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Research Article

Construction Database-Supported and BIM-Based Interface Communication and Management: A Pilot Project

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Construction projects are subject to numerous interface problems, particularly during the construction phase. The absence of suitable systems or platforms to tackle these issues could hinder the performance of construction management. Thus, the communication and management of interfaces (CMI) are necessary to improve the quality of the management of construction projects. E-mail and generic construction information systems are commonly used communication tools; however, they pose several limitations in recording and managing as well as in responding to interface problems. Building information modeling (BIM), by contrast, saves and delivers information in a digital format in a 3D computer-aided design (CAD) environment. The adoption of BIM technology integrated with web technology for construction projects allows users to communicate interface issues and obtain responses for them effectively. Thus, this study develops a database-supported and BIM-based CMI (DBCMI) system for general contractors to enhance their CMI work efficiency during the construction phase. To confirm the efficacy of the CMI, the DBCMI system was used in a building project in Taiwan. The case study results reveal that the proposed DBCMI system is an effective communication and management platform, particularly for practical CMI work integrated with BIM technology. This study concludes with the benefits of using the proposed system and possible limitations in its further application.

1. Introduction

A construction project faces numerous interface issues emerging from various fields that must be effectively resolved to enhance construction management. To this effect, the effective communication and management of interfaces (CMI) can be an essential aspect for a project's stakeholders. General contractors must consider a suitable platform with which to exchange feedback and responses related to construction interface management. While e-mail and general construction information systems are widely used communication tools, their ability to record and manage interface problems and responses is limited. Building information modeling (BIM) technology, by contrast, can digitize and deliver information in a 3D computer-aided design (CAD) environment [1]. In the context of construction interface management, BIM technology can help project stakeholders manage and track interfaces integrated with 3D BIM illustration. Thus, BIM as an information technology (IT) can contribute toward improving the efficiency and success of a construction project [2, 3].

BIM-based information systems are currently used in construction interface management because no appropriate platform yet exists for project participants to integrate CMI work with BIM technology. Furthermore, the limitation of file-based BIM model format needs to be overcome to provide the effective illustration for construction BIM-enabled interface management. Therefore, the aim and objective of the study is to develop a database-supported and BIM-based CMI (DBCMI) system to overcome the file-based BIM model limitation and enhance the efficiency of CMI work in a web environment. This study creates a novel database-supported and BIM-based communication platform that enables project participants to discuss, share, and respond to problems and issues related to the BIM elements-based interface during the construction phase. The DBCMI system enables project engineers and project managers to access records of previous and current discussions regarding BIM models for a given project and to manage and respond to interface problems (Figure 1). The DBCMI system can also be used during the construction phase to track the most recent problems and responses to BIM-based interface issues from project engineers. We applied the DBCMI system to a Taiwan building project case study to verify the effectiveness of CMI applications. This study presents the findings, suggestions, benefits, and limitations of the DBCMI system for further practical implementation.

2. Literature Review

The interfaces should be identified and managed effectively for all the participants involved to minimize deleterious changes during the construction phase of the project [4–6]. Only limited research has examined interface management issues in construction. Al-Hammad proposed 19 common interface problems identified based on four categories (financial problems, inadequate contract, specification, and environment problems) [7]. Also, there are many research studies focusing on the frameworks and approaches special in construction interface management [6, 8–12]. There are some research studies focusing on case studies for construction practical interface management [10, 13–17]. There are some construction interface management research studies focusing on information system developments [5, 11, 18–21]. The above research studies focus mostly on the interface management approaches and internet-based interface management system developments in construction.

BIM is a digital tool that supports continual updating and sharing of project design information [22]. BIM is a process of creating and using digital models for design, construction, and/or operations of projects [23]. Eastman et al. described the BIM as tools, processes, and technologies that are facilitated by digital or machine-readable documentation about a building [1]. BIM is a process focusing on the development, use, and transfer of a digital information model of a building project to improve the design, construction, and operations of a project or portfolio of facilities [24]. BIM provided a digital technology for describing and displaying information required in the planning, design, construction, and operation of constructed facilities [25].

During the construction phase, there are many information system developments integrated with BIM technologies. Ku and Mahabaleshwarkar presented the concept of building interactive modeling (BIM) which complements with BIM technology to enhance collaborative information and knowledge sharing [26]. Chen and Luo explored and discussed the advantages of 4D BIM for a quality application based on construction codes integrated with product, organization, and process (POP) data definition structure [27]. Lin applied BIM concepts and approaches to enhance the construction interface management implementation [21]. Han and Golparvar-Fard leveraged 4D BIM and 3D point cloud for monitoring construction progress deviations at the operational level [28]. Matthews et al. proposed a new object-oriented workflow and processes for progress management integrated with cloud-based technology during construction [29]. Costin et al. utilized RFID-BIM integration to generate real-time data to produce leading indicators for building protocol control [30]. Lin et al. proposed a BIM-based defect management (BIMDM) system for on-site quality management during the construction phase [31]. Fang et al. integrated BIM and RFID technologies to provide cloud-enabled RFID indoor localization solution [32]. Park and Cai developed WBS-based dynamic multidimensional BIM database for total construction as-built documentation [33]. Hamledari et al. developed to automatically update schedule and progress system using BIM technology and industry foundation classes (IFC) during construction [34].

Numerous information systems have been developed for various purposes; however, few studies have focused on system development in the context of construction interface management integrated with BIM technology. There is a lack of suitable platforms for BIM-based CMI work based on literature reviews. Moreover, the limitation of traditional file-based BIM model format needs to be overcome in sharing and visualizing the latest construction progress [35]. To solve this problem and overcome the limitation of file-based BIM practices for interface management, this study develops web-based DBCMI system to enhance CMI work efficient. Especially, the proposed approach and system proposed in the study differ from other existing BIM software and BIM-related information system development.

3. Research Method

From interviews with senior project managers and engineers experts in Taiwan's construction industry, the study obtained the following major problems relating to interface management experienced by general contractors [36]: (1) no suitable platforms or functions are available to support the interface management of CMI work, (2) the records of communication and responses regarding interfaces are insufficient and incomplete, and (3) it is unclear whether the problems are caused by problem parts in the construction project.

To overcome these problems, the proposed system needs to incorporate the following: (1) full integration of CMI work with the construction projects and activities, (2) records of the communications and responses for each interface issue for CMI work, and (3) links between the contents of CMI work with the elements of the BIM models used in the project.

The study proposes the concept of BIM-based interface management for GC during construction (see Figure 2). There are three proposed statuses for CMI work in the study. They are pending confirmation status, continued discussion

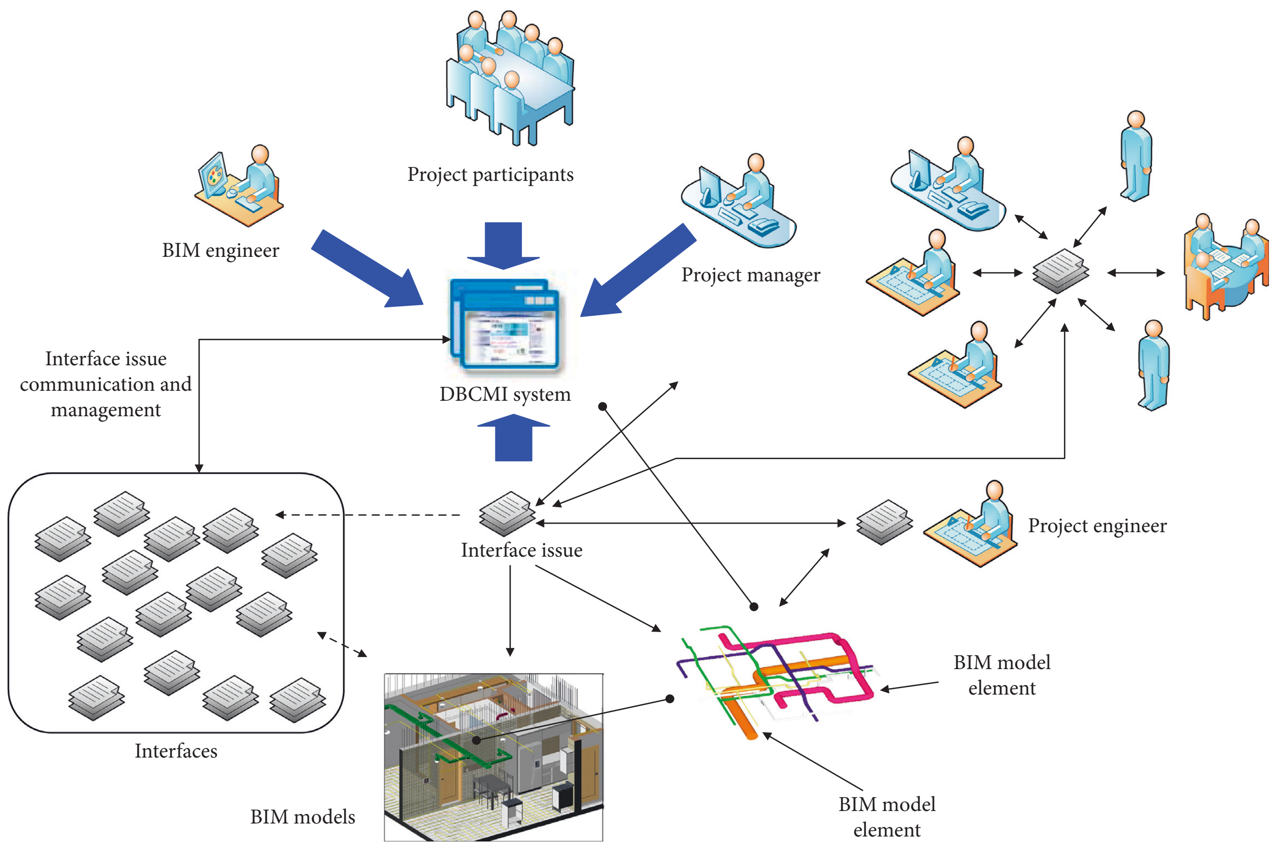

Figure 1: The application of DBCMI system for construction interface management.

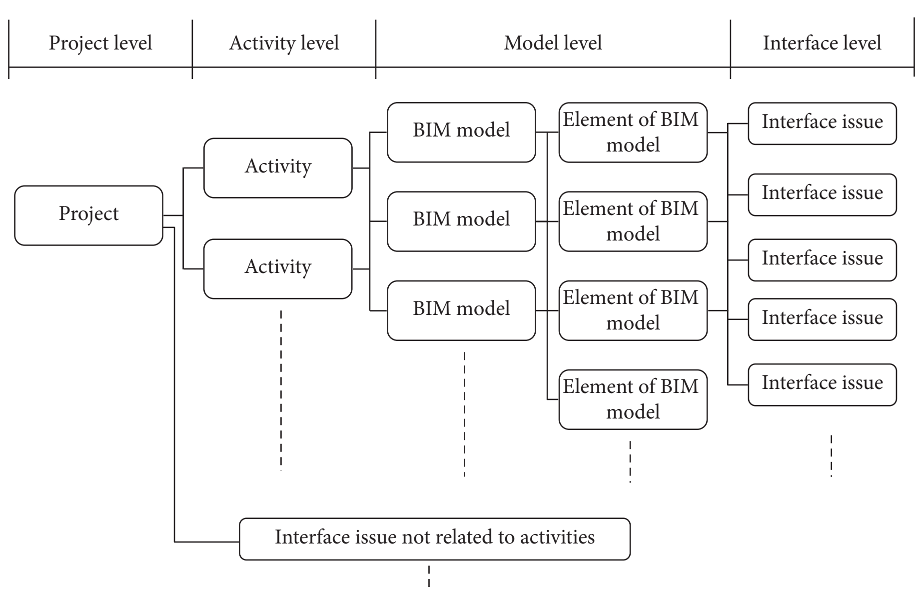

Figure 2: The concept of BIM-based interface management for GC during construction.

status, and completed discussion status (see Table 1). In order to help project engineers and project managers to access and manage interface problems integrated with elements of BIM models, this study proposes interface breakdown structure (IBS) and model breakdown structure (MBS) approach integrated with BIM. An interface breakdown structure (IBS) in interface management is a deliverable-oriented breakdown of a project into related interfaces (elements). IBS is an hierarchical representation of interfaces, starting from higher levels and going down to finer level interfaces (elements). This is similar to the approach of the Work Breakdown Structure (WBS). Furthermore, a model breakdown structure (MBS) in

Table 1: Description of CMI status in case study.

Status	Description
Pending confirmation	Proposed interface is awaiting the project manager's confirmation prior to the initiation of a discussion
Continued discussion	Ongoing discussion with related engineers or awaiting responses to a project manager's confirmation
Completed discussion	Final phase of discussion and confirmation received from the project manager

interface management is a deliverable-oriented breakdown of a BIM model into smaller elements of BIM models for interface management. A model breakdown structure is a key interface integrated with elements of BIM models. Figure 3 shows the framework of database- and BIM-based interfaces communication and management integrated with IBS and MBS. Figure 4 illustrates the preprocessing of BIM models for CMI work.

The CMI-related information stored in elements of BIM model includes both CMI-related problems and solutions. The major information for CMI should include topic of interface, description of interface, response of interface, or related attachments (e.g., documents, reports, drawings, and photographs). CMI-related problems and solutions in the BIM-based communication and respond are associated with projects, activities, people, and organizations. Identifying the relationships between interfaces and all CMI-related information are essential for project managers and project engineers when tracking and managing interfaces in the project. Additionally, the most recent CMI-related problems and solutions can be acquired from project engineers and then shared and linked with corresponding BIM model elements for interface management and future reference. The DBCMI system is a web-based platform that utilizes 3D BIM model illustration with different levels of access to CMI work that depends on user roles. When information is updated in the DBCMI system, the server automatically sends e-mails to the related project participants associated with the interface issue.

There are three stages for CMI work in the study. In the initial stage, the responsible participants or project managers identify all interface issues. In the second stage, the project participants edit the interface issues, select an appropriate BIM model and its elements, and link the interface problems associated with the BIM model's elements. These may include accounts of unconfirmed interface issue problems, detailed situation information, and solutions to problems. In the final stage, the engineer submits the interface issues associated with the BIM model elements to the DBCMI system for approval. After obtaining approval from the project manager, responsible participants respond to problems via the selected interface in the DBCMI system. The system tracks the most recent status and shows the result for each interface problem. Participants can directly access the related interface issues and mark up the comments by linking the BIM model elements. The following section describes the development of the proposed DBCMI system.

4. System Implementation

The DBCMI system is developed and executed in Microsoft Windows Server 2010 for use by the project manager, project engineers, the BIM manager, and BIM engineers. This study uses the BIM model as a visual tool for the interfaces. The BIM model elements are broken down and entered into the database of DBCMI system in advance. These elements are linked with the interface information in the DBCMI system for interface management using API programming. The proposed DBCMI system enables participants to access the related interface information and records through the database-supported elements of the BIM models, which were developed for this study using Autodesk Revit and Trimble Tekla Structure.

Interface issue information integrated with the BIM elements in the BIM models was achieved using application programming interface (API) and Microsoft Visual Basic .Net (VB.Net) programming language. Furthermore, WebGL technology is utilized to display BIM models and elements of the BIM models in the web environment in the study. Figure 5 shows the framework of the DBCMI system. Figure 6 presents the system and modules of the DBCMI system. Figure 7 illustrates the system process flow chart used in the DBCMI system.

The DBCMI system utilizes a three-tier architecture to integrate the database-supported elements with the BIM models' illustration. This improves and enhances the BIM-based interface management. The three distinct tiers are the database layer, the application layer, and the presentation layer, which are described in the following.

The database layer comprises two databases on the server side: the BIM-CMI database and the BIM elements database. The BIM-CMI database stores and maintains all communication records regarding interface issues, and the BIM elements database stores all information related to the BIM model elements. The two databases are associated with a unique ID linked to the main index by a primary key. The unique ID is required for retrieving complete interface information from the two databases to perform data associations needed for data mapping for CMI work. A firewall protects the system database from intrusion.

The application layer integrates and utilizes BIM software for various applications required for indexing, updating and transferring data/information, visualizing the status, and generating reports. When the application programming interface (API) modules in the DBCMI system receive a request from the client, the application layer can acquire and analyze the data based on the request and present the results to the client side.

The presentation layer, the main illustration platform of the DBCMI system, enables the project manager and project engineer to access and edit the interface communication records and the responses to topics associated with the BIM model elements via a PC or tablet (client side) for CMI implementation.

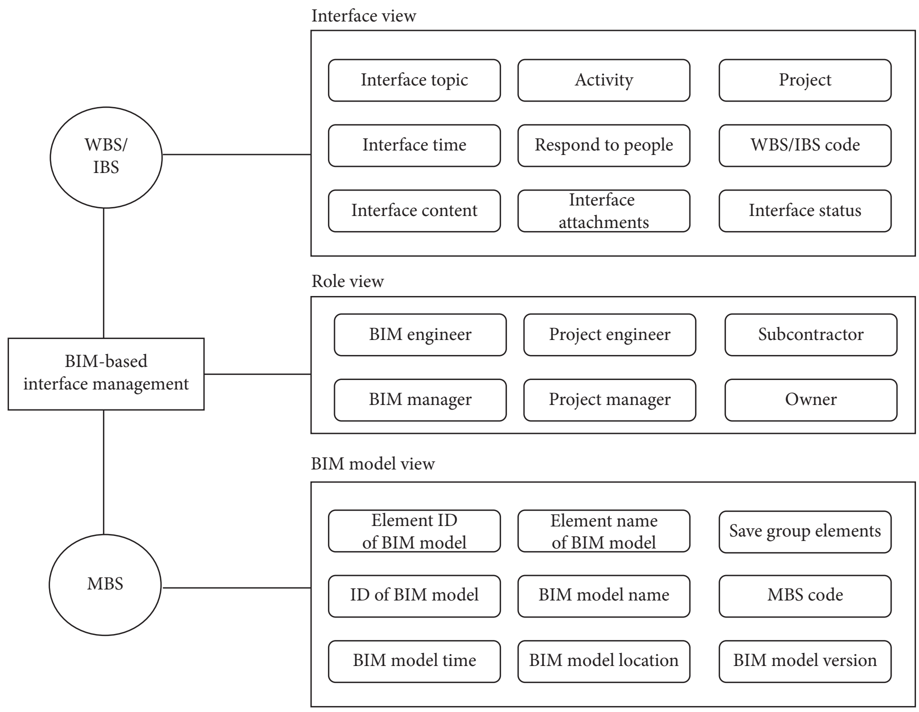

Figure 3: The framework of database- and BIM-based interfaces communication and management.

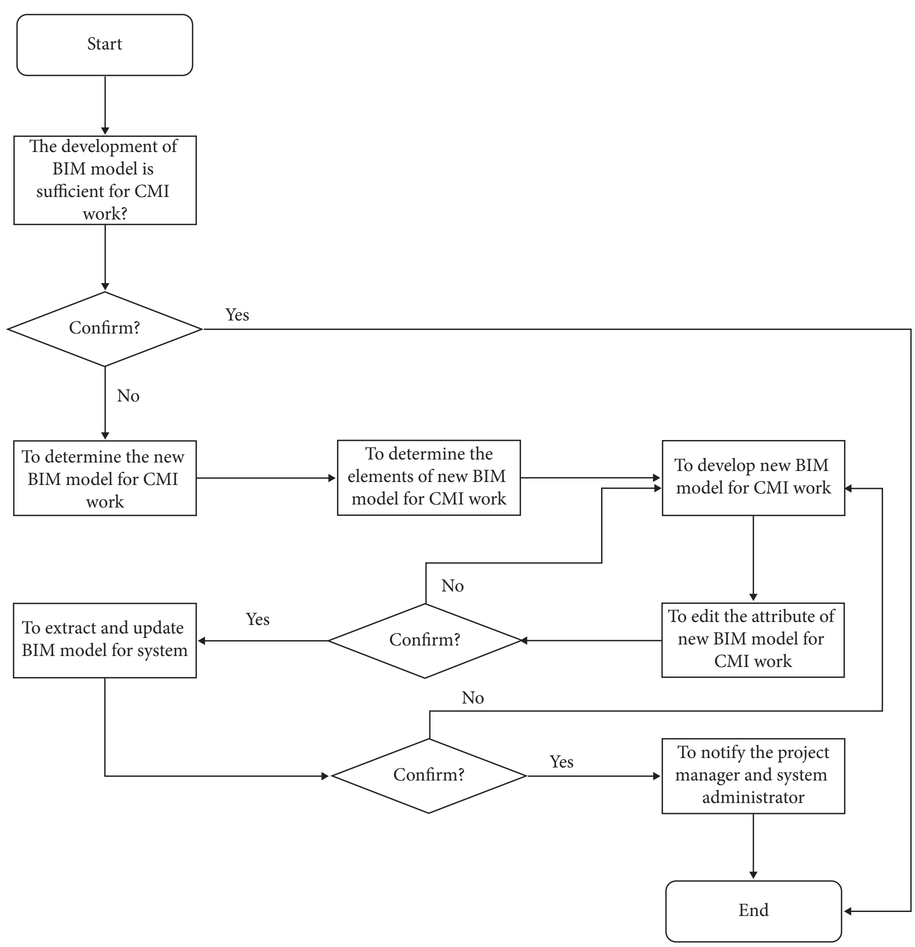

Figure 4: The preprocessing of BIM models for CMI work.

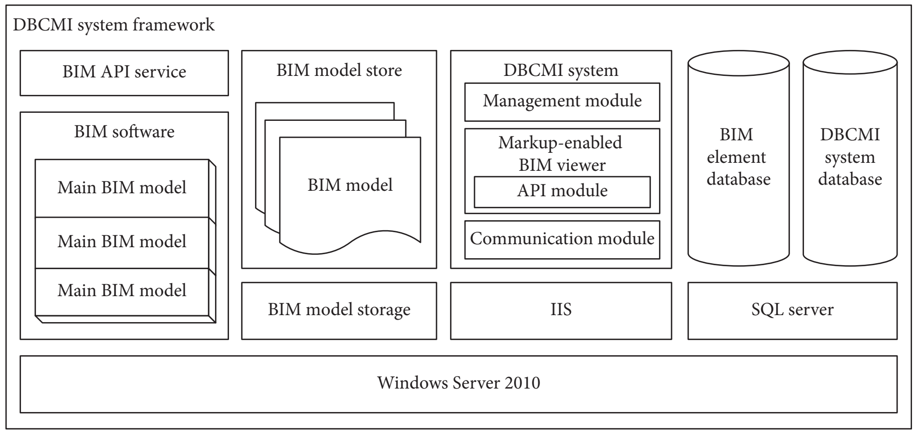

Figure 5: System framework of the DBCMI System.

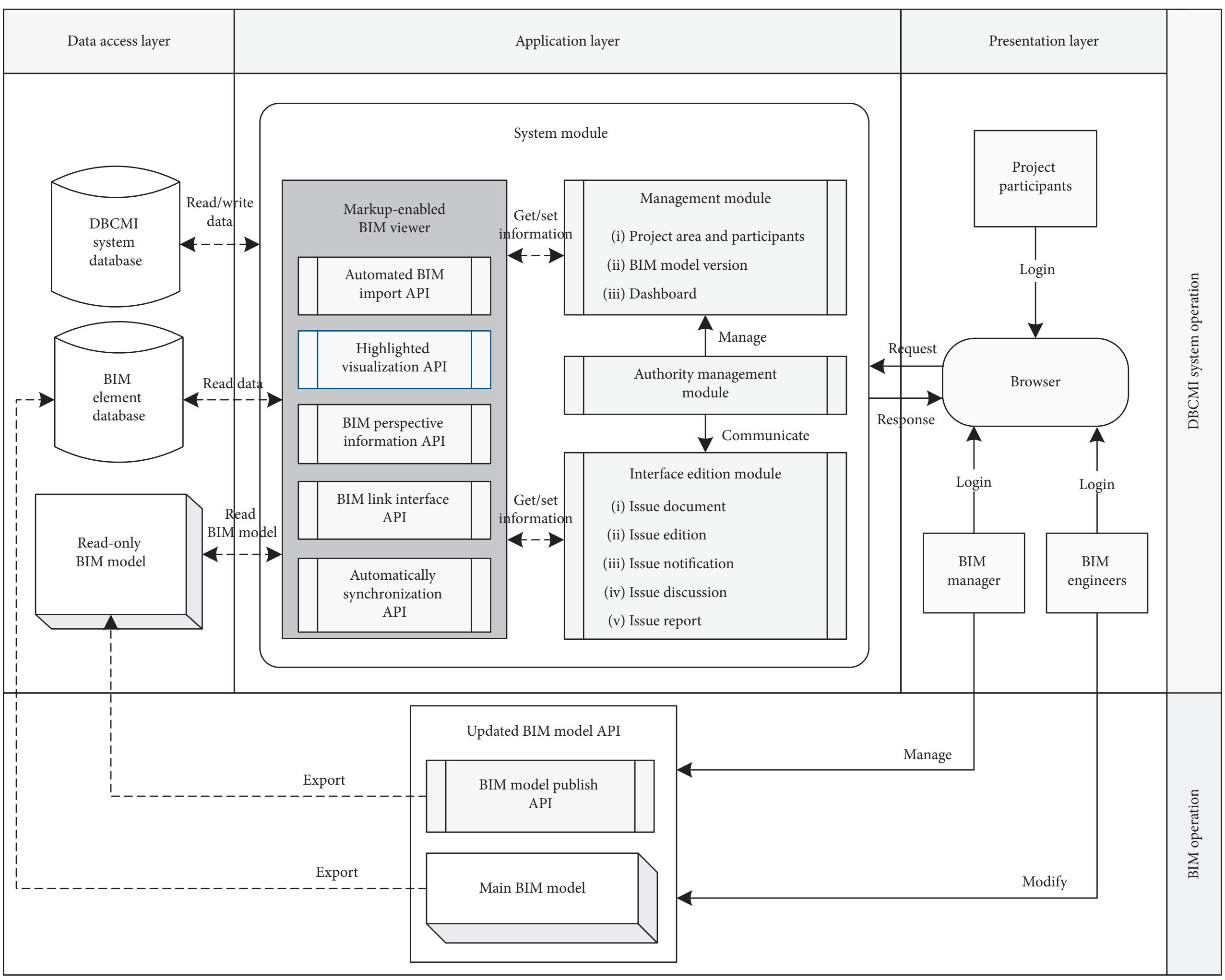

Figure 6: System and modules of the DBCMI system.

This study develops a novel markup-enabled BIM viewer integrated with WebGL technology to enhance and track interfaces of markup information linkage with the elements of BIM models efficiently during the CMI work process. The markup-enabled BIM viewer can be defined as a 3D CAD graphic representation of interface issues linking relationships between BIM objects and attributes of interfaces. The markup-enabled BIM viewer, which is defined in multiple objects, is constructed from variables that can be decomposed into elements of BIM model to store the identified problems of CMI work. The markup-enabled BIM viewer allows users to access CMI-related problems stored in layers based on

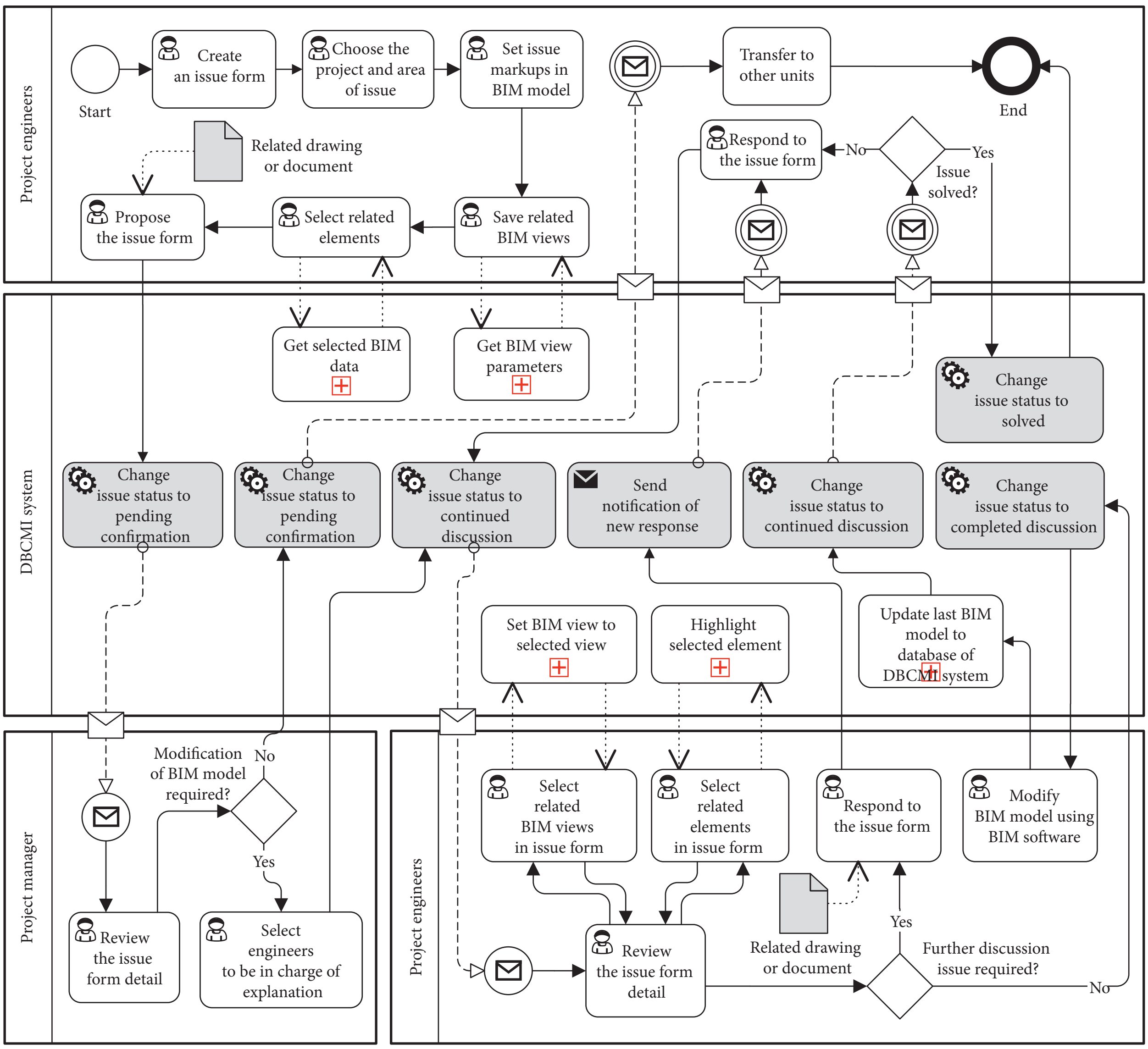

Figure 7: The system process flow chart used in the DBCMI system.

interface problem. Only authorized participants can access the markup-enabled BIM viewer for interface issue information entry and update based on their responsibilities in the DBCMI system. The BIM approach retains digital interface information and enhances CMI-related discussion and communication in the BIM environment. The markup-enabled BIM model elements are designed to be easily integrated with interfaces and elements of BIM models. Assisted by the 3D BIM approach, CMI-related problems in the markup-enabled BIM viewer can be identified and managed effectively during the process.

The following section demonstrates the implementation functionalities of the DBCMI system.

4.1. Authority Management Module. The proposed module includes an access control mechanism that prevents unauthorized users from accessing sensitive information. Only registered project participants have access to the DBCMI system, and access rights and authorities vary for different project participants.

4.2. Interface Edition Module. This module provides an environment for project participants to edit interface information (or attached files), select elements of BIM models, and communicate with each other in a similar way to instant messaging, enabling users to exchange comments online. Project participants can post questions, responses, and comments, thereby generating records of discussions regarding particular topics.

4.3. Search Module. To enable project participants to search the interface quickly and easily, the search module offers indexing, full text search, element ID search, and location/area search functions.

To integrate the system with the elements of BIM model, the DBCMI system incorporates the following six API programming modules.

4.4. Automated BIM Import API Module. This module improves the effectiveness of importing BIM elements into the editing format by automating the process. Users can directly edit the interfaces of the BIM models.

4.5. Highlighted Visualization API Module. This module uses bright colors to highlight relevant elements of the BIM model, providing the user with swift and effective access to the relevant interface.

4.6. BIM Link Interface API Module. This module links the two databases through an element ID index. This data association can be used to retrieve complete information and records of interfaces for data mapping.

4.7. BIM Perspective Information API Module. This module allows the project participants to save their current view of the BIM model (i.e., view position, direction, elevation, distance, and zoom information) so that other project participants can access the same view to get a clear understanding of the interface and BIM model elements.

4.8. Automatic Synchronization API Module. This module enables users to access the latest BIM model elements in the system. To maintain an accurate and efficient system performance, the module automatically synchronizes updated BIM model element information.

4.9. Dashboard API Module. This module enables users to access the latest interface status and information directly through the dashboard. To improve the tracking and management performance for CMI work, the module automatically synchronizes the newest updates to interfaces in the dashboard.

The BIM engineer is responsible for creating the BIM models, breaking the BIM model down into elements, and saving them in the BIM elements database prior to commencing CMI work operations. The BIM engineer also updates and resynchronizes the BIM elements database when the content of the BIM models is changed or revised. Finally, Figure 8 illustrates comparison of CMI work process in the current practice and the proposed DBCMI system.

5. Pilot Case Study

5.1. Pilot Case Description. This section presents a pilot study demonstrating BIM implementation to manage construction interfaces in Taiwan. The case includes a general contractor who has 28 years of experience and intends to adopt BIM to enhance construction interface management for a 13-month commercial building project with approximately 2,350 activities. The project comprises three underground and 16 above-ground floors. The general contractor has previously adopted BIM for interface management but believes that the models are not free from certain limitations. Consequently, the contractor utilized the DBCMI system to communicate and manage interfaces and verify its effectiveness for CMI.

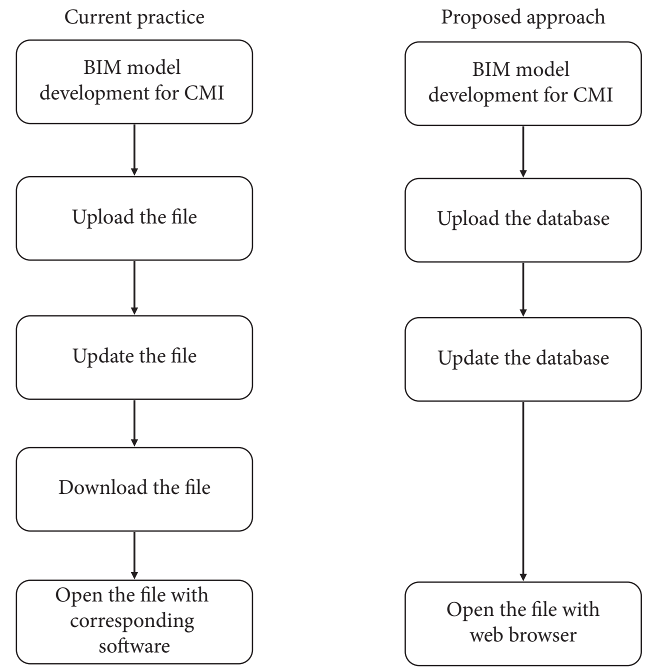

Figure 8: Comparison of CMI work process in the current practice and the proposed approach.

We asked all participating engineers to evaluate the DBCMI system and conducted a field test by first inviting participants to discuss the possible issues faced while using the DBCMI system. Here, we present the case of an interior decoration engineer in charge of door installation on the first floor of the project. Prior to installation, the engineer was required to undertake certain prework and thus used the system to enter and edit related interface information for interface management. Next, the engineer selected interior-related elements in the BIM model using the markup-enabled BIM viewer and edited the associated WBS, IBS, and MBS codes. Upon entering the information and attaching the related files, the engineer assigned two on-site engineers to the issue on the DBCMI system. Once this request was confirmed by the project manager, the pending status changed and the selected participants were notified via e-mail.

As the DBCMI system reflected a continued discussion status, one of the two responsible on-site engineers received an automated e-mail notification and was required to respond to the related interface issue. To do so, the on-site engineer selected the interface issue, accessed the door installation elements in the concerned BIM model, and reviewed the content (Figure 9). The on-site engineer identified possible delays in the schedule owing to specific reasons and accordingly the system highlighted in red the impacted elements of the BIM model for door installation to indicate the delay (Figure 10). The on-site engineer then submitted the issue along with the necessary explanation. Once the issue was updated in the system, both the interior decoration engineer and the other on-site engineer were e-mailed an update.

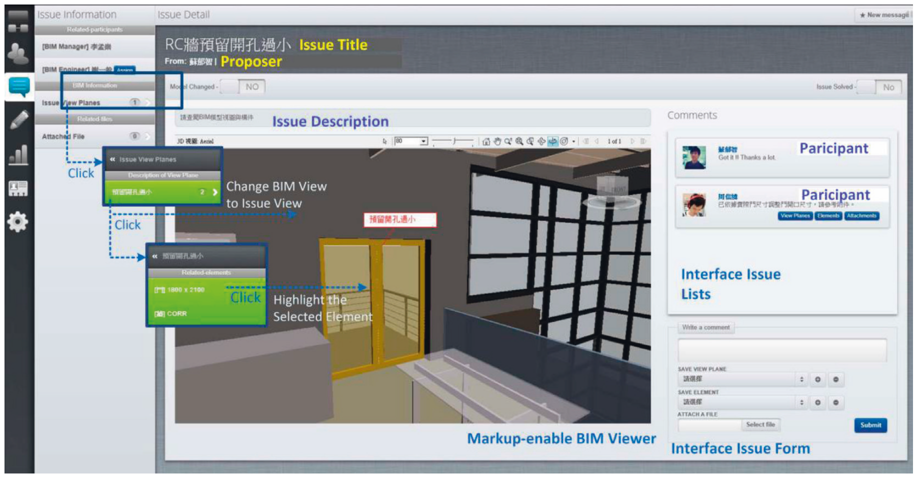

Figure 9: The interface-sharing using the DBCMI system in case study.

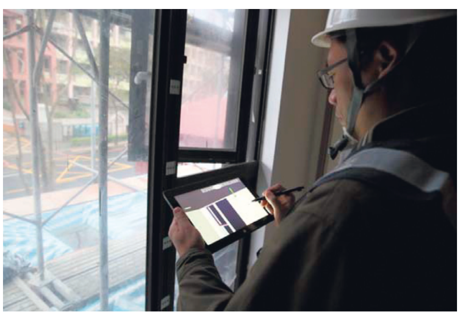

Figure 10: On-site engineer accessed and responded interface contents using the DBCMI system at construction site in case study.

The interior decoration engineer then proposed the closure of the interface discussion and waited for the project manager to confirm this action. Once the project manager confirmed the closure, the DBCMI system updated the issue with a completed discussion status. All authorized participants were notified of this update via e-mail.

5.2. Field Tests and Results. Prior to conducting the field experiment, we installed the DBCMI system on the general contractor's main server. Participants in the project were asked to use the DBCMI system for CMI work. We performed tests to verify if the system operated in line with the specified tasks and validated system utility. As part of the tests, the participants—including two project managers with 20 years of experience, six senior project engineers with 10 years of experience, five junior project engineers with two years of experience, and three BIM engineers with four years of experience—were asked to provide feedback via questionnaire. The questionnaires focused on evaluating system function and determining user satisfaction with system capabilities. Then, we asked the users to compare the system with previous approaches and grade its usage, functionality, and capability on a five-point Likert scale, where 1 denotes "not useful" and 5 is "very useful." In addition, we asked the participants to offer recommendations for possible improvements to the DBCMI system. We observed that the majority of participants used the DBCMI system for BIM. Table 2 shows the results for the tests and Tables 3 and 4 list the project engineers and project managers' evaluation comments.

Below are our major findings for the DBCMI system and its benefits. First, 85% of respondents agreed that the system facilitated their access and referral to BIM-related interface information that was integrated with BIM model elements. Second, 86% of respondents could use the system to collaborate with other stakeholders and share interfaces related to the BIM elements in the 3D BIM models. Finally, 90% of respondents stated that the DBCMI system facilitated effective communication and management in a web-based BIM environment.

However, the respondents also highlighted certain limitations. First, the number of updates of content stored on the DBCMI system was insufficient to complete CMI work. Second, modifying and updating the BIM models was time consuming and the BIM engineers needed considerable assistance. Unfortunately, certain participants were unwilling to provide feedback on interface updates and related procedures.

The respondents offered the following recommendations on the basis of their system usage. First, project managers and engineers should be allowed sufficient time to edit and respond to BIM-related CMI information. Second, support from the senior management regarding system implementation is imperative to ensure successful utilization of the DBCMI system. Third, project engineers should be sufficiently trained to review the BIM models using the markup-enabled BIM viewer. Finally, the results from the initial case study should be used in user education regarding the BIM software and emphasizing the need for training.

In sum, the case study highlights that senior management support is essential to successfully implement and adopt BIM on-site. In this case study, the job site manager extended complete support to incorporate the DBCMI system and encouraged project engineers to use the BIM model and DBCMI system for CMI work to communicate BIM-related interface issues. In addition, when utilizing

Table 2: System evaluation results.

	Standard deviation	Average rating
System usage		
Ease of interface communication	0.63	4.64
User interface	0.52	4.65
Willingness to use system for interface communication	0.53	4.32
Ease of use	0.63	4.64
System capability		
Reduces rework	0.47	4.71
Easy of finding BIM-based CMI information	0.52	4.23
Improves BIM-based CMI problems and results tracking	0.47	4.71
Reduces BIM-based CMI communication rework	0.52	4.50
Enhances BIM-based CMI response records	0.43	4.62
Reduces BIM-based interface issues sharing problems	0.52	4.50
Illustrates and understand BIM-based interfaces clearly	0.43	4.23
Enhances BIM-based interface illustrations using BIM model elements	0.41	4.76
Improves BIM-based complete records for CMI work	0.42	4.53

Note. The mean score is calculated on the basis of the participants' rating on a five-point Likert scale, where 1 = "strongly disagree" and 5 = "strongly agree."

Table 3: Project engineers' evaluation comments.

No.	Participant comments
1	The proposed DBCMI system integrated with the markup-enabled BIM viewer is very useful in handling identified interface problems with related BIM model elements.
2	The DBCMI system saves considerable time (almost one-third) when handling interface problems and responses (e.g., reentry of information) and helps me to communicate and resolve interface issues at the job site effectively.
3	I can use the DBCMI system to respond to current interface problems (or discussions) and easily access unfinished interface results.
4	The system helps me to understand all interface problems, explanations, and illustrations through the BIM models easily and quickly.
5	The DBCMI system is very effective in the CMI process and allows me to communicate the BIM model elements related to the interface issues with the engineers.
6	The biggest advantage of DBCMI is that it records all communication regarding the BIM model elements. This is helpful when I need to refer back to necessary information about the elements.
7	The DBCMI system is very effective for interface management integrated with BIM. I can access the system via the Internet to read interface information.
8	The case study does not cover all interface issues regarding the BIM models. Therefore, there are likely to be problems in the practical application of BIM technologies for interface management.
9	While the practical application is subject to many limitations, the DBCMI system can enhance the performance of interface communication.
10	I previously used e-mail to check and track the latest inspection results and modification work for the final as-built model. With the proposed markup-enabled BIM viewer under the DBCMI system, I can now do the same more quickly and effectively. The system significantly helps project engineers to communicate and discuss interfaces and improves the decision-making process.

BIM as a communication tool for CMI work, it is necessary to update the model to its latest version.

6. Conclusions

The BIM approach has been one of the most promising developments in the architecture, engineering, and construction (AEC) industry in recent times. The CMI work can be integrated with BIM technology to assist stakeholders such as project managers, project engineers, and BIM engineers in the construction phase of their projects. This study thus proposes a novel database-supported BIM-based CMI system integrated with elements of the BIM model to enhance CMI work. The DBCMI system allows project participants to manage and respond to all interfaces via a web environment integrated with WebGL technology.

The academic and practical literature suggests numerous BIM-based system developments related to construction interface management; however, the majority of the BIM-based systems for CMI work are file based. A key characteristic of the proposed DBCMI system is its ability to overcome the limitations of file-based BIM models, thus enabling more effective visualization and sharing for BIM-based interface management during the project construction phase. In addition, we introduce IBS and MBS approaches to integrate BIM and interface management. This solution can improve the visualization of interface discussions and management among project participants. In particular, it helps effectively integrate discourse in the BIM model and improve the communication of information when interfaces are related to BIM model elements. Further, the API modules used in the DBCMI system are designed and developed with a simplified user interface and operations to increase the willingness of participants to use the system, especially among participants who are unfamiliar with BIM software.

In this study, we verify the effectiveness of the proposed DBCMI system for CMI work by applying it to a Taiwanese building project. The results of the case study reveal that the system allows participants to identify, track, coordinate, and manage interfaces that are integrated in the database-supported elements of the BIM models. The field experiment results further support that the proposed system with BIM and WebGL technology provides an effective, user-friendly platform for construction interface management.

Table 4: Project managers' evaluation comments.

No.	Participant comments
1	Generally, using screen captures of BIM models and communicating interface discussions with related engineers can be time consuming. The system is a helpful communication platform for BIM models integrated with illustrations on the web that saves much time when communicating interfaces.
2	The DBCMI system helps me to manage current interface results and track all ongoing interfaces effectively. The system is more convenient and helpful than e-mail.
3	The DBCMI system provided me with easy access to related interfaces and information and it helps communicate and handle interface problems and responses.
4	I previously used e-mail to check and track interface issue results and work. However, with the DBCMI system, I can trace and manage the same more quickly and effectively. In fact, the system is very useful for project engineers and managers when handling interface problems and responses.
5	The DBCMI system records all communication regarding the BIM model elements, which is very helpful when I need to refer to related information. Also, the DBCMI system's functions differ from those of existing BIM tools and software.
6	It took me a while to learn the DBCMI system. In the beginning, it was not easy and I needed other engineers' assistance to use the system. However, I am now used to managing and responding to interface issues using the system.
7	One of the problems I faced before using the DBCMI system was not being able to understand the mistakes identified and illustrated by the BIM models. The DBCMI system helps me to understand all problems, explanations, and illustrations regarding construction interface issues more easily.
8	The proposed markup-enabled BIM viewer in the DBCMI system could significantly enhance interface discussions and responses and applies an effective view of construction interface management.

This study makes the following major contributions. First, we introduce IBS and MBS approaches integrating BIM and interface management. Second, we develop a novel markup-enabled BIM viewer using API to simplify BIM-based interface management. Finally, the database-supported DBCMI system overcomes the limitations associated with using traditional file-based BIM models for CMI work.

Going forward, construction interface management can be improved and integrated with innovative technology. For example, BIM can be integrated with augmented reality (AR) and virtual reality (VR) technology to visualize construction interface management effectively by general contractors during the construction phase.

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The author declares that there are no conflicts of interest regarding the publication of this paper.

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