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Lý dynasty palatial buildings (11th–13th centuries): Architectural divergence within the East Asian timber tradition from archaeological perspectives

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Abstract

Lý dynasty palace architecture (1010–1225) represents the pinnacle of Đại Việt civilization and the flourishing of Thăng Long as the capital in Vietnamese history. However, the complete absence of any remaining *in situ*, above-ground timber structures has created a major "heritage gap" in its architectural history. This article presents the results of research into the morphological identification of Lý dynasty palace architecture based on the groundbreaking archaeological discoveries made during excavations at the Thăng Long Imperial Citadel in 2002–2004, 2008–2009, and 2012–2014. Through analysis of foundation systems and building materials and through cross-cultural comparison, the study indicates that the Lý-period palace formed part of a large-scale timber-timber tradition, employing a vermilion-lacquered bracket system (*dougong*) and a distinctive tubular tile roofing system. The results demonstrate that, although Lý-period architecture shares the common technical grammar of contemporary East Asian timber architecture—including Song China, Goryeo Korea, and Nara/Heian Japan—it developed distinctive features through flexible adaptation to tropical climatic conditions and a system of decorative symbols deeply rooted in local Buddhist culture. The study not only provides a reliable scientific basis for hypothetical reconstruction in digital form, but also repositions the value and independent status of Đại Việt architecture within the broader history of early East Asian architecture.

Keywords: Lý dynasty palatial architecture; Thăng Long Imperial Citadel; Architectural archaeology; Bracket system; Dougong; East Asian timber architecture; Architectural reconstruction

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1. Introduction

Following his accession to the throne in the autumn of 1010, Emperor Lý Thái Tổ (Lý Công Uẩn)—the founding monarch of the Lý dynasty (1009–1225)—relocated the royal capital from Hoa Lư (present-day Ninh Bình) to the citadel of Đại La (present-day Hanoi). He subsequently renamed the capital Thăng Long ("Ascending Dragon"). In 1054, during the reign of Lý Thánh Tông, the state was renamed Đại Việt. After this historic transition,

the Thăng Long imperial capital consolidated its position as the geopolitical nucleus and the foremost cultural emblem of the Đại Việt state throughout subsequent centuries. The urban planning layout strictly adhered to a tripartite walled-citadel schema consisting of La Thành (Outer Rampart), Hoàng Thành (Imperial Citadel), and Cấm Thành (Forbidden City) (Figure 1). Within this system, Hoàng Thành and Cấm Thành functioned as the palatine core, where palace and pavilion complexes were concentrated for royal residence and court rituals. Official chronicles, including the *Đại Việt sử ký toàn thư* (大越史记全书; Complete Annals of Đại Việt) and *Việt sử lược* (越史略 [Tran, 2005]; Abbreviated History of Việt), record the transfer of the capital and the associated large-scale construction campaigns, which featured the Càn Nguyên Palace at the center and satellite structures such as Tập Hiền Palace, Giảng Võ Palace, Long An Palace, and Hưng Thiên Pagoda. Taken together, these data delineate Thăng Long as a royal architectural complex of diverse typologies and monumental spatial scale.

Based on synthesized evidence from textual sources, epigraphy, and particularly urban archaeological data, the Thăng Long citadel is recognized as a large-scale urban structure whose core, Cấm Thành, covered approximately 100 hectares. The planning concept of 1010 was not merely a passive adaptation to natural topography but a refined application of fengshui and East Asian cosmological principles in landscape creation. As articulated in the *Thiên đô chiếu* (迁都诏; Edict on the Transfer of the Capital), the Lý court identified Long Đỗ as the reference point situated "exactly in the middle of North, South, East, and West" (Ngô, p. 244), reflecting the philosophy of "the center of the center." In ancient urban-planning terms, this constituted the establishment of an *axis mundi* (world axis)—a sacred coordinate that located Càn Nguyên Palace at the convergence of geopolitical and spiritual energies, thereby affirming the perpetual legitimacy of the dynasty. At this site, the Lý court elevated Buddhism to the status of a state religion to consolidate socio-political cohesion. This policy catalyzed the extensive construction of monumental, complex timber structures wherein Buddhist symbolism was intrinsically integrated to actualize the concept of an "ideal city," effectively positioning the dynasty at the absolute center of the contemporary world order. This autonomous and flourishing spiritual foundation enabled Lý-period palace architecture to establish a highly distinct identity within the broader East Asian cultural sphere.

However, due to the vicissitudes of history and the ravages of time, all above-ground Lý-period timber structures have completely vanished from the earth, leaving an "architectural heritage gap" spanning nearly a millennium. Although textual records are invaluable, they are frequently schematic, brief, and ambiguous, lacking quantitative technical parameters and thus posing

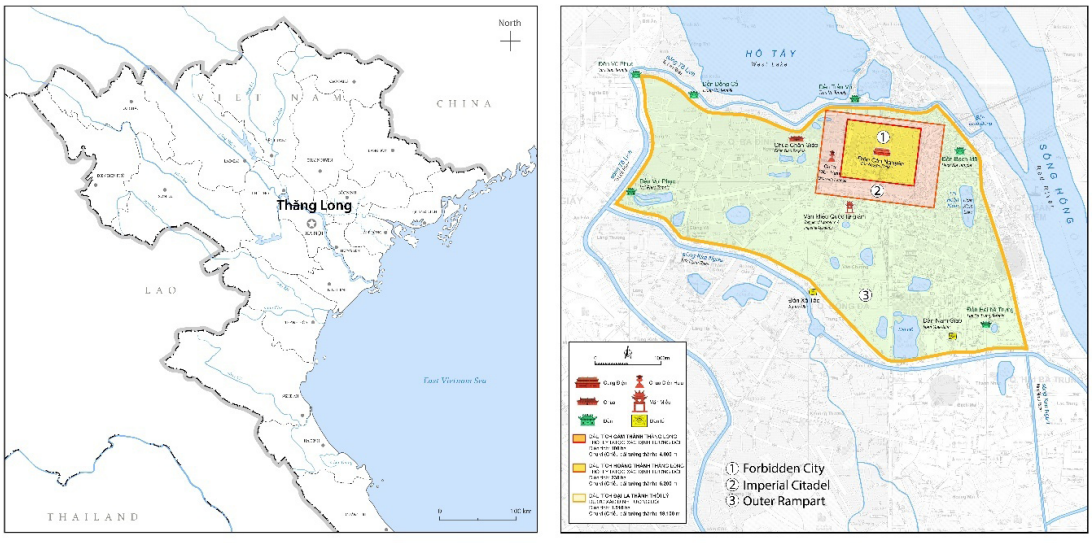


Figure 1. Spatial configuration and urban structure of the Thăng Long Imperial Citadel during the Lý dynasty (1010–1225). Source: Maps by Bui Minh Tri

a monumental challenge for morphological decoding. Despite over a century of scholarly attention since the early 20th century, the historical scarcity of archaeological data and the lack of sustained international comparative research have left numerous unresolved enigmas regarding the physical reality of the very "soul" of the Thăng Long capital.

In this context, this study presents pioneering results on decoding the morphology of Lý dynasty palace architecture, constructed upon a foundational dataset garnered from large-scale excavation projects directed by our institute at the Thăng Long Imperial Citadel site, including the 18 Hoàng Diệu site (2002–2004), the National Assembly House site (2008–2009), and the Vườn Hồng site (2012–2014) (Figure 2). Through an interdisciplinary methodology combining urban archaeology, terracotta architectural model analysis, epigraphic records, and crucially, comparative analysis with the genealogy of East Asian palace architecture (China, Japan, and Korea), this article delves deeply into construction technologies, material regulations, and architectural morphology. The objective of this research is not merely to fill the gap in identifying Vietnam's historical architectural appearance, but to establish a benchmark case study for comparative research on the cross-cultural interaction and morphological transformation of ancient palace architecture within the East Asian cultural sphere.

Owing to the exceptional significance of the in situ archaeological discoveries and their profound role in East Asian cultural interactions, the Central Sector of the Imperial Citadel of Thăng Long, Hanoi, was officially inscribed on the UNESCO World Heritage List in the autumn of 2010 (UNESCO World Heritage Centre, 2010). This decision was recognized based on three core outstanding universal values (OUVs) under criteria (ii), (iii), and (vi), namely: (a) the unique creativity in urban planning and architectural decorative arts; (b) the cultural interchange and convergence of Asian civilizations; and (c) the exceptional and long-standing continuity of an Asian-style political power center. Within this massive heritage framework, the Lý dynasty palace architectural complexes serve as one of the earliest and most peak material testaments to all three criteria (M. Bui, 2016b). Consequently, the architectural morphologic decoding and wooden structural reconstruction of the Lý dynasty presented in this study extend beyond academic fulfillment; they provide a vital scientific foundation to realize international commitments for the conservation and interpretation of the site's OUV.

2. Research context and methodological framework for decoding palace architectural systems

2.1. Conceptualization and systemic features of palace architecture

Within the pre-modern East Asian sociopolitical institutions, the term palace architecture does not merely designate a type of residential structure, but is rather established as a physical entity materializing sovereign

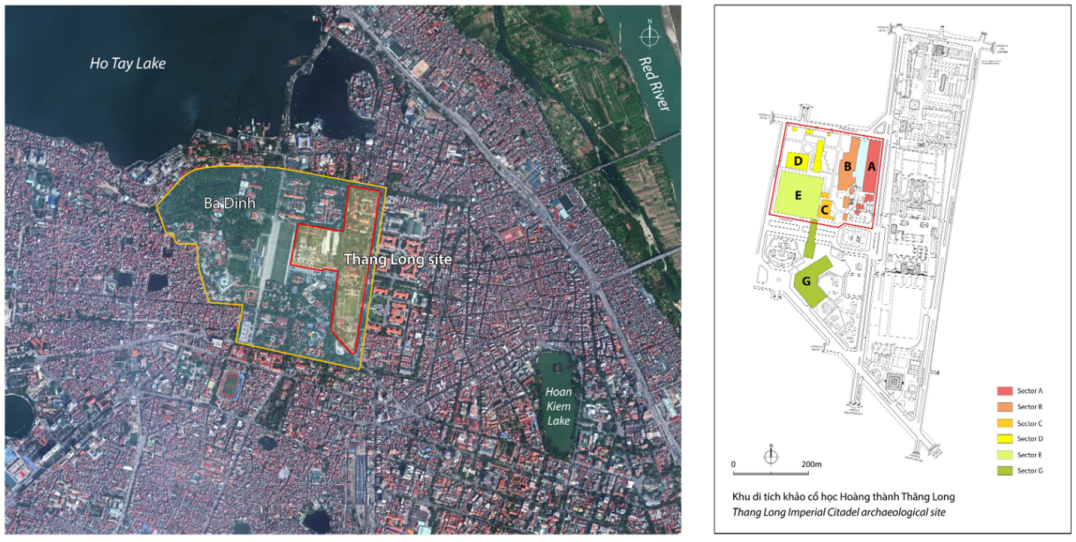


Figure 2. General view of the Thăng Long Imperial Citadel archaeological site within the modern urban context of Hanoi. Source: Maps by Bui Minh Tri

ideology. This denotes a system of structures initiated, planned, and governed directly by the dynastic institution, typically positioned at the central coordinates or the immediate peripheries of the imperial capital.

From a functional perspective, these buildings not only created spaces for state administration and imperial residence, but more importantly, functioned as the material symbols of supreme power, affirming the legitimacy and majesty of the dynasty through architectural language. Every single detail, from the foundation layout to the superstructure's supporting framework, was engineered to fulfill rigorous ritual protocols while simultaneously reflecting the strict hierarchical stratification within the spiritual life of the imperial family.

The core identifying feature of palace architecture lies in the fusion of monumental scale and craftsmanship that attained the pinnacle of refinement, characterized by the complexity of large-scale architectural systems and artistic decorative programs deeply imbued with the stylistic imprints of the era. Consequently, palace architecture has consistently been positioned by academia as the most objective "mirror" reflecting the developmental level of construction science, technology, and the distinctive cultural nuances of a nation, in a dialectical correlation with other East Asian civilizations sharing the same contextual milieu. Decoding the Lý dynasty palace architecture at Thăng Long is, therefore, a concerted effort to establish a crucial chapter in the history of construction technology, demonstrating the independent evolution and autonomy of Vietnamese timber architecture and craftsmanship within the broader regional civilizational flow.

2.2. Current state of documentation and research challenges

Similar to the timber architectural traditions of East Asia in China, Japan and Korea, the Vietnamese palace architectural system of the Lý dynasty established its defining features upon an interlocking load-bearing timber framework and a complex tiled roof system (M. Bui, 2018). However, the organic nature of timber gives these structures a finite lifespan, making it difficult for them to survive intact over centuries under the severe effects of the tropical monsoon climate, as well as cataclysmic historical events such as capital relocations, warfare, fires, and the continuous reconstruction undertaken by successive dynasties. Consequently, contemporary archaeology primarily accesses fragmented, isolated "pieces of the puzzle": foundation vestiges buried deep within stratigraphic layers and displaced building materials.

Major archaeological excavations at the Imperial Citadel of Thăng Long in 2002–2004, 2008–2009, and 2012–2014 uncovered the substantial foundation systems of Lý dynasty palace and pavilion complexes of varied scales, together with a synchronous technical infrastructure system including enclosure walls, drainage networks, wells, and brick-paved pathways, alongside millions of architectural remains, including roof tiles. These discoveries provide empirical evidence of the advanced urban planning logic and high-level technological capabilities of the Lý court, confirming the presence of a magnificent timber architectural complex with a highly elaborate tiled roof system (M. Bui, 2016a, 2016b, 2019; Tong, 2020).

However, despite the vast quantity of artifacts, the comprehensive morphological identification of Lý dynasty palace architecture continues to face systemic challenges due to the lack of direct, empirical scientific datasets. A crucial, qualitative divergence between Vietnamese palace architecture of the Lý dynasty and contemporary heritage complexes—such as the Forbidden City in Beijing, Changdeokgung in Seoul, or the ancient timber temples of Nara—lies in the radical rupture of above-ground architectural entities. Vietnam currently preserves no original timber palace structures from the Lý–Trần periods (1009–1400), or even from the Lê Trung Hưng period (1533–1789).

The surviving timber structures are primarily religious and ritual buildings located in the rural peripheries of Thăng Long, dating to later periods from the 16th century onward, and are characterized by structural frameworks utilizing *kẻ truyền* (inclined pass-through beams) and *chồng rường* (stacked short beams) systems. Although some structures were rebuilt on older foundations, their original morphology has been profoundly altered through successive generations of restoration. Even the rare wooden components surviving from the Lý and Trần periods are insufficient to reconstruct a comprehensive picture of the roof-supporting systems. Therefore, the ultimate "knot" in decoding Lý dynasty architecture is the absence of data regarding the building's body (the timber frame) and the roof superstructure, while the Vietnamese epigraphic corpus and historical records have virtually left a lacuna regarding detailed technical descriptions of form, dimensions, and assembly regulations. This challenge demands that we establish a specialized methodological approach based on a dialectical dialogue between *in situ* field foundation vestiges and the "visual history" preserved within terracotta architectural models. The core objective is to reconstruct the structural principles and normative regulations of the lost tradition of Vietnamese *đấu-củng* (斗栱; *dougong*; bracket systems; hereafter *dougong*) architecture.

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2.3. Methodological framework and systemic decoding process

To address the challenge of reconstructing architectural morphology within the context of a fractured material record, this study establishes a multi-dimensional methodological framework grounded in an interdisciplinary, mutually supportive, and cross-verifying approach, structured around three strategic pillars.

Firstly, the study centers its decoding methodology on the systematic analysis of the visual record preserved within terracotta architectural models. Between 2011 and 2015, we conducted comprehensive surveys and intensive analyses of terracotta house and tower models presently preserved in museum collections across northern Vietnam. Although these artifacts primarily delineate idealized exterior forms, we position them as empirical, "fossilized" architectural evidence of their era, serving as invaluable conceptual architectural prototypes. Consequently, they function as a critical epistemological bridge for decoding the exterior morphology of superstructures—crucial datasets that stratigraphic archaeological data by itself cannot fully provide.

This methodological orientation shares a profound ideological parallel with the breakthrough approach pioneered in 1932 by the renowned architect and master of ancient Chinese architecture, Liang Sicheng (1901–1972). If Liang Sicheng pioneered a rigorous academic paradigm by decoding Tang dynasty (618–907) architectural systems through the visual materials preserved within the Dunhuang cave murals (Liang, 1932), then within the Vietnamese context, this study charts a specialized, culture-specific trajectory: decoding Lý–Trần architectural morphology through the lens of terracotta architectural models. We define this corpus not merely as craft artifacts, but as a priceless form of visual record that encapsulates the structural essence of Vietnam's long-lost timber architecture.

Secondly, the study applies typological comparative analysis and inter-regional dialogue. In parallel with decoding the domestic models, the architectural characteristics of the Lý dynasty are rigorously cross-examined with contemporary palace systems in Japan (Architectural Institute of Japan, 2007; Nishi & Hozumi, 1996), Korea (Joo, 1988; Kim, 2022; Lee, 2019), and China (Chen, 1985; Liang, 2023), with particular reference to the building codes and structural regulations of the Tang and Song (960–1279) periods. This method not only aids in identifying the universal structural laws governing East Asian timber architecture, but also serves as a rigorous scientific filter for isolating and highlighting the distinctive localized nuances of Vietnam. It is precisely through this inter-regional comparative lens that the "architectural divergence" in creative thinking and the structural fluidity of construction techniques under the Lý court are sharply demonstrated. This stands as clear evidence of the sophisticated cultural acculturation and resilience of the Vietnamese people: while actively participating in a shared East Asian technical ecosystem, Lý Dynasty palace architecture successfully established an independent evolutionary path, firmly affirming the status of an autonomous architectural tradition.

Thirdly, the study employs an empirical decoding method based on the organic relationship between the roof-supporting system and the morphology of tubular tiled roofs. Inheriting the tripartite structural model (foundation–body–roof) from the methodological framework of Pan and He (2005), we establish a systematic correlation analysis procedure based on the cross-examination between *in situ* field foundation vestiges and the visual record preserved within terracotta models. The pivot lies in the structural dissection of architectural components on the models for direct comparison with excavated *dougong* timber specimens from the Thăng Long Imperial Citadel site. The structural and normative correspondence of bracket-set configurations serves as the "golden key" for decoding the roof-supporting framework. By analyzing the detailed mechanical function of *đấu* (斗; *dou*) and *củng* (栱; *gong*) in close relation to intercolumniation and the reinforcement of plinth foundations on site, the study establishes a standardized reference system, providing a solid scientific foundation for reconstructing the morphology of Lý dynasty palace architecture (M. Bui, 2015, 2016a, 2016b, 2021).

Simultaneously, the breakthrough of this study lies in decoding the dialectical interaction between tubular roof tiles—a highly codified and symbolic roofing material—and the load-bearing structural framework. From a holistic observation of East Asian palace architecture, we identify tubular tiles not merely as cladding or protective materials, but as elements that complete the overall roof profile, which is supported by *dougong* of varying complexity. The relationship between tubular tiles and *dougong* architecture is one of strict mutual interdependence: the *dougong* system determines the eaves projection and roof pitch, while the shape, weight, and quantity of the tiles in turn define the technical parameters of the supporting structure below. The seamless coordination of these two elements constitutes a prominent technical hallmark of traditional palace architecture across the region.

To deepen the systematic rigor of this process, the decoding and reconstruction workflow is designed in alignment with the integrative framework proposed by Pietroni and Ferdani (2021). We conceptualize reconstruction as a cognitive process (cognitive model), within which data processing and knowledge decoding represent the critical links. At the data-processing stage, we execute a process of digitizing fragmentation, converting displaced roof-tile assemblages, stone column bases, and plinths into structured data through photogrammetry and typological classification. The core task lies in knowledge decoding, where we attempt to "decipher the silence" of long-lost timber structures. Using terracotta models as visual maps, alongside wooden components excavated *in situ* and contemporary historical texts and inscriptions, this workflow enables the clear identification of distinctive divergent nodes of cultural identity. It is at this juncture that the Lý dynasty *dougong* system is empirically demonstrated to be an architectural entity deeply shaped by Đại Việt Buddhist aesthetic philosophy, rather than a passive continuation. The organic connection among these heterogeneous data layers ensures that each reconstructed three-dimensional (3D) entity constitutes a transparent, controlled, and traceable scientific hypothesis.

This study does not stop at the mere replication of physical forms, but aims toward constructing a sustainable digital heritage interpretation model. By referencing contemporary conservation frameworks such as Farhan *et al.* (2025), the research establishes a trajectory linking archaeology with the preservation of historic urban identity. The 3D reconstruction workflow operates through the continuous interaction and cross-verification among four core data layers: *In-situ* evidence, displaced artifacts, textual comparison, and cross-cultural analogy. We apply the method of "mathematization" to transform archaeological fragments into precise technical parameters, while concurrently utilizing "synchronous structural analogy" to bridge the lacunae in the superstructure's roof-supporting framework.

This trajectory is further operationalized through a multilayered methodological framework and a data transparency protocol for heritage reconstruction (Table 1). The reliability scale ranging from 30 percent to 100 percent, coupled with color-coded indices from Red to Blue, functions as an intuitive knowledge map, enabling readers to clearly recognize the boundary between objective material evidence and analogical hypotheses, thereby substantiating the authenticity and independent status of the Lý dynasty palace model within the broader evolutionary flow of East Asian architecture.

3. Structural morphology of Lý dynasty palace architecture: An analysis of archaeological data

3.1. Architectural ground plans and stratigraphic engineering

The large-scale archaeological excavations conducted at the Thăng Long Imperial Citadel site in 2002–2004 and 2008–2009 uncovered a monumental complex of architectural foundation remains, alongside a vast corpus of building materials sufficient to identify the structural scale and spatial appearance of the architecture in this period. Over a total excavation area spanning 42,000 sqm, archaeologists revealed a high-density structural assemblage, including 53 building-foundation remains, 7 enclosure wall foundations, 6 water wells, and 13 drainage channels (Bùi, 2016b, 2019). These quantitative data constitute authentic material evidence, firmly confirming the monumental scale and high density of structures within the Forbidden City of Thăng Long under the Lý dynasty (Figure 3).

Structural analysis of the horizontal plans and vertical sections demonstrates that Lý-period builders had attained an exceptional engineering mastery in adapting foundation treatments to the deltaic geology. The footprints of the building foundations were clearly demarcated through a multi-layered engineered earth-filling technique using highly plastic clay transported from distant mountainous and hilly regions to the capital, which was periodically reinforced with layers of architectural debris and vitrified ceramic production waste (broken pottery, bricks, and tiles) to drastically optimize structural stability. Notably, the perimeters of these architectural platforms were stabilized by sub-structural wooden pilings driven below the ground line, topped with curb-edge retaining brickwork made of rectangular bricks, while the interior surfaces were paved with high-fired square bricks characterized by a distinctive imperial yellow hue. The synchronous presence of cloister corridors, enclosure walls, and sophisticated water-supply and drainage networks (wells and culverts) systematically organized around the core structures empirically demonstrates an advanced urban-planning mindset. This strongly suggests that the grand construction of the Thăng Long Imperial Palace complex following the relocation of the capital in 1010 was a monumental state project, requiring the mobilization of immense resources and an exceptionally rigorous organization of engineering and craftsmanship.

3.1.1. Gravel-rammed pier foundations and structural transformation

The most defining diagnostic feature for identifying Lý dynasty architecture through archaeological evidence is the

Table 1. Multilayer methodological framework and data transparency protocol for heritage reconstruction

Type of evidence	Processing and verification procedure	Reconstructed architectural component	Reliability (color code)
I. *In situ* evidentiary data	Multisource digitization of excavation records: integration of the national coordinate grid with H-BIM error-control procedures; integration of AutoCAD technical drawings; digitization of detailed field photographs; reconstruction of the axis grid and plan layout from excavation records (2002–2009).	Overall plan: verified identification of the foundation system, column grid, bay spacing, and the division between interior and exterior spaces; podium steps, floor levels, transitional spaces, and synchronous infrastructure.	High (95%–100%); Red
II. Displaced artifacts	Mathematization and morphological decoding: analysis of roof-tile inclination angles; typological and functional analysis of artifacts; structural decoding based on terracotta house models and excavated *dougong* timber specimens; symbolic interpretation: reconstruction of decorative distribution patterns according to the presumed curvature of ridge and eave lines; analysis of bioclimatic adaptation through roof structures and tile systems; establishment of a corpus of local architectural terminology.	Superstructure morphology: roof surface structure (pitch, tile arrangement, number of roof tiers); reconstruction of the supporting frame and *dougong* system; decorative systems on the ridge, eaves, gables, and other distinctive artistic features of the Lý period.	Relatively high (75%–85%); Yellow
III. Textual and symbolic data	Historical philology and interdisciplinary cross-checking: analysis of architectural terminology in contemporaneous inscriptions, stele texts, bronze bells, and Lý–Trần poetry and prose; interpretation of capital planning and palace names; correlation of inscriptional terms with archaeological remains to identify features of local Buddhist architecture; reading Buddhist symbolism and leaf-shaped motifs as a "genetic code" of local cultural identity.	Cognitive identification and aesthetic nuances: identification of the building's name, spatial function, and spiritual planning; reconstruction of roof tiers, bracket-set systems, and the dominant vermilion-lacquered and gilded finishes shaped by Đại Việt Buddhist aesthetics.	Medium (50–60%); Green
IV. East Asian comparative data (analogical)	Structural analogy and cross-cultural comparison: use of regional architectural reference systems (Song, Liao, Goryeo, Nara–Heian) and technical treatises such as *Yingzao Fashi* to decode missing components; analysis of load-bearing proportional logic and structural similarity; identification of both affinities and divergences in indigenous architecture.	Structural principles and systemic knowledge models: reconstruction of the logic of the upper timber structural framework; definition of locally distinctive wooden structural details and bracket-set systems; formulation of a complete reconstruction model through comparison with contemporaneous East Asian architectural standards.	Hypothesis (30%–50%); Blue

Note: This framework was developed based on the methodological workflow used for the heritage reconstruction of the Thăng Long Imperial Citadel and was informed by the transparency criteria proposed by Pietroni and Ferdani (2021) and the heritage building information modeling (H-BIM) classification system

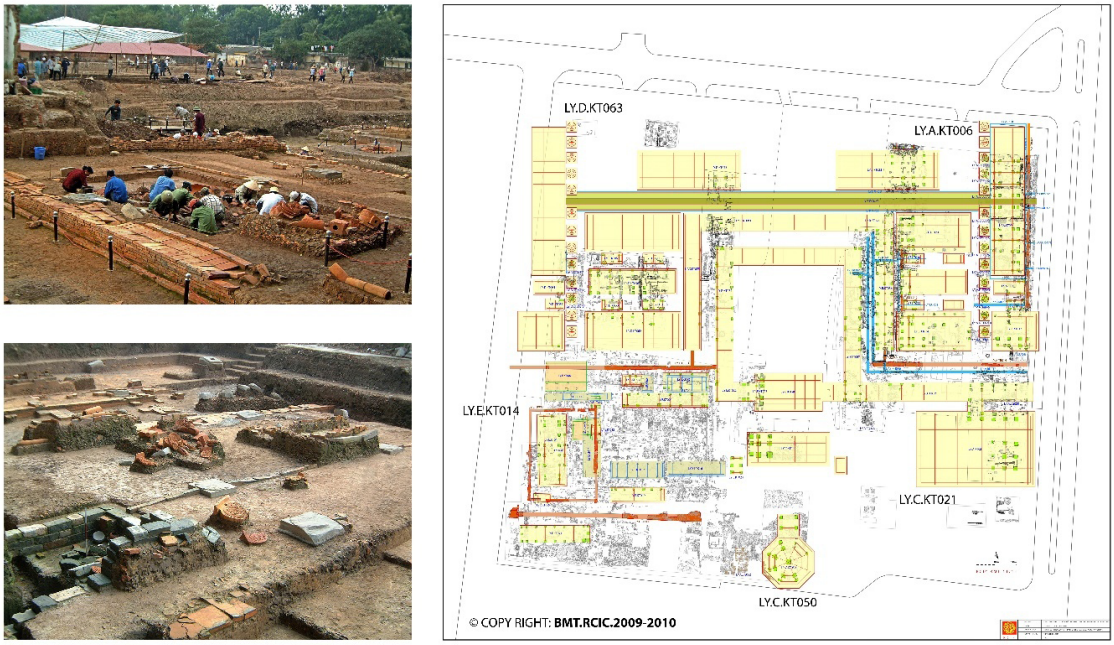


Figure 3. General plan of the Lý dynasty architectural remains excavated at the Thăng Long Imperial Citadel site. Source: Photos (2004) and drawing by Bui Minh Tri

system of independent column pier foundations. Rather than utilizing continuous strip footings, Lý architecture employed independent square foundation pits arranged systematically according to a standardized columnar grid layout. These pits were internally reinforced with river gravel, small brick-and-tile fragments, or ceramic shards, serving as the primary load-bearing points for the monumental wooden columns.

This gravel-rammed pier foundation technique (gravel-pillar foundation) represents a distinctive engineering achievement, reflecting a sophisticated adaptation to the soft alluvial soils of the Red River Delta. These foundation pits typically measured 110–150 cm along each side and varied from 150 cm to over 300 cm in depth. They were densely compacted with hard materials—most commonly river gravel mixed with ferruginous hill soil—to drastically prevent structural settlement (M. Bui, 2015, 2016a, 2016b) (Figure 4). Although this technique was pioneered during the Đinh–early Lê period (the 10th century), it was only under the Lý dynasty that this engineering method was highly standardized, becoming the normative construction code for large-scale monumental buildings. In addition to single square pits, the site also yielded rectangular double-pier foundations designed to support twin column bases, typically implemented in smaller structures with specialized structural framing systems (M. Bui, 2016b).

Concurrent with this post-pad foundation system was the discovery of 148 stone column bases for timber posts, comprising 73 square above-ground stone bases and 75 earth-buried stone bases (H. Bui, 2017). Metric measurements record a wide diversity of dimensions, ranging from 60 × 60 cm at the smallest to 100 × 100 cm at the largest. Based on the surviving traces of the column-bearing surfaces (mirror traces) on these stone bases, the column diameters are commonly determined to be between 38 cm and 59 cm, with certain exceptional principal interior columns reaching a diameter of 70–80 cm. The vast quantity and monumental scale of this stone column base system provide compelling quantitative evidence confirming that the Thăng Long Imperial Palace architecture was primarily composed of large-scale, round-column timber frame structures.

From an artistic perspective, the Lý dynasty stone column bases were masterfully crafted, commonly adorned with sharply carved, elegant lotus-petal motifs. Notably,



Figure 4. Archaeological remains and three-dimensional reconstruction of the pebble foundation system of Lý dynasty architecture at the Thăng Long Imperial Citadel site. Source: Photos (2004 and 2009) and three-dimensional reconstruction by Bui Minh Tri

archaeology has brought to light high-status stone column bases featuring exceptionally intricate ornamentation: the inner registers of the lotus petals are carved with undulating dragons and stylized chrysanthemum scrolls, or the four vertical faces of the stone base feature realistic, exquisite depictions of musical ensembles and dancers performing vibrantly (Figure 5). The presence of these masterfully crafted stone bases was not isolated or sporadic but was deployed consistently across entire architectural layouts, reflecting the intensive investment in the craft expertise and the thorough "aestheticization" of load-bearing structural components within the premier palatial and court structures.

Technically, certain stone column bases demonstrate a multi-functional design logic: they functioned not only to support vertical columns but were also engineered with mortise slots to accommodate ground sills or partition walls. Notably, the archaeological data also reveal the co-existence of two concurrent techniques: above-ground columns (resting on stone bases) and earth-buried posts (set deeply into the ground). This combination yielded a unique structural solution: the peripheral veranda columns were buried deeply (to enhance structural stability and wind-shear resistance against typhoons), surrounding the interior rows of secondary columns and principal columns, which rested upon stone column bases (to mitigate structural decay induced by termites and ground dampness) (Figure 6). This stands as a crucial indicator of the specialized construction techniques deployed for highly important structures within the Thăng Long Forbidden City during the early Lý period (M. Bui, 2016b).

3.1.2. Morphological layouts and polygonal architectural features

Analysis of the regularities and spatial distribution of pier foundations reveals a remarkable diversity in the architectural floor plans of the Lý dynasty, encompassing rectangular, square, hexagonal, and octagonal typologies. The most prevalent configuration is the horizontally elongated rectangular plan (long-house form) detailed with an odd number of bays (7, 9, 11, or 13), which directly embodies the solemn spatial hierarchy of palace architecture. Concurrently, ancillary structures featuring an even number of bays (2, 6, 8, or 10) of a smaller scale, alongside extensive axial processional cloisters, coexisted to establish a fluid structural continuity within the overall palace complex (Figure 3).

Among the odd-bay structures, the Thăng Long Imperial Citadel site has yielded traces of exceptionally distinctive wooden halls of monumental proportions, most notably the palatial structure designated as LY.A.KT021. This stands as the largest single architectural footprint ever uncovered at the site, commanding a floor area exceeding 2,280 sqm (measuring 38 m in width and over 60 m in length) and structurally sustained by a massive matrix of 96 timber columns.

To contextualize this scale more vividly, this grand hall can be directly cross-examined with the celebrated *Daibutsuden* (Great Buddha Hall) of Tōdai-ji Temple in Nara—widely recognized as one of the largest ancient timber monuments in the world, founded in 743. While the *Daibutsuden* encompasses a floor area of



Figure 5. Representative stone column bases from the Lý dynasty at the Thăng Long Imperial Citadel site (a, b, c) and Phat Tich Pagoda site (d). Source: Photos by Bui Minh Tri ([A, B, C] 2016; [D] 2021)

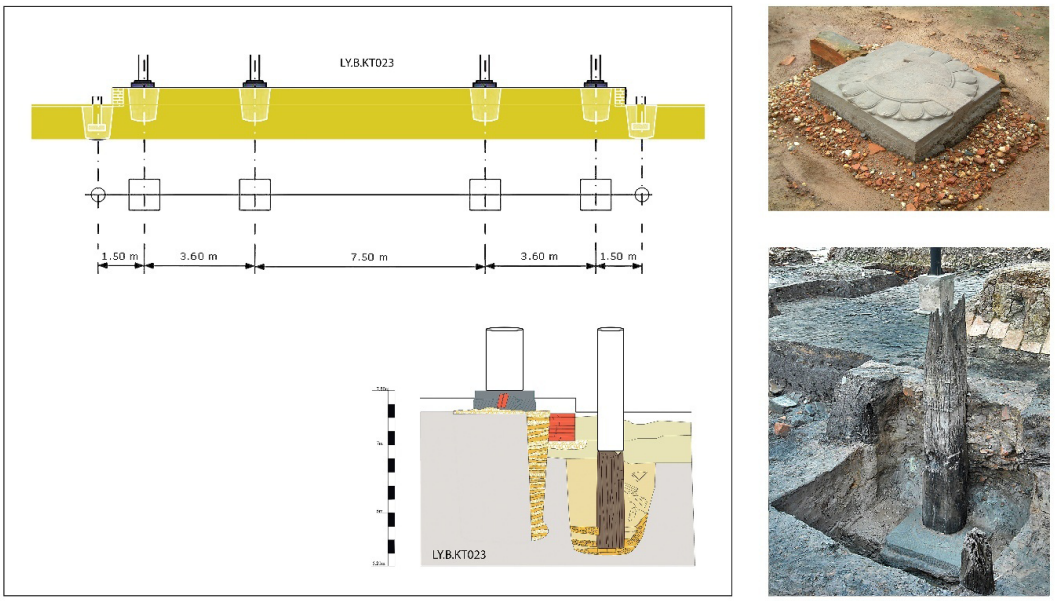


Figure 6. Architectural remains from the Lý dynasty showing a hybrid construction technique combining buried-column and above-ground-column systems. Source: Drawing and photos (2004 and 2010) by Bui Minh Tri

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approximately 2,850 sqm (50 m wide and 57 m long), the LY.A.KT021 structure at Thăng Long exhibits an even greater longitudinal profile, stretching over 60 m in length, with its total spatial footprint closely approaching the dimensions of the iconic Japanese temple hall. This striking convergence in architectural scale provides robust material evidence confirming that Lý dynasty palace architecture had achieved a monumental threshold of timber construction and structural engineering fully peer to contemporary East Asian imperial standards.

The most defining typological hallmark of the Thăng Long Imperial Citadel is the empirical manifestation of the polygonal architectural group. Of paramount significance is the discovery of two parallel alignments of hexagonal pavilion structures in Sector A (LY.A.KT006) and Sector D (LY.D.KT063), symmetrically organized flanking the core central palace complex along the principal north–south axial grid. Within this group, the alignment in Sector A brought to light a continuous chain of 11 foundation clusters extending across a linear distance of over 82 m, with regular intervals of 8.0 to 12.0 m between individual pavilions. Each foundation pier of this architectural type comprises six circular, gravel-rammed sub-piers arranged masterfully in a six-petal floral pattern encircling a central square rammed-gravel nucleus; the overall compound diameter spans 3.40 m, with the diameter of each individual small gravel pier ranging between 100 and 110 cm.

Most notably, the single most critical architectural hallmark discovered is a monumental octagonal structure designated as LY.C.KT050, possessing a substantial floor area of 706 sqm. This complex structure comprises 16 columns symmetrically organized in eight concentric pairs encircling a massive central principal column. The surrounding square pier foundations are exceptionally gargantuan, measuring 180 × 180 cm, while the central column's foundation measures a substantial 240 × 240 cm, systematically reinforced with dense layers of river gravel to sustain the colossal static load of the superstructure's mass. The perimeter of this platform was structurally secured by a solid 45° inclined brick-paved containment ribbon, creating a highly stable structural connection with the square-brick-paved courtyard below (Figures 3 and 7A). The presence of this formidable central column—a highly specialized engineering component requiring a polyhedral structural joinery system and an intricately radiating roofing framework—strongly supports the hypothesis of a magnificent, monumental multi-tiered palace structure of towering proportions. This empirical deduction aligns closely with systemic records in the *Đại Việt sử ký toàn thư* regarding Lý-period octagonal palace architecture, such as the Thiên Khánh Palace (founded in 1030): "The Thiên Khánh Palace was constructed in front of the Trường Xuân Palace as the locus for the sovereign to conduct state affairs. It was engineered in an octagonal form, with Phoenix Bridges (cầu Phượng Hoàng) constructed flanking both the front and the rear" (Ngô, 1993, p.91; Pham & Pham, 2019).

When re-examined within the broader comparative context of East Asian architectural evolution, the octagonal monument at Thăng Long establishes a profoundly unique typological character. In China, multi-tiered octagonal plans were almost exclusively restricted to Buddhist pagodas, such as the timber Sakyamuni Pagoda of Fogong Temple in Shanxi (Chen, M., 1966); in Japan, octagonal forms are traditionally typified by single-story hakkaku-dō pavilions, such as the Yumedono at Hōryū-ji Temple in Nara, or the rare three-story timber pagoda at Anraku-ji in Nagano (Architectural Institute of Japan, 2007; Hamashima, 1986). By contrast, the strategic emergence of a monumental, multi-tiered octagonal palace pavilion at the very heart of the Thăng Long Forbidden City stands as a highly localized and exceptional architectural phenomenon (Figure 7B and 7C). This structure was neither a mere scenic pleasure pavilion nor a conventional religious sanctuary; rather, it functioned as a supreme sovereign monument of paramount symbolic gravity dedicated to major state and courtly rituals, effectively demonstrating the independent architectural philosophy and the distinctive political sovereignty of the Lý dynasty.

Furthermore, the quantitative data from the excavations provide robust verification of the advanced technical capabilities governing Lý-period Đại Việt palace architecture. The intercolumniation of Lý buildings attains a remarkably wide span, averaging 5.1–5.7 m. In the southwestern sector (Sector E, the National Assembly House site), we specifically identified traces of grand two-row columnar structures featuring an astonishing intercolumniation ranging from 6.0–7.5 m. These structural metrics not only surpass those of numerous contemporary buildings across the region, but also confirm an exceptional mastery in the sourcing, processing, and engineering of monumental timber members, enabling the orchestration of vast, awe-inspiring, and solemn interior spaces.

3.1.3. Modular coordination and standardized measurement

An analysis of the spatial dimensions and geometric proportions of the foundation system demonstrates that Lý dynasty palace architecture was not constructed arbitrarily, but strictly adhered to the principles of modular coordination and proportional design. Architectural

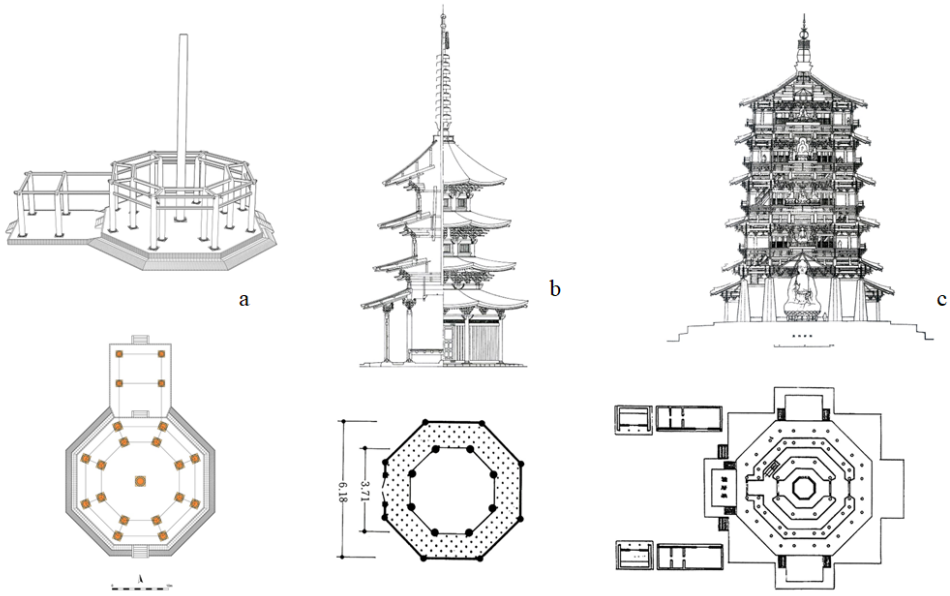


Figure 7. Lý dynasty octagonal architecture in typological comparison with traditional East Asian architectural models: (a) Ground plan of the octagonal structure at the Thăng Long Imperial Citadel. (b) Three-story octagonal timber pagoda at Anraku-ji Temple, Japan, ca. 1290; (c) Sakyamuni Pagoda of Fogong Temple, Shanxi, China, built in 1056. Sources: (a) Drawing by Bui Minh Tri and Nguyen Quang Ngoc; (b) adapted from the official repair report published by the Nagano Prefectural Board of Education in cooperation with the Japanese Commission for the Protection of Cultural Properties (Bunkacho), titled *Kokuhō Anraku-ji Hakkaku Sanjūnotō Shūri Hōkokusho* (Repair Report of the National Treasure Three-Story Octagonal Pagoda of Anraku-ji Temple), 1953; and (c) reprinted from Liang (2023)

components—such as vertical columns, horizontal beams, and intercolumniation rules—were all meticulously organized according to harmonic proportional relationships derived from a standardized basic unit of measurement. Through the statistical analysis of a vast corpus of empirical foundation data, the Japanese architectural archaeologist Kazuto Inoue reconstructed the standard metrological unit utilized during the Lý period. The results indicate that the Lý *thước* (traditional Vietnamese foot) corresponded to the *chi* (尺; Chinese foot) used in Song-dynasty China, with 1 *thước* measuring approximately 29.98 cm, conventionally rounded to 30 cm (Inoue, 2015). This shared metrological paradigm, which aligns closely with the historical records in *Weights and Measures in China from the Third to the Fourteenth Century* by Guo (1993), provides definitive material evidence confirming the integration of Đại Việt's technical standards into the broader East Asian imperial architectural tradition.

This highly standardized character is further manifested in the building orientation, precise astronomical alignment, and cosmological and geomantic principles: all monumental structures were planned strictly along a principal north–south axial grid, exhibiting an intentional azimuthal deviation of approximately 4°–5° toward the northeast. Moreover, according to M. Bui (2015), the spatial metrics of Lý-period architecture—encompassing total length, width, and intercolumniation—generally adhered to a strict mathematical rule of divisibility by three. This rigorous mathematical consistency reflects an advanced threshold of state-level architectural administration and highly professional construction management, demonstrating a unified operational continuum that seamlessly bridged conceptual design with material realization (M. Bui, 2015).

3.2. Decoding the timber load-bearing system

3.2.1. Dynastic vision and the context of capital construction

Chronicle-based sources provide a comprehensive panorama of the grand construction activities in Thăng Long, demonstrating the deliberate formation of an architectural complex that embodied absolute royal

sovereignty. Immediately following the landmark capital relocation in 1010, a large-scale urban planning strategy was vigorously executed, marked by the emergence of monumental palatial complexes such as Càn Nguyên Palace, Tập Hiền Palace, and Giảng Võ Palace, alongside multi-tiered pavilion structures such as the Ngũ Phượng Tinh Pavilion. Based on a cross-referenced analysis of the *Việt sử lược* and *Đại Việt sử ký toàn thư*, this study identifies that the Lý dynasty experienced at least 56 major state-led construction phases, with the years 1010, 1029, and 1203 marking critical watershed moments in planning reorganization. Within the corpus of 116 specifically identified and named structures, this historical context reflects not only the dynasty's administrative spatial requirements but also the profound flourishing of architectural art under Buddhism as the state religion. This historical matrix forms the essential basis for establishing the conceptual framework necessary for reconstructing an imperial capital characterized by high construction density and complex morphology.

3.2.2. Survey of the timber framework and the morphology of the superstructure

In the complete absence of surviving timber elements, the reconstruction of the load-bearing framework—the structural backbone of the building—heavily relies on the forensic interpretation of *in situ* archaeological evidence combined with strict morphological analogy.

(i) Materials and durability: This study establishes that the structural durability of Lý dynasty palace architecture was guaranteed through a rigorous, state-controlled material selection process. Palaeobotanical analysis indicates a definitive preference for the traditional "four hard timbers," with a particular emphasis on Sến mật (*Madhuca pasquieri*). Owing to its exceptionally high density and outstanding natural termite resistance, this timber could easily support the substantial dead loads imposed by complex multi-tiered roof structures. This empirically demonstrates that Lý-period master builders possessed a sophisticated understanding of the physical and mechanical properties of indigenous timber when subjected to humid tropical conditions (M. Bui & Nguyen, 2015).

(ii) Enclosure form and climatic adaptation: Based on the physical traces of sub-floor brick foundations for ground sills, alongside recovered wooden balustrade components and decorative panels, this study identifies the ubiquitous presence of timber curtain walls and partition paneling acting as a flexible substitute for load-bearing masonry walls. The integration of these wooden panels with wooden pivot doors, structurally verified by the stone pivot sockets excavated *in situ*, created a highly flexible enclosure system. This architectural solution offered a high degree of climatic adaptation: it enabled the building to maintain strict imperial enclosure and spatial demarcation while simultaneously optimizing passive air circulation, perfectly attuned to the microclimatic conditions of the Red River Delta.

(iii) Establishing standards of proportion and geometric formula: While roof tiles and ornamental schemes allow for the reliable identification of the exterior façade, the reconstruction of the internal load-bearing framework remains a paramount challenge because the organic timber material has completely vanished. However, the overall spatial scale of the buildings has been reliably established through the footprint of the foundation bases and the columnar grid excavated at the site. On this planar foundation, the pivotal issue in the 3D reconstruction process is to mathematically determine the height of the principal columns—a critical parameter governing overall façade proportions, yet one for which no direct technical drawings survive.

By applying a systematic proportional cross-examination with contemporaneous East Asian palace architecture, this study formulates an analytical hypothesis grounded in the geometric correlation between principal column height and the width of the *mingjian* (明间; central bright bay). Accordingly, the height of the Lý-period principal interior columns is estimated to have ranged from 5.10 m to 5.70 m, equivalent to 17–19 *thước*. This metric serves as the foundational geometric formula for establishing the height of the roof-supporting timber framework and for reconstructing the building's vertical façade.

An indispensable basis for this structural hypothesis is the tight correspondence between archaeological data and textual records. Our analysis of the eaves projection in Sectors A and B, which commonly ranges from 1.20 m to 1.80 m (approximately 4 to 6 *thước*), corresponds seamlessly with the eyewitness account written by the Yuan dynasty (1271–1368) envoy Chen Fu (1259–1309) during his mission to Đại Việt in 1293 in *Annan Jishi* (安南即事; *Record of an Envoy to Annan*): "Although the roof structures rose high, the eaves extended outward only 4–5 thước" (Chen, 1293). When these structural dimensions are cross-examined with the standardized codes for the fourth type of eaves outlined in the *Yingzao Fashi Jiedu* (营造法式解读) (Pan & He, 2005) and with Fu's (2009) seminal studies on Song–Yuan architecture, a highly significant indigenous characteristic emerges: although Lý-period court architecture operated within the shared technological ecosystem of East Asian timber framing, it retained highly distinctive indigenous proportions characterized by these relatively compact and elegant eaves. This dynamic interaction between East Asian

regional norms and internal localized variations provided a transparent, scientifically reliable geometric basis for the 3D reconstruction of the complex roof-supporting system in the superstructure.

3.2.3. Decoding the dougong system and superstructure norms

The decoding of the roof-supporting framework—long regarded as the "soul" and the load-regulating brain of ancient East Asian timber architecture—at the Thăng Long Imperial Citadel once faced severe epistemological challenges due to the fragmented nature of the material record. However, the synchronous discovery of a tripartite corpus of evidence—encompassing excavated timber components, stone architectural elements, and terracotta architectural models—has made it possible to establish a solid methodological framework for reconstructing the morphology of Lý dynasty palatial architecture. The paramount achievement, representing a pioneering scientific contribution to the history of Vietnamese palatial architecture yielded by our experimental research program since 2011, is the definitive identification of the *dougong* through the systematic convergence of empirical archaeological evidence and epigraphic records (M. Bui, 2015, 2016b, 2021).

Firstly, in terms of material artifacts, systematic excavations within the Lý-period cultural strata brought to light red-lacquered timber components exhibiting a high degree of technical specificity. A prime diagnostic example is a large, square *đấu cái* (枓斗, *ludou*; principal load-bearing block) engineered with specialized mortise channels. This functions as the central load-bearing node of a bracket set, uniquely characterized by a cross-shaped mortise channel on its upper face designed to receive interlocking bracket arms, and a square mortise on its underside to connect directly with the column head. This exact morphological configuration complies with the technical standards documented in the historical *Yingzao Fashi* (Li, 1103/1983), empirically demonstrating the existence of a sophisticated, multi-tiered structural system. Furthermore, the discovery of a *giao đấu* (交斗, jiaodou; interlocking block)—a structural block detailed with a continuous rectangular interlocking groove, measuring precisely 20 cm in width on its upper surface, 13 cm in height, 15 cm in width at its base, with a mortise channel width of 12 cm—provides definitive physical evidence of a critical load-bearing joint. This specialized joint allowed bracket arms or tie-beams to pass directly through the structural center of the block, linking the heterogeneous components of the timber framework into a mechanically unified and structurally stable entity (Figure 8A and 8B). The substantial 12 cm mortise width directly signals a structural capacity designed to accommodate large-scale bracket-and-beam members, a scale fully commensurate with the immense dead loads imposed by the monumental tubular-tiled roof structures reserved for imperial palatial architecture. This tight metric correspondence between the *in situ* dimensions and the morphological profiles sculpted onto terracotta models reinforces the empirical authenticity of our 3D reconstruction workflow, proving the existence of a scientifically calculated, large-timber engineering tradition under the Lý court.

Although fully intact cantilevered bracket arms have yet to be recovered, the physical presence of these highly specialized *đấu* blocks, alongside two excavated *xà-củng* timber members (integrated bracket-beams) adorned with cloud-patterned ends (measuring 63.4 cm and 46.3 cm in length), constitutes substantive material evidence for a complex *dougong* system engineered to sustain a monumental, multi-tiered pavilion roof. We identify the Lý period *xà-củng* not merely as an ornamental element, but as an integrated, multifunctional structural component (integrated multi-functionality) that played a pivotal mechanical role in extending well beyond the column core to maximize the cantilevered roof projection span. Most revolutionary, the anatomical analysis of structural mortises executed at precise beveling angles of 55.5° and 63.4° on the component bodies provides definitive empirical verification for the existence of a monumental hexagonal palace pavilion structure within the Forbidden City precincts (Figure 8C). This specialized beveling craftsmanship allowed the radiating timber members to converge precisely at a critical structural node to form the standard 120° turning angle required by a regular hexagonal plan. This monumental discovery not only operationalizes the qualitative hypotheses derived from terracotta models into precise, mathematical engineering parameters, but also firmly confirms that Lý dynasty master builders had fully mastered the complex structural logic governing East Asian large-timber construction, while successfully achieving an extraordinary threshold of refinement and architectural autonomy.

Secondly, iconographic and physical evidence yielded from terracotta architectural models and contemporaneous brick-and-stone pagodas and towers—such as those excavated at the Thăng Long Imperial Citadel, and surviving at Quỳnh Lâm Pagoda, Trò Pagoda, and Bình Sơn Pagoda—provides substantial material data that enables the definitive identification of a highly distinctive and identity-rich bracket-set system. Cross-examination of these diverse sources firmly confirms the systemic presence of *liên đấu củng* (连斗栱, *liandougong*; continuous intercolumnar

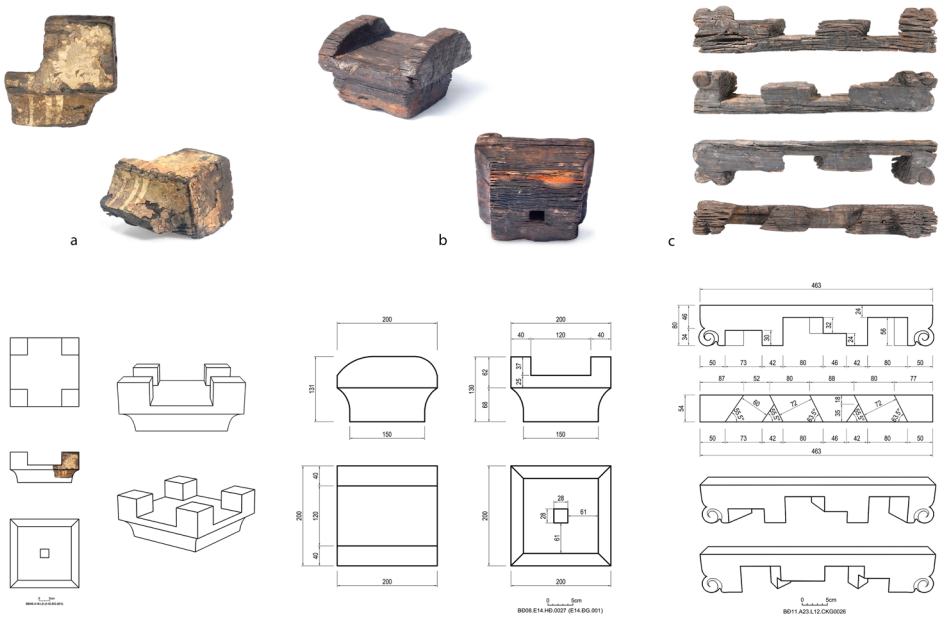


Figure 8. Excavated timber *dougong* components from the Lý dynasty at the Thăng Long Imperial Citadel site. Source: Photos (2014) by Bui Minh Tri and drawings by Bui Minh Tri and Nguyen Quang Ngoc

bracket sets) distributed in a high-density horizontal alignment. This structural index indicates that the Lý–Trần *dougong* system was not merely confined to column heads, but was also vigorously deployed at intermediate positions between bays, establishing a continuous visual and technical rhythm across the architectural facade.

From a structural perspective, Lý-period architecture commonly employed the *củng xuyên* (栱穿, *gongchuan*; interlocking piercing-bracket) framework, operating systematically according to the rigorous *xuất tam đấu* (出三斗, *chusandou*; triple-tier projection) specification. Through a comparative morphological cross-examination with twelfth-century wooden structures in Japan, Đại Việt architecture demonstrates a clear stylistic preference for a compact, structurally dense form, typically utilizing two to three tiers of cantilevered projecting arms (M. Bui, 2016b; Tomoda, 2017). The structural limitation in the number of projecting tiers was brilliantly compensated for by the indigenous *tàu mái che rui* solution (the monumental eave-interlocking beam engineered to shelter and secure the rafters)—a technically ingenious engineering adaptation to humid tropical conditions that effectively guaranteed the long-term stability of the timber framework against severe environmental weathering.

At this juncture, the study identifies a profound divergence in aesthetic and cosmological thinking between Đại Việt and contemporary East Asian states: while contemporary regional architecture commonly deployed the conventional *renzi-gong* (人字栱; inverted V-shaped intermediate brackets) in the intermediate position, Đại Việt artisans introduced the highly stylized bodhi-leaf motif into this *zhongbei* (中备; central-intermediate support) position as a symbolic and artistic breakthrough. This creative substitution transformed a purely utilitarian, mechanical support point into a sacred space of pronounced Buddhist spiritual expression, forging a highly distinct identity for Vietnamese palace architecture. This structural creativity was further heightened through the direct physical integration of spiritual and mythological sculptural motifs—such as dragon heads, Garuda, and Kinnari—directly into the roof-support system. This seamless fusion of rigorous load-bearing function and rich sculptural language stands as the greatest point of architectural divergence, firmly confirming Lý dynasty *dougong* architecture as a living cultural form and an unassailable testament to the endogenous engineering capacity and creative sovereignty of a self-ruling dynasty.

From a comparative morphological perspective, the bracket sets sculpted on the terracotta models exhibit complete anatomical correspondence with the authentic

wooden components excavated *in situ*, as reflected in their substantial volumetric presence, the elegantly tapered lower profiles, and the characteristic curved chamfering. Typological analysis of these representative models (Figures 9–10) demonstrates the full, standardized presence of all requisite components, explicitly including the *lư đấu*, the *lệnh củng* (令栱, *linggong*; arcuate bracket arm), the *tề tâm đấu* (齐心斗, *qixindou*; center-share block), and the system of *tán đấu* (散斗, *sandou*; auxiliary blocks) anchoring the ends of the arms. Through systematic scientific interpolation spanning from single-layer to multi-layer frameworks, this study firmly establishes that Lý dynasty palace architecture possessed a complex *dougong* system defined by two to three projecting tiers (M. Bui, 2016b; 2021).

Notably, in terms of formal interpretation, Lý-period *dougong* exhibit a clearer morphological continuity with robust Tang-style architectural norms than with the more delicate Song-style forms, as explicitly reflected in their large, thick blocks, strict emphasis on primary load-bearing utility, and substantial volumetric gravity. Although intentionally simplified in scale, these architectural models effectively function as three-dimensional technical blueprints captured in terracotta, confirming the absolute normative consistency between the miniature bracket-set forms and the monumental wooden components discovered during excavations (Figure 9). This convergence serves as the "golden key" to unlocking the magnificent, authentic appearance of Thăng Long royal architecture during the Lý–Trần era, while triumphantly affirming the independent and sovereign status of Vietnamese architecture within the broader history of East Asian civilization.

Thirdly, inscriptional evidence derived from the Lý-period epigraphic corpus—exemplified by the Sùng Khánh Pagoda bell inscription (*Sùng Khánh tự chung minh*, dated 1113) and the Viên Quang Pagoda stele inscription (*Viên Quang tự bi minh*, dated 1210)—provides the final, critical pieces of the puzzle for establishing the standardized technical terminology and aesthetic nuances of court architecture during this era. Epigraphic concepts such as *đan lô* (丹栌, *danlu*; red-lacquered bracket blocks) and *họa củng* (画栱, *huagong*; decorated bracket arms) firmly confirm that the Lý dynasty *dougong* system operated not merely as a utilitarian, load-bearing framework, but also as an elaborately crafted artistic medium imbued with potent symbolic value. Furthermore, the descriptions documented by the Song scholar Fan Chengda (1126–1193) in his *Guihai Yuheng Zhi* (桂海虞衡志) regarding the extensive deployment of vibrant red lacquer and refined decorative motifs (Fan, 1175/2011) align seamlessly with the empirical traces of lacquer and gilding observed on authentic timber artifacts excavated *in situ* at the Thăng Long Imperial Citadel (M. Bui & Nguyen, 2015; Pham, 2016). This tight correspondence between textual historiography and forensic archaeological evidence allows us to definitively validate the historic authenticity of a radiant, polychromatic palace architectural style, in which large-timber master craftsmanship and exquisite surface ornamentation were seamlessly fused into a single integrated whole.

The structural identification of the *dougong* system provides the indispensable backbone and the regulatory convergence point for resolving the most challenging engineering puzzles concerning form, geometry, and load distribution in Lý dynasty palace roofs. In an archaeological context where above-ground timber elements have completely vanished, this stood as the most complex technical knot: how a large-timber framework could successfully regulate the cantilevered eaves projection and evenly distribute the immense dead loads of a monumental tubular-tiled roof weighing tens of tons. The *dougong* mechanism offers a clear, empirical answer, confirming that Đại Việt architecture of the eleventh to thirteenth centuries had not only mastered the standardized technical threshold of East Asian timber framing but also possessed the sophisticated engineering capacity to command monumental architectural space. This study definitively establishes Lý dynasty court architecture as a highly unified structural entity: from the large-timber framework anchored upon massive stone plinths to the red-lacquered *dougong* support system and the magnificent tubular-tiled roof, it represents a mature architectural paradigm that shared the foundational structural logic of the East Asian region while proudly embodying the distinctive aesthetic nuances and cultural identity of the Lý dynasty.

Through a systematic cross-examination of wooden structural remnants, stone architectural evidence, and terracotta models, this study identifies a striking, spectacular phenomenon of architectural divergence. While maintaining a deep, organic relationship with the shared East Asian technical ecosystem inherited from the Tang and Song periods, Lý dynasty palace architecture successfully established its own sovereign identity through the structural optimization of integrated framing and a clear design prioritization of complex polyhedral geometries, such as regular hexagonal and octagonal structures. This intricate roof-supporting framework served not only a rigorous engineering function but also generated a powerful visual effect of lightness, buoyancy, and soaring elegance, capturing the bold spirit of cultural autonomy and the expansive aesthetic sensibility of an independent



Figure 9. Terracotta architectural models and stone pagodas illustrating tubular roof tiles and load-bearing dougong systems during the Trần dynasty (13th–14th centuries). Source: Photos by Bui Minh Tri (2009; 2013–2014)

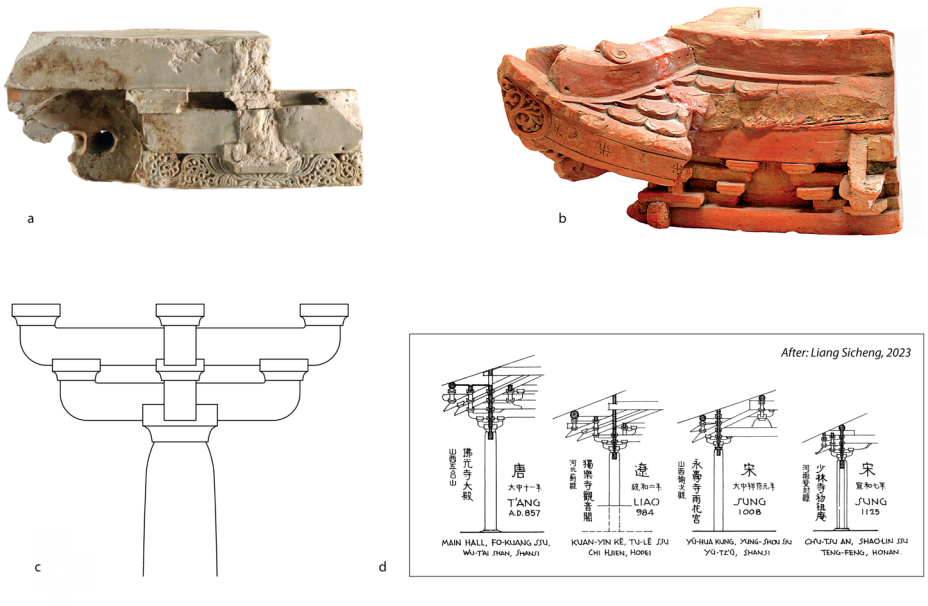


Figure 10. Structural analysis of the Lý–Trần dougong systems in comparison with Chinese Tang–Song *dougong* systems based on the documentation by Liang Sicheng (reprinted 2023). (a) *Dougong* model on a white-glazed ceramic pagoda tower, Lý dynasty, Thăng Long Imperial Citadel site; (b) *dougong* model on a terracotta pagoda tower, Trần dynasty, Nam Định Museum (Ninh Bình); (c) restored drawing of the Lý dynasty dougong based on architectural model documentation; (d) drawing illustrating the Evolution of the Chinese "Order" from *History of Chinese Architecture* by Liang (2023, p. 355). Source: Photos (2013 and 2025) Bui Minh Tri and drawing by Bui Minh Tri and Nguyen Quang Ngoc

polity. The convergence of these complementary sources not only establishes a robust, highly empirical framework for the archaeology of architecture in Vietnam, but also formally repositions the prideful, distinguished status of Lý dynasty palace architecture upon the global map of world cultural heritage.

3.3. Roof morphology and the artistic language of architecture

3.3.1. Roofing systems and technical symbolism

The results of our comparative field investigations across Japan, Korea, and China over multiple decades have established a systematic reference framework demonstrating systemic commonalities between the palace architecture of Đại Việt under the Lý dynasty and the broader architectural civilization of East Asia. This universal typological matrix is identified first and foremost through the complex *dougong* framing, the interlocking tubular and flat roofing tile systems arranged in alternating alignments, and particularly the specific morphology of the hip-and-gable roof, known in regional East Asian architectural terminology as *mái yết sơn* (歇山, *xieshan*). This represents a highly standardized specification wherein a steep primary roof-plane is harmoniously integrated with subsidiary vertical gable roofs—a configuration universally designated by international scholarship as the "East Asian hip-and-gable roof" (Figure 11).

The calculated selection of the *xieshan* form—historically positioned as one of the most complex and highest-ranking architectural typologies within the East Asian building hierarchy—demonstrates both the supreme royal stature of the Lý dynasty and its political ambition to construct a magnificent capital. However, the core scientific value of this study lies in definitively establishing that behind this superficial formal similarity in structural specification was a powerful, intense strategy of cultural adaptation and hybridization, through which enclosing components were successfully transformed from purely utilitarian technical elements into potent visual markers of dynastic autonomy for the Lý court.

The strict inter-dependency between the enclosing roof structure and the internal load-bearing timber framework stands as a masterclass testament to the sophisticated mathematical and geometric knowledge embedded in contemporary architectural design. Within this structural paradigm, the *dougong* bracket sets determined the clear cantilevered projection and horizontal span of the roof, while conversely, the cumulative dead weight and physical density of the tubular and flat tile system directly regulated the ultimate load-bearing capacity and technical cross-

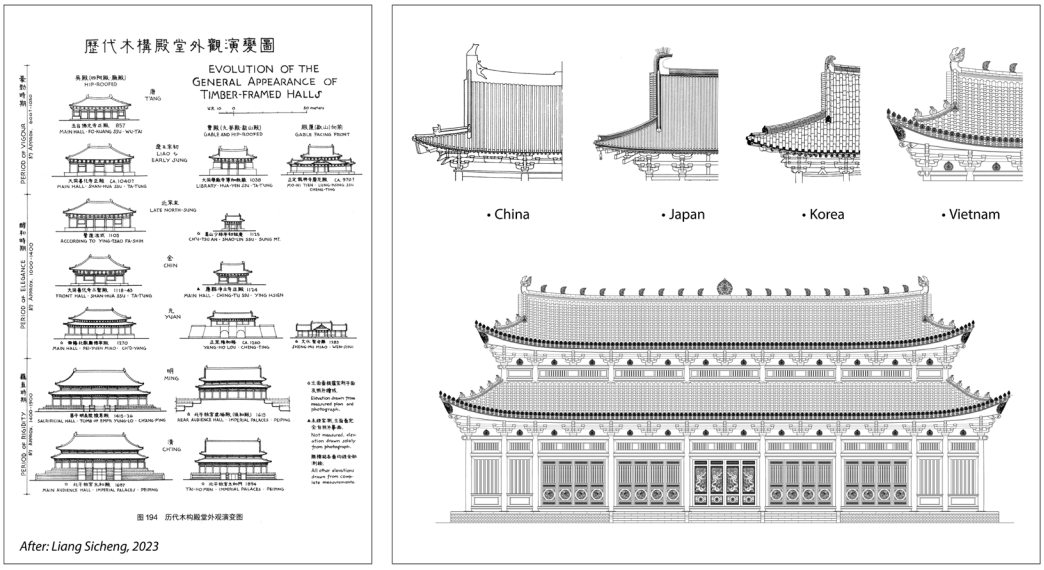


Figure 11. Morphological comparison of roof profiles in Lý dynasty palatial architecture and regional East Asian architectural traditions. Sources: Drawings compiled and reconstructed by Bui Minh Tri, based on architectural charts from Liang (2023, p. 359), Japan Association for Conservation of Architectural Monuments. (2013), and National Research Institute of Cultural Heritage (1984)

sectional parameters of the supporting timber framework beneath. This deeply coordinated structural relationship successfully resolved complex mechanical challenges while simultaneously engineering an extraordinary artistic ensemble, wherein the rich red color of the fired terracotta seamlessly merged with high-relief sculptural motifs of the lotus, dragon, and phoenix to eloquently project the profound philosophical and religious values of Lý-period Đại Việt society.

The monumental physical scale and imperial volume of the Lý palace complexes are quantitatively validated by the staggering archaeological corpus of 98,856 roofing artifacts uncovered during systematic excavations at the Thăng Long Imperial Citadel (Table 2). The overwhelming dominance of specialized curved tiles and interlocking tubular tiles, alongside the absolute typological diversity of decorative elements such as bodhi-leaf crests and auspicious zoomorphic sculptures, reflects not only the immense surface areas of the imperial roof structures but also provides empirical data for identifying the advanced technical threshold of ceramic engineering and the supreme aesthetic refinement achieved during this era. To decode the intricate morphology and exact functional placement of these fragments, this study moves decisively beyond descriptive archaeology, situating the Thăng Long discoveries within the wider evolutionary macro-stream of regional architectural history to establish a standardized terminology system. The rigorous scientific classification of eave tiles, roof-body tiles, main ridge tiles, alongside specialized dragon tiles and phoenix tiles, forms the indispensable foundation for all subsequent 3D digital reconstructions (Figure 12).

Within this highly regulated system, the roof-covering infrastructure ceased to perform a purely sheltering

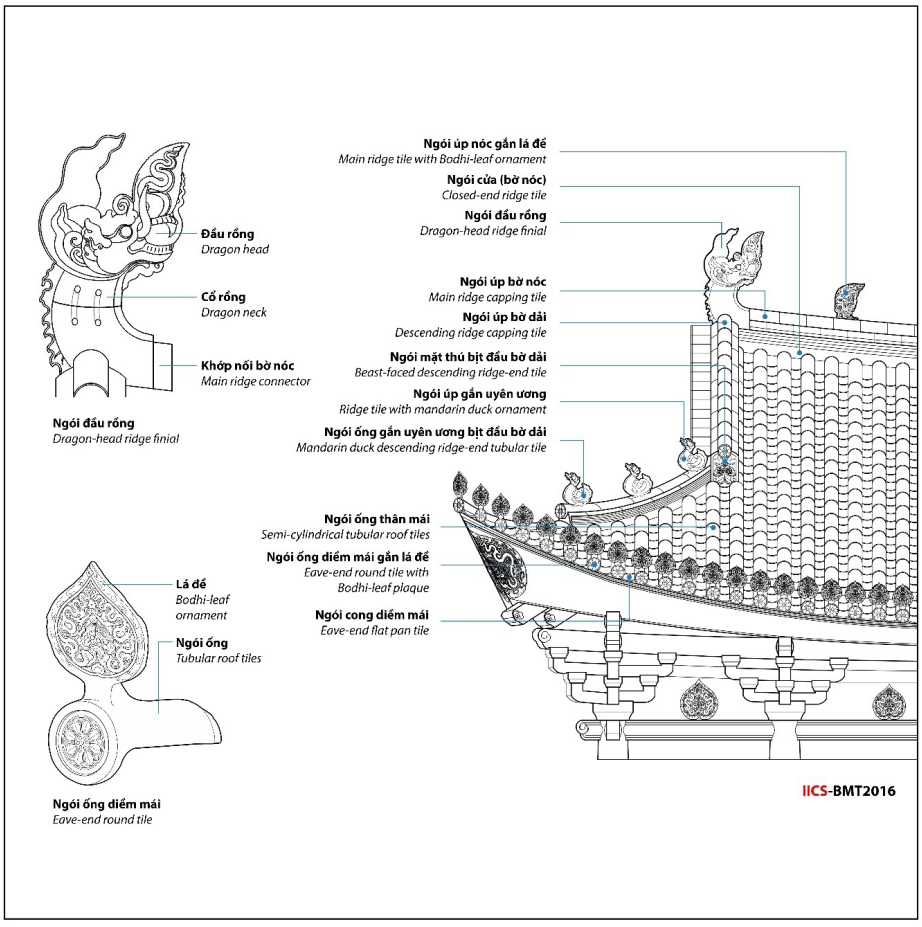


Figure 12. Terminology diagram of Lý dynasty palace roof tiling system (11th–13th centuries). Source: Drawings by Bui Minh Tri

Table 2. Quantitative statistics of Lý-period roofing materials

No.	Artifact type	Quantity (pieces/artifacts)	Remarks
1	Roof tiles for the main roof surface	85,614	
1.1	Curved tiles	53,396	Concave/yin tiles
1.2	Tubular tiles	32,218	Convex/yang tiles
2	Eave roof tiles	8,838	
2.1	Tubular-end tiles	4,066	Decorated with dragon, lotus, and chrysanthemum motifs
2.2	Symmetrical bodhi-leaf plaques attached to tubular tiles	4,764	Mounted on tubular tiles; decorated with dragon, phoenix, and jewel motifs
2.3	Irregularly shaped tiles	8	Bodhi-leaf plaques decorated with dragon and phoenix motifs
3	Ridge tiles	3,592	
3.1	Central ridge tiles	76	Decorated with dragon and phoenix motifs
3.2	Ridge tiles with offset bodhi-leaf plaques	2,501	Decorated with dragon and phoenix motifs
3.3	Ridge tiles with mandarin duck motifs	676	Used on descending ridges
3.4	Undecorated ridge tiles	339	Used on the ridge crest and descending ridges
4	Gable-end decorative figures	789	
4.1	Dragons	437	Head and neck preserved
4.2	Phoenixes	352	Head and neck preserved
5	Lion-head ornaments	23	Installed at the ends of descending ridges
	Total	98,856	

function, evolving instead into an advanced technical complex endowed with rich symbolic and artistic meaning. While the roof-body tile group optimized architectural drainage through a hydrological and cosmological solution defined by an alternating "one-yin-one-yang" configuration perfectly adapted to the torrential precipitation of the humid tropical climate, the eave-tile group became the primary site for a bold strategy of identity-driven localization. Thăng Long royal architecture radically shattered the widespread East Asian convention of employing standard circular eave tiles (瓦当, *wadang*) by seamlessly fusing a symmetrical, triangular terracotta bodhi-leaf plaque decorated with auspicious imperial motifs directly onto the back of the eave tiles. This profound morphological divergence transformed the linear eave band from a sharp technical edge into a dynamic, three-dimensional spiritual halo, visually projecting the spectacular flourishing of Buddhism as it became the supreme ideological and spiritual foundation of the ruling dynasty (Figure 13).

The cultural value of the Lý imperial roof also resides in the striking visual convergence of its rich, natural terracotta red with complex iconographic motifs that asserted royal authority and sacral status. High-relief motifs of the lotus, imperial dragon, phoenix, and sacred mandarin ducks enriched the visual vocabulary of the superstructure, acting as an elite medium for projecting the philosophical underpinnings of Đại Việt society. This aesthetic elaboration was intensely magnified by the monumental sculptural systems anchoring the roofs, featuring colossal dragon and phoenix ridge-end heads reaching 130–150 cm in height and weighing in excess of 100 kg, alongside ridge-body tiles mounted with sacred mandarin duck figures and elaborate bodhi-leaf crests decorated with auspicious animals. The production of these monumental elements required master-level kiln technology and ceramic firing controls, while their precise installation along the ridges and eaves demanded highly sophisticated structural engineering coordination by master builders. This painstaking orchestration generated a striking architectural silhouette—a proud, buoyant, and upward-reaching roof form that established a highly distinguished aesthetic character, sharply demarcated from contemporary East Asian palace conventions (M. Bui, 2018) (Figure 14).

By introducing the bodhi-leaf ornament—the supreme visual signifier of the radiant halo of the Buddhist *Dharma*—directly into the structural enclosure system,



Figure 13. Comparative analysis of eave-end tile variants between Thăng Long and East Asian traditions. Sources: Photos by Bui Minh Tri (2010), including photographic data courtesy of the Tokyo National Museum and Cultural Heritage Online, Japan (https://bunka.nii.ac.jp/)



Figure 14. Terracotta roofing and decorative tiles from Lý dynasty palatial architecture excavated at the Thăng Long Imperial Citadel site. Source: Photos and drawing by Bui Minh Tri (2010–2015)

Lý-period court architecture fundamentally revolutionized the symbolic vocabulary of imperial roofing art. These auspicious creatures did not function merely as apotropaic, protective motifs; rather, they articulated a deeply humanistic philosophy and the benevolent, people-centered governance of a prosperous sovereign dynasty. Within the sacred topography of the Thăng Long capital, the co-existence of monumental administrative palaces alongside representative state-supported religious institutions, such as the Chân Giáo Pagoda (dated 1024) and the Diên Hựu Pagoda (dated 1049), forged a uniquely integrated cultural and ideological space. It was precisely this intense Buddhist inspiration that elevated the bodhi-leaf motif into the dominant mode of visual expression, creating two primary institutional roof typologies: dragon-tile roofs and phoenix-tile roofs (Figure 15). The seamless synthesis of delicate leaf-shaped filigree with monumental, high-relief sculptural decoration produced an unparalleled national tradition of roofing art, wherein structural beauty and conceptual gravity were impeccably fused, confirming the independent cultural manifestation and sovereign historical status of Vietnamese architecture within the East Asian civilizational sphere.

3.3.2. Roofing techniques and roof-frame configuration

The structural transformation of reconstructed roof art from speculative graphic restitution into a coherent, structurally viable architectural entity requires the strict integration of excavated material evidence with the comprehensive corpus of Lý–Trần terracotta models. Building upon the rigorous identification and classification of roofing components, this study reconstructs the prevailing roof profile of the Thăng Long palace complexes as the prestigious *xieshan* typology. This was by no means a simple borrowed architectural form, but a composite, highly creative system through which profound morphological adaptation took place. The ultimate distinctiveness of Đại Việt court architecture lay not merely in rich surface ornamentation, but fundamentally in its deliberate intervention into roof proportions, pitches, and load parameters, thereby forging a highly localized architectural expression that retained the regional East Asian typological framework while fiercely asserting autonomy in both spatial and structural concepts.

From an architectural-aesthetic perspective, detailed geometric analysis of the excavated tile system strongly

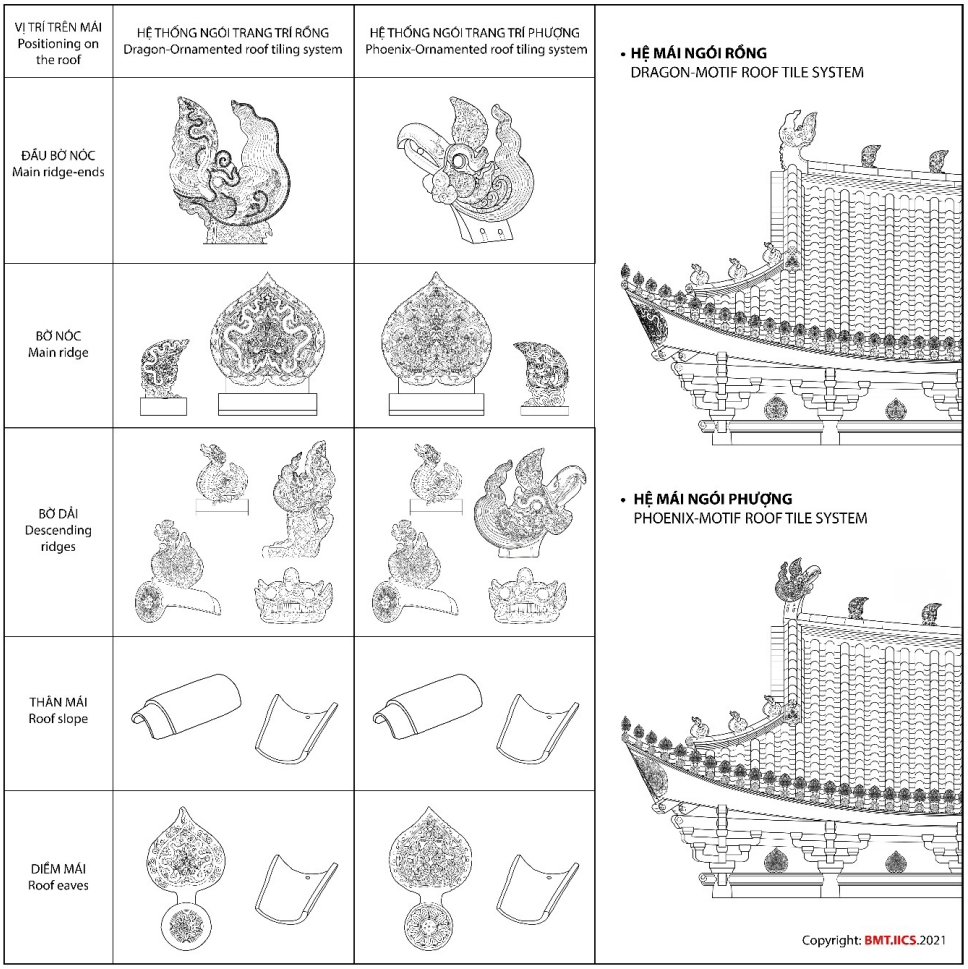


Figure 15. Diagram of roof tiles and roof morphology of Lý dynasty palace architecture with dragon and phoenix motifs (11th–13th centuries). Source: Drawings by Bui Minh Tri and Nguyen Quang Ngoc

suggests that Lý-period roofs were designed with a refined, organic curvature that generated a powerful visual effect of lightness and buoyancy, comparable to the upward lift bof a soaring bird's wings. This heritage feature finds an explicit textual echo in the 1107 inscription on the *Bảo Ninh Sùng Phúc stele* (*Bảo Ninh Sùng Phúc tự bi minh*) (Institute of Literature, 1977), which vividly describes the imperial eaves as "spreading out like cascading wings" and the palace structure as "flying toward the four directions" (Nguyen, 2010). This so-called "flying bird wing" effect should not be interpreted as a peripheral, purely decorative gesture. Rather, it directly resulted from the highly coordinated structural interaction between the curved corner hips and large-scale ornamental components, whose combined upward thrust visually released the immense dead weight of the terracotta, animating the heavy roof into a proud, agile, and dynamic architectural form (Figure 14).

The structural roof pitch constituted another distinctive technical marker of this localized evolution. In his *Annan Jishi*, the Yuan dynasty envoy Chen Fu described the Đại Việt roof form as being characteristically "steep and seemingly on the verge of tipping" (Chen, 1293). Read through the precise lens of architectural geometry, this empirical observation suggests that Đại Việt master builders did not follow the prevailing contemporary East Asian trend of creating a sagging, concave roof curvature. Specifically, while Northern Song architecture achieved a smoother, sweeping silhouette by mathematically calculated roof-folding methods—systematized as *zheju* (折举; roof-estimation) or *zhesha* (折剎; roof-slatting) in the *Yingzao*

Fashi (Li, 1103/1983)—Lý–Trần architecture deliberately maintained a characteristically straight and steep roof profile. This pragmatic engineering solution effectively optimized rainwater drainage velocity under torrential tropical monsoon conditions while simultaneously generating an impression of towering monumentality, especially when juxtaposed against the relatively compact eaves projection, which commonly measured around four to six *thước*.

In terms of roofing technique, although Lý architecture operated within the broader East Asian tubular-flat tile convention, it established a distinct independent identity through its specialized eave tiles and capping elements, whose artistic morphology completely diverged from regional norms. Forensic engineering studies of the eave pan-tiles, each exhibiting an elongated body of approximately 45–48 cm, reveal a sophisticated mathematical understanding of perspective and optical adjustment. Given an actual roof slope angle of 30°, the master artisans intentionally mounted the terracotta bodhi-leaf plaque at an angle of 66° relative to the tile's water-running plane, resulting in a precise 36° deviation from the vertical axis (Figure 16).

Geometric analysis indicates that this structural orientation was a deliberate visual compensation rather than a constructional accident. Because the eave tiles were positioned high above the ground level, this 36° compensatory angle ensured that, from the natural viewing position of an observer standing in the palace courtyard, the decorated surface of the bodhi-leaf plaque would appear visually upright, flat, and appropriately proportioned. This allowed the high-relief dragon and phoenix motifs to be perceived with maximum clarity and zero foreshortening distortion. The brilliant combination of a pragmatic, steep roof profile with calculated perspective correction demonstrates an advanced command of architectural optics and visual science, in which core technical values were creatively adjusted both to mitigate climate pressures and to amplify the sacred dignity of royal spaces.

Taken together, these architectural findings demonstrate that the artistic language of the Lý roofing system was highly symbolic yet deeply grounded in rigorous technical control. East Asian regional norms were not simply reproduced, but were fundamentally transformed through a substantial process of systemic localization. This historic transformation was achieved, above all, through the indigenous capacity to resolve massive gravitational loads by means of rhythmic, buoyant forms. Rather than appearing as a static, oppressive, and heavy volume, the complex system of auspicious creatures—especially dragons, phoenixes, and mandarin ducks, with their outstretched, ascending profiles placed at critical structural nodes—acted as a visual and mechanical counterbalance to the dead weight of tens of thousands of terracotta tiles. When integrated with perspective corrections and the calculated interplay of natural light across the multi-tiered tile surfaces, this massive roofing infrastructure bypassed any oppressive visual effect, generating an impression of uplifting elegance and relief along the skyline of the Thăng Long capital.

The palace roof of the Lý dynasty was therefore far more than a mere enclosing element; it stood as a material demonstration of the highly integrated synthesis between the engineering mastery of structural mechanics and gravitational distribution, Buddhist visual sensibility, and the expansive artistic language of royal authority. The ultimate convergence of advanced pyrotechnic and ceramic technology, calculated roof engineering, and perspectival design enabled Thăng Long architecture to achieve a distinctive morphological breakthrough, claiming a singular, prideful position within the history of premodern Asian palace architecture.

3.3.3. Methodology of reconstruction and regional comparison

The process of decoding Lý-period roofing architecture represents a methodological shift from model-based extrapolation and regional typological comparison toward an evidence-based reconstruction rigorously grounded in primary field data. The critical turning point of this study lies in the precise identification of the exact function and spatial placement of each roof tile type through systematic archaeological fitting. The reconstructed models are therefore established upon a dialectical integration between the empirical material attributes of the recovered artifacts—including their morphology and dimensions—and the strict technical parameters of architecture, such as structural loads and roof pitch.

To establish the distinctive national value of the Thăng Long heritage assemblage, this study situates this architectural entity in a direct dialogue with contemporary Song-period architecture in China—a high point of regional construction systematized in the imperial *Yingzao Fashi* (Li, 1103/1983). This comparative cross-examination between the Thăng Long forensic discoveries and Li Jie's normative codification not only reveals a deep, dynamic field of cultural exchange but also firmly validates the historical existence of an independent, autonomous, and highly distinctive royal architectural tradition (Table 3).

The results of this comparative analysis firmly demonstrate that Lý dynasty palace architecture was by no means a passive imitation of northern models. Operating

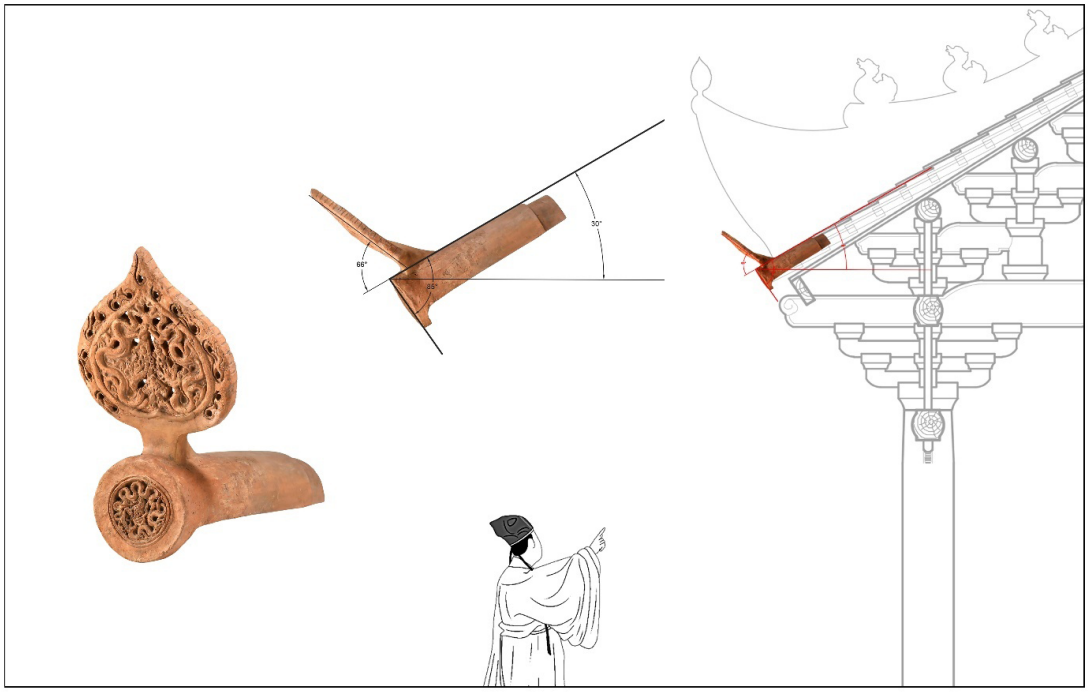


Figure 16. Analysis of roof slope and perspective correction techniques derived from eave-end tiles of Lý dynasty palatial architecture. Source: Drawings by Bui Minh Tri and Nguyen Quang Ngoc

on the foundational basis of the "common technical grammar" of East Asian timber architecture, Đại Việt craftsmen successfully established a distinct, sovereign "architectural dialect." This highly localized dialect emerged through the creative, unique integration of sacred Buddhist iconography directly into the architectural components, forging an unprecedented aesthetic language in which monarchical majesty and divine spiritualism were fully and absolutely interwoven. This synthesis stands as clear evidence of the dynasty's spirit of cultural self-reliance and its exceptional capacity for formal innovation.

In other words, Lý-period palace architecture represents a high-level convergence between universal technical standards and the specific artistic imagination of Đại Việt. While the Song Dynasty pursued architectural completion through institutional codification and strict normative order, the Lý dynasty carved its lasting historical mark by fundamentally redefining the aesthetics of ornamental forms—successfully transforming the physical space of monarchical power into a profound architectural masterpiece shaped by localized genius and the radiant Buddhist spirit of the age.

4. Reconstruction philosophy and dialogue with East Asian experiences

4.1. Dialogues with East Asian reconstruction practice

In the history of ancient capitals, macro-level urban planning functions as the structural framework of a state, whereas palace architecture represents the very "soul" that reflects dynastic authority and the zenith of contemporary aesthetic thought. At the UNESCO World Heritage site of the Thăng Long Imperial Citadel, these profound symbolic values survive primarily as subterranean foundation remnants and dispersed architectural materials embedded within complex archaeological strata, leaving significant lacunae in our understanding of a once-splendid palace landscape. For this reason, the task of decoding palace forms is not merely an urgent scholarly imperative, but also a vital act of heritage preservation and historical interpretation achieved through direct reference to successful, time-tested models in Japan, Korea, and China. Practical lessons from these neighboring nations offer multifaceted perspectives on how to rigorously negotiate the dialectical relationship

Table 3. Comparative analysis of palace roofing systems: Lý dynasty (Đại Việt) vs. Song dynasty (China)

Comparative item	Lý dynasty palace architecture (Đại Việt)	Song dynasty palace architecture (China)	Comparative assessment
Structural system	Using the bracket-set system (*dougong*)	Using the bracket-set system (*dougong*)	Both traditions shared a common technical vocabulary, reflecting a comparable level of timber construction development in East Asian court architecture.
Roof form	Hip-and-gable roofs (*xieshan*) and other complex imperial roof compositions were widely used in palace architecture.	Hip-and-gable roofs (*xieshan*) and other complex imperial roof compositions were also widely used in palace architecture.	The two traditions were similar in overall roof composition and in their participation in the hierarchical roof order of East Asian palace architecture.
Formal articulation and aesthetics	Roof forms emphasized upward curvature, with a more expressive and visually articulated decorative silhouette.	Roof forms emphasized upward curvature as well, but within a more codified framework later systematized in *Yingzao Fashi*.	Both traditions followed the same formal principle of the upturned roof profile.
Materials and color	Roofing materials were dominated by red terracotta, with evidence of locally adapted glazed tiles in some contexts.	Glazed roof colors were more strictly regulated according to court rank, especially yellow and green.	Đại Việt adopted glazed-roof technology but adapted it to a localized visual hierarchy rather than reproducing Song court conventions directly.
Characteristic roof ornament	Decorative elements included bodhi-leaf eave attachments, ridge ornaments with mandarin duck imagery, and sculptural dragon- and phoenix-head terminals at the gable ends.	Decorative elements included circular-ended tube tiles, roof-beast sequences, and *chiwen* ornaments at ridge ends.	The strongest divergence lies in roof ornamentation, where Lý palace architecture developed a distinctly Buddhist-influenced decorative concept.
Symbolic language	Royal authority and Buddhist sacrality were closely intertwined in the architectural decoration of the palace roof.	Palace symbolism emphasized secular authority and the normative hierarchy associated with Confucian political order.	The contrast reflects different ideological frameworks shaping court space and architectural meaning in the two traditions.

between empirical archaeological evidence and theoretical architectural hypotheses.

A notable paradigm is Japan's long-term research and reconstruction of *Heijo-kyo* (平城京, *Pingcheng Jing*), the Nara-period capital (710–784), where scholars successfully deployed digital technologies and 3D modeling as scientific verification tools to test hypotheses concerning load-bearing structures. The reconstruction methodology implemented at Nara—systematically advancing from the forensic interpretation of *in situ* remnants to hypothetical architectural drawings and eventual physical restitution—demands intensive interdisciplinary collaboration and a long-term institutional perspective. Step by step, this process revives the material culture of the heritage site while simultaneously elevating public historical consciousness and supporting national education.

Similarly, major heritage initiatives at the Donggung Palace (东宫, *Donggong*) in Korea and the Daming Palace (大明宫, *Daming Gong*) in China provide invaluable lessons in seamlessly synthesizing field archaeology, comparative historiographical analysis, and traditional large-timber construction techniques, drawing upon the foundational architectural archaeological frameworks established by scholars such as Yang (2001). In particular, Korea's specialized engineering experience in restoring complex mortise-and-tenon joinery alongside the traditional *dancheong* (丹青, *danqing*) painted decorative system offers critical comparative reference points for interpreting the complex *dougong* systems and courtly architectural polychromy of the Lý dynasty. These multi-layered, highly integrated approaches provide a valuable methodological roadmap for the digital and physical reconstruction of complex superstructures at Thăng Long—most notably the monumental octagonal palace structures, which remain a sophisticated architectural puzzle requiring the seamless convergence of rigorous archaeological reasoning and advanced structural analysis, a methodology profoundly demonstrated in the works of Kashiwada (2010).

4.2. From archaeological evidence to experimental reconstruction (2014–2021)

The period between 2014 and 2021 marked a watershed turning point in the systematic reconstruction of Lý-period court architecture, as the decoding process became standardized through a rigorous, multilayered methodological framework and a highly transparent interpretive process. At the core of this operation was the establishment of a verifiable, organic nexus connecting the empirical archaeological evidence excavated from the Thăng Long Imperial Citadel with a structured matrix of scholarly technical hypotheses. Through the implementation of a highly detailed exploded-view diagram (Figure 17), each targeted palatial building was conceptually dissected into five independent operational layers. This specialized diagram operated as a foundational tool for managing reliability by applying a standardized, strict color code: red represented *in situ* structural evidence, yellow denoted artifact typology and comparative material remains, and blue indicated secondary comparative hypotheses. This created a transparent forensic procedure that cleanly separated objective archaeological data from subjective scholarly inference.

Within this multilayered reconstruction paradigm, the *dougong* played the decisive role in decoding the unique and intricate structural logic of the Lý dynasty. It functioned not merely as an intermediate technical component designed to transfer the immense dead loads of the tubular tile system and monumental roof ornaments safely down to the load-bearing column grid, but also served as the primary diagnostic criterion for identifying and defining the distinct identity of Lý palace architecture within the

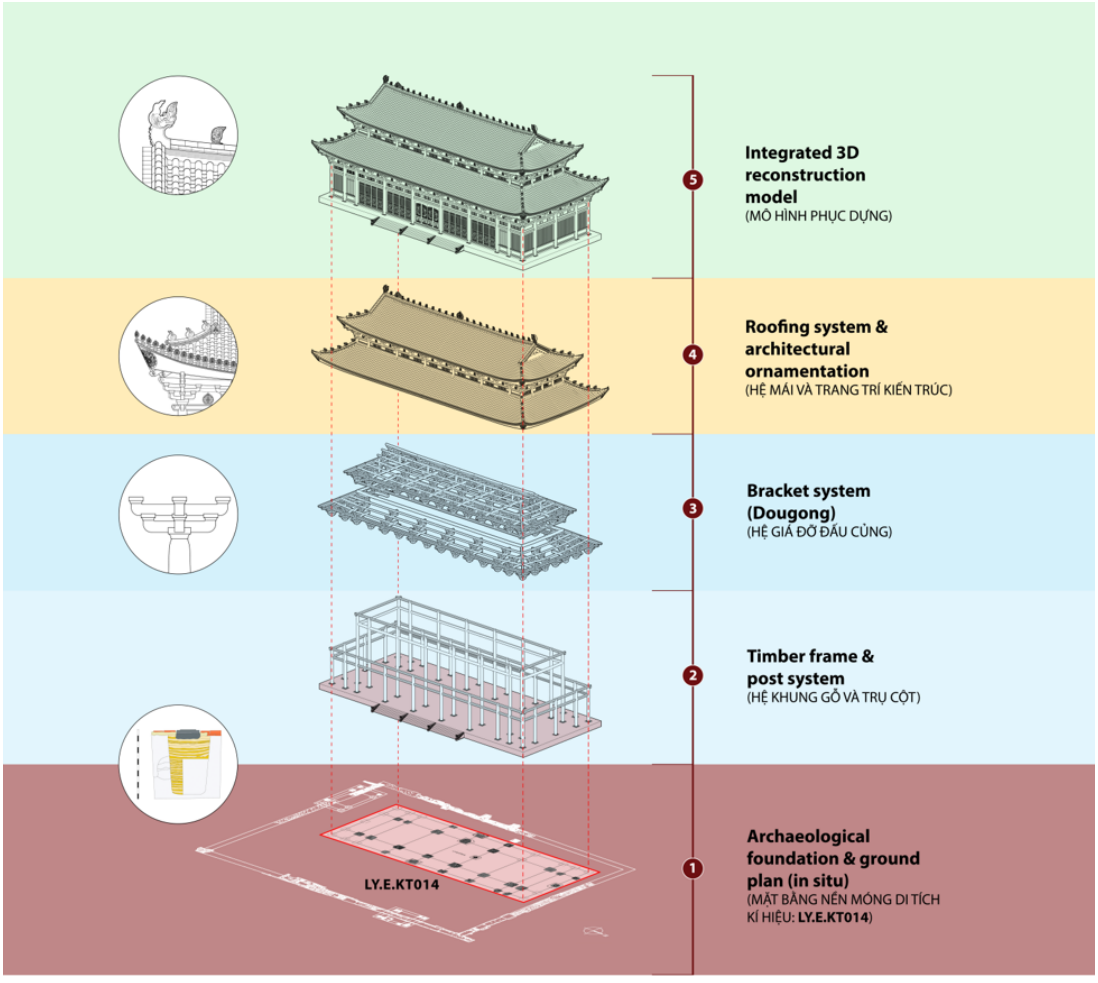


Figure 17. Multi-layered methodological diagram illustrating the reconstruction workflow of Lý dynasty palace architecture. Source: Diagram by Bui Minh Tri and Nguyen Quang Ngoc

broader East Asian civilization. Furthermore, the roofing system and its accompanying architectural sculpture represented the absolute apex of Lý-period imperial aesthetics. Based upon the vast corpus of triangular bodhi-leaf plaques attached to round awning tiles, alongside ridge capping tiles mounted with high-relief dragons, phoenixes, and sacred mandarin ducks excavated *in situ*, this specific reconstruction layer successfully restituted the brilliant, majestic, and polychromatic appearance of the lost palaces within the former Thăng Long Imperial Citadel. The geometric calculation governing the relationship between the roof pitch and the *dougong* bracket spacing reflects the profound engineering mastery of contemporary master builders, producing an imperial roofscape that was simultaneously visually graceful—through its sweeping, buoyant curved eave corners—and structurally resilient against severe tropical environmental impacts.

At the same time, drawing upon the pioneering methodological approaches in architectural archaeology and structural history established by seminal regional scholars such as Liang Sicheng (Liang, 1932, 2023), Fu Xinian (Fu, 2009), and Chen Mingda (Chen, 1966), this research advanced its analytical boundaries through a fundamental paradigm shift from system-based interpretation to empirical, evidence-based reconstruction. Beginning with the landmark successful reconstruction of the representative palace structure LY.E.KT014 in 2015–2016 (Figure 18), the exact spatial form of a monumental seven-bay building was definitively verified through the discovery of a network of 42 rammed-pebble foundation pits, corresponding to a large-timber structural framework of 42 major columns spanning a total footprint of 623.2 sqm (M. Bui, 2016a, 2016b).

Building upon that pivotal milestone, the subsequent five years from 2016 to 2021 witnessed sustained, comprehensive analysis executed upon a vast macro-volume of stratigraphic and material data. This intensive process allowed the standardized reconstruction methodology to expand systematically across the entirety of the archaeological site, encompassing Sectors A, B, C, D, and E. In 2021, following a protracted and highly challenging scientific journey, the comprehensive overall reconstruction of the central palace architecture of the Thăng Long Imperial Citadel was officially unveiled to the international community, successfully reviving a magnificent architectural complex consisting of 65 distinct major buildings from the thousand-year-old subterranean remnants buried beneath the ground (Figure 19) (M. Bui, 2021). This monumental achievement not only confirms that the imperial capital of Thăng Long possessed an

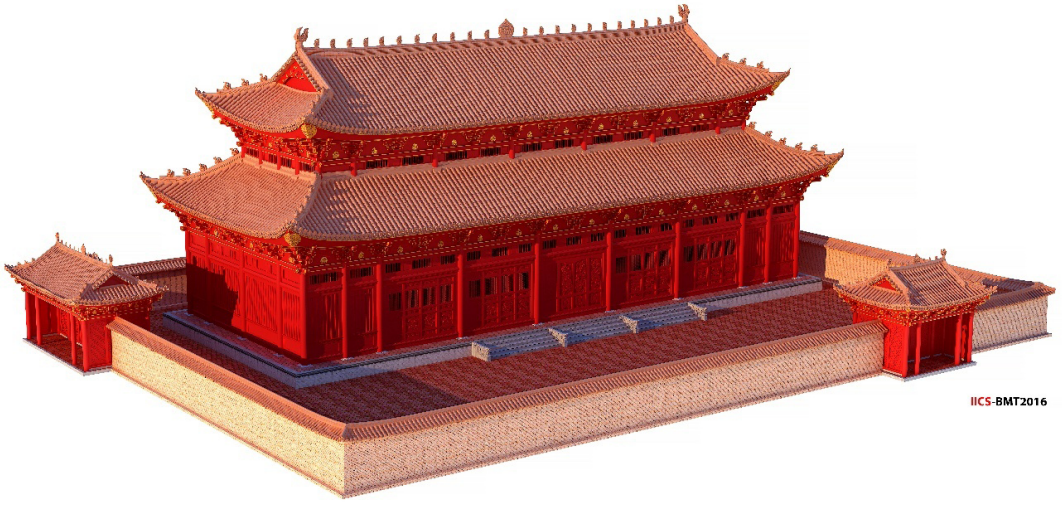


Figure 18. Three-dimensional morphological reconstruction of the Lý dynasty architectural structure LY.E.KT014 based on archaeological evidence. Source: Three-dimensional reconstruction by Bui Minh Tri

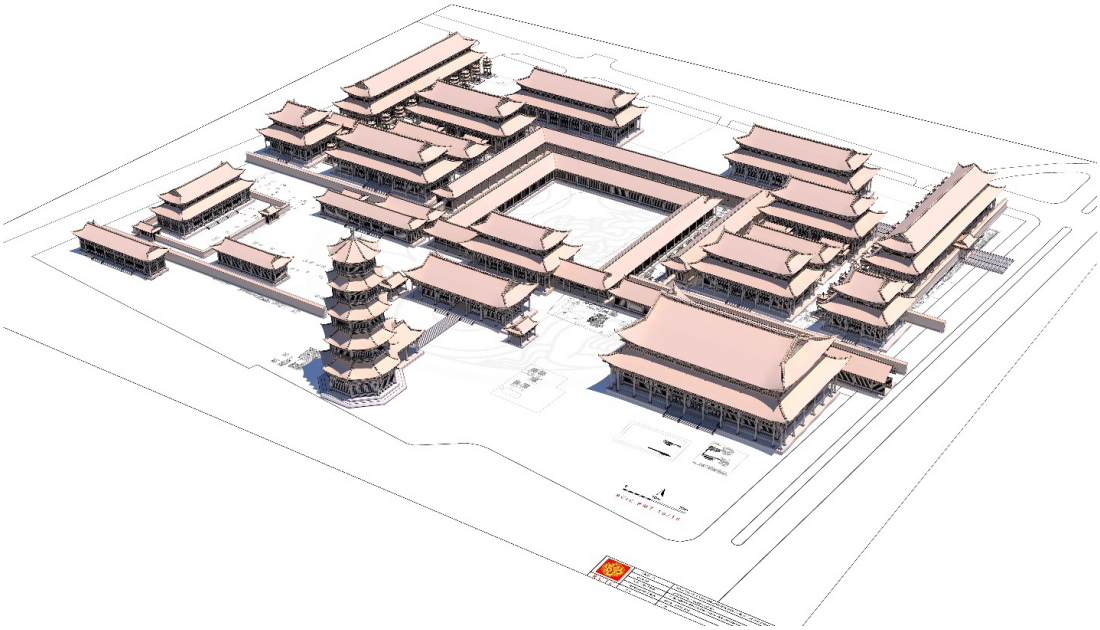


Figure 19. Comprehensive three-dimensional reconstruction of Lý dynasty architectural morphology at the Thăng Long Imperial Citadel site, based on archaeological evidence, 2021. Source: Three-dimensional reconstruction by Bui Minh Tri and Nguyen Quang Ngoc

advanced construction capacity fully comparable to the greatest royal palace complexes in contemporary East Asia, but also establishes the pioneering, foundational value of this theoretical framework and digital restoration methodology for the preservation of world-class royal architectural heritage. Through the systematic reconstruction of these ruins, this study does far more than recover the physical "soul" of Thăng Long; it firmly reasserts the sovereign identity, cultural autonomy, and independent historical status of Đại Việt architecture within the global heritage landscape.

4.3. The intersection of empirical archaeology and contemporary digital conservation

Dialogue with East Asian architectural experiences is by no means limited to identifying formal similarities or morphological divergences; it simultaneously unlocks innovative methodological approaches to contemporary digital heritage conservation. Following the integrated procedure proposed by Pietroni and Ferdani (2021), this study affirms that virtual reconstruction must function strictly as a scientifically testable hypothesis rather than an exercise in free creative invention. By rendering the reliability of data entirely transparent through a standardized color-coding index (Table 1), this research establishes a rigorous precedent for fidelity in translating fragmented archaeological entities into digital assets, empowering future generations of scholars to systematically retrace, audit, and reassess the entire decoding process.

The study and structural reconstruction of architecture from highly fragmented archaeological remains constitutes an exceptionally challenging and sophisticated field of global scholarship. However, in the objective spirit of empirical science, it must be transparently recognized that all current digital reconstruction models possess inherent limitations regarding absolute dimensional accuracy. Because the Thăng Long material record consists of fragmented entities that have suffered severe stratigraphic distortion and the irreversible effects of time, the digital transformation process inevitably introduces inherent systematic interpolation errors. Objective variables stemming from ancient handmade production techniques, alongside physical deviations between the surviving artifacts and their pristine original profiles, represent distinct margins of uncertainty that modern simulation technologies can only minimize, but never entirely eliminate.

Accordingly, these virtual reconstruction results must be understood as the most reliable, scientifically verified hypotheses currently attainable—functioning essentially as an open interpretive system that remains dynamically poised for revision and updating whenever new empirical field evidence emerges. Explicitly clarifying these technical limitations does not diminish the scientific value of this monumental project; on the contrary, it robustly affirms the research team's profound methodological caution and rigorous commitment to academic integrity in reconstructing the authentic appearance of the world heritage site.

In the contemporary context of rapid urbanization across Vietnam, the systematic digitization of Thăng Long's architectural forms directly addresses the critical socio-cultural challenge of safeguarding cultural identity while balancing the intensive pressures of modern urban development. This sustainable approach aligns closely with the participatory digital framework proposed by Farhan *et al.* (2025), which conceptualizes digital heritage assets not merely as static archival documentation, but as powerful, active interpretive tools capable of reviving the tangible and intangible spirit of historic cities. The holistic reconstruction of Lý-period palace architecture through the advanced lens of digital archaeology therefore transcends the boundaries of a purely antiquarian study, emerging instead as a highly sustainable, forward-looking strategy for protecting and promoting the cultural identity of Đại Việt in the digital age.

5. Conclusion

The Thăng Long Imperial Citadel exists not merely as a physical entity, but has been established as a representative model of the continuous, unbroken morphological evolution of Vietnamese architecture and urban planning. Functioning as a "living museum," this heritage site reflects the shifts in court governance thinking and imperial aesthetics across dynasties. The archaeological discoveries here have provided a cross-temporal reference frame, demonstrating the eco-technical adaptability of the Vietnamese people: from specific foundation-treatment solutions on the weak geology of the Red River Delta, to harmonious urban spatial planning thinking within a complex hydrological ecosystem. The integration between large-timber craftsmanship and the distinctive terracotta material system not only establishes a high technical level but also materializes the deep Oriental philosophical values accumulated over many centuries.

The core theoretical contribution of this study lies in the clarification that Lý-period architecture was not a passive inheritance from Chinese models or East Asian timber traditions, but an autonomous architectural system, shaped by the close interaction between the natural environment, royal symbolism, and indigenous cultural identity. Analyses of bioclimatic adaptation—reflected through the roof pitch to optimize tropical water drainage and the specific tile roof system (eaves tiles and decorative ridge tiles with bodhi leaf and mandarin duck motifs)—have established a distinct standard of function and art. In particular, the localization of the *dougong* through the integration of Buddhist motifs (bodhi leaf, lotus, dragon, phoenix) created a unique aesthetic language, where secular authority was completely intertwined with religious sacredness. The presence of these architectural material typologies not only reflects the uniqueness of courtly art but also serves as a mode of expression for the stature of the Thăng Long capital in regional history.

From a technical and morphological perspective, the research has consolidated the empirical basis for identifying Lý-period architecture as belonging to the *dougong* structural system. Although sharing the common protocols of regional timber architectural civilization, Đại Việt architecture affirmed an independent developmental process, becoming one of the standard palatial models in East Asia. It is the integration between load-bearing function and the localized sculptural symbolic system, combined with Champa artistic influences (bodhi leaf, dragon, garuda, kinnari), that outlined a magnificent spatial structure for the Lý-period Thăng Long capital. This is not only a morphological breakthrough but also the establishment of a distinctive royal symbolic system, affirming Đại Việt's position in the historical flow of ancient East Asian architecture.

In summary, the journey of decoding Lý-period Vietnamese palace architecture over the past 15 years (2011–2025) has achieved important accomplishments, highlighting the successful restoration of the heritage site's appearance based on 3D technology. For the first time in a millennium, the appearance of the Thăng Long capital has been recreated, contributing to the revival of quintessential cultural values that had once been buried underground. Although the current reconstruction models still serve as verified scientific hypotheses, they have created a foundational premise to recognize and reassess the universal values of the Thăng Long Imperial Citadel World Heritage Site. This research not only enhances public awareness and serves historical education, but also makes a practical contribution to the common repository of human architectural history. This is the basis for restoring the authenticity of the historical picture of the Thăng Long capital, affirming the enduring position of Đại Việt architecture in the digital age and the global flow of civilization.

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Conflict of interest

The authors declare they have no competing interests.

Author contributions

Conceptualization: Minh Tri Bui
Formal analysis: Minh Tri Bui
Methodology: Minh Tri Bui
Investigation: Minh Tri Bui
Project administration: All authors
Resources: Minh Tri Bui
Writing–original draft: Minh Tri Bui
Writing–review & editing: All authors

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Availability of data

The data supporting the findings of this study are available from the corresponding author upon reasonable request.

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