Addis Ababa University

(Since 1950)

SCHOOL OF GRADUATE STUDIES

ADDIS ABABA INSTITUTE OF TECHNOLOGY

School of Civil and Environmental Engineering

(Major in Construction Technology and Management)

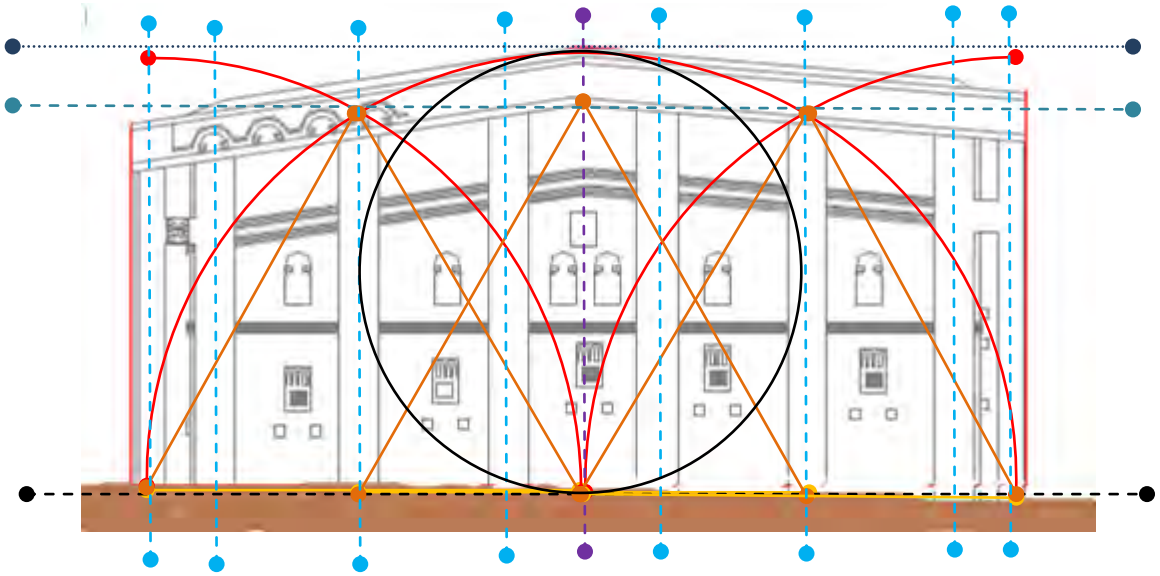
Sacred Geometry Principles on the Construction of the Monolithic Rock-hewn Churches of *Lalibela* and its Structural Formations

By:

Kiros Mesele Berhe

Kirabird1@yahoo.com

+251-915-24-64-52/+251-910-07-39-91



April, 2015

Addis Ababa, Ethiopia

Sacred Geometry Principles on the Construction of the Monolithic Rock-hewn Churches of *Lalibela* and its Structural Formations

A thesis submitted to the School of Graduate Studies, Addis Ababa Institute of Technology (Addis Ababa University) in the partial fulfilment of the requirements for degree of Masters of Science in Civil and Environmental Engineering (major in Construction Technology and Management).

By: Kiros Mesele Berhe

Kirabird1@yahoo.com

This is to certify that the thesis prepared by Kiros Mesele: **Sacred Geometry Principles on the Construction of the Monolithic Rock-Hewn Churches of *Lalibela* and its Structural Formations** and submitted in the partial fulfilment of the requirements for degree of masters of Science in Civil and Environment Engineering (major in Construction Technology and Management) complies with the regulations of the university and meets the standards with respect to originality and quality.

Signed by board examiners:

a.	Prof. Dr. –Ing. Abebe Dinku Advisor	_____ Signature	_____ Date
b.	Eng. Yibltal Zewde External Examiner	_____ Signature	_____ Date
c.	Dr. Ephraim Senbetta Internal Examiner	_____ Signature	_____ Date
d.	Dr. Agizew Nigussie Chairman	_____ Signature	_____ Date

April, 2015
Addis Ababa, Ethiopia

Declaration

I, the undersigned, declare that the thesis is my original work, has not been presented for a degree in any other University (Institute) and that all sources of materials used for the thesis have been duly acknowledged.

Name: Kiros Mesele Berhe

Signature: _____

Place: Addis Ababa Institute of Technology, Addis Ababa University

Date of Submission: April, 20, 2015

E-mail Address: Kirabird1@yahoo.com

Phone Address: +251-915-24-64-52/+251-910-07-39-91

Acknowledgments

I gratefully acknowledge my advisor *Prof. Dr. –Ing*, Abebe Dinku for his invaluable guidance and constant encouragements.

With most precious and deep mutual understanding on the issues, with higher value taker in my all duties, Tibebu Assefa; God bless through all your precious idea, by step for this country.

I also acknowledge Ethiopian Roads Authority (ERA) giving me the opportunity to attend my postgraduate study with all the support I needed.

Tadesse Girmay I want to give you great thanks for his assistance by the first draft of the proposal. At last I am very much thanking full to all my friends for their encouragements.

Special Tanks! Nigusu and Moges (staff from ARCCH) and Alex (Staff from Amhara Cultural Heritages Conservation Bureau, *Lalibela*)! For their collaboration during all site works and providing materials! Without you the site work wouldn‟t be as I planned. Wow, Moges really I appreciate your positivity.

Kiros Mesele

Forward

We must always work hard to apply our knowledge in which we acquire it through long process of learning towards bringing a change in our living condition and for our country, means people. It is not a matter of coming up with new scientific investigation, but only to put our knowledge together and a little effort in adopting the existing well-developed technology to the best of our local conditions and capacities.

We must therefore prepare ourselves for a new and best system and be aware of the fact that there is always a better and better ways to solve our problems.

Kiros Mesele

Dedication

To all human beings; seekers of the ancient wisdom on sacred places!!!

Table of Contents

Pages

List of Figures

Pages

List of Tables

List of Acronyms

a.m.s.l: above mean sea level

ARCCH: Ethiopian Authority for Research on Conservation of Cultural Heritages.

EOT: Ethiopian Orthodox *Tewahdo*

GMR: Golden Mean Ratio

ICOMOS: International Council on Monuments and Sites

UNESCO: United Nations Educational, Scientific and Cultural Organization

WHS: World Heritage Sites

Abstract

Man imitates the nature to create his own output and builds many existing structures to symbolize his achievements. Analysing the forms, arrangements, symbols, and figures of the structures usually lead to new idea. One of the structures man strives to devote his wisdom are sacred buildings. All of creation evolves out of a sacred geometric patterns incorporated within the molecular seed structure. When these seed patterns are incorporated into our architecture, a vibration exchange takes place between the building and its occupants in a way that is similar to the connection we have with nature, and which leads to a sense of well being.

Among many historical sacred sites being known Ethiopia is its rock-hewn churches. Rock hewn churches of *Lalibela*, carved into the rugged mountainsides below ground level and they are ringed by trenches and courtyards and connected to each other by a tangled maze of tunnels and passages. The rock churches constructed during the *Zagwe* dynasty also express the zenith of Ethiopian civilization. Many generations have been a part of this architecture which stands enormous reminding of that glorious past. Ethiopian architecture evolved in various ages in different parts and regions of the country. The emergence and decay of great empires and dynasties in the country, each in their way influenced the growth and shaped the evolution of Ethiopian architecture.

Geometry has existed in many buildings and design forms across centuries. Geometric proportions in architectural patterns represent a design language, as words do in a spoken language. The visual expression of the order of these laws is best represented through the discipline of geometry. Geometry is the blueprint of the creation and the generator of all forms. Geometric ratios and proportions existed and were employed in the design and construction of *Lalibela* rock-hewn churches and ceremonial sites. They were invariably built with dimensions that incorporate mathematical numbers, constants and ratios such as the golden/sacred mean, and the use of geometries based on proportional circles, proportional rectangles and triangles. Sacred geometry is the geometry used in the planning and construction of religious structures such as temples, churches, mosques, religious monuments, altars and tabernacles.

The research will address mainly on what principles of construction methods adopted? Investigating the construction sequencing (built up or built down?), (either in-out caving or out-in caving?), structural formations and geometry of the monolithic churches. The methodology used for the available resources will be by field study, measurement and taking as built drawings and studies. Finally this research ends with conclusion and opening recommendations for further investigations.

By an overview of the main architectural features of the churches of *Lalibela*, and of the decorations that are carved on their surfaces, considerations come to mind how little it is known of the 12th century Ethiopian art!

Key Words:
Church, Construction sequence, Geometric proportion, Lalibela, Monolithic, Rock-hewn, Sacred geometry, Structural arrangements and Zagwe dynasty.

Organization of the Thesis

The thesis is organized in to six chapters. The first chapter, the introduction part, comprises statement of the problem, objectives of the study, scope of the study and methodology of the study as major elements. Chapter two holds the broaden parts of the study, which is the literature review includes the natural settings of the study area, historical backgrounds, sacred architecture and geometry, structural formations and geometry of sacred buildings and construction of ancient rock churches. In chapter three the monolithic rock-hewn churches of *lalibela* are described on their art and architecture, principles of structural formations and ways of construction. The fourth chapter focuses on the current situations of the churches and conservation needed. Discussion and analysis is assessed in the fifth chapter. Finally conclusion and recommendation are set in the sixth chapter.

CHAPTER ONE: INTRODUCTION

1.1. General Background

A deliberate action of a man is the output of what is there in his consciousness. This consciousness is the centre of all creation. It is the central force for the creation of the universe. Nature is the result of consciousness and a man always reflects in his all actions by imitating nature. Nature is there with in man, and man is there with in nature. The importance of exploring the historical basis of any human achievement is unquestionable. It gives a complete understanding of how ideas came to be the way they are now. It is the flow of consciousness to the practical output. Man imitates the nature to create his own output and builds many existing structures to symbolize his achievements. Analysing the forms, arrangements, symbols, and figures of the structures usually lead to many new ideas. One of the structures man strives to devote his wisdom are sacred buildings. Buildings are finger prints for manifestation of human civilization in every aspect. The clear geometry that arouses message, as a science of building structure, is a useful tool for describing anything of both the abstract and material world.

Human being himself is the yardstick of the measurement world. Man uses his palm, foot, thumb, arm, as centimetres, meters, kilometres etc., to measure everything he wants to make fit to himself. The structural formations and integrities lie in the use of forms; but, the question is how to and by what principles these forms were shaped and put together? So, designers of the past have been striving to bring out different principles by analysing the forms of ancient ruins. It is this motive and unexpected observation of the „swastika" symbolic shape of windows in *Bete Mariam* draws the researcher"s attention to study on the construction and engineering aspect of the churches. The researcher was so surprised founding the swastika symbol there, because it is associated with the Nazi symbol of the Hitler regime and symbolic signs of the secret societies which are called "illuminati". And, being the researcher had been questioning about "illuminati" in different books and videos (by Gidey G/Kidan series books on secrete societies, documentary videos by David Icke and Henry Linkoln BBC documentary films on Rein-le-chateau Churches Geometrical patterns etc), and seeing this symbol with in *Lalibela* churches increased the researcher"s curiosity.

It is known, however, that the swastika was the ancient Persian symbol of the sun and predates the Nazi period by far. It is also important to observe that one is clock wise and the other one is anti-clock wise direction. Nowadays, it has a symbolic importance to the Ethiopian Orthodox *Tewahdo* Church. In one hand it symbolizes the sun and the sun represents the power and rule of Jesus Christ, on the other hand it represents the power and rule of Jesus Christ at every direction of the world [1]. However, for more findings, the researcher started the journey!

[1] *Tibebu A., 2007. Proportion: the Visual Dimension of Urban Design in the case of the MRHCs of Lalibela, AAU.*

There are many rock structures roughly built into natural caves and cliffs. There are well executed and continued to fascinate the modern world. Ajanta Caves (group of about 30 caves carved out of the sides of a steep gorge from basaltic cliffs) and Ellora caves in central India; ancient buildings of Petra "city of rock" in Greek; ancient city of Arabia (in what is now south western Jordan) carved out of sandstone; a series of caves and underground churches dating from the 5th century in Cappadocia (Turkey)[2] various stone temples and structures in China and considerable number of rock churches (rock hewn and cave churches) in Ethiopia are few of rock structures around the world.

Some of them still stand to serve different purposes, purpose for which they originally came to exist or changed their course. Others disintegrated hiding their history in ruins. Some of them are carved out or built to serve religious purposes; like the rock churches in Ethiopia and Buddhist temples in India. Others as place of burial like the Lycia tombs in Turkey [3]. Rock hewn churches and cave churches with varying degree of connection to rocks are Christian structures widely distributed in hill and caves of northern Ethiopia [4].

Ethiopia is a country known for its rock-hewn churches. Though it is difficult to date these churches accurately, it is very likely that most of them are flourished during the early medieval period, 12th century AD. Undoubtedly, however, there are few churches, which date back to the late *Axumite* period (5th and 6th centuries AD). Beside, in the late *Axumite* period, Rock-hewn ecclesiastical buildings were highly developed and widespread in Ethiopia during the *Zagwe* period. Builders of the time were apparently more interested in rock churches than wood and masonry buildings (built-up churches), because, they have noticed locally that the later were perishable and easy to destroy. The historical base of the rock-hewn churches of *Lalibela* lies in the period of the *Zagwe* dynasty. Their construction is attributed to one of the prominent kings of *Zagwe* dynasty, Emperor *Lalibela*. They are found in *Lasta*, which was the dominant and major centre of the *Zagwe* rulers. Built up rock churches along with rock hewn churches can be classified as rock churches. The definition seems more appropriate to be used in the context of this study for it includes both rock hewn and churches built in caves. In Ethiopia, there are number of rock churches which fit into these categories. Several of the churches are carved out of solid rocks, churches partly or completely separated from bed rocks; others are simply cave churches with a facade cut from the rock, or simply a cave with few pillars [5].

There are still others, churches built up into natural caves. This typology is extended by *Anfray (1985*) in his consideration of the rock hewn churches, rock church tradition of the southern highland regions (*Shawa, Sidamo* and *Bale*). His six forms differentiate between varying degrees of incorporation within rock, from excavated monolithic churches to those half-built, half carved. *Anfray* also differentiates churches built within caves and those which incorporate caves in their structure.

[2] *Microsoft Encarta, 2008.*
[3] *Tibebu A. 2007, et al.*
[4] *Buxton D.1947. The Christian Antiquities of Northern Ethiopia, et.al*
[5] *Findlay, L. 1943. The Monolithic Churches of Lalibela in Ethiopia*

According to *Bidder (1958)* rock churches in Ethiopia, especially rock hewn churches, share few characteristics with rock structures in other parts of the world. On the other hand they embrace different features, which are defining characteristics of rock churches in Ethiopia. There are number of internal and external features unique to rock churches of the country. In the case of rock hewn churches, the closest resemblance to them are the temples of Ellora in India. These structures are freed from the surrounding rock: yet these are different in sprit and character [6]. In fact, there is significant difference even among rock churches in the country in the way they are hewn or built. There are number of rock churches hewn from the front of a cliff. *Debre Tsion Maryam, Abba Yohanni, Abraha-Atsebaha, Abune Yemata* and *Maryam Korkor* in Tigray [7] and *Bete Abba Libanos* and *Bilbala Giyorgis* in *Lasta* are few churches known to be hewn this way. On the other hand most of rock churches in *Lasta* are believed to be carved out through a process that involved excavation of trenches from top [8].

1.2. Statement of the Problem

The rock-hewn churches of *Laibela* have long interested visitors and historians and have unsatisfied archaeologists and geologists seeking their sequence of construction. Do they belong to one grand ceremonial monastic plan, or a long-lived ritual centre, continually refashioned over time? Since the churches are cut into live rock, the conventional signals of archaeological phasing are hard to find.

A certain historical, geological and archaeological study was performed in the *Lalibela* churches area in order to examine its features in the frame of the town evolution and to evaluate the general stress state of the church, to envisage the most urgent interventions to prevent damage and to consolidate the building [9]. The *Lalibela* area, though not affected by large faults or strong deformations, as indicated by the general sub horizontal setting of the alternate massive and scoraceous basalts with fragmented texture flows, presents widespread and well developed fracture systems. Their structural assessment therefore concentrated on the fracture pattern affecting the rocks around the church. The study was planned to understand which of the fractures were of geological (natural) origin, and what a role they played in the tension setting of the church, and which fractures were instead originated by the church tensional state.

In the surroundings of the *Bete Gabriel-Rufael* church the study revealed the presence of differently oriented systems of fractures composed of one or more sets, mainly affecting the scoriaceous basalt level. The main system is constituted by a sub-horizontal set that shows a great lateral persistence and continuity also at depth. The fractures are few three to four meters spaced and can be followed in the rock mass all around the church. They show a very regular orientation with only few degrees of difference around the horizontal plane resulting in a much clustered contour diagram.

---

[6] *Bidder, I. 1958. Lalibela: The Monolithic Churches of Ethiopia*
[7] *Natnael Ketema, 2012. Archaeological Study of Rock Churches in Lasta, Northern Wollo, p1-3*
[8] *Ital. J. Geosci. 2012, Integrated geological-architectural pilot study of the Biet Gabriel-Rufael rock hewn church in Lalibela, northern Ethiopia), pp. 176*
[9] *Ital. J. Ibid.*

The cross-section cutting across the churches as well as the sketches of the front and the backyard of the church allow to observe the continuity of the sub-horizontal fractures. Two hypotheses can be suggested about the origin of this set: i) the fractures developed during the cooling of the scoriaceous basalt level, after its deposition or ii) the fractures are the result of unloading, as suggested by the fact that the most superficial fractures belonging to this set follow the morphological surface; on the other hand, also previously formed fractures can be involved in later unloading and can be enhanced by thermal expansion [10].

The researcher due addressing the above problems of *Lalibela*, assessed by professionals to extract information about the structural formations and integrity of the churches and sequencing on the construction of rock-hewn churches; while, locally usually said as follows below, which is the question of all, who concerned about the churches construction. Also it had mentioned in (*Tilahun T., 2010.)* as they express their pleasure while they travel to *Lalibela* for the annual Merry Ethiopian Christmas festivity, *Ghena*.

ቅዱሰ ላሊበላ የላስታው ደብር

ውስጡ አረንጓዴ ነው ባህር

እሰይ የልቤ ደረሰ(2)

ዐየኁ ዐለም አየ እግሬ ደርሶ

የዲንጋይ ወጋግራ የዲንጋይ ምሰሶ

እሰይ የልቤ ደረሰ(2)

“አረ እንደምን አድርጎ ሠራው”

“አረ እንደምን አድርጎ አነጸው”

ለመጥረብያ እንኳን እጀታ የለው!

[10] *Ital. J. Ibid.*

1.3. Research Questions

The research questions are:

a) What principles governed the structural formation, integrity and stability of the monolithic rock-hewn churches of *Lalibela*?

b) How does the structural system influence the construction sequencing of the monolithic churches of *Lalibela*?

1.4. Objectives of the Study

The objectives of the study are;

a) To identify the ways of construction and its sequencing; either is it Top - Bottom or Bottom -Top construction and its carving either In-Out or Out-In; which gives a glimpse on its construction in which structural knowledge and architectural principles had been considered;

b) To investigate principles governed its architecture, structural formations and arrangement and site layout of the churches; and

c) To assess their current situation and their major failure. Further, to draw a lesson for the restoration and conservation activities by understanding on its critical structural patterns.

1.5. Scope of the Study

The research work is limited to four monolithic free standing individual rock hewn churches as they are situated inside spaces surrounded by the terrain of the area from which they were hollowed out.

1.6. Expected outputs of the Study

The expected outputs of the research are:

a) The structural formations which account for its structural integrities and arrangements.

b) The ways of construction sequencing, either Top-Bottom or Bottom-Top; and its caving either Out-In or In-out.

c) Built drawings for the four monolithic churches based on measurements and surveying.

d) Report on systems of structural integrity and their current situation and its input for need of restoration and conservation.

1.7. Significance of the Study

The significances of the study are:

a) It will create understandings on the basic sacred geometrical principles incorporation for the *Lalibela* churches architecture in which it provides well life form of the occupants by forming sacred spaces.

b) It will create understandings of natural geometrical patterns of creations.

c) It provides a well-studied and organized documentation as bridge of knowledge transfer for the next generation.

d) It provides a possible guidance for the need of conservation, which is a major current issue.

e) It will uncover the 12th century architectural principles advancement and bases for construction systems.

f) This research will be of great importance in promoting architectural and engineering knowledge of the period and the relics under study for it integrates heritages which holds vital place in the society. And, its tourism attraction more on its scientific documentation and its reliability.

g) It attracts for further research on this related areas.

1.8. Limitations of the Study

A research is an organized study and disciplined investigation into a subject in order to discover facts, to establish or revise a theory, or to develop a scientific direction based on the facts discovered, while doing this it needs a group of collaborations and aids for a better output. Having this in mind, the budget constraint is the major problem, it discourage the whole activity of the work. The financed budget for the research couldn‟t even cover a trip‟s transportation cost. *Lalibela* rock hewn churches have so many stake holders, international, national, regional and local. The international stakeholders don‟t have a major influence on the research of this type except acknowledging the place as wonder. But Nationally, *Lalibela's* churches have got two stake holders the Authority of Research and Conservation on Cultural Heritages and the Ethiopian Orthodox Church Head Office, which has a stronghold of the site through its bureaucratic system from top to down. Regionally, the Amhara National Regional State has also a stake since the site is found in its region. Locally the people and the clergies have a concern of the site. So for the research work it is inevitable to get a written consent of each of all these which took me long time to have an access to the site and even seems not interested for to be researched.

The research work was planned to be done with a precision instrument called total station, however, the financial drawbacks also lay its burden in using the instrument. Time is also one of the constraints for this

research work. With all these limitations, the quest for uncovering *Lalibela's* construction art and science has been done diligently.

1.9. Research Methodology

While doing the research, the methodology that the researcher followed starts from collecting the relevant books which are focused on *Lalibela* and ancient medieval sacred buildings", churches" and cathedrals" architecture and their principles. From these literature reviews the researcher found the application of sacred geometry principles in much in their floor plans, elevation plans and their structural elements.

Beside these all, focusing on the decorations on the walls, ceilings and symbolically carved windows of the *Lalibela* churches highlighted to the researcher on the knowhow of this sacred geometry principles. And then, the researcher took a tape measurement on different parts of the monolithic rock hewn churches of *Lalibela*; in addition to this the researcher studied the detailed architectural as built drawings of the churches and their geometric configurations. By these all the researcher understands the application of sacred geometry principles. For further detail elaboration of the research methodology which had been followed, refer to sub section 1.9.2.

1.9.1. Sources of the Data

The methods to be employed to achieve the objectives of the research are:

Primary Data

- **Site Observation, Assessment and Investigation:** includes
  - Taking actual dimension measurements of typical monolithic buildings" elements, using measuring taps. If possible using clinometers to measure vertical angles and distance.
  - By taking photographs for each churches and major cracks occurred throughout the churches in expressive manner
  - Taking scaled measurements of as built drawings and plan layouts of monolithic churches.

Secondary Data

- **Literature Review:** includes published books, articles and resources related to the topic. Particularly by taking available drawings as built drawings.
- **Local Traditions:** sayings about *Lalibela* rock-hewn churches

1.9.2. Research Design

An expressive flow chart describes the research methodology in order to achieve the intended output of the research in a scientific and economical way, as shown in Figure 1.

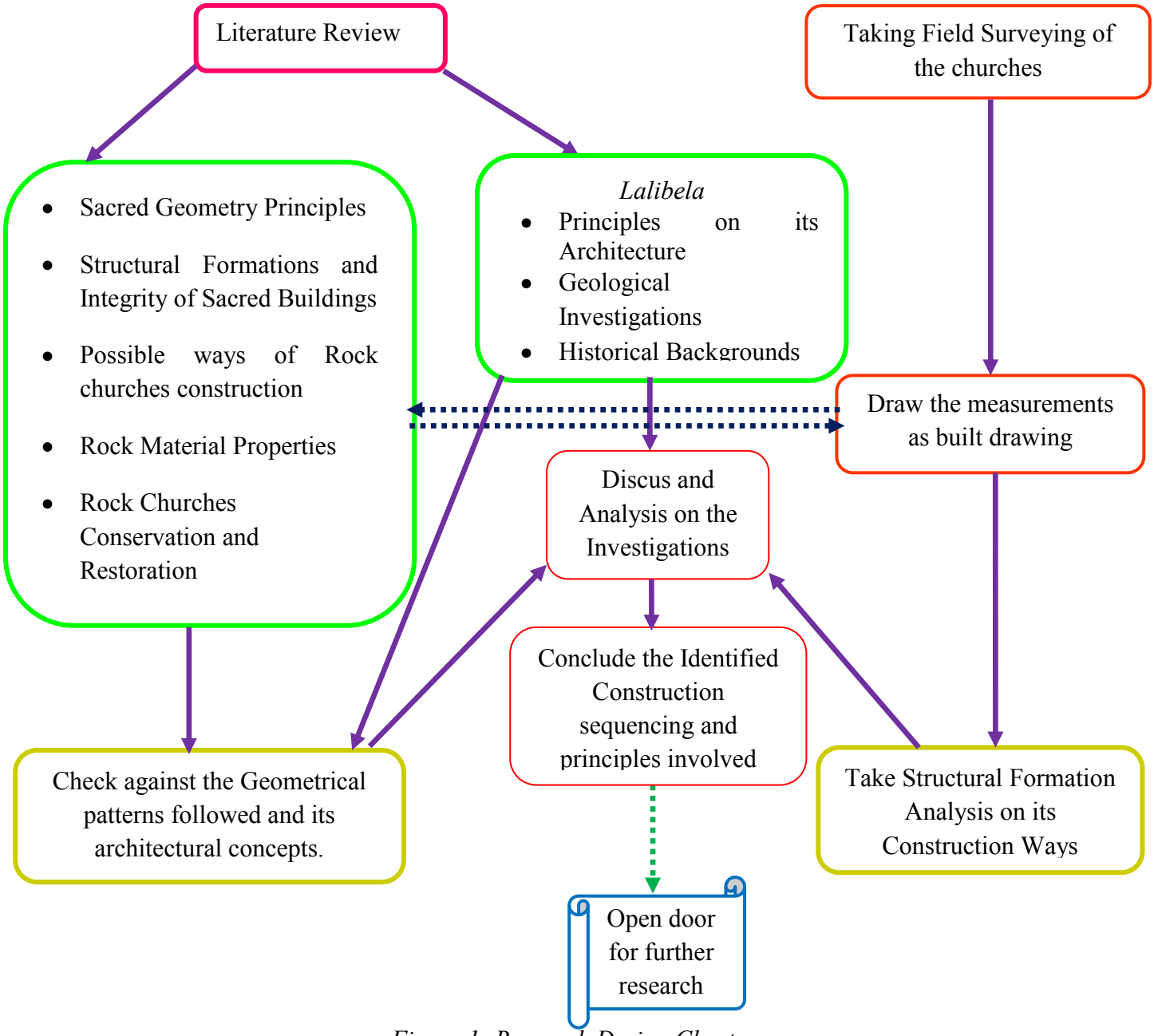


Figure 1: Research Design Chart

1.9.3. Drawing and Analysis of the Data

- **Geometrical sketching works**: includes
  - Transforming the actual measurements on site and by using as built drawings.
  - Geometrical configuration sketching on the scaled papers and check their geometric principles and finding the configuration.
  - And, relate with the site layout to investigate the construction activities synchronization.
- **Finally conclusions will be set and recommendations will be forwarded.**

CHAPTER TWO: LITERATURE REVIEW

2.1. Definitions

- **Aisle (Division in Church):** - an area of a church separated from the nave or central area by pillars, especially one forming a passage between seats. Literature
- **Altar (raised ceremonial religious structures):** - a raised typically flat-topped structure or area where religious ceremonies are performed.
- **Ashlar (Masonry using thin slabs of stone):** - Masonry uses thin slabs of squared stone as facing material.
- **Barrel-Vault:** - Ceiling with half-cylinder shape.
- **Basilica (Ancient Roman building):** - a building with a central nave, a columned aisle on each side, and typically a terminal semi-circular apse. It was used as a court of justice, an assembly hall or an exchange.
- **Bas-relief (Flat Sculpture):** - Sculpture in which the design projects slightly from a flat background, but without any part being totally detached from the background.
- **Beja: -** The principal subgroup of the Cushitic people (includes Ethiopian and Sudan Muslims).
- **Courtyard:** - an area of ground that is adjacent to a building and enclosed by walls.
- **Cliff:** – High steep rock face
- **Corbel:** - a bracket of stone that juts out of a wall to support a structure above it.
- **Eaves (Part of Roof):** - the part of a roof that projects beyond the wall that supports it.
- **Eucharist (Symbolic bread and wine):** - the symbolic or consecrated bread and wine eaten and drunk during the ceremony of communion.
- **Façade (Visible Surface):** - the face of a building, especially the principal or front face showing its most prominent architectural features.
- **Folige (Building Ornamentation):** - architectural ornamentation based on leaves and stems.
- **Grotto:** - a cave, especially one with interesting natural features.
- **Gujarati:** - a member of a people lives mainly in the Indian state of Gujarat.
- **Hymn (Religious Song):** - a song of praise to God, a god, or a Saint.

- **Illuminati:** a group claiming to have received special religious or spiritual enlightenment, especially an 18th-century German secret society with deist and republican ideas
- **Jesuit:** - a member of the Society of Jesus, a Roman Catholic religious order engaged in missionary and educational work worldwide. The order was found by Saint Ignatios Loyola in 1534 with the objective of defending Catholicism against the Reformation.
- **Kabballah:** a body of mystical Jewish teachings based on an interpretation of the Hebrew Scriptures as containing hidden meanings.
- ***Lalibela*:** a word combination of words "*Lal*" means honey in "*Agewgna*", which is grouped under Cushitic language, and "*Yebelal*" –means eaten a honey.
- **Monkey Head:** a feature of windows and doors for Axumite architecture.
- **Narthex:** an entrance hall at the west end of a Christian church between the porch and the nave.
- **Nave (Central Part of Church):** the long central hall of across-shaped church, often with pillars on each side, where the congregation sits.
- **Porch (Covered Entrance):** a covered shelter at the entrance to the building.
- **Ravine:** a deep narrow valley, especially one formed by running water.
- **Regolith:** the layer of loose rock particles that covers the bed rock of most land on the Earth and the Moon.
- **Ruins (Broken Remains**): the physical remains of something such as a building or city that has decayed or been destroyed (*often used in the plural*)
- **Swastika (religious symbol):** an ancient religious symbol formed by a Greek cross, usually with the four ends of the arms bent at right angles in a clockwise or counter clockwise direction
    - **(Nazi symbol):** a Nazi and fascist symbol formed by a Greek cross with the four ends of the arms bent in a clockwise direction
- **Stele:** an ancient stone slab or pillar, usually engraved, inscribed or painted and set upright.
- **Sanctuary:** Holy place (eg. Church, Mosque or Temple).
- **Plinth:** the part of the wall of a building immediately above the ground.
- **Tablets:** a slab of stone or wood used for inscription

NB: Source for the definitions: (Microsoft Encarta Dictionary, 2007)

2.2. Natural Settings of the Study Area

The area, *Lalibela*, is known for rock-hewn churches distributed in mountainous landscape and in relation with destination and movement of the Ark of Covenant. Of all rock churches located in *Lasta*, the rock-hewn churches of *Lalibela* are famous. The churches contributed a lot in making the area known to the outside world and an important centre of tourist destination. Considerable number of tourists, researchers and pilgrims set foot to this area every year. Most of Ethiopian tourists visit these churches in connection with religious celebrations, such as Christmas and Epiphany. The number of foreign tourists also rises during these ceremonies. The site of the churches is described as follows.

Figure 2: The study area: the churches of Lalibela(Source: www.google.com/Road to Ethiopia*)*

2.2.1. Geographical and Environmental Settings

Lalibela at present is the main town in *Lasta*, located in the North *Wollo* Administration Zone, *Amhara* region, about 700km north and direct air distance of 338.9km of Addis Ababa, on 12^0 02‟ north latitude and 39^0 02‟ east longitudes and it is situated at an altitude of about 2630m a. m .s .l. in the Ethiopian highlands [11].

[11] *Mengistu G. 2004. The Rock Churches in and around Lalibela: Archaeological and Geological Study, p28*

Lalibela, the capital of *Bugna* district, getting its present name "*Lalibela*" after King *Lalibela*, previously it was called *Roha*. *Bugna* district is neighboured by *Waghmra* Zone and *Tigray* region in the North, *Mekket* district in the south, *Gidan* district in the east, and South *Gondar* in the west. *Bugena* district covers around 280,000 ha and has average annual rainfall between 650-750mm. The area has two rainy seasons from June to September (big rains) and from March to April (small rains). The annual average temperature is different during cool and hot seasons. During cool seasons the higher temperature ranges from 17-23^{o}C and the lower ranges from 2-8^{o}C, while in hot seasons, the highest temperature ranges from 19-25^{o}C and the lowest is from 8-12^{o}C, generally its temperature climate referred to as *Woina Dega* [12].

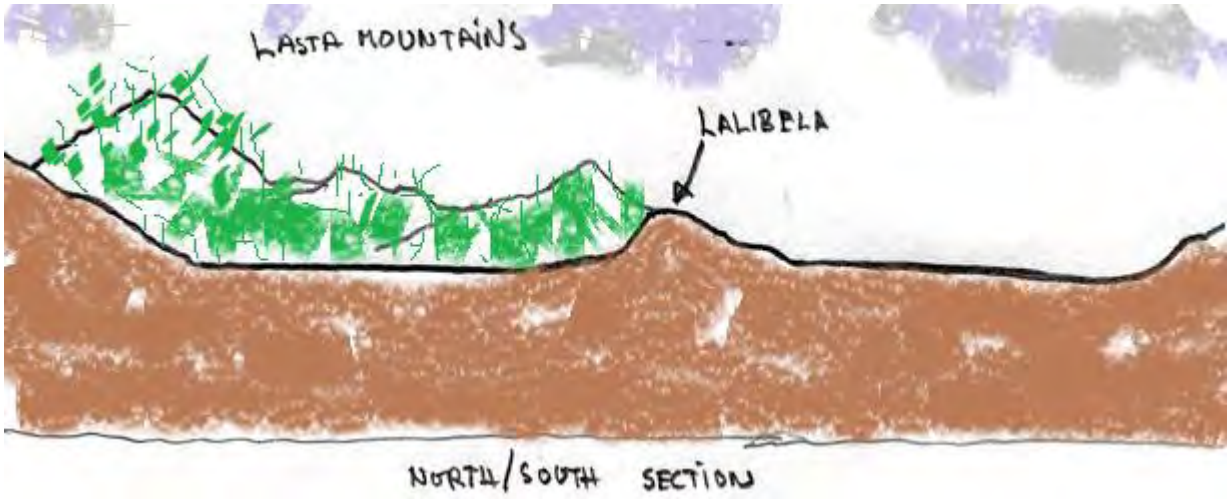


Figure 3: Schematic North-South section through Lalibela (Source: By Mark Jarzombek)

The geographical setting of the area is highly dominated by uplands which range from 4200 to 1600m a. m. s. l.; of the total number, 37% of *woreda's* landscape is upland (mountainous), 20.35% plain and 42.65% rugged terrain [13]. The third highest mountain in Ethiopia, Mount *Abune Yosef*, having 4200m high is found near *Lalibela*. As a result, the largest part of the town"s area is difficult for construction and other similar activities because of natural constraints such as steep slopes, valleys and rugged terrain [14].

2.2.2. Geology of the Area

The northern part of the Ethiopian plateau is composed of two main different typologies of rocks; Oligocene flood basalts and Mio-Pliocene volcanoes. The region is dominated by outcrops of Tertiary volcanic rocks comprising basalt, trachyte and tuff [15]. The geological series of the area, from the oldest and stratigraphical lower unit, consist of the following formations [16].

- **The *Ashangi* Formation**: mainly comprises olivine basalt alternating with agglomerates and tuff. This formation predominantly consists of alkaline basalts with inter-bedded pyroclastics and rare rhyolites erupted from fissures [17].

[12] *Tibebu A.,Ibid, p110.*
[13] [15]*Natnael K., Ibid, p19.*
[14] *Mengstu G. Ibid, p29.*
[16] *Merla et al 1979*
[17] *Kazmin, V. 1975. Explanation of the Geological Map of Ethiopia, the Provisional Military Government of Socialist Ethiopia.*

- **The *Amba Aiba* Basalts (Oligocene–Miocene)**: which mainly consist of flood basalt with rare tuffs? The flows are characterized by columnar jointing and have thickness up to tens of metres. Accordingly the *Amba Alaji* rhyolites (Miocene) generally overlie the *Aiba* basalts. This formation consists of a succession of alkaline to perialkaline rhyolites, alkaline and trachytic alkaline flood basalt. The acidic rocks are thick ignimbrites and tuffs, which crop out widely in the area and form typical landscape elements such as steep walls and cones [18].

- **The *Termaber* formation basalts (Miocene to Pliocene)**: are at the top of the local stratigraphical series. The *Termaber* formation comprises lenticular basalts with a large component of tuffs, scoriaceous lava flows and typical red palaeosols. These are dominant rock type in the area [19].

Generally geological formations of the area are result of the Tertiary Ethiopian volcanism, which resulted in flood basalts and associated ignimbrites and rhyolites. In *Lalibela* area and its environs, only Oligocene flood basalts (*Aiba* Formation) and lower part of the Miocene Alaji Formation (rhyolites, welded tuffs, basalts, and scoriaceous basalts) are exposed [20].

The rocks from which the churches are hewn is among the factors determine the structure of the churches. According to *Lindahl (1970)* irregularity in the shape of the churches is partly related to irregularity of the rocks. The rocks from which the churches are hewn also play significant part in deteriorations related to weathering [21].

As to the study of Teprin Associati, the ten rock hewn churches were constructed on the westward facing steep slope in the centre of the town of *Lalibela*. The rocks in *Lalibela* area are Tertiary volcanic predominantly tuff, trachyte and basalt. The dominant rock out of which the churches were hewed is basic reddish and pink tuff. Basalt is present at the top and bottom of the stratigraphic section in some places. None of the churches were hewed from basaltic rocks. Stratigraphically at the top, fill composed of variable size rock fragments, soils and regoliths were identified all along the westward facing slope.

The fill material which is composed of silt and tuffaceous angular rock fragments is thought to have been deposited by men who were chiselling out of the hill in making the churches and its surrounding tunnels. The regolith is a product of weathering processes on the volcanic rocks. This outcrops only to the north of *Bete Medehanalem*.

[18] *Natnael K. 2007. Ibid*
[19] *Delmonaco, G., Margottini C. & Spizzichino D. 2010. Weathering Processes, structural degradation and slope–structure stability of rock-hewn churches of Lalibela (Ethiopia).*
[20] [21] *Asfawossen Asrat, Yodit Ayalew and Metasebia Demissie. 2008. Geological and geotechnical properties of the medieval rock-hewn churches of Lalibela, northern Ethiopia*

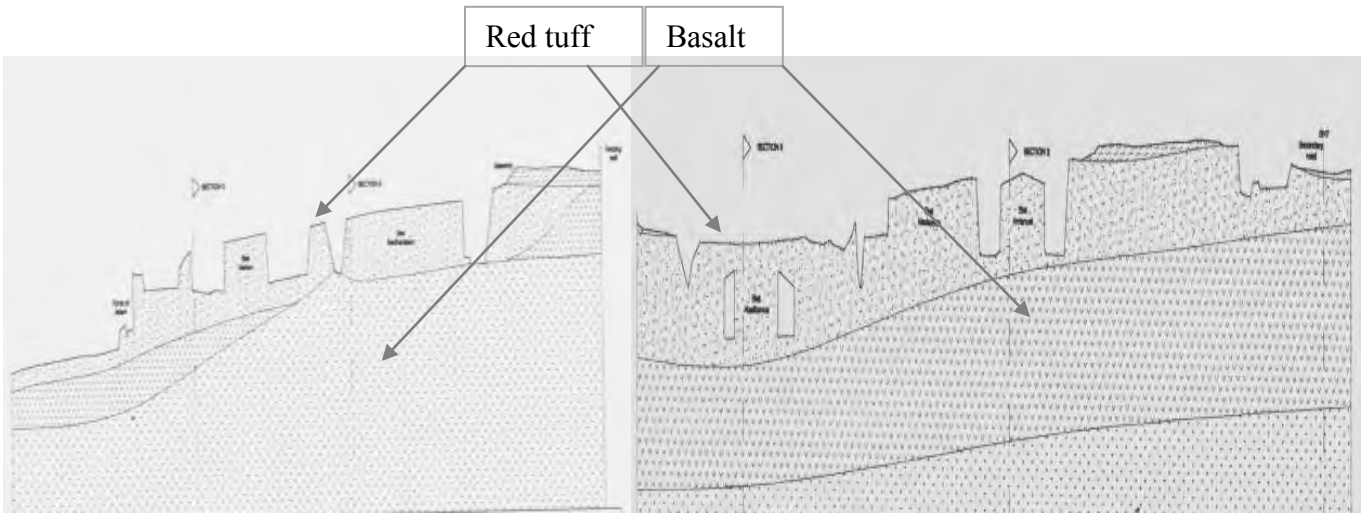


Figure 4: Sections along churches that shows the kind of stone strata (Source: Teprin Associate)

These rock hewn churches are being steadily cracked due to weathering and erosion by surface and sub surface waters. The static groundwater is lower than the floor of the churches. However, in *Bete Ghiorgis,* located at a lower topographic position, leakage of groundwater is evident close to the gate of the church indicating relatively shallower groundwater levels.

2.3. Historical Backgrounds

Lasta area is considered as the origin of dispersion for *Agaw* societies of which are currently found in various regions. Apart from *Lasta* and *Wag* the *Agaws* are widely distributed to *Halhal Bogos* in Eritrea; *Dembya* in *Begemidir* and *Agaw Midir* in *Gojjam* [22], *Wejerat* and *Tembien* in *Tigray*. The *Agaw* society has various names in different regions. In *Wollo* they are called *Wag*, in *Gonder-Qimant*, in *Gojjam - Agaw (Awi)* and in Eritrea - *Blen*. Their language is generally called *'Agaw* ', which belongs to the central Cushitic language group [23].

According to Ethiopian historical recorded sources, most of which were compiled from the late fifteenth century onwards, the *Zagwe* dynasty began in the first half of the 10th century, i.e. ca. 930 AD. The *Zagwe* rulers are therefore supposed to have ruled the country for a period of three centuries. The long period of the *Zagwe* is contested on the number of kings, all in all eleven, would each of them have to rule an average of over thirty years. This is extremely high compared to comparable lists in Ethiopia and elsewhere.

[22] *Sergew Hable Sellasie. 1972. Ancient and Medieval history of Ethiopia to 1270.*
[23] *Mengistu G. 2004: Ibid, p18*

2.3.1. The Land Ethiopia

At times it becomes very important to be reminded that Ethiopian civilization which has spanned at least 3000 years and which has left its impact on nearly everything in our lives and society. Imagine UNESCO has listed 830 World Heritage Sites, out of which 10 are in Ethiopia [24]. This is the first rank from all African countries and less than 19 other world countries. This is a tangible proof of the creative genius and industry of this ancient land, people, and also of the gifts bestowed on it by nature.

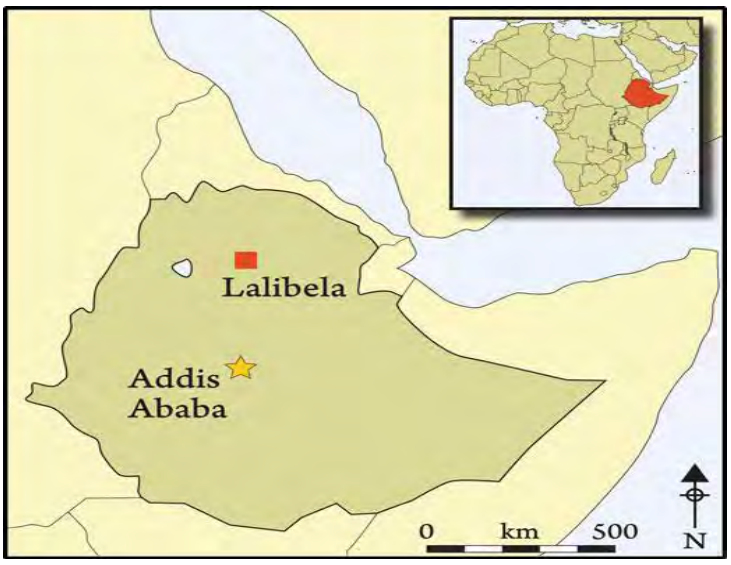


Figure 5: The Land Ethiopia (Source: http://antiquity.ac.uk /ant/084/ant0841135.htm)

Going through the towns of *Yeha, Axum, Lalibela, Gonder, Harar* and *Bale* etc. you find many beautiful buildings. Some are monuments, palaces, temples, churches, mosques and memorials. Most of them had their foundation after the coming of Christianity. Many generations have been a part of this architecture which stands enormous reminding of that glorious past. The earliest and most remarkable evidence of Ethiopian architecture is found in the cities of the *Axumite* Civilization which boast of a unique town planning and existing obelisks. The medieval period saw the synthesis of *Axumite* and indigenous styles of architecture. The *Gonderian* period brought the influence of Western architectural forms to Ethiopia. Thus Ethiopian architecture is a synthesis of indigenous styles and a certain external influences which has lent it a unique characteristic of its own.

The concept of architecture and engineering probably emerges as soon as the early cave man began to build his own shelter to live in. Human being first began to create and fix his own shelter when he stepped out from the natural habitat of dense jungle covers. With the artistic faculties of man awakened in the search for larger and better-sheltered spaces, he began to build, with inherent aesthetic sense, shelters that seemed pleasing to the eye. Thus, architecture emerged which is a combination of needs, imagination, capacities of the builders and capabilities of the workers.

[24] *www.shareranks.com/contries with largest number of WHS, Wikipedia, free encyclopaedia*

Architecture accommodated the local and regional cultural traditions, social requirements, economic prosperity and religious practice of different times. Hence, the study of architecture and engineering reveals to us the mental intensity of the people and capabilities of the workers and currently helps us understand the rich wisdom of Ethiopia.

Ethiopian architecture evolved in various ages in different parts and regions of the country. The emergence and decay of great empires and dynasties in the country, each in their way influenced the growth and shaped the evolution of Ethiopian architecture. May external influences have also shaped the nature of Ethiopian architecture and so has the influence of different regions of the country. Architecture of Ethiopia has incorporated various styles and techniques. Let us have a look at the process of evolution of Ethiopian architecture.

2.3.1.1. *De'amat* Architecture (ca. 800-400 BC)

The best known building of the period in the region is the ruined 8th century BC multi-story temple at *Yeha,* in Ethiopia, believed to have been the capital of *De'amat*. Ashlar masonry was especially dominant during that period[25].

a) b)

Figure 6: a) The ruin of the temple at Yeha, Tigray Region; b) The Nubian Desert in North Eastern Sudan (Source: Wikipedia, free encyclopaedia, 2008).

Having the De"amat"s period of civilization in mind and its tertiary during that period, in which, the Nubian Desert was part of the ancient region called Nubia, specifically Upper Nubia, which was occupied successively by Egyptian and Ethiopian kingdoms for several thousand years. As Egyptian control weakened after 1100 BC, Nubian reasserted its independence and became known as Kush. A new capital and religious centre was established at Napata.

These kingdoms ruled along the corridor of the Nile and derived importance from their strategic location, which linked sub-Saharan and northern Africa. The area became an important cultural and trade centre. Nubia was converted from paganism to Christianity in the 6th century AD. In the 14th century the region was gradually converted to Islam by Arab conquerors, which brought Arabic language and culture to Nubia.

[25] *Microsoft Encarta, 2008*

Nubian sites from the pre-Christian era are of great interest to archaeologists and historians. Between *Abri* in the north and the area of Kuraymah and Marawi in the south, on both banks of the Nile, there is a series of modestly scaled but important and accessible temples, pyramids, and other monuments that attest to the power and prosperity of the Nubian kingdoms. The ruins linked to Napata, one of the ancient capitals of the Cushitic kingdoms, which are located in the present-day area of Kuraymah and Marawī, are of particular significance [26]. And , here why the researcher put these two similar temples founded at the same historical periods and probably in the same tertiary, may they are the output of the same people called Cushitic which are now Ethiopian(Upper Nubia) and Sudan(Nubia), and may it needs further research as well historically.

2.3.1.2. *Aksumite* Architecture (ca. 4th BC – 9th AD)

Aksumite architecture flourished in the region from the 4th century BC onward, persisting even after the transition of the *Aksumite* dynasty to the *Zagwe* in the 12th century, as attested by the numerous *Aksumite* influences in and around the medieval churches of *Lalibela*. Most structures, however, like palaces, villas, commoner's houses, and other churches and monasteries, were built of alternating layers of stone and wood. The protruding wooden support beams in these structures have been named "monkey heads" and are a staple of *Aksumite* architecture and a mark of *Aksumite* influence in later structures. Some examples of this style had whitewashed exteriors and/or interiors, such as the medieval 12th century monastery of *Yemrehanna Krestos* near *Lalibela*, built during the *Zagwe* dynasty in *Aksumite* style. Contemporary houses were one room stone structures or two storey square houses or roundhouses of sandstone with basalt foundations. A good example of still-standing *Aksumite* architecture is the monastery of *Debre Damo* from the 6th century.


a)

b)

Figure 7: a) Church of Abune Aregawi at the Debre Damo monastery, constructed around the mid-6th century. b) Church of Yimrahane Kirstos, constructed around 10th century AD (Source: Microsoft Encarta, 2008)

[26] *Wikipedia Free Encyclopaedia, Microsoft Encarta, 2008, Ibid*


a)

b)

Figure 8: a) An Aksumite palace; b) King Ezana's Stele in Axum (Source: Microsoft Encarta, 2008)

2.3.1.3. Medieval Period (*Ze'agwe* Period) Architecture (ca. 9th – 12th AD)

Ethiopian architecture continued to expand from the *Aksumite* style, but also incorporating new traditions with the expansion of the Ethiopian state. Styles incorporated more wood and rounder structures in commoner's architecture in the centre of the country and the south, and these stylistic influences were manifested in the construction of churches and monasteries. Throughout the medieval period, *Aksumite* architecture influences and its monolithic tradition persisted, with its influence strongest in the early medieval (Late *Aksumite*) and *Zagwe* periods (when the churches of *Lalibela* were carved). Throughout the medieval period, and especially from the 10th to 12th centuries, churches were hewn out of rock throughout Ethiopia, especially during the northern most region of *Tigray*, which was the heart of the *Aksumite* Empire [27]. However, rock-hewn churches have been found as far south as *Adadi Maryam* (15th century), about 100 km south of *Addis Ababa*. The most famous example of Ethiopian rock-hewn architecture is the eleven plus rock churches of *Lalibela*, carved out of the red volcanic tuff found around the town.


a)

b)

Figure 9: Among the monolithic churches of Lalibela a) Bete Ghiorgis; b) Bete Amanuel

[27] *Microsoft Encarta, 2008, Ibid*

2.3.1.4. *Gondarine* Architecture (ca. 16th – 18th AD)

During the early modern period, the absorption of new diverse influences such as Baroque, Arab, Turkish and Gujarati Indian style began with the arrival of Portuguese Jesuit missionaries in the 16th and 17th centuries [28]. Portuguese soldiers had initially come in the mid-16th century as allies to aid Ethiopia in its fight against *Adal*, and later Jesuits came hoping to convert the country. Some Turkish influence may have entered the country during the late 16th century during its war with the Ottoman Empire, which resulted in an increased building of fortresses and castles. Ethiopia, naturally easily defensible because of its numerous flat-topped mountains and rugged terrain, yielded little tactical use from the structures in contrast to their advantages in the flat terrain of Europe and other areas, and so had until this point little developed the tradition. Castles were built especially beginning with the reign of *Sartsa Dengel* around the Lake *Tana* region, and subsequent Emperors maintained the tradition, eventually resulting in the creation of the *Fasil Ghebbi* (royal enclosure of castles) in the newly founded capital (1635 AD), Gondar. Emperor *Susenyos* (1606-1632 AD) converted to Catholicism in 1622 AD and attempted to make it the state religion, declaring it as such from 1624 until his abdication; during this time, he employed Arab, Gujarati (brought by the Jesuits), and Jesuit masons and their styles, as well as local masons, some of whom were *Beta Israel* [29]. With the reign of his son *Fasilides*, most of these foreigners were expelled, although some of their architectural styles were absorbed into the prevailing Ethiopian architectural style. This style of the *Gondarine* dynasty would persist throughout the 17th and 18th centuries especially and also influenced modern 19th century and later styles.


a)


b)

Figure 10: Fasilides's Castle, Gondar, Amhara Region (Source: Microsoft Encarta,2008)

[28] [29] *Microsoft Encarta, Free Encyclopaedia, 2008, Ibid*

2.3.2. *Ze'agwe* Empire

The gradual decline of the political power of the *Axumite*, led to decisive fall of the kingdom and gave the way for the rise of a kingdom among the *Agaws*. Based on the available evidences the *Agaws* were an integral part of the *Axumite* Kingdom in the 6th century. Besides the task of securing the trade route to *Sasu*, gold producing area in the west and accompanying merchants, the *Agaws* were also stationed in *Begemidir* and *Gojjam* to serve the same purposes. There is no certainty regarding circumstances in which the kingdom ascended to power. Widely used version attributes the dynastic change to a marriage between a daughter of the last *Aksumite* king *Dil Ne'ad* and one of his generals, *Mera TekleHaimanot*, a man from *Lasta* and the founder of the *Ze'agwe* dynasty. According to the tradition the power transition was peaceful [30].

There are a number of possible derivations of the word *Zagwe*. Some writers claim that it is an abbreviation of *Zewge* Michael, the Christian name of *Mera Tekle Haimanot*, and the founder of this dynasty. Others believe that it drives from *Agaw*, the place where the tribe originated while a third view is that the word drives from the *Ge'ez* verb **"ኣገ·የየ"** meaning "to pursue, to chase, to persecute"". The second explanation seems the most probable since the previous dynasty also took its name from a locality and more specifically a capital city-Aksum. As a capital city which could symbolize the whole empire had not yet been established by the *Zagwe* they took instead the name of the region where the tribe of this dynasty originated, the north-central part of Ethiopia [31].

There are also no clear pictures regarding the period the dynasty stayed in power. Figures vary from 133 years to 375 years. However, the available evidences provide dates either 1268 or 1270 for the fall of the dynasty [32]. According to *Taddesse (1972)* the tradition of building rock churches of the *Zagwe* period began during the reign of *Yimrehane Kiristos*. He built a church and another building in the cave where the church is found. The church is built under a huge cave in densely forested site called *Wegre Sehin* [33]. The church of *Yimrehane Kiristos* is located at the distance of 42 km from *Lalibela*.

Lalibela is the famous monarch of the *Zagwe* dynasty. He is widely mentioned in connection with the eleven plus rock hewn churches which still stand in a city named after him. The churches are among precious ancient architectural edifices man kind ever known. There are also claims for other churches built by *Lalibela*, such as *Adadi Mariam* close to Addis Ababa and at the pilgrim centre at Lake *Zequalla* [34].

[30] *Taddese 1972 et al,*
[31] [32] *Sergew H.S, 1972, Ibid P239.*
[33] *Mengistu G.2004 Ibid*
[34] *Finneran, N. 2007. The Archaeology of Ethiopia*

Table 1: *The Name of Kings Reigned During the Za'agwe Period (Source: Tibebu A, 2007)*

Item	Name of the King	Period	Governing Year	Remark
1	Mera Tekele haymanot	912-925E.C.	13	
2	Mirara	925-940E.C.	15	
3	Harbye	940-957E.C.	17	
4	Tete Widem	957-997E.C	40	
5	Girma Seyum	997-1037 E.C	40	
6	Jan Seyum	1037-1077 E.C	40	
7	Yemerehane Kirstos	1077-1117 E.C	40	
8	Gebre Mariam	1117-1157 E.C	40	
9	Lalibela	1157-1197 E.C	40	
10	Nakoto Laab	1197-1237 E.C	40	
11	Yetebark	1237-1245 E.C	8	

2.3.3. King and Priest *Lalibela* (Jan.7,1109 – Jan.18,1205G.C)

Lalibela was a son of *Jan Seyum*, and his mother was *Kirewerna Redei (Tembene and Agew).* He was born in *Bugna woreda* at *Roha*. The name *Lalibela* is derived from *Agaw* word "*Lal-Yebela"* which is a compound word. "*Lal*" in *Agew* means bee or honey and so called by his mother "*Lal-yebela"* to signify his being infested by a swarm of bees colony during his baby hood, which means "honey eater", as (*Birhane D. 1950 EC).*

Figure 11: King and Priest Lal-Yebela (Source: Lalibela Air Port Station, By: Artist, Teferi.)

He has a brother called *Gebremariam* and a sister called *Rebka*. She was so jealous about and gave him a poison so as to take the throne from king *Gebremariam*. However, he died and resurrected after three days. As to his hagiography, he was ordered by God to excite churches from rock for those who travel as pilgrim long distance to visit Jerusalem. *Lalibela* went to study all places of Jerusalem via Egypt. He built 210

churches. Some of his rock hewn churches are *Adaadi Marim* in *Guragie, Ghiorgis* church in *Tenta Kaleb* and *Mekdes Mariam in Mokadisho,* Somalia [35].

He wrote inscriptions found inside *Bete Michael* and *Bete Debre Sina* and very much devoted to praying and religious practices rather than politics. And, eventually he dead near *Bete Mariam* while he was praying with no suffering. Traditionally, when he died all the eleven churches were let by light and for this reason the EOC dedicated him as a saint and celebrates him on special day June, 18 (*Sene,* 12).

2.3.4. Rock Churches in Ethiopia

There are a number of monolithic churches elsewhere in the world. However, none have the free-standing external walls of the *Lalibela* churches and more closely resemble cave monasteries in that they consist of tunnels into a single rock. Many other churches were hewn from rock in Ethiopia, outside of *Lalibela*. This practice was very common in *Tigray*, where the outside world knew of only a few such churches until the Catholic priest *Abba Tewelde Medhin Josief* presented a paper to the Third International Conference of Ethiopian Studies in which he announced the existence of over 120 churches, 90 of which were still in use [36]. Also, *Tibebu* mentioned that, there are more than 130 rock churches in Ethiopia built during the *Axumite* period, but none of them are congregated at a place as *Lalibela's*. Despite *Dr. Josief's* death soon after his presentation and *Tibebu's* mention, research over the next few years raised the total number of these rock-hewn churches to 153 [37]. However, all of these were built 800 years ago before the churches of *Lalibela*. They are two or three sided. *Abreha we Astebeha* was believed to be the pioneer to build churches from a single rock on mountain tips. Since this time there is uninterrupted trend of carving edifices from parts of mountain.

The tradition of hewing churches from solid rocks and building churches in caves (churches built under protective roof of caves) in Ethiopia has long history. The first churches of this type probably emerged in *Tigray*, which later made its way to other parts of the country. But it is important to note the tradition of hewing and building churches in rocks is not a phenomenon completed its development in a given geographical area. For instance the dates for the rock churches of *Tigray* range roughly from the 4th to the 15th centuries [38]. Thus, the elements in the churches could be indicative of varied styles developed over extended time. Rock hewn churches like *Abreha we Atsbeha* and *Wukro Kirkos* most likely represent the first group (the earliest churches) of rock churches. These two churches are believed to be hewn during the first Christian kings; *Ezana* and *Sizana (Abreha* and *Atsbaha* respectively) [39].

[35] *Tibebu A.2007, Ibid*
[36] *Ghelawdewos Araia. The Magnifecence of Aksum: Revisiting Ethiopian Civilization*
[37] *Philip Briggs, 2002. Ethiopia: The Bradt Travel Guide (Chalfont St. Peters, Bradt).*
[38] *Gerster, G. 1970. Churches in Rock; Early Christian Art in Ethiopia*
[39] *Lepage, C. and Mercier, J. 2005. Ethiopian Art: The Ancient Churches of Tigrai*

The first church in Ethiopia was probably built up church, which possibly incorporated elements of both local and outside influences. The original church of *Tsion Mariam* (destroyed in the 16th century) at *Axum* is believed to be built around the first half of the 4th century, soon after the introduction of Christianity to Ethiopia [40]. A reconstruction of the earlier church of *Axum Tsion* is an attempt to give insight into the style of the earlier church and it is based upon an eye witness account by Alvares, who describes a five-aisled basilica, and also with reference to the giant rock hewn church of *Medihanealem* at *Lalibela* [41]. According to *Sergew* and *Taddese (1972)* the coming of the nine saints marked a turning point in Ethiopian church history. Churches began to be built in mountains and hills in distant places. This had strong connection with introduction of monasticism. The monastic traditions introduced to Ethiopia in the early days of Christianity were another turning point in the tradition of building churches. The nine saints who came to Ethiopia at the beginning of the 6th century established their places of worship in the mountains of Tigray [42]. The influence of these establishments on the styles of built up and rock hewn churches of the later periods are immense. Monasticism has played a significant role in site selection as well. Most of the rock churches either in *Lasta* or in *Tigray* are largely distributed to mountains difficult to be accessed using vehicle.

Political factors might have also played significant role in selection of places for establishment of churches. The gradual decline of *Axum* as a Christian state in the 9th century is partly attributed to destruction of *Aximite* posts in the red sea by the Muslims and the Beja rebellion, in the second half of the eight century [43]. During these obscure centuries some of *Axumite* people driven into the hills of *Tigray* by the Beja invasion extended their civilizing activities to the wild regions south of the capital [44]. It seems in accessible mountains which can serve as hiding places during this period of uncertainty were preferable.

The influences on the rock churches on Ethiopia are attributed to both local and outside elements. There is a general agreement on strong influence of *Axumite* architectural styles of different structures, built for wide ranging purposes, on the architectural styles of later periods [45]. Excavated *Aksumite* sites of *Enda Mikael, Ta`akha Maryam* and *Enda Sem`on* provided wealth of information on the *Aksumite* architectural styles. Number of features from of these structures continued to be used in the later periods both in built up and rock churches [46]. The methods endured in the early and medieval rock churches with fascinating harmony in styles different from the known Pre-Christian Axum. In fact the elements in built up structures of this period began to be copied in rock structures long before they appeared in rock churches. Many of architectural features represented in stone on the storied *Aksumite* stele were generally of wood. This include wooden door and window frames, beams, more defining protruding feature known as "Monkey Head" [47].

[40] *Heldman, M and Munro-Hay, S. 1993. African Zion: the Sacred Art of Ethiopia*
[41] *Finneran 2007, Ibid*
[42] *Sergew H.S, 1972, Ibid*
[43] [44] *Trimingham 1952 et al*
[45] *Buxton 1947, Ibid*
[46] *Munro-Hay, S.1991. Aksum: An African Civilization of Late Antiquity.*
[47] *Phillipson, D. 1998. Ancient Ethiopia, Axum: its Antecedents and Successors.*

These elements continued to be copied from *Axumite* pre-Christian structures into Christian churches of the earlier period with lasting influence on church architecture [48]. The famous monastery church of *Debre Damo* reflects the way different elements of the earliest pagan structures used. "Monkey head", a protruding timber pieces inserted into walls and door and window frames are widely applied in this church [49]. Timber beams are another integral element in built up structures. They are used as a strengthening element within walls [50]. In some cases of built up churches of later period round monkey heads are missing. For instance the church of *Yimrehane Kiristos* has no monkey heads on the walls. Monkey heads are applied only on door and window frames of this church. The same fashion is followed in most of rock hewn churches in the country.

According to Buxton (1971) the local methods of construction, which belongs to the pre-Christian tradition, are integrated with methods of church construction brought to the country from outside along with Christianity. He attests the presence of features clearly indicating outside influences. Such influences could possibly be from regions Ethiopia had close ties in Christian times. He further states; the styles in rock and built up churches trace their origin back to Syria on one hand and Egypt and Nubia on the other hand. But possible influence of Nubia and Egypt needs carefully investigation. Excavations at *Adulis* and *Hawlti-Melazo* have brought to light the ruins of basilicas of Syrian type. This may be due to the influence of the nine Saints, since the majority of them are believed to have been of Syrian origin [51].

Most of the churches in Ethiopia have either round or rectangular shape. But round churches are believed to be later than rectangular ones. Round churches are common in the southern part of the country while rectangular churches are characterise church in northern part of the country [52]. Influences from the basilica of Byzantine world, the rectangular shapes of the *Aksumite* tradition and possible influence from Hebrew temples are presented as possible models for rectangular structure of earliest churches in Ethiopia [53]. Rectangular churches are still evident in many parts of *Tigray* [54]. Ethiopian Orthodox *Tewahido* Church building is expected to be divided into three areas.

- *Kene Mahlet* is the place where hymns are sung. To this part the populace at large has ready access.
- The next chamber is the *Kiddist* or "*anda taamar* ("place of miracles") which is generally reserved for the priests but to which laymen have access for the administration of communion.
- The inner most part is the *makdes* or *kedduse keddusan* where the *tabot* (Ark) rests and to which only senior priests and the king are admitted.

[48] [54] *Munro-Hay 1991, Ibid.*
[49] *Buxton, D. and Matthews, D. 1974. The reconstruction of Vanished Aksumite Buildings*
[50] *Buxton 1947, Ibid*
[51] *Sergew 1972: Ibid, p121*
[52] *Marcos and Marsie 1959; et al*
[53] *Lindahl 1970, Ibid*

2.4. Rock-Hewn Churches of Lalibela

The roofs of the *Lalibela* churches are level with the ground and are reached by stairs descending into narrow trenches. The churches are connected by tunnels and walkways and stretch across steep drops. The interior pillars of the churches have been worn smooth by the hands of praying worshippers. The rock-cut churches are simply but beautifully carved with mouldings of various shapes and sizes, different forms of crosses, swastikas and Gothic Style windows. Several churches also have wall paintings.

2.4.1. Presentation of the Churches

The churches are located in the centre of the town surrounded by the houses of villagers. It is also quite clear that the churches have been the bases for the beginning of settlement pattern and development of the town. Historical and traditional sources show that the construction of the churches preceded the establishment of the town. The well known rock-hewn churches of *Lalibela* are eleven in number; but there are two monolithic sanctuaries that have been recently found [54], which are *Bete Hawariat* and *Bete Estifanos*, this makes the total number of churches are twelve.

According to their location, they are divided into three groups, separated by the seasonal river Jordan. The first group comprises seven churches located north of the Jordan River, while the second group comprises four churches situated south of the Jordan River. *Bete Ghiorgis* is located in isolation on a sloping rock terrace southwest of both the first and the second group of churches. As shown below in table 2 they are grouped based on their location.

Table 2: The Three Groups of Lalibela Churches (Source: Mengstu G., 2012)

Item	First Group	Second Group	Third Group	Remark
1	*Bete Medhanealem*	*Bete Gabriel we Rufael*	*Bete Ghiorgis*	
2	*Bete Mariam*	*Bete Merkorios*		
3	*Bete Meskel*	*Bete Amanuel*		
4	*Bete Denagil*	*Bete Aba Libanos*		
5	*Bete Debre* Sinai and Golgotha			@1st group-Twin churches
6	*Bete Hawariyat* and *Estifanos*			@1st group-Recently found

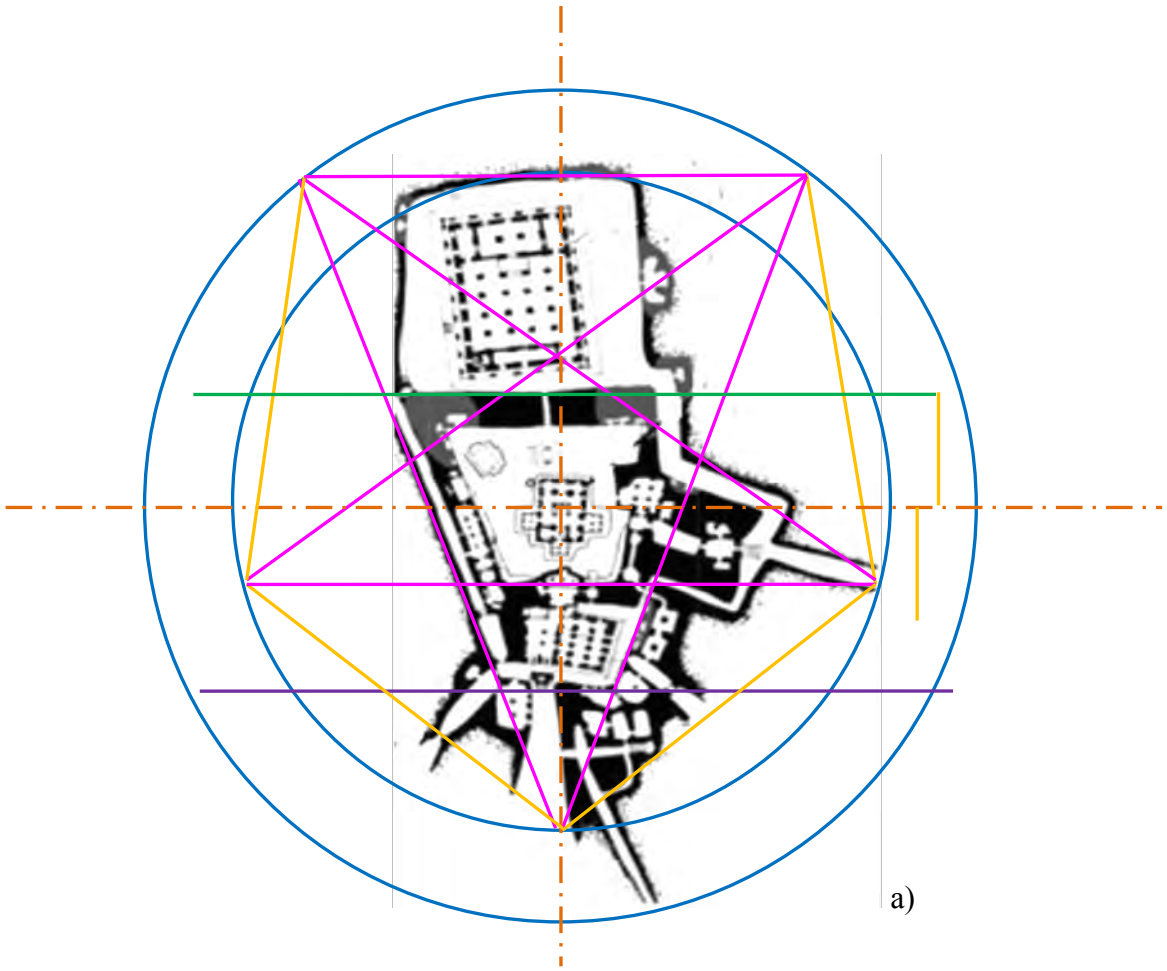
These seven churches termed as "First Groups" for two main reasons. Firstly, churches of this group are believed to have been the first to be constructed. Secondly, these churches are usually the first to be accessed by visitors from the town centre. The first group consists of *Bete Medhanealem* in the east, the *Bete Mariam* sub-group (including *Bete Denagil* and *Bete Meskel*) in the centre and *Bete Debre* Sinai-Golgotha and *Bete Hawariat-Estifanos* in the west in the shape of trapezoidal and detail of *Afro Ayegeba* cross as whole.

Trenches and tunnels connect the churches to one another. This group of churches symbolizes the earthly Jerusalem. From this group of churches, *Bete Mariam* and *Bete Medhanealem* are strictly monolithic, while the others are semi-monolithic.

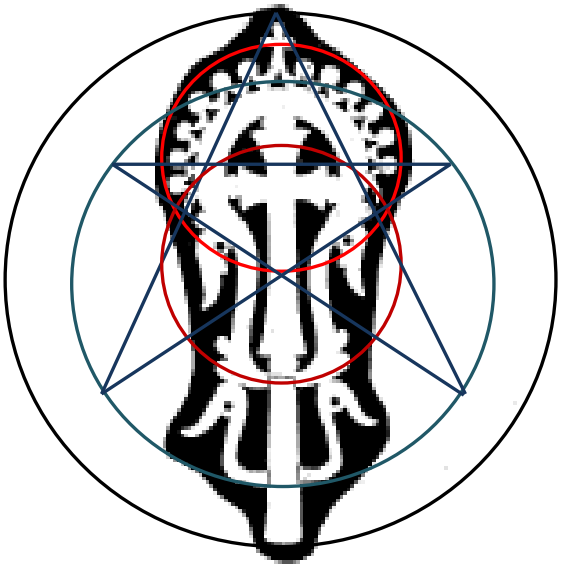
[54] *Tibebu A. 2007, Ibid*

From the whole complex, *Bete Medhanealem, Bete Mariam* and *Bete* Golgotha are well known and distinguished mainly by their own unique features. *Bete Medhanealem* stands out due to its huge size and the large number of pillars (both inside and outside), *Bete Mariam* due to its exterior porches and mural paintings (decoration), and *Bete* Golgotha due to its bas-relief figures, several altars, and the presence of the tomb of king *Lalibela*. And, *Bete Denagil* is the least impressive, lacking basically and kind of decoration and *Bete Meskel* is the smallest. The *Bete Hawariyat* is known by its golden colour roof and ways to endless cave and the remains of holy people.

As shown below Figure 14a) when the researcher makes a circle centred at *"Amde Berhan"* column, which considered as a great mystery holder pillar, found at *Bete Mariam* gets a circle which covered the whole churches with a pattern of pentagonal, considered as one of the nature creation patterns template. And, though it needs a detail study on the art of sculpturing the Ethiopian Orthodox Tewhado Crosses (EOTC), as you observe below in figure 14b there is a similarity in basic patterns with the "Afro Ayegeba" cross, which said locally, holds the design of the churches.



a)



b)

Figure 12: a) The first (northern) group of churches' geometrical layout and its' correlation with the design of b) The "Afro Aygeba" Cross.

The second group is situated south of the Jordan River and separated from a rock plateau in the north, east and south by a broad artificial outer trench, which is about 11 meters deep. A cone-shaped hill, locally called *Betelehem*, occupies the centre of this group, surrounded by a partially exposed trench. The oldest *Axumite* architecture style is more reflected in the second group of churches than in the first complex. For example, *Bete Amanuel* with its projecting and recessed walls is typically *Axumite* in style. The monumental facades of *Bete Gabriel* and *Bete Aba Libanos* have also some features identical to the *Axumite* style of architecture. From this group, only *Bete Amanuel* is purely monolithic. From this group the original entrance of *Bete Gabriel* is still hidden and unknown; presently the access to the church is provided by a long bridge crossing the main trench. And also, there are well unknown structures below the churches which are very shallow.

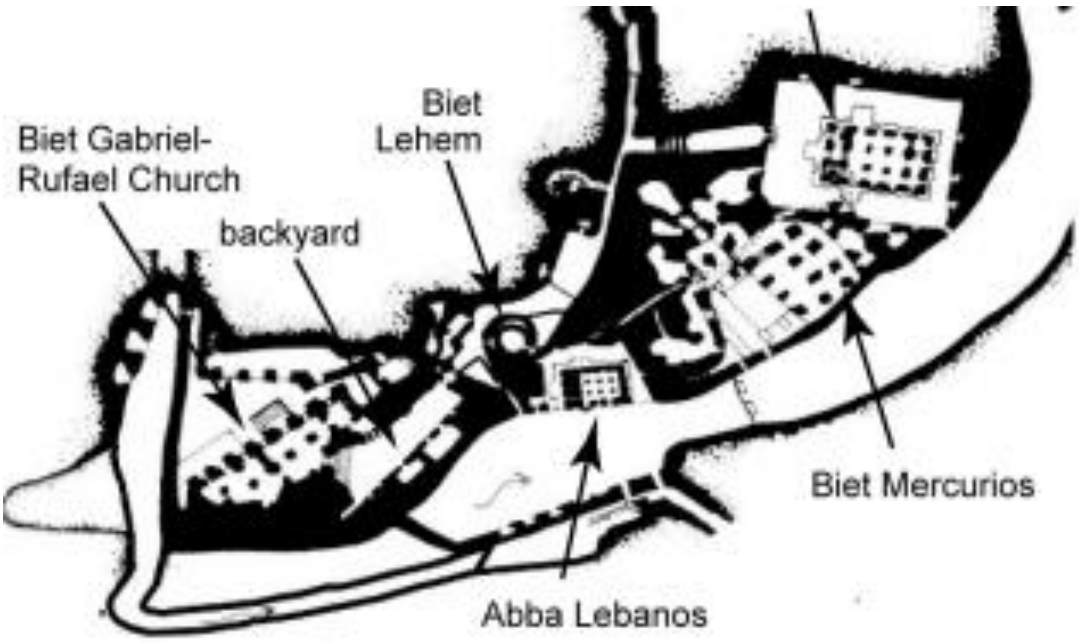


Figure 13: The Second (Eastern) group of churches (Source: LAUREANO, 2008).

In the third group, there is only one monolithic and isolated church, *Bete Ghiorgis*, which is going to be described later in detail in (section 3.4.).

Figure 14: The Third Group, St. George's Church (Source: By George Steinmetz)

2.4.1.1. Bete Mariam (House of Marry)

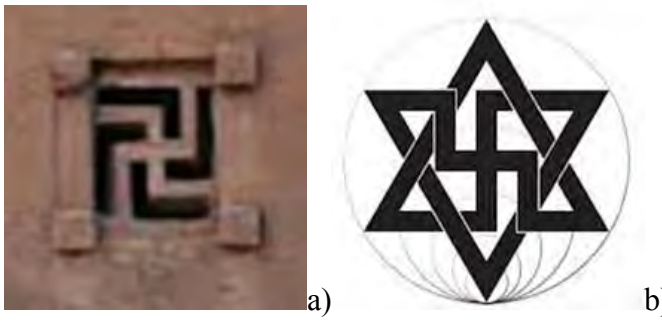
Bete Mariam is the central church in the first group surrounded by a trapezoidal courtyard. It is a one storey monolithic building with seven rooms and it is the first work of *Lalibela* as said locally. The wider courtyard of *Bete Mariam* has a special place in *Lalibela*, mainly because it is used for the sacred dances during Christmas. In the floor of the surrounding courtyard, there is a deep rectangular pool, which is locally believed to make barren women fertile if they bathe there and get the blessing of priest.

Bete Mariam is a rectangular church and from the exterior mouldings running horizontally around the walls, there are three rows of windows better viewed from the outside, for which *Bête Mariam* is the most famous. The upper rows of windows are undecorated and rectangular without any fillings. The lower row windows are decorated with a variety of cross forms, which are very impressive. There are more than nine varieties of crosses including the swastika. Another important features displayed on the exterior of *Bete Mariam* are three projected porches which come out from the main structure. They are found in front of the three entrances at the west, north and south sides of the church, giving a cruciform shape to the floor plan. Each porch has an almost flat roof, a double entrance beneath round arches with corbels, a central pillar without base or capital, and a doorway opening to the church. The doorways exhibit an *Axumite* framework style with carved monkey-head corner posts. There are bas-relief figures above the western porch, at the main entrance of the church. It contains carved seats of which one is for *Lalibela*. It is accessed from the courtyard of *Bete Medehanealem* and has a way that leads to *Bete Golgotha* which has one roof with that of *Bete Mariam*.

a) b)

Figure 15: Bete Mariam Church; a) The NE-SW Direction b) E-W Direction, the Front Elevation

The interior of *Bete Mariam* is a fully developed basilica. It is decorated with icon graphs of St. Marry and Joseph, Star David (Shield of David), Seal of Solomon, Swastika symbols, two headed bird and St. George icon graph at the west gate. It consists of the narthex, a nave, two aisles and a domed sanctuary. The nave and aisles are formed between two rows of five rectangular pillars. The church also has a semi-circular gallery on the first floor (mezzanine floor), consisting of seven rooms.



a) b)

Figure 16: a) Symbolical window of Swastika at Bete Mariam b) Star of David (Source:www.google. swastika sign origin/fig.)

At the eastern end of the nave there is a column permanently covered with a white decorated cloth, which has a length of around 7.60m and a width of 48*48cm. The pillar is locally called as "*Amde Birehan"* the „pillar of light" and symbolizes the order given to *Lalibela* by God. It is considered as an Ark or taboo. There is still no clear justification as to why the pillar is covered, except the oral traditions narrated by priests. It is said to have been covered in the 16th century (*Gondarine* period) by the contemporary head of the *Lalibela* churches, *Kahnat Zena Gebriel*. The priests say that the pillar was covered because the past and the future of the world are written on it. It is also stated that this pillar symbolizes the unity of faith. The pillar also symbolizes the pillar that was seen by the biblical father Jacob"s dream in which he saw angels descending and ascending on it *(Genesis 35:14).* Also, it is also said that, the secret name of God is written in different languages on its surface. In the Ethiopian Orthodox *Tewahdo* Church the pillar represents the Holy Virgin Mary. Besides, Hancock described this column very clearly, about as thick as a good-sized tree trunk, it ascended upwards out of the rock floor and disappears into the gloom above. It is completely wrapped, spiral-fashion, in a very old, discoloured shroud of cloth that bears faded traces of washed-out colouring. The priests also says that the pillar is sacred and that engraved upon it are certain writings by King *Lalibela* himself. Apparently this writing may provide as a pertinent primary information sources, the intentions of the constructors by this magnificent work and how the rock-hewn churches were made.

2.4.1.2. Bete Medehanealem (House of World Saviour)

It is the second work of *Lalibela* and the widest and the biggest of all. It is 11m high, 34m wide and 24m long. It has 72 pillars (34 inside and 38 outside), 52 windows, and 3 doors.

Figure 17: Bete Medehanealem Church from the North-West Direction

Its floor is black and brown coloured while its roof is red coloured. A huge courtyard surrounds it. The church is rectangular in shape, and is also the largest. It is perhaps the largest and widest monolithic rock-hewn church in Ethiopia, even in the World.

The roof of *Bete Medhanealem* is decorated with architectural elements and it is low-pitched and appears like a saddleback with a double slope, possessing a central dividing line at the central axis. On either side of this dividing line, the roof is ornamented with large relief crosses connected by blind arcades that reflect the eight bays of the interior. A frieze of round arches carved in relief also decorates the vertical edges of the roof. The unique feature of *Bete Medhanealem* is the presence of external columns on all four sides of the church. These columns extend from the main plinth of the church to the gabled roof to support the projecting eaves, which in turn are part of the basic structure of the church. The existing external columns are 34 in number and rectangle in plan. Some of the columns have collapsed, however, and they are now replaced by new built-up structures. One of the collapsed columns is still seen fallen at the north-western corner of the churchyard (in the trench).

The exterior walls are decorated with two rows of windows. The windows in the lower row are rectangular and filled with panels of pierced stone, each of which is ornamented with a central cross. In the east wall of the church a continuous pattern of swastikas are found alternating with Greek crosses in this row. The upper row windows have round arches supported by brackets. Each of them has also ten small circular openings. It has three doors, in the north, south and east sides, respectively. Semi-circular arches supported by the bracket capitals top them. The main entrance is in the centre of the church. From this western door, a staircase leads to the narthex.

The interior wall sides are without decorating, but still very impressive. According to the basilica plan it follows, it has a nave, five aisles, and eight bays separated by 38 columns. The first bay on the western side

makes up a narthex, and the last two bays on the eastern side form the *meqdes* (sanctuary), which is accessible only to priests and deacons. The aisles have flat ceilings, while the nave has a barrel-vault. The interior of the church is dominated by four rows of rectangular pillars, which support the nave and aisles. Unlike the exterior, the interior pillars are ornamented with bracket-capitals, and are linked to each other by semi-circular arches. In the north-eastern corner of the interior, there are three empty graves (tombs), which symbolically represent those of Abraham, Isaac and Jacob, the Biblical fathers. It has a wide monolithic *Bethelehem* to the south of the main building adorned with crosses on its windows. Generally, three unique features distinguish *Bete Medhanealem*. These are;

- Its huge and impressive size,
- The large number of pillars both inside and outside, and
- The five aisle plan.

Due to these features, some visitors have tried to compare the church with a Hellenistic Greek temple; other scholars have suggested that it is a copy of the original copy of *Axum Tsion Mariam*, which was destroyed by *Ahmed Gragn* in the 16th century A.D [55].

2.4.1.3. Bete Debre Sinai and Golgotha (Mount Sinai and Golgotha)

Bete Debre Sinai and *Bete* Golgotha are twin churches. A tunnel at the western end of *Bete Mariam* leads to the twin churches. They are six meters below the level of this courtyard (both are semi-monolithic and separated by a wall, east of which is Golgotha and to the west is *Debre* Sinai). Access to the churches is through a surrounding trench, which is 10.5 meters deep. The twin churches appear from outside as one, and are usually referred to together by the local people as *Bete Michael*.

The exterior wall are smooth without dividing mouldings, but with two rows of windows. There are simple Greek crosses as well as windows that are more elaborate, the latter are the same as the windows of *Bete Giorgis*. The three essential doorways are without the square "monkey-head" *Axumite* framework. The northern doorway is a simple arched opening, which provides a link of *Bete Debre* Sinai with *Bete* Golgotha. *Debre* Sinai is a semi-monolithic church exposed on three sides by the excavation of a trench. The interior of *Debre* Sinai consists of a nave and two aisles, which are divided by two pairs of rectangular pillars. The pillars are carefully carved and connected to each other by round arches. They are cruciform in cross-section, with double capitals, and decorated with a variety of crosses. *Debre* Sinai displays the usually east-west orientation of Ethiopian churches, and its sanctuary is placed in an upraised position. The church takes its name from Mount Sinai, where Mosses had received the tablets with the Divine Laws from God.

[55] *Mengstu G. et al, Buxton, 1947 Ibid*

Figure 18: Bete Debre Sinai and Golgotha Church from the South-West Direction

It is the third work of *Lalibela* which is situated below *Bete Mariam* ground level and attached to the mountain, *Mame Gedel,* to its western and eastern parts. Within its narrow width and deep length, contains two separate rooms supported by four indented and eight free standing columns. It has three external, two internal doors and five windows. One of its windows has similar pattern as *Bete Mariam* and *Bete Medehanealem*. While its external wall surface is adorned with ten semi-circular motifs, has no any picture internally. Entering deep inside, one gets the well decorated *Lalibela's* own altar. Besides, one of its column and the ceiling is decorated with carved cross.

It has four gates that lead to the church. One of the rooms of *Bete Mariam* found on the top of this building. It has eight cross shaped columns unlike the others. *Lalibela's* stick and cross, and a symbol of Adam"s tomb all found here. Twelve iconographies of the Apostles are seen carved on its internal wall surfaces. The tomb of Adam, which is called "*Keranyo*" is a box shaped monolithic stone hollowed inside. The tomb serves as an entrance gate for churches found in the east. *Lalibela* was buried here. It has places that commemorate Bethlehem, Nazareth, and *Geliala* of Jerusalem. Though it is named as one church it is compartmented to three by the name of *Selassie* (Trinity), *Debre* Sinai and Golgotha sanctuaries. East of *Lalibela's* altar, an entrance leads to *Kidest sillasie's* altar. It has 6.28m long and 5.60m width. There is also a covered pillar as *Bete Mariam* which is 5.25m long. There are also three rock altars decorated with holy pictures from the Bible. Since it is highly respected, it is not allowed to visit it and even inside most of its walls are covered with curtains.

2.4.1.4. Bete Meskel (House of the Cross)

Bete Meskel is a small grotto church carved into the northern wall of the *Bete Mariam* courtyard. It has only one façade, facing south. The whole length of the façade is decorated by ten blind arcades, which are similar to those of *Bete Medhanealem*. There is a relief cross carved beneath in the distance between the 4th and 3rd arch (counted from the right). It is a very common decorative pattern of the *Lalibela* churches.

Figure 19: Bete Meskel from the South-West Direction

On the facade there are two visible doors that imitate the *Axumite* „monkey-head" framework. It is the right side door, which leads into the interior of the church, while the left one opens into a back room. There is also a third door in the northern face of the church, but it is carved at an inaccessible position and does not serve as an entrance to the church. The facade has two windows. One of the windows has a swastika cross design through which a Greek cross is pierced.

The interior space is a very small gallery with two aisles divided by a row of four pillars. It is mainly identified with a decoration of many relief crosses. It might be because of this the church bears its name. It is also well-known for maintaining the most highly decorated cruciform *Menber* (liturgical furniture serving as a resting place for the taboo), which is accessible for visitors.

2.4.1.5. Bete Denagel (House of Virgins)

Bete Denagel, which is the fifth work of *Lalibela,* located to the south of *Bete Mariam*. It is a semi monolithic structure supported by four columns. To the right of *Bete Denagil*, a subterranean way leads to holy water of *Bete Golgotha* and its baptistery. Since this part is filled with water, it is closed with wooden door to protect people from falling in.

Figure 20: Bete Denagel from the East direction

It is partly projecting outwards and partly grotto (in a cave), last impressive and the roughest among the rock churches of *Lalibela*. It has only two doors, in the west and north sides, and one false window in the north. The interior part is very dark and contains four rectangular pillars. The cruciform pillars and bracket capitals are the only architectural of its church. It is believed to have been dedicated to the memory of 50 median

nuns who were killed in the 4th century by the order of a certain Roman Emperor [56]. There is also another belief held by some *Lalibela* priests, who claim that it is dedicated to the 36 saintly women who were among the 120 close followers of Jesus Christ. There is also one major local tradition, which says that *Bete Meskel* and *Bete Danagel* were intentionally hewn by king *Lalibela* on the left and the right side of *Bete Mariam* for his followers. The King himself was supposed to have offered prayers in *Bete Mariam*, and his men and women followers in *Bete Meskel* and *Bete Denagel*, respectively.

2.4.1.6. Bete Hawariat *and* Estifanos *(House of Apostles and* Estifanos*)*

To the right of *keranyo*, there are two monolithic sanctuaries that have been recently found, they are *Bete Hawariat* and *Bete Estifanos*. This makes the total number of churches at *Lalibela* twelve. *Bete Hawariyat* is found northwest of *Bete Golgotha* while *Bete Estifanos* is south of *Bete Hawariyat*. *Bete Hawariyat* has two rooms topped by an attractive golden colour roof. *Bete Estifanos* is similar to *Bete Hawarite* but has a subterranean way more than 60m long with a remarkable shape and workmanship that connects the holy of holies to the congregation area. In side left and right of the cave way, there are remains of people and additional endless cave ways which are still hard to be known where they can take. The cave way has height a little bit higher than human height and wider breadth however due to the heap of soil piled at the entrance, it makes difficult to access easily.

Figure 21: Bete Hawariat and Estifanos from South direction

2.4.1.7. Bete Gabriel we Rafael (House of Gabriel and Rafael)

A one storey structure connected to the mountain and accessed by wooden bridges to its story level. The ground floor of this church is filled with water and gives no service. The gate to the ground floor is not still known. It has eight external columns, of which five of them continued to the ground floor and the rest three remains at the upper floor. Internally, there are two columns. It has short room height in relative to the others. *Bete* Rafael and *Bete* Gabriel are situated under one roof. Inside *Bete* Rafael, there is one huge column and two windows.

[56] *Zemedkun B., 2000. History of Sacred Monasteries in Ethiopia, (in Amharic). Addis Ababa.*

Externally its wall has recessed slots inscribing windows. The two doors have wider veranda. It has wider door at the south that takes to Eucharist Kitchen, store and amazing caves, which are too wide. Its western gate takes to *Bete* Rafael. Travelling through the cave way, a gate of wood which was during *Lalibela's* time is confronted.

Figure 22: Bete Gebriel we Rufael from the Eastern Direction

Bete Gabriel is a church located between two trenches on the north and south. The monumental northern facade is very beautiful. It is ornamented with ogival niches whose top shape is similar to the top part of the *Axumite* stele. In addition, the two niches contain two doors in *Axumite* style, and five of them are windows. Near *Bete* Gabriel, there is a curved band of rock locally called "the path to Heaven" or "*Meferareja*" as locally said. Another important part of the *Bete* Gabriel complex is a well and underground cistern down in the courtyard.

The interior space is a carefully carved-out hall divided by arched pillars. The interior is smaller in size than the exterior suggests. The lower part of the church, which is supposed to be the lower floor, seems unexcavated, and is simply considered as a large block of rock. However, on the floor of the church, there are a number of partly covered holes of various sizes, which are said to go down to a considerable depth. This leads to a suspicion that there may be another excavated room of the church whose entrance is probably hidden. The three straight Latin crosses carved into the wall are the only decorations displayed here. Its disorientation and unusual plan lead some people to imagine that it was not originally intended to serve as a church. The original entrance of the church, which is still hidden, is another reason forwarded by the people who favour the idea that the building originally served for a civic purpose. As philipson have suggested, before the conversion of the building to a church, it might have served as a residence of the royal family, a secular assembly hall, or a treasury.

2.4.1.8. Bete Merqorious (House of Merqorious)

The widest church, next to *Bete Medehanealem*, situated in connection to the encircling mountain of *Bete Amanuael* is his seventh work, *Bete Merkorious*. It is supported by seven columns, of which two are damaged and one of its columns is decorated with carved pictures. What is peculiar to this church is its monolithic altar carved from the parent stone beneath it. This church was damaged in the 16th century and

rehabilitated by an Italian restorer, Anglina. Among the many ways that lead to this church, the subterranean flat dark way traditionally symbolizes the hell. Likewise, the church itself symbolized Heaven.

a) b)

Figure 23: Bete Merqorious Church a)from N-W Direction b) from S-W Direction

It is the most seriously damaged rock-hewn church in *Lalibela*. It has partially collapsed, and was discarded for church serve for a long period, until it was repaired in 1989. Since then it has been used a worship centre. It is irregular in shape. The pillars supporting the roof are very rough and unequally spaced. Originally, there were 20 irregularly shaped pillars, but today, only 18 still exist. 8 pillars are integrated into the facade; the other 10 are found in the interior of the church, while two others have fallen apart outside. The interior walls are poorly decorated with paintings of saints, such as St. George, St. *Merkorios*, and the Virgin Marry and Her Child. There were also other paintings on cotton fabrics attached to the walls by a thick layer of loam, ox-blood and straw. These paintings have been brought to Addis Ababa, and are now shown in the National Museum.

Some people think that it was not originally a church. This is because it is neither correctly oriented nor conventionally planned. In addition, objects of secular function such as shackles have been found in deep trenches excavated in 1966. These findings led people to conclude that the building was a hall of audience, an assembly hall, or a court of justice rather than a church. The church is dedicated to a Martyr of Rome, St. *Merkorios*, which recalls the contacts of early Christian Ethiopia with the Roman Empire.

2.4.1.9. Bete Abba Libanos *(House of Abbot* Libanos*)*

As one accessed by a trench way from south, finds a structure, unlike the others, attaching its roof to the parent rock, *Bete Abba Libanos*, his eighth work. It has four columns, three gates and 35 closed and open windows.

Figure 24: Bete Abba Libanos church, Front Elevation and Right Side Elevation

It is a cave rock-hewn church located southwest of *Bete Amanuel*. It is rectangular. Its roof is not separated from the rock but a kind of tunnel detaches the other four sides. There are people who thought that *Bete Abba Libanos* is an unfinished structure considering the roof, which remains attached to the original rock mass, but locally claims that the building resembles an Ethiopian priest carrying the *taboo* (Ark) on his head. Its facade displays many *Axumite* architectural features, similar to *Bete Amanuel*. We find here the *Axumite* friezes and the alternate recession and projection of the walls, but unlike in *Bete Amanuel*, the horizontal bands are missing.

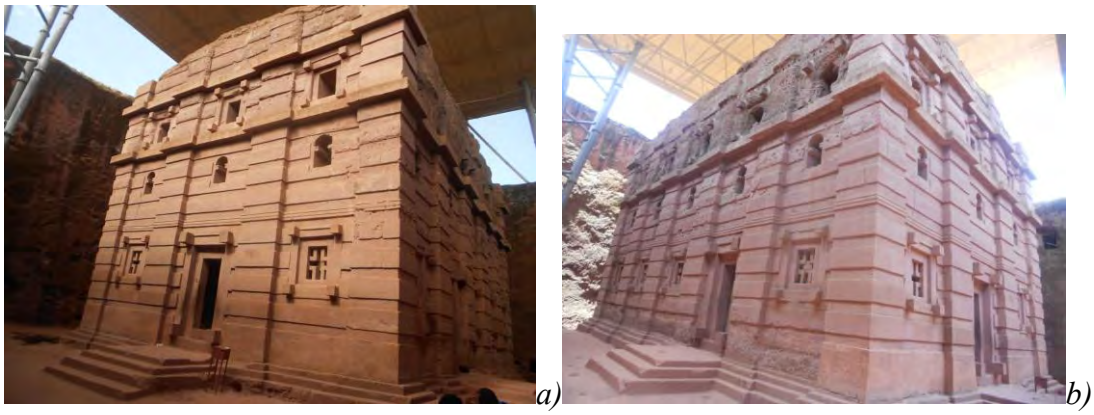
It has three rows of windows. Unlike the top and the middle ones, the bottom row windows displays the *Axumite* monkey-head frames, and has cross-shaped openings. The upper ones are square false windows, and the middle ones are ogival. The church‟s main entrance is located in the south wall, after climbing five steps. Its ground plan resembles that of *Bete Amanuel,* but on a much reduced scale. The church looks large from the outside, but its interior is very small. It might be the smallest of the second group of *Lalibela* churches. Although the main entrance of the church is from the south, the aisles and the nave are oriented east to west, as usual. There are only two arches in this church, one at the western end and the other at the eastern end of the nave, giving entrance to the sanctuary. In this church, there is a tiny light high up in the middle of the altar wall shining day and night. However, an adequate explanation has not yet been given for the mystery of this light and its source.

The church is dedicated to one of the monastic saints in the EOTC who came from abroad, probably from Rome. This saint, *Abba Libanos*, who was also called *Matta*, had a special place in the mind of the *Zagwe* kings, especially Emperor *Lalibela*. For example, land grants were given by king *Lalibela* to the monastery of *Debre Libanos* in dedication to this saint [57].

[57] *Crummey D., 2000. Land and society in Christian Kingdom of Ethiopia, from the 13th – 20th c.*

2.4.1.10. Bete Amanuael (House of Emmanuel)

The most beautiful of all that depicts *Axumites* construction more than any other *Lalibela's* work is his ninth work *Bete Amanuael*. This was believed to be the prayer house of *Lalibela* and his family. It is inside a court yard of mountain and accessed by three gates one of which is from *Bete Merkorious*. Its wall is carved with horizontal strips. It has 24 external columns and 45 windows. Its upper floor level is approached by a monolithic stair.



a) b)

Figure 25: Bete Amanuael church a) from S-W direction b) from N-W direction

It is the only purely monolithic and carefully hewn church of the second group at the centre of a quadrilateral courtyard. It is a rectangular church. The external facade shows the *Axumite* style of alternating recessed and projecting stonework. It imitates the old Ethiopian wood and stone method of construction, so that it offers an almost classic example of the *Axumite* style, more so than any other church in *Lalibela*.

The external walls are richly decorated with horizontal carvings, which make it very elaborate in appearance. The alternating vertical and horizontal mouldings on the four facades of the church from the base up to the summit are impressive. There are three rows of windows displayed in the facades. The lower windows are cross-shaped, those in the middle are round-arched with capitals, and the upper ones are square-headed. The bottom and the top windows display fully developed frames with corner posts of *Axumite* style. The top row windows have no fillings. As usual, it has three doorways; the main entrance is in the west wall accessible by four steps. *Bete Anamuel* is a three-story building in which the ground floor in cross-shaped, the first floor is arched over, and the second is square-headed.

Internally it follows a true basilica plan, which contains five bays, a mighty vaulted nave, two aisles, and a domed sanctuary. Rectangular columns separate the nave and the aisles. The division of the interior of *Bete Amanuel* is like that of *Bete Mariam*, except for the absence of the central pillar here. In *Bete Amanuel*, there are four complete and four three-sided pillars. It is the most beautifully carved church, with a typical ancient *Axumite* architectural style. Every feature of the church seems to have been derived from the style of *Debre Damo* and *Yemirhane kristos* [58].

[58] *Buxton, 1964. Ethiopian Medieval Architecture: The Present State of Studies: Journal of Semitic Studies, Vol.IX.No.1.*

2.4.1.11. Bete Ghiorgis (House of George)

Bete Ghiorgis, which is distinctively cross shaped, is the last work of *Lalibela*. It is situated afar from the other two groups of churches and accessed by a cave way. The building is inside the courtyard which is perforated by caves holding remains of holy peoples. Its walls, going up, slightly narrow, but horizontal bands of different width make an optical illusion so that it appears perfectly symmetric and monumental.

It is decorated by two rows of windows. The nine windows in the bottom row are blind and imitate the *Axumite* "monkey-head" framework. The twelve windows in the upper row have ogival arches and bracket capitals. It has three doors in the west, north and south. The main entrance in the west is approached by seven wide steps (representing the seven heavens). The main doorway has a shallow porch ornamented by simple mouldings. Its roof top is concentrically cross shaped and stepped down to drain the roof top through stone spout centred at each arms of the cross.

It is an isolated monolithic church situated a few minutes' walk to the southwest of both the first and second groups of *Lalibela* churches. Access to the church is possible through trenches with gateways and tunnels. It is excavated as a beautiful monolithic church at the centre of a rectangular courtyard. In the wall of the courtyard, there are burial niches, small round caves, and chambers. In the floor of the courtyard, there is a cistern or baptismal pond. The cruciform shape from top to bottom has the form of piece liturgical furniture, the *Menber* (the resting place for the *taboo*). The church is standing on a sort of three-stepped base. A relief of three similar Greek crosses inside each other decorates its roof. On the north, south and west sides, there are gutters and spouts that drain water from the roof.

Figure 26: The Bete Ghiorgis church

The interior space is a simple cruciform area without freestanding pillars. Its floor plan is a cross form with nearly equal arms. The dome, the arches and the four high reliefs pillars and very harmoniously planned and carved. The dome above the sanctuary in the eastern arm of the cross is decorated like a war defending plate "*walta*" in relief. There is no genuinely free standing pillar; instead, the arches are supported by four three-sided pillars (pilasters) with corbels.

The most interesting feature here is that the thickness of the wall increases step by step downwards. The architecture is also sophisticated in that the horizontal bands of mouldings of the exterior walls correspond to similar bands in the interior. Generally, the stepped platform, the projecting corner beams in doors and windows of the bottom row, and the tower-like characters indicate the influence of *Axumite* architecture on it. The designation of the church is dedicated to the martyr St. George. Its cruciform plan, proper orientation, harmonized proportion and decorations are features that distinguish it from the other churches. These outstanding and precise architectural elements represent the apex of rock-hewn church tradition in medieval Ethiopia.

2.5. Sacred Geometry and Architecture of Sacred Buildings

Sacred is a Latin word derived from which "sacersacr" means "Holy" dedicated to a deity or religious purpose, considered being Holy or very important and treated with great respect [59]. Sacredness is the goal to enable the mind to become a channel through which the physical energies can connect with the energies of the Divine. In order to achieve this goal, sacred science seeks to understand the relationships between proportion and progression in forms of the physical objects and their correlation with proportion and progression on the mental and/or spiritual level.

The physical is the level of manifested form. We experience a physical form or forms using our senses. We can smell, touch, hear, taste or see physical objects. Sacred science deals with proportion and progression in geometric shapes or forms as well as in musical scales, colours and so on. On the mental and spiritual level, proportion and pattern represents the "principle" and progression represents the "expansion, progression or evolution". Therefore, through sacred science we can discover how the principles of creation work on all levels of the mind: physical, emotional, mental and spiritual.

In all traditions, sacred architecture is a blessed space representing the entire cosmos in miniature. The symbolic structure of sacred architecture re-enact the local creation legend in which confusion is brought to order. Sacred architecture is spiritual wisdom made visible, a map of the real which exists outside and within us, a map of our spiritual journey for gathering and integrating the fragmented confusions of our lives into a coherent whole.

This research will survey worldwide sacred architecture traditions for their common underlying principles, and how to read their geometric symbolism. English Architect, Sir Christopher Wren (1632-1723) said that "Architecture aims at Eternity; and therefore, is the only thing incapable of modes and fashions in its principles." Cathedrals, like other sacred structures, were designed not by desire, new styles or fashion, but according to the timeless principles of sacred architecture and the typical patterns which emerge from number and geometry. Learn about the basic schemes at work guiding cathedral floor plans and elevations. "We shape our buildings; thereafter they shape us." -- Winston Churchill

Buildings can have a profound influence on our health, psychic and spiritual state of being. Harmony and balance, light and colour, relationship to landscape, ecological considerations, energy efficiency and geometric form are contributing elements of shelter which aspires to be developing rather than draining. We resonate at both cellular and consciousness levels with our environment. By creating an environment around us that is supportive to both our inner and our outer senses, we can enhance our human links with nature. So that our buildings become our havens, and our work places support our creativity.

[59] *Encarta Dectionary, 2008.Ibid*

2.5.1. Sacred Geometry

All of nature evolves out of simple geometric patterns incorporated within the molecular seed structure. Each of these basic patterns contains information that enables plants, minerals, animals (and humans) to develop into complex and beautiful forms, each with an inherent awareness of its location in space and time. Being part of nature, we have a relationship with it at the cellular level which is experienced vibrationally, and which is development. When these seed patterns are incorporated into our architecture, a vibrational exchange takes place between the building and its occupants in a way that is similar to the connection we have with nature, and which leads to a sense of well being.

The derivation of the term "*Geometry*" from the Greek words "*Geo"*, "Earth" and *metrein*, "to measure" is an accurate description of the works of the earliest geometers, who were concerned with problems such as measuring the size of fields and laying out accurate right angles for the corners of buildings [60]. Sacred geometry is the architecture of the universe; which is the eternal visual language wrapped around the root concepts of the manifest universe and it is the unchanging, perfect and timeless geometrical realties springing from Divinity [61]. Geometry is thought of as sacred when it is used as a figurative bridge in understanding, exploring or representing the nature of consciousness and existence. As a result the application of sacred geometry in association with spiritual idea and the worship of deity can be found in abundance in both our ancient and most recent cultures.

Sacred geometry is the science and awareness of the structure of form understood as the vessel for the consciousness and intelligence of the universal mind. Its forms summarize self-existing knowledge of universal laws. That which exists does so through a geometric template that is primarily formed by the meditation of the universal mind and secondarily by the numerous pools of collective mind that comprise galaxies, stars, worlds and species. In this way the universe we know exists in ratios of geometry on an infinite scale and as such it is possible to understand through deep and further investigations on the area.

It is a geometry that is sacred to the observer or discoverer. This meaning is sometimes described as being the language of the God of the religion of the people who discovered or used it. Sacred geometry can be described as attributing a religious or cultural value to the graphical presentation of the mathematical relationship and the design of manmade objects that symbolize or represent the mathematical relationships. Sacred geometry defines the nature of space and time. The universe is created by thought consciousness which manifests in physical reality through geometric blue print. It repeats in circles giving the illusions of linear time so one can experience emotions. Sacred geometry is the root of all language in the universe. It is the creation of all reality by which the unity of all creation is understood. The forms of sacred geometry, fit together perfectly to each other. Similar to regular geometry, there are five unique shapes in sacred geometry which are crucial to understand any geometry, they are called Platonic Solids.

[60] *Microsoft Encarta, 2008, Ibid*
[61] *Tibebu A., 2007, et al. Ibid*

2.5.1.1. The Platonic Solids

These five shapes are called the perfect solids or platonic solids after the master Plato (approx 428 – 347 BC). These regular polyhedral (a geometric object with straight edges and flat faces) are known as the **Tetrahedron, Cube, Octahedron, Dodecahedron** and the **Icosahedrons**. They are known as perfect because of their unique construction. They are the only forms we know of that have multiple sides which all have the same shape and size. What is of particular note about these forms is that they all fit within each other. Allowing for a change in relative size their vectors (projections of their radii) provide for a perfect blending of form. Where one is all others are, precisely present through association.

The perfect solids are universals; that is to say they function as the typical foundation of all forms. For example, nature utilizes these forms as templates in the mineral realm where crystals closely approximate the perfection of these solids and further derivations of them. Fascinatingly, our DNA spiral appears to conform to the structure of what is called a ratcheted dodecahedron; ratcheted in geometry terms means spun at regular degrees, in this case in the pattern of an accordion with 12 turns of 30 degrees for each stage. The vibrating ether energy that shapes the atom moment by moment also shapes the planets, the stars and all the rest of the universe in the very same way. The Platonic energy fields at the quantum level should therefore also be found at the macroscopic scale of our own planet Earth. The scale of the wavelengths may be different but the ratio of the interfering ether wavelengths are the same, the ratio is inherently fixed by the geometry of the Platonic solids. Another way of saying the same thing is that atoms, planets and stars are interconnected by the fractal patterns of the Platonic solids.

Existence is a sea of geometry in the womb of the universal mother. From the structures of atoms to the proportions of our bodies, geometry factually permeates our world. The wisdom holders of our oldest traditions conceptualized existence through the medium of sacred geometry, planting it at the roots of our planetary culture. The perfect solids have been central to the philosophy of our world‟s greatest thinkers. In the *Timaeus* Plato states that each of the perfect solids is related to one of the fundamental elements of earth, air, fire and water with the fifth being the life force or *Prana*. The cube is traditionally associated with Earth, Tetrahedron with Fire, Octahedron with Air, the Icosahedron with Water and the Dodecahedron with *Prana*. A platonic solid has certain characteristics by definition.

- Its faces are all the same size.
- The edges of a Platonic solid are all the same length.
- It has only one size of interior angles between faces.
- If a platonic solid is put inside a sphere (of the right size) all the points will touch the surface of a sphere.

With this definition there are only six shapes that all have those characteristics;

- Tetrahedron (4-faces),
- Cube (6-faces),
- Octahedron (8 faces),
- Pentagonal dodecahedron (12-pentagonal faces)
- Icosahedrons (20 faces), and
- Sphere.

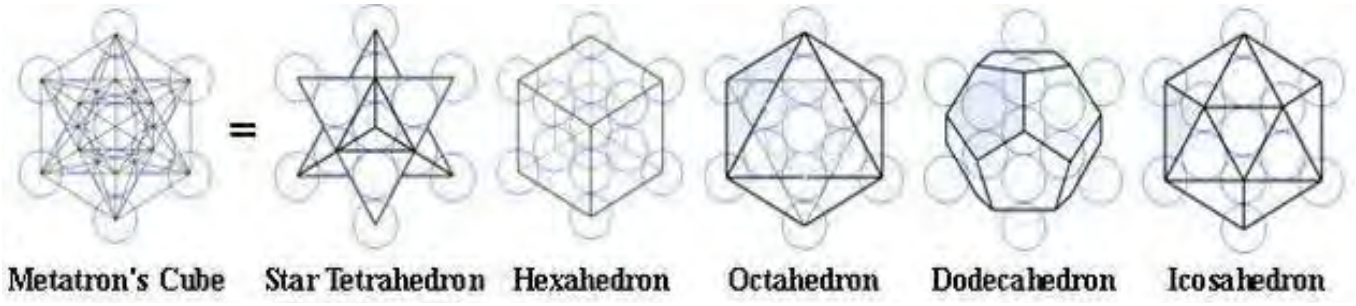


Figure 27: The platonic solids' geometry and historical correspondence (Source: Durnvalo, p160)

Recent cosmological theories postulate that the universe is a dodecahedral network [62]. It can be conceptualized by meditating on the idea of a ball of dodecahedrons that may not have an outside because it includes everything. It is interesting to note here that this idea is not necessarily new. The Dodecahedron has been long been held as a geometrical symbol for the unnameable and indescribable nature of the body or personification of primal cause, namely the manifest universe. That the material universe should be found to be directly related to the form of the dodecahedron makes sense in regard to ancient wisdom teachings.

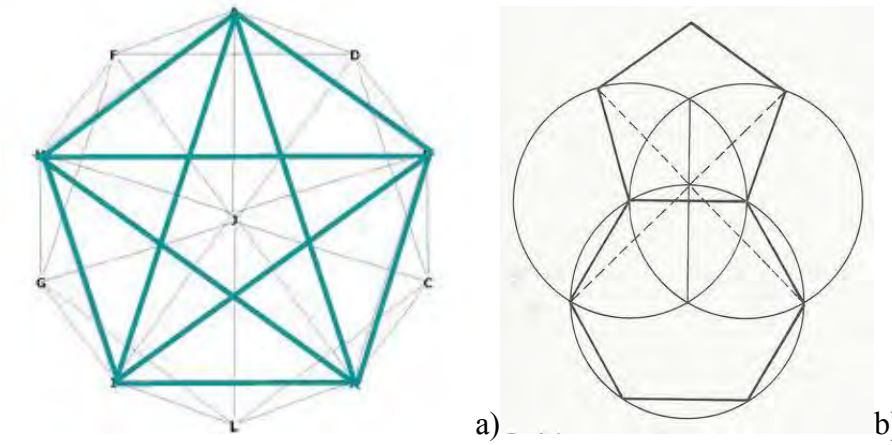


Figure 28: a) Top View of Icosahedrons b) The construction of pentagon from Vesica Piscis and its union with Hexagon.

[62] *Jean-Pierre Luminet et al. 2000. Dodecahedral Space Topology as an Explanation for weak wide-angle temperature correlations in the cosmic microwave background nature 425-593.*

Everything is associated with sacred geometry of the platonic solids. Sacred geometry can in detail describe any subject whatsoever, there is not one thing you can pronounce with your mouth that cannot be completely, utterly, and totally described, with all possible knowledge, by sacred geometry [63]. The whole universe, from macrocosm to microcosm, is made up of little spheres in one way or the other, Earth, Moon, Sun, stars, light waves. All consciousness, including human is solely based on sacred geometry.

Table 3: The platonic solids' geometrical explanations (Source:www.enchantedlearning.com/../Solids/)

Polyhedron	Vertices	Edges	Faces (no. in Greek)	Vertex Configuration	Historically Corresponding Elements
Tetrahedron	4	6	**4 'Tetra...'**	3.3.3	Fire
Hexahedron (Cube)	8	12	**6 'Hexa...'**	4.4.4	Earth
Octahedron	6	12	**8** „Octa..."	3.3.3.3	Air
Dodecahedron	20	30	**12 'Dodeca...'**	5.5.5	Ether
Icosahedrons	12	30	**20** „Icosi..."	3.3.3.3.3	Water

The cube and sphere have special character which the others do not have. That is both the sphere and the cube can perfectly contain the other four platonic solids and each other symmetrically, by their surface assuming you have the right size. All are basics to architects and engineers since they are basis of structures. They are ABCs of sacred geometry. The five platonic solids come from the Fruit of life, which is hidden within the lines of Metatron"s Cube.

2.5.1.2. The Metatron's Cube

Metatron is an archangel in Judaism and in Christian myths. According to Jewish medieval apocrypha, he is Enoch, ancestor of Noah, transformed into an angel. Though there are no references to Metatron as an angel in the Jewish or Christian scriptures (Old and New Testament); however, Genesis 5:24 is often cited as evidence of Enoch's bodily ascension into heaven "And Enoch walked with God: and he was not; for God took him". Although he is mentioned in a few brief passages in the Talmud, Metatron appears primarily in medieval Jewish mystical texts and other post-scriptural mysterious sources, such as the Books of Enoch. In Rabbinic tradition, he is the highest of the angels and serves as the celestial scribe. Metatron is mentioned in the Pseudepigrapha and most prominently in the Hebrew Merkabah Book of Enoch. The book describes the link between Enoch, son of Jared (great grandfather of Noah) and his transformation into the angel Metatron.

[63] *Tibebu A., 2007 et al Ibid*

Medieval Italian mathematician Fibonacci discovered the special geometrical figure that he named the "Metatron Cube" (called in honour of Archangel Metatron). This cube integrates tightly all five perfect platonic solids in one single geometrical figure, as shown below. Fibonacci was really called Leonardo Pisano and lived in Pisa between 1170 and 1240. He was in great part responsible for the rebirth of mathematics and geometry after a long period of decadence between the end of the Greek classical period and the early middle ages. He is more well known for his discovery of the so-called Fibonacci Numbers (or Fibonacci Sequence**:** 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89 ... etc, where each new number is the sum of the two previous ones) that, in the relation of each sequential two, progressively get closer and closer to the famous proportion called the "Golden Ratio" (or: 1.61803..., with an infinite number of decimals without any repeating pattern) at the base of the beauty attribute of all naturally created things. This Golden Ratio, and its relation to beauty, has been at the heart of the sacred geometry since its Pythagorean inception.

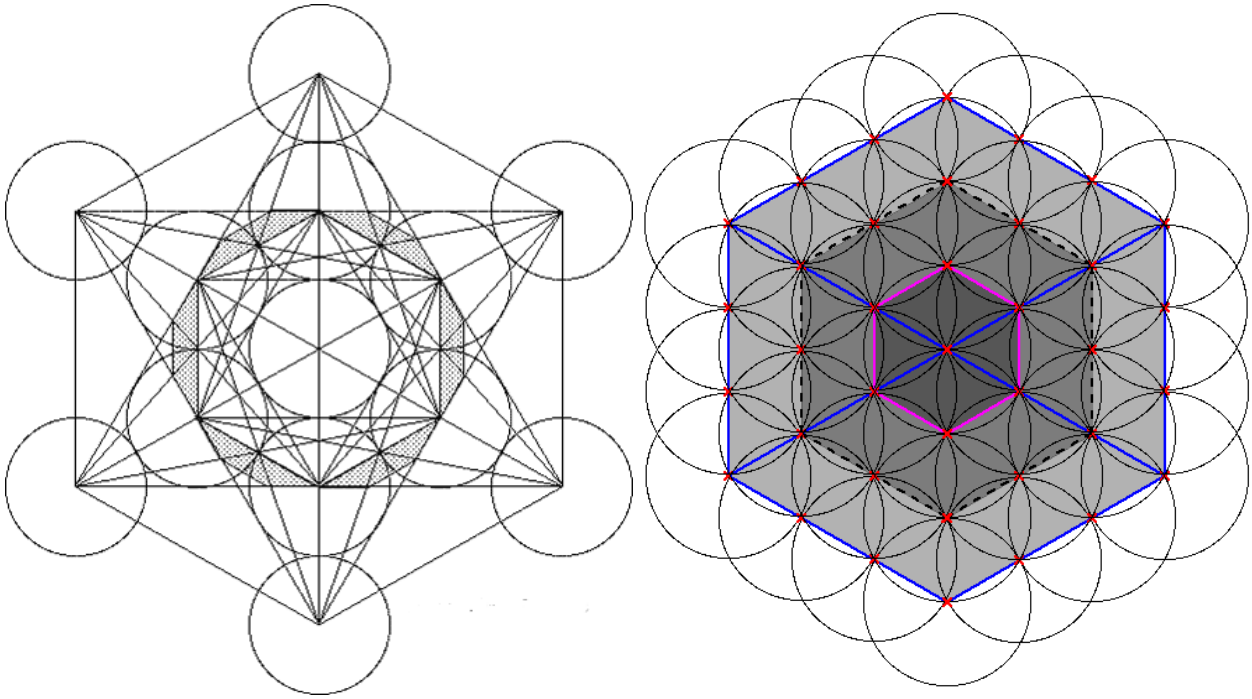


Figure 29: The Metatron Cube (Source: By Drunvalo Melchizedek)

Metatron‟s cube is a two-dimensional geometric figure created from 13 equal circles, which of 6 circles are placed in a hexagonal pattern around a central circle with 6 more extending out along the same radial lines. These 12 spheres around 1, forms the Metatron‟s cube. It is considered one of the most holy of the ancient sacred geometrical symbols and one that encodes the five Platonic solids. It is a sacred geometrical symbol that forms a map of creation, and it is this „map‟ that the mystics, wisdoms and ancient civilizations have revered throughout the ages of time. Over 13 billion years ago, during what is referred to on earth as the „big bang‟, source (God, Infinite Intelligence) gave birth to the universe/s and it is this symbol of Metatron‟s cube that explains this „birth‟ and the infinite expanding field of Creation in all directions of time and space. Thus the field of source energy (represented by Metatron‟s Cube) permeates through every level, through every aspect of creation. One of the key concepts of sacred geometry is the flower of life. Within this figure, through various expansions, contractions, and connections, one can find a blueprint for concepts adopted by

Platonic philosophy and even ancient Judaism to be the basis for the universe and life [64]. When considering the flower of life shape, it is important to realize that this is actually a two-dimensional representation of a three-dimensional form. Through expanding the flower of life shape to contain 125 spheres, one creates a new shape, from which the "fruit of life" can be extracted (from this vantage point, one sees only thirteen spheres in the fruit of life, but in actuality, there are seventeen, with two both in front and behind of the middle sphere). By connecting the middle point of each sphere to the middle point of all others, Metatron‟s cube can be found [65]. Although, the three-dimensional view and the shape of Metatron's cube has its own significance in relation to sacred geometry and other forms of philosophy, it is more widely recognized as the basis for deriving the platonic solids, as seen here below.

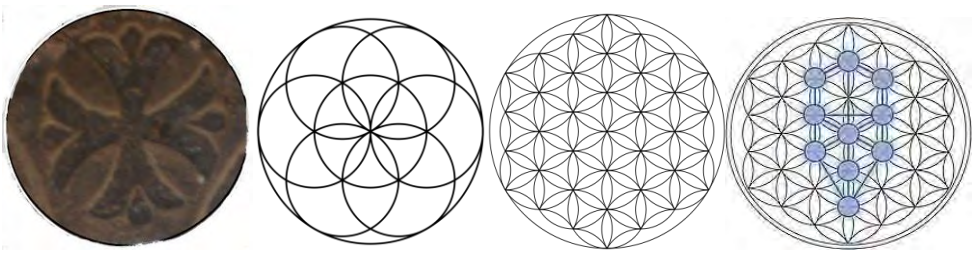


Figure 30: The Egg (at Lalibela), Seed, Flower and Tree of Life respectively (Source:en.wikipedia.org/wiki/Flower of Life/)

2.5.1.3. The Flower of Life

The Flower of Life is the name new age movement author Drunvalo Melchizedek gives to a geometrical figure composed of multiple evenly-spaced, overlapping circles. This figure forms a flower-like pattern with the symmetrical structure of a hexagon. A Flower of Life figure consists of seven or more overlapping circles, in which the centre of each circle is on the circumference of up to six surrounding circles of the same diameter. However, the surrounding circles need not be clearly or completely drawn; in fact, some ancient symbols that are claimed as examples of the Flower of Life contain only a single circle or hexagon. Drunvalo Melchizedek has called these figures symbols of sacred geometry, asserting that they represent ancient spiritual beliefs, and that they depict fundamental aspects of space and time. Melchizedek claims that Metatron's Cube may be derived from the Flower of Life pattern, and that the Platonic solids within it were thought to act as a template from which all life springs.

The flower of life is a pattern of beautiful balance and symmetry. It is the mother pattern from which all other forms of nature‟s geometry emerge. It is this fact that gives it its name. Within it can be found such forms as Metatron‟s Cube and the Perfect Solids. It has been known and studied for thousands of years by our most advanced cultures. The oldest known example of the Flower of Life (Seed of Life) is found many sacred places, such as in the Temple of Osiris in Abydos, Egypt and also here in *Lalibela*. The Flower of Life is central to the study of sacred geometry. Within it are found volumes of universal knowledge pertaining to the vehicle of life and the universal mind.

[64] [65] *Drunvalo Melkchizedek, 1985-1994. The Ancient Secretes of the Flower of Life, Volume I and II.*

It is because of this access to such knowledge that it was kept secret and given only to advanced initiates of mystery schools such as that of the ancient Egyptian pyramid builders. Today its value laid open for all to contemplate. The Flower of Life is a geometrical pattern composed of many circles. All the circles are evenly spaced and of the same size. They overlap in a manner which forms a hexagonal lattice. The sequence below has been called the genesis sequence after the Book of Genesis, within which it is stated that God created Heaven and Earth in seven days. This sequence of geometry is figurative for that awesome process of becoming each day (symbolic for any conceivable period of time) as represented by a sphere.

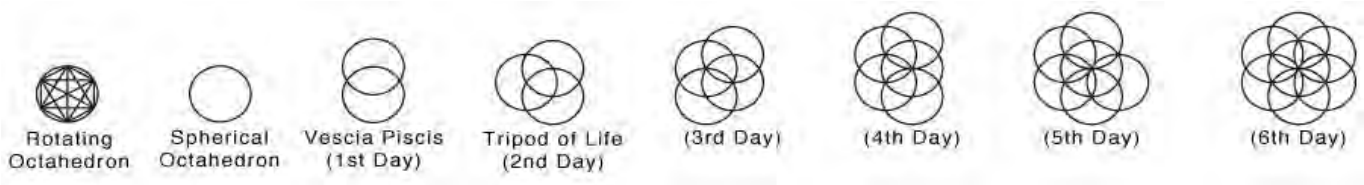
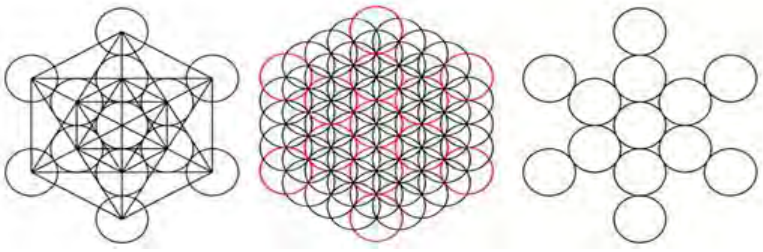


Figure 31: The patterns of creation for six days and geometrical interpretations (source: www.google. com/ Sacred Creation and Geometry)

The first sphere is considered as the self-existing primal cause and the following six spheres the further stages of manifestation. What is interesting to note here is that the pattern called the Seed of Life (6) is formed with the addition of the sixth circle, the seventh day being one of rest. A further 12 circles or spheres are arranged around the Seed of Life to produce the Flower of Life, making 19 circles in total. Although it is often represented as comprising just these 19 circles it is understood to have infinite further layers. The two-dimensional image expands in layers that are multiples of 6: 6, 12, 18 and 24.The Flower of Life provides the structure for many forms of geometry. For instance, Metatron‟s cube, below is created from the further extensions of the Flower of Life. The form called the Fruit of Life emerges from the Flower of Life which is considered the foundation for the Perfect Solids. This is why the Flower of Life is considered the primary pattern, which gives structure to all others.



a) b) c)

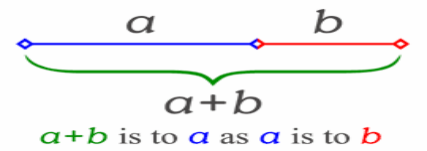
Figure 32: a) The Metatron Cube; b) The Flower of Life and c) The Fruit of Life Respectively

The Seed of Life is formed from seven circles being placed with six fold symmetry, forming a pattern of circles, which act as a basic component of the Flower of Life's design [66]. The Seed of Life is a symbol supposed to depict the six days of creation. The first day is believed to be the creation of the Vesica Piscis, then the creation of the Tripod of Life on the second day, followed by one sphere added for each subsequent day until all seven spheres construct the Seed of Life on the sixth day of creation [67].

[66][67] *Drunvalo Melkchizedek, 1985-1994. Ibid.*

2.5.1.4. The Golden Mean Ratio

The Golden Ratio is a mathematical constant (Phi) which has been applied in art, architecture and music since the foundations of civilisation as it is a primary pattern of the ratios of nature. It is found at the heart of aesthetics as Phi is the natural proportion of form, symmetry and self-similarity. For example it appears in the ratios of ferns, snowflakes, and the human body. All natural proportion is a close approximation of Phi: Φ: 1:1.618 or „A" plus „B" is to „A" as „A" is to „B".



The starting point is the division of a line segment in mean and extreme ratio. A point on a line segment divides this segment in mean and extreme ratio of the whole segment to one part is the same as the ratio of that part to the remaining part of the line segment.

Given a line segment c = a + b, divided in mean and extreme ratio

$$(a+ b)/a = a/b$$

This division of the line segment is called the golden section. The ratio (a+b)/a is called the golden number and often represented by the Greek character capital PHI, ø.

Calculation of the golden number, ø; let, c = a + b

$$c/a = a/b$$

$$c/a = a/(c - a)$$

$$= 1/ ((c/a) -1); \text{ let } x=c/a$$

$$x=1/(x-1)$$

$$x^2 - x - 1 = 0$$ (Ref: en.wikipedia.org./wiki/golden ratio))

As ø=c/a and ø >0 it follows that ø is the positive solution of the quadratic equation, (x = (-b+√ (b^2-4ac))/2a), we get;

$$Ø = (1 + \sqrt{5})/2 \approx 1.618$$ ---------- [1]

In some applications the inverse of the golden number is more appropriate, we get

$$\varphi = 1/ Ø = (\sqrt{5} - 1) / 2 \approx 0.618$$ ---------- [2]

As $ø^2 = ø + 1$ it follows that all natural powers of ø can be expressed as mø + n where m and n are entire numbers. As $φ^2 = 1 - φ$ it follows that all natural powers of ø can be expressed as mφ + n where m and n are entire numbers. Ø and φ are linked to the Fibonacci numbers.

The Golden section refers to rectangles that have a ratio of 1:1.6. This means that if the width of a rectangle is 1m long, the length will be 1.6m long. The Golden Section (or Golden Ratio or Golden Mean or Golden Rectangle) appears in a lot of ancient Greek architecture and has been analyzed extensively by the famous mathematician Fibonacci. The ratio of 1:1.6 is said to be "pleasing to the eye."

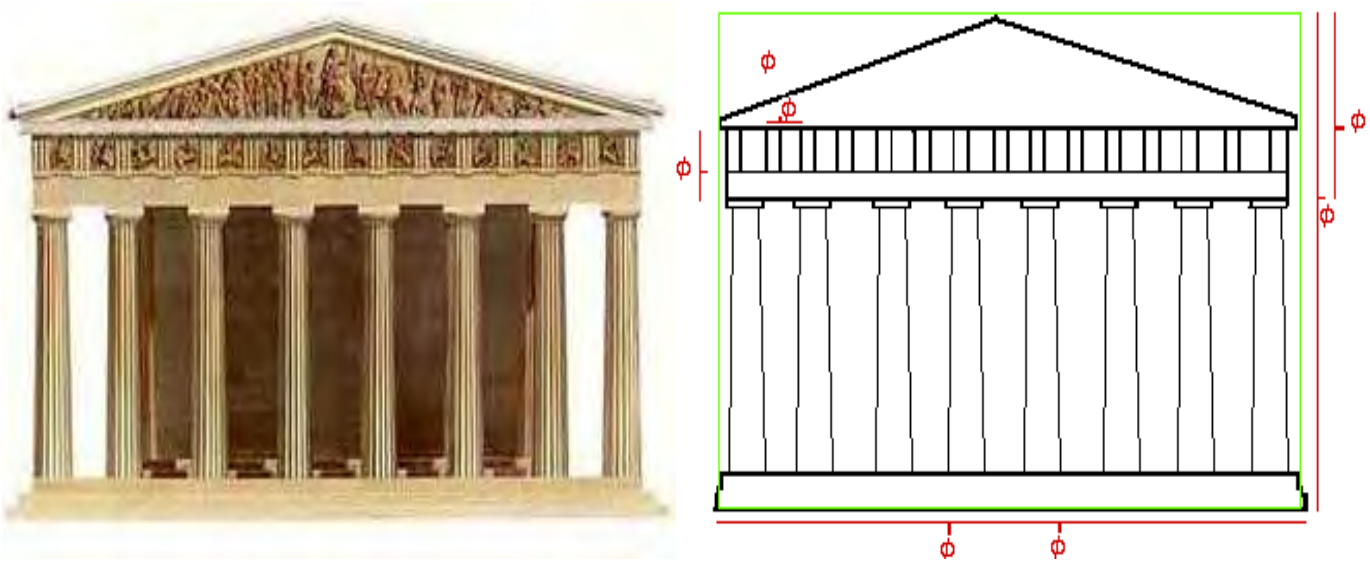


Figure 33: The Golden Proportions in Parthenon, Greece (Source: www.google.com/parthenontemple)

The Golden Ratio is a universal law in which is contained the ground-principle of all formative striving for beauty and completeness in the realms of both nature and art, and which permeates, as a paramount spiritual ideal, all structures, forms and proportions, whether cosmic or individual, organic or inorganic, acoustic or optical; which finds its fullest realization, however, in the human form [68].

The Golden Ratio has many fascinating properties; for instance, in its relationship to pentagrams the below images show Phi and how the pentagram, as a pentagon, forms one face of the dodecahedron, one of the Perfect Solids. Phi is also the proportion between your forearm and upper arm or lower leg and upper leg. The rule is that the closer to the ratio of 1:1.618 forms are the more aesthetically pleasing they are to the eye, like the proportions of a rose. It is partly for its beauty that the most notable temples of our world involve its application. Temples such as the Parthenon in Greece as shows above or the Pyramids of Giza in Egypt demonstrate its ratio. Phi is the ratio of wholeness, and it is because of this that it gained another of its names, the Divine Proportion.

[68] *Drunvalo Melkchizededk, 1985-1994.Ibid.*

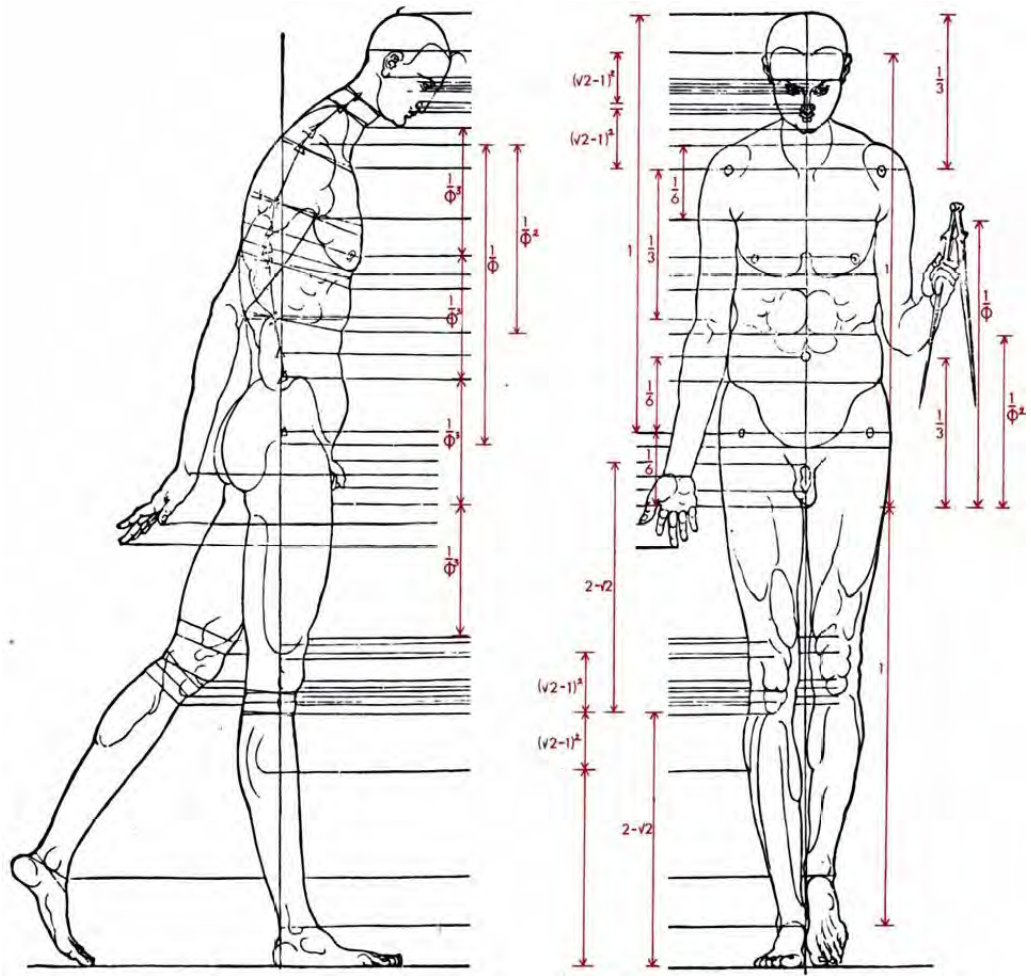


Figure 34: The Golden proportions in human body (Source: www.goldennumber.net/))

The spiral or spiritual nature of the Fibonacci sequence, as it unfolds, wishes to inform us about the cyclical nature of the cosmos. Planets, stars, galaxies, seasons and even life and death itself are cyclical. Since the Fibonacci sequence wishes to inform us about the power of spirals, let‟s wrap this sequence around a circle. In doing this, we can connect our starting number zero to the numbers in the sequence divisible by 3 with those being 3, 3, 9, 6 and 6**.** Notice these numbers are separated by three numbers between them, showing us the power of the Trinity within the Fibonacci sequence**.** Connecting these numbers, we can actually form what is known as the Seal of Solomon or Star of David**.** We can also construct what is known in sacred geometry as Metatron‟s Cube.

A mediaeval Italian mathematician Leonardo Pisano, also known as Leonardo Fibonacci, (c. 1170 – c. 1250) detailed a now famous logarithmic spiral in his book *Liber Abaci* (book of calculation). This book brought the Hindu Numerals (0, 1, 2, 3, 4, 5, 6, 7, 8 and 9) to western culture. It was a mathematical problem that was popular in the early 1200‟s (regarding an immortal population of rabbits with an exponential breeding rate) which led him to its discovery. The Spiral he discovered is as infinite in its expansion as the rabbits are immortal and is named after him, the Fibonacci sequence. The sequence progresses with an approximate ratio of 1:1.618 or: 0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, and 144. . . each number being the sum of the last two preceding it. In this respect the Fibonacci sequence very closely approximates the Golden Ratio.

A logarithmic spiral is one in which the size of the spiral increases but its form remains a constant. Yet the Fibonacci sequence is not a perfect logarithmic spiral because its growth is an approximation of 1:1.618, not an exact ratio of 1:1.618. This is where it differs from the Golden Ratio. However, the difference is so minute that it is not apparent to the eye. This close approximation to Phi is found in the Fibonacci sequence by dividing each number in the sequence by the number preceding it. While no one spiral accounts for the growth of life forms, it is this ratio, Phi, which appears to function as the primary archetype. All life forms grow according to these natural ratios as existence is geometry in motion.

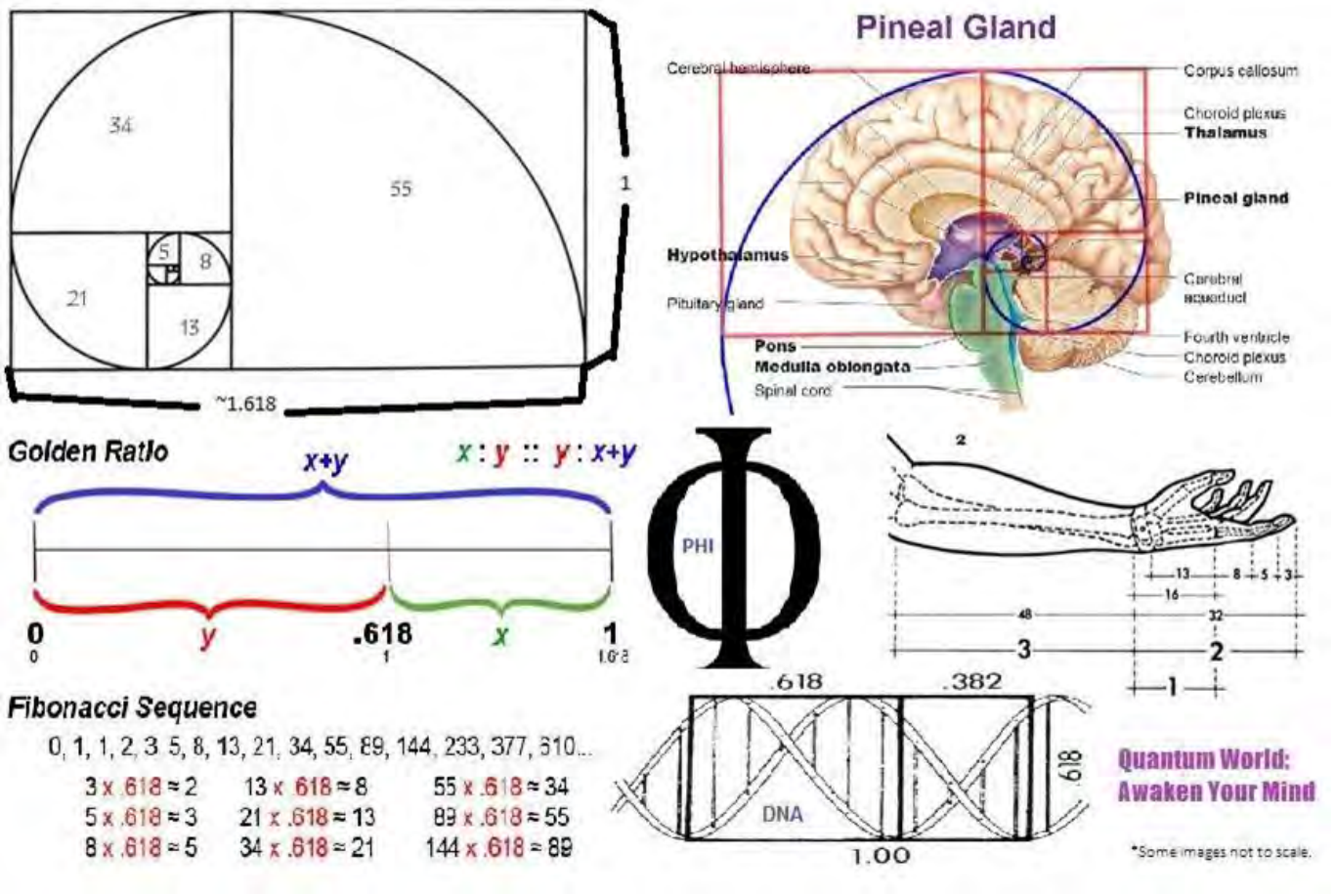


Figure 35: The Golden Ratio in the Human Body (Source: https://www.facebook.com/Quantum World Awaken Your Mind)

2.5.1.5. The Equilateral and Golden Triangles

The triangle is the simplest and one of the most familiar of all polygons. It is used in construction and design of every description. We see it in the framework of buildings and bridges. Because it is a rigid figure, the shape of a triangle cannot be changed when a load is applied to it. For this reason the triangle provides an excellent support for many structures. A triangle is a polygon that has three sides. An altitude of a triangle is a segment drawn from a vertex perpendicular to the side opposite that vertex, or perpendicular to that side extended. A median of a triangle is a segment drawn from a vertex to the midpoint of the side opposite that vertex.

2.5.1.5.1. Equilateral Triangle

In geometry, an equilateral triangle is a triangle in which all three sides are equal. In traditional or Euclidean geometry, equilateral triangles are also equiangular; that is, all three internal angles are also congruent to each other and are each 60°. It has three altitudes and three medians which are the same and equal. They are regular polygons, and can therefore also be referred to as regular triangles. Assuming the lengths of the sides of the equilateral triangle is *a*, we can determine using the Pythagorean Theorem that: „The geometric centre of the triangle is the centre of the circumscribed and inscribed circles".

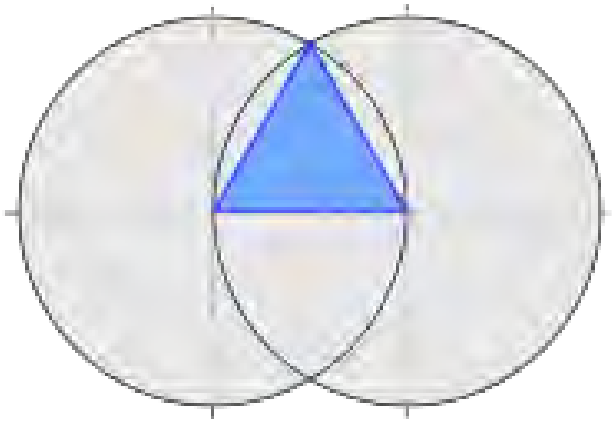


Figure 36: The Equilateral Triangle

In an equilateral triangle, the altitudes, the angle bisectors, the perpendicular bisectors and the medians to each side coincide. Every triangle centre of an equilateral triangle coincides with its centroid, and for some pairs of triangle centres, the fact that they coincide is enough to ensure that the triangle is equilateral. The triangle of largest area of all those inscribed in a given circle is equilateral; and the triangle of smallest area of all those circumscribed around a given circle is equilateral [69]. An equilateral triangle is the most symmetrical triangle, having 3 lines of reflection and rotational symmetry of order 3 about its centre. Among all triangles of given perimeter, the equilateral one has the largest area. Among all triangles with given area, the equilateral one has the least perimeter.

A regular tetrahedron is made of four equilateral triangles. Equilateral triangles are found in many other geometric constructs. The intersection of circles whose centres are a radius width apart is a pair of equilateral arches, each of which can be inscribed with an equilateral triangle. They form faces of regular and uniform polyhedral. Three of the five Platonic solids are composed of equilateral triangles. In particular, the regular tetrahedron has four equilateral triangles for faces and can be considered the three-dimensional analogue of the shape. The plane can be tiled using equilateral triangles giving the triangular tiling.

[69] *Dorrie, Heinrich, 1965, 100 Great Problems of Elementary Mathematics, Dover Publication. 379-380.*

2.5.1.5.2. Golden Triangle

A golden triangle, also known as the sublime triangle, is an isosceles triangle in which the smaller side is in golden ratio with its adjacent side:

$$\varphi = \frac{1+\sqrt{5}}{2}.$$

Golden triangles are found in the nets of several stellations of dodecahedrons and icosahedrons. Also, it is the shape of the triangles found in the points of pentagrams. The vertex angle is equal to

$$\theta = \cos^{-1}\left(\frac{\varphi}{2}\right) = \frac{\pi}{5} = 36°.$$

Since the angles of a triangle sum to 180°, base angles are therefore 72° each. The golden triangle can also be found in a decagon, or a ten-sided polygon, by connecting any two adjacent vertices to the centre. This will form a golden triangle. This is because: 180(10-2)/2=144 degrees is the interior angle and bisecting it through the vertex to the centre, 144/2=72. The golden triangle is also uniquely identified as the only triangle to have its three angles in 2:2:1 proportion.

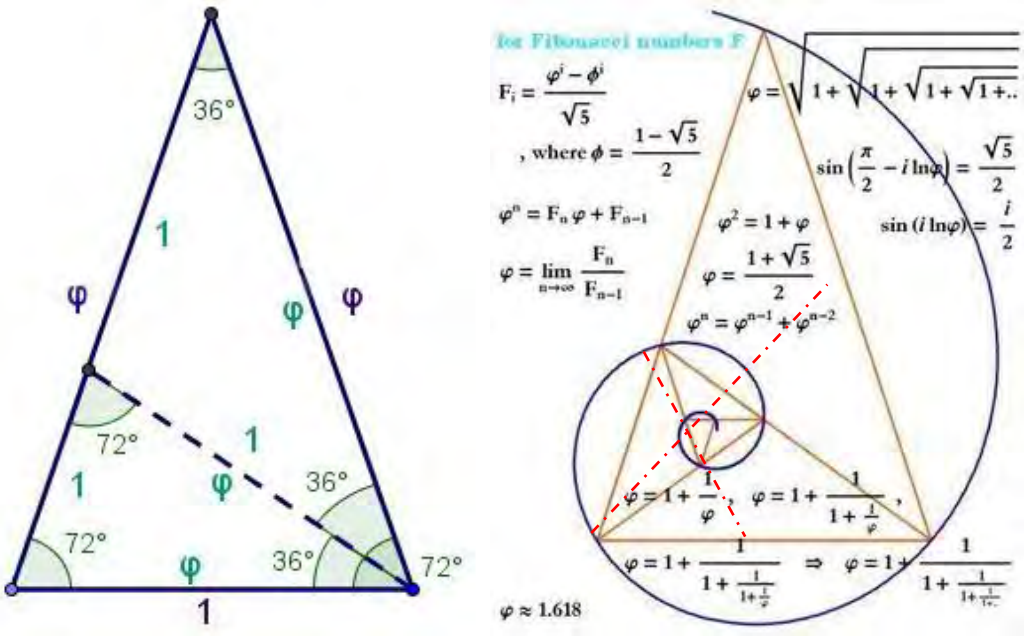


Figure 37: The Golden Triangle and inscribed in a Fibonacci spiral (source: en.wikipedia.org/wiki/golden triangle)

The golden triangle is used to form a sequential Fibonacci spiral. By bisecting the base angles, a new point is created that in turn, makes another golden triangle. The bisection process can be continued infinitely, creating an infinite number of golden triangles. A Fibonacci spiral can be drawn through the vertices. This spiral is also known as an equiangular spiral [70].

[70] *Livio, Mario,2002. The Golden Ratio: The Story of Phi, the World's Most Astonishing Number.*

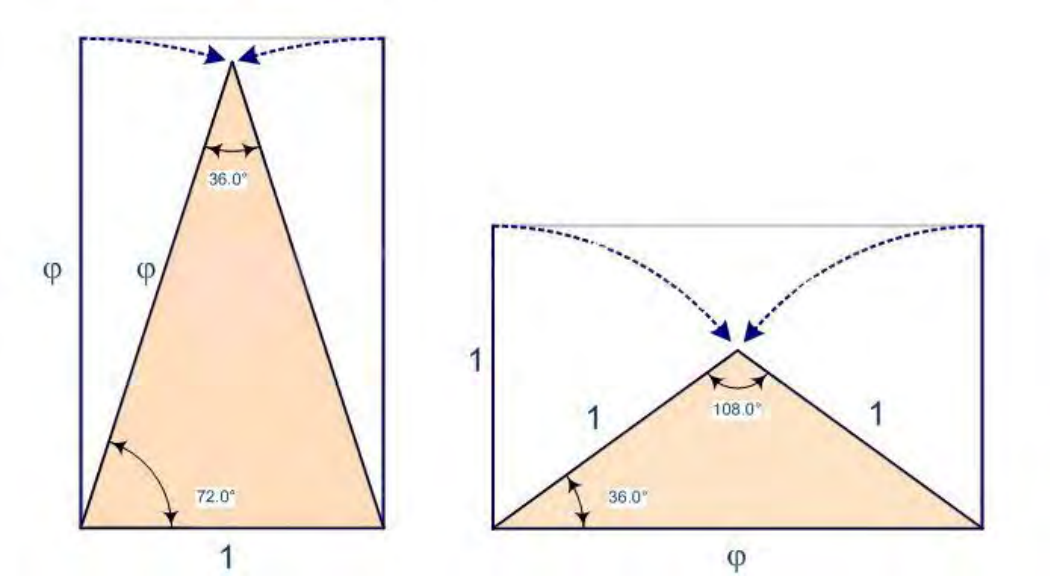


Figure 38: Creating the Golden Triangles from the Golden Rectangle(source: en.wikipedia.org/wiki/golden triangle)

These two golden triangles can be created easily from the golden rectangle by removing one of the sides and collapsing the two open sides until they meet in the middle as shown above in figure 40. Interestingly the angles of these two triangles are all multiples of 36.

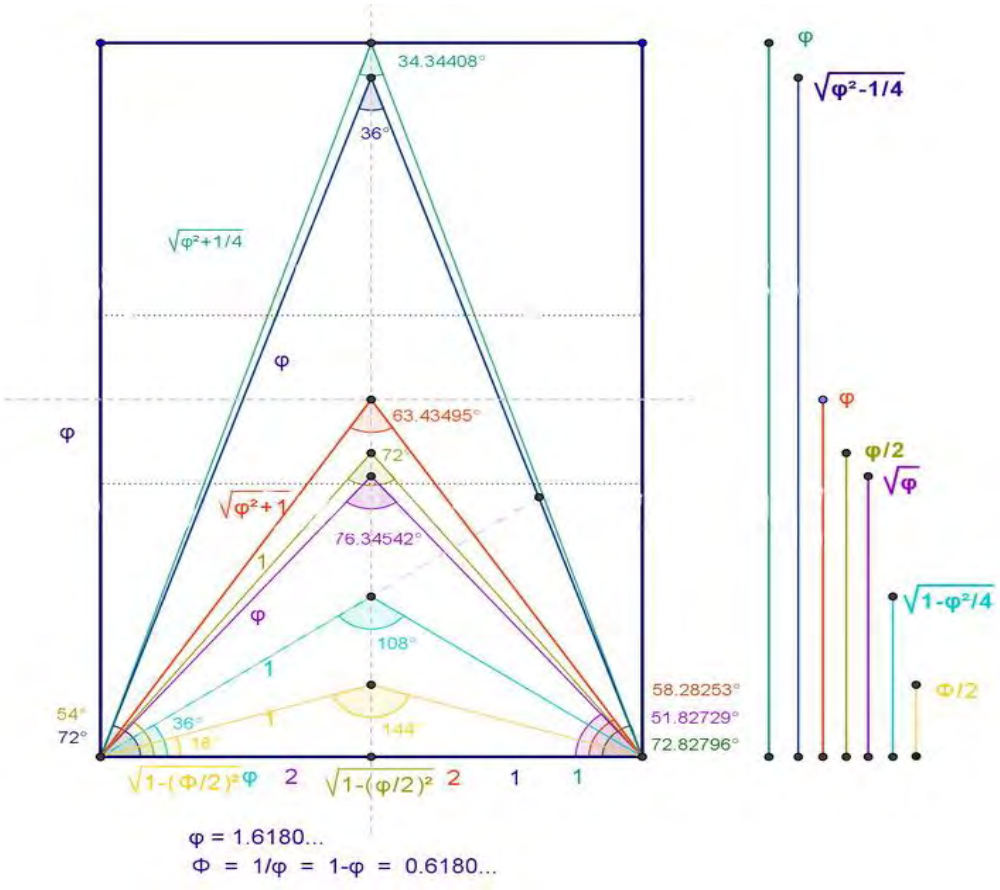
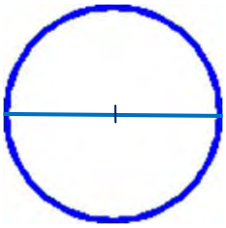


Figure 39: The Golden Triangles inside a Golden Rectangle(source: en.wikipedia.org/wiki/golden triangle)

2.5.1.6. Geometry in Architecture

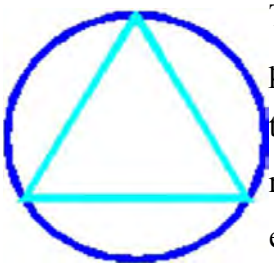
The word geometry refers to the science of properties and relations of magnitudes such as points, lines, surfaces, or solids in space and the way the parts of a particular object fit together (Concise Oxford English Dictionary, 1999). Our ability to create music and interpret sounds is initially a mechanical interpretation of wave patterns, not through quantitative differences but proportional differences. The architecture of the buildings we inhabit as our dwellings, our work places, our healing and education centres, and our churches and temples, has similar impact on our senses as the architecture of nature. In understanding how this connection between nature and manmade objects works, one should considered the meaning of numbers and their associated geometric forms.

The essence of duality



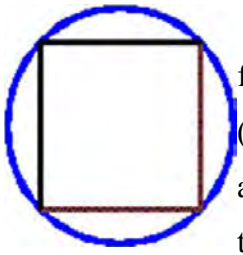
If we look at the geometry the circle represents God, the circumference being that which encompasses all that is, and the area being all that is. All geometric forms that evolve out of prime numbers are contained within the circle, for it is the circle that defines their symmetry. Implicit within a circle, and its most fundamental product or creation is its diameter. The diameter is a straight line - it defines two points (at its ends, which lie on the circumference), thus symbolising duality or polar opposites. One, in the sense of absolute exclusivity as distinct from one as a unit amongst many, is incomprehensible, and only God is absolute unity. Try to imagine that you alone existed within an infinite void would be incapable of identifying even yourself as there would be no datum point for recognition to occur. One therefore is meaningless, as only God is absolute unity, and one represents creation unmanifested.

The power behind creation



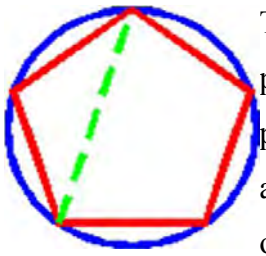
The next step in creation, moving from 2 points on the circumference of a circle is 3 points. When these are in symmetry with each other, they define the equilateral triangle. Three linear structural elements connected together at their end points form a rigid frame, which is a fundamental engineering principle. The triad or trinity in esoteric terms expresses a rigid structure, and demonstrates the stability within creation by virtue of the principles of the Father, the Son and the Holy Spirit. All subsequent steps in creation contain triangles. The 3-dimensional version of the triangle is the tetrahedron, a solid object contained within a sphere, but one which is pure of form because it contains 4 faces all of which express the trinity. It has no diagonals, no shortcuts between its defining points. Although it appears to be a 3-dimensional object, it is really multi-dimensional, and represents consciousness on higher planes of reality wherein all manifestations are aware of their existence within the trinity. It also demonstrates how every single addition (point) in creation gives rise to another triangle as part of a larger rigid framework, the basis of construction of a stable universe.

The Manifestation into Matter



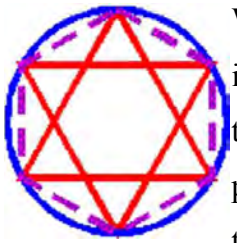
Next we have four, the square, symbolizing creation in matter. The square defines the four directions of north, south, east and west, and in its 3-dimensional form, the cube (contained within a sphere) defines the 3 directions of 3-dimensional reality. The square and the cube represent physical manifestation unevolved. The potential that lies within them is understood. For example, the square's diagonal implies another square, which in turn contains a diagonal with an even larger square. Continued on, this creates a spiral which is the dynamic energy within all creation, and symbolizes involution (complication) and evolution, progress towards the infinite, both inwards and outwards. Four also represents the first product of the procreative process that is of multiplication 2 x 2 = 4.

The potential contained within matter

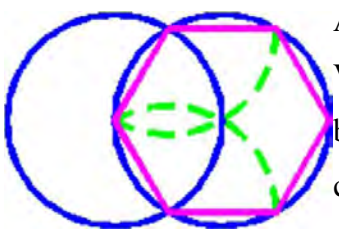


The next step with five brings consciousness into matter by virtue off, the golden proportion. Five points equally spaced on the circumference of a circle give rise to the pentagon, within which lies the pentagram or five pointed star. This is generally accepted as representing man; the head, two legs astride, and two arms outstretched. The diagonal of a pentagon, in proportional relationship with its side defines Phi. This is the purest form of proportion, and thus represents human consciousness in its greatest and most harmonious state. As such, it cannot be defined in absolute terms. Perfect consciousness in matter is something to be required. An evolved consciousness recognises perfect harmony, but in the imperfect state it is given no status. All creative expressions that emanate from man can be evaluated to the degree in which they incorporate the golden proportion

The power of spirit and brings it into matter



Whereas five expresses the potential for harmony hidden within the world of matter is clear in its representation of symmetry and balance. The hexagon has all its diagonals passing through the centre of the circle and equal to the diameter. Within it lies the hexagram (6 pointed star) and its 3-dimensional form the star tetrahedron. The hexagram is made up of two superimposed equilateral triangles, one inverted. The trinity has replicated itself in the world of matter as represented by the inverted triangle. The hexagram thus presents the challenge for mankind to recognize His own divinity.



A similar relationship between God and His creations in matter can be seen in the Vesica Piscis, where two circles overlap. A connection exists in these two symbols because the Vesica is the geometric basis for establishing the hexagram. The Vesica can also be seen as the two aspects of God within the material level of creation:

masculine and feminine, the polar opposites in humanity arising out of duality. Two circles apart define separation between male and female, but in the overlapping they are integrated. The Vesica thus expresses the powerful potential in mankind to achieve harmony through the blending of the masculine and feminine qualities. The overlap area has traditionally been seen as a fish or the Piscean Christ.

When we incorporate these symbols, they need only be understood as a topic out of which the design evolves. The power within the symbols is vibrational, and the way they are used should optimally be compatible with the inhabitants. This is the role of the designer, to identify that compatibility. When vibrational symbols are used as a rigid format springing from the mind, their power is limited. The mind is a tool. Only when thought is coupled with intent arising from the heart, does manifestation occur.

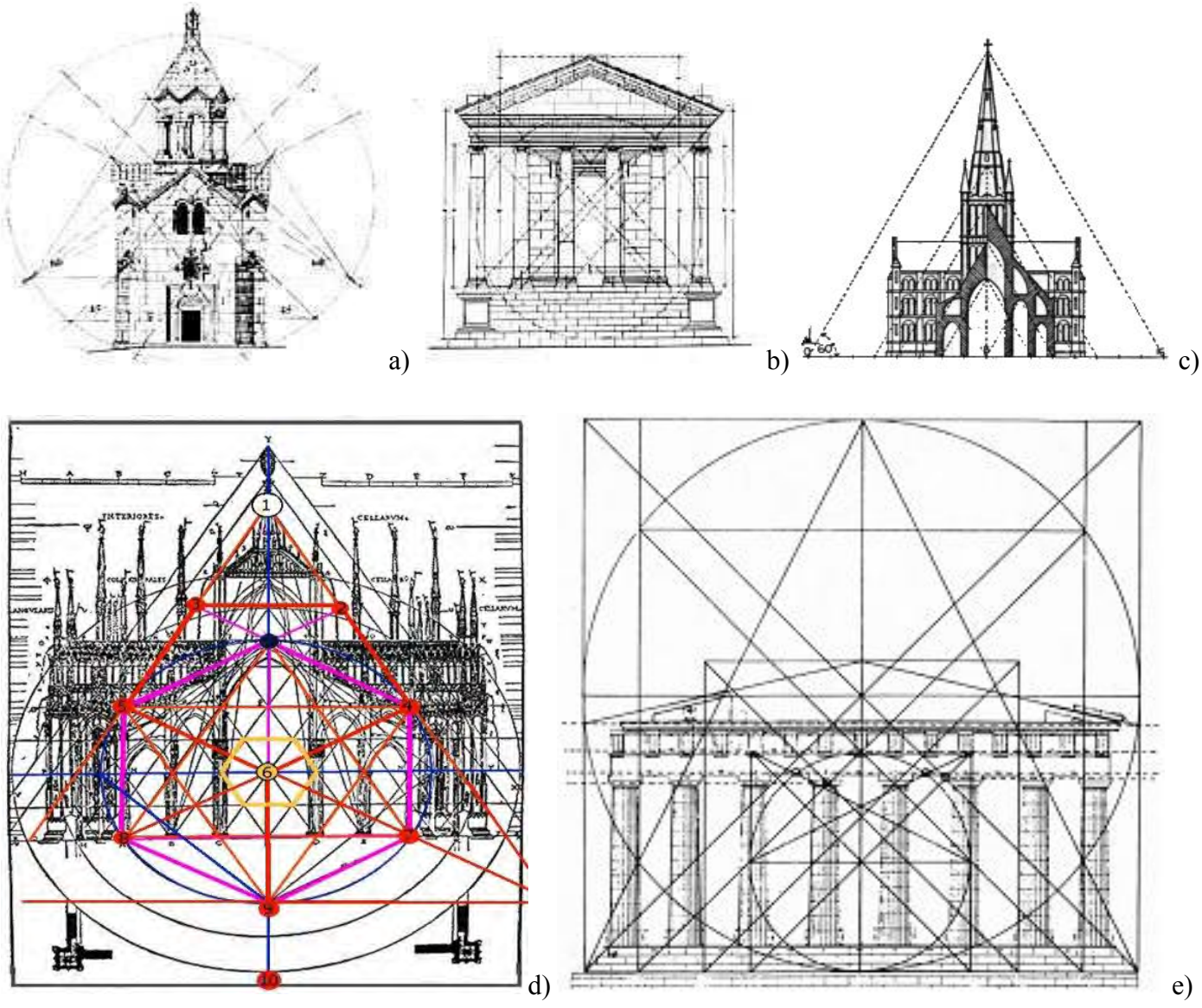


Figure 40: The Architecture of a) Haghbat bell tower, Armenia; b) the 1st c. Hellenistic temple of Garni, Armenia; c) Salisbury Cathedral in Salisbury, England; d) e)The Parthenon, Athens,Greek (source: Microsoft Encarta: Free Encyclopedia, 2008)

2.5.2. Sacred Architecture

Sacred architecture is a religious architectural practice concerned with the design and construction of places of worship and/or sacred or intentional space, such as churches, mosques, stupa (Buddhists Shrine), synagogues (House of worship for Jewish congregation), and temples. Many cultures devoted considerable resources to their sacred architecture and places of worship. Religious and sacred spaces are amongst the most impressive and permanent monolithic buildings created by humanity. Conversely, sacred architecture as a setting for meta-intimacy may also be non-monolithic, momentary and strongly private, personal and non-public.

Sacred, religious and holy structures often evolved over centuries and were the largest buildings in the world, prior to the modern skyscraper. While the various styles employed in sacred architecture sometimes reflected trends in other structures, these styles also remained unique from the contemporary architecture used in other structures. With the rise of Christianity and Islam, religious buildings increasingly became centres of worship, prayer and meditation.

The discipline of the history of architecture itself closely follows the history of religious architecture from ancient times until the Baroque period, at least. Sacred geometry, iconography and the use of sophisticated semiotics such as signs, symbols and religious motifs are endemic to sacred architecture. Architect Norman L. Koonce has suggested that the goal of sacred architecture is to make "transparent the boundary between matter and mind, flesh and the spirit" [71]. And, it is also suggested by scholars that it is to be psychologically healthy, human beings need to experience their natural setting, the setting we were designed for, which is the garden. Meanwhile, as we know, that entering into a religious building is a symbol for entering into spiritual relationship. In which sacred space can be analyzed by three factors affecting spiritual process:

- Longitudinal space emphasizes the procession and return of sacramental acts,
- Auditorium space is suggestive of proclamation and response, and
- New forms of communal space designed for gathering and return depend to a great degree on minimized scale to enhance intimacy and participation in worship.

The historical sacred architecture cultures in different countries and different religious perspectives shows the understanding of the base of the art and wisdom commonly as follows.

[71] *Michael E. Desanctis, 2002*

Ancient Architecture

Sacred architecture spans a number of ancient architectural styles including Neolithic (New Stone Age) architecture, ancient Egyptian architecture and Sumerian architecture (Mesopotamian art and architecture, the arts and buildings of the ancient middle eastern civilizations that developed in the area (now Iraq) between the Tigris and Euphrates rivers from prehistory to the 6th century BC). Ancient religious buildings, particularly temples, were often viewed as the dwelling place, of the gods and were used as the site of various kinds of sacrifice. Ancient tombs and burial structures are also examples of architectural structures reflecting religious beliefs of their various societies. Ancient Egyptian religious architecture has fascinated archaeologists and captured the public imagination for millennia.

Classical Architecture

Around 600 BC the wooden columns of the temple of Hera at Olympia were replaced by stone columns [72]. With the spread of this process to other sanctuary structures a few stone buildings have survived through the ages. Since temples are the only buildings which survive in numbers, most of our concept of classical architecture is based on religious structures. The Parthenon which served as a treasury building as well as a place for veneration of deity is widely regarded as the greatest example of classical architecture.

Indian Architecture

Indian architecture is related to the history and religions of the time periods as well as to the geography and geology of the Indian subcontinent. India was crisscrossed by trading routes of merchants from as far away as China as well as weathering invasions by foreigners, resulting in multiple influences of foreign elements on native styles. The diversity of Indian culture is represented in its architecture. Indian architecture comprises a blend of ancient and varied native traditions, with building types, forms and technologies from West, Central Asia, and Europe.

Buddhist architecture developed in South Asia beginning in the 3rd century BC. Two types of structures are associated with early Buddhism: viharas and stupas [73]. Originally, Viharas were temporary shelters used by wandering monks during the rainy season, but these structures later developed to accommodate the growing and increasingly formalized Buddhist monasticism. The architectural structure of the stupa spread across Asia, taking on many diverse forms as details specific to different regions were incorporated into the overall design. The initial function of the stupa was the veneration and safe-guarding of the relics of the Buddha.

Byzantine Architecture

Byzantine architecture evolved from Roman architecture. Eventually, a style emerged incorporating near East influences and the Greek cross plan for church design. In addition, brick replaced stone, classical order was less strictly observed, mosaics replaced carved decoration, and complex domes were erected.

[72] *Richard Kieckhefer, 2004*
[73] *Encarta Dectionary, 2008.Ibid*

One of the great breakthroughs in the history of western architecture occurred when Justinian's architects invented a complex system providing for a smooth transition from a square plan of the church to a circular dome (or domes) by means of squinches or pendentives. The prime example of early Byzantine religious architecture is the Hagia Sophia in Istanbul.

Islamic Architecture

Byzantine architecture had a great influence on early Islamic architecture with its characteristic round arches, vaults and domes. Many forms of mosques have evolved in different regions of the Islamic world. The earliest styles in Islamic architecture produced *Arab-plan* or *hypostyle* mosques during the Umayyad Dynasty. These mosques follow a square or rectangular plan with enclosed courtyard and covered prayer hall. Most early hypostyle mosques had flat prayer hall roofs, which required numerous columns and supports [74].

The Ottomans introduced central dome mosques in the 15th century that have a large dome cantered over the prayer hall. In addition to having one large dome at the centre, there are often smaller domes that exists off-centre over the prayer hall or throughout the rest of the mosque, in areas where prayer is not performed. Domes have been a hallmark of Islamic architecture since the 7th century. As time progressed, the sizes of mosque domes grew, from occupying only a small part of the roof to encompassing the entire roof above the prayer hall; although, domes normally took on the shape of a hemisphere [75]. A common feature in mosques is the minaret, the tall, slender tower that usually is situated at one of the corners of the mosque structure. The top of the minaret is always the highest point in mosques that have one, and often the highest point in the immediate area.

Medieval Architecture

The religious architecture of Christian churches in the middle ages featured the Latin cross plan, which takes the Roman basilica as its primary model with subsequent developments. It consists of a nave, transepts, and the altar stands at the east end. Also, cathedrals influenced or commissioned by Justinian employed the Byzantine style of domes and a Greek cross (resembling a plus sign), cantering attention on the altar at the centre of the church.

Gothic Architecture

Gothic architecture was particularly associated with cathedrals and other churches, which flourished in Europe during the high and late medieval period. Beginning in the 12th century, it was known as "the French Style" during the period. The style originated at the abbey church of Saint-Denis in Saint-Denis, near Paris [76]. Other notable gothic religious structures include Notre Dame de Paris, the Cathedral of Our Lady of Amiens, and the Chartres Cathedral.

[74] *Hillenbrand R., 2011.*
[75] *Asher, Catherine B., 1992.*
[76] *Andrzej Piotrowski, 2011*

Renaissance Architecture

The Renaissance brought a return of classical influence and a new emphasis on rational clarity. Renaissance architecture represents a conscious revival of Roman architecture with its symmetry, mathematical proportions, and geometric order. An important Renaissance contribution to the development of Western architecture was the revival of the dome, an architectural feature that was first introduced by the Romans. Brunelleschi's great dome on the cathedral of Florence is one of the outstanding achievements of the period. Renaissance architects were also interested in secular buildings of all kinds, including palaces, libraries, and theatres.

Baroque Architecture

Evolving from the renaissance style, the baroque style was most notably experienced in religious art and architecture. Most architectural historians regard Michelangelo's design of St. Peter's basilica in Rome as a precursor to the Baroque style. Baroque style can be recognized by broader interior spaces (replacing long narrow naves), more playful attention to light and shadow, extensive ornamentation, large frescoes, focus on interior art, and frequently, a dramatic central exterior projection.

Modern and Post-Modern Architectures

Modern architecture spans several styles with similar characteristics resulting in simplification of form and the elimination of ornament. While secular structures clearly had the greater influence on the development of modern architecture, several excellent examples of modern architecture can be found in religious buildings of the 20th century. Post-modern architecture may be described by unapologetically diverse aesthetics where styles collide, form exists for its own sake, and new ways of viewing familiar styles and space abound.

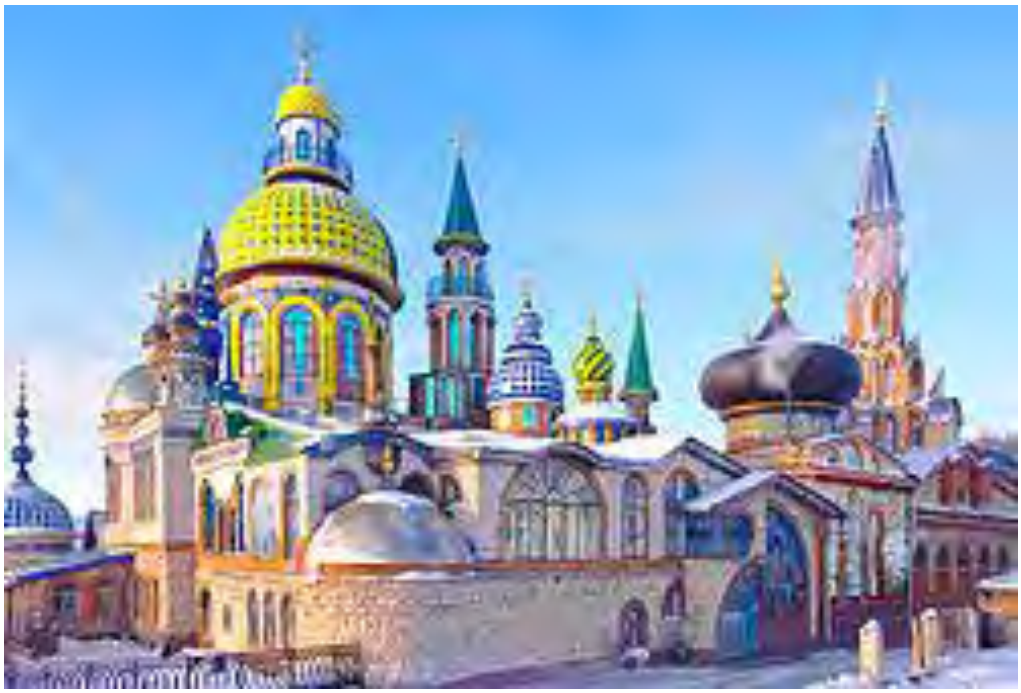


Figure 41: The Temple of All Religions in Kazan, Russia, combining various forms of religious architecture (Source: Wikipedia, the free encyclopedia.htm)

2.5.2.1. Churches' Architecture

Church architecture refers to the architecture of buildings of Christian churches. It has evolved over the two thousand years of the Christian religion, partly by innovation and partly by imitating other architectural styles as well as responding to changing beliefs, practices and local traditions. From the birth of Christianity to the present, the most significant objects of transformation for Christian architecture and design were the great churches of Byzantium, the Romanesque Abbey churches, Gothic cathedrals and Renaissance Basilicas with its emphasis on harmony [77]. These large, often ornate and architecturally prestigious buildings were dominant features of the towns and countryside in which they stood. But far more numerous were the parish churches spread across the Christian world, the focus of Christian devotion in every town and village. While a few are counted as inspiring works of architecture to equal the great cathedrals, the majority developed along simpler lines, showing great regional diversity and often demonstrating local vernacular technology and decoration.

The church is often built of the most durable material available, often dressed stone or brick. The requirements of liturgy have generally demanded that the church should extend beyond a single meeting room to two main spaces, one for the congregation and one in which the priest performs the rituals of the Mass. To the two-room structure are often added aisles, a tower, chapels, and vestries and sometimes transepts and mortuary chapels. The additional chambers may be part of the original plan, but in the case of a great many old churches, the building has been extended gradually, its various parts testifying to its long architectural history.

Figure 42: The typical architecture of Christian Basilica (Source: http://www.google.com/ Wikipedia/ Churches Architecture.)

[77] *Ward-Perkins, J. B., 1994. Studies in Roman and Early Christian Architecture. London.*

2.5.2.1.1. Characteristics of the Christian Buildings

In the first three centuries of the early Christian church, the practice of Christianity was illegal and few churches were constructed. In the beginning Christians worshipped along with Jews in synagogues and in private houses. After the separation of Jews and Christians the latter continued to worship in people's houses, known as house churches. These were often the homes of the wealthier members of the faith. St Paul, in his first letter to the Corinthians (chapter 16:19) writes: *The assemblies of Asia greet you. Aquila and Priscilla greet you much in the Lord, together with the assembly that is in their house.*

From the first to the early fourth centuries most Christian communities worshipped in private homes, often secretly. With the victory of the Roman Emperor Constantine in 312 AD, Christianity became a lawful and then the privileged religion of the Roman Empire. The faith, already spread around the Mediterranean, now expressed itself in buildings. Christian architecture was made to correspond to civic and imperial forms, and so the basilica, a large rectangular meeting hall became general in east and west, as the model for churches, with a nave and aisles and sometimes galleries and clerestories. While civic basilicas had apses at either end, the Christian basilica usually had a single apse where the bishop and presbyters sat in a dais behind the altar. While pagan basilicas had as their focus a statue of the emperor; Christian basilicas focused on the Eucharist as the symbol of the eternal, loving and forgiving God. However, the church buildings grew out of a number of features of the ancient Roman period; showing atrium (courtyard), narthex (vestibule), central nave with double aisles, a bema for the clergy extending into a transept, and an exedra or semi-circular apse.

Atrium: when early Christian communities began to build churches they drew on one particular feature of the houses that preceded them, the atrium, or courtyard with a colonnade surrounding it.

Basilica: is an ancient Roman building type on which early Christian church designs were based. Basilicas have a long central hall, or nave, separated from side aisles by rows of columns. At the end of the nave is a raised platform, or bema, where an altar typically stood. Behind the bema is a semi-circular apse. People enter the basilica through a roofed porch, or narthex, that faces onto a square courtyard called an atrium. The roofed walkways on the side of the atrium form an ambulatory.

Bema: a raised dais called a bema formed part of many large basilica churches. This bema extended laterally beyond the main meeting hall, forming two arms so that the building took on the shape of a T with a projecting apse. From this beginning, the plan of the church developed into the so-called Latin cross which is the shape of most Western Cathedrals and large churches. The arms of the cross are called the transept.

Mausoleum: the mausoleum of a noble Roman was a square or circular domed structure which housed a sarcophagus (stone coffin). The circular or polygonal form lent itself to those buildings within church complexes that perform a function in which it is desirable for people to stand, or sit around, with a centralized focus, rather than an axial one.

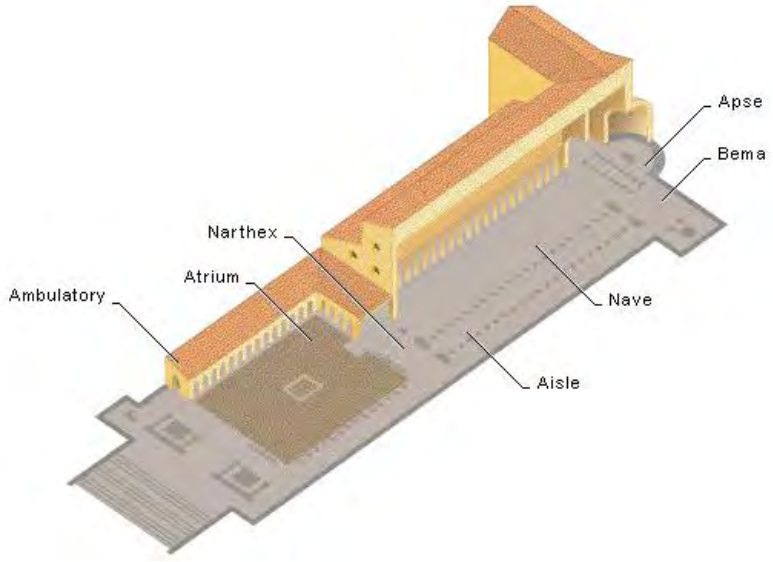


Figure 43: An Early Christian Basilica (Source: Microsoft Encarta, 2008)

Latin cross and Greek cross: most cathedrals and great churches have a cruciform ground plan. In churches of Western European tradition, the plan is usually longitudinal, in the form of the so-called Latin cross with a long nave crossed by a transept. A square plan in which the nave, chancel and transept arms are of equal length forming a Greek cross, the crossing generally surmounted by a dome became the common form in the Orthodox Church. Churches of the Greek cross form often have a narthex or vestibule which stretches across the front of the church. This type of plan was also to later play a part in the development of church architecture in Western Europe.

Eastern Orthodoxy and Byzantine Architecture: these buildings copied pagan tombs and were square, cruciform with shallow projecting arms or polygonal. They were roofed by domes which came to symbolize heaven. The projecting arms were sometimes roofed with domes or semi-domes that were lower and adjusted the central block of the building. Byzantine churches, although centrally planned around a domed space, generally maintained a definite axis towards the apsidal chancel which generally extended further than the other apses.

Medieval West: participation in worship, which gave rise to the porch church, began to decline as the church became increasingly clericalised; with the rise of the monasteries church buildings changed as well. The two-room church became in Europe the norm. The first room, the nave, was used by the congregation; the second room, the sanctuary, was the preserve of the clergy and was where the Mass was celebrated. The buildings became more clearly symbolic of what they were intended for.

The Reformation: in the early 16th century Martin Luther and the Reformation brought a period of radical change to church design. According to the ideals of the protestant reformation, the spoken word, the sermon, should be central act in the church service. This implied that the pulpit became the focal point of the church interior and that churches should be designed to allow all to hear and see the minister.

Modernism: the idea that worship was a corporate activity and that the congregation should be in no way excluded from sight or participation is owed to the liturgical movement. Simple one-room plans are almost of the essence of modernity in architecture. Different principles and practical pressures produced other changes. Parish churches were inevitably built more modestly. Often shortage of finances, as well as a 'market place' theology suggested the building of multi-purpose churches, in which secular and sacred events might take place in the same space at different times.

Postmodernism: the Post-modern movement in architecture formed in reaction to the ideals of modernism as a response to the perceived blandness, hostility, and utopianism of the modern movement. The functional and formalized shapes and spaces of the modernist movement are replaced by unapologetically diverse aesthetics: styles collide, form is adopted for its own sake, and new ways of viewing familiar styles and space abound. Perhaps most obviously, architects rediscovered the expressive and symbolic value of architectural elements and forms that had evolved through centuries of building often maintaining meaning in literature, poetry and art; but which had been abandoned by the modern movement.

2.5.2.1.2. Factors Affecting the Architecture of Churches

The process by which church architecture developed and individual churches were designed and built was different in different regions, and sometimes differed from church to church in the same region and within the same historic period. Among the factors that determined how a church was designed and built are the nature of the local community, the location in city, town or village, whether the church was an abbey church, whether the church was a collegiate church, whether the church had the patronage of a bishop, whether the church had the ongoing patronage of a wealthy family and whether the church contained relics of a saint or other holy objects that were likely to draw pilgrimage. Collegiate churches and abbey churches, even those serving small religious communities, generally demonstrate a greater complexity of form than parochial churches in the same area and of a similar date.

Churches that contain famous relics or objects of veneration and have thus become pilgrimage churches are often very large and have been elevated to the status of basilica. However, many other churches enshrine the bodies or are associated with the lives of particular saints without having attracted continuing pilgrimage and the financial benefit that it brought. The popularity of saints, the veneration of their relics, and the size and importance of the church built to honor them is without consistency and can be dependent upon entirely different factors.

2.5.2.2. The Visual Art

Art is the product of creative human activity in which materials are shaped or selected to convey an idea, emotion, or visually interesting form. The word art can refer to the visual arts, including painting, sculpture, architecture, decorative arts, crafts, and other visual works that combine materials or forms. In this article art refers to the visual arts. The visual arts have traditionally consisted of painting, sculpture and architecture.

In ancient Greece, the word "techne" is the closest equivalent to art. "Techne", which means work or technical skill, can be applied to the fashioning of any sort of object [78]. But the Greeks had a special appreciation of mimesis (the imitation of reality) in painting and of especially pleasing proportions in sculpture and architecture. The ancient Romans used the word "ars", but "ars" still referred to a technique or a method of working, not to the expressive, creative activities that we now associate with art. During the Middle Ages (about 350 to 1450 AD), Christianity dominated Western culture. Thus the main purpose of the visual arts was to teach people, many of whom could not read, about religion. Art taught by means of delight, drawing people"s attention and helping them understand the spiritual through fascinating forms, ornately carved and painted decoration, precious materials , and coloured light pouring forth from stained glass.

Art categorized for the sake of understanding and interpretation. It is easiest to compare and make connections between works that are similar in fundamental ways. We might instead think of painting, sculpture, and architecture as corresponding roughly to two-dimensional art, three-dimensional art, and arts that enclose or define space.

- **Painting and Two-Dimensional Art** - Painting involves applying a pigment on a surface. Other two-dimensional media include vase painting, mosaics, stained glass, illuminated manuscripts, sand painting, ink painting, and all forms of drawing and printmaking.

- **Sculpture** - a broad category comprises three-dimensional objects, whether freestanding (without other structures for support) or attached to a background and called relief sculpture. Sculptors can make their objects by modelling a soft material such as clay or wax; by carving hard materials, such as stone or wood; or by assembling different sorts of materials.

- **Architecture** - is the art of creating structures in which we can live, work, worship, and play. Architects, more than painters and sculptors, are concerned with the function of their buildings as well as with the visual appearance, structural solidity, and way in which a building fits into the landscape.

[78] *Barnes, Bernadine, 2008. "Art." Microsoft Student [DVD]. Redmond, WA: Microsoft Corporation.*

Art has served a variety of purposes: to honour the dead, to recall the appearance of rulers or relatives, to give visual form to gods, to create sacred places, to display wealth, to teach, and to give pleasure. Even if we think of art as isolated from the rest of life, we still must turn to architects to design buildings with important functions. We still value design in furniture and other useful everyday objects. The methods and materials have changed dramatically, but art is still very much a part of our lives.

- **Recording Appearances** - An artist‟s ability to reproduce the appearance of things in our world lies behind some of the earliest uses of art.

- **Making Visible the Invisible** - Art can also make visible things we normally cannot see. Throughout history, people have made images of gods, angels, and demons; of events from the distant past or the far-off future; and of what they wished the present would be. Some of the most important works of architecture are religious structures, such as cathedrals, chapels, mosques, or temples. Their sizes, plans, and decoration reflect the religious practices of the people who use them.

- **Communicating** - Art in all its forms can display wealth, power, and prestige. Because of the high value of art, it may seem affordable to only an elite class of patrons and collectors.

- **Delighting** - An important purpose of art is to delight. Some works of art are beautiful or charming in themselves. Others delight us through their visual intricacy, by reminding us of patterns in nature, and in many other ways [79].

[79] *Barnes, Bernadine. 2008. Ibid*

2.5.2.3. Rock-cut Architecture

Rock-cut architecture is the creation of structures, buildings, and sculptures, by excavating solid rock where it naturally occurs. Rock-cut architecture is designed and made by man from the start to finish. The terms 'cave' and 'cavern' are often applied to this form of man-made architecture. However, caves and caverns, which began in natural form, are not considered to be 'rock-cut architecture' even if extensively modified [80]. Although rock-cut structures differ from traditionally built structures in many ways, many rock-cut structures are made to replicate the facade or interior of traditional architectural forms. Interiors were usually carved out by starting at the roof of the planned space and then working downward. This technique prevents stones falling on workers below. The main uses of rock-cut architecture were temples (like those in India), tombs (like those in Petra, Jordan), cave dwellings (like those in Cappadocia, Turkey) and religious worship places (like those in *Lalibela*); though, some scholars argue that may not firstly constructed intentionally for religious purposes, rather, it was for the purpose of defence mechanism (by looking the thick structure of walling (locally called *Meferareja*) in *Bete Gebreal*, and also considered as royal housing and/or centre of courts, due to the tools and some materials founded in *Bete Merkorious* in 1960s" by Architect S. Angeline, Scientific Director of the Conservation team.

Some rock-cut architecture, mostly for tombs, is excavated entirely in chambers under the surface of relatively level rock. If the excavation is instead made into the side of a cliff or steep slope there can be an impressive facade, as found in *Bete Abba Libanos*, Lycian tombs, Petra, Ajanta and elsewhere. The most laborious and impressive rock-cut architecture is the excavation of tall free-standing monolithic structures entirely below the surface level of the surrounding rock, in a large excavated hole around the structure. *Lalibela* and Ellora in India provide the most spectacular and famous examples of such structures.
Rock-cut architecture, though intensely laborious with ancient tools and methods, was most probably combined with quarrying the rock for use elsewhere; the huge amounts of stone removed have normally vanished from the site. Rock-cut architecture is also said to be cut, hewn, etc., "from the living rock". Another term sometimes associated with rock-cut architecture is monolithic architecture, which is rather applied to free-standing structures made of a single piece of material. Monolithic architecture is often rock-cut architecture but monolithic structures might be also cast of artificial material, e.g. concrete.

The creation of rock-cut tombs in ancient Israel began in the 8th century BC and continued through the Byzantine period. The Nabataeans in their city of Petra, now in Jordan, extended this tradition, carving their temples and tombs into the yellowish-orange rock that defines the canyons and gullies of the region. These structures, dating from 600 BC to about 300 BC, are particularly important in the history of architecture given their experimental forms [81].

[80] *Ching, Francis D.K., 2012. A Visual Dictionary of Architecture (2nd edition.). John Wiley & Sons, Inc. p. 6*
[81] *M.Rababah, 2005*

Large scale rock-cut structures were also built in ancient Egypt and among important monuments could be mentioned the Great Temple of Ramesses II, known as Abu Simbel, located along the Nile in Nubia near the borders of Sudan about 300 kilometres from Aswan in Egypt. It dates from about 1280 BC, and consists of a monumentally scaled facade carved out of the cliff and a set of interior chambers that form its sanctuary [82].

The earliest instances of Indian rock-cut architecture, the Barabar caves date from about the 3rd to the 2nd century BC, also occupies an important place in the history of Indian Architecture. They were built by the Buddhist monks and consisted mostly of multi-storey buildings carved into the mountain face to contain living and sleeping quarters, kitchens, and monastic spaces [82]. As time progressed, the interiors became more elaborate and systematized; surfaces were often decorated with paintings. At the beginning of the 7th century Hindu rock-cut temples began to be constructed at Ellora. Unlike most previous examples of rock-cut architecture which consisted of a facade plus an interior, these temples were complete three-dimensional buildings created by carving away the hillside. They required several generations of planning and coordination to complete. The technological skills associated with making these complex structures moved into China along the trade routes, which consist of hundreds of caves many with statues of Buddha in them. Most were built between 460 and 525 AD [83]. Here also, in *Lalibela*.

[82] *Aidan Dodson, 1999*
[83] *S. Nagaraju, 1981*
[84] *Vidya Dehejia, 1972*

2.6. Structural Formations of Sacred Buildings

Though main purpose of many buildings may be different, simultaneously it provides an envelope of protection to the inhabitants and their contents. In order to do this it needs to retain its structural integrity under all loads or forces that it is likely to be subjected to. The form that the structure will take depends on a number of factors such as purpose and location as traditionally buildings have been constructed using locally sourced materials.

The way it is constructed is mostly dependant on the structural concept and type of materials that is used. Solid structures are constructed where the walls act both to enclose and support. This means that the walls will have to be of sufficient thickness in order to accept the loads applied and transfer them to the foundations. Whereas, skeletal structures consists of a framework which supports all loads and resists any imposed loads and transmits these to the foundations. This type of structure consists of a system of beams and columns which create a framework. The frame itself does not provide the enclosing of the building so an additional system is needed, thus walls can be placed over this framework or between the external structural members in order to enclose it. Most people will be familiar with the framed building. And, surface structures are either made of thin structure of solid material which is curved to provide stiffness, such shells where it acts as both the supporting and enclosing element; and a thin flexible membrane structure stretched across supporting members.

A monolithic structure covers buildings carved, cast or excavated from a single piece of material, in historic forms rock. The most basic form of monolithic architecture is a rock-cut building, like the monolithic churches of *Lalibela*. These are cut out of solid rock, to which they remain attached at the base. In most cases this is evident from the remaining surrounding rock, but sometimes a building is cut from a projection, as in the *wukro* and *Abreha we Atsebeha* rock churches in *Tigray*, and only inspection at close quarters reveals that the building is monolithic. Buildings with a structural material that is poured into place, most commonly concrete, can also be described as monolithic. The term monolith is normally used for object made from a single large piece of rock which is detached from the ground.

Defining the plan of the courtyard and the building itself is essential, therefore this research clearly shows the principles by which *Lalibela* used for determining the space in the building, structural element arrangements, formations and the mountain wall and the space of the building.

2.6.1. Structural Formations and Integrity

Structural integrity is a performance characteristic which is applied to a component, a single structure, or a structure consisting of different components. And, it is the quality of the elements to hold together under a load, including its own weight, resisting breakage or bending. It assures that the construction will perform its designed function, during reasonable use, for as long as the designed life of the structure. Members are

constructed with structural integrity to ensure that catastrophic failure does not occur, which can result in injuries, severe damage and death during construction and after.

Structural failure refers to the loss of structural integrity, which is the loss of the load-carrying capacity of a component or member within a structure, or of the structure itself. In a well-designed system, a localized failure should not cause immediate or even progressive collapse of the entire structure. Ultimate failure strength is one of the limit states that must be accounted for in structural design. Structural integrity is the ability of a structure or a component to withstand a designed service load, resisting structural failure due to fracture, deformation, or fatigue. It is a concept often used to produce items that will not only function adequately for their designed purposes, but also to function for a desired service life.

Figure 44: The internal structures of Bete Medhanealem

To construct an item with structural integrity, a primarily consideration is given on the properties of a material and then determine a suitable size, thickness, or shape that will withstand the desired load for a long life. A material with high strength may resist bending, but, without adequate toughness, it may have to be very large to support a load and prevent breaking. However, a material with low strength will likely bend under a load even though its high toughness prevents fracture. A material with low elasticity may be able to support a load with minimum deflection (flexing), but can be prone to fracture from fatigue, while a material with high elasticity may be more resistant to fatigue, but may produce too much deflection unless the object is considerably oversized.

Structural integrity must always be considered during designing buildings and must carefully be balanced the properties of a material with its size and the load it is intended to support. Also, the integrity of each component must be carefully matched to its individual application, so that the entire structure can support its load without failure due to weak links. When a weak link breaks, it can put more stress on other parts of the structure, leading to continual failures [85].

[85] *Andrew E. Samuel, John Weir - Elsevier 1999; Introduction to Engineering Design: Modelling, Synthesis and Problem Solving Strategies; Page 3-5*

The need to build structure with integrity goes back as far as recorded history. Houses needed to be able to support their own weight, plus the weight of the inhabitants. The elements needed to be strong and tough enough to do their jobs. Failure of a structure can occur from many types of problems. Most of these problems are unique to the type of structure or to the various industries. However, most can be traced to one of these main causes.

- Either due to size, shape, or the choice of material, is that the structure is not strong and tough enough to support the load. If the structure or component is not strong enough, catastrophic failure can occur when the overstressed construction reaches a critical stress level.

- Due to instability, whether due to geometry, design or material choice, causing the structure to fail from fatigue or corrosion. These types of failure often occur at stress points, such as squared corners, causing cracks to slowly form and then progress through cyclic loading. Failure general occurs when the cracks reach a critical length, causing breakage to happen suddenly under normal loading conditions.

- May be caused by construction techniques default. This may be due to improper selection of materials, incorrect sizing, improper treating, failing to adhere to the design, or poor workmanship. These types of failure can occur at any time.

- May be from lack of consideration of unexpected problems. Harm and natural disasters can all overstress a structure to the point of failure. Improper training of those who use and maintain the construction can also overstress it, leading to potential failures.

2.6.2. Structural Arrangements and Geometry

We live in a time of rapid change. Technology has just taken a giant leap forward. Something is changing almost every day. Today computer assisted design allows us to visualize building structures that could not be imagined before, and allows us to analyze the structural behaviour of the most complex structures imaginable. Furthermore, since advanced construction technology can carry out whatever we design, everything seems to be possible. The availability of tools of almost unlimited power makes it difficult to decide what should be designed and built, and what should not. So there is no easy measure of what is a "good" design and what is not, or even what is a "good" structure and what is not. This applies especially in a world where sensationalism is often a value in itself and therefore seems to justify the excessive cost that often goes with structurally unreasonable designs. Also, professionals no longer seem to be able to intuitively understand the behaviour of complex structural systems, because they don‟t have to. They feed into the computer what they have and see whether it works. And they are often challenged by the architect of an extreme design concept. Often this leads to the question, what should govern during construction: statics or aesthetics?

This is clearly the wrong question because for a building to stand up the structure has to function. For the building to be economical, the structure has to be buildable. Beyond that, the building form should persuasively and elegantly express its purpose and meaning, and express its integral relationship with the natural environment. The design of each and every building needs to be a process of creating such a result. And there are many more aspects to be considered and integrated into this process. Like all art, each undertaking is an attempt at a perfect result. In architecture and Engineering, the work is undertaken by a team, much like the members of a chamber music group or a jazz band. To make good music, they all need to listen to each other. If they are out of tune, none of their separate efforts are of much use because the dissonance will hurt the ears and make noise rather than art.

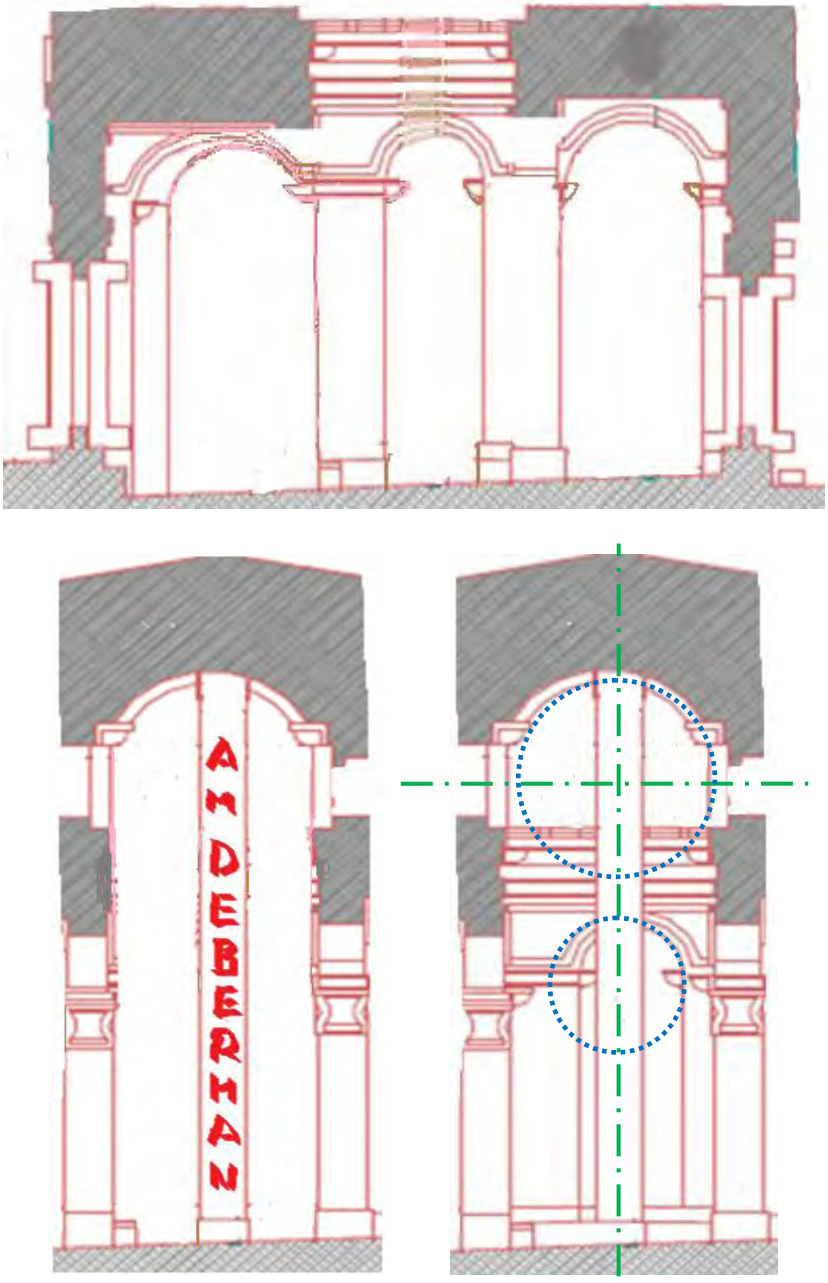


Figure 45: The internal structural element of Bete Mariam and geometry

Structural form and architectural form need to be in tune for a building to be considered "good." To be "good" requires that the building serves its function, is a solid structure, is an impressive piece of art, and

obeys the demands of a sustainable natural environment, a requirement of which we have newly become aware. To explore these relationships in some depth, it is important to investigate the role of structural form in architecture in the past.

Building is one of the oldest occupations of the human race. The form of the dome houses derived from the process of construction and the handling of naturally available materials. Yet its geometry of intersecting arches and hoops resulted in an ingenious structural system of great efficiency, because it carried the forces from its own weight and from wind and weather down to the ground in the most direct way. If we measure structural efficiency by the ratio of the weight of the structure to the external load that it can carry, the domes of the ancient communities were among the most efficient structures ever built. They are capable of carrying loads many times their own weight. In fact, it is unlikely that they ever failed due to the impact of the forces to which they were subjected. Their life span was limited by other factors, such as the durability of the materials and the changes which the traditions and of the community demanded.

As we know, structures with deep, properly shaped curvatures, such as arches or vaults, are vastly more efficient in transmitting loads than shallow flexural members such as beams and even trusses. The success of these ground-supported domes was based not only on their structural efficiency, but also on the shape of the envelope. The envelope, integrating wall and roof into one continuous surface shape, resulted in a "minimal surface" as today‟s structural engineers would call it. The envelope enclosed a maximum of usable space with a minimum of surface area, reducing the amount of material needed.

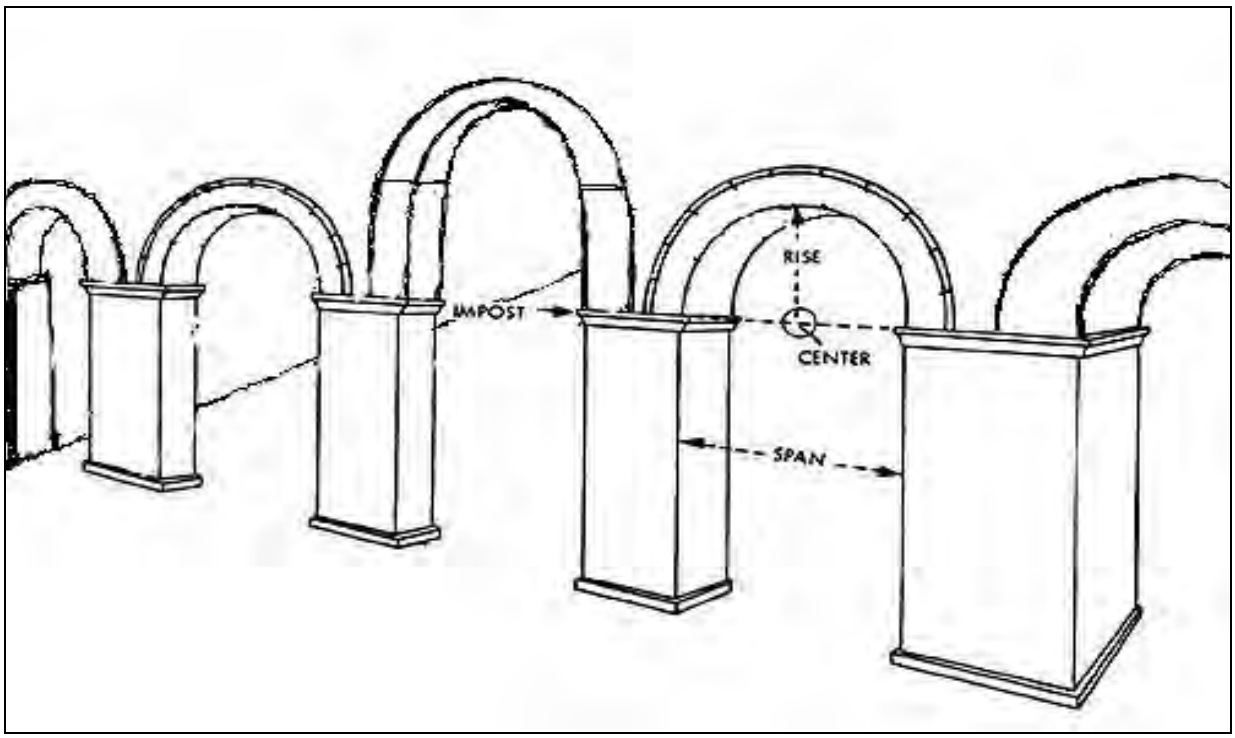


Figure 46: The internal structural elements integration of Bete Medhanealem

A barrel vault, also known as a tunnel vault or a wagon vault, is an architectural element formed by the extrusion of a single curve (or pair of curves, in the case of a pointed barrel vault) along a given distance.

The curves are typically circular in shape, lending a semi-cylindrical appearance to the total design. The barrel vault is the simplest form of a vault: effectively a series of arches placed side by side, i.e., one after another. It is a form of barrel roof. As with all arch-based constructions, there is an outward thrust generated against the walls underneath a barrel vault. There are several mechanisms for absorbing this thrust. One is, of course, to make the walls exceedingly thick and strong, this is a primitive and sometimes unacceptable method. A more elegant method is to build two or more vaults parallel to each other; the forces of their outward thrusts will thus cancel out each other. This method was most often used in construction of churches, where several vaulted naves ran parallel down the length of the building. However, the outer walls of the outermost vault would still have to be quite strong or reinforced by buttressing. The third and most elegant mechanism to resist the lateral thrust was to create an intersection of two barrel vaults at right angles, thus forming a groin vault.

Ancient Romans most probably were the first to use this building method extensively on large-scale projects, and were probably the first to use scaffolding to aid them in construction of vaults spanning over widths greater than anything seen before. However, Roman builders gradually began to prefer the use of groin vault; though more complex to erect, this type of vault did not require heavy, thick walls for support and thus allowed for more spacious buildings with greater openings and much more light inside, such as *thermae*.

After the fall of the Roman Empire, few buildings large enough to require much in the way of vaulting were built for several centuries. In the early Romanesque period, a return to stone barrel vaults was seen for the first great cathedrals; their interiors were fairly dark, due to thick, heavy walls needed to support the vault. In 13th and 14th century, with the advance of the new Gothic style, barrel vaulting became almost died out in constructions of great Gothic cathedrals; groin vaults reinforced by stone ribs were mostly used in the beginning, and later on various types of spectacular, ornate and complex medieval vaults were developed. However, with the coming of the Renaissance and the Baroque style, and revived interest in art and architecture of antiquity, barrel vaulting was re-introduced on a truly grandiose scale, and employed in the construction of many famous buildings and churches [86].

[86] *http://www.stpetersbasilica.org/Interior/Nave/Nave.htm*

Figure 47: the Arch form of the upper vault ceiling longitudinally and a structures showing direction of lateral forces.

With a vault design the vectors of pressure result in a downward force on the crown while the lower portions of the arches realise a lateral force pushing outwards [87]. As an outcome this form of design is subject to failure unless the sides are thick, anchored or buttressed to very heavy building elements or substantial earthwork sidings. For example, at adjacent walls to the vaulted structure of *Bete Ghiorgis* is up to one meter thick, adding the buttressing strength may needed to secure the curved design. The inherent difficulty of adequately lighting vaulted structures has been widely acknowledged [88]. Such openings could compromise the integrity of the entire arch system. In many of the monasteries a natural solution was arcades which could have high vaulted construction with an open courtyard to allow ample lighting.

Since a few years have been applied Newtonian mechanics to calculate numeric stress loads for ancient vaults [89]. These analyses have typically used a finite element algorithm to calculate gravity induced stresses from the self weight of an arched system. In fact analysis of the vault has become a benchmark test "because of the complex membrane and in extensional bending states of stress" involved. In terms of comparison to other vaulting techniques the vaulted arch is inherently a weaker design compared to the more complex groin vault. The barrel vault structure must rest on long walls creating less stable lateral stress, whereas the groin vault design can direct stresses almost purely vertically on the apexes.

At the top of a dome, the curving walls push inward toward the centre. This force holds the dome in a rigid, stable shape. Soon, ancient builders began experimenting with arches. Around 100 A.D., Roman builders rotated an arch in a circle and discovered that it created a strong three-dimensional shape the monolithic dome.

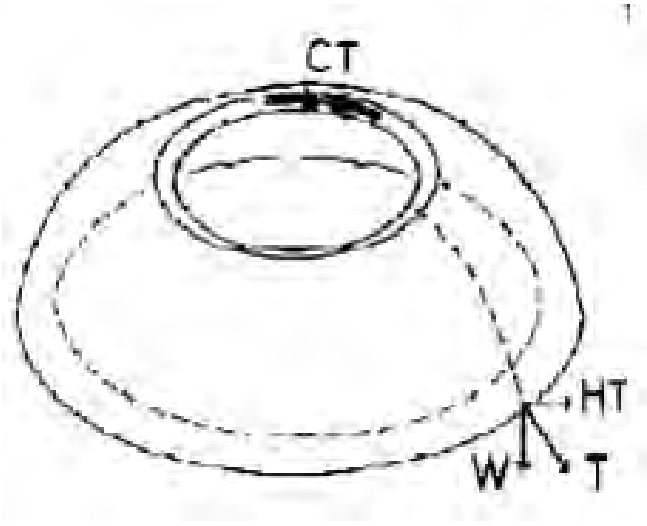
[87] *Mount Holyoke College, 2014. The Art of Cathedrals: Stresses in barrel vaulted design". Mtholyoke.edu.*
[88] *Friedrich R. 2003. Traditional Domestic Architecture of the Arab Region.*
[89] *Gui-Rong Liu, 2003, Mesh Free Methods: Moving Beyond the Finite Element Method, CRC Press.*

In time, they were capping churches and mosques with this new and brilliant design. A dome is composed of a series of rings, resting on each other and it is characterized by a thrust, with pushes on the walls. Two forces are acting in a dome:

- The thrust (T), which pushes down with an angle on the walls
- A concentric thrust (CT), which acts in every ring and compresses it

The thrust (T) is composed of 2 forces:

- A horizontal force (HT), which tends to push the walls apart
- The weight (W), which is the weight of the masonry



a)

b)

Figure 48: a)The Dome: the forces applied on the elements; b) The internal structural arrangements of Bete Ghiorgis

2.7. Construction of Ancient Rock Churches

The first attempt in the field is surveying the property in to draw the bounds and the land surface layout. The property will be presented through various geometrical elements such as points, lines, arcs, circles, and other defined geometry shapes. Surveyors use different tools which use projection of line referenced point on a stick in order to measure the variations of the heights on the ground. This tool uses various angel theorems and postulates to find location of property boundaries, property corners, utilities and building layouts..

After completion of this step the surveying used to develop a working drawing for the building. In these drawing you will see triangles, rectangles, squares, arches and other geometry shapes and forms to create their design. The architects through our history have used these shapes to create famous structures all over the world. If you look around the town, you will see these shapes. The designers use geometry in their design in order to calculate the spacing of their columns and beams for proper strength for the building. The construction phase would not be possible without the knowledge of basic geometry. Points, lines, measurements and angles are often used to lay out the building in accordance to the architect drawings. The constructors use these basic geometry elements to shape the land, construct the buildings and ensure proper drainage from property.

Since earliest times human society has used the materials provided by nature to build structures intended for public and private living as well for sacred places. The structures that characterised villages and cities were modelled on the forms of nature itself [90]. They could be overstated and indeed made magnificent through the skills men acquired in working in wood and stone. Wherever noble materials were not available, human ingenuity was capable of adapting the same models to make similar structures out of different construction materials. This process underwent a significant motion when the natural forms were rationalised in the discipline of geometry. Architecture became the art of organizing man-made spaces. Human civilization has progressed as people have learnt to inhabit and construct, and the evidence of this progress represents essential documentation for our knowledge of history. The historical building heritage, in its dual valence as monument and document, presents stratification over the millennia, offering itself to us today as a comprehensive archive of the material history of humanity [91].

Ancient builders were solidly rooted in their territory, and this gave them a profound knowledge of the environment in which they operated. The monuments which have withstood the test of time are the most telling proof of their creators' ability to cope with the various local hazards. Material expertise, linked to a familiarity with natural forms resulting in sampling construction prototype, has been handed down over the centuries in what we can identify as the rules of the art [92].

[90] *Dragados, 2003. Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003, ed. S. Huerta, Madrid: I. Juan de Herrera, SEdHC, ETSAM, A. E. Benvenuto, COAM, F.*
[91] *Bellomo and D' Agostino 2001.*
[92] *Conforto and D'Agostino 2001.*

Thus we see that an example of ancient building is a self-sufficient product conceived according to a global spatial approach in which the structural function is only one of the functions involved. Very soon buildings were made out of concrete, mortar and steel, and at that point they were conceived as monuments of civilization of infinite durability.

When building in rock, the material is at once load and load-bearing, so that the architectonic and structural approaches form part of a single vision. This overlapping of the geometrical and structural functions permits a favourable distribution of tensions, which in any case are in general not particularly great. The physical and mechanical properties of rock have always been part of the culture of construction, and the construction prototypes never failed to consider the different nature of materials. The marked capacity of rock for resistance to compression led to construction forms conceived for a naturally stabilising gravity, while awareness of a much lower resistance to footing emerges clearly in all the ancients' practical philosophy of building, witness the inter columns, domes, large staircases and overarching structures [93].

The ancient construction was conceived as a single unit based on an expert synthesis of geometric forms and made of natural indigenous materials. The whole course of ancient architecture is characterised by buildings made out of an infinite variety of materials and geometric forms, and is as remarkable as it is many aspect. The materials and geometric forms were manipulated by means of a range of building techniques which made an essential contribution to the final effect of each architectonic creation. For millennia ancient buildings may conceived and erected with less recourse to a mechanical-analytic vision of nature, but thanks to an ongoing reflection on phenomena leading to a comprehension of those laws of nature which were to be interpreted and stated in rational and analytic terms much later by the new science. This process covered all human activities related to nature. This mysterious entity, as revered as it was left unexplored, has only recently been studied objectively and systematically, achieving extraordinary results in a very short space of time. Thus for millennia the history of humankind was engaged in ongoing reflection and speculation on experience leading to the definition of rules of thumb which accompanied the progress of the various civilizations. These rules represent a constant recourse to application of skills, and in fact they still inform our everyday activities, even when we are using the most sophisticated products of technological innovation.

For thousands of year architectures relied on rules of the art known to the architect who conceived the design and which were also familiar in a material. The results of this respected culture are before the eyes of us all, but to trace an ideal trajectory we can cite the erection of *Axum* stele, the *Fascilide's* castle in *Gonder*, or again the *Jegole* wall in *Harar*. These creations, spanning a thousand years, are evidence of a building process whose underlying conception is in practice of mystery. Knowledge of the building process adopted in antiquity is one of the key issues in current scientific research into the science of construction. There is no doubt that the rules of the art were based on a spatial conception of the construction elements and not on the prevalently mono dimensional outlook that characterises the new science.

[93] *D' Agostino 1997.*

The fundamental construction element in modern architecture is the solid mono dimensional beam or pile (upright or transverse), columns, arches, domes, slabs and walls. These elements could be flanked and built over to form the facade of a building, or arranged or superimposed as porch to provide a massive supporting structure. By studying this element we can identify the fundamental rule of art underlying its construction, and discover to what extent its rational conception embodied what we would call high safety coefficients, across the range of different applications. Thus the attempt to identify the rules of the building art seems to be the key to reaching a full understanding of the historical approach to construction.

2.7.1. Tuff Rock of *Lalibela* Churches: Properties

Tuff (from the Italian tufo) is a type of rock consisting of consolidated volcanic ash ejected from vents during a volcanic eruption. Tuff is sometimes called tufa, particularly when used as construction material, although tufa also refers to a quite different rock. Rock that contains greater than 50% tuff is considered tuffaceous.

Rhyolitic Tuff: for petro-graphical purposes, tuff is generally classified according to the nature of the volcanic rock of which it consists; this may be the same as the accompanying lavas if any were emitted during an eruption, and if there is a change in the kind of lava which is poured out, the tuffs also indicate this equally clearly. Rhyolite tuffs contain pumiceous, glassy fragments and small scoriae with quartz, alkali feldspar, biotite, etc. The broken pumice is clear and isotropic, and very small particles commonly have crescentic, sickle-shaped, or biconcave outlines, showing that they are produced by the shattering of a vesicular glass, sometimes described as ash-structure.

Trachyte Tuff: contain little or no quartz but much sanidine or anorthoclase and sometimes oligoclase feldspar, with occasional biotite, augite and hornblende. In weathering they often change to soft red or yellow clay-stones, rich in kaolin with secondary quartz.

Basaltic Tuff: is also of wide spread occurrence both in districts where volcanoes are now active and in lands where eruptions have long since ended. They are black, dark green or red in colour; vary greatly in coarseness, some being full of round spongy bombs a foot or more in diameter, and, being often submarine, may contain shale, sandstone, grit and other sedimentary material, and are occasionally fossiliferous. When weathered they are filled with calcite, chlorite, and serpentine, especially where the lavas contain nepheline or leucite, are often rich in zeolites, such as analcite, prehnite, natrolite, scolecite, chabazite, heulandite, etc.

2.7.2. Site Investigations of *Lalibela* Rock-cut Churches

It is obvious that to construct such huge and unique rock hewn churches needs special investigation on the site and the material requirements for the intended goal. *Lalibela*, before carving his churches, gathered all the necessary materials for 10 years [94]. Living inside shelters, he was carving his churches for 23 years. He bought a land from *Qeyet* and started constructing his churches in 1116 E.C (1122G.C). Traditionally, the site of these churches was selected by his praying after being directed by God. The churches are testimonies of that civilization where engineering is deep rooted in the womb of hard rock. Thus, *Lalibela* testifies the absolute knowledge of the properties of the rock materials which could sustain for a long period of time, constructible and carrying with sufficient strength of the loads.

2.7.3. Excavations and Sequencing of the Construction Works

The rock-cut churches of Ethiopia have long fascinated visitors and historians and have unsatisfied archaeologists seeking their sequence of construction. The questions raised with in the researcher are like; do they belong to supernatural plan, which may be difficult to investigate through adapted scientifical ways, or a long-lived ritual centre continually refashioned over time? Since the churches are cut into live rock, the conventional signals of archaeological phasing are hard to find. The archaeologists R.Mensan and C.M´enard addresses these problems at the famous site of *Lalibela*, showing that, embedded in the cuts and openings, the spoil heaps, and even in the now mislaid sediments, the stratigraphic sequence is there to be read. But, as the researcher opinion, obviously to know the strata of the rocks it is possible to study either from the existing courtyard walls or from the churches. Whereas, to know the construction sequence merely from the strata of the soil heaps may mislead, unless the way of the construction methods, the way they cart away the excavated materials and the mass of labour crews are formulated.

Interest has intensified in the last decade or so, mainly devoted to the iconography on the walls of the churches [95] the typology of the monuments‟ architecture [96] and its liturgical functions [97] and archaeological investigations. But comprehensive engineering investigation of *Lalibela* has not been yet well studied; and in addition the unwillingness of the clergy to allow scholars to generate a mass of knowledge independent from the religious narrative, the bureaucracy for sharing documents, movable heritages for photograph, and the general influence that the nature of the site is difficult to recover any information. Hence it seemed that the exploration of *Lalibela* had come to an impasse.

The work studied here, was aimed at providing the ways of construction, structural formations and understanding the rock materials of the churches, independent of the art historical evidences and archaeological methods.

[94] *Tibebu A.2007. p111 et al Ibid*
[95] *Lepage, 1999. Ibid*
[96] *Gervers 2003a. Ibid*
[97] *Gervers 2000. Ibid*

Since the creation of one church-builder was removed by the chisel of the next [98] the stratigraphy is hard to read, but it is nonetheless present in the order of cutting, in the dumping of the rock pieces and in subsequent sedimentation [99]. However, it may not get the target of knowing the way of its construction by observing from its dumping of rock pieces and subsequent sedimentation, unless its way of excavation and chiselling defined well. And, the study did not require entry to the churches and geological formation of the area but focused on structural formations of the elements , easiest way of cart away the excavated materials from the area and the construction methodology adopted in order to get the targeted output.

2.7.3.1. The Construction Sequence

To get such structures, it is needs well visualization and conceptualized ideas and works. Thus, in order to print out these highly visualized buildings it needs a well formulated and calculated excavation methodology. From the perspective of the technological advancement during that period, it might not expected to use advanced machine"s, which are currently usable hand tools, rather it is a simple locally moulded hammer tools, as the researcher mentioned in chapter one, in which the local people admiring how *Lalibela* constructed the churches without sophisticated tools. The hand tool, which the *Lalibela* had been used for chiselling also found at the *Lalibela* Museum. Archaeologists R.Mensan and C.M´enard suggested on its sequences by the method of „superimpositions" widely used in rock art studies, and they encounter examples. Such as,

- In the Northern Group, doorways overlooked a void, indicating that a pathway outside the door had been outdated and dug away.
- In the north wall of *Medhanealem*, an opening high up and asymmetric to the wall gives access to earlier chambers.
- The north-west facade at *Bete Gabriel we Rufael* shows a hanging staircase leading to a now removed courtyard, another replacement courtyard served by new openings, and a now 9m deep courtyard cutting away most of the previous features, with a cistern dug in its base.

However, the mentioned signals may have their own impact on deduction for the construction sequence. The major agenda is to deduct on this huge engineering manifested work needs understanding of the intended out puts based on their structural formations and ways of excavations.

As shown below, based on satellite imagery and site visited photographs, indicated that the dumps of debris resulting from the making of the monuments are found almost everywhere on the site, mainly at each of the four sides of every church. The disposal of the rock fragments must have posed a serious problem for the constructors and block access roads for dumping the fragments. To the immediate north of the eastern group, where the researcher detected a huge dump clearly overlapping ancient ground levels and portions of a large-block masonry wall found in situ, may be used as a retaining wall.

[98] *Gervers 2003a. Ibid*
[99] *Francois-Xavier Fauvelle-Aymar 2010. P1138*

And, as archaeologists" consideration, "may these refuse dumps contain a complete stratification of the site from its beginnings, thus mirroring the phasing of its successive transformations, with broken tools, ceramic shreds and other artefacts preserved in the heaps of stratified stone chippings". It seems giving less value on its construction period which had been mentioned in much historical documentation, which are 23 years and its arts and medieval architecture in Ethiopia.

Figure 49: Lalibela: map of the site, showing the location of the churches (numbered) and the areas of spoil (in colour) resulting from the cutting of the monuments (satellite photograph: Google Earth. Geomorphological observations and mapping: L. Bruxelles/INRAP/CFEE).

Lalibela was always flat to the generation of sediments, which would collect naturally in the open-air cuttings and courtyards. Furthermore, cutting ever-deeper monolithic walls naturally increased the process of weathering, sometimes weakening them to the point of collapse. There are several cases on the site where one can observe remnants of now-disappeared rock-cut buildings. This is the case in the courtyard of present day *Libanos*, which was cleared of its heaps of sediment after about 1970 (compare the picture in Phillipson 2009: p143) revealing a number of features belonging to former buildings.

The widening of the open-air courtyards for the purpose of cutting out new monuments created virtual water tanks liable to collect all the water of the massif. This situation would sometimes lead to unexpected and possibly catastrophic events. This can be seen in the front courtyard of *Gabriel-Rufael* where the original ground level was lowered by 9m, and an outflow was bored through the monolithic wall bordering the courtyard. It is likely that the constructions at *Lalibela* continually modified the geo-morphological and hydrological systems, which could both accelerate the process of sedimentation and aggravate its removal. One can suggest that these two processes did not always function at the same time. The clearance and redeposition of sediment implies a strong centralised power, able to maintain the monuments against the elements, while the accumulation of sediment suggests times when such power was on the decline.

The rocky massif in which the *Lalibela* complex is set consists of basaltic scoriae embedded between two dark flows of basaltic lava, part of the *Aiba* formation [100]. This substratum in which the churches were hewn cannot be described as volcanic tuff [101]. The church-builders aimed for the scoriae, which they could cut, but avoided or left un-hewn the much harder basalt at the bases of the churches, such as at the base of *Bete Medhanealem* and *Bete Ghoirgis* to the Southwest direction. It is remarkable that all the constructions at *Lalibela* were dug in the same deposit of basaltic scoriae, to the exclusion of basalt proper. This testifies to an intentional choice probably informed by a good empirical knowledge of the properties of the bedrock. This empirical knowledge seems to have been active over a long period of occupation around *Lasta* and with in the Northern part of the country mainly.

But, according to *Francois-Xavier Fauvelle-Aymar (2010)* the construction or the excavation activity do not performed for certain period of construction, which mainly mentioned for 23 years of construction period, rather it is transformed from the cave dwellings to a monumental churches; "we are able to trace an early phase of settlement, which may have begun long before the site was transformed into a Christian religious complex". They called this phase „Troglodytic". It is characterised by small entrances to narrow tunnels running a few metres under, and generally parallel to, the surface of the rock, leading to little dome-shaped chambers as shown below in the figure. Small flights of stairs also belong to this phase. Though most of these features have been erased by subsequent transformations of the site, some openings can still be observed hanging above the modern level of circulation.

In a second phase which they called „Hypogean", the inhabitants of the site continued to occupy, or reoccupied, the galleries of the previous phase but transformed some of them into a network of cubic chambers, heightening ceilings, and ornamenting entrances with *Aksumite*-like pillars and doorways. At the time, these doorways (today hanging over the void) connected with open-air courtyards, newly-excavated passages deeper in the massif, and with peripheral corridors or trenches that were attached to the interior spaces. They mentioned the associated monuments with this phase, such as *Bete Masqal* and *Bete Denagil*, respectively north and south of *Bete Maryam*, and parts of others, such as the central chamber of *Bete* Gabriel we Rafael. The east part of the courtyard of *Bete Maryam*, where an ancient circulation level can still be observed, also belongs to this phase. It may be useful to some readers to add that the designation „Hypogean" is used here in a completely different sense than Phillipson (2009), who uses it to designate all non-built architectural feature whatever its morphology and function.

[100] *Asfawossen Asrat et al. 2008a & b*
[101] *Phillipson 2009: p124*

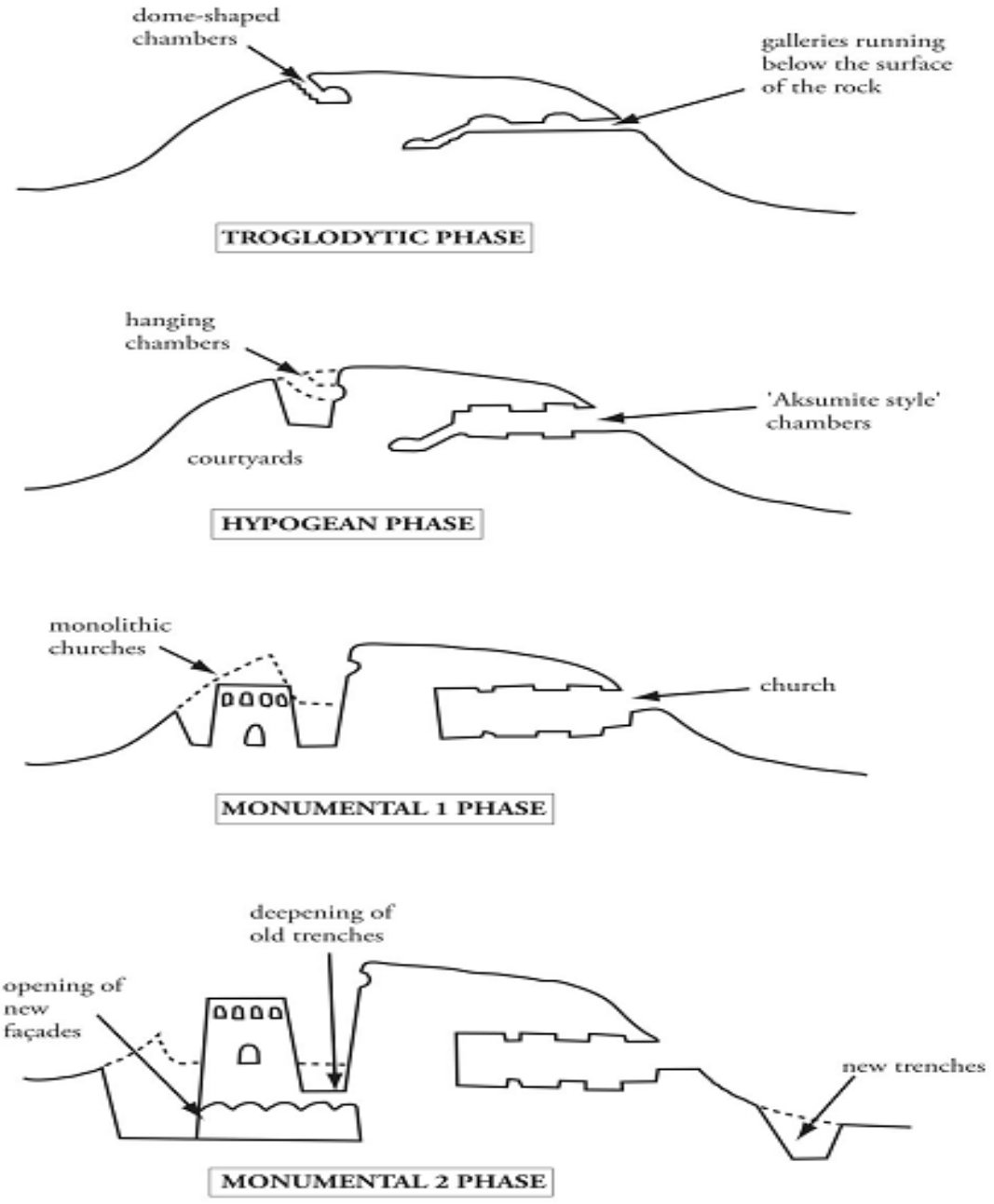


Figure 50: Construction Sequencing of the Churches (Source: Francois-Xavier Fauvelle-Aymar, 2010)

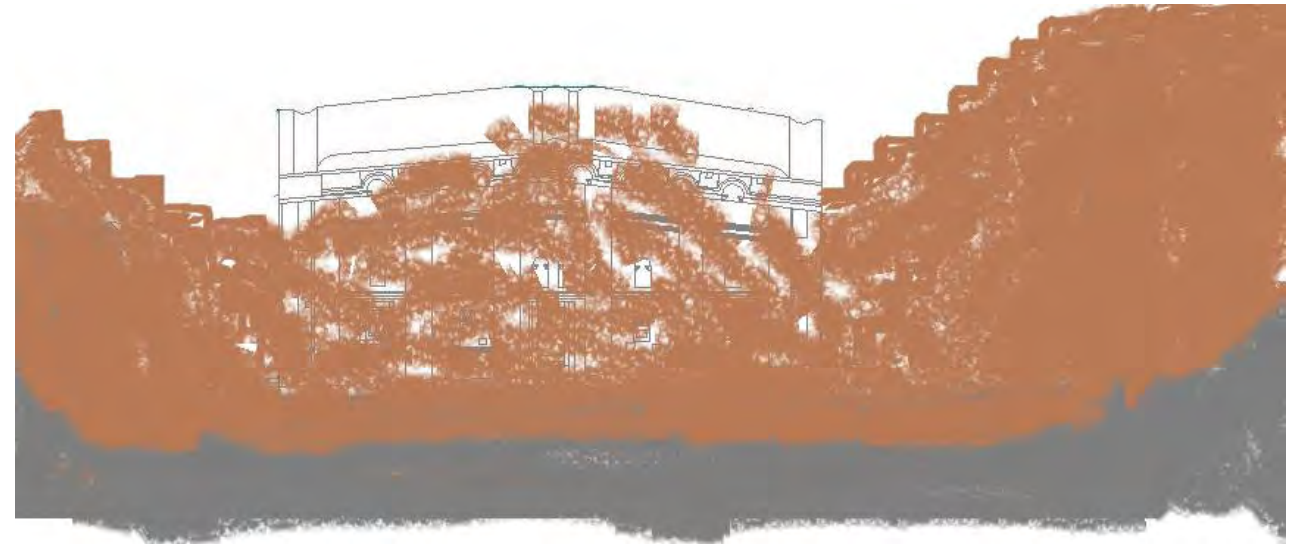
The next phase in the sequence called it „Monumental 1". It includes the first properly monolithic monuments excavated into the heart of the massif, which were cut out and cored so as to take a form nearer to that of conventional buildings. This sometimes entailed widening and deepening previously-existing open-air courtyards, as in the case of *Bete Maryam*. In the course of these transformations, some pre-existing Hypogean monuments were preserved as projecting remnants because the extension of the excavation would otherwise have broken into subterranean spaces. Other structures had a facade cut and designed on the exterior while being internally transformed into churches. The churches of *Bete Maryam* and *Bete Medhanealem* clearly belong to this Monumental 1 phase, as is also the case with a now-disappeared monumental access (above the „Tomb of Adam") to this set of churches. Possibly, though they are not certain, that most of the monuments of the Eastern Group, belongs them to this phase.

They called the last phase, probably the existing features, as the „Monumental 2" phase. It is mainly characterised by a considerable lowering of the outside levels. The aim was apparently to create facades, accesses and windows to newly excavated churches below the ground level of the previous ones. As a result, the monumental access to *Bete Maryam* found itself truncated and unusable as such. During this phase, not only were new churches probably created *(Bete Golgota-Selassie),* but also other monuments were transformed into churches (e.g. *Bete Marqorewos,* in which it considered as it was non-religious monuments), the whole site becoming a Christian religious complex that lost some of its civilian or defensive features. For this reason, it seems that the Monumental 2 phase is marked by an ideological split from the previous phase.

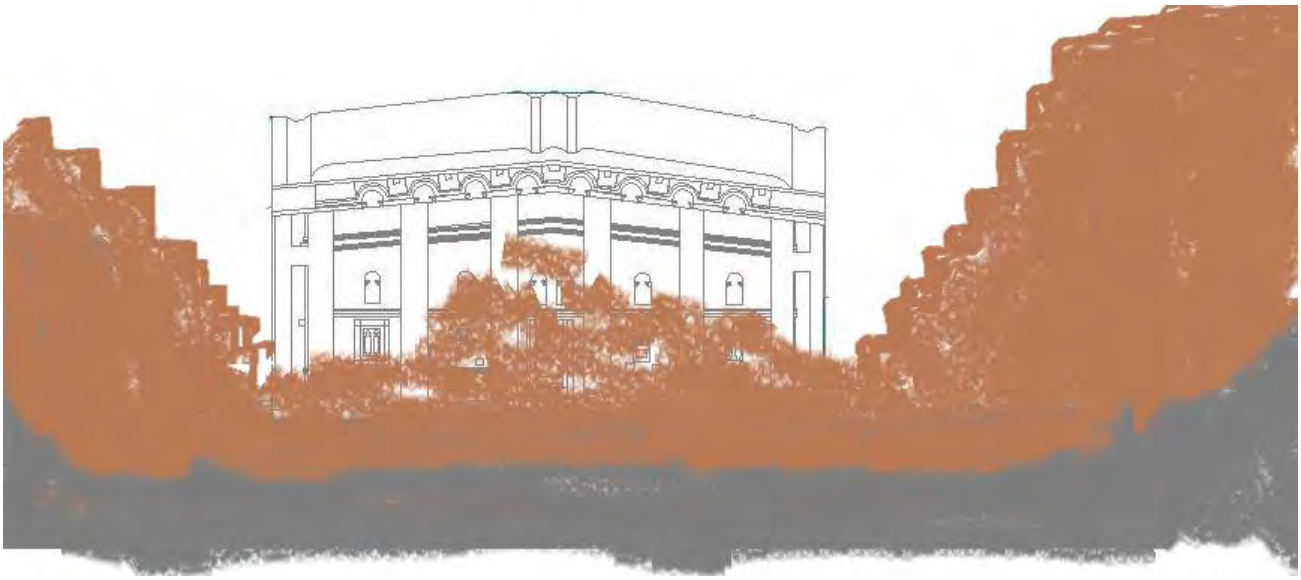
In addition they are declaring the status (phases) during 16th century based on the description of the site given by Alvares at the beginning of the 16th century indicates that the site may have been in its Monumental 2 phase at that time, though that Alvares admiring beyond the realm world experience occurrence, which is difficult to witnessing for those who didn"t see the churches physically. From this point on is what they call it the „Filling-in" phase. This was a time when there was no longer any centralised (religious or political) power able or willing to maintain the site as a ceremonial centre. It is not known what exactly took place in *Lalibela* between the 16th and the mid 12th century"s, and we cannot rule out the possibility that the site went through one or several periods during which it exerted some sort of strong spiritual attraction, thus reinforcing the sacredness of its churches, though the sacredness of a buildings do not detailed in architectural manner simply given the sacredness by the name of churches. But whatever the case they describes it doesn"t loss the wisdom expend on this ancient Ethiopian engineering magnificent; obviously, the site may underwent several centuries of change without basic changes in its sacred architecture: sediment accumulated and filled up the trenches, some monuments collapsed and their debris was not cleared, and new settlements were established on the top of the debris dumps and filled-up trenches. This was the situation encountered by Sandro Angelini in the 1960s [102] when he started to clear the trenches and the courtyards. The sequence deduced from stratigraphic observation aligns best with the models of Phillipson or Gervers in that it points to several phases of occupation and transformation of the site. However, their sequencing suggests a much longer chronological development culminating in two important monumental phases.

Though, most previous researchers and visitors attempting on issues to the historical aspects, heritage values and trying to understand by which *Lalibela* have followed a different styles, types of churches, or decoration styles, paintings and religious beliefs. Such an approach has contributed significantly to the fields. But it must also be admitted that this approach can be partly circular in the sense that each specialist may unconsciously produce as many characteristic types as required to reflect his/her own field of competences and to fit the expected historical sequence he/she has in mind.

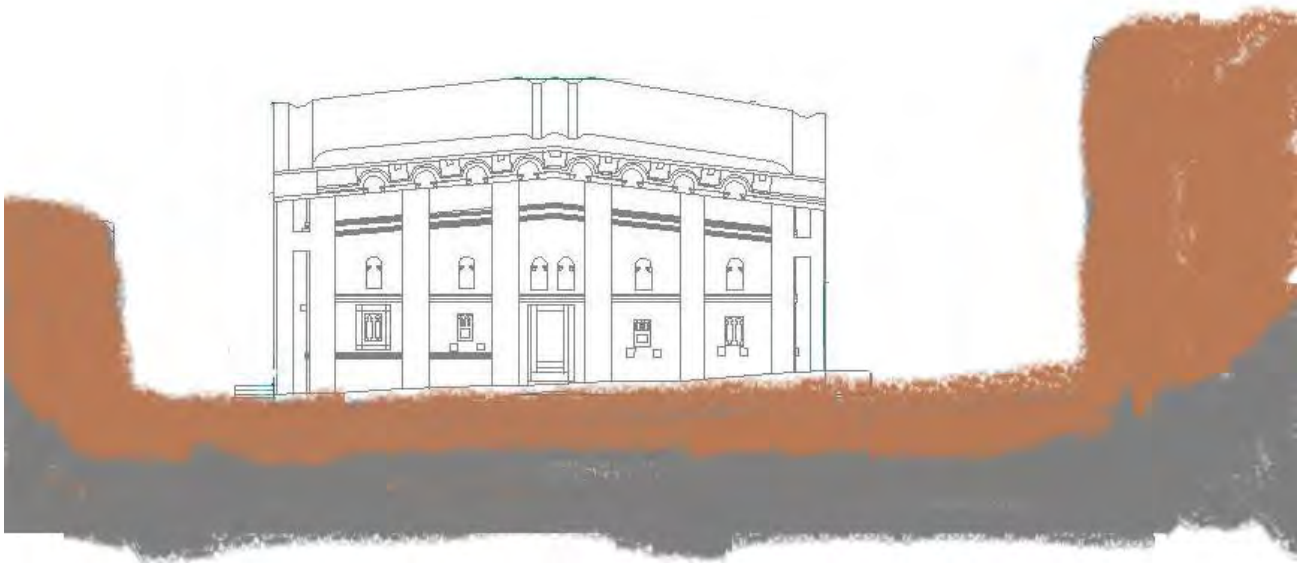
[102] *Angelini 1967*



a)



b)



c)

Figure 51 : The Construction Sequence of the monolothic Churches (Source: Angeline,Lalibela Phase-I, Coservation Action plan. IMF Inc)

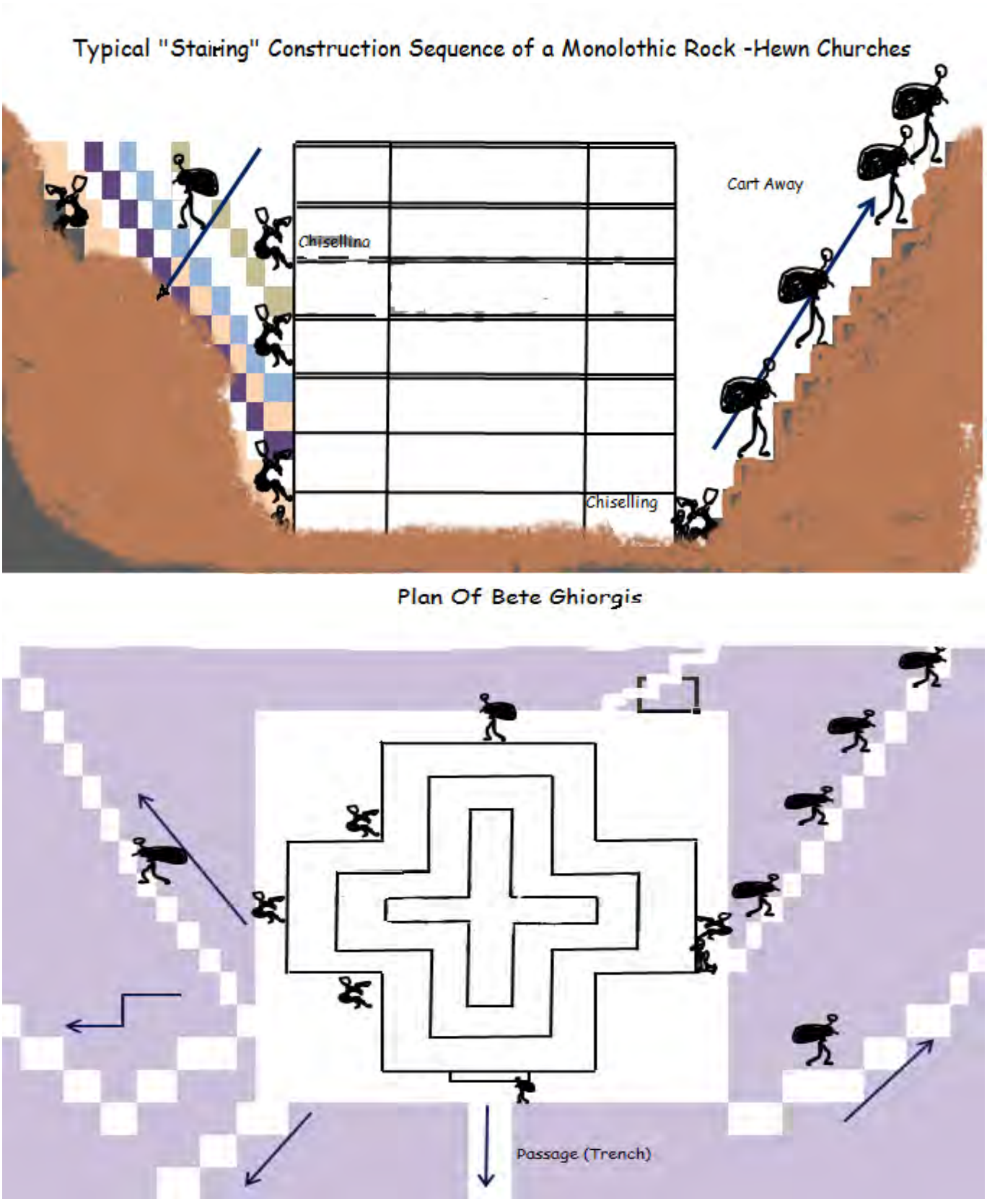


Figure 52: The excavation sequences by elevation and floor view

The researcher has shown here that there is considerable potential for architectural and geometrical analysis of the churches for its considerable ways of excavation methodology. This is based on the possible ways of removing the excavated materials and chiselling the churches structure without any rework, which is difficult to do again, the distribution and layering of soil heaps and the study of sedimentation, including sediments now removed.

One key aspect of the *Lalibela* churches construction is that the interiors were carved with just as much detail as the exteriors. The skill and tolerance needed to accomplish this must be in due consideration. Such rock-cut buildings are, for logical reasons, carved from the top down for the external as it elaborates above in the figure 53 and 54. But, this may not applied to the interior, rather reversely from bottom to up by formation of stair, which requires a great deal of coordination among the masons/chisellers, by achieving the vaults and then work their way downward to the floor, with a complete plan already sketched out in their mind.

CHAPTER THREE: MONOLITHIC ROCK-HEWN CHURCHES OF *LALIBELA*

3.1. Site Layout of the Churches

When the researcher question about the layout and geometrical alignment of the churches, similar attempt had been made by *Tibebu Assefa* as "why *Lalibela* put his building in such three groups, as he does not have scarcity of similar type of rock in either of the groups?. And, the constructors may not do anything without reason". It is obvious; to think that the work may have been done with a simple and random selection of the sites seems not to give the values of the constructors" wisdom on the career. The terrain of *Lalibela* is slopping and the churches are situated at a distance to each other making three groups. When one conceives to construct as such, unlike slicing the space from the air and constructing up, it is a must to limit the range of space needed for hollowing out the pre conceived form [103].

As researcher"s consideration, following locally sayings on the construction progress of the churches may it give a clue what considerations and principles the constructors followed; it is that *Lalibela* start the construction from *Bete Mariam, Bete Medhanealem, Bete Debre Senai* and *Golghota, Bete Meskel, Bete Denagel, Bete Hawareyat, Bete Gebriel we Rufael, Bete Merqorious, Bete Abba Libanos, Bete Amanuel and Bete Ghiorgis* respectively. Observing the churches from the top of mount *Taboor*, where locally said God shows to *Lalibela* how he should construct the churches, a certain geometrical alignments and layout is visualized.

For a moment the researcher sat himself at mount *Taboor*, which is at the centre of the circle shows in figure 13, and goes with the sprit and situations of *Lalibela's* perspective and considers the distance from mount *Taboor* to these groups of churches and their overall site configuration. Immediately drawing a circle centring at mount *Taboor* and founds an intersection area which imbedded all the churches, which is golden mean ratio proportioned rectangular area with inscriptions of visca piscus as shown in figure 13. And, also in consideration the path of the trenches a certain Fibonacci sequential curvatures are observable, though it needs detail topographical surveying of the area to put on the ground. In addition as you observe from figure 13, the group of churches are configured in an extraordinary manner, by connecting *Bete Mariam* from the Northern group, *Bete Amanuel* from South-Eastern group, *Bete Ghiorgis* the third group and a point at the mount *Taboor*, which is an important mark identifying exactly the location of the point for further research.

[103] *Tibebu A. 2007, Ibid*

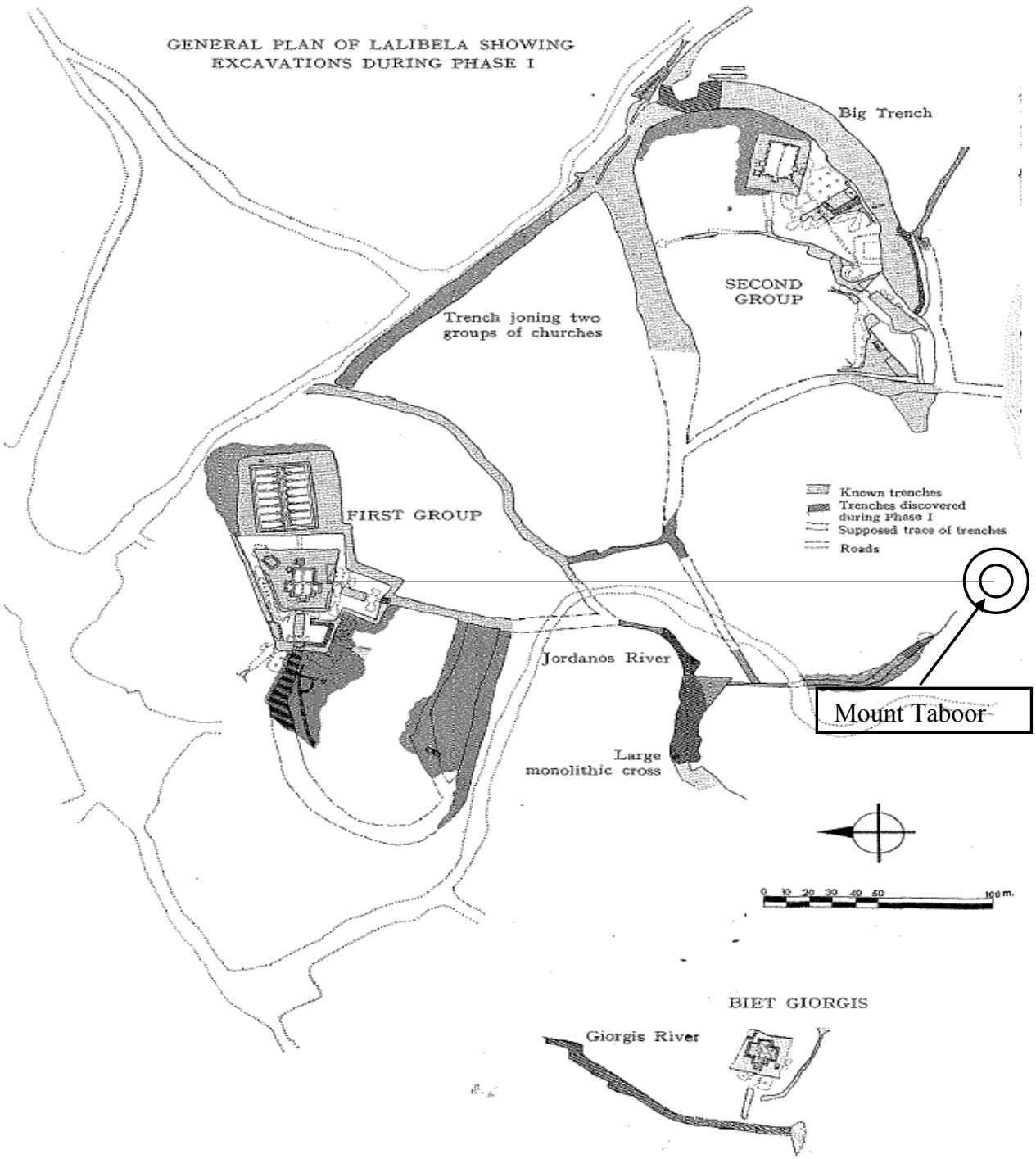


Figure 53: The Site Layout of the Area (Source: Lalibela Phase - I, Conservation Action Plan, IMF Inc)

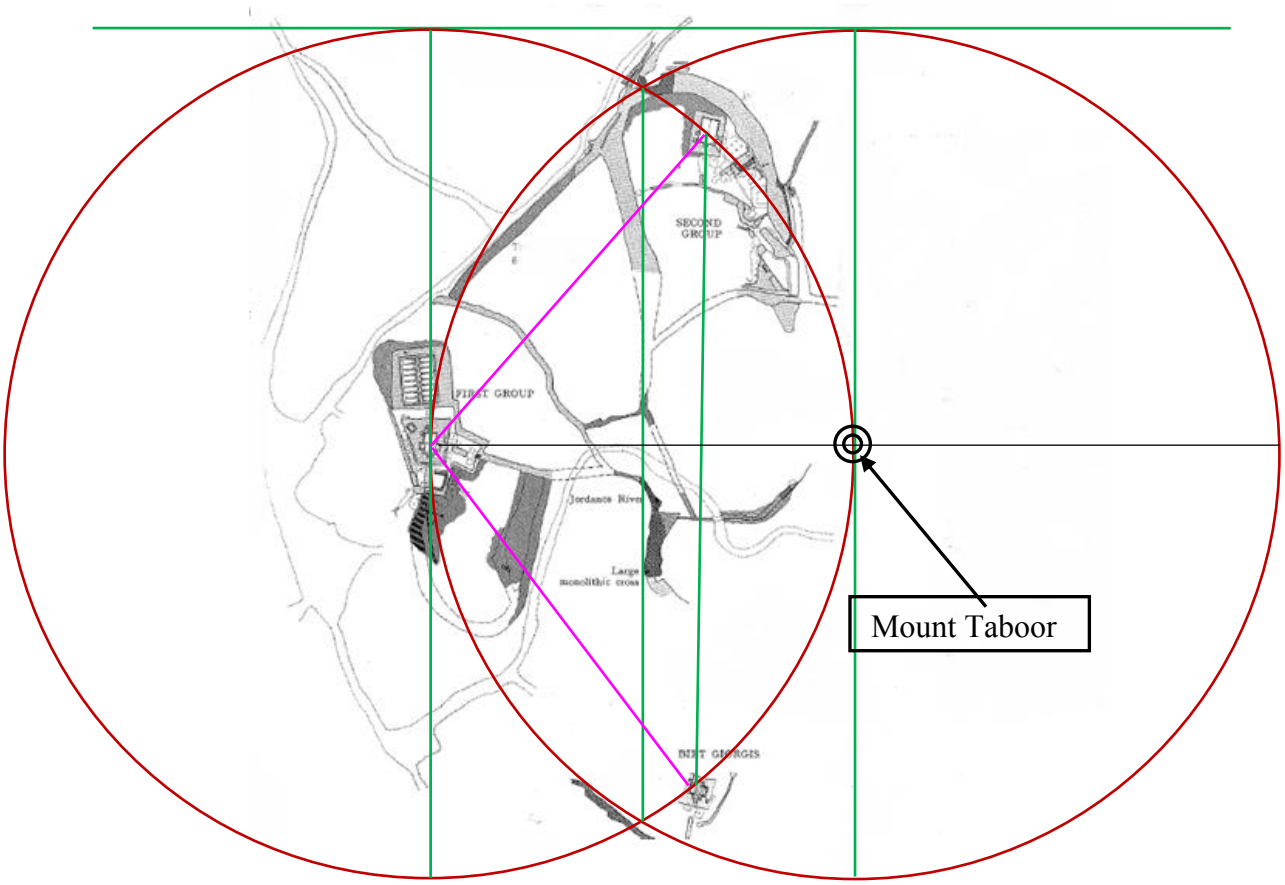


Figure 54: The Site Layout of the Lalibela Churches, inscribed by the intersection of two identical circles : Normally said the Visca Picis, the beginning of nature creation; (Source: Lalibela Phase - I, Conservation Action Plan, IMF Inc)

After the researcher had search out all these using second hand data; and had thinking, the whole buildings might have a tendency to be connected internally through open channels and tunnels. While the researcher was observing at court yard of *Bete Mariam*, at its entrance gate to *Bete Hawareyat* which is on the top of where tomb of *Lalibela* is found, observed the "Seed of life" sealed on porch columns and also it is sealed on gates of *Bete Mariam* and *Bete Amanuael* doors. Of course, the founding of this seal shows the application of sacred geometry through the construction of the churches thoroughly and a certain scientifically justifiable principles are adapted.

3.2. *Bete Mariam* (House of Merry)

The floor plan and E-W front elevation of *Bete Mariam* is in the form of crossed shaped and symmetrically constructed church. The built area has a quadrilateral courtyard inscribed again by a truncated triangular shaped mass of stone forming a trench with rectangular punch outs. The church covers an area of 165m^2. To carve such block a rectangular mass of stone including the porches and a certain geometrical configuration and final targeted building should be visualized. So inscribing everything of the church in a circle, it is evident to get the centre of the building at the collinear with „Amdeberhan". Dividing this into five equal parts in all its sides, we can get the alignments of parts of the building and from this mass of stone it is possible to carve out the elements.

The church has 15.30m length, 14.90m width and 9.89m high and its elevation is determined from the top. So it is possible to get the first hint of its pre-visualized design. Taking the corners of the church as the radius of the circle, possible to get a circle inscribed the whole area.

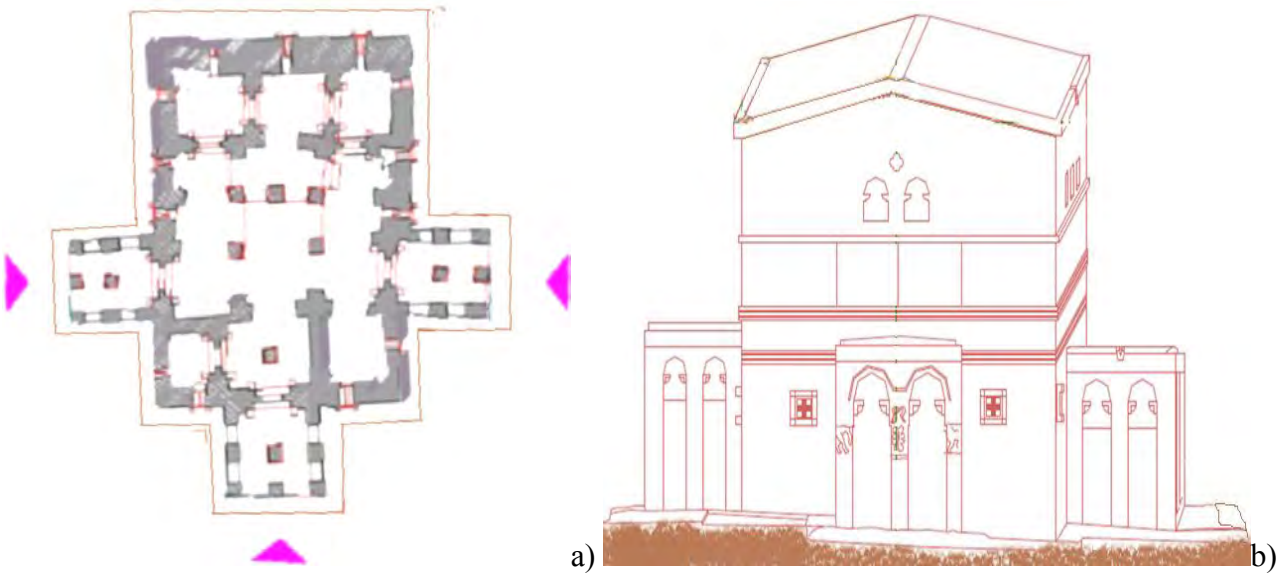


Figure 55: a) The Floor Plan of Bete Mariam b) The Front (East-West) Elevation Plan of Bete Mariam

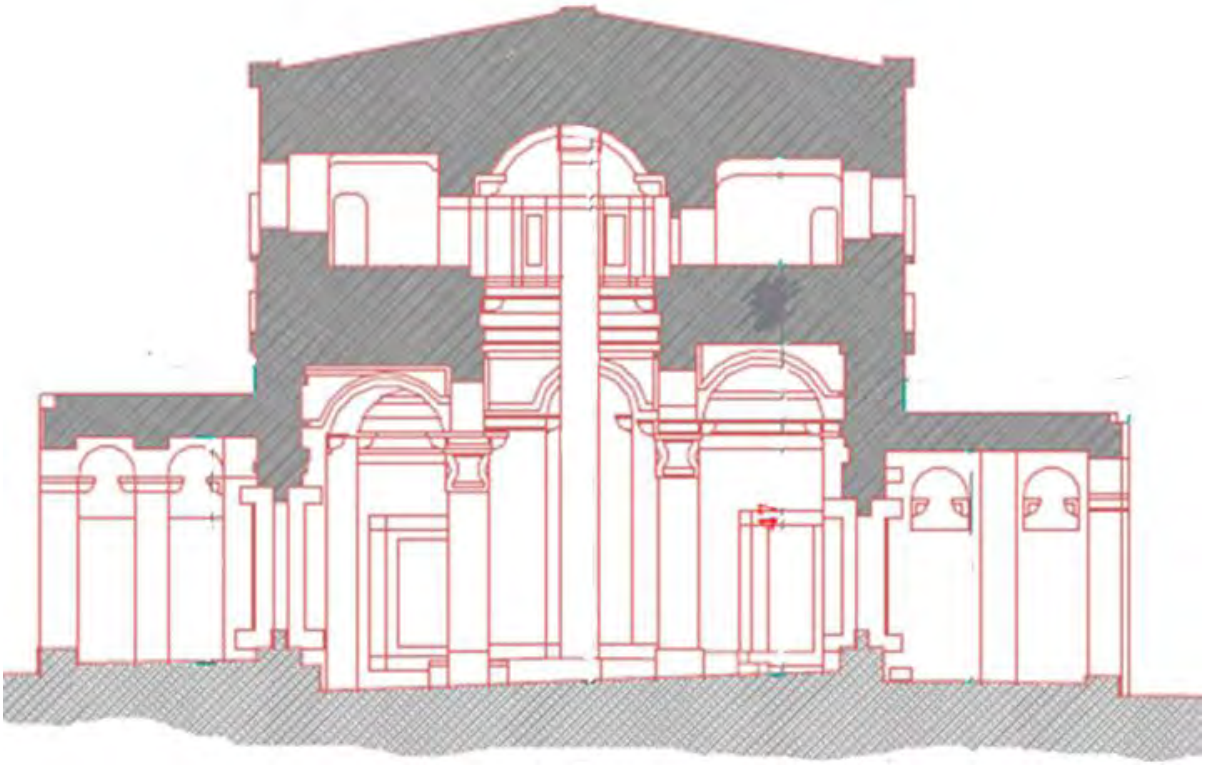


Figure 56: The Section Elevation Plan of Bete Mariam

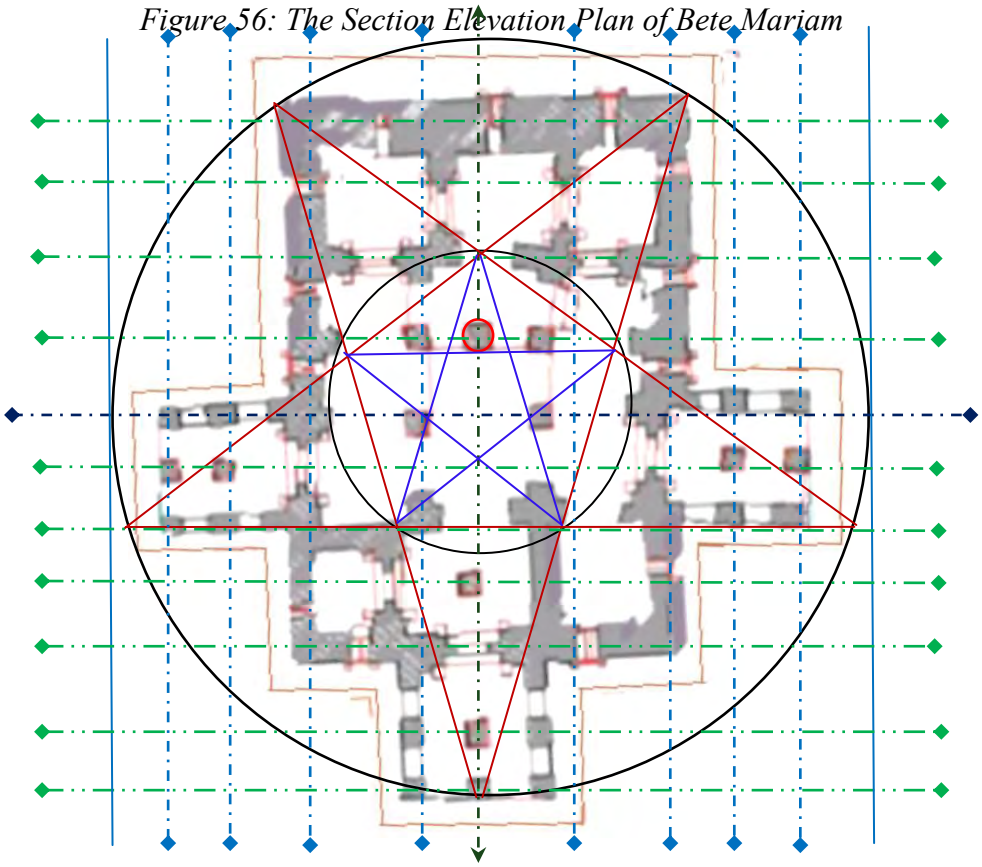


Figure 57: The Floor Plan of Bete Mariam and under the geometrical configuration of golden proportioned pentagram, which is the top plan of icosahhedron.

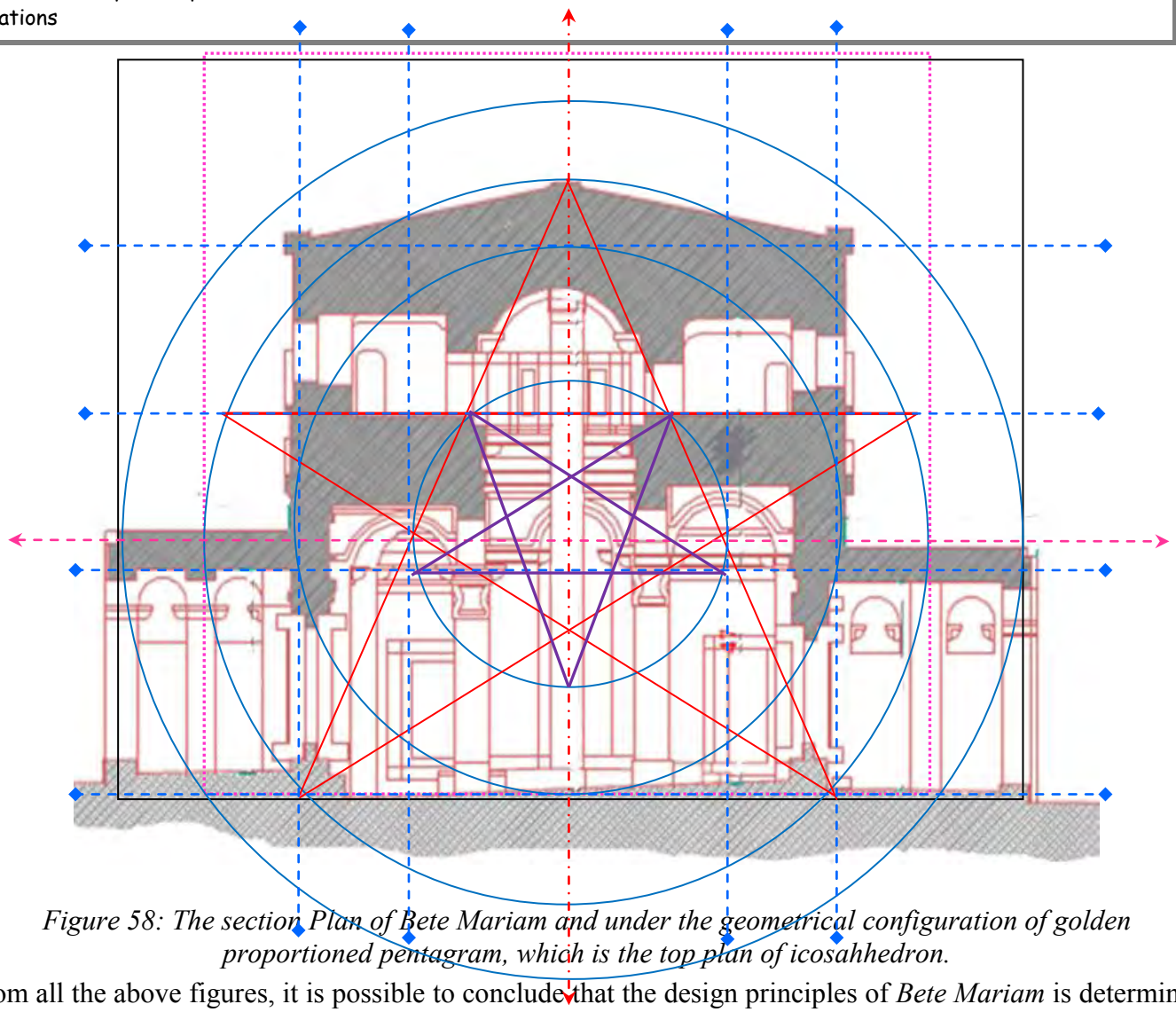
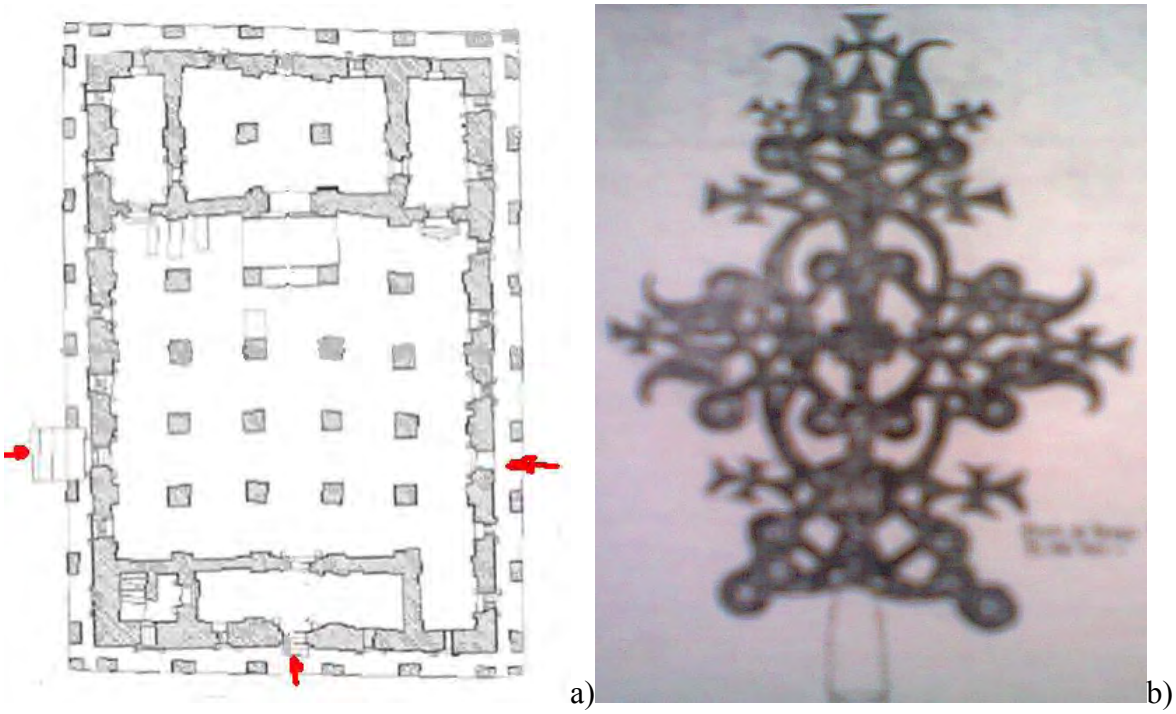


Figure 58: The section Plan of Bete Mariam and under the geometrical configuration of golden proportioned pentagram, which is the top plan of icosahhedron.

From all the above figures, it is possible to conclude that the design principles of *Bete Mariam* is determined by understanding the golden proportion of the pentagram, which is the top plan of the icosahedrons.

3.3. *Bete Medhanealem* (House of World Saviour)

Bete Medehanealem has a length of 34.35m; width 24.05m and a height of 12.20m with built up area of 826m². As any design the first thing to be decided from the functional point of view is its width and length. A length and width are the first dimensions that come in the minds of the builders of this church. Mathematically, the square root of the width is the length ($24.05^2 + 24.05^2 = 34.35^{2)}$, in which similarly in the alignment of the columns. This is the Fibonacci series, which limits to the golden rectangle.



a) b)

Figure 59: a) The Floor Plan of Bete Medhanealem b) The cross which had been suggested hold the design of Bete Medhanealem

Plan of *Bete Medehanealem* describes that the longer dimension in the patterns of equilateral triangles for the formation of dodecahedron. Here the half and quarter circles are used to identify the geometrical configuration of the front elevation of the plan so as to inscribe the plan using its two opposite corners. The plan has a pattern of equilateral triangles, which is recurrent in all the other plans too.

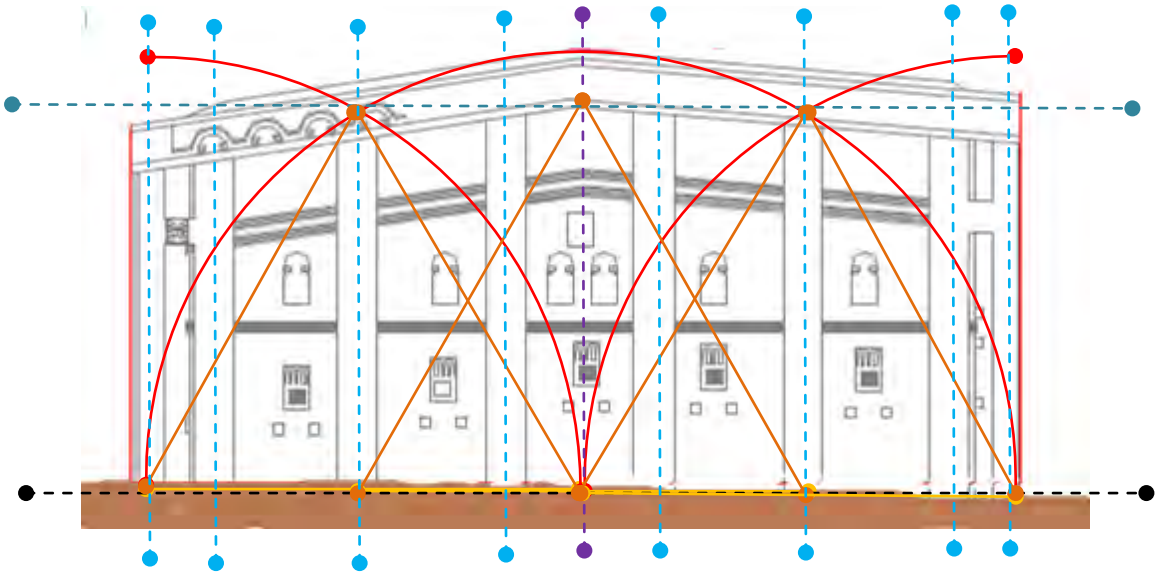


Figure 60:The Rare Side Elevation Plan of Bete Medhanealem

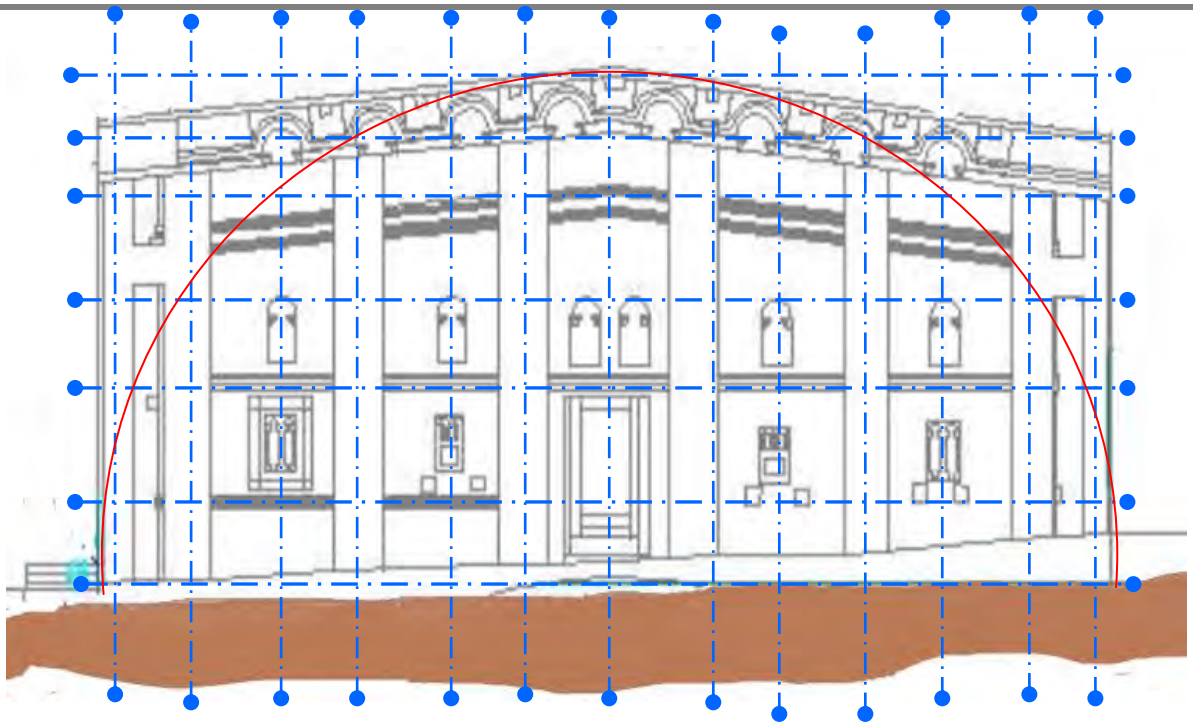


Figure 61: The Front (East-West) Elevation Plan of Bete Medhanealem

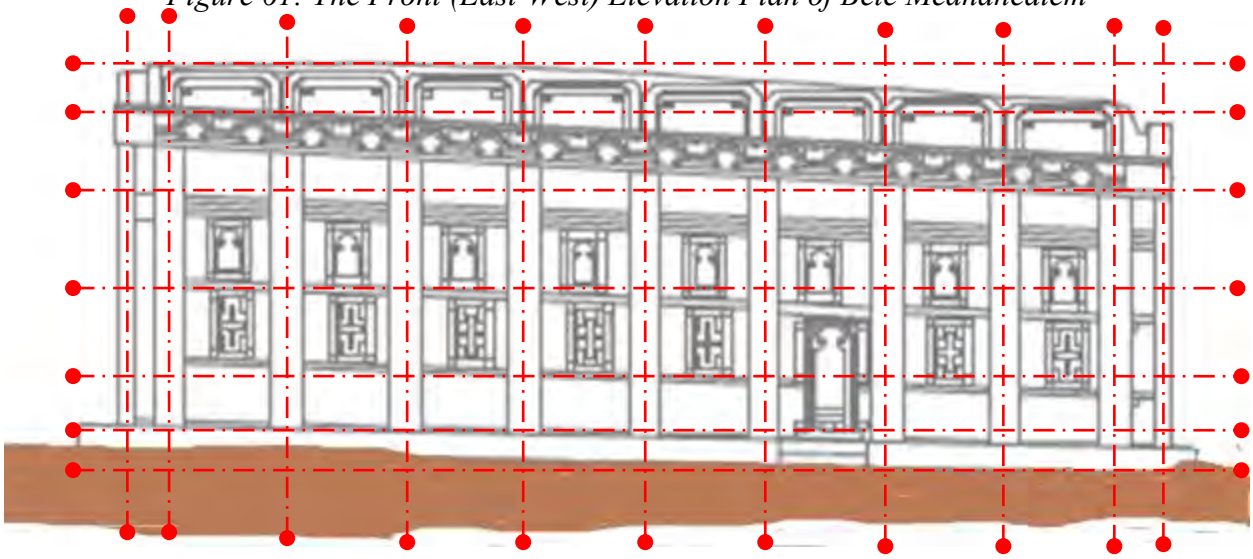


Figure 62: The Left (South-North Orientation) Side Elevation Plan of Bete Medhanealem

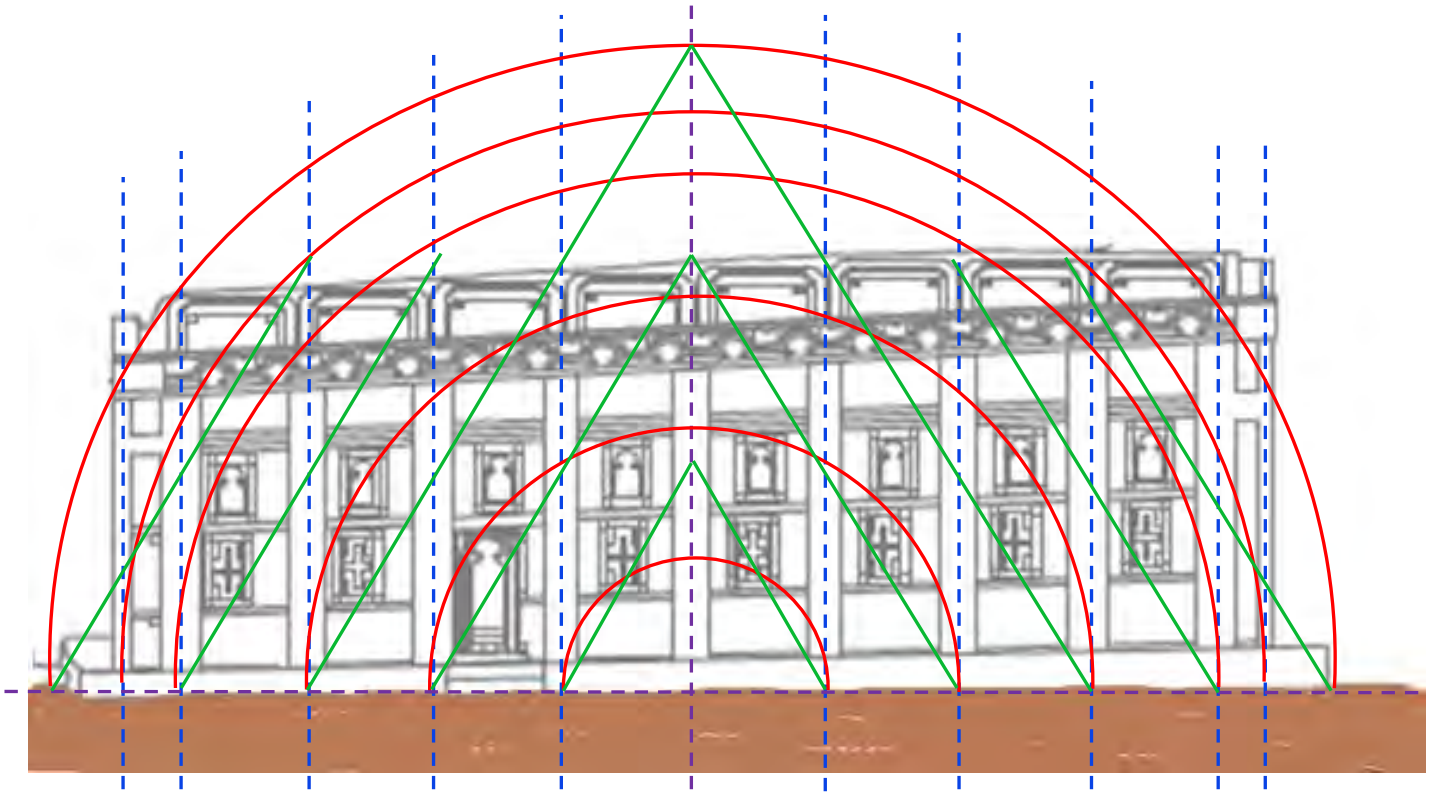
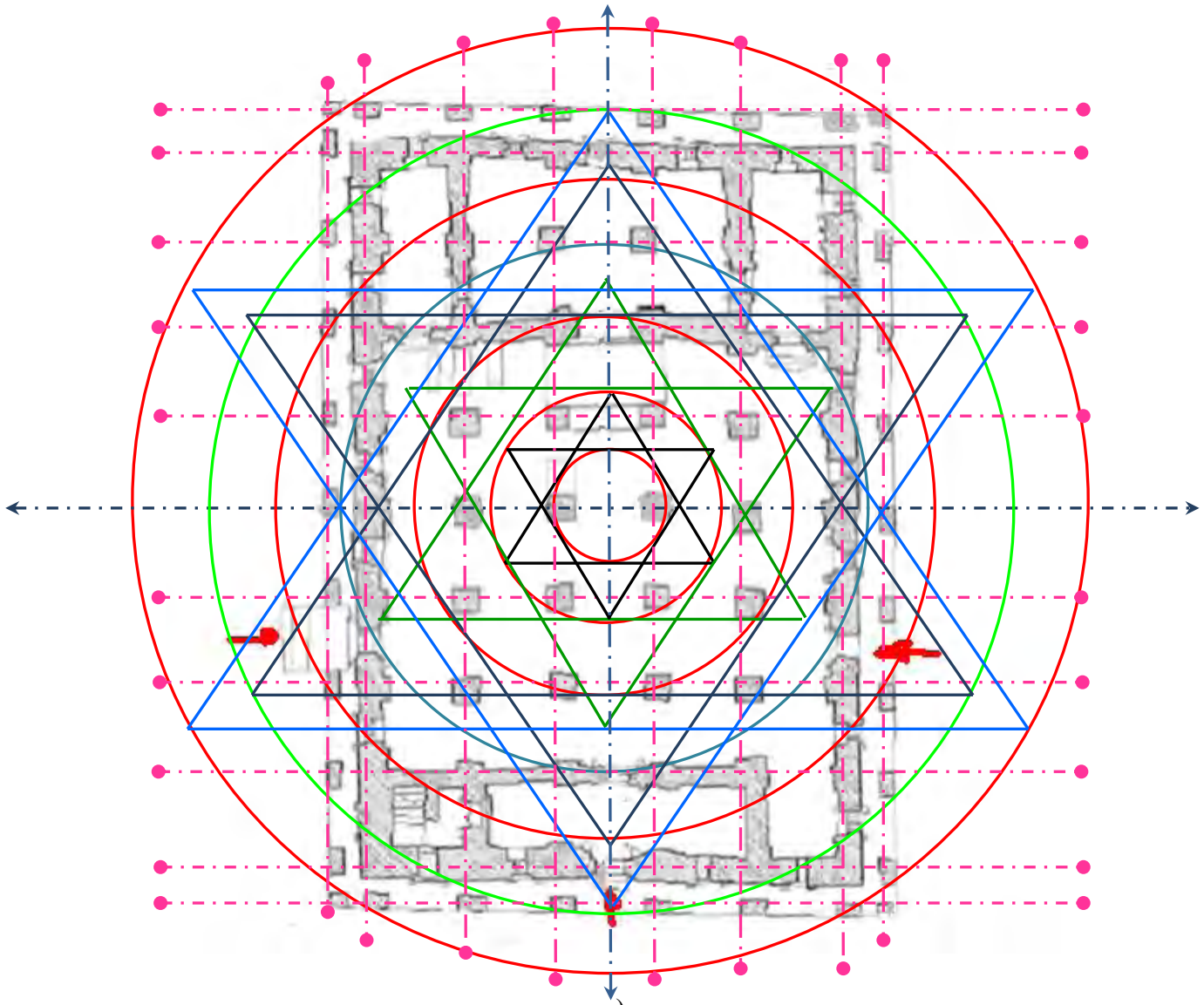
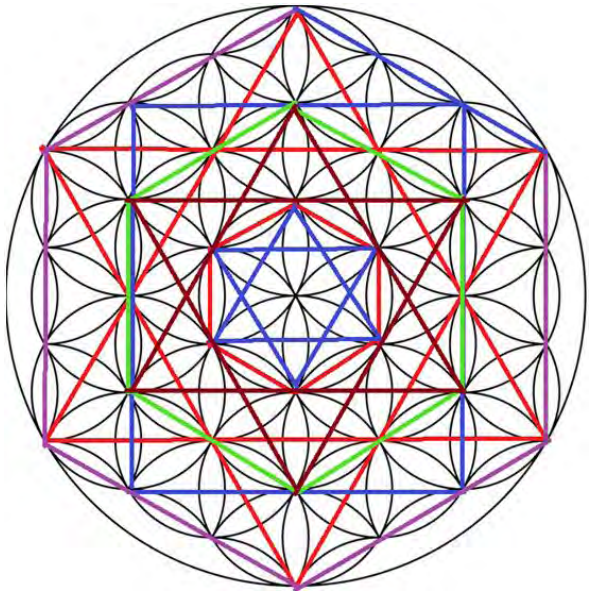


Figure 63: The Front Elevation Plan of Bete Medhanealem and under the geometrical configuration of consecutive golden proportioned of circles

Figure 64: The Section Plan of Bete Medhanealem and under the geometrical configuration of consecutive golden proportioned of circles



a)



b)

Figure 65: The Floor Plan of Bete Medhanealem and under the geometrical configuration of consecutive golden proportioned of circles and its Similarityy with geometrical configuration of Flower of Life.

3.4. *Bete Amanuael* (House of Emmanuel)

Bete Amanuel is rectangular shaped monolithic building stands upright having a shape similar to *Bete Mariam* due to the verandas at each door but without porch. As we saw on the site plan description this church has defined or limited the side of the polygon that accounts for the layout of the whole premises of *Lalibela*. (Courtyard size is 29.87 by 22.68 with a depth of 13.4m)

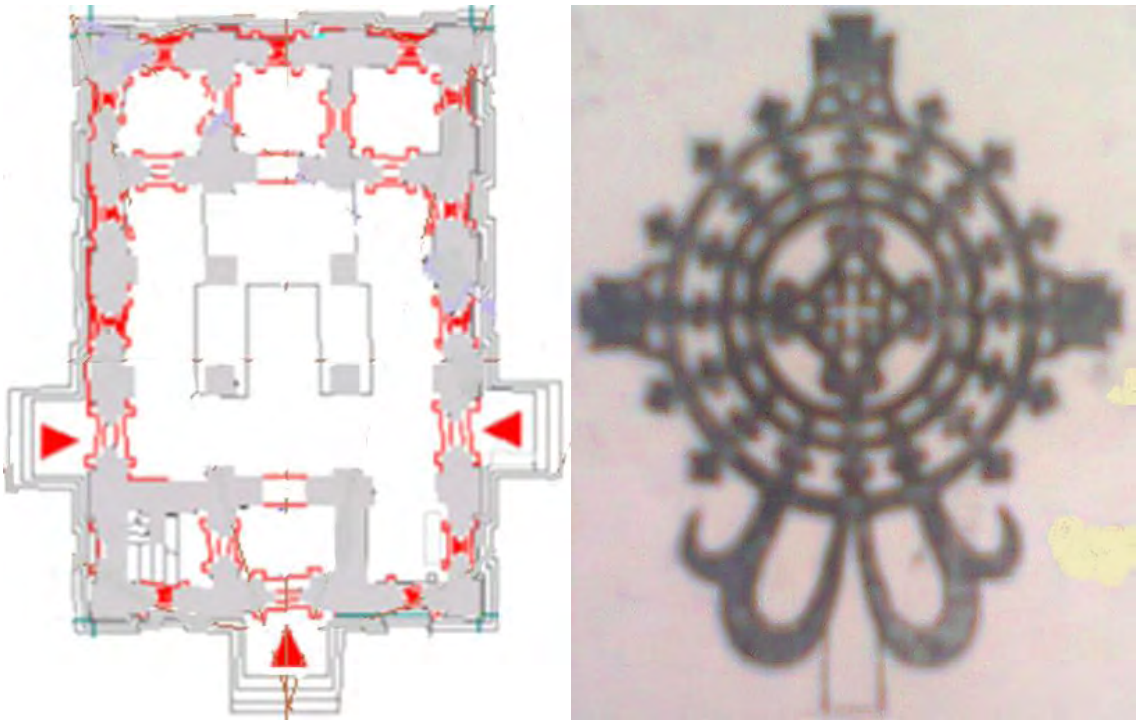
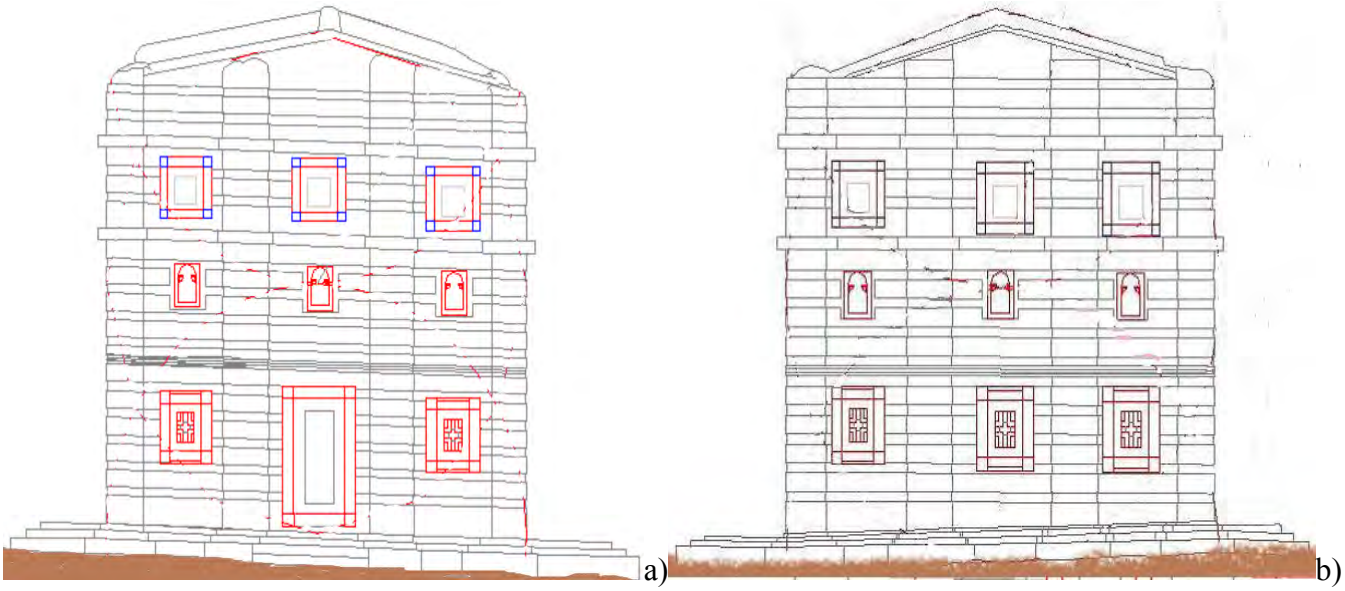


Figure 66: a) The Floor Plan of Bete Amanuel b) The cross which had been suggested hold the design of Bete Amanuel



a) b)

Figure 67: a) The Front (East-West) Elevation Plan of Bete Amanuel b) The Rare Side Elevation Plan of Bete Amanuel

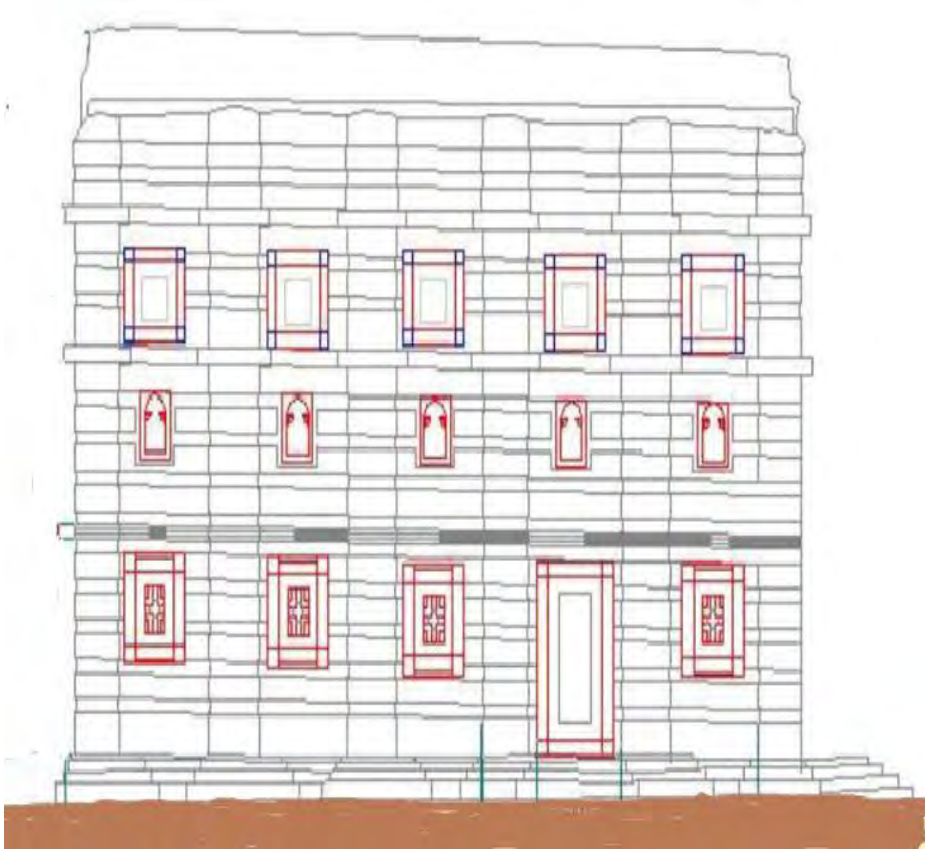


Figure 68: The Left (South-North Orientation) Side Elevation Plan of Bete Amanuel

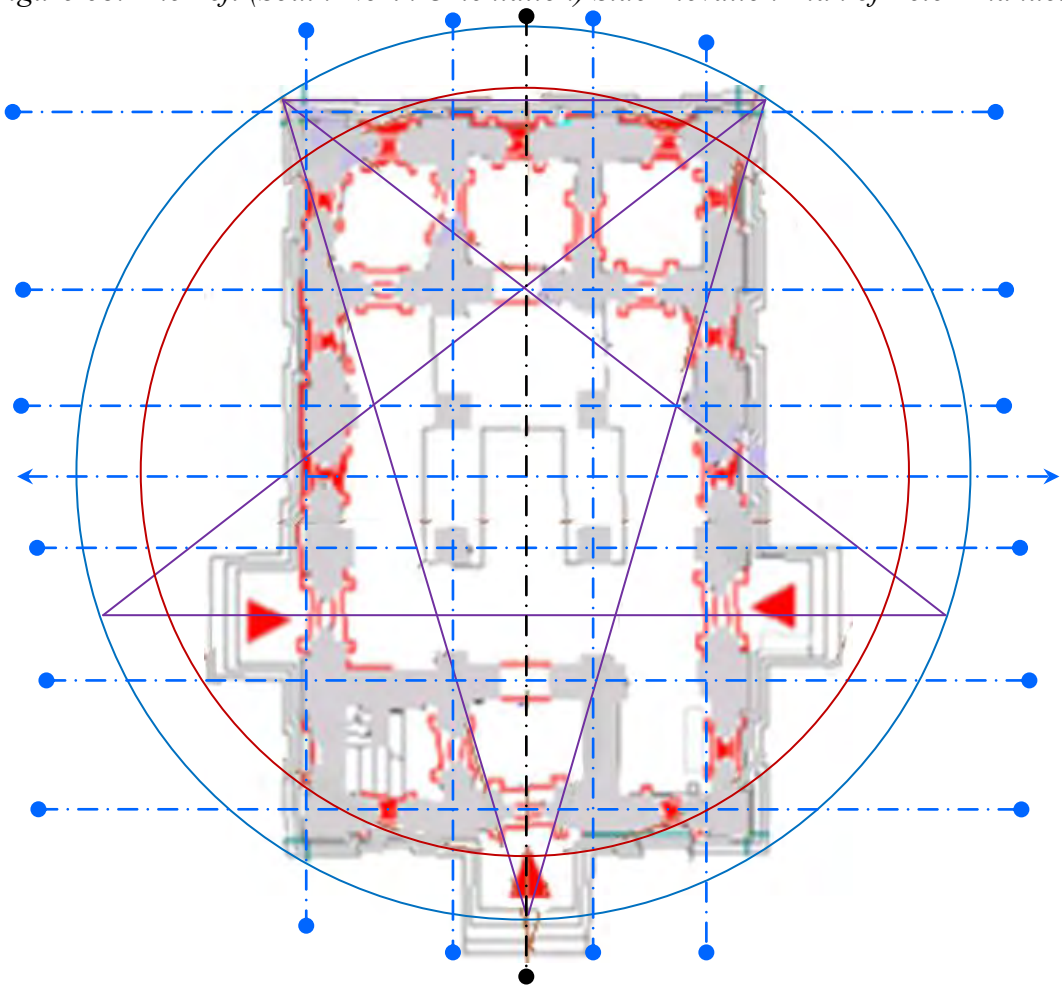


Figure 69: The Floor Plan of Bete Amanuel and under the geometrical configuration of golden proportioned pentagram, which is the top plan of icosahhedron.

This building is rectangular and enables to align it with the diameter of the circle for computation purpose. Its plan has a width 11.5m and length of 17.65m.

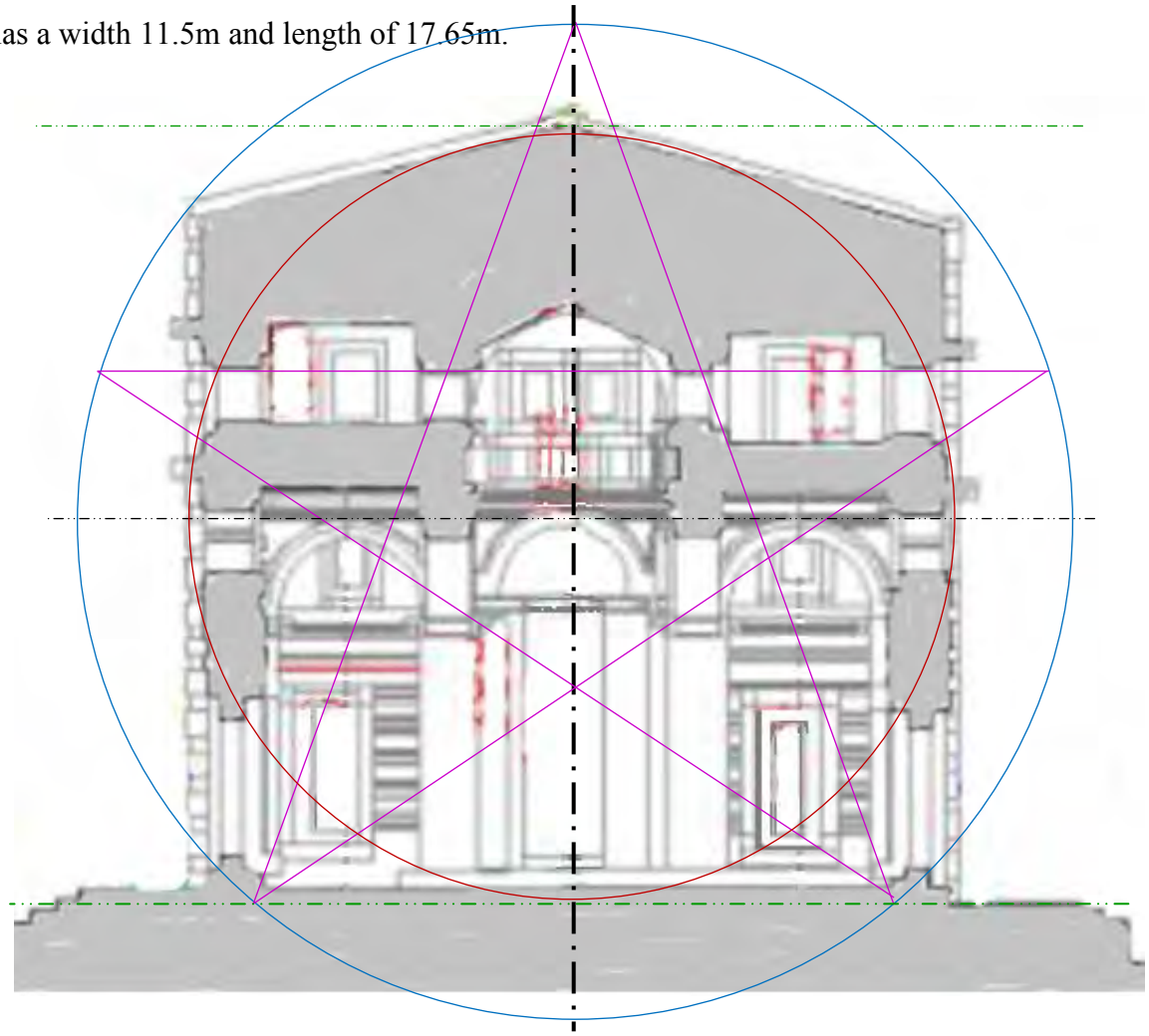
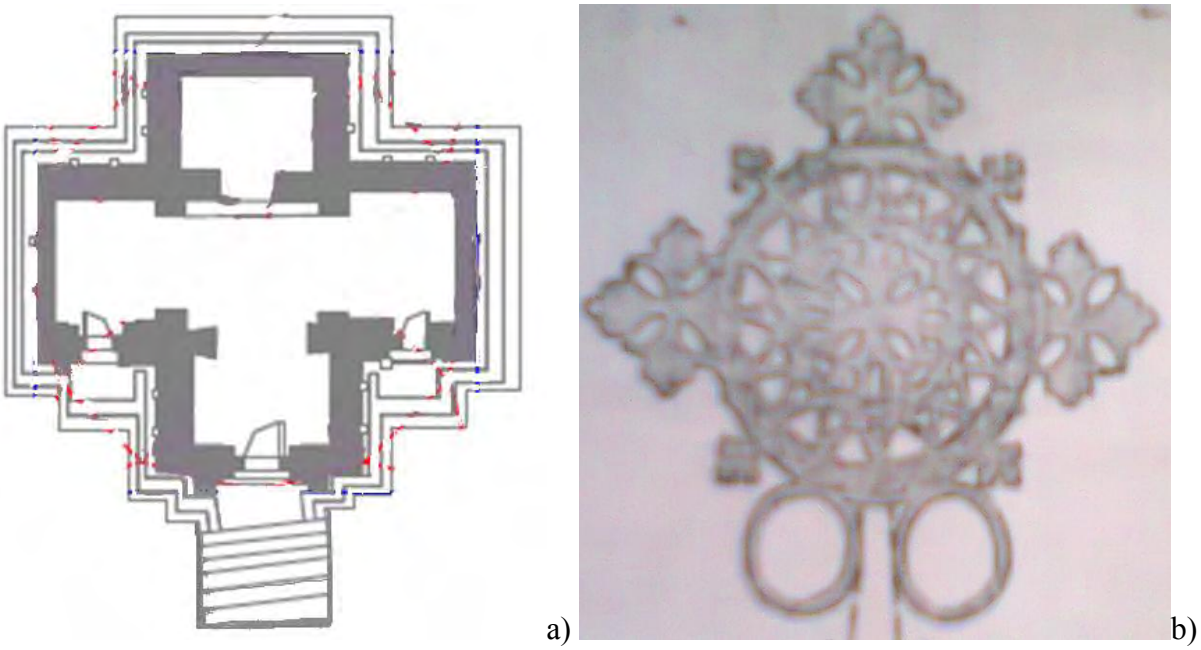


Figure 70: The section Plan of Bete Amanuel and under the geometrical configuration of golden proportioned pentagram, which is the top plan of icosahhedron.

3.5. *Bete Ghiorghis* (House of George)

One of the most sophisticated details of *Bete Giorgis* is that the wall thickness increases step by step downwards but that the horizontal bands of moulding on the exterior walls cleverly hide the increase. The roof decoration, often used today as the symbol of the *Lalibela* monuments, is a relief of three equilateral Greek crosses inside each other. The church is set in a deep pit with perpendicular walls and it can only be entered via a hidden tunnel carved in the stone. It rises from the bottom of a roughly rectangular pit approximately 11m deep, and is approached by an entrance trench some 30m long. It is cruciform in plan and stands on a high stepped plinth. The lower windows, carved according to the *Aksumite* pattern, are all false and do not penetrate into the church"s interior. The higher windows, one central to each face, are in a distinctive style. However, when viewed from the inside, they do not appear central because no account was taken for the thickness of the wall thus demonstrating that the design was based primarily on external appearances.



a) b)

Figure 71: a) The Floor Plan of Bete Ghiorgis b) The cross which had been suggested hold the design of Bete Ghiorgis

a) b)

Figure 72: a) The Front (East-West) Elevation Plan of Bete Ghiorgis b) The Side (North-South) Elevation Plan of Bete Ghiorgis

Bete Ghiorgis is almost Latin cross shaped building which is 12*12*12m cube, set inside a pit created by the surrounding terrain having a built up area of around 144m^2. The courtyard has quadrilateral shape. In geometry, the opposite angles of quadrilaterals in circle are equal to two right angles. Based on this, *Bete Ghiorgis* has a square shape inscribed by a circle as shown below. He may first set an area that inscribes this. So the two equilateral triangles that are cross joined hint that *Lalibela* used a regulatory diagram of star tetrahedron, for defining the pit of *Bete Ghiorgis*. So taking the dimensions of the four sides of the floor plan coincides with the elevation plan, which the geometry in the nature creation pattern inscribed in Metatron cube.

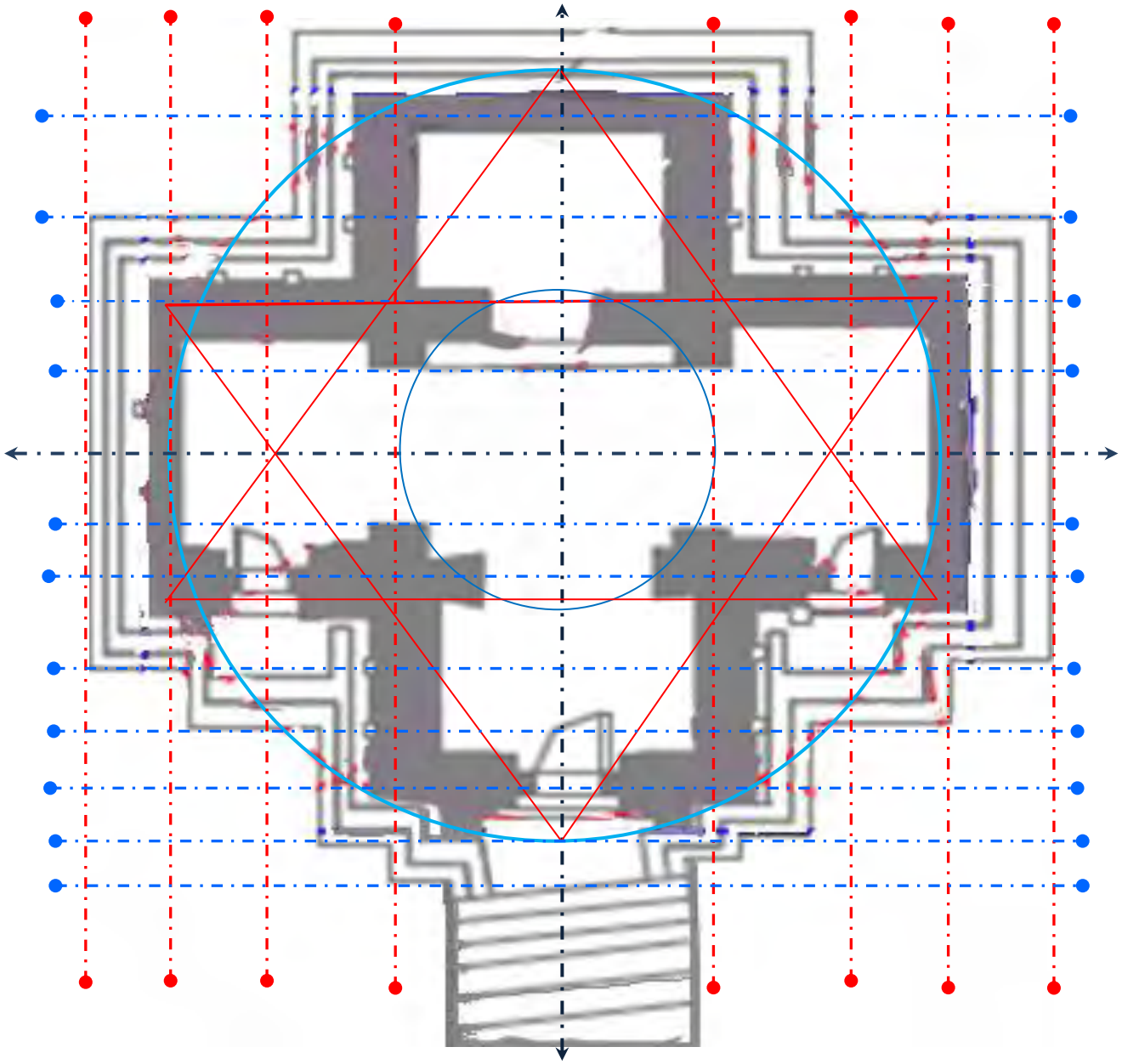


Figure 73: The Floor Plan of Bete Ghiorgis with the Geometrical formation of Hexagon (TetraHedron).

The blocking of *Bete Ghiorgis* is sculptured from a cube whose dimension is 15*15*15cm (Metatron cube). Thus the plan has equal length to width dimension which is 12m and its height is also best fit with the sides. It is therefore possible to say that *Bete Ghiorgis* has a pattern of platonic solids, which bases the principles of nature creation geometrical patterns. The rest divisions in the building are based on continued proportions that come out from this basic concept.

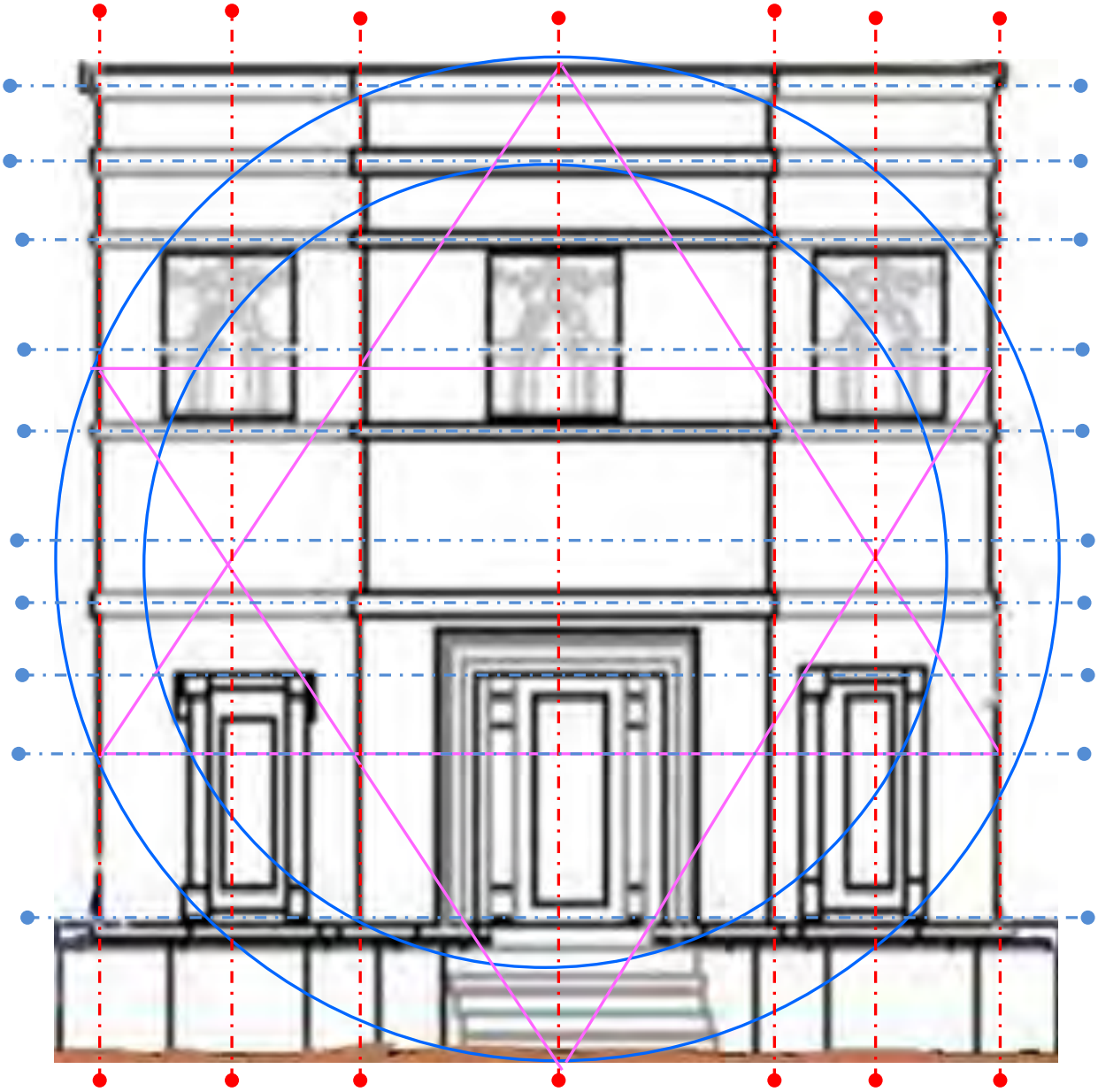


*Figure 74: The Front Elevation of Bete Ghiorgis with the Geometrical formation of Hexagon (TetraHedron) and inscribed (sculptured from the 15*15*15 Metatron Cube).*

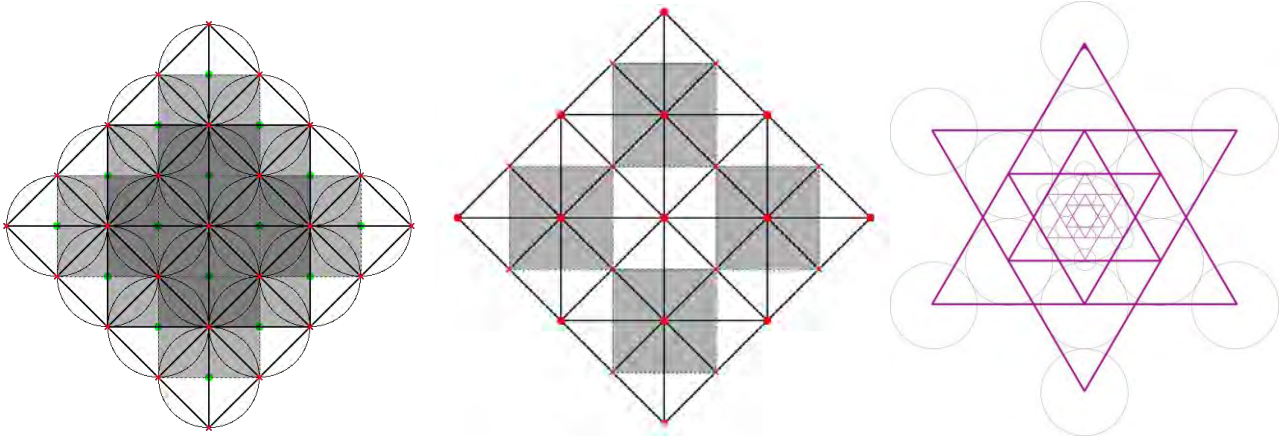


Figure 75: An XY projection of the inner grid of Metatron Cube. The structure has 4 vertical layers separated by a height 1/2 times the edge size.

CHAPTER FOUR: CURRENT SITUATION OF THE CHURCHES AND CONSERVATION NEEDED

4.1. Current Situations

The rock-hewn churches of *Lalibela* were one of the first twelve sites to be inscribed by UNESCO on the World Heritage List in 1978 [104]. It was also one of the first restoration projects to be sponsored by the World Monuments Fund in the 1960s. Since then, conservation of the site has continued to be a focus for international support in the context of evolving heritage disciplines and practices. The World Heritage status of the site has contributed to a sense of shared global responsibility for its conservation and to socio-economic development through the use of heritage as a tourism resource. This development needs to be balanced to prevent irreversible damage and loss of inestimable heritage resources. *Lalibela* is a living heritage. The churches, the ecclesiastical objects and the religious practices constitute an important part of the local community and traditional way of life. The conservation challenge is to safeguard both tangible and intangible aspects of the site in the context of development and town expansion.

With increasing globalisation of heritage, World Heritage Management has emerged as an interdisciplinary field of study with the potential to create new opportunities for multidisciplinary research and dialogue both globally and locally. ICOMOS, in its first evaluation of world heritage nominations, included the eleven rock hewn churches of *Lalibela* as one of cultural sites which both corresponded to the requirements for the criteria for cultural properties and the necessary minimum standards of documentation (ICOMOS, 1978a). In its recommendation, ICOMOS proposed that the site should be inscribed under criteria I, II and III, having identified three distinguishing types of church: built-up cave churches, rock-hewn cave churches and rock-hewn monolithic churches (ICOMOS, 1978b).

- Under the first criterion, the eleven churches represented as an ensemble "a unique artistic achievement" due to their scale, variety and audacity in form.
- Under the second criterion, it was recognised that the building of the churches by King *Lalibela* as a New Jerusalem and a substitute destination of pilgrimage for his people had a "considerable influence" on the development of Ethiopian Christianity.
- Under criterion three, the church ensemble was identified as a "unique testimony" to Ethiopian civilisation during the medieval and Post-Medieval periods. Under this last criterion, the remains of the traditional historic houses, built in two storeys and circular form, were recognised as equally important for preservation as the rock-hewn churches.

[104] *Elene Negussie (Dr.), Oct. 2010.Conserving the Rock-Hewn Churches of Lalibela as a World Heritage Site: a case for international support and local participation.*

The principal aims of the World Heritage Convention are to ensure the identification, protection, conservation, presentation and transmission to future generations of cultural and natural heritage of outstanding universal value. The need for international assistance to protect heritage of universal significance formed a fundamental part of the conceptual development of World Heritage.

The World Monuments Fund working to assist in the safeguarding of endangered cultural heritage. Thus, obviously the rock-hewn churches of *Lalibela* became one of the first restoration projects to receive sponsorship from the organisation. The project involved assistance by a team of Italian conservators including documentation, stabilisation efforts and an initiative to remove a bituminous coating to the external surface, preventing the natural breathing of the rock, thereby causing deterioration.

More recently, the World Monuments Fund has partnered with UNESCO and Ethiopian institutions to address conservation of the rock-hewn churches, site management, presentation and training of local personnel in order to achieve sustainable conservation practices. Other international assistance of major significance includes the EU-funded project „Temporary shelters over five churches in *Lalibela'*, led by UNESCO. It involved the building of temporary shelters to protect the rock-hewn churches from rainfall and erosion, as well as new cultural and visitor centres (UNESCO, 2006).

A strengthening involvement on such important monument cannot be an easy task; still it shall be more difficult because of the possible current problems. It has not to be forgetting that the churches are characterized by a very thick roof; such thickness represents a heavy rock body, dangerous in swinging motions for the whole structure and its weathering durability. Therefore the aim to make the buildings safe in the event of every action (natural and manmade) needs to stop the devastating cracks and weathering of the material, due paying attention to the many parts of the buildings.

From site observations a lot of critical issues could be raised, on which it needs great considerations for its sustainability from attempting on its current situations. From its nature of formations and international recognitions many works would be expected on conserving the site, though it needs devoted and discerning experts, national and international institutions. Current situations of the site is in a serious case, the lengthened cracks in every part of the churches goes to devastated failures and it highly affects the durability of the rock materials. Different scientific investigations could be possible to find out and propose solutions on the factors that could affect on its elements. As the researcher‟s opinion and comments the possible major factors shall assessed as follows.

4.1.1. Manmade Factors

Conscious and unconscious acts of people continued threatening these heritages. The destructions are directed against tangible and intangible heritages. Trading cultural materials is ever increasing business. The business sometimes accommodates theft and illicit transfer of movable heritages into its system. Graffiti on different parts of the churches is another factor which causes physical deterioration. Graffiti are evident in almost all of rock hewn churches. The effect of such acts in reducing aesthetic value of the churches is not taken seriously.

Destructions related to maintenance and other conservation activities are the other factors which lead to physical deterioration of the churches. In churches of like *Bete Mariam* and *Medihanialem* cracks are filled with mortar without detail study. Besides physical deteriorations, such type of conservations also affects aesthetic values of the churches. On the other hand creating awareness among the community regarding shared ownership of the churches holds central position in creating favourable environment for heritage management activities and resultant tourism.

Figure 76: The manmade factor due to conservation activities at Bete Amanuel and Bete Medhanealem

4.1.2. Natural Factors

Results of studies conducted on churches *Lalibela* identified weathering as a major nature caused factor of deterioration. Disintegration of volcanic agglomerates and scoriae is resulted from wetting and drying cycle. Samples from weathered rock samples from *Bete Abba Libanos* showed concentration of salt [105]. The effects of weathering are observable in the churches like *Aba Libanos* and *Bete Gebrel* and *Rufael*. According to (Delmonco et al 2010) the natural soil formations resulted from raindrops on roof of churches is dominant cause of degradation of roofs of churches like *Bete Merkoreos*. Of all rock churches water caused deterioration was critical in the churches of *Bete Medhanealem* and *Bete Amanuel*. As indicated below the church had gone through maintenances. But it remained under critical condition as seeping through the roof is causing destruction of roofs and walls (inside and outside) of the church.

[105] *Delmonaco et al 2010*

The current look of eastern façade and part of the southern side of the *Bete Merkoreous* church are result of the recent renewal. Degraded original pillar from the inside and outside of the church seems not able to support the thick roof above it much longer. Soils formed on the roof of the church are indicative of seriousness of deterioration process. Cracks on the walls of the church are also sever compared to other churches. Traces left by rain water on roof, ceiling and walls of the church indicate high concentration of salt. Rain water and resultant flood, weathering and biological causes of destruction are the most threatening natural causes in most of rock hewn churches of *Lalibela*. On the other hand water seeping through roof and walls of buildings take the largest part as natural cause of destruction.

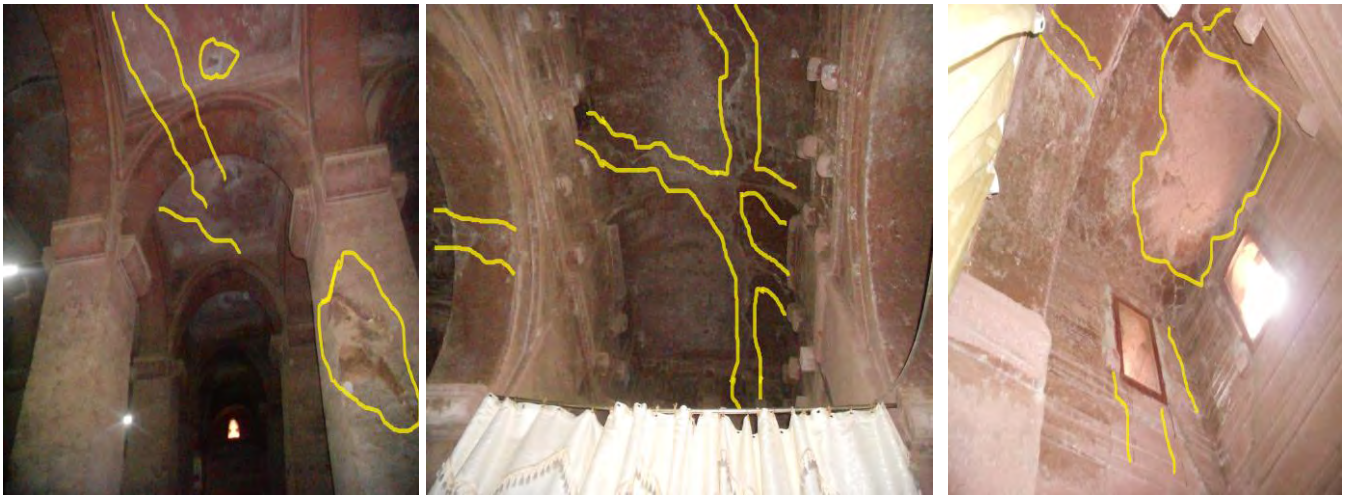


Figure 77: The Patten of cracks at Bete Amanuel (Internal), which shows continual cracks on the roof to the wall and deterioration.

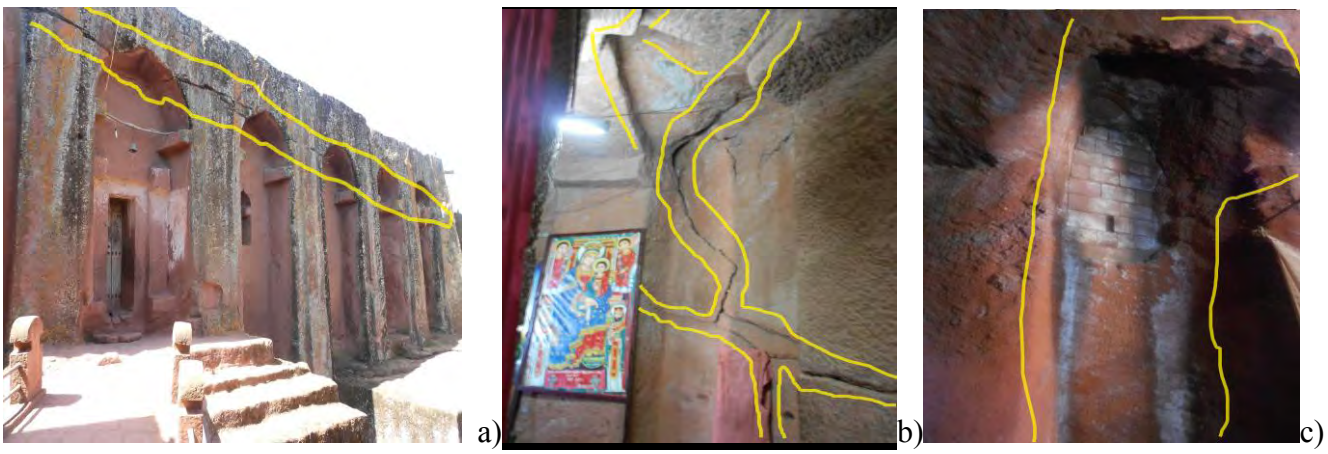


Figure 78: The Pattern of cracks at Bete Gebriel we Rufael a)The external eastern façade of the curche shows the most seveour longitudinal crack b) the internal branched crack jointly on the wall and roof c)highly deteriorated part of the internal wall and formation of efflorescence.

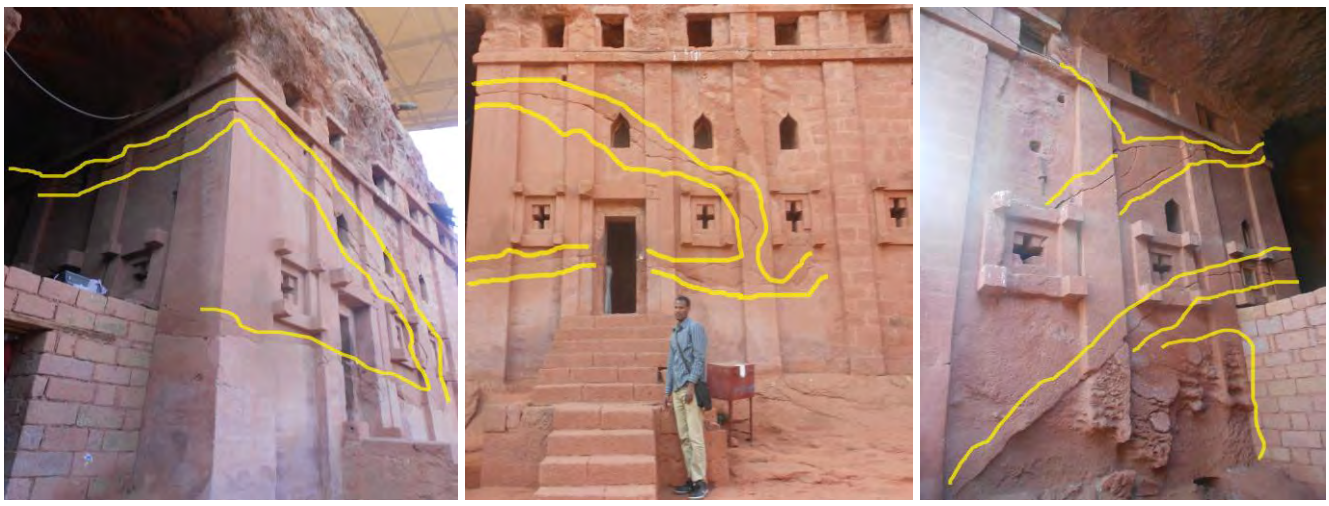


Figure 79: The pattern of cracks at Bete Abba Libanos (External); as you show the crack circled through the three sides of the church and at the base of the church shows high deterioration of the wall.

Figure 80: High deterioration of the wall shows here openly at the gate to the courtyard of Bete Ghiorgis, though it is not critically part of the structural elements of the church and it is most probably due to storm rain water and weather effect.

4.1.3. Forms of Failures

As it is mentioned above the cracks are dispersed in every part of the churches, though mostly the cracks are concentrated at the ceiling and walls. As locally said, some of their columns also have been destructed by earthquake during the 16th century, such as at *Bete Medhanealem* and currently it is modified (masonry built), though some scholars argue that the area is low for earth quake influence. The cracks located at the ceiling are throughout the longitudinal and some effloresce effects are observed. This may be probably the presence of moisture and salt on the material nature. In general detail investigations and tests on identifying the forms of the failures and its cause is the major aspect and directive measure for a better conservation action plan.

At present, though it may need further investigations able to interpret fully the fracture set and to specify its principal causes, rather to make a rough diagnosis; that the building, born as a strong monolithic structure, became much weaker in consequence of kinematical mechanisms. It could be possibly by the presence of several geological fractures, and activated by several actions (mainly manmade and seismic forces). A specific joint-cause that made worse the static condition certainly was the weathering damage that affected the monument increasing the cracks pattern.

4.2. Conservation Needed

Particular attention has not been given to analysing the ancients' practice of architecture, in order to understand their approach to construction. This couldn‟t enable us to draw up guidelines for the conservation of a heritage which, when monuments are considered as documents, is seen as a vast record of history. This holds well for our own heritage and also for that of other civilizations.

This research has thrown light on the methodological differences distinguishing the concepts of construction and structure, construction being identified with in its entirety, and structure considered as the supporting or load-bearing entity of the construction. This research also highlights the unitary nature of that practice, which provides what is wanted for a number of requisites; statics was one of these, but it was not given undue importance. Constructions were viewed in a much more complex spatial dimension than the schematic structural approach taken today. They were based on techniques which recognised the importance of the art of building (beauty), ensuring longevity measured in centuries and immune to the most common natural hazards such as drainage effects.

Building was undertaken according to «rules of the art» which remained unwritten right down to the 19th century. Today our entire building heritage needs an archaeological, geological and structural approach, for it belongs to a unique and irreproducible building culture based on the laws of nature. The mechanical reinterpretation to which it has been subjected over the last century has resulted in a profoundly misguided approach to conservation. Ignoring every principle of correct historical evaluation, interventions were carried out using approaches, materials and techniques carried over from the new structural engineering, developed for industrial materials and based on the dichotomy between construction and structure. Since earliest times human society has used the materials provided by nature to build structures intended for public and private living. The structures that characterised villages and cities were modelled on the forms of nature itself.

The tradition of conserving historical heritage through the protection of monuments, sites and related elements must be integrated in a larger strategy of sustainable management and developments. Threats to the churches can be seen in the physical deterioration of the churches because of manmade and natural agents. There are number of factors which lead to physical deterioration of heritages. Identifying the nature and scale of destructive forces helps determine intervention methods. It also enables to take measures before it

results in total loss of heritages. The geography where the churches are located, without doubt, helped preservation of the churches.

Francisco Alvares visited *Lalibela* in the early 16th century (Alvares 1540 [1943]), providing an early record of the organisation, topography and state of preservation of the site. King Minilik II brought two restorers from Armenia, Mose Philip and Mose Berttin, to restore the columns however the restoration was held back in 1914GC due to Minilik"s death. It was then after 40 years, in 1962GC that Emperor Haile Selassie brought, an Italian restorer called Kambus who finished the restoration of the columns. And again from the 1960s onwards, that the site, now more easily reachable from the capital Addis Ababa, attracted the attention of amateurs, scholars in architecture, art history, liturgists and archaeologists. A programme of preservation was also implemented under the protection of UNESCO, the World Monuments Fund, and the Ethiopian authorities.

Conserving the churches and heritages related to them requires not only knowledge, skill, competency and understanding of methods of conservation but the culture itself to ensure these cultural values are retained. Conservation tasks which range from documentation and guarding to physical interventions like maintenances and restorations requires implementation of appropriate methods and skills. Conserving heritages should not be a task which involves merely the community as a guardian of the heritages, and it is also a task attributed to professionally managed developments and implementation of techniques of conservation. Though, a preventive measure which involves the immediate community play an important role in conserving tangible and intangible heritages of these churches.

Compared to other aspects of heritage management, the conservation aspect is stagnant. Observable tasks conducted on the churches so far is shelters which cover the roofs of four rock hewn churches. The shelters are even criticized for ignoring aspects related to aesthetic values of the churches and do not address geological and geotechnical properties of the rocks from which the churches are hewn [106]. Patching cracks, restoring paintings, and many other restoration methods are witnessed in most of the churches. Except few cases there are no records of restoration activities i.e. techniques and materials used, technicians employed and the role of the community and many other aspects took share in restoration and maintenance tasks. In fact handful restoration tasks in the churches are conducted under supervision of administrators of each church. In such cases traditional methods and materials are employed.

Preventive conservation and maintenance play an important role in protecting the churches. Taking physical measures to safeguard the churches before destructions result total or partial loss of heritages will be recommended. Preparedness for post destruction maintenances is another aspect of conservation. The final stage in heritage conservation is emergency operations and restoration programs. Institutional conservation of the churches is very recent.

[106] *Asfawossen, 2008 et al*

Though there are some observable conservation tasks conducted by *Lalibela* Town Culture and Tourism Office, most of the churches maintenances are conducted without necessary preliminary assessments and the personnel employed are not qualified for the tasks. But remarkable conservation activities are conducted with limited resource and manpower. The task of implementing proven methods with qualified personnel results better conservation of the churches. In other words it is well organized and well managed conservation activities which results sustenance of the churches.

Conducting structural assessments of existing buildings may face challenges in the course of their work as the fact building codes focus more of on new buildings rather than existing ones; original design and construction documents of far historical buildings are often not available; and the difficulties of estimating the reliability of existing buildings. But, structural assessments of existing buildings may needs:

- Assessments of the overall integrity of buildings; or
- Assessments of buildings or parts thereof affected by structurally compromising events (may be natural or manmade factors).

In doing these, basic understanding of the art and structural formations are mandatory. Conducting structural assessments of existing buildings should work with all documents and drawings which say it require conducting the assessments, such as original design and construction documents and drawings. Alternatively, if these documents and drawings are not available, professionals may determine that they require additional field work, such as obtaining measurements of the structural elements, to obtain the needed information to conduct their assessments;

- Access to original documents, as well as maintenance and repair records of buildings being assessed;
- Access to buildings being assessed and all the critical areas professionals identify; and
- Additional investigations which are determined to be required after reviewing preliminary data.

In conducting structural or geological assessments of these rock-hewn buildings should review original design and construction documents, including as-built drawings, if available, prior to visiting buildings for inspection. This review will help professional to:

- Understand buildings‟ structural systems and layouts;
- Identify critical areas for inspection;
- Identify the specified loads to assess usage and possibility of overloading; and

- Verify if unauthorized additions or alteration works that affect the structure of buildings have been carried out.

In addition, professionals conducting structural assessments of existing buildings are expected to visit the buildings and carry out, with due diligence, visual inspections of:

- The condition of building structures; to identify types of structural defects, signs of structural distress and deformation, and signs of material deterioration;
- The loading on building structures; to identify which can result in overloading;
- Additions or alteration works affecting building structures; to identify additions or alteration works that can result in overloading or adverse effects on structures; and
- Non-structural components that might affect structural systems.

If signs of structural deterioration or defects are present, professional should provide opinions on the severity of the deteriorations or defects and recommend appropriate actions to be taken. Such actions might involve repair works or full structural investigation to parts or the whole of buildings.

Conducting visual inspections of different parts of the churches may be difficult, as places which are allowed only for priest, such as *mekdes*. It is, therefore, important that exercise professional judgment to determine which covered areas should be exposed for inspection. Reference to structural layout plans to determine the presence of critical structural elements is crucial under such circumstances. Inspections will, on occasion, yield information that indicates a structural problem might exist, requiring testing that was not included in the original scope of the inspection. If inspections are being conducted because buildings were affected by potential structurally compromising events (manmade and/or natural), professionals may choose to limit the scope of their assessments to the structural elements that were affected by the events, as determined by their visual inspections. In such situations, persistent inspections and testing might be required.

It needs to quantify observed structural deterioration or defects and analyze their potential impact on structures, as well as provide opinions on the potential impacts of the deterioration or defects. In situations where only specific areas are being inspected due to known incidents, one need not analyze overall structures; elements suspected to have been affected should, however, be thoroughly assessed to ensure their structural integrity has not been compromised or, if compromised, the remaining structural integrity is sufficient for the loads they will be exposed to.

CHAPTER FIVE: DISCUSSION and ANALYSIS

5.1. Structural Formations and its Architecture

Looking on the structural formations and architecture of a building is the most fundamental. It is the guidance for its design and the construction methods. Principles of the structural formations and integrities play a major role for the construction sequence, especially for the case of rock excavation in which it is difficult for remedial corrections by which the elements should set. Defining the area of the excavation with all its working spaces is the beginning of the formulation for proceeding constructing the building out of the mass rock. With this all process the entire mission will accomplish. This is a matter of putting a blue print for the final output, unless it will be more of guessing and estimation; if this, it makes difficult to get as existing structures.

When you look figures for the monolithic churches the researcher put crosses beside their floor plan which are specifically assigned crosses for which locally said it is there their design, though till now they do not in detail elaborated. However, it is reasonable to have a guide as blue print either as sculptured wooden materials or in the form of crosses. You have to, because to construct such precision and engineering without any guidance is difficult to imagine. Thinking about the former built-up and carved churches around the area may also strengthen the constructors‟ ability on rock carvings and the art behind. Observing the floor and elevation plans and the building size clearly shows the principles based on nature creation patterns and proportions by which *Lalibela* used for determining the space within the buildings and the mountain walls and the courtyard of the buildings.

When we speak of sacred architecture we are not speaking just of churches and temples, but of all buildings that are designed in accordance with the laws of sacred geometry. Sacred geometry is primarily concerned with the mysterious and symbolic significance of geometrical forms, rather than their logical development and ordinary application. When the principles of sacred geometry are understood and correctly applied in the design and construction of buildings, those buildings will possess a supernatural power that can speak to the deeper layers of our awareness and effect changes in the structure of our lives. Buildings designed and constructed in this manner possess this power and deserve to be called sacred architecture.

The principles of sacred geometry, however, lie behind the design of all of the great buildings of the past. The Parthenon, for instance, has been admired for centuries as an example of the application of geometric beauty to architectural design. The other shapes, forms and ratios upon which architects based their designs from remote antiquity until the middle of the twentieth century were not even mentioned. Why are the ancient geometrical laws of proportion, harmony, and form so neglected? First, we are taught that there has been a steady advance in culture and technology from remote prehistory to our own era. The great buildings of the past, can therefore be briefly admired and then quickly forgotten. Second, contemporary buildings, no

matter how empty and barren they may be in contrast to the buildings of the past are considered superior by architects and their critics because they are consistent with the scientific materialism of the twentieth century. To state that beauty in architecture is based upon objective laws that reflect a spiritual rather than a material reality is to challenge the philosophical assumptions upon which our society and our institutions are based.

These assumptions, however, are fundamentally unfavorable to the practice of architecture as an art. In their narrow focus upon that which has weight and measure they deny any transcendental meaning to art or life, and that which has long been thought divine is dismissed as superstition. Even the word "beauty" has been replaced in common discourse by the cool and distant word "aesthetics." Aesthetic sensitivity, in turn, is considered to be a subjective reaction that is wholly based upon behaviors learned in the past of the individual observer. There is, therefore, no theoretical basis in what is called "philosophical materialism" for the evaluation of architectural quality other than functional efficiency, and function is tacitly defined to exclude any relation to the psychic, as opposed to the material needs of those who will use a building.

And if we look without intolerance at what we have achieved, in contemporary buildings, we will find nothing that can compare with a medieval and ancient structure. We will also find, perhaps to our surprise, that there has been an accelerating degradation of architectural design ever since the ancient principle of proportion fell into disgrace. The loss of the principle was not the only cause of the decline: architecture is a social art and the commercial forces involved in the construction of our built environment are formidable. But the principle was of direct importance to architects and builders. As it was gradually given up in response to the rationalism of the 18th century enlightenment and replaced by the cult of the individual creative ego, architectural quality began to slide down an ever-steepening slope toward our terrible contemporary environment.

5.2. Construction Techniques

To perceive the issues concerning the construction ways of the churches it is better to consider sayings about the churches, such as;

- The churches of *Lalibela* were not constructed, they were excavated;
- The churches was created by first carving out a wide trench on all four sides of the rock, then painstakingly chiselling out the interior;
- The labour required completing such a task with only hammers and chisels is astonishing and popular legend has it that angels came every night to pick up where the workmen had left off.
- One of the churches, *Bete Maryam*, contains a stone pillar on which King *Lalibela* wrote the secrets of the buildings' construction. It is covered with old cloths and only the priests may look on it, and so on.

All these are some sayings on its construction astonishment and perceptions. Further beside the religious perspectives, the scientific view of its construction or excavation sequence strengthens the constructors" wisdom. The churches have been in continuous use since they were built in the 12th century. The first Europeans to see these extraordinary holy sites were Portuguese explorers in the 1520s.

Church tradition recognises the huge task represented by the cutting of these churches and their associated trenches, passages and tunnels. It is explained the completion of the excavation during the reign of a single king by attributing much of the work to angels who, after the workmen had downed tools for the day, came in on the night shift and worked twice as fast as the human workers had done. In this way, work proceeded so fast that all the churches are said to have been completed within the King *Lalibela's* quarter-century rule.

Some of the research offers a different explanation. David Phillipson argues that "the oldest of the rock-hewn features at *Lalibela* may date to the 7th or 8th centuries, about 500 years earlier than the traditional dating. These first monuments were not originally churches, although they were subsequently extended in a different architectural style and converted to ecclesiastical use. Later, perhaps around the 12th or 11th century, the finest and most sophisticated churches were added, carved as three- or five-aisled basilicas and retaining many architectural features derived from those of ancient Aksum, which had flourished some 400–800 years previously. It is the last phase of *Lalibela's* development which may be dated to the reign of the king whose name the place now bears. The church complex was extended and elaborated. Several of the features attributed to this last phase bear names like the Tomb of Adam or the Church of *Golgotha* which mirror those of places visited by pilgrims to Jerusalem and its environs. This naming has extended to natural features: the seasonal river which flows though the site is known as *Yordanos* (Jordan) and a nearby hill is *Debra Zeit* (Mount of Olives). It seems that it was King *Lalibela* who gave the place its present complexity and form: a substitute for Jerusalem as a place of pilgrimage. It may be significant that, early in King *Lalibela's* reign, the Muslim Salah-ad-Din (Saladin) had captured Jerusalem, and for this reason Ethiopians may have felt precluded from making their traditional pilgrimage to the Palestinian Holy Land. Today, a cloth-draped feature in the Church of *Golgotha* is pointed out as the Tomb of King *Lalibela"*.

However, David Phillipson, has proposed that the churches of *Merkorios*, *Gabriel-Rufael*, and *Danagel* were initially carved out of the rock half a millennium earlier, as fortifications or other palace structures in the declining days of the *Axumite* Kingdom, and that *Lalibela's* name simply came to be associated with them after his death. On the other hand, local historian *Getachew Mekonnen* credits *Masqal Kibra, Lalibela's* queen, with having one of the rock-hewn churches *(Abba Libanos)* built as a memorial for her husband after his death.

Phillipson began by noting that Ethiopia was so often thought of in terms of famine, war and poverty. Yet "Ethiopia had a unique past, important not only for the country's own citizens but for all people's understanding of their place in the world." He recounted the popular tradition that King *Lalibela* received a

vision telling him to build a New Jerusalem which would last forever, and ordered the building of the churches in the 13th century, but added that little research had previously been done to confirm whether this was true. There was evidence of a lack of co-ordination over the site as a whole. His overall conclusion was that *Lalibela* had evolved through three principal phases "through which progression could tentatively be recognised":

Phase A: *Merqorios*; *Bete* Gabriel *we* Raphael; *Bete Denagel* and *Betelehem*- These churches could be as old as the 7th and 8th centuries, perhaps belonging to a period of political disruption and fragmentation initiated by the decline of Aksum. They may not have been built initially as churches, and *Aksumite*-style features are rare, if present, at all.

Phase B: *Bete Medhanealem; Bete Maryam*; *Bete Ammanuel*; *Bete Meskel*; *Bete Giorgis* - These churches are firmly Christian and their "largely basilica architecture owes much to *Aksumite* inspiration with clear indications of a desire to emphasise *Lalibela's* status as a successor to Aksum. A date in the 10th or 11th century would fit this scenario."

Phase C: *Bete Gologotha and Senai*; and *Bete Abba Libanos* - "*Lalibela* Phase C saw the production of those hypogea which are specifically linked by tradition to King *Lalibela* himself. It also takes in locations which are central to the view of *Lalibela* replicating the topography of the Holy Land."

There is some controversy as to when some of the churches were constructed. David Buxton established the chronology, noting that "two of them follow, with great fidelity of detail, the tradition represented by *Debre Damo* as modified at *Yemrahana Kristos*." Since the time spent to carve these structures from the living rock must have taken longer than the few decades of King *Lalibela's* reign, Buxton assumes that the work extended into the 14th century.

Contrary to theories advocated by writers like Graham Hancock, the great rock-hewn churches of *Lalibela* were not built with the help of the Knights Templar; abundant evidence exists to show that they were produced solely by medieval Ethiopian civilization. For example, while Buxton notes the existence of a tradition that "Abyssinians invoked the aid of foreigners" to construct these monolithic churches, and admits that "there are clearly signs of Coptic influence in some decorative details" (hardly surprising given the theological, ecclesiastical, and cultural links between the Ethiopian Orthodox and Coptic Orthodox Churches), he is adamant about the native origins of these creations: "But the significant fact is remains that the rock-churches continue to follow the style of the local built-up prototypes, which themselves retain clear evidence of their basically *Axumite* origin." The role of foreigners in the construction appeared to have been greatly exaggerated. His final point came back to today, however: the churches were under threat from over-usage.

The *Lalibela* churches are carved, inside and out, from soft red tuff rock. Their architecture is distinctive: four of them stand as isolated blocks in deep pits, while others have been cut into the face of a cliff. It is much more difficult to establish a sequence or chronology for a rock-hewn building than for a conventional one, especially when, as at *Lalibela*, it is still in regular religious use. Not only are the *Lalibela* churches more refined and accomplished works than other rock-hewn monuments in other parts of the north Ethiopian highlands, they also form interconnecting complexes which provide evidence for their development and chronological order.

The churches are also a significant engineering feat, given that they are all associated with water (which fills the wells next to many of the churches) exploiting an artesian geological system that brings the water up to the top of the mountain ridge on which the city rests. These huge solid blocks of stone that was left isolated was carved with columns, crosses, sculptures, and domed ceilings inside, and courtyards in front and back. Each one is different from the others in size and decoration. Most are connected by tunnels and rock-hewn paths. The entrances and long steps down to the courtyards and the passageways are also carved out of the red tuff rock.

As the researchers opinion giving the credit of the constructors‟ wisdom and deep understanding of the nature with its remarkable eternal arts to the angles; may seems covering their mental capacity and understanding besides mentioning some scholars the involvement of foreigners. It is not known whether this attribution is original or some hidden secretes which do not want to be public. Be that as it may, *Lalibela* remains to this day a major Ethiopian intellectuality centre. The arrival of numerous tourists in addition to the pilgrims presents major witnesses on its remark ability and great issues arousal place on all its architecture, construction, art and its final motives.

CHAPTER SIX: CONCLUSIONS and RECOMMENDATIONS

6.1. Conclusions

1. The rock-hewn churches at *Lalibela* exemplify a building tradition that has been used in Ethiopia since the 6th and 7th centuries, but these churches are attributed to the 12th century King *Lalibela*. They demonstrate for the higher level of architectural detail in their construction and creations of human civilization.

2. The layout (grouping) of the churches is impossible to imagine arbitrarily, rather they are inscribed by the intersection of identical circles, which forms the Visca Piscis.

3. The layout of the first groups of the *Lalibela* churches clustered in the form of the pentagram, which have the same geometrical configuration with the „Afro Aygeba" cross.

4. The *Bete Mariam* design principles lay on Icosahedrons platonic solid top plan, which forms the pentagram floor plan and elevation plans.

5. The *Bete Medhanealem* design principle lay on the golden rectangle proportion, which is the basic pattern proportion and progression of Metatron"s cube.

6. The design of *Bete Amanuel*, as like as *Bete Mariam* design principles, lay on Icosahedron platonic solid top plan, which forms the pentagram floor plan and elevation plans.

7. The design of *Bete Ghiorgis* is based on the principles of star tetrahedron inscribed with in Metatron Cube (15m*15m*15m). The church of *Bete Giorgis* is a nearly perfect cube, hewn in the shape of a cross, and is oriented so that the main entrance is in the west and the holy of holies in the east.

8. In general the floor plans of the churches and their elevation are based on the same principles and proportions, sacred geometry; this is gives us the well visualized and pre designed of the churches.

9. The similarity and original principles of churches are still very much interesting. For convenience, let us consider the visual similarity of shapes. *Bete Mariam* and *Bete Amanuel* have almost similar shape except that of *Bete Mariam* is with trapezoidal courtyard and *Bete Amanuel* is with quadrilateral. If we consider the other two *Bete Medehanealem* and *Bete Ghiorgis*, we can say that they have shapes, rectangular and crossed square shaped. The *Bete Medhanealem* building is rectangular; while *Bete Ghiorghis, Bete Amanuel* and *Bete Mariam* are cross shaped.

10. There are two basic types at *Lalibela*: rock-hewn cave churches which are cut inward from more or less vertical cliff faces and rock-hewn monolithic churches which imitate a built-up structure but are actually cut in one piece from the surrounding rock and separated from it by an encircling trench.

11. The construction of the churches is based on stair formation methods which is the most efficient and systematic ways of excavation. And, it is the best way of hauling the excavated materials out of the courtyard area.

12. The possible method of construction was for craftsman to first form stairs and sequential sink trenches directly into the base, then to slowly chisel away excess stone to reveal exterior spaces and climbing up by forming the reverse upward stair inclination to form cavity for the interior spaces.

13. All blueprints for the churches, which used as drawings, are all sculptured on these immovable heritages (crosses and sculptured wooden).

6.2. Recommendations

1. The Archaeological investigation of the area is highly recommended, for the tunnels in which their destination is unknown and covered areas due to sedimentation. This finding will provide the scope of the study area and probably the destination of the tunnels may tell us further the intention of the constructors.

2. The geological investigation of the area is great important for understanding its former site selection art and for its conservation activities.

3. In the shortage of documents for the churches construction ways in the country, close studies of the movable and is of great importance. Detail assessments on these immovable heritages will assuredly increase the originality of the arts and intention of the constructors.

4. The historical comparative studies of these churches have the power to reveal the period of construction and history of developments in rock churches of the country.

5. Studying the drainage system and channels of the churches area reveals the advancement of their construction methods and highly pre-considerations and futurity of the area.

6. Studying engineering rock properties may give a direction on its load bearing capacity of the structural elements.

7. Well coordinated and cooperated study of the detailed surveying, may be areal surveying, gives the exact site plan and arrangements of the groups.

8. Studying the symbols involved everywhere on the churches wall, ceilings and columns reveals their messages and intentions which the constructors want to transfer.

9. The ever twinkle light at *Bete Abba Libanos* needs astronomical investigations.

10. Why the columns at *Bete Mariam (Amde Berhan)* and *Bete Gholgota* covered, may needs detail investigation which may tell us the ways of its construction and further.

11. The iconography study of the pictures may give us the pigments used during that time and their durability and painted time.

On Conservation Activities

12. The management plan needs to identify objectives and a long-term vision for the site based on stakeholder participation and interdisciplinary collaboration. Furthermore, it needs to strike a balance between conservation, access, local community interests and sustainable economic use, while ensuring preservation of the outstanding universal value as the primary objective.

13. Different framework plans are required to ensure sustainable development in *Lalibela*. A sustainable heritage framework will cover conservation actions relating to the rock-hewn churches, the historic traditional houses, movable objects, policies to safeguard intangible heritage and the landscape setting.

14. A sustainable tourism and visitor framework is required to control visitor flows, traffic and congestion, finding new methods of financing heritage and ensuring high quality experiences. An environmental framework plan is necessary to come to terms with environmental degradation, waste management and water policy.

15. A local community framework plan must ensure local participation in decisions concerning the world heritage site and in the benefits of tourism. The development of traditional handicrafts activities has proved a particularly important resource for cultural and economic development.

16. Well studying the structural arrangements and understanding of the architectural principles gives a direction for the conservation activities. Rumours arising on the previous conservations are emanating from less consideration of the architectural values and understanding of the art principles. Though, the local people believe that whether it is conserved or not the churches will ever last till lasting the world.

17. Standards as for new construction and also for conservation activities are mandatory, because as in our country there are monuments, buildings and palaces which are keeping for conservation.

BIBLIOGRAPHY

Published Materials

1. Aidan Dodson.1999.Egyptian Rock-Cut Tombs. Shire Publications.
2. Alvarez F., 1970. Narrative of the Portuguese Embassy to Abyssinia during the year 1520-1527 by Lord Stanely, Burt Franklin, New York.
3. Andrew E. Samuel, John Weir, Elsevier 1999. Introduction to Engineering Design: Modelling, Synthesis and Problem Solving Strategies; Page 3-5
4. Andrzej Piotrowski, 2011. Architecture of Thought, U of Minnesota Press, p.23
5. Angelini Sandro, 1967, Lalibela Phase-I, Conservation Action Plan Report, IMF Inc.
6. Anfray, 1990.The Ancient Ethiopians. Paris, Armand Colin.
7. Asfawossen Asrat, Yodit Ayalew and Metasebia Demissie. 2008. Geological and Geotechnical Properties of the Medieval Rock-hewn Churches of *Lalibela*, Northern Ethiopia: Implication on their Deterioration and Conservation. Paper read at the International Conference of Pale anthropology, Palaeontology and Archaeology in Ethiopia.
8. Asher Catherine B.,1992. Aurangzeb and the Islamization of the Mughal style. Architecture of Mughal India. Cambridge University Press. P.256. ISBN.
9. Barnes, Bernadine.2008. "Art."Microsoft Student [DVD]. Redmond, WA: Microsoft Corporation.
10. Baye Felleke, 2003 EC. *Lalibela*: A General Survey of the Rock Churches. Alem Printers. Ethiopia, Addis Ababa.
11. Bidder, I. 1958. *Lalibela:* The Monolithic Churches of Ethiopia (Translated by Rita Grabham-Hortmann. M. Du Schauberg, Cologne.
12. Buxton D.1947. The Christian Antiquities of Northern Ethiopia, printed by Charles Batey for the Society of Antiquities, London, Oxford.

    _____.1964. Ethiopian Medieval Architecture: The Present State of Studies: Journal of Semitic Studies, Vol.IX.No.1.

    _____.1971. The Rock-Hewn and Other Medieval Churches of Tigre Province, Ethiopia. Printed from Archaelogia Vol.CIII.

13. Buxton, D. and Matthews, D. 1974. The reconstruction of Vanished Aksumite Buildings. From Rassegna di studi Etiopici, Roma; V. xxv, pp. 55-77.

14. Ching, Francis D.K., 2012. A Visual Dictionary of Architecture (2nd Edition,). John Wiley and Sons, Inc.p.6.ISBN 978-0-470-64885-8

15. Crummey D., 2000. Land and society in Christian Kingdom of Ethiopia, from the 13th – 20th c. Urbana: university of Illinois Press.

16. Delmonaco, G., Margottini C. and Spizzichino D. 2010. Weathering processes, Structural Degradation and Slope-Structure Stability of Rock-hewn Churches of *Lalibela* (Ethiopia).

17. Dragados, 2003. Proceedings of the First International Congress on Construction History, Madrid, 20th-24th January 2003, ed. S. Huerta, Madrid: I. Juan de Herrera, SEdHC, ETSAM, A. E. Benvenuto, COAM, F.

18. Drunvalo Melkchizedek, 1985-1994. The Ancient Secretes of the Flower of Life, Volume I and II. Light Technology Publishing.

19. Dorrie, Heinrich, 1965. 100 Great Problems of Elementary Mathematics, Dover Publication. 379-380.

20. Elene Negussie (Dr.), Oct. 2010.Conserving the Rock-Hewn Churches of Lalibela as a World Heritage Site: a case for international support and local participation. /ICOMOS Scientific Symposium/ Dublin, Ireland.

21. Finneran, N. 2007. The Archaeology of Ethiopia. London, Routledge.

22. Findlay, L. 1943. The Monolithic Churches of *Lalibela* in Ethiopia. Cairo.

23. Friedrich R.2003. Traditional Domestic Architecture of the Arab Region.

24. Gerster, G. 1970. Churches in Rock; Early Christian Art in Ethiopia. London, Phaidon press Ltd.

25. Ghelawdewos Araia. The Magnificence of Aksum: Revisiting Ethiopian Civilization.

26. Gui-Rong Liu,2003, Mesh Free Methods: Moving Beyond the Finite Element Method, CRC Press.

27. Heldman, M and Munro-Hay, S. 1993. African Zion: the sacred art of Ethiopia. New haven and London: Yale University press.

28. Hillenbrand, R.2008Masdjid. I. In the central Islamic lands. In P.J. Bearman, Th. Bianquis, C.E. Bosworth, E. van Donzel and W.P. Heinrichs. Encyclopaedia of Islam online. Brill Academic Publisher. ISSN 1573-3912.

29. Ital. J. Geosci. 2012, Integrated geological-architectural pilot study of the Bete Gabriel-Rufael rock hewn church in *Lalibela*, northern Ethiopia, (Boll. Soc. Geol. It.), Vol. 131, No. 2© Società Geologica Italiana, Roma.

30. Jean-Pierre Luminet, 2000. Dodecahedral Space Topology as an Explanation for weak wide-angle temperature correlations in the cosmic microwave background nature.

31. Kazmin, V. 1975. Explanation of the geological map of Ethiopia. The provisional Military Government of Socialist Ethiopia; Ministry of mines, energy and water resources geological survey of Ethiopia, bulletin no. 1

32. Lepage, C. and Mercier, J. 2005. Ethiopian Art: The Ancient Churches of Tigrai. Editions Recherche sur les Civilizations, Paris.

33. Lindahl, B. 1970. Architectural History of Ethiopia in Pictures. The Ethio-Swedish Institute of Building Technology, Addis Ababa.

34. Livio, Mario, 2002. The Golden Ratio: The Story of Phi, the World's Most Astonishing Number. New York: Broadway Books

35. Marcos Daoud and Blatta Marsie Hazen. 1959. The Liturgy of Ethiopian church. Ethiopian Orthodox Church Kingston, Jamaica.

36. Mengistu Gobezie, Jan. 2012. Lalibela: A Museum of Living Rocks. Addis Ababa.

37. Merla, G., Abbate, E., Augusto, A., Piero, B., Paolo, C., Milvio, F., Mario, S. and Paolo, T. 1979. *A* Geological Map of Ethiopia and Somalia. Consiglo Nazionale delle Ricerche, Italy.

38. Microsoft Student With Encarta Premium, 2008.DVD.

39. Michael E. DeSanctis. 2002. Building from Belief: Advance, Retreat, and Compromise in the Remaking of Catholic Church Architecture. Liturgical Press. ISBN

40. M. Rababeh, Shaher Rababeh, 2005.How Petra was Built: an Analysis of the Construction Techniques of the Nabataean Freestanding Buildings and Rock-cut Monuments in Petra, Jordan Oxford, England: Archaeo press.

41. Mount Holyoke College, 2014. The Art of Cathedrals: Stresses in barrel vaulted design". Mtholyoke.edu.

42. Munro-Hay, S.1991. Aksum: An African Civilization of Late Antiquity. Edinburgh University Press, Edinburgh.

43. Pankhurst, R. 1990. A Social History of Ethiopia: Northern and central Highlands from Early Medieval Times to Rise of Emperor Tewdros II. St Edmundsbury Press, Bury St Edmunds, Suffolk, England.

44. Philip Briggs, 2002. Ethiopia: The Bradt Travel Guide, Chalfont St. Peters, Bradt. 5th Edition.

45. Phillipson, D. 1998. Ancient Ethiopia, Axum: its Antecedents and Successors. British Museum Press, London.

_____.2009. Ancient Churches of Ethiopia; fourth-Fourteenth Centuries. Yale University, New Haven and London.

46. Richard Kieckhefer, 2004. Theology in Stone: Church Architecture from Byzantium to Berkeley. Oxford University Press, USA. ISBN

47. S. Nagaraju, 1981. Buddhist Architecture of Western India, c. 250 BC-AD 300. Agam Kala, Prakashan.

48. Sergew Hable Sellasie. 1972. Ancient and Medieval history of Ethiopia to 1270. United Pinter Addis Ababa.

49. Terpin Associati, 2001. *Lalibela*: Detailed Design Study of Shelters; Project No 7 ET 106- Design Report Section, Geotechnical design Report.

50. Tadesse Tamirat. 1972. Church and State in Ethiopia; 1270-1527. The Clarendon Press, Oxford.

51. Trimingham, J. S. 1952. Islam in Ethiopia. Oxford University Press; Geoffrey Cumberlege publisher.

52. Vidya Dehejia, 1972. *Early Buddhist Rock Temples; a Chronology.* Cornell University Press.

53. Vocabulary of Islamic Architecture, 2006. Massachusetts Institute of Technology. Archived from the original on 2005-11-24. Retrieved 2006-04-09.

54. Ward-Perkins, J. B., 1994. Studies in Roman and Early Christian Architecture. London.

55. Wiley, Francis Ching, Mark Jarzombek, Vikramaditya Prakah, 2006. A Global History of Architecture.

56. Zemedkun Bekelle, 2000. History of Sacred Monasteries in Ethiopia (in Amharic). Addis Ababa.

57.ብርሃነ መስቀል ደስታ፤ 1958ዓ.ም. ዜና ላልይበላል፡ አዲስ አበባ፡፡

58.ጥላሁን ታደሰ በነበሩ፤ህዳር 2010 እ.አ.አ.፤ ንጉስ ወ ካህን ላሊበላ፤ አዲስ አበባ፡፡

Unpublished Materials

1. Barnes, Bernadine, 2008. "Art." Microsoft Student [DVD]. Redmond, WA: Microsoft Corporation.
2. Mark Jarzombek (Prof), 2009. *Lalibela* and *Libanos*: The King of Hydro-Engineer of 13th Century Ethiopia, School of Architecture and Planning. Massachusetts Institute of Technology, Cambridge. England.
3. Mengistu Gobezie. 2004. The Rock churches in and around *Lalibela*: Archaeological and Geological study. MA Thesis Department of Archaeology and Management, Addis Ababa University.
4. Natnael Ketema, July, 2012. Archaeological Study of Rock Churches in Lasta, Northern Wollo. MA Thesis, Department of Archaeology and Heritage Management, Addis Ababa University.
5. Tibebu Assefa, August, 2007. Proportion: The Visual Dimension of Urban Design in the case of the four Monolithic Rock Hewen Churches of Lalibela. MSc Thesis, Department of Urban and Regional Planning, Addis Ababa University.

Web Source: -

- http://www.africanworldheritagesites.org/cultural-places/ancient-ethiopia/lalibela.html
- http://wwwgohistoric.com/places/rock-cut-churches-lalibela/photos
- http://www.Google.com/search=Rock ChurchesLalibela,UNESCO,WHC.
- http://www.en.wikipedia.org/wiki/Lalibela
- http://www.sacred-destinations.com/ethiopia/lalibela
- http://www.World-Mysteries.com/Sacred geometry/ Flower of Life/ the secret to how Universe works lies within the geometric pattern. What is the flower of life?
- http://www.stpetersbasilica.org/wiki/Lalibela
- http://www.whc.unesco.org/en/list/18
- www.google.Com/roadtoEthiopia-Date;Dec.18,2013. @3.30am
- www.Peo.on.Ca/Publications/guidelinespracticebulletinz.pdf.Date, march,20,2014.@2.00pm