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Decoding the Geometrical Construct of Rama Temple, Sirpur

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Abstract Construction of Hindu temples in India started from about 1st C BCE, but today there are very few examples of those temples. In the state of Chhattisgarh (erstwhile known as Dakshin Kosala), which is in central India, there is evidence of the construction of brick and stone temples from 5th C CE. These temples are categorized either as 'Rectilinear Type' or 'Stellate and Semi- Stellate Type'. Though these temples have survived the ravages of time, the techniques of their construction and the principles of their layout on the ground are lost in ambiguity. Some research has been performed on the plan forms of the temples, the elevational levels, the philosophy embedded in them etc. but very less work has been done on the geometric construct of the plan form of the stellate temple of Chhattisgarh. This paper aims to decode the hidden geometric construct of one of the earliest brick stellate temples of India, which is Rama Temple in Sirpur, Chhattisgarh. For this, a primary survey was conducted and detailed measurement at the base level of the temple was done. The measured drawing was then drafted, and the layout was verified statistically and otherwise from various published research works based on canonical texts to arrive at some principles of geometric layout. Prima facie studies show that some ancient geometrical principles are followed in the layout of the planform of this temple. Similar studies on other temples will prove the principle of laying out such temples in India and thus will help in filling up a gap in the lost legacy of temple architecture in India.

Keywords Temple Architecture, Geometric Construct, Proportions, Measurement, Computer-Aided Drawings

1. Introduction

The state of Chhattisgarh, India, is located at latitude 17° 46′ N to 24° 5′ N and longitude 80° 15′ E to 84° 20′ E. The political boundary of this state roughly includes the territory of the ancient region of South Kosala or "*Dakshina Kosala*" [1]. The religious traits of Chhattisgarh can be traced back to 200 BCE, as one of the earliest inscribed images of Lord Vishnu was found near Malhar [2]. Hardy [3] said that "*The history of Indian temple architecture would have been written differently if the Malhar temple had been discovered earlier*". The Kosala was a region in central India sponsoring a distinctive regional school of temple architecture and sculpture [4].

During the 4th-5th century CE, Sirpur was one of the important *Vaishnavite* centers of *Dakshina Kosala* [2]. Sirpur, Chhattisgarh (Latitude- 21° 20' 39.6564" N, Longitude - 82° 11' 25.4256" E), was a city of considerable importance and is situated on the right bank of the river "Mahanadi" [5]. It contains several temples, Rama Temple (constructed in the 7th century CE) is one of the oldest temple structures.

2. Studies on Temple Geometry

Many research works have been done on the geometrics of the temple plans. With the help of an ancient text, Harding [6] has identified the basic geometrical principles of Durga Temple, Aihole. Kramrisch [7] has done a study on the proportions of various elements of a temple structure. Gandotra [8] has developed a new logical system "Square Circle Sequence" to understand the geometry of temples.

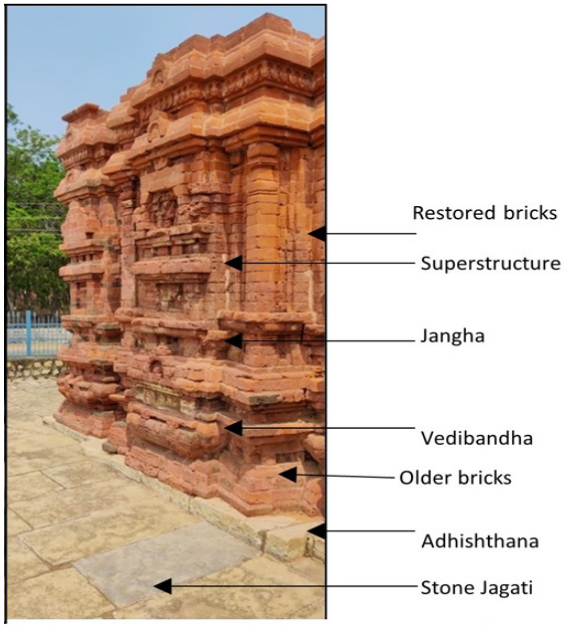
Gandotra [8], points out "*Other than being architectural and sculptural marvels the ancient Hindu temples represent philosophical, cosmological, metaphysical, astrological, astronomical, geographical, geological knowledge of ancient architects*". Meister [9], in his paper "Measurement and Proportions in Hindu Temple Architecture" has described the evolution of *Hindu* temples of central India from 5th to 15th century and has also analyzed the geometry of Rama Temple, Sirpur. Studies have established that the Indian *Hindu* temples have a complex geometry from ancient times. Provided that, modern tools and technologies were not available in ancient times, hence, it is obvious that, there must be some methods and set of rules to lay out such geometry on the ground. This study is an approach to understanding the geometrical construct of the Rama temple, Sirpur.

3. Rama Temple Sirpur

The Rama temple, Sirpur is one of the earliest forms of stellate temples in the region, estimated to be constructed in the 6th-7th century CE [2]. The temple was first noted by J. D. Beglar [10]. Beglar has mentioned more than one Rama temple in Sirpur [11], one of these temples is presently known as the Laxman temple [5]. In the present day, the temple does not have any central shrine, image or deity inside. The temple probably belongs to the *Vaishnavite* cult in earlier days [2]. Though because of the plan form, Meister suggests that the structure is a "Shaivite" temple [12]. In the Chhattisgarh region, the plan form of the temples can be broadly categorized into two categories 1. Square or Rectilinear- further divided into four sub-parts, a) Simple square plan, b) Rectangular Plan, c) Square plan with simple projection, d) Staggered square plan with recesses and 2. The stellate plan- is further categorized into two parts semi stellate and uniform stellate plan [1].

Source: Murigan, I. (2020, June 23). Rama Temple, Sirpur [Photograph].Blogger.Com

Figure 1. Front View of Rama Temple, Sirpur



Source: Authors, 2022

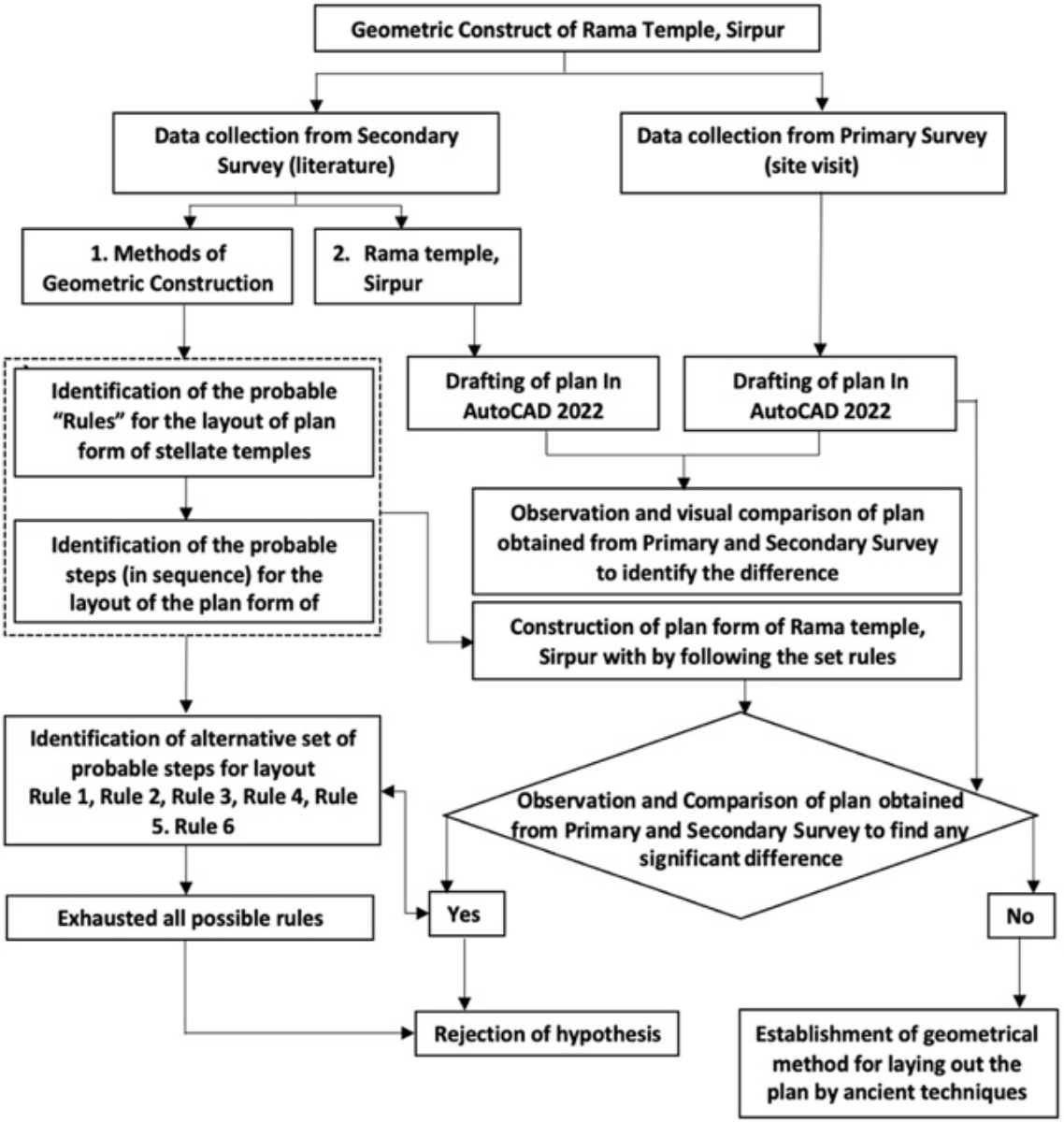
Figure 2. Various Parts of Rama Temple, Sirpur

Rama temple falls under semi stellate category with a square *Garbhagriha* (sanctum sanctorum) and *Mandapa* (hall). The temple structure is now in ruins but it was constructed with burnt bricks except for the stone platform (*jagati*, plinth) (refer to Figures 1, 2). The brickwork was finished with lime plaster and stucco [2]. The structure has suffered damage and lost its *Shikhara* (curvilinear roof). The present structure consists of stone *Jagati*, *Adhishthana* (base on which walls stand), *Vedibandha* (moulded base of the temple) and *Jangha* (wall) [5,13], these are labelled in Figure 1 and Figure 2. The structure is a heritage building, restored and conserved by the Archaeological Survey of India (ASI), Chhattisgarh.

4. Methodology

To decode the geometric construct of the Rama temple, the data is collected from both primary and secondary surveys. The secondary survey is done on two aspects, first aspect of the secondary survey was, methods of the geometric construct of sacred structures and particularly stellate temples. Regarding this, the works of Harding [6], Gandotra [8], Kramrisch [7], and Meister [9,12] were studied. The second aspect of the secondary survey was the information about Rama Temple, Sirpur. In this aspect, studies done by Beglar [11], Stadtner [4], Meister [9,12], Sharma [5], Minj [10], Patnaik [2], Nigam & Minj [1] were studied. Based on data collected from 2nd aspect of the secondary survey a plan for Rama temple, Sirpur was drafted in AutoCAD, 2022*[1]

[1] * All the drafting work is done in AutoCAD version 2022 (Computer Software) Autodesk by Authors.



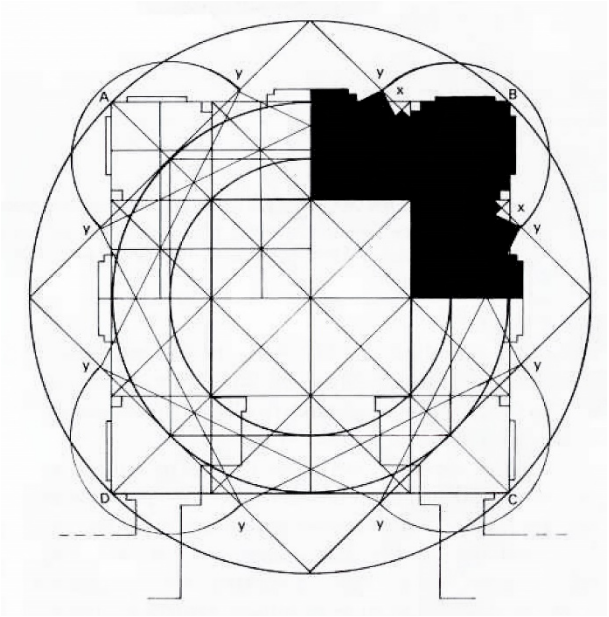
Source: Authors, 2022

Figure 3. Methodology

For the primary survey, a visit was paid to the Rama temple, where measurements and photographs were taken. Based on data collected from the site visit, the plan for Rama temple was drafted. It has been observed in a visual comparison that the measured plan is having some different dimensions than the plan obtained from the literature study. This difference was due to the difference at the level of both the plans (Adhishthana level and base level). Based on principles of geometric construction in ancient times, studied from literature, 7 sets of rules were created and by using these rules, the plan of the Rama temple was drafted by authors. The plans obtained after the primary survey (the actual plan of the temple) and obtained from the literature study of geometric construction, were compared on the basis of dimensions and plan form. To identify the difference between them, statistical analyses were done (refer to Figure 3). As no statistical difference was found, so geometrical construction methods were established.

5. Geometric Analysis and Decoding

Meister [9,12] prescribed that; the plan of Rama temple has a construction grid. A very unique geometry of the Rama temple is prescribed by Meister [9], "A two-square measure of the grid has been used as radius for the circles that locate the turned squares that fix the position of the intermediate facets on the wall" (refer to Figure 4).



Source: Meister [9]

Figure 4. Geometrics of Rama Temple, Sirpur

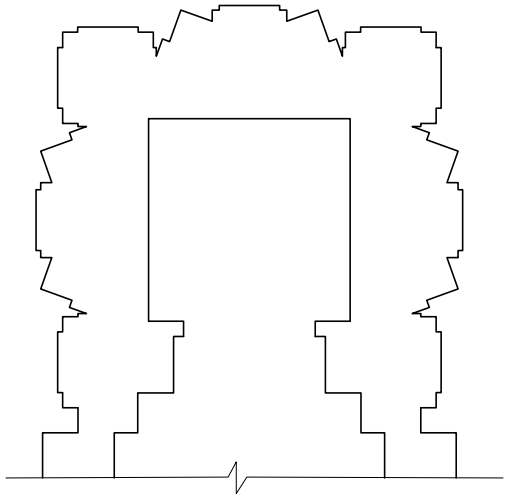
To understand the geometrics suggested by Meister, his drawing of Rama Temple was drafted (To describe the geometry, the general "command" words of AutoCAD are used for better understanding of the reader such as "Mirror" "Rotate" etc.). As Yossef et al. [14] describe that using extended technologies and software like AutoCAD in presenting and documenting can be beneficial for heritage sites as it does not hamper the physical condition of the monument.

While redrafting the plan, as gotten from the literature, it was observed that the architect (*sutradhara*) of the temple might have used some geometric proportions with an astonishing degree of precision. A few general observations about the overall geometry and proportion of the temple plan are-

1. The shape of *Garbhagriha* is square.
2. The outermost boundary of the temple is also carved out from a square, which is approximately double the size of, the square of *Garbhagriha*.
3. The geometry of the plan has a pattern; a particular module is repeated in the temple by "mirror" -ing and "rotate" -ing.
4. Other than square and rectangular projections there are twelve oblique triangular projections in the temple at a certain angle.
5. Measurements are somehow showing some common factor in the proportions of various parts of the plan form.

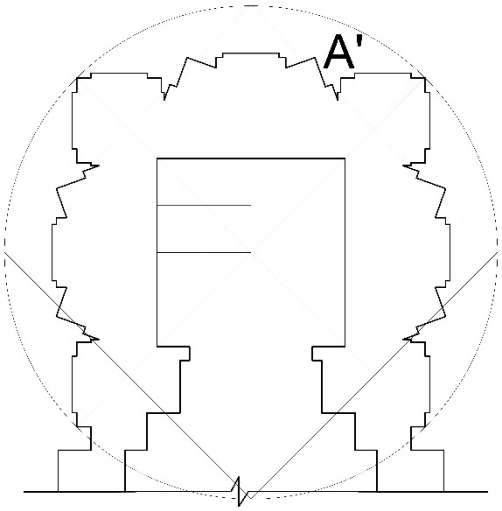
A physical survey was conducted to better understand the geometric construct of the Rama temple's ground plan. In this survey, the measurements were taken with standardized [as per IS1269 (part2) 1997, Code of the Bureau of Indian standards] measuring instruments like measuring tape, laser meter etc. For the acute angles (where it was not possible to measure by tape) paper folding technique was used as shown in Figure 7.

The measurements were drafted to depict the proportion of the sides and projection of the plan form as depicted in Figure 5.



Source: Authors, 2022

Figure 5. Ground Plan of Rama Temple, Sirpur (as per primary Survey)



Source: Authors, 2022

Figure 6. Application of Meister's Geometry on measured drawing of Rama Temple, Sirpur

Meister [9] suggests the geometrical principle "The turned squares fix the position of the intermediate facets of the wall". After analysis of dimensions and plan form, it has been identified that the plan analyzed by Meister [9] and the plan measured on-site and drafted by authors do not follow the same geometric principle as suggested by Meister [9]. The difference in the profile of the temple plan is highlighted with point A in Figure 4 and A' at Figure 6.

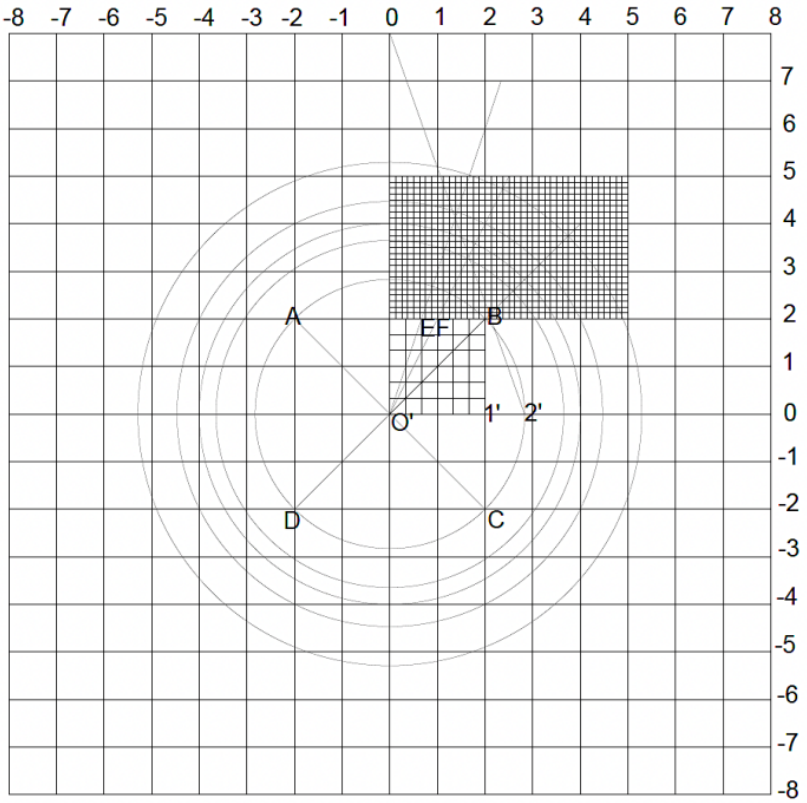
Source: Authors, 2022

Figure 7. Measurement of angles in primary survey

The temple is under ASI and a lot of conservation and restoration work has been done which can be witnessed on the site (refer to Figure 2). The plinth level plan is still older; hence the analysis of the geometrical construct was conducted on the plinth level plan, which is also the plan at the base of the temple.

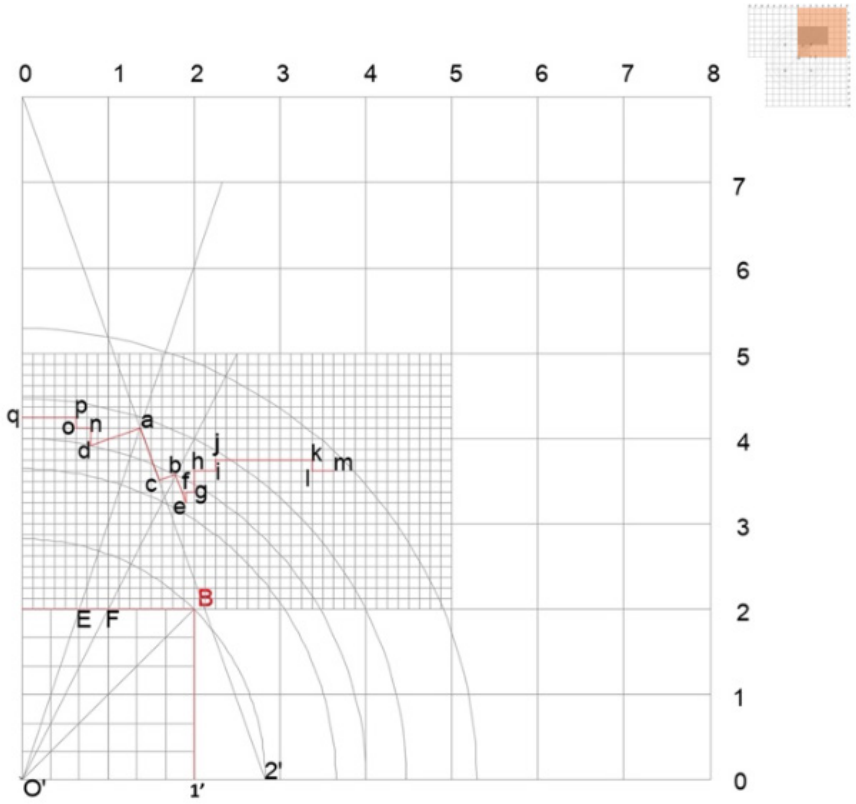
This study intends to find out the methods of laying out the plan form at its base, situated at the plinth level on *Adhishthana* of Rama Temple, Sirpur. By using the trial-and-error method and after several trials, some geometrical construction methods were identified, which might have been followed by the ancient *Sutradhara* of Rama temple.

It has been observed that the plan form of Rama temple, Sirpur, has a module: - which is repeated in its complete geometry. So, to decode the geometry, that module is constructed with the basic geometrical methods as studied in the literature. A basic construction geometry (refer to Figure 8) was laid out first by using three construction grids, 3x3 grid "*Pitha Vastu Purusha mandala*", 8x8 "*Manduka/ Chandita Vastu Purusha mandala*" and16x16 "*Padmagarbha Vastu Purusha mandala*", the names of the grids described by Prasad [15]. A square ABCD is constructed. A Pythagorean triangle 0-O'-2' was constructed geometrically as explained by Kelley [16]. A circle with a diameter of 8 grids with O' as a centre and another circle with the diagonal of "*Garbhagriha*" as its diameter with O' as the centre with its offset circles were constructed. These offset circles were equidistant from each other, having a distance equal to 1'-2', the E' being the center of the side BC of square ABCD (refer to Figure 8). Two rays O'E and O'F were drawn and extended. Each grid is divided into 8x8 smaller square grids.



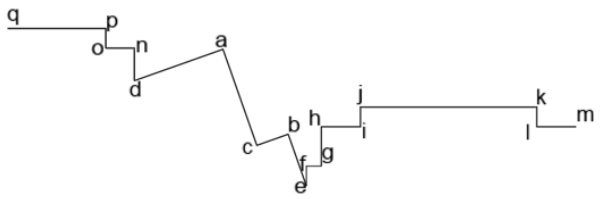
Source: Authors, 2022

Figure 8. The obtained Basic geometry from the method described



Source: Authors, 2022

Figure 9. The obtained geometry of Rama Temple from geometrical method described



Source: Authors, 2022

Figure 10. Module "qm" of the obtained geometry of Rama Temple

One portion of Figure 8 is enlarged two times for better understanding (refer Figure 9). To achieve the geometrical shape of the temple, the rectilinear and square projections of the exterior wall of the plan were obtained from the grids. The rays O'E, O'F and O'B and circles were used to locate the temple structure's oblique triangular projections, a,b,c,d, and e (refer to Figure 9). Rest of the points of the temple geometry was marked out on the grids. By following the above methods, a module "qm" is obtained (refer to Figure 9 and 10). By different combinations of geometric transformations ("Mirror" -ing and "Rotate" -ing) [17] of this module, the geometry of the Rama temple can be achieved. By following these geometrical methods one can draw the plan of Rama Temple, Sirpur with or without taking the help of any modern tools and technology.

5.1. Testing for Significance

The module of plan form obtained by following the geometrical methods explained above was scaled up to the actual measurements of the Rama temple. To check whether the geometries are significantly different, a few statistical tests were conducted on the data set. The measurements of the sides of the plan form in the module of the actual temple and the constructed temple were compared statistically and it has been identified that the difference between the mean of both the data set is 0.0043m only. To check whether this difference is significant or not a hypothesis is created-

H_0: $\mu \neq \mu_1$ (both the values are significantly different)

H_1: $\mu = \mu_1$ (both the values are significantly the same)

The data set is very small in number and related to each other (because they consist of measurements of the module of the same temple) hence, a two-tailed "paired T-test" for 5% significance was done on the data set. Its value of it came to 0.4428, which is much greater than 0.05 (refer to Table 1). Hence the null hypothesis may be rejected and both the data set may be considered to be significantly not different from each other.

Table 1. Testing the measurements of module of the plans

Side	Actual μ (in m)	Constructed μ1 (in m)
qp	0.3	0.31
po	0.05	0.06
on	0.07	0.09
nd	0.11	0.1
da	0.33	0.3
ac	0.33	0.32
cb	0.07	0.11
be	0.18	0.17
ef	0.09	0.06
fg	0.03	0.05
gh	0.15	0.13
hi	0.15	0.13
ij	0.05	0.06
jk	0.6	0.56
kl	0.05	0.06
lm	0.15	0.13
Mean	0.169375	0.165
Difference in Mean		0.004375
Paired T Test		0.44283253

Source: Authors

6. Conclusion

The study proves that, the geometry in its simplest form, followed by the authors for the reconstruction of the plan form of Rama Temple, Sirpur, gives the same results as the temple plan as it exists today. Hence, the construction geometry explained in the paper may also be the geometry followed by the ancient *Sutradharas* for laying out the plan of Rama Temple, Sirpur.

The actual process of laying the temple is now in oblivion and hence these types of studies will help in not only understanding the steps sequentially but also can help in the development of an algorithm for “re-creating” the plan forms of ancient Hindu temples with the help of modern CAD systems.

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