



A MATHEMATICAL REVIEW OF AN ANCIENT INDIAN TEMPLE ARCHITECTURE: A CASE STUDY

Dr. Payel Ghosh, Assistant Professor, Department of Mathematics, Raidighi College, Raidighi, South 24 Parganas, Zip-743383, West Bengal, India

Abstract: *The Hindu tradition of temple construction created a rich legacy of temples spread across India. The architectural form of every temple reflects ongoing constructive and philosophical experimentation based on approved sacred texts. Even, the Islamic architectures also follow their standard format. This paper works over the practice of the knowledge in the constructive geometry of temple framework. There are several specific structures of temples, monuments in India depending on different culture and religion. This paper aims to find out the similarity of an ancient Hindu temple with specific regional temple architecture and tries to predict great bonding between architecture and mathematics.*

Keywords: Hindu temple; Orissa style; Mathematics in architecture; Geometry & proportion.

Introduction: Mathematics was considered as one of the highest sciences in ancient India. Indian mathematicians made great historical achievements in several fields of number system be it the invention of zero or Vedic mathematics. We can see the use of mathematics from Harappan civilization (2500 B.C.) when several scales for the measurement of length, weight were discovered during excavations. We know that from ancient time, Indian minds fascinated with higher numbers. We know that how prince Gautama Buddha correctly recited the counting beyond the koti on the centesimal scale: Hundred kotis are called ayuta, hundred ayutas niyuata, hundred niyutas kankara, hundred kankaras vivara, hundred vivaras ksobhya, hundred ksobhyas vivaha, hundred vivahas ustanga, hundred ustangas babula, hundred babulas nagabala, hundred nagabalas tithi lambha and so on upto another twelve terms ending with tallaksana [1]. The 1st-millennium-BCE *Sulbasutras* (“Cord-Rules”) which is collections of brief prose sentences prescribing techniques for constructing the brick fire altars gives idea of mathematical activity of that era. The knowledge of geometric fundamentals such as the Pythagorean theorem, values for the ratio of the circumference of a circle to its diameter (i.e., π), and values for the ratio of the diagonal of a square to its side (Square root of $\sqrt{2}$) can be believed at Vedic context [2]. Stephen Knapp [3] has written in his book “Advancements of Ancient India’s Vedic Culture”, the development of mathematics starting from the inception of numerical system to vedic mathematics, advanced algebra to geometry and also described the Shulba Sutras that recorded the basis of these geometrical formulas used for the Vedic temples and altars. The Sutras explain the technique to make a square of the same area as that of a triangle, a circle of the same area as that of a square and make a circle double, triple or one third of the area of a square. In an another Sutra, it is explained that how the area of a square can be produced by the length and breadth of a rectangle together equal the area of the square produced by the diagonal, which is later known as Pythagoras theorem.

The application of mathematics was there from ancient period. Standardized weighting system, measurement of length during Mohenjo-Daro civilization, design of wheel of bullock cart during Harappa civilization, discovery of cause of lunar and solar eclipses, record time and formulate calendars are some of the applications of mathematics in daily life of ancient civilization. We can see the application of mathematics in building palaces, monuments of ancient Indian civilization. In this paper



we will describe how the mathematics i.e. geometrical formulas used in making temples of ancient India. There are several articles and papers which describes the architecture of different temples and monuments of India using mathematics. Dokras et.al. described mathematics in Borobudur Temple design in their book [4]. Partha Sarathi Mishra has chosen Orissan temple's architecture [5], Muzaffar Ali et. al. discussed different mathematical methods and justified them with applications in Hindu temples Parthenon and Pyramid etc. [6] There are many more mathematical studies on the architecture of Indian monuments and ancient temples.

Case study on an ancient temple:

Ancient Indian architecture used several mathematical calculations and design principles to give a particular shape of temples and historic monuments according to socio-economic culture of different regions of the country. One of those ancient temples in eastern part of India is Jatar Deul which was structured on about 1000 AD. Today Jatar Deul is an ISI protected heritage structure because of its historical background. English surveyor Renel (1764-77) first spotted this structure within a deep forest during the river route survey of lower part of the Ganges.[7] Intensive survey of Mr. Kalidas Dutta in 1930 tells that a copper plate was found during deforestation of deep forest of Sundarban that tells its erection in the year 897 of the Bengali Sak era corresponding to A.D. 975 by Raja Jayanta Chandra Chandra. The architecture of it was a bit confusing to the researcher to understand whether it is temple or watch tower. Satishchandra Mitra described this structure as watch tower in his book Jassore-Khulnar Itihas [8] while Kashinath Dikshit described it as a mughal period architecture. However, later on he described it as Orya temple architecture back to days of lingaraj and konark.

Fig1. Front and side view of Jatar Deul (source [7])



The term temple is derived from the Latin word 'Tempulum' that denotes a square or a rectangular place for the purpose of worship. The silpa text of Odisha mentions three types of temples, rekha deul, pidha deul and khakara deul [9]. According to its shape, Jatar Deul imitates the shape of rekha deul of orya temple architecture. Rekha Deula or Rathaka Deula is also called the Vimana or Garbhagriha. The structure of Rekha Deula is a curvilinear in shape with majority cylindrical in structure, while the top portion converges. It looks like a tall building with a canonical mass like shape on the top namely "Shikhara". Shikhara covers and protects the sanctum sanctorum which is called "Garbhagriha". Fig 2

shows the outer structure of Rekha Deula. Majority of Odisha temples like Sun Temple of Konark, Jagannath Temple, Lingaraj Temple follows this structure.

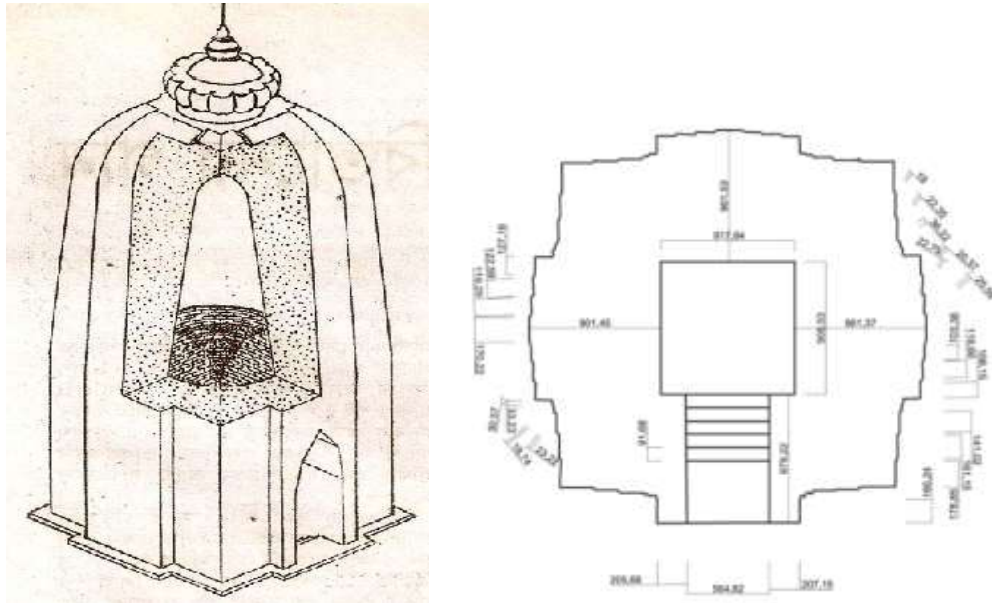
Fig 2: Structure of Rekha Deula (source [9]) Fig 3: Different parts of Jatar Deul as Rekha Deula



Fig 3 shows the different parts of Jatar Deul. Starting from the top, there is the Shikhara protecting the inner sanctum. In odia “Rekha” means a straight line which is reflected in the shape of outer wall structure and the walls are designed with different motifs that signify the period of construction. It is seen that Jatar Deul has a base of 9.37 meter each side (outside) with a slightly rectangular projection in the middle and appointed arched entrance on the east, measuring 2.9 meter. It rises to a height of about 30.48 meter. The inside cellar is about 3.05 meter square with thick walls. It has a high plinth built on a high ground. Its floor is about 1.83 meter below the present level of the ground and reached by a flight of steps [10]. The spire follows corbelling methods but the exact height of the temple cannot be found as the original spire was damaged by an Englishman [8].

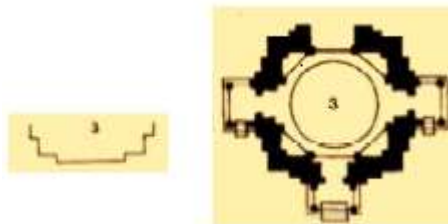
Fig 4: Basic structure of Jatar deul (source [8])

Fig 5: Projection of the base of Jatar Deul



The projection of base of the structure is self-copying, self-formatting, self-look alike and self motivated which follows the basic structure of Orissa temples.

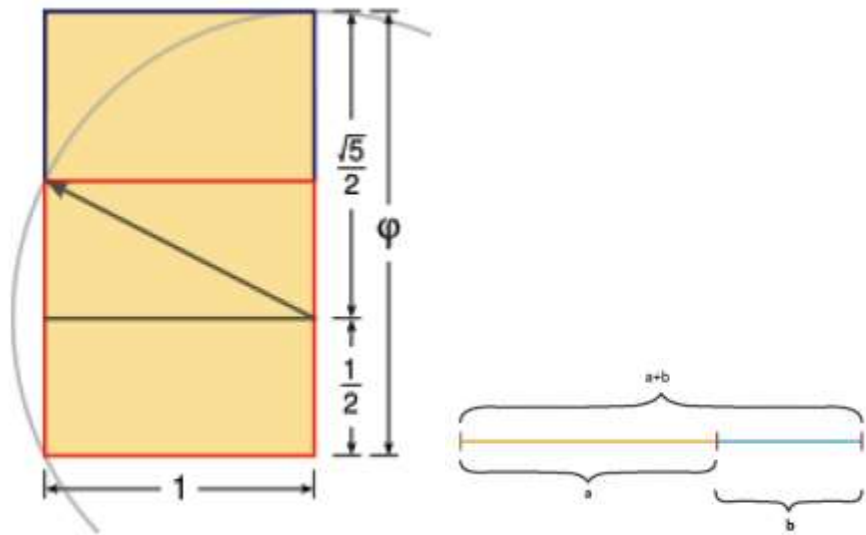
Fig 6: Self similar projections of base plans (Source [11])



Architecture and mathematics:

Mathematics and architecture has a close relationship with each other. In Hindu thought, number is considered to be an expression of the structure. There was a need to establish a certain geometry which will attract the eyes and arouse the brain of the observer. In all types of architectural achievements, several fundamental principles of math have been used. Most of the complex patterns of temple architecture are easily explained using Fractal geometry. However, architectures' most favourite and mostly used one is the golden ratio to portray a balanced structure. The golden ratio is also termed as extreme and mean ratio. It exists when a line is divided into two parts and the longer part (a) divided by the smaller part (b) is equal to the sum of (a) + (b) divided by (a), which both equal 1.618.

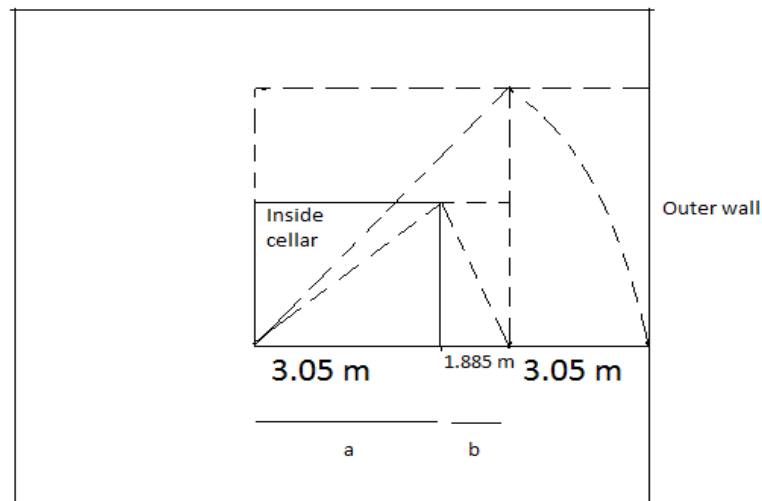
Fig 7: Golden ratio diagram (source [6])



$$\frac{a}{b} = \frac{a+b}{a} = 1.618 = \varphi$$

To justify the golden ratio in the architecture of Jatar Deul, a pictorial representation is shown here. However, there is a small gap between the computed length of outer wall and collected length of the same. Due to the reconstruction, the intricate work on the wall and also the spire lost its beauty and actual measurement as it was in the ancient period. According to Fig 1 and Fig 3, it is seen that the Deul is constructed on a larger base than its outer walls length. Considering that part in mind, we can say that the golden ratio is preserved for this construction. However, the exact length of the larger base was not measured during the project.

Fig 8: Golden ratio diagram for Jatar Deul





Conclusion: It is very clear from the discussion that whatever be the era, ancient temples are based on simple geometry and a basic ratio to make the construction a balanced one. Also the basic structure follows the architectural behavior of a specific type of feature depending on the region of our country. This paper tried to compare an ancient and not so famous temple due to its location with the specified corpus of Orissa temple. Therefore, any temple can be determined as specific regional architecture which is an instance of style.

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