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Advancing Timber for the Future Built Environment

Restoration Methodology for Medieval Wooden Structures Based on Excavated Remains in Seoul

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ABSTRACT: This study examines the restoration design and exhibition strategies of timber-framed residential architecture excavated from the Gongpyeong area in Seoul, focusing on the structural and spatial characteristics of mid-Joseon urban dwellings. Utilizing archaeological remains such as foundation stones, retaining stones, and drainage systems, the research reconstructs architectural forms based on traditional Korean timber-frame logic. The methodology emphasizes dimensional analysis, structural typology, and historical documents to restore twelve houses dating to the 16th century. Furthermore, three exhibition approaches—1:1 physical reconstruction, digital visualization, and scaled models—are evaluated in the context of underground museum design. This case offers a model for integrating archaeological heritage into contemporary urban environments while balancing authenticity and accessibility. The study contributes both theoretically and practically to the fields of wooden architecture restoration and cultural heritage display, particularly within the dense fabric of modern cities.

KEYWORDS: Timber-framed architecture, Joseon urban housing, Architectural restoration, Heritage exhibition, Archaeological reconstruction

1 – INTRODUCTION

Seoul, the capital of South Korea, is a historical city with over two millennia of urban history. As modern development continues, various historical remains are constantly uncovered beneath the surface. These archaeological relics are vital to the city's identity and serve as educational and cultural assets. However, tensions between dense development and heritage preservation persist, and achieving balance between the two has emerged as a pressing issue in urban planning and cultural heritage governance. The Gongpyeong area, a mixed residential-commercial center during the Joseon Dynasty, epitomizes such challenges. Since the 2000s, large-scale urban redevelopment has led to the excavation of multiple relics.[5] In 2015, large-scale remains of mid-Joseon residential buildings were unearthed in Blocks 1, 2, and 4 of Gongpyeong. These findings prompted a demand for full preservation. As a compromise, an underground heritage exhibition hall was created in exchange for a 200% FAR (floor area ratio) incentive for the developer. This precedent, known as the "Gongpyeong Rule," became a symbolic case for reconciling development and preservation in Seoul.[6]

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[5] In Gongpyeong Zone 1, 2, and 4, mid-Joseon period residential remains were excavated. After three rounds of cultural heritage reviews and five months of negotiations, the developer agreed to create an exhibition hall on the first basement level and donate it to the Seoul Metropolitan Government. In return, the city provided a 200% floor area ratio (FAR) incentive.

[6] The Enforcement Decree of the Building Act was revised to exclude preserved archaeological spaces from calculations of floor area and building area. Additionally, the Enforcement Decree of the Cultural Heritage Protection and Excavation Act expanded public support for small-scale excavations. Furthermore, through the *Historic Downtown Master Plan*, the Seoul Metropolitan Government

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This initiative extended beyond conservation, introducing a new model wherein public exhibitions were linked with heritage donation. Legislative and institutional reforms followed, including amendments to the Building Act and the Act on the Protection and Investigation of Buried Cultural Properties. These changes institutionalized the conservation of archaeological relics within urban architectural planning. This study focuses on the restoration and exhibition processes at Gongpyeong 1·2·4 (2017) and 15·16 (2024), aiming to reconstruct timber-framed structures from mid-Joseon urban dwellings and convert them into an accessible exhibition space.

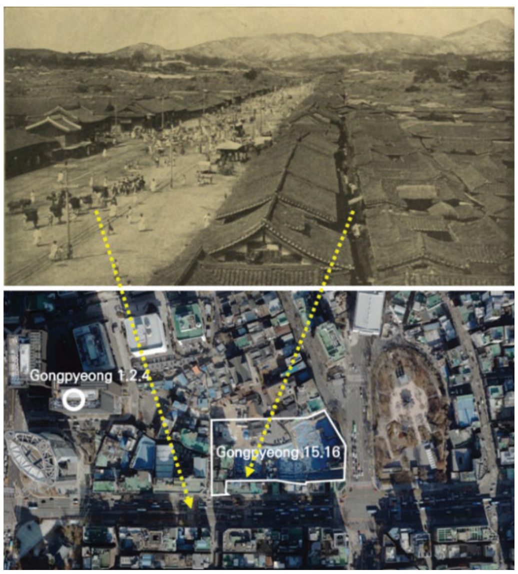

Figure 1 The Gongpyeong site and archival images.

Traditional East Asian timber architecture, particularly Korean examples, relies on column-beam framing systems. Foundation stones and platforms are critical indicators for reconstructing architectural layouts and structural systems. Additionally, remnants of ondol heating, wooden floors, and kitchen installations allow partial interpretation of spatial usage. This study investigates twelve timber-structured houses excavated from the Gongpyeong districts, with restoration centered on mid-Joseon period layers, which were distinguishable due to a large-scale fire during the late 16th century and subsequent reconstruction. The study proposes a methodology for restoration and various strategies for their exhibition.

2 – PRINCIPLES AND CRITERIA OF RESTORATION DESIGN

2.1 Principles of Restoration Design

The Gongpyeong relics were mostly composed of foundation elements such as column bases, platform stones, and paving stones, many of which were incomplete. Complications included later intrusions into stratigraphy, making it difficult to determine precise boundaries or original building placements. Thus, the restoration process had to rely on estimation and controlled imagination while minimizing subjectivity through the adoption of four guiding principles.

Figure 2. Excavation plan of Gongpyeong 15 16 area.

First, the restoration followed the archaeological reports as primary sources, including those published in 2017, 2023, and 2024. Interpretations of foundations, presumed plans, and other data were derived from these. Revisions were made when discrepancies or new insights emerged through consultation with archaeologists.

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encouraged the exhibition use of preserved relics and explicitly stated the possibility of providing incentives when such sites are donated to the city.

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Figure 3. Archaeological Condition of Structure A-12.

Second, comparative data from other mid-Joseon urban excavation sites in Seoul—such as the Cheongjin District and Gun'gisi relics—were referenced. These provided typologies including L-, U-, and courtyard-shaped layouts with combinations of ondol, wooden floors, and kitchen areas. [7] Third, structural diversity was encouraged. Based on previous planning, building groups were categorized into upper-class, middle-class, and lower-class residences, and different timber frameworks were applied accordingly. Fourth, indirect sources such as historical records, surviving buildings, pictorial maps, and early 20th-century glass-plate photographs were analyzed. Legal codes like the Gyeongguk Daejeon and Joseon Wangjo Sillok informed dimensional guidelines, while extant examples like Imcheonggak, Maengssi Haengdan, and Dosan Seodang contributed to structural interpretation.

2.2 Standard Structural Criteria

Unified structural criteria were established for column dimensions, beam types, and rafter spacing based on surviving remains and early Joseon construction customs. Square timber columns were adopted, with three thickness categories (6, 6.5, 7 chi), adjusted according to span and placement.

Figure 4. Photo of Gunja-jeong Pavilion of Imcheonggak.

Column heights were set based on a 1478 Joseon royal edict that restricted pillar lengths by social status: 11 chi for high officials, 10 chi for middle class, and 8 chi for lower-status buildings. Buildings with attached eaves (toe-kan) followed asymmetric framing where necessary, reflecting precedents such as Dongnakdang and Imcheonggak.

Three primary roof framing styles—3-beam, 5-beam, and semi-5-beam types—were used depending on the building hierarchy. Purlins followed both traditional matched and staggered styles. Beam proportions were set at a width-to-height ratio of $1{:}\sqrt{2}$. Rafters varied according to the framing system and were spaced at 1 ja intervals. Eave depth was calculated based on stone foundation edges, or 3.5 ja where no evidence existed.

Roof types included tiled (waga) and thatched (choga), determined by post spacing, foundation quality, and building function. Hip-and-gable roofs were excluded from corner buildings to maintain historical consistency. Instead, gabled roofs using matched or staggered purlins were uniformly applied.

Figure 5. Current Status of Excavated Urban Infrastructure.

Additionally, the relationship between the drainage system and building plans was reconstructed. The spatial configuration was designed to align entrances, walls, and bridges with extant watercourses, based on excavation data and early photographs.[8]

3 – PHASES OF RESTORATION DESIGN

The restoration design of each building site was conducted in six main phases: delineating site boundaries, determining floor plans, planning sections, defining the roof structure and connections, establishing the original ground level, and specifying interior floor types and fenestration. These phases do not imply a strictly

[7] Bae, C., Jeon, B., and Heo, Y. "Plan Types of Joseon Mid-to-Late Period Buildings Found in Excavations around Jongno, Seoul." *Journal of the Architectural Institute of Korea*, vol. 34, no. 5, May 2018, pp. 31–40.

[8] Jangseogak Archives. Saseoin Gaokdo-hyeong, Yi Im Piwa-ga Plan, Gunso Gaok Yeonjeopdo-hyeong. Doseodang Gyehoe-do (Late 16th Century). Seonmyo Joje Jae-gyeong Suyeon-do (1655). Hongik University Museum Collection. Samgong Burhwando (1801). Gyeonggi Gamyeong-do (Early 19th Century). Glass plate photographs (ca. 1900–1910), National Museum of Korea and Seoul National University Museum Collections.

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sequential workflow; in practice, many steps were iterative, overlapping, or subject to revision. For instance, in the northern sector of the site, which included unexcavated zones, the lot boundaries were finalized only at the last stage, and the placement of main entrances was likewise determined post factor. In the fourth phase, related to roof forms at angular connections, initial plans included a variety of roof types—hip-and-gable (paljak), pyramidal (ujingak), and gable (matbae). Following expert consultation, these were unified as gable roofs to better express the architectural characteristics of the mid-Joseon period.

3.1 Determining Site Boundaries

The first step involved defining the overall lot boundaries for each residential unit, based on the remains of perimeter walls and their spatial relationship to surrounding building foundations. Where such remains were unclear, boundaries were extrapolated using extensions of existing walls and historic cadastral maps from 1912.

Figure 6. Estimated Floor Plan Based on Excavated Remains.

In Area (A) of Districts 15 and 16, both wall remains and traces of historic pathways were clearly distinguishable and matched well with the cadastral records, facilitating straightforward demarcation. However, in Area (B), discrepancies between excavation results and historical maps necessitated comparative analysis of stratigraphic phases to determine periods of alignment. For earlier layers with insufficient data, drainage channels were used as alternative reference features. In cases of missing data due to unexcavated zones, three hypothetical reconstructions were proposed.

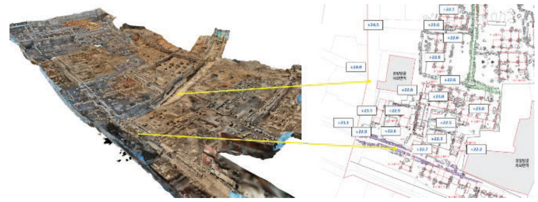

Figure 7. Topographic level data acquired through 3D scanning.

Furthermore, the terrain levels were carefully inferred using 3D scanning data from the excavation. In Area (B), for instance, the drainage channel bottom was measured at +21.7m, the courtyard at +22.3m, and two tiers of raised foundations at +22.5m and +23.0m respectively. Across the entire site, an elevation differential of more than 2 meters was observed between lower and upper building clusters.

3.2 Determining Floor Plans

The second step focused on deducing column positions based on surviving foundation stones and rubble cores. Grid lines were drawn through the centers of these remains, and missing columns were interpolated based on traditional timber frame logic.[9] Key to this process was identifying the historical unit of measurement (yongcheok) employed.

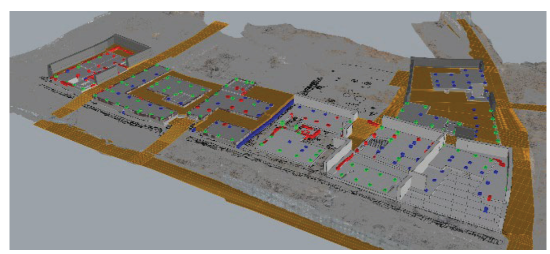

Figure 8. 3D Modeling of Foundation Stones and Site Formation.

Through CAD-based measurement and analysis following established methodologies, two primary units were found: 304mm for Area (A) and 310mm for Area (B).[10] In Districts 1, 2, and 4, both 301mm and 309mm were used, implying multiple construction periods or craftsmen. These findings informed not only column spacing but all subsequent dimensional decisions.

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[9] In the 3D modeling phase, the remains were classified using different colors based on their state of preservation: red was used for areas where the original archaeological remains were excavated; blue indicated parts where only foundation stones or rubble were identified; and green marked areas that were not preserved but could be reasonably reconstructed based on archaeological evidence.

[10] Park, D. (2007). Estimation of Ancient Korean Buddhist Temple Construction Units Before the 7th Century. Master's Thesis, Seoul National University.

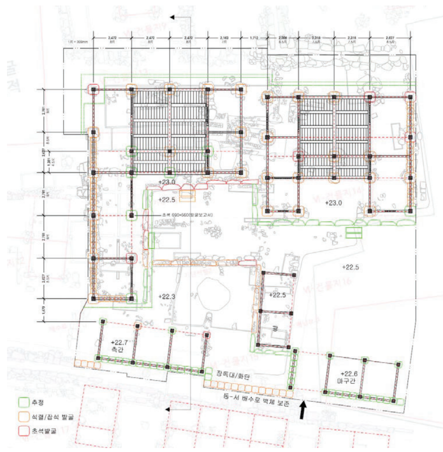

Figure 9 Reconstructed Floor Plan (Building Site B).

Well-preserved column bases allowed accurate reconstructions of bay widths and interior modules, revealing, for example, that core halls had wider spans than subsidiary wings. Where linear stone formations were found without clear column correlations, they were interpreted as wall footings or boundary fences depending on their spatial context.

3.3 Section Planning

This phase involved estimating building heights and roof scales, requiring more interpretive latitude than floor plans.

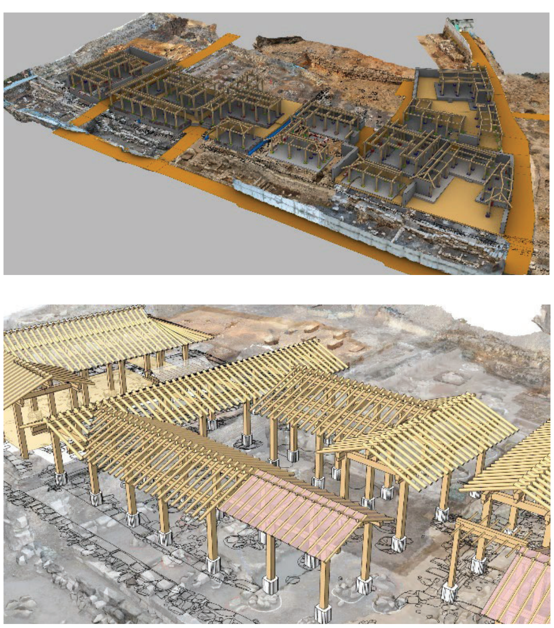

Figure 10. 3D Model of Structural Restoration.

A key principle was proportional scaling between the front-to-back width of structures and their overall height. Column heights for main buildings referenced the 1478 court regulations on house height by social status: 11 cheok (3,399mm) for nobility and high officials, 10 cheok (3,090mm) for mid-level housing, and 8 cheok (2,408mm) for lower-status or auxiliary structures.

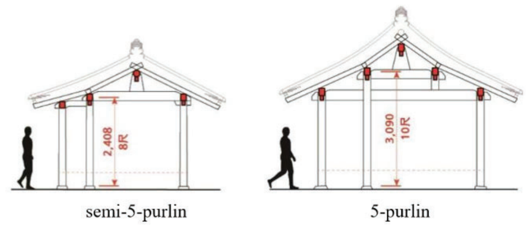

Figure 11. Column heights and roof types applied to the major reconstructed buildings.

Roof ridge heights and pitch angles were determined based on the number of purlins and spacing of columns. As a result, buildings were reconstructed as 3-purlin, semi-5-purlin, or full 5-purlin types, depending on structure and scale.

3.4 Roof Joints at Angles

ere building wings joined at right angles, roof types were carefully considered. These intersections depend on the relative sizes and orientations of the adjoining roofs, and how the purlins align. Surviving examples reveal a wide variety of configurations based on region, era, and function.

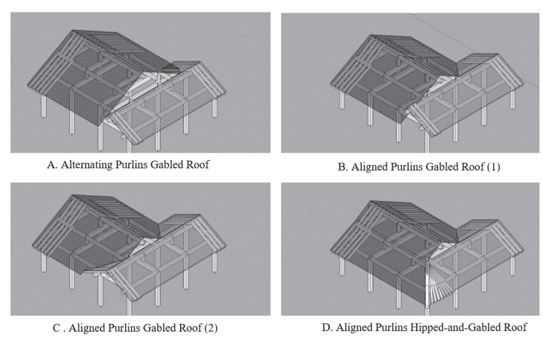

Figure 12. Typological classification of four corner structures and associated roof forms.

This study reviewed early Joseon roof typologies and concluded that unified gable roofs without projecting hips (chuneo) offered the most consistent reflection of mid-Joseon construction norms. The intersections used both matching and alternating purlins, referencing historical precedents like the Yoon Du-seo house in Haenam and the Hyangdan residence in Gyeongju.

3.5 Establishing Living Floor Levels

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This step involved estimating the level of inhabited floors relative to the excavation surface. Determining the level of courtyards, floors, and thresholds allowed further articulation of elevation differences, eaves heights, and street relationships.

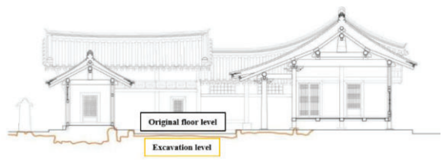

Figure 13 Example of Excavation Surface and Living Surface.

Where flagstone paving, retaining stones, or covered drains remained intact, these were used as benchmarks. In Area (A), Buildings 17 and 18 showed a difference of over 1.5 meters between the lowest and highest points, suggesting a split-level courtyard.

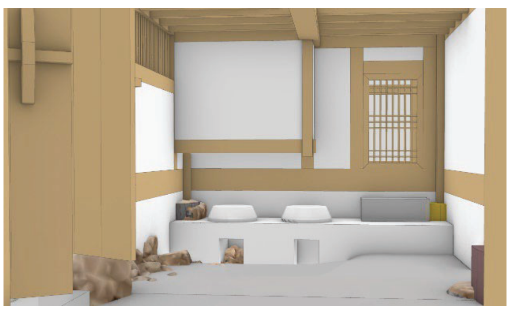

Figure 14. Reconstructed View of the Kitchen Space.

The absence of paving on the upper level led to the use of foundation top surfaces as floor reference. The main hall's floor was elevated 600mm above this to accommodate the wooden sill and frame. Kitchens were accessed by descending steps to allow stoking from below.

3.6 Finishing Materials and Fenestration

This phase finalized floor surface types (ondol, wood, or earth), interior zoning, and the selection of window and door types. Only areas with clear evidence of ondol flues were reconstructed as heated rooms, reflecting the limited diffusion of ondol during the mid-Joseon period. The presence of bronze braziers further suggested transitional heating methods.

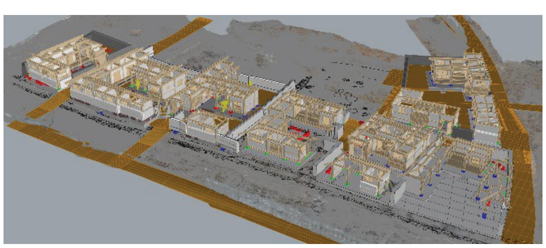

Figure 15. 3D Modeling of Elevation Reconstruction.

Charred wood residues informed the reconstruction of maru (wooden-floored) areas, while floorless peripheral bays were generally restored as earthen floors unless wooden traces were found. Functional zoning informed the placement and type of fenestration, and façade compositions were based on comparative study of surviving buildings and historical illustrations.

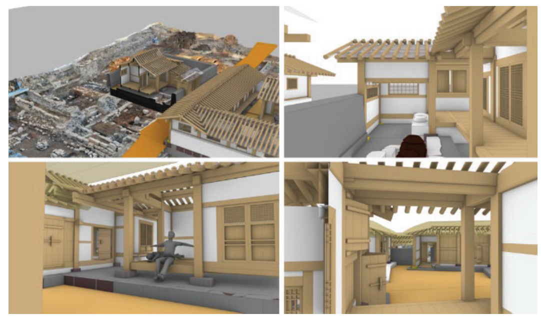

Figure 16. Examples of Reconstructed Elevation and Interior Space.

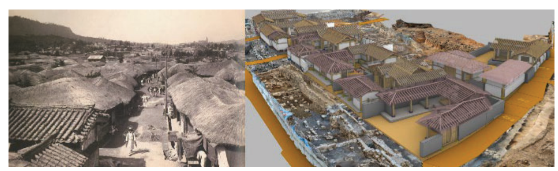

Figure 17. Classification of Roofing Types: Thatch (Choga) and Tiled Roofs (Waga).

Given the coexistence of tile and thatched roofs in the area into the 20th century, buildings with unclear or shallow foundations and narrow column spacing were interpreted as thatched. Subsidiary wings of lower hierarchical status were similarly restored with thatched roofs.

4 – EXHIBITION STRATEGY IN SUBTERRANEAN SPACE

The restoration results were developed under the constraint of subterranean display environments and were organized into three main exhibition strategies, informed by international precedent studies. First, the 1:1 full-scale reconstruction method reproduces architectural elements directly above the excavation site. This immersive format allows visitors to experience spatial dimensions and traditional timber structures firsthand. However, it poses legal and technical limitations due to the risks of interfering with buried heritage and the challenges of maintaining traditional materials like timber in indoor exhibition settings. In the exhibition hall of Zones 1·2·4, full-scale models were installed above the remains using elevated decks. In the future exhibition

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hall for Zones 15·16, only partial segments will be reconstructed, employing lightweight materials such as wireframes or acrylic. Hanging fabric printed with architectural outlines has also been considered as a non-invasive method for conveying the structure without direct contact with the ruins.

Figure 18. Exterior View of the Gongpyeong 1·2·4 Urban Archaeological Museum (2017).

Second, the digital and graphic restoration method employs projection, animation, and virtual environments to represent both architecture and its broader urban context, including streetscapes and daily life scenes. This non-material display mode avoids physical alteration of the ruins while enhancing public understanding. In this project, only 2 of the 13 restored structures are being realized physically, while the rest will be represented through digital means. The exhibition will be built into the basement of a newly constructed building, and extended restoration efforts include urban features like walls, roads, and drainage systems (amgeo), enabling the visitor to visualize the broader spatial context. All restoration content was developed through interdisciplinary consultation and institutional review.

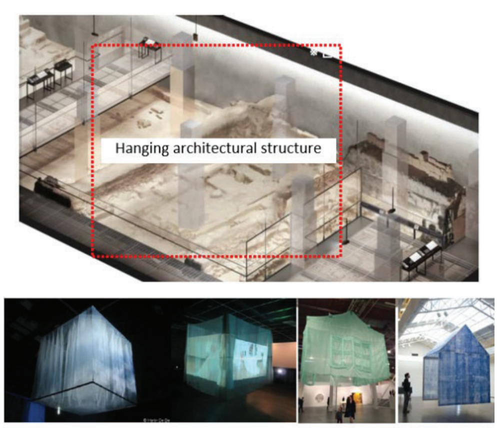

Figure 19. Proposed Restoration Plan for the 15·16 Museum (2025).

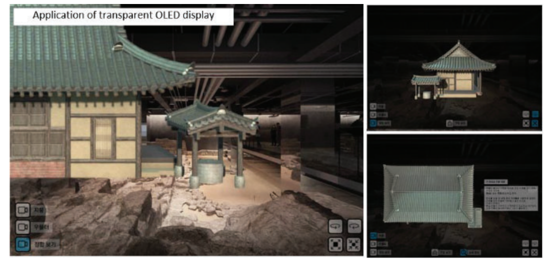

Figure 20. Case of Digital Visualization Using OLED Display Technology.

Third, scaled physical models and interpretive panels represent a conventional method, offering a clear visual overview without damaging the ruins. Particularly useful in restricted spaces, this approach enables flexible scaling and multiple levels of detail. However, the lack of immersive spatial experience necessitates complementary use of lighting, sound, and media effects to engage visitors. These three strategies—1:1 reconstruction, digital visualization, and physical modeling—each have distinct advantages and limitations. Their combination should be calibrated to the character of each relic, its preservation condition, exhibition space limitations, and the desired level of visitor engagement.

5 – CONCLUSION

This study analyzed the restoration design process and exhibition strategies for medieval timber-frame dwellings excavated from the Gongpyeong site in central Seoul, focusing on twelve reconstructed houses dated to the mid-Joseon dynasty. Special emphasis was placed on interpreting timber-framed structures using archaeological stone remnants—foundation stones (choseok), rubble cores (jeoksimseok), sill stones (gomagiseok), and paving stones (bakseok)—to reconstruct both the structural logic and architectural form. Through analysis of spatial modules (kan), standard timber dimensions (yongcheok), and historical regulations on column height, this research sought to ensure structural consistency and historical fidelity in the restoration process.

The restored houses reflect the diversity and hierarchy of 16th-century urban dwellings and are presented to the public through a combination of full-scale models, digital reconstructions, and scaled exhibits. These varied modes of display serve not only architectural documentation purposes but also represent an evolving paradigm of turning buried heritage into civic cultural assets. The project thus exemplifies a new model of balancing authenticity and accessibility in urban archaeological heritage management.

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Moreover, the restoration process involved detailed examination of structural systems, spatial organization, and material culture of the mid-Joseon period. It demonstrates that the restoration of buried wooden architecture need not rely solely on visual form, but can pursue academic rigor and interpretive richness through structure-based reasoning. The exhibition strategy—incorporating multiple media and non-invasive methods—suggests new possibilities for presenting timber architecture in dense urban contexts, especially when direct reconstruction is limited by legal and physical constraints.

This paper proposes an integrative framework for restoring and exhibiting timber-framed architecture from archaeological remains within urban environments. By doing so, it expands empirical understanding of Korea's traditional joinery architecture while also offering a practical model for interdisciplinary collaboration among urban planners, heritage managers, and exhibition designers. The project serves as a precedent that could inform future research and practice within the Wood Construction Technical Community.

Nonetheless, this study also faced clear limitations. The restoration was unavoidably dependent on inference, due to the partial and fragmentary nature of the archaeological data. The timber joinery systems, central to structural restoration, had to be hypothesized in the absence of surviving examples from the early Joseon period. Even the extant examples from the late Joseon era reveal significant regional variation and individualized craftsmanship, making a single restoration scenario one of many plausible interpretations. Furthermore, the author acknowledges the philosophical tension inherent in participating in such reconstruction efforts, particularly as a historian who has long approached heritage reconstruction with skepticism. However, the non-invasive methodologies adopted—such as using suspended structures, VR media, and scaled models—offered a path forward that preserved the authenticity of the archaeological record while still allowing public engagement and interpretive storytelling. In this regard, the project reflects a practical compromise that could serve as a model for future restorations of subterranean or sensitive heritage sites.

Moving forward, further integration of structural analysis, interpretive strategies, and urban cultural research will be necessary. In particular, empirical measurement of regional variations in timber-frame joinery, as well as continued archival investigation, will remain critical components of future collaborative research within the Wood Construction Technical Community.

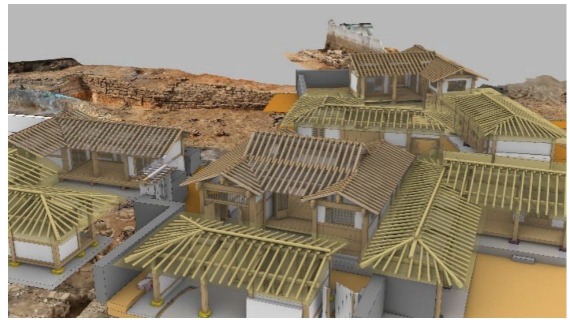

Figure 20. Restoration Overview of Excavated Remains in Gongpyeong.

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