

ORION
SCHOLAR JOURNALS



(REVIEW ARTICLE)



Significance of mathematics and geometry-formation of temples in India: The golden era of evolution

Santoshi Misra * and Sirisha David

St. Ann's College for Women, Mehdiapatnam, Hyderabad, Telangana, India.

International Journal of Engineering Research Updates, 2021, 01(01), 050–055

Publication history: Received on 10 March 2021; revised on 12 April 2021; accepted on 15 April 2021

Article DOI: <https://doi.org/10.53430/ijeru.2021.1.1.0056>

Abstract

Temples are a rich source of powerhouse filled with magnificent effects of acquiring peace and divine knowledge in understanding the oneness of creation and the creator. The entire cosmos reflects in knowing the supreme intelligence of the creator residing in the thoughtful minds of the humankind. Temples in India have always been an epitome of our enriching culture, heritage and ancient history carved beautifully on the walls and ceilings in imparting the principles of glorifying life led during the past which needs to be carried to the future generations. Mathematics has always been at the forefront going hand in hand with temple architecture giving it perfect shape and geometry for the holistic development of society. The present article is an attempt to focus on the geometry involved in the construction of ancient temples which served the purpose of providing the techniques and methods in knowing the divine power spread infinitely among the cosmos. Modernization of humankind globally has been evolving massively in terms of technology, comfort and wealth but is subjected to mental stress, trauma, and depressive life. Keeping in tune with nature and cosmos helps in becoming one with the supreme power. Modern temples being constructed today with archeology need to look at the mastery of mathematics and art with which the ancient temples were built.

Keywords: Mathematics; Geometry; Indian Temples; History; Architecture

1. Introduction

The branch of mathematics dealing with shapes, lines, curves, surfaces (2D, 3D Figures) etc., is termed as geometry derived from Greek words: geo-earth and metrein-measure. The ancient era to modern science records numerous sculptures, monuments, artifacts etc., showcasing stupendous works of people with immense knowledge in geometry discovering several concepts which helped the current generation evolve themselves in terms of skills to enhance their geometrical knowledge in understanding the ancient history and its significance for future growth. Geometry and geometrical figures surround us every day. The urge to measure shapes led to the discovery of geometry. The buildings which include schools, colleges, universities, offices, commercial complexes, homes etc., have the foundation of shapes, lines, dimensions, and points. Geometry is used by NASA and Astro science departments to study planets, stars, area, and surface of outer space etc., which are again examples of shapes.

Egyptians used basic geometry in 2900 BC, to build pyramids having a square bottom with four triangular faces, Pythagoras amazed the world with his geometrical facts and figures in proving that the interior angles of a triangle would add up to 180 degrees and later the famous Pythagorean theorem was discovered which states that “The sum of the squares of the lengths of each of the triangle’s legs is the same as the square of the length of the triangle’s hypotenuse.” This property has many applications in science, art, engineering, and architecture. Some other famous Greeks that helped in the development of geometry are Syracuse and Rene Descartes. Syracuse discovered the

* Corresponding author: Santoshi Misra
St. Ann's College for Women, Mehdiapatnam, Hyderabad, Telangana, India.

volume of spheres and cylinders and analysis of a circular area. Rene Descartes put geometry and algebra together which led to the section of geometry known as coordinate geometry. Thales of Miletus is the first Greek philosopher to use deductive reasoning to prove mathematical relationships. In 1100 BC, the Chinese discovered aspects of mathematics that are continued to be used today, such as the number systems and concepts of algebra and geometry.

Indian culture being enormously sacred and divine, used geometry as part of their culture in the construction of temples as ancient Indian mathematicians were very skillful in geometry. The alters were created and constructed to honor the divine with immense affection and gratitude. The Sulba Sutras, written from around 800 BC to 200 BC, are instructions on how to construct these altars. The people of the Hindu faith want to make their Gods happy and proud. To do so, they followed the instructions of the Sulba Sutras very carefully, so mathematical veracity was of high importance. The Sulba Sutras do not provide any proof, unlike Euclid and The Elements. In the Sulba Sutras, instructions on how to construct circles, squares, rectangles, and triangles for their altars were the unknown beginnings of the use of geometry. They did however include ideas such as constructing a square of area equal to a given rectangle. However, the biggest connection to geometry included in the Sulba Sutras was its instructions on ropes measuring the altars. The rope which is stretched along the length of the diagonal of a rectangle produces an area which the vertical and horizontal sides make together which is almost identical to the Pythagorean Theorem.

Ancient Indians have used the knowledge of geometry in other disciplines deriving comprehensive conclusions which can be found in old scriptures. The concept of progression following a particular pattern becomes a rule which in modern terms is understood as iteration, repetition etc., with an illusion based productive outcome. Indians understood this beautiful illusion by repeated practice by applying their knowledge and skills in arts, crafts, and applied science. They worshipped nature in several forms and were enthusiastic to reveal the mystery of creation. They understood that the creation is an outpour of principles relative to self-similarity, iteration and repetition while observing the same in mountains, trees, water, everything around them. They gave their tribute as a form of temple to the ultimate creator by following the principles of his creation. The discussions below are a small trial to reveal those processes in which the ancient builders incorporated the basic principles of fractal geometry i.e., self-similarity, repetition, and iteration in the making of Indian temples.

2. Fractal Geometry and its Significance in the architecture design

The term 'Fractal' comes from the Latin word 'Fractus' which means 'broken'. Fractal means, the recursive geometrical forms, bearing self-similarity on different scales. According to the Fractal Foundation – "A fractal is a never-ending pattern. Fractals are infinitely complex patterns that are self-similar across different scales. They are created by repeating a simple process repeatedly in an ongoing feedback loop. Driven by recursion, fractals are images of dynamic systems – the pictures of Chaos. Geometrically, they exist in between our familiar dimensions as mentioned by Bovill C. [1]. Fractal patterns are extremely familiar since nature is full of fractals. For instance: trees, rivers, coastlines, mountains, clouds, seashells, hurricanes, etc.

Abstract fractals – such as the Mandelbrot Set – can be generated by a computer calculating a simple equation over and over." Benoît B. Mandelbrot (20 November 1924 – 14 October 2010) was a Polish-born, French, and American mathematician, who first compiled all the research and ideas of hundreds of years about self-similarity and coined the term 'Fractal'. Fractal geometry has different roles in different sectors. In Architecture, it acts as a mode of expression to reveal the beauty of the complexity. It gives wings to the ideas of an architect and reflects the process of energy flow of the universe through buildings and monuments. Hindu temples are one of the best examples of buildings with the fractal phenomenon, which were constructed in the past, long before the evolution of Fractal Theory using the concept of self-similarity which forms the basic principles of organization in the Hindu Temple Architecture given by Datta S. [2]. The Hindu Temple is designed and constructed as miniature forms of the Cosmos as envisioned in Hindu philosophy and beliefs as expressed by Robert L. Devaney [3].

3. Fractals and Temple Designs

The evolution of the ancient Indian temples is very vast from the time of cave temples to the modern era complex designs and structures following a pattern of experimentation and implementation. Over a period, temple architecture has taken a sophisticated look with complex patterns which showcases the extreme involvement and intelligence of the architectures. As a result, the temple construction took over a serious outlook with an inherent sense of fractal geometry show cased by Dutta T. [4].

4. Geometry and its application

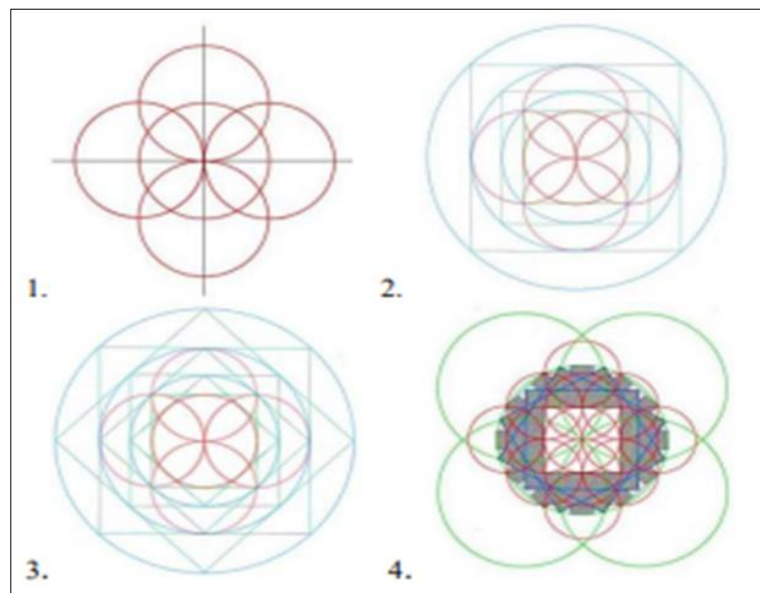
In Hindu thought, number is considered an expression of the structure of the universe and a means of effecting the interplay between the universe and Human life given by Eliade Mircea [5]. When numbers are given shape and form, geometry comes into play. To be able to impart the symbolic meanings to the mind of the observer through the eyes and brain, there was a need to establish a certain geometry which will attract the eyes and arouse the brain. To be able to convey these meanings through form, a strong relationship had to be developed between form and meanings in a decipherable language conveyed by Goldberger AL [6]. This relationship that develops between forms and their meanings within the Hindu temple is essential to its function which is done using fractals which can be visualized by Adam Hardy [7].

4.1 Vastupurusha mandala

The basic plan form of any temple is built upon the *Vastupurushamandala*, which is a square, representing the earth symbolizing order and completeness of the endless life in a profound manner. In the foundation of any Hindu temple, cosmos is embodied by laying down the diagram of Vastupurushamandala on a selected ground. This divine diagram reflects the image of cosmos through its fractal qualities. The Mandala can be considered an ideogram, while the temple is the material manifestation of the concepts it embodies. The Vastupurusha is a key concept in Hindu temple architecture. The plan of the Hindu temple strictly follows the principles described in Puranas related to the Vastupurushamandala.

4.2 Temple Geometry

In Hindu temple architecture, geometry always plays a vital and enigmatic role. The geometry of a plan starts with a line, forming an angle, evolving a triangle, then a square and distinctly a circle and so on, ultimately deriving complex forms. As per the previous discussion, the occurrence of complexity, results into self-similarity and further it leads to the occurrence of fractal geometry. Geometry is a disciplined field, and the fractals follow it. Both have definite paths of action, which was expressed by Dhrubajyoti Sardar, S. Y. Kulkarni [8]. In following diagrams as shown below, the role of fractal theory in basic geometry of Hindu temple plans is exhibited.



1. Basic Diagram; Figure 2. Generating nested squares and circles; Figure 3. Showing diagonal square; Figure 4. Generation of plan forms

Figure 1 The role of fractal theory

4.3 Vinayasutra-Layout and Orientation

In Sanskrit 'Vinyaasa' means orientation and 'sutra' means thread, line, or axis. It is related with the lay out and orientation of temple plans. Vastupurushamandala is the base of evolution of a temple plan. Vinyasasutra comes into play after the initial evolution of the temple plan. During the determination of the axis and orientation of the temple and its surroundings, ancient architects used to follow the process described in Hindu scripts like Vastushashtra, Manasara etc. However, all the plans followed geometries with fractal character.

4.4 Temple Complex

The design of the temple complex varies according to the style of the temple. Most of the temples in North India do not have a boundary wall. However, in the South Indian style, it is an essential design element of the temple complex. In some areas, the entire temple complex consists of only the Mulaprasada. To the trained eye, the miniature fractals of the main shrine stand out in a well-designed temple complex. All the elements including the Toranas, Gopurams, miniature shrines, Pushkarinis etc. either have been repeated in a disciplined order or have been constructed following the rules of fractal theory.

4.5 Evolution of plans through iteration

In keeping with the site plan, the plan of the main temple structure also follows the rule of fractals. At the very beginning, the steps are the simplest form of fractals from which the halls or mandapas grow expansively. First, the Mukhamandapa or the hall of entrance and then the Ardhmandapa, the half-heighted hall and finally the Maha Mandapa, the grand hall is positioned. After the mandapas, comes the Mulaprasada, which encloses the Garbhagriha, the inner sanctum. The enclosures of these halls and the spaces gradually take the shape following the fractal theory. The basic plan form also followed the iteration and gradually became more complex from a simple quadrangle or square plan. It follows the repetition in recesses or in projections.

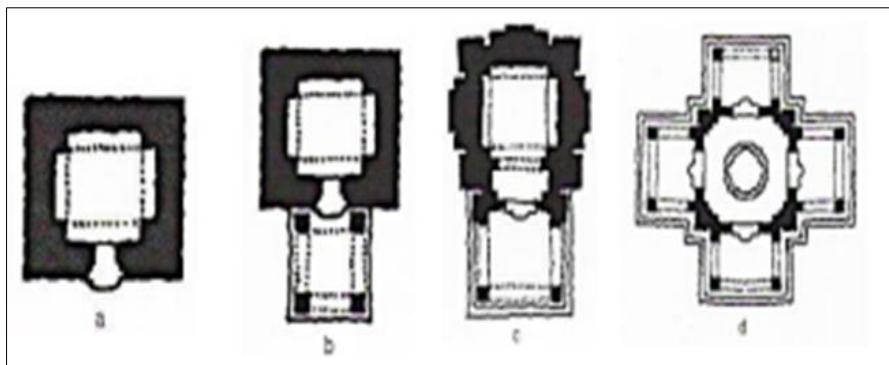


Figure 2 a. Shrine alone, Figure 2b. Shrine with porch (a covered shelter projected in front of the shrine), Figure c. Shrine with Antarala (vestibule or intermediate chamber which connects the main sanctuary and the pillared hall of the temple) and porch, Figure d. Sarvatobhadra shrine with four entrances

4.6 Integration of the concepts with an example showcasing Telangana temple architecture

The most remarkable aspect of the relationship of fractal geometry and Hindu temple architecture is that, not only does the physical manifestation of a Hindu temple confirm to the geometry of fractals, but also the theory behind fractal geometry, i.e., the fractal concept is parallel to the concept and idea of temple and its philosophy. The parameters of replication in multiple iterations, self-similarity, dynamics, and complexity at varying scales are the ones that render Hindu temples fractal-friendly, therefore, forming the base for fractal analysis in the Hindu temple. The *Vastu Purush Mandala*, geometrical basis of the Hindu Temple plan, is the result of fractal iterations. As an example of temple architecture, Ramappa temple, thousand pillar temple and Jogulamba temple are taken for further study and findings.

4.7 Ramappa Temple

Ramappa Temple is a 13th-century engineering marvel, named after its architect – Ramappa. The Ramappa Temple showcases the outstanding craftsmanship of the great Kakatiya dynasty. Also known as the Rudreswara Temple (built by Kakatiyas) of Telangana it has been selected as a World Heritage Site by the United Nations Educational, Scientific and Cultural Organization (UNESCO). Located in the village of palampet in Telangana state, Ramappa temple is also known as Ramalingeswara temple. It is a walled complex built around 1213 AD. during the Kakatiya period by a Kakatiya general Recharla Rudra under Ganapati Deva. The temple is dedicated to Lord Shiva, where Lord Ramalingeswara is worshipped.

4.8 Features of the temple

- The structure is of the pyramidal type, consisting of four storeys
- Decorated beams and pillars of carved granite and dolerite

- Distinctive and pyramidal Vimana (horizontally stepped tower) made of lightweight porous bricks called floating bricks that reduced the weight of the roof structures.
- The temple's sculptures are of high artistic quality and illustrate regional dance customs and the culture of Kakatiyas.
- The temple is known for the bracket figures which spring from outer pillars and are shown as supporting the roof projections.
- The temple falls under the protection of the Kakatiya Heritage Trust (KHT), which has been pushing it for the World Heritage tag since 2012.

4.9 Thousand Pillar Temple

The Thousand Pillar Temple or Rudreswara Swamy Temple is a historic Hindu temple located in the town of Hanumakonda, Telangana state dedicated to lord shiva, Vishnu and surya. Rudreswara Temple locally known as Veyisthambala Gudi (Thousand pillars temple) is one of the fine and earliest available examples of Kakatiya art, architecture, and sculpture. It was built by Rudra Deva and named after him as Sri Rudreswara Swamy temple with the presiding deity as Rudreswara, in 1163 AD in the style of later Chalukyan and early Kakatiyan Architecture, star-shaped and triple shrined (Trikutalaya). The temple is a fine specimen of architecture and sculpture with One thousand pillars. There are richly carved pillars, perforated screens, exquisite icons, rock cut elephants and the monolithic dolerite Nandi as components of the temple. Strengthening of foundations like sandbox technique, the skill of Kakatiya sculptors is manifest in adroit craftsmanship and flawless ivory carving technique in their art. The ingenuity of Kakatiya sculptors is visible in likes of lathe turned, and shiny polish in dolerite and granite stone sculpture and craftwork of Nava Rangamandapa.

4.10 Jogulamba Temple

Alampur is a sleepy town situated on the banks of Tungabhadra River, in the state of Telangana. Alampur is considered as the western gateway of Srisailam. Here the marvelous temple and remains of some ancient temples signify Badami Chalukyan architecture. The region was ruled by many South Indian dynasties. The principal deities at the Jogulamba temple are Jogulamba and Balabrahmeshwara. Goddess Jogulamba is considered the 5th Shakti Peetha among 18 shakti peetams in the country.

5. Conclusion

The need to relate all these streams of thought and study is to be able to demonstrate that even though the integrated whole doesn't form a part of imparted knowledge of a person, the concept and idea manifested, does impact the human mind in the way discussed above. This fact is due to the philosophical connotations of the various strategies and tactics employed in its construction, which meets not only the human eyes but the intellect and touches it deeply.

This paper, therefore, attempts to provide a point of view for the reader and observer, by integrating various streams of thought and presenting a new perspective. It is advocated that the primitive, but beautifully complex, and satisfying form of these temples has been arrived at; not using complex computer algorithms, generative of structures; but by intuitive processes, giving a fair idea of human intrinsic affiliations, satisfying intellectual needs. It is estimated that, had fractal geometry not been used in the physical manifestation of the temple philosophy, it would have been difficult to impart the knowledge intended by temple construction. The implementation of fractal geometry ensures that the underlying structure resemble the structure found in nature and hence provides the temple with its aesthetic appeal. It has been noticed that, not only does the physical manifestation follow the principles of fractal geometry, but also the idea of construction, i.e., the concept of the temple and its philosophy, is akin to the concept of fractal geometry and fractal progression. The use of fractal geometry in the construction and design of temples is evident, but the question raised here is, 'why?'. This can be answered by analyzing the cosmological and philosophical requirements the temple structure aims to fulfil symbolically, alongside the theory of fractals. The article manifests an interdisciplinary approach which can be further broadened with detailed focus and study for the benefit of society and nation.

Compliance with ethical standards

Acknowledgments

The authors wish to thank Principal, St. Ann's College for women in providing us an opportunity to explore with innovative research carried out in the completion of the article. We would also place on record our family members who have always been supportive and encouraging in the due course of research work.

Disclosure of conflict of interest

There was no clash between the authors, as they worked harmoniously without any conflict or disturbance during the research work.

References

- [1] Bovill, C. Introduction. In: Fractal Geometry in Architecture and Design. Design Science Collection. Birkhäuser, Boston, MA. https://doi.org/10.1007/978-1-4612-0843-3_1 1996.
- [2] Datta, S. Infinite Sequences in the Constructive Geometry of Tenth-Century Hindu Temple Superstructures. *Nexus Netw J* **12**, 471–483 (2010). <https://doi.org/10.1007/s00004-010-0038-0> 2010.
- [3] Robert L. Devaney. (Boston University) A First Course in Chaotic Dynamical Systems: Theory and Experiment. April 2020, <http://dx.doi.org/10.1201/9780429280665>, ISBN: 9780429280665 2020.
- [4] Dutta T. Iconography and t\Temple Architecture. (P. U. Gadkari, Ed.) Architecture Time Space & People. May 2013; 13(5): 32-39, 2013.
- [5] Eliade Mircea. Symbolism, the Sacred and the Arts. Edited by Diane Apostolos-Cappadona. New York: Crossroad Publishing Co., The Journal of Religion: Volume 66, Number 4, Oct.,1986, DOI: <https://doi.org/10.1086/487471> 1986.
- [6] Goldberger AL. Fractals and the birth of gothic: Reflections on the biologic basis of creativity. *Modular Psychiatry*. 1996; 99-104. <http://www.researchgate.net/publication/14100651> Impact Factor: 15.15 · Source: PubMed, 1996
- [7] Adam Hardy. The Temple Architecture of India. England: John Wiley & Sons Ltd. 2007, The Journal of the American Oriental Society, July 1, 2008, [https://www.thefreelibrary.com/The Temple Architecture of India. -a0208288510](https://www.thefreelibrary.com/The+Temple+Architecture+of+India.-a0208288510), 2008
- [8] Dhruvajyoti Sardar, S. Y. Kulkarni: Role of Fractal Geometry in Indian Hindu Temple Architecture, Volume 04, Issue 05, DOI: <http://dx.doi.org/10.17577/IJERTV4IS050709>, ISSN: 2278-0181, IJERT May 2015.