Comparative Case Study on Ancient Construction and Modern Construction of Gad mandir Ramtek and Swami Narayan Mandir Nagpur

Mangesh R. Farkunde[1], Prof. G. D. Dhavale[2], and Asst. Prof. Mrs. P. B. Gadge[3]
[1]*M tech Student, Dept. of Civil Engineering, BDCOE, Maharashtra, India*
[2]*Professor, Dept. of Civil Engineering, BDCOE, Maharashtra, India*
[3]*Asst. Professor, Dept. of Civil Engineering, BDCOE, Maharashtra, India*

***Abstract*—This research shows the comparative exploration on ancient construction technique in Ramtek and its durable characteristics which stronger existence. On the other hand, the modern technique which is used in the Swami Narayan mandir and its structural characteristics. This research paper discusses the environmental impact of construction and the preservation of vernacular techniques of construction as the heritage. So, it presents a proposed construction technique using a durable structure system with enhanced local materials to be able to survive a long period of time and conserve the unique character of structure. In addition, the proposed structural/architectural design of affordable structure is compared with the traditional and modern temple techniques through their strength, thermal insulation and cost. The comparison outcome shows the material properties, physical and chemical features, stability of structure and conservation maintenance.**

***Index Terms*—Ancient construction techniques; Ramtek Gadmandir, Modern techniques; Swami Narayan Mandir, Ram mandir Structural., etc**

I. INTRODUCTION

The history of building is marked by a number of trends. One is the increasing durability of the materials used. Early building materials were perishable, such as leaves, branches, and animal hides. Later, more durable natural materials such as clay, stone, and timber, and, finally, synthetic materials, such as brick, concrete, metals, and plastics were used. Another is a quest for buildings of ever greater height and span; this was made possible by the development of stronger materials and by knowledge of how materials behave and how to exploit them to greater advantage. A third major trend involves the degree of control exercised over the interior environment of buildings: increasingly precise regulation of air temperature, light and sound levels, humidity, odours, air speed, and other factors that affect human comfort has been possible. Yet another trend is the change in energy available to the construction process, starting with human muscle power and developing toward the powerful machinery used today.

The present state of building construction is complex. There is a wide range of building products and systems which are aimed primarily at groups of building types or markets. The design process for buildings is highly organized and draws upon research establishments that study material properties and performance, code officials who adopt and enforce safety standards, and design professionals who determine user needs and design a building to meet those needs. The construction process is also highly organized; it includes the manufacturers of building products and systems, the craftsmen who assemble them on the building site, the contractors who employ and coordinate the work of the craftsmen, and consultants who specialize in such aspects as construction management, quality.

II. LITERATURE SURVEY

In the paper [1], by Dr. Mir Mohammad Azad, Abhik Barua, (October 2017). there is a proposal to Ancient Egyptian architecture is the architecture of ancient Egypt, one of the most influential civilizations throughout history, which developed a vast array of diverse structures and great architectural monuments along the Nile, among the largest and most famous of which are the Great Pyramid of Giza and the Great Sphinx of Giza. In the paper [2], by Ar. Swapna Ashok

Dhavale, Ar. Leena Prasad Aphale and Ar. Madhulika Bhumkar. (2017). This paper attempts to understand an ancient settlement from the urban regional sustainable development through study of the ancient silk weaving industry. The study of this ancient town and the hinterland clearly shows the spatial pattern and architecture that had evolved in response to the prevailing economic (weaving industry- flow of raw material, process involved) social (communities involved in the skilled processes) and political (rulers and their aspirations) conditions. In the paper [3], by Aradhna Shrivastava, Vijay Kumar Shukla, (February 2019). In this paper we are going to study about the failure of traditional buildings structure like cracks in beam column slabs or failure of these component due to various reasons like permanent loading, creep, temperature stress, shrinkage, settlement of foundation, moisture. In this study we will classify the type of failure in component and suggest the method to rehabilitate the component without changing its homogeneity. Study has been to implement the method for the restoration of building with original material keeping in mind that material deviation does not help in proper boning of component. In the paper [3], by Pravin S. Velapurkar, Pooja D. Taralgatti, Rahul D. Kapase (2020). The ancient structure present in Maharashtra state likes caves forts wadas old temples etc play measure role to improve traditional and cultural value of the state. In the paper [3], by Er. Mohammed Sahil, Er. Prafull Kothari (May 2020). This Paper is the case study of the architecture of lotus temple. In this paper the details about the lotus temple (general detail) and the architectural and structural study of lotus temple how to construct lotus temple, which type of problem/challenges arises during construction and the study of structural drawings. In the paper [3], by Rohith Jain, Mohammed Junaid, Kishore N, Yashwanth Gowda (ICEI-2022). Masonry is one of the most important components of a structure which is under the action of compression and lateral loads. The results obtained, describe the suitability of different masonry combinations under different conditions. In the paper [3], by Liming Zhu, Baofeng Miao, Shiling Xing. (2018). This paper will respectively from natural vibration and the two aspects of urban development brought about by the vibration, analyzes its present form in order to prospect for its future, put forward the corresponding development strategy. In the paper [3], by Entidhar Al-Taie, Nadhir Al- Ansari, Sven Knutsson (2012). The materials used and the design of the buildings were very suitable from both environmental and engineering perspectives. This work is a critical review of the progress and development of engineering practices and construction materials used in ancient Mesopotamia

III. LITERATURE OVERVIEW

From these papers we have study the most influential civilizations throughout history, which developed a vast array of diverse structures.

Studied about the failure of traditional buildings structure like cracks in beam column slabs or failure of these component due to various reasons like permanent loading, creep, temperature stress, shrinkage, settlement of foundation, moisture.

IV. AIM AND OBJECTIVES

AIM: The Comparative exploration on the structural and physical features of ancient and modern structure.

OBJECTIVES: On the basis of Structural comparative exploration following objectives considered.

1. On the basis of comparison structural and architectural features will be studied.
2. By evaluating between two structure structural stability tested.
3. In the basis of comparison bonding material and its compressive strength checking.
4. What are the economic differences in between the ancient and modern structure?
5. How its construction process was worked.
6. What are the physical and chemical properties?
7. What techniques used in the repairs works.
8. How its structural durability.
9. Which one is best feasible and durable?
10. What technology used in the both structures.

Do not use abbreviations in the title or heads unless they are unavoidable.

V. METHODOLOGY

This research presents a comparative exploration on ancient and modern techniques of construction. Following parameters considered for studying comparatively:

A. Visualizing structural features.
B. Construction techniques and different materials.

C. Structural systems and bonding material.
D. Design principles of temple.
E. Design and construction techniques.

A. Visualizing structural features.

i. Structural members:

In the ancient structure Ramtek Gadhmandir temples, there is structural member without any composition. Every structural member (Column, Beam, Floor and dome roof) has made up of single material, i.e., stone. which is carved in different designs for different members during they build.

In the modern structure Swaminarayan temple, all structural member with any composition. Every structural member (Column, Beam, Floor and dome roof) has made up of single material, i.e., stone material. which is carved in different designs for different members during they build.

ii. Binding materials:

In the Ramtek temples, the binding materials between the structural members is same which is whitish mortar. The composition of binding materials is lime, jaggery, belfruits and fine sand.

In the Swaminarayan temple, the binding materials between the structural members is same which is whitish mortar. The composition of binding material is lime, jaggery, belfruits and fine sand.

iii. Damages and repair works:

The Ramtek Temples structure was constructed 500 years ago, As compared to their age, damages are minor. Which is conserve and maintain well. Various exterior members of the structure got damages and repairs by the bonding composition of lime mortar.

The Swaminarayan temple structure was recently constructed, there was no defects found.

Fig: Ramtek Temples image details

Fig: Swaminarayan Temples image details

B. Design principles of Temples

A Hindu temple is a symmetry-driven structure, with many variations, on a square grid of Padas, depicting perfect geometric shapes such as circles and squares.

Susan Lewandowski states that the underlying principle in a Hindu temple is built around the belief that all things are one, everything is connected.
The design, especially the floor plan, of the part of a Hindu temple around the sanctum or shrine follows a geometrical design called vastu-purusha-mandala.
The name is a composite Sanskrit word with three of the most important components of the plan.
Mandala means circle, Purusha is universal essence at the core of Hindu tradition, while Vastu means the dwelling structure. Vastupurushamandala is a yantra. The design lays out a Hindu temple in a symmetrical, self-repeating structure derived from central beliefs, myths, cardinality and mathematical principles
Equal weights at equal distances are in equilibrium, and equal weights at unequal distances are not in equilibrium but incline towards the weight which is at the greater distance.

i Symmetry and Proportion

The ancient temples are based on the geometrical property. The selection of symmetrical plan shapes and layouts is of great importance in seismic design, because symmetry about the elevation axis is of less dynamic significance than plan symmetry. In Indian temples the use of square as the basic unit and of triangle as the principle governing the layout resulted in strictly symmetrical plans and layouts along one or two principal axes, which in turn resulted in simple structural systems and an increased structural strength against seismic forces.

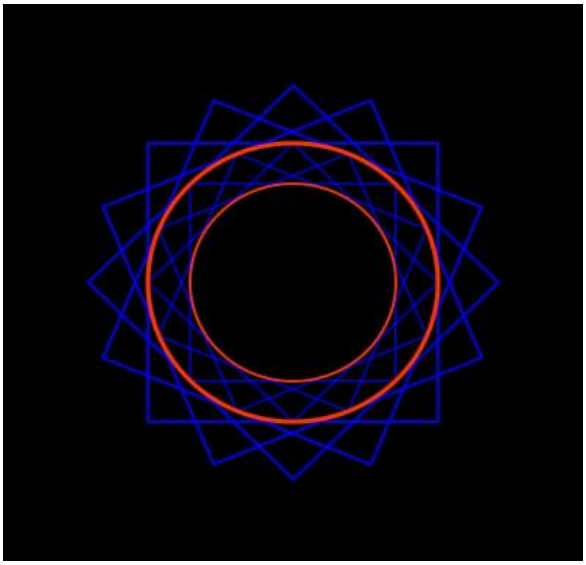

Fig: Square and circular plan symmetry-I

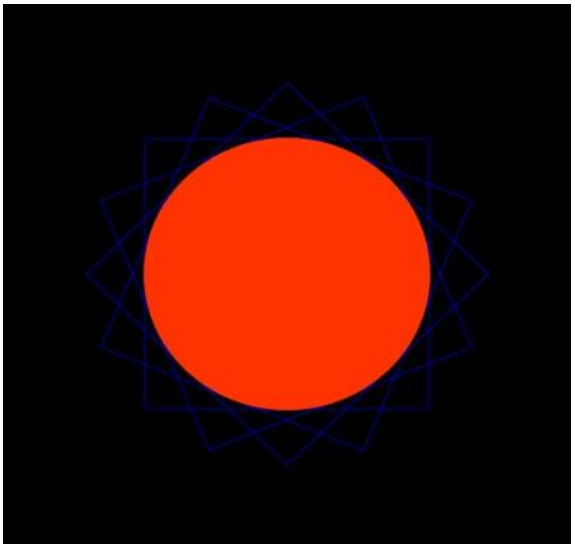

Fig: Square and circular plan symmetry-II

ii Structural Plan Density

Structural plan density defined as the total area of all vertical structural members divided by the gross floor area. The size and density of structural elements is very great in the Indian temples as compared to the today's buildings. For a R.C.C. framed building it is generally 3, but in Indian temples this can go as high as 47% as it is in the case of the Surya temple Konark.

iii Elements of Hindu Temple

The sanctuary as whole is known as the “Vimana” that consists of two parts. The upper part of the Vimana is called as the “Sikhara”.
The lower portion inside the Vimana is called as the “Garbhagriha” (cella or inner chamber).
Pradakshina patha: meaning the ambulatory passageway for circumambulation. Mandapa: is the pillared hall in front of the garbhagriha.
Antarala: meaning the vestibule or the intermediate chamber.
Ardhamandapa: meaning the front porch or the main entrance of the temple leading to the mandapa.
Gopurams: meaning the ornate tower at the entrance of the temple complex specially found in south India.
Pitha: the plinth or the platform of the temple.
Toranas: the typical gateway of the temple mostly found in north Indian temple.
The Amalaka: the fluted disc like stone placed at the apex of the sikhara.

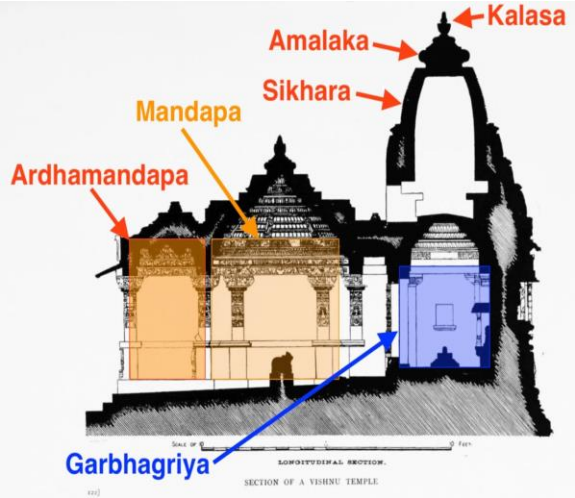

Fig: Parts of Hindu Temple

C. Design Construction Techniques of Hindu Temple

The construction of temple is an art, a science and a complicated creative study with a blend of mathematics, logic, geography, geology, science, ecology, art, sculpting, music, light and sound, religion, social sciences and astrology.

i Selection of the Site

The gods always play where groves, rivers, mountains and springs are near, and in towns with pleasure gardens. Thus, most of the ancient surviving temples were built on the mountain peaks, lush valleys, grooves, near the water body, the essential necessity is the existence of water.

ii Inspection, Insemination and Leveling of the site

After the inspection of the site for its consistency it is important to check the condition of the soil. This can be determined by performing some simple test on the site. In this a pit is dug on the site and the soil which has been taken out is put back again and checked whether the level of the packed soil is higher, same or lower. The land with the higher and the same level of packed soil are selected for the construction. Secondly, the pit is filled with the water and left overnight; the quality of the soil is evaluated according to the quantity of water remaining in the pit. Finally, the fertility of the soil must be tested. This is tested by sowing a seed at the chosen site on a auspicious day and the germination is observed. If the growth of the plant is satisfactory the land is considered suitable for the construction of temple.

iii Orientation, Measurements and Layout

The nature of the main deity greatly influences the orientation of the temple. According to the orientation of the plan the placement of the idol is decided. The specific directions of the deity are as such: East facing-any and all gods and goddess, because it's the best orientation. West facing-is According to the orientation of the plan the placement of the idol is decided. The specific directions of the deity are as such: East facing-any and all gods and goddess, because it's the best orientation. West facing-is for the Shiva family of the Hindu pantheon such as Shiva, Ganesh, Linga, etc. South facing-is for the monkey god Hanuman, and other aggressive gods and goddess, Yama or the god of death etc.

iv Selection of Material

In a class of Hindu society use of stone for all kind of temples. The stone is considered as the most sacred building material. The temple made in brick is hundred times more worthy than wood and the temple constructed in stone is ten thousand times more worthy than in brick. The temples of male deity are generally made of stone and brick, the female deity temples are usually made of brick and wood, and temple with all the materials are considered neutral. The stones are used in temple construction according to the availability and climate of the region such as granite in the south, marble in the west, sandstone in the central and limestone in the coastal areas, sandstone is never used in coastal areas and generally locally available stone is preferred. The hard and even stones are used for the plinth, columns, beams and slabs.

v Process of Temple Building

i. Laying the Foundation

The foundation of the temple is 2-meter-deep pit. The pit is dug throughout the base and is wider than the base of the temple. The stones are laid one above the other without mortar towards the structure boundary. At the base of the foundation on the exact centre of the garbhagriha a hollow duct is placed running from the foundation base to the base of the main idol of the temple, for performing the ritual called as garbhadhana.

ii. Assembly of Elements

The final and the most important stage for the construction of the temple is the assembly of all the

parts together. After carving of the individual pieces is completed, the different levels of the temple with its different parts are pre-assembled to check the accuracy of the joints and to avoid any mismatch and misfit during the time of placing the part at its actual position in the temple.

iii. Joinery system

The stone construction the architectural elements and the decorative details of the temple continued to follow the timber construction details for centuries in one form or another even though the original purpose and the context was lost The major joining systems used were different types of mortise and Tenon joint and the lap joint. The mortise and Tenon joints were mostly used for the horizontal assembly and the lap joints were used in the vertical assembly. Another kind of joint is a kind of mortise and Tenon joint i.e., a peg is fixed between the two mortises cut out in two different stones, this joint is usually used between the two courses of masonry to avoid the movement of the stones due to lateral forces. In the past natural binders were used to unite the joints together. In the present days cement acts as the binding agent between the joints. In the past the use of steel was strictly prohibited as steel gets rusted and reduces the age of the temple. But temples constructed during the 13th and 14th century shows the use of iron clamps and wedges, with ends sealed in molten lead.

iv. Plinth

The plinth stones placed above the foundation stones act as the retaining wall for the rubble compacted earth Above this compacted rubble are laid stone slabs for the flooring of approximately 200 mm to 300 mm. The stones of the plinth are place one above the other and they are made stable with the self-weight. The number of courses of stones at the plinth varies according to the size of the temple from 3 to 10 numbers. On the stone floor of the temple, where exactly the vertical components were raised, was marked with chisel marks (mason marks) and grooves for the pillar bases without lines for raising walls and entrances.

v. Wall

The main structural masonry walls are constructed as a stone composite masonry with stone, brick with lime or mud as the masonry core. The thickness of the stones varies from 300 to 4500 mm. The average thickness of the masonry wall varies from 800mm–1200mm.Large stone act as ties and thus strengthens the walls. The joints are very fine either without any mortar or with fine lime mortar. Over the wall are the stone beams.

vi. Column and beams

The columns are monolithic structure. They are made up of 5 parts and all are interlocked by the mortise and Tenon joints. The five parts consists of two parts of the base one part as the shaft and two as the capital of the column. The top of the column has the brackets which provide a good bearing for the beams and reduce the spans. The beams were placed over the column structure which further supports the roofing system of the temple.

vii. Mandapa

The mandapa of the temple may be flat roofed in the south and have pyramidical superstructure in the north. The mandapa ceiling is built with basic beam and slab construction method. Octagonal patterns were constructed by placing the triangular slabs across the corners of the square plan. The square bay of the mandapas were reduced to stepped pyramidical roof via triangular corner slabs or diagonal beams.

viii. Sikhara

The sikhara is the pyramidical structure built on the garbhagriha of the temple. Corbelling construction system is used for the construction of the sikhara. The sikhara is usually hollow from inside or in some cases filled with rubble. The apex of the superstructure is mounted by a single piece of stone called as amlaka in the north and sikhara in the south.

V. CONCLUSION

On the basis of the above literature papers, we have studied the most influential civilizations throughout history, which developed a vast array of diverse structure. Studied about the sudden failure of traditional buildings structure like cracks in beam column slabs or failure of these component due to various reasons like permanent loading, creep, temperature stress, shrinkage, settlement of foundation, moisture. Also, we conclude by undertaking a structural study of temples taking examples from north Indian and south Indian temples. In an attempt to graphically analyses the structure with respect to its

structural stability. On the basis of the above studies the stability of the temple structure depends mainly on the load applied rather than material failure. The material concerning the main geometrical property of the temples from the India.

REFERENCES

[1] R. G. Blakemore, History of Interior Design and Furniture: From Ancient Egypt to Nineteenth-Century Europe, John Wiley and Sons 1996, p.100

[2] Dr. Mir Mohammad Azad, Abhik Barua, (October 2017) "Case Studies of Ancient Egyptian Architecture". ISSN: 2394-3661, Volume-4.

[3] Ar. Swapna Ashok Dhavale, Ar. Leena Prasad Aphale, Ar. Madhulika Bhumkar. (2017) "Regeneration of Ancient settlements and Cultural Industrie-a- Case Study of Paithan, Maharashtra, India" ISSN 0974-3154, Volume 10,

[3] Aradhna Shrivastava, Vijay Kumar Shukla, (February 2019)" Rehabilation and Maintenance of Ancient Building- A Case Study of Surguja District". ISSN: 0976-6499, Volume 10,

[4] Pravin S. Velapurkar, Pooja D. Taralgatti, Rahul D. Kapase (2020) "CHECKLIST PREPERATION FOR CONSERVATION WORK OF ANCIENT STRUCTURE - A CASE STUDY ON HARNESHWAR TEMPLE, VELAPUR" ISSN:2277-7881, Volume-9.

[5] Er. Mohammed Sahil, Er. Prafull Kothari (May 2020) "Case Study on Architecture of Lotus Temple" ISSN: 2278-0181, Volume 09,

[6] Rohith Jain, Mohammed Junaid, Kishore N, Yashwanth Gowda (ICEI-2022) "Study on Behaviour of Masonry Walls using Different Masonry Unit and Mortar Combinations" ISSN: 2278-0188,

[7] K.M. Rebec, B. Deanovic and L. Oostwegel (2022) "Old buildings need new ideas: Holistic integration of conservation-restoration process data using Heritage Building Information Modelling"

[8] Liming Zhu, Baofeng Miao, Shiling Xing. (2018). "Ancient Buildings Vibration Control Technology Research Status and Future Prospects" (ASSEHR), volume 300,

[9] Entidhar Al-Taie, Nadhir Al- Ansari, Sven Knutsson (2012) "Progress of Building Materials and Foundation Engineering in Ancient Iraq" Vols. 446-449 (2012) pp 220-241.