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Mathematical Principles in the Architecture and History of Gangaikonda Cholapuram Temple

Dr. S. Murugesan, Dr.T.Aasaithambi

Professor, Department of Mathematics, Jairupaa College of Engineering, Tiruppur.

Professor, Department of Mathematics, Sri Shanmugha College of Engineering and Technology (Autonomous), Pullipalayam, Sankari, Salem.

Abstract

The Gangaikonda Cholapuram Temple (Brihadisvara temple), built in 1035 CE by Rajendra Chola I. It is the masterpiece of Dravidian architecture. This research paper examines the role of geometry, symmetry, proportion, measurement systems and structural engineering in design of the temple. Through an analysis of its dimensions and engineering features the study demonstrates that mathematical principles informed key architectural decisions, particularly in the vimana and the Chola Gangam reservoir.

Keywords: Mathematics, Geometry, Chola Architecture, Gangaikonda Cholapuram, Structural Engineering, Symmetry, Proportion.

1. Introduction

The Gangaikonda Cholapuram Temple is a symbol of ancient architecture, mathematics, science, and engineering. It serves as an immortal testimony to the architectural skills of the Cholas. It was built in 1035 AD by King Rajendra Chola I. This temple was established to commemorate the historical event of bringing the sacred water of the Ganges River to the Chola kingdom, one of his great victories. Following this, Gangaikonda Cholapuram emerged as the capital of the Chola Empire. In the construction of this temple the contribution of mathematics to the architectural design of this temple and explains the excellence of ancient Indian science and architectural tradition.

2. Historical background

This temple was actually built to celebrate Rajendra Chola I's successful military march into North India.

For nearly 250 years, Gangaikonda Cholapuram served as the capital city for the Cholas, acting as the main hub for their politics, culture, and religious life.

In fact, the Chola kings who came after Rajendra Chola I were all crowned right here. So, this place isn't just a temple for worship—it stands as a real testament to the incredible architecture and political power of the Chola empire.

3.Temple Architecture - Geometry

The temple is designed based on geometry. The entire design is based on geometric principles, ensuring symmetry, stability and visual harmony.

Geometry of Squares

The central sanctum is designed in a square layout. In the traditional Indian architecture, the square is a sign of balance, order and cosmic harmony.

4.Proportions and Symmetry

The temple is bilaterally symmetrical in its design, with each side of the central axis mirroring the other.

Approximate measurements:

Height of Vimana ≈ 55 m Base dimension ≈ 30.5 m

Height-to-base ratio:

55 / 30.5 ≈ 1.8

This ratio is part of structural stability and visual balance. The proportional system is based on an optimization, based on the stability of the structure, where the decrease of the ratio of height to base increases the vertical prominence and decreases the moments of bending

5. Measurement Systems

Ancient Chola architects employed standardized measurement systems.

Common units included:

Angula (finger unit)

Hasta (cubit)

The modular relationship can be represented as:

L = n × m

where:

L = total length

n = number of modules

m = basic measurement unit

This modular approach ensured uniformity and precision throughout construction.

6.Structural Engineering and Equilibrium

Gangaikonda Cholapuram Temple is a good example of good structural engineering. This stability is a consequence of the equilibrium conditions:

$\sum F = 0$ (Sum of Forces) $\sum M = 0$(Sum of Moments)ΣF = 0 (Sum of Forces) ΣM = 0 (Sum of Moments)

The weight is evenly distributed on the heavy granite structure by the base. The base of the square is wide and the curve helps to prevent overturning and to keep the temple standing for centuries.

Stress Analysis: The stress on the structure is expressed as: σ = F/A Where: σ = Stress F = Force A = Area

The temple has a large foundation area, so the loading is evenly distributed, thus reducing stress and increasing durability

7.Mathematical Analysis of the Vimana

The vimana of Gangaikonda Cholapuram differs from the Brihadeeswara Temple at Thanjavur. While Thanjavur follows a relatively straight pyramidal profile, Gangaikonda Cholapuram exhibits a graceful inward curvature.

This gradual reduction may be modeled mathematically as:

h_n = H / (n + k)

where:

h_n= height of a tier

H = total height

n = tier number

k = curvature constant

This produces a smooth geometric profile and improves load distribution.

8. Urban Planning & Spatial Mathematics

Gangaikonda Cholapuram city was laid out very carefully. Important structures as: Temple Royal family roads water reservoirs were laid out according to systematic spatial principles. This is an instance of geometric planning at the urban scale.

9. Mathematical and Hydraulic Analysis of Chola Gangam

The Chola Gangam reservoir represents an outstanding example of hydraulic engineering. The storage capacity can be represented as:

V = l × b × h

where:

V = volume

l = length

b = breadth

h = depth

The uniformly arranged steps indicate a modular measurement system. if

h_s= height of one step

n = number of steps

Then:

H = n × h_s

where H is the total depth.

Hydrostatic Pressure

Water pressure is given by:

P = ρgh

where:

P = pressure

ρ = density of water

g = gravitational acceleration

h = depth

This demonstrates that Chola engineers understood practical hydraulics.

10.Brihadeeswara Temple Feature

Gangaikonda Cholapuram Height ~66 m ~55 m Base Width ~30 m ~30.5 m Ratio ~2.2 ~1.8 Geometry Linear Pyramid Curvilinear Pyramid Stability High Improved Load Distribution Direct Distributed The lesser slenderness ratio and the inward curvature indicate better structural efficiency.

11. Conclusion

Gangaikonda Cholapuram Temple is a successful example of the blend of mathematics, engineering and architecture. The monument was constructed with a combination of elements such as geometry, symmetry, proportion, modular measurement systems, principles of equilibrium and hydraulic engineering.

The temple and the Chola Gangam reservoir are evidences to prove that the engineers of the medieval Chola had practical mathematical knowledge of a very high order. Their achievements still offer us useful insights into the relationship between mathematics and architecture.

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