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Forensic architectural analysis of traditional mosque architecture in Kerala: the miskhal mosque as a vernacular Islamic typology

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Abstract

This study presents a forensic architectural analysis of the Miskhal Mosque in Kuttichira, Calicut (c.1300–1340 CE), one of the earliest multi-storeyed mosques on the Malabar Coast and a significant example of Kerala's vernacular Islamic architectural tradition. The research investigates how indigenous timber-laterite construction systems were adapted to accommodate Islamic spatial requirements within Kerala's tropical monsoon environment. Using architectural forensic methodologies, the study examines the mosque's spatial organisation, structural logic, and material behaviour. The analysis demonstrates how local master carpenters (*thachans*) translated Islamic liturgical requirements into a vertically organised architectural system supported by composite timber and laterite construction. The findings reveal a climate-responsive structural strategy based on material complementarity, passive ventilation, and moisture regulation. By foregrounding architectural forensics, the study contributes to a deeper understanding of vernacular Islamic architectural systems that evolved through maritime cultural exchange along the Malabar Coast.

Keywords Forensic architectural analysis, Kerala, Miskhal mosque, Vernacular Islamic architecture, Timber-laterite construction

1 Introduction

The arrival of Islam along the Malabar Coast presents a distinctive narrative in the spread of Islamic architecture across the Indian subcontinent. Unlike the northern regions, where Islamic architecture evolved through military conquests and imperial patronage, Kerala's Islamic architectural traditions emerged through peaceful maritime trade networks and cultural exchange. The monsoon-driven trading patterns of the Indian Ocean facilitated sustained contact between Arab merchants and the Malabar Coast, establishing a framework for cultural synthesis that profoundly influenced regional architectural development (Shokoohy 2013). The spice trade, particularly in pepper and cardamom, not only enabled commercial exchange but also fostered the transmission of architectural ideas and practices. These trading relationships, dating back to the seventh century CE, enabled Islamic religious requirements to be gradually interpreted through local building traditions. This process produced an architectural synthesis rooted in cultural accommodation, where religious practices and building traditions evolved without political coercion (Dale 1980). The port towns along the Malabar Coast, including Calicut (modern Kozhikode), emerged as crucial nodes in this network of cultural exchange. These settlements became centres of architectural innovation, where local master builders (*Thachan*) interpreted Islamic spatial requirements through the lens of Kerala's sophisticated timber building traditions. The Miskhal Mosque, constructed during Calicut's golden age as a trading entrepot, stands as a testament to this peaceful cultural synthesis.

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This study positions itself within scholarship on vernacular Islamic architecture by challenging the prevailing emphasis on monumentality associated with imperial centres. Drawing on the theoretical framework of hybrid authenticity in Islamic architecture (AlSayyad 2011), this research examines how local building traditions can create authentic expressions of Islamic religious space without necessarily adopting standardised architectural vocabularies. The research employs multiple theoretical lenses to examine the Miskhal Mosque: architectural forensics provides methodological frameworks for analysing building systems and deterioration patterns; cultural geography concepts illuminate the spatial relationships between trading communities and architectural development; and theories of architectural adaptation guide analysis of how religious requirements were reconciled with local building traditions. The study's primary objectives encompass both technical and cultural dimensions of architectural analysis. It aims to document and analyse the sophisticated timber construction systems characteristic of Kerala's mosque architecture, examining how traditional carpentry techniques were adapted to create Islamic religious spaces. Furthermore, it investigates the spatial organisation principles that emerged from the synthesis of Islamic requirements with Kerala's architectural traditions. The selection of the Miskhal Mosque in Kuttichira, Calicut, as the primary case study is based on its architectural complexity, historical depth, and representative value within Kerala's mosque tradition. As one of the earliest multi-storeyed mosques on the Malabar Coast, it encapsulates key characteristics of timber-based mosque construction, maritime cultural exchange, and long-term adaptive use. Located within an urban historic precinct shaped by continuous occupation, the mosque also reflects the cumulative impact of successive interventions and institutional management practices. In contrast to rural mosques that face abandonment or material neglect, the Miskhal Mosque represents a living heritage site under sustained religious use, making it a critical reference for understanding both resilience and vulnerability in Kerala's mosque architecture. Insights derived from this case are therefore transferable to both urban and rural mosque contexts across the region, particularly those facing material degradation under similar climatic and institutional conditions. Through detailed analysis of the Miskhal Mosque, this research contributes to a broader scholarly understanding of how Islamic architecture adapts to local contexts through peaceful cultural exchange rather than conquest. This approach provides valuable insights into alternative narratives of Islamic architectural development, particularly relevant to understanding the spread of Islam through Indian Ocean trading networks.

Despite a growing body of scholarship on Islamic architecture in South India, significant research gaps persist in the study of Kerala's traditional mosques. Existing literature has largely focused on stylistic description, historical narration, or religious symbolism, while systematic investigations combining architectural forensics with the institutional and material realities of mosque management remain limited. In particular, there is a lack of in-depth studies that integrate the architectural implications of the Waqf system with forensic analysis of timber–laterite construction under tropical monsoon conditions. As a result, deterioration processes, material failures, and conservation challenges are often addressed descriptively rather than diagnostically. This study addresses these gaps by applying architectural forensic methods to a historically and socially embedded mosque, thereby advancing a methodological framework that links material performance, climatic adaptation, and institutional stewardship in the conservation of vernacular Islamic architectural heritage.

2 Literature review

2.1 The maritime mercantile diaspora

The historiography of Indian Ocean trade networks reveals the profound impact of the Hadrami diaspora on the Malabar Coast. These mercantile connections evolved into complex socio-cultural transformations through the influence of Hadrami merchants and scholars from Yemen's Hadramaut region, whose presence is documented from the first century CE through medieval period maritime exchanges (Ilias 2007). The geographical nexus of Hadramaut, encompassing the port cities of Mukalla and Shihr, alongside the inland scholarly centres of Shibam, Sewun, and Tarim, established a sophisticated network of maritime expertise and Islamic scholarship. This dual heritage significantly influenced their role as cultural intermediaries in the Indian Ocean trading system (Khalidi 2004). Maritime archaeological evidence and historical records, particularly the Tarisappalli Copper Plate of 849 CE, substantiate the early establishment of Arab Muslim communities along the Malabar Coast. The strategic evolution of port towns such as Buddfattan, Hili, Hiraqiliya, and Jurfatan demonstrates the sophisticated commercial infrastructure developed by these traders (Lambourn 2008, 2011; Prange 2018).

The symbiotic relationship between the Hadrami merchants and local political structures, particularly the Zamorins of Calicut, exemplifies medieval political economy at its most sophisticated. The Zamorins' strategic provision of protection and tax-free land grants to these traders reflects a sophisticated understanding of international commerce's role in state-building (Khalidi 2004). This patronage facilitated the establishment of

significant Muslim settlements in strategic locations such as Challiyam, Parappanangadi, Tanur, and Ponnani, creating nodes of cultural and commercial exchange (Dale 1980). The process of Islamisation, initiated by figures such as Malik Ibn Dinar, manifested through the systematic establishment of religious infrastructure across the coast. This development of mosques from Kodungallur to Mangalapuram represents an early example of institutional religious expansion through commercial networks (Mohamed and Mohammad 1999). The intensification of Hadrami migration during the seventeenth and eighteenth centuries accelerated this process, creating lasting religious and cultural transformations (Hudawi and Abdul Jaleel 2011).

A particularly significant sociological phenomenon emerged in the formation of the Mappilla Muslim community, which exemplifies the complex processes of cultural hybridisation. The community developed through both direct lineage and conversion, creating a social hierarchy, with the *Thangals* and Arabis representing different strata of religious and social authority (Koya 1976). The emergence of Arabic-Malayalam as a linguistic medium reflects this cultural synthesis. The adaptation of the matrilineal *Marumakkathaya* system by the Mappila Muslims, particularly the *Koyas* of Calicut, demonstrates a successful integration of Islamic principles with local matrilineal traditions (Devi and Sree Devi 2018; Sebastian 2016). The architectural legacy associated with Hadrami maritime networks differs fundamentally from the conquest-driven Indo-Islamic traditions of northern India. Instead of monumental architecture associated with Muslim political power, the Hadrami influence manifested through subtle adaptations of local building traditions. The construction of mosques, palaces, and *tharavadus* using indigenous materials and techniques generated a vernacular architectural language responsive to both Islamic liturgical needs and tropical monsoon conditions (Mohamed and Mohammad 1999). The social stratification within the Mappila community, particularly the distinction between Thangals, Keyis, and Koyas as superior groups, and Puslars and Ossans as occupying lower social strata, reflects the complex intersection of religious, economic, and social factors in community formation (Razak 2007). The physical manifestation of these social distinctions in residential architecture and settlement patterns provides valuable insights into the materialisation of social hierarchies in medieval Indian Ocean societies.

2.2 Architectural heritage of mosques in Kerala

The development of Islamic architecture along the Malabar Coast illustrates a process of cultural synthesis and architectural adaptation that complicates monolithic interpretations of Islamic architecture. The establishment of Muslim communities in Kerala, facilitated by the maritime spice trade routes and monsoon winds, led to the evolution of a distinctive architectural vocabulary that stands in marked contrast to the Indo-Islamic architecture of northern India (Asher 1992). Unlike the Mughal architecture of northern India, which emerged from cultural assimilation following military conquests, Kerala's mosque architecture developed through voluntary cultural exchange and adaptation. This process fostered a more nuanced architectural language that respected both Islamic liturgical requirements and regional building traditions. The mosques share remarkable architectural similarities and demonstrate the sophisticated building traditions of medieval Malabar. The architectural style of these mosques draws interesting parallels with the Koothambalam (temple theatre) of Hindu temples, highlighting the indigenous influence on Islamic religious architecture in the region (Fig. 1). The fundamental Islamic requirement for communal worship space underwent significant adaptation in Kerala's tropical context. While the prototype of mosque architecture derives from the Prophet Muhammad's house in Medina, characterised by an open courtyard and portico, Kerala's monsoon climate necessitated substantial modifications. The traditional open courtyard was transformed into an enclosed, elevated space, creating positive emptiness that serves the rhythmic patterns of daily prayers. The technical execution of Kerala's mosques demonstrates indigenous building knowledge, following a systematic construction methodology that integrated local materials and craftsmanship. The construction typically employed a granite foundation that elevated the structure above flood levels, laterite block walls chosen for their porosity and workability, and an elaborate timber superstructure that represented the pinnacle of local craftsmanship. Central to this architectural tradition was the role of the *Thachan*, or master carpenter, who, despite occupying a lower position in Kerala's caste hierarchy, commanded tremendous respect for their comprehensive knowledge of construction principles (Arfeen 2022). The timber roof system evolved from simple double-pitched structures to complex gabled hip roofs, demonstrating both technical advancement and cultural symbolism. The structural system, comprising an intricate arrangement of beams, purlins, and rafters, showcases the technical mastery of local craftsmen and their ability to create complex architectural solutions using indigenous materials and techniques. Across the Islamic world, mosque architecture has consistently absorbed local building cultures, producing diverse typologies shaped by climate, materials, and craftsmanship. The absence of domes and monumental minarets in Kerala's mosques reflects a long-standing Islamic tradition of regional adaptation, shaped by the continuity

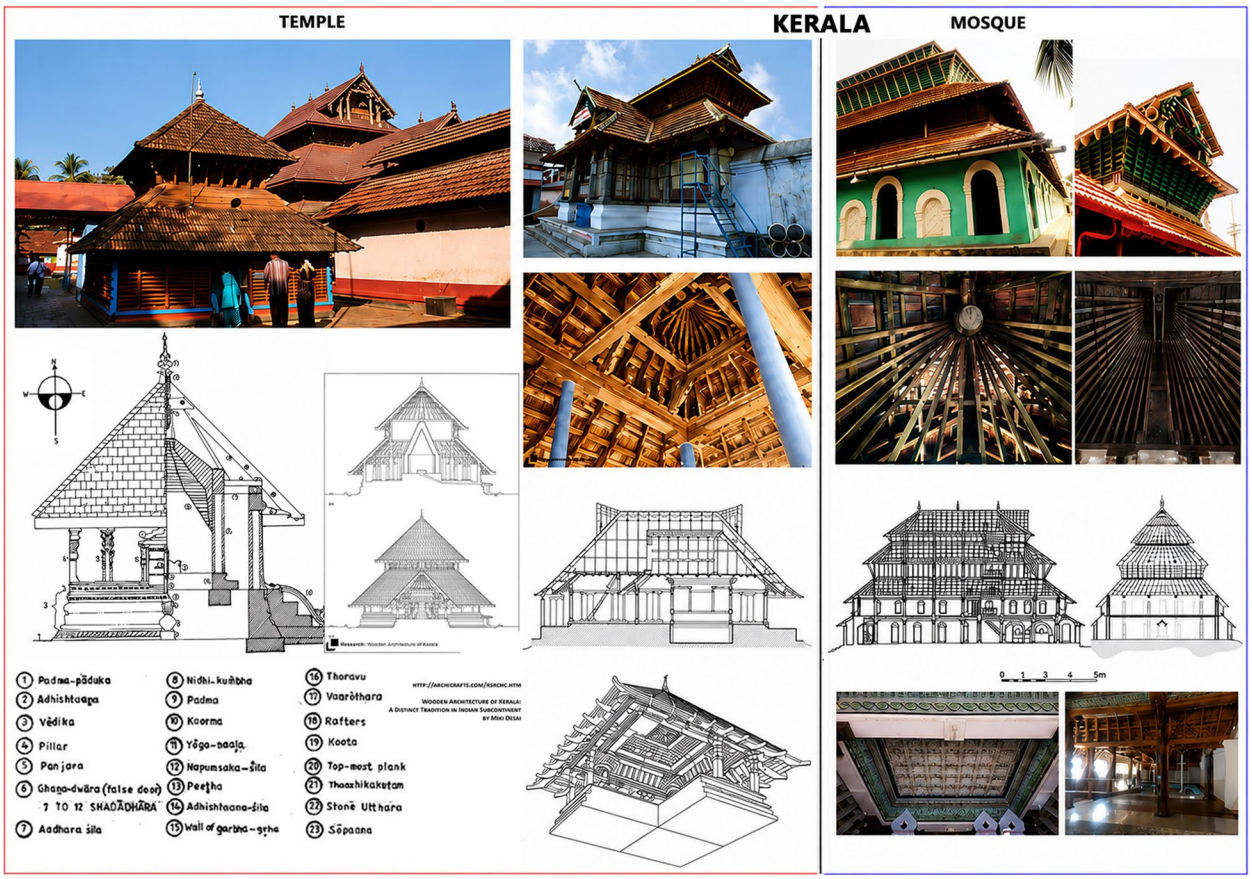

Fig. 1 Plate showing temple and mosque architecture in Kerala (Source: Images adapted from ArchiCrafts, https://archicrafts.com, and supplemented with the author's original photographs)

of indigenous timber-based construction systems and tropical monsoon climatic logic rather than deviation from Islamic architectural principles. The region lacked a tradition of dome construction, and the predominantly wooden construction methods were unsuitable for dome building. The decorative program of Kerala mosques demonstrates an adaptation of Islamic principles to local artistic traditions. This architectural vocabulary is not unique to the Miskhal Mosque but is consistently observable across several historic mosques in Kerala, including the Muchchundi Masjid, Juma Masjid of Calicut, and mosques at Tanur and Ponnani. These structures share common characteristics such as steeply pitched tiled roofs, timber column grids, internalised prayer halls, and the absence of monumental vertical markers. Comparable spatial and structural strategies can also be observed in contemporaneous Hindu temple-associated structures such as the Koothambalam and Nalukettu houses, particularly in roof geometry, column proportions, and carpentry systems. These parallels confirm that Kerala's mosque architecture evolved as a regional building tradition rather than as isolated stylistic experiments.

2.3 Historic mosques of Kuttichira

The historic settlement of Kuttichira lies within the Thekkepuram region of Calicut city in Kerala's Kozhikode district (Fig. 2). Three prominent historic mosques define the religious landscape of Kuttichira: The Miskhal Masjid, Muchchundi Masjid, and Juma Masjid (Fig. 3). These structures maintain their orientation towards Makkah while incorporating local building techniques and materials. Among these historic structures, Miskhal Masjid holds particular significance (Fig. 4). Built by Nakhooda Miskhal, a wealthy Yemeni merchant and ship owner who settled in Calicut, the mosque originally stood as a seven-story structure, an extraordinary architectural achievement for its time. Its prominence was particularly noteworthy as it transcended typical height restrictions imposed on other structures of that period. Following the Portuguese attack of 1510, the mosque was reduced to its current four-story configuration (Shokoohy 2013). The multiple stories served various community functions, with upper tiers accommodating a madrasa (religious school), resting areas, and spaces for public gatherings and discussions. The Muchchundi Masjid, constructed

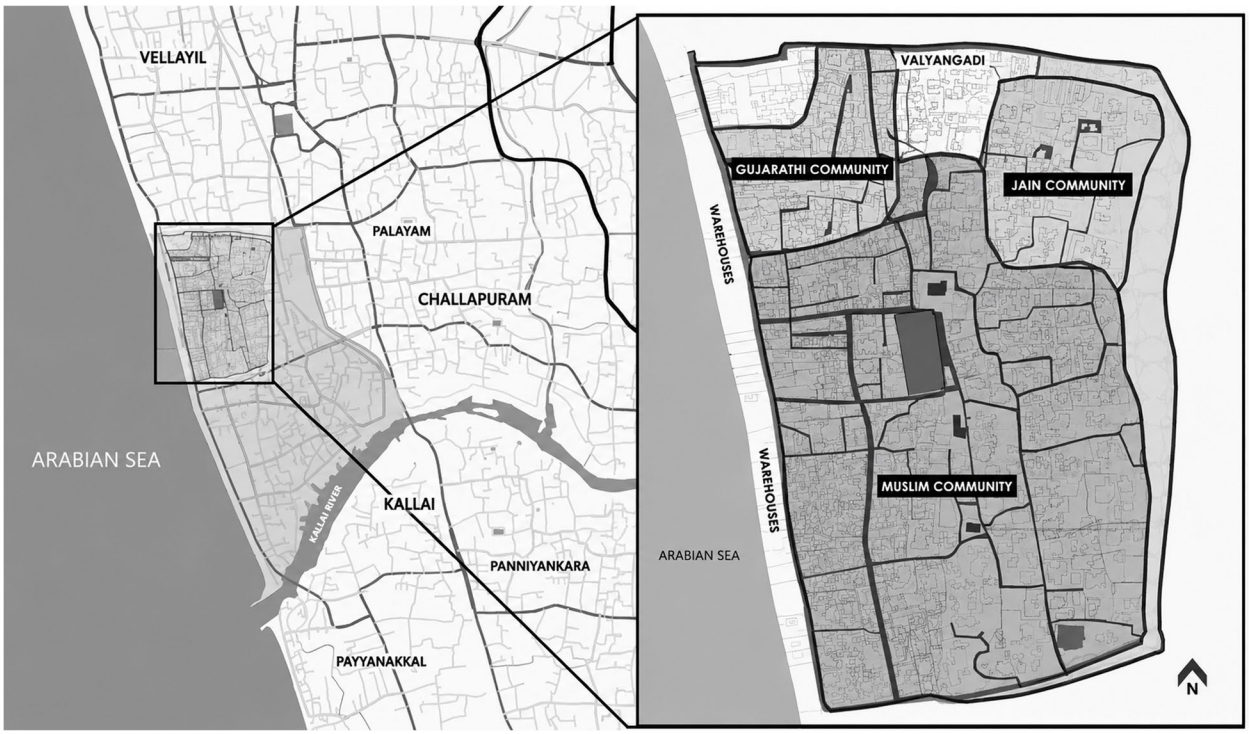

Fig. 2 Map of Kuttichira in Thekkepuram region (Source: the author)

Fig. 3 **a** Miskhal Palli, **b** Jami Palli, and **c** Mucchundi Palli (Source: the author)

in the 13th century CE, predates the Miskhal Masjid by a century, making it the oldest of Kuttichira's three mosques. Historical inscriptions document the Zamorin's donation of property to the mosque, indicating the ruler's support for Islamic institutions. The Juma Masjid, dating to the 14th century, has undergone sensitive spatial expansion with the incorporation of courtyards.

3 Methods

This research adopts an architectural forensic methodology to investigate the material behaviour, construction logic, and deterioration mechanisms of the Miskhal Mosque. Architectural forensics, as employed in this study (Friedman 2010), refers to the systematic examination of building fabric using non-destructive and minimally invasive techniques to diagnose structural and material performance over time. The methodology integrates visual condition mapping, measured documentation, and photographic surveys with targeted technical assessments. Non-destructive techniques such as infrared thermography were employed to identify moisture accumulation and concealed timber decay, while material sampling and laboratory analysis of lime mortar composition were undertaken to assess binder–aggregate ratios,

Fig. 4 Miskhal mosque, 2006 (Source: the author)

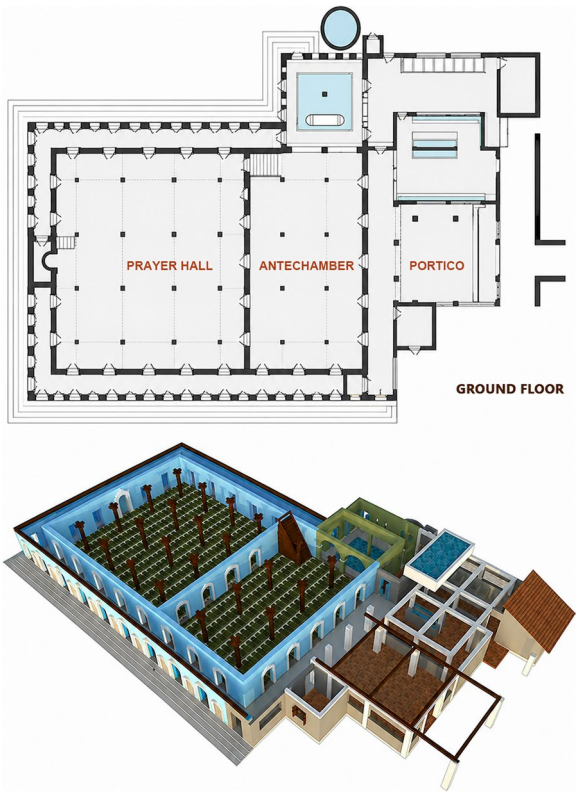

Fig. 5 Ground floor plan (Source: the author)

porosity, and deterioration patterns. These methods enabled the identification of incompatibilities between original materials and later interventions, allowing deterioration processes to be traced back to their material and environmental causes rather than treated as isolated defects.

Field research conducted over multiple seasons allowed documentation of the mosque's response to monsoon conditions, critical for understanding the environmental adaptation strategies embedded in its design. Detailed mapping of timber joinery systems and structural connections was undertaken to document traditional construction techniques. The research also incorporates archival analysis, examining historical documents, repair records, and early photographs to understand the building's evolution over time. Oral histories from the local Muslim community and traditional craftsmen provided valuable insights into building use patterns and maintenance traditions. This comprehensive methodological approach allows the analysis of both tangible and intangible aspects of the mosque's architecture, revealing the complex relationships between religious requirements, environmental responses, and local building traditions that characterise this unique architectural synthesis.

4 Architectural analysis

4.1 Spatial organisation

The Miskhal Mosque exemplifies a sophisticated adaptation of Islamic spatial requirements to Kerala's architectural traditions. Rising four stories to a height of 18 m, the mosque's spatial organisation represents an indigenous interpretation of Islamic space (Shokoohy 2013). The primary prayer hall, oriented towards Makkah, demonstrates how local builders reconciled directional requirements with traditional Kerala building forms. The mosque's spatial hierarchy reflects a synthesis of Islamic ritual requirements and regional architectural logic. Unlike the courtyard-centred organisation typical of Middle Eastern mosques, the Miskhal Mosque employs a system of interconnected interior spaces more characteristic of Kerala's traditional architecture. This adaptation responds directly to the tropical monsoon climate by internalising spatial openness rather than relying on exposed courtyards (Lewcock and Freeth 1978). The vertical organisation of space presents particular interest, with the building's four levels serving distinct but complementary functions (Fig. 4).

4.1.1 Ground floor

The mosque's primary access is facilitated through an impressive arrangement of five doors situated beneath the portico; each framed within semi-circular arches adorned with wide borders that echo the mosque's overall architectural language. The ground floor layout is illustrated in Fig. 5. The central arch, deliberately scaled larger than its counterparts, creates a hierarchical emphasis marking the primary entrance. The antechamber, measuring 9.50 by 15.50 m, demonstrates precise spatial planning with its five-bay width and three-aisle depth configuration, positioned strategically to the east of the main prayer hall (Fig. 6). The transition between spaces is carefully orchestrated through

Fig. 6 **a** Antechamber and the old ablution chamber **b** Main Prayer Hall **c** Mihrab (left) and Mimbar (right) (Source: the author)

a series of corresponding doorways. Four doors on the antechamber's western wall provide access to the prayer hall, aligned with the entrance portals beneath the colonnade. Two narrow corridors run along the northern and southern peripheries, extending around the western side of the structure. These corridors are punctuated by doorways that correspond with the internal access points, all featuring the characteristic semi-circular arch motif. This systematic arrangement of openings creates a fluid circulation pattern while maintaining the spiritual hierarchy of spaces. The main prayer hall presents a perfect square plan measuring 15.50 m on each side, organised around four rows of columns supporting a wooden ceiling system like the antechamber. The spatial arrangement demonstrates proportional relationships, with peripheral bays measuring approximately 1.75 m in width, while the central intervals between columns span 3.60 m, precisely double the width of the side bays. The prayer hall's focal point, the mihrab, takes the form of a deep semi-circular niche with corresponding arch treatment. While its basic configuration appears original, the decorative framework, featuring pilasters with distinctive bases and capitals supporting a foliated arch, likely dates to the 17th century. The European influence is evident in the proportions and moulding treatments, reflecting the cultural exchanges characteristic of Kerala's colonial period. Adjacent to the mihrab, an exquisitely carved wooden mimbar serves as both a functional and decorative element (Fig. 6). Its five-step ascent to a canopied speaker's platform demonstrates sophisticated woodworking techniques. The canopy, supported by six turned wood columns, two featuring prominent circular bases and capitals, integrates seamlessly with the balustrades. The mimbar's decorative panels and coffered ceiling, crowned by a concave-sided "roof" evoking textile canopies, exemplify the refined architectural craftsmanship of the period. The columns, each crafted from single wooden blocks, are crowned with modest wooden brackets supporting substantial beams. The ceiling system employs an ingenious arrangement of dual rafters: a lower tier of heavier members secured in precisely cut notches within the beams, overlaid with lighter rafters positioned perpendicular to the primary set, providing both stability and aesthetic refinement. The antechamber's columns, though partially restored, largely retain their original form, featuring distinctive five-register shafts alternating between square and octagonal sections. The lower register's enhanced height creates a subtle visual emphasis. These architectural elements find parallels in other historic mosques of Calicut and show strong stylistic connections to the stone columns of Kayalpatnam's older mosques, suggesting a regional architectural vocabulary. Notable modifications to the original structure are evident, particularly in the northern section of the antechamber, where the removal of original doors and eastern corridor segments accommodated a later extension housing the ablution pool (Fig. 7). The current configuration features two arches opening directly from the antechamber to the ablution chamber. While the chamber was initially designed as a two-story structure, subsequent ground-level extensions northward facilitated the enlargement and remodelling of the ablution pool.

4.1.2 First floor

The first floor of the Miskhal Mosque exemplifies a masterful integration of form and function within Kerala Mosque architecture. Access is provided through a strategically positioned staircase at the northwest corner of the antechamber. This vertical circulation element serves as a crucial transition point, marking the shift from the ground floor's religious functions to the more diverse activities accommodated in the upper levels. The thoughtful positioning ensures that movement to and from upper floors does not disturb sacred activities below. Historically, the upper structure served dual purposes, reflecting the mosque's broader community role. As both a madrasa and the administrative office of the qadi, this space exemplified how traditional Kerala Mosque architecture successfully accommodates educational and administrative functions alongside

Fig. 7 Spatial additions—Lavatories, new ablution area, front portico (Source: the author)

its primary religious purpose. This multi-functional approach highlights the sophisticated spatial programming, creating environments capable of serving various community needs while maintaining appropriate separations between different activities. The architectural significance of the first floor is particularly evident in its impressive spatial volume, achieved through an innovative structural system that creates a double-height ceiling of approximately 4.5 m. This engineering achievement was made possible through the implementation of a double-column system, where wooden columns were stacked vertically and interconnected by beams to ensure structural stability. This solution not only provided comfortable ceiling height but also demonstrated the advanced understanding of load distribution and structural mechanics possessed by medieval Kerala's builders. The careful alignment of upper and lower columns, combined with the strategic beam placement, created a robust structural framework that has endured over time. In its current configuration, the first floor continues to serve the community with adaptations to modern needs. The main space, maintained with carpet flooring, hosts occasional gatherings and public discussions, demonstrating the enduring flexibility of the original design. This successful adaptation of historical space for contemporary use offers valuable insights into architectural preservation that maintains both structural integrity and social utility. Adjacent to the main space, a room above the ablution chamber, accessible from the first-floor roof level, serves as secure storage for mosque property, highlighting how practical considerations were integrated into the original architectural program (Fig. 8).

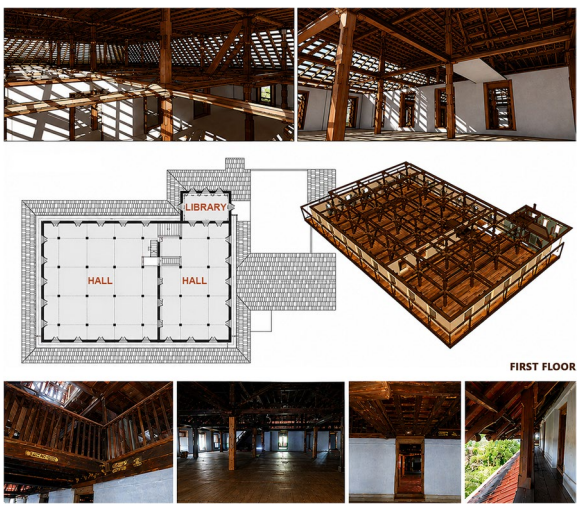

Fig. 8 First floor (Source: the author)

4.1.3 Second floor

The upper levels of the Miskhal Mosque display remarkable architectural complexity in their structural design and spatial organisation, with each floor showcasing distinct characteristics that enhance the building's functionality and aesthetic appeal. The second floor is accessed via a thoughtfully designed staircase incorporating a landing at the crossbeam level. This level, measuring 11.90 m by 20.90 m, employs a complex structural system that builds upon the lower floors' engineering principles while introducing unique spatial and environmental solutions. The second floor's structural integrity is maintained through an ingenious arrangement of dual-layered cross beams working in concert with vertically stacked column shafts. What distinguishes this level, however, is its innovative roof design, which departs from conventional approaches. Unlike lower levels, the second floor foregoes stone walls and balconies in favour of a more open, dynamic solution. The roof structure extends outward through cantilevered beams that rest directly on the columns, creating deep eaves that encircle the entire floor, hence protecting from Kerala's intense monsoon climate while

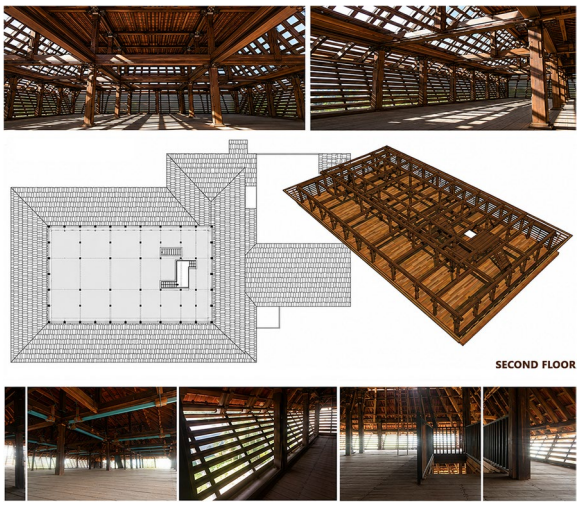

Fig. 9 Second floor (Source: the author)

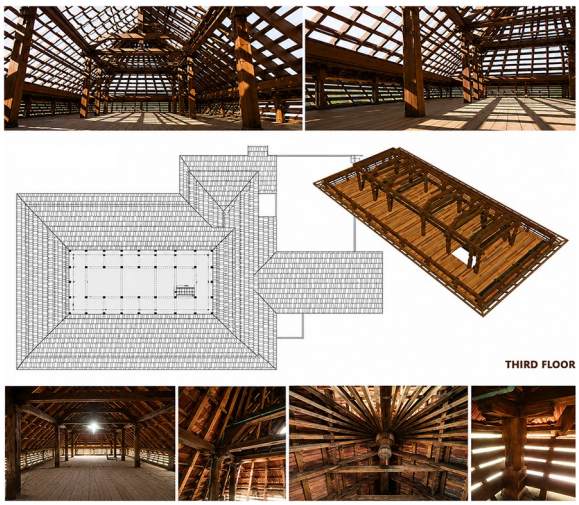

Fig. 10 Third floor (Source: the author)

creating a striking visual effect that emphasises the building's horizontal lines. The most ingenious aspect of the second floor's design is its environmental control system around the perimeter. Carefully engineered lighter struts have been installed beneath the eaves, fitted with outward-sloping louvres. This arrangement serves dual purposes: facilitating natural ventilation while managing daylight admission to interior spaces (Fig. 9).

4.1.4 Third floor

The transition to the third floor, effectively an attic space, occurs through another flight of stairs positioned on the eastern side of the building. This ascending journey leads to a generously proportioned landing that precedes entry into the mosque's uppermost enclosed space. This final level, situated directly beneath the roof apex, presents a more intimate scale with dimensions of 17 m by 8 m, roughly half the width of the floor below. This reduction creates a more focused spatial experience while maintaining the structural principles established in the lower levels. The third floor's structural system maintains continuity with the levels below through two rows of columns that align precisely with the main structural supports of the building. This vertical alignment ensures efficient load transfer throughout the entire structure. The *thachans* demonstrated remarkable ingenuity in addressing the challenges presented by the roof spans at this level. Additional posts, securely tied together with beams, were introduced at each end of the roof to reduce the crossbeam spans, creating a robust and stable structural system. One of the most striking features of the third floor is the visible articulation of the roof structure on the interior. The careful craftsmanship is particularly evident at the western end, where the hip roof configuration creates a focal point as all rafters converge to a single point. This structural solution not only serves its practical purpose but also creates an aesthetically pleasing geometric pattern that draws the eye upward, emphasising the vertical culmination of the building (Fig. 10).

4.2 Structural system

The Miskhal Mosque embodies technological syncretism in its construction methodology. Traditional Kerala carpentry techniques, developed through centuries of temple and palace construction, were adapted to serve the mosque construction. The building employs a composite system, combining load-bearing laterite walls with an intricate timber framework. This system demonstrates understanding of both materials' properties, using laterite's compressive strength for walls while exploiting timber's tensile capabilities in the complex roof structure. The mosque's column system merits attention. The ground floor features sixteen columns arranged in a grid pattern, supporting the upper stories through an intricate system of beams and brackets. These columns are carved from single pieces of teak. The alternating square and octagonal sections of the columns reflect both structural efficiency and aesthetic refinement. The roof structure represents perhaps the most sophisticated element of the building's structural system. Multiple tiers of rafters and purlins create a three-dimensional load distribution network. This system allows for both structural efficiency and natural ventilation, crucial in Kerala's tropical monsoon climate. The structural system of the Miskhal Mosque stands as an exemplar of medieval Kerala's architectural ingenuity, demonstrating masterful integration

of indigenous building traditions with Islamic spatial requirements. Rising from a stone plinth comprising four circumferential steps, now partially obscured by the modern entrance hall's raised floor at the eastern facade, the mosque employs a composite structural system that harmoniously combines load-bearing laterite masonry with an intricate timber framework. At the foundation level, the original building, encompassing both the prayer hall and antechamber, establishes its structural integrity through robust laterite stone masonry walls. This choice of material reflects a deep understanding of local building traditions and material properties. Laterite, with its excellent compressive strength and ability to be quarried and shaped easily, provides the solid base necessary for supporting the mosque's elaborate wooden superstructure. The mosque's structural sophistication is particularly evident in its column system, which forms the backbone of its load-bearing framework. Sixteen columns, meticulously arranged in a grid pattern across the ground floor, create the primary support system for the upper stories. These columns, carved from single pieces of teak, showcase both structural efficiency and artistic refinement through their distinctive design featuring alternating square and octagonal sections. This arrangement is not merely decorative but serves a crucial structural function, optimising load distribution while maintaining aesthetic harmony. The column arrangement plays a pivotal role in sustaining the tiered roof structure. The system demonstrates understanding of load transfer and structural hierarchy, with each element carefully positioned to contribute to the overall structural stability. Perhaps the most remarkable aspect of the mosque's structural system lies in its roof design, which employs multiple tiers of rafters and purlins to create a complex three-dimensional load distribution network. Figures 11 and 12 illustrate the structural system.

4.3 Cultural synthesis

The Miskhal Mosque represents a seminal example of cultural and architectural synthesis, blending Islamic religious principles with Kerala's indigenous building traditions. Its architectural and decorative elements reflect a process of negotiated authenticity, where local techniques and materials were adapted to fulfil Islamic liturgical requirements while retaining the essence of Kerala's vernacular style.

4.3.1 Architectural synthesis

The architectural synthesis evident in the Miskhal Mosque should be understood not as a deviation from Islamic architectural traditions but as a regionally grounded expression of them. Islamic architecture, historically, has never been a singular formal language; rather, it has evolved through continuous negotiation with local materials, technologies, and cultural practices. In Kerala, this negotiation occurred through the mediation of indigenous master craftsmen (*thachans*), whose expertise in timber construction, roofing systems, and climatic adaptation shaped the architectural realisation of Islamic religious space. The mosque's structural system combines load-bearing laterite walls with an intricate timber framework, a hallmark of Kerala's traditional *thachushastra* (carpentry principles). Laterite, quarried locally, provided thermal mass and moisture resistance, ideal for the humid monsoon climate, while teak wood, selected for its durability and resistance to insects, formed the primary material for pillars, beams, and decorative elements. This fusion of materials created a climate-responsive system: the laterite walls stabilised indoor temperatures, while the timber superstructure allowed for natural ventilation through its perforated screens and elevated floors. The current four-story elevation demonstrates a vertical stratification unique to Kerala's interpretation of Islamic architecture. Unlike the horizontal, courtyard-centred layouts of Middle Eastern mosques, the Miskhal Mosque employs interconnected interior spaces, internalising open areas to protect worshippers from heavy rains. The prayer hall, oriented toward Makkah, integrates seamlessly into this layout, aligning Islamic directional requirements with Kerala's spatial vocabulary. The tiered, tiled roofs and gopuram-style arches at the entrance underscore the regional adaptation. The timber roof structure, supported by 24 intricately carved pillars, represents the pinnacle of Kerala's carpentry traditions. Joints and pegs were used instead of nails, allowing flexibility to withstand monsoon winds while maintaining structural integrity. This engineering sophistication extended to the 47 engraved doors and the mihrab-style openings, which facilitated cross-ventilation while adhering to Islamic aesthetic principles. During renovations, a wooden mimbar (pulpit) adorned with geometric motifs was added, reflecting the seamless continuation of craft traditions.

4.3.2 Cultural adaptations

The mosque's design reflects a profound cultural dialogue between Arab traders and the Malabar coast's Hindu-majority society. *Perunthachan* (master carpenter) and the local *thachans,* who traditionally built Hindu temples and palaces, adapted their skills to Islamic prohibitions against figurative art by developing a new lexicon of geometric and floral patterns. The decorative program of the Miskhal Mosque provides tangible evidence of cultural adaptation at the level of craftsmanship. Timber ceilings, brackets, columns, and the mimbar are articulated through geometric abstraction, vegetal motifs, and

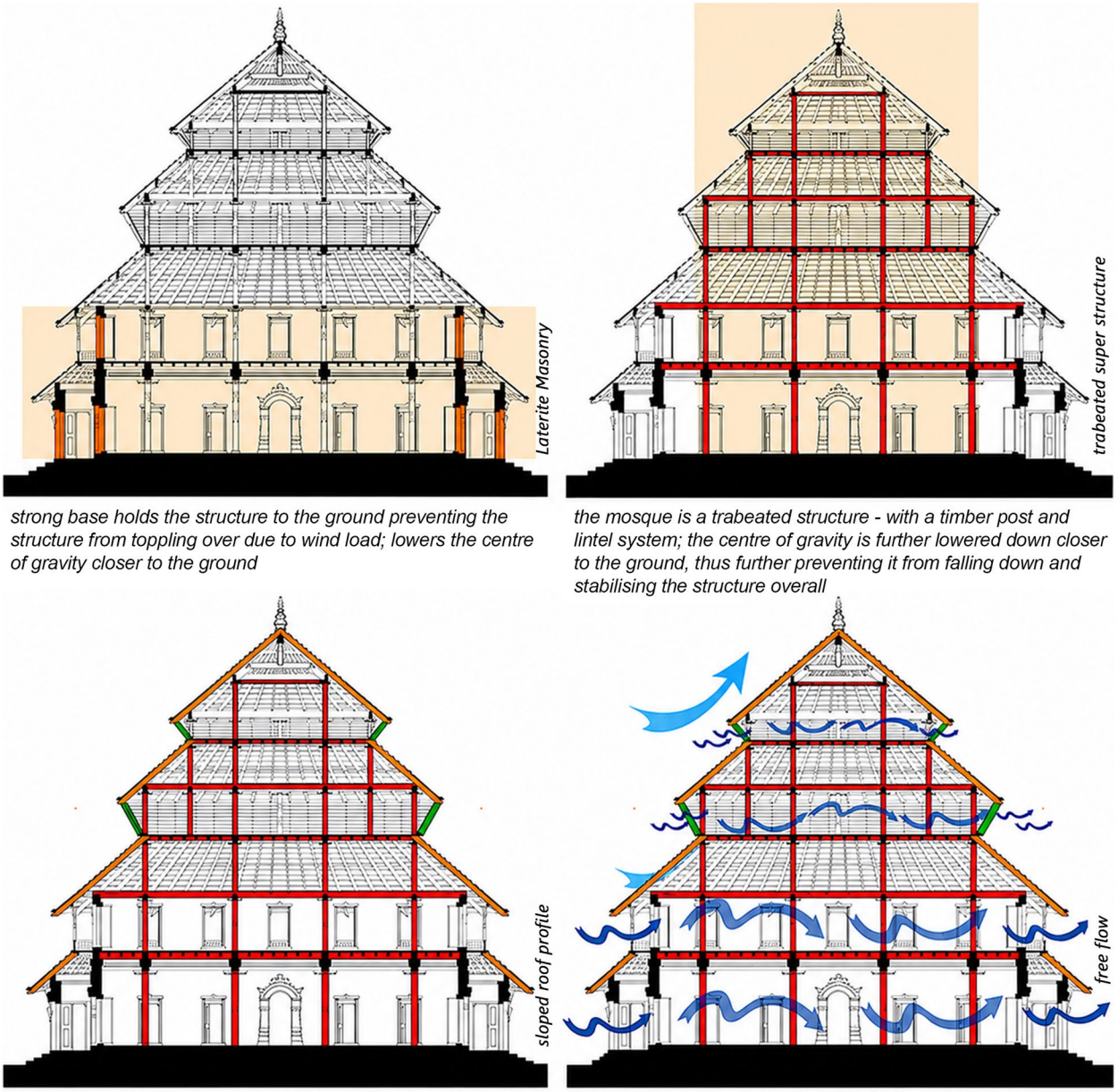

Fig. 11 Structural analysis (Source: the author)

repetitive patterns that align with Islamic aniconic principles while remaining rooted in Kerala's ornamental traditions. Lotus-derived forms, layered mouldings, and bracket profiles closely resemble those found in temple architecture yet are stripped of figural representation. Figures 13 and 14 show the Decorative gable end of the roof facing the east side. Figure 15 shows the decorative detail of the balustrade provided in the first-floor veranda. This selective abstraction demonstrates how local craftsmen recalibrated their visual vocabulary to accommodate Islamic aesthetics without abandoning inherited techniques. The ceilings and pillars feature lotus motifs and arabesque carvings, echoing temple aesthetics while complying with aniconic principles. This synthesis is most evident in the gopuram-like arches, which reinterpreted temple gateway designs for Islamic

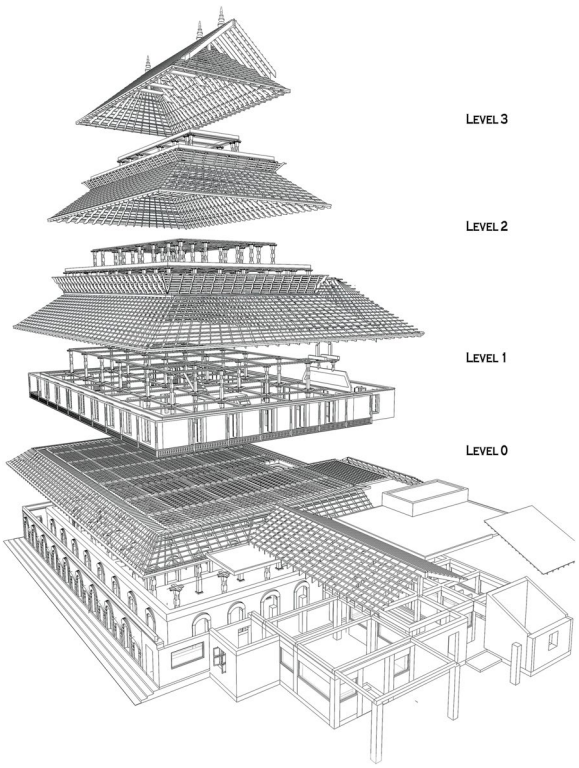

Fig. 12 Axonometric section of the Miskhal Mosque (Source: the author)

Fig. 13 Decorative gable end of roof facing east side (Source: the author)

liturgical use. The mosque also embodies the Zamorin dynasty's pluralistic ethos. After the Portuguese partially destroyed the mosque in 1510, the Hindu Zamorin rulers financed its reconstruction using timber salvaged from the demolished Chaliyam Fort, symbolising inter-communal solidarity. This collaboration extended to ritual practices: during Ramadan, the Zamorin family and

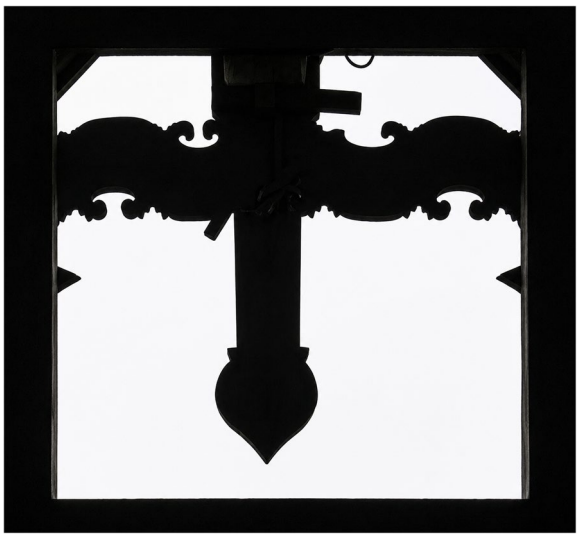

Fig. 14 Detail of carved timber gable ornament (east elevation) (Source: the author)

Fig. 15 Detail of decorative balustrade provided in the first-floor veranda (Source: the author)

Muslim leaders continue to meet at the mosque, reaffirming centuries-old bonds. The spatial hierarchy of the mosque further illustrates this cultural negotiation. While traditional Islamic mosques prioritise communal courtyards, the Miskhal Mosque's vertical floors served distinct functions, a response to Kerala's dense urban fabric and climatic needs. The ground floor accommodated daily prayers, while upper levels hosted educational and administrative activities, mirroring the multi-functional *nalukettu* homes of Kerala's elite.

4.3.3 Comparative spatial logic: mosque and temple traditions in Kerala

The architectural logic of the Miskhal Mosque reveals significant overlaps with Hindu temple-associated

structures in Kerala, particularly in spatial hierarchy, structural organisation, and environmental response. Both traditions prioritise raised plinths, timber column grids, deep roof overhangs, and internalised spaces that mitigate heavy monsoon rainfall. While temples organise space around ritual circumambulation and hierarchical sanctums, the mosque reorients similar structural systems toward congregational prayer and qibla alignment. The reuse of identical construction principles for distinct ritual functions underscores the adaptability of Kerala's architectural systems and confirms that mosque construction was embedded within existing regional building knowledge rather than introduced as an alien typology.

5 Architectural diagnosis and material implications

The deterioration observed at the Miskhal Mosque cannot be understood merely as a consequence of age or environmental exposure; rather, it is fundamentally linked to disruptions in the building's original material logic. The mosque was conceived as an integrated timber–laterite system optimised for Kerala's humid tropical climate, where moisture regulation, material breathability, and structural flexibility were critical to long-term performance. Most failures identified were not intrinsic to the historic construction but resulted from later material interventions that disrupted established environmental and material equilibria.

Kerala's monsoon climate subjects buildings to prolonged cycles of saturation and drying, demanding construction systems capable of accommodating moisture without retaining it. Historically, this was achieved at Miskhal Mosque through an elevated plinth, porous laterite masonry, breathable lime-based plasters, and a timber superstructure that permitted controlled movement and ventilation. Disruption of this moisture-management system emerged as the primary cause of material degradation. Rising damp conditions were intensified by inadequate drainage and water-retaining installations introduced in later phases, leading to persistent moisture accumulation at column bases and wall junctions. These conditions accelerated material decay and triggered localised structural settlement, particularly in areas adjacent to later additions.

A critical source of deterioration was the introduction of cement-based mortars and concrete elements that conflicted with the behaviour of the original materials. Unlike traditional lime mortars, cement is rigid and impermeable, preventing moisture migration and evaporation. When applied to laterite walls, cement trapped moisture within masonry cores and at timber interfaces, creating conditions conducive to salt crystallisation, biological growth, and progressive decay. This incompatibility compromised the synergistic relationship between laterite and timber, transforming moisture-buffering assemblies into zones of chronic deterioration.

Timber elements were particularly affected by inappropriate surface treatments. The application of synthetic and enamel paints to wooden columns, beams, and brackets formed impermeable skins that inhibited evaporation. As a result, moisture became trapped within the wood, accelerating fungal attack and internal rot. In several instances, decay progressed invisibly beneath intact paint layers, undermining structural capacity before external symptoms became apparent. These failures underscore the vulnerability of timber architecture to modern coatings that disregard traditional material behaviour.

The insertion of ferro-cement jali panels further disrupted the mosque's architectural and environmental performance. Beyond their visual incongruity, these elements obstructed natural airflow patterns integral to the building's passive ventilation strategy. By restricting cross-ventilation, they increased internal humidity levels, exacerbating moisture-related deterioration of both timber and masonry. Their rigidity also introduced stress concentrations at junctions with flexible timber components, contributing to localised cracking and material fatigue. Such interventions illustrate how seemingly minor architectural alterations can have cascading environmental and structural consequences in vernacular buildings.

Collectively, these deterioration patterns demonstrate that the resilience of Kerala's traditional mosque architecture depends on the continuity of its original material and environmental logic. Timber–laterite systems operate as integrated assemblies in which breathability, flexibility, and moisture regulation are interdependent. When modern materials disrupt this balance, deterioration accelerates rather than diminishes. The implications for conservation are therefore architectural rather than procedural: effective preservation must be grounded in an understanding of vernacular construction physics, climatic adaptation, and material compatibility. Conservation strategies that ignore these principles risk undermining the very systems that enabled such structures to endure for centuries.

6 Discussion and conclusions

The forensic architectural analysis of the Miskhal Mosque reveals how Kerala's vernacular building traditions were adapted to accommodate Islamic spatial requirements within a tropical monsoon environment. The study demonstrates that the mosque represents a regionally grounded architectural typology shaped by indigenous construction systems, climatic adaptation, and maritime cultural exchange on the Malabar Coast.

First, the mosque illustrates a distinctive vertical spatial organisation, where prayer, educational, and administrative functions are distributed across multiple floors. This typology differs from the courtyard-based layouts commonly associated with mosque architecture in other Islamic regions and reflects adaptation to the dense urban fabric of historic Calicut.

Second, the building's timber–laterite structural system demonstrates a sophisticated strategy of material complementarity. Laterite masonry provides compressive stability and moisture buffering, while the timber superstructure accommodates tensile forces, structural movement, and natural ventilation. This integrated system enabled the mosque to respond effectively to the climatic pressures of monsoon rainfall and high humidity.

Third, architectural forensic analysis reveals that recent deterioration is largely the result of incompatible modern interventions, including cement mortars, synthetic coatings, and ferro-cement elements. These materials disrupt the breathability and flexibility of the original construction system, leading to moisture retention and accelerated decay.

Fourth, the mosque illustrates how vernacular Islamic architecture emerged through collaboration between Muslim patrons and indigenous craftsmen, rather than through direct replication of West Asian architectural models. The building therefore, represents a regional architectural tradition shaped by local materials, craft knowledge, and socio-cultural interaction.

Finally, the study demonstrates the value of architectural forensics as a methodological approach for understanding historic construction systems and guiding conservation strategies. Effective preservation of Kerala's historic mosques requires approaches grounded in material compatibility, climatic responsiveness, and continuity of traditional construction knowledge.

More broadly, this case study offers transferable insights for the study and conservation of vernacular Islamic architecture across tropical monsoon regions. It affirms that such architectures encode sophisticated environmental and structural knowledge systems that merit rigorous scholarly attention rather than marginal treatment within global Islamic architectural histories. By foregrounding regional innovation rather than imperial patronage, the study contributes to a more plural and decentralised understanding of Islamic architectural development in South Asia. Future research could extend this forensic methodology to other Indian Ocean contexts, such as Yemen, East Africa, and Southeast Asia, to further map patterns of architectural adaptation shaped by climate, trade, and craft traditions. In an era of increasing climatic uncertainty, the passive environmental strategies embedded in structures like the Miskhal Mosque offer valuable lessons for both heritage conservation and contemporary sustainable design.

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Dr. Shahim Abdurahiman – data collection; conceived, designed and performed the analysis. The author read and approved the final manuscript.

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Ethics approval and consent to participate
Permission to conduct the interviews for the purposes of this research was obtained from all respondents, who were fully informed about the purposes of this research and how their responses would be used and stored. All interviewees have been anonymised.

Consent for publication
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