

BIM-Based Forward Collaborative Design Platform Model for Architecture: Postprint

Authors: Yang Xin, Jiao Ke, Lu Heng, Huo Haobin

Date: 2018-10-26T00:00:00+00:00

Abstract

With the progressive enhancement of computer processing capabilities and continuous development of software functionalities, applications based on BIM three-dimensional design in architectural engineering design have been increasingly expanded, with relatively practical methods available for massing scheme comparison, planning submission and preliminary design, discipline-specific construction drawing design, and three-dimensional detailed design drawing production. However, the implementation of full-process, multi-disciplinary forward collaborative design using BIM remains fraught with difficulties, primarily attributable to the incompatibility of BIM model storage methods with traditional design architecture, the inability to effectively split model deliverables, and excessive reliance on foreign BIM software that precludes sufficient functional expansion. This paper summarizes the current work architecture of design institutes, analyzes the requirements and challenges in extending from CAD design to BIM forward design, and proposes a “data-model separation” architecture for a BIM forward design platform centered on a relational database coupled with a model and drawing file manager. This architecture employs separate storage management for non-geometric information—including design deliverables, review and approval annotations, and progress control—while establishing interconnections through unique ID values, thereby integrating geometric models and non-geometric information into an organic whole to achieve integrated management.

Full Text

Research on BIM-Based Forward Collaborative Design Platform Models for Architecture

Yang Xin, Jiao Ke, Lu Heng, Huo Haobin

(Guangdong Provincial Architectural Design and Research Institute, Guangzhou, Guangdong 510010, China)

Abstract

With the continuous improvement of computer processing capabilities and software functionality, BIM-based 3D design applications in building engineering have gradually expanded, offering practical methods for massing scheme comparison, planning submission and preliminary design, discipline-specific construction drawing development, and 3D detailed design documentation. However, achieving full-process, multi-disciplinary BIM forward collaborative design remains challenging. The primary obstacles include: BIM model storage methods that cannot adapt to traditional design frameworks, ineffective splitting of model deliverables, and excessive reliance on foreign BIM software that limits functional expansion. This paper summarizes current design institute workflows, analyzes the requirements and challenges in extending from CAD design to BIM forward design, and proposes a “digital-model separation” architecture for BIM forward design platforms centered on a relational database coupled with a model/drawing file manager. This architecture enables separate storage and management of non-geometric information such as design deliverables, review annotations, and progress control, connecting them through unique ID values to integrate geometric models and non-geometric information into an organic whole for unified management.

Keywords: Forward Design; BIM; Collaborative Platform

CLC Number: TU37; TU17

In the entire building project design process, the informatization of work deliverables, real-time communication and collaboration, and proper classification and retrieval of discrete results determine the efficiency and quality of BIM forward design applications. Traditional CAD-based collaborative design workflows, as shown in [Figure 1: see original paper]-1, fundamentally involve managing drawing files and text documents within project folders, with supplementary methods such as standardized file naming, layer conventions, and external references to enhance coordination standardization and convenience.

However, under this approach, various types of building design information remain dispersed across different layers in separate CAD files, making secondary development extremely difficult. As BIM has evolved, using parametric components as basic storage units, with model-based drawing extraction and annotation for documentation, has become the mainstream approach for information-based design. In this paradigm, designers, reviewers, and project managers shift their focus from discrete, point-based drawings to integrated parametric models, as illustrated in [Figure 1: see original paper]-2.

Under this design mode, collaborative platforms must transition from file-based coordination to component-based coordination, demanding more sophisticated data architectures and formats. Key challenges include:

First, the increased workload of 3D design: Beyond 2D planar information,

designers must manually specify 3D information, spatial clipping relationships, component priority relationships, and methods for expressing non-geometric data.

Second, collaborative workflows under repeated modifications: Traditional CAD design relies heavily on designer experience, with issues annotated directly on drawings. This approach enables direct and effective communication, as reviewers can immediately locate annotations when cross-referencing 2D drawings. In 3D collaboration, however, model-based annotations must be handled and displayed consistently across different views.

Third, the reusability of design knowledge: China has published numerous standards, specifications, standard drawing collections, and technical measures. During the 2D-to-3D transition, integrating these established practices and typical details into BIM-based design models presents a significant challenge.

Fourth, effective work breakdown and workload statistics: For centralized design model information, participants struggle to divide work scopes and content using traditional CAD splitting and external referencing methods. Therefore, establishing rational and effective BIM-based work breakdown structures is crucial.

Fifth, integration of technical and enterprise management: In the building industry's informatization process, extensive research has focused on improving production methods, enhancing efficiency, and reducing errors and rework. For the AEC sector, characteristics such as numerous participants, diverse data formats, and intensive capital investment pose major challenges for information technology implementation.

Sixth, scalability for building industrialization: With pilot programs for general contractors preparing construction drawing design documents in Shanghai and Shenzhen, BIM forward design must incorporate manufacturing-style industrialization practices, including compatibility with fabrication systems and integration with material management concepts.

While challenges (1), (3), and (4) can be addressed through secondary development on BIM platforms, challenges (2), (5), (6) require open, universal data collaboration platforms.

3 Basic Functional Requirements for Forward Collaboration Platforms

For establishing universal data collaboration platforms, it is essential to ensure data originates from broad and accurate sources while maintaining consistency across collaborative iterations. Specific application requirements include:

Model-Based Design Information Coordination: Due to the complexity of building projects, mature BIM modeling platforms are developed by specialized software companies such as Autodesk's Revit. Design institutes typically

conduct collaborative design based on these existing platforms, requiring only moderate customization. The process largely resembles CAD external referencing, with Revit utilizing linked models and worksets for design model collaboration. Both methods rely on file servers to properly split model files for cross-referencing and 3D coordination, while enabling multiple designers within the same discipline to simultaneously edit a single model.

Phase-Based File Management: CAD-based collaborative design platforms (such as HuiZhi and WeiHeng) have matured. This function aims to compensate for modeling software's inadequate capabilities in file permissions, versioning, and archiving through secondary development. For Revit-based collaboration, the uncertainty of model splitting has prevented the emergence of mature project model architecture management platforms, leaving only unified naming conventions for models and families.

Project Component-Level Permission Management: In large projects with numerous participating disciplines, CAD platforms previously enabled permission-based control over work content and phases through DWG files. BIM-based collaborative platforms must similarly manage operational zones and system access for different roles within the model.

Review and Approval Processes, ISO Management, and Archiving: All design deliverables must undergo checking, reviewing, and approval before formal archiving and distribution. Traditional CAD platforms processed annotations on DWG files to generate plot-ready documents meeting archiving requirements.

Integration of Technical and Enterprise Management: As building industrialization advances and design-construction integration pilots expand, BIM forward design platforms must integrate with enterprise management systems, synchronizing design information, process data, unified technical standards, and operational management with component fabrication and site conditions in real time.

4 Comparison of Mainstream BIM and Collaboration Platforms

Currently, five mainstream BIM design platforms exist, with their focuses and data collaboration capabilities summarized in -1:

1. **Autodesk AutoCAD:** Coordinates through external referencing of planar drawings ("overlay drawings"), with manual cross-disciplinary review and checking.
2. **Autodesk Revit:** Supports workset-based collaboration via a central file on a file server, with local files for each designer enabling simultaneous editing. Multi-disciplinary coordination uses model linking.
3. **Bentley Microstation (ProjectWise):** Offers relatively complete collaboration functions with web-based viewing and annotation.

4. **Trimble Tekla:** Primarily used for steel component and connection detailing, with strong fabrication functions but limited collaboration capabilities.
5. **ArchiCAD:** Mainly for architectural single-discipline full-process design, with strong modeling, documentation, and collaboration functions but limited application for structural and MEP disciplines.

Microstation independently provides the multi-terminal ProjectWise collaboration platform. Due to its efficient underlying data architecture, it has been extensively developed in the infrastructure sector—for example, East China Investigation, Design & Research Institute has achieved mature 3D collaborative design through secondary development on Microstation [3]. Revit, with its robust modeling, family libraries, user-friendly interface, and convenient operation, is widely applied in civil building projects with numerous secondary development tools [1][4][7]. However, its collaboration relies primarily on model splitting and worksets, lacking a systematic collaborative design platform, and data storage efficiency based on RVT model files remains low.

5 Technical Architecture and Functions of Collaboration Platforms

From a technical perspective, constrained by the large scale of BIM platform development and the complexity of component types and data relationships, modeling and operation software is currently based on the five aforementioned platforms with secondary development for extended functions. However, key processes in traditional forward design—such as drawing management, review annotations, automated plotting and archiving, and detailed permission control—cannot be directly implemented within BIM platforms. Therefore, the critical challenge is to efficiently integrate with existing BIM core software through secondary development and internal/external data exchange, enabling organic integration between BIM management and enterprise production management.

Mainstream data storage approaches include file storage and relational database storage. File servers represent traditional collaborative methods, storing model files, drawings, and text documents on shared servers with permission-based access for viewing, editing, and plotting. Relational database storage organizes all parametric data in classified “tables,” enabling direct database operations (addition, deletion, modification, sorting, statistics) on table fields through program preprocessing. The architecture is illustrated in [Figure 5: see original paper]-1.

The core of this collaborative model is “digital-model separation” : within BIM modeling platforms like Revit, geometric and fabrication models are created, modified, and documented while recording corresponding component ID values. The forward design platform tracks these IDs and separately stores version and status information in an independent database to enable functions like review, approval, and workload statistics. Through ID association, editing non-geometric attributes (annotations, status parameters, strength properties) only

requires modifying corresponding key values in the MySQL database without altering Revit model parameters, significantly reducing computational complexity, improving BIM model design efficiency, and ensuring project design depth and deliverable consistency.

Based on this architecture, a typical BIM forward design platform structure is shown in [Figure 5: see original paper]-2. The data layer separately stores 2D/3D model files and component non-geometric data, which are integrated through the middleware layer to provide unified functions at the application layer, avoiding data inconsistencies caused by repeatedly invoking different software and platforms. Using this model, the authors previously developed a lightweight collaborative management platform for prefabricated buildings [2], which efficiently performed customized data processing and query functions. As shown in [Figure 5: see original paper]-3, during the prefabricated design of an affordable housing project in Baiyun District, Guangzhou, the platform effectively controlled component design phases and version progress, ensuring consistency between design deliverables and fabrication drawings.

This paper analyzes BIM forward design process requirements based on traditional CAD collaborative design, including model-based coordination, file management, component permission management, non-geometric information storage, and review processes. Through comparative analysis of existing design institute collaboration architectures, BIM design requirements, and relevant platform capabilities, it proposes a digital-model separation architecture for forward design collaborative management platforms based on relational databases and file servers. This approach integrates existing model file collaboration with information-based coordination methods, using unique ID values to ensure data consistency while avoiding redundant work between modeling software, collaboration platforms, enterprise management systems, and communication tools. Based on this architecture, the authors have successfully implemented a lightweight collaborative management platform for prefabricated buildings [2] that efficiently performs customized data processing and query functions, providing guidance for developing and refining forward BIM collaborative design platforms.

References

- [1] Jiao Ke, Yang Yuanfeng, Zhou Kaixuan, et al. Research on BIM-based full-process structural design methods[J]. *Journal of Information Technology in Civil Engineering and Construction*, 2015, 7(5): 1-7.
- [2] Yang Xin, Jiao Ke. Research and application of BIM-based prefabricated building collaborative management system GDAD-PCMIS[J]. *Journal of Information Technology in Civil Engineering and Construction*, 2017, 9(03): 18-24.
- [3] Chen Jian, Li Pengzu, Wang Guoguang, Jiang Haifeng. Research and application of 3D collaborative design system for hydropower project hubs[J]. *Water Power*, 2014, 40(08): 10-12+100.
- [4] Jiao Ke, Yang Yuanfeng. BIM Structural Design Methods and Applica-

- tions[M]. Guangzhou: China Architecture & Building Press. 2016
- [5] Zhang Yang. Research on BIM-based construction project information integration and management[D]. Tsinghua University, 2009.
- [6] Liu Xing. Research on BIM-based construction project information collaborative management[D]. Chongqing University, 2016.
- [7] Luo Yuanfeng, Jiao Ke. Research and application of parametric rebar modeling method for prefabricated building components based on Revit[J]. Journal of Information Technology in Civil Engineering and Construction. 2017, 9(4): 41-45.
- [8] Wang Lei, Yu Shenhai. Discussion on BIM collaborative design mode based on Revit[J]. National Symposium on Modern Structural Engineering. 2014

Note: Figure translations are in progress. See original paper for figures.

Source: ChinaXiv –Machine translation. Verify with original.