

Development of Web-based BIM Models Inspection and Modification Management System for Supervisions

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Abstract –

The building information modelling (BIM) approach, which is utilized to retain information in a digital format, facilitates easy information updating and transfer in the three-dimensional (3D) CAD environment. When the application of BIM models are adopted in the project, the inspection and the inspection and modification records of BIM models are necessary to be communicated and managed effectively. However, emails, one of the most convenient ways, is selected and adapted as a communication tool among BIM manager, BIM engineers, and supervisions during the BIM models inspection and modification process. Also, it cannot record and manage the BIM models inspection and modification information and results effectively during the process. Therefore, this study develops a web-based BIM models inspection and modification management system integrated with workflow management. Concepts for supervisions to enhance BIM models inspection and modification work efficiency. The proposed system is applied to a case study of a building project in Taiwan to verify its efficacy. Finally, the study identifies the major benefits, limitation, and facing problems throughout the case study.

Keywords –

BIM; Building Information Modeling; Workflow Management; Web-based System

1 Introduction

Development of information communication technology (ICT) arouse the modern architecture, engineering, and construction (AEC) industry upgrading to Informatization. Researchers have been investigating the components and repercussions of building product models[1]. Building Information Modeling (BIM) as a new term appeared in 2006 Autodesk new product description[2]. From conceptual to descriptive in nature, research or industry bodies as well as commercial

software vendors import BIM into advanced study and practical applications. BIM is becoming mature due to developing collaboration platforms and related BIM uses. So stakeholders focus to manage BIM models information better than before.

Nowadays Cloud-based collaboration platforms have solved the interoperability of multi-disciplinary team. All of them have BIM models collaborative function corresponding to specific stakeholders. But this kind of operating mode have not been implemented in traditional inspection yet. Currently, supervision still inspects construction company BIM models in construction phase by email approach, a unilateral delivery method, which is lacking of communication with each other and leads to dispersing BIM models information. Therefore, the current traditional BIM models inspection must be improved, and also modifiable management workflow between supervision and construction company.

To address the above problems, this study expects to integrate BIM models with workflow management and web-based technology to develop an inspection and modification system of BIM models. It can improve the workflow management of inspection and modification for BIM models, and interactive coordination efficiency of supervision and construction company. Furthermore, supervision may utilize this system to control BIM models status in process. Through BIM models inspection and modification management system, supervision can proactive manage BIM models in the construction phase and confirm BIM models status in workflow. The system will also promote the consistency, correctness and completeness of BIM models information in the inspection and modification workflow.

2 Literature Review

Building information modeling (BIM) is an emerging technological and procedural shift within the Architecture, Engineering, Construction and Operations (AECO) industry[4], then BIM is not just a

technological change, but also a change of process[5]. A set of interacting policies, processes and technologies are generating a “methodology to manage the essential building design and project data in digital format throughout the building’s life-cycle”[3].

Establishing the goal of each phase in the building’s life cycle play an important role in BIM application. Each phase of milestones need to deliver documents, meeting records and signing contracts. Besides, milestones would separate design, construction and operation phase. The content of policy decision must be finished at this stage and the promise must be fulfilled at next stage[6]. Therefore, there is need for a framework that positions BIM as an ‘integration of product and process modelling’ [7] and not just as a disparate set of technologies and processes.

Tien-Hsiang Chuang et al.(2011) indicate that BIM desktop applications can only integrate information on-site. Difficulties remain in obtaining and updating information from other sites, which restricts communication and information distribution between different sites. The study utilize the concept of software as a service (SaaS) and cloud computing in order to develop a visual system for BIM visualization and manipulation. This system cannot only visualize three-dimensional (3D) BIM models, but manipulate 3D BIM models through the web without the limitations of time or distance. Therefore, the system can facilitate communication and distribution of information between related participants in order to manage projects effectively and efficiently[8].

Rong-Chin Kuo et al.(2014) describe current BIM integrating, exchanging and managing information in BIM collaboration. Across disciplines have been major challenges in the AEC industry. This research designed and constructed a “BIM collaboration cloud platform” is based on Microsoft virtual desktop infrastructure (VDI). The platform benefits of the advantages of cloud computing which helps facilitate the integration of information across disciplines during the design and construction phase[9].

Zhiliang Ma and JiankunMa et al.(2017) indicate that existing collaboration platforms may be unable to support the collaboration among multiple participants and specialties due to this characteristic. The study formulates the application functional requirements for such a BIM-based collaboration platform by analysing case studies of integrated project delivery(IPD) projects. And then their conclusions indicated that a dedicated BIM-based collaboration platform is necessary. Formulated application functional requirements can be used in the development of such a platform or for customizing an existing commercial collaboration platform to improve the support of IPD projects[10].

3 System Development

Web-based BIM models inspection and modification management system includes three-tier framework : BIM models inspection and modification management and BIM model tracking mechanism.

3.1 System Framework

The system primarily assists BIM models inspection and modification between supervision unit and construction company. In order to dynamic communication in the workflow the study integrates BIM models inspection and modification management and three-tier framework, supplemented by permissions check. Furthermore, supervision unit may monitor the progress of BIM models inspection and modification status via configuring BIM model status as well as BIM model tracking mechanism for effective managing BIM models (see Figure 1).

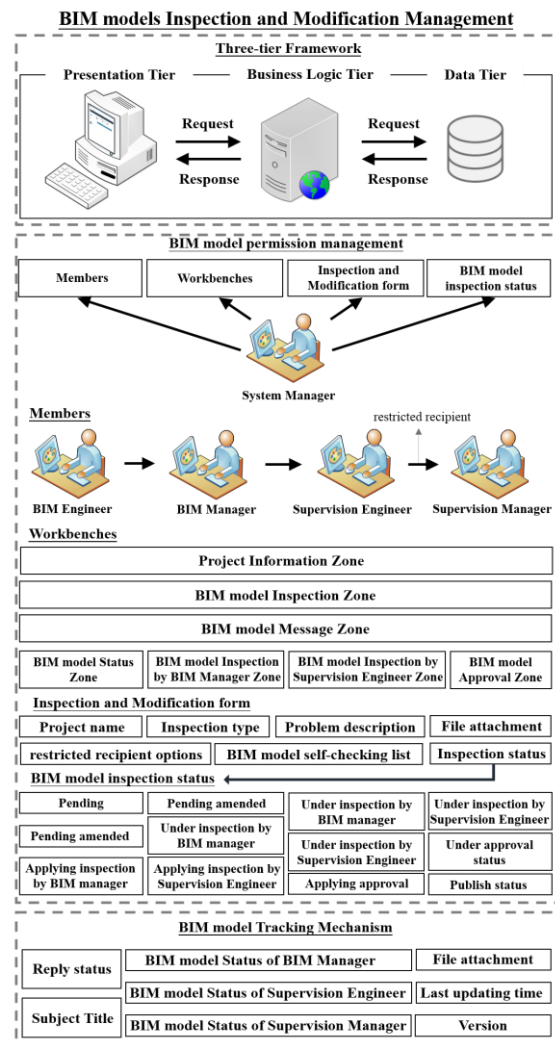


Figure 1 The Framework of BIM Models Inspection and Modification Management System

3.2 System Workflow

The main purpose of the system provides supervision unit the work flow of BIM models inspection and modification to manage the AEC models of a construction company during the construction phase. Moreover, the system utilizes the same form throughout the work flow of the system for guaranteeing the correctness, completeness and consistency of inspective and modifying information (see Figure 2).

1. After BIM engineer has finished AEC models, logging in web-based BIM models inspection and modification management system, the BIM engineer get into BIM model inspection zone completing the inspection and modification form. In order to properly manage AEC BIM models uploading in a file attachment method, the format of BIM models allows txt, pdf, doc, jpg, png, nwc, nwd format, and then must get standardized name of the file. When BIM engineer submit the form at first time, the status of BIM model will display "pending" status.
2. If BIM manager has received the notification in BIM model inspection, the inspection of the form will start related BIM models. If BIM model inspections were passed by BIM manager, BIM models status of the form will ask for applying inspection status by supervision engineer. In case they were rejected by BIM manager, BIM models status of the form will be asked for modification of BIM engineer, pending amended status by supervision engineer.
3. When supervision engineer has received the notification of BIM model inspection then supervision engineer started to inspect the form and related BIM models. If BIM model inspections have been passed by supervision engineer, BIM models status of the form will be ask for applying approval status of supervision manager. If they were rejected by supervision engineer, BIM models status of the form will be ask for under inspection by BIM manager.
4. When Supervision manager receive the notification of BIM model approval then start to inspect the form and related BIM models. If BIM model inspections are passed by supervision manager, BIM models status of the form will become publish status update information of BIM models for owner and supervision unit. Otherwise, if they are rejected by supervision manager BIM models status of the form will proceed to under inspection by supervision engineer for reinspection.

3.3 BIM models inspection and modification management

BIM models inspection and modification management consists of three-tier framework, BIM model permissions management, and BIM model tracking mechanism, as follow:

Three-tier framework consists of Presentation Layer, Business logic Layer, and Data Layer, as follow:

- Presentation Layer

This layer mainly transports the system members requestments to Business logic Layer and obtains Business logic Layer's output to display to related members. According to permissions of the system members to user's interface via Bootstrap for allowing supervision unit and construction company to utilize the system by computer or mobile device.

- Business logic Layer

This layer provides the web service for the BIM models inspection and modification by Drupal content management system and Apache HTTP server transporting the request of the presentation layer to data layer and extracts information from it. And transports the information of data layer to presentation layer.

- Data Layer

The system manages database and data backup via phpmyadmin. This layer stores all of the related system information.

BIM model permissions management consists mainly of members, workbenches, inspection and modification form and BIM model inspection status of BIM models inspection and modification management system. The workbench of system includes Member Management Zone, BIM model Inspection Zone, BIM model Status Zone, BIM model Inspection by BIM manager Zone, BIM model Inspection by supervision engineer Zone, BIM model Approval Zone, BIM model Message Zone, and Project Information Zone. Each workbench has specific rules to control system permissions. But all system members have access to project information zone, BIM model inspection zone and BIM model message zone.

The system has four kinds of members: BIM engineer, BIM manager, supervision engineer, and supervision manager, as follow:

1. BIM Engineer: This member mainly fills out the inspection and modification form and has BIM model status zone alone for BIM model condition in inspection and modification progress.

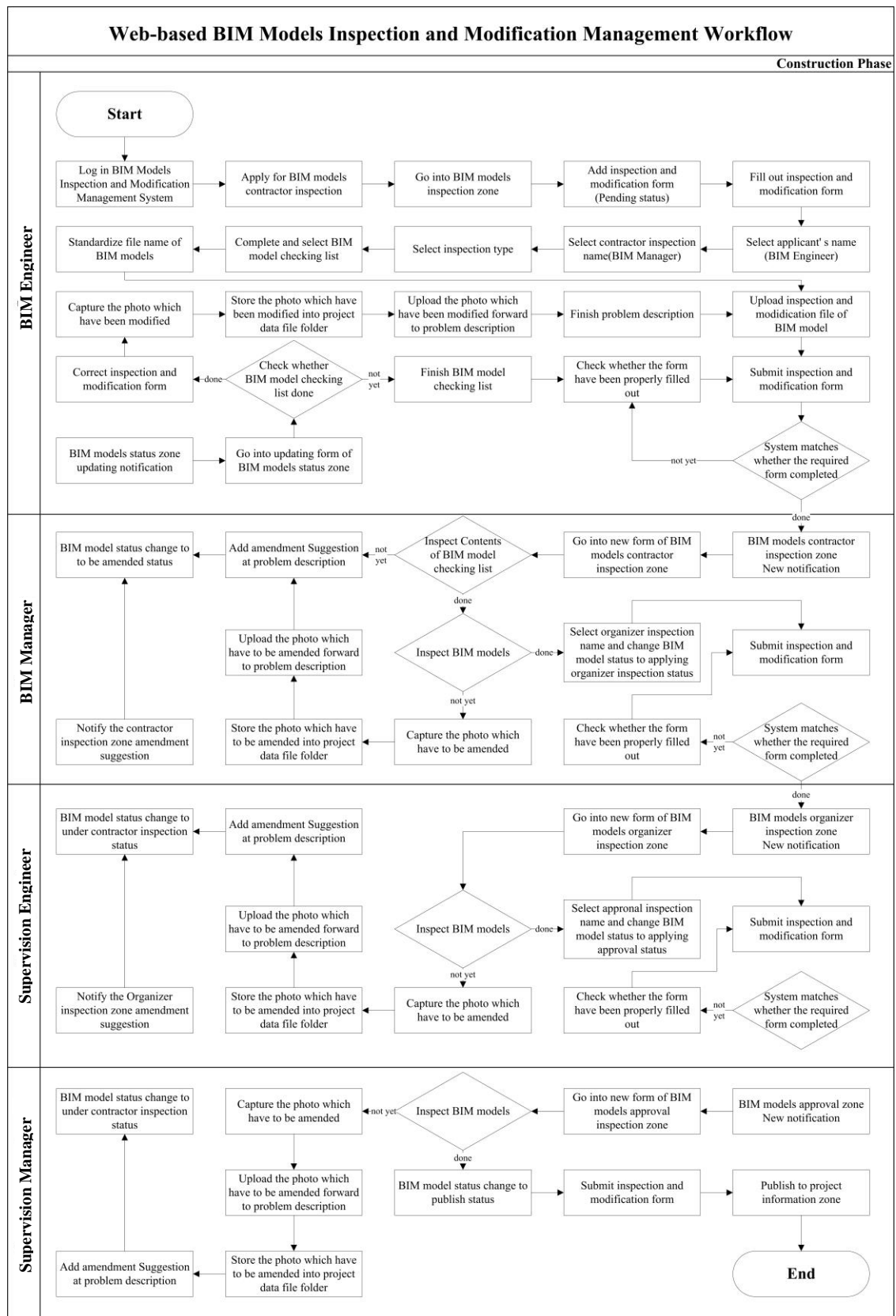


Figure 2 Web-based BIM Models Inspection and Modification Management Workflow

2. BIM Manager: This member primarily inspects BIM Engineer's BIM model and has BIM model Inspection for implementing models or giving advice.
3. Supervision Engineer: This member inspects BIM Engineer's BIM model being received by BIM manager and has BIM model inspection for implementing models inspection or giving advice.
4. Supervision Manager: This member primarily inspects BIM Engineer's BIM model having received from supervision engineer and has BIM model Approval Zone for implementing models approval or giving advice.
5. System manager: This member primarily sets up the system, which masters members registration and system permissions management before the project starts.

The content of inspection and modification form includes project name, BIM model inspection status, restricted recipient options, inspection type, BIM model self-checking list, problem description and file attachment. Especially, the name of file attachment is according to PAS1192-2:2013 published by British(as shown in Figure 3) .



Figure 3 The name of file attachment in the system

BIM model inspection status consists of pending status, pending amended status, applying inspection by BIM manager status, under inspection by BIM manager status, applying inspection by supervision engineer status, under inspection by supervision engineer status, applying approval status, under approval status and publishing status. According to permissions configuration, both system member and their workbenches have particular BIM model status before the project starts.

3.4 BIM model tracking mechanism

Permits each system member clear rights and efficient management is according by each permission of system members for clear rights and efficient management. BIM model tracking mechanism has eight kinds of functions including reply status, subject title, BIM model status of BIM Manager, BIM model status of Supervision Engineer, BIM model status of Supervision Manager, file attachment, last updating time, and version, as follow:

1. Reply status : When inspection and modification form has been changed, this column will display two kinds of symbols, one is “New”, another is

“updated”. New symbol will display to each members, when they receive the form for first time, and updated symbol will show to all the system members when someone modifies or adds suggestions(as shown in Figure 5).

2. Subject Title : The content of the column shows the name of inspection and modification form via BIM engineer applying.
3. BIM Model Status of BIM Manager : The column shows the result of BIM model status which has been changed by BIM Manager. BIM Model Status of BIM Manager has four items, including pending amended status, under BIM manager status, applying inspection by supervision engineer status, and pending status.
4. BIM Model Status of Supervision Engineer : The column shows the result of BIM model status which has been changed by Supervision Engineer. BIM Model Status of Supervision Engineer has three items, including under inspection by BIM manager status, under inspection by supervision engineer status, and applying approval status. These three items represent three situations. When Supervision Engineer choose under inspection, BIM Manager must inspect again and then choose the BIM model status. When Supervision Engineer choose under inspection, it means that the form is inspected. When Supervision Engineer choose applying approval status item, Supervision Manager must inspect and then choose the BIM model status.
5. BIM Model Status of Supervision Manager : The column show the result of BIM model status which has been changed by Supervision Manager. BIM Model Status of Supervision Manager has three items including under inspection by supervision engineer status, under approval status, and publish status. These three items represent three situations. Under inspection by supervision engineer status item means that the form needs to be inspect again. Under approval status item means that the form is being inspected, and publish status item means that has been notified every system member.
6. File attachment : The file of BIM models inspection and modification management system is mainly nwc format because it commonly used to view and discuss BIM model.
7. Last Updating time : The column primarily provides the newest updating time. System members inspect and modify early to improve efficiency between members and shorten the period of inspection and modification for proactive management.
8. Version : The column indicates that the sum of inspection and modification and allows time

control by Supervision unit and applies related knowledge management in the future.

4 Case study

4.1 Description of the case study

The present study used Autodesk Revit 2017 developing the proposed BIM model and converting rvt to nwc format. And then, the system as BIM model inspection and modification platform exists between construction company and supervisions. The case type chose construction phase of medium building engineering to test the system benefits and limitations, because of general and ordinary scale.

4.2 Implementation

The case building that is examined in the present study is construction phase of National Taipei University of Technology, Sixth Academic Building. First, BIM engineer converts the built rvt format BIM model to nwc format, and furnishes inspection and modification form then applying inspection. Second, BIM manager receives notification of BIM model inspection by BIM manager zone. When the form passes, BIM manager turns the BIM model status to apply inspection by supervision engineer status, on the contrary turn the status to pending amended status. This moment the reply status column of BIM engineer's BIM model status zone display new update message. BIM engineer utilizes this zone to modify the BIM models and gets the latest inspection status(as shown in Figure 4). Finally, by repeatedly modifying and inspecting the BIM model, passing the inspection of BIM engineer, supervision engineer and supervision manager, and then publishing the BIM model information to project information zone by supervision manager for renewing the latest information to all members in the system.

4.3 Discussion

The system solves many of practical problems, for example BIM engineer may transmit BIM models to wrong recipients, BIM manager or supervision unit's members may inspect incorrect models because lacks version control, and all members cannot understand what situation BIM models inspection are. So the system provides some solutions as follow:

- The inspection and modification form of system limits authors and recipients via fixed button items to avoid wrong submitting.
- The system utilizes BIM model tracking

mechanism to monitor BIM model status and centralize BIM model information, for example versions and BIM model status of all members.

- Through web-based BIM models inspection and modification management workflow clear defines responsibilities of supervision unit and construction company for more efficient and higher quality production.

However, the system handles many of practical problems above. Some limitations and difficulties still existence as follow:

- The system only designs photos uploading and text editing for describing BIM model, it cannot operate BIM construction management software online. System members have to view, rotate, and markup models by their own BIM construction management software.
- The system status changes by permitted members presently, it is inconvenient because members must change status by themselves. In the future, the system may optimize for automation of BIM model status changes.

5 Conclusion

BIM technology has already developed the BIM modeling mode by changing design model to construction model. But Supervision unit cannot control the status of BIM model's modification and inspection during construction BIM modeling process, as well as construction company cannot timely obtain the result of BIM models approval and the suggestion of the unit concerned. In addition, supervision receives the file of BIM model by papers, emails, FTP, or cloud-based platform which are one way delivery, and the whole procedure lacks permission of management.

To improve the efficiency and workflow management of BIM models inspection and modification between supervision unit and construction company. The study develops Web-based BIM models inspection and modification management system, integrating BIM models inspection and modification management and tracking mechanism with permission management and dynamic communication method.

1. For submitting BIM models inspection, Web-based BIM models inspection and modification management system proposes permissions management solution. It helps supervision unit managing BIM models information and actively controlling inspecting progress.

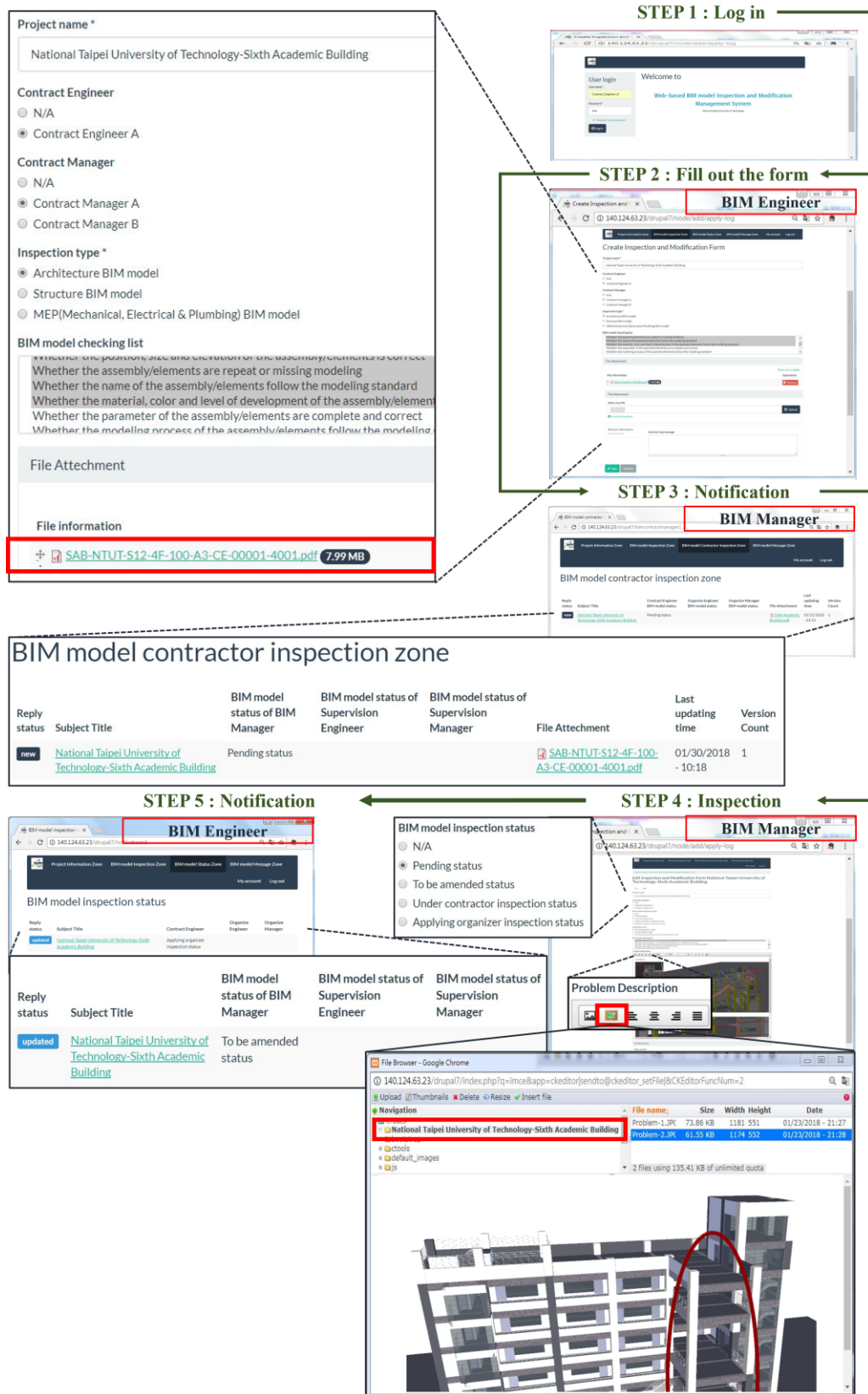


Figure 4 Operation of the BIM model inspection and modification management system

2. BIM models inspection and modification management system supplements traditional inspection workflow. BIM manager, supervision engineer and supervision manager inspect BIM models by single inspection and modification form. It helps improving the correctness, completeness and consistency of BIM models information.
 3. BIM model self-checking list helps BIM engineer examining models and providing other members initial inspection. Supervision unit can obtain error-prone items in the list at the end of the project, for next related project inspecting focus.
 4. BIM model message function strengthens communication and the efficiency of BIM models modification among BIM engineer and BIM manager, and then enhances BIM engineer the site experiences.
 5. BIM model tracking mechanism provides active BIM models inspection and modification management in the construction phase. Let all members understand what present BIM models inspective phase is now and which version is.
 6. BIM model developing process information will be stored in system's database, analyzing the amendment suggestion and feedback to inspection and modification form to adjust the form item for assisting construction phase BIM modeling and BIM knowledge management.
 7. Frequently, BIM models have variety of elements and components in the construction. The numerous number of inspection and modification forms will be submitted, so we need to visualize the inspective status for better management.
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