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HBIM (Heritage Building Information Modeling) Strategy for Managing Repair of Wooden Architectural Heritage in Korea

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Abstract

Since 2021, the Korea Heritage Service and the Korea Foundation for Traditional Architecture and Technology (KOFTA) have been advancing the HBIM project to systematically manage the repair history of cultural heritage. The initiative aims to establish a scientific decision-making framework for the preservation and maintenance of architectural heritage. This paper explores the development, outcomes, and future potential of the HBIM strategy specifically in the context of managing repairs to Korea’s wooden architectural heritage. Starting this year, the Korea Heritage Service and our foundation have embarked on a research project to develop a public platform that facilitates access to repair history HBIM. This platform will enable stakeholders at repair sites to conveniently access existing HBIM data and integrate previously scattered cultural heritage repair records. Ultimately, the Korea Heritage Service and our foundation remain committed to creating a system where comprehensive repair information can be effectively managed and utilized in close coordination with on-site restoration activities via the HBIM platform.

1. Introduction

Repair is an essential process for preserving the original form of architectural heritage. When carrying out repairs on cultural heritage, it is crucial to record related information, and such records and data must be systematically managed to ensure they can later serve as valid references for future repairs.

If these records—containing extensive and valuable information—are not continuously maintained, they risk being lost over time, making it difficult to verify key details necessary for preserving the authenticity of the cultural heritage.

This is particularly critical for architectural heritage, as much of the important information is only uncovered during dismantling and repair. If proper documentation is not conducted at this stage, it may become impossible to recover or verify that information in the future.

Since 2021, the Korea Heritage Service and the Korea Foundation for Traditional Architecture and Technology (KOFTA) have been promoting the HBIM (Heritage Building Information Modeling) project to manage the repair history of cultural heritage. This initiative integrates and manages all data generated throughout the life cycle of architectural heritage using 3D models. The project aims to establish a system that supports scientific decision-making for the preservation and maintenance of architectural heritage. In its first phase, the project targets 306 wooden architectural heritage sites designated as National Treasures and Treasures.

This paper investigates the development, outcomes, and future applicability of the HBIM strategy in the context of managing repairs to Korea’s wooden architectural heritage.

2. Integrated Management of Repair Information for Architectural Heritage

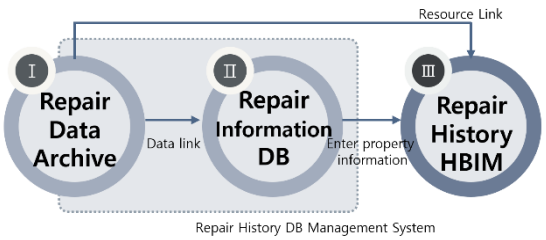

Figure 1. Integrated Management Process.

2.1 Archive of Repair Documentation

A data archive system has been established and utilized to systematically manage various types of documentation generated during the restoration of architectural heritage. In particular, valuable records that provide insight into the building's history—from its original construction to the present—have been actively identified and collected. The collected materials are organized using a standardized file-naming system, allowing users to easily understand the overall repair history of a building at a glance. Additionally, the system supports searches by individual components, specific locations, and different stages of the repair process.

Plan	• Ancient drawings, Glass Plates, Joseon Gojeok Dobo (Illustrated Record of Joseon Antiquities), Measured Drawings, Hand Drawings, 3D Scanning • Repair Design Drawings, Design Change Drawings, Measured Drawings from Dismantling Survey, Completion Drawings , etc.
Picture	• (Construction Photos) Status before Repair, Status after Dismantling, Under dismantling, Dismantled Members, During assembly, After Completion • Photos from the Japanese Occupation, Historical Documentation Photos, Various Survey Photos, Video Data
Book	• Repair and Supervision Report, Design Documents, As-built Documentation, Repair and Survey Report(Dismantled Component Survey, Tree ring and Species, Non-destructive Survey, Dancheong, etc.), Measured Survey Report, Research Report
Document	• Official Documents (Application/Approval, Initiation/Design Change/Completion Report, etc.) Technical Guidance Meeting Documents • Old records, Meeting Minutes, Papers, Articles, etc.

Figure 2. Repair Documentation.

2.2 Repair Information Database

A database is a structured collection of data that is organized and stored for shared use across various tasks.
To systematically manage information required for the repair of architectural heritage, a data structure was designed, and a database framework was applied to organize and input the information accordingly.

Heritage information is categorized into basic information, historical background, repair history (including start and completion dates, causes of repair, repair details, and design changes), management information, and research/investigation data (such as measured surveys, decorative painting documentation, periodic inspections, and safety assessments). These entries are linked with relevant archival materials within the system.

Basic	• An Overview of Cultural Heritage, Form, Size
History	• Repairs Prior to the modern era, Year of Construction, Year of Completion, Details of Repair, Related Data
Repair History	• Repairs since the modern era, Year of Construction, Year of Completion, Cause of Repair, Details of Repair, Repair Change, Related Data
Managem -ent	• Factors influencing heritage management • Management Information, Technical Environment Information, Disaster Prevention Facility Information
Research	• The Results of Various Investigations and Studies • Measured Survey, Dancheong, Regular Inspection, Safety Inspection, etc. • Tree ring, Tree species, Dismantling Survey, Non-Destructive Investigation, etc. • Maintenance design, Site improvement work, Minor repair, Alteration of the current state, etc.

Figure 3. Repair Information.

Traditional wooden architectural heritage in Korea is distinguished by a joinery-based construction system. Owing to this structural characteristic, each individual component plays a vital role in assessing the cultural significance of the heritage asset. Consequently, repair-related information has been documented at the component level.

Each component is assigned a unique identifier, and its historical attributes are systematically recorded, including material specifications, repair history, design alterations, construction techniques, date of production, physical traces, and decorative painting details. Associated photographs and drawings are also linked, enabling integrated access to both textual and visual data. Ultimately, this information functions as attribute data within the BIM environment, supporting informed conservation and management practices.

Basic	• Code Number, Year of Installation
Material	• Material type, Source information, Usage Amount
Repair History	• Year of Repair after 1900s, Details, Documentations
Change History	• Repair Year, before and after Change, Reason for Change, Related Data
Additional	• Specification, Number installed, Shape Joinery Method, Presence of origin members(Production Age), Manufacturing(Installation) Technique, Traces of Tool Use, Replaced members, Related Data
Dancheong	• Dancheong(painting on traditional Korean architecture) Classification, Types of Dancheong, Year of Repair, Related Data

Figure 4. Component Repair Information.

3. Development of HBIM for Wooden Architectural Heritage

3.1 How to Build HBIM Models

KOFTA has established detailed standards for 3D modeling of Korean wooden architectural heritage, based on the "Historic BIM Guidelines" issued by the Korea Heritage Service. These standards comprehensively reflect the diverse forms and construction techniques unique to each building.

A standardized drawing, functionally equivalent to a proposed plan, is generated by eliminating structural displacements from the measured as-is drawingsthat document the current condition. Based on this refined drawing, a 3D BIM modelis constructed. The modeling process fundamentally mirrors the assembly logic of traditional timber structures, wherein each component is modeled in accordance with its actual dimensions and shape, and assembled as if replicating traditional joinery techniques. The elements are arranged with precise alignment to kan (bay width), vertical height, and the central axis. After the initial assembly, joinery components are fine-tunedusing a combination of repair documentation, photographic records, and current site conditions, in order to minimize intersections and inconsistenciesbetween structural elements.

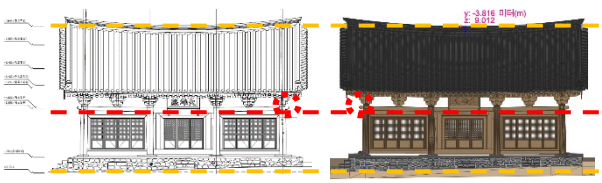

Figure 5. Standardardized Drawing.

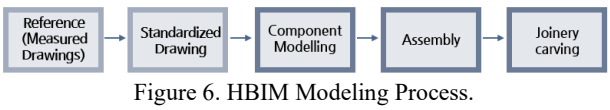

Figure 6. HBIM Modeling Process.

All identifiable structural elements were modeled based on the principle of a one-to-one correspondence between each part and its digital object. Where appropriate, elements that could be managed collectively were organized into composite objects. A unique identifier was assigned to each element to enable individual-level historical record management. The geometry of each component was modeled to accurately reflect the

architectural style, principal construction techniques, and detailed characteristics—such as joinery forms and installation methods—ensuring that the model faithfully represents the building’s overall features.

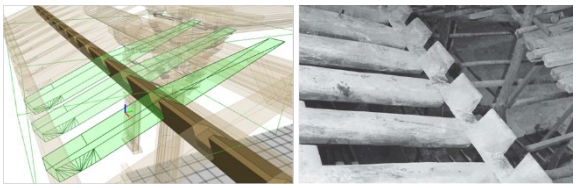

Figure 7. Example of Joinery Carving.

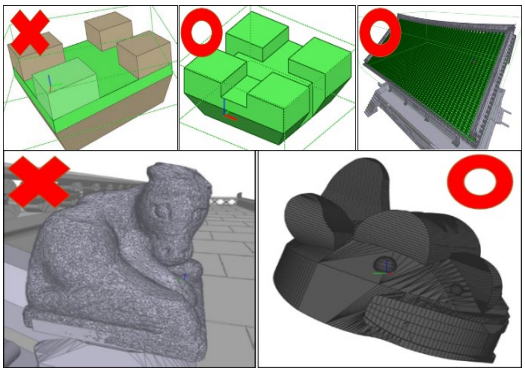

Figure 8. Standard for Component Object Definition.

In cases where detailed representation was difficult—such as with elaborate carvings or decorations, composite materials behind plastered walls, foundation fill, backfill behind the stylobate, or filler materials beneath kiwha (roof tiles)—these elements were simplified in the model. Instead, drawings and photographs were linked to allow users to check the details externally.

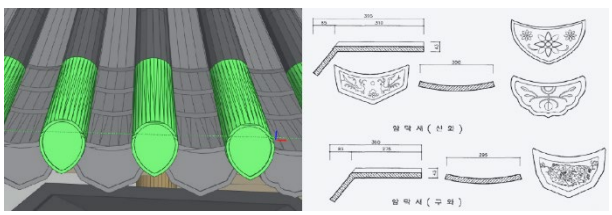

Figure 9. Example of Linked Attachment for Roof Tiles.

Figure 10. Example of Linked Attachment for Dancheong.

Due to limitations in mapping and data volume, elements such as dancheong (decorative painting)and mukseo (ink inscriptions)were excluded from the model itself. Instead, related photographs and drawings were provided as linked information.

In cases where dismantling was not carried out or no records existed and the internal structure or components could not be verified, the model was created with a reduced LOD (Level of Development) or based on comparable case studies. In such instances, it was clearly noted that the content was an assumption, enabling additional verification during future dismantling and repair.

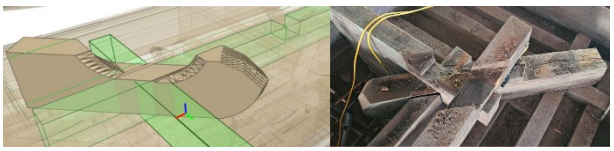

Figure 11. Expressions for Areas Not Accessible for Inspection.

3.2 Visual Intuition in HBIM Representation

Since most traditional wooden architectural heritage structures are assembled using timber joinery, 3D modeling enables disassembly and reassembly simulations by each individual element. This addresses the limitations of 2D drawings and allows better spatial understanding of complex buildings, such as multi-story or irregular-plan structures, which are difficult to grasp from drawings or on-site observations alone. Interior components like roof structures, foundations, and backfill—typically hidden from view—can also be examined through related data in the model. Furthermore, HBIM enables the identification of past construction records for buildings where elements have been removed or structural changes have occurred, making current observation difficult.

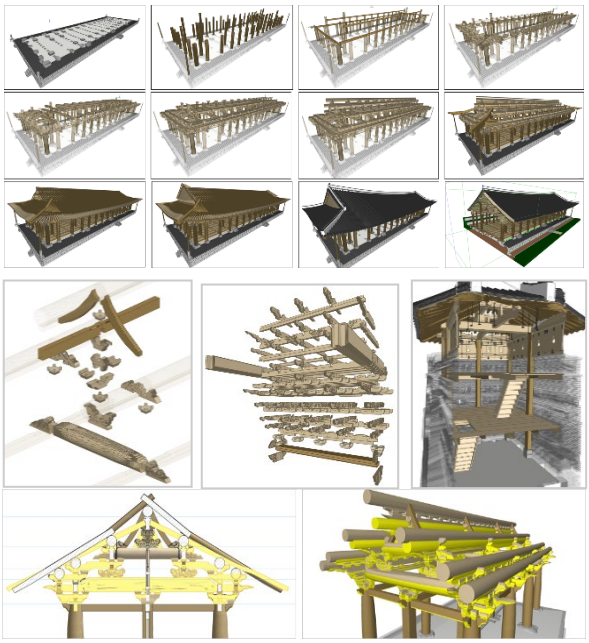

Figure 12. Visual Intuition in HBIM Representation.

3.3 HBIM Development for Repair History Management

Geometric information and component objects are managed within a 3D model, while a history management system is developed based on attributes such as repair records, construction techniques, and materials. Furthermore, by embedding links to key documentation—including photographs and drawings—a comprehensive documentation management system is established, enabling integrated access to all relevant data through a unified HBIM model.

To manage the repair history of architectural heritage components, each object is assigned a unique identification code. Based on criteria such as component location, function, and geometry, elements are classified into a four-tier hierarchy: major category, intermediate category, minor category, and subcategory. Each component is then assigned a seven-digit code accordingly.

In this code, the first digit represents the building number, the second indicates the floor level, the middle three digits specify the location, and the final two digits denote the object management type (e.g., single component, joint component, or grouped component). This coding system is available in both Korean and English versions.

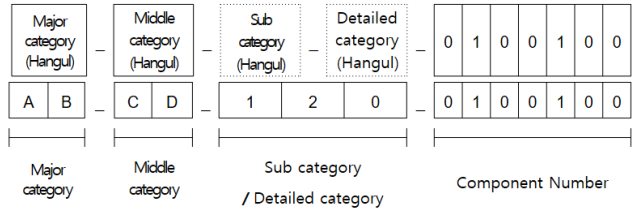

Figure 13. Criteria for Assigning Component Object Names and Code Numbers.

Property data related to repair history are assigned to each individually coded component object of the architectural heritage, based on the repair history database. The BIM model facilitates systematic management of fundamental data necessary for the maintenance and preservation of architectural heritage, organized by component object.
Repair history attribute data are managed using an Excel-based table structure, which allows continuous data entry through the expansion of rows and columns according to component codes. In particular, when additional repairs are performed or multiple records exist for a specific year or component, new rows are added to accommodate the expanded information, enabling comprehensive tracking of each component’s repair history.

Figure 14. Example of Attribute Information Output.

To complement the geometric data of the model and the textual repair history, the HBIM incorporates linked archival materials—such as photographs, drawings, and documents—categorized by component, time period, and construction phase. For components that are technically challenging to represent within the HBIM, corresponding photographs and drawings are attached, and these limitations are documented within the attribute information.

As a supplement to the repair history attribute data, the HBIM system integrates additional documentation detailing damage conditions for each component, outcomes of repair activities such as replacement and reinforcement, and modifications in form, technique, materials, or structure. These records enable comprehensive tracking and validation of interventions throughout the entire repair process—before, during, and after execution.

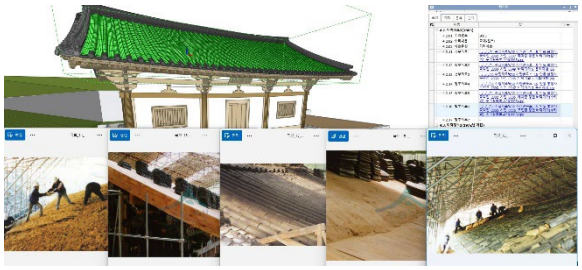

Figure 15. Resources Attached to the HBIM Model.

3.4 HBIM Modeling Tools and Standard Formats for Information Discloser

The software used for creating HBIM to manage the repair history of architectural heritage must meet the following criteria:

- It must be capable of exporting data in an open standard format for information exchange (IFC).
- It must support Korean language for component object names(code names), layer classifications by element, and attribute information.
- The object list should be organized by layer, sorted by component object names (in Korean), and structured to activate according to element classifications.
- It should allow for extensibility and easy modification of attribute information.
- It should support curved and non-standard forms (NURBS and polygon modeling approaches should be considered).
- The data should be optimized with comprehensive consideration of HBIM data quality and usability.

Programs such as Revit, Archicad, CATIA, and Rhino have been used for developing HBIM. Among these, Rhino's curved modeling capabilities and Archicad are generally preferred, as they tend to better fulfill the functional requirements mentioned above.

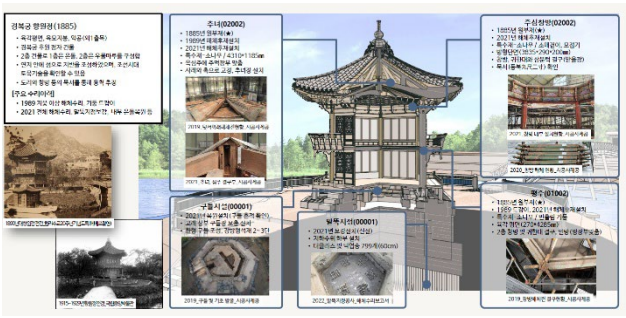

Figure 16. Repair History Data Accessible via HBIM System.

HBIM is ultimately delivered in the standard IFC format. A quality management process is implemented to minimize errors that may occur during the conversion from native model files to the IFC format.

- It is verified whether component objects are classified as individual or grouped objects with assigned code names, and whether sorting and activation by element layer are properly supported.
- After conversion, potential errors are examined in the following aspects: geometric information (e.g., missing objects, incorrect

component object selection, broken surfaces, and element color rendering), attribute information (e.g., Korean language support, input order consistency, and data accuracy), and attached resources (e.g., hyperlink errors).
- The data are optimized through file size reduction to enhance usability and practical applicability

4. Conclusion

4.1 Ongoing Achievements of HBIM Development

As of June 2025, a total of 273 wooden architectural heritage sites have been designated as National Treasures or Treasures in Korea, encompassing 306 individual buildings. Among them, the repair history data for 116 sites has either been completed or is scheduled for completion.
For completed 103 buildings, approximately 330,000 repair-related records have been collected, averaging around 3,500 records per building. As a result of assigning component codes to the building elements, the repair history of approximately 3,000 components per building has been systematically organized.

unit : place quantity

Division	Year	Complete/ Plan	Accumulation	Note
1	2021	30	30	Complete
2	2022	24	54	
3	2023	23	77	
4	2024	26	103	
5	2025	13	116	In progress
6	2026	8	124	Schedule
7	2027	14	138	
8	2028	14	152	
9	2029	14	168	
10	2030	14	182	

Table 1. Current Status of HBIM Project for Wooden Architectural Heritage.

When the repair history is constructed solely based on information remaining from the past, there are limitations in verifying the data, making it difficult to accurately understand the repair details and characteristics of the building. In such cases, a question mark is entered in the relevant fields to indicate uncertainty, and the item is organized so that it can be investigated during future dismantling and restoration work.
For cultural heritage sites currently undergoing or scheduled for dismantling and repair, new information is generated that supplements the past repair history. These sites are classified as subjects for verifying previously unknown internal details through dismantling. During the dismantling and repair process, it is possible to confirm both historical and typological information, which underscores the necessity of constructing a repair history database and HBIM system.

Cultural heritage requires ongoing maintenance as needed. Repair history information is not limited to the past but is continuously produced in the present and future, necessitating ongoing management. Therefore, maintenance work that manages newly produced repair history information must be conducted concurrently.
Even for targets where HBIM construction has been completed by the foundation, monitoring is carried out for cultural heritage undergoing new repairs, and new materials and information are regularly updated.

For sites planned for repair, past repair information is provided for reference, and close cooperation with repair sites is maintained to enable the input of newly generated information into the HBIM system. When the client directly constructs the HBIM during dismantling and repair, the foundation provides construction standards and manuals and cooperates to transfer the resulting data for integrated information management.

4.2 Case Study on Maintenance of HBIM

A representative example of repair history maintenance is the Jinnamgwan Hall in Yeosu. The HBIM for this site was initially developed in 2021 as part of this project; however, it did not include information from the dismantling and repair works conducted since 2017. Subsequently, the foundation selected Jinnamgwan for maintenance, and with the cooperation of Yeosu City, various data were collected and entered into the archive. On-site investigations were carried out by construction phases to document the techniques and outcomes for each component, and this new information was updated in the existing HBIM model. After completion, additional related materials and repair reports were collected for a second update to enhance data accuracy and accumulate information for integrated management.
The maintenance of Jinnamgwan yielded significant results, such as precise identification of internal component shapes, joinery methods, and quantities that could not be confirmed through non-destructive surveys. Furthermore, changes in the condition were systematically recorded and incorporated into the repair history.

The Nogangseowon Lecture Hall in Nonsan is another example where the local government independently created a BIM model during dismantling and repair works. After completion, various repair data, results, and the BIM model were transferred to the foundation, which plans to integrate the repair history information into the BIM for ongoing maintenance. This case demonstrates that creating the repair history and BIM simultaneously at the repair site can yield more accurate results. Moreover, the organic cooperation between data producers and managers establishes a good precedent for integrating high-quality repair histories of cultural heritage and building a sustainable management system.

According to the “Guidelines on National Heritage Repair Works,” documenting the characteristics and outcomes of dismantled and replaced components at repair sites has become mandatory. By linking such information, it is expected that the repair history construction and management system for cultural heritage will be continuously maintained.

4.3 Utilization Strategies for Repair History HBIM

Beginning this year, the Korea Heritage Service and our foundation have been conducting a research project aimed at establishing a public platform that enables the use of repair history HBIM. This platform will allow stakeholders at repair sites to easily access existing HBIM data and view previously dispersed cultural heritage repair records in an integrated manner. It will also support scientifically informed decision-making by enabling multifaceted access to objective data, ultimately contributing to the preservation of the original state of heritage assets and the securing of appropriate construction timelines.
However, for those involved in restoration to effectively utilize advanced HBIM technologies, there is a growing need for expert

training programs and the development of operational manuals related to its application and maintenance.
In addition, customized utilization strategies will be developed not only for restoration professionals, but also for researchers and the general public.

Ultimately, the Korea Heritage Service and our foundation will continue to work toward a system in which integrated repair information can be managed and utilized in close connection with on-site restoration through the HBIM platform.

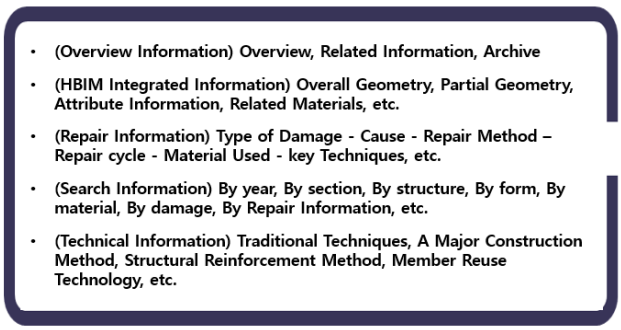

Figure 17. Information for the Public Disclosure and Search.

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