

A Study On Structural, Material And Climate Responsive Features Of Ambreshwar (Ambernath) Temple, Maharashtra, India

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Abstract: *Religious architecture across civilizations has consistently demonstrated a high level of structural understanding, material efficiency, and environmental adaptation. The Ambreshwar Temple, located at Ambarnath Temple, represents a significant example of medieval Indian temple construction using the Hemadpanti architectural style. Built in 1060 CE, the temple showcases advanced engineering principles such as load-bearing construction, dry masonry, and climateresponsive design. This study aims to analyze the structural systems, material properties, and environmental adaptability of the temple through a systematic methodology involving site observation, documentation, and analytical interpretation. The findings highlight the effectiveness of basalt as a construction material, the efficiency of gravity-based load transfer systems, and the integration of climatic considerations into architectural design. The study further emphasizes the relevance of traditional construction techniques in modern sustainable engineering practices.*

Keywords: Temple Architecture, Hemadpanti Style, Basalt, Load Transfer, Climate Responsive Design

I. INTRODUCTION

Across civilizations and historical periods, religious architecture has served as a manifestation of both cultural identity and engineering excellence. Structures such as the Temple of Karnak in Egypt and Mesoamerican pyramids demonstrate early applications of geometry, load transfer, and material behavior. These monuments were not merely symbolic but were engineered to withstand environmental forces over extended periods of time. The emphasis on durability, symmetry, and structural stability reflects a universal understanding of construction principles rooted in empirical knowledge



Within the Indian subcontinent, temple architecture evolved into a sophisticated system that integrates structural efficiency with climatic responsiveness. Unlike many ancient monuments that exist only as ruins, Indian temples continue to function as active cultural and religious centers. Temples such as Brihadeeswara and Konark Sun Temple demonstrate mastery in stone construction and environmental adaptation. These structures were designed to resist monsoon conditions, temperature variations, and long-term weathering, highlighting a deep understanding of material science and structural behavior. In the regional context of Maharashtra, temple architecture is strongly influenced by the availability of basalt stone and climatic conditions. The development of the Hemadpanti style during the Yadava period introduced dry masonry techniques, where precisely cut stone blocks were assembled without mortar. This method relied on gravity, friction, and interlocking geometry to achieve structural stability. The resulting structures exhibit compact planning, thick load-bearing walls, and symmetrical layouts that enhance durability and resistance to external forces. The Ambreshwar Temple stands as a prominent example of this architectural tradition. Built during the 11th century, the temple represents a transition from rock-cut architecture to fully developed structural systems. Its design incorporates a mandapa–garbhagriha arrangement with a sunken sanctum, which enhances both symbolic significance and structural stability. The temple’s continued survival over centuries under harsh environmental conditions makes it an important case study for civil engineering analysis. By examining its structural systems, material characteristics, and climate-responsive features, valuable insights can be derived for modern sustainable construction practices.

II. LITERATURE REVIEW

Samir P. Parmar and Debi Prasad Mishra (2021) presented a comprehensive study on ancient Indian temple construction, focusing on architectural styles, structural systems, geometry, and construction technology. The paper explains how Hindu temples reflect cultural, scientific, and philosophical advancements, highlighting elements like mandapas, shikharas, and garbhagriha along with regional styles such as Nagara and Dravidian. It also emphasizes the role of geometric principles like Vastu Purusha Mandala, symmetry, and fractal geometry in temple design, relating them to cosmic and human body concepts. Additionally, the study discusses traditional construction techniques, material selection, and assembly methods that ensured durability and seismic resistance. Overall, the research highlights the relevance of these ancient principles in modern architecture for sustainable, stable, and culturally meaningful design.

Shantaram Nivrutti Nagare and Abhishek Singh (2019) presented a study on the heritage and architectural development of the Gondeshwar Temple area in Sinnar, focusing on the Hemadpanthi construction style. The paper highlights the use of basalt stone in dry masonry techniques, showcasing precision construction without mortar and ensuring long-term durability. It explains the temple’s Panchayatana layout, where a central shrine is surrounded by four subsidiary shrines, reflecting symmetry and planned spatial organization. The study also discusses key architectural components such as the garbhagriha, mandapa, and shikhara, along with intricately carved stone elements that serve both structural and aesthetic purposes. Additionally, it emphasizes efficient load distribution through thick walls and stone columns, contributing to the temple’s stability. Overall, the research connects traditional construction methods with modern applications, promoting sustainable and culturally responsive architectural practices.

Boddani Guna Sekhar (2023) presented a study on the scientific and geographical principles involved in Hindu temple construction, emphasizing the integration of ancient knowledge systems in architecture. The paper highlights the application of Vastu Shastra, where temple design is aligned with the five natural elements and cardinal directions to maintain balance and energy flow. It explains the role of magnetic fields and cosmic energy, suggesting that temples are strategically oriented to harness positive vibrations. The study also discusses classical texts such as Manasara, Mayamata, and Samarangana Sutradhara, which provide guidelines for proportions, layout, and structural design, ensuring both stability and symmetry. Additionally, it emphasizes site selection based on geographical factors like terrain, water sources, and climatic conditions to achieve environmental harmony. The research further explains structural elements such as garbhagriha, mandapa, and shikhara, focusing on their functional and spiritual significance.



Overall, the study connects traditional temple construction techniques with modern sustainable practices, highlighting their relevance in contemporary architecture

Ar. Anjali V. Narad, Ar. Priya Gupta (Raut), Ar. Kalpana R. Thakare presented a study on the Markanda Temple complex in Gadchiroli, focusing on its historical, architectural, and cultural significance. The paper highlights the temple's Hemadpanthi style of construction, characterized by the use of locally available stone and dry masonry techniques, ensuring durability and strength without the use of mortar. It explains the intricate carvings and detailed sculptures on the temple walls, depicting mythological themes and showcasing high craftsmanship. The study also discusses key architectural elements such as the garbhagriha, mandapa, and shikhara, emphasizing their structural and spiritual importance. Additionally, it describes the temple's layout and orientation, reflecting symmetry and traditional planning principles. The research further connects these ancient construction techniques with modern architectural practices, highlighting their relevance in sustainable and heritage-based design.

Kumud Kanitkar (2005) explores the Ambarnath Śiva Temple in Maharashtra, demonstrating how its rare sculptural panels serve as visual "foot-notes" for the construction rituals described in ancient medieval texts like the Samarāngana-sūtradhāra and Aparājitapṛcchā. The study highlights that medieval temple building was a collaborative effort between the Yajamāna (patron-king), the Ācārya (preceptor-priest), and the Sūtradhāra (master architect), all of whom are uniquely portrayed in portrait sculptures on the temple's walls. By analyzing small interior panels that illustrate specific technical and ritual stages—such as the kalaśāropana (installation of the pinnacle) and the installation of the prāsāda-puruṣa (golden effigy)—Kanitkar argues that these carvings acted as a permanent record of the "art and science" of temple architecture, intended to preserve the complex interplay of ritual and construction for posterity.

Aparna Bhogal (2021) presents a study on the Ambarnath Śiva Temple in Maharashtra, identifying its sculptural panels as the earliest known stone depictions of the Siddhas (the "perfected ones") in the region. While the temple was traditionally linked to Śaiva Saiddhāntika and Pāsupata preceptors, Bhogal argues that the Narathara (human frieze) section shows a significant influence from the Siddha and Nath traditions. The research meticulously identifies specific figures from the eighty-four Mahāsiddhas, such as Virūpā, Kānhapā, and Matsyendranāth, by correlating the stone reliefs with hagiographical stories found in Tibetan and local Marathi texts like the Līlācaritra. For instance, one relief depicts the legend of Virūpā transfixing the sun in the sky to settle a tavern debt, while another captures the spiritual and sexual competition between Kānhapā and the yogini Bahudi. Ultimately, the study suggests that these 11th-century carvings serve as an early visual record of esoteric Tantric practices and Sahajiya philosophies, predating other known Siddha sites in Maharashtra by nearly two centuries.

In "A Monument Interpreted," M.S. Mate and J.C. Sonar reconstruct the pre-Islamic religious landscape of Devgiri by conducting an archaeological forensic analysis of the structural components salvaged from the Jami Mosque. By classifying repurposed materials according to the Yadava architectural order and drawing comparisons to established regional archetypes—such as the **Ambarnath temple** —the authors categorize these fragments into distinct typologies to estimate that dozens of temples once populated the fort area. Ultimately, the study highlights the significant urban footprint of these complexes, which occupied over \$163,000 \text{ sq. ft.}\$ within the inner fort, effectively framing medieval Devgiri as a vital center of pilgrimage and commerce before its 14th-century transformation.

The 1881-82 *Report of the Curator of Ancient Monuments in India* offers a critical perspective on the preservation of the 11th-century Ambarnath Temple, framing the site as a structurally vulnerable yet architecturally significant monument in a "ruinous state." The Curator's entry highlights a methodology centered on prudent stabilization and comprehensive documentation, explicitly advocating for the removal of invasive **pīpal** trees to prevent further masonry collapse while prioritizing the preservation of existing 1868 survey casts over aggressive physical restoration. By documenting the deterioration of the temple's roof and the loss of its original enclosing wall, the report provides an essential archival baseline, reflecting a colonial-era conservation philosophy that favored the systematic protection of historical knowledge and the mitigation of environmental decay through minimalist, site-specific interventions.



III. METHODOLOGY

The study of the Ambreshwar Temple was conducted using a structured and systematic methodology aimed at understanding its architectural, structural, and material characteristics. The research began with a detailed site survey and field visit, which involved direct observation of the temple's spatial organization, structural components, and surrounding environmental conditions. This initial stage provided a practical understanding of the temple's physical configuration and construction techniques.

Following the site visit, extensive documentation was carried out through photographs, sketches, and written observations. This process enabled accurate recording of architectural details, material conditions, and structural features. The collected data was then compiled and analyzed to identify key aspects related to load transfer, material performance, and climatic adaptation. Based on this analysis, specific research objectives were formulated to guide the study.

The final stage involved detailed technical evaluation and interpretation of the collected data. The analysis focused on structural systems, material properties, and climate-responsive features. By adopting a stage-wise approach, the study ensures clarity, accuracy, and depth in understanding the engineering principles embedded within the temple's construction.



IV. TECHNICAL ANALYSIS

The Ambreshwar Temple represents a significant advancement in structural engineering, particularly in the transition from rock-cut architecture to free-standing stone construction. Unlike monolithic structures, the temple is composed of individually cut and assembled stone blocks, requiring precise jointing and alignment. This shift necessitated a thorough understanding of load transfer mechanisms, material behavior, and structural stability.





The temple employs a trabeated structural system, also known as the post-and-lintel system, where horizontal beams are supported by vertical columns. In the absence of tensile materials such as steel, the entire structure relies on compressive forces for stability. Loads from the roof and superstructure are transferred vertically through stone beams, columns, and loadbearing walls to the foundation. The use of short spans and closely spaced supports minimizes bending stresses and ensures that all structural elements remain within safe compressive limits.

The foundation system of the temple is designed to distribute heavy loads effectively over the underlying soil. A stepped stone foundation increases the base area, reducing bearing pressure and preventing settlement. This system ensures uniform load distribution and long-term stability, even under varying soil and environmental conditions. The durability of the temple over centuries indicates the effectiveness of its foundation design and load transfer mechanisms.



V. MATERIAL ANALYSIS

The primary construction material used in the Ambreshwar Temple is Deccan basalt, a dense igneous rock known for its high compressive strength and durability. The selection of basalt was influenced by its local availability and suitability for loadbearing structures. Its dense crystalline structure provides resistance to weathering, moisture penetration, and chemical degradation, making it ideal for long-term construction.

Basalt exhibits high density and strength, allowing it to withstand significant compressive loads without deformation. The material's low porosity limits water absorption, reducing the risk of internal deterioration. Additionally, its thermal properties enable it to absorb and release heat gradually, contributing to temperature regulation within the structure. The use of basalt demonstrates an understanding of material properties and their impact on structural performance and environmental adaptation.



VI. CLIMATE RESPONSIVE FEATURES

The design of the Ambreshwar Temple incorporates several climate-responsive features that enhance its durability and environmental performance. The thick stone walls act as thermal mass, reducing temperature fluctuations within interior spaces. This passive cooling mechanism maintains a stable internal environment despite external climatic variations.

The geometric configuration of the temple, including its projections and recesses, creates self-shading surfaces that reduce direct solar exposure. This design minimizes heat gain and prevents excessive thermal stress on the structure. The orientation of the temple allows controlled entry of sunlight while avoiding prolonged exposure to intense afternoon heat.

Rainwater management is achieved through elevated plinths and sloped surfaces, which prevent water accumulation and direct runoff away from the structure. The corbelled construction further ensures that water is shed outward, reducing the risk of infiltration. These features demonstrate a comprehensive approach to climate adaptation, integrating material properties, geometry, and spatial planning.



VII. RESULTS AND DISCUSSION

Vertical Load Transfer Through Stone Columns

Stone columns transfer loads from beams and roof slabs directly to the foundation through compression. Their large cross-sectional area keeps stress within safe limits, ensuring structural stability.

This principle is beneficial in modern engineering as it ensures safe load distribution, prevents structural failure, and helps in designing efficient vertical loadcarrying systems.

Clear and Continuous Load Path

The temple follows a direct load path from roof to foundation through properly aligned elements. This minimizes stress concentration and avoids bending or shear failures.

Such a system is beneficial as it improves structural safety, reduces chances of failure, and ensures efficient force transfer in modern buildings.

Massive Load-Bearing Wall System Thick basalt walls carry vertical loads and provide lateral stability to the structure. Their large thickness reduces stress and increases rigidity.

This is beneficial as it enhances strength, improves resistance to external forces, and increases the lifespan of structures.

Stepped Spread Foundation System

The stepped foundation increases base area, reducing soil pressure and preventing settlement. It ensures gradual and uniform load transfer to the ground.



This helps in modern construction by improving foundation stability, reducing differential settlement, and ensuring safety of structures on varying soils.

High-Density Durable Material Selection

Basalt stone provides high strength, durability, and resistance to weathering. Its low porosity reduces moisture-related damage.

Proper material selection is beneficial as it increases durability, reduces maintenance cost, and improves long-term performance of structures.

Structural Symmetry and Geometric Stability

The symmetrical layout ensures uniform load distribution and reduces stress concentration. It improves overall balance and structural efficiency.

This is beneficial as it enhances stability, reduces torsion effects, and improves performance under dynamic loads like earthquakes.

Raised Plinth for Moisture Protection

The raised plinth prevents moisture from entering the structure and protects masonry from water damage. It also improves drainage around the structure.

This is beneficial as it increases durability, prevents deterioration, and ensures longer service life of buildings.

Dry Masonry and Interlocking Construction

Interlocking stones and friction provide stability without mortar. The heavy weight increases resistance to movement and displacement.

This is beneficial as it promotes sustainable construction, reduces material usage, and allows flexibility and ease of maintenance.

Stellate (Star-Shaped) Structural Plan

The star-shaped plan improves stiffness and distributes loads efficiently. Projections act as supports against lateral forces.

This is beneficial as it enhances structural strength, improves resistance to external forces, and increases overall stability.

Tapering Shikhara Structural Form

The tapering form reduces load towards the top and lowers the center of gravity. This improves stability and ensures efficient load transfer.

This is beneficial as it reduces structural stress, improves stability of tall structures, and optimizes material usage.

VIII. CONCLUSION

The Ambreshwar Temple stands as a remarkable example of traditional engineering excellence, demonstrating the effective integration of structural systems, material properties, and climate-responsive design. Its longevity and stability highlight the efficiency of gravity-based construction methods and the suitability of basalt as a building material. The study reveals that traditional construction techniques were not only sustainable but also highly resilient under environmental stress.

The insights derived from this analysis emphasize the relevance of historical construction practices in modern engineering. By understanding and adapting these principles, contemporary design can achieve improved sustainability, durability, and environmental compatibility. The Ambreshwar Temple thus serves as both a cultural monument and a valuable case study for future architectural and civil engineering applications.

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