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A Rule-driven Modeling Method for Chinese Timber Beam-frame Structures Using Historical Building Information Modeling and Industry Foundation Classes Framework

Pingbo Hu, Xueru Wang, and Jie Jiang*

School of Geomatics and Urban Spatial Informatics, Beijing University of Civil Engineering and Architecture,
No. 15, Yongyuan Road, Huangcun Town, Daxing District, Beijing 102616, China

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The digital representation of Chinese timber beam-frame structures (CTBFS) is critical for heritage conservation and information sharing. However, existing historical building information modeling (HBIM) approaches provide limited support for encoding the rule-based proportions and construction logic embedded in CTBFS, while current industry foundation classes (IFC)-based methods cannot explicitly represent the component semantics and construction relationships inherent to CTBFS. Unlike conventional approaches that primarily focus on geometric parametrization, in this research, we introduce an integrated HBIM-IFC framework designed to capture both the formal rules and assembly logic governing CTBFS. The methodology formalizes traditional construction knowledge into a standardized digital structure, ensuring semantic consistency and interoperability across platforms. It first establishes a component-family-oriented HBIM approach, where beam-frame elements are defined as parametric families governed by historical manuals with embedded relationship logic. Subsequently, this HBIM foundation is translated into an IFC extension strategy using property sets and relationship entities, representing timber-specific semantics without compromising the core IFC schema. Experiments on two CTBFS typologies validate that the proposed framework enables an integrated and interpretable representation of geometry, formal rules, construction logic, and component relationships while maintaining interoperability, thereby supporting sensor-driven documentation workflows and the standardized digital exchange of timber architectural heritage.

1. Introduction

Architectural heritage constitutes a vital carrier of human civilization, embodying not only historical and cultural values but also sophisticated construction knowledge accumulated over long periods of practice.(1) Among various architectural systems, Chinese timber beam-frame structures (CTBFS) represent a highly developed construction tradition characterized by rule-based proportions, standardized component typologies, and complex construction logic. These

*Corresponding author: e-mail: jiangjie@bucea.edu.cn
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structures rely on coordinated relationships among beams, columns, and connecting members to form stable spatial systems, making their accurate digital representation essential for heritage conservation, documentation, and information sharing.

Historical building information modeling (HBIM) has emerged as an important digital technology for the documentation and management of heritage buildings.[2] By extending building information modeling concepts to historical contexts, HBIM enables the integration of geometric representation with semantic, material, and historical information. Those research works have demonstrated significant potential in parametric modeling, data management, condition assessment, and interdisciplinary collaboration for heritage applications. A fundamental stage for HBIM is to create object models.

Currently, the automated scan-to-BIM workflow is the dominant approach, utilizing deep learning algorithms, Grasshopper plugins, and other technologies to perform the automated or semi-automated modeling of point cloud data.[3–5] This process can automatically identify and segment the basic components of brick and stone buildings, such as doors, windows, and walls.[6–8] The recent sensing technologies such as terrestrial laser scanning (TLS), photogrammetry, and depth sensors have become fundamental tools for the documentation of architectural heritage. These sensing systems enable the acquisition of high-resolution three-dimensional point clouds that capture the geometric characteristics and material conditions of historical structures. Integrating such sensor-derived datasets into HBIM environments is therefore essential for the accurate digital representation, structural interpretation, and long-term monitoring of heritage buildings. Additionally, some scholars have explored localized timber components, including roof trusses, floors, and staircases.[9–11] However, most HBIM approaches for CTBFS are developed on the basis of modern construction logic and emphasize geometry-oriented modeling, which limits their applicability to Chinese timber beam-frame systems. The rule-based proportions and construction logic embedded in traditional timber architecture must also be encoded within digital models to enable the meaningful interpretation of the sensor-acquired data. The geometry of beam-frame components is not arbitrarily defined but governed by formal proportional rules derived from historical construction manuals. These rules determine component dimensions, spatial organization, and interdependencies among structural elements. Current HBIM-based approaches generally model beams, columns, and related components as isolated parametric objects, lacking generic component family and relationship design methods capable of encoding such rule-based proportions and construction logic. As a result, the underlying construction principles of CTBFS are often implicit, difficult to interpret, and not reusable across different modeling scenarios.

The Industry Foundation Classes (IFC) standard provides an open and widely adopted framework for information exchange in building information modeling and plays a critical role in ensuring interoperability and long-term data preservation.[12,13] By adopting the IFC data standard, interoperability among HBIM platforms such as Revit, ArchiCAD, and FreeCAD can be achieved, thereby minimizing information loss and ensuring consistency across systems. To date, more than 20 application software vendors support the IFC standard, enabling automated data exchange among their products.[14] However, despite its complexity, the IFC standard currently supports only a limited number of use cases in the architecture, engineering, construction, and facility management (AEC/FM) industry,[15] and further development is required to accommodate a broader range of application scenarios. Wang *et al.* proposed a method for constructing a specification semantic model for BIM-based intelligent fire protection review.[16] This method builds a knowledge ontology based on the IFC standard and uses it as the structured object for the provisions. By establishing logical expressions, a specification semantic model is created to achieve the rapid structured expression of fire protection codes. The current IFC schema is primarily oriented toward modern construction systems and does not directly support the explicit representation of CTBFS-specific component semantics and construction relationships. Key aspects such as beam-frame component classifications, timber-specific semantic attributes, and construction relationships reflecting beam-column interactions are insufficiently defined. Directly extending IFC through new entities may compromise standard compatibility, while existing methods often fail to achieve an explicit and interpretable representation of construction logic.

To address these challenges, in this study, we propose an integrated HBIM and IFC-based representation framework for CTFBS. The core objective is to explicitly model the rule-based proportions and construction logic of CTBFS within HBIM and to enable their standardized expression in IFC without modifying the core schema. A rule-driven, component-family-oriented HBIM design method is developed to embed formal construction rules into parametric component families and to define construction logic through explicit relationship modeling. Building upon this HBIM representation, an IFC extension strategy based on property sets and relationship entities is established to explicitly express CTBFS-specific semantics and construction relationships while maintaining interoperability. The remainder of this paper is organized as follows. In Sect. 2, we present the proposed methodological framework; in Sect. 3, we report the results; in Sect. 4, we discuss the findings; and in Sect. 5, we conclude the study.

2. Methods

The proposed methodological framework for the representation of Chinese timber beams, as shown in Fig. 1, encompasses two crucial components, namely, the rule-driven HBIM design for CTBFS and the IFC-based semantic and relational extension framework. The proposed approach begins with the construction of parametric HBIM component families for beams, columns, and connecting members, each containing the geometry, semantics, and relationships. Building upon the HBIM model, an IFC extension strategy is applied to represent CTBFS-specific semantics and relationships while preserving interoperability with standard IFC-compliant platforms.

2.1 Rule-driven HBIM design for CTBFS

The rule-driven HBIM design aims to explicitly embed the rule-based proportions and construction logic of CTBFS into a parametric modeling framework. Traditional Chinese buildings are not assembled from arbitrary components; instead, their geometry is derived from codified proportional systems documented in canonical manuals such as "Yingzao Fashi"[17] and "Gongcheng Zuofa Zeli".[18] These texts prescribe standard dimensions, cross-sectional

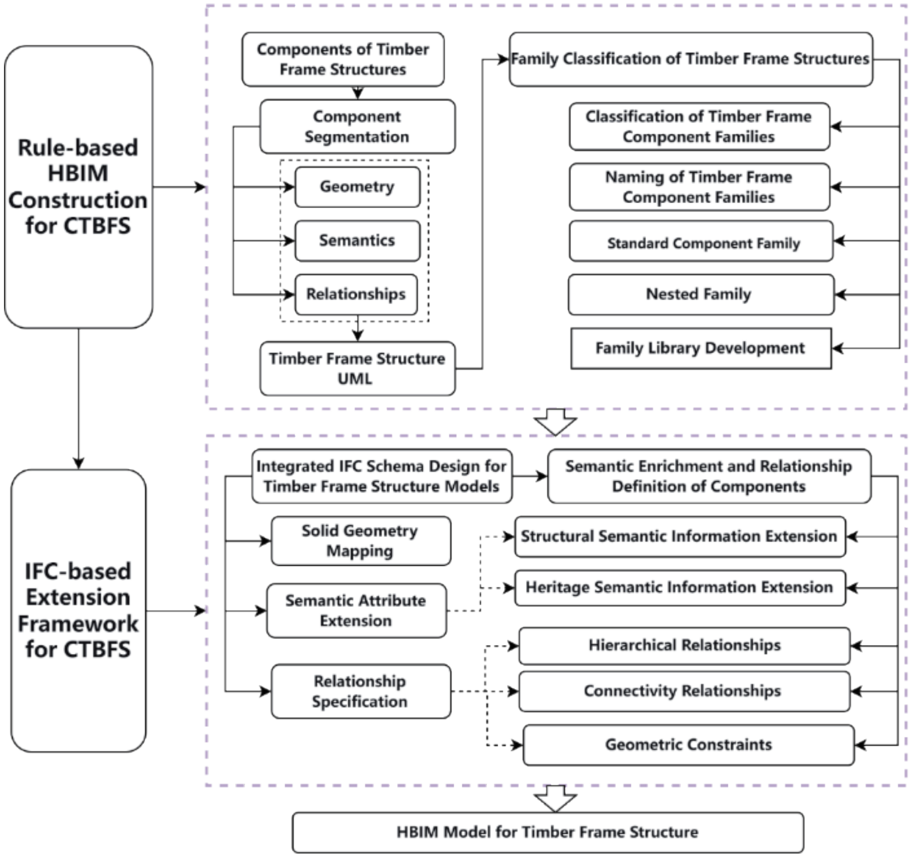


Fig. 1. Overview of proposed method.

proportions, and hierarchical relationships among members including beams, columns, purlins, and brackets. Therefore, a general, hierarchical-tree based representation was introduced for Chinese timber buildings, as shown in Fig. 2. To accurately capture this structural logic, the rules governing CTBFS are manually extracted from historical construction manuals. These proportional rules are then incorporated into a template library to ensure geometric consistency among components. Each structural member is modeled as a reusable parametric family governed by rule-based constraints, rather than being created through manual geometric drafting.

Figure 2 illustrates that CTBFS can be decomposed into a finite set of parametric component families, including primary load-bearing members (e.g., columns and beams), secondary components (e.g., Fang), and auxiliary joinery or connecting elements. These components are arranged in hierarchical tiers, where upper-level geometry is propagated and constrained by the dimensions and configuration of lower-level structural units. Within each family, parameters encode rule-based proportions derived from classical manuals, such as bay span, timber grade, and roof pitch, while allowable ranges and adaptation conditions ensure historical consistency and structural plausibility.

A hierarchical model organization is adopted to capture the dependency relations among components. Changes to a governing parameter, such as bay width, automatically scale related

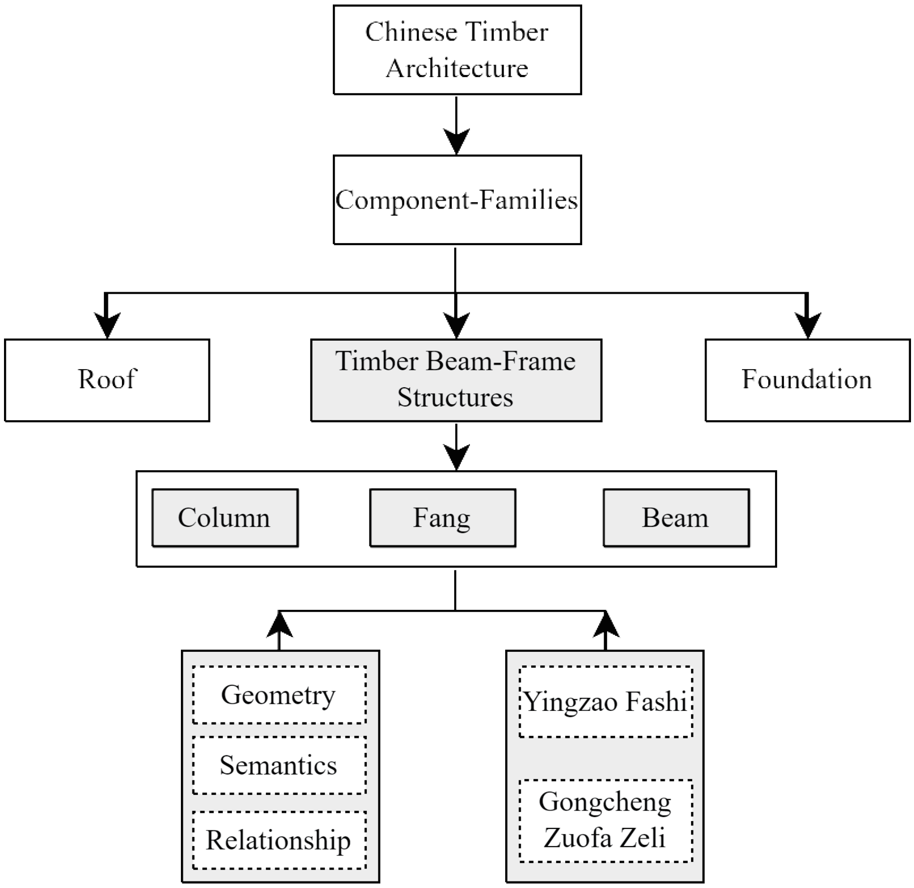


Fig. 2. Hierarchy-tree representation of CTBFS.

members while preserving proportional integrity. Construction logic, which refers to the modeling rules governing the assembly and spatial dependencies among components, is further formalized by embedding adjacency and connection rules: beams must be seated on column tops at prescribed elevations; Fang must intersect columns or beams at predefined insertion points. These construction rules are not pre-encoded in templates but are applied dynamically during the modeling process as the model is being constructed, reflecting the assembly logic inherent in traditional timber craft.

In addition, the rule-driven parametric definitions are enriched with semantic attributes such as construction function, joinery type, structural hierarchy, and compatibility constraints. These attributes transform the HBIM model into a structured knowledge container in which geometry, semantics, and construction rules are tightly integrated. Through this representation, Chinese timber structures can be reconstructed in a repeatable, scalable, and interpretable manner across diverse heritage sites, without losing the underlying craft logic. The hierarchical component-family logic and embedded construction rules are further formalized through class relationships, as illustrated in the Unified Modeling Language (UML) model in Fig. 3.

As can be observed in Fig. 3, the UML class diagram constructed in this study clearly delineates the structural hierarchy and semantic relationships inherent to the Chinese timber

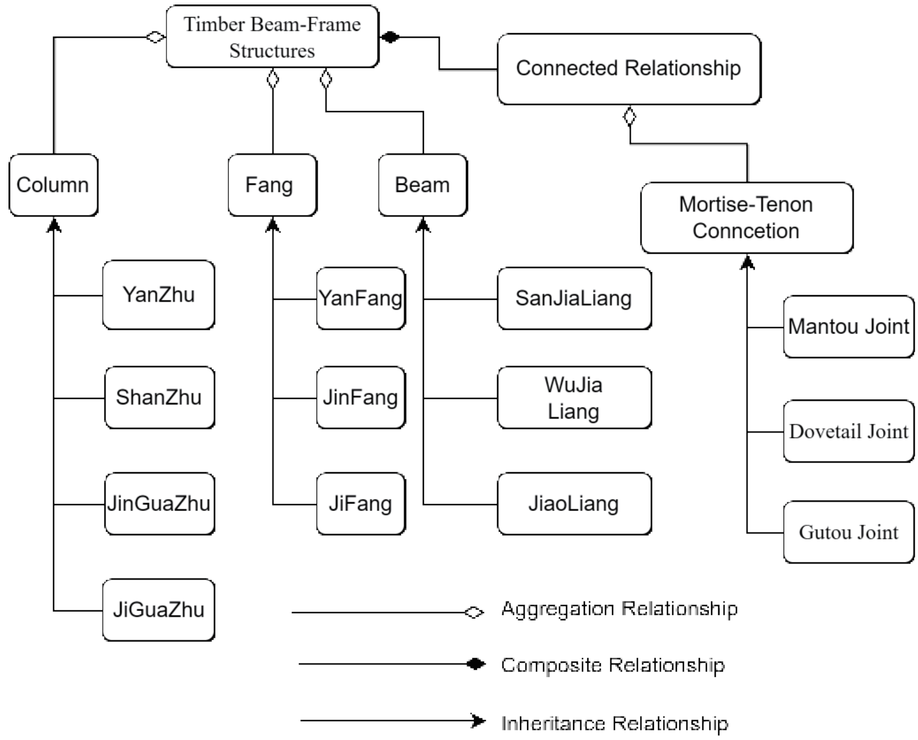


Fig. 3. Generated UML for CTBFS.

beam-frame system. The diagram systematically represents the classification and construction logic of components, such as beams, columns, and Fang sets, through class inheritance, composition, and association relationships. Primary load-bearing components (e.g., columns and beams) are linked to secondary components (e.g., Fang) via explicit relational connections, reflecting the traditional construction principle of "governing the small by the large" and the multilevel dependencies among members. Attribute definitions encompass not only geometric parameters (e.g., cross-sectional dimensions and length) but also integrate semantic information such as construction function, joinery type, and structural hierarchy, thereby explicitly encoding rule-based proportions and construction logic within the model structure. This UML model provides a formalized logical framework for subsequent HBIM parametric family design and IFC semantic extension, ensuring tight coupling among geometric data, component attributes, and construction rules. Moreover, these timber beam-frame structures are designed as parametric components capable of achieving LOD 400, encoding not only precise geometry but also detailed semantic attributes and construction logic. Lower LODs can be derived through the abstraction of these parametric rules.

2.2 IFC-based semantic and relational extension framework

While HBIM provides a rule-driven and semantically enriched representation of CTBFS, a complementary mechanism is required to ensure interoperability, long-term preservation, and cross-platform exchange. Rather than modifying the core IFC schema, which would compromise compatibility, the proposed approach adopts a noninvasive extension strategy that systematically maps CTBFS characteristics into the existing IFC ontology, as shown in Fig. 4.

As shown in Fig. 4, the whole framework is achieved by leveraging IFC's flexible property set and relationship structures. Individual components including columns, beams, Fang, and joinery elements are classified according to their structural roles and mapped to corresponding IFC base classes (e.g., IfcBeam and IfcColumn), while CTBFS-specific information, such as element typology, timber grading, joinery type, and construction hierarchy, is expressed through custom IfcPropertySet definitions. In parallel, construction logic and dependency rules are encoded using IFC relational entities (e.g., IfcRelConnects and IfcRelAggregates), which record support conditions, seating relationships, bearing paths, and other structural interactions without requiring schema additions. Through this combined use of property sets and relationships, the implicit construction logic captured in HBIM becomes explicit, traceable, and machine-interpretable within IFC. To express Chinese timber construction features that are absent in modern IFC schemas, additional structures and semantics are introduced at the property-set level, as shown in Fig. 5.

Figure 5 shows that the proposed approach defines extended component categories (e.g., primary beam, secondary beam, corner column, mid-bay column, bracket arm, and ridge purlin) and supplements them with cultural and structural attributes, including timber grade, cross-sectional proportional rules, joinery typology, functional hierarchy, and construction role. These

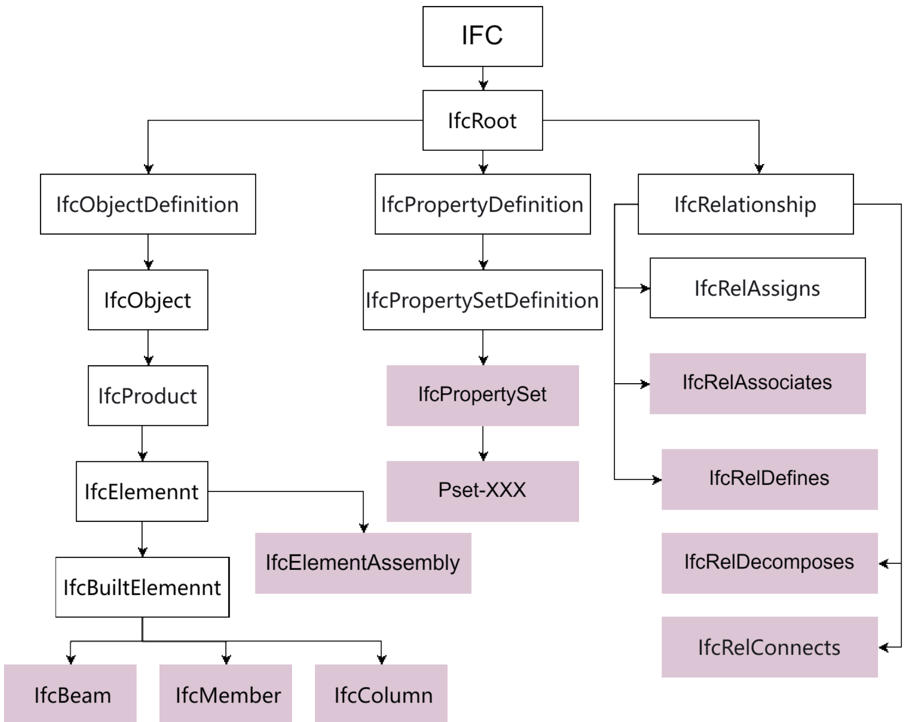


Fig. 4. (Color online) IFC-based extension framework for CTBFS.

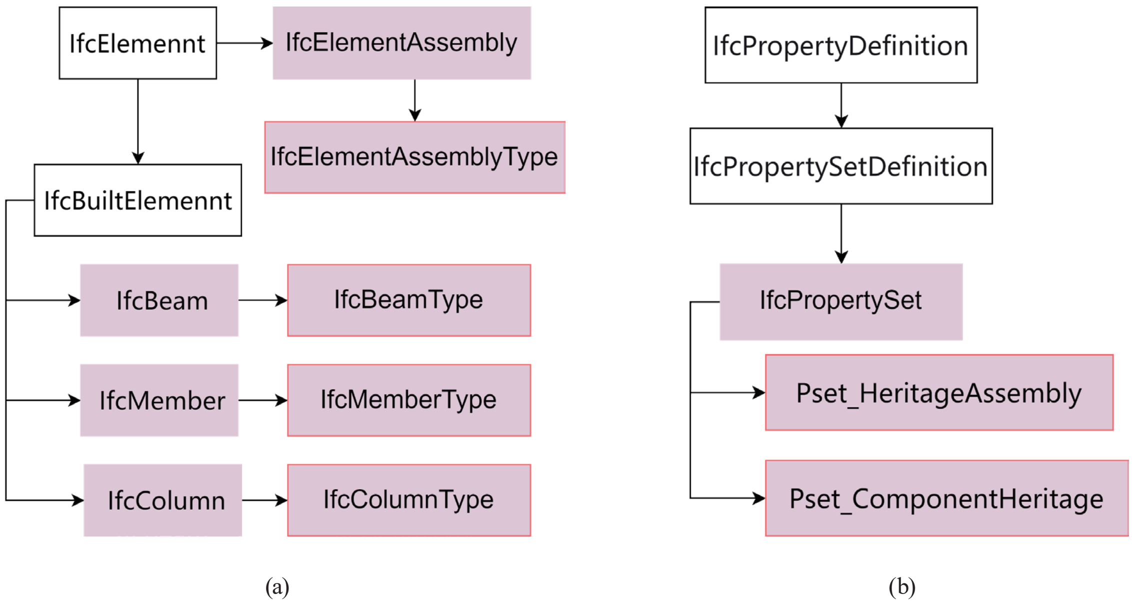


Fig. 5. (Color online) Extensions for CTBFS. (a) Structural extension. (b) Semantic extension.

extensions are encapsulated within custom property sets that attach to standard IFC entities, thereby avoiding schema modification while retaining the full representational richness of CTBFS.

Moreover, beyond individual component metadata, Chinese timber buildings are characterized by systematic dependency chains, load transfer, seating, alignment, and assembly restrictions. Such construction logic is formalized using IFC relational entities, as shown in Fig. 6.

Figure 6 shows that the proposed UML framework integrates geometric-semantic information by defining component hierarchical relationships, connection rules, and geometric constraints. Aggregation relationships are employed to assemble components, such as beams, columns, and tie-beams, into a unified beam-frame system, while connection rules combined with geometric constraints explicitly define the relational logic between beams and columns, beams and tie-beams, as well as tie-beams and columns. For example, IfcRelConnects captures load-bearing and seating connections between beams and columns, IfcRelAggregates structures the hierarchical assembly of column-beam-purlin systems into bays and roof units, and IfcRelAssociates enables the linkage of components to their governing rulesets or historical interpretations. By integrating these semantic and relational structures with exported geometric instances, the resulting IFC file becomes a faithful representation of not only physical geometry but also the embedded knowledge governing CTBFS construction.

3. Results

To validate the proposed framework, the methodology was implemented and tested on two representative forms of CTBFS, each exhibiting distinct architectural characteristics and

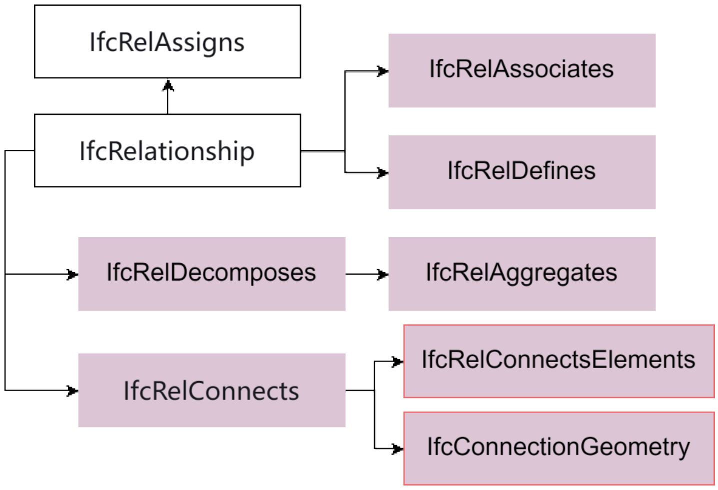


Fig. 6. (Color online) Extension of representation of geometry, semantics, and relational logic for CTBFS.

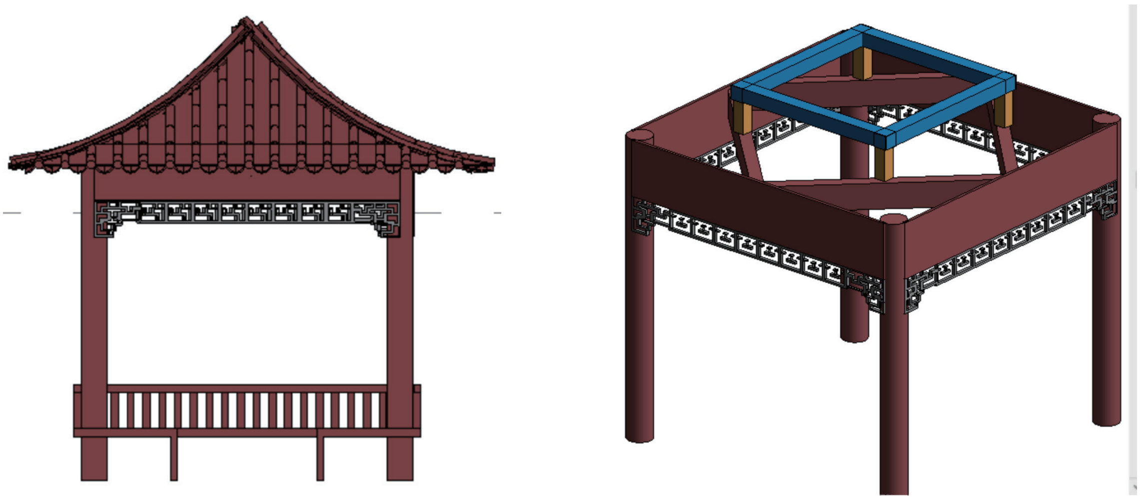
construction complexities. The selection of these two cases is based on their complementary structural typologies, complexity levels, and coverage of typical CTBFS formal rules, as presented in Figs. 7 and 8.

The first case is a Four-corner Pavilion (Fig. 7), which represents a centralized, symmetrical structure featuring a multilayered bracket set (dougong) system with integrated column-and-beam relationships. This pavilion typology embodies complex, hierarchical jointing systems and nonlinear geometric relationships, thus testing the framework's capability to handle intricate rule-based assemblies. The second case is a Five-purlin Small-style Building (Fig. 8), which exemplifies a simpler, linear hall-type structure characterized by continuous purlin alignment, standardized beam-column connections, and clear hierarchical dependencies among structural members. As a widely adopted vernacular form, it validates the framework's applicability to more common, repetitive timber construction systems. Together, these cases span a spectrum from high-complexity ceremonial architecture to everyday structural practice, ensuring that the proposed modeling and extension methods are robust across varying levels of detail, regularity, and rule formalization. Both structures were reconstructed using the developed rule-driven HBIM method and subsequently exported as IFC models enriched with the proposed semantic and relational extensions.

3.1 Results of HBIM models

The results of the rule-driven HBIM modeling process for the two CTBFS examples are illustrated in Fig. 9. In both cases, the proposed parametric component-family design successfully captured rule-based proportions and the construction logic derived from "Yingzao Fashi" and related manuals.

Figure 9 illustrates that the structural members of the Four-Corner Pavilion, including columns, tie beams, architraves, and purlins were generated according to the hierarchical-tree



(a) (b)

Fig. 7. (Color online) Four-corner Pavilion: a centralized symmetrical structure with dougong. (a) Overall view. (b) Detailed timber beam-frame structures.

(a) (b)

Fig. 8. (Color online) Five-purlin Small-style Building: a linear hall-type structure. (a) Overall view. (b) Detailed timber beam-frame structures.

decomposition defined in Sect. 2.1. Modifying master parameters, such as bay width and column height, resulted in consistent geometric propagation to subordinate members, demonstrating the scalability of the rule-driven approach. While for the Five-purlin Small-style Building, standardized structural repetition across multiple bays was achieved efficiently using the same parametric family set. The component hierarchy ensured that beams, Fang, and roof members adapted automatically to variations in primary frame geometry. These results confirm that the HBIM model encodes not only the geometric form, but also the repeatable and interpretable construction logic applicable across traditional building typologies.

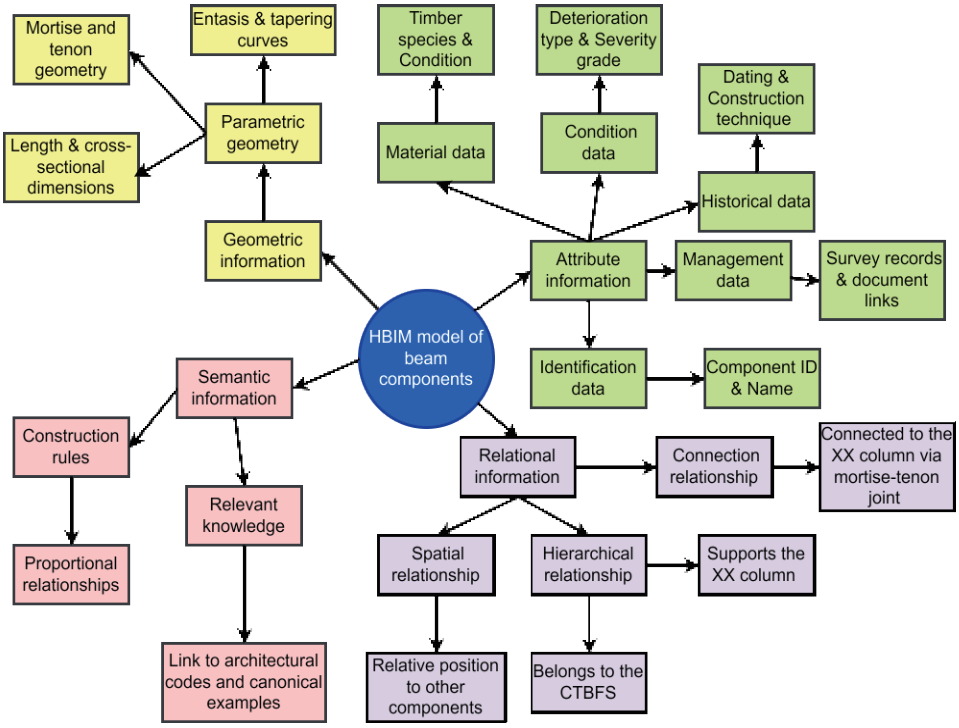


Fig. 9. (Color online) Unified HBIM modeling results for CTBFS.

3.2 Results of IFC-based extension frameworks

The IFC-based extension framework was applied to the reconstructed HBIM models of both validation cases to evaluate its effectiveness in preserving CTBFS-specific semantics and relationships while ensuring cross-platform interoperability, as presented in Fig. 10.

As shown in Fig. 10, the IFC-based extension framework successfully represents the overall timber beam-frame structure of the validation cases, integrating both geometric and semantic information. Each reconstructed HBIM component was correctly mapped to a corresponding IFC base class (e.g., IfcColumn or IfcBeam) and enriched with CTBFS-specific attributes through custom property sets. These attributes include timber grade, joinery typology, construction role, and hierarchical position. Furthermore, construction relationships, such as load-bearing connections between beams and columns and the aggregation of structural members into bays, were explicitly encoded using IFC relational entities (e.g., IfcRelConnects and IfcRelAggregates). The results demonstrate that the proposed semantic and relational extensions effectively preserve CTBFS-specific knowledge while maintaining data interoperability across platforms. Moreover, the extended geometric-semantic relationships based on the IFC standard for each component are constructed and visualized in Figs. 11–13.

As illustrated in Figs. 11–13, the proposed IFC extension framework effectively captures the geometric and semantic relationships of key CTBFS components, namely, Fang, Column, and Beam. Each figure demonstrates how component-specific properties (such as cross-sectional

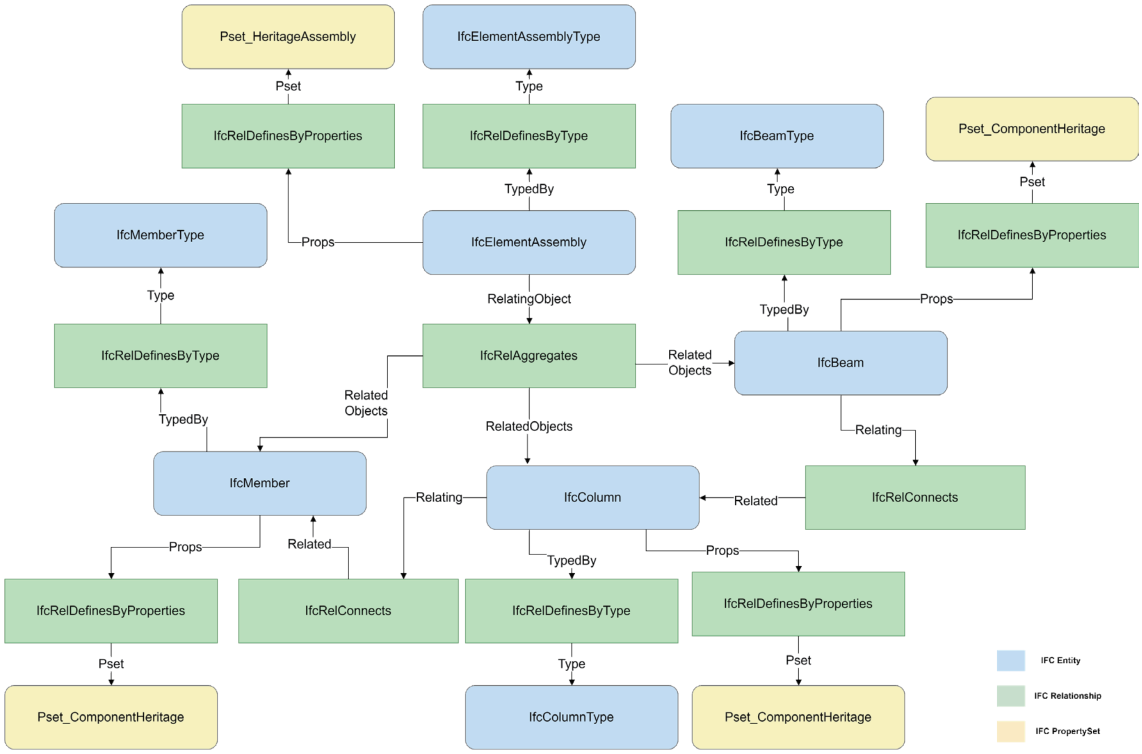


Fig. 10. (Color online) Results of extended geometric-semantic relationships of CTBFS.

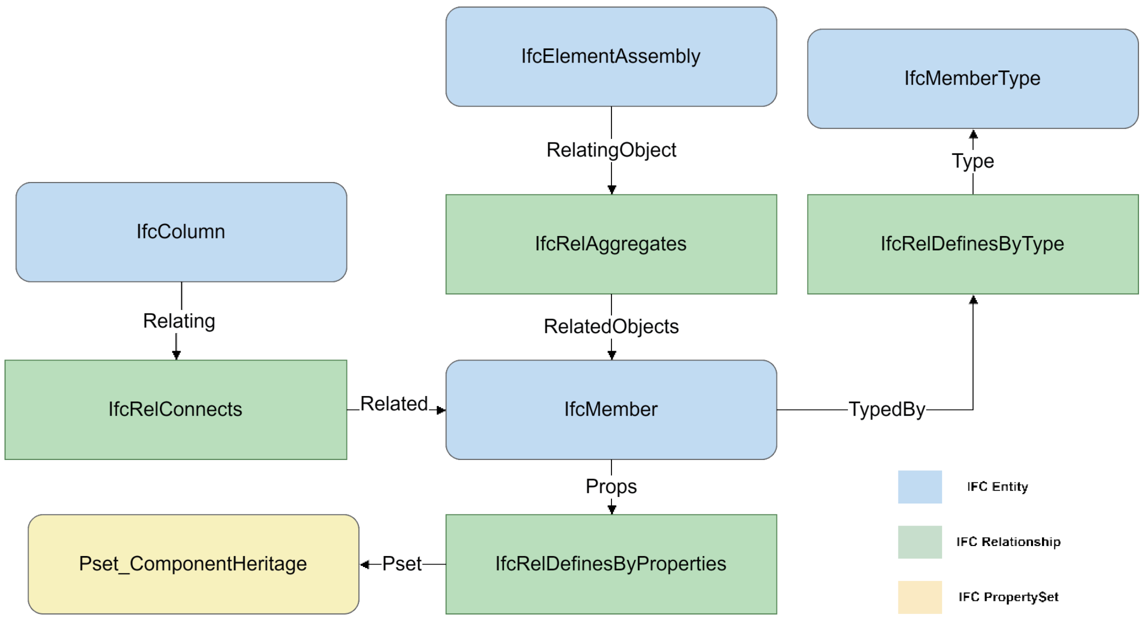


Fig. 11. (Color online) Results of extended geometric-semantic relationships of Fang component.

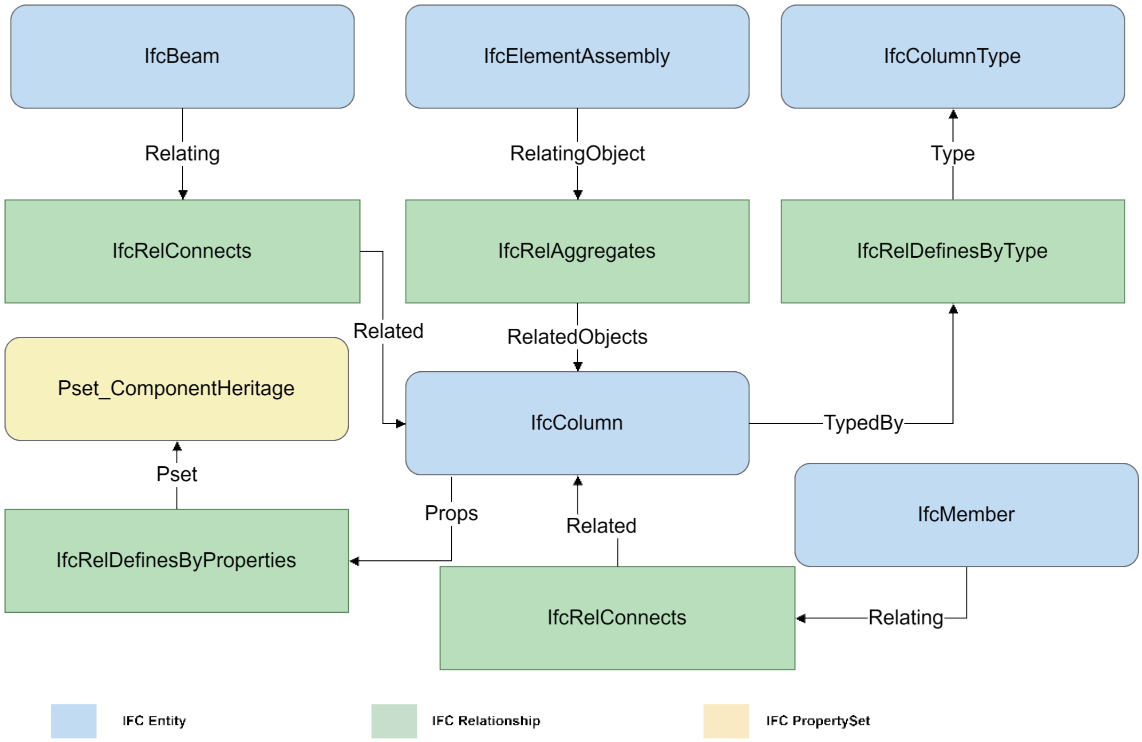


Fig. 12. (Color online) Results of extended geometric-semantic relationships of Column component.

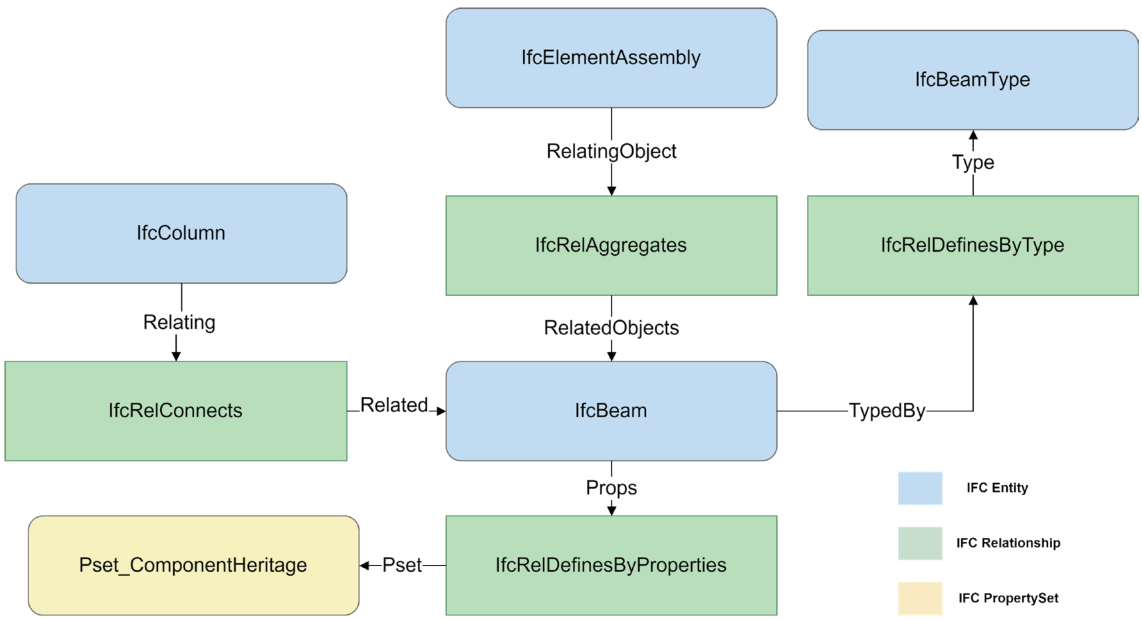
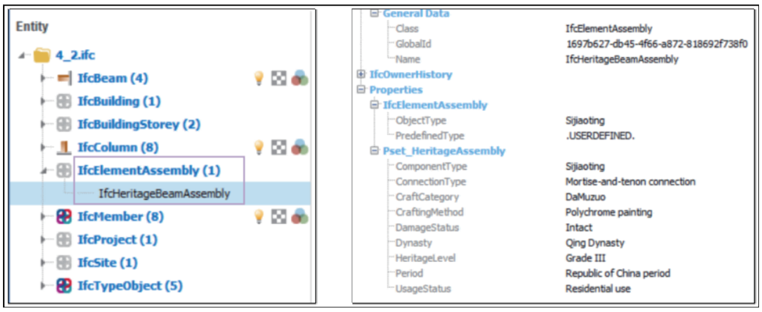


Fig. 13. (Color online) Results of extended geometric-semantic relationships of Beam component.

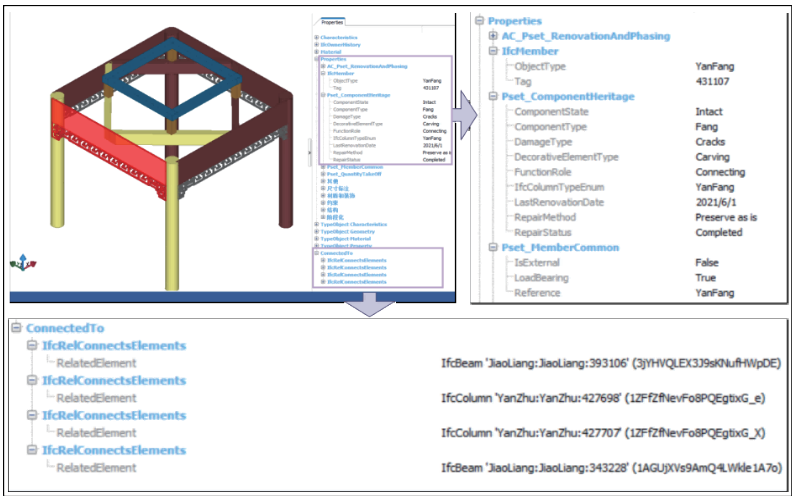
dimensions, timber grade, joinery type, and hierarchical role) are encapsulated within custom property sets attached to the corresponding IFC entities. Furthermore, the relational structures defined in the IFC model explicitly represent connections and dependencies among components, such as seating, bearing, and aggregation relationships. These visual and semantic representations confirm that the proposed approach not only preserves the geometric accuracy of traditional timber structures but also enriches them with machine-interpretable construction logic, thereby supporting cross-platform interoperability and heritage data preservation.

3.3 Results of CTBFS representation details

The detailed geometric-semantic representations of the Four-corner Pavilion and Five-purlin Small-style Building are illustrated in Figs. 14 and 15, respectively. These figures demonstrate the capability of the proposed IFC extension framework to capture both the overall structural configuration and the fine-grained semantic relationships of key subcomponents.

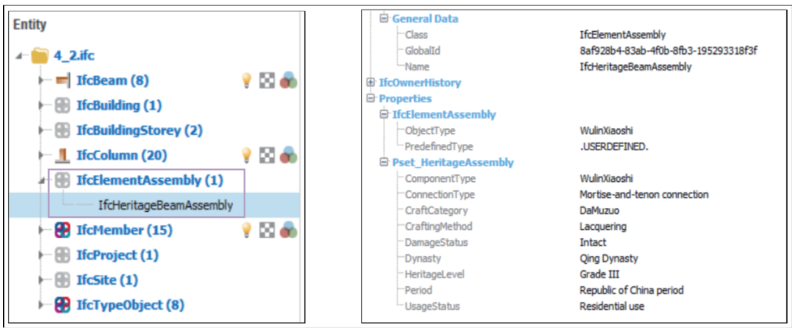


(a)

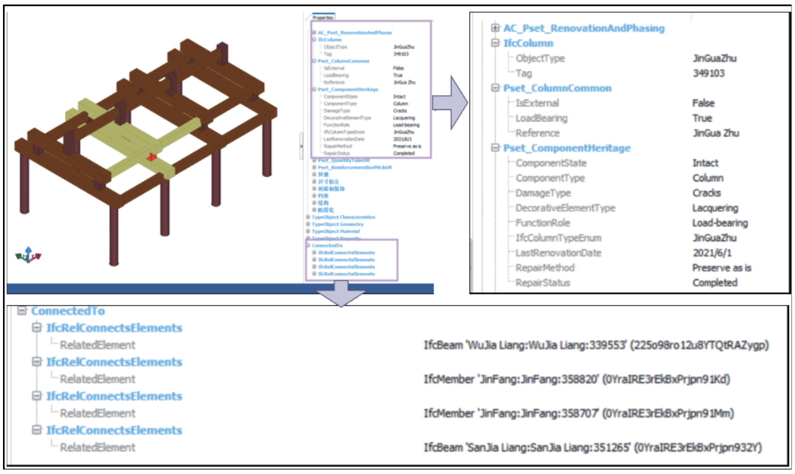


(b)

Fig. 14. (Color online) Results of the extended geometric-semantic relationships on Four-corner Pavilion. (a) Overall representation. (b) Detailed view of YanFang subcomponent (highlighted in red).



(a)



(b)

Fig. 15. (Color online) Results of extended geometric-semantic relationships on Five-purlin Small-style Building. (a) Overall representation. (b) Detailed view of JinGuaZhu subcomponent (highlighted in pale green).

As shown in Fig. 14(a), the overall timber beam-frame structure of the Four-corner Pavilion is represented with integrated geometric and semantic attributes, where each component is associated with CTBFS-specific properties such as construction role, timber grade, and joinery type. Figure 14(b) zooms into the YanFang subcomponent, illustrating how localized connection rules and hierarchical dependencies are explicitly encoded within the IFC model. Similarly, Fig. 15(a) presents the overall representation of the Five-purlin Small-style Building, emphasizing its linear hall-type layout and standardized beam-column relationships. Figure 15(b) details the JinGuaZhu subcomponent, showcasing the embedding of component-specific semantics and relational constraints. These results confirm that the proposed IFC-based extension not only preserves the holistic structural logic of CTBFS but also enables the explicit representation of subcomponent semantics and relationships, thereby supporting detailed heritage documentation, interoperable data exchange, and future analytical applications.

4. Discussion

4.1 Advancement of proposed UML models for HBIM

The UML model developed in this study (Fig. 3) serves as a formalized logical framework for capturing the hierarchical structure, semantic attributes, and construction relationships inherent to Chinese timber beam-frame systems. Unlike previous HBIM studies that often develop project-specific parametric objects with limited reusability,(19,20) the proposed UML framework defines a generic, rule-driven component family system for Chinese timber structures. This system systematically encodes component semantics, formal proportional rules, and hierarchical dependencies, enabling the automatic propagation of structural logic across different building typologies.

It explicitly represents component classifications and dependencies, such as beams, columns, and Fang, through inheritance, composition, and association constructs, reflecting the traditional principle of "governing the small by the large." This hierarchical organization enables rule-driven parametric design in HBIM, ensuring the consistent propagation of master parameters such as bay width and column height. Moreover, the model integrates geometric parameters (cross-sectional dimensions and length) with semantic attributes such as construction function, joinery type, and timber grade, transforming it from a geometric container into a structured knowledge base that encapsulates historical craft rules. The formalized relationships in the UML also provide a clear blueprint for implementing IFC semantic extensions, ensuring traceability between design logic and digital representations.

Furthermore, the UML-based representation demonstrates strong compatibility with Geographic Information Systems (GIS) and urban semantic modeling standards such as CityGML. The structured class hierarchy, explicit relationships, and semantically enriched attributes defined in the UML model align well with the object-oriented and multiscale modeling principles underpinning CityGML. By mapping CTBFS component classes (e.g., Beam, Column, and Fang) to corresponding CityGML feature types or extending the CityGML Application Domain Extension (ADE) mechanism, the proposed UML schema can be seamlessly integrated into city-scale heritage documentation and 3D urban models. This integration enables not only building-level geometric and semantic representation but also supports urban-contextual analyses, such as heritage zoning, visual impact assessment, and disaster risk management. The UML model thus serves as a bridge between detailed architectural modeling and macroscale urban information systems (GIS/CityGML), promoting interdisciplinary data interoperability and holistic heritage governance.

4.2 Compatibility of IFC-based framework

The proposed IFC-based extension framework maintains full compatibility with the standard IFC schema by utilizing existing mechanisms, primarily IfcPropertySet and built-in relationship entities such as IfcRelConnects and IfcRelAggregates, rather than modifying or adding new core entities.(21,22) This nonintrusive strategy ensures that the construction logic and semantic knowledge encoded within the HBIM environment are transferred to IFC in a clear and machine-interpretable form while remaining compliant with existing IFC standards and pipelines.

In contrast to traditional IFC-based workflows,(23,24) which typically represent historic timber buildings as geometry-dominant models and consequently lose procedural, semantic, and contextual information during exchange, the IFC models generated through the proposed framework retain both geometric fidelity and the embedded cultural logic of CTBFS. Component typologies, joinery attributes, proportional rules, material grades, and hierarchical dependencies are recorded through custom property sets, while construction relationships are explicitly

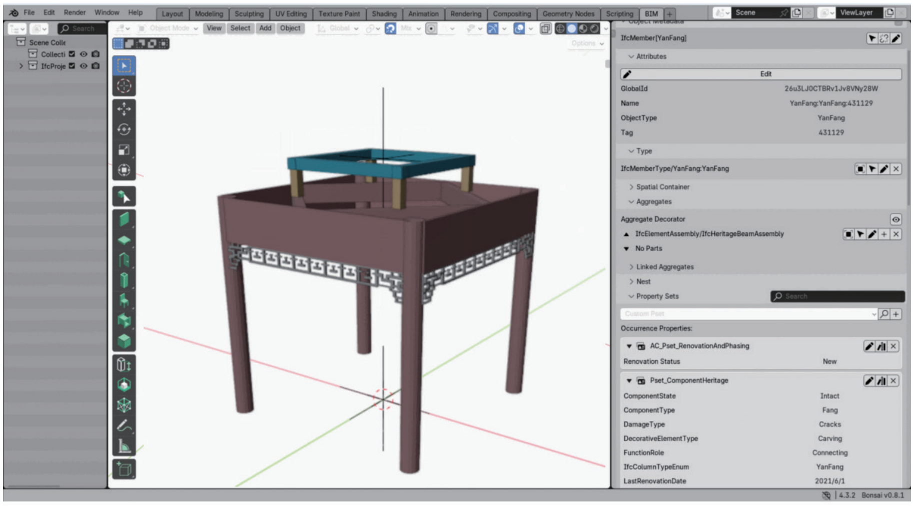


Fig. 16. (Color online) Visualization of construct CTBFS in common Blender platforms.

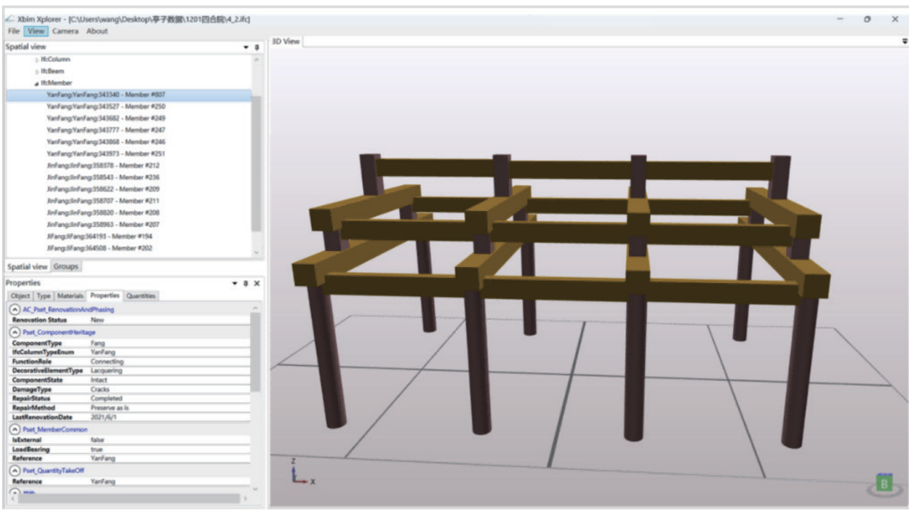


Fig. 17. (Color online) Visualization of construct CTBFS in common Xbim platforms.

expressed using IFC relational entities. As a result, the exported IFC files function not only as geometric records but also as standardized, semantically enriched carriers of traditional craft knowledge.

The interoperability and practical usability of the proposed approach were validated across multiple IFC-compliant platforms, such as Blender (Fig. 16) and Xbim (Fig. 17), without the need for schema extensions, plug-ins, or manual adjustments. These platforms accurately display both physical geometry and semantic attributes, demonstrating that the extended IFC models are readily interpretable across diverse data environments.

As can be seen from the Figs. 16 and 17, these platforms successfully display both geometric and semantic information of CTBFS without requiring any modifications to the imported files, confirming the interoperability and usability of the proposed IFC extension strategy. Moreover, the framework supports long-term extensibility. Additional heritage typologies, semantic descriptors, or relationship patterns may be incorporated by expanding custom property sets rather than altering the core schema, ensuring that future developments do not compromise interoperability or data longevity. Accordingly, the proposed approach provides a robust pathway for the standardized representation, preservation, and exchange of CTBFS knowledge across HBIM platforms and heritage information systems.

5. Conclusions

In this study, we proposed an integrated HBIM-IFC representation framework to explicitly model the rule-based proportions, construction logic, and semantic relationships inherent to CTBFS. In contrast to traditional geometry-oriented heritage modeling approaches, the proposed method systematically embeds rule-driven parametric design into HBIM and transfers the encoded construction knowledge into IFC without modifying the underlying schema. Validation on two representative building typologies demonstrates the methodological soundness and applicability of the framework. By enabling a rule- and logic-aware representation within a standardized information modeling environment, the proposed framework contributes to bridging traditional construction knowledge and contemporary digital heritage standards.

The proposed HBIM-IFC framework remains constrained in several aspects. The parametric library covers only core structural members and lacks complex bracket systems, decorative details, and regional variants, limiting representational completeness. Construction rules are manually encoded and depend on expert interpretation, making the workflow time-consuming and difficult to scale. In the future, we will expand component libraries, explore semi-automated rule extraction and parameter inference from point clouds and textual sources, and investigate abstraction methods that enable differentiated levels of detail. Additionally, by linking sensor-derived geometric information with rule-driven semantic modeling, the proposed framework can facilitate the transformation of raw sensing data into structured and interpretable digital representations of timber construction systems, thereby supporting future applications including the structural assessment, digital conservation, and sensor-based monitoring of traditional timber architecture.

Acknowledgments

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About the Authors

Pingbo Hu received his D.S. degree from Wuhan University, China, in 2018 and is currently working at Beijing University of Civil Engineering and Architecture. His research interests are in cultural heritage digitization and 3D modeling. (hupingbo@bucea.edu.cn)

Xueru Wang received her B.S. degree from Anhui University of Science and Technology, China, in 2022 and has been pursuing her M.S. degree at Beijing University of Civil Engineering and Architecture, China, since 2023. Her research interests are in building information modeling, cultural heritage digitization, and the Industry Foundation Classes (IFC). (2108570023111@stu.bucea.edu.cn)

Jie Jiang received her D.S. degree from China University of Mining and Technology (Beijing) in 2000 and is currently working at Beijing University of Civil Engineering and Architecture. Her research interests are in spatiotemporal information modeling and digital twin cities. (jiangjie@bucea.edu.cn)