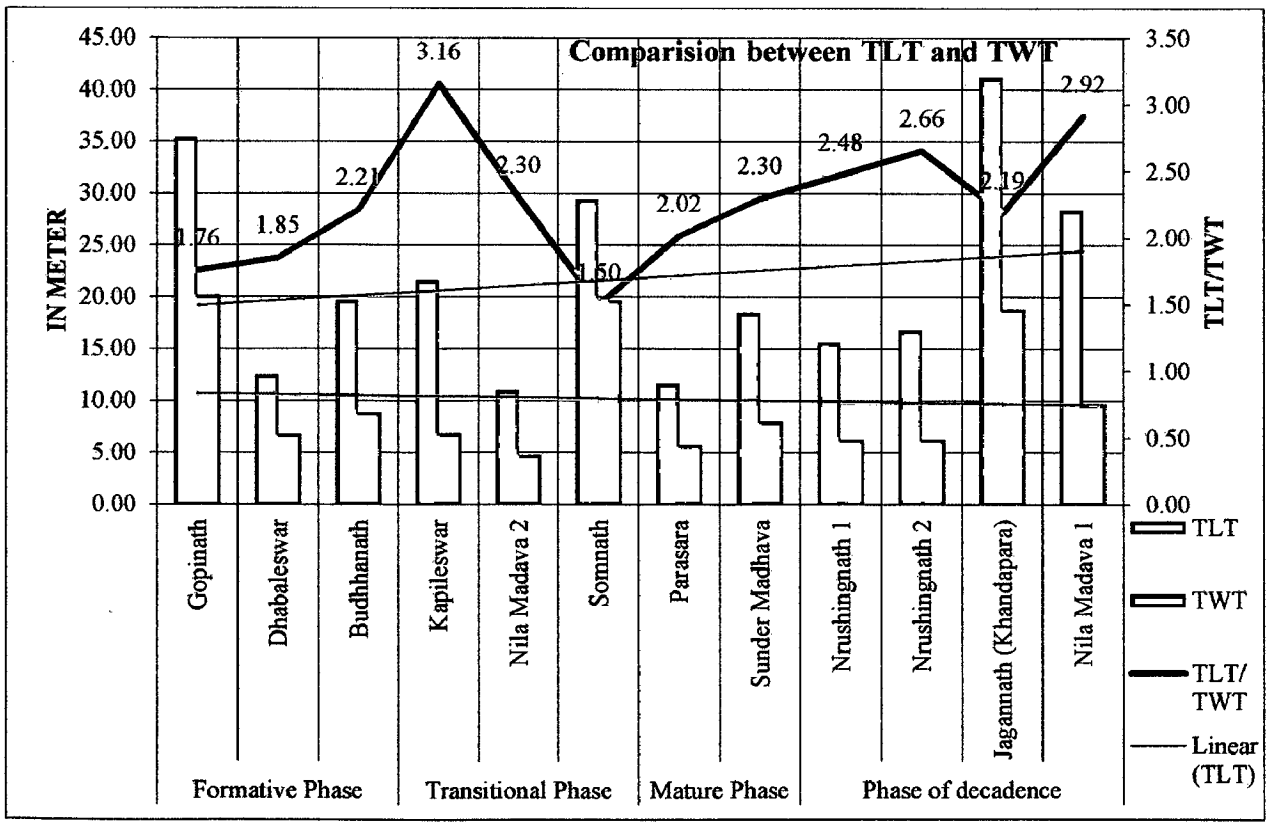
consideration it did not affect the overall build form width as they gradually expanding length wise. The overview of the sample collected temple has been discussed below.

Table 5.6 Total length and Total Width of the Sample Temple

Phases	Temple Name	TLT (in M)	TWT (in M)	TLT/TWT
Formative Phase	Gopinath	35.41	20.17	1.76
	Dhabaleswar	12.50	6.76	1.85
	Budhhanath	19.68	8.89	2.21
Transitional Phase	Kapileswar	21.67	6.86	3.16
	Nila Madava 2	11.06	4.80	2.30
	Somnath	29.43	19.66	1.50
Mature Phase	Parasara	11.66	5.78	2.02
	Sunder Madhava	18.49	8.05	2.30
Phase of decadence	Nrushingnath 1	15.66	6.33	2.48
	Nrushingnath 2	16.80	6.33	2.66
	Jagannath (Khandapara)	41.28	18.88	2.19
	Nila Madava 1	28.45	9.76	2.92

TLT =Total Length of the Temple

TWT =Total Width of the Temple



Graph 5.7 Relation between width and length of total build form

From the above table and graph it has been observed and analysed that the ratio between the overall length and width of a temple has come in between 1.50 to 3.16. That means the build form is massive and structurally stable. The average ratio of TLT and TWT is 2.28. When plotted a linear trend of the TLT it has been observed that it is gradually increasing in nature. That means the total length of the temples gradually increase with respect to time. But when the linear trend line of the TWT gives a parallel resultant which means they did not change with respect to time. The overall scenario is due to the addition of the different halls in length wise and not in width wise. The added parts of the temples are Jagamohana, Natyamandapa and Bhogamandapa.

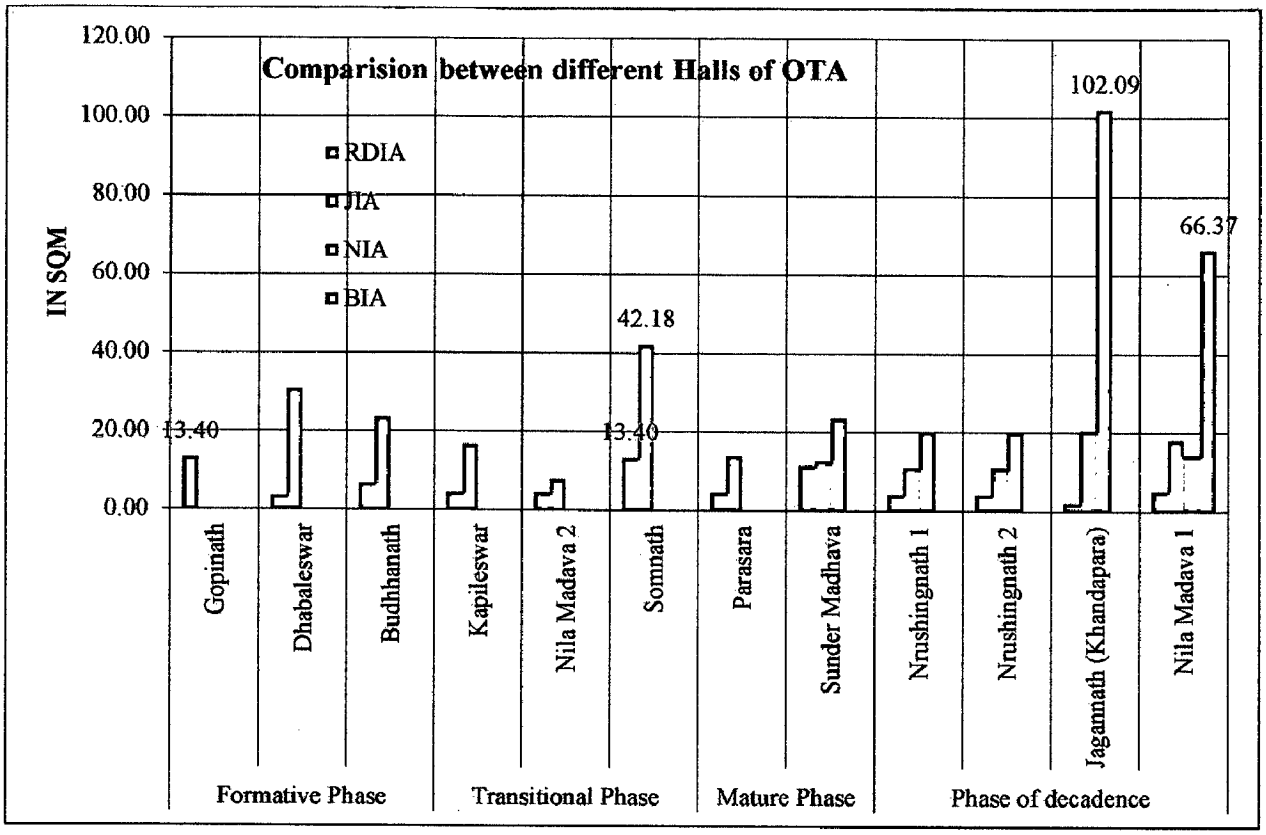
Later in the 13th and 14th century some parts had been added to the temple complexes as they are Anand Bazar (food market/ Prasad sevana market), Koili Vaikuntha (Ponds) Niladri Vihar (gardens), Snana Bedhi (bathing places for the god and goddess) around the garbhagriha.

5.1.9 Relation between Different hall areas

Table 5.7: Different Hall Areas of Orissan Temple Architecture

Phases	Temple Name	RDIA (Sq. M)	JIA (Sq. M)	NIA (Sq. M)	BIA (Sq. M)
Formative Phase	Gopinath	13.40	0.00	0.00	0.00
	Dhabaleswar	3.63	30.72	0.00	0.00
	Budhhanath	6.71	23.65	0.00	0.00
Transitional Phase	Kapileswar	4.56	16.83	0.00	0.00
	Nila Madava 2	4.56	8.01	0.00	0.00
	Somnath	13.40	42.18	0.00	0.00
Mature Phase	Parasara	4.73	13.91	0.00	0.00
	Sunder Madhava	11.59	12.70	23.60	0.00
Phase of decadence	Nrushingnath 1	4.22	11.19	19.92	0.00
	Nrushingnath 2	4.22	11.19	19.92	0.00
	Jagannath (Khandapara)	2.02	20.51	102.09	0.00
	Nila Madava 1	5.34	18.15	14.32	66.37

RDIA = Rekha Deul Inner Area
JIA = Jagamohana Inner Area
NIA = Natyamandapa Inner Area
BIA = Bhogamandapa Inner Area



Graph 5.8: Different Hall Areas of Orissan Temple Architecture

Major parts of Orissan Temple Architecture are Garbhagriha, Jagamohana, Natyamandapa and Bhogamandapa respectively in the plan form. Form the below it has been analysed that the Gopinath temple has only Garbhagriha (Formative phase). But later in Dhabaleswar and Budhhanath temple has both Garbhagriha and Jagamohana and other major parts are not present. It has been continue till the sunder Mahadev temple in the mature phase and after that Natyamandapa has been added to the main temple. It has been also analysed that the Bhogamandapa were the latest addition to the main temple that comes in the phase of decadence in the Nila Madava temple. Here the major finding is the relation between the inner areas of the different halls that comes addition with respect to the time era.

Form the above graph and table it has been observed that the area of the garbhagriha is maximum in Gopinath Temple, Kakudia and Somnath Temple, Budhapara i.e. 13.40 m^2, the maximum area of the Jagamohana is maximum in Somnath Temple, Budhapara i.e. 42.18 Sq.M, the area of the Natyamandapa is maximum in Jagannath Temple, Khandapara i.e. 102.09 Sq.M, and also the area of the Bhogamandapa is maximum in the main Nila Madava temple, Kantilo i.e. 66.37 Sq.M. It has been analysed that the Natyamandapa and Bhogamandapa area are maximum in the phase of decadence whereas the area of the Garbhagriha and Jagamohana are maximum in the transition Phase.

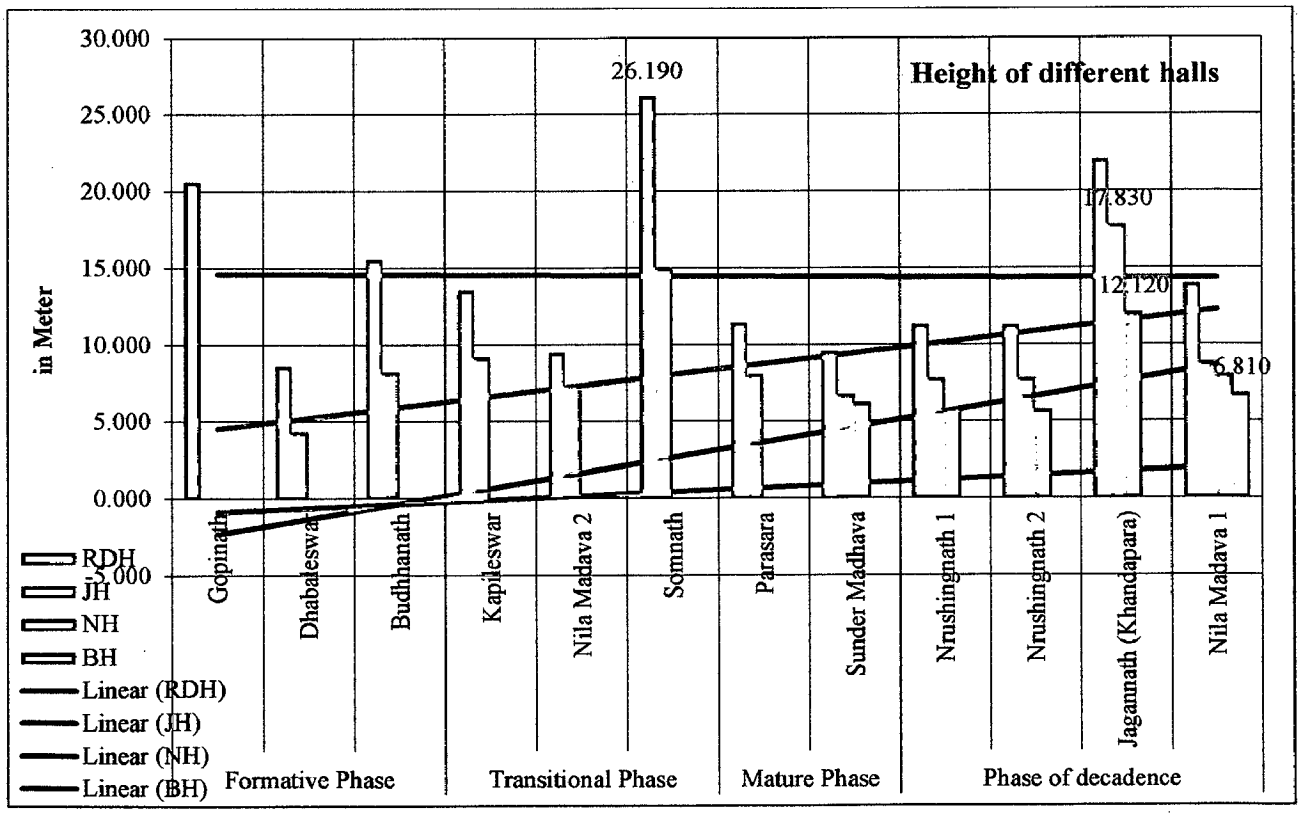
5.1.10 Relation between Different hall heights

As from the above table and graphs it has been clear that the different parts were added in due respect of time. It has been interesting to analyse the relation between the heights between the different parts of the Orissan temple Architecture.

Table 5.8 Different Hall Heights of Orissan Temple Architecture

Phases	Temple Name	RDH (in M)	JH (in M)	NH (in M)	BH (in M)
Formative Phase	Gopinath	20.615	0.000	0.000	0.000
	Dhabaleswar	8.610	4.360	0.000	0.000
	Budhhanath	15.575	8.235	0.000	0.000
Transitional Phase	Kapileswar	13.535	9.185	0.000	0.000
	Nila Madava 2	9.480	7.070	0.000	0.000
	Somnath	26.190	15.055	0.000	0.000
Mature Phase	Parasara	11.440	8.050	0.000	0.000
	Sunder Madhava	9.540	6.780	6.245	0.000
Phase of decadence	Nrushingnath 1	11.320	7.805	5.785	0.000
	Nrushingnath 2	11.275	7.805	5.785	0.000
	Jagannath (Khandapara)	22.050	17.830	12.120	0.000
	Nila Madava 1	13.945	8.885	8.020	6.810

RDH =Rekha Deul Height
JH =Jagamohana Height
NH =Natyamandapa Height
BH =Bhogamandapa Height



Graph 5.9 Different Hall Heights of Orissan Temple Architecture

As it is discussed earlier that the height of the main temple (i.e. height of the garbhagriha is maximum) did not have any relation with respect to phase of Orissan temple architecture. The linear trend line shows it is parallel to the X-axis that means sample temples heights did not relate to the time era. The maximum height is in the Somnath Temple, Budhapara and i.e. 26.190 M. But the linear trend line in the Height of Jagamohana of the sample temple shows it has been increased with respect to time. The maximum height of the Jagamohana is found in the Jagannath temple, khandapara and i.e. 17.830 M.

In Orissan Temple Architecture the major parts like Natyamandapa and Bhogamandapa were absent hence the analysis has been done with limited numbers. The maximum height of Natyamandapa is found in the Jagannath Temple, khandapara in the mature phase and i.e. 12.20M. The plotted linear trend line of the Natyamandapa height shows a gradual increase in height with respect to the time era. But in between the sample temple Bhogamandapa is only present in the main temple of the Nila Madava temple and its height is 6.810M.

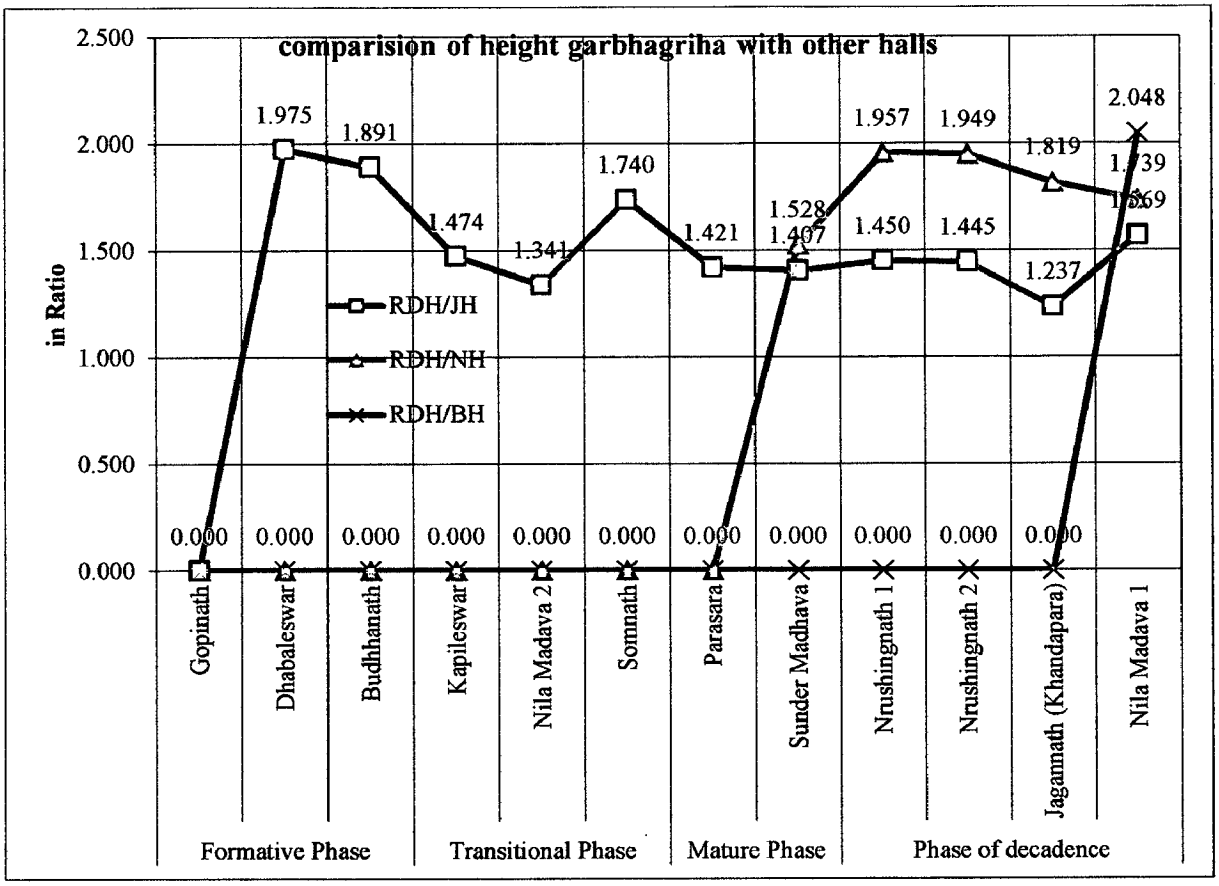
It has been visually observed that RDH (Rekha Deul Height) > JH (Jagamohana Height) > NH (Natyamandapa Height) > BH (Bhogamandapa Height). There is a certain angle maintained in each temple which is gradually decreases with respect to the time era.

5.1.11 Relation between Different hall heights with Garbhagriha

Table 5.9 Relation between the different hall Heights with height of the main shrine

Phases	Temple Name	RDH (in Meter)	RDH/JH	RDH/NH	RDH/BH
Formative Phase	Gopinath	20.615	0.000	0.000	0.000
	Dhabaleswar	8.610	1.975	0.000	0.000
	Budhhanath	15.575	1.891	0.000	0.000
Transitional Phase	Kapileswar	13.535	1.474	0.000	0.000
	Nila Madava 2	9.480	1.341	0.000	0.000
	Somnath	26.190	1.740	0.000	0.000
Mature Phase	Parasara	11.440	1.421	0.000	0.000
	Sunder Madhava	9.540	1.407	1.528	0.000
Phase of decadence	Nrushingnath 1	11.320	1.450	1.957	0.000
	Nrushingnath 2	11.275	1.445	1.949	0.000
	Jagannath (Khandapara)	22.050	1.237	1.819	0.000
	Nila Madava 1	13.945	1.569	1.739	2.048

RDH =Rekha Deul Height
JH =Jagamohana Height
NH =Natyamandapa Height
BH =Bhogamandapa Height



Graph 5.10 Relation between the different hall Heights with height of the main shrine

Now the inter-relation between the height of the garbhagriha with the other parts height. It has been visually observed that the heights of the temples gradually decease from the Garbhagriha to the Bhogamandapa. The angle varies from 15° to 40° according to the length of the overall temple.

The ratio between the Garbhagriha and the Jagamohana gradually decreases with respect to the time and the ratio comes in between 1 and 2. Maximum value is 1.975 in the temple Dhabaleswar temple, Berhampur (Formative phase) and the lowest is 1.237 in the temple Jagannath temple, khandapara (Phase of decadence). The average ratio on the selected sample temple is 1.541 (which is very close to golden mean ratio 1.61), not considering the Gopinath temple as did not had Jagamohana.

The ratio between the Garbhagriha and Natyamandapa has been found to be decreasing with respect to time era. The average ratio is found to be 1.798 considering temples having Natyamandapa only. The maximum ratio is found to be 1.957 in the temple main temple of Nrushingnath temple, Nair. But the ratio of the only temple having Bhogamandapa Nila Madava temple is 2.048.

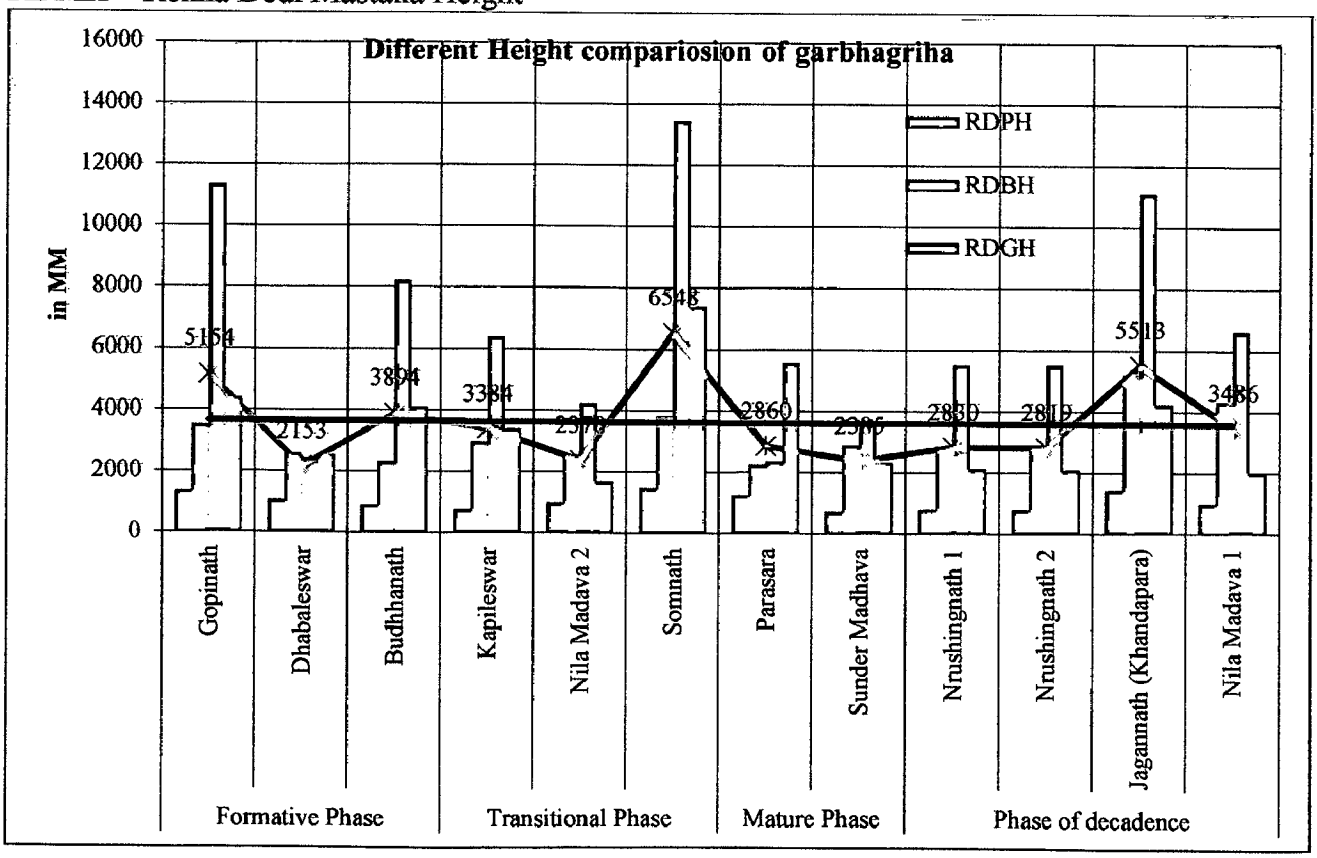
5.1.12 Relation between Different heights of garbhagriha of OTA

Commonly Orissan temple architecture had four different parts when considering height, as they are Pitha (Plinth of the temple), Bada (base of the temple), Gandi (body of the temple) and Mastaka (head of the temple). Each part had further division on each segment but due the availability of data and time restriction detail analysis of each data has not been possible.

Table 5.10 Relation between Different heights of Garbhagriha

Phases	Temple Name	RDPH (in MM)	RDBH (in MM)	RDGH (in MM)	RDMH (in MM)
Formative Phase	Gopinath	1365	3510	11340	4400
	Dhabaleswar	1065	2580	2415	2550
	Budhhanath	910	2335	8210	4120
Transitional Phase	Kapileswar	760	2970	6400	3405
	Nila Madava 2	990	2555	4245	1690
	Somnath	1490	3830	13460	7410
Mature Phase	Parasara	1255	2260	2360	5565
	Sunder Madhava	725	2895	3580	2340
Phase of decadence	Nrushingnath 1	800	2860	5525	2135
	Nrushingnath 2	800	2860	5525	2090
	Jagannath (Khandapara)	1450	5220	11125	4255
	Nila Madava 1	990	4345	6630	1980

RDPH = Rekha Deul Pitha Height
RDBH = Rekha Deul Bada Height
RDGH = Rekha Deul Gandi Height
RDMH = Rekha Deul Mastaka Height



Graph 5.11 Relation between Different heights of Garbhagriha

Form the above table and graph it has been analysed that each part has a proportional relation to each other. Each Bada is smaller as compare to other elements, in each phases of Sample Orissan temple architecture. It has been observed that, in the hierarchy basis height of Gandi > Mastaka > Bada > Pitha. The entire garbhagriha (on height basis) has been compared to the height of a human figure. The average linear trend line shows in the graph predicts that there has not been any discrepancy of relation between these four elements of the garbhagriha taking into consideration.

5.1.13 Relation between Different heights of Jagamohana of OTA

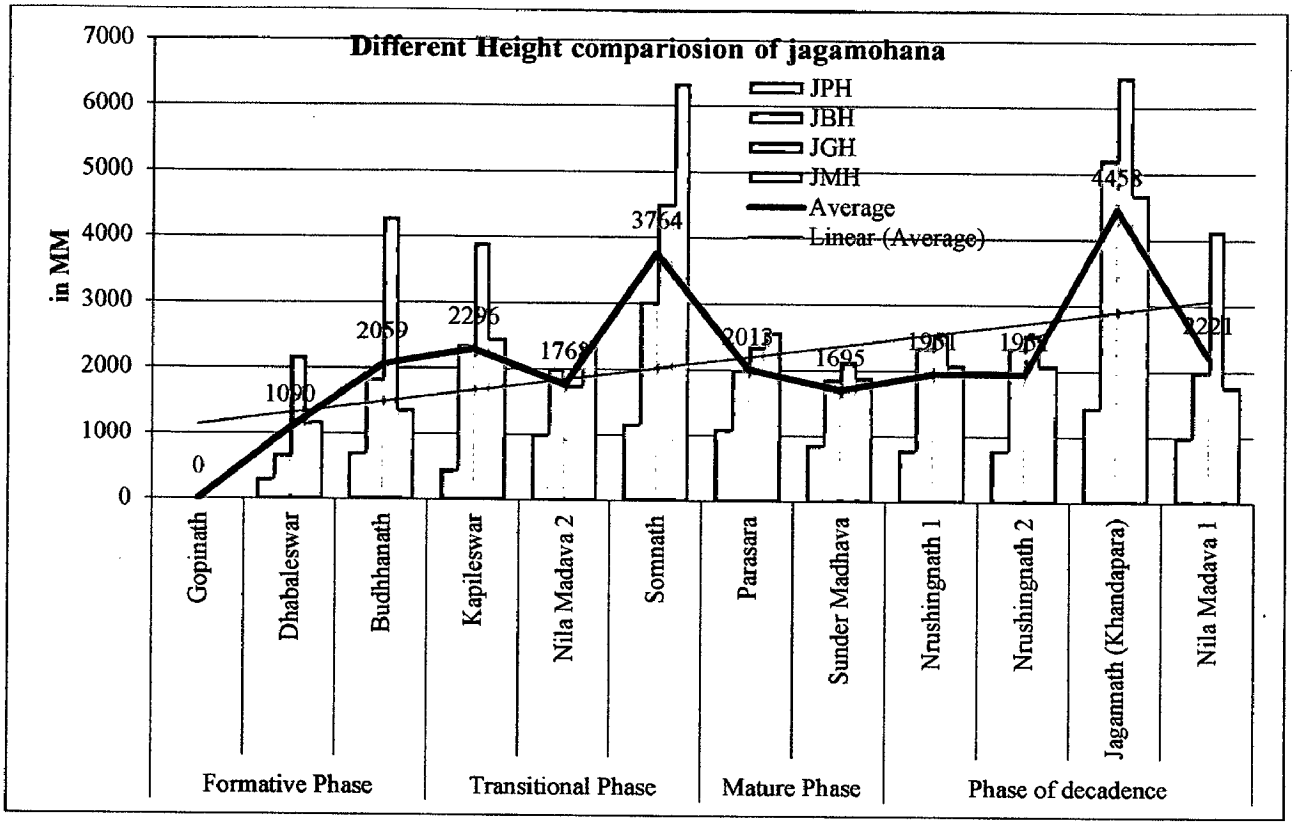
As garbhagriha, here also the availability of data and time restriction detailed analysis of Jagamohana. All the four elements of the height are same as seen in the garbhagriha. But their heights are as consistent as seen in height comparison of garbhagriha.

Gopinath temple in the formative phase did not have any Jagamohana, so not considering that the selected temples did not have any proper proportional relation to each other as proceed in time line. It has been found that the Gandi has been the highest part of the Jagamohana (exception has seen in the Somnath temple, Budhapara). It has been analysed that height of Gandi > Bada > Mastaka > Pitha. The average linear trend line predicts that it gradually increase with the increase in time era

Table 5.11 Relation between Different heights of Jagamohana

Phases	Temple Name	JPH (in MM)	JBH (in MM)	JGH (in MM)	JMH (in MM)	Average
Formative Phase	Gopinath	0	0	0	0	0
	Dhabaleswar	315	685	2175	1185	1090
	Budhhanath	715	1845	4295	1380	2059
Transitional Phase	Kapileswar	455	2360	3910	2460	2296
	Nila Madava 2	990	1980	1755	2345	1768
	Somnath	1175	3025	4515	6340	3764
Mature Phase	Parasara	1105	2005	2360	2580	2013
	Sunder Madhava	875	1865	2135	1905	1695
Phase of decadence	Nrushingnath 1	800	2360	2555	2090	1951
	Nrushingnath 2	800	2360	2555	2090	1951
	Jagannath (Khandapara)	1450	5220	6475	4685	4458
	Nila Madava 1	990	1980	4140	1775	2221

JPH = Jagamohana Pitha Height
JBH = Jagamohana Bada Height
JGH = Jagamohana Gandi Height
JMH = Jagamohana Mastaka Height



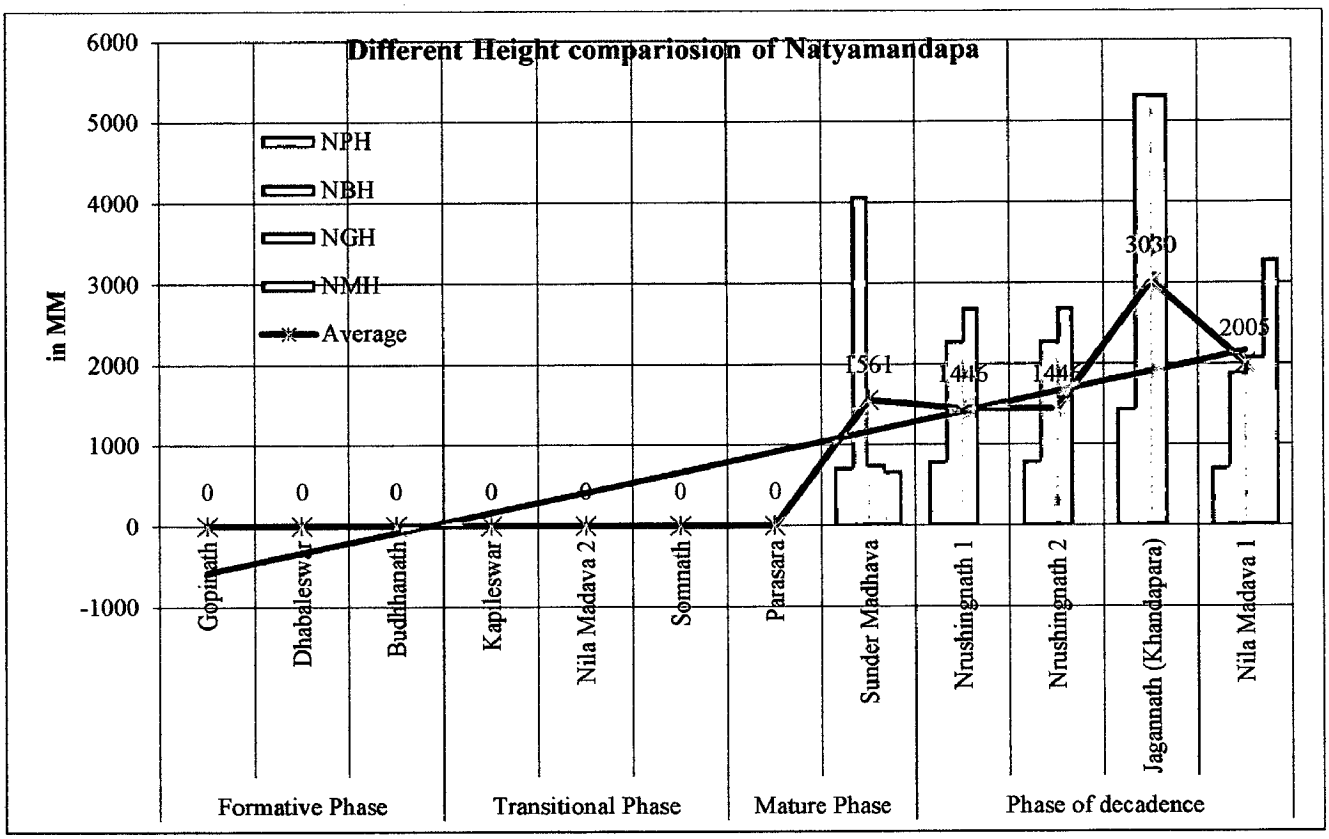
Graph 5.12 Relation between Different heights of Jagamohana

5.1.14 Relation between Different heights of Natyamandapa of OTA

Table 5.12 Relation between Different heights of Natyamandapa

Phases	Temple Name	NPH (in MM)	NBH (in MM)	NGH (in MM)	NMH (in MM)
Formative Phase	Gopinath	0	0	0	0
	Dhabaleswar	0	0	0	0
	Budhhanath	0	0	0	0
Transitional Phase	Kapileswar	0	0	0	0
	Nila Madava 2	0	0	0	0
	Somnath	0	0	0	0
Mature Phase	Parasara	0	0	0	0
	Sunder Madhava	725	4075	760	685
Phase of decadence	Nrushingnath 1	800	2285	2700	0
	Nrushingnath 2	800	2285	2700	0
	Jagannath (Khandapara)	1450	5335	5335	0
	Nila Madava 1	725	1905	2090	3300

NPH = Natyamandapa Pitha Height
NBH = Natyamandapa Bada Height
NGH = Natyamandapa Gandi Height
NMH = Natyamandapa Mastaka Height



Graph 5.13 Relation between Different heights of Natyamandapa

As most of the selected temple till the Parasara temple, Paradeep ghar (mature phase) did not had Natyamandapa, hence the analysis of these temples are excluded

From the above table and graph it has been observed that the height of the Bada and the Gandi height are almost equal (exception has been found in Sunder Madhava temple whose Bada > Gandi). The plotted linear trend line predicts the average heights are increasing with respect to time era (i.e. phases to phases the average height of the Natyamandapa has been increases.)

5.2 Analysis based on Vastu purusha Mandala Study

5.2.1 Analysis of Garbhagriha with Vastu Purusha mandala

As it has been understood from the literature and the case studies the Hindu temple are basically derived from the vastu purusha mandala. According to Hindu mythology, the size of the Deity is determined by the owner of the temple, (or king of the area). At the birth time, the situation of the stars predicts the life of that person.

So the calculation of his graha and nakhyatras (stars) of that particular person the size of the main deity is decided. After deciding the size of the deity, it is considered as the one box of the vastu purusha mandala (central one).

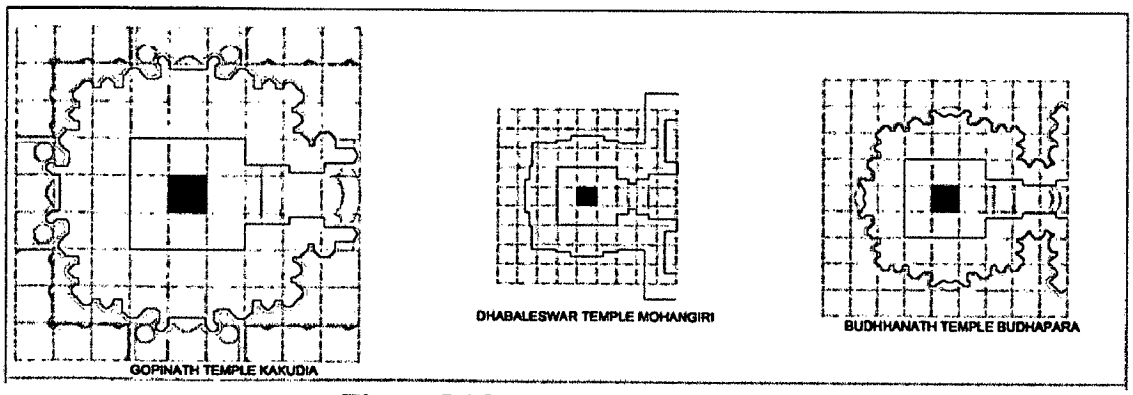


Figure 5.1Garbhagriha of Formative phases

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

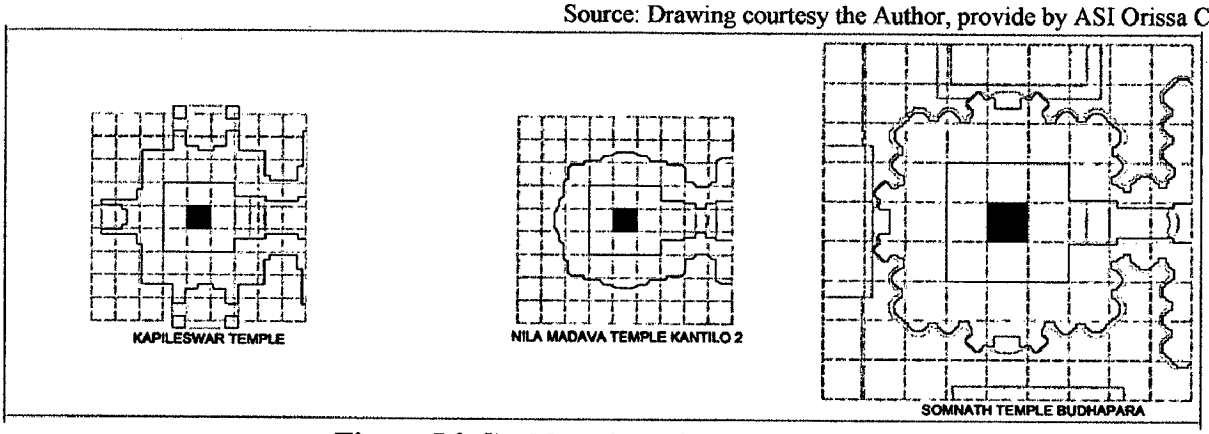


Figure 5.2 Garbhagriha of Transition phases

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

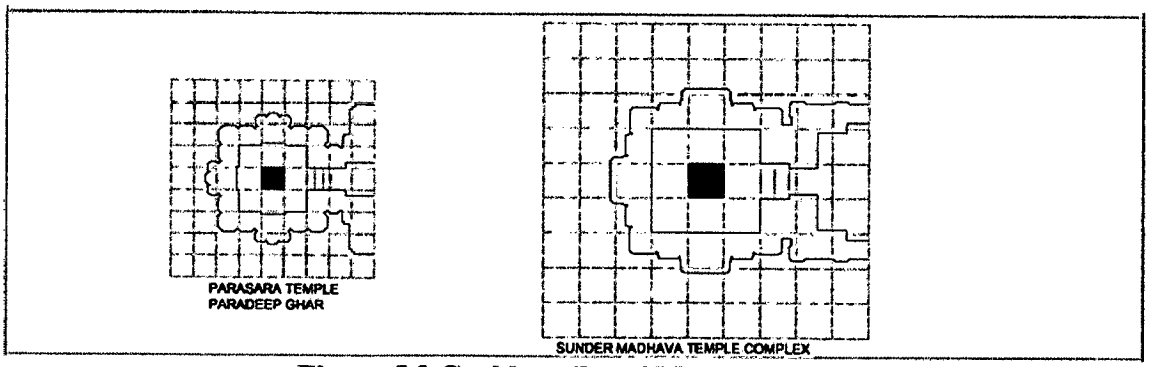


Figure 5.3 Garbhagriha of Mature phases

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

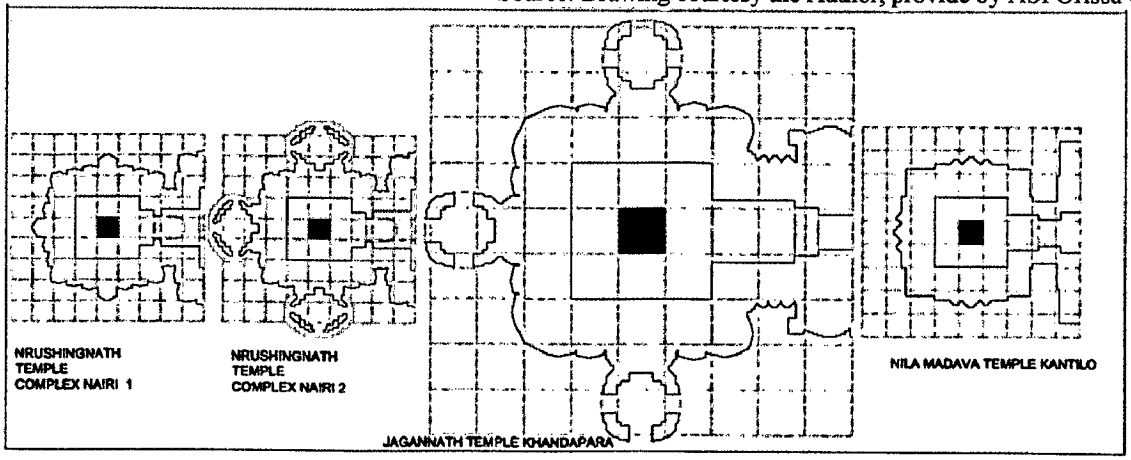


Figure 5.4 Garbhagriha of Phase of Decadence

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

And the inner garbhagriha size is 3X3 of that box. And the total height of the garbhagriha is 10 times that of height of the deity (also known as dasatala). If it known that the height of the total garbhagriha is known then each part of the elements of the temple can be determined. The inner 3X3 circle is dedicated to the main deity. The next external 16 boxes has been kept for the wall areas. The outer boxes are kept for the pradikhyana path, the holy circumference of the temple. Except east side (entry side), rest all three side had one each box, that has been kept for the parswa debatas.

When kept a 3X3 squares kept as inner side of garbhagriha the calculation of each parts of the garbhagriha has been simplified. And again considering these 3X3 squares as central part and made 9X9 mandalas, it has given a clear idea about the location of the Antarala, Jagamohana size, location of the parswa debatas and more. The central red coloured squares are the base of the deity.

5.2.2 Analysis of Jagamohana with Vastu Purusha mandala

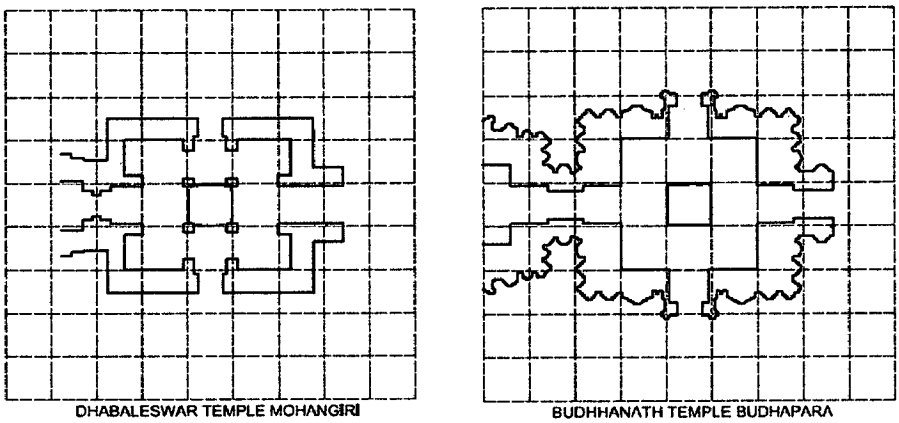


Figure 5.5 Jagamohana of formative phases

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

Jagamohana has also direct relation to the vastu purusha mandala. The Jagamohana of the Orissan temple architecture are also almost square in the size.

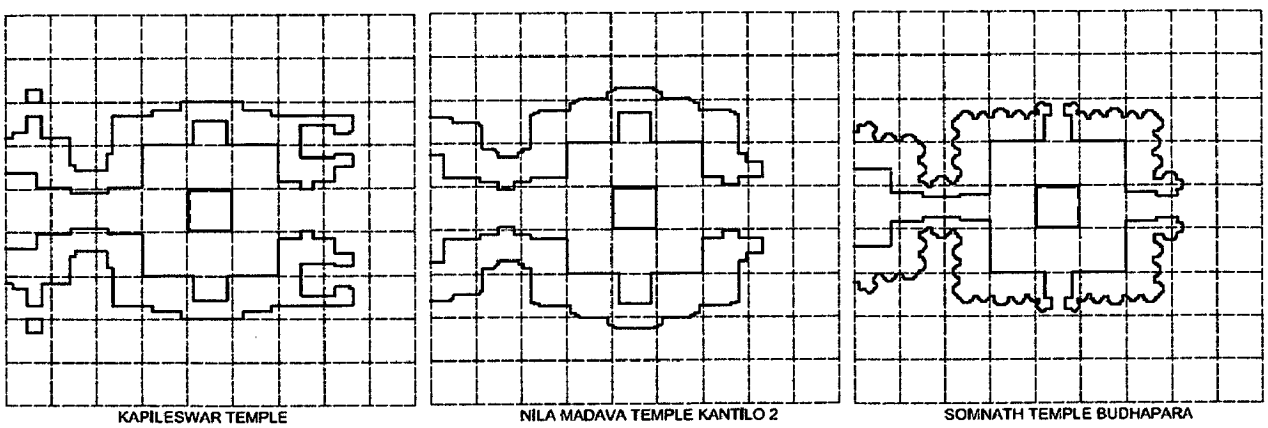


Figure 5.6 Jagamohana of Formative phases

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

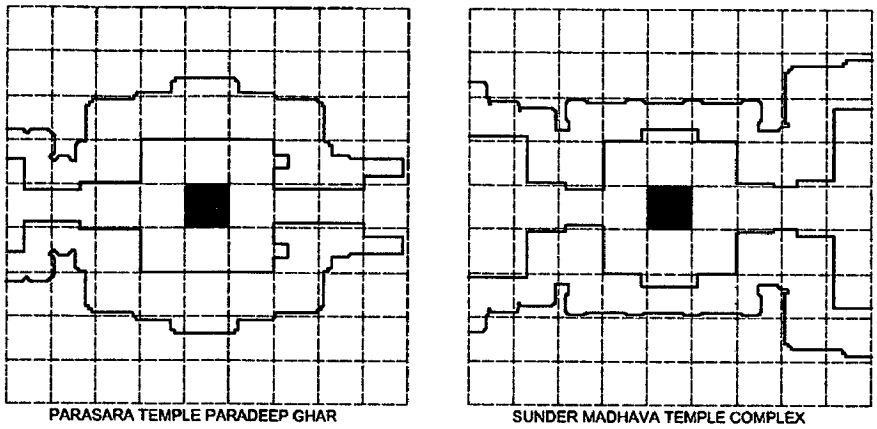


Figure 5.7 Jagamohana of Mature Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

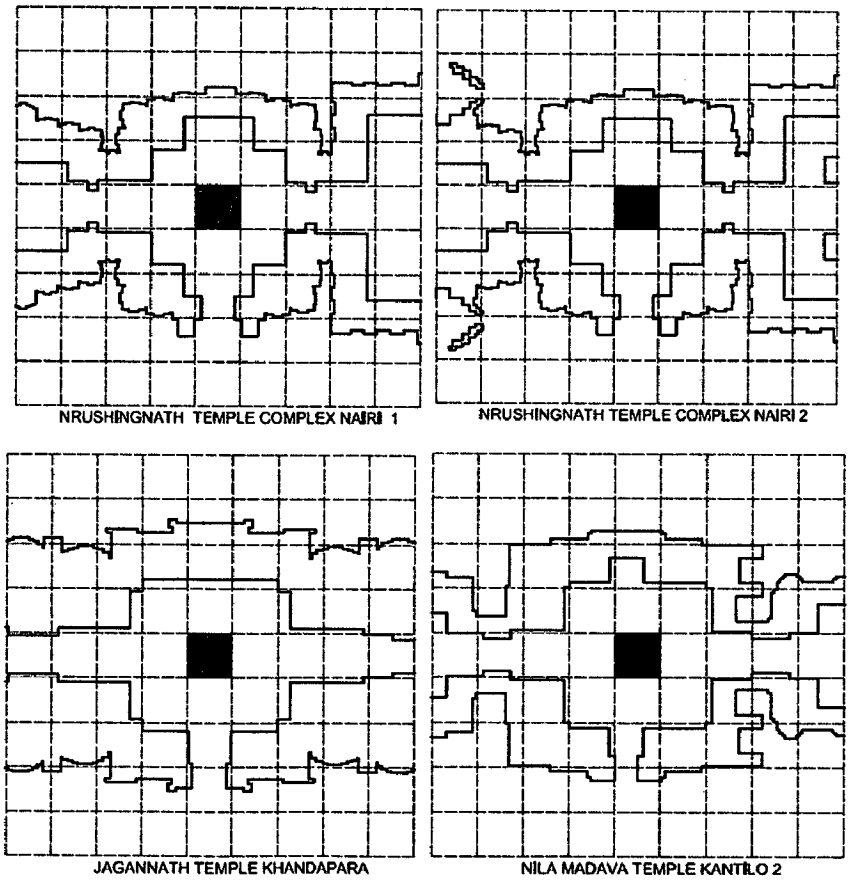


Figure 5.8 Jagamohana of Phase of Decadence

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

When analyzing the Jagamohana in different phases of Orissan temple architecture, it has been found that the all its 8 cardinal points has some meaning that resembles with the vastu purusha mandala. From east the main entry to the Jagamohana and from the west the location of the antarala is located. At the south there has another entry to the Jagamohana. And each square has different meaning related to vastu purusha mandala. Central red coloured square is the center of garbhagriha where the brushava (bull) is located. Other 8 squares are kept vacant as prayer hall for the general public.

5.3 Analysis based on Fractal geometry

5.3.1 Fractalization of garbhagriha pagas

Inner side of the garbhagriha has the typical square form but there has been found of corbelling on the outer side of the garbhagriha found. Generally pagas are the plan form of the projection of the garbhagriha. There are three kinds of Pagas are there, as they are Raha Paga (when side deities are situated), Kanaka Paga (corner part of the garbhagriha) and Anradha Paga (intermediate part of the Raha and Kanaka Pagas).

Many different techniques of fractalization to achieve great visual complexity to express the idea of multiplying and growth are found in existing Orissan Temple. The plan forms of garbhagriha (outer part of Rekha Deul) are gradually changed from inner square form to modified circular form in the change of time.

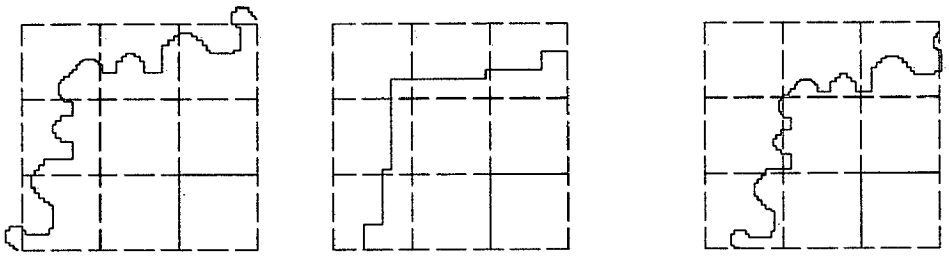


Figure 5.9 Kanaka Paga of Formative Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

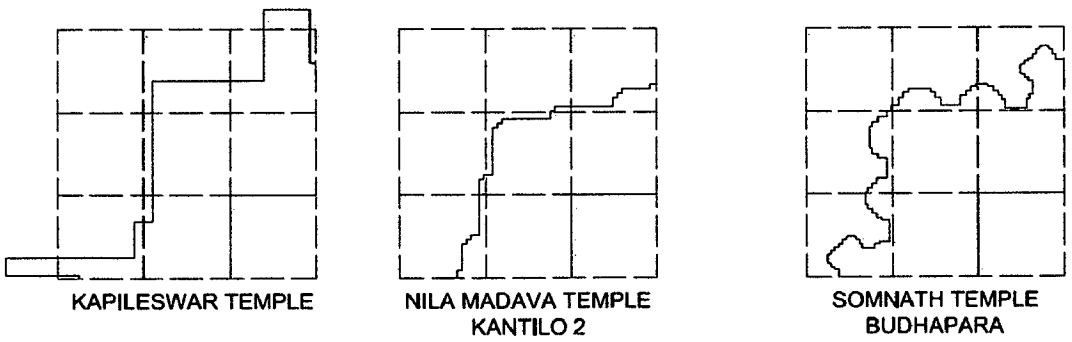


Figure 5.10 Kanaka Paga of Transition phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

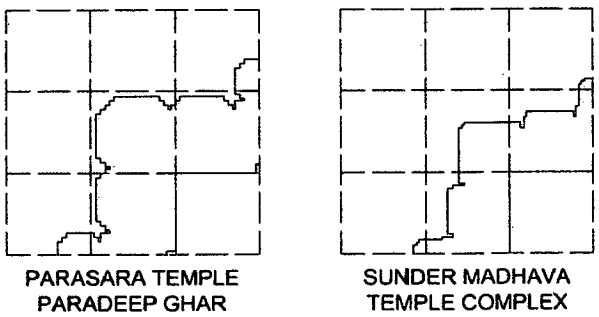


Figure 5.11 Kanaka Paga of Mature Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

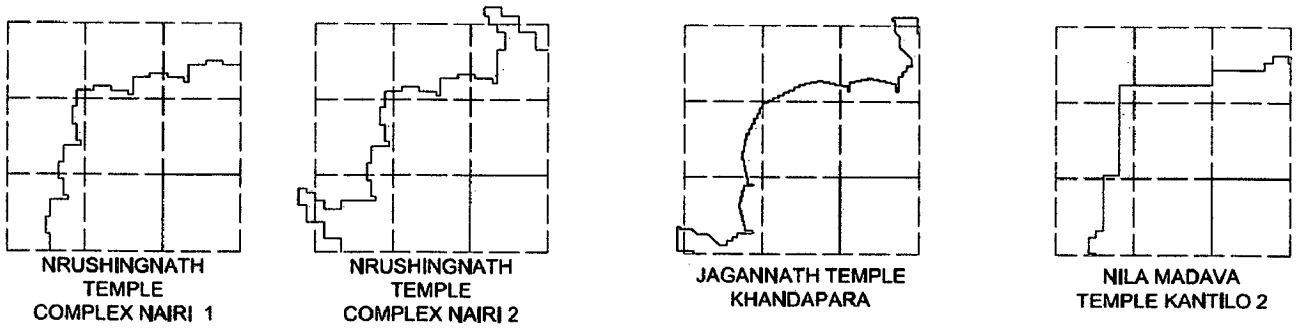


Figure 5.12 Kanaka Paga of Phase of Decadence

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

When analyzing the kanaka Paga it has been found that line follows in a self-similar pattern and that can be explained in terms of fractal geometry. The jaggedness found in this area explains the self-similar property of the shapes that follow the construction techniques. The geometry based on these kanaka Pagas has been depending upon the position of the 9 planets and 32 stars of the temple owner. The Kanaka Paga in each side of the temples is Self-similar iteration in a decreasing scale and repetition, superimposition and juxtaposition upon each other. Hence they explain the presence of fractal geometry in the Orissan temple architecture. Likewise these things are clearly visible in case of raha Paga and Anrdha Paga as well.

The repetition of identical shapes, either in the vertical or in the horizontal, or vertically as well as horizontally, is another frequently used procedure to add visual complexity to the temple form. The rules of repetition and decrease act conjointly. Stella Kramrisch describes the significance of these processes in her book The Temple as Purusha.

In addition to repetition, different motifs are superimposed in three dimensions upon each other; motifs are inscribed within different kinds of motifs and several different kinds of themes and motifs are condensed and juxtaposed together into one complex new entity. Together, all these operations create the total temple form crawling with complex detail, vibrant, dynamic and self-similar like the cosmos it is supposed to represent.

5.4 Visual Analysis of Mastaka

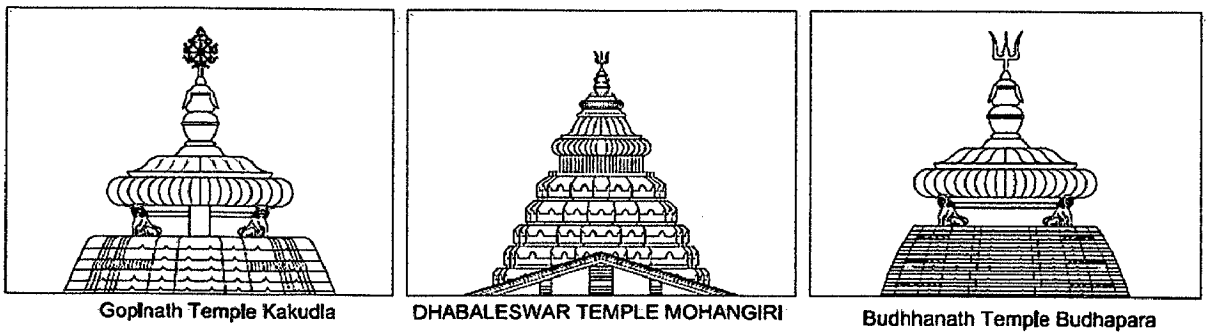
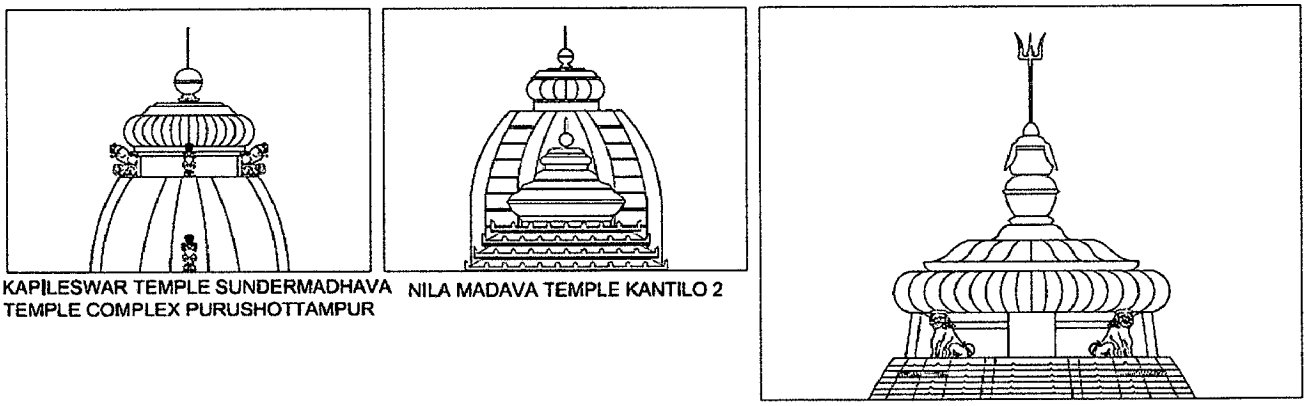


Figure 5.13 Mastaka of Formative Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter



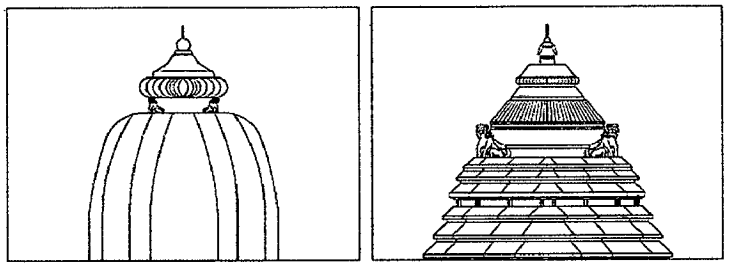
KAPILESWAR TEMPLE SUNDERMADHAVA TEMPLE COMPLEX PURUSHOTTAMPUR

NILA MADAVA TEMPLE KANTILO 2

Somnath Temple Budhapara

Figure 5.14 Mastaka of Transition Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

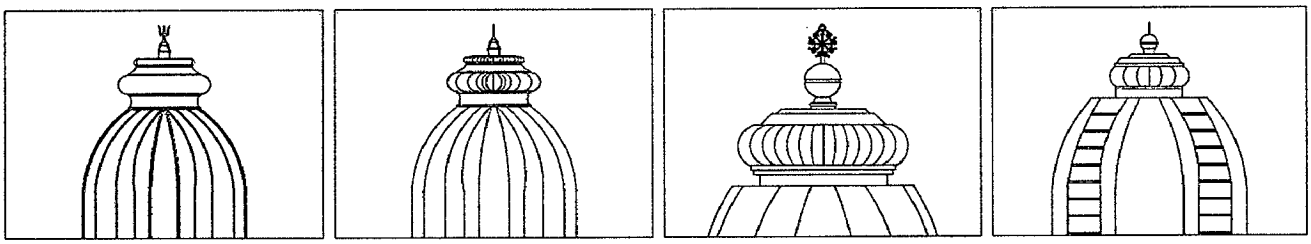


PARASARA TEMPLE PARADEEP GHAR

SUNDER MADHAVA TEMPLE COMPLEX PURUSHOTTAMPUR

Figure 5.15 Mastaka of Mature Phase

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter



NRUSHINGNATH TEMPLE COMPLEX NAIRI 1

NRUSHINGNATH TEMPLE COMPLEX NAIRI 2

JAGANNATH TEMPLE KHANDAPARA

NILA MADAVA TEMPLE KANTILO

Figure 5.16 Mastaka of Phase of Decadence

Source: Drawing courtesy the Author, provide by ASI Orissa Chapter

There are mainly two different kind of temples are found in the Orissan style of architecture. As they are saiva and viashanava. The main differentiate element of these temples is that, in the saiva temple there is trident (trisul) at the top most part of the temple and in the vaishanava temples mainly in the Jagannath temples, there is a wheel (chakra) on the top most part of the temples. And other kinds of temples which are derivative of these temples have only flags at the top most part of these temples.

The Orissan temple architecture has different kinds of Mastaka in different phases. When analyzing the drawings the plan and elevations of these temples it has been observed and analyzed that their visual linkage between all parts of the Orissan temple architecture. The visual angle found between them varies from 15° to 45° in different phases. The as the elements are added in later periods gradually the visual angle between them decreases as the length of the total temple complex increases era to era.

CHAPTER - 6
CONCLUSIONS

6.1 Introduction

The Indian subcontinent in its long and varied history dating from 2500 BC to the colonial period has left behind in the form of its architectural legacy different types of buildings in a variety of architectural styles. The diversity of Indian culture is evident from the different forms of artistic expressions in its built heritage. Among them is the temple architecture of India which has given India a truly magnificent form of architecture.

The temples in India especially Orissan temple architecture are found everywhere varying from small villages to the metropolitan cities. The Orissan Temples are not only the abode of God forming the link between God and man and a place of worship, but they are also the cradle of knowledge, art, architecture and culture. The practices and traditions of temples has its influence on the social, economic and traditional values system in India even today as it was in the ancient times. Today even as new temples continue to be built the character of Hindu temples follow age old traditions though its architectural style is influenced by the local architectural styles and locally available building material and skills.

This dissertation is a research into the foundation of the Orissan Hindu temples and the development of temple architecture in Orissa. The distinctive architectural styles of Hindu temples have so developed due to its broad geographical, climatic, cultural, racial, historical and linguistic differences which are especially significant in the evolution of Orissan Hindu temple architecture i.e. form formative phase to phase decadence through Transitional phase and Mature Phase.

While Orissa the regions share a common origin in thatched huts and modest timber forms, as reflected in early bas-relief depictions and their actual rock-cut representations, further evolution of the structural shrine in each region charters an independent course. But even though the appearance of the temple differed in the basic philosophy that guided, their planning and layout was the same guided by manuals on architecture.

There are several ancient scriptures and books or manuals in Hinduism. Among these are the scriptures that have guided Hindus on techniques and structural rules of architecture. The technical treatises written in Sanskrit, which is an ancient language of India (the language of the Vedas), gives the basic rules in the field of architecture and sculpture are called as the Shilpa Shastras and Vastu Shastras. The Mayamata and Mansara is the other two well-known treatise of all form of Indian temples on architecture and iconography respectively. For

Orissan temple there are many treatises as Bhusan Pradipa, silpa Ratnakar, Vastu Sastra Upanishad, Silpa Sarini, Silpa Prakash, Padma Kesari, Deul Mapagunagara, Bhusana Prakash, Soudhkagama.

6.2 Major study Findings

The rules from these treatises were strictly followed for the construction of temples dating back from the 5th Century A.D and followed even today throughout the country in different temple forms and styles. The temple is a link between the physical world of man and divine world of God. And to connect them, the plan of cosmos was graphically copied in the foundation of the temples. Thus the typical plan of a Hindu temple is an illustration of sacred geometry where the temple is representation of the mandala. Here the sacred geometry means the science the accurate laying out the ground floor of the temple in relation to the astronomical movements and positions and the cardinal directions. The mandala is the sacred form consisting of the intersection of the circle and the square. Thus the Orissan Hindu architecture, religious or vernacular, according to the sects in the ancient times was based on the geometry of the Vastupurushamandala.

The basic construction technique used in early Hindu temple was the trabeated system or the post and the beam method and which was extended by the use of corbelling techniques. This method was originally used for wooden construction in India and was later adopted for the stone structures as well. The column-beam-corbel method of construction however became the main structural principle governing the construction of every Hindu temple. The principles of equilibrium of forces in action by means of arch, vaults and other forms of functional engineering rules never really played a major part in the evolution of Hindu temple. The Hindu architects thus remained attached to its own traditional techniques and accomplished his task of construction by carefully study of the laws of gravity, obtaining the strength by the mass supporting mass and stability by the solid resistance of the weights acting vertically, all pressure being transmitted directly down wards. The construction technology used in the construction of the Hindu temple, the processes involved during its construction, the human skills required and methods utilized by architects and their team, all of this together bring out the art, science and philosophy behind the construction of the Hindu temple.

6.3 Major Analytical Findings

This dissertation covers the analysis based on dimensional analysis, like plan area ratio of the temples means the total built-up area Vs. total wall area of the temple, temple height Vs. Time era, temple overall built-up area Vs. Time era. This dissertation also explains

some kind of structural analysis like the slenderness ratio vs. the time era, total height vs. total width oh the temple with respect to time era and relation between the total area and the height of the temple with respect to time era. There is also explanation of hall areas vs. time of construction, and inter-relation between different parts heights relation with each other of different halls.

The tradition of temple construction is carried out by various organized groups of architects, artisans and workmen who were employed in the various aspects of temple construction. Today even though there are few of these associations remaining that still maintain the tradition of the construction of the temples On the basis of the above studies this dissertation concludes by undertaking a dimensional shape & geometrical study of Orissan temples taking examples from primarily different time periods of Orissan temples in an attempt to graphically analyze the structures with respect to its structural stability.

The finding of this dissertation on the basis of the above studies undertaken has been that the massive nature the stability of the temple structure depends mainly on the geometrical compatibility of the elements with respect to the dimensions that varies from different phases of Orissan temple architecture and their inter-relationship with time era. A dimensional analysis therefore constitutes an important step in shape and geometrical assessment of this kind of structures. The data concerning the main geometrical property of temple from different location of Orissa from different phases of Orissan temple architecture here have been collected and elaborated through some specific though limited number of examples. In spite of the limited number of samples it is possible to find some interesting trend even though the absence of statistical validity constitutes a starting point for future works concerning the geometrical analysis of the temples.

6.4 Scope for Future Studies

The Hindu temples of India have been a subject of study for numerous historians, religious scholars, art historians, photo-journalists, archaeologists, architects and other professionals. There is scope for much study on Orissa as well as other Indian Hindu temples in different regions of India not just based on the iconography, form and transformation but more on their building technology and structural analysis through shape and geometrical study on dimensional consideration. Some studies have been undertaken, For example it is known that numerous temples have fallen due to different calamities from time to time, yet there are even today examples of temple which haven't fallen either due to earthquake or cyclone or other natural calamity as because these temple were constructed in the form of an interlocking system as per laid out in the ancient manuals. Therefore these structures tend to

vibrates along with the earth's vibrations, and will sway but not fall under any circumstances during earthquakes or cyclones. Therefore there is scope for further understanding of the structural aspects through understanding of shape grammar of Hindu temple.

BIBLIOGRAPHY

1. Amma, T, A, Sarasvati, (1979), "Geometry in Ancient and Medieval India", New Delhi, Motilal Banarasidas.
2. Banarjee, J. (1985). "The Development of Hindu Iconography". Delhi.
3. Binda, L.; et al. (2000) "Survey and Investigation for the Diagnosis of Damaged Masonry Structures: "The Torrazzo of Cremona", 12th Int. Brick/Block Masonry Conf., Madrid, Spain, pp.237- 257.
4. Bose, K. (1982). "Canons of Orissan Architecture". Kolkata: Cosmo Publication.
5. Brown, P. (1942). "Indian Architecture: Buddhists and Hindu Period". Bombay: Taraporevala.
6. Chand, D. S. (July-2005). "Orissan Temple Architecture". Orissa Review, 49-51.
7. Deheja, V. (1979). "Early Stone Temples of Orissa". New Delhi: Vikash Publishing House Pvt. Ltd.
8. Grover, S. (1988). "The Architecture of India: Buddhist and Hindu". Ghaziabad: Vikhas Publishing house Pvt. Ltd.
9. Harle, J. C. (1986). "The Art and Architecture of Indian Sub-continent". New Delhi: Penguin Books.
10. Huntington, Susan L. and John, C, (1985), "The Art of Ancient India", New York.
11. Karmisch, S. (1946). "The Hindu Temple". New Delhi.
12. Kundu Anish, (July, 2009), "Orissan Temple Architecture: Symbols of cultural heritage", Architecture – Time Space & People, pp-32-44.
13. Lourenco, P.B., Roque, J.A., (2006), "Simplified indexes for the seismic vulnerability of ancient masonry buildings." Construction and Building Materials, 20, pp 200-208. http://www.sciencedirect.com/
14. Meister, M. (1991). "Encyclopaedia of Indian Temple Architecture". AIIS.
15. Michell G, (1974), "Early Western Calukyan Temples", London, AARP.
16. Michell, G. (1977). "The Hindu Temple". London: B.I. Publication.
17. Md Rian I, Jin-Ho Park, Hyung Uk Ahn (2007). "Fractal geometry as the synthesis of Hindu cosmology in Kandariya Mahadev temple, Khajuraho". Building and Environment. PP 4093-4107.
18. Patnaik, S. K. (June- 2006). "Sri Jagannath Temple – A study of its Cosmic Symbolism". Orissa Review, 117-121.
19. Philip E. Harding, (2000) "south Asian Geometry and Durga Temple, Aihole", South Asian Studies 20, pp 25-35.

20. Tartakov, Gary Michael, (1997). "The Durga Temple at Aihole: A Historical Study", Delhi, Oxford University Press.
21. Trivedi, Kirti. (1989), "Hindu temples: models of fractal universe", The Visual computers, pp-243-258
22. Voiwahsen, A. (1969). "Living Architecture Indian", London, Grosset and Dunlap.

Web Sites

1. http://dcsymbols.com/mastersquare
2. http://www.basas.org.uk/indology.htm
3. http://asi.nic.in/asi_aboutus_organization_headquarter.asp
4. http://orissa.gov.in/Portal/
5. http://www.exoticindia.com
6. http://www.sanathanadharma.com/temple/constru.htm
7. http://www.architexturez.net/+/subject-listing/000018.shtml
8. http://solargeometry.com/temple.htm
9. http://www.hindupedia.com/en/Temple_Construction

ANNEXURE

Survey Schedule

Serial No

1. Name
   - Present Name
   - Past Name
2. Location
   - Latitude, Longitude and Elevation
   - Address
   - Approach
   - Tradition and Legends
3. Ownership
   - Single/ Multiple
   - Public/ Private
   - Any Other (Specify)
   - Name
   - Address
4. Age
   - Precise Date
   - Approximate Date
   - Source of information
5. Property type
   - Precient/ building / structure/ landscape/ site/ tank
   - Subtype
   - Typology
6. Property use
   - Abandoned / in use
   - Present use
   - Past use
7. Significance
   - Historic
   - Cultural
   - Social
   - Associational
8. Physical Description
   - Surrounding
   - Orientation
   - Architectural features
   - Raha niche and parsva devatas
   - Decorative features
   - Building materials
   - Construction techniques
   - Styles
   - Special features (if any)
9. State of preservation
   - Good/ Fair /Showing signs of deterioration / advanced
   - State of decay/ danger of dissappearence
10. Grades (A/B/C)
    - Architectural
    - Historic
    - Associational
    - Social/ cultural
11. Reference notes
12. Maps/ Plans/ Drawings
13. Date of Documentation