THE APPLICATION OF BUILDING INFORMATION MODELLING IN A CONSTRUCTION PROJECT IN CHINA

X. Hu[1], D. Zeng[2], Y. Xu[3], C. Liu[4]

[1]PhD research, Deakin University, Australia

[2]PhD, Shandong Jianzhu University, China

[3]Professor, Shandong Jianzhu University, China

[4]PhD, Deakin University, Australia

larry.hu@deakin.edu.au

ABSTRACT

Previous studies have proved the application of Building Information Modelling (BIM) can lead to greater efficiencies. Slowly adopting new technologies and limited technological innovation are criticised for the construction industry. In this paper, we present research that examines the practices of BIM technologies for the clash detection and coordination among building structure, equipment and pipelines, quantity statistics and construction simulation in a construction project in China. The BIM application significantly promotes the abilities to achieve construction schedule, quality, budget, and scope objectives in the project. The technological capabilities of BIM, the illegal issues of BIM outputs and developing cooperative project management culture are needed in order to promote BIM application in the construction industry.

Keywords: Building Information Modelling, China, Construction Project, Clash detection

INTRODUCTION

Construction projects and project management systems become more complex in the modern construction industry. Although information and communication technologies have apparent potentials for development in the construction industry, slowly adopting new technologies and limited technological innovation are characterised and documented, because of structural and work nature of the construction industry such as disintegration, undefined workload, project changes, construction variation, outdated skills, and fieldwork environment (Davies and Harty, 2013). Building information modelling (BIM) is "an intelligent 3D model-based process that equips architecture, engineering, and construction professionals with the insight and tools to more efficiently plan, design, construct, and manage buildings and infrastructure”(Autodesk, 2016). In the BIM system, modelling a construction project in digital form can support project participates in optimising their decisions and actions by simply and naturally displaying a building using a digital model. More importantly, BIM provides a pathway and tool to clear the extremely interdependent feature of structures, architectural layout, and the mechanical, electrical, plumbing, fire life safety systems, and technologically connects project participants (Dossick and Neff, 2009). Therefore, the BIM application can add values for the construction industry through technology innovation.

This research aims to summarise the experience from a successful BIM application in a large-sized construction project in China, which can promote the BIM application in a construction project and demonstrate the application value in the project design and construction stages. Furthermore, some comments for improving the BIM technology and application are provided, which are desired to promote technological innovation and productivity enhancement in the construction industry.

BIM APPLICATION IN THE CONSTRUCTION INDUSTRY

Research on BIM benefits is desirable due to that BIM is considered as a key in solving problems in the construction industry by governments and construction professionals (Demian and Walters, 2014). A BIM-based system possesses the benefits to information management, as the system can exchange considerable information more accurately, on-time and appropriately through diverting information flow and away from the extranet system (Demian and Walters, 2014). Mäki and Kerosuo (2015) investigated BIM as a new technology and a tool in site management and pointed out that few site managers have the abilities in performing BIM software although actively using BIM is beneficial for their daily work of site managers, and insufficient contents of the BIM models are also identified for construction work. Furthermore, the use of BIM in facilities management is increased in coordination, consistency and computation of building information and knowledge management during a building’s life cycle of design, construction, maintenance and operation (Becerik-Gerber et al., 2011).

In the Chinese construction industry, some pioneering participants (especially design institutes) began to explore the BIM application and benefits in construction projects since 2003. Some BIM research institutes have been founded and attempted to apply BIM technologies in project inanition, planning, design, tender, construction and maintenance. Cao et al. (2016) investigated the drives of designers and general contractors to apply BIM in construction projects and studied how different inspirations are affected by organisational BIM capability and other contextual aspects through surveying data in the Chinese construction sector. Ding et al. (2015) surveyed key factors for the BIM adoption by architects in China and believed that the motivation, technical issues and capability of BIM are the statistically significant influences affecting architects' BIM utilise. However, little research about BIM applications can be identified in the Chinese construction projects.

BIM APPLICATION IN A CONSTRUCTION PROJECT

The Jinan West Railway Station is a high-speed railway station in Jinan city of Shandong province in the People's Republic of China. The Station Square Integrated Project delivers the station square, commercial buildings, public transit facilities and underground engineering sub-projects. The integrated project is with a construction area of 320,000 square metres including the underground construction area of 240, 000 square metres. The typical nature of this project is large-scale underground engineering works and complex pipeline installation. Improving design accuracy and reducing design changes are vital management factors in guaranteeing to reach the construction schedule established. Therefore, in order to realise the construction schedule and budget targets through improving pipeline installation efficiency, the project client introduced the BIM system in this project. The main contents of the BIM application consist of the clash detection and coordination among building structure, equipment and pipelines, quantity statistics and construction simulation.

The major precondition is to model the virtual building using the Revit software based on design drawings. The modelling procedures are generally from building structures to building services, from top to bottom, and from big module to small model. The virtual models of building structure and equipment and pipelines are displayed in Figure 1a and Figure 2b, respectively.

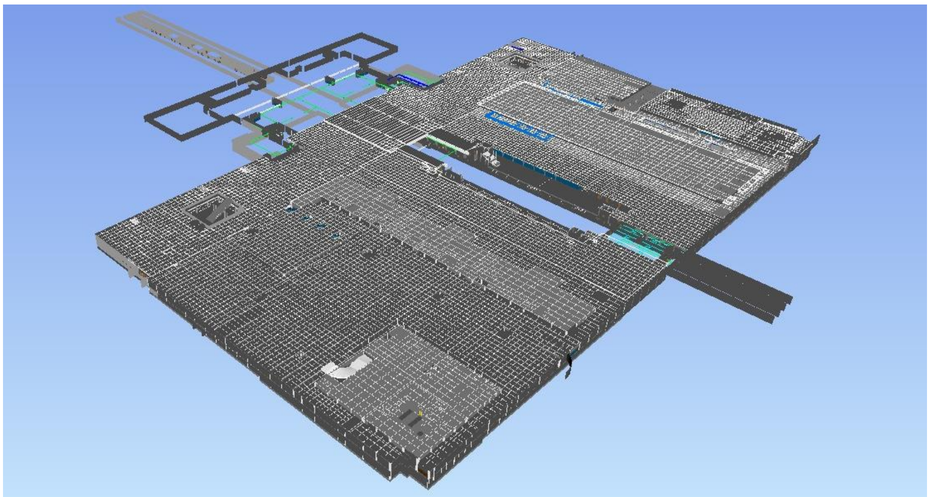

Figure 1a. The virtual model - Building structure

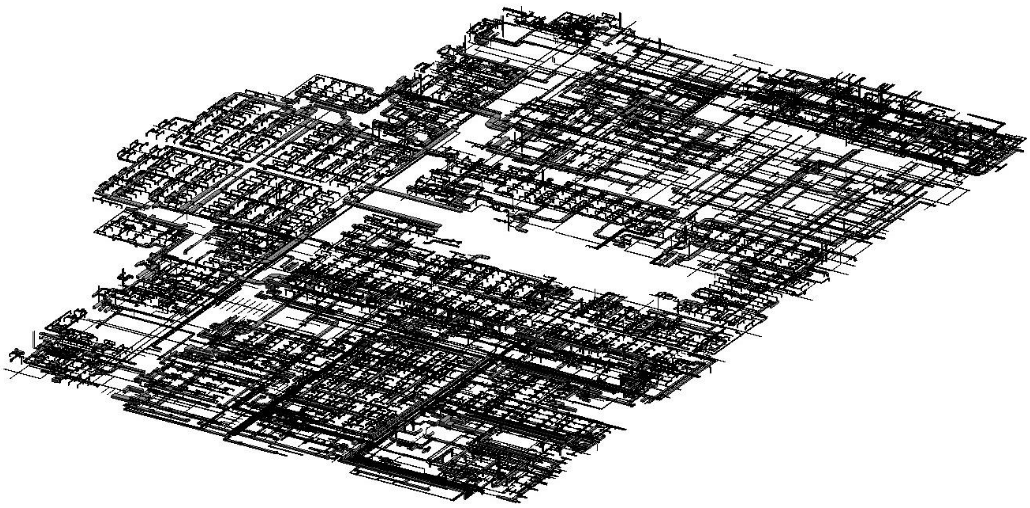

Figure 1b. The virtual model - Equipment and pipelines

The clash detection and coordination among building structure, equipment and pipelines

Firstly, using the produced virtual models, the clashes among building structure, equipment, and pipelines are detected. The process mainly includes three aspects. The first aspect is to check the clashes inside the building structure model, especially for the unreasonable layout of architectures and engineering. For example, a beam elevation is very low and closes to the door, so that there is not enough clear height for the outflow passage. The second aspect is to check the clashes between the virtual models of building structure and the equipment and pipelines. This kind of clash should be adjusted and usually from adjusting the pipelines. For instance, Figure 2 demonstrates a clash between a beam and chilled water pipe, hot water return pipe, cooling water supply pipe. The third aspect is to detect the clashes among the equipment and pipelines of electrical, plumbing, fire life safety and HVAC systems using the automatic detection function of the Revit MEP software. For example, Figure 3 displays a clash between a ventilation pipe and a fire pipe.

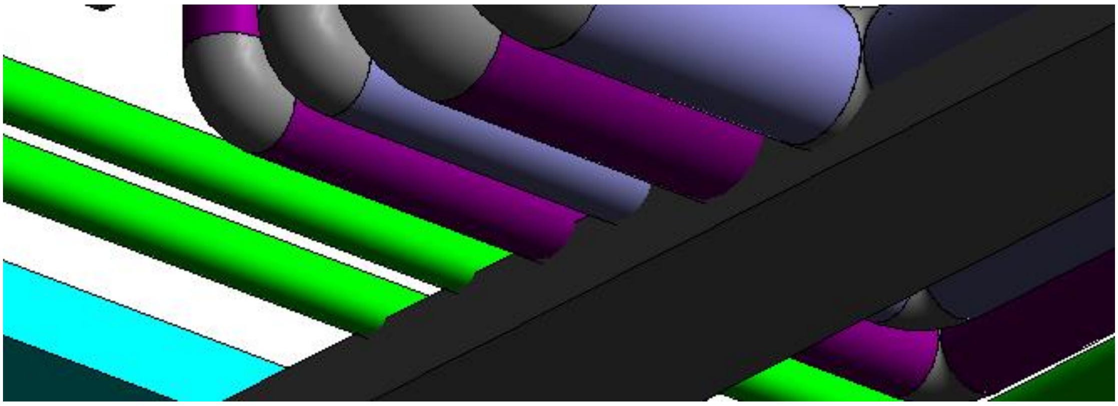

Figure 2. A clash between a beam and a chilled water pipe, a hot water return pipe, a cooling water supply pipe

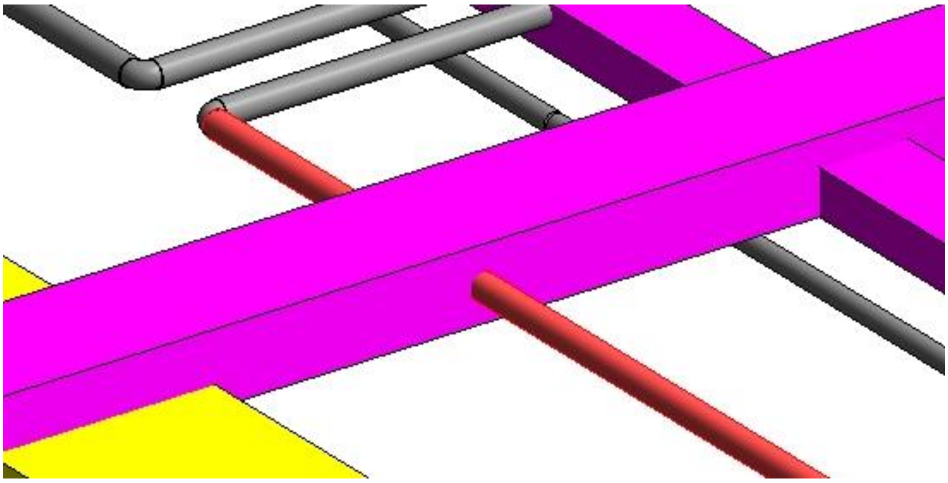

Figure 3. A clash between a ventilation pipe and a fire pipe.

Secondly, the coordination and design optimisation for building structure, equipment and pipelines are operated according to these detection results. More than 1,000 positions in design drawings are needed to adjust in this project. Experienced architects and engineers are needed in the process of coordination, adjustment and optimisation. The BIM models provide precise information of line elevation and location features for the architects and engineers. An illustration of the coordination and adjustment of pipes are shown in Figure 4.

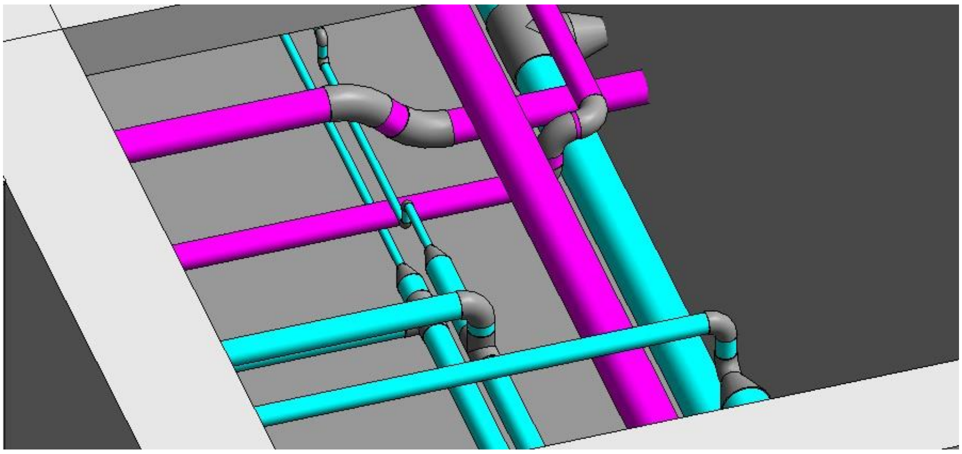

Figure 4. A sample of the adjusted pipes

Finally, a report and three-dimensional design outputs are provided for the client. The report generally provides the information of the clash detection, coordination and adjustment among building structure, equipment and pipelines. The three-dimensional design outputs primarily consist of comprehensive pipeline drawing, partial cross-sectional views, partial three-dimensional isometric drawings and BIM models in the DXF file format. Figure 5 is a sample of a partial three-dimensional isometric drawing.

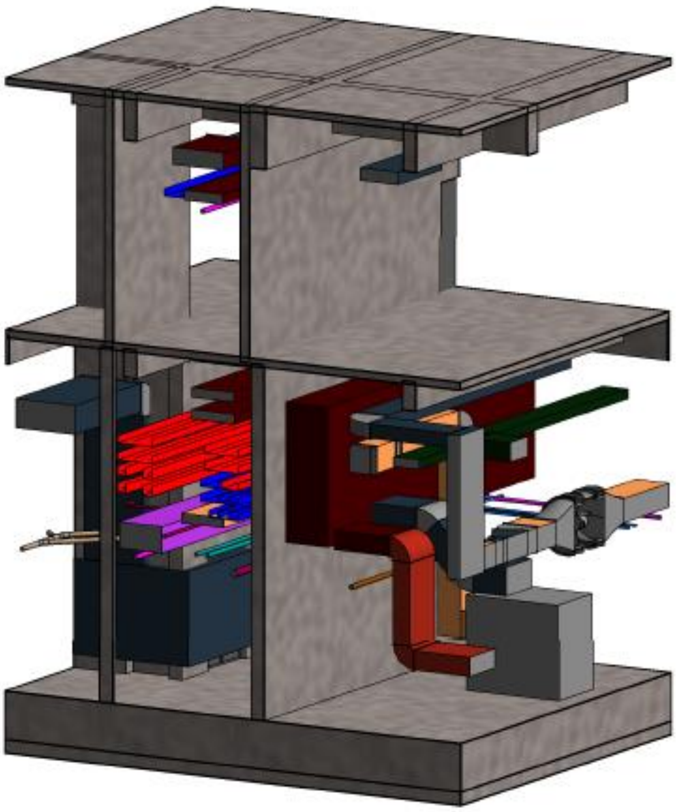

Figure 5. A sample of a partial three-dimensional isometric drawing

Quantity statistics

Quantity statistics is to compute the quantities of construction and materials based on the adjusted BIM models. There are three ways to calculate the quantities from the BIM models: building the connections between the BIM models and other project cost software through the Application Programming Interface (API), directly accessing BIM databases by the Open Database Connectivity (ODBC), and using the automatic statistical function to import the model results into Excel sheets. As a result, it can be concluded that the correct detailed BIM models can provide the accurate quantity statistics and then supports project budget management.

Construction simulation

Construction simulation is to perform construction process in the dynamic four-dimensional formation by combining BIM models with time factors using Navisworks. Construction simulation can support visualization and simulation for a construction process, and can achieve dynamic management and optimisation for a construction schedule. In this project, construction simulation is mainly used in the complex pipeline installation, which includes three key work procedures such as work breakdown, construction schedule and simulation video. Using construction simulation, the construction schedule is optimised; the issues of cross construction is avoided; the requirement information of construction materials and labours is obtained; and which all support to achieve of the established construction schedule.

DISCUSSION FOR PROMOTING BIM APPLICATION

Some comments and improvements are also identified in the process of BIM implication in this project. Firstly, BIM engineers should understand the construction process and management in accurately and clearly modelling the building. Secondly, the material list produced by the BIM system has differences with the traditional material list which is produced by the construction budget software in China. Thirdly, some BIM technique capabilities need to be developed, such as modelling the inclination of the drain pipe and displaying the detailed information of daily construction in construction simulation. Fourthly, the BIM outputs are a lack of the legal validity compared to the design drawings, therefore, in which some engineers and builders did not accept the BIM outputs. Actually, the legal issues related to BIM have repeatedly been recognised from the previous BIM studies (Kuiper and Holzer, 2013).

Although the BIM technology has potentials in developing construction management, lack of collaboration among project participates is a significant application challenge. For example, some project changes in fieldwork could have not been reflected in the BIM models due to lack of communications between the general contractor and BIM professional. Whether BIM is utilised or not in a project, organisational and cultural divisions among all project participates probably hinder collaborative work and problem-solving in a complex construction nature of the various expertise and professionals needed for construction projects (Dossick and Neff, 2009). Establishing a collaboration project management culture for all participants could be a vital pathway to promote the BIM effective application in construction projects (Fanrong et al., 2013).

CONCLUSIONS

The BIM software has been successfully applied in the Jinan West Railway Station Square Integrated Project. The BIM application significantly promotes the achievements of the construction schedule, quality, budget and scope objectives through the process of clash detection and coordination among building structure, equipment and pipelines. Before the process, virtual buildings should be modelled using the Revit software based on design drawings. After the process, three-dimensional design outputs and a report including the results of the clash detection, coordination and adjustment are provided for the project client. Moreover, the function of quantity statistics in BIM provides the building information related to construction quantities and project cost. Construction simulation supports to solve construction difficulties in complicated construction systems and to value the benefits for the project schedule target.

The BIM application would definitely add values to manage construction projects and drive project success. The participants in construction project management have also been recognising the BIM advantages and preparing to adopt BIM. However, the knowledge framework of BIM engineers, the technological capabilities of BIM, the illegal issues of BIM outputs and establishing cooperative project management culture are needed to be locally and internationally developed. Consequently, these requirements and strategies of BIM applications should be deeply investigated so as to promote the BIM application in the construction industry. Future studies are also expected to utilise and enhance BIM technologies in more situations during the project initiation, planning, design, construction, maintenance and operation phases.

REFERENCES

Autodesk (2016). 'BIM 101 - An introduction to building information modelling', http://www.autodesk.com/solutions/bim/overview, viewed: 10 April. 2016.

Becerik-Gerber, B., Jazizadeh, F., Li, N., Calis, G. (2011). 'Application areas and data requirements for BIM-enabled facilities management', *Journal of construction engineering and management, ASCE,* Vol.138, pp. 431-442.

Cao, D., Li, H., Wang, G., Huang, T. (2016). 'Identifying and contextualising the motivations for BIM implementation in construction projects: An empirical study in China', *International Journal of Project Management,* In press, doi:10.1016/j.ijproman.2016.02.002.

Davies, R., Harty, C. (2013). 'Measurement and exploration of individual beliefs about the consequences of building information modelling use', *Construction Management and Economics,* Vol. 31, pp. 1110-1127.

Demian, P., Walters, D. (2014). 'The advantages of information management through building information modelling', *Construction Management and Economics,* Vol. 32, pp. 1153-1165.

Ding, Z., Zuo, J., Wu, J., Wang, J. (2015). 'Key factors for the BIM adoption by architects: a China study. Engineering', *Construction and Architectural Management,* Vol. 22, pp. 732-748.

Dossick, C.S., Neff, G. (2009). 'Organizational divisions in BIM-enabled commercial construction', *Journal of construction engineering and management, ACE,* Vol. 136, pp. 459-467.

Fanrong, J., Youquan, X., Dalin, Z., Lingmin, Z., Qin, Z. (2013). 'Application of BIM Technique in Some Comprehensive Pipeline Project', *Construction Technology*, Vol. 42(3), pp. 107-109.

Kuiper, I., Holzer, D. (2013). 'Rethinking the contractual context for Building Information Modelling (BIM) in the Australian built environment industry', *Australasian Journal of Construction Economics and Building*, Vol. 13 (4), pp. 1-17.

Mäki, T., Kerosuo, H. (2015). 'Site managers' daily work and the uses of building information modelling in construction site management', *Construction Management and Economics* Vol. 33, pp. 163-175.